NUREG-2215

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United States Nuclear Regulatory Commission
Protecting People and the Environment

Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities

Final Report

Office of Nuclear Material Safety and Safeguards

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Office of Nuclear Material Safety and Safeguards

ABSTRACT

This Standard Review Plan (SRP) provides guidance to the U.S. Nuclear Regulatory Commission (NRC) staff for reviewing safety analysis reports (SARs) for (1) a Certificate of Compliance (CoC) for a dry storage system for use at a general license facility and (2) a specific license for a dry storage facility that is either an independent spent fuel storage installation (ISFSI) or a monitored retrievable storage installation (MRS). This SRP does not apply to wet storage ISFSIs or MRSs (e.g., GE-Morris). NUREG-2215 is a consolidation of existing guidance for staff's use when reviewing applications for licenses and certificates for spent fuel dry storage systems and facilities, and as such, it is not intended to offer new or differing guidance.

The objectives of this SRP are to assist the NRC staff in its reviews by doing the following:

- promoting a consistent regulatory review of a SAR for an ISFSI or MRS license, or for a CoC
- promoting quality and uniformity of these reviews across each technical discipline
- presenting a basis for the review's scope
- identifying acceptable approaches to meeting regulatory requirements
- suggesting possible evaluation findings that can be used in the safety evaluation report

This SRP was published for public comment and the responses to those comments are available at ML19303C896. This NUREG is a rule as defined in the Congressional Review Act (5 U.S.C. 801-808). However, the Office of Management and Budget has not found it to be a major rule as defined in the Congressional Review Act.

This SRP may be revised and updated as the need arises on a chapter-by-chapter basis to clarify the content, correct errors, or incorporate modifications approved by the Director of the Division of Fuel Management. Comments, suggestions for improvement, and notices of errors or omissions should be sent to and will be considered by the Director, Division of Fuel Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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ABBREVIATIONS AND ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AISC	American Institute of Steel Construction
ALARA	as low as is reasonably achievable
ANO	Arkansas Nuclear One
ANS	American Nuclear Society
ANSI	American National Standards Institute
APSR	axial power shaping rod
ASCE	American Society of Civil Engineers
ASD	allowable stress design
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
B_4C	boron carbide
B&PV	boiler and pressure vessel
BPR	burnable poison rod
BPRA	burnable poison rod assembly
BR	breathing rate
BWR	boiling-water reactor
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
CISCC	chloride-induced stress-corrosion cracking
CoC	certificate of compliance
CR	control rod
CRC	commercial reactor critical
DBA	design-basis accident
DCF	dose conversion factor
DDE	deep dose equivalent
DOE	U.S. Department of Energy
DP	decommissioning plan
D/Q	deposition parameter
DSF	dry storage facility
DSS	dry storage system
EALF	energy of average neutron lethargy causing fission
EDEX	effective dose equivalent from external exposure

EIA	Energy Information Administration
EP	emergency plan
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
FEA	finite element analysis
FPP	fire protection program
GBC	generic burnup credit
GCI	grid convergence index
GTCC	greater-than-Class-C (waste)
GTRF	grid-to-rod fretting
HLW	high-level radioactive waste
HPS	Health Physics Society
H/X	hydrogen-to-fissile atom ration
I&C	instrumentation and controls
IBA	integral burnable absorber
IBC	International Building Code
ICRP	International Commission on Radiological Protection
IEEE	Institute of Electrical and Electronics Engineers
ISFSI	independent spent fuel storage installation
ISG	Interim Staff Guidance
k_{eff}	effective neutron multiplication factor
LDE	lens (eye) dose equivalent
LWR	light-water reactor
MMS	metal matrix composite
MofS	margin of safety
MOX	mixed-oxide
MPC	multipurpose cask
MRS	monitored retrievable storage installation
MT	magnetic particle testing
MTHM	metric ton heavy metal
MTU	metric ton of uranium
NCRP	National Council on Radiation Protection and Measurements
NDE	nondestructive examination
NFH	nonfuel hardware
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation

