EPRI
Electric Power
Research Institute

Keywords:
Low-level radioactive wastes
Liquid waste processing
Liquid waste management

EPRI NP-7386-V3P2
Project 2414-34
Final Report
May 1994

Radwaste Desk Reference

Volume 3, Part 2: Liquid Waste Management

Prepared by
Right Angle Industries
Melbourne, Florida

Radwaste Desk Reference

Volume 3, Parts 1 and 2

This volume of the *Radwaste Desk Reference* contains fundamental practical and regulatory information on the processing and management of liquid radioactive wastes at nuclear power plants. Because its information is based entirely on industry practice, the work can serve as an extensive "how-to" manual for both the newcomer and the experienced radwaste professional responsible for liquid waste activities.

INTEREST CATEGORIES

Radioactive waste management
Occupational radiation control

KEYWORDS

Low-level radioactive wastes
Liquid waste processing
Liquid waste management

BACKGROUND The technical, regulatory, and economic factors affecting radwaste management are so broad that no one individual is an accomplished expert in all facets of radwaste management. Hence, a need exists for a comprehensive reference manual capturing the collective knowledge of recognized industry experts on a variety of radwaste issues. In late 1987, radwaste experts from member utilities joined with EPRI to identify radwaste issues, collect authoritative information, and divide it into discrete modules. The resulting *Radwaste Desk Reference* comprises several volumes of expert information on a broad range of radwaste management activities.

OBJECTIVE To develop a reference manual specific to the processing and management of liquid radioactive waste at commercial nuclear power plants.

APPROACH The project team selected a question-and-answer format for this report because such a format could be accessed by radwaste professionals with a variety of experience and interests. The questions were generated at two meetings of utility radwaste professionals and EPRI contractors, with supplemental questions produced during development of the individual reports. The project team then selected acknowledged industry experts to draft responses to the questions, some of which were combined or divided into further questions. Utility experts reviewed and commented on the responses, and their comments and recommendations were incorporated into the final publication.

RESULTS Volume 3, Part 1 of the *Radwaste Desk Reference* offers a comprehensive guide to processing liquid radioactive waste. This part includes several sections on liquid waste processing fundamentals—such as ion exchange, filtration, evaporation, and adsorption—providing valuable training information for new radwaste technicians and supervisors. Other sections address operation of liquid waste demineralizers, filtration systems, and evaporators.

Volume 3, Part 2 of the *Radwaste Desk Reference* provides a complete guide to managing liquid radioactive waste. It includes extensive information and operating practices related to liquid waste generation and control, liquid waste processing systems at existing U.S. nuclear plants, processes for managing wet wastes (handling, dewatering, solidifying, processing, and packaging), and liquid waste measurement and analysis.

In all, the two parts of this very readable report can be used as a primary resource reference book for nuclear managers and experienced radwaste supervisors as well as colleges and universities. Volume 1 of the *Radwaste Desk Reference* addresses dry active waste generation, processing, and measurement. Volume 2 describes low-level waste storage, transportation, and disposal.

EPRI PERSPECTIVE The radwaste technician, engineer, or supervisor can use this report to obtain both general and specific information on a wide range of liquid radioactive waste processing and management issues. The report's format addresses complex issues in the same fashion as they arise in the field—as a question. The responses to the questions are based on existing nuclear industry knowledge and actual field practice, thereby minimizing the need for field testing and maximizing the transfer of practical experience. Related EPRI research includes the following: *Sourcebook on Ion Exchange for Liquid Radwaste Treatment* (EPRI report TR-103326), *BWR Radwaste Precoat Filter Optimization* (report NP-5483), *Pretreatments and Selective Material for Improved Processing* (report NP-5786), and *Engineering Evaluation of Selective Ion Exchange Radwaste Processing at Susquehanna* (report NP-6120).

PROJECT

RP2414-34
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Radwaste Desk Reference

Volume 3, Part 2: Liquid Waste Management

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Abstract

EPRI began, late in 1987, to produce a Radwaste Desk Reference that would allow each of the member utilities access to the available information and expertise on radwaste management. EPRI considers this important because radwaste management involves a wide variety of scientific and engineering disciplines. These include chemical and mechanical engineering, chemistry, and health physics. Radwaste management also plays a role in implementing a wide variety of regulatory requirements. These include plant-specific technical specifications, NRC standards for protection against radiation, DOT transportation regulations and major environmental legislation such as the Resource Conservation and Recovery Act.

EPRI chose a question and answer format because it could be easily accessed by radwaste professionals with a variety of interests. The questions were generated at two meetings of utility radwaste professionals and EPRI contractors. The names of the participants and their affiliation appear in the acknowledgments.

The questions were organized using the matrix which appears in the introduction and below. During the writing phase, some questions were combined and new questions added. To aid the reader, each question was numbered and tied to individual Section Contents. An extensive index provides additional reader assistance.

EPRI chose authors who are acknowledged experts in their fields and good communicators. Each author focused her or his energies on specific areas of radwaste management activities, thereby contributing to one or more volumes of the Radwaste Desk Reference.

Volume 1, which is already in publication, addresses dry active waste generation, processing and measurement. ***Volume 2*** addresses low level waste storage, transportation and disposal. This volume, ***Volume 3,*** is being issued in two parts. Part 1 concentrates on the processing of liquid radioactive waste, whereas Part 2 addresses liquid waste management.

Acknowledgments

This volume of the Radwaste Desk Reference includes the work of many individuals who helped guide the project, generate the questions, edit and illustrate the text, and prepare this text. The project manager at EPRI responsible for this volume was Carol Hornibrook.

Utility personnel and EPRI subcontractors who, in addition to the authors and project staff, generated the initial questions include (in alphabetical order):

Mr. Aussie Clement, Tennessee Valley Authority
Mr. Galen Clymer, Florida Power Corporation
Mr. Mike Michalski, Entergy Operations
Mr. Roger Stigers, Pennsylvania Power and Light
Mr. Al Castagnacci, Duquesne Light

The following individuals are recognized for their efforts in reviewing this volume of the RWDR:

Jeff Edwards, TU Electric Company
Sallie Fisher, Puricons, Inc.
Mike Naughton, TARAwest Technologies
Brian Lunn, Boston Edison Company
John Moylen, Boston Edison Company
Clint Miller, Pacific Gas & Electric Company
Jene Vance, Vance and Associates

EPRI also is indebted to Ms. Jodi Danaher, a technical editor who assisted with the preparation of this draft. Desktop publishing, layout, and supplemental illustration were provided by Ms. Margie Kelly of Computer Publishing Company.

Table of Contents

Note: This is a summary Table of Contents intended to provide the reader with an overview of the information contained in each section of the report. A detailed section Table of Contents is included beginning on page 2 of each section of the report.

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INTRODUCTION

Introduction

This volume, the third in the series entitled the *EPRI Radwaste Desk Reference*, deals primarily with liquid waste processing and management. Due to the large volume of information, it has been divided into two parts:

> <u>Processing Liquid Waste</u>: This report focuses on the principles of ion exchange, filtration, evaporation and absorption processes.
>
> <u>Liquid Waste Management</u>: This report focuses on the operational aspects of liquid waste generation, control, minimization and measurement within nuclear power plants.

For Volumes 1 and 2, a matrix was proposed in an effort to identify those areas of radwaste management that, potentially, could be included as independent sections of a Desk Reference volume. Section numbers were proposed where the reader might look to find information on specific subjects. However, as the Desk Reference series of reports has developed, the original matrix concept no longer offers the best mechanism for identifying radwaste topical areas.

Accordingly, the table on the next page replaces the matrix used in previous volumes. It identifies both the applicable volume and section number for various radwaste subject areas. In addition, this page can be used as an errata sheet to replace the matrix pages from Volumes 1 and 2. As new volumes are published, additional errata sheets will be produced for this pages to replace outdated tables.

Cautions

It is important for the user to realize that each nuclear facility has different operational capabilities and constraints. Therefore, the information contained herein does not precisely reflect questions every radwaste professional will ask. Instead, they cover the major issues which affect liquid waste processing and management. In other words, *they offer information and guidance to resolve plant-specific questions.*

RADWASTE DESK REFERENCE REPORT SERIES

SUBJECT AREA	RWDR VOLUME	SECTION NUMBER
Dry Active Waste	**1**	—
DAW Generation	1	1100
DAW Handling	1	1200
DAW Assay	1	1600
Transportation and Disposal	**2**	—
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Shipping and Shipping Documentation	2	1900
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Transportation Checklists	2	2400
LLW Management Inspection and Audit Checklists	2	2500
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Dewatering and Solidification of Wet Wastes	3, Part 2	3700
Wet Waste Packages and Packaging	3, Part 2	3800
Liquid Waste Measurement and Analysis	3, Part 2	3900
Mixed Waste	**4**	—
Mixed Waste Generation and Control (being developed)	4	4000
Mixed Waste Packages and Packaging (being developed)	4	4100
Mixed Waste Storage (being developed)	4	4200
Mixed Waste Disposal (being developed)	4	4300

Looking for Information

If you need specific information on a particular topic, there are several ways to find it:

- If it is basic, the Glossary section may be all you need. If the required information is more complex, first try to determine what the major subject area is (ion exchange, filtration, plant systems, solidification, etc.). Next consult the table on the previous page.
- As an alternative, refer either to the Table of Contents or the Section Contents that appear at the beginning of each volume or section, respectively. Question numbers and topics appear in the individual Section Contents.
- As a third approach to locating information, review the alphabetical Index at the end of each volume. The Index provides the page numbers where the topic is discussed. For Volume 3, the Index is combined for both Parts 1 and 2. Looking in the Index of either report will point you to the specific report and page number.
- A bibliography is included for assisting the reader to locate additional related information outside of the Desk Reference.

SECTION I

(3300 SERIES QUESTIONS)

LIQUID WASTE GENERATION AND CONTROL

Section I Contents

Liquid Waste Generation and Control

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Water Management Programs

Leaks and Leak Rates

Chemical Control Program

Item Topical Description **Item Number**

Identifying and Controlling Organic Contaminants

Controlling Other LRW Contaminants

Listing of Illustrations

Illustration Topical Description **Figure Number**

3301

What is a water management program?

Water management and inventory control are practical at all plants for some or all of the plant systems, regardless of which organizations are responsible for operating the systems. However, system operations and inventory control do not necessarily constitute a water management "program" in and of themselves. A water management program is a formalized program with defined objectives and responsibilities. In meeting the objectives, the program typically will involve such items as:

- Daily inventory tracking.
- Water usage planning.
- Source (inleakage) reduction.
- Leakage (water loss) reduction.

3302

Why is it necessary to have more than one class of water?

The expense of maintaining only one class of water in the plant would be prohibitive, because the millions of gallons required would have to meet the highest quality standards needed for the most restrictive application. For example, no unit manager would approve the use of demineralized water to cool a main condenser, any more than s/he would allow the filling of the reactor vessel with raw river water.

Maintaining the proper volumes of untreated cooling water, processed component cooling water, demineralized water, and reactor grade feedwater—as well as other specially processed water required throughout the station—is essential to the safe and economical operation of the plant.

3303

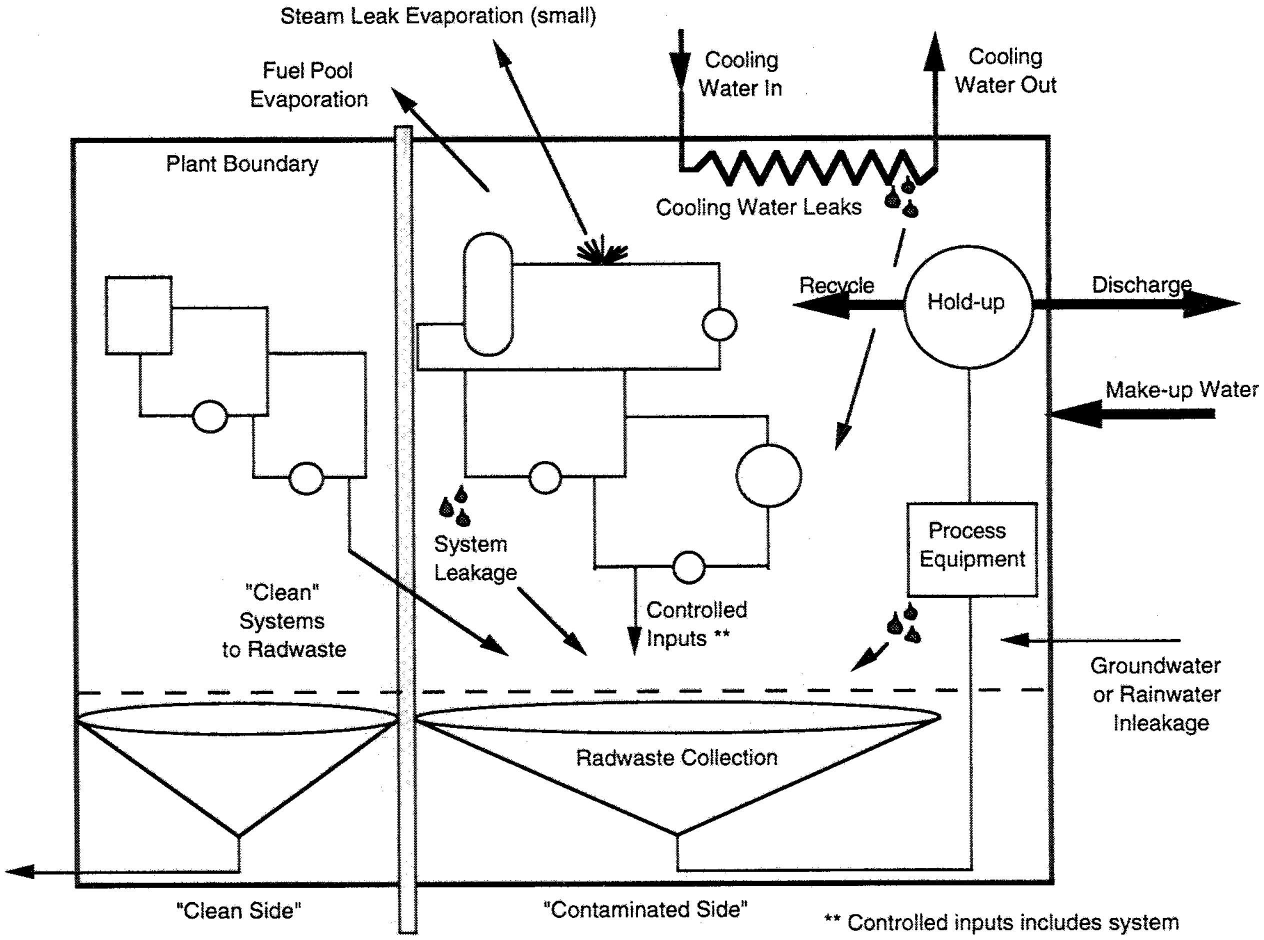
What are the objectives of a water management program?

The basic objectives may vary from plant to plant. However, are some common elements in all water management programs. Two of the more common elements are:

1. Ensure that adequate quantities of water are available for plant operations as required by the plant Technical Specifications.

2. Ensure that adequate tankage or system volumes are available for planned activities, such as refueling or torus drain down.

Figure 3303
Water Management: Sources and Losses



** Controlled inputs includes system draindowns, demin flush/backwash, decant, etc.

Other secondary objectives are more variable among plants, depending on the site-specific conditions or operating philosophies. These objectives may include:

1. Minimize the use of makeup water by maximizing recycle and the use of in-plant sources.
2. Minimize the recycle of impurities to plant systems by maximizing the use of the plant makeup system and the discharge of lower quality water.
3. Minimize the input volumes to radwaste to reduce operating demands on processing equipment or to minimize the plant discharge volumes.
4. Maintain adequate collection tank capacities for receiving waste water from planned and unplanned events.

If the plant is visualized as a closed system, as in Figure 3303, water inventories can be monitored and regulated by tracking plant influents and effluents.

3304

What are the elements of a water management program?

The elements of an effective water management program include:

- Maintaining Water Inventory
- Maintaining Makeup and Discharge Capability
- Maintaining Water Quality and Cleanup Capability

Maintaining Water Inventory

A minimum volume of condensate or similar quality water must be maintained for normal operation and to cool the reactor during off-normal events and postulated accidents. The minimum volume is dictated by the technical specifications. The maximum volume is limited by plant tank capacity and the need to have tankage available to collect leakage and/or controlled inputs. For PWRs, there must also be a sufficient volume of borated water to ensure core subcriticality during all normal and accident conditions.

The water inventory is affected by many factors, including evaporation, systems leakage, plant discharges, changing requirements for outages and maintenance. Maintaining a balanced water inventory requires:

1. careful tracking of the current water inventory;
2. planning for short-term needs; and
3. control of inleakage and discharge flows to/from the plant.

The general equation relating these activities is:

$$I = (M+i) - (E+d)$$

Where:	I	=	Inventory	Total of all water in the plant.
	M	=	Makeup	Water introduced into the plant.
	i	=	inleakage (net)	Total ground & cooling water leaks.
	E	=	Evaporation	Fuel pool, steam leaks and tanks.
	d	=	Discharge	Water discharged to the environment.

Maintaining Makeup and Discharge Capability

If, for some reason, the makeup rate cannot be maintained sufficient to overcome a large discharge rate, then volume control will be impossible to maintain. For example, a deficient makeup flow rate will eventually cause tank levels to drop below allowable levels.

Similarly, if the discharge rate cannot be maintained at a rate sufficient to overcome excessive inleakage, then, once again, volume control will be impossible to maintain. For example, some plants can only discharge at a low rate. Thus, if the amount of inleakage—which is not available for internal recycle—is higher than the discharge rate, overflow of system/tank capacity will result.

Maintaining Water Quality and Cleanup Capacity

The ability to "upgrade" water which has picked up solids or dissolved salts and reuse it as higher grade water is central to a good water management program. All ion exchange, filtration, evaporation or other cleanup operations are designed to remove and concentrate impurities picked up by liquids and allow the cleaned liquid to be reused. Water brought into the plant as makeup, or which leaks in as groundwater, rainwater or from piping leaks, must be cleaned and recycled for environmental or economic reasons.

To incorporate these basic Water Management Program elements, various techniques have been implemented at plants to meet their individual operating styles and equipment. Segregation of liquid waste streams, collection sump monitoring programs, administrative control of demineralized water usage, inleakage control programs, and redefinition of water quality criteria have all been employed to conserve processing capacity and enhance economics. In all cases, prevention of the mixing of large volumes of clean water with contaminants or with small volumes of contaminated water is the basis for a sound management approach.

3305

What are the benefits of a good water management program?

The implementation of a comprehensive water management plan can help a plant accomplish the following:

- identify water requirements during varying modes of operation;
- diagnose problems or inefficiencies with process equipment;
- quickly identify excessive influent sources;
- increase processing efficiencies using waste stream segregation;
- plan for water inventories before and after refueling and outage conditions;
- improve the perception of regulating agencies reviewing plant operations by minimizing liquid discharges to the environment; and
- reduce and/or predict wet and solid waste generation rates.

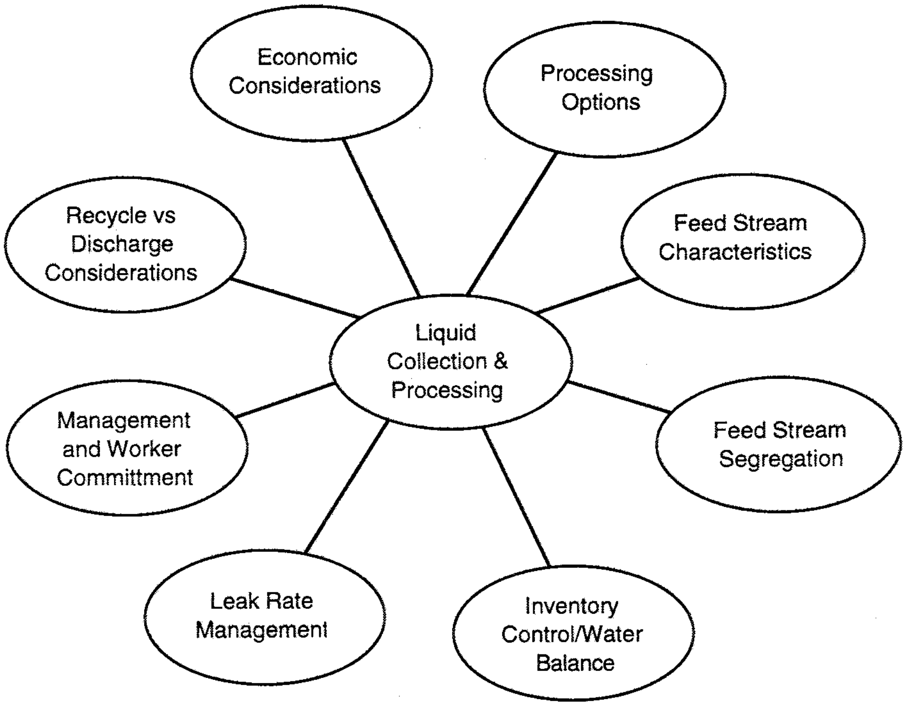
3306

What considerations influence decisions made for collection, processing and re-use of LRW?

The primary factor that guides the decision-making process for liquid radioactive waste (LRW) management is plant operations. The objective is to obtain the best water quality possible at an acceptable cost. The short range benefits of good LRW management are steady-state plant operations, low cost and low waste volume. The long range benefit is extended equipment and plant life.

Figure 3306 shows the wide variety of secondary factors that play an important role in the LRW decision-making process:

Figure 3306
Liquid Collection and Processing Considerations



3307

What is an acceptable inleakage rate?

Inleakage into radwaste systems is a function of many different variables. Some of these are:

- Plant type (PWR or BWR)
- Systems design
- Equipment design
- Maintenance activities
- Plant size
- System modifications
- Plant operating condition

At the same time, the inleakage rate(s) that a plant considers "acceptable" is a function of:

- Available water supply
- Influent quality
- Economic considerations
- Tank capacities
- Plant operating conditions

Therefore, there is no one inleakage rate which all plants would consider acceptable. Plants were designed to accommodate varying rates of inleakage during normal operations and during design based occurrences.

Based on data collected for EPRI as part of the development of reports NP-3370 and NP-5526, average inleakage rates during power operation in PWRs ranged from less than 1 gpm to inleakage rates in the 10-30 gpm range. By contrast, BWR ranged from average inleakage rates of about 20 gpm to a maximum input of almost 150 gpm during periods of excessive inleakage.

One goal of any radwaste program should be to minimize, to the extent possible, system leaks into radwaste as well as the elimination of "external" inleakage from cooling water sources, rainwater, groundwater, etc. As always, the ALARA aspects and plant operations should be considered when determining if a plant's inleakage rate is "acceptable" compared to the personnel exposures or plant down-time necessary to repair system leaks.

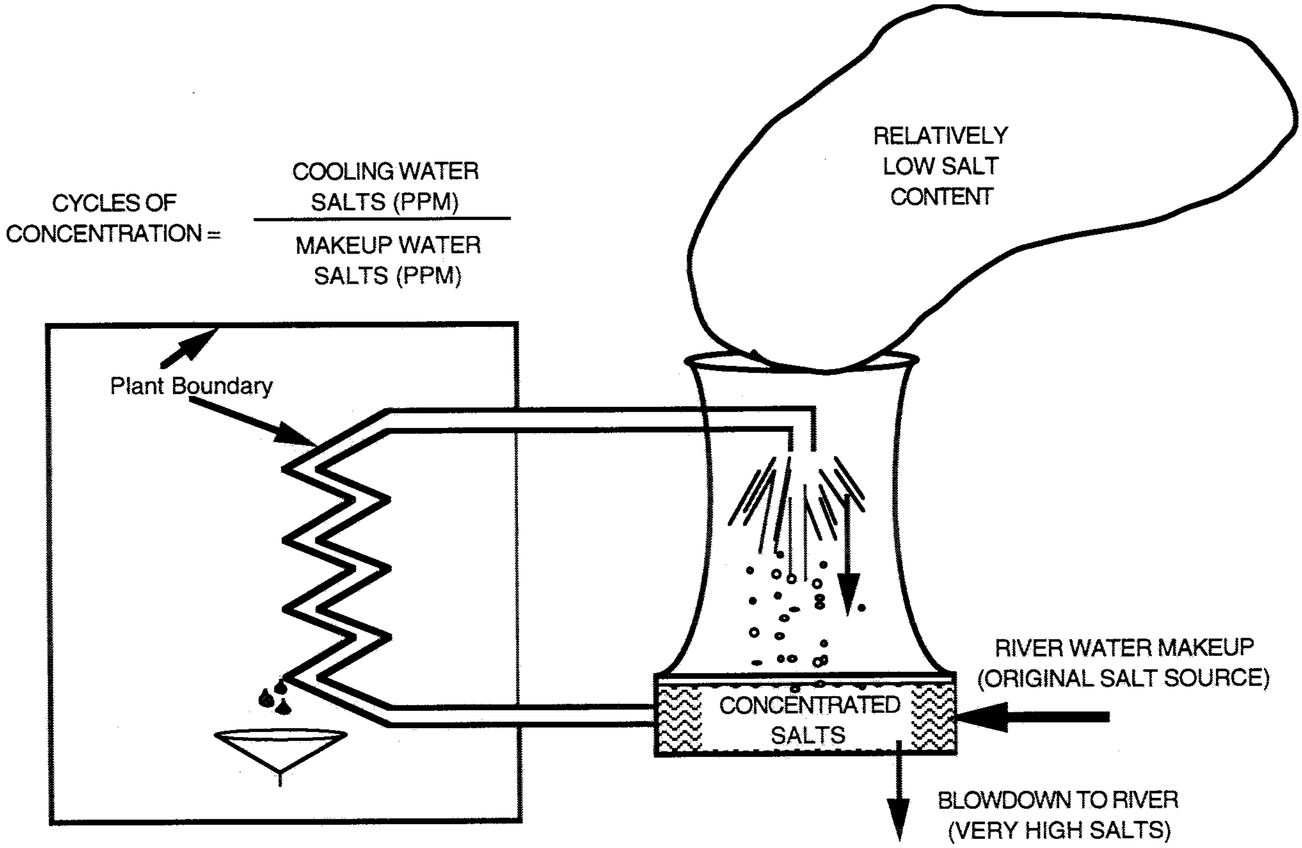
3308

Why are leaks from raw cooling water sources so important?

The radwaste system is designed to collect and process all potentially contaminated water that leaks from plant systems. These systems can contain water ranging in quality from reactor-grade water to cooling water containing salt concentrations several times greater than raw makeup water (based on cycles of concentration). Figure 1-9 illustrates how cycles of concentration can lead to cooling water leaks with significantly high salts concentrations.

As can be seen from Figure 3308, the cooling water can become concentrated with salts. This, in turn, adversely affects radwaste processing performance. These concentrated solutions deplete resin capacity, resulting in premature chemical exhaustion of ion exchange resin. In addition, they form deposits in process equipment, such as evaporators, resulting in fouling, heat transfer inefficiencies, corrosion, etc.

Figure 3308
Cycles of Concentration



3309

How do you develop a leak reduction and control program?

The development of a comprehensive leak reduction and control program requires a cooperative effort from various plant support groups and organizations. The keys to developing a good program include:

1. Set plant or corporate goals relative to plant inleakage. These goals should not be based solely on leak rate. They should, instead, incorporate indicators such as water quality (chlorides, conductivity, suspended solids, etc.), relative inleakage rates from "external" sources, time since leak was reported, etc.

2. Formalize the program through procedures, standardized reporting (i.e., leak identification and prioritization reports), and plant/corporate policies.

3. Educate the workers through training programs. Elements of a training program on leak reduction and control include:

    - Proper methods to identify potential leaks.
    - Appropriate actions to take if leaks are identified.
    - Radiological concerns from excessive leakage throughput the plant.
    - Potential to impact dry waste generation.
    - Economic penalties associated with a 1 gpm leak of primary-grade water versus a 1 gpm leak of raw cooling water. (See example later in this section.)

By stressing these issues during General Employee Training (GET) or specialized training courses, employees may become more conscious of leaks throughout the plant, as well as appropriate corrective and preventive measures to minimize "problem" leaks.

4. Assign worker accountability. Supervisory personnel should be held accountable for assuring that work authorizations are completed for identified leaks and that appropriate actions are being taken to control or fix these leaks. Periodic progress reports summarizing the program's effectiveness relative to established goals should be submitted to upper management.

5. Implement consistent enforcement policies. Like many other programs, if the policies and procedures are not enforced, the program most likely will be ineffective.

3310

What are the elements of an effective leak reduction control program?

In the real world of radwaste management, it is impractical to simply establish programs aimed at permanently eliminating all leaks. The fact is that plants were designed to handle "acceptable" inleakage rates. The key to an effective leak reduction control program is to identify those leaks that have the biggest impact on (1) plant operations and (2) radwaste processing, and then initiate prompt corrective actions.

Keeping in mind that the objective of any power plant is to produce electricity, the first priority of any leak reduction and control program is to ensure the health and safety of personnel and the public. The second program priority is to ensure that leaks are controlled so that the plant will never be shut down due to inadequate tank capacities. Fortunately, these are not difficult tasks at most plants.

Also, as part of the plant's overall water management program, it is an important priority to assure that processed water is suitable for reuse within the plant (or discharge to the environment) and that processing operations are as efficient as possible. The quality of the water that is collected as a result of leaks is directly proportional to the throughput of the radwaste processing system. Therefore, it is the high conductivity leaks that a plant typically is most concerned about due to the effects of premature chemical exhaustion of radwaste demineralizers.

There are several elements of a successful leak reduction control program. These are:

- Worker education and training.
- Leak identification procedures.
- Reporting and leak characterization.
- Leak repair prioritization.
- Effective maintenance programs to repair leaks.
- Temporary control techniques prior to leak repair.
- Cooperation between groups to identify, characterize, prioritize and repair leaks in a timely manner.
- Enforcement policies.

3311

What are appropriate actions if a leak is discovered?

This is really a plant-specific situation. However, there are some general actions that should be followed routinely.

Once a leak is identified, procedures should dictate reporting requirements to identify the location, type and severity of the leak. These procedures would require that some or all of the following reporting requirements be completed. The group or individual(s) responsible for these tasks vary from plant to plant.

- Notify Health Physics or Radiological Protection Group that a leak exists.
- Survey the area and isolate the leak as appropriate.

- Complete a "Leak Identification Report," defining:
  - Location (exact location in plant).
  - Type of Leak (valve, fitting, pump seal, etc.).
  - System where leak is originating.
  - Equipment ID Number (if applicable).
  - Approximate leak rate.
  - Conductivity and solids content of the water (chemistry).
- Complete a maintenance request (MR) or work authorization (WA) to fix the leak and prevent redundant reporting.
- Route copy of above forms to appropriate individuals.

Many times the conductivity and solids content of the water can be determined simply by knowing what system the leak originates from. The system can usually be identified by a valve number, pump number, etc. in the line. If the system cannot be identified, the Chemistry Department may be required to analyze a sample.

3312

What elements should be included when prioritizing leaks for repair?

A comprehensive list of all maintenance requests or work authorizations to repair leaks should be maintained and continuously updated by the liquid radwaste supervisor or a dedicated individual. Specific goals should be established by the plant to repair a certain number of leaks each week. In order to repair those leaks that have the greatest impact on plant operations or radwaste efficiencies, leaks should be prioritized for repair. Considerations for prioritizing leaks include:

- Does the leak jeopardize personnel safety (particularly important for steam leaks)?
- Could the leak impact available tank capacities required to handle upset conditions?
- Could the leak result in the loss of plant subsystems (i.e., does the leak identify a problem that could lead to failure of the pump, valve, etc., resulting in system shutdown)?
- Can the leak be repaired while the plant is on line?
- What is the quality and flow rate of the leak? For this consideration, leaks can be prioritized as a function of conductivity, flow rate and suspended solids. Many plants should concentrate on ionic and suspended solids introduction into radwaste systems to improve processing efficiencies.
- Is the leak from a contaminated system (i.e., is it a source of contamination)?

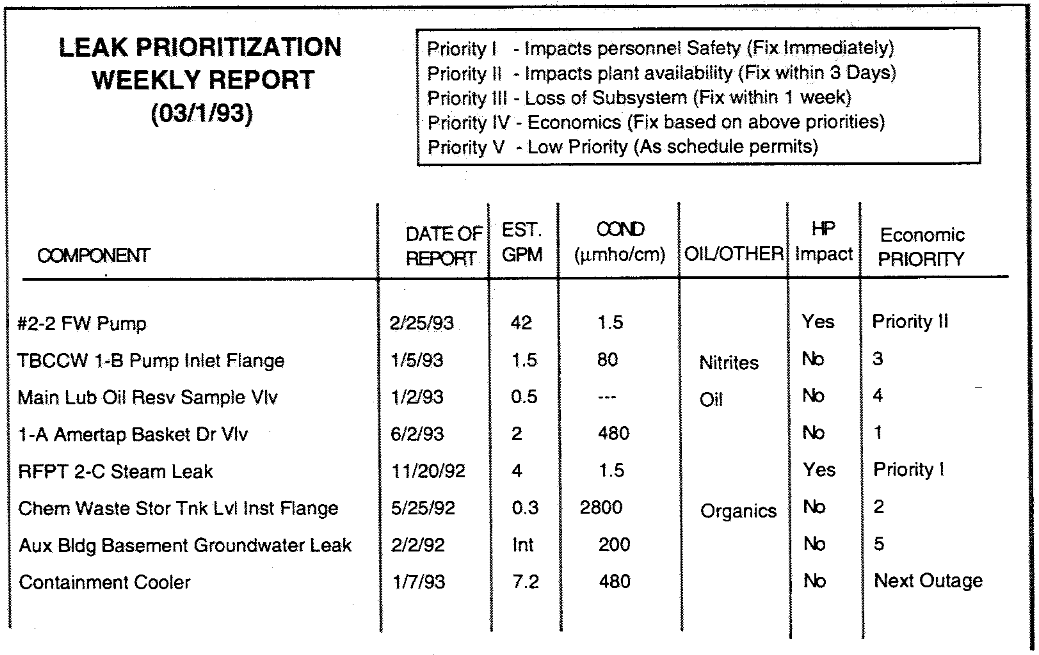
- Is the leak in a contaminated area such that it could spread the contamination?
- What is the cost of maintaining the leak? (For example, in terms of laundry and dry active waste production, contaminated leaks and leaks in contaminated areas cost considerably more to maintain than clean system leaks in clean areas.)
- What is the available manpower to repair the leak?

Once these, as well as other plant specific factors are considered, repair schedules should be developed based on the established priority of the leak. This list should be updated on a regular basis due to changing plant operating conditions, equipment degradation resulting in increased leakage, newly identified leaks, etc. On a functional basis, many plants group the above considerations into three general priorities:

Priority 1 — Leaks affecting plant operations and safety.
Priority 2 — Contaminated system leaks or leaks in contaminated areas.
Priority 3 — Clean system leaks in clean areas.

For other plants, a multi-tiered leak tracking and prioritization system works best. An aggressive weekly leak prioritization report is shown in Figure 3312.

