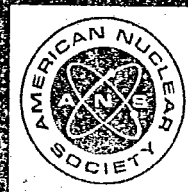


American Nuclear Society

design criteria for an independent spent
fuel storage installation (water pool type)

an American National Standard



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**American National Standard
Design Criteria for an Independent Spent
Fuel Storage Installation (Water Pool Type)**

Secretariat
American Nuclear Society

Prepared by the
**American Nuclear Society
Standards Committee
Working Group ANS-57.7**

Published by the
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American National Standard

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Foreword (This Foreword is not a part of American National Standard Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type), ANSI/ANS-57.7-1988.)

This standard provides criteria for the design of a water basin Independent Spent Fuel Storage Installation (ISFSI) for Light Water Reactor (LWR) spent fuel. It sets forth performance and design requirements as well as general guidelines which will assist in both design and licensing efforts. The standard also presents interface requirements in the event the installation is located at an existing nuclear facility.

ISFSIs represent a new step in the nuclear fuel cycle. This new or additional step is required in order for the industry to develop and analyze alternate methods and approaches to the back-end of the fuel cycle.

An ISFSI could be substantially larger than any existing spent fuel storage facility associated with either a nuclear power plant or a fuel reprocessing plant.

An ISFSI would function solely in a protective custodial capacity, providing stable safe storage conditions pending some future disposition of the spent fuel. The stored spent fuel would be maintained in a quiescent state by the activities conducted at an ISFSI. This does not preclude mechanical handling activities related to fuel storage, such as the canning of damaged fuel assemblies and rod consolidation. Such activities do not involve the exposure of the fuel itself to the storage environment other than that resulting from defective fuel cladding.

While the spent fuel is in passive storage, decay heat and the modest pressure within the fuel rods would be the only driving forces for dispersal offsite of the radionuclides contained in the spent fuel. To minimize even these forces, the spent fuel is kept under water for at least a year after discharge from a reactor before being transferred to an ISFSI. The shielding requirements for personnel occupancy of the storage area assure a depth of water over the stored fuel which also contributes to heat storage capability. The design requirements set forth in the standard are based on the principals of maintaining occupational exposure ALARA.

The provisions of this standard are based on the assumption that the storage pools would be operated with their water level required for in-storage radiation shielding being at or below grade.

The heat storage capability of the storage pool would allow adequate time to take corrective action in case of a breakdown of the cooling system. In the event of an earthquake or other extreme natural phenomena, sufficient makeup water will be available to maintain safe storage conditions.

In general, the safe storage of spent fuel assemblies is achieved by maintaining the integrity of the fuel cladding. Fuel cladding is designed to withstand a far more severe environment in a reactor than in storage in an ISFSI. Under the low temperature conditions of static storage, the cladding will provide an effective primary barrier to the escape of fission products and fissile materials from the stored fuel. The pool water will be an effective secondary barrier for the confinement of the small amounts of radioactive materials that may be released from the spent fuel.

A section is provided which identifies interface considerations for shared systems and facilities for situations where the installation is located at or near an existing nuclear facility. Appendices are provided for informational and clarification purposes. The appendices are not part of the mandatory criteria of the standard. Use of the appendices by the designer is optional.

It should be noted that although American National Standard Criteria for Nuclear Criticality Safety Controls in Operations Where Shielding Protects Personnel, ANSI/ANS-8.10-1983 (R 1988) provides general guidance for nuclear criticality safety controls, the standard is not directly applicable to ISFSI criticality control because it permits a single failure to result in criticality in facilities where personnel are adequately protected from the results of criticality by radiation shielding. This standard follows the more conservative criterion utilized in the nuclear power industry that no single failure can result in nuclear criticality.

The membership of Working Group ANS-57.7 of the Standards Committee of the American Nuclear Society for its revision was:

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6-11-1988

Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)

1. Introduction and Scope

1.1 Introduction. This standard is intended to be used by those involved in the ownership and operation of an Independent Spent Fuel Storage Installation (ISFSI) in specifying the design requirements and by the designer in meeting the minimum design requirements of such installations.

