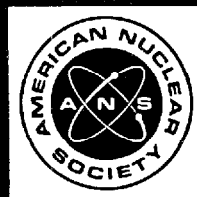


American Nuclear Society

**design criteria for an independent spent
fuel storage installation (dry type)**

an American National Standard



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

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Foreword

(This Foreword is not part of American National Standard Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type), ANSI/ANS-57.9-1992.)

This standard provides design criteria for an independent spent fuel storage installation (ISFSI) for light water reactor spent fuel that incorporates one or more of the dry storage concepts. The dry storage concepts covered include three major types: cask (silo), drywell (caisson), and vault (canyon). The standard sets down performance and design requirements along with general guidelines that will assist in the design and licensing efforts. Also presented are interface requirements where the installation is located at an existing nuclear facility. The standard is intended to be consistent with and provide guidance in meeting the requirements of the regulations in Title 10, "Energy," Code of Federal Regulations, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."

An ISFSI provides for the custody of spent fuel in a stable and quiescent state pending its future disposition. This does not preclude mechanical handling activities related to fuel storage, such as rod consolidation and the canning of assemblies or consolidated fuel rods. Such activities do not involve the exposure of the fuel itself to an uncontrolled environment.

Although the spent fuel is in passive storage, decay heat and the small volume of pressurized gas within the fuel rods are mechanisms that have the potential for causing off-site release of the radionuclides contained in the spent fuel. To lessen the effect of these mechanisms, the spent fuel is kept in storage at the nuclear power plant for at least 1 yr after reactor discharge before being transferred to an ISFSI. The radiological protection requirements for personnel occupancy of the storage area set forth in the standard are based on the principle of maintaining occupational exposure consistent with the as low as reasonably achievable (ALARA) principle.

In general, the safe storage of spent fuel assemblies is achieved by maintaining a minimum of two independent barriers between the fuel and the environs. The fuel cladding is considered the primary barrier for undamaged fuel. Fuel cladding is designed to withstand a far more severe environment in the reactor than in the low-temperature conditions of static storage at an ISFSI. The confinement integrity of the cladding is to be maintained during handling and storage in the ISFSI. In addition, the complete confinement system for the stored fuel is conservatively designed to withstand damaging events, including earthquake or other extreme natural phenomena, so that there is an effective secondary barrier(s) to the release of radioactive materials under all credible conditions.

A section is provided that identifies interface considerations for shared systems and facilities in those cases where the ISFSI is located at or near an existing nuclear facility. An ISFSI that cannot be demonstrated to be independent of a nuclear facility in respect to all support services that are important to confinement cannot be licensed under 10 CFR 72. In such cases, the criteria and performance requirements set forth herein might not be applicable. Appendices that are not part of the mandatory criteria of the standard are provided for information and clarification.

American National Standard Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement, ANSI/ANS-8.10-1983(R1988), provides general guidelines for nuclear criticality safety in shielded facilities. It permits a single failure to result in criticality in facilities where personnel are adequately protected by radiation shielding. The ISFSI standard requires that the more conservative criterion be utilized in the nuclear power industry so that no single failure can result in nuclear criticality.

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Contents	Section	Page
1.	Introduction	1
1.1	Scope	1
1.2	Limits of Application	1
1.3	Operating Functions	1
1.4	Overall Design Bases	2
1.5	Application of Codes and Standards	2
2.	Definitions	2
3.	Installation Function	4
4.	ISFSI Systems	4
4.1	Transportation Package Handling Area	4
4.2	Fuel Unit Handling Area	5
4.3	Fuel Unit Transfer Area	5
4.4	Storage Area	5
4.5	Heating, Ventilation, and Air Conditioning (HVAC)	5
4.6	Buildings	6
4.7	Radwaste Treatment	6
4.8	Electrical Power, Instrumentation and Control (I&C), and Communications	6
4.9	Fire Protection	6
4.10	Physical Protection	6
4.11	Accountability	6
4.12	Nuclear Criticality Safety	6
4.13	Radiological Protection	6
5.	ISFSI Performance Requirements	6
5.1	Transportation Package Handling Area	6
5.2	Fuel Unit Handling Area	7
5.3	Fuel Unit Transfer Area	7
5.4	Fuel Unit Storage Area	8
5.5	Heating, Ventilation, and Air Conditioning (HVAC)	8
5.6	Buildings	9
5.7	Radwaste Treatment	9
5.8	Electrical Power, Instrumentation and Control (I&C), and Communications	9
5.9	Fire Protection	9
5.10	Physical Protection	9
5.11	Accountability	9
5.12	Nuclear Criticality Safety	9
5.13	Radiological Protection	10
6.	Design Requirements	10
6.1	Transportation Package Handling Area	10
6.2	Fuel Unit Handling Area	12
6.3	Fuel Unit Transfer Area	15
6.4	Storage Area	16
6.5	Heating, Ventilation, and Air Conditioning (HVAC)	19
6.6	Buildings	21
6.7	Radwaste Treatment	21

6.8	Electrical Power, Instrumentation and Control (I&C), and Communications	22
6.9	Fire Protection	23
6.10	Physical Protection	25
6.11	Accountability	25
6.12	Nuclear Criticality Safety	25
6.13	Radiological Protection	26
6.14	Decommissioning	27
6.15	Quality Assurance	27
6.16	Interfaces for an ISFSI Located on an Existing Nuclear Facility Site	27
6.17	Structural Design	27
7.	References	28
Appendices		
Appendix A	Illustrative Flow Diagrams and Storage Concepts	31
Appendix B	Guidance for Computing the Limiting Fuel Temperatures During Storage in Unlimited, Limited Air, and Nonoxidizing Atmospheres	38
Appendix C	Characteristics of Typical LWR Spent Fuel Shipping Casks That May Interface with an ISFSI (Dry)	41
Appendix D	Physical Characteristics of Typical LWR Fuel Assemblies	42
Appendix E	Source Terms	46
Appendix F	Guidelines for Nuclear Criticality Safety Considerations	51
Appendix G	Guidelines for Radiological Risk Assessment	55
Appendix H	Seismic Analysis	57
Figures		
Figure A-1	Illustrative ISFSI Flow Diagram	31
Figure A-2 through 4	Illustrative Internal Movement Diagrams	32
Figure A-5 through 7	Illustrative Storage Concepts	35
Figure F-1	Water Added Between Assemblies, Then to Assemblies	53
Figure F-2	Water Added to Assemblies, Then Between Assemblies	54
Figure F-3	Water Added Simultaneously Between and to Assemblies	54
Tables		
Table D-1	Principal Characteristics of Representative Nuclear Fuels from Babcock & Wilcox and Combustion Engineering	42
Table D-2	Principal Characteristics of Representative PWR Nuclear Fuels from Westinghouse	43
Table D-3	Principal Characteristics of Representative PWR Nuclear Fuels from Exxon	44
Table D-4	Principal Characteristics of Representative BWR Nuclear Fuels from General Electric and Exxon	45
Table E-1	PWR Representative Decay Heat Generation Rates	46
Table E-2	Guidance Data on LWR Fuel Crud	47
Table E-3	Guidance Data on PWR Fuel Crud	47
Table E-4	Guidance Data on BWR Fuel Crud	48
Table E-5	Parameters Used to Calculate Radiation Source Terms	48
Appendix E3	Tables	49
Table F-1	Density of Various Water Forms	51

