HIGH FORCE COMPACTION
ITS CAPABILITIES AND LIMITATIONS FOR
DRY ACTIVE WASTE PROCESSING

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ABSTRACT

A study was performed of the operating experience of high force compactors (HFC's), particularly the volume reductions achieved. These operating data were then employed in an economic analysis to determine the conditions under which HFC's are cost-justified in the U. S. The results indicate that this technology is best applied in the U. S. in the same way that it has been justified in other countries, for central processing facilities or in a mobile configuration, for the servicing of multiple plants.

INTRODUCTION

The large volumes of dry active waste (DAW) being generated at many nuclear plants have prompted utilities to review DAW processing alternatives. These alternatives now include the high force compactor (HFC), sometimes referred to as the super-compactor. The HFC is a hydraulic press, available to U.S. utilities in several configurations and designed to accept either 30 or 55-gallon drums of DAW. It will compress these drums, and their contents, at pressures which cannot be approached by conventional compactors. The HFC is characterized by volume reduction capabilities, and a capital cost, which are intermediate between standard compaction and incineration technologies. With such characteristics the HFC may provide waste disposal cost savings which are less than an incinerator, but a return on initial investment that may be more attractive than either incineration or standard compaction. The economics of this technology are therefore worthy of investigation for producing savings in storage and disposal costs.

This paper summarizes the results of an investigation of HFC performance and operating costs with the objective of making general conclusions as to HFC economic attractiveness. Specific objectives of this study were:

1. To determine the operating results, particularly volume reductions, achieved at operating HFC facilities.
2. To analyze the operating costs and potential for payback of investment of HFC's versus competitive technologies.
3. To determine the approximate conditions, particularly waste generation rates, at which HFC's are cost justified.

TECHNICAL DESCRIPTION

There are at least 8 different HFC designs which are currently offered in the U.S. Compressive forces vary from a low of 135,000 lb. total force to a high of 7,800,000 lb. Those designs which can justifiably be called HFC's, in the sense that they achieve exceptionally high VRF's, have forces in excess of 1,200,000 lb. These units accept either 30 or 55-gallon drums of waste which have normally been pre-compacted with a conventional compactor. They will crush the steel drum with its pre-compacted waste to yield cylinders which retain their approximate 24-inch diameter but have heights of 3-inches to 2-feet, depending upon waste composition. These crushed drums are then stacked within an overpack, usually a 55 or 85-gallon drum.

One HFC which is being offered is shown in Figure 1. This particular system will crush 55-gallon drums in a vertical orientation using a two-stage compaction cycle. The first cycle reaches 1,100,000 lb. and the second 3,500,000 lb. force. The unit is approximately 4' x 4' x 10' high, not including the hydraulic skid, and weighs 35 tons. The bell which surrounds the compacting platen acts as a die so that the crushed drums do not exceed 24.5 inches as the drum is compressed, assuring its compatability with overpacks. This HFC comes equipped with HEPA filtration systems and a bell or shroud which totally encloses the drum during compaction cycles. The system can be obtained with drum conveying equipment for remotely operated insertion and removal of drums. The equipment can be further augmented with an inventory control system which measures, records and stores the crushed drums. Such an inventory system is now in operation at the Karlsruhe Research Center.

Fig. 1

EXPERIENCE

HFC systems are currently operating in W. Germany, Belgium, France and Japan. One system is designed as a mobile unit to service several power plants. All others are designed, and were cost-justified, as central processing facilities to which a number of power plants would send their waste providing high utilization.

The Karlsruhe facility, as an example of a central processing facility, now processes in excess of 300 tons/year of waste. It is estimated that approximately 50% of this waste consists of metal scrap. The cost-justification of the Karlsruhe system thus included the following points:

1. A large percentage of metallic waste and building-material wastes would be processed which would be incompressible with any technology other than the HFC.
2. Waste volumes are ultimately expected to be in excess of 200,000 ft^3/year.
3. Waste storage is required due to the closure of the Asse disposal site, and costs are high (in W. Germany approximately \$65/ft^3).