This standard continues the set of American National Standards on spent fuel storage design. Similar standards are: Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations, ANSI/ANS-57.2-1983 [1]; Design Objectives for Highly Radioactive Solid Material Handling and Storage Facilities in a Reprocessing Plant, ANSI/AICHE N305-1975 [2]; Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type), ANSI/ANS-57.9-1984 [3]; Design Criteria for Consolidation of LWR Spent Fuel, ANSI/ANS-57.10-1987 [4]; and Guidelines for Establishing Site-Related Parameters for Site Selection and Design of an Independent Spent Fuel Storage Installation (Water Pool Type), ANSI/ANS-2.19-1981 [5].¹

1.2 Scope. This standard provides design criteria for systems and equipment of a facility for the receipt and storage of spent fuel from light water reactors. It contains requirements for the design of major buildings and structures including the shipping cask unloading and spent fuel storage pools, cask decontamination, unloading and loading areas, and the surrounding buildings which contain radwaste treatment, heating, ventilation and air conditioning, and other auxiliary systems. It contains requirements and recommendations for spent fuel storage racks, special equipment and area layout configurations, the pool structure and its integrity, pool water cleanup, ventilation, residual heat removal, radiation monitoring, fuel handling equipment, cask handling equipment, prevention of criticality, radwaste control and monitoring systems, quality assurance requirements, materials accountability, and physical security.

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

1.3 Limits of Application. This standard applies for use in the design of an ISFSI which has the following limitations:

(a) The installation is for underwater storage of spent fuel.

(b) The fuel unit to be stored

- (1) is only commercial LWR UO₂ fuels,
- (2) has aged a minimum of one (1) year after discharge from the reactor core.

(c) The normal water level of the storage pool is at or near final design grade level.

(d) Operating functions include:

- (1) Cask receiving and washdown,
- (2) Cask monitoring, cooling, and decontamination,
- (3) Cask unloading,
- (4) Cask decontamination and minor maintenance,
- (5) Fuel unit storage, transfer, and incidental handling as required,
- (6) Water treatment and waste handling,
- (7) Cask loading and preparation for shipping,
- (8) Spent fuel assembly canning, and
- (9) Related activities such as, rod consolidation.

(e) The installation design life is forty (40) years. (This does not necessarily mean that the fuel units will be stored for that period of time.)

(f) Cask crane travel does not pass over fuel unit storage pool(s), or any other locations where fuel units are stored.

(g) Casks received shall have been analyzed for use in this installation.

1.4 Overall Design Considerations

(a) Short-lived high specific activity radionuclides, particularly those of Iodine and Xenon are no longer present in significant quantities in spent fuel that has aged for more than one (1) year since discharge from the reactor core.

(b) The underwater storage of aged spent fuel is a low hazard potential activity. Very little of the radioactivity present is available in a dispersible form and there is no mechanism present to cause the release of radioactive materials in significant quantities from the installation.

(c) Decay heat is not a significant design consideration in an ISFSI because the spent fuel shall have aged a minimum of one (1) year since discharge from the reactor core.

(d) Because of the low potential for airborne radioactive materials above a spent fuel storage pool, the building housing such pools need not be designed for confinement.

2. Definitions

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

2.1.1 Design Event I

2.1.1.1 Definition. Design Event I consists of that set of events that are expected to occur regularly or frequently in the course of normal operation at the installation.

2.1.1.2 Examples

2.1.1.2.1 Cask receipt, inspection, unloading, and maintenance.

2.1.1.2.2 Fuel unit transfer from cask to pool or pool to cask.

2.1.1.2.3 Collection and disposal of air or waterborne radionuclides generated during ISFSI operation.

2.1.1.2.4 Fuel rod consolidation, if performed at the ISFSI.

2.1.2 Design Event II

2.1.2.1 Definition. Design Event II consists of that set of events that although not occurring regularly, can be expected to occur with moderate frequency or on the order of once during any calendar year of installation operation.

