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Recommended Changes to Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility — For Nuclear Regulatory Commission Review

2011 TECHNICAL REPORT

Recommended Changes to Guidelines for Operating an Interim On-Site Low Level Radioactive Waste Storage Facility – For Nuclear Regulatory Commission Review

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Interim Report, December 2011

EPRI Project Manager
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This document does **NOT** meet the requirements of
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ABSTRACT

The majority of commercial U.S. nuclear stations have constructed on-site low-level waste (LLW) storage facilities, and most of these same utilities are experiencing or have experienced at least one period of interim on-site storage. EPRI has issued two revisions of *Guidelines for Operating an Interim On-Site Low Level Radioactive Waste Storage Facility. Revision 1* of these *Guidelines* focused on operational considerations and incorporated many of the lessons learned while operating various types of LLW storage facilities. The NRC reviewed Revision 1 of this document and issued Regulatory Issue Summary (RIS) 2008-32, Interim Low-Level Radioactive Waste (LLRW) Storage at Nuclear Power Plants, which recognized the methodology outlined in Revision 1 as an acceptable method for recordkeeping, determining waste forms and waste containers, and monitoring and inspecting the interim long-term storage of LLRW.

This document constitutes "recommended changes" to *Revision 1 of Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility*. It was developed to update operating experience and reflects over 3 years of on-site storage at over 92 US reactors (>270 reactor-years) It proposes to regulators and industry organizations (for example, American Nuclear Insurers—ANIs) a revised, technically justified, and risk-informed inspection strategy. It is important to understand that this document is published for USNRC review and is not completely aligned with existing guidance from regulators and other industry organizations.

The existing Revision 1 Operating Guidelines (1018644) and Supplemental Information Manual (1018651) continue to represent an acceptable storage methodology and should continue to be referenced to ensure regulatory compliance in conjunction with applicable regulatory guidance such as the USNRC RIS 2008-32.

Keywords
Guidelines
Interim LLW storage
Low-level radioactive waste

EXECUTIVE SUMMARY

The majority of commercial U.S. nuclear stations have constructed on-site low-level waste (LLW) storage facilities, and most of these same utilities are experiencing or have experienced at least one period of interim on-site storage. Revision 1 of these *Guidelines* focused on operational considerations and incorporated many of the lessons learned while operating various types of LLW storage facilities. The NRC reviewed Revision 1 of this document and issued Regulatory Issue Summary (RIS) 2008-32, Interim Low-Level Radioactive Waste (LLRW) Storage at Nuclear Power Plants, which recognized the methodology outlined in Revision 1 as an acceptable method for recordkeeping, determining waste forms and waste containers, and monitoring and inspecting the interim long-term storage of LLRW.

Caution

It is important to note that this document constitutes “recommended changes” to the Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility. It was developed to update operating experience and to reflect over 3 years of on-site storage at over 92 US reactors (>270 reactor-years). It proposes to regulators and industry organizations such as American Nuclear Insurers (ANIs) a revised, technically justified risk-informed inspection strategy. It is important to understand that this document is published for NRC review and is not completely aligned with existing guidance from regulators and other industry organizations.

The existing Revision 1 Operating Guidelines (1018644) and Supplemental Information Manual (1018651) continue to represent an acceptable storage methodology and should continue to be referenced to ensure regulatory compliance in conjunction with applicable regulatory guidance such as the USNRC RIS 2008-32.

Background

The US Low-Level Radioactive Waste Policy Amendments Act of 1985 established a timetable for states to provide for the disposal of low-level radioactive waste. However, despite the established schedule, no new disposal sites have opened. At the time of report publication, the majority of commercial U.S. nuclear plants do not have access to disposal of Class B/C wastes. Although several disposition options are being investigated or offered, the lack of access has forced the affected nuclear plants into a period of on-site interim storage pending an alternative disposal option.

Over the last decade, EPRI has responded to a continuing need for technical guidance concerning on-site storage by initiating the *Interim On-Site Storage of LLW* research project. This effort has resulted in a series of more than a dozen reports detailing the many regulatory, engineering, and operational aspects of on-site storage to assist utilities in developing and optimizing their own interim on-site storage program (EPRI reports 1003436, 1007863, 1007862, 1003027, TR-105891, TR-105784, TR-105787, and TR-105785). EPRI revises these reports periodically to capture additional industry experience, expand on operational aspects of storage facility management, and produce specific guidance documents related to interim on-site storage.

Objectives

To produce a single, comprehensive guide for the safe, efficient, and routine operation of an on-site LLW storage facility.

Approach

The project team convened a committee of U.S. and international utility and industry subject-matter experts. This committee captured and synthesized existing regulations, regulatory guidance, nuclear insurance guidelines, current industry experience, technical data related to waste forms, containers and storage options, and guidance from existing EPRI storage reports into two program documents that contain "recommended changes" to the existing EPRI guidance. In addition to updated operating experience, the revision focused on clarification of outside storage requirements and a revision to inspection and monitoring strategies.

Results

The industry update process resulted in development of this document*, Recommended Changes to Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility – For NRC Review,* and the supporting *LLW On-Site Storage Operating Guidelines – Supplemental Information Manual, Version 2* [66] (Note that the DRAFT supplemental manual will be published in the future in conjunction with Version 2 of the Operating Guidelines following NRC review). These two documents complement each other and provide technically valid, risk-informed guidance for managing an on-site storage program for LLW. The documents consider industrial, environmental, and radiological safety as they relate to occupational workers, plant equipment, and the public, as well as holistic consideration of waste characteristics, forms, containers, and storage facilities.

This document of "recommended changes" continues to summarize the available information set forth in the Interim On-Site Storage series of reports. It also captures the existing regulatory guidance, other guidance derived from industry experience, and the lessons learned operating LLW storage facilities. The outside storage revision process resulted in enhanced guidance that also reflects recent severe environmental, geological, and meteorological events. Alternate guidance for inspection and monitoring stored waste containers was developed; and the resultant proposed guidance supports a technically justifiable, proven, and safe container inspection program.

Looking Forward

EPRI intends the end product of the NRC review process and revision to serve as a routine reference document to help utilities develop storage procedures, perform monitoring and inspection of storage facilities, and ensure compliance with existing regulations and regulatory guidance. EPRI further anticipates that the user will continue to refer to and utilize this report and the related EPRI storage reports as part of the routine operation of the storage facility to maximize safety and compliance, while minimizing radiation exposures and waste management costs.

It is important to recognize that existing disposal options have a limited lifespan, and the life of these disposal options may be shorter than the waste generating life of most nuclear facilities.

Therefore, it is necessary for nuclear power plants to be prepared for and, in the majority of cases, implement interim on-site storage for at least some LLW.

The continuing need for interim LLW storage facilities is not unique to the United States. Most nuclear facilities outside the United States operate long-term, interim LLW storage facilities pending construction or availability of a national or provincial disposal repository. Accordingly, the great majority of commercial and government-owned nuclear facilities in the United States and internationally will rely on interim on-site storage for some forms of LLW for at least part of their operating life. Therein lies the importance of EPRI's Interim On-Site Storage of LLW report series, the condensed *Recommended Changes to Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility – For NRC Review:* 2011 (EPRI report 1024733) and the supporting *LLW On-Site Storage Operating Guidelines – Supplemental Information Manual, Version 2.* These two documents are designed to provide facility owners the information needed to implement and maintain a safe, regulatory compliant, and technically sound storage program using a risk-informed approach.

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1
INTRODUCTION

The majority of commercial USA nuclear stations have constructed on-site LLW storage facilities, and most of these same utilities have experienced at least one short period of interim on-site storage. These Guidelines focus on operational considerations and incorporate many of the lessons learned while operating various types of LLW storage facilities.

1.1 Purpose and Report Use

The overriding objective of this report is to provide guidance that can be used to develop and implement a safe and efficient site-specific low level waste storage program that is based on a regulatory compliant risk-informed approach. It is anticipated that the user of this DRAFT report will refer to it throughout the development and implementation of the storage program to ensure that major program components are being addressed and are being performed in a timely manner. It is further anticipated that the user will continue to refer to and utilize this report and the related EPRI storage reports as part of the routine operation of the storage facility.

All program reviews should consider the guidance in this and the supporting LLW On-Site Storage Operating Guidelines – Supplemental Information Manual, Version 2 [66], regulatory requirements, ANI storage inspection criteria [67], and industry OE. The basis for program exceptions should be documented for future reference.

It is important to understand that this DRAFT of the guidelines has not been reviewed by the USNRC and is not completely aligned with existing guidance from regulators and other industry organizations.

The existing Revision 1 Operating Guidelines (1018644) and Supplemental Information Manual (1018651) continue to represent an acceptable storage methodology and should continue to be referenced to ensure regulatory compliance in conjunction with applicable regulatory guidance such as the USNRC RIS 2008-32.

1.2 Definitions

The regulatory guidance in this document is derived from USA regulations. However, the guidance may be applicable to any LLW storage facility operated by domestic and international members of EPRI's Nuclear Business Group. The following definitions clarify key terms which may not have a common meaning to the international community.

- Low Level Radioactive Waste (LLW) is a general term for a wide variety of radioactively contaminated wastes. These wastes include protective clothing, machinery and related components, processed solids, and other substances that have been contaminated with varying levels of radioactivity. Various countries subdivide LLW into other categories, such as medium level waste and intermediate level waste. The USA subdivides LLW by "waste Class," including Class A, Class B, Class C, and Greater Than Class C (GTCC) wastes [47].

For the purpose of these Guidelines, unless otherwise specified, the term LLW encompasses all of these international and domestic subcategories.

- Dry Solid LLW is solid radioactive waste which was not generated as a result of liquid treatment processes. This includes combustible solids, compactable solids, metal, plastics, concrete, and similar dry wastes.
- Wet Solid LLW is any radioactive waste arising from liquid treatment processes (e.g., spent ion exchange resin, spent cartridge filters, evaporator concentrates, sludge). In some countries, this is also simply called "wet wastes." Prior to shipment for disposal, wet solid waste may be further processed to ensure that there are no free liquids, therefore meeting the waste acceptance criteria for disposal.
- Liquid LLW is defined as low level radioactive liquid (e.g., oil, decontamination solutions, aqueous liquids). For interim storage considerations, liquid waste is further defined as any waste that contains free liquid in amounts which exceed the requirements for disposal as established by the disposal facility licensing authority.
- Solidified LLW for storage purposes is liquid waste or wet solid waste that has been converted into a solid waste form to meet the waste acceptance criteria for disposal. This category includes waste encapsulated into a solid waste form.
- Waste Container means any container used to collect and store LLW. The waste container may or may not be the transport waste package. If and when a waste generator determines that a waste container is the transport waste package, only at that time is the waste generator required to comply with the transport package regulations in 49CFR.
- Waste Package means a packaging plus its contents as used for transport in accordance with 49CFR. Packaging means a receptacle and any other components or materials necessary for the receptacle to perform its containment function. [64]. It should be noted that the contents of a transport waste package may be a waste container.
- Waste Storage Module or Storage Shield refers to a structure or movable module (typically reinforced, high density concrete) that provides safe interim storage for a waste container, including protection from adverse environmental conditions and inadvertent intruder access, as well as providing shielding to reduce radiation dose rates to personnel, surrounding area, and site boundary. For the purposes of this DRAFT Guidelines document, a waste storage module or shield may contain or store a waste container or waste package, but it is not in itself a waste container or waste package. A waste storage module or shield with stored radioactive contents must be located within a licensed area, although it may be located within another structure or facility, or it may be located on a utility approved outside interim storage pad.

Unless otherwise stated, the use of the term "surveillance program" in this document and the supporting *LLW On-Site Storage Operating Guidelines – Supplemental Information Manual, Version 2* [66] refers to a proceduralized program to inspect and/or otherwise monitor a specific item using the recommended specified criteria.

1.3 Storage of Hazardous Waste and Mixed Waste

Storage of hazardous waste, as specified under the Resource Conservation and Recovery Act (RCRA), is not addressed in this document. Some plants will need to store LLW that also contains hazardous wastes. These mixed wastes are regulated both by the US Nuclear Regulatory Commission (USNRC) (for the radioactive component of the waste) and by the US Environmental Protection Agency (USEPA) (for the hazardous component of the waste). The guidance provided in this document applies only to the materials being stored in accordance with USNRC regulations.

1.4 Clarification of the Term "Interim Storage"

This document is specifically intended for management of radioactive waste that is ultimately destined for final disposal. It is not intended to be used for control of radioactive material (RAM) that is temporarily stored or staged for reuse. It also does not address storage of partially full containers that are "in-service. The term "interim storage," as used throughout this report, refers to storage within existing or planned interim on-site LLW facilities. **As used herein, interim storage refers to a long term perspective (i.e., years) as opposed to short term, "buffer storage" facilities provided for routine plant operation, even though both may be similar in design**. It is important to note that most buffer storage facilities were not constructed for LLW interim storage. Instead, most buffer storage facilities were originally designed as holding or staging areas pending one of the following situations:

1. Awaiting the accumulation of a sufficient number of LLW packages to constitute a full shipment.
2. Awaiting laboratory analyses for packaged LLW. Such analyses are necessary to complete waste classification and shipping document preparation.
3. Awaiting relief from temporary suspended access to existing disposal sites.
4. Awaiting availability of a special transport package or vehicle.
5. Awaiting approval from a disposal site to initiate a shipment pursuant to the advance notification requirements of the NRC, a particular state, compact authority, etc.
6. Awaiting approval from the regulator, disposal site, or other agency or consignee to ship the waste in a specific container, waste form, or package.
7. Holding LLW for decay of very short-lived radionuclides.
8. Awaiting the initial operation of a new processing facility or processing capacity (e.g., the plant may be waiting in line pending a backlog of waste at the waste processing facility).

These clarifications are significant to several utilities operating under specific licensing or other legal/contractual limitations related to on-site storage. Hence, for the purposes of this document, the term "interim storage" is intended to mean interim retention of radioactive waste until a final disposal option becomes available.

1.5 Organization of This Report

The remainder of this report provides three types of "guidance:"

1. **Regulatory Guidance** – This is guidance which is derived from regulatory sources, including regulations, USNRC Information Notices, USNRC Generic Letters, and similar documents. This guidance is closely aligned with the exact wording from the referenced documents. For easy identification, regulatory guidance is shown in italics and has a heavy vertical bar to the left of the paragraph, as illustrated by the bar to the left of this paragraph.
2. **EPRI/Industry Guidance** – This is guidance derived from existing EPRI interim storage publications, American Nuclear Insurers storage guidance, ANSI/ ANS Standards, INPO good practices, industry operating experience and lessons learned, and other non-regulatory sources. In addition, a review of USNRC Inspection Manuals and Procedures related to interim storage suggested a need for developing and including some additional guidance <u>not specifically included in nor quoted from</u> regulations or regulatory guidance documents (i.e., not verbatim regulatory guidance). The EPRI guidance in Revision 1 of this document, though not regulatory required, has been recognized by the NRC as an acceptable method for recordkeeping, determining waste forms and waste containers and monitoring and inspecting the interim long-term storage of LLRW. The basis for deviations from the guidance should be documented for future reference.
3. **Recommendations** – These are proven, industry experience and lessons learned based options that have passed through a technical peer review. Therefore they allow the user to adopt a practical, proven solution that has inherent justification by way of reference, minimizing the time required and potential for error when developing storage programs. There are relatively few recommendations, as compared to other guidance items. In general, a plant electing to operate an interim storage facility in accordance with this document would be aligned with Regulatory and EPRI/Industry Guidance and should develop and document specific justification for any deviations from existing guidance. In contrast, the interim LLW storage facility operator is not required to implement any recommendations in this series and is not required to develop or document any specific justification for ignoring such recommendations. For easy identification, recommendations are clearly identified with the word **RECOMMENDATION** capitalized and in bold at the beginning of the paragraph.

