THE COMPREHENSIVE WASTE MANAGEMENT SYSTEM AND A UNIQUE APPROACH TO ON-SITE LLW STORAGE

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ABSTRACT

A systematic technical and economic evaluation of low level radioactive waste (LLW) products, services, and operating practices has been performed. This evaluation has resulted in an improved understanding of the entire LLW cycle and included technical evaluations of existing and proposed LLW processing, solidification, and volume reduction systems and equipment, important insights into the economics of the LLW cycle, and identification of waste generator needs that require cost effective engineered solutions. The body of knowledge generated by the analysis, methodologies developed, and the included products and services are collectively referred to as the Comprehensive Waste Management System (CWMS). Other studies of LLW management practices and equipment applications have addressed specific problems and issues, but have frequently stopped short of applying the overall systems engineering approach utilized by the CWMS evaluation. Generally, problems addressed by other studies and the associated solutions were not integrated into a comprehensive plan, with the consequence that some generators made (and are making) decisions based on incorrect, incomplete, or misleading data. A strong need for valid technical and economic data covering the entire LLW cycle seems to exist in the nuclear industry today. Simplified curves, showing cost savings possible from the application of various volume reduction systems have been prepared for PWR and BWR reference designs. The curves and supporting data have proved to be directly useful in aiding generators in formulating waste management plans. Economic models and data which calculate operating and disposal costs for plant specific applications of radwaste processing and volume reduction equipment, and also determine costs for various plant specific on-site LLW storage options have been programmed onto an IBM-PC. The resulting economic analysis tool can be taken to plant sites to perform such cost determinations in the field. An important aspect of the CWMS evaluation was the confirmation of the need for three important new or improved LLW products or services for the U. S. nuclear industry. Those items are a truly mobile high force (super) compactor, an improved resin dryer, and a LLW storage cask which is transportable to disposal sites. All three items were evaluated from technical, economic, and regulatory standpoints, and are described further in the body of this paper.

INTRODUCTION

The low-level radioactive waste generated as a result of nuclear power plant operations has, over the last ten years, passed from relative obscurity to a position of much higher visibility. Ten years ago the costs of treating, packaging and disposing of LLW were modest; there was little regulatory attention directed toward LLW, and there was plenty of low cost disposal site space available. Decisions regarding LLW matters were typically made by persons well down in the ranks of generator organizations, and there was little public awareness of LLW practices or disposal methods. Of course, as almost everyone is well aware, conditions affecting the LLW cycle have changed drastically over the last ten years, to where today LLW processing, volume reduction, packaging, storage, transportation and disposal operations are being affected by economic, technical, and regulatory forces which are in a highly dynamic state. The Low Level Waste Policy Act of 1980, the new waste form criteria and disposal site regulations of 10CFR61, impending IAEA regulations, non-uniform disposal site regulations, skyrocketing disposal costs, new processing technologies from overseas and domestically, additional nuclear plants coming on line, new faces in the marketplace, and strong public involvement, all have produced volatile, sometimes unpredictable conditions working on LLW cycle activities. These changing conditions may presently be unmatched in magnitude or number in any other nuclear fuel cycle activity.

At the time the Comprehensive Waste Management System (CWMS) studies were begun, shortly after Westinghouse's Waste Technology Services Division (WTSD) was formed in March 1983, there was a definite need to develop an improved understanding of LLW cycle dynamics, and the many forces at work in the LLW area. Important decisions needed to be made regarding current products and services, proposed product improvements, and possible new products and services. Industry input was sought relative to LLW problem areas and needed improvements. LLW cycle (Figure 1) economics were carefully examined using computer based economic evaluation tools on an IBM-PC (personal computer). Existing technologies were reviewed, some old ones dusted off, and new technologies considered. This paper describes some of the CWMS methods and results which led in part to the development of two new product/service combinations, and the introduction of a new service based on a previously developed technology. CWMS data has aided some generators in formulating waste management decisions, and will continue to be available to others as needed.

ECONOMIC EVALUATION TOOLS AND METHODS

In support of the CWMS activities, WTSD has performed two types of economic analyses examining the economics of LLW processing, volume reduction, packaging, storage, transportation and disposal. The first type of analysis focuses on the economics

COMPREHENSIVE WASTE MANAGEMENT SYSTEM

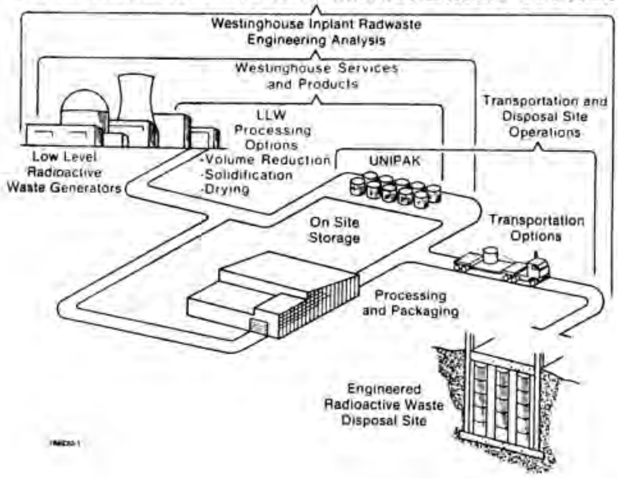

Figure 1. Comprehensive Waste Management System

of different methods of processing and volume reduction; the second evaluates the economics of different approaches to on-site storage of LLW.

