U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER™ iPWR DESIGN

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 - Organization responsible for the review of effectiveness of radwaste systems and health physics.

Secondary - Organizations responsible for the review of (1) radwaste system design and performance, and (2) 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. Wet wastes, including spent resins (bead or powdered), filter sludge, process and reverse osmosis concentrates, and spent cartridge filter elements, are normally 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 normally byproducts of the operation of ventilation 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 shipment for offsite disposal.

Compressible dry wastes, such as contaminated rags, paper, and clothing, normally undergo a compaction process to reduce the volume of waste shipped offsite. Special provisions are needed to assure that contaminated airborne radioactivity is not released to the process area 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 widely varying chemical species encountered during power plant operations. For the purpose of this position paper, free liquid is defined as liquid that is still visible after stabilization or dewatering is complete, is drainable from the low point of a punctured container, or is drainable from a localized pool trapped within a waste matrix. Based on the U.S. Nuclear Regulatory Commission (NRC) staff’s judgment, vendors and operators need to implement certain measures to accomplish the following:

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- Establish process parameters within which systems must be operated to obtain complete stabilization, encapsulation, solidification, as applicable
- Assure proper waste form properties are achieved
- Assure systems are operated within established process parameters
- Have provisions to detect free liquid in containers and waste matrix before shipment 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. Insofar as 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 Design-Specific Review Standard (DSRS) Section 11.4 provides further guidance and a list of supporting references on expanded NRC and industry guidance in processing and storing radioactive wastes.

This position paper sets forth minimum branch requirements 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. <u>Processing Requirements</u>

   A. <u>Dry Wastes</u>

      i. Compaction devices for compressible dry wastes (rags, paper, and clothing) should include a ventilated 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 processing should be treated as radioactively contaminated solids and packaged for disposal in accordance with applicable Federal, State, and local regulations addressing 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 with a suitable binding agent (e.g., cement, 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. 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 DOT regulations under Title 49 of the *Code of Federal Regulations* (CFR), Parts 171–180. Furthermore, the activity level of the dewatered wastes, subject to receiving burial site requirements, may dictate the type of container to be used. Stabilization or encapsulation of spent resins and filter sludge in a suitable binder is also an acceptable alternative.

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, 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

Operators should assure the complete stabilization or dewatering of wet wastes by implementing a Process Control Program (PCP) or by methods to detect free liquids within container contents before shipment.

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, 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.

B. Free Liquid Detection

Using suitable methods, the operator should check each container filled with stabilized or dewatered wet wastes to verify the absence of free liquids using the PCP. An alternate method may be used if an off-normal condition exists 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 is not alone sufficient to ensure that free water is not present in the container. Provisions to be used to 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, 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.

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 (ODCM) or an equivalent program.

4. Portable Solid Waste Systems

The following supplementary guidance should be incorporated into the design and use of portable (mobile) 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, as 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 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 ODCM 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 and Appendix 11.4-A to this DSRS 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. The assignment of safety classifications and applicability of acceptance criteria to SSCs are described in Regulatory Positions C.5 and C.6 of RG 1.143.

5. <u>Additional Design Features</u>

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 LWMS.

E. RGs 1.143 and 1.189 require that provisions be designed to minimize the probability and effect of fires and explosions. 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 DSRS Section 11.4 and Appendix 11.4-A to DSRS Section 11.4. This evaluation should be performed in parallel with the fire hazards and protection analysis conducted under Standard Review Plan Section 9.5.1 for plant areas identified with the presence of combustible and inflammable radioactive materials.

F. 10 CFR 20.1406 requires that the facility design and operational procedures 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 in DSRS Sections 11.4 and 12.3, Appendix 11.4-A to this DSRS section and RG 4.21. The NRC guidance also identifies industry standards and guidance documents.

C. REFERENCES

1. RG 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light Water Cooled Nuclear Power Plants.”

2. RG 1.189, “Fire Protection for Nuclear Power Plants.”

3. RG 4.21 “Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning.”

4. 10 CFR 20.1406, “Minimization of Contamination.”

5. 49 CFR Parts 171–180, “Subpart C—Hazardous Materials Regulations.”