



Solid Radioactive Waste Processing System for Light- Water-Cooled Reactor Plants

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**American National Standard
Solid Radioactive Waste
Processing System for Light-
Water-Cooled Reactor Plants**

Secretariat
American Nuclear Society

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**American Nuclear Society
Standards Committee
Working Group ANS-55.1**

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Foreword

(This foreword does not contain any requirements of American National Standard “Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants,” ANSI/ANS-55.1-2021, but is included for informational purposes.)

A key aspect for the further development of nuclear technology is the effective management of low-level radioactive waste generated during facility operation. Fundamental to the effective management of radioactive waste is the design, construction, and operation of radioactive waste processing systems. This standard was originally issued to provide design guidance for in-plant solid radwaste systems. In 2001, the U.S. Nuclear Regulatory Commission (NRC) granted design relief in Regulatory Guide 1.143 (Rev. 2), “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants,” when it allowed ANSI/ASME B31.3, “Process Piping,” as an option to ANSI/ASME B31.1, “Power Piping,” to be used for radioactive waste systems.

The revision of this standard incorporates the design relief granted by the NRC in 2001 and to service continued operation at nuclear facilities and new nuclear facility construction.

It is the purpose of this standard to provide requirements for the design and operation of in-plant solid low-level radioactive waste processing systems. It is the intent of this standard to identify a basis for establishing uniform practices and minimum requirements for the design, fabrication, and operation of those systems as applied to nuclear facility operations (e.g., power plants, institutions, and laboratories that generate wastes approved for disposal under *Code of Federal Regulations* (CFR) Title 10, “Energy,” Part 61, “Licensing Requirements for Land Disposal of Radioactive Waste”). This standard’s scope does not address systems used to process waste from nuclear facilities that potentially contain fissile material in sufficient quantities to require controls to avoid criticality, i.e., wastes containing quantities of fissile or long-lived radionuclides that are classified as high-level or transuranic radioactive waste atypical of NRC-licensed commercial facilities and beyond the scope of 10 CFR 61. Systems applicable to non-low-level waste that use this standard might have to meet additional requirements beyond the scope of this standard. This standard addresses the technical practices and requirements necessary for solid radioactive waste processing operations while maintaining consideration for reducing radiation exposures to the environment, the public, and facility operating personnel.

This standard might reference documents and other standards that have been superseded or withdrawn at the time the standard is applied. A statement has been included in the references section that provides guidance on the use of references.

This standard does not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance. The user is advised that one or more of these techniques could enhance the application of this standard.

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Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants

1 Scope

This standard¹⁾ sets forth the design, construction, and performance requirements for a solid radioactive waste processing system for light-water-cooled reactor plants. For the purposes of this standard, the solid radioactive waste processing system begins at the interface with the liquid radioactive waste processing system boundary and at the inlets to the spent resin, filter sludge, evaporator and/or membrane concentrate, and phase separator tanks. In addition, this standard pertains to dry active waste (DAW), mixed waste, and other solid radioactive waste forms that are generated as part of the operation and maintenance of light-water-cooled reactor plants. The system includes facilities for temporary (up to 30 days of anticipated normal waste generation) on-site storage of packaged waste but terminates at the point of loading the filled drums and other containers on a vehicle. The solid radioactive waste processing system is not a safety-class system as defined by ANS-51.1-1983 (R1988) (withdrawn) [1]²⁾ or ANS-52.1-1983 (R1988) (withdrawn) [2].

2 Acronyms and definitions

2.1 Acronyms

ALARA:	as low as reasonably achievable
ASME:	American Society of Mechanical Engineers
ASTM:	American Society for Testing and Materials
BPVC:	<i>ASME Boiler and Pressure Vessel Code</i>
CFR:	<i>Code of Federal Regulations</i>
DAW:	dry active waste
DOT:	Department of Transportation
HIC:	high-integrity container
HEPA:	high-efficiency particulate air
PCP:	process control program
PLC:	programmable logic controller
NRC:	U.S. Nuclear Regulatory Commission
RWCU:	reactor water cleanup
TEMA:	Tubular Exchanger Manufacturers Association
URC:	ultrasonic resin cleaner

¹⁾ The current standard, ANSI/ANS-55.1-2021, is hereinafter referred to as “this standard.”

²⁾ Numbers in brackets refer to corresponding numbers in Sec. 11, “References.”