The economic evaluations are performed on an IBM-PC using the LOTUS 1-2-3 software package. The combination of IBM and LOTUS provides a system capable of performing complex calculations that is compatible with computer capabilities found at most plant locations. For locations that do not have access to an IBM-compatible machine, a portable computer can be used to perform the economic calculations.

Whenever possible, the economic calculations are based on site-specific data. If, for some reason, site-specific data is not readily available, the calculations can be run using data from well known references, such as ONWI-20[1], for baseline data. That data can then be modified, according to information from similar plants, to create a reasonably accurate estimate of waste generated at any given site.

The calculations require several inputs: financial assumptions, burial charges, transportation charges, radiation level and curie content of the waste, capital equipment costs, and site operating expenses. None of the above parameters are fixed in the calculations, and users are free to vary the numbers according to individual preference. Realistic values are available based on experience and the work of knowledgeable organizations (e.g., EPRI).

The financial assumptions include discount rate for money, income tax rate, property tax, insurance rate, and depreciation method (straight-line and accelerated tables). Burial charges are computed from Barnwell and Hanford rate schedules. In addition, the rates can also be modified to forecast the effects of possible future rate schedules for new or existing burial facilities. Transportation charges are standard charges on a per-mile basis; the mileage to a burial site is assumed or actual. Radiation level and curie content preferably are actual values provided by waste generators and should be based on volume (for surface radiation levels) and shipment container (for curie content). Capital equipment costs are made as realistic as possible by using data from waste generators, EPRI or DOE reports, and other market information. Site operating expenses are either actual operating expenses, or are based on time-motion analyses and engineering estimates. Any input parameters can be changed easily to suit individual circumstances.

Thus far, the calculations have been very useful in putting the costs of on-site storage and volume reduction options in perspective. WTSD has provided economic comparisons for several waste generators, and for internal purposes. This service will continue to be available to any waste generator who could benefit from plant-specific economic analyses.

The CWMS economic evaluation software, data, and methodologies will continue to be updated and improved. Considering LLW cycle dynamics, it should be useful for some time to come to have computerized financial analysis capabilities available. For example, as new state compact LLW disposal facilities are being considered and rate structures proposed, financial "what if" questions can be answered in both general and plant specific terms.

Looking ahead, consideration will be given to expanding the CWMS cost models and data base to support cost analyses of waste management schemes for high level waste (HLW), transuranic waste (TRU), and spent fuel. For facilities such as the federal Monitored Retrievable Storage (MRS) facility where LLW, HLW, TRU, and spent fuel will all be received and/or generated, it could prove useful to have a single economic evaluation system to study the operating cost impact of proposed changes to waste management systems and procedures while still in the design phase.

GENERAL ECONOMICS

Low-level waste processing, packaging and disposal is expensive. Since waste generators have little, if any, control over burial charges, they must do whatever possible to control the volume of waste sent to a burial site. However, if the economics of processing (including volume reduction) become excessive, any potential economical savings at the burial facility will be overshadowed.

Figure 2 contains a set of curves which show burial and operating costs versus percent volume reduction for wastes generated at a typical 1000 MWe PWR. The curve for burial and operating costs of composite waste is derived from summing the costs for liquid waste; resins, filter sludge, and cartridge filter waste; compactible waste; and noncompactible waste. Similar curves have been prepared for BWRs, an example of which is shown in Figure 3.

The cost savings (principally burial savings) resulting from application of a volume reduction technique must be compared to the total cost of implementing the volume reduction method to determine the potential economic advantage derived by performing the volume reduction. Table 1 lists various alternatives for volume reduction, and addresses several aspects of the economics: total cost estimate, maximum cost savings for typical 1000 MWe PWR and BWRs, annual savings required for the waste generator to "break even," whether the method is economically attractive, and if mobile service is available.