This document also is extensively referenced using the symbol [x], where x is the number of the reference in Appendix A. In some cases, multiple references are enclosed in brackets, [x,y,z]. If a multiple reference includes Regulatory Guidance, then the Regulatory Guidance is also annotated as described above.

1.6 Supplemental Guidance

As stated previously, this report is intended as a general guidance document, providing the foundation for the successful operation of an on-site LLW storage facility. A supporting EPRI document "*LLW On-Site Storage Operating Guidelines – Supplemental Information Manual, Version 2*" has been developed to provide additional supplemental information needed by program managers for implementing and maintaining an on-site storage program. **That document is specifically not intended as a stand-alone guide for storage** and should be used in conjunction with this guidelines report.

1.7 Time Value of the Technical Data

As with all technical information, the regulatory requirements, disposal site criteria, and state-of-the-art practices will change over time. Every effort has been made to ensure that all technical data, regulatory requirements, disposal site criteria, etc., are current at the time of publication. It is incumbent upon the user of this report to remain current with advancements in LLW technology, particularly with regard to on-site storage requirements and disposal site waste acceptance criteria for their state/regional compact.

2
GUIDANCE ON STORAGE FACILITY START-UP EVALUATION

This document of "recommended changes" focuses on operating an interim low level waste (LLW) storage facility as opposed to the design and construction of the facility. However, operation includes start-up evaluations of certain design features, such as the proper operation of fire suppression systems, floor drains, ventilation, accident analysis (50.59), etc. Similarly, during the plant life cycle, new interim storage facilities may be added, existing facilities may be expanded, or significant design modifications may be made. Each of these evolutions would be followed by a start-up evaluation.

This Chapter identifies key storage facility and program features which should be evaluated prior to storing LLW in a new, expanded, or otherwise modified on-site storage facility.

RECOMMENDATION: It is recommended that a similar evaluation be performed:

- Prior to storing waste in a facility that has not previously stored waste of this type, form, activity, and high dose rate.
- Prior to storing waste in a facility which was not originally designed for such waste.
- Following revisions to regulatory requirements and other industry guidance to ensure the program remains regulatory compliant and aligned with industry standards and incorporates current industry experience.

RECOMMENDATION: Although not a requirement, it is recommended that a periodic comprehensive review be performed of the storage facility and all storage activities, records, procedures, etc. Ideally, this should be performed by an outside organization or as a peer review by another utility.

2.1 Licensing, Safety Analysis Report, and Other Regulatory Requirements for Start-up

2.1.1 Previous USNRC Guidance Replaced or Deleted

Most storage facilities at USA commercial nuclear plants were constructed prior to 1994. In August 1994, the USNRC released a draft of SECY-94-198, *Review of Existing Guidance Concerning the Extended Storage of Low-Level Radioactive Waste* [1]. Although it was not officially signed and issued by the Commission, SECY 94-198 appeared to replace SECY 93-323 [63]. SECY-94-198 also combined, revised, and superseded the guidance in the following USNRC reference documents: SECY-90-318 [60], Generic Letter GL-81-38 [33], Information Notice IN-90-09 [36], Information Notice IN-89-13 [35], and Generic Letter GL-85-14 [31]. Those were primary reference documents used in the design and construction of LLW storage facilities, and some revised or deleted key passages from those documents may appear in plant procedures, license technical specifications, or the Safety Analysis Report (SAR). Note that throughout this Guidelines document, wherever reference [1] is specified, it refers to SECY-94-198 and the references included in SECY-94-198, which are [31, 33, 35, 36].

The operator of a storage facility should review procedures, technical specifications, and the SAR to determine if any of the following considerations need to be addressed:

NOTE

Throughout this document the terms "safety evaluation", "safety analysis" and "50.59 evaluation" as quoted from previous USNRC guidance now refers to application of the 50.59 process or what is called a 50.59 Review which includes: Applicability Determinations, 50.59 Screenings, 50.59 Evaluations and License Amendment Requests. When applying the 50.59 process an "evaluation" may not be required if the target activity is screened out.

- References to GL-81-38, IN-90-09, IN-89-13, and GL-85-14 appeared to be superseded by SECY-94-198. However, SECY-94-198 was never formally issued by the Commission.
- SECY-94-198 states: *The USNRC staff has eliminated any language relative to the above documents that implies a 5-year "limit," beyond which storage would not be allowed, or which imposes any special review requirements. [1]* Since SECY-94-198 was never formally issued, the 5-year limit was not eliminated. However, NUREG 0800 Revision 3 - March 2007, section 11.4 SOLID WASTE MANAGEMENT SYSTEM, as referenced by the NRC at a public meeting on waste storage conducted on January 30, 2008, states: "It should be noted that under SECY 94-198 and SECY 93-323, the provision requiring a Part 30 license for the storage of waste beyond 5 years has been eliminated".
  - Further, the NRC recognizes the practicality that some licensees may be forced to store LLW in excess of five years while awaiting approval, construction and licensing of a suitable LLW repository.
  - *Planning for interim waste storage should be for a period of time based on the status of the licensee's State or regional compact disposal facility program. [1]*
- *The previous requirement for power reactor licensees to obtain a separate Part 30 license for storage facilities located within a Part 50 licensed area has been deleted. [1]*
  - *However, if a licensee terminates its Part 50 license pursuant to decommissioning, then a Part 30, Part 70, or Part 72 license will be required to store any remaining byproduct material, special nuclear material, or Greater Than Class C (GTCC) waste, respectively. [1]*
  - *Commercial storage of LLW generated by "other licensees" on the reactor site will still require a separate Part 30 license for the operation of that facility. [1]*

  Note: Nuclear Regulatory Commission jurisdiction over storage of LLW generated and stored on-site will be retained in Agreement States in accordance with 10 CFR 150.15(a)(1). Indemnity coverage will be provided under and in accordance with your existing indemnity agreement *with the Commission. [1]* (See Chapter 7 for additional guidance for GTCC waste storage.)

- *10 CFR Part 50.59 evaluations are normally required when new LLW storage facilities are constructed. A §50.59 evaluation is also required for certain changes to existing facilities, including increases in total stored waste volumes and activities beyond those previously evaluated and included in the SAR. [1]* Utilities may wish to refer to NEI-96-07, Rev. 1 (2000), with regard to 50.59 reviews. [65]
  - *In instances where no changes in the facility or procedures as described in the safety analysis report are involved in the storage of LLW, then a §50.59 evaluation would not be required. [1]*
- *Waste no longer is required to be processed before storage nor packaged in a form ready for transport and disposal at the end of the storage period. The intent of that previous guidance was to ensure that waste could be stored in a stable form and to eliminate double handling of the LLW, and the resultant increase in radiation exposures, from processing waste into one form for storage and then into another for disposal. [1]* This is addressed further in Chapter 5, Guidance on Waste Forms for Extended Storage.
- *Each license issued under 10CFR50 authorizing the possession of byproduct and special nuclear material produced in the operation of the licensed reactor includes, whether stated in the license or not, the authorization to receive back that same material, in the same or altered form or combined with byproduct or special nuclear material produced in the operation of another reactor of the same licensee located at that site, from a licensee of the Commission or an Agreement State, or from a non-licensed entity authorized to possess the material. [1]* This is specified in 10CFR50.54(ee)(1).

2.1.2 Adding Storage Capacity or Storage Facilities

For proposed increases in storage capacity for LLW generated by normal reactor operation and maintenance, the safety of the proposal must be evaluated. Generally, Part 50 licensees are already authorized under 10 CFR Part 30 to possess byproduct materials produced by the operation of their facility, within the limits of their operating license, and they will have described storage of LLW in their SAR. [1] (Some plants may also have storage specifications and limitations in their Technical Specifications.)

General Guidance for Adding Storage Capacity

To increase storage capacities authorized in the SAR, or to construct new storage facilities, perform an evaluation of the safety of LLW storage, document that evaluation, and make it available for USNRC staff inspections. (See Chapter 7 for additional guidance for GTCC waste storage.) *Then either: [1]*

1. *amend your licenses where necessary to allow storage of LLW;*
2. *perform a §50.59 evaluation, <u>document the evaluation</u>, and <u>report it to the Commission annually</u>; or*
3. *conduct an evaluation under §20.1501 and <u>maintain a record of the results</u> in accordance with §20.2103(a).*

It also is possible to store waste from one nuclear plant at another nuclear plant, as has been accomplished by at least one USA nuclear utility. This requires a license amendment, which will specify the storage capacities and other limitations. This is discussed further in the following paragraphs. (Note that local restrictions or state laws may prohibit this capability.)

Specific Guidance for Adding Storage Capacity

- Begin your evaluation with a review of the technical specifications, SAR, and any USNRC correspondence related to on-site storage. Identify any special authorizations and requirements for LLW storage. [2] Note storage limitations with regard to:
  - Stored waste types, containers, and waste forms.
  - Stored radionuclides and activity limits, including license possession limits (e.g., Part 30 or Part 70 license). [2]
  - Physical and chemical form of the stored waste.
  - Stored waste classifications (e.g., GTCC waste stored in an ISFSI).
  - Limitations on stored volumes of each waste type.
  - Limitations on dose rates (package dose rates and facility exterior dose rates).
  - Any special storage considerations or restrictions.
- *In cases where no changes in the facility or procedures, as described in the SAR, are involved for storage of LLW, prepare safety evaluations of such storage in accordance with 10 CFR 20.1501. [1]*
- *In cases where the provisions of 10 CFR 50.59 apply, you may provide the added capacity, document the §50.59 evaluation, and report it to the Commission annually or as specified in the license. [1]*

  Note: *When §50.59 evaluations are required, Inspection and Enforcement Circular No. 80-18, dated August 22, 1980 [10], provides information on preparing §50.59 evaluations for changes to radioactive waste treatment systems, including those located in LLW storage facilities. [1]*
- *If you determine that an unreviewed safety question exists, or that a change in the technical specifications is required, as specified in §50.59, or that an existing license condition needs to be changed to accommodate LLW storage: [1]*
  - *Authority for storage should be requested through application for an amendment to your §50 license to the Office of Nuclear Reactor Regulation (NRR), accompanied by an environmental evaluation that considers the incremental impact as related to reactor operations. [1]*
  - *Application should also be accompanied by a showing that the storage provisions will not impact on the safety of reactor operations and will not foreclose alternatives for disposal of the wastes. [1]*

Multi-Station Interim Storage Facility Authorization

Some USA nuclear utilities that own multiple nuclear stations have applied for and received approval to ship LLW generated at one station for interim storage at a second station within the same utility. This required a license amendment for the receiving station. The station offered the following insights as possible guidance for other utilities considering such a license amendment:

- An environmental impact analysis was required as part of the license amendment submission package. The NRC allowed the station to reference the existing environmental impact report developed for plant operation.
- The amendment request has to be noticed in the federal register for 30 days as part of the review and approval process.
- The amendment submission documents must clearly state that the <u>new storage approach will not create an unfunded liability</u>.
- The time from submission to approval of the amendment was approximately seven months.
- No reference was made to any storage term either as part of the amendment request or the final amendment.

Facility Type and Location

Inside Storage

Selecting the optimal facility location requires careful evaluation of numerous considerations related to existing facilities, waste volumes, package type, physical access, security, site boundary proximity, etc. The principle considerations and recommended approach are addressed in existing EPRI reports. [12,13,15]

RECOMMENDATION: When selecting a storage facility and/or location, the preferred option is storage inside a structure. This is considered a best practice, but is **<u>not a regulatory requirement</u>**.

Outside Storage

Some sites may not have the physical space to support additional storage structures and therefore will rely on outside storage on open pads, yards, or other exposed areas. Outside storage is not prohibited by current regulations, however that approach does increase the liabilities associated with environmental and meteorological conditions, and to some degree seismic events, and therefore requires careful evaluation and disposition of several option-specific considerations. Additionally, outside storage is discouraged by ANI [4]

RECOMMENDATION: If outside storage is selected, ensure the related guidance in this and the accompanying Supplemental Information document [66] is implemented and implementation plans and exceptions to the guidance <u>are documented</u> for future reference by site and industry organizations. The following additional considerations that are based on industry storage experience should be addressed in the program and supporting documentation:

- Outside storage location issues:

  - Evaluate OSHA requirements concerning the location of existing and future power lines relative to crane transport to and from the outside storage and crane operations during waste handling activities
  - Evaluate location of existing and future underground utilities and piping for load restrictions relative to crane and waste transport to and from the outside storage and during waste handling activities
  - Evaluate logistical interferences associated with movement of materials, vehicles and temporary or permanent radiologically controlled areas during anticipated outage and maintenance activities relative to crane and waste transport to and from the outside storage area and during related waste handling activities.
- Gaseous releases from containers stored in outside (or enclosed, unmonitored structures) would be difficult to monitor and quantify
- Design storage modules with no sharp edges and develop supporting pre-use and in-use inspection criteria for modules to ensure surfaces and edges are smooth
  - Transport cask handling criteria may provide an acceptable basis.
- Ensure crane capacity and supporting boom angles comply with the evaluated storage configuration.
- Proceduralize a crane pre-use operability check and dry run for each lift evolution.
- Develop a program to require and validate rented/leased cranes and/or rigging preventative maintenance and surveillance programs to minimize the potential for failures during use.
- Consider the use of multiple drop-deck style trailers for modules/shields in lieu of lifts at the storage pad. (Comanche Peak, Ft Calhoun)
  - This approach eliminates second, outdoor lifts of storage module and/or waste container.
  - Ensure trailer design (e.g., open support beams) is adequately addressed in the 50.59 Review.
    - **OE:** At one station, the 50.59 review as it related to tornados, did not consider the effect of depressurization during a tornado with an open beam design and therefore that evaluation was inadequate.
- Verify module and container transport rigs (tractor and trailer) can access and fit into the target area.
- For outside transport trailers, consider the following:
  - Adding steel "stops" to prevent the module from sliding on or off the trailer during transport. This will also assist with module-trailer alignment during loading and removal evolutions.
  - Evaluate loaded module on trailer to determine if it will create a high radiation area during transport that requires additional radiological controls.

  - **OE:** One station welded a steel shield plate to the deck of their site module transport trailer. The additional shielding reduces dose rates to levels <100 mR/hr.
    - **Caution:** ensure the additional shielding does not compromise tractor, trailer, or transport path load limits.

- Storage modules should be designed to support lifting with a liner inside to preclude the need for open air lifts in outside areas.
- Storage modules should be designed with sampling and inspection ports to preclude lifting lid.
- Bringing storage or transfer modules into the Protected Area from the Owner Controlled Area will typically require security search of the inside of the module and may not be ALARA – the use of security seals could preclude this.
- If an ISFSI pad is used as a storage area, ensure that the ISFSI license conditions and SAR are reviewed and allow the activity.

2.2 Practical Storage Facility Start-up Evaluations

Prior to storing LLW, an overall evaluation of the interim storage facility should be performed to ensure that all facility features function correctly, identify any potential operating concerns and limitations, and capture baseline data. If this evaluation is being performed concurrent with LLW being moved into the facility, then it also starts the clock for subsequent inspections, surveillances, and monitoring.

- Start-up evaluations should be performed by individuals trained in accordance with:
  - USNRC IE Bulletin No. 79-19, "Packaging of Low Level Radioactive Waste for Transport and Burial." [4,11]
  - USNRC requirements related to handling, packaging and storage of Radioactive Material Quantities of Concern (RAMQC). [59]
  - USDOT regulations in 49 CFR 172 Subpart I related to (1) transportation Security Awareness training, and (2) Transportation Security Plan training.
  - Other USDOT hazmat training requirements, as applicable.