Volume reduction experience with the Karlsruhe system, as well as other systems, is reported to meet or exceed original expectations. A summary of volume reduction data obtained from plant personnel is shown in Table 1 and is compared with standard drum compactor and box compactor VR experience.

As shown in Table I, compacted waste densities vary significantly depending upon waste composition. The volume reduction (VR) factors which can be derived from Table I by ratios of densities also, therefore, vary significantly. The range of VR factors for non-metal wastes is at least 2.6 to 5.0 for a standard drum compactor and 6 to 11 for the HFC.

TABLE I

Waste Densities (lb/ft) for Compaction Systems in Use

	Initial Bulk Density	Compacted Waste Density		
		Drum Compactor	Box Compactor	1500 Ton HFC
Metallic Scrap (pipe, filters, conduit)	75-200	75-200	75-200	300
Non-Metallic Waste (paper, rubber, plastics, glass)	8-10	26-40	25 - 36	63-90
Mixed Metallic & Non-Metallic	15	-	-	156

The data recently reported by EPRI[1] for standard drum compactors in U.S. power plants indicates that product densities can differ by as much as 50% depending upon the use of anti-spring back devices and, in particular, dedicated and experienced DAW processing crews. EPRI further reports the success of administrative techniques for pre-sorting of wastes, and use of decontamination methods, which simply eliminate certain wastes as non-radioactive.

Current U.S. experience with DAW generation rates was also reported by EPRI. These data are summarized in Table II.

TABLE II

As-Shipped Average Annual Waste Volumes (ft^3/Year)

	BWR	PWR
Compactable	14,300	4,800
Non-Compactable (Wood, filters, conduit, pipe, valves)	8,100	5,750
Total	22,400	10,550

ECONOMIC ANALYSIS

On the basis of the data presented in Tables I and II, a series of economic analyses were performed. The basis for one such analysis, including the VR assumptions made, is summarized in Table III. For this study, the waste composition and volumes are consistent with EPRI's "average BWR" data shown in Table II, that is, a plant with 50,000 ft^3 of pre-compacted DAW of which approximately 20% would not be compressible with a standard compactor (in Table III this is called "metallic" waste for simplicity). Burial at Barnwell was assumed in this analysis.

TABLE III

Basis for Economic Analysis

	Standard Drum Compactor	Box[3] Compactor	High Force Compactor
Initial Waste Volume			
Metallic	8,000	8,000	8,000
Non-Metallic	42,000	42,000	42,000
VR Factor			
Metallic Waste	1.0	1.0	3
Non-Metallic Waste	3	4	8
Compacted Waste Volume			
Metallic	8,000	8,000	2,700
Non-Metallic	14,000	10,500	5,300
Total	22,000	18,500	8,000
No. Containers Shipped	2,993	189	998[1]
Container Volume Buried[2]	22,400	18,900	11,300
No. Shipments	43	19	17

(1) Assumes an average of 3 drums per overpack

(2) Based on buried volumes of 7.5 ft^3/drum, 100 ft^3/box and an average of 3 drums per 85 gal overpack

(3) The volume reduction factors and compacted waste volumes in this column would also be representative of a standard drum compactor with dedicated crew and other administrative controls.

Calculated operating costs are shown in Table IV. The HFC was found to provide savings of \$110,000 per year in operating costs over the nearest competitive technology considered, the box compactor. It should be noted that, based on the referenced EPRI survey, the results for the box compactor in Table IV are approximately the same as for a standard drum compactor with anti-spring back devices and dedicated crew.

To determine if the capital investment for an HFC is cost-justified, a fixed charge rate is assumed. This rate, assumed here to be 17%, represents the utility's annualized cost of the capital investment expressed as a percentage of the total installed cost of the equipment. For the HFC to be economically justified, annual operating cost savings with the HFC must exceed the annualized cost of the capital investment, providing a payback. If the operating savings are divided by the fixed charge rate, the result is the maximum investment which could be justified for those savings.