If mobile service is available, a waste generator can benefit in several ways. First, a large capital expenditure is not required. Second,

Table I. Volume Reduction Economical Comparison

HARDWARE	INSTALLATION COST ESTIMATE (2)	SAVING REQ. PER YEAR TO "BREAK EVEN" (3)	PER YEAR MAX. SAVINGS PWR	PER YEAR MAX. SAVINGS BWR	ECONOMICALLY ATTRACTIVE? SINGLE PLANT PWR	ECONOMICALLY ATTRACTIVE? SINGLE PLANT BWR	ECONOMICALLY ATTRACTIVE? DOUBLE PLANT PWR	ECONOMICALLY ATTRACTIVE? DOUBLE PLANT BWR	MOBILE SERVICE AVAILABLE?
3:1 Compactor	0.2M	41 K	114 K	120 K	Yes	Yes	Yes	Yes	Yes
6:1 Compactor	3.8 M	220 K	291 K	325 K	No	No(4)	No	No(4)	Yes
Steam-Resin Dryer (5)	0.75 M	62 K	40 K	290 K	No	Yes	No	Yes	Yes
Crystallizer	4.3 M	250 K	210 K	N/A	No	No	Yes	N/A	No
Incinerator (6)	13.7 M	748 K	40 K	53 K	No	No	No	No	Yes
Fluidized-Bed Incinerator (7)	24.2 M	1303 K	274 K	1300 K	No	No	No	No	No

NOTES: (1) Entire analysis highly dependent on disposal site rates, disposal waste form requirements, and disposal site quotas.
(2) Based on EPRI Report RP 1557-11[2].
(3) Annual savings required for 15 year period to pay for equipment installation. The savings compare operating costs with transportation and burial savings.
(4) Sights with higher generation rates may economically justify a compactor.
(5) Assumes an existing cement or polymer solidification system.
(6) DAW incineration only.
(7) Will incinerate resins and dry liquids.

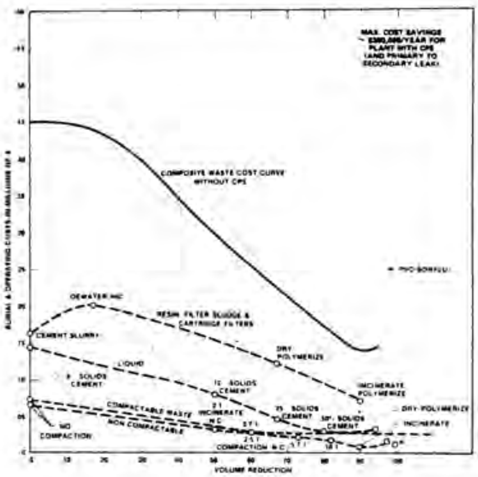

Fig. 2 Typical PWR - 1000 MWe Cost Comparison of Waste Processing

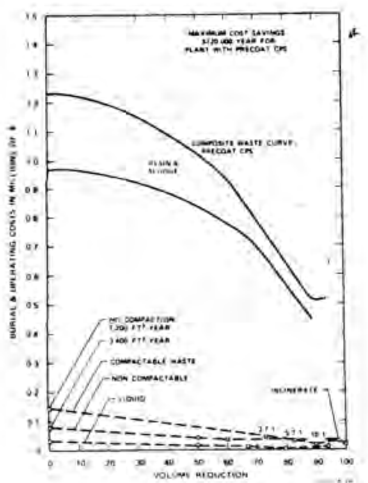

Fig. 3 Relative Costs for Waste Processing at a Typical BWR - 1000 MWe Plant with Precoat CPS.

maintenance costs and concerns are not the responsibility of the generator, but rather the company performing the service. Third, there is no lead time associated with construction or installation on site. Fourth, as new techniques become available, or as existing techniques of volume reduction are improved, the mobile service subscribers need not go to the expense of purchasing new equipment to replace obsolete existing equipment. Therefore, when considering implementing new volume reduction processes, generators should also consider mobile service to ensure all reasonable options have been evaluated.

Interim on-site storage can pose a financial burden on some generators. There is a good chance that interim on-site storage may be necessary, at least until regional burial sites are available. Two alternatives for interim storage are large Buildings for On-site Storage (BOSS) which are large, shielded buildings, and small, self-shielded containers, such as UNIPAKs. The BOSS concept requires a large capital outlay (up to several millions of dollars) and two to four years of planning, design, and construction. The UNIPAK concept (discussed later in this report) requires a minimum of capital expense, and therefore results in a significant savings over interim storage periods for most situations.

Although economics is not the sole driving force for a decision on what method to use for volume reduction or for interim on-site storage, it is an important factor. Therefore, the balance of this paper deals with the technology and economics of two volume reduction techniques and an interim storage method which are part of the Westinghouse Comprehensive Management System for LLW.

Product/Service Specific Evaluations

High-Force Compactor

As discussed above, over the last several years, significant regulatory and economic forces have affected the transportation and burial of low-level radioactive wastes. These forces include steadily increasing burial site prices, more restrictive packaging and waste form requirements for burial, and implementation of volume restrictions at currently operating burial sites.

Dry Activated Waste (DAW) produced at nuclear power plants accounts for the largest fraction of the radioactive waste volume generated and shipped for burial. The application of volume reduction techniques to DAW, therefore, merited attention in order to reduce a plant's overall radwaste packaging, transportation and disposal costs.