2.1.2.2 Examples

2.1.2.2.1 Failure of any single active component to perform its intended function upon demand.

2.1.2.2.2 Spurious operation of certain active components.

2.1.2.2.3 A loss of external power supply for a limited duration.

2.1.2.2.4 Minor leakage from flanged piping or component connections.

2.1.2.2.5 A single operator error followed by proper corrective action.

2.1.3 Design Event III

2.1.3.1 Definition. Design Event III consists of that set of infrequent events that could reasonably be expected to occur once during the lifetime of the installation.

2.1.3.2 Examples

2.1.3.2.1 A credible passive failure of a radioactive liquid retaining boundary.

2.1.3.2.2 A loss of external power for an extended interval.

2.1.4 Design Event IV

2.1.4.1 Definition. Design Event IV consists of the events that are postulated because their consequences may result in the maximum potential impact on the immediate environs. Their consideration establishes a conservative design basis for certain systems with important confinement features. Typically this set of events will consist of site specific design events as defined in Section 2.2, Design Phenomena. By adherence to the requirements of this standard, the designer may exclude such events as criticality, total loss of pool water, and dropped cask as Design Event IV possible events.

2.2 Design Phenomena. Those natural phenomena and man-induced low probability events for which an ISFSI is designed. Subpart E of Title 10, Code of Federal Regulations, Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)" [6] or ANSI/ANS-2.19-1981 [5] provides the requirement for identification and evaluation of design basis external natural or man-induced events. Subpart F of 10 CFR 72 [6] provides the general design criteria for structures, systems, and components that are important confinement features.

2.3 Fuel Unit. The fundamental item to be stored in the ISFSI. It can be a spent fuel assembly, canned spent fuel, or consolidated fuel rods.

2.4 Important Confinement Features. Those features of the ISFSI whose function is:

(a) to maintain the conditions required to store spent fuel safely (e.g., heat removal system if provided), or

(b) to prevent damage to the spent fuel during handling and storage (e.g., cask unloading equipment), or

(c) to provide reasonable assurance that spent fuel can be received, handled, stored, and retrieved without undue risk to the health and safety of the public. Dose commitment criteria provided in American National Standard Guidance for Defin-

ing Safety-Related Features of Nuclear Fuel Cycle Facilities, ANSI N46.1-1980 [7] are available for use in determining systems, structures, and components that have important confinement features with respect to public health and safety.

2.5 Independent Spent Fuel Storage Installation (ISFSI). A complex designed and constructed for the storage of spent fuel and other radioactive materials associated with spent fuel storage. An ISFSI which is located on the site of another facility may share common utilities and services with such other facility and still be considered to be independent, provided that such sharing of utilities and services or physical connections does not:

(a) increase the probability or consequences of an accident or malfunction involving components, structures, or systems that are important confinement features, or

(b) reduce the margin of safety as defined in the bases for any technical specifications of either facility.

2.6 Movable Storage Racks. Structures designed to store spent fuel and capable of being moved while containing stored fuel assemblies.

2.7 Non-Interruptible. Once required to operate, cannot be cut off by an event external of the site.

2.8 Nuclear Criticality Safety. Protection against the consequences of an inadvertent nuclear chain reaction, preferably by prevention of the reaction.

2.9 Nuclear Facility. Structures, buildings, and systems provided which utilize or process fissionable material.

2.10 Passive Failure. A failure of a component to maintain its structural integrity or the blockage of a process flow path.

2.10.1 Credible Passive Failure. The passive failure of a piping system or single structural steel load bearing member at a discontinuity; the integrity of which has not been verified by volumetric examination (e.g., radiographic, ultrasonic).

2.11 Primary Criticality Control. A control parameter on which principal reliance is placed in assuring that subcritical conditions are maintained.

2.12 Shall, Should and May. Shall denotes a requirement, should denotes a recommendation, and may denotes permission, neither a requirement

nor a recommendation.