2.2.1 Start-up Review of Physical Facility Design Features

- *Verify personnel training and administrative procedures have been established to ensure both control of radioactive materials and minimum personnel exposures. [1]*
- On-site storage facilities should be located inside a fenced security area. [4]
  - They should not be located close to the site boundaries (fence line exposure issues, 40 CFR 190 direct dose considerations from skyshine, potential offsite releases) or in areas that are susceptible to flooding. [4]
  - Note that the recommendation for a fenced security area is an ANI rate-setting technical consideration which might be satisfied by other physical access restrictions.

The NRC does not require a fenced security area for all stored waste, although reasonable physical security measures are required. The extent of the security measures will be plant-specific, locally determined, and must be appropriate to the type of materials stored (e.g., extensive physical controls are required for Radioactive Material Quantities of Concern, whereas less stringent controls are required for very low activity wastes).

- On-site storage facilities (buildings) should be provided with fire/smoke detectors and a suitable fire suppression system. [4]
  - Alarm systems should be monitored in a constantly manned location, such as the control room or guard station. [4]
  - The fire/smoke detectors should be periodically tested. [4] ALARA should be considered in the placement of these devices in the design to minimize occupational dose from testing.
  - If a liquid suppression system is used, provisions should be made to contain the fire suppression liquids (e.g., curbs, drains, collection tank, etc.). [4]
  - *Fire suppression devices may not be necessary if combustible materials are minimal in the area. [1]*
  - If gaseous suppression systems (e.g., CO_2) are used, the system should be provided with an interlock to warn of an automatic discharge when people are present in the building.

    For example, storage buildings at Ontario Power Generation are equipped with a CO_2 deluge system that is interlocked with the building lights. It can only be initiated by manual local action and only if the lights are turned off. This procedure requires that when an alarm is received, a person checks the building to ensure that no one is present, turns off the lights, then initiates the system. If the system were to initiate automatically when someone was in the building, they would be asphyxiated. It also provides local confirmation that the alarm is real before the system is activated. This is not the standard for most plants.

- *Confirm that provisions are incorporated for collecting liquid drainage, including provisions for sampling all collected liquids. [1,4]*
  - *Routing of the collected liquids should be to radwaste systems if contamination is detected or to normal discharge pathways if the water ingress is from external sources and remains uncontaminated. [1]*
  - In general, it is considered that the above requirements refer to an enclosed building, or that the outside storage module is designed and capable of collecting any liquid that escapes the waste container inside the storage module or other outside storage container.
  - The collection system should be sized such that no leakage can escape the facility. [4]
  - The collection system should contain leak detection capabilities (i.e., sump high level alarms). [4]

- Alarm systems should be monitored in a constantly manned location such as the control room or guard station. [4]
- The alarm system should be on a routine maintenance and surveillance schedule. [4]

RECOMMENDATIONS: In general, alternatives to the use of electronic leak detection systems should be evaluated to ensure the following considerations are addressed:

- During the design and construction phase, the collection system should be sized based on the largest amount of liquid that could enter the facility (most likely the fire suppression system, if applicable). If a fire occurred, a central alarm station should be notified.
- The building should be inspected such that other water intrusions are identified (e.g., leaking water under doors) and repaired.
- The sump should be inspected periodically and kept dry. Therefore, anytime liquid is discovered in the sump, it should immediately be sampled, analyzed and processed or released, as appropriate.
- It should be recognized that the probability of something happening that will trip a high level alarm for a properly sized sump is almost zero; moreover, the dependability of an infrequently used high level alarm or an electronic leak detection system will degrade quickly.

- *Confirm that provisions have been established for reprocessing and repackaging of stored wastes. [1]* This may include shipping to an offsite vendor for reprocessing/repackaging.
- *Any storage plans should address any potential reprocessing requirements for eventual shipment and burial. [1]*
- *Procedures should require waste stored in outside areas to be held securely by installed hold-down systems. [1]*
  - *The hold-down system should secure all containers during severe environmental conditions up to, and including, the design basis event for this waste storage facility. [1]*
  - Ensure that any required hold down capabilities are available and are serviceable.
  - With regard to on-site storage modules, such as circular storage shields for liners and high integrity containers, most are quite heavy; however, they range from 14,000 lbs to just over 100,000 lbs; some rectangular storage modules weigh as little as 9,000 lbs. Design basis meteorological events may include tornadoes in excess of 300 mph, underscoring the need to secure the lighter containers.
  - For any on-site storage shield or module with removable lids, the lids (the top) should be securely fastened to the shield body and fastening and torque specifications if applicable should be included in operating procedures. Although lids can weigh up to 20,000 lbs, they can be displaced by a design-basis tornado, thereby exposing the stored waste container(s). Subsequent depressurization (suction) created by the tornado could lift the stored waste containers or lid from the storage module, turning

them into projectiles. For this reason, the majority of storage shield designs include a means of securing the lid to the sides of the storage module.

- The above considerations should be addressed as part of the 50.59 review for on-site storage modules and other outside storage containers.
- That review should include the entire storage system including the facility/module, container, and waste form.
  - **OE:** At one station a severe environmental condition was a hurricane that moved a full, improperly secured cargo container to another location on site.
  - **OE:** Seismic activity with a magnitude of 5.8 (Richter), resulted in physical movement of loaded dry fuel storage canisters on the outside storage pad that weighed ~117 tons. The canisters did not topple in that event.

- Confirm that all containers, including empty containers, are protected from reasonably expected severe environmental conditions, including fire and flooding. [2]
- If outdoor storage is necessary, the pad should be adequately bermed to allow for the collection of rainwater and/or leakage from the stored containers. [4]
  - The operative word here is "should." This should be addressed—either require berms or justify deletion—as part of the 50.59 review related to control of leakage for on-site storage pads.
- *External weather protection should be included where necessary and practical to ensure container integrity against corrosion from the external environment. [1]*
  - In cold climates, protection may be required from freezing for wet solid wastes (resin, filters, concentrates).
  - The impact of freeze-thaw cycles on concrete containers, modules, and structures also needs to be evaluated (e.g., small cracks or cavities could accumulate water which will cause further damage during freeze/thaw cycles).
  - *The following documents should be reviewed. Exceptions to the requirements or recommendations should be documented for future reference.*
    - *USNRC Manual, 84900-02 Inspection Requirements, Section 02.02 Adequacy of Storage Area (10/20/2000).*
    - *USNRC Regulatory Issue Summary (RIS) 2008-32 that includes references to Generic Letters, NUREG, SECY papers, Information Notices and 10CFR.*
- *Procedures should require storage containers to be raised off storage pads, where water accumulation can be expected to cause external corrosion and possible degradation of container integrity. [1]* Ensure that this capability exists <u>before</u> attempting to place waste on the outside storage pad. Note that "storage container" in this statement refers to the "waste container" and not a storage shield or storage module.
- Efforts should be made to locate LLW storage facilities so as to reduce extremes of temperature or humidity (e.g., do not locate near a boiler room, laundry area, etc.). [2]

- Confirm that any required checks of fire protection systems have been performed (i.e., ensure that the fire suppression system is functioning properly). [2]
- Confirm that ventilation systems are installed as necessary and are functioning properly. [2]
- *Prior to start-up, ensure that procedures have been (1) written, (2) approved by management, and (3) are available to storage facility workers for the following: [1,2]*
  - Safe placement, inspection, and repackaging of LLW in storage. [2]
  - *Periodic testing of fire and smoke detectors. [1,4]*
  - Periodic testing of liquid collection system alarms. [4]
  - Periodic testing of any installed security alarms.
  - Continuously manned monitoring and response to fire, smoke, security, and liquid collection system alarms. [4] (See note in paragraph 2.2.1 regarding electronic leak detection systems and alarms.)
  - A routine maintenance and surveillance schedule for all fire, smoke, security, and liquid collection alarm systems. [4] (See note in paragraph 2.2.1 regarding electronic leak detection systems and alarms.)
  - **RECOMMENDATION:** All facility equipment should be included in existing plant preventative maintenance and surveillance programs.
  - **RECOMMENDATION:** Operating procedures for the facility should be aligned with license and facility design documents.
    - **OE:** The ventilation system operating procedures for one site's storage facility did not reflect design considerations. As a result, the system was not aligned in accordance with the design basis. This resulted in inadequate ventilation for the facility.
  - Periodic inspection should be performed of the facility physical parameters, such as the full function of doors, latches and locks, berms, etc. This is especially important in areas that are shared with other plant functions.
  - *The results of all testing, surveillances, and maintenance must be documented and available for review. [1,2]*
- *Maintain a record of the results of start-up evaluations in accordance with 10 CFR 20.2103(a). [1]*

2.2.2 Radiation Surveys, Monitoring, and Limitations

For any LLW storage facility, the allowable quantity of radioactive material is dictated, in part, by the dose rate criteria for both the site boundary and unrestricted areas on-site: [1] (This is, of course, in addition to any licensing conditions and any physical design restrictions.)

- Dose rates within and around the LLW storage facility must be monitored routinely.
  - Surveys should be performed and documented just prior to start-up to develop baseline data for the restricted area boundary and for the site boundary. This starts the clock for subsequent surveys and monitoring.

  - An ALARA (as low as reasonably achievable) plan should be developed which describes the location of high and low dose rate packages, portable shielding, and the use of low dose rate packages to shield higher dose rate packages. Skyshine must be considered. The ALARA plan should seek to minimize exposure to (1) workers, (2) storage facility exterior, (3) restricted area boundary, (4) site boundary and (5) the 40 CFR 190 critical receptor.
  - The ODCM and REMP programs should be reviewed to determine if changes are necessary to adequately address the LLW storage facility.
- *On-site dose associated with interim storage will be controlled per 10 CFR Part 20, including the ALARA principle of 10 CFR 20.1101. [1]*
- *10 CFR 20.1301 limits the exposure rates in unrestricted areas. [1]*
- *The 40 CFR Part 190 limits restrict the annual dose from direct radiation and effluent releases from all sources. [1]*
  - *Off-site doses from on-site storage must be sufficiently low to account for other sources (e.g., an additional dose of < 1 mrem/year contributed by stored waste is not likely to cause the limits of Part 190 to be exceeded). [1]*
- Inspect the storage area(s) to assure adequacy with respect to all radiological posting and waste container labeling requirements. [2]
- *Total activity limits should be established and known to the storage facility operators. [1]*
  - Waste management strategies should be based on the results of the 50.59 review of onsite storage relative to existing UFSAR accident scenarios, such as a fuel handling or radioactive material handling accident. Determination of the requirements for the storage facility and stored wastes should envelope the potential radiological impact of storage operations, e.g., conservative release calculations should also be performed. These calculations may include the need to develop new X/Q values for both control room habitability and the offsite critical receptor. This will be defined on a site by site basis consistent with the site-specific licensing requirements.
  - In the event nuclide-specific controls apply, these should also be included in procedures and record systems.
  - In the event that the total activity of the stored waste (inventory) approaches the current design assumptions after the appropriate decay corrections have been applied to that inventory, an evaluation of the operating strategies should be performed to define any additional precautions for storage and/or strategy changes. Decay corrections also should be performed on each waste package prior to shipment. (See also section 3.3.1.)
- *Prior to start-up, ensure that other procedures have been (1) written, (2) approved by management, and (3) are available to storage facility workers for the following: [1,2]*
  - Perform periodic radiological surveys if radioactive materials or waste are stored in the facility. (For the site boundary dose, many plants install thermoluminescent dosimeters (TLDs) to track the accumulated dose.)

- Perform additional radiological surveys when adding new packages to the storage facility which have dose rates sufficiently high to affect the restricted area boundary dose rate or site boundary accumulated dose.
- Perform additional radiological surveys whenever significant shuffling (rearranging) of stored waste packages or portable shielding has occurred. This would include an evaluation of any potential increase in dose rates within the storage facility due to the movement of low dose rate packages which serve as shielding for high dose rate packages.
- Verify posting and labeling of storage facilities, restricted area boundaries, and waste containers.
- *The results of all surveys, TLD readings, and other methods of radiological monitoring must be documented and available for review. [1]*
- Locate the storage pad outside the predominant stack plume pathway to minimize the potential for positive tritium analysis results and document baseline measurements prior to pad construction.
- Eliminate the need for open-air (dry-air) transfers to storage modules if practical. Consider:
  - Cranes rated to lift loaded storage modules from a site transporter to the storage location.
  - The use of a transfer bell (Vogtle) that is loaded inside a structure and mates with the staged storage modules.
  - Site-specific module and container transporters (e.g., drop-deck trailer) that eliminate the need for outside crane support. (refer to Section 2.1.2 for additional considerations)
- Ensure module and container labels and postings are durable relative to temperature, moisture and wind extremes and ultraviolet fading.
- Assess the combined effect of the outside waste storage area and other radioactive material storage areas (including dry fuel storage) will have on site boundary dose.

2.2.3 Dry LLW and Solidified LLW Storage

- *Ensure that all staging and storage areas for dry or compacted LLW are located in restricted areas where effective material control and accountability can be maintained. [1,2]*
- *Controls should be in place to segregate and minimize the generation of dry LLW to lessen the impact on waste storage. [1]*
  - *Integration of volume reduction hardware or the use of off site volume reduction services should be considered to minimize the need for additional waste storage facilities. [1]*
- *Ensure that the following design objectives and criteria have been addressed for solidified waste storage containers and facilities; [1]* proceduralize where appropriate:

- *Casks, tanks, and liners containing solidified radioactive waste should be designed to State and local codes to preclude or reduce the probability of occurrence of uncontrolled releases of radioactive materials because of handling, transportation or storage. [1]*
- *Accident mitigation and control for design basis events (e.g., fire, flooding, tornadoes, etc.) must be evaluated and protected against unless otherwise justified. [1]*
- *All solidified radwaste should be located in restricted areas where effective material control and accountability can be maintained. [1]*
- *Although solidified waste storage structures are not required to meet seismic criteria, protection should be afforded to ensure the radioactivity is contained safely in a seismic event. [1]*
- *Contamination isolation and decontamination capabilities should be developed. [1]*
- *Provision should be made for additional reprocessing or repackaging because of container failure and/or, as required for final transporting and disposal as per USDOT and disposal facility criteria. [1]*
- *When significant handling and personnel exposure can be anticipated, ALARA methodology should be incorporated as per Regulatory Guide 8.8 and 8.10. [1]*

2.2.4 Wet LLW Storage

- *Ensure that the following design objectives and criteria have been addressed for wet waste storage containers and facilities; [1]* proceduralize where appropriate:
  - *The facility supporting structure and tanks should be designed to prevent uncontrolled releases of radioactive materials because of spillage or accident conditions. [1]*
  - *Structures that house liquid radwaste storage tanks should be designed to seismic criteria as defined in the USNRC Standard Review Plan, Section 11.2. [1,44]*
  - *Foundations and walls shall also be designed and fabricated to contain the liquid inventory that might be released during a container/tank failure. [1]*
  - *All wet LLW storage tanks or containers should be designed to withstand the corrosive nature of the wet waste stored. The duration of storage under which the corrosive conditions exist shall also be considered in the design. [1]*
  - *All wet LLW storage structures should have curbs or elevated thresholds, with floor drains and sumps to safely collect wet waste, assuming the failure of all tanks or containers. Provisions should be incorporated to remove spilled wet waste to the radwaste treatment systems. [1]*
  - All wet LLW storage tanks and containers shall have provisions to monitor liquid levels and to alarm potential overflow conditions. [1] (Do not confuse stored liquids with stored resin or other wet solid wastes. For wet solid wastes stored in containers (e.g., HICs), it should be acceptable to have the ability to check for water inside the concrete storage module on a periodic basis. However, in the case where wet solid

waste can be transferred to the storage tank or container by waste system piping, such as an in-plant resin transfer system, then level alarms are needed.)