Most operating nuclear plants compact DAW in standard box or drum compactors which achieve net compacted waste densities of approximately 30 lbs/ft^3. Compaction may be preceded by some sorting for recoverable items or segregating of clean from contaminated waste.

Westinghouse Hittman Nuclear Incorporated, a subsidiary of Westinghouse Electric Corporation, recently completed a comprehensive review of current DAW handling and packaging processes. CWMS economic studies indicated strong financial incentive for developing increased DAW volume reduction capabilities. As a result, an integrated DAW processing, volume reduction and packaging service, called $AVPAK, was developed. The $AVPAK service introduces significant improvements over existing practices and equipment. At the heart of the $AVPAK service is a high force compactor.

The Westinghouse High-Force Compactor (designated "COMPACT 1") is a mobile, 1000-ton ram-force compactor designed to volume reduce DAW. During the design of COMPACT 1, WTSD performed tests on representative samples of DAW to determine how much volume reduction is obtained by different applied ram forces. The 1000-ton force utilized by COMPACT 1 provides over 98% of the volume reduction that a 1500-ton press would yield, yet permits the compactor assembly and ancillary equipment package to remain light enough to be mobile.

The $AVPAK service itself includes an optional selective sorting scheme which first separates reusables, such as metal objects, dosimeters and tools, from the general waste. Clean waste is then segregated from contaminated waste and processed separately for burial at a local sanitary landfill. These sorting and segregation operations result in only contaminated waste being sent to a low-level waste burial site and, therefore, result in direct volume reduction. The contaminated waste is then processed through the COMPACT I.

The COMPACT I unit is expected to spend no more than one month at a typical reactor site to handle all the dry activated waste generated at the site in one year. The total one month period can be done in one site visit, or can be broken down into segments depending on the needs of the waste generator, thus saving generators the large capital investments required to install permanent compaction facilities which may be needed only a few weeks each year.

The supporting equipment and hydraulic high pressure compactor will be mounted on a standard highway truck trailer. The compactor will have integral off-gas and off-liquid collection systems. A typical scope of supply for the DAW processing and compaction service is provided in Table 2.

Comparative economic analyses of savings possible per year for various DAW volume reduction techniques show that volume reduction by high-force compaction results in the highest annual savings. Typical values for volume reduction of 10,000 cubic feet nuclear power plant DAW using a high-force compactor show savings on the order of $290,000 in packaging, transportation, and burial costs per year when compared with no compaction, and over $175,000 compared with normal 3:1 compaction. This assumes that mobile compaction services have been utilized, as opposed to capital purchase and installation of a high force compactor. Greater savings would be realized for plants which generate more than average amounts of DAW.

Table 2. Scope of Supply - Westinghouse Hittman Nuclear Incorporated DAW Processing and Compaction Services

- On-site service crew consisting of supervision and technicians to:
  - collect DAW from collection points in plant(s)
  - perform waste sorting and segregation
  - operate supporting equipment and radwaste high pressure compactor
  - package clean waste for burial at local landfill
  - plan and schedule waste shipments
- Sorting and segregating work stations
- Mobile clean waste granulator and radwaste high pressure compactor
- All expendable materials including drums, poly bags, overpacks, etc.
- Unshielded transportation services to local landfill and licensed burial site

Resin Dryer

The Resin Volume Reduction Service (RVRS), based on a steam resin dryer, is a new waste processing technology capable of reducing the volume of spent resins by twice that achieved by conventional resin dewatering methods. This advanced system demonstrates that resins being shipped to disposal sites can be cost effectively reduced in volume further than that achieved by conventional means. Tests run on a full-scale prototype RVRS unit confirm the ability of the equipment and drying techniques to achieve superior resin volume reduction. The resin dryer was designed, developed, fabricated, and assembled in the early 1970'sat the Westinghouse Research & Development Center. Following a successful full scale demonstration, the resin dryer was disassembled and the technology patented and filed away. In 1974, with radwaste disposal costs averaging less than $\$1.00/ft^3$, there was no economic incentive for waste generators to volume reduce resins. In 1984, however, with disposal costs climbing rapidly, the picture has changed and volume reduction of resins using the Westinghouse resin dryer is now cost effective for nuclear facilities which generate large quantities of bead resin. Several BWR plants fall into this category. CWMS economic analyses have confirmed the economics of resin drying.

For efficient utilization, resin dryer operations should be coordinated with the periodic change of the deep bed condensate demineralizer beads. For discussion purposes, assume a single BWR generates approximately 8,000 ft^3 of bead resin annually. Resin would be processed (dewatered) in batches of 180 ft^3 (dewatered volume) approximately once every eight or nine days. This is the volume of resin to be shipped to disposal per bed change. It is estimated that about 50 hours of RVRS operating time is required to volume reduce a batch (180 ft^3 dewatered) of resin. The final volume of dried resin discharged to the container and shipped for disposal will be approximately 90 ft^3 per bed changeout.