2.13 Spent Fuel Assembly. A single fabricated unit of fuel rods (and support structures) discharged from a light water power reactor, still in the same mechanical configuration in which it was irradiated, and meets the criteria for post-irradiation decay of this standard. It contains recoverable uranium, plutonium and fission products.

3. Installation Function

The primary function of the ISFSI is the interim protective, custodial storage of spent fuel. The ISFSI is not intended to process or utilize the nuclear material. The ISFSI is designed to preserve the primary barrier of the fuel unit and provide an additional secondary barrier against the potential release of particulate radioactive materials to the immediate environs. The primary barrier normally is the fuel cladding for which protection against damage and degradation is provided by storage confinement, storage environment, fuel handling equipment, and decay heat removal system, as required.

Radioactivity control is provided by several secondary barriers. The pool water itself retains the radioactive particulate material which may be released from the spent fuel and provides personnel protection in the form of shielding from gamma radiation. Subcriticality of the spent fuel while in storage is ensured by the design features of the storage racks. Subcriticality of the spent fuel during normal handling is ensured by the design features of the handling system.

A pool water cleanup system is provided to remove dissolved and suspended radioactive material. The pool water cooling system is a closed system to preclude releasing radioactivity to the local environs. A pool water makeup system is provided to allow compensation for losses of pool water level.

In areas of the installation with the potential for significant release of airborne particulate radioactive material, the heating, ventilation, and air conditioning system provide filtration of the effluent air.

If rod consolidation is to be performed within the ISFSI, guidelines for the consolidation equipment and required interfaces are presented in ANSI/ANS-57.10-1987 [4].

4. Installation System Descriptions

An ISFSI, for the purpose of this standard, is functionally divided into the following systems:

4.1 Fuel Unit Storage and Cask Unloading Pools (Structural and Liner). The fuel unit cask and storage pools system includes the structures within which the functions of spent fuel cask unloading/loading, and storage of spent fuel take place. The design and configuration of these pools are closely interrelated with the cask handling, fuel handling, and fuel storage rack systems.

4.2 Fuel Unit Storage Racks. The fuel unit storage rack system includes structures located in the fuel unit storage pool. They support and maintain the spent fuel assemblies in a subcritical geometry during storage.

4.3 Fuel Unit Pool Water Makeup, Cooling and Cleanup. The fuel unit pool water makeup, cooling and cleanup system includes equipment for the removal of decay heat by an external 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 also provides makeup water to the ISFSI pools under normal and emergency conditions. The above system functions can be performed by physically separate systems.

4.4 Fuel Unit Cask Handling. The fuel unit cask handling system includes equipment for cask receiving, monitoring, cooldown and flushing, unloading, decontamination, and preparation for reshipping.

4.5 Fuel Unit Handling. The fuel unit handling system includes the equipment for removal of the fuel units from the cask, transfer of the fuel units to the storage racks, inspection of racks and fuel units, and handling of damaged fuel units.

4.6 Heating, Ventilating and Air-Conditioning. The heating, ventilating and air-conditioning (HVAC) system includes all air moving and treatment equipment and associated controls required for protection of the general public and installation personnel from potential release of airborne radioactive particulates, and maintenance of air quality suitable for operating personnel and equipment operation.

4.7 Buildings. The building system includes the superstructures for the cask and fuel storage pools and other structures required to house various components.

4.8 Radwaste Treatment. The radwaste treatment system includes equipment for handling, treatment, and preparation for disposal of liquid, gaseous and solid radioactive wastes.

4.9 Electrical Power, Instrumentation and Control (I&C), and Communications. The electrical power, I&C, and communications system includes electrical power, system control and status indication, lighting, communications, alarms, radiation monitoring, and access control.

For electrical power, the system provides for on-site power distribution and the onsite terminus of the offsite power supply. The system includes equipment required to distribute power to components and subsystems indentified as follows. The offsite power subsystem terminates at the feeder breakers.