Figure 3312
Leak Prioritization Report



LEAK PRIORITIZATION WEEKLY REPORT (03/1/93)

Priority I - Impacts personnel Safety (Fix Immediately)
Priority II - Impacts plant availability (Fix within 3 Days)
Priority III - Loss of Subsystem (Fix within 1 week)
Priority IV - Economics (Fix based on above priorities)
Priority V - Low Priority (As schedule permits)

COMPONENT	DATE OF REPORT	EST. GPM	COND (µmho/cm)	OIL/OTHER	HP Impact	Economic PRIORITY
#2-2 FW Pump	2/25/93	42	1.5		Yes	Priority II
TBCCW 1-B Pump Inlet Flange	1/5/93	1.5	80	Nitrites	No	3
Main Lub Oil Resv Sample Vlv	1/2/93	0.5	---	Oil	No	4
1-A Amertap Basket Dr Vlv	6/2/93	2	480		No	1
RFPT 2-C Steam Leak	11/20/92	4	1.5		Yes	Priority I
Chem Waste Stor Tnk Lvl Inst Flange	5/25/92	0.3	2800	Organics	No	2
Aux Bldg Basement Groundwater Leak	2/2/92	Int	200		No	5
Containment Cooler	1/7/93	7.2	480		No	Next Outage

3313

How do I identify the source of a leak?

Identification of leaks throughout a plant may be accomplished via a combination of several methods:

1. Visual identification during routine plant operations. For this method, employee training and procedures are required to ensure that all personnel know what to do if a new leak is identified (e.g., call Operations, Radiation Protection, Maintenance, etc.). Visual identification can be made a part of routine radiation surveys or maintenance planning activities. Also, dedicated plant walkdowns can be made to identify new leaks and update the status of previously identified leaks.

2. Install run time meters or event counters on floor drain sump pumps to monitor volumes of water being pumped from the sumps to collection tanks. For this method to be effective, operators must monitor daily sump volumes and be aware of typical sump inputs in order to identify abnormal inleakage into the sump. Operators must also be informed of "controlled" inputs into radwaste, such as system drain downs, etc. The degree of accuracy when using run time meters is typically dependent upon the size of both the sump and pump.

   Limitations on the use of run time meters or event counters to effectively monitor inleakage rates include:

   - Operators must be aware of controlled inputs into the sumps.
   - Small leaks that could be a serious problem due to high conductivity are very hard to detect.
   - Because several sumps are often interconnected, water pumped from a sump has the potential to end up in another sump, or even back in the same sump, as a result of faulty check valves. If water leaks past a check valve and back into one or more sumps, operators will not receive accurate information relative to inleakage into the sump.
   - For run time meters, accuracies are dependent upon pump operating performance.

3. Establish administrative limits on conductivity, silica, etc. in radwaste collection tanks to alert operators of the possibility of raw water inleakage and the need for corrective actions. Here again, operators must be aware of controlled inputs into sumps. In addition, administrative controls should be established to limit controlled inputs into the various drains.

4. For chemically treated cooling systems, such as the Component Cooling System for PWRs or the Closed Cooling System for BWRs, monitor the additions to the Head Tank. Typically, chemicals (such as nitrites for corrosion control) are added to closed cooling systems via the Head Tank. These nitrites, combined with water that is normally high in conductivity, results in premature chemical exhaustion of resin beds. By monitoring the Head Tank, operators can detect leakage from the system (and into radwaste) from decreasing levels. Upon determining that a leak exists, a walkdown of the system would be required.

5. Chemistry measurements of the impurities in the water inputs also can be used to identify the source of a leak.

If methods 2 or 3 are used to identify potential leaks, P&ID's then should be reviewed to determine all potential sources into the sump or collection tank. A walkdown of the system is required next to identify the location of the leak.

3314

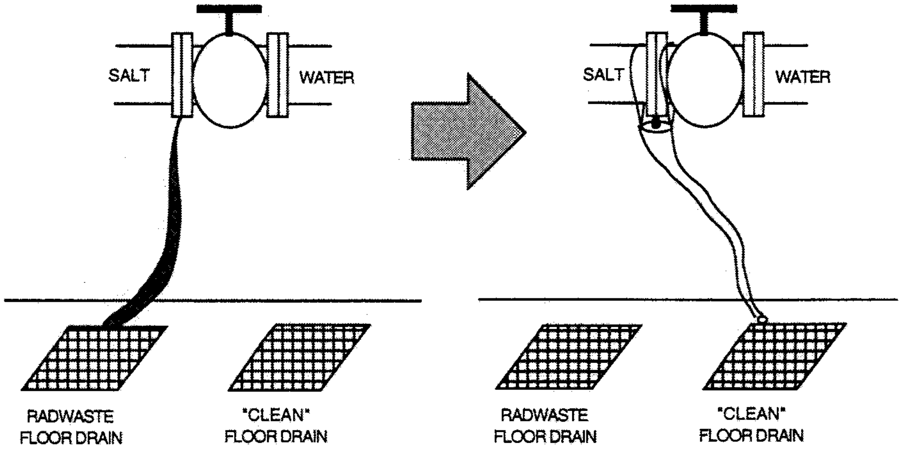
How do I prevent the introduction of high conductivity water into LRW systems?

Obviously, the most effective method to control the introduction of high conductivity water into LRW systems is to identify the sources of the influent and to repair the leak. The characterization and prioritization techniques discussed previously can be used to identify those leaks which are the most detrimental to LRW processing and establish prompt repair schedules. However, sometimes a leak presents a problem in radwaste, but the leak cannot be fixed without shutting down a required system. For many of these instances, the radwaste operator simply must live with the inleakage. For these situations, aggressive measures should be taken to minimize the impact of the leak by reducing the leak rate, minimizing the size of the contaminated area, and minimizing the volume of dry waste and laundry generated.

There are some cases, such as some high conductivity cooling water leaks, where the liquid is not contaminated radioactively, but the leak is draining into a radwaste drain. In this case, it may be possible to temporarily divert the leak using flexible hoses or drain collection funnels and routing the liquid to a non-radioactive drain. Depending on the leak, small dikes (called berms) made of angle-plastic (looks like angle-iron) may be temporarily installed to divert this water to "clean" drains. If leaks are small enough, they may be collected in separate drums, bladders, 5-gallon plastic collection bottles etc. These containers then can be sampled and processed separately or pumped back into the system for reuse.

Figure 3314
Diverting Clean Leaks to Clean Drains

IF LEAK CANNOT BE REPAIRED, <u>TEMPORARILY</u> DIVERT TO SEGREGATE (if possible)



3315

What can I do with water that no longer meets primary system requirements?

Various "grades" of water exist within a plant. When recycled water no longer meets primary system water quality requirements, it should be "down-graded" for use in other systems. As a general rule, the lowest acceptable grade of water available— based on chemistry and radiological requirements—should be used whenever practical. Some of these other applications include:

- Decon/washdown of cubicles
- Waste solidification
- Resin sluicing during changeout
- Backflush filter/demins and backflushable filters
- Hydrolazing drains and piping systems
- Respirator cleaning
- Filter maintenance operations

In some cases, it may be desirable to discharge the water (e.g., if there is an excess water inventory). The following considerations apply to recycling versus discharging excess water inventory:

- Plant Tech Spec limits on liquid discharges
- Plant water quality requirements for recycle
- Process requirements relative to influent water quality
- Tank hold-up capacities
- Available processing equipment
- Economic considerations
- INPO goals and nuclear insurance carrier concerns
- Plant cooling water source (i.e., small lake, river or cooling water pond)

3316

What are the advantages and disadvantages of recycling water inventory?

Advantages of Recycling

1. Make-up water can be a source of additional contaminants, depending on the water treatment system. Using recycled water often increases overall water quality.
2. It may be more economical to recycle (waste stream/plant specific).
3. Recycling protects against problems caused by a limited local water supply (i.e., droughts, contaminated water supply, etc.).
4. Recycling limits the quantities of radioactive and chemical contaminants discharged to the environment.
5. Recycling is politically desirable to recycle water rather than to discharge, regardless of the quality of the potential effluent stream.
6. It usually is operationally easier to process and recycle than to discharge.

Disadvantages of Recycling

1. It may be more economical to discharge some waste streams (e.g., high organics) than to recycle.
2. Process/effluent chemical quality requirements are more stringent than for discharge.

3317

Why do I need a chemical control program?

Most nuclear plant workers think of a chemical control program strictly in terms of controlling the types and quantities of chemicals introduced into plant liquid process streams, equipment drains, floor drains or sumps. However, impurities from any source—whether it is decaying leaves in the river which supplies makeup water, ion exchange resin fines, or a solvent inadvertently dumped into a floor drain—eventually will find their way to a sensitive plant component. This is true even after the bulk of the contaminant has been captured on some "concentrating" radwaste processing medium, such as ion exchange resins or a particle filter.

Thus, the need for stringent chemistry control over reactor feedwater cannot be over-emphasized. Since the earliest days of energy conversion using steam, the salt concentration effect of boiling water has been recognized. For plants which evaporate (boil) millions of gallons of water per hour for months at a time, even minute amounts of solids or organics, not detected by available instrumentation, can have severe economic effects. The reduction of heat transfer on heat exchangers and the destruction of materials due to uneven thermal stresses caused by these deposits ultimately can lead to a failure of the plant's primary steam production and support systems.

In addition to the damage caused by these dissolved solids, certain chemicals, such as halogens, organics, heavy metals and other species, may accelerate corrosion. Moreover, they can form harmful chemical compounds that can undermine the structural integrity of these same plant components. Certain contaminants in the plant process streams also may interfere with the operation or capacity of water cleanup systems.

In addition, for a nuclear plant, the corrosion, activation and fission products suspended or dissolved in the reactor water must be controlled in order to minimize localized concentrations of radionuclides in plant sub-systems. Allowing these contaminants to remain in reactor systems could cause significant problems to personnel due to high local radiation dose rates.

Since the constant makeup of water into the plant introduces far higher levels of impurities than water which has been demineralized, evaporated, and polished after recycle (not to mention conservation of the inherent heat value), economics favor the reuse of plant process water. For this reason water which has been "salvaged" after cleanup in radwaste systems should be thought of as feedwater and not as some troublesome liquid waste from plant drains and waste collection processes.

Most of the radwaste produced in a nuclear plant can be traced back to some chemistry-related function. Obviously, wet wastes are produced as chemical impurities. These impurities are concentrated on a disposable media (ion-exchange resins, filter material, etc.) to allow separation of the dissolved and insoluble materials from process water prior to its' reuse. Not so obvious is the relationship between corrosion, the resultant crud, and subsequent solid waste generation.

It should be obvious from the above that plant chemistry and water purity have a profound effect on plant operations, safety and long range plant economics, as well as the relatively short-term problem of radwaste generation.

3318

What methods are available to control chemicals from entering the plant as well as within plant boundaries?

Recent legislation around the country has made it mandatory to maintain a hazardous chemical inventory. The same information used to protect employees from the health effects related to hazardous materials can be included in administrative programs designed to protect plant processes and hardware. In many cases, the regulated materials are the same. In all cases, identical management techniques can be employed, regardless of the program objectives.

A chemical control program at a Light Water Reactor must have all of the administrative programs in place to positively isolate harmful chemicals from sensitive systems and components. Some elements of an effective program are:

Positive Inventory Control

All chemicals stored or used on site must be listed. Maximum amounts, relevant safety information, and storage locations should be recorded.

Hazards Evaluation

All chemicals used on site must be evaluated to determine if their use poses any threat to the integrity of plant components or systems. However, it is important to note that *such an evaluation should be performed by a chemist familiar with the properties of the chemicals and the operations in which they will be used.* The results of this evaluation may permit unrestricted use, limited use under controlled conditions (usually requiring a plant permit), or a total ban on a particular substance. This last category will be invoked only if the substance is particularly harmful to plant personnel or equipment and a less harmful substitute product is readily available.

Control of Specification

As part of the specifications for materials or work to be performed by contractors, the specific substances that are not permitted on site should be identified clearly.

Training

All permanent plant and contractor personnel should be familiarized with the requirements and goals of the Chemical Control Program during routine training. The effects of these substances on plant operations should also be explained.

Engineering

Engineering procedures for plant modifications should include provisions for isolating activities involving the use of controlled substances from critical components. Features such as pluggable drains should be considered for maintenance and operations work areas. In addition, an ongoing review of new information related to the durability and chemical resistance to damage of plant components should be maintained.

Distribution

Permits and required authorizations should be proceduralized to ensure that absolute control is exercised over controlled materials. A locked area should be used for storage of controlled items.

Audits

Periodic audits should be conducted to evaluate compliance with chemical control procedures.

Detection

Chemistry personnel should be provided with the capability to detect any substance that may inadvertently come in contact with sensitive plant components.

Incident Review

An evaluation should be completed for all incidents in which unacceptable levels of controlled substances are detected in the plant. Control strategies should be revised to reflect new findings.

Note: It is important to communicate information concerning prohibited chemicals to the purchasing organization. If it cannot be purchased, it is far less likely that a restricted chemical can get on site.

3319

How do you verify the acceptability of a chemical for on site use?

The first line of defense for the introduction of chemicals on site should be the plant Chemical Control Program. A good program will be able to determine the effects of abrasives, desiccants, corrosives, cleaning agents, absorbents, glues, ink markers, and decontamination agents, as well as other materials. A thorough evaluation should be performed for every existing chemical and for all new chemicals brought on site.

All chemicals introduced on site should have a Material Safety Data Sheet (MSDS) supplied by the manufacturer, as well as a description of the physical properties on a separate data sheet. These data sheets will provide such information as melting points, flash points, solubility, effects on mixing, halogen content, and similar information.

3320

What parameters are monitored to maintain water quality and minimize liquid radwaste?

The following system parameters impact on plant water quality. As such, they affect radionuclide generation and the corrosion rate in plant piping and equipment. They also can contribute to or inhibit other forms of deterioration in components and pressure barriers. Control of these parameters can help reduce radwaste generation in Light Water Reactors.

1. **pH** — This is a measure of the degree of acidity or alkalinity in a liquid. Controlling pH retards the effects of corrosive compounds on plant components.

2. **Conductivity** — Conductivity is the concentration of dissolved salts in a liquid.

3. **Chloride** — Chlorides are halogens, along with iodides, bromides and fluorides. Halogens have been shown to accelerate certain types of cracking in the various stainless steels used in plant components.

4. **Oxygen** — Careful control of oxygen helps minimize corrosion. Oxygen is a contributor to stress corrosion cracking. It also can contribute to shorter powdered resin precoat filter service runs.

5. **Hydrogen** — Hydrogen has been shown to aid embrittlement in some components used as pressure barriers in nuclear power plants.

6. **Heavy Metals** — These include mercury, which can combine with other available metals to form a special type of replacement corrosion.

7. **Organics** — These are carbon-hydrogen based compounds, such as oils, greases, mineral acids, solvents, plastics, etc. Organics may raise the conductivity and corrosive potential of the liquid. It is usually measured as TOC (Total Organic Carbon).

8. **Silica** — This weakly ionic compound (usually found as SiO_2) usually comes from surface water runoff. Diatomaceous filtration systems are another source of silica. Silica has been found to impede heat exchange on fuel cladding. In some BWRs, silica also can affect turbine performance if carried over in steam.

9. **Total Suspended Solids**— This is a measure of the amount of undissolved solid matter contained in reactor water. This parameter is not usually specified in liquid but is instead specified as the degree of "turbidity" in feedwater.

10. **Miscellaneous** — Such chemicals as sulfur, copper, iron, zinc, and dissolved gases also are monitored due to their effects on the liquid or on the formation of other potentially harmful compounds.

3321

How do you control organic intrusion into liquid process streams?

Both administrative and engineering controls may be employed to minimize the probability that organics from any source will be introduced into plant systems. As with any contamination or foreign substance control program, distance and solid pressure barriers are the most effective means of preventing the mixing of two incompatible substances. Both of these are used in the design and operation of a modern power plant.

However, in some cases, the organics may be formed by chemical compounds combined with specific ambient conditions within the power plant. (An example of this would be the formation of bacteria in plant sumps or tanks.) Therefore, state-of-the-art detection capability is a necessity for providing information for early identification of potential organic problems areas and specific contaminants.

In addition to the problems associated with the intrusion of organics, there presently is no volume-efficient method of disposing of cleanup media fouled by oil-based substances. For example, a small volume of lubricating oil can render large amounts of ion exchange resins useless, with associated penalties of loss of equipment availability and costly disposal of waste.

3322

What engineering controls are used to control organic intrusion?

Organics may be introduced into feedwater systems by condenser leaks. Another common source is the release of ion exchange resin fines or organosulfates from condensate polishers. Careful monitoring of hotwell condensate conductivity, coupled with an aggressive tube leak identification, location and plugging program, can minimize organic intrusion from condenser leaks.

The release of fines can be reduced by:

- Modifying the URC resin cleaning procedures to eliminate cation fines; or
- Using resin washing systems that employ vibrating screens.

The release of organic compounds from resins can be reduced by establishing limits on the "throw" of organics in the resin purchase specifications. This forces the supplier to adequately remove solvents and other leakables prior to shipment of the resins.

Organics may be introduced into liquid radwaste treatment systems from sources internal to the plant and from external sources. The internal sources include:

- lubricating oils used for most rotating equipment.
- Glycols from chilled water systems.

External sources include:

- Cooling water leaks into the plant.
- Groundwater seepage.

These sources can be controlled or reduced by several methods, including:

- Drip pans on pumps and other equipment.
- Curbed (bermed) areas around the source.
- Oil skimmers on sumps.
- Oil intercept devices on drain lines.

If these methods cannot be employed to the point where they are 100% effective, then methods should be considered to remove the organics from the liquid waste stream. Such methods include:

- Carbon adsorption in the process vessels.
- Organic destruction equipment (e.g., UV/ozone or UV/peroxide)

3323

What administrative controls are used to control organic intrusion?

Physical barriers are normally included as part of the original plant design or added during major upgrade projects as plant operating experience is gained. By contrast, administrative controls can be implemented at any time. A number of management techniques can be employed to control organic intrusion. These include:

- Chemical Control Program
- Controlled Chemicals List
- Routine Drain Sampling
- Makeup Monitoring
- Detection Capability
- Administrative Limits
- Emergency Response
- Training

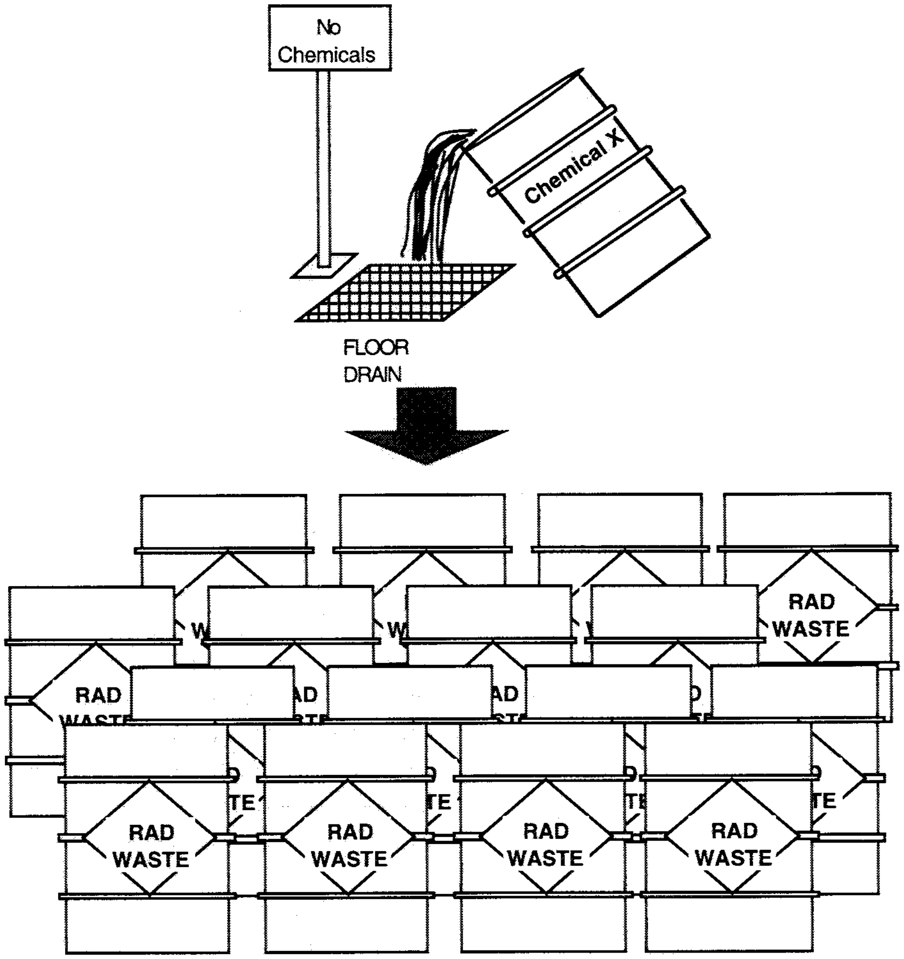
Each of these administrative controls is discussed in detail below.

Chemical Control Program

Chemicals are added to the plant liquid process streams to control—among other things—organic intrusion. However, it is important to control all chemical use within the plant to prevent the accidental addition of excessive chemical quantities or chemicals that can do more harm than good. The aim of such a chemical control program is to develop and maintain procedures that provide for the separation or total isolation of potential contaminants from sensitive areas and components, and to monitor the level of all chemicals in process streams.

The banning of all potential contaminants that are not absolutely necessary for use in the plant is the most basic form of control. Obviously, some potentially troublesome organics—those that are necessary for normal operation and maintenance—can be placed on a permit system so that the volume of each substance can be maintained in an inventory for real-time accounting purposes. For example , solvents, floor waxes, and cleaners can be closely controlled. Some commodities, such as turbine lubricating oil, may not be controlled as closely, but a usage log will prevent the excessive makeup to reservoirs from proceeding unchecked. Again, a complete list of the quantities and types of organics available in the plant at any time will make detection and elimination much easier in the event of an indication of organics in a plant system.

Figure 3323
Reducing Waste Volume through Chemical Control



Controlled Chemicals List

A list of approved chemicals should be generated and maintained by the plant. This list should be updated frequently, and audits of storerooms and work areas should be conducted routinely to assure compliance. All new chemicals and other controlled materials purchased, as well as those used by site vendors, should be approved prior to their being brought on site.

Routine Drain Sampling

Another administrative control which will minimize the intrusion of some organics into feedwater is the use of routine collection point inspections and sampling to provide early detection of an oil spill or slow leakage. A routine visual inspection of plant sumps will provide a rough indication of oil seepage into plant collection systems. Personnel doing a quick visual determination of the magnitude of the sheen caused by floating oil will learn to determine when an abnormal amount is present. Because sumps use bottom suction, the presence of a small amount of oil may be allowed to accumulate prior to removal by workers using portable equipment. Black light or special viewing devices may be helpful in making an accurate "eyeball estimate."

More labor intensive, but certainly more accurate, is the routine sampling of radwaste liquid influent for Total Organic Carbon. When samples are analyzed for determination of filter and demineralizer performance (conductivity, TSS, Silica, e.g.), TOC data may be used to trend the inleakage of most organics into plant drains or leakage past equipment seals and barriers. In addition, the occasional sampling of oil sump separator effluents and points such as Reactor Feed Pump Bearing drains also may aid in determining the source of low levels of organic contamination.

The above methods provide earlier (and cheaper) detection of oil leakage than investigation of the causes of low filter throughputs or fouled resin.

Makeup Monitoring

Maintenance and operations personnel should record the amount of lubricating oil added to reservoirs to maintain proper oil levels. This will help in monitoring the quantity of oil appearing in radwaste and other plant systems. Oil, or any chemical, added to a tank or supply sump replaces oil which had to go "somewhere." Given three identical pumps with similar duty cycles, the pump that uses more oil than its companion equipment is a likely candidate for a maintenance investigation. However, without historical log information, you must either guess at the source or initiate an expensive sampling program to find a possibly intermittent leak or seal failure.

Detection Capability

Maintaining instruments which can be used to identify solvents, oils or other organics used in the plant—and knowing their limitations—also is of great value in terms of controlling organics. For example, a library of infrared "fingerprints" may identify a particular solvent used at the plant and, thus, it's potential source. When combined with the permit system for controlled materials, this approach may even identify a specific user and a specific intrusion location. For chemists with gas or liquid chromatography, this task is simplified considerably.

Some organics—especially those which enter the plant with river water or whose origins are outside of the controlled area—may be undetectable in low concentrations, or they may be compounded with non-organic substances. In these cases, special procedures may have to be developed. Some compounds that are undetectable in feedwater may only be apparent after passing through the reactor. Special processes to simulate the effect of the reactor on the compound, or methods to convert the compound to some measurable form, may be needed. Hopefully, the experiences of other plant operators across the country can provide additional guidance.

Administrative Limits

Administrative limits for storing chemicals and organics should be established at key process points to provide some administrative level at which corrective action is mandatory. These limits should be set at a level that provides good detectability. Storage quantity limits should be low enough to provide time to gain control of problem organics at a concentration below that which can cause damage.

Emergency Response

In order for an administrative control plan to be effective, some specified action must be taken in the event of a serious intrusion of organic substances. After a substance is detected, action must be taken to isolate the source, remove intruding substances that have already entered the systems, and prevent or minimize damage to sensitive components.

An administrative action plan should be in place that would prescribe action for all predictable— and some unpredictable— scenarios. A list of key personnel, equipment, and priority actions to be taken to minimize the damage from an organic intrusion must be compiled, and possible safety impacts and should be estimated. Part of this procedure should include a post-event critique of plant personnel responses to refine actions to be taken at the next occurrence.

Training

Administrative control of intrusions are made somewhat easier if the general plant population is aware of chemical and organic control methods and the consequences of improper use or handling. Some elements of an effective training program include:

- Discussion of problems related to organic intrusion and plant chemistry in the annual Employee Qualification and Retraining program.
- Training for specified personnel in permitting, control, and proper disposal of chemicals and organics.
- Marking of drains to indicate the systems which can tolerate elevated levels of organics. Employees may be reminded of each drain's function by a distinctive color code or other marking.
- Appointing a designated contact for information on chemicals and organics.
- Locking all chemical storage areas and issuing controlled substances only through hot tool cribs to personnel with chemical use permits.
- Training chemistry personnel in the techniques necessary to detect problem substances and interpret the indications of plant instrumentation and analytical devices.

3324

How do I determine the sources of organic contaminants found in sumps?

The following checklists should be used as guides to determining the sources of organic contamination in sumps:

Oil in Sumps

1. Check the P&IDs to determine which equipment drains into that sump.
2. If equipment draining into the sump contains an oil separation unit or coalescing filter, check those for proper operation or overloading.
3. Audit maintenance logs to determine if maintenance activities in the area might have been the source of oil.
4. Check lube oil reservoirs located in drained areas to determine if excessive makeup to a storage or supply vessel indicates leakage.
5. Check nearby sumps to determine if the oil is being found is a common problem (i.e., common to more than one sump).
6. Increase the sump inspection frequency to determine if oil intrusion into the sump is time or event related. In many cases, portable automatic samplers may be useful in reducing the amount of manpower needed for sampling.
7. Examine logs and question personnel on back shifts.
8. If the concentration of oil is light, install a local carbon absorption filter in the sump in recirculating mode.
9. If the source of oil cannot be determined, an oil soluble dye may be used to help find the source of oil intrusion.

Organics in Sumps

1. Perform all of the above. In addition, perform the following:
2. Determine the nature of the organic in question. If possible refer to a library of organic characteristics developed in administrative plans.
3. Based on knowledge of plant activities and systems, try to localize the use of a particular solvent or other product.

3325

How do I identify the sources of oil contaminants in tanks?

Radwaste Collection Tanks

If oil is detected in the plant radwaste collection tanks (preprocessing), perform the following actions *prior to processing the tank*:

1. Obtain a sample to determine the type of oil or other contaminant.

> Note: Avoid recirculating the tank to avoid coating the vessel walls or emulsifying the oil.

2. Audit logs to determine the hours when the tank was in service.

3. Check the companion collection tanks to determine the magnitude of the problem.

4. If possible, perform a visual inspection of the tanks, or take a sounding using oil-sensitive gels or others, to determine the amount of oil in the tank.

5. Using a floating suction or oil skimmer, attempt to drain the bulk of the oil from the top surface of the tank. Sample this material to determine the type of oil or other contaminant.

> Note: In the case of polyester based oils (i.e., those that form a film on the bottom of the tank), such as electro-hydraulic fluid, a bottom drain or suction must be used.

6. Visually inspect plant sumps to determine the source of the oil. In cases where trace amounts are found, equipment and other sources which use oil must also be checked. Small pumps and motors which contain low-volume oil reservoirs for bearings may have failed.

7. Perform the preceding checklist for each sump exhibiting oil intrusion.

Sample Tanks

If oil is detected in the radwaste sample (post-processing) tanks, perform the following:

1. Determine the extent of oil contamination in the tank.

2. Check the appropriate collection tank for evidence of oil contamination.

3. Perform the preceding checklist for the tank(s) exhibiting oil intrusion.
4. If possible, try to determine the amount of oil on the filter and demineralizer equipment. If a deep bed demineralizer is used, a rinse may restore some of the resin capacity, and prolong the resin life.
5. Using the bypass or recycle lines, return the contaminated sample tank contents to a collection tank. (If possible, use a tank that was previously contaminated with oil.)
6. Load additional carbon or other oil absorbing products onto the filter and demineralizer.
7. Reprocess the contaminated sample tank.
8. Increase the frequency of TOC analyses to ensure that oil is not sent back to feedwater. As a result of oil coating the sides of the tank, a single analysis may not offer adequate protection against a mid-tank oil discharge to feedwater.
9. If the reprocessing does not reduce the organic contamination to acceptable levels, and no other oil removal equipment is available, sample the tank for plant discharge. If NPDES permits and plant procedures allow, an oil solubilizing agent or suitable chemical might be employed to aid in cleaning the remaining traces of oil from the tank.
10. Closely monitor TOC in subsequent sample tank loads until the levels are below acceptable limits.

3326

How do I identify the sources of organic contaminants in reactor coolant?

If unexplained conductivity excursions are evident in the reactor coolant, but no organics are detected in the feedwater, perform the following:

> Note: During the exposure of some hydrocarbons to high energy conditions in the reactor (i.e., ionizing radiation, heat), molecular bonds may be broken. This can produce an increase in conductivity. Concentrations of hydrocarbons in feedwater that are below detectable limits may be responsible for conductivity excursions in the vessel.

1. Examine plant charts and logs to determine if an operational event can be correlated with elevated conductivity. Changes in feedwater path,

including the addition of sample tank contents to the flow path and placing demineralizers in service, should be suspected.

2. Review plant activities, including maintenance, operations and contract labor, to determine if any cleaning, system drainage, etc. has taken place.
3. Inspect open permits for chemicals, solvents, and other controlled materials that might offer a clue to the possible identity of the intrusion.
4. Attempt to stimulate the conductivity increase in the laboratory by heating, exposing a reactor water sample to ultraviolet radiation, or by any other method that would simulate in-reactor conditions.
5. If causing an increase in conductivity is successful, find the source of the contaminant by working "backward" through the liquid process stream. In this case, you are looking to identify where the contaminant is less dilute to help isolate the source. For example, if there is less contaminant upstream of a specific pump, then the pump is the likely source of the intrusion.
6. Question operators at other plants to determine if similar problems were encountered at their facilities.

3327

Why are halogens a concern in power plants?

Halogens in plant water systems, in combination with other conditions (such as pressure/stress conditions and oxygen concentrations), have been shown to promote intergranular stress corrosion cracking of austenitic stainless steel. Therefore, aggressive efforts are made to eliminate all sources of halogens throughout the plant.

3328

How do you prevent contaminants from IE resins from entering LRW?

Contaminants from ion exchange resin can come from various sources as a result of manufacturing processes, degradation of the resin itself, or release of sub-ppm salts and organics concentrated on the resin. Defective plant hardware or operational practices may also lead to resin or contaminant intrusion. In each case, precautions may be taken to prevent contaminants from damaging plant components.

The following methods may be employed to minimize the elution of soluble or particulate impurities from IX resins:

Manufacturing Impurities

During the manufacturing process, some organic impurities may be left on the surface of resins causing elution of TOC when they are first placed in service. This released organic matter would then be apparent in the condensate, sample tank water, etc., and would have to be removed prior to use of the liquid in-plant systems. In some cases, a slight lapse in quality control may be the cause of organic contamination.

Performing a pre-service rinse, purchasing pre-rinsed resin, or changing types of resin all may help resolve this problem. Usually, the manufacturer will be of considerable help in solving this type of problem. Some utilities have found it helpful to include organic contamination limits in the specifications for purchased ion exchange (IX) resin.

Resin Degradation

In some cases, poor control of regeneration, out-of-spec flow rates or temperature, or poor handling and storage conditions can cause ion exchange resin to lose its structural or chemical integrity and generate resin fines or cracked resin beads. Careful control over the specifications for ion exchange products in relation to the intended storage, handling and in-service conditions is extremely important. Broken beads and fines can pass through filters and contaminate plant systems.

Resin should not be allowed to freeze during shipment or storage. It should be loaded and transferred carefully. In addition, limitations on reagent strength and processing parameters should be carefully observed.

Performance and Equipment Limits

Operational upsets can often cause resin that is performing normally to temporarily loose part of its capacity or release specific ions and entrained solids. Resin which is operating normally (especially if it is near its capacity limit) often may elute the more loosely held species if a temperature rise takes place. It also may lose apparent capacity if flow increases (such as due to channeling). And, it may lose part of it's "unofficial" load of retained solids if pressure spikes are incurred.

Inlet temperatures of vessels should be checked from time to time if loss of capacity is suspected (all other parameters being equal). In addition, rapid valve closure times might well be the reason for occasional bursts of solids from demineralizers. Equipment inspections at regular intervals are extremely helpful in detecting broken internal ion exchange vessel components, such as screens, retention elements, laterals and drains which affect the condition and performance of resin.

3329

What plant conditions will increase the potential for problems with colloidal material?

Although colloidal matter is always present in some quantity, certain plant conditions present increased levels and attendant processing challenges. During episodes that produce large quantities of service or cooling water inleakage to radwaste systems, it may be apparent that turbidity specifications in processed water are difficult to maintain. Increased settling time in tanks will be of little use in improving turbidity, and demineralization has little, if any, effect. In some cases, a reduced flow rate through a filter, or demineralizer, may remove a small percentage of the colloidal material.

During crud bursts resulting from plant start-ups or other changes in load, a large amount of colloidal material may be released into the primary systems. Processing through letdown or Reactor Water Cleanup (RWCU) will eventually reduce turbidity to some extent.

Problems with water clarity due to colloidal impurities sometimes will interfere with refueling operations.

