ONSITE LOW LEVEL RADIOACTIVE WASTE STORAGE
A SIMPLIFIED APPROACH?

R. J. Smith
W. E. Reynolds
Gilbert/Commonwealth
Reading, Pennsylvania

ABSTRACT

The time has come when generators of low level radioactive waste must act on plans to accommodate waste generated after January 1, 1986. Several alternatives present themselves - 'wait-and-see' with the hope that one or more disposal sites will remain available after the date that they may legally exclude all waste shipments from originators outside their compact; attempt to stop producing waste considering that halting operation may actually increase waste production; build an interim storage facility onsite to hold waste generated until a disposal site becomes available within the generator's compact area.

This discussion assumes that the onsite storage option has been chosen. Again, alternatives present themselves in the search for the ideal solution - an inexpensive, immensely flexible, easy to operate storage facility. This paper seeks to outline considerations which must be addressed in order to obtain a solution as close to ideal as reasonably obtainable. As such, it describes a simplified approach which may at first seem to be anything but simplified. Use of these guidelines will, however, result in a usable, intelligently designed facility which minimizes initial capital expediture and guards against costly pitfalls which may result from a 'lowest cost' or 'wait-and-see' approach.

This paper discusses considerations giving guidelines and recommendations which would, if followed, form a solid base from which the design, fabrication, and operation of an optimal onsite storage facility would result.

INTRODUCTION

Gilbert/Commonwealth has been involved with onsite storage of low level radioactive waste since the late 1970's. Our experience in the area of onsite storage has grown to include not only low level waste but also unique applications such as long term storage of fuel reprocessing waste from British Nuclear Fuels Limited in the U.K.

In the area of low level waste storage, our experience has been applied to numerous designs for utilities such as Sacramento Municipal Utility District, Philadelphia Electric, General Public Utilities, Central Electricity Central Board (U.K.), Kyushu Electric (Japan), and to the development of a G/C Standard Generic Design.

Storage of low level waste onsite in the U.S. serves as an insurance policy for utilities which will allow them to continue operation in the event they can no longer ship to a disposal site. As with any insurance or stopgap measure, cost is of foremost concern.

The initial reaction to most low level waste storage needs is to construct a simple, lightly shielded warehouse or to construct a pad for outside storage of waste within a fenced and lighted area. These approaches are both 'simple' and 'low cost' but for the majority of applications will not meet the current regulatory requirements.

There are numerous approaches to low level waste storage being offered which basically meet the current regulatory requirements. These range from expensive sophisticated and complex designs to those offering a low construction cost but with the penalty of high operating and maintenance cost.

For those utilities faced with the need to provide additional onsite storage, determining which of the many and varied approaches most closely matches their needs, at the lowest cost, is not an easy task. Similar to most major technical needs, the variety of approaches and solutions is as varied as and in direct proportion to the number of people involved. In order to 'sort out' the various storage approaches, it is essential that needs be clearly defined and realistic performance requirements established to meet those needs.

The major criteria that must be examined so that overall storage facility performance requirements can be established are as follows:

- Waste Quantities
- Waste Characteristics
- Applicable Codes and Regulatory Requirements
- Operational Flexibility
- Storage Methods
- Alternative Future Uses

Establishment of a realistic performance requirement in these areas will minimize the overall cost of providing onsite storage capabilities.

Waste Quantities

According to current regulatory guidelines, onsite storage facility capacity is limited to that volume of waste which represents five years of waste generation for a given plant. Realistic determination of a projected five year accumulation is often difficult.

The starting point for establishing the storage capacity are the currently available plant documents such as PSAR, FSAR, radioactive shipment records (RSR), and semi-annual effluent release reports. Additional data can be obtained from similar documents and industry reports on waste generation. The information obtained from these sources will formulate the baseline data for determining the required storage capacity.

In evaluating the baseline data, consideration must be given to plant status (plant availability) at the time of waste generation, type of waste processing system used, processing system performance, and planned modifications to plant radwaste related systems. The baseline data should be segregated by general waste categories for later use when evaluating packaging requirements.