NSA	neutron source assembly
OFA	optimized fuel assembly
O/M	oxygen to metal
ORNL	Oak Ridge National Laboratory
P&ID	piping and instrumentation diagram
PAR	protective action recommendation
PM	project manager
PMF	probable maximum flood
PMP	probable maximum precipitation
PRA	poison rod assembly
PT	liquid (dye) penetrant testing
PWR	pressurized-water reactor
QA	quality assurance
QAPD	quality assurance program description
RCA	radiochemical assay
RES	NRC Office of Nuclear Regulatory Research
RG	regulatory guide
RT	radiographic examination
SAE	Site Area Emergency
SAR	safety analysis report
SDE	shallow (skin) dose equivalent
SER	safety evaluation report
SFA	spent fuel assembly
SFPO	NRC Spent Fuel Project Office
SFST	NRC Division of Spent Fuel Storage and Transportation
SI	système international d'unités (International System of Units)
SNF	spent nuclear fuel
SRP	Standard Review Plan
SSCs	structures, systems, and components
TEDE	total effective dose equivalent
TLAA	time-limiting aging analysis
TSUNAMI	Tools for Sensitivity and Uncertainty Methodology Implementation
U_3O_8	triuranium octoxide
UO_2	uranium dioxide
UT	ultrasonic testing
X/Q	atmospheric dispersion

UNITS

Bq	becquerel
°C	degrees Celsius
Ci	curie
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
°F	degrees Fahrenheit
ft	foot
ft^2	square foot
ft^3	cubic foot
g	gram
GWd/MTHM	gigawatt days per metric ton heavy metal
GWd/MTU	gigawatt days per metric ton of uranium
hr	hour
in.	inch
K	Kelvin
kg	kilogram
kgf	kilograms force
km	kilometer
ksi	thousand pounds per square inch
lb	pound
m	meter
m^2	square meter
m^3	cubic meter
mb	millibar
MeV	mega electron volt
mCi	milliCurie (one-thousandth of a Curie)
mg	milligram (one-thousandth of a gram)
mi	mile
mJ	millijoule
mm	millimeter (one-thousandth of a meter)
MPa	megapascal (million pascals)
mph	miles per hour
mrem	millirem (one-thousandth of a rem)
ms	millisecond
mSv	millisievert (one-thousandth of a sievert)
MWd/MTHM	megawatt days per metric ton heavy metal
MWd/MTU	megawatt days per metric ton of uranium
Pa.	Pascal
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch

psig	pounds per square inch gauge
s	second
Sv	sievert
μCi	microcurie (one-millionth of a curie)
yr	year

GLOSSARY

The U.S. Nuclear Regulatory Commission (NRC) staff has defined the terms provided in this section for the purposes of this Standard Review Plan (SRP).

Acceptance Test. Tests conducted by the applicant to ensure that the material or component produced was fabricated in compliance with the material or component design requirements of the application. Acceptance tests are also used to ensure that the process is operating in a satisfactory manner by using statistical data for selected measurable parameters.

Accident Condition. The extreme level of an event or condition, which has a specified resistance, limit of response, and requirement for a given level of continuing capability, which exceeds off-normal events or conditions. Accident conditions include both design-basis accidents and conditions caused by natural and manmade phenomena. These conditions include events that are Design Events III and IV in American National Standards Institute/American Nuclear Society (ANSI/ANS) 57.9, “Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type).”

Aging Management Program. See definition in Title 10 of the *Code of Federal Regulations* (10 CFR) 72.3, “Definitions.”

Amendment of a License or CoC. An application for amendment of a license or a CoC is generally submitted when a holder of a specific license or CoC desires to change the license or CoC (including a change to the technical specifications that accompany the license or CoC). The application must fully describe the desired change(s) and the reason(s) for such change(s), and follow as far as applicable the form prescribed for original applications. See 10 CFR 72.56, “Application for Amendment of License,” and 10 CFR 72.244, “Application for Amendment of a Certificate of Compliance”.

Areal Density. Mass per unit area, usually expressed in grams per square centimeters (g/cm^2). In this SRP, this term is used to describe the distribution of neutron absorber content in a material.

Assembly Defect. Any change in the physical as-built condition of the SNF assembly except for normal in-reactor changes such as elongation from irradiation growth or assembly bow. Examples of assembly defects include (a) missing rods, (b) broken or missing grids or grid straps (spacers), and (c) missing or broken grid springs.

As Low As Is Reasonably Achievable (ALARA). See 10 CFR 20.1003, “Definitions,” and 10 CFR 72.3, “Definitions.”

Basic Safety Criteria. The following are considered the basic safety criteria for design of the spent fuel storage system or facility:

- Maintain subcriticality.
- Prevent the release of radioactive material above amounts that ensure compliance with regulatory dose requirements, including ALARA.
- Ensure that doses do not exceed the levels that ensure compliance with regulatory dose requirements, including ALARA.

