

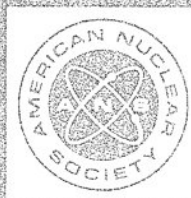
American Nuclear Society

**design requirements for light water reactor spent fuel
storage facilities at nuclear power plants**

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**American National Standard
Design Requirements for Light Water Reactor Spent
Fuel Storage Facilities at Nuclear Power Plants**

**Secretariat
American Nuclear Society**

**Prepared by the
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Standards Committee
Working Group ANS-57.2**

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Foreword

(This Foreword is not a part of American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants, ANSI/ANS-57.2-1983.)

This standard sets necessary design requirements for the designer of spent fuel storage facilities at water cooled nuclear power plants. It gives general guidelines and specific design parameters which could assist in both the design and licensing efforts if used. However, the designer is not relieved of the responsibility for complying with specific construction codes referenced herein. U. S. Nuclear Regulatory Commission (NRC) regulatory guides exist that contain information useful in designing systems and components. This standard was developed under sponsorship of the American Nuclear Society and was approved as an American National Standard in 1976 (N210-1976). In this revision, it has been extensively changed and completely reorganized. Working group ANS-57.2 which developed and rewrote the standard had the following membership during the period in which it was prepared:

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Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants

1. Introduction and Scope

1.1 Introduction. Spent nuclear fuel represents a potential risk to the health and safety of the general public and of personnel involved in its handling. It also represents a substantial investment on the part of the owner organization. However, protection of the general public and operating personnel must take precedence over any other consideration in design and construction of spent fuel handling and storage facilities. This requirement is consistent with protection of the owner's investment in the fuel.

1.2 Scope. This standard presents necessary design requirements for facilities at nuclear power plants for the storage and preparation for shipment of spent fuel from light-water moderated and cooled nuclear power stations. It contains requirements for the design of the following:

- Fuel storage pool
- Fuel storage racks
- Pool makeup, instrumentation and cleanup systems
- Pool structure and integrity
- Radiation shielding
- Residual heat removal
- Ventilation, filtration and radiation monitoring systems
- Shipping cask handling and decontamination
- Building structure and integrity
- Fire protection and communication.

1.3 Objectives. This standard defines the functions of spent fuel facilities at nuclear power plants including both equipment and systems. This standard includes basic requirements and system arrangements with consideration for design, construction, fabrication, maintenance, operation and licensing.

This standard is based on systems engineering criteria developed and presented in American National Standards Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants, ANSI/ANS-51.1-1983 [1], and Nuclear Safety Criteria for the Design of

Stationary Boiling Water Reactor Plants, ANSI/ANS-52.1-1983 [2].¹

2. Definitions

backup system. An alternate system of similar functional capability to the normally operating system. It need not be the same seismic category and safety class as the system it backs up.

cell. A unit for storage of an individual fuel assembly. It is a subassembly of a storage rack.

control components. Items that control coolant flow or reactivity and must be handled or shifted in position during fuel loading or refueling. Examples are: control rods, flow limiting orifices, burnable poison rods.

crane.

1. **Auxiliary Fuel Handling Crane** - a crane used for handling equipment including fuel assemblies and new fuel shipping containers.

2. **Cask Crane** - a crane designed for handling spent fuel shipping casks.

demineralized water. Water purified by ion exchange to a quality at least equal to Type IV in American National Standard Specification for Reagent Water, ANSI/ASTM D 1193-77 [3].

failed fuel. A fuel assembly with a perforation of or a defect in the fuel cladding, or any distortion or break causing a structural change that requires, due to the fuel condition, any of the following:

Use of abnormal handling procedures or equipment,

Premature replacement of a fuel assembly,

Replacement of its component parts or restrictions on plant operation.

fuel damage. Damage to a fuel assembly that breaches the cladding or distorts or disrupts spacer grids, fuel rods, end fittings or overall

¹Numbers in brackets refer to corresponding numbers in Section 7, References.

envelope dimensions, rendering it unfit for service in a reactor.

fuel handling accident. An accident associated with nuclear fuel handling procedures having the potential to adversely impact nuclear safety by increasing k_{eff} or causing radioactivity release.

fuel handling machine. Equipment operating over the spent fuel pool specifically designed for handling fuel and control components.

natural phenomena. Environmental conditions, some examples of which are earthquakes, tornadoes, flooding, lightning, hurricanes, snow and ice.