The resin drying system is essentially a batch process in which successive batches of 28 cubic feet of resin-water slurry is dewatered, then vacuum dehydrated to produce 7 cubic feet of dried resin. In the first stage of the process, the resin-water slurry is charged from the plant resin hold-up tank or an intermediate resin feed tank into the drying chamber to a predetermined level. Termination of this charging operation is accomplished automatically and an indication displayed on the control panel. The free water is then removed by vacuum filtration through the settled resin bed and returned to plant systems.

In the second stage of the process, the heated drying chamber is evacuated and superheated steam is passed through the wet resin to fluidize the bed. The system can utilize plant supplied steam; however, the RVRS includes a steam generating package boiler unit.

Heat is supplied to the wet resin from two sources - super heated steam and external heaters located around the drying chamber walls. Energy from these two heat sources is controlled automatically by temperature sensors in the resin bed. Water removal is accomplished under vacuum. As the resin loses water, heat is continuously added to the fluid bed to maintain the bed temperature in the range consistent with the resin thermal stability. When a preset bed temperature is obtained, the fluidizing-drying stage is halted and the vacuum system isolated.

In the third stage, the resins are dried to their final stage of dryness by spraying the partially dried resins into the evacuated waste container using a two-fluid spray nozzle with super heated steam as the transport medium. Filling of the burial package is automatically controlled by a level sensing device.

The water removed from the wet resin is condensed along with the fluidizing and transport steam and sent to the plant drains. The overall volume reduction obtained in the process is on the order of 50% of the initial volume of the dewatered resin. To reduce radioactive carryover of volatile species, such as iodine, the fluid bed residence time and temperature are controlled to prevent resin decomposition. In addition, vent discharges are routed to the plant off-gas/ventilation system.

The entire RVRS, including the optional boiler for the self-contained steam supply is skid mounted with external dimensions that permit portability. The system will be kept weatherproofed. At plant sites, the RVRS can be set up in the vicinity of where *resin processing* is currently performed, that is, inside or adjacent to the Radwaste Building, or Auxiliary Building. Access to resin delivery and recirculation lines, dewatering return lines, service water, air and power is required. The resin dryer based RVRS is a service designed to fit today's needs, and is a good example of how, as economics change, new or existing technologies can become cost competitive, where formerly they may not have been.

Spent resin drying has become a desirable volume reduction technique because of the rapid escalation of burial charges. Resin drying follows resin dewatering, and results in an additional 50% reduction in volume of the resin and sludge (compared with 17% volume reduction from the dewatering).

Based on 1983 Barnwell burial rates, resin drying can save from $30 to $80 per cubic foot for simple transportation and burial (depending upon curie content and radiation level). This number considers operating costs, transportation costs, and burial charges, but does not include the capital investment of the resin dryer.

A cost effective means of resin volume reduction is the use of a mobile resin drying service. The financial advantage is the elimination of large capital expenditures for equipment including construction and installation costs. Logical reasons for using a mobile service for resin volume reduction, in addition to avoiding capital costs, are: no increase in permanent plant staff required, no additional O&M costs, no necessity to go through NRC licensing actions, retaining the option of employing new or improved resin volume reduction technologies when available, and better utilization of available radwaste facility space. Westinghouse Hittman Nuclear Incorporated will offer a transportable resin dryer system in the near future.

UNIPAK

The operation of nuclear facilities also inherently produces LLW that requires shielding for storage and/or transportation. WTSD is designing a family of low cost casks for on-site shielded storage and subsequent transportation and disposal of LLW. These casks are known collectively as "UNIPAKs."

The concept for UNIPAKs grew from the legitimate concern that some radwaste generators may no longer be able to ship their radioactive waste off-site after January 1, 1986 because of provisions in the Low Level Waste Policy Act (LLWPA) of 1980. Language in the LLWPA encourages individual state plans for disposal of LLRW, and establishes a process for the development among the states of "regional compacts" for waste management; the LLWPA also specifically provides that (January 1, 1986) those states in a regional compact may prohibit the shipment of wastes from states that are not part of the compact. UNIPAKs are a cost-efficient, practical alternative to the large radioactive waste storage buildings which some utilities are considering for temporary storage of LLW prior to final shipment and burial.

While the UNIPAK can be considered as a "stand-alone" product, it is designed to interface with a variety of LLW processing systems and equipment, and can be transported readily by existing transportation systems.

The UNIPAK is a thick-walled, shielded cylindrical cask, (Figure 4) designed for the storage, transportation, and disposal of LLW. LLW materials which require shielding are most appropriate for placement in a UNIPAK (with appropriate processing and/or solidification where required); examples of these are resins, filter sludges, settled sludges, concentrated liquids (evaporator bottoms), incinerator ash, and decontamination solutions. LLW with no shielding requirements, such as lightly contaminated compacted dry combustibles and trash, would not normally be stored in a UNIPAK.