For a typical plant, waste shipping records should be available for several years which indicate in general terms the type, volume, and activity of waste shipped for disposal. This data will reflect site specific developments (outages, discontinued shipping practices, system changes, etc.) which limit its applicability in projecting future generation rates. Utilization of prior shipping data without regard to the evaluation criteria referred to may result in significant undersizing of the storage facility. To minimize the possibility of inaccurate sizing, past waste shipping data should be converted to currently acceptable shipping form. Conversion of waste data to currently acceptable forms can be readily accomplished by utilizing prior system performance data to determine acceptable volumes based on recent system performance.

For waste processing systems currently in use, or proposed for installation, generally acceptable performance data is available which can be used to calculate anticipated volumes of waste.

The impact of plant status (plant availability) on waste generation for the period of record varies from facility to facility. Available data should be evaluated to determine waste generation associated with planned outages and unscheduled outages. Ideally, waste data should represent that volume generated during normal plant operation (including scheduled outages) over five years with an allowance included which represents waste generation during unscheduled outages. One method for determining this allowance is to compare actual plant availability versus design availability to determine a scale up factor for application to the five year waste volume.

After the storage volume requirements have been developed, the resulting volume can be compared with published reports such as EPRI Research Project 1557-3 (EPRI Report, NP-3370, published February 1984), using available data from similar plants as appropriate to check the validity of the results. If the calculated volume of generated waste falls far below or above the average values in the published reports, additional evaluation may be required to determine the cause of the divergence. Generally, large differences in volumes can be attributed to system and/or operational differences from those reported in the published reports.

The final step in determining the required storage capacity is to evaluate future modifications to assess the impact on waste generation. The future addition of equipment such as incinerators, filter backfits, or incorporation of evaporator crystallizers must be factored into the volume projections and the required volumes adjusted accordingly. Similarly, the removal of process systems must be accounted for in the volume determination.

Waste capacity calculations which take into account these considerations can indicate an increase or decrease in required capacity as great as 50% over a straight line projection of shipped waste over a five year period.

Waste Characteristics

A procedure similar to determination of waste volumes should be utilized to determine the anticipated source terms and isotopic content of the waste. This is needed to establish general shielding requirements and material handling constraints.

The importance of accurate source terms predictions lies in the potential costs associated with later additions shielding. For typical facilities, the variation in source terms within a given waste category are small in comparison to volume variations. The impact of adding future processes such as volume reduction can result in shielding requirement increases of 50% or greater over that required for current existing processes. Due to the potential for large variation in source terms for adding processes such as volume reduction, early evaluation of the impact on the storage facility must be made. The addition of shielding to a completed facility to accommodate such a change is costly and may result in a favorable process being eliminated from future consideration.

For shielding, the most critical factor impacting costs is proximity of the storage facility to the plant boundary and the targeted contribution to total offsite dose from the facility. Locating a storage facility close to the plant boundary in combination with a very low targeted contribution to offsite dose will result in shielding being the largest factor in overall building costs.

Following determination of the waste volume to be stored and the design basis source terms, the facility design codes and standards must be evaluated.

Applicable Codes and Regulatory Requirements

There are two major documents which control the design of onsite storage facilities for low level radioactive waste. These are USNRC Generic Letter 81-38 and NUREG 0800 11.4A. The issues addressed in these documents can be segregated into three major areas as shown in Table 1.

TABLE 1

GENERIC LETTER 81-38
NUREG 0800-11.4A

LICENSING CRITERIA	BASIC DESIGN CRITERIA	RADIOLOGICAL CRITERIA
10CFR50	Waste Form*	10CFR50, App. A (Pathways)
10CFR50.59 (Op. Stations)	Facilities Design	10CFR20 (Onsite Dose)
IE Circular 80-18 (Radwaste Mod)	Additional Criteria*	40CFR190 (Offsite Dose)
10CFR100 (Accident Analysis)	*See 10CFR61 and NRC BTP on Waste Form and Waste Classification	RG 1.109 (Effluent Release Dose)
10CFR30 - if outside 10CFR50 criteria		RG 1.21 (Waste Activity Ratg)
		RG 8.8 (ALARA)
		RG 8.10 (ALARA)

In general, the licensing criteria followed for most onsite storage facilities at operating stations are covered in 10CFR50. Under 10CFR50.59, the completion of a Safety Evaluation Report is required to demonstrate that there are not unreviewed safety questions and that postulated accidents will contribute only a small portion of the 10CFR100 release limits (typically less than a small fraction, well below 10%, of the limits).