- Verify that all potential release pathways of radionuclides (e.g., evolved gases, breach of container, etc.) shall be controlled, if feasible, and monitored in accordance with Part 50, Appendix A (General Design Criteria 60 and 64). [1]
- *Surveillance programs should incorporate adequate methods for monitoring breach-of-container integrity or accidental releases. [1]*

2.3 Security of Stored LLW and Interim Storage Facilities

- Confirm that LLW is stored in a restricted area and is secured against unauthorized removal.[2] A location inside the protected area is the most desirable and cost-effective security control option, but is not required.
  - *If adequate space in the protected area is not available, the storage facility should be placed on the plant site and both a physical security program (fence, locked and alarmed gates/doors, periodic patrols) and a restricted area for radiation protection purposes should be established. [1]*
- Confirm that access control and security procedures conform to the plant physical security plan. [2] This also applies to RAMQC and any related Safeguards Information (documents, inventories, computer files).
  - *Confirm that storage plans address container protection as well as unauthorized removal of stored waste or other radioactive materials. [1,2]*

Access control and security must also conform to any additional controls established in the Transportation Security Plan and Transportation Security Plan Risk Assessment, as specified in 49 CFR 172 Subpart I.

3 GUIDANCE ON RECORDS AND RECORDKEEPING FOR EXTENDED STORAGE

Regulations by USNRC and USDOT mandate keeping records of specific information on packaged low level waste (LLW) shipped for disposal. These recordkeeping requirements are an integral part of existing waste management programs at power plants. Storing waste in an interim on-site storage facility will impose additional recordkeeping requirements on the utility, which relate primarily to storage facility design and capacity evaluations, inventory control, monitoring and inspection.

Regulatory guidance documents provide explicit recordkeeping requirements for storage of LLW which are addressed in this Chapter. The unique control and accountability requirements for Special Nuclear Material [56,68] are not specifically addressed in the EPRI storage series.

Nuclear insurance carriers also establish certain recordkeeping requirements, particularly with regard to the duration of record storage (ANI/MAELU Technical Guidelines for LLW storage). Other items are included that are considered prudent for recordkeeping purposes, such as information required for the USNRC's Uniform Low Level Radioactive Waste Manifest in 10 CFR 20, Appendix G. Taken together, all of these guidance documents constitute a comprehensive recordkeeping program.

3.1 Records of Worker Training

- Records of worker training should include:
  - USNRC Inspection and Enforcement (IE) Bulletin 79-19 training
  - Hazmat worker training
  - Transportation Security Awareness training
  - Transportation Security Plan training (including RAMQC considerations)
  - Procedures training
  - Crane and forklift training and qualifications
  - Process Control Program training

3.2 Records of Evaluations for Increased Storage Capacity

- *Maintain a record of the results of such evaluations in accordance with 10 CFR 20.2103(a). [1]*

- *To increase storage capacities authorized in the SAR, or to construct new storage facilities, perform an evaluation of the safety of LLW storage, document that evaluation, and make it available for USNRC staff inspections. Then either: [1]*
  - *amend your licenses where necessary to allow storage of LLW; [1]*
  - *perform a §50.59 evaluation, document the evaluation, and report it to the Commission annually; or [1]*
  - *conduct an evaluation under §20.1501 and maintain a record of the results in accordance with §20.2103(a). [1]*

3.3 Records for Inventory Control

3.3.1 General Guidance on Stored Waste

- Records must identify any applicable authorized possession limits and provide adequate accountability to ensure the possession limits are not exceeded [2] (e.g., Part 30 or Part 70 licensees, or if identified during a Part 50 license risk analysis).
- Records must be maintained for all waste placed in storage. [2]
- *Records of waste types, containers, contents, waste forms, dates of storage, dates of inspection, etc., should be maintained. [1,2]*
- Records of radioactive waste shipments.
  - When waste is eventually shipped to an off site processor or to a disposal facility, all of the information on the USNRC's Uniform LLW Shipping Manifest will be needed. Utilities should consider capturing supporting data as early in the storage period as possible.

3.3.2 Specific Guidance on Stored Waste Container Records

- Container Identification Code (i.e., unique container ID)
- Date Placed in Storage
- Reference Decay Date – This is the date that the nuclide distribution (e.g., scaling factors, correlation ratios) was established. Typically, this is the date that the activity was measured or the survey was performed. It is needed for decay correction calculations to determine the radionuclide content after a specified storage period. The decay corrected radionuclide content would be used in the inventory control function and in the shipping and disposal functions.

  (Note: In the event that the total storage inventory is approaching a level that requires possible changes to normal operating procedures, a decay correction should be performed.)
- Container Storage Location – Should include sufficient detail to locate the container easily. The location detail for high dose rate packages and Radioactive Material Quantities of Concern is of special concern and should have detailed location information for retrieval and periodic inspection.

- Physical form of contents including material, density, processes used, tare and gross weight, etc.
- External radiation and contamination survey
- Container Manufacturer, Type and Model Number
- Container Manufacturer's Serial Number – The container integrity monitoring program will likely require certain numbers of containers of each type and manufacturer to be inspected at programmed intervals. For high integrity containers, a manufacturer could change design details over the storage period. Thus, it could later prove important to know exactly when a container was manufactured in order to trace it back to a certain container lot number. These could be subjected to intensified monitoring or be listed as candidates for early disposal.
- Date of Packaging (or Date Packaged)
- Chemical Form (Bulk waste) – This refers to the most prevalent chemical form of the waste. In addition, if the waste was generated as part of a large decontamination process, the process also should be indicated.

  Note: Utilities which are unable to obtain high quality characterization of waste streams or packages should consider saving a clearly labeled lab size sample of each batch of high dose rate, processed waste (such as dewatered resin) placed in storage. If any questions concerning the nature of the waste in storage arise during the storage period, samples will be available for analysis without the need of trying to sample closed waste packages.
- Total Activity
- Radionuclide Identity and Quantity
- Chelating Agents (>0.1% by volume)
- Solidification Agent – Include any sorbent, solidification binder, or stabilization media.
- Quantity of H-3, C-14, Tc-99 and I-129 – The isotopes, H-3, C-14, Tc-99 and 1-129, are generally considered to be highly mobile in a disposal environment and, therefore, are most often limiting in terms of radiation exposure hazard associated with the disposal site. The quantity of each of these four nuclides is required by 10 CFR 20, Appendix G, to be included on the Uniform Low Level Waste Manifest.
- Waste Class in Accordance with 10 CFR 61

3.3.3 Utility-Specific Data

In addition to the preceding data, each utility should evaluate its own unique situation with respect to waste storage documentation. Some utility-specific data may include:

- Information on waste potentially vulnerable to biological action.
- Documentation on any locally tested and certified IP-2 or Type A packages.
- Process Control Program historical file related to waste processing and stabilization including Topical reports or Process Control Program waste form proof of process documents.

- A review of state-specific regulations and requirements related to storage.
- Rigging and handling equipment certifications - for rigging that is in storage with the container (e.g., attached slings, grappling devices).

3.4 Records of Monitoring and Inspections

3.4.1 General Guidance for Facility Monitoring and Inspection Records

- Records must be maintained to demonstrate that: [2]
    - inspections of LLW packages are being performed to assure they maintain integrity; [2]
    - radiation surveys of individual packages and the storage area, in general, are being performed; [2]
    - any required effluent sampling is being performed; and [2]
    - security inspections are being performed. [2]
- The storage facility operator should know where hard copy records are archived.
- **RECOMMENDATION:** Preference should be given to using the existing nuclear plant document control system, as many waste records are already stored there, and the records personnel are very knowledgeable on record retention techniques.
- **RECOMMENDATION:** It is recommended that storage records be maintained in electronic format.
    - Where possible, the database should be located on a network level computer, which offers greater protection from loss and greater security from theft. (Such data may be used for malicious purposes, as discussed in various NRC issued or endorsed guidance documents on Radioactive Material Quantities of Concern and Radionuclides of Concern. [59])
    - Retain a backup copy of all software applications used to create and manage the database. (Data could be stored longer than such applications are available on the market.)
    - Backup copies of all electronic databases should be maintained in a separate, secure location from the original database.
    - Maintain the data hardware and storage media in a reasonably current technology. This may require periodic migration of data to new hardware.

    Note: Electronic data management technology has a short service life. Efforts should be made to ensure that the data storage system does not become obsolete by the end of the storage period. This challenge is often compounded by shuffling older computer equipment to storage operations and separating storage databases from the normal plant data network. There are many instances of data being recorded in electronic format and not being retrievable later because the original hardware became obsolete.

- Maintain current data by container or waste package number. Essentially, the entire history of any waste should be traceable by the waste container number from the point of collection to the point of disposal, including repackaging.
    - For electronic databases, the container ID number should be the key waste tracking and record link for all storage activities, inspections, etc.

If radiofrequency identification device (RFID) tagging is used, the container ID will be the connecting point between the RFID tag information and the storage database.

4

GUIDANCE ON WASTE CONTAINERS FOR EXTENDED STORAGE

The USNRC places requirements on the permitted containers for storage and disposal. The USDOT also places requirements on packages and packaging used in transporting the waste to the disposal site. Nuclear insurers provide guidance on container storage based on lessons learned from industry storage experience. Ideally, containers used for on-site storage and eventual disposal will meet all regulatory and disposal requirements and guidance when first placed in storage (although that is not a requirement). This Chapter summarizes the regulations and guidance that are relevant to waste containers for on-site storage.

Note: American Nuclear Insurers discourages outdoor storage, although recognizing that some plants have no other option. [4] Outside storage may, therefore, impact insurance rates, which should be factored into any cost analyses for storage facility design.

4.1 General Guidance

The following design objectives and criteria are applicable for dry low level waste (LLW) storage containers and facilities: [1]

- *Containers should generally comply with the criteria of 10 CFR Part 71 and 49 CFR Part 170 to minimize the need for repackaging for shipment. [1]*
- *Containers should meet the guidance included in USNRC Branch Technical Position on Waste Form, Rev 1 [61]*
- Radioactive waste and radioactive material containers should, as a minimum, meet the requirements of a general design package (e.g., 55 gallon drums, B25 boxes, sealand containers, high integrity containers (HICs), metal liners, etc.). [4]
- Guidance should be provided regarding container integrity requirements and acceptance criteria. [4] A determination should be made to ensure the integrity of each container and package used for each waste type and waste stream. [2]
  - Determine which wastes can be stored in each container/package.
  - Determine which wastes cannot be stored in each container/package.
- *The waste container should be designed to ensure radioactive material containment during normal and abnormal occurrences. [1]*
- *The waste container materials should not support combustion. [1]*

- Radioactive wastes and materials should be repackaged when containers are degraded to the point where integrity is questionable or leaking (depending on the specific waste and package characteristics, this may be accomplished using an overpack of the original package). [4]
- On-site storage facilities for radioactive waste and radioactive material should incorporate the necessary features to allow for removal of containers in storage. [4]
- Each container should be accessible and retrievable in order to provide timely removal and repackaging of problem containers. [4]
- Radioactive wastes and materials can be repackaged in outdoor areas assuming appropriate radiological controls are in place. Note that while acceptable, this is not a preferred option as it exposes the licensee to increased liability related to environmental and personnel exposure controls. [4] It is also important to note that repackaging refers specifically to transferring the waste material from one container to another (versus placing a waste container in an overpack).
- *Waste stored in outside areas should be held securely by installed hold-down systems. [1]*
  - *The hold-down system should secure all containers during severe environmental conditions up to, and including, the design basis event for this waste storage facility. [1]*
  - The above considerations should be addressed as part of the 50.59 review for on-site storage modules and other outside storage containers. Refer also to the discussion in section 2.2.1 related to hold-down considerations for outside storage pads.
- The laterals (internals) for dewatering liners and HICs are certified for finite time periods (e.g., five years). The laterals may also be subject to damage when a loaded container is lifted for movement to storage. Dewatered containers stored for any period of time should undergo, and will likely be required to undergo dewatering verification prior to disposal. This must be considered when selecting the waste container internals and balancing that selection against the anticipated storage duration. Note that some liners and HICs come with sampling tubes which may assist with verification of "no free-standing liquids" and, therefore, eliminate the need for dewatering via the laterals after their certification has expired.
- **RECOMMENDATION**: Sampling tube design and use should be carefully evaluated to ensure tube failure or clogging does not occur because of freeze related tube/dewatering stone fracture, bead fracture, or other high solids content in the waste container.
- **RECOMMENDATION**: A generator should be prepared to take additional dewatering actions <u>regardless of the storage period duration</u>. Lateral failure and/or degradation of container contents (e.g., bead resin fracture resulting from freeze-thaw cycles) may result in the need for non-traditional dewatering verification methods (e.g., container breach or reprocessing the container's contents). Conditioning waste to create a solid monolith using approved processes would mitigate the potential for future dewatering issues.
  - **OE:** There have been numerous industry events related to free standing water in containers following final dewatering. The period between final dewatering (certification) and identifying free standing water ranges from as low as several weeks to several years. Additionally, several stations have experienced physical failures or clogging of dewatering laterals, membranes, and verification stones. Those

types of failure modes would compromise the accuracy of future dewatering verification efforts.

4.2 ALARA and Radiological Guidance

- *All packages must be clearly labeled in accordance with 10 CFR 20.1904(a) and 20.2006. [1]*
- Configuration (e.g., placement, stacking, etc.) of the radioactive waste or radioactive material containers within the building or outdoors is important. [4]
  - Waste should not be stacked in such a way that it will increase the hazard of damaging the container or spilling the contents. [4]
  - **RECOMMENDATION:** Stacked containers should be secured in a manner that prevents containers tipping or falling during a design basis catastrophic event (e.g., tornado, hurricane, seismic, flooding).
    - **OE:** At one station a severe environmental condition was a hurricane that moved a full, improperly secured cargo container to another location on site.
    - **OE:** Seismic activity with a magnitude of 5.8 (Richter), resulted in physical movement of loaded dry fuel storage canisters on the outside storage pad that weighed ~117 tons. The canisters did not topple in that event.
  - Higher dose rate items should be segregated and/or shielded. [4] This should be accomplished in accordance with the site ALARA plan.
- *Increased container handling and personnel exposure can be anticipated during storage. Consequently, the methodology for maintaining exposures as low as reasonably achievable (ALARA) should be consistent with USNRC Regulatory Guides 8.8 and 8.10. [1,39,40]*

4.3 Guidance on Corrosion Protection

- *Container integrity should be ensured against corrosion from the external environment: external weather protection should be included where necessary and practical. [1]*
  - All containers should be selected and stored to prevent container degradation due to corrosives, environment, and physical/mechanical stresses. [4]
- *Compatibility of container materials with waste forms and with environmental conditions external to the containers is necessary to prevent significant container corrosion. [1]*
  - *Container selection should be based on data that demonstrates minimal corrosion from the anticipated internal and external environment for a period well in excess of the planned storage duration. [1]*
  - *Container integrity after the period of storage should be sufficient to allow handling during transportation and disposal without container breach. [1]*
  - *If liquids exist that are corrosive, proven provisions should be made to protect the container (i.e., special liners or coatings) and/or to neutralize the excess liquids. [1]* For example, experience at Ontario Power Generation indicated that liquids in resin

containers had a low pH following extended storage, which they contribute to cation resin breakdown releasing sulfur [57].

- *Potential corrosion between the solid waste forms and the container should also be considered. In the case of dewatered resins, highly corrosive acids and bases can be generated that will significantly reduce the longevity of the container. [1]*
- *The Process Control Program should implement steps to ensure the above incompatible and corrosive conditions do not occur. [1]*
- *Container material selection and coating should ensure that container breach does not occur during interim storage periods. [1]*
- *If deemed appropriate and necessary, highly non-corrosive materials (e.g., stainless steel) should be used. [1]*
- Containers must be compatible with the waste/material being stored and should be suitable for the anticipated storage conditions. [4]
- In instances when contracted vendors are providing the process, the implementing contractor should clearly delineate the quality criteria to be applied and the vendor should provide a certificate of conformance for each waste container processed to a final form.