For control and status indication, the system includes equipment to provide the operator with system status and allow for proper operations of the ISFSI.

For lighting, the system includes equipment to provide work area and security lighting under normal and abnormal conditions.

For communications, the system includes the equipment to provide for public address, evacuation alarm, communication between in-plant locations and communication with locations remote to the installation.

For alarms, radiation monitoring, and access control, the system includes the equipment to provide warning of abnormal conditions such as high radiation levels, airborne radiological contamination, or unauthorized access.

5. Installation Performance Requirements

Systems and subsystems which comprise the ISFSI shall be designed to perform the following functions under designated Design Events:

5.1 Fuel Unit Storage and Cask Unloading Pools

5.1.1 Provide sufficient shielding in accessible spaces adjacent to the pool (including the operating floor above) to ensure that when the pool is at design fuel unit inventory and at design water depth, the expected direct radiation dose rate from the fuel units should not contribute more than 10 mRem per week to any person occupying such space for Design Events I and II.

5.1.2 Retain pool water depth above stored fuel units at the minimum level² defined for shielding for Design Events I through IV.

5.1.3 Consider the effect of interfacing systems when designing the pool(s) to meet Design Events I thru IV.

5.2 Fuel Unit Storage Racks

5.2.1 Maintain the capability to remove and insert fuel units for Design Event I and subsequent to Design Events II thru IV.

5.2.2 Prevent physical damage to stored fuel for Design Events I and II.

5.2.3 Preclude nucleate boiling on the surface of any stored fuel for Design Event I. Cooling with nucleate boiling may be permitted for Design Events II thru IV.

5.2.4 Maintain the stored fuel array in a sub-critical configuration for Design Events I thru IV.

5.2.5 Limit physical damage to that extent which would still permit insertion and removal during handling operations for Design Event I and subsequent to Design Events II thru IV.

5.2.6 Protect fuel units from mechanical damage during insertion and removal operations for Design Event I.

5.3 Fuel Unit Pool Water Makeup, Cooling and Cleanup

5.3.1 Provide cooling capacity to maintain the specified annual average bulk pool water temperature for Design Event I.

5.3.2 Provide capability to recover from loss of cooling before bulk boiling of the storage pool water occurs for Design Event II.

5.3.3 Provide capability to recover from loss of cooling before the design limits of the pool structures are exceeded for Design Events II and III.

5.3.4 Provide capability to add deionized water to the storage pool at a rate greater than the loss of pool water by evaporation for Design Event I.

5.3.5 Provide capability to maintain minimum water depth with deionized water for Design Event II.

5.3.6 Provide capability to add water to the storage pool to maintain minimum water depth above stored fuel units for Design Events III and IV.

5.3.7 Provide the capability to maintain an annual average gross storage pool water activity level of 5×10^{-4} microcurie/ml or less for Design Event I.

5.3.8 Provide the capability to maintain adequate visual clarity so as to allow observation of assembly identifiers while in their stored position for Design Event I.

5.3.9 Provide the capability to control minimum water depth over the stored fuel or pool water chemistry, or both, for Design Events I thru IV to maintain the design iodine decontamination factor.

5.4 Fuel Unit Cask Handling

5.4.1 Provide for cask off-loading and loading of the transport carrier for Design Event I.

5.4.2 Provide for the inspection, monitoring, decontamination, venting, and flushing of casks received at and to be shipped from the installation for Design Event I.

5.4.3 Move casks, in both loaded and unloaded conditions, between positions within the storage installation for Design Event I.

5.4.4 Provide auxiliary cooling (if required on the basis of cask design) for casks within the installation at the transport off-loading station for Design Event I and II.

5.4.5 Prevent mechanical damage (damage which could result in a cask drop, cause a loss of cask integrity or result in the failure of the cask to perform any of its design functions) during cask handling operations for Design Events I thru IV.

5.4.6 Prevent movement of the shipping cask over arrays of stored fuel for Design Events I thru IV.

5.5 Fuel Unit Handling

5.5.1 Provide for underwater handling of fuel units between cask unloading pool and rack storage positions for Design Event I.

