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

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Contractor Witness Waters

Other

Reporter R. Davis

(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 recommendation. "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 Transportation 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.