The basic design criteria for the storage facility can be categorized into the areas of waste form, facility design, and additional criteria.

The waste form to be stored within the facility plays a major role in the design. Storage of currently acceptable shippable waste forms generally do not require compliance with Reg. Guide 1.143 for solidified wastes. Should storage of large volumes of dewatered resins in HICs be contemplated, the facility seismic analysis should be adequate to conform to the requirements of Reg. Guide 1.143 in that a potential for the accumulation of radioactive liquids resulting from materials handling accidents must be considered.

The incorporation of Reg. Guide 1.143 most significantly impacts the required level of quality control on systems and structures associated with collection and handling potentially contaminated liquids which result in increased building and design costs. For storage facilities storing solidified wastes, general industrial level quality control is sufficient.

The design codes and standards typically applied to storage facilities are indicated in Table 2.

TABLE 2

BASIC DESIGN CRITERIA

WASTE FORM	FACILITY DESIGN	ADDITIONAL CRITERIA
49CFR127/173 (DOT Pkg)	29CFR Series (General Safety)	Insurance Underwriter Req
10CFR71 (NRC Pkg)	NFPA (Fire Safety)	PUC
10CFR61	UBC (Seismic)	Local Building Codes
ANS N14.9.2M	ACI-318-83 (Concrete)	
	ASHRAE (HVAC)	
	AISC (Steel)	
	ANSI B31.1 (Piping)	
	ANSI A58.1-72 (Building Loads)	

In addition to the general codes, local codes and insurance underwriter requirements must be factored into the design. Typically, local codes govern the design in areas of energy efficiency, safety aspects, fire control considerations, and building height restrictions. Failure to adequately research local code requirements can result in delay and the potential for costly redesign to achieve compliance.

Operational Flexibility

Once the waste quantities source terms and governing codes and standards have been determined, consideration must be given to the degree of flexibility a facility design allows. Ideally, a storage facility should allow for limitless variation in container sizing, minimim cost expansion in any direction, no restriction on waste isotopic extremes, and a host of other desirable features.

A storage facility design which offers everything at a minimum cost is unattainable. The major items regarding flexibility that should be evaluated are expansion capability and waste container variations. The ability of a storage facility to be readily expanded will allow for optimum sizing of the initial unit and reduce the initial capital investment. Designs which require costly construction techniques or result in long shutdown times and exposure risks for facility additions should be avoided.

The ability of a storage facility design to handle a wide range of container types is desirable from an operations standpoint. Designs which limit storage to a single container or extremely small range of containers will limit the utility's ability to adapt to changes in regulations and will restrict future process changes which may require alternate size containers. Designing for a single container type does offer the advantages of a simplified design but the long term impact of such a limitation must be weighed against the operational restrictions it imposes.

For most operating facilities, the range of container types used is limited and designing for selected future container types results in moderate cost increases while providing greater flexibility. For utilities with more than one operating plant, the range of containers used can vary widely and a single design which encompasses these ranges can offer significant savings should a single design be applied for all sites.

Storage Methods

Two major types of low level waste storage techniques are correctly utilized in the nuclear power industry:

- Open Floor - all containers stored within one large shielded area.
- Shielded Cell - groups of containers stored in multiple, separately shielded storage areas.

The open floor concept is generally used for low activity waste using local material handling techniques. Storage efficiency of an open floor facility is maximized by limiting the number of container types. Floor area utilization is limited by stacking height restrictions. Open floor storage is similar to typical warehousing operations.

The use of open floor storage for higher activity waste which requires remote handling, and for various container sizes, results in reduced storage efficiency. This leads to a larger building volume, all of which must be shielded for maximum exposures.

