U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

BRANCH TECHNICAL POSITION 11-3

DESIGN GUIDANCE FOR SOLID RADIOACTIVE WASTE MANAGEMENT SYSTEMS INSTALLED IN LIGHT-WATER-COOLED NUCLEAR POWER REACTOR PLANTS

REVIEW RESPONSIBILITIES

Primary - Organizations responsible for the reviews of the effectiveness of radwaste processing systems and health physics in confirming that processed waste products meet regulatory requirements on waste classifications and characteristics for transfers and disposal and shipment.

Secondary - Organizations responsible for the reviews of radwaste system design features, system capacities, and performance in processing and packaging liquid, wet, and solid waste materials.

A. Background

During normal operation of a nuclear power plant, radioactive materials are generated in the form of “wet” and “dry” wastes (NUREG-1418 and NUREG/CR-6147). Wet wastes, including spent resins (bead or powdered), filter sludge, process and reverse osmosis concentrates, and spent cartridge filter elements, are typical byproducts of the operation of liquid waste processing systems. Dry wastes, including activated charcoal, high-efficiency particulate air (HEPA) filters, rags, paper, and clothing, are normal byproducts of the operation of ventilation

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air and gaseous waste processing systems and are generated during maintenance and refueling operations.

Wet and dry wastes require processing by using appropriate waste management systems before packaging and shipment for offsite disposal.

Compressible dry wastes, such as contaminated rags, paper, and clothing, normally undergo sorting and compaction processes to reduce the volume of waste shipped offsite. Special provisions are needed to assure that contaminated airborne radioactivity is not released to process areas during compaction.

Liquid wet wastes, such as evaporator and reverse osmosis concentrates, are stabilized (i.e., combined with a suitable binder) before shipping to render the waste immobile and, thereby, mitigate the consequences of potential ruptures to shipping containers. Other wet wastes, such as spent resins (beads or powdered) and filter sludge, are either stabilized or dewatered before shipping. Spent cartridge filter elements are packaged with suitable absorbers in shielded containers or stabilized before shipping.

Although a number of available processes are capable of solidifying wet wastes under controlled conditions, free liquids can potentially remain in containers following stabilization, given the potential presence of various chemical compounds in liquid and wet wastes generated during plant operations and maintenance. For the purpose of this branch technical position (BTP) paper, free liquid is defined as liquid that is still visible after stabilization or dewatering is complete, that is drainable from the low point of a punctured container, or that is drainable from a localized pool trapped within a waste matrix. Based on operating experience, vendors and operators need to implement certain measures to accomplish the following:

- Establish process parameters within which systems must be operated to obtain complete stabilization, encapsulation, and solidification of wastes, as applicable
- Assure that proper waste form properties are achieved
- Assure that systems are operated within established process parameters
- Establish provisions to detect free liquid in containers and waste matrix before wastes are packaged and shipped offsite

Similar restrictions apply to dewatered products to provide greater assurance that these products meet the receiving burial site's free liquid restrictions at the time of receipt.

Following packaging, wastes are normally stored for decay of shorter lived radionuclides and to accumulate sufficient wastes for shipment offsite. Because the continuous operation of the solid waste management system (SWMS) is contingent on the availability of storage space for the interim period between waste packaging and shipment offsite, the applicant should give consideration to providing ample storage capacity to accommodate wastes during periods when offsite shipments are not possible (e.g., during inclement weather, natural disasters, or labor strikes). Furthermore, in view of the reduced availability of burial site disposal capacity, it may be desirable to provide additional onsite short-term storage capacity to accommodate surges in solid waste volume resulting from interruption or limitations in offsite disposal services. Upon resumption of the disposal services, the stored wastes could then be shipped in an orderly fashion.

The criteria in Section B, below, provide adequate and acceptable design solutions for the concerns outlined above. Appendix 11.4-A to Standard Review Plan (SRP) Section 11.4, "Solid Waste Management System," provides further guidance and a list of supporting references on expanded U.S. Nuclear Regulatory Commission (NRC) and industry guidance in processing and storing radioactive wastes. In all cases, the objectives are to meet NRC requirements under Title 10 of the *Code of Federal Regulations* (10 CFR) 61.55, "Waste Classification"; 10 CFR 61.56, "Waste Characteristics"; and 10 CFR 20.2007, "Compliance with Environmental and Health Protection Regulations"; and any parallel criteria imposed by waste storage facilities and waste disposal sites licensed under NRC or Agreement State regulations.