3330

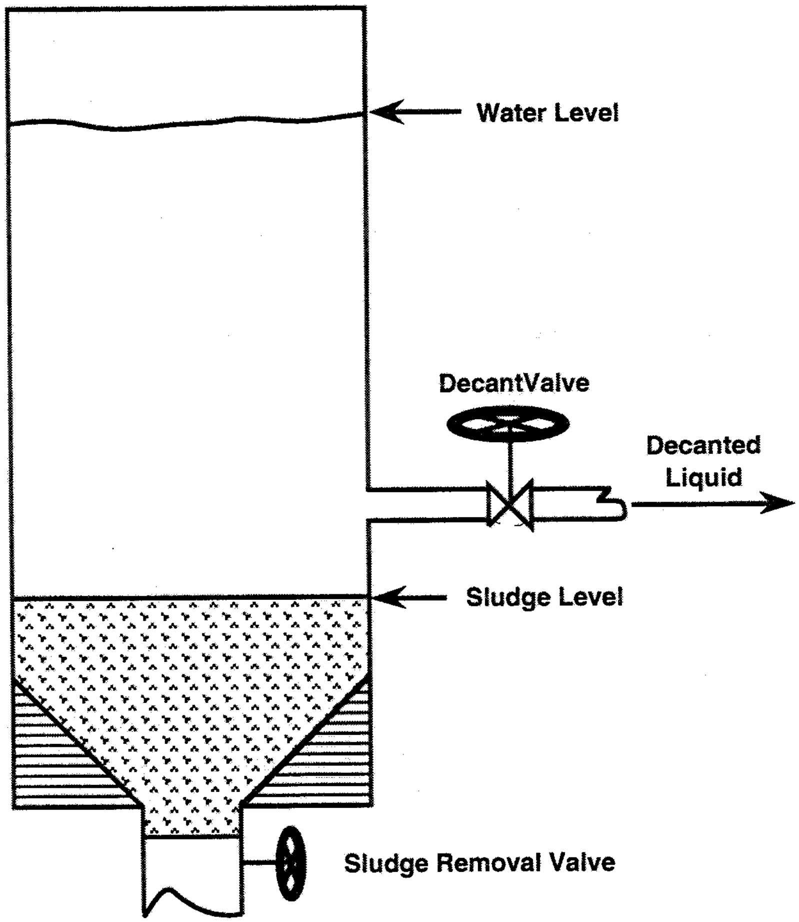
What do you do with liquids from condensate phase separators?

There are two sources of water resulting from condensate phase separator operations:

1. Decant water from the phase separation process; and
2. Transport water from the disposal container filling and dewatering process.

Both sources should be routed to the floor drain collector tank (or equivalent) for subsequent processing. It is desirable that these sources be piped directly to the collector tank. However, drainage to a floor drain sump also is acceptable.

Figure 3330
Decanting Liquids from Phase Separator



3331

What are good trending indicators for an effective LRW control program?

Various parameters can be tracked and used as performance indicators or diagnostic tools to alert plant operators to potential operational problems. The key to successfully using tracking and trending techniques comes from experience and knowledge of plant operating conditions. A radwaste operator must be aware of "normal" changes in process streams resulting from such things as seasonal changes (spring runoff, tidal changes, etc.), induced crud bursts, system draindowns, etc.

The following listings identify the trending parameters that are most commonly used to track LRW system performance:

Influent into Radwaste System

- Tank and sump levels
- Tank and sump discharge rates (run time meters, event counters)
- Gallons processed (integrator totals)
- Hold-up tank levels
- Influent water quality
    - Conductivity
    - Turbidity
    - Activity

Filter Systems

- Gallons processed
- DF
- Differential pressure
- Precoating differential pressure
- Differential pressure rate of rise

Ion Exchangers

- Gallons processed
- DF
- Effluent conductivity
- Effluent silica concentration
- Effluent TOC concentration

Evaporators

- Gallons processed
- Overhead conductivity
- Overhead TOC concentration
- Bottoms TOC concentration
- Bottoms TSS concentration
- Processing rate
- Steam pressure

Processed Liquids

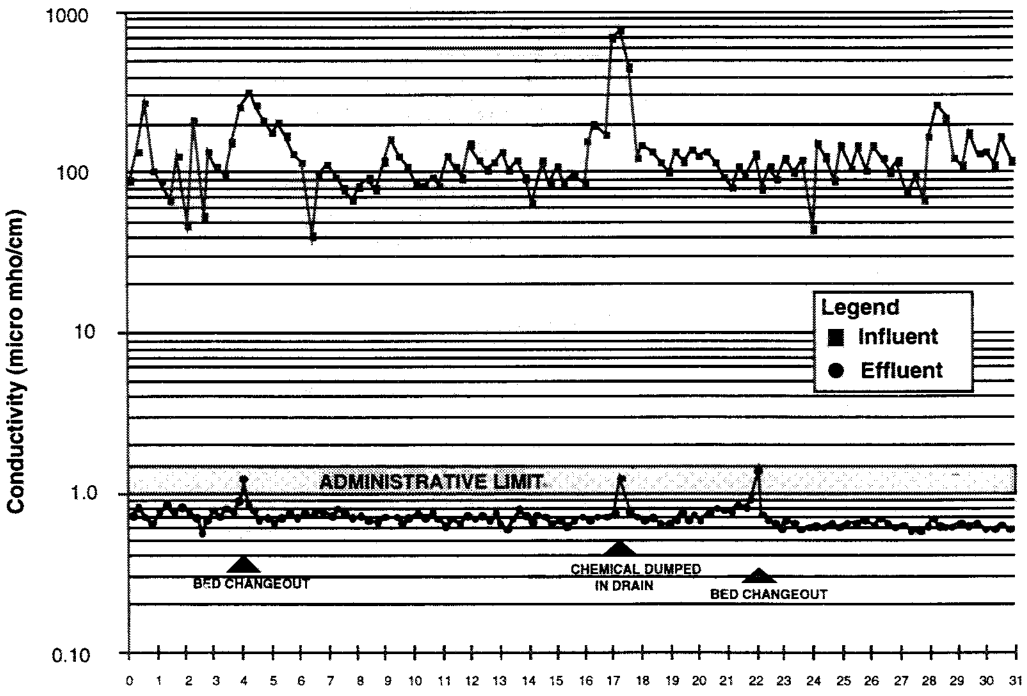
- Water quality
  - See parameters above
- Gallons discharged
- Gallons recycled
- Tech spec limits vs total discharges
- Recycle criteria vs recycled water quality

Wet Solid Waste Generation (Resins, Filter Media, etc.)

- Wet waste volumes requiring ultimate disposal
- Gallons throughput per cubic foot processing medium

Figure 3332 illustrates trending data that could be used to identify problems, estimate bed changeout, project radwaste generation, etc.

Figure 3331
Radwaste Demineralizer - Tracking Conductivity by Month



3332

How do you prevent metal filings from entering the primary system during maintenance?

The common name for this program is the plant FME (Foreign Material Exclusion) program. A number of methods are available to control solids from underwater grinding, cutting and other machining operations from entering radwaste or other plant systems. Each method is highly dependent on the specific location and operation performed. Thus, the response to this question will focus on the general actions taken to minimize the intrusion of chips, filings and other debris into sensitive components. Some of the methods available are listed below:

- Use of glove bags
- Positive flow
- Area isolation
- Magnets
- Tape
- Pipe barriers

Use of Glove Bags

In most plant areas, a tool and the surface to be machined may be placed in a clear plastic catch containment called a glove bag. These are mounted in a support or attached by adhesive or tape to the surrounding pipe, hangar, etc. At the completion of the operation, all debris generated as a result of the work will be contained in the plastic and disposed as radwaste.

Positive Flow

The area surrounded by machine work may be flushed at all times by a suction line through a filter assembly. The velocity of the flush water must be high enough to guarantee that the largest size particle will be captured, but that the flow will not interfere with the performance of work. Some underwater tools are equipped with integral vacuum attachments and hoods to ensure retention of debris.

Area Isolation

In some instances, a whole work area may be sealed off with plastic or some other material. The intent is to restrict the movement of chips and other solids (e.g., while grinding). This area may later be cleaned before removal of the temporary barriers to minimize waste volumes.

Magnets

In the case of ferrous (iron) or some other metals, the placement of strong magnets in the work area will catch metallic debris. (This is primarily for underwater operations, but it also can be used for specialized dry work activities.)

Tape

Double-sided tape may be used to hold particles for removal after the completion of work.

Pipe Barriers

If grinding is to be performed inside a pipe or similar enclosed area, dams or filter socks may be used to catch debris and prevent it from migrating to other parts of plant systems.

In many cases steel and other metallic debris will not present a problem in radwaste systems. However, the control of these particles must be assured to protect sensitive components in safety related systems and components with tight clearances.

3333

How do you minimize bacteria growth in hydraulic fluids?

Very little bacterial growth occurs in hydraulic fluid. Consequently, no additives have been added to hydraulic fluid. This can be verified by reviewing Material Safety Data Sheets (MSDS) when the fluid is received by the plant's chemical control program.

3334

How do you minimize underwater adsorption of radionuclides?

Materials designed for underwater use in spent fuel pools are typically made of stainless steel or other water resistant materials. However, radionuclides are still adsorbed by the microscopic pores present. Weak ionic bonding takes place, causing attachment of certain radionuclides to the cask, spent fuel pool crane, or other items in the spent fuel pool.

While there is no 100% method to prevent adsorption from occurring, it can be minimized by washing down the item with deionized water (D.I. water) prior to placing it into the pool. This will fill many of the available pores, and bonding sites will be minimized.

After the item is removed from the spent fuel pool, tank, etc., wash the item with D.I. water again to remove any lose contamination prior to beginning any formal decontamination process. After movement of the item to another location, aggressive decontamination may begin and with less effort required. Without pretreatment with D.I. water, some radionuclides will eventually leach out after the decontamination is complete, especially after changes in temperature or humidity.

SECTION II

(3400 SERIES QUESTIONS)

PWR Liquid Waste Processing Systems

Section II Contents

PWR Liquid Waste Processing Systems

Item Topical Description **Item Number**

Listing of Illustrations

Illustration Topical Description **Figure Number**

3401

PWR Waste Processing Systems

The systems which collect and process liquids throughout the plant are different (in design) for nearly every PWR. Therefore, it is impossible to describe "typical" processing systems that are applicable to every plant. This section describes, in general terms, the operational objectives of the various PWR liquid processing systems and addresses operational issues relevant to each system.

In general, PWR processing systems which clean up and maintain water quality throughout the plant consist of the following:

- RCS Cleanup (Chemical and Volume Control System — CVCS)
- Boron Reclamation
- Secondary Side Cleanup - Condensate Polishing System (CPS)
- Steam Generator Blowdown
- Spent Fuel Pool Cleanup System (SFPCS)
- Liquid Radwaste System:
  - Floor Drains or Low Purity Liquids **
  - Equipment Drains or High Purity Liquids **
  - Chemical Drains
  - Detergent or Laundry Wastes

** Floor and equipment drains are combined in many PWRs

Although not completely accurate for all PWRs, Figure 3401 illustrates a general system flow diagram for typical PWR processing systems.

3402

What is the purpose of the RCS Cleanup system?

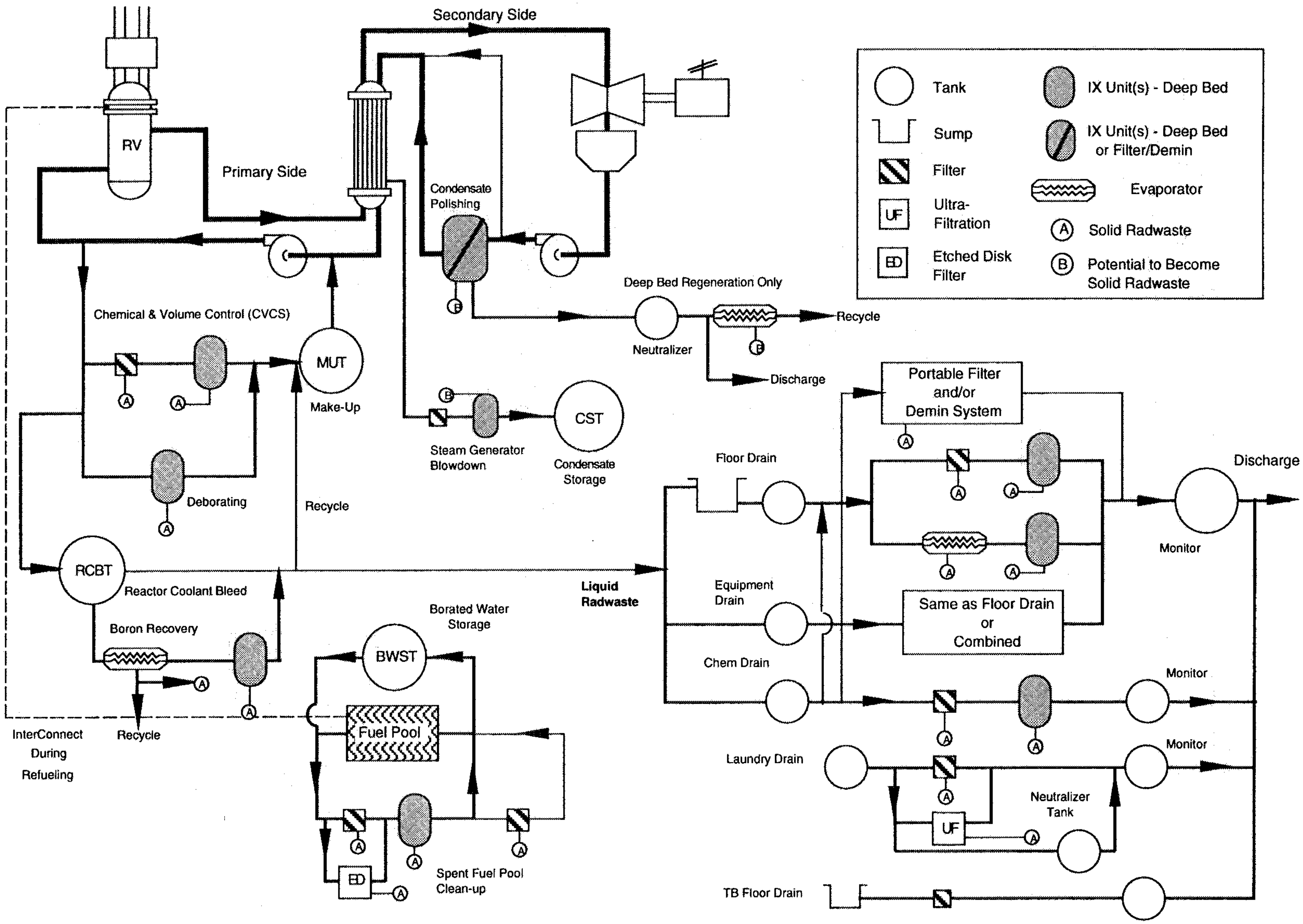
The RCS Cleanup system, more commonly referred to as the Chemical and Volume Control System (CVCS) or the Makeup and Purification (MUP) System, has several operational objectives. These include:

- Controlling the reactor coolant system inventory during all phases of normal reactor operation.

- Receiving, purifying and recirculating reactor coolant water.

- Maintaining the required boron concentration of the reactor coolant system.

Figure 3401
PWR Liquid Waste Processing System (General System Flow)



- Adding chemicals and other additives to the reactor coolant system for pH, oxygen, etc. control.

- Providing high pressure injection in the event of a leak.

- Allowing for degasification of reactor coolant.

3403

What should be considered in changing corrosion inhibitors?

Corrosion inhibitors are used principally in closed cooling water systems. Their primary function is to reduce the effect of internal corrosion caused by cooling water. More than 12 different types of corrosion inhibitors are available, but only a few find widespread use in nuclear power plants. Considerations such as metallurgy, temperature, pollutant discharge limits, dissolved oxygen, microbial activity, flow velocity, solids content and degree of unattended protection all play a part in the choice of a corrosion inhibitor.

Three general methods of corrosion protection can be employed:

- Chemical absorption onto the metal surface
- Formation of a protective coating
- Reaction with some corrosive element in the water

Some commonly used inhibitors include:

Chromates

These are excellent corrosion inhibitors. However environmental toxicity problems limit its use. Chromates are difficult to remove via ion exchange processing.

Polyphosphates

Phosphates form a durable film for the protection of metal surfaces. However, they are sensitive to pH excursions and are generally ineffective in iron-rich environments. They also present a strong potential for microbial growth. Phosphates are generally blended with other compounds and metals.

Nitrites

These perform well in ferrous systems due to their ability to passivate clean as well as rusted surfaces. They provide only limited protection against chloride and sulfate attack, and they do little (without additives) to protect copper. Nitrite also creates ion exchange problems if it enters radwaste systems, and it will also support microbial growth with conversion to nitrates.

Surface Chelants

Chelates form a surface barrier that is effective in protecting metal surfaces. The chelating film is self limiting and does not impede heat transfer. Detectability and control in radwaste are poor.

Molybdates

Molybdate salts are superior to some other metals due to lower toxicity, and they are equal in corrosion protection but at slightly higher cost.

A number of blends of metals and organics are available as corrosion inhibitors, each with specific advantages and disadvantages. Due to the number of variables to be considered in each application, system supplier recommendations should be considered for each system requiring protection.

3404

What is the purpose of the boron recovery system?

In PWRs, soluble boron is added to the reactor coolant system for control of reactor criticality. (Boron is a neutron absorber.) At the beginning of a refueling cycle, the boron concentration is established at several thousand ppm, and this concentration is gradually reduced to several hundred ppm near the end of the refueling cycle through the use of RCS feed and bleed operations and deborating demineralizers. The reduction in boron concentration is performed at the end of the cycle to maintain reactor criticality when all control rods have been withdrawn fully from the core.

Reactor coolant water containing high boron concentrations and which is "let down" from the RCS is typically collected in large shielded tanks called Reactor Coolant Bleed Holdup Tanks or Letdown Tanks. Some plants make no effort to remove the boron from RCS letdown and merely process the water to remove radioactive contamination prior to discharge. Other plants attempt to recycle as much water as possible.

To permit reuse of the water at lower boron concentrations, the boron must be removed, typically through the use of a Boron Recovery Evaporator (BRE). The resulting concentrated boron (bottoms) from BRE operations are usually handled in one of two ways: the boron concentrates are either temporarily stored for addition back into the RCS (recycle) or are packaged for disposal as radioactive waste.

The decision is generally based on several factors, including the following:

- Purity of the concentrates (i.e., levels of other undesirable chemical impurities such as silica, organics, etc.).
- Storage capacity for boron concentrates.
- Availability and cost of replacement boric acid.
- NPDES release limits for boron.
- Operability of the BRE.
- Plant philosophy to maximize recycle capability.

3405

What are some advantages of the boron recovery system?

Boron recovery offers a number of advantages, including:

- Less water discharged to the environment.
- Less make-up water required.
- Reduced boric acid procurement cost (possibly as high as $100,000/ year)
- Increased flexibility of the liquid radwaste system due to lower input volume.

3406

What are the operational objectives of the CPS?

The Condensate Polishing System (CPS) in a PWR maintains a high level of quality in condensate water flowing back to the reactor in a BWR or to the Steam Generators (S/G) in a PWR. This is accomplished by removing impurities from the liquid process stream via filtration and demineralization. Minimizing the amount and type of soluble and insoluble impurities returned to the reactor or S/G serves to limit the deposition and concentration of these impurities in the steam formation process.

Depending on the plant, condensate polishing systems will consist of one of two different filtration and ion exchange techniques: deep bed demineralizers or filter/demineralizers. Most commonly, the CPS consists of 6 to 8 full flow demineralizers (including one or two units on standby). These are aligned in parallel to handle the rated condensate flow. Effluent water quality is continuously monitored to assure that steam generator water quality specifications are maintained.

3407

What can be done to reduce secondary resin waste generation?

Typically, PWR condensate polishing systems are designed to remove chemical impurities introduced from condenser tube leaks and corrosion from within the secondary condensate and feedwater systems. It is only when primary to secondary leaks occur in the steam generator tubes that there is the opportunity for radioactive contaminants to enter the secondary system, thereby being deposited on secondary resins.

Therefore, to limit secondary resin wastes, PWRs should:

- Limit steam generator tube leaks.
- Maintain tight condenser tubes.
- Minimize leaks into the condenser.
- Specify corrosion resistant materials for replacement components in secondary systems.
- Specify resins designed to remove the predominant chemical species present.

3408

What are the operational objectives of SFPCS?

The Spent Fuel Pool Cooling and Cleanup System is designed to remove decay heat generated by stored spent fuel assemblies and to purify the spent fuel pool cooling water by filtration and demineralization. During normal operation, this system provides circulation, filtration and demineralization of the fuel pool cooling water. During refueling, this system also provides these functions for water in the reactor cavity and equipment storage (shipping cask loading) cavity.

The objectives of the system relative to processing include:

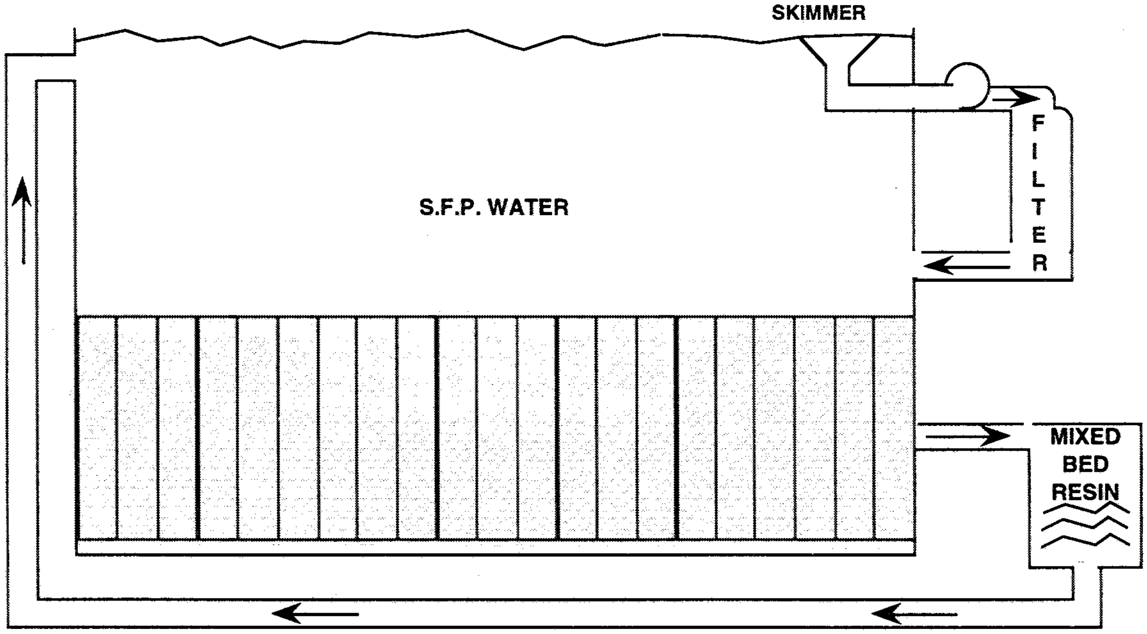
- Minimizing corrosion product buildup on assemblies stored in the pool.
- Controlling water clarity to facilitate refueling operations and efficiently handle fuel assemblies and reactor internals under water.

- Minimizing secondary sources of beta and gamma radiation that could be released to the reactor building environment. (This is accomplished through the control of corrosion and fission product concentrations in the water.)

The spent fuel pit clean up system (SFPCS) normally employs at least two filter systems. The first is the surface water cleaning system (a skimming filter). This is designed to remove floating debris, such as lint, paper, etc.

The second system is for removal of radionuclides using a filter or a resin clean up system. Its purpose is to remove particulate or radioanions or cations from the water in order to reduce the dose rate from the pool water itself. This would require at least an annual replacement.

Figure 3408
Spent Fuel Pool Cleanup System (SFPCS)



3409

How do you minimize biological growth in the SFPCS and other systems?

Biological growth is a function of pH, temperature and temperature ranges, flow rates, organic concentrations, operating conditions, type of organisms, chemical additives, etc. Thus, normal plant operating practices can promote biological growth. This is particularly true for stagnant or near-stagnant bodies of water, such as tanks and some portions of the spent fuel pool.

The following general considerations should be followed to minimize biological growth:

- Use corrosion inhibitors that do not promote biological growth.
- Implement periodic cleanup of areas where biological growth is likely to occur. This will eliminate or minimize the fuel (i.e., food sources, such as dirt, debris, etc.) that promote biological growth.
- Prevent the introduction of raw cooling water likely to contain high concentrations of biologics.
- Prevent the introduction of hydrocarbon material, such as oil, hydraulic fluid, etc. These organic compounds promote the growth of biological material.
- Maintain sufficient flow rates and avoid stagnation of liquids.
- Use an appropriate chemical additive (hydrogen peroxide, chlorine, ozone, etc.) to prevent growth.

Note: Chemical addition is very system dependent and should be based upon the type of local organisms, construction materials, water quality requirements, operating parameters, etc.

3410

What are good housekeeping practices related to the SFPCS?

The following minimum housekeeping activities should be performed for the SFPCS:

- Implement a detailed program to characterize items stored in the pool so that material can be packaged and shipped as soon as possible. Don't store items in the pool for extended periods unless absolutely necessary.

- Maintain water flow to minimize stagnation that could promote biological growth. A good flow rate also will optimize the filtration of solids.
- Decontaminate items before they are put in pool (e.g., fuel casks).
- Never wash or sweep debris into the pool.
- When performing maintenance on items around or above the pool (e.g., auxiliary building crane, spent fuel pool bridge crane, refueling platform), use enclosures, glove bags, catch basins, etc. to collect debris that might inadvertently end up in the pool.

3411

What effect does temperature have on SFP water management?

Generally, water management is influenced the most by elevated temperature resulting from spent fuel pool (SFP) operations. Radwaste operators must be aware of the following considerations resulting from elevated fuel pool temperatures:

- Evaporation of SFP water will increase with temperature, thereby necessitating makeup to the pool.
- Increased releases of tritium will occur through evaporation from the SFP . This will increase the tritium concentration above the pool and requiring attention to inhalation exposures of operators ventilation requirements.
- Higher SFP water temperatures will promote the growth of biological organisms.
- Most organic resins used in SFPCS suffer performance degradation when exposed to temperatures above approximately 130°F.

3412

Liquid Radwaste System

The Liquid Radwaste System is designed to collect, segregate and process potentially contaminated water from various sources throughout the plant for recycle and reuse within the plant to the extent that is practical. Liquid wastes are generally collected and processed based upon expected water quality, although individual plant system designs and operations will vary considerably. The techniques most commonly used to process these liquid waste streams include filtration, ion exchange and evaporation.

Waste collection subsystems typically found in PWRs consist of:

- Low Purity Waste System (Floor Drains)
- High Purity Waste System (Equipment Drains)
- Chemical Waste and Detergent (Laundry) Wastes

Techniques typically used to process these liquid waste streams include filtration, ion exchange and evaporation.

3413

Floor Drain

These low purity wastes consist of liquids with potentially high electrical conductivity, suspended solids and dissolved solids content. Figure 3417 illustrates typical PWR low-purity (floor drain) sources.

3414

Equipment Drain

These high purity wastes consist of liquids with relatively low electrical conductivity, suspended solids and dissolved solids content. Essentially, these liquid wastes are nearly opposite in water quality to floor drain waste.

3415

What are the considerations in recycling floor drain waste?

In PWRs, treated floor drain wastes are not normally recycled. The reason for this is that most plants have instituted the use of ion exchange treatment of the floor drains in place of evaporation. In the ion exchange process, the boron in the waste quickly saturates the resin bed and, in subsequent processing, the boron will pass through the bed without removal.

The intent is to discharge the boron and retain the radioactive materials on the ion exchange resins. Thus, there is no intent to recycle the ion exchange effluent. The recycle of such wastes would require a concentration step to increase the boron concentration. Additional purification steps would be needed to remove impurities that have been introduced at levels that are suitable for recycle. This is not considered practical.

3416

What is the objective of the chemical drain system?

The chemical drain—or the chemical hold up and volume control system—is primarily designed to maintain the required water inventory, soluble boron concentration, and correct water chemistry for the reactor coolant system. This system is also designed to reduce, through various filters, the quantity of fission products impurities, and maintain the proper plant chemistry requirements. It will also serve as a pathway for the recovery of the boric acid make-up water for later reuse.

3417

What disposal techniques are used for decontamination wastes?

Prior to beginning an on site decontamination campaign, notify the intended disposal facility. The three existing disposal facilities each have differing acceptance criteria for the disposal of chemical decontamination wastes. New facilities planned or under construction are likely to have local variations on the controls for disposing of decontamination wastes. At existing disposal sites, exceptions to the disposal criteria have been allowed provided advance notification was made and all parties agreed to the procedures and final waste concentrations.

Depending on the decontamination process, clean up of the chemical decontamination agent may involve resins (powdered or bead), and the final product for disposal may or may not require solidification. Typical decontamination wastes—such as the LOMI, CAN-DECON, CITROX and other oxidation/reduction processes—may be disposed of in a dewatered form. Other processes, such as electropolisher residue, will, in all likelihood, require neutralization and eventual solidification.

> *Note: The disposal of decontamination wastes is discussed in detail in the EPRI report, Interim On-Site Storage of Low Level Waste, Volume 5: Waste Forms.*

3418

What methods are used for cleaning laundry?

The three laundry cleaning approaches used with success at nuclear plants are:

- On site wet washing using mild detergents and water (operated by plant staff or contractor personnel).
- On-site dry cleaning, typically using freon as the dry cleaning agent (operated by plant staff or contractor personnel).

- Off-site processor using wet wash or dry cleaning.

Note 1: A common mixed waste stream is the evaporator still bottoms from dry cleaning units. This waste stream typically contains very low levels of radioactivity, and could contain very small quantities of freon contaminants.

Note 2: Nuclear laundry systems and processes are discussed in detail in report NP-7309, EPRI Guide to Managing Nuclear Protective Clothing Programs.

3419

How can I process laundry waste?

For plants or laundry facilities using wet washing, the following alternatives exist for processing the contaminated liquids:

- Filtration via process filters
- Ion exchange
- Reverse osmosis
- Evaporation

Typically, laundry wastes contain very low levels of radioactivity. Many plants simply filter the liquid stream and discharge the effluent in accordance with the plant's (NPDES) discharge permit.

3420

How can I minimize solids (e.g., dirt) introduction into LRW?

Dirt, floor sweepings, metal grinding debris, etc. can enter the LRW system through floor drains and during system maintenance. This can be minimized by using:

- Installing strainers, berms and portable dikes around floor drain covers.
- Installing glove bags/debris control mechanisms during maintenance.
- Isolating work areas during maintenance.
- Performing general housekeeping (vacuuming, dry wiping) prior to wet washing.

- Implementing administrative controls.
  - Restrict debris from being swept into drains.
  - Require cleanup procedures following grinding, welding, etc.
  - Implement enforcement actions.

3421

What considerations impact on sludge buildup?

Controlled vs Uncontrolled Settling/Collection Points

LRW systems are designed to remove solids from liquid process streams via filtration and sedimentation. In this case, solids collection is intentional and is not considered to be a problem.

Some plants also use certain collection tanks as "settling tanks" for solids separation. This allows for settling and drawing (decanting) from an elevated suction point. The remaining, precipitated solids are periodically resuspended via tank spargers, eductors, etc. and then removed for further processing. The result is increased run times on filters and filter demineralizers. The key is having the ability to periodically clean the tank so that ALARA and corrosion concerns are minimized.

Potential Collection Points

- Collection equipment: sumps, tanks, fuel pool.
- Process equipment: evaporators, hold-up tanks, phase separators (by design).

Composition

- Resin beads, resin fines.
- Radionuclides and organics.
- Miscellaneous: dirt, cement, welding slag, silt, metal filings, fibers (paper, cloth, mop strings).

Source Identification and Minimization

- Determine why the problem exists and whether these solids should be in the waste stream?
- River silt ==> Cooling water inleakage.
- Resin fines ==> Backwash and loading operations, equipment malfunctions, inadequate filtration/separation.

- Cement, dirt, weld slag, metal filings, etc. ==> Maintenance procedures and housekeeping practices.
- Microbes ==> Inadequate flow (stagnation), chemical additives, oil/organic intrusion.

Engineering Design

- Minimize areas of concentration (e.g., crud traps).
- Ensure recirculation capabilities.
- Ensure easy access for cleaning.
- Include planned settling and/or solids removal in system design (phase separators, weirs in sumps, bag filters, etc.).
- Include proper filter micron sizes.
- Install catch screens over drains.

System Operations

- Ensure equipment is operating properly.
- Ensure procedural compliance during bed loading and backwashing.
- Maintain proper flow during tank recirculation, resin transfers, etc.

Maintenance & Housekeeping

- Restrict sweeping into floor drains.
- Sweep before washing down.
- Cover drains during maintenance (if possible).
- Periodic cleaning of catch screens.
- Keep plant clean and free of debris.

3422

What parameters are measured for waste holdup tanks and monitor tanks?

As a minimum, the following parameters typically are measured in waste holdup tanks to maintain water quality and minimize solid waste generation:

- Conductivity
- Gross activity
- Turbidity

For waste monitor tanks, the following parameters typically are measured:

- Radionuclide concentrations
- Conductivity
- Total suspended solids
- pH

SECTION III

(3500 SERIES QUESTIONS)

BWR LIQUID WASTE PROCESSING SYSTEMS

Section III Contents

BWR Liquid Waste Processing Systems

Item Topical Description **Item Number**

Listing of Illustrations

Illustration Topical Description **Figure Number**

3501

BWR Waste Processing Systems

All boiling water reactors (BWRs) in the U.S. are of General Electric design. However, the systems which collect and process liquids throughout the plant are different (in design) for nearly every BWR. Therefore, it is impossible to describe "typical" processing systems that are applicable to every plant. This section describes, in general terms, the operational objectives of the various BWR liquid processing systems and addresses operational issues relevant to each system.

In general, BWR processing systems that clean up and maintain water quality throughout the plant consist of the following:

- Reactor Water Cleanup System (RWCU)
- Condensate Cleanup or Condensate Polishing System (CPS)
- Spent Fuel Pool Cleanup System (SFPCS)
- Liquid Radwaste System:
    - Floor Drains or Low Purity Liquids
    - Equipment Drains or High Purity Liquids
    - Chemical Drains
    - Detergent or Laundry Wastes

Although not completely accurate for all BWRs, Figure 3501 illustrates a reasonable system flow diagram for typical BWR processing systems.