operating basis earthquake (OBE). The earthquake that, considering the regional and local geology and seismology and specific characteristics of local subsurface material, could reasonably be expected to affect the plant site during the operating life of the plant. It is the earthquake that produces the vibratory ground motion for which those features of the nuclear power plant, necessary for continued operation without undue risk to the health and safety of the public, are designed to remain functional.

plant conditions. The purpose of categorizing Plant Conditions (PC) is to provide a means of establishing design requirements to satisfy operational and safety criteria of the facility. These are: defined by normal operation (PC I), classified on the basis of expected frequency of occurrence (PC II and III), or postulated because their occurrence may result in the maximum potential impact on the immediate environs (PC IV and V). Evaluation of the consequences of any such event can then be used to specify the performance requirements of the systems and subsystems within the facility.

1. plant condition I

a. Definition. PC I events are those events that are expected to occur regularly or frequently in the course of normal operation at the facility.

b. Examples

- (1) Fuel handling
- (2) Spent fuel shipping
- (3) Storage of leaking fuel that resulted in up to ten percent of the Technical Specification limit for Reactor Coolant activity during power operation

(4) Inspection of fuel within the storage facility

(5) Storage of new fuel in the spent fuel facility.

2. plant condition II

a. Definition. PC II events are those events with a best estimate of frequency of occurrence $(F) \geq 10^{-1}$ /reactor year.

b. Examples

(1) Loss of a pump in the spent fuel pool cooling system

(2) Spurious operation of an active element; e.g., relief valve, control valve

(3) Single error of an operator

(4) Full core removal

(5) Single failure in the electrical or control system

(6) Loss of normal spent fuel cooling up to eight (8) hours

(7) Storage of leaking fuel that resulted in up to 25 percent of the Technical Specification limit for Reactor Coolant activity during power operation

(8) Minor pool liner leakage in an amount that can be handled by the radwaste system on a continuous basis.

c. The facility shall be designed so that a PC II event shall not cause a loss of function of the reactor coolant system, reactor containment barriers or any other engineered safety features system or component.

3. plant condition III

a. Definition. PC III events are those events with a best estimate frequency of occurrence (F) such that $10^{-1} > F \geq 10^{-2}$ /reactor-year.

b. Examples

(1) A passive failure of a radioactive liquid retaining boundary that prevents the affected system from performing its design function

(2) A loss of offsite power for up to eight (8) hours

(3) Drop of a fuel assembly with its associated handling tool onto the racks from its normal operating height

(4) Storage of leaking fuel that resulted in up to 100% of the Technical Specification limit for Reactor Coolant activity during power operation

(5) Overfilling of the pool

(6) Loss of non-Seismic Category I portion of the Spent Fuel Pool Cooling System

(7) Loss of air supply to seals on gates, resulting in leakage from the pool

(8) Operating Basis Earthquake (OBE)

(9) Drop of the spent fuel cask from controlled normal height.

4. plant conditions IV and V

a. Definition. PC IV and V consist of that set of possible events that are not expected to occur during the life of the facility, but are postulated because their consequences would include the potential for the release of significant amounts of radioactive material. These faults are the most severe that must be designed against, and thus represent the limiting design case. Best estimate frequency of occurrence (F) per year is $10^{-2} > F > 10^{-6}$.

b. Examples

(1) Rupture of all fuel rods in a spent fuel assembly

(2) Inadvertent opening of a gate (cask loading isolation or transfer canal isolation) when the adjoining area is empty resulting in reduced shielding

(3) Effects of facility design basis natural phenomena

(4) Drop of the spent fuel cask from maximum achievable height

(5) Safe Shutdown Earthquake (SSE)

(6) Loss of offsite power for up to seven days.

pool. A single isolable body of water with a free surface. Examples are the spent fuel storage pool, the cask handling pool, the fuel transfer canal, and reactor refueling cavity (or well).

rack. A structure consisting of an assembly of cells.

redundant component, system or subsystem. A component, system or subsystem that independently duplicates the function of another component, system or subsystem.

safe shutdown earthquake (SSE). The earthquake based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is the earthquake that produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional.

safety classification. Components shall be classified as Safety Class 3 or as Non-Nuclear

Safety (NNS) in accordance with definitions set forth in section 3.3 of American National Standards Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants, ANSI/ANS-51.1-1983 [1], and Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants, ANSI/ANS-52.1-1983 [2].

seismic category I. The category of nuclear safety related structures, systems and components that are required to perform their nuclear safety function during or after an SSE as necessary to accommodate any event involving an SSE.