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

1. Introduction

This standard provides design criteria for systems and equipment of an installation for the receipt and storage of spent fuel from light water reactors (LWRs) or from water pool-type independent spent fuel storage installations. The standard addresses only dry storage, which includes vault, metal cask, concrete silo, and drywell. The standard also addresses the preparation and reshipment of spent fuel to a geological repository. The standard presents interface requirements for shared systems and facilities for the situation where the installation is located at or near an existing nuclear facility.

Consolidation of whole fuel assemblies at the installation is covered by the standard. This installation is independent of nuclear power stations and reprocessing facilities and may or may not be located at an existing nuclear power station or reprocessing site. This installation is designed to receive and indefinitely store spent fuel elements that have experienced cooling times in excess of 1 yr at an in-plant facility, at another independent spent fuel storage installation, or both.

1.1 Scope. This standard is intended to be used by the owner and operator of a dry storage-type independent spent fuel storage installation (ISFSI) in specifying the design requirements and by the designer in meet the minimum requirements of such installations.

The standard includes requirements for the following: the design of major buildings and structures, shipping cask unloading and handling facilities, cask decontamination, loading and unloading areas, spent fuel storage areas and racks, fuel handling equipment, radiation shielding, special equipment and area layout configurations, air or gas quality, storage area integrity, air or gas cleanup, fuel inspection, ventilation, residual heat removal, radiation monitoring, prevention of criticality, radwaste control and monitoring systems, provisions to facilitate decommissioning, quality assurance, materials accountability, and physical security.

This standard continues the set of American National Standards on spent fuel storage. Similar standards are:

(1) Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants, ANSI/ANS-57.2-1983 [1].¹

(2) Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type), ANSI/ANS-57.7-1988 [2];

(3) Guidelines for Establishing Site-Related Parameters for Site Selection and Design of an independent Spent Fuel Storage Installation (Water Pool Type), ANSI/ANS-2.19-1988(R1990) [3]; and

(4) Design Criteria for Consolidation of LWR Spent Fuel, ANSI/ANS-57.10-1987 [4].

1.2 Limits of Application. This standard applies to the design of an ISFSI that has the following limitations:

(1) Dry storage only.

(2) The spent fuel to be stored

(a) is only commercial LWR UO₂ fuel.

(b) has aged a minimum of 1 yr after discharge from the reactor core.

(c) can arrive at the installation in three forms: undamaged whole fuel assemblies, canned damaged whole fuel assemblies, and close-packed consolidated fuel rods.

(3) Fuel will be received from off-site locations in a U.S. Nuclear Regulatory Commission (NRC) certificated transportation package that is physically compatible with the systems of the installation.

1.3 Operating Functions. The operating functions are:

(1) Transportation package receiving and handling.

(2) Transportation package unloading.

(3) Decontamination, minor maintenance, and temporary storage of the transportation package.

(4) Fuel unit lag storage.

(5) Fuel unit preparation (which could include canisterization or rod consolidation) for storage and transfer to and from lag storage.

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

(6) Fuel unit transfer and emplacement in storage.

(7) Fuel unit retrieval and loading of transportation package.

1.4 Overall Design Bases

(1) Short-lived, high specific activity radionuclides, particularly those of ^{131}I and ^{133}Xe , are no longer present in significant quantities in spent fuel that has aged for more than 1 yr since discharge from the reactor core.

(2) Decay heat generation is significantly reduced in 1-yr-old spent fuel; notwithstanding this reduction in heat generation, the maximum temperature of the fuel during handling and in storage must be limited to prevent deleterious metallurgical and chemical reactions.

(3) The confinement integrity of the fuel cladding is to be maintained during handling and storage.

(4) Siting considerations or engineered site features preclude direct flooding of the installation.

1.5 Application of Codes and Standards. The structures and mechanical and electrical systems (piping, electrical raceways, and ducts) of the installation shall be designed to meet applicable commercial standards for fabrication and construction except as specifically supplemented in Section 6, Design Requirements, of this standard.

2. Definitions

The terminology defined herein will be referred to throughout the standard.

canning (canned). The placement of spent fuel in a container for purposes of confinement.

commercial standards. Standards that would be used in the design of conventional or commercial industrial facilities in the vicinity of the ISFSI.

NOTE: Examples of commercial standards are American National Standards ANSI/ACI 318-89, Building Code Requirements for Reinforced Concrete (for concrete structures); ANSI/ASME B31.1-1989, Power Piping (for process piping); ANSI/API 620-1986, Rules for Design and Construction of Large, Welded, Low Pressure Storage Tanks, and ANSI/API 650-1988, Welded Steel Tanks for Oil Storage (for tanks); and the American Institute of Steel Construction publication, "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design—1989" (for steel structures).

confinement. The structure, systems, or components provided for the purpose of preventing

the release of radioactive particulate matter to the environs above the radiological protection limits; it may be either a physical barrier or high-efficiency filtration.

damaged fuel. Fuel units that exhibit visible evidence of structural damage to the fuel rod cladding or container.

design events. Design events are occurrences that need to be considered in system and installation design. They can be classified according to their expected frequency of occurrence and, when so classified, used in conjunction with objectives associated with maintenance of system capability to provide a logical and systematic approach to protection by design. This standard employs four design event categories that are referenced to specify system performance requirements in Section 5, ISFSI Performance Requirements.

The set of design events for a particular ISFSI, and the classification of each event of that set according to frequency of occurrence, can be determined only upon consideration of the functional design and external environment unique to that ISFSI. For each of the following design event categories, however, certain events, expected to be appropriate for a typical ISFSI, are provided as guidance for developing a site-specific set of events:

(1) Design Event I. Design Event I consists of that set of events that are expected to occur regularly or frequently in the course of normal operation of the ISFSI. Examples are the following:

(a) Transportation package receipt, inspection, unloading, maintenance, and loading.