TABLE IV

Operating Costs

	Standard Drum Compactor	Box Compactor	HFC
Burial Cost(1) ($21.50/ft^3)	$482,000	$406,000	$243,000
Transportation Cost (1500 mi @ $1.73/mi)	112,000	49,000	44,000
Cost of New 55-gal Drums (30 each)	90,000	-	-
Cost of 100-ft^3 Boxes ($400 each)	-	74,000	-
Cost of Reconditioned 55-gal Drums ($9 each)	-	-	27,000
Cost of 85 gal Overpacks ($65 each)	-	-	65,000
Differential Labor Cost	20,000	-	40,000
	$704,000	$529,000	$419,000

(1) Includes the following costs per cubic foot: Base Fee $14.50, State Perpetuity $2.50, State LLW Tax $4.00, County Tax 2.4%.

Table V provides a summary of the operating savings and maximum justifiable investment for the HFC. As shown, for the case described previously, the "average BWR", the maximum investment would be $647,000. If storage building cost savings are considered in the analysis (at $15/ft^3 of storage space for DAW) then the maximum investment jumps to $1,312,000.

In addition to the "average BWR" case, Table V shows results of an analysis for 100,000 ft^3/yr. of uncompacted waste and analyses performed for plants which have a waste composition which is similar to the "average PWR" of the EPRI studies. An HFC that is capable of producing the assumed VR factors will have an installed cost of $1,400,000. Therefore, the only cost-justified case considered would be the BWR with 100,000 ft^3/yr. waste and taking credit for storage building cost savings.

TABLE V

Economically - Justified Investment

	Disposal Savings	Max Cap Cost	Storage Savings	Max Cap Cost w/Storage
BWR Waste Composition				
50,000 ft^3/yr	$110,000	$ 647,000	$223,000	$1,312,000
100,000 ft^3/yr	220,000	1,294,000	446,000	2,624,000
PWR Waste Composition				
20,000 ft^3/yr	57,000	335,000	116,000	682,000
40,000 ft^3/yr	114,000	670,000	232,000	1,365,000

SENSITIVITY ANALYSIS

Of the many variables which would affect the conclusions in Table V, the following have been analyzed, with results as shown:

1. HFC volume reduction factor - If the volume reduction factors assumed for Table IV are increased 50%, disposal cost savings would increase by $100,000 per year.

2. Shipping distance - If the transportation distance increases to 2,000 miles, savings are increased $6,000, which is not significant to the conclusions.

3. Number of overpacks/shipment - For the HFC, overpacks per shipment cannot be significantly increased because overweight shipping limits are reached at about 50 overpacks per shipment already assumed in Table IV.

4. Use of new drums - If new drums are used rather than reconditioned drums, savings decrease $63,000, which is significant to the investment payback.

CONCLUSIONS

The following conclusions are drawn from this study:

1. High force compactors are currently providing volume reductions for dry active waste material which are not attainable by other compaction technologies. The range of volume reductions achieved is at least 1.5 to 11 over uncompacted materials, depending upon waste composition.

2. In general, for individual nuclear power plants, a high force compactor is economically justified in the U.S. only for the largest waste generators. Alternatively, this technology can be justified for servicing a number of plants, which is how it is currently being used in other countries, in either mobile configuration or in a central processing facility.

3. Economic justification depends greatly upon the utility's treatment of on-site storage costs. If such costs are not included in the analysis, then it is doubtful that an HFC could provide a payback for any individual plant.

4. Burial site costs are far more significant in the operating cost analysis than are transportation costs, making the analysis relatively independent of the distance to the burial site.

5. Waste composition affects the choice of compaction technology. The expectation of large amounts of metal-bearing wastes help to support the choice of a HFC.

REFERENCES

1. Identification of Radwaste Sources and Reduction Techniques, EPRI RP 1557-3, C.P. Dettete, G.S. Daloisio, M.D. Naughton, November 1983.

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