The proposed standard sizes of UNIPAKs, shown in Figure 5, are equivalent in their internal dimensions with existing LLW storage and shipping casks (see DOE/RLO-SFM-82-6, Waste Containers for

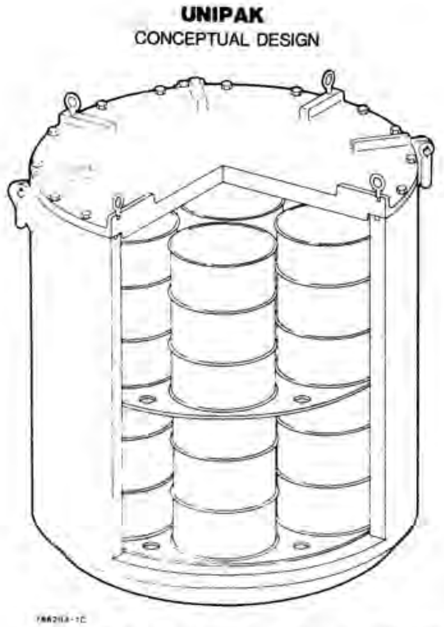

Figure 4. UNIPAK Conceptual Design

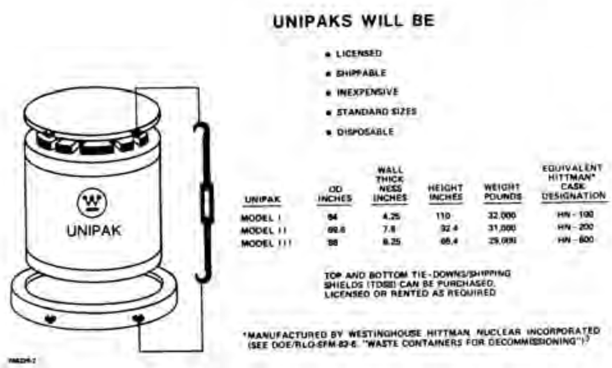

Figure 5. UNIPAKs

Decommissioning). As a result, UNIPAKs are compatible with a number of LLW processing options and containers. UNIPAKs can also be custom-built for specific volume and shielding requirements.

Currently, Westinghouse is developing three different UNIPAKs for handling various quantities of wastes, as defined by the Code of Federal Regulations Title 49 paragraph 173 (49CFR173). Large steel or polyethylene containers will be available as disposable liners for each UNIPAK, if required.

The Model I UNIPAK can handle fourteen 55-gallon drums arranged piggyback on two pallets of seven each, or one large container having an envelope volume of 170 cubic feet. The shielding provided by the 4.25-inch-thick cast steel wall of this UNIPAK makes it acceptable for transporting greater than Type A quantities of LLW materials. This design has been used to form the cost and volume estimates performed for CWMS evaluations.

The Model II UNIPAK can handle three 55-gallon drums or one large container with an envelope volume of 70 cubic feet. This UNIPAK has 7.8-inch-thick cast steel walls and can handle Type B materials.

The third UNIPAK can handle seven 55-gallon drums or one large container with an envelope volume of 85 cubic feet. Shielding provided by the 6.25-inch-thick cast steel walls permits handling greater than Type A quantities of LLW. Other sizes of UNIPAKs with different volumes and shielding capabilities are being considered as well.

The large disposable steel or polyethylene containers, or liners, mentioned above can be fabricated to fit the UNIPAKs. Standard steel liners come equipped for a variety of waste processing operations, including in-container solidification of liquids, resins and filter sludges; resin dewatering; demineralization and filtration; and packaging of irradiated components and cartridge filters. The standard steel liners come equipped with slings and snap tight lids. Liners with grapple rings and a variety of openings can be provided, as can liners that are capable of withstanding pressure or vacuum. In addition, custom-designed liners can be provided for specific applications.

UNIPAKs are especially useful for interim on-site storage (sheltered or outdoor storage) as an alternative to large shielded radwaste storage buildings. Most LLW shielding requirements can be met with the three types of UNIPAKs mentioned above. Custom-built casks can also be provided to satisfy most volume or shielding needs.

In the transportation mode, UNIPAKs will exceed the requirements for a Type "A" shipping container and with the addition of an overpack or shipping skirts, the UNIPAK will meet the requirements for a Type "B" container. These containers require that surface dose rates not exceed 200 mrem/hr on contact and 10 mrem/hr at 2 meters.

After being used to transport waste to a disposal site, UNIPAKs can be buried intact, or alternatively, the internal liners can be removed and buried and the UNIPAK returned for additional waste shipments. Options are also available to use the UNIPAK as a structural element in a modern engineered disposal site, and even to retrieve the UNIPAK at a later date.