(b) Spent fuel assembly transfer from transportation package to storage area.

(c) Handling of radioactive waste generated during ISFSI operation.

(d) Fuel unit preparation.

(e) Insertion of fuel units into or retrieval from storage structure.

(2) Design Event II. 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 a calendar year of ISFSI operation. Examples are the following:

(a) A loss of external power supply for a limited duration.

(b) A single operator error followed by proper corrective action.

(c) Minor mechanical failure of spent fuel transfer machine during operation.

(d) Failure of any single active component to perform its intended function upon demand.

(e) Spurious operation of certain active components.

(f) Minor leakage from flanged piping or component connections of radioactive liquid waste handling system.

(3) Design Event III. Design Event III consists of that set of infrequent events that could reasonably be expected to occur during the lifetime of the ISFSI. Examples are the following:

(a) A loss of external power supply for an extended interval.

(b) Major mechanical malfunction involving the spent fuel transfer machine during operation (no loss of shielding but retrieval of fuel required).

(c) Dropping a fuel unit in a hot-cell area.

(d) Passive failure of radioactive liquid waste retaining boundary.

(e) Loss of shielding optical oils in a hot-cell viewing window.

(4) Design Event IV. 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 that are important to confinement. Typically, this set of events consists of plant-specific design events as defined in Design Phenomena.

design phenomena. Those natural phenomena and man-induced low probability events for which an ISFSI is designed. Title 10, "Energy", Code of Federal Regulations (CFR), Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste," Subpart E, "Siting Evaluation Factors," [5] or ANSI/ANS-2.19-1981(R1990) [3] provides the requirement for identification and evaluation of design basis natural or man-induced events. 10 CFR 72, Subpart F [6], provides the general design criteria for structures, systems, and components that are important to confinement.

fuel rod. That portion of the spent fuel assembly that contains the recoverable uranium, plutonium, and fission products. These items are long, slender, cylindrical, sealed metallic tubes termed cladding, containing sintered pellets of fuel material.

fuel unit. The fundamental item to be stored in the ISFSI. It can be a spent fuel assembly,

canned spent fuel assembly, or packaged consolidated fuel rods.

important to confinement. Those features of the ISFSI whose function is

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

(2) To prevent damage to the spent fuel during handling and storage (e.g., transportation package unloading equipment), or

(3) 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.

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 that is located on the site of another facility can share common utilities and services with such a facility and be physically connected with such other facility and still be considered to be independent, provided that such sharing of utilities and services or physical connections does not

(1) Increase the probability or consequences of an accident or malfunction involving components, structures, or systems that are important to confinement, or

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

lag storage. In-process surge storage of fuel units.

limited air. The storage atmosphere that limits the inventory of oxygen such that if all the oxygen is assumed to react chemically with the fuel pellets, the fuel rod cladding would not be damaged.

nuclear facility. Structures, buildings, and systems provided to utilize or process fissionable material, i.e., nuclear power plant or reprocessing plant.

rod consolidation. The process of reducing the spacing between fuel rods.

shall, should, and may. "Shall" denotes a requirement. "Should" denotes a recommenda-

tion. "May" denotes permission, neither a requirement nor a recommendation.

spent fuel assembly. A single fabricated unit of fuel rods (with support structures) discharged from an LWR, still in the same mechanical configuration in which it was irradiated, and that meets the criteria for post-irradiation decay of this standard. It contains recoverable uranium, plutonium, and fission products.

storage concepts. The following definitions are based on the major characteristics of each concept, namely the predominant heat transfer path, shielding, portability, location with respect to grade, degree of independence of individual storage cells, and the storage structure:

(1) **cask (silo).** Above-ground, portable, or nonportable structures containing one or more individual storage cavities. Each cavity could contain one or more fuel units. Shielding is provided primarily by structural material such as steel, cast iron, or concrete. Heat removal is by conduction through the structural shielding material to the atmosphere.

(2) **drywell (caisson).** Stationary, below-ground, lined, individual storage cavities containing one or more fuel units. Shielding is provided by the surrounding earth and a shield plug. Heat removal is by conduction through the earth to the atmosphere.

(3) **vault (canyon).** Above- or below-ground, reinforced concrete structures containing an array of storage cavities. Each cavity could contain one or more fuel units. Shielding is provided by the structure surrounding the stored fuel units. Heat removal is a predominantly by forced or natural air movement over the exterior of the cavities. Heat rejection to the atmosphere is either direct or via a secondary cooling system.

transfer machine. The equipment required to move the fuel units between the fuel handling area and the storage area; it may include a shielded confinement enclosure, transport vehicle, and handling equipment.

transportation package. A container used to transport spent fuel to or from an ISFSI. It may, in particular, consist of one or more receptacles, spacing structures, radiation shielding, and devices for cooling or for absorbing mechanical shocks. The vehicle, tie-down system, and auxiliary equipment may be integral parts of the container. Title 10, "Energy," Code of Federal Regulations, Part 71, "Packaging and Transpor-

tation of Radioactive Material" [7], provides regulatory requirements for packaging and transporting of spent fuel beyond the confines of the ISFSI site.

unlimited air. The storage atmosphere that does not limit the availability of oxygen as a design feature of the ISFSI.

validated computational methods. A calculational method that has been tested, by comparison with experimental data or previously validated calculations, to establish the reliability of results obtained when the method is applied to conditions of interest.

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 fissile material. The ISFSI is designed to preserve the primary confinement barrier of the fuel unit and provide an additional secondary barrier against the potential release of particulate radioactive materials to the immediate environs. Normally, the primary barrier is the fuel cladding for which protection against damage is provided by the storage configuration, storage environment, fuel handling equipment, and decay heat removal system, as required.

The radioactive material contained by the secondary barrier is primarily that associated with the crud or contamination. The combination of primary and secondary barrier comprises a confinement system that provides the necessary radiological protection.

The storage area will retain fuel units in a dry environment under conditions designed to maintain the as-received integrity of the fuel cladding.

Subcriticality of the fuel units while in storage is ensured by design features of the storage area. Subcriticality of the fuel units during handling is ensured by the design features of the fuel unit handling and fuel unit transfer areas.

The final heat sink for dissipation of decay heat will be the biosphere. The method of transferring decay heat to the biosphere will employ natural mechanisms (radiation, convection, conduction). Forced convection heat transfer might be required in some ISFSI designs.

The effluent air from areas of the installation with the potential for significant release of airborne radioactivity will be treated to prevent release of the radioactivity to the environs.