2.2 Shall, should, and may

shall, should, and may: The word “shall” is used to denote a requirement; the word “should” is used to denote a recommendation; and the word “may” is used to denote permission, neither a requirement nor a recommendation.

2.3 Definitions

ALARA: As low as reasonably achievable.

Class A, B, and C waste: See *Code of Federal Regulations* (CFR) Title 10, “Energy,” Part 61, “Licensing Requirements for Land Disposal of Radioactive Waste” [3].

container: The primary receptacle forming an isolation boundary between the contained waste and the environment.

dewatered: Liquid or slurry wastes that have had excess free liquid removed to meet applicable burial site criteria.

dry active waste: Radioactively contaminated compactible and noncompactible material, such as rags, paper, plastic, and rubber (compactible) and wood, glass, concrete, and metal (noncompactible).

free liquid: Uncombined liquid not bound by the solid matrix of the solid waste mass, such as liquid that can be drained from a container.

hazardous waste: Waste that is

- (a) listed as a hazardous waste in Subpart D of 40 CFR 261 [4], or
- (b) exhibits any of the hazardous characteristics identified in Subpart C of 40 CFR 261 [4], or
- (c) is otherwise identified as a hazardous waste by applicable state regulations.

high-integrity container: A U.S. Nuclear Regulatory Commission (NRC)-approved or state-approved container that provides waste stability for near-surface disposal in accordance with 10 CFR 61 [3].

homogeneous: The condition in which the waste and radionuclides are uniformly distributed throughout the package.

low-level waste: Radioactive waste (radwaste) not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or by-product material as defined in Section 11e.(2) of the Atomic Energy Act of 1954 [5] (uranium or thorium tailings and waste).

mixed waste: A waste that meets both the definition of a low-level radioactive waste and the definition of a hazardous waste.

normalized inputs: The design-basis values for a plant of specific power rating.

process control program: A set of procedures used to ensure that a wet waste (concentrates, media, mechanical filters) is converted to a dry consistent waste form that meets all applicable regulatory and disposal site requirements.

short-lived isotopes: Radionuclides with half- lives of less than 8 days.

slurry wastes: Liquid radioactive wastes of high insoluble content (greater than 0.1% insoluble solids by weight).

solidification agent: Material that, when mixed in prescribed proportions with liquid or slurry waste, can form a freestanding product with no free liquid. Includes material used to encapsulate solid objects like cartridge filters.

solidify: To immobilize by a method that converts the liquid, slurry, or finely divided dry waste to a solid that is monolithic with a definite volume and shape and bounded by a stable surface with a distinct outline on all sides (freestanding).

stability: Refers to a waste form that meets the requirements established for structural stability in order to meet 10 CFR 61 [3] requirements. A stable waste form will generally maintain its physical dimensions and its form under the expected disposal conditions. The NRC “Waste Form Technical Position” [6] provides guidance on acceptable methods to demonstrate waste stability.

treatment: Any method, technique, conditioning, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous material; or designed to recover energy or material resources from the waste; or designed to render the waste nonhazardous or less hazardous, safer to transport, store, or dispose of, or amenable for recovery or storage, or reduced in volume.

3 Objectives

This standard establishes minimum requirements for the design and construction of the solid radioactive waste processing system, including temporary waste storage, to achieve the performance, safety, and operational objectives specified in this section.

3.1 Performance objectives

The solid radioactive waste processing system shall be designed and constructed to collect, process, package, and temporarily store liquid and solid wastes in a timely and economical fashion to avoid adverse effects on unit capacity or availability and to limit generation of radioactive and mixed wastes.³⁾

For this standard, temporary waste storage is defined as the area needed to store up to 30 days of anticipated normal waste generation for packaged radioactive waste that is ready for shipment.

The handling and monitoring of solid radioactive waste shall meet the requirements of Criteria 60 and 63 of 10 CFR 50, Appendix A [8]. Packaging and waste form stabilization shall meet the requirements of Sections 61.7, 61.55, 61.56, and 61.58 of 10 CFR 61 [3] as well as specific waste disposal site requirements. The off-site shipment and disposal shall be in accordance with applicable Department of Transportation (DOT), NRC, Environmental Protection Agency, and state regulations (see Appendix A).

In addition, radioactive mixed wastes cannot be treated or stored for longer than 90 days without interim (part A) or final (part B) permits. Refer to 40 CFR 264 [9] and to 40 CFR 265 [10] for permit requirements.

³⁾ Waste minimization and volume reduction techniques should be emphasized pursuant to the NRC’s policy statement on low-level waste volume reduction [7].