5.5.2 Protect fuel units from damage that would jeopardize the integrity of the fuel cladding during handling within the installation for Design Events I and II.

²Typical minimum water depth for shielding one (1) year old fuel is 8 ft. (2.44 m).

5.6 Heating, Ventilating, and Air-Conditioning

5.6.1 Allow isolation of areas or zones subject to airborne contamination from other areas or zones not potentially contaminated for Design Events I and II.

5.6.2 Control interior ambient temperatures within design limits for Design Event I.

5.6.3 Collect airborne particulate radioactive material near its source for Design Event I.

5.7 Buildings

5.7.1 Protect fuel unit storage pool and fuel unit handling areas from the effects of external environmental conditions for Design Events I thru III.

5.7.2 Allow for the control of access to and the prevention of the spread of contamination from areas constituting potential sources of surface contamination for Design Events I and II.

5.7.3 Provide suitable barriers to prevent the spread of fires from local potential sources for Design Events I thru III.

5.8 Radwaste Treatment

5.8.1 Collect, treat, and prepare for disposal of all potentially contaminated liquid effluents for Design Event I.

5.8.2 Collect, prepare for shipping, and deliver to transport vehicles, all solidified liquid wastes and other solid radwaste material for Design Event I.

5.8.3 Collect, temporarily store, and allow monitoring of potentially contaminated cask wash-down water for Design Events I and II.

5.8.4 Provide means for measuring the amount of radioactivity in effluents for Design Events I thru III.

5.9 Electrical Power, I&C and Communications

5.9.1 Provide motive power for all electrically operated components for Design Event I.

5.9.2 Provide adequate lighting within the storage pool to ensure that stored fuel units can be properly identified under the specified conditions for water turbidity for Design Event I.

5.9.3 Monitor process system, effluent, and area radiation levels for direct radiation, gaseous and airborne particulate activity for Design Events I and II.

5.9.4 Provide the instrumentation and alarm functions necessary for each process system to ensure that significant system failures can be detected and the systems can be placed in a safe condition for Design Events I and II.

5.9.5 Provide onsite communications for the installation for Design Events I thru IV.

5.9.6 Provide interior and exterior lighting for normal operation and physical security for Design Event I.

5.9.7 Provide the minimum interior and exterior lighting required for personnel safety for Design Event III.

5.10 Nuclear Criticality Safety. Demonstrate by analysis that the fuel unit transfer, handling, and storage systems maintain the fuel subcritical for Design Events I thru IV.

5.11 Physical Security. Onsite and offsite communications, observation access control interlocks, and alarm systems shall remain operable for Design Events I thru III.

6. Design Requirements

The Design Requirements for the ISFSI are presented separately by system. The Design Events to which these requirements apply are given in Section 5, "Installation Performance Requirements."

6.1 Fuel Unit Storage and Cask Unloading Pools**6.1.1 Codes and Standards**

6.1.1.1 The fuel unit storage and cask unloading pools shall be designed in accordance with applicable commercial codes and standards. The following codes and standards represent an acceptable level of design and construction:

(a) Building Code Requirements for Reinforced Concrete, ANSI/ACI 318-1983 [8];

(b) Specification for Structural Concrete for Buildings, ANSI/ACI 301-1984 [9];

(c) The Structural Welding Code, ANSI/AWS D1.1-1986 [10];

(d) Recommended Practices for Welding Reinforcing Steel, ANSI/AWS D1.4-1979 [11].

6.1.1.2 The purchase of materials shall be based on the following codes and standards which represent an acceptable level of capability to meet the design requirements.

(a) Steel Products Manual [12];

(b) Specifications for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities, ANSI/AISC N690-1984 [13];

(c) 1986 ANSI/ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Plant Components" [14].

6.1.2 Conditions of Design

6.1.2.1 The cask unloading pool should be designed to accept a variety of shipping casks.³

³Physical and operational characteristics of licensed fuel casks and advanced cask designs in progress are given for guidance in Appendix F.