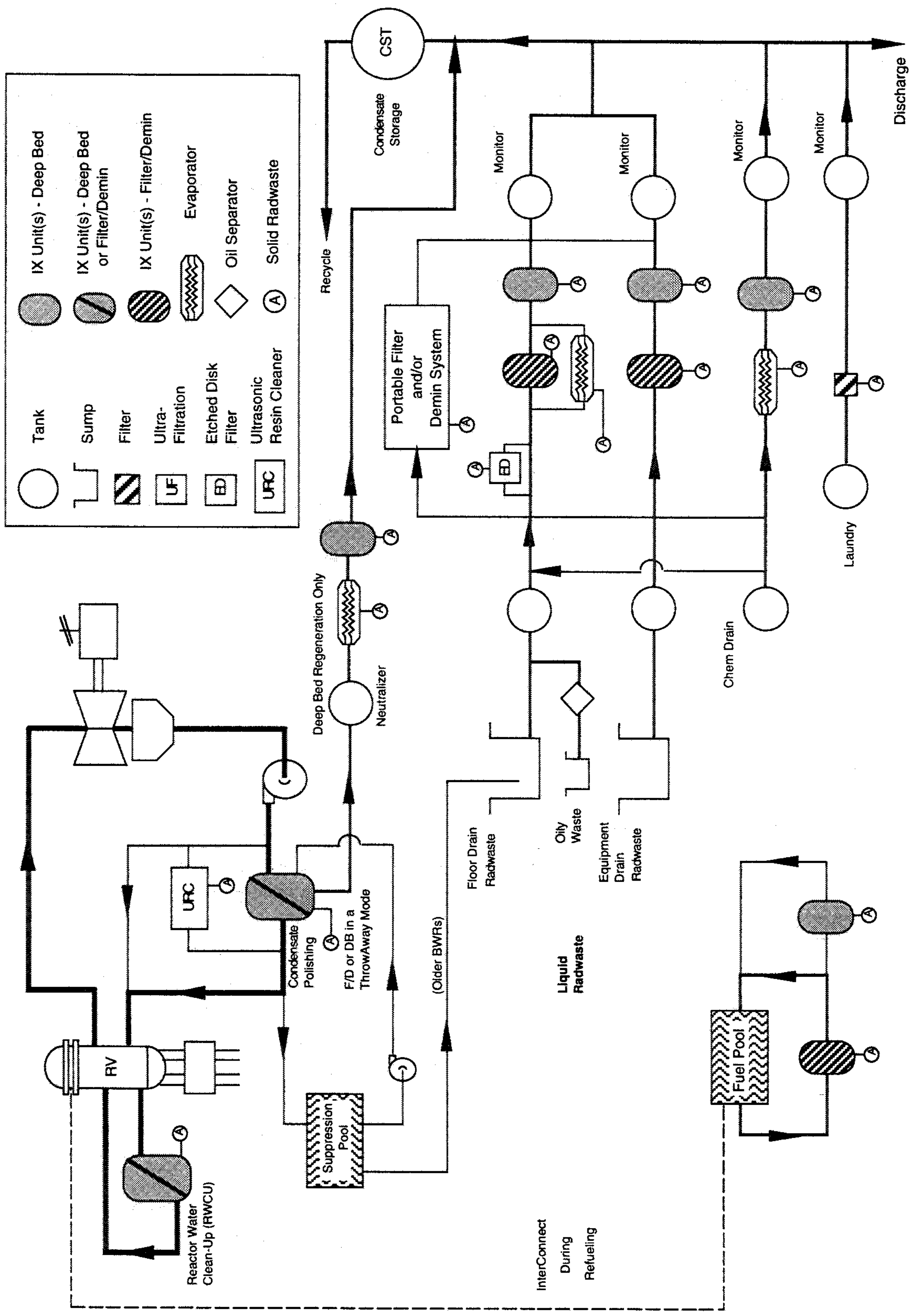
3502

What are the operational objectives of the RWCU?

The RWCU system maintains reactor water quality by continuously processing a portion of the reactor coolant to remove impurities. The basic operational objectives of the system are to:

1. Reduce soluble and insoluble waterborne impurities in the reactor water in order to maintain water quality within specifications.
2. Reduce heat and reactor water loss during the process.
3. Provide a method of removing excessive primary coolant during start-up, hot standby and shutdown.
4. Reduce the secondary source of beta and gamma radiation (resulting from the presence of corrosion and fission products).
5. Assist in recirculation during low flow situations to maintain an even reactor temperature.
6. Isolate the system following a pipe break within the RWCU System, a LOCA, or an initiation of Standby Liquid Control.

Figure 3501
BWR Liquid Waste Processing System (General Flow Diagram)



In a typical BWR, pressure precoat filter/demineralizers are used for processing the water. The wet solid waste produced by this system typically has the highest concentration of radioactivity when compared to other processing systems.

3503

What is the impact on radwaste systems of lowering the T.O.C. limits in the RWCU?

The total organic carbon (T.O.C.) is a measure of the oxidizable organic carbon within the system. These organic molecules will be destroyed when they pass through the core because of the radiation and the temperature.

When organic molecules break down within the primary system, they may release sulfates or halogens. The result of this is the production of corrosive compounds, a lowering the pH of the RWCU, and more rapid degradation of working parts either in the RWCU or the radwaste process system.

3504

What alternative corrosion inhibitors are available?

More than 12 different types of corrosion inhibitors are available, but only a few find widespread use in nuclear power plants. Considerations such as metallurgy, temperature, pollutant discharge limits, dissolved oxygen, microbial activity, flow velocity, solids content and degree of unattended protection all play a part in the choice of a corrosion inhibitor.

Three general methods of corrosion protection can be employed:

- Chemical absorption onto the metal surface
- Formation of a protective coating
- Reaction with some corrosive element in the water

Some commonly used inhibitors include:

<u>Chromates</u>

These are excellent corrosion inhibitors. However environmental toxicity problems limit its use.

Polyphosphates

Phosphates form a durable film for the protection of metal surfaces. However, they are sensitive to pH excursions and are generally ineffective in iron-rich environments. They also present a strong potential for microbial growth. Phosphates are generally blended with other compounds and metals.

Nitrites

These perform well in ferrous systems due to their ability to passivate clean as well as rusted surfaces. They provide only limited protection against chloride and sulfate attack, and they do little (without additives) to protect copper. Nitrite also creates ion exchange problems if it enters radwaste systems, and it will also support microbial growth with conversion to nitrates.

Surface Chelants

Chelates form a surface barrier that is effective in protecting metal surfaces. The chelating film is self limiting and does not impede heat transfer. Detectability and control in radwaste are poor.

Molybdates

Molybdate salts are superior to some other metals due to lower toxicity, and they are equal in corrosion protection but at slightly higher cost.

A number of blends of metals and organics are available as corrosion inhibitors, each with specific advantages and disadvantages. Due to the number of variables to be considered in each application, system supplier recommendations should be considered for each system requiring protection.

3505

What should be considered in changing corrosion inhibitors?

There are several factors that should be considered:

1. The primary factor is to select a corrosion inhibitor that is effective in protecting the metal surfaces of the cooling water system.

2. The different corrosion inhibitor agents may have different impacts on the radwaste treatment systems in the case of cooling water system leaks and when draining the system.

Chromates and nitrates will consume ion exchange capacity in the radwaste system. The chromate ion could cause the resins to become mixed wastes. The nitrites will oxidize to nitrates, and nitrate loading on ion exchange resins could cause oxidation problems on the resins. This, in turn, could cause gas generation in the packaged waste or even an exothermic reaction during resin dewatering.

3506

What is the expected impact of extended fuel burnup on isotopic distribution?

The longer fuel cycles associated with the extended fuel burnup will increase the inventory of activation products (such as Co-60) deposited on the fuel surfaces. The larger inventories will, in turn, lead to higher concentrations of Co-60 in reactor coolant and in waste treatment systems.

The inventories of the long-lived radionuclides will increase in the fuel in the fuel rods. If there are no pin-hole leaks, then there will be no change in the isotopic distribution in radwaste. If there are pin-hole leaks, then there will be an increase in the mobile, long-lived radionuclides (such as Cs-137 and I-129) in the reactor coolant and in waste water systems.

3507

What is the impact on radwaste in reducing the reactor water silica limit?

Generally, ion exchange is the processing method for treating those liquid wastes that will be recycled for re-use in the plant. If the silica limit is reduced for water recycled, then there will be a greater consumption of ion exchange resins in the treatment system. The magnitude of the increase in resin consumption will depend on:

1. The established silica limit;
2. The ratio of silica to other anions in the waste;
3. The ion exchange processing configuration;
4. The resin used in the process; and
5. The processing temperature.

For plants that treat waste water by evaporation, there should be a minimal impact on reducing the silica limit.

3508

What are possible sources of high sulfate in the reactor water system?

Sulfates may be introduced into the RCS from two possible sources:

1. The condensate polishers.
2. The reactor coolant purification system.

The likely source of the sulfates are ion exchange resin fines (cation) that are carried into the reactor. Within the reactor, they decompose to form sulfates. It also is speculated that an organo-sulfate compound may be leached from the resin and introduced into the reactor as a trace organic. Again, this decomposes to leave a residual sulfate ion.

3509

What are the operational objectives of the condensate polishing system?

The Condensate Polishing System (CPS) in a BWR maintains the reactor-grade quality of condensate water flowing back to the reactor by removing impurities from the stream. Impurities are removed by filtration and/or demineralization.

Depending on the plant, BWRs typically employ one of two different filtration and ion exchange techniques: deep bed demineralizers or filter/demineralizers. Typically, the CPS consists of 6 to 8 full flow demineralizers (including one or two units on standby). These are aligned in parallel to handle the rated condensate flow. Effluent water quality is continuously monitored to assure that reactor water quality specifications are maintained.

3510

What are the operational objectives of SFPCS?

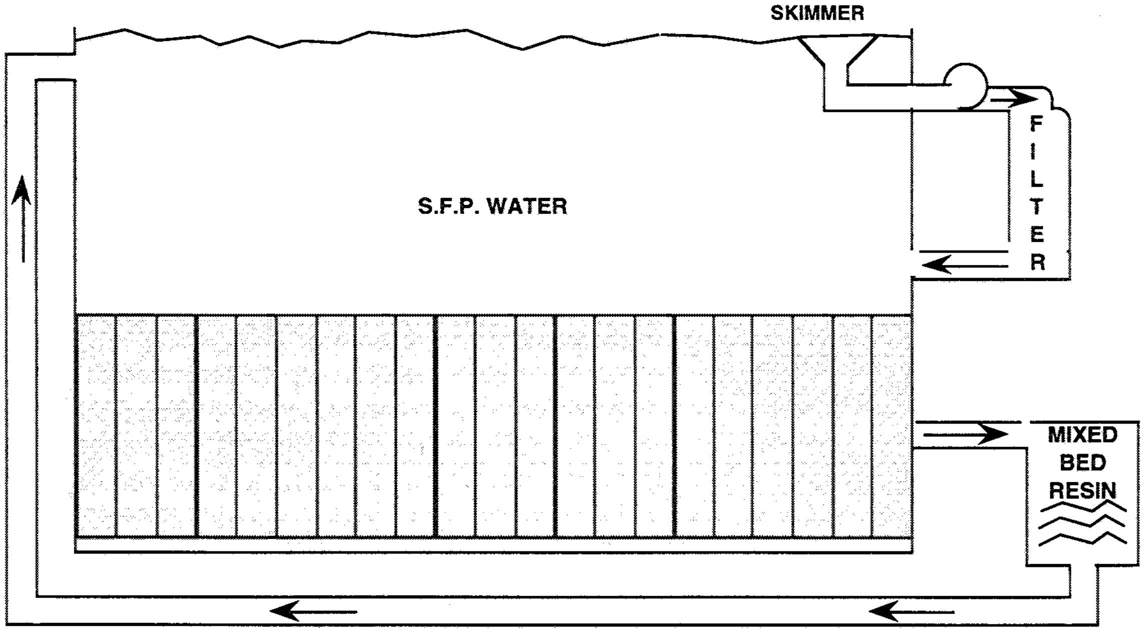
The Spent Fuel Pool Cooling and Cleanup System is designed to remove decay heat generated by stored spent fuel assemblies and to purify the spent fuel pool cooling water by filtration and demineralization. During normal operation, this system provides circulation, filtration and demineralization of the fuel pool cooling water. During refueling, this system also provides these functions for water in the reactor cavity and dryer/separator pool.

The objectives of the system relative to processing include:

- Minimizing corrosion product buildup on assemblies stored in the pool.
- Controlling water clarity to facilitate refueling operations and efficiently handle fuel assemblies and reactor internals under water.

- Minimizing secondary sources of beta and gamma radiation that could be released to the reactor building environment. (This is accomplished through the control of corrosion and fission product concentrations in the water.)

Figure 3510
General Layout of a Spent Fuel Pool Cleanup System



The spent fuel pit clean up system (SFPCS) normally employs at least two filter systems. The first is the surface water cleaning system (a skimming filter). This is designed to remove floating debris, such as lint, paper, etc.

The second system is for removal of radionuclides using a spun woven filter or a resin clean up system. Its purpose is to remove particulate or radioanions or cations from the water in order to reduce the dose rate from the pool water itself. This would require at least an annual replacement.

3511

How do you minimize biological growth?

Biological growth is a function of pH, temperature and temperature ranges, flow rates, organic concentrations, operating conditions, type of organisms, chemical additives, etc. Thus, normal plant operating practices can promote biological growth. This is particularly true for stagnant or near-stagnant bodies of water, such as tanks and some portions of the spent fuel pool.

The following general considerations should be followed to minimize biological growth:

- Use corrosion inhibitors that do not promote biological growth.
- Implement periodic cleanup of areas where biological growth is likely to occur. This will eliminate or minimize the fuel (i.e., food sources, such as dirt, debris, etc.) that promote biological growth.
- Prevent the introduction of raw cooling water likely to contain high concentrations of biologics.
- Prevent the introduction of hydrocarbon material, such as oil, hydraulic fluid, etc. These organic compounds promote the growth of biological material.
- Maintain sufficient flow rates and avoid stagnation of liquids.
- Use an appropriate chemical additive (hydrogen peroxide, chlorine, ozone, etc.) to prevent growth.

Note: *Chemical addition is very system dependent and should be based upon the type of local organisms, construction materials, water quality requirements, operating parameters, etc.*

3512

What are good housekeeping practices related to the SFPCS?

The following minimum housekeeping activities should be performed for the SFPCS:

- Implement a detailed program to characterize items stored in the pool so that material can be packaged and shipped as soon as possible. Don't store items in the pool for extended periods unless absolutely necessary.

- Maintain water flow to minimize stagnation that could promote biological growth. A good flow rate also will optimize the filtration of solids.
- Decontaminate items before they are put in pool (e.g., fuel casks).
- Never wash or sweep debris into the pool.
- When performing maintenance on items around or above the pool (e.g., auxiliary building crane, spent fuel pool bridge crane, refueling platform), use enclosures, glove bags, catch basins, etc. to collect debris that might inadvertently end up in the pool.

3513

What effect does temperature have on SFP water management?

Generally, water management is influenced the most by elevated temperature resulting from spent fuel pool (SFP) operations. Radwaste operators must be aware of the following considerations resulting from elevated fuel pool temperatures:

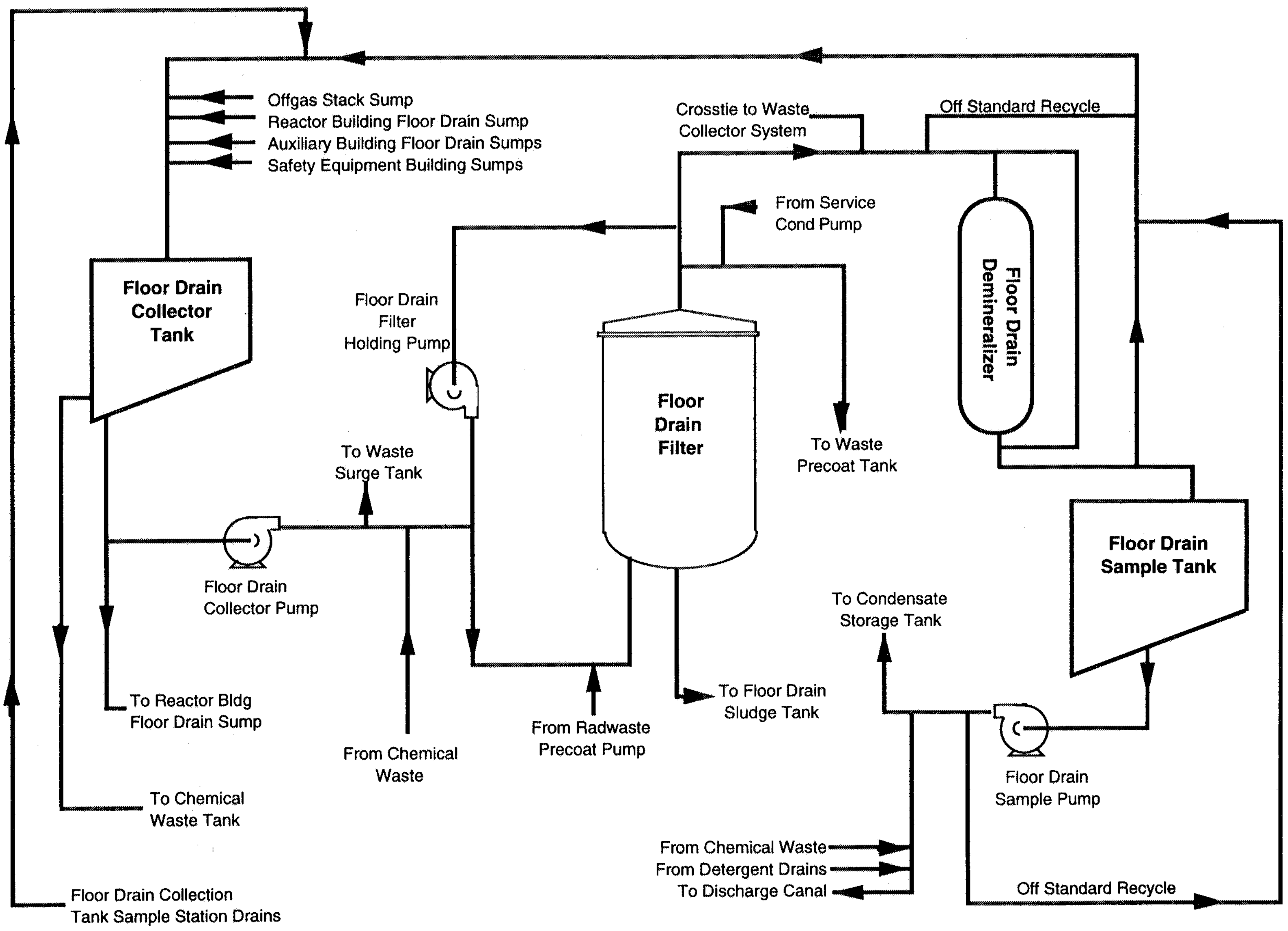
- Evaporation of SFP water will increase with temperature, thereby necessitating makeup to the pool.
- Increased releases of tritium will occur through evaporation from the SFP . This will increase the tritium concentration above the pool and requiring attention to inhalation exposures of operators ventilation requirements.
- Higher SFP water temperatures will promote the growth of biological organisms.
- Most organic resins used in SFPCS suffer performance degradation when exposed to temperatures above approximately 130°F.

3514

Liquid Radwaste System

The Liquid Radwaste System is designed to collect, segregate and process potentially contaminated water from various sources throughout the plant for recycle and reuse within the plant, as appropriate. Liquid wastes are generally collected and processed based upon expected water quality, although individual plant system designs and operations vary considerably.

Figure 3515
Floor Drain Sources



Waste collection systems typically found in BWRs consist of:

- Low Purity Waste (floor drains)
- High Purity Waste (equipment drains)
- Chemical Waste and Detergent (Laundry) Wastes

Each of these subsystems is discussed in detail later in this section. Techniques typically used to process these liquid waste streams include filtration, demineralization and evaporation.

3515

Floor Drain (including oily waste)

These low purity wastes consist of liquids with potentially high electrical conductivity, suspended solids and dissolved solids content. Figure 3515 illustrates typical BWR low-purity (floor drain) sources.

3516

Equipment Drain

These high purity wastes consist of liquids with relatively low electrical conductivity, suspended solids and dissolved solids content. Essentially, these liquid wastes are nearly opposite in water quality to floor drain waste.

3517

What are the considerations in recycling floor drain waste?

Considerations relative to recycling floor drains include:

Recycle criteria — Does the effluent meet plant recycle criteria?

Process configuration — Can TOC levels be reduced to recycle levels?

Economics — Is it more economical to reprocess the water until it meets recycle criteria, or discharge the water and use makeup?

Plant Tech Spec limits for liquid discharge (activity limits, dilution flow, etc.) — Is the plant approaching discharge limits, or could discharging the water effect future plant operations?

Operations — Is it easier relative to sampling, dose projections, monitor calibration, discharge permitting, etc. to recycle rather than to discharge?

System capacity — Is the tankage and processing rate adequate to allow for recycle of water that does not meet recycle limits?

Public relations — Does it make sense from a public relations standpoint to discharge if recycle is a viable option (relative to other factors)?

3518

What is the objective of the chemical drain system?

The chemical drain system is designed to collect the miscellaneous chemical wastes from the "hot" chemistry laboratory and from other chemical sinks or decontamination areas throughout the plant. These wastes are collected separately from other liquid wastes because of their high soluble chemical content and their potential to contain high chlorides or other chemicals that could impact normal radwaste processing. The separate collection allows the wastes to be sampled to determine the most appropriate method of treatment.

3519

What methods and disposal techniques are used for decontamination wastes?

Prior to beginning an on site decontamination campaign, notify the intended disposal facility. The three existing disposal facilities each have differing acceptance criteria for the disposal of chemical decontamination wastes. New facilities planned or under construction are likely to have local variations on the controls for disposing of decontamination wastes. At existing disposal sites, exceptions to the disposal criteria have been allowed provided advance notification was made and all parties agreed to the procedures and final waste concentrations.

Depending on the decontamination process, clean up of the chemical decontamination agent may involve resins (powdered or bead), and the final product for disposal may or may not require solidification. Typical decontamination wastes—such as the LOMI, CAN-DECON, CITROX and other oxidation/reduction processes—may be disposed of in a dewatered form. Other processes, such as electropolisher residue, will, in all likelihood, require neutralization and eventual solidification.

> *Note: The disposal of decontamination wastes is discussed in detail in the EPRI report, Interim On-Site Storage of Low Level Waste, Volume 5: Waste Forms.*

3520

What quality of water should you require from a vendor supplied system for suppression pool clean up?

For the past decade, the BWR suppression system has been maintained employing the same water standards as the primary coolant. These standards were developed by both the GE BWR operating group and EPRI, with some input by INPO.

However, studies currently are underway by EPRI and participating utilities to assess the benefits of more relaxed water quality standards for spent fuel pools. The concept under study recognizes that most fuel pools can be operated as closed systems when the plant is operating normally. Thus, it may be unnecessary to maintain the same level of water quality that is needed during refueling when the reactor cavity is filled and directly connected to the SFP, thereby making the SFP part of the plant primary system. When the plant is operating normally and the SFP is operated as a closed loop, it may be more cost effective to operate without the SFP demineralizers or filters in service, except as needed to control aggressive ions, high conductivity, etc. As indicated above, this currently is under evaluation, and the results of the study will be reported in a separate document.

3521

What methods can be used for laundry cleaning?

The three laundry cleaning approaches used with success at nuclear plants are:

- On site wet washing using mild detergents and water (operated by plant staff or contractor personnel).
- On-site dry cleaning, typically using freon as the dry cleaning agent (operated by plant staff or contractor personnel).
- Off-site processor using wet wash or dry cleaning.

> *Note 1: A common mixed waste stream is the evaporator still bottoms from dry cleaning units. This waste stream typically contains very low levels of radioactivity, and could contain very small quantities of freon contaminants.*

Note2: Nuclear laundry systems and processes are discussed in detail in report NP-7309, EPRI Guide to Managing Nuclear Protective Clothing Programs.

3522

How can I process laundry waste?

For plants or laundry facilities using wet washing, the following alternatives exist for processing the contaminated liquids:

- Filtration via process filters
- Ion exchange
- Reverse osmosis
- Evaporation

Typically, laundry wastes contain very low levels of radioactivity. Many plants simply filter the liquid stream and discharge the effluent in accordance with the plant's (NPDES) discharge permit.

3523

How can you minimize solids (e.g., dirt) introduction into LRW?

Dirt, floor sweepings, metal grinding debris, etc. can enter the LRW system through floor drains and during system maintenance. This can be minimized by using:

- Installing strainers, berms and portable dikes around floor drain covers.
- Installing glove bags/debris control mechanisms during maintenance.
- Isolating work areas during maintenance.
- Performing general housekeeping (vacuuming, dry wiping) prior to wet washing.
- Implementing administrative controls.
    - Restrict debris from being swept into drains.
    - Require cleanup procedures following grinding, welding, etc.
    - Implement enforcement actions.

3524

What considerations impact on sludge buildup?

Controlled vs Uncontrolled Settling/Collection Points

LRW systems are designed to remove solids from liquid process streams via filtration and sedimentation. In this case, solids collection is intentional and is not considered to be a problem.

Some plants also use certain collection tanks as "settling tanks" for solids separation. This allows for settling and drawing (decanting) from an elevated suction point. The remaining, precipitated solids are periodically resuspended via tank spargers, eductors, etc. and then removed for further processing. The result is increased run times on filters and filter demineralizers. The key is having the ability to periodically clean the tank so that ALARA and corrosion concerns are minimized.

Potential Collection Points

- Collection equipment: sumps, tanks, fuel pool.
- Process equipment: evaporators, phase separators (by design), URC units.

Composition

- Filter media: resin beads, resin fines, DE, powdered resin.
- Radionuclides and organics.
- Miscellaneous: dirt, cement, welding slag, silt, metal filings, fibers (paper, cloth, mop strings).

Source Identification and Minimization

- Determine why the problem exists and whether these solids should be in the waste stream?
- River silt ==> Cooling water inleakage.
- Resin fines ==> Backwash and loading operations, equipment malfunctions, inadequate filtration/separation.
- Cement, dirt, weld slag, metal filings, etc. ==> Maintenance procedures and housekeeping practices.
- Microbes ==> Inadequate flow (stagnation), chemical additives, oil/organic intrusion.

Engineering Design

- Minimize areas of concentration (e.g., crud traps).
- Ensure recirculation capabilities.
- Ensure easy access for cleaning.
- Include planned settling and/or solids removal in system design (phase separators, weirs in sumps, bag filters, etc.).
- Include proper filter micron sizes.
- Install catch screens over drains.

System Operations

- Ensure equipment is operating properly (URC units, etc.).
- Ensure procedural compliance during bed loading and backwashing.
- Ensure adequate settling times for phase separators.
- Maintain proper flow during tank recirculation, resin transfers, etc.

Maintenance & Housekeeping

- Restrict sweeping into floor drains.
- Sweep before washing down.
- Cover drains during maintenance (if possible).
- Periodic cleaning of catch screens.
- Keep plant clean and free of debris.

3525

What parameters are measured in waste collector and monitor tanks?

In equipment drain collector tanks, few parameters are typically measured. However, for long-term performance trending and diagnostics, the following should be measured and recorded on a collection tank batch basis:

- Conductivity
- TOC
- Turbidity
- Gross Activity

In equipment drain sample tanks or monitor tanks, the following typically are measured:

- Conductivity
- TOC
- Silica
- Gross activity
- Chlorides

In floor drain collection tanks, the following parameters typically are measured:

- Conductivity
- TOC
- Turbidity
- Gross activity

In the floor drain sample tanks that are not recycled for re-use in the plant, the following typically are measured:

- pH
- Total Suspended Solids
- Radionuclide concentrations
- Conductivity

In the floor drain sample tanks that are recycled to the plant for re-use, the following parameters typically are measured:

- Conductivity
- Chlorides
- TOC
- Gross Activity
- Silica

3526

What is used to verify sludge levels in phase separators and containers?

In phase separators, the most successful devices being used to detect sludge levels are the thermal conductivity probes. The probes are calibrated for the thermal attenuation of the media surrounding the probe (e.g., air, water, sludge, etc.). In several nuclear plant applications, they have performed reliably and reasonably trouble free.

One disadvantage of these devices is that they are a single point measurement and not continuous like a differential pressure level instrument. This characteristic leads to multiple probes and higher cost for the instrumentation.

For disposal containers, visual observation using TV cameras and remote monitors is the most common method for monitoring sludge levels in disposal containers. Sonar devices were used in earlier designs, but they require that the probe be submerged in water to effectively detect the sludge level. Also, there were difficulties in keeping the probes clean during container filling operations.

SECTION IV

(3600 SERIES QUESTIONS)

HANDLING SOLID WET WASTE

Section IV Contents

Handling Solid Wet Waste

Item Topical Description **Item Number**

Operating Systems so as to Minimize Waste Generation

Processing and Transferring Solid Wet Waste

Listing of Illustrations

Illustration Topical Description **Figure Number**

3601

What is meant by zero release?

In its broader sense, zero release means that the nuclear plant would allow no radioactive effluents to be released into the environment. In reality, this can be approached but never fully realized, because of the virtual impossibility of containing gaseous effluents.

More specifically, the term zero release is applied to those plants that are designed to release no liquid effluents. Zero release of liquid effluents is being practiced by only a few nuclear plants in the U.S.

The release of radioactive materials in gaseous effluents can be minimized by:

- Allowing for greater decay of radioactive gases prior to release.
- Operating with high integrity fuel.
- Operating with minimum gaseous and steam leaks.
- Minimizing plant contamination levels, especially airborne contamination.

3602

How do you determine the preferred release mechanism of a radionuclide (gas, liquid, or solid)?

The form of a release of radioactivity is dependent primarily upon economics. It would be prohibitively expensive to discard a gas stripping/gas decay system in favor of an immediate liquid solidification system. Radwaste forms are based on the natural occurring physical processes that take place to help in a reduction of the volume.

As an example, consider tritium. 10CFR20 allows tritium to be released into the environment *provided the concentration is below 10CFR20 MPC limits for free release and the release is monitored.* Liquid radioactive waste systems are unable to remove tritium effectively, as its physical characteristics are essentially identical to nonradioactive water. Consequently, it is released into the environment in the form it is produced, either as a vapor (as a result of evaporation) or as a liquid (as a result of resin processes). Thus, the preferred choice for release of this radioisotope would depend on the mechanism used to treat the liquid process stream.

Noble gases usually have short half lives and are stored for decay. On the other hand, if they are not stripped out from the liquid prior to processing, then the total isotopic concentration of the waste form would be higher, thereby causing additional disposal site charges for curie content.

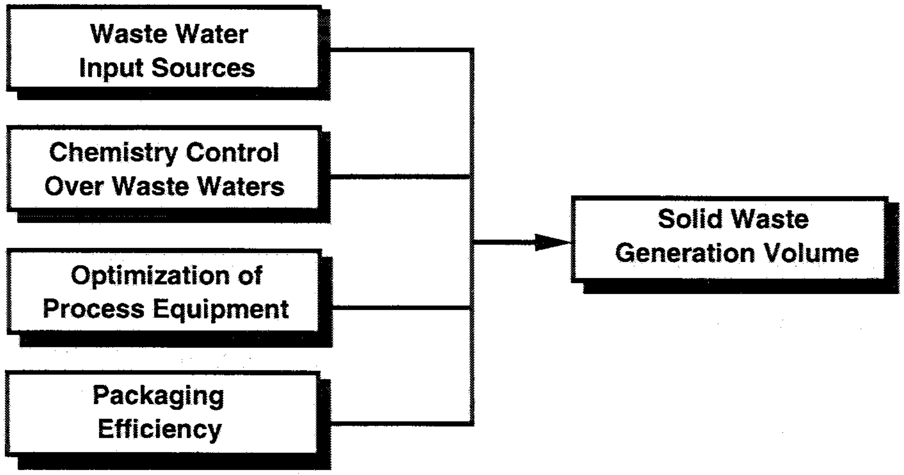
Activation products and other particulates will be trapped by filter clean up systems. The amount of time invested in cleaning up water within a plant waste system depends on the mixing ratio assumed for the discharge canal and the release limits established in the environmental Tech Specs. The cleaner the release, the more rapid the depletion of the resins, or the longer the run on the evaporator. The economics for determining when the cleaning is no longer cost effective is determined on a plant by plant basis.

3603

What are the key factors that control solid wet waste generation?

Independent of the final processed waste form for liquid waste, the volume of wet waste (i.e., resins, filters) generated and packaged for disposal is directly dependent on the following:

Figure 3603
Keys to Solid Wet Waste Generation



1. Minimization of waste water input sources. This may include, but not be limited to, restrictions on usage by operations and maintenance whenever possible. A systematic analysis of all input sources should be performed on all liquid allowed into the waste stream to determine which are not essential or are inadvertent.

2. Chemistry control over all waste waters. This will enhance volume reduction. This must include pH control, conductivity, TOC (total organic carbons), chlorides, and other corrosive products, as well as

station dependent parameters (such as chromates in a PWR). If these factors are not controlled, the processing equipment will not function properly.

3. Optimization of functioning equipment. If all equipment is not functioning properly or as designed, the system's performance will be degraded. An example of this would be the bypassing of a TOC pretreatment filter before the resin bed sees the flow.
4. Best packaging efficiency. The selection of the waste container and the processing method (e.g., dewatering, solidification) with the most efficient loading characteristics can improve volume reduction by as much as 50%.

3604

What changes can be made to radwaste processing systems without performing a 10CFR50.59 review?

The 10 CFR 50.59 review is not required for the following items:

1. Liquid Wastes:
   a. Type or manufacturer of resins.
   b. Order of resins within a system's lineup.
   c. Substitution of charcoal for resins or resins for charcoal.
   d. Length of processing run.
   e. Type or order of pretreatment.
   f. Adjustments of temperature (provided that they are within the design basis).
   g. Adjustment of pH (provided that it is within the design basis).
   h. Operational dose rate limits.
   i. The addition of extra filtration or changes in the filter pore size.
2. Solid Wastes:
   a. The order of procedural steps.
   b. Ventilation discharge pore size or design modifications.
   c. Compactor pressure.
   d. Operational software changes.

3605

Can radwaste changes be made without a Reg. Guide 1.143 review?

Regulatory Guide 1.143 references the requirements for performing a 10CFR50.59 safety review. The same requirements that exist for a 50.59 report are found in a Regulatory Guide 1.143.

3606

When and how should wet waste pH adjustments be made?

For best volume reduction, pH adjustments should be done prior to processing the wet waste. Most radwaste systems based on evaporators will tend to become acidic, especially in PWRs. The adjustment can be made during or before processing, and the final product will be at the required pH. The most frequently used chemical to neutralize the pH is sodium hydroxide (NaOH).

Adjusting the pH *after* processing *will increase the volume of waste.* This is usually done for electropolisher waste or other extreme pH waste.

CAUTION: *Care must be used when adjusting a pH that is below 3 or above 11. Large quantities of opposite pH or large changes can cause a chemical explosion.*

3607

What temporary actions can be taken to reduce water temperature prior to LRW processing?

1. The liquids coming down for process may be as high as 200°F. If this is a problem, then a heat exchange system may be necessary. Waste can be cooled with station component cooling water, or station system water.
2. If holding tank space is available, letting the water go to a spare chemical control tank may suffice, and allow natural cooling to take place. The chemical holding tank, usually large, is a part of plant CVCS (Chemical and Volume Control System) line up. Operations approval, a safety analysis and procedural changes may be needed.
3. If a small amount of water is involved, leaving the liquid in the pipes for a short while will eventually lead to cooler water provided the solids don't fall out of solution.

3608

When do you use, feed or bleed the deborating deionization system?

For all purposes, feed and bleed is the process of adding a volume of water free of boron (e.g., deionized water) to replace borated water on a volume for volume basis. Near the end of the fuel cycle, massive amounts of water are required to dilute the low boron concentration to even lower concentrations.

The deborating ion exchanger can be placed in service on the purification flow to remove boron quickly and, once removed, the boron cannot be recycled. The deborating ion exchanger also will saturate quickly at levels of 200 ppm and above at a rate of 40 - 60 gpm. Consequently, adjustments of boron in the primary system is done on a large scale by using feed and bleed for concentrations greater than 150-200 ppm boron and by ion exchange at concentrations below 200 ppm.

3609

What contingency plans should be available for excessive inadvertent leakage?