Benchmarking. Establishing a predictable relationship between calculated results and reality. The main goal of benchmarking is to gain a quantitative understanding of the difference, or "bias," between calculated and expected results and the uncertainty in this difference (bias uncertainty). Also known as code or method "validation."

Breached Spent Nuclear Fuel (SNF) Rod. An SNF rod with cladding defects that permit the release of gases or solid fuel particulates from the interior of the fuel rod. SNF rod breaches include pinhole leaks, hairline cracks or gross ruptures.

Burnable Poison Rod (BPR). A rod containing neutron-absorbing material that, during long-term neutron flux exposure, loses its absorbing capability at a controlled rate.

Burnable Poison Rod Assembly (BPRA). An assembly of BPRs used to absorb neutrons created in the nuclear reactor to control the power produced in the associated fuel assembly during the early core life. The BPRs are inserted into the assemblies through the upper end fittings of the assembly and held in place against lift forces in the core by a retainer mechanism. BPRAs may be approved for storage with SNF assemblies when stored within the assembly envelope.

Burnup. The measure of the thermal power produced in a specific amount of nuclear fuel through fission, usually expressed in units of gigawatt days per metric ton of uranium (GWd/MTU). For the purpose of assessing the allowable contents, the maximum burnup(s) of the fuel should be specified in terms of the average burnup of the entire fuel assembly (i.e., assembly average). Additionally, for SNF criticality analyses that rely on burnup credit, a minimum required assembly average burnup will be specified. For the purpose of assessing fuel cladding integrity in the materials review, the rod with the highest burnup within the fuel assembly should be specified in terms of peak rod average burnup. For assemblies with mixed oxide (MOX) or thoria rods, the units will usually be megawatt days per metric ton heavy metal (MWd/MTHM).

Can for Damaged Fuel (aka Damaged Fuel Can). A metal enclosure that is sized to confine damaged SNF contents. A can for damaged fuel must satisfy fuel-specific and dry storage system (DSS)-related functions for undamaged SNF, as required by the applicable regulations.

Canister. In a DSS for SNF, a metal cylinder that is sealed at both ends and may be used to perform the function of confinement. Typically, a separate overpack performs the radiological shielding and physical protection functions during storage on the storage pad, while a separate transfer cask performs these functions during operations such as canister loading, preparation for storage, and transfer into the storage overpack.

Canning. One method to store damaged or consolidated SNF or nuclear fuel debris, placing it in a separate container (e.g., can for damaged fuel), and confine it in such a way that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage (per 10 CFR 72.122(h)(1)).

Cask. See Spent Fuel Storage Cask.

Certificate of Compliance (CoC). See 10 CFR 72.3.

Certificate of Compliance Holder (CoC Holder). See 10 CFR 72.3.

Certificate of Compliance User (CoC User). The general licensee that has loaded a DSS, or purchased a DSS and plans to load it, in accordance with a CoC issued under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste."

Collective Dose. See 10 CFR 20.1003.

Committed Dose Equivalent (H_T 50). See 10 CFR 20.1003.

Committed Effective Dose Equivalent (H_E 50). See 10 CFR 20.1003.

Co-locate. To locate a 10 CFR Part 72 facility on the same site as another fuel cycle or other radioactive materials facility. Facilities that are co-located may share common facilities. For example, a specific license ISFSI may be co-located at a power reactor site licensed under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," or 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." General license ISFSIs must be located at a power reactor site that is authorized to possess or operate nuclear power reactors under 10 CFR Parts 50 or 52. These co-located ISFSIs may share the storage pad (as a common facility) with materials stored under the 10 CFR Part 50 or 52 license (e.g., reactor-related greater-than-Class-C (GTCC) waste) also being stored on the same storage pad as the SNF that is stored under the 10 CFR Part 72 license.

Confinement Boundary. In a DSS for SNF, the outer boundary of the confinement system that prevents the release of radioactive material to the environment.

Confinement. The ability to limit or prevent the release of radioactive substances into the environment.

Confinement System. See 10 CFR 72.3.

Confirmatory Calculations. Independent calculations performed by the NRC reviewer to confirm the adequacy of the applicant's analyses. These calculations do not replace, nor do they endorse, the applicant's design calculations.

Construction. Includes materials, design, fabrication, installation, examination, testing, inspection, maintenance, and certification as required in the manufacture and installation of structures, systems, and components (SSCs).