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

4. ISFSI Systems

An ISFSI (dry), for the purpose of this standard, is divided functionally into areas and systems described in the following sections. *Some of these systems are applicable only to a particular storage concept.*² If water pool concepts are used in conjunction with a dry ISFSI, refer to ANSI/ANS-57.7-1988 [2].

4.1 Transportation Package Handling Area.

This area is the portion of the installation that contains systems for the receipt and shipment of transportation packages. In addition to its principal function, this area supports the decontamination, preparation, and maintenance of transportation packages and provides temporary storage and internal handling facilities.

4.1.1 Receiving and Shipping. The receiving and shipping system includes provisions for the following activities: moving the transportation package and its transport vehicle into and out of the off-loading area; washdown of the package and vehicle; loading/unloading the transportation package from the vehicle; storing personnel barriers, overpacks, and impact limiters; and shipment of low-level waste. Also included are the lifting yokes and devices necessary for the removal of transportation packages from their transport vehicle.

4.1.2 Decontamination. The decontamination system includes the space and equipment needed for removing radioactive contamination from the exterior of the transportation packages, whether loaded or empty.

4.1.3 Maintenance. The maintenance system includes the equipment and areas required to ensure the continuing in-service status of each transportation package, including such operations as replacement of valves, seals, examination, and exchange of transportation package internals. This is not intended to include cask

recertification. The system also includes provisions for equipment decontamination.

4.1.4 Preparation. The preparation system includes a work location of sufficient space to accommodate the largest transportation package to be processed as well as the greatest quantity of transportation packages that are to be handled at any given time. The work location includes adequate working area around each package at each required work elevation; an area to accommodate package secondary heads, special tools, and equipment; means for cavity sampling and flushing; and access to pressurized air, water, vacuum, and off-gas systems. If contamination or shielding barriers are to be used, this system includes storage space for these barriers.

4.1.5 Holding and Transfer. The holding system includes interim storage of transportation packages during receiving and shipping operations. The transfer system includes equipment for moving transportation packages within and between the transportation package handling area and the fuel unit handling area.

4.2 Fuel Unit Handling Area. This area contains the portion of the installation that includes a shielded cell having appropriate remote handling devices, viewing windows, or closed circuit television monitoring to permit removal and insertion of fuel units into or out of transportation packages or transfer machines. The fuel units are prepared for storage in this area, which could include canisterization and rod consolidation functions.

4.2.1 Loading and Unloading. The loading and unloading system includes remote removal, as well as the interim storage, of the primary head of the transportation package; grapples for loading and unloading fuel units; means for inspection and cleaning the sealing surface of the head before replacement; and, when appropriate, means for protecting the exterior of the transportation package from contamination and for preliminary cleaning of contaminated tools and equipment prior to removal from the shielded cell.

4.2.2 Preparation. The preparation system includes equipment for transfer and handling of fuel units; for preparing fuel units for storage, fuel unit inspection, lag storage prior to preparation; and for lag storage of the fuel units prior to transfer to or after returning from the storage area.

4.3 Fuel Unit Transfer Area. This area is the portion of the installation that contains systems

²See Appendix A for further clarification.

and the equipment (such as a transfer machine or crane) required to move prepared fuel units from the fuel unit handling area to the storage area and the equipment required for loading and unloading the fuel unit in the storage area. The fuel unit transfer area interfaces with the fuel handling area and storage area and could contain components of the storage area.

4.4 Storage Area. This area is the portion of the installation that contains systems for the storage of the fuel units. The three principal dry storage concepts have been defined in Section 2, Definitions. Each of these concepts comprises the systems that are identified in the following paragraphs.

4.4.1 Closure. The storage closure system includes the equipment required for placement and removal of the closures of storage cells. This system could, if appropriate, be incorporated in the fuel unit transfer area.

4.4.2 Storage Monitoring. The storage monitoring system includes the instrumentation and associated controls that are required for obtaining selected measurements pertaining to the condition of the fuel and to the integrity of the confinement system.

4.4.3 Storage Heat Removal. The storage heat removal system includes the equipment, if needed, for the removal of decay heat.

4.4.4 Storage Confinement. The storage confinement system includes the shielding structure and associated internals, within which the fuel unit is stored, that provide both physical and radiological protection.

4.5 Heating, Ventilation, and Air Conditioning (HVAC). The HVAC system includes all air moving and cleanup equipment and associated controls required to

(1) Protect the general public and ISFSI personnel from potential release of airborne radioactive particulates from all fuel units handling and processing areas except the final storage area.

(2) Remove fuel unit decay heat during handling and lag storage.

(3) Maintain air quality suitable for operating personnel and for equipment operation.

(4) Provide forced cooling of storage concepts where required.

4.6 Buildings. The building system includes the structures used to house the transportation package, fuel unit handling, fuel unit transfer, and the storage areas. Also included is the housing of support systems.

4.7 Radwaste Treatment. The radwaste treatment system includes equipment for handling, treatment, and preparation for disposal of liquid, off-gas, and solid radioactive wastes.

4.8 Electrical Power, Instrumentation and Control (I&C), and Communications. The electrical power, I&C, and communications system includes electrical power; control, indication, and alarms for process, material handling, and the storage systems; lighting and communication; and radiation monitoring for normal operating and emergency conditions.

4.9 Fire Protection. The fire protection system includes equipment, structures, and design features used to prevent, detect, extinguish, and control the spread of fires.

4.10 Physical Protection. The physical protection system includes equipment provided for on-site and off-site security-related communications, physical barriers, access control, intrusion detection, surveillance, security-related alarms, and security lighting systems.

4.11 Accountability. The accountability system includes equipment and design features provided to maintain required records; verify the identity of incoming and outgoing fuel units; maintain the identification and location of fuel units during on-site handling, processing, and lag storage; and complete the periodic inventory of fuel units while in storage.

4.12 Nuclear Criticality Safety. The nuclear criticality safety system includes the design features of the fuel unit handling and storage areas of the ISFSI that maintain subcriticality. For nuclear criticality safety concerns regarding rod consolidation, refer to ANSI/ANS-57.10-1987 [4].

4.13 Radiological Protection. The radiological protection system includes the design features of the ISFSI that limit both occupational and general public exposure.

5. ISFSI Performance Requirements

Systems that comprise the ISFSI (dry) shall be designed to perform the following functions for designated design events.³ *Some of these systems are applicable only to a particular storage concept.* If water pool concepts are used in conjunction with a dry ISFSI, refer for guidance to ANSI/ANS-57.7-1988 [2].

³See Appendix A for illustration of storage concepts.