6.1.2.2 The cask unloading pool shall be designed such that a dropped cask cannot impact on stored fuel or result in a loss of functional integrity.

6.1.2.3 The fuel unit storage pool shall be designed to withstand, without loss of functional integrity, the impact of the maximum load over the pool, dropped into the pool from the highest position attainable by the load.

6.1.2.4 The design of the pools should include a system of gates between adjacent pools so that any one pool may be isolated from the other pools in order to minimize the spread of contaminants in case of an accident in one pool, or a pool may be emptied without affecting the water level in adjacent pools.

6.1.2.5 Design methods, loading, etc., shall be in accordance with 6.15.

6.1.2.6 The minimum permitted pool water level for proper shielding under normal operations shall be identified for the fuel unit storage pool. There shall be no penetrations through that part of the pool structure below the minimum water level. There shall be no permanently installed piping which could serve as a syphon to lower the water level below the minimum level.

6.1.3 Interfaces. The fuel unit storage and cask unloading pools interface directly with the cask handling, fuel handling, fuel storage rack, and pool water makeup systems. Such systems may be totally or partially supported by the pool structures.

6.1.4 Testing, Inspecting and Maintenance. The fuel unit storage and cask unloading pools shall be constructed to assure that water contaminated with radioactive materials shall not be inadvertently released to the environs. Means shall be provided for detection and control of leakage from the pools. Means shall be identified for repairing damage to the pool structures in the event of any incident which might reduce their reliability. Provisions for such means shall be incorporated in the pool design but the necessary equipment need not be provided until required.

6.1.5 Design Documentation. Documentation of calculations and analyses shall be provided to substantiate conformance with this standard and federal, state and local requirements. Certification of conformance with applicable standards shall be required for specified structural materials. Design drawings, specification and calculations shall be checked by a qualified person.

6.2 Fuel Unit Storage Racks

6.2.1 Codes and Standards

6.2.1.1 The spent fuel racks shall be designed in accordance with commercial codes and standards representing an acceptable level of design as specified in reference [14].

6.2.1.2 The specification and purchase of the equipment shall be based on codes and standards representing an acceptable level of capability to meet the design requirements that are specified in references [6] and [8].

6.2.2 Conditions of Design

6.2.2.1 The fuel unit storage racks shall be designed to ensure subcriticality by an adequate safety margin as defined in 6.10.

6.2.2.2 The fuel unit storage racks shall be designed for the design earthquake.

6.2.2.3 Design methods, loading, etc., shall be in accordance with 6.15.

6.2.2.4 The structural design of the racks may be free-standing, individually supported on embedments in the pool floor, or supported in modules by combination compression-tension embedments in the pool walls.

6.2.2.5 Each storage position in the racks shall be designed with sufficient clearance and lead-in capability to permit fuel unit insertion and removal during handling operations without damaging the fuel unit. Allowance should be made for spent fuel unit bowing.

6.2.2.6 Each storage position in the racks shall be designed to support and guide the fuel unit to prevent damage from excessive lateral, axial, and bending loads during handling and storage.

6.2.2.7 All surfaces contacting the fuel units shall be free of burrs, sharp corners, edges and weld beads that could mar or damage the fuel unit surface. Projection of bolt heads or other fasteners into the interior of the fuel compartment shall not be permitted unless the projection is blended smooth with the interior surface to prevent interference with fuel unit insertion or removal operations.

6.2.2.8 Provisions should be made for the storage of defective fuel assemblies in canisters.

6.2.2.9 All materials of construction shall be capable of withstanding cumulative radiation exposures of 1×10^{10} Rad gamma and 1×10^5 Rad epithermal and fast neutron, and shall be compatible with pool water chemistry.

6.2.2.10 A permanent identification of each storage location shall be provided. For fixed racks, this may be on the racks themselves or an indexing system. For movable racks, identification shall be provided on the racks themselves.