Controlled Area. See 10 CFR 72.3. See also10 CFR 20.1003. The definition in 10 CFR 20.1003 is broader in scope and allows for, or includes, establishment of access controls to areas within the site for any reason (for radiation protection).

Critical. The state of a fissile material system where the rate of production of neutrons, from fission and other sources, is equal to the rate of loss, from absorption and leakage. A system that is exactly critical will have a constant population of neutrons.

Damaged Spent Nuclear Fuel. Any fuel rod or fuel assembly that cannot meet the pertinent fuel-specific, DSS, or dry storage facility (DSF)-related regulations in 10 CFR Part 72. See Chapter 8 of this SRP.

Deep-Dose Equivalent (H_D). See 10 CFR 20.1003.

Degradation. Any change in the properties of a material that adversely affects the performance of that material; adverse alteration.

Design Bases. See 10 CFR 72.3.

Design Criteria. The criteria the facility or cask designer uses to show that the design meets all of the requirements in 10 CFR Part 72. Design criteria can include, but is not limited to, safety margins, maximum stresses, maximum or minimum material temperatures, dose rates, and k-effective (k_{eff}).

Design-Basis Earthquake. The design earthquake ground motion for a site where a DSF may be used, or where a DSF may be sited. DSF siting requirements for a specific license are determined in accordance with 10 CFR 72.102 or 10 CFR 72.103.

Design Event (I, II, III, or IV). Conditions and events as defined and used for an ISFSI in ANSI/ANS 57.9.

Dry Storage System. A system that typically uses a cask or canister in an overpack as a component in which to store SNF in a dry environment. A DSS provides confinement, radiological shielding, sub-criticality control, structural support, and passive cooling of its SNF during normal, off-normal, and accident conditions.

Dry Storage. The storage of SNF in a DSS, which typically involves drying the DSS cavity and backfilling with an inert gas.

Emergency Power. The power supply that is selected to furnish electric energy to instruments, utility service systems, the central security alarm station, and operating systems in amounts sufficient to allow safe storage conditions to be maintained and to permit continued functioning of all systems essential to safe storage when the primary power supply is not available.

Exemption. The request for an exception from application of a specific regulatory requirement that otherwise is required. The NRC must explicitly approve an exemption and will only do so if the applicable regulatory requirements are met. See, for example, 10 CFR 72.7, “Specific exemptions”.

General License. Authorizes the storage of SNF in an ISFSI at power reactor sites to persons (i.e., general licensee) authorized to possess or operate nuclear power reactors under 10 CFR Part 50 or 10 CFR Part 52. The general license is limited to (1) that SNF which the general licensee is authorized to possess at the site under the specific 10 CFR Part 50 or 10 CFR Part 52 license for the site, and (2) storage of SNF in casks approved under the provisions of 10 CFR Part 72, Subpart L, “Approval of Spent Fuel Storage Casks.” See 10 CFR 72.210, “General license issued,” and 10 CFR 72.212(a)(1)–(2).

Gross Breach. A breach in the spent fuel cladding that is larger than either a pinhole leak or a hairline crack and allows the release of particulate matter from the spent fuel rod.

Hairline Crack. A minor SNF cladding defect that will not permit significant release of particulate matter from the spent fuel rod and therefore presents a minimal as low-as-is-reasonably-achievable concern during fuel handling operations.

High Burnup Fuel. SNF with assembly average burnup (see "Burnup") that exceeds 45 GWd/MTU.

Hoop Stress. The tensile stress in cladding wall in the circumferential orientation of the fuel rod.

Insolation. Exposure of a material to sunlight; the rate of solar radiation received per unit area.

Intact Spent Nuclear Fuel. Any fuel rod or fuel assembly that can meet the pertinent fuel-specific or system-related regulations for the transportation package (10 CFR Part 71, "Packaging and Transportation of Radioactive Material") or dry storage system (10 CFR Part 72). Intact SNF rods may not contain pinholes, hairline cracks, or gross breaches. Intact SNF assemblies may have assembly defects if able to meet the pertinent fuel-specific or DSS-related regulations.

Intended Function. A design-bases function defined as either (1) important to safety or (2) failure of which could impact a safety function.

K_{eff}. "k-effective." Effective neutron multiplication factor including all biases and uncertainties at a 95-percent confidence level for indicating the level of subcriticality relative to the critical state. At the critical state, k_{eff} = 1.0.