Besides the handling of resins and sludges, UNIPAKs will be particularly useful for disposal of contaminated piping, valves, and other radioactive components. Waste can be "aged" *in a UNIPAK* to let radiation levels decrease through radioactive decay, thereby possibly reducing the "curie" and "Rad" charges at a burial site. Waste can also be "staged" in UNIPAKs to gain increased shipping efficiency.

There are many advantages to using a UNIPAK, several of which are financial in nature. Various CWMS studies performed by Westinghouse, demonstrate that the UNIPAK alternative is more economical than the BOSS system under most circumstances in which money costs exceed 1%. Indeed, the economic advantage at a 14% money supply was demonstrated by this study. One major reason the UNIPAKs are more economical is that a large capital investment is not required, as it is for a BOSS. This point is discussed further in the section on UNIPAK economics below.

Since the future status of burial grounds is uncertain (at best), the scenarios of burial grounds remaining available, closing for only a short period of time, and becoming permanently unavailable required examination. If burial grounds continue to be available, the potential savings resulting from minimal capital expenditures for the UNIPAK waste collection storage and transportation alternative increase.

If burial grounds are closed for only a short period of time (months versus years), on-site storage building economics remain unattractive by comparison, and having opted for the UNIPAK alternative will again result in significant cost savings. If burial grounds are closed for long periods of time (years or indefinite), the UNIPAK method is still the most attractive option available.

As indicated in this study, the UNIPAK system is financially favorable when compared with BOSS system. Additionally, using the UNIPAK alternative permits the flexibility to respond to changing burial ground availability with minimal time delay, LLW storage program changes at the site, and variations in capital availability. Table 3 summarizes the UNIPAK benefits for the different changing burial ground availability scenarios.

The conclusion is that timely investment in UNIPAKs will reduce capital costs and long term expenditures for storing LLW, assure an alternate path should burial grounds close, and provide an efficient, ALARA consistent way to ship wastes to existing or future burial grounds when interim on-site storage is no longer required.

Table 3. Burial Ground Scenarios

WHAT IF –

BURIAL GROUNDS CONTINUE TO BE AVAILABLE?

- UNIPAKs provide large potential savings because no major up front capital expenditures required.
- Depending on burial ground charges, aging of radwaste on site in UNIPAKs may be economically attractive.
- UNIPAKs can be used as repositories for radioactive components removed from the plant and for low level waste staging.

BURIAL GROUNDS ARE CLOSED FOR ONLY A SHORT PERIOD (MONTHS VERSUS YEARS)?

- On-site storage building economics are very unattractive.
- UNIPAK use will result in even more dramatic cost savings.

Tables 4 and 5 present typical results of an economic analysis of on-site storage comparing UNIPAKs and a shielded building for on-site storage. These tables are for a reference 1000-MW PWR. As the tables show, the calculations cover a 15-year period, motivated by the depreciation tables provided by the IRS.

The conclusions which can be drawn from comparing the two tables are typical of most of the analyses performed. UNIPAKs sheltered in a simple Butler type building have a Net Present Value (NPV) of approximately one half that of a large, shielded BOSS (for this example, the NPV of the sheltered UNIPAK is $6 million, while the BOSS has an NPV of $12 million). Significant additional savings can be realized if the UNIPAKs are not sheltered in a building (for this example, the NPV is $5 million). (The location of a site is the prime motivation for sheltering the UNIPAKs, which would be for convenience in operation and protection from the weather).

Table 4. Low-Level Radioactive Waste Handling and Storage Net Present Value Calculation UNIPAK (Sheltered) Method for Storage of LLW (in thousands of dollars)

COST ITEM	TOTAL	YEAR: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAPITAL INVESTMENT	$1,545	772	772														
EQUIPMENT INVESTMENT	$6,021		1348	1168	1168	1168	1168										
RESIDUAL VALUE	$0							0	0	0	0	0	0				
OPERATING EXPENSE	$2,450		235	235	235	235	235	235	235	235	235	235	100				
SHIPPING & BURIAL	$3,312							662	662	662	662	662					
TAX & INSURANCE	$533	23	46	46	46	46	46	46	46	46	46	46	46				
TOTAL	$13,861	796	2402	1450	1450	1450	1450	944	944	944	944	944	146	0	0	0	0
DEPRECIATION TAX ADJ	($3,783)		-140	-313	-427	-542	-657	-551	-414	-292	-169	-46	-46	-46	-46	-46	-46
OPERATING EXP TAX ADJ	($2,881)	0	-118	-118	-118	-118	-118	-449	-449	-449	-449	-449	-50	0	0	0	0
NET CASH FLOW	$7,197	796	2145	1019	905	790	675	-56	81	203	326	449	50	-46	-46	-46	-46
	=========																
NET PRESENT VALUE	$6,295 K																

Table 5. Low-Level Radioactive Waste Handling and Storage Net Present Value Calculation Building of On-Site Storage (BOSS) Method for Storage of LLW (in thousands of dollars)