This BTP sets forth an acceptable approach in addressing the above concerns and is not intended to prohibit the implementation of more rigorous design codes, standards, or quality assurance measures than those indicated herein.

B. BRANCH TECHNICAL POSITION

1. Processing Requirements

   A. Dry Wastes

      i. Compaction devices for compressible dry wastes (e.g., rags, paper, and clothing) should include a ventilation shroud around the waste container to control the release of airborne radioactivity generated during the compaction process.

      ii. Activated charcoal, HEPA filters, and other dry wastes that do not normally require stabilization should be treated as radioactively contaminated solids and should be packaged for disposal in accordance with applicable Federal, State, and local regulations that address the presence of other toxic and hazardous materials.

   B. Wet Wastes

      i. Liquid wet wastes, such as evaporator and reverse osmosis concentrates, should be rendered immobile by combining them with a suitable binding agent (e.g., cement or asphalt) to form a homogeneous solid matrix (absent of free water) before offsite shipment. Adsorbents such as vermiculite are not acceptable substitutes for binding agents.

      ii. Spent resins and filter sludge, if acceptable to the receiving burial site, may be shipped dewatered in high-integrity containers. These dewatered wastes are subject to (1) Subsections B.2.A.ii and B.2.B below, (2) to the receiving burial site's maximum free-liquid criteria (upon receipt at the burial site), and (3) applicable U.S. Department of Transportation regulations under 49 CFR Part 171, "General Information, Regulations, and Definitions," through 49 CFR Part 180, "Continuing Qualification and Maintenance of Packagings." Furthermore, the activity level of the dewatered wastes, subject to receiving burial site

requirements, may dictate the type of burial container to be used, such as high-integrity containers. Stabilization or encapsulation of spent resins and filter sludge in a suitable binder is also an acceptable alternative in stabilizing such wastes.

iii. Spent cartridge filter elements may be packaged in a shielded container with a suitably acceptable absorber, although solidifying the elements in a suitable binder is desirable.

iv. When using binding agents, the operational safeguards should be implemented to prevent the introduction and mixing of chemical additives with ion-exchange resins that could result in the generation of exothermic reactions and explosive gas mixtures.

2. Assurance of Complete Stabilization or Dewatering

System operators should assure the complete stabilization or dewatering of wet wastes by implementing a process control program (PCP) or by methods used to detect free liquids in container contents before shipment. The elements of the PCP are described in NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants: A Guidance Manual for Users of Standard Technical Specifications," issued October 1987; NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized-Water Reactors"; and NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling-Water Reactors."

A. Process Control Program

i. Stabilization, encapsulation, or solidification (binding) agents and potential waste constituents should be tested and a set of process parameters (e.g., pH, ratio of waste to agent) should be established with boundary conditions that reasonably assure that stabilization will be complete, with essentially zero free liquid and appropriate waste form characteristics.

ii. Dewatering procedures, equipment, and potential waste constituents should be tested and a set of process parameters (e.g., settling time, drain time and drying time) should be established with boundary conditions that reasonably assure that dewatering will be complete, with essentially zero free liquid.

iii. The solid waste processing system (or liquid waste processing system, as appropriate) should include appropriate instrumentation and wet waste sampling capability necessary to successfully implement and/or verify the PCP described in Subsections B.2.A.i and/or B.2.A.ii, above.

iv. The plant operator should provide assurance that the process is run within the parameters established under Subsections B.2.A.i and/or B.2.A.ii, above. The licensee should maintain appropriate

records for individual batches, showing conformance with the established parameters by waste forms.

B. Free Liquid Detection

Using system-specific procedures, system operators should check each container filled with stabilized or dewatered wet wastes to verify the absence of free liquids using the PCP and implementing procedures. An alternate method may be used when abnormal conditions exist during processing, but the alternate method must be documented and its effectiveness must be demonstrated using real or simulated waste material. Visual inspection of the upper surface of the waste in the container alone is not sufficient to ensure that free water is not present in the container. Provisions that verify the absence of free liquids should consider actual stabilization procedures in avoiding a thin layer or clumps of encapsulation on top or throughout the waste media without affecting the balance of the waste content in the container, and possibly leaving pockets of free-standing liquids within the waste matrix.

3. Waste Storage

A. Tanks accumulating spent resins from reactor water purification systems should be capable of accommodating at least 60 days of waste generation at normal generation rates. Tanks accumulating spent resins from other sources and tanks accumulating filter sludge should be able to accommodate at least 30 days of waste generation at normal generation rates.