- *Storage containers should be raised off storage pads, where water accumulation can be expected to cause external corrosion and possible degradation of container integrity. [1]*
- The long term integrity of the container grapple rings, lifting lugs, and slings should be evaluated along with the rest of the container.

4.4 Guidance for Container Design and Testing

4.4.1 Key Package Design Requirements Applicable to LLW Storage

General package design requirements are set forth in 49 CFR 173.410. The following general requirements may apply to stored waste containers if and when a licensee decides that a waste container has been re-designated as a transport waste package in accordance with the definitions in section 1.2:

- *Containers can be easily handled.*
- *Container lifting attachments are capable of handling three times the container gross weight.*
- *Lifting attachments must be testable and capable of being proven competent for use at the end of the storage period (i.e., waste packages must be safely retrievable at the end of storage).*
- *Container must be free of protrusions and easily decontaminated.*
- *Design should permit no water accumulation on outer surfaces.*

(In general, this applies to a container that:

- o *serves as both the waste storage container and the transport waste package, or*

  - *is not designed to withstand long periods of exposure to moisture, or*
  - *for situations where a realistic potential exists for degradation of the integrity of the stored transport waste package.*

  Generally, this does not apply to waste containers stored within enclosed storage modules that protect the waste container, or to high density polyethylene high integrity containers. In general, it is not expected that minor moisture condensation from thermal cycling would be sufficient to degrade the integrity of a package. Periodic inspections, and inspection before transport, should specifically address degradation to ensure of the integrity of the package is maintained.)

- *There should be no unsafe add-ons to the container.*
- *Container contents should be compatible with container materials.*

Note that most steel liners have not been tested, nor are they required to meet the IP-2 qualification criteria in 49 CFR 173 or those of 10 CFR 71 but they can continue to be shipped in casks. There is no indication that there is any problem with their acceptance at disposal sites for solidified or Class A wastes. However, utilities should seriously consider coating these containers for longer-term integrity. This is especially true for the inside of steel containers used for ion exchange resin or other corrosive contents.

USNRC regulation 10 CFR 61.56 [47] provides the basis for regulating packaging wastes for disposal, which has applicability to waste containers used for storage. It provides the minimum requirements to facilitate handling at the disposal site. In addition, statements in the USNRC Branch Technical Position [32] further expand the USNRC's position on waste packaging. The following paragraphs identify the key USNRC requirements for all waste containment for disposal—and which also have applicability to on-site storage.

4.4.2 10 CFR 61.56 [47]

- *Waste must not be packaged for disposal in cardboard or fiberboard boxes. [47]* This applies primarily to utility dry solid waste (DSW).

4.4.3 USNRC Branch Technical Position (BTP) [32]

- *The container should be resistant to degradation caused by radiation effects. [32]*
- *The container should be resistant to biodegradation. [32]*
- *The container should remain stable under the compressive loads inherent in the disposal environment. [32]*
- *The container should remain stable if exposed to moisture or water after disposal. [32]*
- *The as-generated waste should be compatible with the container. [32]*

The regulations also call for testing to grant approval (certification) of the waste forms. The USNRC stopped issuing topical reports on LLW and no longer approves waste forms. Waste form submittals must now be made to individual states or to the E-5 Committee of the CRCPD (Conference of Radiation Control Program Directors) as coordinated by the USDOE at Idaho National Labs. Refer to the BTP for detailed HIC design and acceptance criteria.

5
GUIDANCE ON WASTE FORMS FOR EXTENDED STORAGE

It is the USNRC's position that it is desirable to place waste into storage in a form suitable for disposal, but only if there is sufficient assurance that the waste will ultimately be acceptable for disposal. [1] The guidance in this Chapter addresses both waste that is processed and ready for disposal, as well as waste that has been safely packaged but is in a form that is easily reprocessed or repackaged to meet future disposed waste acceptance criteria.

5.1 General Guidance on Waste Form

- *Where possible, waste should be processed before storage, packaged in a form ready for transport and disposal at the end of the storage period in accordance with the requirements in 49 CFR Parts 170-189 and 10 CFR Part 61 respectively. [1]*
- *Where a disposal route has not yet been defined, waste should be processed and stored safely in a form that will not unreasonably foreclose future options. [1]*
- *Adequacy of the waste form or package should be reassessed before disposal. [1]* Industry experience suggests that this should be applied to every package.
- Some waste forms (i.e., liquids) are not appropriate for long term storage. [4]
    - Industrial waste forms (e.g., corrosives, hazardous materials, flammables, etc.) should not be stored with radioactive wastes/materials. [4]
    - Raw (untreated, unprocessed) radioactive waste or unpackaged radioactive materials should not be placed in the LLW storage facility. [4]
- *The packaged material should not cause fires through spontaneous chemical reactions, retained heat, etc. [1, 47]*
- *All wet LLW in interim storage will require additional reprocessing before shipment offsite. [1]*
    - Industry experience supports this USNRC guidance as being applicable to waste stored for as little as 90 days.
    - As a minimum, each wet LLW package should be evaluated to verify it meets the waste acceptance criteria for disposal prior to shipment to a disposal facility, with special attention given to the amount of free-standing liquid. (Refer specifically to 10CFR61.56(a)(3).)

For waste that is stored outside or in facilities that do not have environmental controls, consideration should be given to thermal treatment or solidification or encapsulation conditioning of the stored wastes. This would produce a stable waste form for this storage option and will:

- mitigate the effects of environmental extremes including temperature and humidity
- in the case of solidification or encapsulation it will render the waste non-dispersible in the event of a design basis catastrophic event (e.g., tornado, hurricane, seismic, flooding)
- the case of solidification or encapsulation it will mitigate the consequences of a container failure
- eliminate the potential for gas generation
- reduces the level of effort required to comply with disposal site requirements related to dewatering

5.2 Guidance for Minimizing Fire Hazards

- Strict application of a plant's process control program (PCP) and chemical control program should prevent any dangerous chemical mixtures in any of the wastes generated by the plant.
- Careful characterization of the wastes prior to packaging will help ensure that the waste packages will not contain incompatible materials.
- Filling and closing the storage packages, thus minimizing voids, will act as an additional barrier in preventing internally generated fires.
- Any remaining waste packages that may represent a fire hazard will need to be stored in fire protected areas with appropriate fire suppression equipment or systems or placed in steel or concrete overpacks or barriers.

5.3 Guidance for Minimizing Gas Generation

- *Gas generation from organic materials in waste containers can also lead to container breach and potentially flammable/explosive conditions. [1]*
    - *To minimize the number of potential problems, the waste form gas generation rates from radiolysis, biodegradation, or chemical reaction should be evaluated with respect to container breach and the creation of flammable/explosive conditions. [1]*
    - *Unless storage containers are equipped with special vent designs that allow depressurization and do not permit the migration of radioactive materials, resins highly loaded with radioactive material, such as boiling water reactor water cleanup system resins, should not be stored for a period in excess of approximately 1 year. [1]*

    RECOMMENDATION: Resin that is stored for any period of time should be packaged in a container that includes a passive vent.

Source Controls

To minimize the potential for gas generation in LLW, suitable source controls should be instituted. Source controls alone can dramatically reduce the probability of gas generation in LLW packages due to biodegradation and chemical reactions, and radwaste managers are encouraged to use these preventive means. Examples of source control include:

- waste stream segregation to the greatest practicable degree (e.g. condensate polisher resins are considerably less likely to support biological growths than are radwaste treatment resins);
- adherence to operating procedures and quality control measures in LLW collection, sorting, segregation, and characterization;
- proper housekeeping and a high degree of cleanliness in areas, equipment and systems where radioactive wastes are generated, handled and treated, so that the probability of biological agents or nutrients (including sanitary waste) entering **or** contaminating the radioactive waste stream(s) is minimized;
- contain and separate oils, grease, solvents and similar hydrocarbons, high detergent-content (especially phosphorus-based) aqueous wastes, etc.

Other Considerations

- Biocides may be applied to control biological growths in certain instances, but only as a last resort and when there is a known, well understood problem.
  - Biocides are relatively short term inhibitors of biological growth, and need to be reapplied periodically.
  - Some biocides should be avoided since they may contain components qualified as hazardous by the USEPA (i.e., result in a mixed waste).
- Oxidizers (i.e. chlorine, chlorites, peroxides) must not be used without full consideration given to potential reactions with the waste forms, containers, seals and gaskets.
- To minimize the possibility of a chemical reaction that would lead to gas generation, a strong chemical control program which prevents mixing of the waste with highly oxidative or other undesirable chemicals should be in place.
- To minimize the potential for radiolysis, ion exchange resin should be removed from service before accumulating levels of radionuclides that can lead to radiolytic decomposition [57]. This applies primarily to decontamination resins (i.e., resin generated during system decontamination projects), since the plant process resins usually do not accumulate sufficient activity.
- Venting devices may be needed to vent the generated gas and relieve the pressure inside the container.
- The potential for gas generation can be reduced by the selection of a suitable waste form. For instance, solidification of wet wastes, such as spent ion exchange resins and filter media, will substantially reduce the potential for gas generation. However, waste solidification is not a universal solution: for example, solidification of incinerator ash in cement may lead to significant gas generation. Other waste forms, such as vitrification or melting, may prove preferential for this waste type.

5.4 Other Regulations and Regulatory Guidance on Waste Form

USNRC regulation 10 CFR 61.56 [47] provides the basis for regulating waste forms for disposal, which has applicability to waste storage. In addition, statements in the USNRC Branch Technical Position [32] further expand the USNRC's position on waste forms. The key USNRC requirements for all disposed waste forms—and which have applicability to stored waste forms—are as follows:

5.4.1 10 CFR 61.56 [47]

- *Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the fluid. [47]* This rule applies primarily to utility oils.
- *Solid waste containing liquid shall contain as little free-standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume. [47]* Applicable to resins, evaporator bottoms, sludges, and filters.
- *Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water. [47]* Applicable to decomposition of organic resins into hydrogen and methane from gas generation.
- *Waste must not contain, or be capable of generating toxic gases, vapors, or fumes harmful to persons "transporting, handling, or disposing of the waste." This does not apply to radioactive gaseous waste. [47]* This does apply to concerns over decomposition of organic resins into hydrogen and methane, resulting in gas generation.
- *Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable. [47]* This is not particularly applicable to most utility wastes.
- *Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20^{o}C (68^{o}F). Total activity must not exceed 100 curies per container. [47]* Not particularly applicable to utility wastes.
- *Waste containing hazardous, biological pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials. [47]* Some wastes, such as liquid scintillation vials from bioassay (urine samples) could fall into this class for international utilities and government facilities.

The regulations in 10 CFR 61 have additional requirements for Class B and C wastes. These wastes must be able to maintain structural stability to inhibit slumping, collapse, or other failure of the disposal trench that could lead to radionuclide migration. Regulations stipulate a period of 300 years as the minimum time a Class B or C waste must retain its integrity. The additional requirements for these higher-level wastes are as follows.

5.4.2 USNRC Branch Technical Position (BTP) [32, 61]

- *The waste should be a solid form or in a container or structure that provides stability after disposal. [32] All Class A liquid wastes, however, require solidification or absorption to meet the free liquid requirements. [61]*

- *The waste shall not contain free-standing and corrosive liquids. That is, the wastes should contain only trace amounts of drainable liquid, and in no case may the volume of free liquid exceed 1% of the waste volume when wastes are disposed of in containers designed to provide stability, or 0.5% of the waste volume for solidified waste. [32, 61]*
- *The waste should be resistant to degradation caused by radiation effects. [32, 61]*
- *The waste should be resistant to biodegradation. [32, 61]*
- *The waste should remain stable under the compressive loads inherent in the disposal environment. [32, 61]*
- *The waste should remain stable if exposed to moisture or water after disposal. [32, 61]*
- *The as-generated waste should be compatible with the solidification media or container. [32, 61]*
- Recognizing that all LLW is intended for disposition at the end of the interim storage period, the waste must meet the waste form requirements for stability set forth in the USNRC *Technical Position on Waste Form, Rev. 1* [61] prior to disposal. The referenced document includes guidance on (1) the processing of wastes into an acceptable, stable waste form, (2) the design of acceptable high integrity containers, (3) the packaging of filter cartridges, and (4) minimization of radiation effects on organic ion-exchange resins. The regulations in 10CFR20 (e.g., Section III.A.1 of Appendix G) [68], requires waste generators and processors to prepare wastes that meet the waste characteristics requirements of Part 61 (including the requirements for structural stability). The recommendations and guidance provided in this technical position are an acceptable method to demonstrate waste stability. [61]
- Meeting the BTP dewatering requirements for disposal will assist with mitigating the potential for waste, container, or container internals degradation for waste stored in facilities that do not have environmental controls such as heat or cooling.

6 GUIDANCE ON MONITORING AND INSPECTION FOR EXTENDED STORAGE

Inspection efforts for storage facilities are generally geared toward assuring that licensees who are storing low level waste (LLW) for extended periods are in compliance with possession limits (e.g., facility limits, SNM accountability [56,68]) and license conditions, and do not develop an "out-of-sight, out-of-mind" attitude. This is normally accomplished by examining the licensee's records to ensure that the required surveys, inspections and accountability checks are being done and then following up with a physical examination of the storage area and waste containers/packages. [2]

The guidance in this Chapter includes facility inspections, surveillances, radiological monitoring, and as low as reasonably achievable (ALARA) considerations. A formal inspection and monitoring program should be established to detect failure or degradation of radioactive waste/material storage containers.

- Waste container inspections, surveillances, tests, and other monitoring should be performed by individuals trained in accordance with:
    - USNRC IE Bulletin No. 79-19, "Packaging of Low Level Radioactive Waste for Transport and Burial." [4,11]
    - USNRC requirements related to handling, packaging and storage of Radioactive Material Quantities of Concern (RAMQC). [59]

6.1 Guidance on Facility Inspections and Monitoring

This section applies to inspection and monitoring of facilities. Container inspection guidance follows in Section 6.2.

- Determine whether the procedures for placement, inspection, and repackaging of LLW are clear and available to all who need to use them, and that they have been approved by management. [2]
- *Verify program documentation exists and is available for: [1,2]*
    - *inspections of LLW packages to assure they maintain integrity; [1,2]*
    - *radiation surveys of individual packages and the storage area, in general; and [1,2]*
    - *any required effluent sampling. [1,2]*
- Inspect the storage area(s) to verify it is being properly maintained with respect to:
    - Access to and housekeeping around waste packages.

  - Lighting provided for visual inspections and to permit identification of unsafe radiological and non-radiological conditions. [2]

    Note: Verify lights are functioning and adequate for the intended purpose. Over time, as the number of stored waste containers increases, the available light to some storage areas and containers will decrease.