5.1 Transportation Package Handling Area**5.1.1 Receiving and Shipping (Transportation Package Handling Area)**

5.1.1.1 Provide for washdown of the transportation package for Design Event I.

5.1.1.2 Provide drainage from washdown areas near the flood drain for Design Event I.

5.1.1.3 Provide equipment for off-loading and loading of the transportation package for Design Event I.

5.1.1.4 Provide auxiliary cooling (if required) to facilitate loading or unloading for loaded transportation packages for Design Event I.

5.1.1.5 Provide restraints to prevent horizontal vehicle motion for vehicles being loaded or off-loaded for Design Event I.

5.1.2 Decontamination (Transportation Package Handling Area)

5.1.2.1 Provide thermal shielding to protect operators while decontaminating transportation packages for Design Events I and II.

5.1.2.2 Provide for drainage of wastewater and cleaning solutions for Design Events I and II.

5.1.2.3 Provide radiological protection in accordance with 5.13.

5.1.3 Maintenance (Transportation Package Handling Area)

5.1.3.1 Provide radiological protection in accordance with 5.13.

5.1.3.2 Provide contamination control for open packages for Design Events I and II.

5.1.3.3 Provide lifting devices to handle package heads and package internals for Design Event I and to fail safe for Design Events II and III.

5.1.3.4 Provide decontamination facilities for package components, tools, and system support equipment for Design Event I.

5.1.3.5 Provide for control and disposal of radioactive material from the cleaning of package internals for Design Event I.

5.1.4 Preparation (Transportation Package Handling Area)

5.1.4.1 Provide working structures for Design Event I that will allow ready access to the transportation package, with consideration for personnel as low as reasonably achievable (ALARA) requirements.

5.1.4.2 Provide devices for handling secondary heads, heavy impact tools, or stud tensioners, for Design Event I.

5.1.4.3 Provide systems required for cavity sampling, flushing, and off-gassing for Design Event I.

5.1.5 Transportation Package Holding and Transfer (Transportation Package Handling Area)

5.1.5.1 Provide an area for the temporary storage of transportation packages for Design Event I.

5.1.5.2 Provide transport equipment to transfer the transportation package within the package handling area and into the fuel unit handling area for Design Event I and subsequent to Design Events II, III, and IV.

5.1.5.3 Provide visual capability to allow observation of all operations in the package handling area for Design Event I.

5.1.5.4 Provide a system for transportation package placement and removal that does not require that the package pass over any other package and that minimizes the passing of one package close to another at the same level for Design Event I.

5.2 Fuel Unit Handling Area**5.2.1 Loading and Unloading (Fuel Unit Handling Area)**

5.2.1.1 Provide radiological protection in accordance with 5.13.

5.2.1.2 Provide controls, interlocks, and alarms on shielded cell entryways to help prevent inadvertent or unauthorized entry into the shielded cell for Design Events I, II, and III.

5.2.1.3 Provide necessary capabilities for preliminary decontamination and packaging of contaminated equipment that is to be removed from the shielded cell for Design Event I.

5.2.1.4 Provide visual capability, through lighting and shielded windows, to allow observation of all operations for Design Event I.

5.2.1.5 Provide ventilation of shielded cell for Design Events I, II, and III.

5.2.1.6 Provide for remote handling of fuel units for Design Event I and subsequent to Design Events II, III, and IV.

5.2.1.7 Provide protection of the fuel units from damage for Design Events I and II. Criteria for the protection of fuel units during rod consolidation are contained in ANSI/ANS-57.10-1987 [4].

5.2.1.8 Provide the capability for special tooling to handle structurally damaged fuel units subsequent to Design Events II, III, and IV.

5.2.1.9 Provide capability to maintain fuel rod temperatures within the allowable temperature-time relationship as required by 5.2.1.9.1 and 5.2.1.9.2 for Design Events I, II, III, and IV.

5.2.1.9.1 Limit the fuel handling and storage temperature history of the fuel rods in unlimited air for Design Events I, II, and III such that no damaged fuel (see Section 2, Definitions) will occur by oxidation of the fuel pellets to U_3O_8 .⁴ For Design Event IV, provide the capability of restoring sufficient cooling to prevent damage of the fuel rods that precludes retrievability of fuel.

5.2.1.9.2 Limit the fuel handling and storage temperature history of the fuel in a limited air or nonoxidizing atmosphere for Design Events I, II, and III such that no damaged fuel (see Section 2, Definitions) will occur. For Design Event IV, provide the capability of restoring sufficient cooling or the nonoxidizing environment (if lost) to prevent damage of the fuel rods that precludes retrievability of fuel. This case requires an analysis be performed to demonstrate that fuel damage will not result from reactions with the amount of oxygen or other corrosive elements permitted by design in the storage atmosphere (See Section 2, Definitions).⁵

5.2.1.10 If required, provide lag storage capability for fuel units removed from the transportation package for Design Events I, II, III, and IV.

5.3 Fuel Unit Transfer Area

5.3.1 Provide protection of the fuel units from damage for Design Events I, II, and III.

5.3.2 Provide for the transfer of fuel units between the fuel unit handling area and the storage area for Design Event I.

5.3.3 Provide the capability to load into or remove fuel units from the transfer machine or the storage area for Design Event I.

5.3.4 Provide the capability to receive fuel units from or return fuel units to the fuel handling area for Design Event I.

5.3.5 Provide the capability to retrieve fuel units from the storage area subsequent to Design Events II, III, and IV.

5.3.6 Limit the fuel cladding temperature in accordance with 5.2.1.9.

5.3.7 Provide radiological protection measures consistent with 5.13.

5.3.8 Provide capability to confine dislodged fuel crud during all fuel unit movements in the fuel unit transfer area and during transfers to or from the storage area for Design Events I, II, and III and provide capability to clean up dis-

lodged crud for Design Event I.

5.3.9 Maintain integrity of at least one confinement boundary for Design Event IV.

5.4 Fuel Unit Storage Area

5.4.1 Closure (Storage Area) Provide radiological protection measures consistent with requirements of 5.13 during closure placement and removal operations for Design Events I, II, and III.

5.4.2 Storage Monitoring (Storage Area)

5.4.2.1 If the limited air or nonoxidizing option is used, provide means for determining that the integrity of the confinement seal has not been impaired for Design Events I, II, III, and IV.

5.4.2.2 Provide monitoring outside containment for airborne radioactivity for Design Events I, II, and III and subsequent to Design Event IV.

5.4.2.3 Provide capability to conduct a periodic physical inventory check of all storage modules during Design Event I.

5.4.2.4 Provide selected storage modules with capability of being periodically monitored for temperature to confirm the thermal calculations for Design Event I.

5.4.3 Storage Heat Removal (Storage Area). Provide heat removal capability sufficient to limit the fuel cladding temperatures in accordance with 5.2.1.9.