B. Storage areas for processed wet wastes (i.e., stabilized or dewatered wastes) should be capable of accommodating at least 30 days of waste generation at normal generation rates. These storage areas should be located indoors and should be protected from freeze/thaw cycles.

C. Storage areas for dry wastes and packaged contaminated equipment should be capable of accommodating at least one full offsite waste shipment.

D. Facility design should include a ventilation exhaust system (for storage areas and processing areas, as needed) and an airborne radioactivity monitoring system (in building exhaust vents or stacks) where there is a potential for airborne radioactivity to be generated or to accumulate in process equipment or buildings. All airborne radioactive releases from storage facilities must be controlled under the provisions of the Offsite Dose Calculation Manual or an equivalent program.

4. Portable Solid Waste Systems

The following supplementary guidance should be incorporated into the design and use of portable (mobile skid-mounted units) volume reduction, stabilization, and/or dewatering systems:

A. Tanks containing wet wastes are limited to in-plant installation and should not be part of the portable system.

B. The use of flexible lines (hoses and connections) should be limited to necessary interfaces with plant systems. Pressure testing of all temporary and flexible lines, connected to plant system piping embedded in concrete and effluent discharge lines or piping buried in soils should be done. Such piping shall have a pressure rating equal to or greater than the system design pressure. Before its use, all flexible piping should be hydrostatically tested to at least 1.5 times the interfacing system design pressure and maintained for at least 30 minutes without leakage or structural deformation to ensure the integrity of the flexible piping and associated fittings.

C. Corrosion-resistant properties should be used for all system piping; valves; and drip pans associated with transfer lines to storage tanks and discharge piping, including features designed for the early detection of leaks and spills.

D. Portable systems should be located, as a minimum, on concrete pads with curbs and drainage provisions to process drains and drip pans or containment boxes to contain radioactive leaks. Provisions should be available for interfacing system drains with the plant's liquid radwaste system. Other safety features may include backflow preventers, siphon breakers, self-sealing quick-disconnects, and operational interlocks to prevent spills. Portable systems should have integral ventilation systems with self-contained filters or should interface with the plant's ventilation exhaust system, and radiation monitoring systems in controlling releases of liquid and airborne process effluents generated as byproducts of system operations. All radioactive effluent releases from portable systems must be controlled under the provisions of the Offsite Dose Calculation Manual or an equivalent program.

E. Mobile liquid waste processing systems with interconnections to permanently installed plant liquid waste management subsystems should include provisions that (1) avoid the contamination of nonradioactive systems, (2) prevent uncontrolled and unmonitored releases of radioactive materials in the environment, (3) avoid interconnections with potable and sanitary water systems, and (4) prevent the cross-contamination of building services, such as water and compressed air, connected to mobile processing equipment.

F. Designs should minimize the potential for spills and leaks to the extent practicable, consistent with maintaining radiation doses as low as reasonably achievable during operations and for the purpose of facilitating decommissioning.

G. Regulatory Guide (RG) 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," and Appendix 11.4-A to this SRP section describe design guidance acceptable to the NRC staff

related to seismic and quality group classifications, safety classification against natural phenomena and man-induced hazards, and quality assurance provisions for structures, systems, and components (SSCs) of the SWMS for liquids and liquid wastes produced during normal operation and anticipated operational occurrences. RG 1.143 discusses the assignment of safety classifications and applicability of acceptance criteria to SSCs based on inventories of radioactive materials and dose estimates to workers and members of the public.

5. Additional Design Features

The following additional features should be incorporated into the design of the solid waste system.

A. Process concentrate piping and tanks should have heat tracing if the concentrates are likely to solidify at ambient temperatures (indoor or outdoor).

B. Components and piping that contain radioactive slurries should have flushing connections and piping runs that minimize the number of bends and traps that may retain radioactivity and lead to increased ambient external radiation exposure rates.

C. Stabilization or encapsulation agents should be stored in low radiation areas, generally less than 0.025 mSv/hour (2.5 mrem/hour), with provisions for sampling.

D. Tanks or equipment that use compressed gases for transport or drying of resins or filter sludge should be vented directly to the plant ventilation exhaust system, which includes HEPA filters, as a minimum, and charcoal filters for radioiodines. The vent design should prevent liquids and solids from entering the plant ventilation system. Liquids, as process-related byproducts and as residual condensation, should be routed to the liquid waste management system.