- *Confirm that all LLW is stored within a restricted area. [1,2]* (In this case, "restricted area" refers to radiological controls. Adequate security considerations also apply to all stored LLW, which are addressed elsewhere in these guidelines or in the licensee's physical security plan.)
- *Confirm that all LLW is secured against unauthorized removal. [1,2]*
- *Confirm that any required checks of fire protection systems have been performed. [1,2,4]*
  - Verify that fire/smoke alarm systems are being monitored in a constantly manned location such as the control room or guard station. [4] In other words, if you have an alarm, you should be able to hear and respond to it 24 hours a day.
  - Verify that personnel monitoring alarms know the correct alarm response.
  - Verify the alarm system(s) is on a routine maintenance schedule, and documentation demonstrates that the system(s) is being properly maintained. [4]
- Confirm that liquid drainage and collection systems, as well as leak detection capabilities (e.g., sump high level alarms, if installed), are functioning properly and that no leakage has escaped the facility. [4] (See also the discussion on electronic leak detectors and sump alarms in section 2.2.1.)
  - Verify that leak detection alarms are being monitored in a constantly manned location such as the control room or guard station. [4].
  - Verify that personnel monitoring alarms know the correct alarm response.
  - Verify the alarm system(s) is on a routine maintenance schedule, and documentation demonstrates that the system(s) is being properly maintained. [4]
- *Determine whether the correct type of container/packaging is being used to maintain the package integrity. [1,2]*
- Check that waste containers are visible to allow routine inspection and that they are readily accessible to workers and inspectors. [2]
- Confirm that the placement or stacking of containers is stable and that the containers are not deformed under load, or likely to fall. [2,4]
- Confirm that the containers are protected from reasonably expected environmental conditions, including fire and flooding, and that the storage location is not subject to extremes of temperature or humidity (i.e., near a boiler room, laundry area, etc.). [2]
  - This should also include protection or control measures related to any design basis catastrophic event (e.g., tornado, hurricane, seismic, flooding).
- Check ventilation of the storage area to determine if it is sufficient to prevent build-up of any gases produced by waste decomposition. [2]

  - Verify that any installed ventilation equipment is working properly and is being maintained in accordance with a documented preventive maintenance schedule.
  - Verify that any ventilation equipment has the correct filters installed and that filters and charcoal replacement frequencies are specified in the preventive maintenance schedule. (This only applies where the facility design calls for such equipment, filters, and/or charcoal media.)
- If outdoor storage is necessary, the following minimum program elements should be implemented: [4]
  - A formal surveillance program should be established to detect failure or degradation of radioactive waste/material storage containers; [4]
  - Routine contamination and dose rate surveys should be performed; [4]
  - Periodic storm drain samples should be taken and analyzed. [4] The frequency should generally be consistent with the normal sampling frequency for all other plant storm drains;
  - The pad should be adequately bermed to allow for the collection of rainwater and/or leakage from the stored containers; and [4]
  - Collected water should be routinely monitored and, if necessary, processed prior to discharge. [4]
  - It is considered that the above requirement for a bermed pad can be met if the outside storage module is designed and capable of collecting any liquid that escapes the waste container inside the storage module. This should be addressed in the 50.59 review.

6.2 Guidance on Individual Container Inspections and Monitoring

This document contains "recommended changes" to Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility. The approach in this document is risk-informed and considers industrial, environmental and radiological safety as it relates to occupational workers, plant equipment, and the public, as well as holistic consideration of waste characteristics, waste forms, containers and storage facilities. It is important to understand that this document has <u>not</u> been reviewed by the USNRC and is not completely aligned with existing guidance from regulators and other industry organizations.

The existing Revision 1 Operating Guidelines and Supplemental Information Manual continue to represent an acceptable storage methodology and should continue to be referenced to ensure regulatory compliance in conjunction with applicable regulatory guidance such as the USNRC RIS 2008-32.

6.2.1 Inspection Frequency

This is a multi-step process. A container risk evaluation is performed. That information is used in conjunction with other container and waste-specific information to determine the inspection frequency.

Container Risk Evaluation

Using the criteria in the following table, perform a container risk evaluation for each container in storage and document the results. This will be used with other data to define a representative package(s). The container should be assigned to the highest risk category in which it meets one or more of the criteria.

Elevated Risk
♦ known to contain, or have a high potential to contain organic material (excluding media)
♦ subjected to temperature extremes
♦ contents were in contact with system or component decontamination process solutions (e.g., aggressive chemicals)
♦ contents originating from known site or process-specific conditions that may affect container or media integrity or gas generation.
♦ containers previously identified as elevated risk based on site or industry OE or historical inspections
Lower Risk
♦ contain solidified, thermally volume reduced, or encapsulated waste
♦ contain only metal waste
♦ contain dry waste only such as trash, metal, paper, plastic, etc.

Inspection Frequency Determination

- *The use of high integrity containers (300-year lifetime design) would permit an inspection program of reduced scope. [1]*
  - Similarly, several waste forms provide additional stability or desirable storage characteristics as discussed in this and other supporting documents.
- **RECOMMENDATION:** For solidified, thermally volume reduced, or encapsulated waste
  - Inspect at least one container the first year that the licensee implements interim on-site storage,
    - THEN inspect one container every ten years.
      - Select the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.
- **RECOMMENDATION:** For raw dewatered wet solid waste in HICs that are:
  - Dewatered so that the freestanding liquid does not exceed 1% by volume at the time of placement in storage, AND
  - Stored inside facilities that are designed to contain 100% of a container's liquid and solid contents OR,

  - Stored outside in modules that are designed to contain 100% of the stored container's liquid and solid contents,
  - Inspect:
    - At least one container the first year that the licensee implements interim on-site storage, then,
    - One container every 5 years – 2 % of 300 year HIC life
  - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

  Note that this periodicity or strategy is not specified in USNRC guidance documents

- **RECOMMENDATION:** For raw, dewatered wet solid flowable waste (e.g., resins, carbon, etc.) in any container that does not meet the criteria in the previous two scenarios (e.g., steel liner), then:
  - Inspect 10% of the stored inventory or one container per year, whichever is greater.
  - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.
- **RECOMMENDATION**: For dry solid and wet filter waste (e.g., cartridges, membranes and septa) in steel waste containers (drums, boxes, liners)
  - Stored inside facilities or stored outside in modules
  - Inspect:
    - 10% of the stored inventory or one container every two years, whichever is greater.
  - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

Tracking historical trends will demonstrate if this percentage should be increased or decreased. [18]

- **RECOMMENDATION**: for dry solid waste in steel waste containers (drums, boxes, liners)
  - Stored outside with no enclosure or other environmental protection
  - Inspect:
    - 5% of the stored inventory per quarter.
  - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

Additional Inspection Frequency Guidance

- If more than one container is in storage, do not inspect the same container in sequential inspections.

- If the storage facility has been exposed to a design basis catastrophic event (e.g., tornado, hurricane, seismic, flooding) or other event of significance, then perform a special inspection of the stored containers as soon as practical (typically same or next day) including:
    - An inventory to verify all containers are accounted for
    - Visual assessment of container or module external surfaces
    - Facility general area radiation dose rates
    - Facility surface contamination levels
    - Gas generation and airborne activity in the vicinity of one or more containers or modules
    - Compare the results to historical surveys and inspection results.
    - Abnormal results should be used in a conservative manner to evaluate additional inspection or containment measures.
- Container inspection frequencies and sampling sizes should be periodically evaluated for revision based on several factors including:
    - the presence of secondary containments
    - an analysis of the site specific inspection results
    - a container risk evaluation by waste form (raw dewatered, solidified, encapsulated)
- Tracking historical trends will demonstrate if the percentage should be increased or decreased. [18]

6.2.2 General Inspection Guidance

- If any inspection criteria identifies an abnormal condition, perform an extent of condition evaluation including the following:
    - a detailed inspection of the inspected container including additional visual, loose surface contamination, dose rates
    - an evaluation of the container's contents and historical inspection results
    - inspect other at-risk containers (same waste type, waste form, storage duration, environmental conditions, etc.)
        - The number inspected should be conservative and representative of the actual or estimated risk
    - evaluate and adjust as necessary the inspection frequency for similar containers and/or waste types
- New or refurbished waste containers should be inspected to detect manufacturing defects or handling damage that could render them unsuitable for waste storage or could accelerate their deterioration.
    - This also applies to containers which have been stored in an empty condition or exposed to an outside environment for an extended period of time. (Stored empty containers can degrade quickly if not properly stored.)

 - Inspect the storage location of empty containers.
 - Empty polyethylene HICs should be stored inside or are otherwise shielded from UV rays which could degrade the containers. (Manufacturer specification.)

- Consider using liquid detection and analysis and/or gas detection and analysis as a supplement to, or alternative for, visual inspection of waste containers.
 - **OE:** STP incorporated a telltale drain in their module design. It can be opened to detect the presence of liquids. A full port ball valve would also support access for flexible video surveillance and gas monitoring equipment. This precludes the need for lid removal and the associated heavy load liabilities and costs.
 - Other plants specify removable small-diameter ports in storage modules to support similar monitoring without a lid lift.

6.3 Guidance on Inspections for Dry Solid LLW and Solidified LLW Storage

- *Potential release pathways of all radionuclides present in the solidified waste form shall be monitored as per Part 50, Appendix A. [1]*
- *Surveillance programs shall incorporate adequate methods for detecting failure of container integrity and measuring releases to the environment. [1]*
- *Perform direct radiation and surface contamination monitoring of waste containers to ensure that levels are below limits specified in 10 CFR 20.1502 and 20.1906, and 40 CFR 173.397. [1]*
 - *All containers should be decontaminated to these levels or below before storage. [1]*
 - *Inspect liquid drainage collection systems and sample all collected liquids. [1]*
 - The results of any sampling should be documented for future inspections.
 - Action items resulting from liquid sampling should be documented for future inspections.
 - Review the action items resulting from previous inspections and sampling to verify appropriate follow-up actions were implemented. [2]
 - *Route any collected liquids to radwaste systems if contamination is detected or to normal discharge pathways if the water ingress is from external sources and remains uncontaminated. [1]*
 - If radioactive waste or radioactive material containers are stored outdoors and they must be placed adjacent to the storm drain system, periodic storm drain samples should be taken and analyzed. [4]
- *Verify that all waste stored in outside areas are held securely by installed hold-down systems. [1]*
 - *The hold-down system should be adequate to secure all containers during severe environmental conditions up to, and including, the design basis event for this waste storage facility. [1]*

  - Verify any required hold-downs are in place, secure, and in good repair.
- *Verify that container integrity is ensured against corrosion from the external environment and that external weather protection is used where necessary and practical. [1]*
- *Verify all storage containers are raised off storage pads, where water accumulation can be expected to cause external corrosion and possible degradation of container integrity. [1]*
- *Procedures should be developed and implemented for early detection, prevention and mitigation of accidents (e.g., fires). [1]*
- Verify that storage facility workers are trained, as applicable, in accordance with:
  - USNRC IE Bulletin No. 79-19, "Packaging of Low Level Radioactive Waste for Transport and Burial." [4,11]
  - USNRC requirements related to handling, packaging and storage of Radioactive Material Quantities of Concern (RAMQC). [59]
  - USDOT regulations in 49 CFR 172 Subpart I related to (1) transportation Security Awareness training, and (2) Transportation Security Plan training.
  - Other USDOT hazmat training requirements, as applicable.

6.4 ALARA and Other Radiological Monitoring Guidance

- Perform periodic (quarterly) contamination and dose rate surveys for the facility and for waste packages and whenever material is removed from or placed into the facility. [4]
- *Inspect the facility to ensure all radiological postings are accurate and present in accordance with 10 CFR 20: [1,2]*
  - within the building.
  - at the exterior of the building.
  - at all exit doors.
  - at the restricted area boundary.
- *Verify that monitoring is being performed at the site boundary for the storage facility and that records are being maintained for all site boundary dose measurements (e.g., thermoluminescent dosimeter (TLD) readings). [1]*
- Monitoring programs should consider site-specific Off-site Dose Calculation Manuals (ODCM)
  - This includes modifying the program to reflect new storage facilities and monitoring requirements and reporting related to ODCM requirements.
- Surveys should include general area radiation and contamination surveys as well as the monitoring of the radioactive waste or radioactive material containers for surface contamination. [4]
- Special radiological surveys (e.g., soil samples, smears, direct frisk, etc.) should be performed when container breach is suspected; [4]

- Storage facilities (buildings) should be monitored by Continuous Air Monitors. [4] (In at least one utility storage facility, American Nuclear Insurers has recognized continuous air sampling systems as an acceptable alternative.)
  - Ensure that any required monitoring is being performed.
  - Verify that the monitoring equipment is operational.
  - Verify that the results of monitoring are being saved and evaluated, and that any such evaluations are being documented.
- *Verify that inspected packages are properly labeled. [1,2]*
  - This requirement specifically refers to transport waste "packages." However, licensees are also required to label or tag all waste containers with their radioactive contents. When a waste container or transport waste package is stored within a waste storage module or storage shield, it is recommended that the storage module/shield be posted.
  - Consideration should be given to labeling each LLW container or package within the storage module/shield with a radioactive material tag so as to identify the contents. However, 10CFR20.1905 [68] specifically exempts containers that "are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record (examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells).
    - **OE:** One site labels the module lids "Notify Radiation Protection Prior to Removal". This was based on a recommendation made by an external industry organization.
  - Tags sometimes become separated from containers/packages, faded or otherwise illegible or damaged. therefore, if tags are used, it is further recommended that the tag or on the waste container or package include a unique serial number or other unique identification or be cross referenced to the container serial number. The container and tag number should be directly linked to container records in the plant inventory database.
  - Verify that ALARA considerations are being used in the placement of the higher activity waste containers in the storage area. [2]
  - Consider the use of a bar-coding system that references the user to a container-specific database.
- Action levels and limits should be established for the above radiological surveys and monitoring. [4]
  - Action items resulting from liquid sampling should be documented for future inspections.
  - Review the action items resulting from previous inspections and surveys to verify appropriate follow-up actions were implemented. [2]

6.5 Site-Specific Technical Basis for Inspection Frequency and Scope

- **RECOMMENDATION:** Using industry experience and the technical basis information in Appendix B, document the site-specific inspection program basis including revisions to inspection frequencies and the supporting data for that decision.

7 GTCC WASTE STORAGE CONSIDERATIONS AND GUIDELINES

7.1 Overview

Greater that Class C (GTCC) waste is a waste designation that is unique to the USA nuclear industry. It refers to the upper end of the international ILW (intermediate level waste) classification. GTCC waste is low level waste (LLW) which exceeds the activity limitations for near-surface disposal set forth in USNRC regulations 10 CFR 61.55. [47, 62]

At the present time, there is no licensed disposal facility for GTCC waste in the USA. This situation forces commercial nuclear reactors to store GTCC waste *on-site* until a disposal facility is constructed and licensed.

In October 2001, the USNRC revised its regulations in Part 72 [56] to accommodate concurrent storage of GTCC waste in an interim spent fuel storage installation (ISFSI). In addition to resolving numerous regulatory issues, this revision had three key effects:

1. A long term storage solution was established for GTCC waste independent of a Part 50 operating license. This allows for termination of the Part 50 license at the end of decommissioning.
2. A long term storage solution for GTCC waste impacts on GTCC waste generation similar to a disposal solution: both long term solutions have the effect of removing a long-standing nuclear plant operating practice of taking measures to avoid GTCC waste generation.
3. It addressed the pending Barnwell LLW repository closure in June 2008. At that time, the closure would (and ultimately did) eliminate access to out-of-region waste, as was required by South Carolina law. As a result, most USA commercial nuclear plants lost their disposal option for Class B/C wastes. At that time, this closure event represented a significant high activity storage volume impact. However, given the advanced state of technology for volume reduction and concentration, most Class B/C waste could be reduced in volume by factors ranging from 5:1 to more than 30:1 by conversion to GTCC waste. The availability of a long term GTCC waste storage option makes this a practical and economic solution to interim on-site storage, as well as reducing the overall stored waste inventory.

   The downside of converting Class B/C waste to GTCC waste is that disposal options may again become available for Class B/C waste. In contrast, the disposal options for GTCC waste are likely to remain uncertain for many years. Converting Class B/C waste to GTCC waste would close the door on a potential future Class B/C disposal route.

Shortly after releasing the revised regulation in 10CFR72, the NRC also issued Interim Staff Guidance 17 (ISG-17), *Interim Storage of Greater Than Class C Waste,* [62] to assist affected licensees in planning and implementing GTCC waste storage in accordance with the new regulation.