COST ITEM	TOTAL	YEAR: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAPITAL INVESTMENT	$10,000	5000	5000														
EQUIPMENT INVESTMENT	$1,500		1500														
RESIDUAL VALUE	$0												0				
OPERATING EXPENSE	$2,700		175	175	175	175	175	175	175	175	175	175	950				
SHIPPING & BURIAL	$3,639							728	728	728	728	728					
TAX & INSURANCE	$4,650	150	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
TOTAL	$22,489	5150	6975	475	475	475	475	1203	1203	1203	1203	1203	1250	300	300	300	300
DEPRECIATION TAX ADJ	($5,750)		-363	-665	-608	-558	-508	-350	-300	-300	-300	-300	-300	-300	-300	-300	-300
OPERATING EXP TAX ADJ	($3,169)	0	-88	-88	-88	-88	-88	-451	-451	-451	-451	-451	-475	0	0	0	0
NET CASH FLOW	$13,569	5150	6525	-278	-220	-170	-120	401	451	451	451	451	475	0	0	0	0
	=========																
NET PRESENT VALUE	$12,460 K																

RESULTS AND CONCLUSIONS

Since almost all low-level waste today is transported to one of two commercial burial sites, the need for interim on-site storage has been small. However, with the 1986 deadline for regional disposal sites fast approaching, radwaste generators may not be able to ship waste off-site until a new disposal site is operational in their regional compact.

One option for interim on-site storage of low-level waste as discussed earlier in this paper is to construct permanent shielded buildings BOSS) at nuclear plant sites in which the waste would be stored. This option, however, is very expensive; each building can cost millions of dollars. Once a new burial site is available, the building will no longer be needed for low-level waste storage.

The Westinghouse Waste Technology Services Division has developed an interim storage alternative: The Approach = $AVPAK + UNIPAK.

The $AVPAK services discussed earlier can significantly reduce the volume of dry activated waste which would have to be stored if shallow land disposal were to be come unavailable. The volume reduced DAW could be stored in suitable containers in an on-site unshielded building. With maximum DAW volume reduction through high force compaction, up-front segregation of clean materials from radioactively contaminated items, and decontamination of recoverables; substantially less storage space will be required for the DAW component of LLW. Table 6 shows the estimated reduction in DAW requiring (burial or) on-site storage after $AVPAK services including high force compaction in COMPACT I. Savings would accrue in the near term from reduced space requirements for DAW storage, and longer term from reduced transportation and burial charges when a LLW disposal site again becomes available.

Table 6. Westinghouse Hittman Nuclear Incorporated DAW Processing and Compaction Services Estimated Reduction in DAW to be Buried

	Current Operations	Hittman Service
1. DAW collected, lbs	300,000	300,000
2. Clean waste and recoverables, fraction	0.10[1]	0.40[2]
3. Compactible contaminated DAW, lbs	270,000	180,000
4. Net compacted waste density, lbs/ft^3	30[3]	55[4]
5. Cu. Ft. shipped to burial site	9,000	3,270
6. Cu. Ft. each shipment	1,000[5]	545[5]
7. Number of shipments	9	6
8. Reduction in waste burial volume		64%
9. Reduction in number of shipments		33%

NOTES:

[1]Sorting for recoverables only

[2]Sorting for recoverables and segregating for clean contaminated waste

[3]Using standard drum compactor

[4]Using high force compactor

[5]Assumes 30,000 lb payload per shipment

Aqueous wastes (liquids, resins, sludges, etc.) requiring shielded storage would be solidified, or loaded into High Integrity Containers and placed into UNIPAKs. The UNIPAKs could then be stored outdoors, or indoors with the DAW until a disposal site becomes available. The overall combination of $AVPAK + UNIPAK provides the most compact, cost effective on-site storage alternative *available* today.

For additional savings, resin drying can be used to further reduce the volume of resin requiring on-site storage, as in UNIPAKs. For any given facility, costs and other aspects should be evaluated using site specific data in order to determine the optimum processing, volume reduction, packaging, and storage options. The CWMS has been used to help select the "best choice" waste management options, and will continue to be available to provide answers to internal and client questions. The $AVPAK + UNIPAK analysis is one example of CWMS application.

REFERENCES

1. J. PHILLIPS, F. FEIZOLLAHI, R. MARTINEIT, W. BELL and R. STOUKY, "A Waste Inventory Report for Reactor and Fuel-Fabrication Facility Wastes," ONWI-20, NUS Corporation (1979).

2. A. S. DAM and L. RUTLAND, "Characterization of Low Level Radwaste Volume Reduction Installations," Electric Power Research Institute with Burns & Roe, Inc.

3. E. W. POWERS, "Waste Containers for Decommissioning," DOE/RLO-SFM-82-6, UNC Nuclear Industries (1982).