E. RG 1.143 and RG 1.189, “Fire Protection for Nuclear Power Plants,” provide guidance for designing systems to minimize the probability and effects of fires and explosions under 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion 3, “Fire Protection.” With respect to the permanently installed SWMS and use of mobile processing equipment, design features and operational safeguards should prevent the introduction of chemical additives in wet wastes that could result in the generation of exothermic reactions and explosive gas mixtures. In addition, fire detection and protection measures should be implemented when combustible or flammable radioactive materials are stored, such as spent resins, charcoal media, and HEPA filters and dry wastes. Specific NRC guidance in meeting these requirements is provided in SRP Section 11.4 and Appendix 11.4-A to this SRP Section 11.4. This evaluation should be performed in parallel with the fire hazards and protection analysis

conducted under SRP Section 9.5.1, “Fire Protection Program,” for plant areas identified with the presence of combustible and flammable radioactive materials.

F. The regulations at 10 CFR 20.1406, “Minimization of Contamination,” requires that applicants for design certifications, construction permits, operating licenses, and combined licenses describe how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste. Specific NRC guidance in meeting these requirements is provided in SRP Section 11.4 and SRP 12.3, Appendix 11.4-A to this SRP section, and RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” Industry guidance is presented in Nuclear Energy Institute (NEI) 08-08A. The NRC guidance also identifies industry standards and guidance documents.

C. REFERENCES

1. Nuclear Energy Institute, NEI 08-08A, “Generic FSAR Template Guidance for Life Cycle Minimization of Contamination,” Revision 0, October 2009. ADAMS Accession No. ML093220530.

2. U.S. Code of Federal Regulations, "Minimization of Contamination," § 20.1406, Chapter 1, Title 10, "Energy.”

3. U.S. Code of Federal Regulations, "Compliance with Environmental and Health Protection Regulations," § 20.2007, Chapter 1, Title 10, "Energy.”

4. U.S. Code of Federal Regulations, “Domestic Licensing of Production and Utilization,” Part 50, Chapter 1, Title 10, “Energy,” Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion 3, “Fire Protection.”

5. U.S. Code of Federal Regulations, "Waste Classification," § 61.55, Chapter 1, Title 10, "Energy.”

6. U.S. Code of Federal Regulations, "Waste Characteristics," § 61.56, Chapter 1, Title 10, "Energy.”

7. U.S. Code of Federal Regulations, Parts 171–180, "Subchapter C, Hazardous Materials Regulations," Parts 171–180, Chapter 1, Title 49, "Transportation.”

8. U.S. Nuclear Regulatory Commission, NUREG/CR-6147, “Characterization of Class A Low-Level Radioactive Waste 1986 1990,” (seven volume report), January 1994.

9. U.S. Nuclear Regulatory Commission, NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants.” October 1987. ADAMS Accession No. ML091050057.

10. U.S. Nuclear Regulatory Commission, NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors." April 1991. ADAMS Accession No. ML091050061.

11. U.S. Nuclear Regulatory Commission, NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors." April 1991. ADAMS Accession No. ML091050059.

12. U.S. Nuclear Regulatory Commission, NUREG-1418, "Characteristics of Low-Level Waste Disposed during 1987 through 1989," December 1990.

13. U.S. Nuclear Regulatory Commission, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Regulatory Guide 1.143, ADAMS Accession No. ML013100305.

14. U.S. Nuclear Regulatory Commission, "Fire Protection for Nuclear Power Plants," Regulatory Guide 1.189. ADAMS Accession No. ML092580550.

15. U.S. Nuclear Regulatory Commission, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," Regulatory Guide 4.21. June 2008. ADAMS Accession No. ML082120212.

SRP Section 11.4, BTP 11-3
Description of Changes

BTP 11-3 "Design Guidance for Solid Radioactive Waste Management Systems Installed In Light Water Cooled Nuclear Power Reactor Plants"

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in BTP 11-3, as referenced in SRP Section 11.4, Revision 3, dated March 2007. See the ADAMS Accession No. ML070730202.

Editorial changes included new abbreviations in several places throughout this section and corrected grammatical errors. Other changes reflect the removal of redundant information.

Technical changes incorporated in this revision include:

I. AREAS OF REVIEW

The areas of review, as described in the background and technical position sections, were revised by expanding technical guidance for describing acceptable methods to process and treat dry and wet wastes, and assure complete waste stabilization using a plant specific PCP to demonstrate compliance with 10 CFR 61.55 and 10 CFR 61.56 and with waste acceptance criteria of a licensed disposal site or a third-party waste broker/processor.