The shielded cell concept of storage minimizes the shielded volume in that the waste pile is enclosed by the cell walls and shield covers. The material handling system is located above the cells outside the primary shielding. This becomes increasingly important as higher activity levels cause shielding thicknesses to increase. The shielded cell concept minimizes exposure levels within the materials transfer area and reduces exposure to the materials handling system. This approach also allows greater variations in container sizes in that individual storage locations for specific containers can be allocated.

Both storage concepts can be successfully combined to allow for optimal storage facility design based on waste source terms and quantities. Utilization of open floor storage for DAW (typically < 100 mr/hr) offers the most cost effective solution whereas cell storage or shielded pit concept provide for cost effective storage of higher activity waste.

Regardless of which storage concept is utilized, the method of waste placement is limited by the physical and structural properties of the container system. Storage concepts which rely on direct stacking of container units are especially limited by the physical and structural properties of the containers.

Direct stacking of 55 gallon drums (generally acceptable in the industry) is constrained by the ability of the drum to withstand (undeformed) loads imposed by subsequently placed drums. Based on testing performed by Gilbert/Commonwealth at Republic Steel, the load carrying capacity of a standard DOT 17 series drum (typically used for radwaste processing) limits stacking height to a maximum of eight levels without the risk of drum deformation. Six high stacking is considered as the maximum for long term storage. The incorporation of intermediate devices such as gratings will allow for slight increases in stack height, but stacking in excess of eight levels increases the risk of deformation and stack toppling. In addition to the structural limitations of a stacked drum, the ability of the materials handling system to accurately place a container within acceptable tolerances to achieve reasonable space utilization is limited. For overhead bridge crane systems, achievable load placement accuracy ranges from greater than ±12 inches to as low as ±1 inch for standard industrial grade crane systems. Storage techniques which require high degrees of materials handling system accuracy (greater than ±1 inch) may not be warranted for a typical storage facility application.

As with 55 gallon drums, currently available large disposal liner systems are limited in structural strength and typically are designed to preclude direct stacking of units without supplemental devices. The storage method selected for use should adequately provide for the container size ranges selected, allow for ease of materials handling, and utilize standard materials handling systems to a practical extent. Systems which rely on sophisticated materials handling and high degrees of load placement accuracy or which rely on container strengths should be avoided in order to minimize insofar as possible the potential for maintenance or emergency materials handling inside the storage areas.

Alternate Future Uses

An area that is sometimes overlooked when storage facilities are being considered is facility use after storage onsite is no longer needed. Eventually radwaste disposal facilities will be readily available, eliminating the need for onsite storage. The facility which was designed for storage should have an alternate use and should be designed to facilitate decontamination and decommissioning to allow for conversion to an alternate use.

Storage facility designs may be adapted to such alternate uses as machine shops, noncontaminated materials storage, decontamination facilities, etc. The time to consider alternate use is in the design stage and not after the facility is completed and operational. Incorporation of design features such as heavy floor loadings, knockout walls, decontaminable coatings, drains, etc. add little to the initial cost but go a long way in allowing easy conversion to alternate uses.

Another consideration which should be weighed during the planning stages is the effect of new 10CFR61 reporting requirements on the overall plant radwaste handling operation. Dramatically increased requirements on radwaste inventory, shipping, and disposal recordkeeping are leading many utilities to incorporate computerized bookkeeping systems. This may lead to the use of a storage facility equipped with an inventory control system to serve as a central clearing house for waste shipments and associated recordkeeping.

Costs

The goal in developing an onsite storage facility is to provide a design which satisfies the established needs at the lowest cost. As part of the design effort, considerable attention must be paid to the overall function of the facility so that not only will the initial capital cost remain low, but the overall operation and maintenance cost will also be minimized.

The incorporation of nonstandard materials, unnecessary codes and standards, and complex materials handling systems do little to satisfy the established needs but cause a major impact to overall costs.