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" to denote permission, neither a requirement nor recommendation. In order to comply with this standard, the design shall conform to its requirements, but not necessarily with its recommendations.

3. Facility Safety Function

The function of the spent fuel storage facility is to store and protect fuel at a plant to assure the capability to prevent or mitigate the consequences of plant conditions that could result in potential off-site exposures that are a significant fraction of the Code of Federal Regulations, Title 10, "Energy," Part 100, "Reactor Site Criteria" [4]. This is accomplished by:

- Preventing criticality
- Removing decay heat
- Preventing fuel damage.

4. Facility and System Description

The spent fuel storage facility, for the purpose of this standard, is functionally divided into the following systems: spent fuel storage pool and cask handling pool, spent fuel cask handling system, cooling and cleanup system, spent fuel racks, fuel storage building, and the electric power, instrumentation and control, and communications systems.

4.1 Spent Fuel Storage and Cask Handling Pools

4.1.1 Subsystem Boundary. The Spent Fuel Storage Pool and the Cask Handling Pool consists of the structure within which irradiated fuel is stored and the spent fuel cask is loaded or unloaded.

4.1.2 Subsystem Components

- (1) Pool Structures
- (2) Pool Liners
- (3) Isolation Valves and Gates.

4.2 Spent Fuel Cask Handling System

4.2.1 Subsystem Boundary. The Spent Fuel Cask Handling System includes equipment for cask receiving, monitoring, cooldown, flushing, loading, unloading, decontamination and preparation for shipping.

4.2.2 Subsystem Components

- (1) Cask Receiving Area
- (2) Spent Fuel Cask Crane
- (3) Cask Decontamination System.

4.3 Cooling and Cleanup System(s)

4.3.1 Subsystem Boundary. The Spent Fuel Pool Cooling and Cleanup system(s) includes equipment for the removal of decay heat by a heat exchanger and for the removal of radioactive materials and particulates from the pool water by circulation through filters and ion exchange units. The system may also provide makeup water to the pools under normal and emergency conditions.²

4.3.2 Subsystem Components

- (1) Spent Fuel Pool Coolers
- (2) Spent Fuel Pool Cooling Pumps
- (3) Spent Fuel Pool Filters
- (4) Spent Fuel Pool Demineralizers
- (5) Spent Fuel Pool Filter/Drain Pumps (if used)
- (6) Makeup System Components.

4.4 Spent Fuel Storage Racks

4.4.1 Subsystem Boundary. The spatial envelope created by the spent fuel storage racks includes cells and bracing, if provided.

4.4.2 Subsystem Components. This subsystem includes, but is not limited to, the following:

- (1) Cells
- (2) Bracing (if provided).

4.5 Fuel Storage Building

4.5.1 Subsystem Boundary. The fuel storage building includes protective envelope with security provisions.

4.5.2 Subsystem Components. This subsystem includes, but is not limited to, the following:

- (1) Security Enclosure
- (2) Fire Protection
- (3) HVAC System.

4.6 Electric Power, Instrumentation and Control (I&C) and Communications

4.6.1 Subsystem Boundary. The Electric Power, I&C, and Communications system includes electric power, system control and status indication, lighting, communications, alarms, radiation monitoring, and any electronic access control systems.

4.6.2 Subsystem Components

- (1) Power Distribution Equipment
- (2) Underwater and Security Lights
- (3) Loudspeaker System and Sound Powered Phones
- (4) Security Access Control
- (5) Radiation Monitoring Equipment
- (6) Temperature and Level Monitoring Equipment.

5. Facility Performance Requirements

(1) PC I occurrences shall be accommodated with margin between any facility parameter and the value of those parameters that would require either automatic or manual protective action. Any release of radioactive materials to an unrestricted area as defined in the Code of Federal Regulations, Title 10 "Energy," Part 20, "Standards for Protection Against Radiation," shall be in conformance with Section 20.106 [5], and the design objectives of Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light Water Cooled Nuclear Power Reactor Effluents," of the Code of Federal Regulations, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities" [6].

(2) PC II occurrences shall be accommodated with necessary corrective action which shall be capable of being performed assuming a single active failure. Any release of radioactive materials in effluents to an unrestricted area as defined in 10 CFR 20, Section 20.3 [5] shall be in conformance with Paragraph 20.106 of 10 CFR 20 [5]. Gaseous and liquid effluents shall also meet the design objectives of Appendix I of 10 CFR 50 [6].

(3) PC III occurrences shall be accommodated with necessary corrective action which shall be

²Typical system diagrams are shown in Appendix A.