7.2 Authorized Storage Locations for GTCC Waste

A generator of GTCC waste has the option of storing the waste either in an ISFSI or in a separate LLW storage facility (including outside storage pad and *on-site* storage modules). For waste stored in a LLW storage facility other than an Interim Spent Fuel Storage Installation (ISFSI):

- If an ISFSI pad is used as a storage area, ensure that the ISFSI license conditions and SAR are reviewed and allow the activity.
- All storage considerations and guidelines addressed in the preceding Chapters apply.
- Additional guidance on GTCC waste container and waste form are provided in this Chapter.
    - Storage in a LLW storage facility offers greater flexibility for waste containers and waste forms, including those discussed in preceding Chapters. This is especially valuable for waste which is still being characterized and evaluated for further processing.
    - If GTCC waste is stored in any container or waste form not discussed in this Chapter, there is a significantly increased probability that the waste will need to be repackaged prior to disposal.
- Careful attention should be paid to the allowable radionuclides and activity limits, as GTCC wastes contain a significant quantity of one or more longer lived nuclides.
- Outside storage is discouraged by nuclear insurers. [4]
- Outside storage of GTCC waste likely represents a potential increase in security concerns (threat of malicious intent), depending on the location of the storage area and the type of storage modules.

Table 7-1 summarizes the licensing authorizations for the various types of radioactive waste which may be stored at an interim spent fuel storage installation (ISFSI). The table makes it clear that the licensee has broad storage options under a Part 50 license. It is also clear that the licensee has multiple options if it desires to terminate its Part 50 license. Note that a specific license obtained under Part 72 intentionally has a much narrower focus.

Table 7-1
Summary of Licensing Authorizations for Radioactive Waste Storage

Waste Types Stored at ISFSI	Part 50	Part 30 (1)	Part 70 (2)	Current Part 72
Spent fuel aged >1 year	✓			✓
Other materials associated with spent fuel storage (including secondary LLW)	✓	✓	✓	✓
Solid GTCC waste	✓	✓	✓	✓
Liquid GTCC waste	✓	✓	✓	(3)
Other LLW (Class A, B or C)	✓	✓	✓	(4)

(1) Byproduct material
(2) Special nuclear material
(3) A survey of decommissioning plants suggests that there is little, if any, liquid GTCC waste which will require *on-site* storage.
(4) Other LLW (Class A, B, or C) cannot be stored in an ISFSI that is specifically licensed under Part 72. An exception applies to such waste which is generated as part of routine ISFSI storage activities, such as inspection and maintenance. However, such excepted waste must be removed and dispositioned in a reasonable period of time.

7.3 GTCC Waste Storage

For GTCC waste stored in a LLW storage facility (i.e., not in an ISFSI), the guidance set forth in preceding Chapters apply. Additional guidance is provided below in the sections on recordkeeping, waste containers, and waste form.

7.3.1 Guidance for Start-Up Evaluation for GTCC Waste Storage

- *Prior to storing GTCC waste in an ISFSI, the licensee must include in its Safety Analysis Report (SAR) how the GTCC waste will be stored to prevent any potential adverse reactions. The SAR should include equipment and facility design, description of planned operations, and other information important to safe receipt, handling, packaging, storage and transfer of GTCC waste. [56, 62]*
- *If a Part 72 specific license has not yet been applied for, then the initial SAR should address GTCC waste storage. [56, 62]*
- *If a Part 72 license already exists, then the SAR must be amended before GTCC waste is stored within the ISFSI. [56, 62]*
- *If GTCC waste storage will be accomplished under a Part 50 license, and if the storage will occur within the ISFSI, then the nuclear plant SAR section governing ISFSI operation must be amended to address GTCC waste storage. [56, 62]*

Note: Remember that the primary consideration of such SAR submissions is to describe how GTCC waste will be stored to prevent any potential adverse reactions with stored spent fuel.

- *A "72.48 review" (similar to a 50.59 review, but applied to an ISFSI) should be accomplished to identify any potential unreviewed safety questions related to storage of GTCC waste under a Part 72 specific license prior to making any changes, tests or experiments at an ISFSI. This should be accomplished using the same level of careful discipline applied to "50.59 reviews" for an operating nuclear plant and GTCC storage under a Part 50 general license. [56, 62]*
- *A Quality Assurance program must be in place prior to receipt of GTCC waste at an ISFSI. This program is part of the QA program for spent fuel storage, as well as any other radioactive materials or waste stored at the ISFSI. [56, 62]*
- *A program for training, proficiency testing and certification of equipment and control operators is required prior to the receipt of GTCC waste at an ISFSI. This same program is required for supervisors of the equipment and control operators. [56, 62]*
  - *This training must include Transportation Security Awareness Training and Transportation Security Plan Training. [56, 62]*

7.3.2 Guidance for Recordkeeping, Reporting, and Training Requirements for Storage of GTCC Waste

The following guidance is in addition to guidance previously provided for recordkeeping of wastes in a LLW storage facility other than an ISFSI. It applies only to stored GTCC waste containing special nuclear material (SNM):

- *Written accounting procedures must be established for material control and accounting (mathematical accounting) sufficient to maintain an accurate accounting of all SNM received, stored, and transferred from storage. [56, 62]*
- *A physical inventory of spent fuel and GTCC waste containing SNM and stored at the ISFSI must be performed at least once every 12 months. [56, 62]*
- *All inventories must be documented, available for inspection, and maintained in duplicate with the duplicate records stored in a separate, remote location. [56, 62]*
- *Records must show the receipt, inventory (including location), disposal, acquisition and transfer of all GTCC waste containing SNM in storage at the ISFSI. [56, 62]*
- Secondary Class A, B and C wastes generated as part of the normal operation of an ISFSI must be tracked and disposed in an undefined reasonable period of time. This indicates a need to record the dates of waste generation, along with the other recordkeeping requirements identified in the preceding Chapters.

7.3.3 Guidance for Waste Containers for Interim Storage of GTCC Waste

- The USDOE has responsibility for providing acceptance criteria for containers used to transfer GTCC waste to a Monitored Retrievable Storage (MRS) facility and for disposal of GTCC waste. The availability of written guidance providing this waste acceptance criteria is not known and it is not anticipated that this will be forthcoming within the next several years.
- The regulations and current guidance documents do not provide any separate design criteria for containers used to store or dispose of spent fuel or GTCC waste.

  - For waste stored in a LLW storage facility other than an ISFSI, refer to the guidelines in preceding Chapters on waste containers for extended storage, including considerations for container corrosion.
  - With regard to storage of GTCC waste in an ISFSI, a survey of decommissioning plants indicates that most are proceeding with the design review for GTCC waste containers using the same criteria applicable to spent fuel storage with additional consideration given to chemical, galvanic, organic or other reactions.
  - *It is incumbent upon the user to ensure that the GTCC waste does not adversely impact on the container, the storage cask, or anything else stored in the ISFSI. [56, 62]*
- The USDOE has already developed several containers which could be used to transfer GTCC waste to an MRS and, subsequently, could be used to store GTCC waste in an ISFSI with a reduced likelihood of repackaging at the end of the storage period. However, these containers have not received final approval from the USDOE and have not been submitted to the USNRC for certification. Therefore:
  - Storage of GTCC waste in any existing container design needs to consider the possibility of repackaging the GTCC waste for final disposal.
  - Such repackaging may occur at the ISFSI, at another appropriately licensed plant processing and packaging area, at an off site vendor facility, or at the final repository. These options should be addressed as part of the long range planning.
- Other GTCC waste containers may be accepted or grandfathered by the USDOE, and decommissioning nuclear plants are using several different container designs. In each case, repackaging prior to disposal remains a reasonable potential.

7.3.4 Guidance for Waste Forms for Interim Storage of GTCC Waste

- For waste stored in a LLW storage facility other than an ISFSI, refer to the guidelines in preceding Chapters on waste forms for extended storage, *including considerations for fire hazards and gas generation*. Remember that:
  - Storage in a LLW storage facility offers greater flexibility for waste containers and waste forms, including those discussed in preceding Chapters. This is especially valuable for waste which is still being characterized and evaluated for further processing.
  - If GTCC waste is stored in any container or waste form not discussed in this Chapter, there is a significantly increased probability that the waste will need to be repackaged prior to disposal.
- *Storage of liquid GTCC waste within an ISFSI is prohibited, regardless of whether the ISFSI is operated under a Part 50 general license or a Part 72 specific license. [56, 62]*
- Waste form acceptance criteria for GTCC waste disposal is uncertain at the present time.
  - Nuclear plants which have GTCC resin, filters, or liquid waste may want to postpone any final waste form or waste conditioning decisions until waste acceptance criteria become available.

- This would require that alternative storage solutions be provided for GTCC liquid waste (e.g., stored in an interim on-site storage facility other than an ISFSI and under the applicable Part 50, Part 30, or Part 70 license).

- *10 CFR Part 72 allows for storage at an ISFSI of solid GTCC waste only (including dewatered resin). [56, 62]*
- Lessons learned from storing dewatered Class A, B and C resin and filter waste demonstrate that dewatered waste accumulates free-standing liquid after even a relatively short period of storage.
  - Although dewatered waste forms may be acceptable for initial short term storage within an ISFSI in accordance with an approved SAR, the dewatering process is typically intended for a period of 90 days prior to disposal. Thus, after a relatively short period, continued storage of dewatered GTCC waste within an ISFSI may lead to a violation of the regulations and ISFSI license.
  - To avoid a violation, monitoring and inspection provisions would need to be made to verify no free-standing liquid in dewatered waste forms (including resin *and* filters), and those inspections—and probable repeated dewatering—would need to be performed at relatively short intervals. The need for such intensive inspection, monitoring, and repeated dewatering requirements suggests that storage of GTCC dewatered waste within an ISFSI is inconsistent with the regulatory intent regarding storing GTCC liquid waste.
  - **RECOMMENDATION:** Thus, it is strongly recommended that alternative storage solutions be provided for GTCC dewatered waste (e.g., stored in an on-site storage LLW facility other than an ISFSI and under the applicable Part 50, Part 30, or Part 70 license). Solidification may become a feasible option in the future within ISFSI container designs—once such design criteria is known—although the need for container solidification internals would significantly impact container design and selection.
- *Other restrictions should be imposed on stored GTCC waste to minimize the potential for chemical, galvanic or other reactions. [56, 62]* Refer to the guidelines and discussions on waste form in Chapters 5.
- *10 CFR 72 prohibits storing Class A, B and C waste in an ISFSI operated under a Part 72 specific license. [56, 62]*
  - *An exception is applied to secondary waste generated as part of the routine operation of the ISFSI (e.g., smears, repackaging, spill control, inspection). [56, 62]*
  - It should be noted that Part 72 does not allow secondary Class A, B and C waste to be stored within the ISFSI for an extended period. The language of the regulations in Part 72 suggests that such secondary waste should be removed from the ISFSI and dispositioned within an undefined reasonable time frame.

7.3.5 Guidance for Monitoring and inspection of Stored GTCC Waste

Routine monitoring and inspection requirements and associated equipment are needed for ensuring the integrity of waste containers, minimizing occupational exposures, and avoiding uncontrolled releases from an ISFSI. The following guidelines apply:

- General scope of inspections and monitoring:
  - ISFSI – Refer to SAR and license conditions for general monitoring and inspection requirements, in addition to the guidelines specified below.
  - Other LLW storage facilities – Refer to the guidance specified in the preceding Chapters on monitoring and inspection.
- General GTCC waste container inspection frequency:
  - ISFSI – Use the same frequency applied for other ISFSI monitoring and inspection frequencies (refer to SAR and license conditions).
  - Other LLW storage facilities – Replicate frequencies specified in the preceding Chapters on monitoring and inspection, which vary based on waste container selection and waste form.
  - *A physical inventory of GTCC waste containing SNM and stored at the ISFSI must be performed at least once every 12 months, regardless of the storage location. [56, 62]*
- *If dewatered GTCC waste is stored within an ISFSI, monitoring and inspection provisions need to be made to verify there is no free-standing liquid. [56, 62]*
  - Those inspections—and probable repeated dewatering—need to be performed at relatively short intervals (i.e., quarterly).
  - The frequency of inspections can be adjusted after developing an historical trend which supports an extended frequency based on verifications of no free-standing liquid at shorter intervals.
  - Each inspection and, if necessary, dewatering cycle, should be documented and records made available for review.
- *Verify that no Class A, B and C waste is stored in an ISFSI operated under a Part 72 specific license. [v]*
  - *An exception is applied to secondary waste generated as part of the routine operation of the ISFSI (e.g., smears, repackaging, spill control, inspection). [56, 62]*
  - Secondary Class A, B and C waste cannot be stored within the ISFSI for an extended period. Verify that such secondary waste is removed from the ISFSI and dispositioned within an undefined reasonable time frame.

7.4 Extended Storage of GTCC Sealed Sources [7]

Disposal is especially difficult for greater-than-Class-C (GTCC) sealed sources. The requirements for classifying waste for near-surface disposal are provided in 10 CFR 61.55. This regulation states that GTCC waste is generally not acceptable for near-surface disposal and must be disposed of in a geologic repository, pursuant to Part 60, unless another disposal method is approved by USNRC. Many sealed source users have discovered that they have no place to ship their GTCC sources for disposal, because no geologic repository is currently available.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 designates the Federal Government as responsible for disposal of GTCC wastes. Congress has designated the Department of Energy (DOE) as the responsible agency for disposal of GTCC waste, however related guidance has not yet been issued by the DOE. It should be noted that DOE efforts to recover GTCC, particularly high activity sources, has been exceptionally successful in recent years.

7.4.1 Guidance for Storing GTCC Sealed Sources

The following information should be maintained relative to GTCC sealed sources:

- *Identification of each sealed source to be placed in storage, including the manufacturer's name, model number, serial number, isotope, and activity. [7]*
- *A description of the accountability program to be implemented by the licensee to ensure that its sources remain in secure storage and are not used. The program should provide reasonable assurance that the licensee can maintain security and account for the sources (inventory at least annually). [7]*
- *A commitment to leak-test the sources at least once every 3 years and immediately before transfer to an authorized recipient. [7]*

7.5 Storage of Fuel Assembly Integral Components in an ISFSI [56]

Title 10, Code of Federal Regulations (10 CFR), Section 72.3, "Definitions," states, " *Spent fuel includes the special nuclear material, byproduct material, source material, and other radioactive materials associated with fuel assemblies.*" Therefore, such materials are not GTCC waste and should be stored in accordance with regulations for spent fuel. Spent fuel storage is beyond the scope of this Guidance document.

8
END OF STORAGE GUIDELINES AND CONSIDERATIONS

Lessons learned from extensive utility low level waste (LLW) storage experience have been translated to guidance for the end of the storage period. This Chapter also provides a discussion of related experience.

8.1 Guidance for End of Storage

- At the end of the storage period, inspect and repair all support utilities and equipment used to inspect, handle, repackage, or reprocess waste (e.g., lighting, crane, drains).
- *All wet solid LLW in interim storage will require additional reprocessing before shipment offsite. [1]*
    - As a minimum, each wet solid LLW package should be evaluated to verify it meets transportation and the applicable waste acceptance criteria for disposal prior to shipment offsite, with special attention given to the amount of free-standing liquid and gas generation.
        - Industry experience supports this USNRC guidance as being applicable to waste stored for very short durations (e.g., as short as several weeks).
    - Determine if waste meets Waste Acceptance Criteria (WAC) for intended disposal facility (may be different from originally planned facility or WAC); repackage and reprocess as necessary. (Some countries refer to WAC as "conditions for acceptance (CFA).")
- Determine if the waste acceptance criteria for the intended disposal site has changed since the time the waste was placed in storage.
- Determine which wastes or packages meet the waste acceptance criteria for disposal for the intended disposal facility.
- Where practical, pursue a first in/first out approach (oldest waste should be considered for first disposal).
    - Verify the storage documentation matches the container selected for removal.
    - Assess the radiological conditions of all waste packages.
    - Reevaluate waste characterization as needed to ensure waste classification.
    - Perform decay analyses to identify the current nuclide concentrations.
- Verify the processed and stored waste meets the process control program (PCP) criteria in effect at the time of shipment to disposal (e.g., free-standing liquid). This involves a review

of the disposal site waste acceptance criteria and the standards applicable to the PCP in effect when the waste was originally processed.