For a typical onsite storage facility design utilizing standard construction, materials, and systems, the range of direct capital costs are typically $3 to $5 million for approximately 60,000 - 80,000 cubic feet of packaged waste. The incorporation of unnecessary codes and standards can increase the direct cost by 5% to 15%. The use of nonstandard materials can similarly impact the overall cost by as much as 10% and potentially result in project delays due to limited materials availability.

It must be remembered that the primary operational function of this facility is as a materials handling system. Material flow into, within, and out of the facility must be carefully considered to avoid creating an operational mess for plant personnel.

For the majority of storage facility designs being offered, the primary materials handling system is an overhead bridge crane or similar device serving a truck bay and a storage area. The materials handling system accounts for approximately 20% or greater of the direct costs and can account for the majority of the maintenance costs.

The importance of careful selection of materials, systems, and design codes and standards cannot be overemphasized. The most common error in designing facilities for storage is the tendency to take a design which satisfies the established needs and 'improve' upon it to the point where it does not offer the least cost solution. The old adage of keep it simple' must become the governing factor in any design.

Design Options

The undertaking of a complete design for an onsite storage facility can involve a team of engineers, designers, and technicians ranging in size from as few as a dozen to over 20 individuals with typical project duration of 4 to 12 months. On the surface, a storage facility design is straightforward, but the effort involved in developing the Safety Evaluation Report, materials handling interfaces, and shielding analysis to support the design effort can be time consuming and costly.

The design options currently being offered range from design only to full turnkey design and construct packages. The approach to be used should be evaluated against inhouse staff availability, time requirements, and design funding available. With a well defined project requirement document, evaluation of design options will be relatively simple.

Typical onsite storage facility design efforts, including the development of a Safety Evaluation Report, require approximately 8,000 to 14,000 manhours of effort through construction, dependent upon the complexity of the design.

For the construction phase of an onsite storage facility, departure from the standard approach of issuing construction packages should be considered. For most storage facility design, construction can be accomplished in a more timely manner and generally lower cost by utilizing a two-contractor approach, with a general contractor for the building structure and support system and a contractor for the materials handling system.

This approach offers cost advantages in that facility systems are typically small and noncomplex and overall project responsibility is borne by the contractor and not the utility purchasing department for equipment and supplies procurement.

Typical construction time of a storage facility ranges from 9 to 12 months with the materials handling system as the critical path in that design and fabrication of a crane system requires approximately 44 weeks to complete.

For utilities that opt to solicit outside assistance in developing and implementing a storage facility design, the effort expended in developing the overall project requirements can form the backbone of the bid document.

The items that are essential for preparation of a realistic design cost are as follows:

- Waste quantities.
- Waste source terms and dose rates.
- Dose rate limitations adjacent to facility site and at plant boundary.
- Container size ranges.
- Expansion requirements.
- Site location, site plan, and topographic map of area.
- Soils data at proposed site.
- Underground utility location at proposed site.
- Project schedule.
- Utility procedures to be followed.
- Scope of work - design only, turnkey, etc.

Summary

The development of realistic facility requirements in the areas previously mentioned will provide for a cost effective design for onsite storage.

Conversion of waste quantities and source terms to currently acceptable forms will allow for optimal facility sizing and provide for buffer capacity when the values are adjusted to account for plant availability.

The codes and regulatory requirements should be the minimum requirement that must be met and should not contain unnecessary requirements that exceed the intended factors. Unnecessary codes and standards result in increased cost and potential delays.

Flexibility in the design should be addressed with respect to the range of anticipated container types and sizes as well as expansion capabilities. Container size ranges should represent current containers plus future container sizes required to support anticipated process changes.

The storage methods employed should be dependent on container size and source terms with open floor storage used for low activity waste and shielded cell for higher activity wastes.

Optional uses for the storage facility once storage is no longer required must be evaluated and general use categories established prior to design. Utilization for certain activities in the future may require application of critical codes and standards.

In order to minimize overall cost, the design should be approached as a typical industrial design and simplified approaches must be maintained. The principal of keep it simple' should govern.

The final cost of the storage facility should include direct cost, indirect costs, operation, and maintenance costs. Designs which offer low initial cost but high overall operation and maintenance costs should be avoided.