5.4.4 Storage Confinement (Storage Area)

5.4.4.1 Provide a storage system structure and associated internals such that the configuration or performance as required for confinement would be sustained during Design Events I, II, III, and IV.

5.4.4.2 Provide radiological protection measures consistent with 5.13.

5.4.4.3 Provide capability for inspection for loss of function of secondary confinement barrier during Design Event I and subsequent to Design Events II, III, and IV.

5.4.5 Storage Foundation (Storage Area). Provide engineered foundations for storage area structures, taking into account the potential for soil liquefaction during a Design Event IV occurrence. If soil liquefaction cannot be eliminated as a possible consequence of a Design Event IV occurrence at the site, provide foundations that might include engineered fill to compensate for undesirable virgin soil characteristics. This requirement does not apply to storage system modules that can continue to provide confinement and shielding independently of a storage foundation failure.

5.4.6 Specific Requirements. In addition to the general requirements set forth in 5.4.1

⁴An example methodology for demonstrating by analysis that the design satisfies this condition is presented in Appendix B.

⁵An example logic for demonstrating that the design satisfies this condition is presented in Appendix B.

through 5.4.5, there are certain requirements that are specific to a particular storage concept.

5.4.6.1 Cask/Silo (Storage Area)

5.4.6.1.1 If the storage system module is portable, provide capability for withstanding the maximum credible drop during transport without compromising the integrity of the shielding structure or confinement seal for Design Event III.

5.4.6.1.2 If uncanistered spent fuel is stored, provide a level of confinement integrity consistent with the radiological protection measures of 5.1.3.

5.4.6.2 Vault/Canyon (Storage Area)

5.4.6.2.1 When uncanistered fuel is stored provide, if applicable, the capability for treating air that has been in contact with fuel for removal of airborne radioactive particulate material before its release to the atmosphere for Design Events I, II, III, and IV.

5.4.6.2.2 Provide interface alignment between the transfer machine and the storage area for loading and unloading for Design Events I, II, and III and subsequent to Design Event IV.

5.4.6.2.3 Provide capability of sustaining the maximum credible drop of a fuel unit when loading or unloading into a vertical storage cavity, or both, without penetrating the secondary confinement barrier for Design Events I, II, and III.

5.4.6.3 Drywell/Caisson (Storage Area)

5.4.6.3.1 If uncanistered spent fuel is stored, provide a level of confinement integrity consistent with the radiological protection measures of 5.13.

5.4.6.3.2 Provide interface alignment between the transfer machine and the storage area for loading and unloading for Design Events I, II, and III and subsequent to Design Event IV.

5.5 Heating, Ventilation, and Air Conditioning (HVAC)

5.5.1 Provide for prevention of ventilation backflow from areas subject to airborne contamination to other areas not potentially contaminated (or less contaminated) for Design Events I and II.

5.5.2 Provide for control of interior ambient temperatures within design limits for Design Event I.

5.5.3 Provide for collection of airborne particulate radioactive material within the area containing the source for Design Event I.

5.5.4 Make provision for monitoring of effluents from potentially contaminated areas during

Design Events I, II, and III and subsequent to Design Event IV.

5.6 Buildings

5.6.1 Protect the structures, systems, and components that are important to confinement from the effects of adverse external environmental conditions for Design Events I, II, and III.

5.6.2 Provide for the control of access to and the prevention of the spread of contamination from areas that are potential sources of surface contamination of Design Events I, II, and III.

5.7 Radwaste Treatment

5.7.1 Provide for collection, treatment, and preparation for disposal of all potentially contaminated liquid effluents for Design Event I.

5.7.2 Provide for containment and allow monitoring of potentially contaminated liquid wastes for Design Events I, II, III, and IV.

5.7.3 Provide for collection, preparation for shipping, and delivery to transport vehicles of all solidified liquid wastes and other solid radwaste material for Design Event I.

5.8 Electrical Power, Instrumentation and Control (I&C), and Communications

5.8.1 Provide power for all electrically operated components for Design Event I.

5.8.2 Provide for monitoring of process systems, effluent, and area radiation levels for direct radiation, gaseous, and airborne particulate activity for anticipated ranges for Design Events I, II, and III.

5.8.3 Provide the instrumentation and alarms necessary for each process system to ensure that loss of system function can be detected so the systems can be placed in a safe condition for Design Events I and II.

5.8.4 Provide on-site communications for the ISFSI for Design Event I.

5.8.5 Provide on-site emergency communications for the ISFSI for Design Events II, III, and IV.

5.8.6 Provide interior and exterior lighting for Design Event I.

5.8.7 Provide the minimum interior and exterior lighting required for personnel safety for Design Events II and III.

5.8.8 Provide the capability, if not otherwise available, to determine the severity of natural design phenomena for Design Events I, II, III, and IV.

5.8.9 Provide capability to check and recalibrate monitoring equipment and all other equipment

that are important to confinement during Design Event I.

5.9 Fire Protection

5.9.1 Provide for the detection of fire and explosion in those areas of the building that are important to confinement, where the potential for fires and explosions exists, for Design Events I and II.

5.9.2 Provide the capability to extinguish fires during Design Events I, II, and III.

5.9.3 Protect against adverse effects to structures, systems, and components that are important to confinement because of operation of fire protection equipment for Design Events I, II, III, and IV.

5.9.4 Provide suitable barriers to impede the spread of fires to systems and equipment that are important to confinement for Design Events I, II, III, and IV.

5.10 Physical Protection

5.10.1 Provide on-site communications, physical barriers, access control facilities, intrusion detection equipment, surveillance equipment, security lighting, and alarm systems for Design Events I, II, and III.

5.10.2 Provide off-site communication for Design Events I, II, III, and IV.

5.11 Accountability

5.11.1 Provide the capability to determine fuel unit identification numbers such that positive verification of shipping records is achievable and initial data entry into accountability records is provided for Design Event I.

5.11.2 Provide the capability to conduct fuel unit inventory for Design Events I and II and subsequent to Design Events III and IV.

5.11.3 Provide equipment and systems necessary to operate and maintain a nuclear material control and accounting system.

5.12 Nuclear Criticality Safety. Provide design features and demonstrate by analysis that the fuel unit transfer, fuel unit handling, and storage areas remain subcritical for Design Events I, II, III, and IV. For those areas that require a criticality alarm system, ensure that the system remains operable for Design Events I, II, and III.

5.13 Radiological Protection

5.13.1 Limit occupational exposure to ALARA levels based on accepted principles of dose reduction for Design Events I and II.