- Inspect for degradation of waste containers, including oxidation (rust), leaks, or visible damage (e.g., punctures, container swelling).
- For wet solid LLW (e.g., resin, filter cartridges), verify no free-standing liquid.
- For solidified LLW, verify no free-standing liquid (e.g., rain, dew) on top of the monolith inside the container.
- If it is a condition of disposal, verify that no excessive void spaces exist in waste containers which were stored without volume reduction conditioning. (Unprocessed waste can undergo subsidence within the waste container.)
- Inspect rigging, grapples, lifting eyes, attaching points, etc. to ensure they still meet the applicable serviceability criteria. This includes both the crane rigging and any permanent attachments to the waste container/package. Replace as necessary.
- Evaluate the internal waste impact on containers (e.g., corrosion, H_2 and CH_4 generation).
- Evaluate changes in USDOT shipping restrictions (typification, labeling, IP requirements) which may require re-labeling or even repackaging.
- Evaluate changes in hazardous waste regulations which might indicate conversion from a LLW to a mixed waste.

8.2 End of Storage Considerations

1. Waste settling during storage can create excessive void spaces (frequently >15%) for some waste packages. This applies primarily to nonmetal wastes which were placed in storage without volume reduction processing. This must be identified and, where necessary, the waste should be reprocessed and/or repackaged to meet the WAC.
2. Many plants which experienced one or more periods of interim, extended storage provided feedback on lessons learned at the end of the storage period while preparing to ship waste for disposal. Repackaging was not particularly common, although reprocessing (dewatering) of previously dewatered resins and filters was common. The following insights were provided from a nuclear plant which experienced an 18-month interim storage period following the closure of Barnwell in 1994/95:
    - Five wet waste containers were placed in storage: four with resin; one with filters. At the time, polyethylene high integrity containers (HICs) were the most common storage approach in the USA. Resin solidification was not practical at that time, and there was no nationally approved binders for filter encapsulation. Moreover, design restrictions inherent to the local storage facility (restrictive sizing of high activity storage vaults) precluded storage in commercially available ferralium HICs.
    - The high activity storage vaults are designed for storage of 80 ft^3 containers. Because that is an unusual container size, they are exceptionally expensive.

- The plant fire protection staff required that all polyethylene HICs be placed in metal overpacks (as experienced at other plants, both in the USA and internationally), which further increased storage costs per container.
- All resin was dewatered, *but the dewatering equipment test report was only valid for 90 days*. After that period, the residual water content within the container was no longer certified to meet disposal criteria. This meant the plant would have to verify that no free-standing water was present before shipment for disposal.
- The plant arranged with the HIC supplier to install a separate dewatering verification tube with a stone filter at the bottom of the HIC. A connecting tube could be easily attached to a fitting in the cover plate of the HIC under the plastic lid, allowing for any free-standing water to be removed without the use of a fill head. This was an excellent pre-planning approach which reduced labor time and some of the associated radiation exposures for removing any residual water.
- Of the four resin HICs placed in storage, three exceeded the free water criteria when removed from storage. The entire process of verification and removal of any free-standing water was both labor intensive and dose intensive. Each metal overpack had to be opened, the plastic HIC lid was removed, the dewatering tube was attached, and the HIC dewatered. The polyethylene HICs also were removed from the metal overpacks and shipped separately for disposal to reduce disposal costs. The entire process from storage removal to shipment averaged one week per stored waste container.
- Filters were stored within a HIC with a suspended encapsulation basket. They had not been cement-encapsulated, as no nationally approved cement binder existed at that time. However, since some of the filters contained a cellulose matrix, a potential existed for gas generation. If gas generation had become a problem, the container could have been filled with cement to mitigate the problem.
- Upon removal of the filter HIC from storage, water could be heard sloshing in the bottom of the container. It was estimated that several inches of water were present in the container, and it was solidified with cement prior to disposal.
- The quantifiable impact to the plant for removing, dewatering, and preparing these five containers for disposal was an extra $40,000 per container and an extra 420 mrem per container. The plant estimates that all of these costs and the associated dose could have been avoided if the waste had been solidified prior to storage.

The plant also removed a sixth container which had been in storage for more than two years. This was an empty metal liner. Although the container was indoors with its lid secured in place, approximately one inch of water was found inside the liner. The liner had a passive vent, and the plant believes that moisture entered the liner via the passive vent. Thus, the source of the water was dew formation on the walls of the container. Again, this emphasizes the need for verifying the absence or presence of free-standing water in wet waste packages prior to shipment. It also highlights the potential benefits of solidification prior to storage.

9
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A
TECHNICAL BASIS FOR CONTAINER INSPECTION

This document, Recommended Changes to the Guidelines for Operating an Interim On Site Low Level Radioactive Waste Storage Facility — for NRC Review was developed to update operating experience that reflects over 3 years of on-site storage experience at over 92 US reactors (>270 reactor-years) and to propose to regulators and industry organizations (e.g., ANI) a revised, technically justified risk-informed inspection strategy. It is important to understand that these "recommended changes" to the guidelines have not been reviewed by the USNRC and is not completely aligned with existing guidance from regulators and other industry organizations.

Using a "system" approach that considers the waste characteristics and form, the storage/disposal containers, and the storage facility design and operation, the integrated result should be a product that exceeds by a significant margin any individual regulatory or other applicable consideration.

The following information can be used when developing site-specific bases for container inspection frequencies and the inspection scope. Additional, current OE should be reviewed and incorporated into that documentation.

General Risk Reduction Information

1. Stored waste containers and their contents are stored in a configuration [structure or enclosure (module)]designed and analyzed for storing that waste in accordance with applicable regulations, site license documents and procedures, manufacturer recommendations, and in most instances in consideration of the guidance in this document and the supporting document Low Level Waste On Site Storage Operating Guidelines – Supplemental Information Manual, Version 2.
2. Individual elements of the storage process are clearly governed by a wide range of specifications, analyses, testing, and controls designed to provide protection to occupational workers, the environment, and the public. Those elements include waste stream characterization and classification, container design, manufacture, testing and monitoring, and storage facility design, construction and operation. Additional requirements related to highway or other modes of transportation apply to waste containers. Similarly, existing and proposed storage facility or waste disposal site acceptance criteria impose additional characterization, form and container requirements.
3. Industry OE related to container movement clearly indicates that moving a container for inspection purposes and/or lifting heavy shield module lids presents a greater risk of container damage or failure. There is a significant amount of industry OE related to crane power and capacity failures, lifting sling failure, HIC grapple failure, and a HIC stuck in a partially inserted configuration in a shipping cask. Other less significant OE may exist.

Solidified, thermally volume reduced, or encapsulated waste

Criteria

- Inspect at least one container the first year that the licensee implements interim on-site storage
- Then inspect one container every ten years.
  - Select the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

Rationale

Solidified, thermally volume reduced, or encapsulated waste reduces the potential for leaching, gas generation, and eliminates free-standing liquids that support corrosion and/or gas generation. Solidification and encapsulation processes provide additional stability and render the waste non-dispersible. Thermally treated waste can be solidified or integrated into a matrix that renders it non-dispersible under normal condition. Additional benefits associated with these waste forms are addressed in detail in many of this document's references.

Raw dewatered wet solid waste in HICs

Criteria

For HICs that are:

- Dewatered so that the freestanding liquid does not exceed 1% by volume at the time of placement in storage, AND
- Stored inside facilities that are designed to contain 100% of a container's liquid and solid contents OR,
- Stored outside in modules that are designed to contain 100% of the stored container's liquid and solid contents,
- Inspect:
  - At least one container the first year that the licensee implements interim on-site storage, then,
  - One container every 5 years – 2 % of 300 year HIC life
  - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

  Note that this periodicity or strategy is not specified in USNRC guidance documents

Rationale

High integrity containers are designed and manufactured for a 300 year life. In many instances the design specifications meet the criteria found in 10CFR61.56 and the Department of Transportation requirements for a Type A package.

The US nuclear industry has been using high integrity containers for over 30 years. Assuming a conservative average generation rate of 2 HICs for each of the 104 operating US reactors (higher for BWRs, lower for some PWRs), the industry has used in excess of 6,000 HICs during the aforementioned time span. Within that period, there are no documented events related to HIC failure while in a fixed position (e.g., stored, not being moved). This includes, but is not limited to failures related to container material degradation for any reason, temperature extremes, or gas accumulation and expansion.

Appendix G to Part 20--Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests, states that:

a. *"High integrity container* (HIC) means a container commonly designed to meet the structural stability requirements of § 61.56 of this chapter, and to meet Department of Transportation requirements for a Type A package."

b. 10CFR61.56: "(b) states:
"The requirements in this section are intended to provide stability of the waste. Stability is intended to ensure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

Waste must have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal."

Further, the USNRC Low-Level Waste Licensing Branch Technical Position On Radioactive Waste Form, section (c) Regulatory Position, 4, High Integrity Containers states:

a. The maximum allowable free liquid in a high integrity container should be less than one percent of the waste volume as measured using the method described in ANS 55.1. A process control program should be developed and qualified to ensure that the free liquid requirements in 10 CFR Part 61 will be met upon delivery of the wet solid material to the disposal facility. This process control program qualification should consider the effects of transportation on the amount of drainable liquid which might e present.

b. High integrity containers should have as a design goal a minimum lifetime of 300 years. The high integrity container should be designed to maintain its structural integrity over this period.

c. The high integrity container design should consider the corrosive and chemical effects of both the waste contents and the disposal trench environment. Corrosion and chemical tests should be performed to confirm the suitability of the proposed container materials to meet the design lifetime goal.

d. The high integrity container should be designed to have sufficient mechanical strength to withstand horizontal and vertical loads on the container equivalent to the depth of proposed burial assuming a cover material density of 120 lbs/ft^3. The high integrity container should also be designed to withstand the routine loads and effects from the waste contents, waste preparation, transportation, handling and disposal site operations, such as trench compaction procedures. This mechanical design strength should be justified by conservative design bases.

e. For polymeric material, design mechanical strengths should be conservatively extrapolated from creep test data.

f. The design should consider the thermal loads from processing, storage, transportation and burial. Proposed container materials should be tested in accordance with ASTM 8553 in the manner described in Section C2(g) of this technical position. No significant changes in material design properties should result from this thermal cycling.

g. The high integrity container design should consider the radiation stability of the proposed container materials as well as the radiation degradation effects of the wastes. Radiation degradation testing should be performed on proposed container materials using a gamma irradiator or equivalent. No significant changes in material design properties should result following exposure to a total accumulated dose of 10 Rads. If it is proposed to design the high integrity container to greater accumulated doses, testing should be performed to confirm the adequacy of the proposed materials. Test specimens should be prepared using the proposed fabrication techniques. Polymeric high integrity container designs should also consider the effects of ultra-violet radiation. Testing should be performed on proposed materials to show that no significant changes in material design properties occur following expected ultra-violet radiation exposure.

h. The high integrity container design should consider the biodegradation properties of the proposed materials and any biodegradation of wastes and disposal media. Biodegradation testing should be performed on proposed container materials in accordance with ASTM G21 and ASTM G22. No indication of culture growth should be visible. The extraction procedure described in Section C2(d) of this technical position may be performed where indications of visible culture growth can be attributable to contamination, additives, or biodegradable components on the specimen surface that do not affect the overall integrity of the substrate. It is also acceptable to determine biodegradation rates using the Bathta-Pramer Method described in Section C (d). The rate of biodegradation should produce less than a 10 *percent loss of the total carbon in the container material after 300 years. Test specimens should be prepared using the proposed material fabrication techniques.*

i. The high integrity container should be capable of meeting the requirements for a Type A package as specified in 49 CFR 173.398(b). The free drop test may be performed in accordance with 10 CFR 7, Appendix A, Section 6.

j. The high integrity container and the associated lifting devices should be designed to withstand the forces applied during lifting operations. As a minimum the container should be designed to withstand a 3g vertical lifting load.

k. The high integrity container should be designed to avoid the collection or retention of water on its top surfaces in order to minimize accumulation of trench liquids which could result in corrosive or degrading chemical effects.

1. High integrity container closures should be designed to provide a positive seal for the design lifetime of the container. The closure should also be designed to allow inspections of the contents to be conducted without damaging the integrity of the container. Passive vent designs may be utilized if needed to relieve internal pressure. Passive vent systems should be designed to minimize the entry of moisture and the passage of waste materials from the container.

m. Prototype testing should be performed on high integrity container designs to demonstrate the container's ability to withstand the proposed conditions of waste preparation, handling, transportation and disposal.

n. High integrity containers should be fabricated, tested, inspected, prepared for use, filled, stored, handled, transported and disposed of in accordance with a quality assurance program. The quality assurance program should also address how wastes which are detrimental to high integrity container materials will be precluded from being placed into the container. Special emphasis should be placed on fabrication process control for those high integrity containers which utilize fabrication techniques such as polymer molding processes.

In summary HICs in use meet all the requirements stated above with the exception of state licensed polyethylene HICs which do not meet the structural stability requirements for burial overburden without the use of a concrete overpack. However since overburden is not a condition waste containers would be subject to in interim storage, the HICs clearly provide a robust and well qualified container for storage such that they can be qualified for risk-informed extended inspection frequencies.

Raw, dewatered wet solid flowable waste (e.g., resins, carbon, etc.) in any container that does not meet the criteria in the previous two scenarios (e.g., steel liner)

Criteria

- Inspect 10% of the stored inventory or one container per year, whichever is greater.
  - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

Rationale

These requirements are similar to existing regulatory and industry agency guidance. Carbon steel is more susceptible to corrosion than poly-based products. Additionally, if exposed to temperature and humidity cycling, the potential for, and rate of corrosion can increase.

Dry solid and wet filter waste (e.g., cartridges, membranes and septa) in steel waste containers (drums, boxes, liners)

Criteria

- Stored inside facilities or stored outside in modules
- Inspect:
  - 10% of the stored inventory or one container every two years, whichever is greater.
    - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

Tracking historical trends will demonstrate if this percentage should be increased or decreased. [18]

Rationale

Filters in a steel liner present a reduced risk when compared to other raw flowable waste streams. The contact area between filter media and the waste container is significantly lower than that of flowable media (resin, carbon, etc.) reducing the potential for surface corrosion. Similarly, the pH of filter elements is relatively neutral, further reducing the corrosion potential. The amount of interstitial liquids is typically substantially less than flowable media, reducing the volume of liquid available for internal evaporation-condensation cycling.

Steel liners with an internal epoxy coating applied under controlled coating programs provide an additional safety margin. The benefits associated with coatings are addressed in detail in several references [17, 26].

Dry solid waste in steel waste containers (drums, boxes, liners)

- Stored outside with no enclosure or other environmental protection
- Inspect:
  - 5% of the stored inventory per quarter.
    - Inspect the more conservative of: a container that is the oldest or has been assigned to the elevated risk ranking.

Rationale

Similar to filter media, dry solid waste in steel containers contains little-to-no moisture content and the contact area (waste-to-container) is not 100%. This results in an environment that is not conducive to corrosion. Again, similar to filter media in steel containers, additional credit can be taken for internal epoxy coatings. Epoxy coatings applied under controlled coating programs increases the safety margin.

Summary

Regardless of the waste type, form, container, or storage strategy, US regulatory guidance, combined with related industry guidance and safety-focused industry standards, mandate by default a “system” approach to storage. Storage strategies must evaluate and integrate considerations related to the waste characteristics and form, the storage/disposal containers, and the storage facility design and operation. When properly implemented, the integrated result will be a product that exceeds by a significant margin, any individual regulatory or other applicable requirement.

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