3.1.1 Solid waste processing

Except as noted below, liquids and solids removed from liquid processing systems, including spent resins, filter sludges, and evaporator and reverse osmosis concentrates, shall be collected, stored for decay when appropriate (i.e., radioactive waste with short-lived radioactive isotopes), solidified or dewatered, and packaged prior to storage and shipment. Other solid wastes, including spent filters, DAW, incinerator ash, and mixed waste shall be appropriately contained, collected, segregated, dewatered/dried when required, packaged, and stored prior to shipment. These requirements may vary if waste is sent to an off-site processor prior to disposal. High-integrity containers (HICs) may be used to provide waste form stability per 10 CFR 61 [3] for dewatered resin and filters.

3.1.2 Packaged waste storage

Storage facilities for packaged wastes should be designed and constructed to reduce the requirements and complexity of handling and to simplify the accountability, identification, inspection, and removal of selected packages for loading and shipment in an as low as reasonably achievable (ALARA) manner.⁴⁾

3.1.3 Packaged waste

Handling facilities and equipment for handling packaged wastes should be sized and selected to accommodate a variety of container types and sizes, shielding requirements, and transport vehicles to be used for shipment.

3.2 Safety objectives

The design and construction of the solid radioactive waste processing system shall be such that the performance objectives of Sec. 3.1 are met while maintaining ALARA. Radiation exposures to operating and maintenance personnel shall be limited to the values and requirements of 10 CFR 20 [12].

4 System requirements

This section addresses the processes and mechanical features that are necessary to establish the overall system design and equipment needs for permanently installed solid radioactive waste systems as addressed in ANSI/ANS-40.37-2009 (R2021) [13].

The solid radioactive waste system shall provide for the temporary storage of packaged waste awaiting transport for up to 30 days of anticipated normal waste generation.

4.1 Process design

There are many equipment combinations that meet the performance objectives of this standard. Figure 1 provides an example flow diagram that illustrates the process flow steps and the possible operations that can be used to achieve the objectives of this standard. Other equipment not shown may be used if it meets the objectives of this standard.

⁴⁾ Interim radwaste storage facilities should be designed in accordance with NRC guidelines established in Section 11.4 of NUREG-0800 [11].