5.13.2 Radiological exposure limits shall be based on 10 CFR 72 [8] for Design Events I, II, and 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, ISFSI Performance Requirements. If water pool concepts are used as part of the ISFSI, refer to ANSI/ANS-57.7-1988 [2].

6.1 Transportation Package Handling Area

6.1.1 Receiving and Shipping

6.1.1.1 Conditions of Design (Receiving and Shipping)

6.1.1.1.1 The transportation package handling equipment should be designed to accept all of the transportation packages expected to be handled at the ISFSI.⁶

6.1.1.1.2 Insofar as is practical, the need to reverse direction of a vehicle within the area, between entrance and egress, should be avoided. If the installation layout will necessitate that the transportation vehicle make a 90-deg turn within the handling area, then a 50% margin factor should be added to the vehicle turning radius.

6.1.1.1.3 The floor surface upon which highway vehicles are loaded and unloaded should be flat and level. Any surface between railroad tracks, except for flange grooves, should be at the same level as the rails and surrounding floor.

6.1.1.1.4 Equipment whose functions are classified as important to confinement shall be located or protected so that a loss of design function is not caused by the movement of the transportation package.

6.1.1.1.5 A system shall be provided for the washdown of road dirt from transportation packages and the transportation package carrier. This system shall have provisions to collect, monitor, and dispose of all wash water that may contain low-level radioactive contamination.

6.1.1.1.6 Drain piping shall be designed to minimize the number of traps, loops, and flanges that might accumulate radioactive particles.

6.1.1.2 Interfaces (Receiving and Shipping). Adequate storage space should be provided for special tools, unique to each transportation package being received, including lifting yokes, slings, and piping connections. Storage space should also be provided for transportation package appurtenances that must be removed while the transportation package is in the loading and unloading cycle.

⁶See Appendix C for typical characteristics of transportation packages.

6.1.1.3 Testing, Inspection, and Maintenance (Receiving and Shipping)

6.1.1.3.1 Safe access shall be provided to all packages, transportation vehicles, and installed components for purposes of testing, inspection, and maintenance.

6.1.1.3.2 Installed components requiring testing, inspection, or maintenance shall be designed for easy decontamination.

6.1.1.3.3 Cranes and other equipment shall be designed to be tested, maintained, and inspected in accordance with industry consensus standards and Occupational Safety and Health Act (OSHA) requirements.

6.1.2 Decontamination

6.1.2.1 Conditions of Design (Decontamination)

6.1.2.1.1 Means shall be provided to decontaminate external surfaces only of the transportation package, including ancillary equipment, as required to meet the contamination limits of Title 49, "Transportation," Code of Federal Regulations, Part 173, "Shippers—General Requirements for Shipments and Packagings," Subpart I, "Radioactive Materials" [9].

(1) If impact cleaning is provided, it should be housed in an enclosed decontamination station. Equipment and capabilities for cleaning up the decontamination agents for possible reuse should be provided.

(2) Waste generated by decontamination operations shall be collected for treatment and disposal.

(3) Drain piping shall be designed to minimize the number of traps, loops, and flanges that might accumulate radioactive particles.

6.1.2.2 Interface (Decontamination). The arrangement of this area shall not restrict the normal flow of operations within the transportation package handling area; it shall provide for ease of transfer of the package into and out of the decontamination area, or to bypass the station if its services are not required. Instruments and equipment for evaluating the degree of contamination should be accessible.

6.1.2.3 Testing, Inspection, and Maintenance (Decontamination)

6.1.2.3.1 Cranes and other equipment shall be designed to be tested, maintained, and inspected in accordance with industry consensus standards (e.g., American National Standard Rules for Construction of Cranes, Overhead and Gantry (Top Running Bridge, Multiple Girder), ANSI/ASME NOG-1-1989 [10], and OSHA requirements.

6.1.2.3.2 Systems used for transfer of radioactive wastes or effluents shall incorporate provision for flushing to permit maintenance.

6.1.3 Maintenance

6.1.3.1 Conditions of Design (Maintenance)

6.1.3.1.1 Means shall be provided to decontaminate equipment.

6.1.3.1.2 Appropriate equipment and space should be provided for ease and expediency of maintenance operations.

6.1.3.1.3 Remote operating capabilities shall be provided for routine maintenance jobs that result in higher than normal radiation doses to operators (e.g., changing fuel baskets).

6.1.3.1.4 Provision for collection, treatment, and disposal of contaminated waste shall be provided.

6.1.3.1.5 Drain piping shall be designed to minimize traps, loops, and flanges to avoid accumulating radioactive particles.

6.1.3.2 Interface (Maintenance). The arrangement of the maintenance area should ensure that activities within the area do not interfere with normal operations in the transport package handling area.

6.1.3.3 Testing, Inspection, and Maintenance (Maintenance)

6.1.3.3.1 Systems designed for transfer of radioactive wastes or effluent shall incorporate provisions for flushing.

6.1.3.3.2 Cranes and other equipment shall be designed to be tested, maintained, and inspected in accordance with industry consensus standards and OSHA requirements.

6.1.4 Preparation

6.1.4.1 Conditions of Design (Preparation)

6.1.4.1.1 Sufficient space shall be provided in the preparation area for the free passage of operating personnel around scaffolds or elevated platforms used to reach the upper parts of the transportation package.

6.1.4.1.2 Provisions shall be made for the inspection and monitoring of variables such as transportation package temperatures, pressures, radiation levels of surfaces and coolants, and seal integrity that are required for the safe handling and transport of transportation packages.

6.1.4.1.3 Provisions shall be made for cooling, sampling of gas, and liquid analyzing samples from, venting, flushing, draining, and filling the transportation package cavity as required for the subsequent unloading or shipping of transportation packages.

(1) Provision for collection, treatment, and disposal of contaminated waste shall be provided.

(2) An off-gas system shall be provided to handle airborne radioactive materials that may be contained in the transportation package cavity on receipt at the facility.

6.1.4.2 Interface (Preparation). The transportation package preparation area will include many utilities common to both the decontamination and maintenance areas and should be planned accordingly. This area may simultaneously handle packages being prepared for fuel unloading, for empty shipment, or for loaded shipment. Therefore, access to or egress from this area for a given operation should not impede the flow of other operations. This station should be located as near as practical to the fuel unit handling area.

6.1.4.3 Testing, Inspection, and Maintenance (Preparation)

6.1.4.3.1 Safe access shall be provided to all side and top surfaces of each transportation package.

6.1.4.3.2 Replacement of valves, seals, and other components shall not be performed unless special provision is made for radiation control. Package internals shall not be examined or exchanged in this area.