Immediate action plans would require the use of extra storage tanks (assuming the water all goes to a drain leading to a waste collection system) such as found in the plant chemical and volume control system (CVCS). If these are not available, several manufacturers make inflatable storage tanks. Caution must be exercised in that the dose rate on these inflatable containers is difficult to control. Manufacturers of tanks can be found in the Nuclear Digest Magazine.

If time allows, contracting with a liquid processing vendor is the next step. Portable demineralizers are available from several vendors.

3610

What methods can be used to clean sumps?

The easiest and most dose effective method is to wash down the slurry with a steam jenny or a high pressure hydrolazer. The slurry sludge is removed from the walls, pipes, etc., and collects on the floor. This can be removed remotely using long handled tools or by putting plastic suited workers in the sump with air movers and/or SCBAs (self-contained breathing apparatus).

Note: A sump is a confined space. Hence the need for air movers and/or SCBAs.

3611

How is sump sludge processed?

Once the sludge and crud is off the walls or components, a wet vacuum is used to pick up the activity and store into a container. (If large quantities, a shovel and bucket may be needed.) This container should be shielded. It is important to continue to monitor the dose rate in the container (vacuum tank) due to the fact that, as the sludge accumulates in the container, the dose rate will go up rapidly.

Sump sludge can be processed in two ways: either through direct solidification or by mixing with resins.

1. Direct Solidification
   - a. Requires a process control program (PCP).
   - b. Water and a binder must be added. Therefore, the waste volume is increased and processing efficiency is reduced.
   - c. Unless much dilution takes place, some sludge (e.g., containment sludge) may exceed Class A transuranic concentration limits. (Most sludge is Class A and does not require stability. However, specific disposal site licenses may require solidification.)
2. Mixing with resins:
   - a. Usually does not require a PCP.
   - b. If the sludge is placed into the liner first, there is good mixing when the resin is added.
   - c. Creates no additional volume to process.
   - d. May violate some disposal site licenses.

3612

How do you blend sludges with resin to ensure 10CFR61 compliance?

Resin sludges typically are blended in phase separators or spent resin tanks prior to transferring the solid waste to a liner for dewatering. Often, resins and sludges from two different sources may be added to the same liner. However, in this latter case, the mixing capability usually is not adequate to ensure complete blending.

3613

What are the effects of oil on liquid processing media?

If organics (oil) enter the RCS, the long chained molecules eventually will decompose. If the molecules aren't broken apart, then they will plug resin and filters, reducing their operating efficiency and capability. If the carbons come in contact with evaporator heating systems, they will char instead of evaporate, thereby causing a loss of system efficiency due to heat loss.

3614

What non-standard LRW processing technology might be feasible?

Both reverse osmosis (R/O) And ultra-filtration (UF) have been available for a number of years. The Electric Power Research Institute (EPRI) has sponsored and published reports on both of these units. Both have experienced reliability problems—in particular, the clogging of the filter membranes and eventual loss of pressure through the system, which has lead to further problems.

3615

What are the advantages and disadvantages of multiple cross-tie connections?

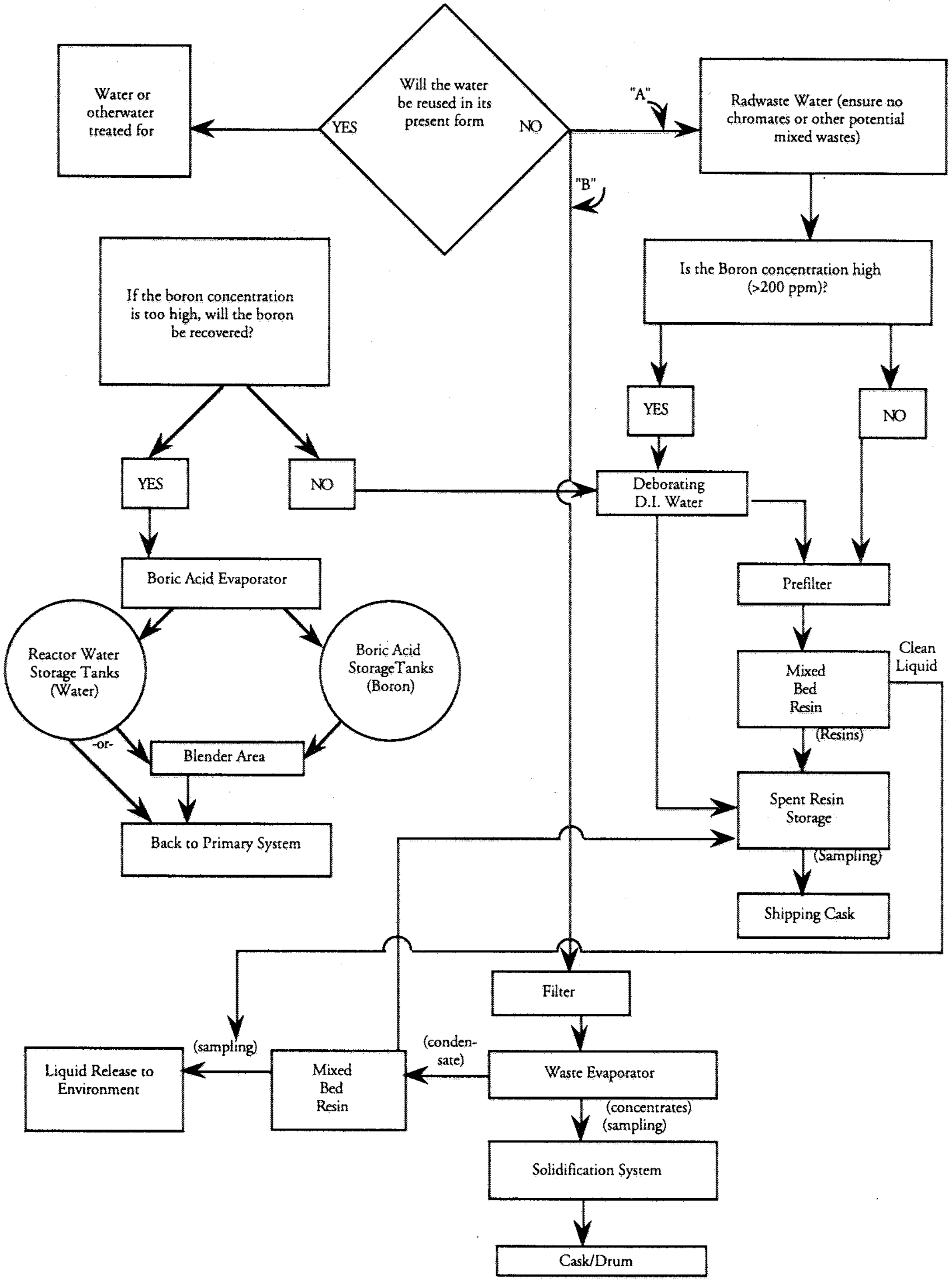
Advantages:

1. Allows the operation of two or more systems simultaneously.
2. Allows flexibility in the system line up, thereby allowing a more efficient processing capability.

Disadvantages:

1. Strong potential for a misalignment of a system.
2. The potential for leaks is increased when additional lines, valves, etc. are added to the system.
3. The potential for hot spots will increase.
4. There will be an increase in system maintenance.

Figure 3616
Flow Diagram for Liquid Radwaste Processing Options



3616

Flow diagram for liquid radwaste processing options.

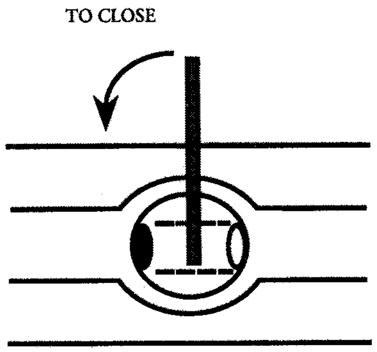
See Figure 3616 on facing page.

3617

What types of valves should be used in radwaste processing systems?

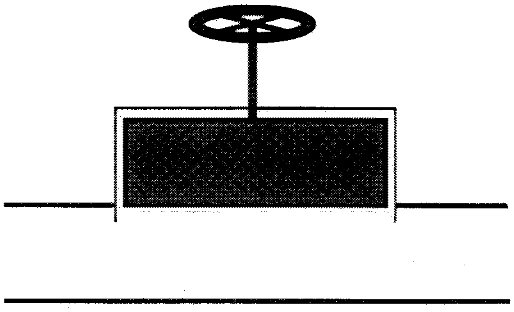
1. A ball valve is very effective in radwaste processing systems, as it rotates shut and has no sealing surface. Top-entry ball valves can be repaired without sludge leakage when the stem is oriented up (vertically). So-called "swing-out" ball valves can have the body bolts tightened as the seat wear so as to extend seat life.

Figure 3617-1
Ball Valve



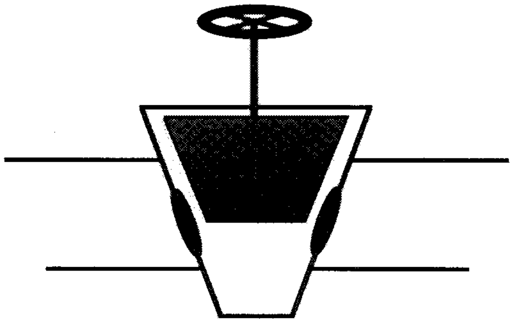
2. A plug valve is simple, easily maintained, and very good for slurries. Plug valves are more difficult to operate than ball valves and are more difficult to repair.

Figure 3617-2
Plug Valve



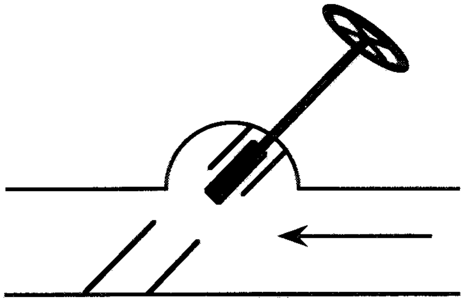
3. A gate valve is good for liquids, but not slurries. It allows liquids to pass from both directions. (The pressure of the water is actually completing the seal.) A gate valve is not recommended for slurries, as the slurries have many places to concentrate, thereby affecting operations and increasing dose rates.

Figure 3617-3
Gate Valve



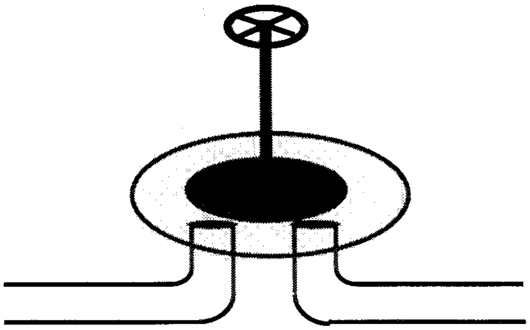
4. A globe valve is used to throttle liquids. Water is allowed to pass through in only one direction. As with gate valves (and for the same reasons), a globe valve is not recommended for slurries.

Figure 3617-4
Globe Valve



5. Diaphragm valves were routinely installed in many plants for liquid and slurry service. However, they have not been successful in radwaste processing systems. This is because diaphragm valves cannot withstand hydro's and suffer frequent bonnet leaks. Moreover, they are often overtorqued by operators, thereby cutting the diaphragm. Another drawback is that the diaphragms have a limited shelf life and must be replaced during the life of the valve.

Figure 3617-5
Diaphragm Valve



3618

What types of slurry pumps are in use?

A slurry pump must move liquid and sludge quickly without causing cavitation of the pump, thereby jamming the operation during transfer. The pumps that accomplish this most effectively are:

Diaphragm Pump

Advantages: This type of pump moves resin and other slurry through suction and will not cavitate easily. The system is easy to operate and inexpensive to purchase and maintain.

Disadvantage: Diaphragms will gradually wear out, requiring the pump to be rebuilt. When the diaphragms are worn out, they will not have sufficient suction to pull and transfer the slurry.

Open Impeller Pump

Advantages: Impeller pumps move liquid and sludge quickly by means of positive pressure. There are few moving parts, minimizing wear and equipment break down.

Disadvantage: The impeller pump will accept only distributed solids; clumps will cause the pump to jam. Excessive solids also will jam the pump.

Progressive Cavity Pump

Advantages: This pump is ideal for slurries and sludges, although sufficient suction head or priming is required.

Disadvantage: Large size needed to move large volumes.

Peristaltic Pump

Theory of operation: This type of pump is relatively new to the nuclear industry. It also is a suction type of pump with typical flow rates of 30-40 gpm. It differs from all other types of pumps in that the liquid or other pumped material never comes in contact with any pump internal components. Instead, the pump rotating members roll across a section of transfer hose, thereby squeezing the slurry out of the line in a specific direction of flow. The vacated hose creates a vacuum, thereby drawing more slurry into the transfer hose.

Advantages: With no internally contaminated parts, it is easy to recover for use outside of contaminated areas. Since liquid does not come in contact with pump internals, there is less wear and corrosion, translating to a significantly longer operating life. The internal slurry transfer hose is easily replaced if contaminated or worn. This type of pump easily transfers solids and concentrates.

Disadvantage: Relatively high cost (as much as three times the cost of most waste slurry pumps).

3619

What precautions should be taken prior to transferring liquid radwaste or resins through temporary hoses?

All temporary hoses must have a pressure rating that must not be purposely exceeded. However, blockages in the system may cause the pressure to be exceeded inadvertently. Consequently, any temporary addition must be evaluated as a plant safety concern through the On Site Review Committee.

During installation, all connections must be made as leak-proof as possible. Testing the line with clean water also is important. This is done by dead heading one end of the transfer hose and applying water to pressurize the line. All connections must be inspected under pressure. If leaks occur, the location of the leak must be disassembled, dried, prepared again, reassembled and retested.

Some plants run their pressure-tested temporary transfer lines through sealed PVC piping. This is an excellent mechanism for controlling liquids from minor transfer line leaks or sprays. Others require all connections to be bagged in plastic bags.

In addition, proper radiological controls must be planned and implemented, including a complete ALARA review. It will almost always be necessary to post the transfer line for the radiological hazard (possibly as a high radiation area), and it may be necessary to shield the transfer line. When shielding is applied, care should be taken not to collapse the line. (This is where the PVC pipe outer casing can be of assistance.)

3620

What types of resin tank mixers are in use?

The objective of resin tank mixers is to uniformly mix the resins and distribute the concentrations of radioactive contaminants. This, essentially, distributes/dilutes the dose rates to a more uniform field. The three types of mixers most commonly used are:

Shear/Propeller Mixer

Advantages: This type of mixer achieves uniform mixing through out most of tank. No additional liquid waste is created during mixing, although some additional liquid is needed only to wash down the mixing blades.

Disadvantages: Shear/propeller mixers are subject to breaking. It is almost impossible to repair the portion inside the resin tank due to high exposure rates. It will mix out a hole in the center of the resins, leaving the remainder on the sides of the tank.

Liquid Sparging Mixers

Advantages: These are simple and reliable to operate. With few moving parts, maintenance down time is minimized.

Disadvantages: The mixing nozzles used in the sparger are prone to plugging, mainly from foreign debris in the resin/slurry mixture. They also may plug with resins if the proper resin-water ratio is not maintained. They also require additional water during the mixing process and, therefore, create additional liquid waste.

Air Sparging Mixer

Advantages: These generate no additional liquid waste.

Disadvantages: This type of mixer may not provide good mixing if there is insufficient sparge surface area.

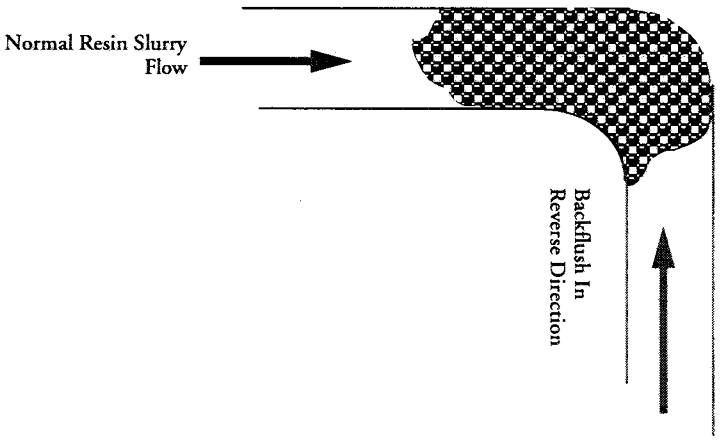
3621

What are my options in addressing a resin plug in a line or a vessel?

Line Plug

Resin plugs can occur at any location in a line if there is not enough water mixed with the resin during transfer. A 7-ft/sec minimum slurry velocity is needed to ensure that the resin stays in separation. Should a resin plug occur, immediately stop the resin transfer and backflush the unplugged portion of the line to the spent resin storage tanks.

Figure 3621
Clearing a Plugged Resin Transfer Line



Add additional water to hydrate the plug. *Do not force it*, as the plug will become more dense if pressured and increase the difficulty of its removal. Once the plug is hydrated, backflush with water. This will remove some of resins that contacted the outer surface of the transfer line. Repeat this process until enough resin is removed to allow the plug to break down and be flushed to the spent resin tank.

If the plug is rigidly held in place and the above procedure fails to remove it, then it may be necessary to hydrolase the plug. This is accomplished by sending the hydolaser into the line until it contacts the plug, where it is then hydrolased free. *Caution must be taken to prevent a backsurge of resin and water through the hydrolasing access point of the piping system.*

If hydrolazing still fails to remove the plug, it will usually be necessary to cut out and replace the affected piping section.

Vessel Plug

Resin plugs do not occur in a vessel where enough water is available to keep the resin suspended. If the water has been removed and the resins has dried, then the addition and agitation of water will free the resin.

3622

How can I remove previously dried resin from a liner?

If a batch of resin has been dewatered and, for some reason, it needs to be repackaged (e.g., dose rates are too high or disposal class limits are exceeded), it can be removed easily from a liner. Using the following method, it is common for an entire liner to be emptied of resin with little exposure and minimal chance of spill.

The first step in the process involves rehydration of the resin. Add water until the resin/water level is at the top of the liner.

Next, lower a suction line (typically a 1/2" PVC pipe connected to a flexible hose) into the liner and sluice the resin (suck it out in a resin/water mixture). Use a diaphragm pump or a peristaltic pump to transfer the resin from the top of the liner to a second liner. Much of the water will be reabsorbed by the resins, so additional water must be added to keep the resins in suspension. (Add the water in the vicinity of the suction line for best results.)

> *Note 1:* *It is important to maintain a solids to water ratio with not more than 50% solids. Otherwise, the suction line could plug.*

> *Note 2:* *Although this is a relatively simple procedure, it is not without its potential problems, such as transfer line blockage or radioactive hot spots. If this is a new process for a specific plant, a review should of the process should be undertaken by the On Site Review Committee. In addition, a procedure should be written and followed, and a complete ALARA review should be accomplished.*

If the resin had been dewatered and allowed to sit (perhaps in storage) for some time, it could be "caked" in the bottom of the container. In this case, flooding the resin cake with water alone may not be enough to release the resin into a slurry state. Instead, some type of a mechanical action is necessary to break up the cake. This could be a series of water jets surrounding the suction pipe. It also could be a mixer in combination with a water jet attached to a suction line or any combination that will prove effective.

> *Note 1:* *Remote operation of this type of nonstandard tooling is sometimes difficult but helpful in keeping exposure down.*

Note2: It is likely that none of the above remedial actions will be in compliance with standard procedures. Therefore, a special procedure must be developed, including an ALARA review and, potentially, a review by the On Site Review Commit-

SECTION V

(3700 SERIES QUESTIONS)

DEWATERING AND SOLIDIFICATION OF WET WASTES

Section V Contents

Dewatering and Solidification of Wet Wastes

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Dewatering Wet Wastes

Solidification of Wet Wastes

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Illustration Topical Description **Figure Number**

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3701

What is meant by "dewatering" of wet waste?

Dewatering wet waste in radwaste applications can be defined as: "The removal of interstitial water trapped between solids, which could potentially drain so as to exceed the regulatory requirements of the disposal facility accepting the waste." The process of dewatering includes several stages:

1. Transfer of wet waste (slurry) to a dewatering container
2. Removal of excess water back to the storage tank (simultaneous with slurry transfer to the container). This is sometimes not as easy as it seems, since the retention of solids in the container depends on the particle size, physical nature of the solids, type and size filter, flow rates, and solids content in the slurry. The best approach is to remove as much water as possible while it is being pumped into the container (i.e., don't let it sit until later).
3. Removal of interstitial water by:
    a. Passing air through the bed, forcing the water down to a collection/removal header.
    b. Squeezing the water with a liner compression bag, blowing air in the intraliner cavity and pumping water from the cake as it is being "produced."
    c. Forcing hot air through the bed, thereby enhancing the mechanical withdrawal with some degree of localized evaporation off the waste.

3702

What general considerations apply to waste dewatering:

Some of the considerations, regardless of the method, are:

1. Minimize radiation exposure.
2. Ensure compliance with "free water" requirements for disposal.
3. Plan and maintain an ability to recover from failure conditions
4. Ensure that the dewatering equipment has the ability to retain "fines" in the disposal container and not return them to the plant waste tanks

5. Ensure that there are sufficient and accurate dewatering system alarms, level indicators, and safeguards.

6. Ensure there is adequate space for the equipment, including sufficient control console separation distance to minimize operator exposure.

3703

What factors adversely affect dewatering?

The factors that can adversely affect the dewatering capability of a given media are:

- Oil and grease
- Biological growth
- Chemical make-up (Some hydroxides are slimy and retain more water-plugging filters).

3704

What are the effects of nitrates on dewatered resins?

Nitrates and, in particular, nitric acid are strong oxidizing agents that can attack the organic based ion exchange resins. This reaction is exothermic and could lead to large heat generation, offgasing, and steam generation. Care should be exercised to preclude nitric acid from depositing on ion exchange resins.

3705

How do I respond to an exothermic reaction?

The immediate action that should follow the identification of a liner heating up is to flood it with water. This provides a heat sink to slow the reaction causing the exotherm.

As the temperature goes down, be sure to cover the resin and keep it vented. This will keep the resin in a stable condition allowing for an investigation and remedial action.

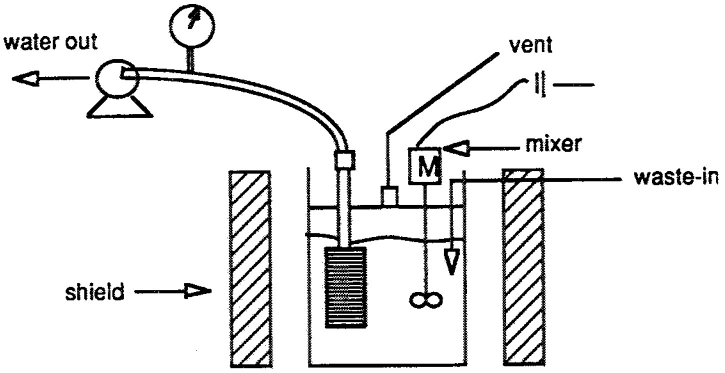
3706

What is filter "blinding" in a dewatering liner?

Blinding refers to the plugging of liner filters or underdrain laterals. Underdrain laterals lie on the bottom of the liner to pull water down through the resin bed. The blinding of filters and/or underdrain laterals is a result of poor compatibility between the solids being filtered and the filters themselves.

To increase the level of assurance that certain waste streams will not blind an underdrain lateral, a test should be conducted in a small container, such as a 55-gallon drum, using the same filter or lateral as will be used in the large container. Consider the following illustration:

Figure 3706
Small Scale Testing of Solids to Filter Compatibility



Continuous pumping through the filter in an arrangement similar to that in the above illustration should provide sufficient information to evaluate the volume of waste feed that can be filtered before blinding. A linear relationship can determine the minimum number of filters needed to assure complete processing of a certain volume of waste (volume as measured in the storage tank). Outside of performing a test similar to the one above, the risk of making the wrong assumption increases significantly.

3707

How do you perform a comparison evaluation of dewatering system technologies?

It is, at best, awkward to have all the major vendors lined up at your facility demonstrating their dewatering systems. However, much information can be learned by reading their operating manuals and procedures. Most vendors will send unofficial copies of these for utilities to review. What to look for:

1. What is the configuration of the dewatering filters? For bead resins, a filter mat on the vertical walls and floors of the liner has been shown to be an acceptable configuration. For powdered resins and sludges, a filter "tree" is likely to be required to obtain the additional necessary filter area for the low porosity sludge material.

2. Does the system recommend a "fill head" for all operations, or only when high levels of activity are expected? It may be simpler to operate without a fill head for low activity liners.

3. Is the fill head, when required, easy to install and remove? (A first time user may wish to travel to another utility to observe this part of the job if they have not used it before. This can be a dose-intensive process.)

4. Does the fill head have a camera and a separate level detector? What is the level detector's capacitance?

5. What type of dewatering pump is used? What are its operating characteristics? Will it easily cavitate or require constant vigilance?

6. What is the duration of the dewatering process (i.e., how long does it take to achieve the desired moisture end point)?

7. How is the completion of the dewatering process verified, and how has this compared with the quality control verification studies performed by the vendor?

3708

What are the advantages of different liner underdrain designs?

When evaluating HICs, from a generic point of view, the areas to be examined are:

1. Acceptance by the disposal facility.

2. Approval by the NRC.

3. Ratio of liner capacity to disposal volume.
4. Price and availability.
5. Storage requirements and restrictions.
6. Special handling requirements (closure tools, lifting bails, etc.), including disposal site handling requirements.
7. Vents (in container or lid).
8. Waste inspection ports.

Depending on the design and the construction material of the HIC, the type of internals and/or underdrains will vary:

1. HICs made of a plastic material, such as polyethylene, can be fitted with a variety of internals in numerous configurations. Each is designed to retain the solid component of the waste while allowing the air and water through. Also, the number of pipes or elements can be designed to distribute the flow evenly, thereby avoiding "channeling".
2. When HICs are made of metal, welding internals components provides an added margin of safety with respect to structural integrity. Also, the controversial use of a bottom plug is an option. This is used for free water verification purposes.

3709

What action can be taken if the HIC underdrain is plugged?

If a HIC underdrain lateral is plugged, as indicated by the pressure indicator in the suction side of the pump, several alternatives exist, depending on the configuration of the internals and the reason for plugging.

If the plugging is caused by fines, or by gelatinous materials, *and* the connection between fittings and filter elements is *strong,* the flow can be reversed or air can be injected to partially unplug some filters. This assumes that the plugged lateral can be isolated from the rest of the internals. Even if this were possible, the nature of the waste itself has not been changed, and, therefore, it will most likely cause similar plugging if processing is resumed.

The recommended course of action would be to sluice the contents of the HIC into another HIC equipped with a suitable set of filters. If this is not feasible, the plugged set of laterals could be isolated (or disconnected) and dewatering resumed with other laterals for a longer period of time.

> *Note:* *This automatically voids the correlation to the dewater test report, and physical verification is usually required prior to shipping.*

Should all of the above prove ineffective, an alternate treatment process, such as solidification, should be considered.

3710

What should be examined on waste liner internals?

As a general rule, when evaluating internals, the areas to be examined are:

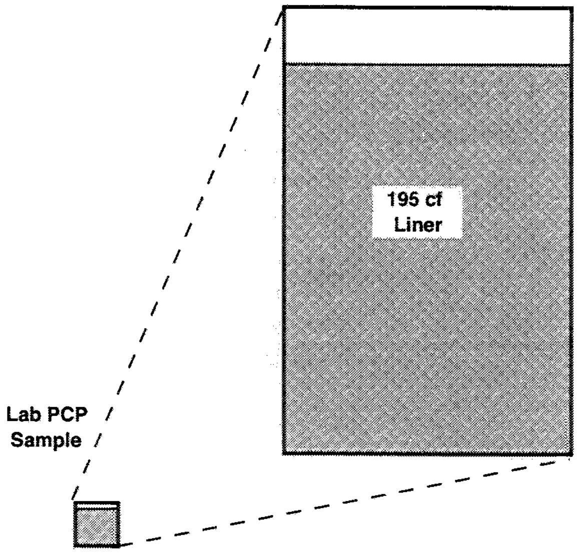
1. The ability to support its own weight and the weight of the waste cake above it.
2. The ability to maintain a seal between the fittings and the filter element(s).
3. The ability to reach the sides and bottom of the container.
4. The ability to maintain its own structure while in transport.
5. The ability to isolate individual levels of internals in the event of localized failure.
6. The extra dewatering elements needed to recover from upset conditions.

3711

How do you verify that the process scale up of a dewatering test is accurate?

Every container and its internals needs to be "qualified" to meet the dewatering requirements by using a dewatering procedure. This is done for every major category of waste: bead resin, powdered resin, charcoal, sludge, etc.

Figure 3711
Scale-Up of Laboratory Test Sample



The procedure by which these wastes are dewatered is derived by a dewater test report. The test consists of a number of steps where data are taken and later analyzed. The data will reflect different characteristics of the media at certain stages, in the dewatering process. Some of these parameters are:

1. The relative humidity of the air into and out of container.

2. The amount of water collected per unit time.

3. The water contents of a sample of media taken from different places in the container.

All of these data are normally plotted and compared time after time for repeatability. When a reasonable number of repetitions yields a consistent dewatering time, that value (in hours) is taken as the minimum dewatering time. Then, a safety margin is added to allow for physical variations in the waste stream.

In order to verify the effectiveness of a dewatering procedure, qualified under certain conditions, the first document to examine is the report and the conditions for testing as well as the "waste" used. If those assumptions and conditions seem reasonable, then the spread of the test data is analyzed with respect to the extra dewatering time allowance taken as a safety margin. Next, a number of random samples (of air or media if possible) are taken, and their analyses are compared to the curves at equivalent times or stages.

All the above comparisons and evaluations are still not **absolute**. They only provide a relative "fit" with the previous testing. The reasons for this should be fairly obvious. The radiological procedures normally will find that any direct measurements *not* acceptable unless the radiation levels are low enough to allow for the sporadic exercise of reaching inside a dewatered liner to take samples.

There are some containers equipped with probes which detect the presence of concentrations of water vapor. These can be fairly accurate, but they do not replace the need for test sampling and analysis.

3712

What can be done to improve packaging efficiency of dewatered powdered resin?

Dewatered powdered resin still contains about 60% water by weight. However, most of that water is retained by the micropores of the resin itself, and some is also adhered to its surface. In the case of powdered resin, this is significantly more water than for bead resin.

In order to reduce the resin volume, some or all of the entrained water would have to be removed. This not only is difficult but it also is undesirable. In the assumption of being able to reduce the dewatered resin volume by 10% by removing some of the water, the "shrunken" resin is liable to expand again if ever in contact with water (or high humidity air).

The practical aspects of packaging efficiency center around two issues:

1. Removing the water from the slurry as fast as it is pumped into the container, therefore making a "solid" cake from the bottom up. The opposite of this introduces many air pockets and increases the degree of complexity of the equipment. In the latter case, the equipment would require a by-pass line while the water is being removed from the container.
2. The physical configuration of the container itself. Hemispherical tops and/or conical bottoms introduce poor efficiency factors. By contrast, flat tops and bottoms improve the ratio of capacity (usable volume) to disposal volume.

3713

What are the approved solidification media?

Solidification of wet waste can be performed using the following approved processes:

1. Cement
2. Asphalt (Bitumen)
3. Polymers

Within the above categories, there are many variations that are sometimes tailored to the specific waste stream and/or the system being used. It is largely because of this wide variety of equipment and solidification media/binders that the NRC requires each plant to qualify its solidification process under a process control program (PCP).

The most widely used method is **cement** solidification. Within cement types, Portland cement is by far the choice of most plants and/or vendors. Portland cement is used as the binding agent. Modifiers and setting accelerators or retardants are also used in the solidification process to accommodate the differences in chemical characteristics of the various waste streams.

For example, in solidifying boric acid concentrates—a rarity these days—lime and sodium sulfate are used to overcome the buffering effect of boric acid and bring the pH of the mixture to 11 or greater. On the other hand, in solidifying any resin mixture which contains partially depleted, strong anion resin, the addition of boric acid as a retardant can allow enough time for thorough mixing of the waste and binder before a pH of 11 is reached. At this point, the viscosity of the mixture increases significantly.

When the **asphalt** or **polymer** processes are used, the chemical characteristics of the waste are not as important, since there is no intended chemical reaction between the waste and the binder. Instead, these two solidification processes involve a physical micro-encapsulation of the waste.

3714

What are the advantages of the different solidification technologies?

At present, there are only three solidification agents that have been approved by the NRC for stabilizing waste:

- Cement
- Asphalt (bitumen)
- Polymers

All three are being used to solidify waste. However, there are some uncertainties associated with each, and there are advantages and disadvantages associated with each.

Table 3714
Comparison of Solidification Technologies

	Cement	Asphalt	Polymers
Basic Solidification Mechanism	Chemical reaction required in a complex hydrating process. Chemicals in waste may interfere with the reaction.	Asphalt material freezes upon cooling, thereby encapsulating the waste materials. Water is driven off.	Chemical reaction in the polymerization step. Chemicals in waste could accelerate or retard the reaction.
Waste to binder ratio	Ratios have been high, but problems have been experienced with poor compressive strength. Incomplete reactions have forced lower loadings.	Moderate to high waste loadings are being achieved. However, they must be kept low for resins to prevent swelling on immersion in water.	Moderate to high waste loadings are achieved. Problems with resin swelling at high loadings have *not* been reported.
Volumetric Effects	There is a volume increase over the volume of waste being solidified that ranges from 50% to 100%.	For resins, there essentially will be no volume change. For evaporator bottoms, there may be a decrease of 40%-60%.	For resins, there will be no volumetric change. For liquids, their will be a volumetric change.
Process Complexity	The chemical reactions in the cement can be complex, depending on the waste being solidified.	The process is primarily a thermal process, where the asphalt and waste are mixed together.	The polymer and waste are required to be mixed together. Also, a hardener is required.
Equipment Complexity	Usually, in-liner mixing devices are used to eliminate the difficulties in cleaning a mixing device. Also has waste metering problems.	Usually requires a mixing device, such as an extruder or wiped film evaporator.	To date, most solidifications are done in-container
Product Durability	There are concerns with the long-term durability of cement waste. Also, the cement is subject to sulfate attack.	Very durable, but questions have been raised regarding biodegradation.	Very durable, with few problems identified to date.

3715

What should be considered in selecting a solidification technology?

In selecting a solidification technology, the following should be considered:

1. **Acceptance by disposal site:** At the time of disposal, will the waste form be acceptable at the for disposal at the intended disposal site?
2. **Waste to binder ratio:** This will vary between waste forms, so no definitive quantitative values can be listed here.
3. **Cost effectiveness:** If the waste to binder ratios are similar, then total cost and replacement parts must be considered.
4. **Complexity of equipment and operation:** Some technologies are more complex than others, and operators will require training. A very complex system can be tolerated if it is much more effective than a simpler technology. If it is not more effective, then the simpler system should normally be selected.
5. **Waste characteristics**: Are the waste stream chemical properties known? Are they compatible with the solidification agent? Do the chemical properties vary widely?
6. **Ease of installation:** A complex connection to the waste system may encourage leaks to occur. Also, if special power or facility requirements exist, installation costs can climb very quickly.

3716

What documentation should you require from a solidification vendor?