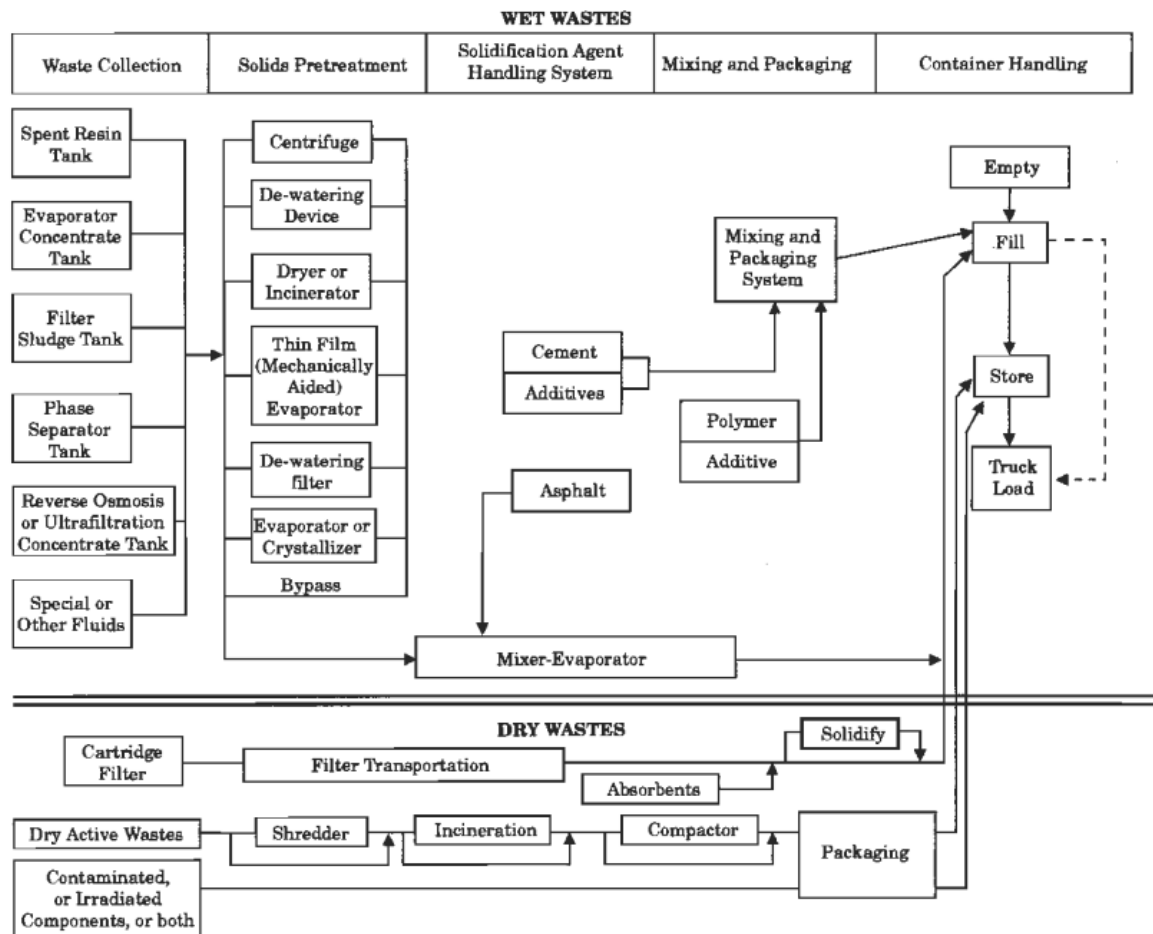


Figure 1 – Process flow

4.1.1 Waste classification

This section classifies the sources to the solid radioactive waste processing system in terms of their physical characteristics.

4.1.1.1 Liquids

Principal liquid radioactive waste sources are floor drains; equipment drains; concentrated evaporator bottoms; resin regeneration, cleaning, and transfer liquids; reverse osmosis and ultrafiltration concentrates; detergents; and chemical wastes from laboratory and decontamination procedures.

4.1.1.2 Slurries

Principal slurry waste sources are filter sludges, powdered resins, and bead resins and include the water used for transport.

4.1.1.3 Wet solid waste

The principal wet solid waste sources are spent filter elements (cartridge or bag) and dewatered sludges and resins that have had free liquid removed.

4.1.1.4 Dried waste residuals

The principal dried waste residual sources are those remaining dry products obtained by the removal of all fluid and bound water from drying and calcination of liquid or slurry waste streams and the incineration or pyrolysis of slurry, wet solid, and dry wastes.

4.1.1.5 Dry active waste

The principal DAW sources are paper, cloth, wood, plastic, rubber, glass, metal components, and ventilation filters and charcoal that are contaminated. DAW may consist of both compactible and noncompactible materials.

4.1.1.6 Special dry radioactive components

Large contaminated core components and discarded equipment components are considered as special dry solids requiring packaging and disposal as radioactive solids but not normally requiring solidification processing within the plant.

4.1.2 Process requirements

The processing requirements included in this section are considered the minimum necessary to meet the performance objectives of this standard. Figure 1 illustrates a set of process flow steps. Selection of the specific operation for each process flow step is an engineering decision based on consideration of the waste type and quantity. Various process combinations are possible, and a “standard system” is not mandatory.⁵⁾

The solid product resulting from the volume reduction, mixing, solidification, and dewatering shall meet all applicable NRC and appropriate state disposal requirements. Waste packages shall meet applicable DOT and NRC transportation requirements.

4.1.2.1 Liquids

Liquid waste shipped for disposal shall be satisfactorily solidified or absorbed using approved absorbent material in sufficient volume to absorb twice the volume of free liquid. Sufficient absorbent material shall be added to meet applicable burial site conditions. The system for processing liquid wastes may include one or more concentration processes. Liquids may be shipped for off-site processing in an appropriate container. If the liquid is radioactive oil, it may be shipped as a liquid in an appropriate container to an approved incinerator or pyrolysis facility.

4.1.2.2 Slurries

The system for processing slurry wastes (mixtures of solids and liquids) shall include the capability to satisfactorily solidify, dewater, or dry and package the waste for shipment. Radioactive waste or clean water may be added prior to the solidification operation if desired for economic or process reasons. The processing of the slurries by dewatering shall result in less than 0.5% of the waste volume as a noncorrosive liquid, or less than 1% in a HIC. The liquid fraction shall also meet applicable burial site criteria that could be more restrictive.

⁵⁾ Guidance on seismic design requirements can be found in Regulatory Guide 1.143 [14].