6.1.5 Transportation Package Holding and Transfer

6.1.5.1 Conditions of Design (Transportation Package Holding and Transfer)

6.1.5.1.1 The requirements for package holding are determined primarily by the design philosophy of the individual ISFSI. In each installation, transportation packages will move from one station to the next with the time duration at each varying from zero (in effect, a bypass) to several hours. If holding areas are not provided, the queue ahead of a given station will immediately block the preceding station will immediately block the preceding station, and operating efficiencies will suffer. If the ISFSI design includes only one station of each type and expects a fairly high transportation package receiving rate, multiple holding areas might be required and should be located near the next step to minimize transportation package handling. If the busier stations are duplicated (or triplicated, quadrupled, or so on), then fewer holding areas serving more than one station may suffice.

6.1.5.1.2 The transfer equipment and its support systems shall be designed to withstand all design loadings, including the design phenomena, while remaining in place. The transfer equipment may lose its function, but this loss of

function shall not result in a loss-of-load incident. Design methods, loadings, and so forth shall be in accordance with 6.17.

6.1.5.1.3 Design of the structure should provide for ease of transfer equipment maintenance including provisions for decontamination.

6.1.5.1.4 Building area layout should be designed to minimize transfer travel during the course of transportation package movement. Transport of the transportation package over fuel units or equipment that are important to confinement shall be precluded by design.

6.1.5.2 Interface (Transportation Package Transfer). The transportation package transfer system interfaces with the other areas 6.1.1 through 6.1.5 in the transportation package handling area.

6.1.5.3 Testing, Inspection and Maintenance (Transportation Package Transfer). Transfer equipment shall be designed to be tested, maintained, and inspected in accordance with accepted consensus standards and OSHA requirements.

6.1.7 Codes and Standards (Transportation Package Handling Area). In addition to commercial codes and standards, the design of concrete and structural steel portions of the transportation package handling area shall conform to the following American National Standards:

(1) Code Requirements for Nuclear Safety Related Concrete Structures, ANSI/ACI 349-85 [11]; and

(2) Specifications for the Design, Fabrication, and Erection of Steel Safety Related Structures for Nuclear Facilities, ANSI/AISC N690-1984 [12].

6.2 Fuel Unit Handling Area

6.2.1 Fuel Unit Loading/Unloading

6.2.1.1 Conditions of Design (Fuel Unit Loading/Unloading)

6.2.1.1.1 Materials shall withstand the cumulative effect of radiation exposures anticipated over their design life.

6.2.1.1.2 Capability for emergency shutdown of the lifting and handling equipment power supply (i.e., manual disconnect) shall be incorporated into the equipment design, independent of and physically separated from the normal controls, but located within the planned work area and readily accessible.

6.2.1.1.3 Handling and process equipment and other support equipment located within the shielded cell shall be designed to function in or be appropriately shielded from the high radiation field produced by unshielded fuel units.

6.2.1.1.4 If provision for remote maintenance is not made, handling equipment for fuel units and transportation package closure lid(s) shall have sufficient redundancy so that no single failure in the handling system will preclude returning unshielded fuel units to shielded storage locations or returning the closure lid(s) to the transportation package.

6.2.1.1.5 Grapples, lifting attachments, and handling equipment for fuel units and transportation package closure lid(s) shall be designed for remote operation, and active lifting components shall be designed to retain their load in the event of loss of actuating power. An independent, remote means shall be provided for disengagement of any grapple in the cell in the event an active grapple component fails to operate. Grapple operating envelopes shall be designed to be compatible with all interfacing storage and transportation systems.

6.2.1.1.6 Grapples and lifting fixtures for handling fuel units or transportation package closure lid(s) shall be designed to provide positive engagement during a lift, and the grapples and associated controls shall be designed to minimize the potential for inadvertent disengagement. A means shall be provided to indicate that positive engagement has been achieved and to indicate the disengaged position.

6.2.1.1.7 Grapples and tools shall be designed to facilitate decontamination, nondestructive testing, maintenance, handling, and storage. Cracks or crevices likely to collect contamination should be avoided.

6.2.1.1.8 Process cranes shall employ redundant limit switches and interlocks to prevent excessive horizontal movement that could affect operation or cause damage to the units being handled, as well as to prevent excessive vertical movement including double blocking. Redundant means of disconnecting power to the cranes shall be available to the operator. Redundant means of braking vertical travel shall be provided. Braking of horizontal motion should be provided as necessary to facilitate the required positioning precision.

6.2.1.1.9 Process fixtures, temporary storage locations, fuel unit containers, and similar devices should be designed with lead-ins and chamfers to facilitate fuel unit insertion and removal. If the possibility exists for fuel units to catch on lips or protrusions during lifting or lowering, the lifting equipment shall have interlocks to sense an unacceptable change (either an

increase or a decrease) in hoisting force and automatically stop further travel.

6.2.1.1.10 Shielded viewing windows and remote viewing equipment (e.g., closed circuit television, periscopes) shall be incorporated into the design of the shielded cell to assist operators in performing required normal process operations and recovery from off-normal events. Adequate lighting shall be provided in the cell to facilitate the remote operation and to permit accurate identification and thorough visual inspection of fuel units for conformance to requirements of the storage area acceptance criteria.

6.2.1.1.11 Remote handling equipment shall be incorporated into the design of the area to permit performance of normal process operations. Particular attention shall be given in the design to methods and equipment required to recover from equipment failures, off-normal events, and accidents.

6.2.1.1.12 Interior surfaces of the shielded cell shall be coated or lined to facilitate decontamination.

6.2.1.1.13 Facilities for putting on and taking off anti-contamination clothing and personnel monitoring (frisking) devices should be provided adjacent to access doors to the shielded cell.

6.2.1.1.14 Use of combustible material in the shielded cell should be minimized.

6.2.1.1.15 Use of water in the shielded cell should be restricted if water can come in direct contact with hot spent fuel rods (flashing of water to steam can cause airborne dispersal of radioactive crud from the cladding surface).

6.2.1.1.16 Design methods, loadings, and so forth shall be in accordance with 6.17. The handling equipment may lose its function, but functional failure shall not result in a loss of load incident or inability to recover from the failure.

6.2.1.1.17 The influence of transient loadings of handling equipment on supporting and surrounding systems and structures shall be included in the design of these systems and structures.

6.2.1.1.18 The special procedures for handling damaged fuel or damaged fuel units should be anticipated and provisions made in the design.

6.2.1.1.19 If damaged fuel is received by the ISFSI for storage, it shall be canned, and provisions shall be made for handling and temporary storage of these containers within the fuel handling area.