The following documents should be requested for evaluation purposes:

1. A Topical Report which must have been filed with the NRC. This must cover, either generically or specifically, the waste forms which are to be solidified on site.
2. A controlled copy of the process control procedure (PCP) to be performed on site with real waste and the expected results of each of the tests to be performed.
3. A copy of the procedure used in the full scale solidification that validates the PCP being proposed. This should include all the results from the tests performed on the full scale solidification and their correlation with the PCP results for the same waste forms.

4. A control copy of the operating procedure to be used on full scale solidifications. An evaluation should be made of how well this procedure correlates to the full scale solidification procedure in the preceding paragraph.

3717

What is meant by "solidification performance"?

Let's begin by defining performance as it relates to the solidification of wet waste. A solidification method's performance can be related to:

1. Its ability to successfully immobilize the wet waste. (This refers to the ability of the solidified waste form to satisfy both the disposal site criteria for the particular waste class and the federal and state regulations governing the same waste class.)

2. The effective volume increase performed. (This will be measured most accurately by using the ratio of the individual volumes of the waste and binder to the combined waste/binder volume.)

Others factors—such as availability, reliability, safety and costs—also are used to measure the performance of any solidification method. However, these are secondary to items 1 and 2 above.

3718

What performance concerns have been raised over cement solidification?

The main concerns raised with cementitious binders are related to their ability to consistently produce quality products. This concern arises when varying chemistry conditions exist in the waste that cannot be predicted by the generator. An example of this is the varying pH and/or solids content of evaporator bottoms. Another example is the different types of resins used for purification of water and which are discarded in a varying degree of exhaustion.

The variety of chemical reactions that can occur in such processes can produce uncertain results in the final product when tested against the criteria stated in the NRC's *Branch Technical Position on Waste Form.* The same plant at two different times in the fuel cycle can produce significantly different wastes on the basis of its chemical characteristics. For the cement binder to successfully solidify a given waste every time, certain adjustments may be necessary to the original solidification formula to compensate for chemical differences.

One of the compensations that has been cited by the NRC and the solidification vendors is to reduce the waste-to-cement ratio (i.e., lower waste loadings). The is expected to overcome many of the interferences between the waste and the cement hydration reaction.

Another concern with using a cement solidification agent for ion exchange resins is the potential of using too little water for the cement hydration reaction. If too little water is added to the resin/cement mixture, the cement hydration reaction will draw the necessary water from the ion exchange beads, which are 50% - 60% water in the dewatered condition. When this occurs, the resin beads will shrink. Then, after the cement has hardened, the resin beads will reabsorb water if the solid waste product is exposed to water. The resin beads expand upon reabsorbing water, causing the concrete to crack.

It has been reported that pressures of up to 5000 psi can be exerted on the surrounding concrete when the beads expand. This process begins at the external surfaces of the solid product and proceeds inward until the entire solid is cracked, whereupon it loses its integrity.

One of the stability tests provided in the NRC's *Branch Technical Position on Waste Form* is a 90-day immersion test. In this test, the bead swelling phenomenon can be evaluated. However, it is important that the immersion test be conducted after ample time has elapsed since the sample preparation to allow the concrete to cure adequately. If the immersion test is conducted too early, the hydration reaction will draw water from the immersion water and not the ion exchange beads, thus giving a false impression that swelling will not occur.

Clearly, this becomes an issue of reliability and repeatability. In contrast, different resin batches solidified by the same method at different occasions may not be equally exhausted or may not be made up of the same ratio of anion versus cation. These variations can lead to significant variations in results, unless the solidification process itself makes provisions (e.g., additives, retardants, etc.) to counter these effects in the final product.

3719

What performance concerns have been raised over asphalt solidification?

The two primary concerns that have been raised relative to asphalt (bitumen) are:

1. *The ability of the solidified product to withstand the overburden under shallow-land burial conditions without suffering deformation.* As deformation takes place, two events follow:
    a. Subsidence will occur in the trench cap, thereby allowing water to penetrate the trench.
    b. Water will be retained on top of the deformed matrix with a consequent solubilization of radioactive components in the waste. This increases migration of nuclides from the solidified waste and may have adverse consequences on the surrounding environment.
2. *Resistance to biological degradation.* For example, in the process of solidifying resin beads, a significant portion of the water content of the bead is extracted and, therefore, the bead volume is reduced accordingly. These "shrunken" beads are then surrounded by asphalt at elevated temperatures which, when cooled, provide a barrier to the resin beads.

    In shallow-land burial conditions, it is feasible to foresee some type of bacteria feeding on certain components of the asphalt. In this scenario, as the matrix degrades, resin beads can be exposed to a humid environment, and water is absorbed by the beads. The resin beads then expand to their original size, which could be up to 100% larger. This causes the matrix to further deteriorate and expose an ever larger surface area. (This expansion can be demonstrated by a prolonged immersion test—nine months versus ninety days.)

It is important to note that not all the asphalts available for solidification are as susceptible to this type of attack. Therefore, careful consideration must be given to the original asphalt properties, such as the degree of oxidation. This is a measure of how free the asphalt is of light hydrocarbons. The more oxidized the asphalt, the more resistant it is to biological degradation, and the more strength it will have on compression. It is suggested, therefore, that oxidized asphalts may provide a better matrix for long term stability when solidifying wet waste.

3720

How do I know if my waste is sufficiently stable to ship for disposal?

For disposal, Class A waste does not require a minimum compressive strength, or leach index, as long as it is labeled "unstable." On the other hand, any media capable of producing a "hard and dry" product is acceptable at all existing disposal sites.

To demonstrate the stability of a low level waste (in accordance with the NRC's *Branch Technical Position on Waste Form*), a solidification process must be qualified by a process control program (PCP) or a similar guidance in their procedure, yielding enough data to ensure long term stability. These data and the related procedure(s) are documented and submitted to the NRC for review in the form of a Topical Report.

In terms of the solidification equipment and solidification media, the Topical Report is usually submitted to the NRC for approval by the equipment manufacturer. On the other hand, the nuclear licensee develops its own in-house PCP to demonstrate compatibility of the vendor's equipment/media to the local in-plant equipment and waste.

In addition to meeting the waste form properties specified by the NRC, the NRC has recently revised the *Branch Technical Position on Waste Form* to require further compressive testing of the sample after conducting the other property tests, such as thermal cycling and water immersion. The NRC also has required that the compressive tests be repeated after a storage period to determine if the product has undergone any degradation during the storage period.

Nearly all of the variations of the three solidification process discussed herein *can* meet the requirements of lOCFR61. Yet, in some cases, those requirements are barely met or never achieved at all. This can be the result of waste-binder incompatibility, or of overextended waste to binder ratios. Moreover, this underscores the importance of testing PCP batch samples on a regular basis.

3721

What approvals are required for using a solidification method?

A solidification method can be used by a waste generator or a contractor provided this method has been acknowledged and accepted by:

1. The disposal facility;
2. The host state, if an agreement state; *or*
3. The NRC, if the host state is not an agreement state.

In practice, if a Topical Report has been submitted to and approved by the NRC, the disposal facility and the host state generally will accept it as an approved waste form. However, this may not always be the case. Either the host state or the disposal facility itself may have additional requirements that may not have been addressed in the Topical Report submitted to the NRC. If that is the case, the generator is responsible for meeting any additional criteria through its own quality assurance program or that of the contractor's.

3722

What are the technical consideration for solidifying waste?

All waste solidification processes must meet the 10CFR61 waste form requirements. If the concentration exceeds the limits set forth for Class A waste, then it must meet the structural stability criteria set forth in the branch technical position on waste form. It may also be necessary to meet additional requirements specified in the disposal facility license.

The 10CFR61 regulations and associated branch technical position for solidified waste may be acquired from the utility technical library or the USNRC.

3723

What are the minimum requirements for a PCP?

As a minimum, the PCP should include the following:

1. Identification of the waste streams to be solidified.

2. Identification of the major chemical constituents in each waste stream.

3. Identification of the range of chemical constituents in each waste stream.

4. Identification of the waste/solidification agent formulation for the solidification process.

5. Any sampling or test procedures required for each waste batch to be solidified.
6. The procedures that control the solidification process.
7. The procedures that control any affecting chemical processes.
8. Back up plans in the event of primary process system failure.
8. Tests for important chemical or radionuclide parameters that may control or affect the liquid wastes.
9. A description of the quality control (QC) processes.
10. A schematic (flow diagram) of the solidification process.
11. A general description of the plant systems that produce each waste stream.
12. Applicable transport procedures.

3724

How do you verify that the scale up of a solidification PCP is accurate?

A test container must be produced using nonradioactive chemical components. Once solidified, the test product must then be cut in half or broken up to verify a 100% thorough solidification. If this is not done, there is no way to verify the scaled up curing process.

Once the product is verified to be uniformly cured, a second test container—with the actual liquids to be solidified—must be produced. This monolith should be core bored, to also verify its center has cured properly. Once both these samples pass, small scale testing should continue on the actual runs, sampling at least 10% of the produced population. If all of these initial sample tests pass, then the rate of inspection could be decreased.

3725

What laboratory equipment is available for PCP testing?

For both solidification testing and resin efficiency testing, a variety of equipment is available through several catalogs, including The Fisher Catalog and VWR Scientific Catalog.

3726

Can I modify a vendor's PCP?

A vendor's PCP data package should include some of the variations in the waste makeup for the formulas most commonly used in the industry. This, however, does not guarantee compliance with all the possible variations that may be encountered from plant to plant, even on the same waste stream.

The NRC's Branch Technical Position on Waste Form does not allow *any* variation. This is obviously impractical and, in reality, there are no set rules with respect to variability of waste composition and the applicability of a certain PCP to those variations. A ±10% variation on any particular parameter traditionally has been yielding acceptable results. Only in those cases where a borderline formula was being used would the 10% latitude result in an unacceptable waste form.

3727

What effect does cement solidification have on ion-exchange resins?

When solidifying ion-exchange resins with cement products, some of the ions exchanged onto the resin will be eluted and exchanged for calcium and magnesium. These are present in very high concentrations during the cement solidification process. This, in addition to a relatively high pH (compared to resin operations), leads to a partial change in the chemical form of that resin.

For example, some of the sodium and other monovalent ions on the resin will be eluted and replaced by calcium. This is governed by chemical equilibria laws and will depend on the entire makeup of both the waste composition and the specific cement used. The sodium eluted from the resin is incorporated into the salts being formed during the hydration of the cement. The impact of this partial elution of ions from the resin on the leachability of the final product has not been directly correlated to date. It is believed, however, to have an insignificant impact on the leach index, as defined in ANS 16.1.

3728

Can you use evaporator bottoms to hydrate resins for cement solidification?

Most waste evaporators will concentrate solids in the range of 20% or greater. In PWRs in particular, this includes boric acid, a solidification inhibitor. The metasilicate produced in an evaporator accelerates the chemical reaction of the solidification process, but a concrete solidification binder will become more brittle as additional metasilicate is added. After a point, the compression requirements of the *Branch Technical Position on Waste Form* may not be met.

It also is important to note that resins do not take place in the chemical process of solidification—they are, instead, encapsulated by the solidification binder. And, by definition, encapsulation of any media will weaken a cement-solidified monolith.

Therefore, if the waste is in such a concentration that the solidified waste form must meet the requirements of Class A stable, then either very little resin can be added to a high concentration of solids in evaporator bottoms, or a very low concentration of solids in evaporator bottoms can be added to a large amount of resins. It is not possible to solidify a large amount of resins with evaporator bottoms containing a high concentration of solids and still have the waste form meet Class A stable requirements.

3729

How long should cement solidified waste cure prior to shipping?

The "curing" of cement is a process which involves many chemical reactions, including the formation of salts and lattices that eventually give the cement billet its final properties. This process can be described as an exponential curve running asymptotically with time. Essentially, this means that the more time that elapses, the better the solidified mass, with most of the curing being done in the early hours after solidification.

Generally, twenty four hours after the exotherm has peaked, the vast majority of the properties have already reached 80% of their final values. Forty eight hours and seventy two hours after the exotherm has peaked contribute correspondingly smaller percentages to the final property values.

A safe waiting period for shipping would be between twenty four and forty eight hours after the time of the exotherm.

3730

What chemical constituents in waste may adversely affect the solidification process?

The solidification process can be quite sensitive to chemical intrusions. Hence, this is one of the key reasons behind the requirement for a PCP. The following chemical contaminants adversely affect the solidification process:

1. Boric acid is a solidification inhibitor. As such, it tends to absorb water away from the chemical curing process. This can be counteracted by the addition of metasilicate.

2. Oils are insoluble. Accordingly, they will mix with the cement powder and prevent solidification.

3. Corrosives (extremes in pH) will prevent achievement of the proper pH during the solidification process.
4. Sulfurs will compete with the oxygen in the liquid, thereby inhibiting solidification.
5. Ammonia can have adverse effects on cement solidification and delay the exotherm.
6. Chromates do not affect solidification in low concentrations. However, they do not render the chromates as nonhazardous (i.e., fails the TCLP), thereby producing a mixed waste. As such, they cannot be buried in the radioactive waste disposal facilities currently in operation.

The concentrations that affect the solidification will vary with the mixture of inhibitors. Thus, no specific value can be given for the mixture. However, upper limits are available when solidification of evaporator bottoms becomes difficult without major adjustments of the PCP. These limits are:

1. Boric Acid: maximum 30% by volume.
2. Oil: maximum 1% by volume (0.55 gallons in a 55 gallon drum).
3. Corrosives: do not use if pH below 5 or above 9.
4. Chromates: above the federal guidelines for mixed waste, disposal becomes difficult.
5. Sulfates: maximum 1% by volume.

3731

What may cause a liner to rupture?

Generally, the only reason a liner could rupture is when an excessive pressure is exerted from the inside. This pressure could be caused by an explosion, such as a rapid exothermic reaction or an excessive buildup of methane. It could also be the result of a swelling of the contents, as in the rehydration of resin.

In the case of cement solidification, the reactions involved in cement hydration are exothermic. When solidifying large containers (100 cubic foot or greater) the rate of heat generation is greater than the rate of heat dissipation. The net effect is a significant rise in temperature of the entire liner contents that may vary from a few degrees to a hundred degrees Fahrenheit. If we consider that the initial temperature of the waste was between 60 and 150 degrees—

depending on what waste it is—it is feasible to foresee a sudden rise in temperature turning large quantities of water into steam much faster than the steam can be released. This can cause an explosion which could rupture either the container or the connection between the container and the fill-head.

Another cause of explosion could be the heat released in several chemical oxidation reactions. The presence of strong oxidizing agents in the waste or binders should be monitored and avoided when using organic ion-exchange resins.

As mentioned above, the swelling effect may be produced by the reabsorption of water by resin beads that may have been encapsulated in cement or bituminous waste. This is discussed further in an earlier question.

3732

What options do you have when a liner has ruptured?

There are three options:

1. Encapsulation in a larger container. This "overpack" normally must be made specifically to accommodate the ruptured liner. It must provide a layer of concrete between the outer container and the ruptured container as well as adequately address the radiation shielding requirements necessary to meet NRC and/or DOT regulations.

   An example of this would be a 120 cubic foot container rupturing and being encapsulated in a 200 cubic foot container. There are some questions that need to be addressed prior to proceeding with this option. The most important is: Are the dose rates (on contact and at two meters) compatible with the shipping requirements of the new *shipping cask* that will be required. If the answer is no, then the only other option available would be on-site storage for however long it takes for the radionuclides to decay to a compatible dose rate on contact and at two meters. This, of course, will depend on the abundance of short-lived nuclides and their contribution to the limiting radiation levels.

2. The other option consists of physically isolating this container by temporarily placing it into a larger container. For this approach, an open top concrete shield container would typically be used. This container would likely be placed in a remote location of the plant until radiation levels allow a close and prolonged interaction with the container itself. The intent would be to evaluate the potential for repair and subsequent disposal of the container.

3. Perhaps the simplest solution would be to place the container within a larger high integrity container (HIC). This minimizes the risk of further processing problems, minimizes exposures, and minimizes delays in disposal. Here, again, the largest concern might be whether the dose rates can be accommodated by the larger *shipping cask*.

3733

What options are available for reprocessing an unsuccessful solidification effort?

It is assumed that cement solidification is the method being used, and that one of the following possibilities has occurred:

1. No setting has taken place, and the product to be recovered is a "thick soup" of radioactive waste plus whatever binding agents may have been added that did not solidify. When this situation occurs, the first thing is to do is to contact the vendor that developed the solidification process and discuss the situation. It is likely that they have seen similar situations in the past and can recommend a quick solution that remains within the variations of the Topical Report.

   It is also possible to take a sample of the solution and determine if raising the pH—by simply adding caustic—would trigger solidification. If this works, calculate the amount of caustic needed for the a full scale version and add it to the solidification liner.

   If that does not work, additional tests must be performed on the sample taken from the liner until a satisfactory formula is selected. Then, the contents of the liner should be withdrawn and directed to a new container, mixing in the new additives according to the ratios determined by the new formula.

Note: *It is important that you carefully follow the vendor's instructions and/or the restrictions of the process control procedures. It is also highly probable that such changes in the PCP will require a review by the On Site Review Committee. The overriding consideration here is that this is an uncommon event that must be carefully evaluated by all of the right organizations. Moving ahead prematurely can lead to further problems, unnecessary exposures and, potentially, produce a waste form that cannot be disposed.*

2. The mixture solidifies partially in various areas of the liner, or the mixture thickens enough that pumping to a new liner is not possible. This type of situation is best dealt with by trying to complete the solidification by providing additional curing time or an external source of heat. Strip heaters can be wrapped around the container for a period of time ranging from one day to a week and the progress of the solidification monitored frequently. The fact that some solidification took place but did not progress to completion indicates that an additional catalyst, such as heat, will take the reaction to completion.

   If this approach does not work, the only option available would be to physically remove the contents of the container. This likely will require remote tooling and/or temporary on-site storage pending the decay of short-lived nuclides. If the radiation levels are low enough that can be allowed, the repackaging operation could take place by moving the "chunks" of dry waste to a High Integrity Container.

SECTION VI

(3800 SERIES QUESTIONS)

WET WASTE PACKAGES AND PACKAGING

Section VI Contents

Wet Waste Packages and Packaging

Item Topical Description **Item Number**

3801

What considerations apply when preparing inorganic ion-exchange media for disposal?

The only major consideration that must be made when preparing inorganic media for disposal different from that of organic media is the capacity for retaining water in the interstitial spaces between resins. Therefore, this affects the amount of effort and time required to dewater this material to satisfy disposal criteria for free water. This will greatly depend on the type of resin being used, as this is a direct measure of the particle size. As such, it can significantly affect the quantity of water trapped in the void space between resins (i.e., adsorbed on the surface).

3802

Can I combine inorganic ion-exchange resins with organic spent resin?

This is not a problem from a chemical reaction point of view, but it does adversely affect your dewatering capabilities. If a combination of resins are dewatered and, essentially, packaged dry in a high integrity container, then there should be no problem. On the other hand, if the dewatering procedure is followed, the procedure must have been derived from testing *that simulated actual conditions in the field.*

3803

What wet wastes can be shipped or disposed in what containers?

1. **Resins, activated carbon, zeolites:** When a waste has a half life of 5 years or greater and a concentration of greater than 1 uCi/cc, a HIC is required. Otherwise, the waste must be solidified in an approved media meeting 10CFR61 requirements for Class A stable or greater. If solidified, it must be in a metal container (e.g., 55 gallon drum, DOT 17C-H container, or steel liner).

2. **Evaporator bottoms:** These must be solidified in a DOT 17C-H container (sizes 5 gallon to 85 gallon) or solidified in a steel liner. If the concentration exceeds 1 uCi/cc of an isotope with a >5-year half life, the same solidification requirements as for resins apply.

3. **Oils:** Same as for evaporator bottoms.

4. **Filters:** Same as for resins.

5. **Liquids:** Cannot be shipped in a wooden container. Cannot be disposed unless absorbed or solidified, depending on disposal site criteria.

3804

What have been the performance concerns regarding HICs?

The concerns that have been raised on using high integrity containers can be categorized into operational concerns and disposal concerns. (Most of these concerns center on plastic HICs.) The operational concerns are, for the most part, related to the exposure that users sometimes have received when trying to close these containers. This concern has been minimized by the use of reliable remote handling tools.

Also, from an operational point of view, the compatibility of adhesive materials with container construction materials has been poor. This has caused some internal components to become "unglued" either during transport or during processing. (Rough handling also is a major contributor to this problem.)

The disposal concerns primarily relate to the long term stability of plastic containers under varying disposal conditions and disposal depths. The major issue raised is their ability to resist creep buckling. Mathematical models developed by the Brookhaven National Laboratories have predicted both the success and failure of each of the plastic containers on the market today depending on what parameters and assumptions were being used in that model.

Another concern raised with plastic containers is the long term stability of the container construction materials, due to possible attack from chemical constituents of the waste itself or in the disposal environment. There may be over one hundred different organic and inorganic chemicals in very dilute concentrations present in what we know as "Low Level Radioactive Waste." This is particularly true for wet waste. The interaction between those chemicals at varying concentrations with the container construction materials is difficult to predict. In addition, the long term effects of such chemicals on container stability is almost impossible to evaluate.

However, it is perceived as safe to dispose of "standard" LLW based on reactivity tests performed by the manufacturers of the plastic compounds that make up these containers. The approved user of the HIC also agrees that there are no significant concentrations of any of the chemicals listed in most operating procedures for these containers. This helps to minimize the possible effects of chemical attack on container construction materials.

3805

What components of available HICs are subject to limitations on HICs?

1. Gaskets must be glued in place for some designs, and the glue must *not* be made of a chemical which would cause the plastic material to degrade.

2. Lubricants to allow lid installation face the same limitations as the gaskets.

3. Torque values for the lids, if necessary for closure, must be achieved and not exceeded.

4. Storage of HICs must be accomplished as described in the container handling procedure. This is primarily to prevent the plastic body from being exposed to ultraviolet light, which breaks down the plastic.

5. Accomplishing these items must be documented as part of the radwaste QC program.

3806

What considerations apply to loading filters into HICs?

1. **Water:** Water is not allowed in a HIC above disposal site criteria. However, inadvertent water may be handled by placing an approved absorber at the bottom of the HIC to absorb the water released by mechanical retention of the filter.

2. **Metal edges:** Some mechanical filters have metal cores, or edges which may damage the HIC. These must be removed prior to placement into the HIC, or the risk of damage to the HIC is increased. (If this is your situation, evaluate the potential for an inexpensive modification to the filter to eliminate the sharp edges. As an alternative, the filters could be placed in plastic or metal cans, provided these "sleeves" allow for drainage.) Foam HICs also are available. The foam protects the HIC from damage during loading.

3. **Gas generation:** There should be no significant gas generation from mechanical filters.

4. **Averaging:** The current practice in the industry is to average the radionuclides over the mass and volume of the filter cartridges in the HIC. If the filters are encapsulated, the averaging may be done over the mass and volume of the HIC contents.

3807

What can I put in the void space in the top of a liner?

Based on the existing regulatory guidance, the void space in a container of waste should be minimized and should be no greater than 15% of the container volume. Any material can be used to fill this void, including both radioactive waste materials and nonradioactive materials. Typically, it is somewhat difficult to introduce different materials into the container because of radiation concerns, etc.

At present, the volume and mass of the material added to the container may be used in the waste classification calculation. However, the NRC currently is developing guidelines for averaging the radionuclide concentrations in the waste classification calculation.

3808

What ALARA methods apply to closing HICs and liners?

The use of remote tools for closing liners and HICs is recommended in any situation where the total exposure for closing that liner is expected to exceed 20 mR. For example, consider a metal container where the closure device consists of a 55 gallon drum top and lid with a bolt-and-ring arrangement. This lid can be replaced by a lid whose lip is pressed under the barrel-top lip with a device called "crimp-a-cap." This device is operated remotely by placing it atop the container. Pressure is delivered through a pneumatic system to crimp the lid onto the lip of the container.

High integrity containers that use a threaded lid are best closed with a remote tool which is positioned in the grooves atop the lid. The lid can then be rotated from outside the process shield with a reach rod.

3809

How do you assure proper closing for crimper caps?

Crimper caps are found on some steel liners. They are very difficult to assure a proper closing, and their use is not recommended. Since they are held in place by friction, there is very little additional work to be performed to secure them. A hammer tapping a board at the perimeter of the lid will help ensure a flat, tight fit.

An additional security measure would be to run wire through existing holes in the lid or drilled into the lips of the lid, taking care not to penetrate the container. This wire is drawn tight and knotted to prevent loosening of the lips. You also should attach and secure an identification seal wire to prevent improper opening.

Note: Do not use crimper caps on a 55 gallon drum. They do not afford the same security as a lock ring.

3410

What options are available for dealing with a contaminated HIC/liner?

1. A simple wash down could bring contamination levels to within limits. This is only advisable if radiation levels are low or remote washing equipment is available.

2. Disposal facilities are normally equipped with cask handling facilities. This enables them to perform at remote cleaning more efficiently than most generators. *Prior notification to, and arrangements with, the disposal facility operator are essential.*

3. For unusual circumstances, a variance can be requested from the disposal facility operator.

3811

What can be done with a dewatered liner which exceeds dose rate, classification, and/or weight limits?

If a dewatered liner exceeds allowable dose rates, classification, and/or weight limits, one or more of the following options may be applicable:

Excessive Dose Rates

Ship in a heavier cask of similar size (e.g., a 170 ft^3 "hot" liner can be shipped in a 200 ft^3 cask. (Be certain that the liner is properly braced or that a predesigned spacer is used in the cask.

Excessive Dose Rates and Classification

With an isotopic analysis, it could be determined that storage (in a shielded area) for a reasonable time (e.g., <1 year) could bring down the dose rates and the activity to within acceptable limits. A qualified Health Physicist should be consulted.

Excessive Dose Rates and/or Classification

Flood the liner and sluice the contents to a solidification liner. Then solidify the waste with approved solidification process, calculating appropriate ratios to meet regulations.

Excessive Dose Rates and/or Weight Limits

Flood the liner and sluice the contents to two or more smaller liners compatible with a suitable cask. Then keep the original liner (now contaminated and with some resin left) for future shipment.

3812

What options are available for a liner with dose rate exceeding shipping cask limits?

It is possible to find shipping casks that have been licensed to allow the insertion of a "skirt" between the cask and the liner. The skirt would provide additional shielding for the liner. Should this option be available, the only consequence could be a delay in shipping while awaiting the arrival of the alternative cask.

An evaluation should be made regarding the isotopic content and their respective contribution to gamma radiation and dose. This applies to both the dose rates on contact and at two meters. If on-site storage could bring the dose rates to within the range of the intended cask over a reasonable period of time, the container can be stored pending decay of the affecting short-lived nuclides.

On the other hand, if the store-for-decay option does not seem reasonable based on an exceedingly long decay time, then consider transferring the wet waste from that container to a smaller container that will fit in a heavier cask. This approach should be evaluated for:

1. feasibility;
2. total radiation exposure; and
3. cost.

3813

What can I do with a HIC/liner that exceeds disposal site criteria due to radionuclide inventory?

If the HIC/liner is loaded with activities wherein the concentrations exceed the limits of Table 1 or Table 2 of 10CFR61, then the container is not in compliance with disposal criteria for near surface burial [10CFR61.55(a)(3)].

At this point, there are three alternatives:

1. Contact the disposal facility to determine if they will accept the package in its present condition.

2. Contact the US government for permission to dispose of the material in an approved DOE facility. This could require many years of negotiations and can cost up to 10 times more than commercial disposal. However, there is existing precedence for this (e.g., TMI core disposal at the Hanford DOE facility).

3. Dilution of the waste form by transferring some of the waste to another container and mixing it in the proportions necessary to allow the container to be acceptable. This method is acceptable for resins and other wet waste. However, if the item is a solid, there may no choice but to refer to the preceding option.

3814

What portions of shipping containers should be inspected prior to use?

In addition to an inspection of the documentation regarding operability and functionality of the container and all of its components, a visual inspection should be performed on the following:

1. The container shell, looking for dents and other marks indicating a possible breach of integrity.

2. Lifting apparatus and lifting eyes, looking for any signs of deviation from normal liner or shipping container standards. An example of this is a pinched cable caught between the shipping cask and the liner itself.

3. Internal components, particularly the integrity of any dewatering devices. Although it is clear that no one can detect visually a hairline crack on a joint between a PVC pipe and a filter connecting to it, the intent of this inspection is to identify and reject obvious nonconformances like broken laterals.

4. Closure devices, including gaskets, looking for signs of wear or tear which could prevent a positive seal. In particular, high integrity containers using a threaded lid need to be tested to ensure the lid goes in easily to the extent that it provides a positive seal as indicated by either the operating manual or some physical marks on both the lid and liner neck. This "dry run" operation could save a significant amount of radiation exposure in the event that it does not work as intended.

Note: The above inspections assume that a prior evaluation of the compatibility of this container's size with the shipping cask and the radioactivity contents has been performed and found satisfactory.

3815

What are the most common violations of NRC regulations for wet wastes?

Violations of the NRC and/or DOT regulations fall into two categories: administrative and functional.

Administrative

1. The most frequent violations are incomplete of incorrect process control programs (PCP) . If the PCP does not accurately describe the waste processing program, the station is considered in violation of NRC requirements.

2. The next most common are improper description (or no description) of changes made to radwaste processing techniques in a 10CFR50.59 review/safety analysis.

3. Finally, a station is considered in violation of NRC requirements if procedures do not accurately describe the radwaste processing method or if the procedures are not followed at all.

Functional

1. The common functional violations include the waste container being improperly loaded with wet wastes

2. In some instances, wet waste containers have not being dewatered properly.

3. Some containers have indications of activity greater than the allowed DOT shipping limits on the outside of the shipping cask (package).

All of these functional violations likely would be discovered by the disposal facility, which would then notify the host state, responsible utility and, finally, the NRC.

> *Note:* *An extensive discussion of packages and packaging of all types for radioactive materials can be found in Volume 2 of the* Radwaste Desk Reference *(NP-7386, V2,* Transportation and Disposal*).*

SECTION VII

(3900 SERIES QUESTIONS)

LIQUID WASTE MEASUREMENT AND ANALYSIS

Section VII Contents

Liquid Waste Measurement and Analysis

3901

What methods are available for on-line oil detection?

If the oil is emulsified or finely dispersed in the waste water, an on-line TOC analyzer could be used to detect oil in the waste. It should be noted, however, that the TOC analyses will detect all organic compounds and not just oil.

Although there is instrumentation available to detect oil droplets in a water stream, none have been installed or used in nuclear plants. Generally, plant waste streams are not clean enough to permit the device to work.

3902

How can I obtain a representative spent fuel pool sample?

Because of the large volume of water in the spent fuel pool, it is difficult to provide enough mixing to ensure complete homogeneity of the pool water properties. The purification and cooling recirculation flow, normally provided on the pool, will provide a reasonable degree of mixing. Utilities have obtained samples from the recirculation flow as representative of the pool water. Multiple samples from the recirculation flow or from dip samples at different locations and depths would, perhaps, improve the representativeness.

3903

What equipment can be used to monitor liquid levels in spent resin tanks?

Thermal conductivity probes can be used to detect liquid levels. However, they are point measurements only and do not provide for continuous level measurement.

Sonar devices have been used with some success where the sensing probe is installed in the air space at the top of the tank and measures the reflected sound wave from the water surface.

Bubblers have been used with success for many years in spent resin tanks. In many of the early cases, plugging problems were traced to calcium carbonate buildup at the air/water interface in the sensing tube from CO_2 concentrations in the air.

Pressure sensors have worked in bead resin tanks, but they have not worked well with powdered resins and sludges.

3904

How can I monitor the resin level in spent resin tanks?

Two devices have been used with reasonable success at detecting resin levels in storage tanks. The first device is based on sonar principles where the probe is submerged in the water above the resin level and the sound reflects off of the resin/water interface.

The second device is a thermal conductivity measurement device. With this device, the probe temperature is affected by the thermal conductivity of the media surrounding the probe. The probe is calibrated for the media that is to be detected. These devices can be calibrated for air, water, and resin media. Thus, they can be used to measure either liquid or resin levels.

3905

How can I representatively sample holdup tanks?

There are two basic approaches to sampling a large bulk volume, such as the holdup tanks. In the first approach, the volume is adequately mixed or agitated, and a sample is collected during the mixing. The assumption is that the mixing will result in nearly homogeneous properties of the liquid. Unfortunately, for many plants, the means of mixing or agitating the tank are either absent or inadequate.

In the second approach, multiple samples are collected at different spatial locations in the tank or at different times while the tank is in recirculation. The samples either can be combined physically or the measured properties can be combined mathematically to determine an average.

3906

How can I representatively sample a spent resin storage tank?

For resin storage tanks with a recirculation capability, the tank can be put into recirculation and a sample pulled of the recirculation flow.

Many plants have installed an in-line sampling device, such as an ISOLOK sampler, on the resin transfer line from the resin storage tank to the resin liner. During the resin transfer step, the sampling device intermittently extracts a small volume of resin and water from the flowing slurry. The resins collected during the transfer should be representative of the storage tank contents.

3907

How can I prepare a composite sample of IE resins?

The resins to be composited should be taken to the "hot" laboratory and placed in a fume hood. If the resins are in a resin/water slurry, they should be placed in a beaker. The resins should be dewatered in the beaker by pouring off all excess water. Eliminating the water prevents the anion and cation resins from separating in the slurry. The resins should be stirred until they are well mixed. A smaller sample then can be extracted from the mixed resins.

3908

What laboratory test equipment is available for bench-scale optimization testing?

For the optimization of filtration processes, laboratory vacuum millipore equipment has been shown to be a valuable tool for studying such processes. This equipment has been used to investigate precoat materials, the effect of body feed materials, and the benefits of the use of polyelectrolytes in destabilizing colloids.

Likewise, millipore filter holders, a peristaltic pump, and a pressure gauge are used to investigate the above filtration parameters in a configuration directly related to full-scale filtration equipment.

For ion exchange processes, plastic or glass columns typically are used. The column diameters typically are 5/8" to 1", with lengths of 8" to 12". For DF measurements, column lengths identical to the full-scale ion exchange vessels normally are used. The flowrates through the column generally are established to match the full-scale vessels.

3909

What type of tank mixers (liquid and resin) are in use?

Both mechanical and hydraulic mixers are in use for mixing resin tanks. Typically, hydraulic mixing is used for liquid tanks, because of the large capacity of most liquid tanks.

Mechanical mixers include the shaft, impellers, and a drive motor with and without gear reducers. The motors typically are powered electrically; however, air motors also would be acceptable. Mechanical mixers generally are mounted only on smaller tank sizes (a few thousand gallons) because of the difficulties associated with mounting and stabilizing the large impellers and shafts. Mechanical mixers offer the advantages that they are not prone to plugging—as are many hydraulic devices—and, if sized correctly for the tank, provide excellent mixing.

The disadvantages of mechanical mixers are:

1. They generally are more expensive than hydraulic mixers.
2. They require a "pull space" external to the tank for the motor and mixing shaft in the event that maintenance is required.
3. In high radiation fields, maintenance access to the mixer may be difficult and may require design accommodations to permit access (e.g., shielding, tank flushing, etc.).

3910

How can I determine if sludge is present in a holdup tank?