The areas of review now address compliance with 10 CFR 20.1406, as it relates to how facility design and operational procedures would be applied to minimize, to the extent practicable, contamination of the facility and the environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste. Specific NRC guidance in meeting these requirements is provided – see listed references.

With respect to specific types of waste forms, the technical discussion was expanded to address operational safeguards in preventing the introduction and mixing of chemical additives with ion-exchange resins that could result in the generation of exothermic reactions and explosive gas mixtures.

With respect to waste storage, the technical discussion was expanded to address the need for ventilation exhaust systems where there is a potential for airborne radioactivity to be generated or to accumulate in process equipment or buildings. In addition, airborne radioactive releases should be controlled and monitored under the provisions of operational programs.

In instances where mobile or skid-mounted process equipment is considered in supplementing the capacity of permanently installed radwaste equipment, the guidance refers to RG 1.143 and Appendix 11.4-A to SRP Section 11.4 for confirming that the design is consistent with seismic and quality group classifications, safety classification against natural phenomena and man-induced hazards, and quality assurance provisions for the associated systems and components.

II. ACCEPTANCE CRITERIA

The acceptance criteria were revised from the prior version of BTP 11-3.

Compliance with 10 CFR 61.55 and 10 CFR 61.56 is explicitly noted in the guidance as opposed to being implied through the development of a PCP, developed before the start of plant operation. Supporting references to NRC and industry implementation guidance documents were added as part of the expanded discussion and listed in a new reference section.

Compliance with 10 CFR 20.1406 was added, as it relates to how facility design and operational procedures would be applied to minimize, to the extent practicable, contamination of the facility and the environment; facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

III. REVIEW PROCEDURES

The review procedures section was updated in recognition of the revisions identified in the areas of review and acceptance criteria sections, as noted in explanations above.

IV. EVALUATION FINDINGS

Not applicable. See evaluation findings described in SRP Section 11.4.

V. IMPLEMENTATION

The implementation of BTP 11-3 is addressed in the corresponding part of SRP Section 11.4 on implementation. No new provisions were added on the implementation of BTP 11-3.

VI. REFERENCES

The following references were added to support the expanded discussions presented in areas of review, acceptance criteria, and review procedures. The added references are:

1. Nuclear Energy Institute, NEI 08-08A, “Generic FSAR Template Guidance for Life Cycle Minimization of Contamination,” Revision 0, October 2009. ADAMS Accession No. ML093220530.

2. U.S. Code of Federal Regulations, "Minimization of Contamination," § 20.1406, Chapter 1, Title 10, "Energy.”

3. U.S. Code of Federal Regulations, "Compliance with Environmental and Health Protection Regulations," § 20.2007, Chapter 1, Title 10, "Energy.”

4. U.S. Code of Federal Regulations, “Domestic Licensing of Production and Utilization,” Part 50, Chapter 1, Title 10, “Energy,” Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion 3, “Fire Protection.”

5. U.S. Code of Federal Regulations, "Waste Classification," § 61.55, Chapter 1, Title 10, "Energy.”

6. U.S. Code of Federal Regulations, "Waste Characteristics," § 61.56, Chapter 1, Title 10, "Energy."

7. U.S. Code of Federal Regulations, Parts 171–180, "Subchapter C, Hazardous Materials Regulations," Parts 171–180, Chapter 1, Title 49, "Transportation."

8. U.S. Nuclear Regulatory Commission, NUREG/CR-6147, "Characterization of Class A Low-Level Radioactive Waste 1986 1990," (seven volume report), January 1994.

9. U.S. Nuclear Regulatory Commission, NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants." October 1987. ADAMS Accession No. ML091050057.

10. U.S. Nuclear Regulatory Commission, NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors." April 1991. ADAMS Accession No. ML091050061.

11. U.S. Nuclear Regulatory Commission, NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors." April 1991. ADAMS Accession No. ML091050059.

12. U.S. Nuclear Regulatory Commission, NUREG-1418, "Characteristics of Low-Level Waste Disposed during 1987 through 1989," December 1990.

13. U.S. Nuclear Regulatory Commission, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Regulatory Guide 1.143, ADAMS Accession No. ML013100305.

14. U.S. Nuclear Regulatory Commission, "Fire Protection for Nuclear Power Plants," Regulatory Guide 1.189. ADAMS Accession No. ML092580550.

15. U.S. Nuclear Regulatory Commission, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," Regulatory Guide 4.21. June 2008. ADAMS Accession No. ML082120212.