6.2.2.11 If the storage pool incorporates a liner, the resting surfaces of the fuel unit storage racks should be designed such that they are positioned at a suitable distance from seams in the liner. This distance shall be based upon the maximum sliding translation under the design earthquake.

6.2.3 Interfaces. The fuel unit storage racks interface directly with the fuel unit storage pool and fuel unit handling systems.

6.2.3.1 The pool structure and liner shall be designed to support the fuel unit storage racks, including the effect of a dropped, movable rack.

6.2.3.2 The arrangement and design of the fuel unit storage racks in the fuel unit storage pool shall be such as to facilitate natural circulation cooling of the spent fuel stored in the racks in order to maintain the cooling requirements set forth in 5.3 for loss of forced cooling.

6.2.4 Testing, Inspection and Maintenance

6.2.4.1 The presence of fixed neutron poisons shall be verified if credit is taken for their use in design. This verification shall be performed before use of the racks.

6.2.4.2 Provisions shall be made for periodic verification of the required physical and chemical properties of fixed neutron absorbers.

6.2.4.3 Fuel unit storage rack modules should be removable under water without loss of structural integrity of remaining racks in the pool.

6.2.5 Design Documentation

6.2.5.1 Documentation of the design calculations and analyses for the fuel unit storage racks shall be provided.

6.2.5.2 Certification of Conformance with applicable standards shall be required for all component materials which come in contact with pool water.

6.2.5.3 Certification of Conformance of loading and homogeneity shall be provided for all fixed neutron absorber materials used in the construction of the fuel unit storage racks where credit is taken for their use in design.

6.2.5.4 Design drawings, specifications, and calculations shall be checked by a qualified person.

6.3 Fuel Unit Pool Water Makeup, Cooling and Cleanup

6.3.1 Codes and Standards

6.3.1.1 The fuel unit pool water makeup, cooling and cleanup shall be designed in accordance with commercial codes. The following codes and standards represent an acceptable level of design:

(a) Title 10, Code of Federal Regulations,

Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979" [15];

(b) American National Standard National Electrical Safety Code, ANSI C2-1981-84 [16];

(c) Power Cable Ampacities, IEEE/IPCEA (IEEE S-135) [17];

(d) American National Standard, "Power Piping" ANSI/ASME B31.1-1986 [18]; and Tubular Exchanger Manufacturers Association Standard (TEMA) [19];

(e) 1986 ANSI/ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Div. 1 [20], and Section II, "Material Specifications" [21], Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks, ANSI/API 629-1986 [22], and Welded Steel Tanks for Oil Storage, ANSI/API 650-1980 [23];

(f) Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation" [24];

(g) National Electrical Code Handbook, ANSI/NFPA 70-1987 [25].

6.3.1.2 The purchase of equipment and materials shall be based on the following codes and standards which represent a level of capability to meet the design requirements:

(a) Electrical Power System Device Function Numbers, ANSI/IEEE C37.2-1979 [26];

(b) Alternating Current Motors, Induction Machines in General and Universal Motors, ANSI C50.2-1955 [27];

(c) American National Standard Complete 1988 Edition of IEEE and ANSI on Distribution, Power, and Regulating Transformers, ANSI/IEEE C57-1988 [28];

(d) All Insulated Cable Engineering Association, Inc. (ICEA) standards listed in Section 7: Power Cable Ampacities, IEEE/IPCEA (IEEE S-135) [17]; Ampacities of Cables in Open Top Cable Trays, ICEA P54-440, 3rd E./NEMA WC 5-1988 [29]; Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy, ICEA S61-402, 3rd Ed./NEMA WC 5-1988 [30]; Standard for Polyolefin Insulated Communication Cables for Outdoor Use, ANSI/ICEA S56-434-1983 [31]; Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable for Transmission and Distribution of Electrical Energy, ICEA S-66-524, 2nd Ed./NEMA WC 7-1988 [32]; Ethylene Propylene Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy, ICEA S-68-516/