Sludge detection instrumentation (if installed) can be used to detect sludge in holdup tanks. However, few holdup tanks, if any, have such instrumentation installed. In the absence of such instrumentation, there are three common methods of determining if a holdup tank has sludge in the bottom:

1. Process the tank contents using the tank bottom drain connection until the tank is nearly empty. As the tank level drops and a sludge layer is encountered, the increased solids content of the water generally will cause the radwaste filters to plug faster.
2. Reduce the level of the tank, and take a turbidity measurement on the waste water. Then place the tank into recirculation to resuspend a portion of the sludge layer (if present). Then take another turbidity measurement.
3. Drain the holdup tank and remove the tank manway for visual inspection.

3911

What temperature monitoring should be performed for IE systems?

Standard organic-based ion exchange resins can be operated continuously at temperatures up to 140°F. They can be operated for short periods of time above this temperature, however, the resins could be seriously degraded. Therefore, unless temperatures in excess of 120°F are expected in collection or holdup tanks, temperature monitoring typically is not provided.

3912

How can I determine if my IE vessels have air voids?

In severe cases of air binding, the flow distribution through the vessel may be so poor that the effect can be seen on the ion exchange performance or in the flow differential pressure. In cases not so severe, it may be difficult to determine if there is air in the vessels.

If in doubt, or as a matter of routine, the vessels should be filled with clean water with the vent valve open until water is detected in the vessel vent line.

3913

What chemical analyses are needed for filter operations?

There are no ideal measurements that can be made that will serve as indicators of proper filter operation and performance. However, a simple turbidity measurement may come as close as possible, especially if coupled over time with the actual filter performance.

If polyelectrolytes are being used, turbidity in combination with conductivity should provide a reasonable indicator of the required polymer dosage and expected filter performance. Turbidity measurements of the filter effluent will give a good indication of the polymer and filter performance.

In both PWR and BWR radwaste processing, the filter run lengths generally are controlled by differential pressure across the filter and not by the radionuclide DFs. However, influent and effluent radiochemical analyses have been used to:

1. Determine the chemical state of a given radionuclide;
2. Determine the minimum pore size required for a filter; and
3. Perform diagnostics on the quality of the precoat.

3914

What chemical analyses are needed for evaporator operations?

The major chemical constituents, organics and suspended solids should be measured for several batches to establish the evaporator operating conditions. Thereafter, it would only be necessary to measure TOC concentrations routinely in the holdup tank to avoid foaming and carryover problems.

If chemical wastes are being evaporated, the pH also should be measured. Because of the low concentrations of the soluble and insoluble contaminants in the holdup tanks, the evaporator concentration ratios generally are large. This means that a continuous measurement of the contaminants is not necessary. This is because the concentration of the controlling soluble and insoluble contaminants can be monitored by periodic sampling of the evaporator bottoms.

3915

What chemical analyses are needed during IE processing?

Initially, the major chemical constituents should be measured on several holdup tanks to correlate conductivity with the soluble contaminant concentrations. Thereafter, conductivity measurements can be used to monitor system performance. Because of the potential for organic fouling, it may be appropriate to measure TOC concentrations in the influent.

Generally, radiochemical analyses are required on the condensate from the evaporator overheads. These analyses will signal excessive carryover of non-volatile radionuclides indicating potential problems with foaming, etc.

In BWR processing of equipment and floor drains, radiochemical analyses usually are performed on the sample tanks only after processing by ion exchange. The subsystem influents and vessel effluents are sampled for radiochemical analyses only rarely, and then mostly for process diagnostic purposes.

In PWRs using multiple ion exchange vessels in series, the influent and the effluent of each vessel typically are sampled for radiochemical analyses. These analyses are required to determine the performance of each bed and to make decisions on media replacement in the individual beds.

3916

How can I determine residual capacity for condensate resin re-use?

Residual capacity can be measured by standard laboratory procedures involving saturation of the resins with standard salt solutions and titration techniques to determine the excess salt not exchanged. However, such determinations will not give an exact measure of the capacity that will be achieved in radwaste. This capacity can be developed gradually based on the laboratory residual capacity measurements and the actual capacity achieved in service in the radwaste system.

3917

How can I determine DFs for liquid waste processing?

Influent and effluent samples are required for gamma spectroscopy measurements to determine system DFs. If system DFs are required, samples from the holdup tank and monitor tanks would be more representative of longer-term average DFs than single influent and effluent grab samples. Grab samples generally are required to measure the DFs across a component in a series treatment configuration, such as filtration followed by ion exchange.

3918

How do you measure very low activity samples?

To achieve lower detection limits on radiation detection systems, there are three things that can be done:

1. Lower the background levels by shielding, different location, etc.
2. Use longer count times.
3. Use larger sample volumes.

If these three methods do not achieve the lower limit of detection required, then large volume samples may be passed through a filter or ion exchange media to concentrate the radionuclides on the media. The media may be counted directly if the counting geometry that has been calibrated for the radionuclides may be removed from the media into a small liquid volume suitable for counting in standard geometries.

3919

How can I determine curie content loading during the process operation?

There are two basic methods for estimating the curie content loading on treatment media during process operation:

1. Measure the radionuclide concentrations in each batch holdup tank processed and accumulate the curie content by calculation.
2. Measure the dose rate at a fixed location relative to the process vessel, and then estimate the curie loading by using an appropriate dose-to-curie calculation.

A variation on these two methods would be to measure the dose rate on the process vessel and also the curie content on the media when the media is removed from service.

3920

What radiochemical analyses should be performed on monitor tanks prior to recycle?

Although plant procedures typically require that only gross activity be measured for monitor tanks, gamma spectroscopy measurements could prove useful for spotting shifts in the radionuclide chemical properties or in the performance of the waste treatment systems. This information can be used to make specific adjustments in the treatment configuration to account for the shifts.

3921

What radiochemical analyses should be used on collector tanks prior to processing?

Gamma spectroscopy measurements on the collector tanks can be used to configure the waste treatment system and to gauge the performance of a given configuration. Without influent measurements, it is virtually impossible to gauge the performance of the treatment system.

3922

How can I determine the physical and chemical form of Co-60?

The typical method for determining the chemical species of Co-60 (i.e., what fraction is colloidal, cationic and anionic) is to pass the liquid sample through a millipore filter followed by cation and anion ion exchange papers. The millipore filter should have a nominal pore size of 0.2 μm to retain a majority of any colloidal particles present.

It should be noted that this method will not give precise fractions because, as the particle sizes get smaller, they may pass through the filter and be removed on the ion exchange media by electrochemical forces. This then would add to the fraction calculated for the cation or anion ion exchange media.

3923

When do I need to sample to comply with 10CFR61?

There are two types of samples collected for compliance with 10CFR61:

1. Routine samples of waste batches or containers, and
2. Periodic (typically annual) samples of the waste types in the waste containers.

The routine samples are collected from each batch or each container to determine either the relative abundances or the absolute concentrations of the gamma radionuclides in the waste batch. Scaling factors are then used in combination with a designated gamma nuclide to derive the concentrations of the non-gamma nuclides.

The periodic sample is collected for shipment to an off site radiochemical analytical laboratory to obtain measurements of the gamma and non-gamma radionuclide concentrations. The ratios of the these nuclide concentrations typically are used for scaling factors.

3924

How can I derive 10CFR61 scaling factors for resins?

Scaling factors are derived from radiochemical measurements of the radionuclides on a small sample of the resins. The resin sample may be collected during recirculation of a spent resin tank, during the transfer step to a disposal liner, or from the disposal liner itself.

3925

How can I determine curie content of resin prior to sluicing into a liner?

Dose rates can be measured on spent resin tanks or on recirculation piping. These are used in dose-to-curie calculations to estimate the curie concentrations in the resin. Alternatively, if a recirculation capability exists on the spent resin tank, the tank can be placed into circulation, and a sample of the resin can be collected for gamma counting on the plant GeLi system.

3926

What are the 10CFR61 concerns when using resins in multiple applications?

There should be no concerns with the re-use of resins in multiple applications if the scaling factors used in characterizing the resins are based on samples of the resins. This will ensure that any differences in the relative radionuclide deposition rates between the two applications are properly accounted for.

3927

How do you representatively sample a cartridge filter?

It is not an easy task to representatively sample a cartridge filter (or perhaps any solid media) for absolute concentrations without resorting to multiple samples spatially separated in the sample mass. However, samples can be obtained that are reasonably representative of the relative abundances of the radionuclides on the filter. There are three methods typically used to sample filter cartridges:

1. Cutting or clipping an accessible surface of the filter.
2. Cutting a core plug from the external surface to the cartridge inner support.
3. Smearing the external filter surface or filter housing.

For relative abundances, all three methods have been shown to yield comparable results.

3928

What errors can arise from solids in a liquid sample?

Typically, gamma spectroscopy counting equipment is calibrated for a given sample geometry. In the case of liquid samples, the geometry may be a one liter sample in a marinelli container.

In the calibration of this geometry, the radionuclides are distributed uniformly in the liquid surrounding the detection crystal. Thus, for an actual sample, the calibration remains valid as long as the radionuclides are distributed uniformly in the liquids. If there are suspended solids in the liquid that are prone to settle in the sample container, they will not be distributed uniformly in the liquids. In fact, if the solids are large enough, they may settle readily to the bottom of the container giving rise to counting errors for the sample.

3929

What surrogate methods are available to determine filter activity?

Millipore filters have been installed on reactor coolant sample lines with the millipore filter membrane being analyzed as a surrogate sample for an actual letdown filter sample. This practice is not widespread, and few studies have been done to demonstrate that millipore filters are, indeed, reasonable surrogates for actual samples. There may be differences between the relative removal efficiencies of the radionuclides on the millipore filter as compared to the actual filter. A first step to avoid such problems would be to use millipore filters that have the same pore rating as the actual filter.

Many plants use smears of the actual filter surface or from the filter housing as a representative sample in place of taking a sample of the actual filter material. These have been shown to be reasonably comparable to samples of the actual filter material. It is important that the surrogate samples should be used only for the relative abundance of the radionuclides and not the absolute concentrations of the radionuclides.

3930

How can I ensure waste homogeneity and isotopic uniformity?

There is no requirement that will ensure that the waste material is homogeneous or that the isotope distribution is uniform. There is a requirement, however, that the sample of the waste material be representative of the material to derive the average concentrations of the radionuclides in the waste material. This could pose problems in sampling if the distributions are extremely inhomogeneous. This also is the reason that dose rate measurements, in combination with relative abundance measurements, are used in dose-to-curie calculations to derive average concentrations in a waste package.

3931

How can I determine waste classification for multiple filter shipments?

There are two basic approaches used to derive the radionuclide concentrations in multiple filter shipments:

1. Determine the concentrations in each individual filter, and then sum them for the waste classification of the total package.

2. Determine the concentrations by using an average of several dose rate measurements of the entire package in combination with dose-to-curie calculations and scaling factors.

The first method also uses dose rate measurements and a dose-to-curie calculation, except on a individual filter basis. Of the two methods, the first is, potentially, more accurate than the latter, but it requires a reasonable filter geometry for the dose-to-curie calculation.

It currently is acceptable to perform the waste classification on the total package. However, utilities have been known to classify each filter individually and assign the highest classification to the entire package. This is unnecessarily conservative and may result in package classifications higher than necessary.

3932

What are the various methods available for obtaining a representative sample of resins?

There are three basic methods for obtaining resin samples. The first is to recirculate the resins in the spent resin tank and collect a sample from the recirculation line during the recirculation. The second method is used if recirculation capability does not exist on the spent resin tank. It involves the collection of multiple samples, using in-line sample devices such as ISOLOK®, during the transfer of the resins to a liner. The third method involves a simple dip sample collected from the liner following the resin transfer. The first two methods are generally considered more accurate than the third method. For the third method it may be difficult to demonstrate that the sample is representative of the entire liner.

3933

What are the advantages to the methods for determining curie content?

There are three basic methods used for determining the curie content in packages:

1. Sampling for absolute concentrations;
2. Sampling for relative abundance;
3. Direct assay.

The advantage of the first method is that there essentially are no calculations involved to get a final usable result. The disadvantages for this method are:

- It requires significant care in the sampling technique to obtain a representative sample.
- It is prone to considerable error because of the care required to obtain a representative sample.
- The counting geometry must be identical to that used in the calibration.
- The radionuclide distribution should be reasonably uniform in the sample to match the calibration standard.

The advantages of the second method are that the sampling requirements are:

- Less stringent than the first method, owing to the fact that relative abundances are less variable than sampling for absolute concentrations
- Dose rate measurements represent a measurement of a substantial portion of the waste package.

The disadvantage of this method is that the dose-to-curie calculation requires a reasonably accurate representation of the waste package geometry and any shielding material between the waste and the point of the dose rate measurement.

The third method involving direct assay offers the advantages that:

- No sampling of the waste material is required.

- If properly calibrated, the direct assay provides greater accuracy in the curie content of the waste package.

The disadvantages are:

- A large fraction of the package should be accessible for the direct assay measurements.
- The analytical calculations to convert the measured spectra and fluxes into average radionuclide concentrations must be calibrated to demonstrate their accuracy.

3934

How do you perform direct assay on waste containers?

Direct assay techniques involve some type of an integrated radiation measurement on the entire waste package or volume. This can be done either by scanning the entire package or surrounding the package with radiation detectors. At present, there are two types of direct assay:

- One for gamma ray measurements.
- One for neutron measurements.

The gamma-ray measurements are used to quantify the gamma nuclide content of the package. Neutron measurements quantify the TRU nuclide content of the package. The gamma-ray direct assay is the most commonly used method of the two.

In the direct assay process there are three basic functions performed by the direct assay device:

1. Obtaining average gamma-ray spectrometric measurements.
2. Obtaining an average flux of the radiation emissions from the package.
3. Using analytical calculations to convert the measured spectra and fluxes into average radionuclide concentrations in the waste package.

Direct assay has been used primarily as a remedy for some of the problems associated with obtaining representative samples. Because the entire waste package is scanned, it can, in large measure, account for inhomogeneities in the radionuclide content of the package. Thus, it can provide a more accurate determination of the curie content.

3935

What direct assay techniques can be used for curie quantification?

Both of the two basic direct assay methods, gamma-ray measurements and neutron measurements, can be used to good advantage in quantifying the curie content of waste packages. They both offer the advantage of scanning the entire package, thus eliminating the difficulties of obtaining representative samples of the waste contents.

There are difficulties associated with the neutron direct assay method. One is that the minimum detection limit may be too high to measure low activity waste streams, such as DAW. The second is that the neutron direct assay requires that the transuranic nuclides must be known for accurate conversion of the neuron flux to radionuclide concentrations. This can be done by sampling the waste or by determining the burnup of the fuel producing the transuranic nuclides using the Cs-134/Cs-137 ratio measured in the waste. The decay of Cm-242 also must be accounted for.

Both the gamma-ray and neutron direct assay methods require careful calibration. Overall, with proper calibration the gamma-ray direct assay method generally is more accurate in determining the gamma radionuclide concentrations in a waste package than other methods involving sampling.

3936

When are TLD strings useful?

TLD strings are useful for determining the dose profiles on packages or irradiated components, particularly where the dose profiles vary over the package or component by orders of magnitude. The TLD strings typically are placed in close proximity to the package or components, such that the dose rate being measured is from the area adjacent to the TLD's.

3937

What options are available for dose profiling?

Dose profiling generally is associated with irradiated hardware. However, dose rate measurements are made on waste packages and used in dose-to-curie calculations.

The dose rate used in the calculation should be the average dose rate. This implies multiple measurements made on the package to reduce the effect of "hot" spots in the container.

Generally, four measurements are recommended at quadrant points around the container. Using the average dose rate instead of the highest dose rate will result in a smaller number of curies in the package and could reduce the curie surcharge.

3938

How can I dose rate containers in high background areas?

Presuming that the cask or container cannot be moved to a lower background area, a tungsten-shielded probe can be used to measure the dose rate on the container in the high background area.

3939

How do you calculate the activity inside pipes, pumps, and valves?

For the gamma radionuclides, a spectrometric gamma-ray measurement can be made with a portable germanium detector system. This will determine the gamma-ray flux and spectra for the radiation coming through the pipe. These measurement results then can be used in radiation transport shielding calculations to estimate the radionuclide concentrations on the internal surface area of the pipe, valve or pump. ***It is important that the geometric model used in the radiation transport calculations be similar to the actual geometry in the measured radiation data.***

The total curie content in piping, valves or pumps is determined by multiplying the radionuclide concentration times the area of the component involved.

For the non-gamma radionuclides, scaling factors typically are used to derive their concentrations relative to a gamma nuclide, such as Co-60. The scaling factors may be derived from laboratory radiochemical measurements of scale removed from a piece of pipe, valve or other component.

3940

What in-line radiation monitors are used for resin transfers?

Alarming dosimeters often are taped to a transfer pipe at several locations to detect the presence of resins in the line:

- They are used on accessible pipe to indicate that a resin transfer operation is in process.
- They are used to indicate a potential plugging problem if the dosimeters do not detect resins at a specified location after the start of the transfer step.
- And, finally, they are used to indicate if a line flush has been successful in removing the bulk of the resins prior to a more detailed hands-on survey.

Recently, teledosimeters have been considered for this application, wherein the dose rates are transmitted to a remote location for readout.

3941

What effect will DRPs have on wet waste measurements?

It is likely that DRPs will have a small effect on most wet waste measurements. Although the specific activity is quite high on a DRP, their mass generally is small (<1 micron). Therefore, when added to the larger mass of the wet waste sample, this activity should not cause a significant increase in the measured concentration in the sample.

However, if the DRP has a large mass and the waste sample was not large, the DRP activity contribution to the total activity measured in the sample could be large, causing a significant error in the measurement.

3942

How can I measure gas generation in a waste container?

Gas generation in a waste container, whether it is hydrogen, methane or CO_2, can be measured by sampling the gas space in the container using a portable gas analyzer. The gas sample could be collected from the fill head opening or from the dewatering header (assuming the liner has been dewatered).

3943

What radionuclides dominate the Tech Spec discharge limits?

This will vary from plant to plant, depending on the liquid waste treatment system, the failed fuel condition, and the chemical conditions in the liquid waste. In terms of curie discharges, the major contributors will be:

Co-58 Co-60
Sb-125 Cs-137

In terms of dose, Cs-137 will dominate under failed fuel conditions.

3944

How can I identify a biological growth problem?

The result of biological activity in plant systems is gas generation and, possibly, odor. Both CO_2 (carbon dioxide) and CH_4 (methane) may be produced by biological activity, depending on the oxidation conditions of the stored waste.

Sampling the gas space in sumps, collection tanks and phase separators may provide a means to detect the gas generation with portable gas analyzes. A more likely location to sample is the gas space of a filled liner. There are examples in the industry where liners have bulged outward from gas pressure caused by biological activity in the liner. At least one utility collects a sample of the resins and precoat sludges in the phase separator prior to transfer to the dewatering liner and determines the gas generation in the sample in the chemistry laboratory.

3945

How can I determine IE column breakthrough?

For typical liquid radwaste processing, either conductivity or radionuclide concentration in the effluent are used to determine ion exchange column breakthrough. Conductivity can be measured:

1. In-line with conductivity probes.
2. In grab samples of the effluent
3. In the sample monitor tank.

The radionuclide concentrations can be measured in grab samples of the effluent or of the sample monitor tank.

3946

How can I identify colloidal removal problems?

Colloidal particulates may pose a removal problem for a liquid waste treatment system configuration using filtration and ion exchange beds operated in series. If there is a potential with colloidal particulate removal, it will be reflected in higher effluent concentrations of the metal activation products of Co-58, Co-60, Mn-54, Cr-51, Sb-125, etc. The reason that the effluent will have higher concentrations of these nuclides—if they are in a colloidal state—is that the colloidal particles are too small to be effectively removed on the filter and on the ion exchange resins. Also, they do not ion exchange efficiently, if at all, on the ion exchange resins.

The DFs should be checked on radionuclides that are known to be soluble as a check to see if the resins are exhausted. Also, effluent conductivity and processing logs should be checked to ensure that the resins are not exhausted. If they are not exhausted, and the effluent concentrations are high, it is likely that you have a colloid removal problem. This can be confirmed in the laboratory using polyelectrolytes and millipore filtration equipment.

3947

How can I perform thermal decay heat calculations?

Thermal decay heat generally is not a problem in most low level waste situations. This is due to the low specific activity of the waste. However, in higher activity waste containers, thermal decay heat calculations have been performed to ensure that overpressurization of the package will not occur and that none of the materials in the package will not be damaged by higher temperatures. The decay heat calculations are performed by:

1. Determining the radionuclide concentrations in the waste.
2. Extracting the average beta particle energy from handbook sources for each nuclide.
3. Extracting the gamma-ray energy for each nuclide.
4. Assuming that all of the energy associated with each disintegration is deposited in the waste.

3948

How can I verify that waste has been solidified?

In most solidification procedures, samples of the waste that is to be solidified are taken to the laboratory and are solidified in accordance with the formulation(s) in the process control procedures. After the appropriate curing time, the samples are qualitatively checked for hardness to ensure that a satisfactory solid product will be produced.

Following the solidification process on the full-scale liner, the solidified product is checked by probing with a wooden or steel rod.

3949

What methods verify waste levels in liners?

In dewatering and solidification liners, float level devices may be installed to give a single point level measurement for the initial filling operations. Visual level control—using remote TV systems—are employed for subsequent filling steps. Continuous level sensors, such as sonar devices, have been used with limited success.

3950

What QC methods will verify that disposal site requirements have been met?

In all situations, the process control procedures should specify the QC methods used to verify acceptance of the waste at the disposal site (assuming a site is currently available).

In addition, for solidification of waste, pre-process tests can be conducted on a laboratory-scale to provide assurance that the full-scale solidification will produce an acceptable solidified product. During the solidification step, the temperature rise in the container can be recorded to indicate the progress of the solidification reaction. Post-processing samples of the full-scale batch can be archived and tested on a periodic basis to provide an indication of the acceptability of the full-scale product.

3951

What low-impact decon methods can be used for discharge monitors?

Most decontamination methods involve the removal of the in-line detection chamber and cleaning of the chamber for return to the monitor. There has been some success with the application of a mirror finish to the detection chamber in keeping the background radiation to acceptable levels.

A daily purge of the chamber has been shown to minimize the buildup of material on the mirror finish. This method can reduce the frequency of cleaning to once every four or five months. However, it is still necessary to remove the chamber for cleaning.

3952

How do you prepare a resin counting standard?

Using new resins, measure the quantity of resins equal to the quantity expected to be available in the sample. Once the resins have been measured, there are two methods for loading the resin with the soluble radionuclides:

1. The resins are spread out on a shallow flat-bottomed container. Then the solution containing the measured quantity of the radionuclide is added to the resins by pipetting. Care should be taken not to add an excess of solution to the beads, such that there is solution which is not adsorbed by the beads. Place the resin beads in the required counting geometry.

2. As an alternative to pipetting the solution onto the resin beads, the resins and solution can be added to a beaker and stirred together for 30 minutes. At the end of that time, the resins are filtered to remove the excess solution. The solution is counted in a standard liquid geometry to determine how much of the radionuclide exchanged onto the resin (should be most of it). The resin then is placed into the required counting geometry.

3953

How can I monitor laundry waste for DRPs?

There are several practical problems with monitoring laundry waste for DRPs. The first is that the entire surface area of the material should be monitored. This requirement—and the need for gamma detection to detect DRPs that may be caught in a garment seam or between layers of cloth that attenuate beta particles—will rule out hand-held frisking as a monitoring mechanism.

Sorting tables with large thick scintillation detectors have been found to be effective in monitoring laundry waste. The sort table (or conveyer system) can be designed such that the detectors are monitoring both the top and bottom of the material, thus eliminating the need to turn the material over.

Conveyer systems also have been used that contain arrays of smaller gas-flow proportional detectors. However, if the DRP is lodged in the garment seam, then the beta particles from the DRP may not be detected because of attenuation by the cloth layer. Thus, gamma detectors also should be used at some point in the monitoring process.

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GLOSSARY

Glossary

absorbent	A material that takes in another material, as a sponge absorbs water.
absorption	The action of an absorbent.
absorption, self	See self absorption.
AC	Alternating current, usually 110 volt, 60 hertz.
accelerator	An additive used during solidification to enhance or expedite the drying or curing process.
acidity	The quantitative capacity of a liquid to react with hydroxide ions.
ACM	Asbestos containing material.
activation	The process of inducing radioactivity by irradiation. Activation occurs primarily in neutron radiation fields.
activation DRP	A discrete radioactive particle formed by activation. The predominate activation product in activation DRPs is cobalt-60.
activation product	A radionuclide formed by activation. Cobalt-60 is often the predominate activation product.
adsorbent	A solid material that holds a contaminant on its surface, as activated carbon holds iodine.
air lift	A hoisting procedure done in air. Usually refers to a lift of a radioactive source without shielding.
air scrubber	A pneumatically operated air file which has been adapted for use as a scrubbing and cleaning tool by attaching scouring pads to the vibrating surface. (Wet scrubbers used on contaminated exhaust systems in some industries are also sometimes called air scrubbers. They are rarely if ever used in nuclear power plants.)
ALARA	As low as is reasonably achievable. As low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety and other societal and socio-economic considerations, and in relation to the utilization of atomic energy in the public interest. (This definition is from pre-1989 versions of 10CFR20).

ALARA paint	The trademark name for a brand of strippable coating.
aliquot	A portion of the whole. A measured part, usually of a liquid sample.
alkalinity	The quantitative capacity of a liquid to react with hydrogen ions.
alpha emitter	A radionuclide that emits alpha radiation.
alpha radiation	Radiation consisting of alpha particles, helium nuclei without associated electrons. The mass of an alpha particle is that of 4 protons.
ANI	American Nuclear Insurers.
anion	A negatively charged ion or radical. Examples include chloride ions (Cl^-), bromide ions (Br^-) and sulfate ions ($SO_4^=$).
anti-coincidence counting	See coincidence counting.
anti-contamination clothing	Protective clothing.
anti-Cs	Anti-contamination clothing. Protective clothing.
anti-springback device	A device which prevents compacted material from expanding after it is compacted. Anti-springbacks are available for both drums and LSA boxes.
Aquaset	A proprietary liquid solidification agent used commonly for oil solidification.
atomic number (Z)	The number of protons in the nucleus of a neutral atom.
background radiation	The radiation that is independent of the sample being measured. It is also used to mean natural background radiation.
backwash	To clean by reversing the normal direction of flow, as in backflushing a filter to wash off the precoat or filtered matter.
bar code	A series of vertical bars representing the binary code for a number from 0 to 9. This is another name for a Universal Product Code. (UPC) label. Bar codes are used on most products to identify the product and manufacturer. They are also used on containers to identify contents.
bar code reader	An optical scanner used to read bar codes.

bare pick	Hoisting a radioactive source (usually a resin liner) in air without shielding.
barge	A non-self propelled vessel.
Barnwell	The NRC licensed low level waste disposal site at Barnwell, South Carolina operated by Chem-Nuclear Systems, Inc.
Below Regulatory Concern	A waste stream that is exempted from NRC concern and control after it is disposed. Specific reactor wastes or waste streams may be exempt under the provisions of 10CFR20.302.
beta emitter	A radionuclide that emits beta radiation.
beta radiation	Radiation consisting of charged particles emitted from the nucleus of an atom during radioactive decay. The mass of a beta particle is 1/1837 that of a proton.
binder	The solidification media used in processing waste for stabilization and/or disposal (e.g., cement, asphalt).
blowdown	*v.* To exhaust steam and condensate from a system component. *n.* The condensate and steam that is exhausted, usually from the secondary side of a steam generator.
boric acid	The additive used for "chemical shim" reactivity control in PWRs and used in the emergency shutdown systems of BWRs.
BRC	Below Regulatory Concern.
BRE	Boron recovery evaporator (PWRs only).
breakthrough (of ion exchange resin)	The first indication of the failure of a resin column to continue to remove a contaminant that it previously removed.
bremsstrahlung radiation	Photons (X-rays) produced when heavy nuclides (those with a high atomic number) interact with beta radiation.
B.t.u.	British thermal unit. A measure of heat.
bubble hood	An air-suppled respirator that consists of a plastic enclosure over the head. It provides cooling as well as clean breathing air.
B&W	Babcock and Wilcox, Inc., a supplier of pressurized water reactors.
BWR	Boiling water reactor.

BWST	Borated water storage tank.
by-product	A secondary waste or material from decontamination or other process.
byproduct material	According to 10CFR20.3, byproduct material is "any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material". That is, all radioactive material in the plant except part of the fuel.
cargotainer	A shipping container that can be transported by truck, rail or barge. Most measure approximately 8 feet by 8 feet by 20-40 feet. Also called an ISO container, sea-land container, or sea van.
carrier	A person engaged in the transportation of passengers or property. In this Desk Reference, a carrier is the transportation company.
car wash	In a nuclear plant, this slang expression is usually used to mean a temporary steam cleaning facility used to decontaminate large equipment.
cation	A positively charged ion or radical. Examples include iron ions (Fe^{++} or Fe^{+++}), sodium (Na^+), silver (Ag^+), and ammonium (NH_4^+).
cask weeping	See weeping (cask).
C.E.	Combustion Engineering, Inc., a supplier of pressurized water reactors.
Celatom	The brand name of a diatomaceous earth-type absorbent approved for use at the Richland, Washington disposal site.
Certificate of Compliance	A document attesting to the fact that a particular shipping cask is approved for certain uses by the NRC.
cf	Cubic feet. Also, abbreviated ft^3.
CFR	Code of Federal Regulations.
channeling (of resin columns)	A condition resulting from improper packing of a resin or charcoal bed in which the solution being treated follows relatively particle-free paths through the bed.
characterize	Usually, to determine radiological characteristics, including chemical and physical characteristics (chemical form and/or particle size).
charcoal	A term that is often used for activated carbon adsorbent in either liquid and gaseous cleanup systems.

chelating agent	An organic compound that forms a chemically stable ring with a metal ion, promoting its solubility. Chelating agents are sometimes used in decontamination solutions. Their disposal is limited because they may promote the migration of radioactive ions in waste.
cherry picker	A term for one type of drum handling device. (This is another name for an "engine hoist.")
Ci	Abbreviation for curies, a measurement of activity.
CITROX	A decontamination agent employing citric and oxalic acid.
Class A waste	Waste comprised primarily of short-lived radionuclides and usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in 10CFR61.56(a).
Class B waste	Waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements of 10CFR61.56.
Class C waste	Waste that must meet more rigorous requirements on waste form and requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements of 10CFR61.56.
>Class C waste	See "greater than Class C waste."
clean waste verification	Verification that waste contains no radioactive contamination and therefore can be disposed of without restrictions because of radioactivity.
closed transport vehicle	A transport vehicle equipped with a securely attached exterior enclosure that, during normal transportation, restricts access of unauthorized persons to the cargo space containing the radioactive materials. It must limit access from the top, sides and ends.
cobalt-60 DRP	See activation DRP.
COD	Chemical oxygen demand.
coincidence counting	Counting that uses two stacked detectors. Only counts that occur within the same time interval (due to the same particle or same nuclear decay) are recorded. The same equipment may also be used in the opposing mode to record events that occur in only one of the two detectors. Technically, this is anti-coincidence counting.

C of C	Certificate of Compliance.
cold pump	The pump used to recirculate water through a filter demineralizer to hold the resin in place while the demineralizer is out of service.
colloid	Very small, non-settling particulate material.
Compact Authority	See Low Level Waste Disposal Compact.
compaction	Reduction of volume by physical compression.
condensate polisher system (CPS)	An ion exchange system that treats the condensed steam from the turbines to re-purify it so that it is suitable for re-use in the boiler. The CPS is part of the primary system in a BWR and part of the secondary system in a PWR.
consignee	The intended recipient of a shipment; the individual (person, company or corporation) listed on the bill of lading to receive a shipment.
container venting	Under certain conditions described in Volume 2 of this Desk Reference, a container of waste can generate gases within the closed container. These gases must be vented (released) from the container prior to shipping.
contamination	Contamination means material where it is not wanted. Usually used to mean radioactive contamination; radioactive material where it is not wanted.
core	The active region of a reactor where neutron irradiation and fission take place.
cpm	Counts per minute. The number of radiation events detected by an instrument in one minute.
CPS	Condensate Polishing System. The secondary system in a PWR.
cps	Counts per second. The number of radiation events detected by an instrument in one second.
CRDM	Control rod drive mechanism (occasionally used to mean the internal filter which the CRDM contains).
critical path	The time line of those activities which determine the length of a project. In a power plant, the project is usually an outage.
critical radionuclide	The radionuclide that will give the most biologically significant dose to the human body under the postulated release conditions.

cross contamination	Inadvertent contamination of clean or previously cleaned areas from contaminated areas.
crud	A common term for corrosion product layer in reactor piping, or on fuel.
CRW	Circulating Raw Water (the turbine cooling system in some PWRs) or Clean Radwaste. Liquid radwaste that is low in dissolved and suspended contaminants (usually BWRs).
CST	Condensate storage tank, the main, primary system, make-up tank in a BWR.
CTV	Closed transport vehicle.
curie	One curie equals 3.700E+10. That amount of radioactive material which disintegrates at the rate of 37 billion atoms per second.
curie content	The number of curies of radioactivity in a package of radioactive material or radwaste.
curing time	The time required for a solidification or encapsulation binder (e.g., cement) to dry and harden.
CVCS	Chemical volume control system, a term used in BWRs for the condensate cleanup system. It is called the Make-up and Purification System in some plants.
daughter radionuclide	Decay product. A radionuclide resulting from the radioactive disintegration of a radionuclide, formed either directly or as the result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.
DAW	Dry Active Waste.
DB	Deep bed. Deep bed ion exchange columns are large vessels containing bead (not powdered) resin. Activated carbon or other absorbents may also be present in deep bed systems.
dead time	The time when a counter cannot function because the count rate is so high that it overloads its detector. High activity samples have a greater dead time than low activity samples.
decay rate	The rate at which a radioisotope decays. Decay rate is usually given in disintegrations per minute.
decontamination	The complete or partial removal of radioactive contamination.

decontamination factor	For a liquid treatment system or process, Decontamination Factor (DF) is the ratio of initial or influent concentration to final or effluent concentration. (A DF of less than one indicates that contamination is being added, not removed.) For surfaces, DF is the ratio of contamination level before decontamination to the contamination level after decontamination.
dedicated equipment	Equipment that is reserved for some exclusive use, such as dedicated equipment for processing DRP waste.
deep pocket	Financial resources. Many lawyers make it a point when filing a suit to include among the defendants those with "deep pocket" in hopes of being able to collect any judgement.
delisting	Excluding or not listing a specific nuclide as part of the shipping papers.
delta	Change or differential.
delta P (ΔP)	Change in pressure. Pressure drop, as across a filter.
demineralize	A process intended to remove ionic constituents.
demineralizer	An ion exchange vessel used to remove some or all of the ions present in a liquid. In radwaste, the term is often used to mean any ion exchange vessel used for water cleanup.
de minimis	An increment of dose equivalent or a radioactive material concentration (above background) so small that it poses no hazard to the general population. At the present time, no such level has been established.
demurrage	A detention fee or other charge for detaining a truck or freight car. (This is normally incurred when on-site problems delay the shipment of a loaded waste vehicle.)
detention charge	A fee charged by a transportation company to cover the expenses (labor, motel, etc.) of a truck driver when the driver must wait at the plant for an inordinate amount of time. Most transporters allow from two to six hours time to pick up a load at the plant site. After that time, the additional time during which a driver and load is detained will be billed to the utility as a detention charge.
dewatering	The removal of water, usually by gravity or pumping (as distinguished from drying). As the term applies to the processing of spent resin, there are two similar but distinctively different meanings:

(1) When solidifying spent resin, the resin is dewatered to obtain the desired resin:water:binder ratio. It is not intended that all free standing water be removed from the resin before addition of the binder. This dewatering effort is a subcomponent of the utility's **solidification** process control program approved by the NRC.

(2) When dewatering resin for disposal without the intent of solidifying, the dewatering pump and system continues to draw water from the resin until the free-standing water is less than 0.5 percent. This dewatering effort is a subcomponent of the utility's **dewatering** process control program approved by the NRC.

DF	Decontamination factor.
difficult-to-measure radionuclides	Radionuclides that are not abundant and do not release easily detected gamma radiation. Difficult-to-measure radionuclides include strontium-90, carbon-14 and iron-55.
discrete radioactive particle	A highly radioactive small particle. Also called hot particle or "fuel flea."
disposal allocation	The amount of radwaste disposal space allocated without penalty to each nuclear generating station under the Low Level Radioactive Waste Policy Amendments Act.
disposal volume	The volume of radioactive waste being shipped for disposal. This is calculated using the exterior dimensions of the package, and it is , therefore, typically greater than the interior volume.
divisible load	A divisible load is one which can be separated into smaller components. The determination is normally only made when a shipment is being considered for an overweight permit.
dose	A general term denoting the quantity of radiation or energy absorbed. For special purposes, it must be qualified (Radiological Health Handbook. US Department of Health Education and Welfare, 1970).
dose rate	A term denoting the rate at which radiation dose is absorbed. See dose.
DOT	US Department of Transportation.
dp	Differential (delta) P, change in pressure, pressure drop, as across a filter.

dpm	Disintegrations per minute. The number of nuclear events occurring in the sample in one minute.
dps	Disintegrations per second. The number of nuclear events occurring in the sample in one second.
drop-off charge	A fee charged by a transportation company to drop off a trailer for loading at a later time. This fee is usually much lower than the charges incurred if the driver must wait at the plant while the trailer is being loaded. (See detention charge.)
DRP	Discrete radioactive particle, also called hot particle or fuel flea.
dry active waste	Dry, solid, low level radioactive waste.
EDTA	Ethylenediaminetetracedic acid. One of the most powerful and widely used, chelating agents.
efficiency (of a counter)	A measure of the probability that a count will be recorded when radiation strikes a detector. The counts per unit time recorded divided by the disintegrations in the same time.
effluent	The solution that flows from a liquid process stream (either a treatment system or the plant itself).
electro-etch	A process of decontaminating a metallic component by dissolving a layer of the metal surface by employing an electric current.
emergency allocations	Special allocation of waste burial volume allotted under the provisions of the Low Level Radioactive Waste Policy Amendments Act.
energy dependence	In a radiation detector, energy dependence is the variation in pulse height (voltage) with the energy of the incoming radiation. Energy dependence allows discrimination and identification of radionuclides if the system has the electronics to resolve the results.
EPA	US Environmental Protection Agency.
EPRI	Electric Power Research Institute.
EP Tox	EP Toxicity.
EP Toxicity	The toxicity of a chemical as determined by a series of definitions and tests established by the Environmental Protection Agency. The EP Toxicity is one method of determining if a new compound or mixture is hazardous.

etched disk filter	A type of in-line filter employing a porous metal filter media with good mechanical resistance to high pressure drops. Etched disk filters can be cleaned by backwashing.
ethylenediaminetetracedic acid	See EDTA.
exclusive use	As defined by 49CFR173.403(i), exclusive use (also referred to as full load or sole use;) means the sole use by the shipper of a transportation vehicle, for which all loading, transportation, and unloading of the vehicle is carried out under the direction of the shipper or destination. No other material may be picked up by the vehicle while under this designation.
exclusive use shipment	As defined by 49CFR173.403(i), exclusive use means the sole use by the shipper of a transportation vehicle, for which all loading, transportation, and unloading of the vehicle is carried out under the direction of the shipper or destination. No other material may be picked up by the vehicle while under this designation.
exclusive use vehicle	A vehicle used in making an exclusive use shipment. (See "exclusive use.")
exempt quantity	A quantity of radionuclides that is exempt from the transportation regulations of 49CFR.
FD	(Sometimes written **f/d.**). Filter demineralizer(s). Engineered systems that perform both ion exchange and filtration on the liquid being treated.
fifth wheel	A typical waste trailer (40-foot long trailer) has four sets of tires, all located near each other at the rear of the trailer. When the trailer is connected to a tractor (the truck), the tractor acts as the fifth set of wheels for the trailer. The connection point between the trailer and tractor is the adjustment point for the fifth wheel, which adjusts the tractor cab-to-trailer separation.
fines	Finely divided ion exchange material.
fire loading	Using ANI standards, the average weight of combustibles per unit areas. ANI fire loading standards are usually in pounds per square foot. (Permissible values are usually in the range of 20 to 100 lb/ft^2). NFPA gives fire loading in B.t.u./ft^2.
fission product	A nuclide that is formed by nuclear fission. Fission products of concern are usually the radioactive ones such as Cs-137 and the plutonium isotopes. Ordinarily, fission products are confined within the fuel and are only of concern if fuel has been breached.

fixed contamination	Contamination that is not easily removed without disturbing the base material. Contamination that is not transferred to the sample when a wipe or smear sample is taken.
flashpoint	In steam cleaning, the location where spray flashes from water to steam and creates turbulent scrubbing action.
flea	See fuel flea.
Floor Dry	The brand name of a diatomaceous earth-type absorbent approved for use at the Richland, Washington disposal site.
Florco	The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
Florcox	The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
Freon	The brand name of several chlorinated, fluorinated hydrocarbons used for degreasing, cleaning and decontamination.
FPCU	Fuel pool cleanup, more often called SFPCU, spent fuel pool cleanup.
free release	Disposal or recycle without restrictions imposed because of radioactive contamination. See also the preferred term, clean waste verification.
ft^3	Cubic feet. Also abbreviated *cf.*
fuel cladding failure	Breaches in the cladding of fuel of any size that release dissolved or particulate radioactive contamination into the primary system.
fuel DRP	A discrete radioactive particle containing fission products from the reactor fuel.
fuel failure	See fuel cladding failure.
fuel flea	A discreet radioactive particle (DRP) derived from irradiated fuel.
gamma emitter	A radionuclide that emits gamma radiation from its nucleus.
gamma radiation	High energy, short wavelength electromagnetic radiation emitted from the nucleus. Gamma radiation is more penetrating than either alpha or beta radiation. Gamma rays are similar to X-rays, except in their formation. They are normally more energetic.

GC	Gas chromatograph or gas chromatography.
GE	General Electric, the only supplier of boiling water reactors in the United States.
GeLi	Lithium drifted germanium. Sometimes abbreviated Ge(Li). A common and useful radiation detector. A GeLi detector coupled with the right electronics, will resolve the energy of the radiation striking it so that isotopes can be identified.
generation volume	The volume of waste measured before any processing other than collection.
GET	General employee training.
G-M detector	Geiger-Mueller detector.
greater than Class C waste	Waste that is "not generally acceptable" for near-surface disposal. It is waste for which waste form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in 10CFR61, proposals for disposal of this waste must be submitted to the NRC for approval, pursuant to 10CFR61.58.
half-life	The time required for one half of a quantity of a pure radionuclide to decay.
halides	Chemicals of the halogen group in the periodic table of elements. Generally, chlorides, fluorides and iodides.
Hanford	Usually used to mean the licensed low level waste disposal site operated by US Ecology near Richland, Washington. Occasionally, the term is used to mean the Hanford Nuclear Reservation operated by the US Department of Energy near Richland, Washington.
hazardous chemical	See hazardous material.
hazardous material	A material that has hazardous properties as defined in 40CFR261. Hazardous materials would be classified as hazardous waste if they were waste. They are hazardous materials while they yet have a use.
hazardous substance	See hazardous material.
hazardous waste	Listed hazardous waste or waste that exhibits defined hazardous properties. See 40CFR261.

High Density Polyethylene	A type of polyethylene plastic in which the molecules are arranged in tight vertical rows to improve puncture resistance and horizontal tears. For a high integrity container, many layers of this plastic are bonded perpendicular to each other. This greatly enhances tearing in either a vertical or horizontal fashion. The resultant material is called "cross-linked polyethylene" and is an exceptionally strong and long-lived plastic.
HDPE	High Density Polyethylene.
heat stress	Any of a series of physiological conditions that may occur if the deep body temperature exceeds 38°C (102.2°F). Symptoms may include fainting, heat cramps, heat rash, heat exhaustion and heat stroke. Monitoring of the deep body temperature is impractical, so an evaluation of potential heat stress conditions usually requires evaluation of the wet bulb globe temperature in the work area, the work conditions and duration, and the protective clothing
HEPA filter	High efficiency particulate air filter. HEPA filters, by definition, must retain at least 99.97% of particulate material 0.3 microns or larger in diameter.
Herculite	The trademark name of a brand of flexible protective covering used for floors, walls, etc. for contamination control and surface protection.
HIC	High integrity container.
Hi Dri	The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
high integrity container	A container that is designed to contain buried waste for 300 years or more when buried.
High Radiation Area	An area, accessible to personnel, where a major portion of the body could receive in any one hour a dose in excess of 100 millirem.
	hot spot For the purposes of the Desk Reference, a hot spot is a small spot on a radwaste container which produces a substantially higher dose rate than most of the container surface.
HVAC	Heating, ventilating and air conditioning.
HX	Heat exchanger.
hybrid decontamination process	Decontamination processes that are part chemical and part mechanical. Strippable coatings are considered hybrid decontamination processes.

hydrolazer	A type of high pressure water cleaner used for decontamination.
IAEA	International Atomic Energy Agency.
ICRP	International Council on Radiation Protection.
I&E	The Inspection and Enforcement branch of the NRC.
IFF	Irradiated fuel fragment. Other names are fuel DRP and fuel flea.
important to safety	10CFR50, Appendix A says that structures, systems and components that are important to safety are those that "provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public."
Inconel	The trademark name of an alloy used in heat exchanger tubes and other reactor components.
influent	The solution that enters an ion exchange system.
ingrowth	The accumulation of daughter radionuclides from the radioactive decay of the parent.
INPO	Institute of Nuclear Power Operations.
Instant-Dri	The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
internal waste volume	The volume of waste which a container can hold. This is calculated using the interior dimensions of the container, and it is, therefore, typically less than the disposal volume.
irradiated components	For the purposes of this Desk Reference, the term "irradiated components" refers to neutron activated components.
irradiated fuel fragment	Fuel DRP or "fuel flea."
ISO container	A type of shipping container that can be transported by rail, truck or cargo vessel. ISO containers are often used for temporary on-site waste storage or to ship waste to processors. They are also called sea vans, cargotainers, etc.
ISOSHLD	The name of a shielding code.

isotopes	Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore the mass number. Almost identical chemical properties exist between isotopes of the same element.
isotopic composition	The content of a sample by radioisotope. Stable (non-radioactive) isotopes are usually not considered.
IX	Ion exchange.
Johnson Screen	A brand of metal screen used to retain resins in ion exchange columns.
Krolite	The brand name of a vermiculite-type absorbent approved for use at the Richland, Washington disposal site.
liquid scintillation cocktail	The organic solvent used in low level beta counting. It usually contains toluene or similar organic solvents.
liquid scintillation counting	Scintillation counting in the liquid state. Liquid scintillation counting detects beta radiation. See scintillation counting.
limited quantity	Maximum amount of a hazardous material for which there is a specific labeling and packaging exception.
listed hazardous waste	Waste containing components listed in Subpart D of 40CFR261.
live time counter	A counter that automatically corrects for dead time in sample counting.
LLD	Lower limit of detection.
LLW	Low level waste.
LLRW	Low level radioactive waste; more commonly referred to as simply LLW.
LLRWPAA	Low Level Radioactive Waste Policy Amendments Act of 1985.
LOMI	Low oxidation metal ion. A decontamination method employing a dilute solution of vanadium picolinate.
long-lived radionuclide	A relative term, indicating the period of time a radionuclide will be detectable in a significant amount. Radionuclides with a half-life of less than 60 days are rarely considered long-lived. Those with a half-life of 100 years or more almost always are.

lower limit of detection	Usually the least amount of material that can be detected with 95% confidence.
low quality steam	Steam at a temperature and pressure very close to the point at which it will become liquid. Sometimes a mixture of steam and water.
Low Level Waste Policy Amendments Act of 1985 (LLWPAA)	A law passed by the US Congress which outlines state and regional responsibilities for the disposal of low level radioactive waste. The LLWPAA also establishes minimum utility waste disposal volumes from 1986 through 1992 and establishes allowable disposal volume surcharges which may be levied against nuclear stations located in unsited compact regions.
Low Specific Activity (LSA)	LSA (Low Specific Activity) is a class of material in which the activity is essentially uniformly distributed and in which the estimated average concentration per gram of contents does not exceed the specifications of 49CFR173.403(n). This allows less restrictive requirements to be applied during shipping.
LPRM	Low power reactivity monitor.
LRW	Liquid radwaste.
LSA	Low specific activity.
LSA box	A box in which LSA waste is shipped. Metal boxes of about 98 ft3 are common.
LWR	Light water reactor, any water cooled reactor except a heavy water cooled reactor.
magnehelic gauge	A type of differential pressure gauge used in air moving systems.
make-up and purification	One of the designations used for the principal reactor coolant cleanup system in a PWR. In a BWR, this is commonly referred to as the make-up demineralizer (MUD) system.
(MUP) system	pressurized water reactor.
manometer	A type of differential pressure gauge used in air moving systems. This is commonly used to measure the flow rate of air through a ventilation system.
massalinn cloth	A low lint, treated cloth often used industrially for wiping and dusting.
maximum permissible concentration	From 10CFR20, Appendix B. The maximum permitted concentration of a radio nuclide in air or water in a restricted or unrestricted area (separate values). Maximum permissible concentrations in restricted areas were calculated to give an individual exposed to this concentration 40 hours per week, 50 weeks per year the

	maximum permissible radiation exposure (5 rem/year whole body for radionuclides for which the whole body is the critical organ) after a period of 50 years. Maximum permissible concentrations in unrestricted areas were calculated to give an individual exposed to this concentration continuously for 50 years, the maximum permissible exposure for people in unrestricted areas (170 mrem/year whole body for radionuclides for which the whole body is the critical organ). Maximum permissible concentrations are being replaced with a new unit, derived air concentration (DAC).
mCi	Abbreviation for millicuries, a measurement of activity.
MDA	Minimum detectable activity.
MICROSHLD	The name of a shielding code.
minimum detectable activity	The smallest concentration or quantity of a radioactive material in a sample that yields a net count above system background with 95% confidence.
mixed bed (resins)	A physical mixture of anion exchange and cation exchange materials.
mixed waste	Mixed low-level radioactive and hazardous waste. Waste that satisfies the definition of low level radioactive waste (LLW) as defined in the Low Level Waste Policy Amendments Act and contains hazardous waste that either (1) is listed as a hazardous waste in Subpart D of 40CFR261 or (2) causes the LLW to exhibit any of the hazardous waste characteristics identified in Subpart C of 40CFR261. (Definition is from Joint EPA/NRC letter, "Guidance of the Definition and Identification of Commercial Mixed Low-Level Radioactive and Hazardous Waste and Answers to Anticipated Questions".)
MPC	Maximum permissible concentration.
MSDS	Material Safety Data Sheets.
multi-channel analyzer	An electronic counting system that is able to discriminate between pulses of different voltages. Multi-channel analyzers are widely used for gamma spectroscopy for radionuclide identification.
mung	A slang term for solids in liquid radwaste streams, possibly a contraction of mud and dung, two elements which share some of its properties.
MUP	Make-up and purification system.
muriatic acid	A technical grade of hydrochloric acid, usually containing some free chlorine. A 1% solution is sometimes used for cleaning concrete.

MWST	Miscellaneous waste storage tank.
MWT	Miscellaneous waste tank.
NaI	Sodium iodide, usually means a thallium drifted sodium iodide detector.
NaI(Tl)	Thallium drifted (activated) sodium iodide detector.
natural background radiation	The radiation in the natural environment, including cosmic rays and radiation from naturally-occurring radioactive elements, both inside and outside the human body.
NCRP	National Council on Radiation Protection.
neutron	An uncharged elementary particle with a mass slightly greater than a proton.
neutron flux	A measure of the rate of neutron flow. Usually measured in number of neutrons per square centimeter.
new waste stream	A term used to refer to a waste stream that has not been characterized according to 10CRF61.
NGA	Not generally acceptable for shallow land burial (i.e., > Class C waste).
NFPA	National Fire Protection Association.
NIST	National Institute of Standards and Technology, formerly the National Bureau of Standards.
non-compactible DAW	DAW consisting of pipe, valves and reactor components that cannot be reduced in volume by the equipment available. What is considered compactible from one plant to the next will vary depending on the compaction equipment available.
non-divisible load	A non-divisible load is one which cannot be separated into smaller components, such as a single resin liner in a shipping cask, a steam generator, or other large component.
non-sited compact region	From the Low Level Radioactive Waste Policy Amendments Act, any area of the United States which is not a sited compact region.
N.O.S.	A shipping designation meaning "not otherwise specified." In other words, there is no other designation for the material on the shipping tables in 49CFR171.8.
NPDES	National Pollutant Discharge Elimination System.

NRC	US Nuclear Regulatory Commission.
Oil-Dri	Formerly called Safe-n-Dri. The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
O&M	Operation and maintenance.
Origen-2	A computer code used to determine the radionuclide inventory from fission and activation during reactor operation. It has been used to determine the radionuclide inventory of activated components.
ORW	Oily radwaste (liquid).
OTSG	Once through steam generator - a steam generator containing straight tubes (these are used in some B&W reactors.)
outage	That period when a piece of equipment is out of service. Often used to refer to a nuclear reactor outage.
overpack	A large container, into which a smaller container is placed. This is frequently used when the smaller container is damaged or contains liquid which must be surrounded by absorbent. The technical definition from 49CFR171.8 is an enclosure that is used by a single consignor to provide protection or convenience in handling of a package or to consolidate two or more packages. (A freight container is not an overpack.)
package	The packaging together with the contents. For example, a 55-gallon drum is considered as packaging when still empty and consists of the drum, lid, bolt/nut, retainer ring and gasket. When it is filled, closed and ready for shipment, it now becomes a complete package.
packaging	The assembly of components necessary to ensure compliance with the packaging requirements of 49CFR171.8 and 10CFR71. (See package.)
packaged volume	The volume of waste as it is packaged ready for disposal. This includes the volume of the burial containers.
parent radionuclide	A radionuclide that decays to form a radioactive daughter radionuclide. A single radionuclide may be both a parent and daughter in a decay chain.
PASS	Post accident sampling system.
passivation	A chemical process to condition a surface to prevent further corrosion or deposition of materials onto it.

pathway	The route by which a radionuclide travels to give a radiation dose. Radionuclides in airborne or liquid effluents may give a population dose through a food chain pathway.
pCi	Abbreviation for picocuries, a measurement of activity.
PCP	Process Control Procedure, a standard method of verifying the effectiveness of waste processing procedures, e. g., solidification.
PC	Protective clothing.
Petroset	A proprietary solidification agent for hydrocarbons and other chemicals.
pH	The negative logarithm of the hydrogen ion concentration in a liquid (or the log of the reciprocal of the hydrogen ion activity). Essentially, this is a measure of the hydrogen ion concentration. A value of <7.0 is considered acidic, whereas a value of >7.0 is considered basic. A value of exactly 7.0 is considered as having a neutral pH.
photon	A quantum or packet of energy emitted as electromagnetic radiation. Gamma rays, X-rays and visible light consist of photons.
P&ID	Pipe and instrument diagram. A common tool to determine the interconnection of systems or the connection of floor drains.
placarding	The placement of prescribed placards delineating the hazard of a material in transport.
planchet	A metal disk used to position samples for counting. Planchets are most often used in proportional counters.
planer/joiner	A wood working device used to remove the surface from wood. Also called a planer/jointer.
pOH	14 minus the pH value. Essentially, this is a measure of the hydroxide ion (OH^-) ion concentration in a liquid.
polishing	Usually final cleaning of high quality water (as condensate polishing demineralizers).
polyvinyl chloride	A plastic material used in plastic products, such as bags, gloves, booties, bubble hoods, and rain suits. It is also a type of pipe used in some temporary piping installations. (Note: PVC releases chlorine gas when burned, which limits its use for incineration operations.)

POPOP	2,2-p-phenylenebis (5 phenyloxazole) a common liquid scintillator.
PPO	2,5 diphenyloxazole, a common liquid scintillator.
predominate radionuclide	An isotope which, because of its concentration, half-life, or chemical characteristics, appears to be the most prevalent constituent of a sample or waste stream. Cobalt-60 and cesium-137 are usually predominant nuclides in reactor waste.
prefilter	A filter that precedes another filter. Usually an air filter that precedes a HEPA filter.
pressurized water reactor	A light water reactor that transfers heat to a secondary (uncontaminated) steam/ water system which powers the turbine.
primary side	The part of a nuclear power plant that contains primary coolant, the water that is heated directly by the fuel.
prior notification shipment	A shipment of radioactive material or waste which presents a hazard sufficient to require notification of the various states along its route of travel. This notification must be made prior to the shipment entering the state.
process control procedure	A standard method of verifying the effectiveness of waste processing procedures, e.g., solidification.
progeny radionuclide	See daughter radionuclide.
proper shipping name	The name of the hazardous material shown in Roman print (not italics) in 49CFR172.101.
pulse pileup	The effect of so many pulses in a counter that the electronics cannot analyze them. The result is the inability of the detection system to account for all the ionizing events.
PVC	Polyvinyl chloride. A plastic material used in plastic products, such as bags, gloves, booties, bubble hoods, and rain suits. It is also a type of pipe used in some temporary piping installations. (Note: PVC releases chloride gas when burned, which limits its use for incineration operations.)
PWR	Pressurized water reactor.
QAD	A shielding code. QAD stands for quick and dirty.
Radiacwash	A brand of mild chemical decontamination solution reportedly containing oxalic acid.

radiation control area	Any area controlled for the purposes of limiting exposure to radiation or radioactive contamination. Normally, the area immediately surrounding a reactor primary system.
radioassay	Analysis for radionuclides.
radiochemical analysis	Analysis using the chemical properties of the radionuclide of interest to separate it from the bulk of the material before radiological counting. Radiochemical procedures generally have much lower MDAs than direct radiological counting.
radioiodine	A radioactive isotope of iodine. The most common ones are I-129 and I-131.
RADMAN	The name of a shielding code that is geared to the needs of the radwaste professional.
radwaste	Radioactive waste.
raw water	Untreated water from wells, lakes, rivers, or other surface sources.
RCA	Radiation control area. Any area controlled for the purposes of limiting exposure to radiation or radioactive contamination. Normally, the area immediately surrounding a reactor primary system.
RCBT	Reactor coolant bleed tank.
RCDT	Reactor coolant drain tank.
RCRA	Resource Conservation and Recovery Act.
RCS	Reactor coolant system.
RDA	Reliably detectable activity.
regeneration (of ion exchange resins)	Chemical treatment to convert or restore the functional groups in an ion exchange material to a specific ionic form.
regenerative heat exchangers	Heat exchangers that transfer heat from primary system water (as it is removed from the primary system for treatment) to the effluent from a treatment system to warm it prior to reintroduction into the primary system.
Reg Guide	See Regulatory Guide.

Regulatory Guide	One of a series of documents published by the NRC which identify one acceptable method of performing some required task or function.
removable contamination	Contamination that can be removed by hand wiping or other nondestructive measures. It is also called smearable contamination. It is usually quantified as the number of disintegrations per 100 square centimeters.
reportable quantity	The quantity specified in column 3 of the Appendix to 49CFR172.101 for any material identified in column 1 of the same Appendix.
RHR	Reactor Heat Removal (System). One of the principle emergency systems in a reactor.
right-to-know	A series of laws that prescribe the information on various work place and environmental hazards that must be available to workers, and in some cases residents and/or emergency workers, in the vicinity of a generator or processor of a hazardous substance.
R/O	Reverse osmosis, a water purification process using a semipermeable membrane.
rock up	A slang term for crystallization, usually applied to boric acid solutions.
RPT	Radiation protection technician.
RQ	Reportable quantity.
RW	Radwaste.
RWCU	Reactor water cleanup.
RWST	Reactor water storage tank.
Safe-T-Sorb	The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
safety related	Important to safety. 10CFR50, Appendix A says that structures, systems and components that are important to safety are those that "provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public".
SARA	Superfund Amendments and Reauthorization Act.

scabbler	A device used to decontaminate concrete surfaces. The device works by battering and chipping away at the surface many hundreds to thousands of times per minute with many small tips attached to a heavy-duty vibrating motor. Most scabblers also have attached or built-in vacuum systems for controlling dust and airborne particulate material.
scaler	An instrument used to count pulses or events registered by a detector.
scaling factor	Known ratios of radionuclides in reactor waste streams which are used to calculate the quantity of some radionuclides which are known to present but are not directly measured in each waste package. Activation radionuclides such as iron-55 and nickel-63 are usually scaled to cobalt-60. Fission radionuclides such as the plutonium isotopes are usually scaled to cesium-137.
scattering	The change in direction of subatomic particles or photons as a result of a collision or interaction.
scintillation cocktail	The fluid used in liquid scintillation counting for beta radionuclides. Most scintillation cocktails contain toluene or other organic solvents.
scintillation counting	The combination of a phosphor, photomultiplier tube, and associated electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.
scintillator	A material that emits light when struck by radiation.
Scotch-Brite	A brand of abrasive pad used for decontamination.
sea-land container	A large cargo container frequently used to haul bulk waste. A typical sea-land container is 8'Wx8'Hx40'L. Their large size also makes them an ideal storage container for reusable radioactive components.
sea van	Sea-land container.
segregation	The process of separating waste according to radiological considerations. This may involve separating bags of trash by dose rate (e.g., 0-5, 5-50, and >50 mrad/hr), separating trash containing discrete radioactive particles from the more routine radioactive trash, or similar segregation systems.
self absorption	Absorption of radiation by the material in which the radioactive atoms are located: in particular, the absorption of radiation within a sample being assayed.
SFPCU	Spent fuel pool cleanup.

SFPCS	Spent fuel pool cleanup system.
S/G	Steam Generator.
SGBD	Steam generator blow down.
shipping cask	A shielded container used to transport one or more other containers. The other containers fit inside the shipping cask and usually are high dose rate and high concentration packages.
shipping paper	A shipping order, bill of lading, manifest or other shipping document serving a similar purpose and containing the information required by 49CFR171.8.
short-lived radionuclide	A relative term indicating the period of time a radionuclide will be detectable in a significant amount. Radionuclides with a half life of less than 30 to 60 days may be considered short-lived for radwaste management purposes.
SI (units)	The term for an international system of standard radiation units. See conversion tables for specific units.
SIMPLE	The name of a shielding code.
sited compact region	From the Low Level Waste Policy Amendments Act, a compact region in which there is located one of the regional disposal facilities at Barnwell, in the state of South Carolina, Richland in the state of Washington, or Beatty in the state of Nevada.
SLCS	Secondary leakage collection system. The system that collects leakage from the turbine condenser cooling system in a BWR.
sludge	Wet particulate solids.
smearable contamination	Contamination that can be removed by wiping with a cloth or rag.
smear survey	A test for loose or removable contamination. Also called a swipe survey.
SNM	See special nuclear material.
sock filter	A slang term for a cloth bag filter used in liquid processing systems.

sorting	The process of organizing, separating, or arranging waste types by characteristic. This usually involves sorting through a container or bag of waste to separate and organize the contents into separate piles or containers. These separate containers may consist of potentially clean waste to be surveyed for release, recoverable protective clothing, wet rags and mop heads, metals and/or noncompactibles, aerosol cans, recoverables tools and equipment, and/or similar categories.
source material	According to 10CFR20.3 'source material' means: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material."
Spec 7A	Specification 7A of the DOT. It is strictly a "performance specification" for Type A quantities of radioactive material.
special form radioactive material	Those materials which, if released from package, might present some direct radiation hazard but would present little hazard due to radiotoxicity and little possibility of contamination. (49CFR173.389(d)).
special nuclear material	According to 10CFR20.3 'special nuclear material' means: (i) plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of Section 51 of the act, determines to be special nuclear material, but does not include source material' or (ii) any material artificially enriched by any of the foregoing but does not include source material". Reactor fuel is special nuclear material.
specific activity	The total activity of a radionuclide (or all radionuclides) per unit weight of a compound, element, radionuclide or waste.
Speedi-dry	The brand name of a clay-type absorbent approved for use at the Richland, Washington disposal site.
stabilization	The process of converting a non-solid waste form, such as resin beads or filter media, into a stable and solid monolith. A typical example would be to mix resin with cement to form a concrete monolith.
stable	Not subject to radioactive decay, non-radioactive.
stable form radioactive material	Radioactive material that has less stringent handling requirements because of its non-dispersible form. See 10CFR20.

State Form 802	The form required by the state of South Carolina before waste is shipped to Barnwell. Failure to file this form can result in fines or in the waste being returned to the shipper.
Stellite	The trademark name of a very hard alloy material used in valve seats. Stellite contains cobalt which, when activated, forms cobalt-60 and contributes to the radioactivity of the corrosion product layer on piping and to activation DRPs.
stress corrosion cracking	A failure mechanism of metals exposed to chemical stresses, heat and/or pressure. Stress corrosion cracking is promoted by the presence of halides such as chloride, especially in hot systems.
strong outside container	The outermost enclosure which provides protection against the unintentional release of its contents under conditions normally incident to transportation. (This is frequently referred to as a strong, tight container.)
strong, tight container	A container which will not leak any of the contained radioactive materials during conditions normally incident to transportation.
sulfonic acid resin	A cation exchange resin containing the -SO_3H functional group.
Superfine	The brand name of a diatomaceous earth-type absorbent approved for use at the Richland, Washington disposal site.
swipe sample	A test for loose or removable contamination. Also called a smear sample.
tankage	Water storage capacity in on site tanks.
tare	A deduction from the gross weight of a container and its substance for the weight of the container.
TCLP	Toxic contaminant leaching procedure.
Technical Specifications	Part of the licence of NRC licensed nuclear plants. This sets forth the technical parameters and requirements for safe operation of the nuclear plant.
Tech Specs	Technical Specifications. Part of the licence of NRC licensed nuclear plants.
Teflon	A trademark for a chemically nonreactive fluorinated hydrocarbon.
theoretical density	The density of a material without air.
thermal cycling	Significant increases and decreases in temperature. Example: waste stored at 60 degrees Fahrenheit subjected to freezing temperatures.

thoron	An older name for Rn-220. Thoron daughters, like radon daughters, are primarily alpha emitters.
T.O.C. (or TOC)	Total organic carbon.
torus	An area of a BWR that is designed to collect excess coolant in certain postulated accidents.
traceable calibration	A calibration that can be traced to the National Institute of Standards and Technology, formerly the National Bureau of Standards.
transport vehicle	A motor vehicle or rail car used for the transportation of cargo by any mode. Each cargo-carrying body (trailer, railroad freight car, etc.) is a separate transport vehicle.
transuranic	Material that contains more than 100 nano-Curies (nCi) per gram of transuranium isotopes.
TRU	See transuranic.
TSCA	Toxic Substances Control Act.
Type A quantity	Type A quantities are divided per 49CFR171 into two categories: A1 and A2. The A1 and A2 values are found in both 49CFR173.435 and 10CFR71. They are defined as follows: A_1 — special form: A material which, if released from the package, might present a direct hazard from the radiation, such as an encapsulated source, but little hazard from the radiotoxicity and little possibility of contamination; and A_2 — normal form: All other radioactive materials.
type "A" package	A package which is designed in accordance with the general packaging requirements of 49CFR173.24 and 173.412 and which is adequate to prevent the loss or dispersal of the radioactive contents and to retain the efficiency of its radiation shielding properties if the package is subject to the tests prescribed in 49CFR173.465.
Type B quantity	When the A_1 and A_2 values are exceeded (49CFR173.435), or when the sum of the fractions exceeds unity, then the amount of radioactive material that is being shipped is considered as a Type B quantity.

type "B" package	A package which meets the standards for type "A" packaging and in addition meets the standards for the hypothetical accident conditions of transport as prescribed in 10CFR71.
uCi	Abbreviation for microcuries, a measurement of activity.
uncontrolled use	Any use of material that is not controlled by the NRC or state by means or a radioactive materials licence. Sometimes called free release.
UF	Ultra-filtration. A method for removing very small particulate material. **Or,** ureaformaldehyde, an uncommon waste solidification agent for aqueous waste.
unsited compact	A group of states that have entered into a compact under the low level waste policy amendments act, but have not yet selected a disposal site.
unsited region	See non-sited region.
ureaformaldehyde	A thermosetting synthetic resin made by condensing urea with formaldehyde. The resultant product forms a semi-stable mass. When mixed with spent resin from a nuclear plant liquid waste stream, it is intended to stabilize the spent resin.
URC	Ultrasonic resin cleaner.
U-tube manometer	See manometer.
vacuum lift	A lifting device that relies on a vacuum created between the waste container and a plate hanging from the crane hook.
voids	The space between the particles in a resin bed.
void space	The dead (empty) space at the top of a liner or HIC. This normally occurs due to settling of the waste during the dewatering process. It also is sometimes used to refer to empty space left in a solid waste package (e.g., drum or box).
VR	Volume reduction.
waste class	The mechanism used by disposal sites to segregate various radioactive wastes according to their half-lives. Long-lived radionuclides offer a greater hazard to future generations and must, therefore, be segregated from short-lived radionuclides. There are four classifications for low level waste: Class A, Class B, Class C, and greater than Class C. See specific class definition for individual description.
waste, mixed	See mixed waste.

water gauge	A measure of differential pressure equivalent to one inch of water. (This does <u>not</u> refer to a gauge for measuring water.)
weeping (cask)	The phenomenon in which certain casks, after removal from underwater storage basins and after decontamination, subsequently exhibit an increase in the level of contamination during and after transportation (see also text).
WEPA	A Westinghouse pressure washing system for reactor cavities.
Westinghouse	A supplier of pressurized water reactors and reactor services.
w.g.	Water gauge.
WISE	Waste Inventory and Shielding Estimator - a shielding and curie estimation code.
X-radiation	Electromagnetic radiation emitted from the electronic structure of an atom. X-rays are similar to gamma rays, except in their formation. They are normally less energetic.
Z	Atomic number.
zeolite	Hydrous silicates of either natural or synthetic origin.
Zonolite	The brand name of a family of clay-type absorbents. Grades 2, 3 and 4 are approved for use at the Richland, Washington disposal site.
50.59 review	A review to assure that a facility or procedure change, or a proposed test experiment, is permissible under 10CFR50.59. The 50.59 review essentially calls for a determination of whether the proposed change, test or experiment involves a change in the facility technical specifications or an unreviewed safety question.

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About EPRI

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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Printed on recycled paper in the United States

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