Lens Dose Equivalent. See 10 CFR 20.1003.

Low Burnup Fuel. SNF with an assembly average burnup (see "Burnup") that does not exceed 45 GWd/MTU.

Margin of Safety (Safety Margin) (MofS). This term may be defined, through a factor of safety, f.s. = capacity/demand, as MofS = F.S. (capacity/demand) – 1 (with minimum acceptable MofS > 0.0)."

Member of the Public. See 10 CFR 20.1003.

Misloading. The placement of SNF in a DSS or DSF storage container in a configuration not supported by the design basis or authorized by the certificate or license and technical specifications for the DSS or DSF container. For reactor-related GTCC waste and solidified high-level radioactive waste (HLW) containers at a DSF, the placement of waste in these containers that do not meet the characteristics of the container's allowable contents.

Monitored Retrievable Storage Installation. See 10 CFR 72.3.

Monitoring. Data collection to determine the status of a DSS or DSF SSC and to verify the continued efficacy of the SSC on the basis of measurements of specified parameters, including temperature, direct radiation, radioactive effluents, functionality, and characteristics of the SSC. With respect to direct radiation and radioactive effluents, according 10 CFR 20.1003, monitoring means the measurement of radiation levels, concentrations, surface area concentrations, or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

Neutron Absorber. Also known as "poison." Materials that have a high neutron absorption cross section and are used to absorb neutrons to make a fissile material system less reactive. They are used to ensure subcriticality during normal, off-normal, and accident conditions in containers of fissile materials.

Nondestructive Examination (NDE). Testing, examination, or inspection of a component that does not affect the functionality and performance of the component. NDE can be broadly divided into three categories: visual, surface, and volumetric examinations. Additional information may be found in the American Society of Mechanical Engineers Boiler and Pressure Code, Section V, "Nondestructive Examination," Appendix A.

The following NDE-related terms are presented in order of increasing severity:

Discontinuity: An interruption in the normal physical structure of a material. Discontinuities may be unintentional (such as those formed inadvertently during the fabrication process) or intentional (such as a drilled hole).

Indication: Sign of a discontinuity observed when using an NDE method.

Flaw: An imperfection in an item or material that may or may not be harmful.

Defect: A flaw that, because of its size, shape, orientation, location, or other properties, is rejectable to the applicable construction code. Defects may be detrimental to the intended service of a component, and the component must be repaired or replaced.

Common NDE examination methods include the following:

LT leak testing

MT magnetic particle examination

PT liquid penetrant testing

RT radiographic examination

UT ultrasonic examination

VT visual examination

Non-Fuel Hardware. Hardware that is not an integral part of a fuel assembly. This is the term used to identify what the regulation refers to as "other radioactive materials associated with fuel assemblies" (see SNF definition in 10 CFR 72.3). While not integral to the assembly, it includes those items that are designed to operate and are positioned or operated within the envelope of the fuel assembly during reactor operation and are stored within the assembly envelope in the storage container. Typical examples of non-fuel hardware include: BPRAs, control element assemblies, thimble plug assemblies, and boiling-water reactor (BWR) fuel channels. Examples of items that do not meet this definition include boron sources, BWR in-core instruments, and BWR control blades.

Non-Mechanistic Event. An event, such as cask tipover, that should be evaluated for acceptable system capability, although a cause for such an event is not identified in the analyses of off-normal and accident events and conditions.

Normal Events and Conditions. Conditions that are intended operations, planned events, and environmental conditions that are known or reasonably expected to occur with high frequency during storage operations. "Normal" refers to the maximum level of an event or condition that is expected to routinely occur (similar to Design Event I in ANSI/ANS 57.9). The DSS and DSF SSCs are expected to remain fully functional and to experience no temporary or permanent degradation of that functionality from normal operations, events, and conditions. Specific normal conditions to be addressed are evaluated for the DSS or DSF and are documented in the SAR for that system or facility.

Normal Means. The ability to move a fuel assembly with a crane and grapple used to move undamaged assemblies at the point of cask loading. The addition of special tooling or modifications to the assembly to make the assembly suitable for lifting by crane and grapple does not preclude the assembly from being considered moveable by normal means.

Off-Normal Events or Conditions. An event or condition that, although not occurring regularly, can be expected to occur with moderate frequency and for which there is a corresponding maximum specified resistance, limit of response, or requirement for a given level of continuing capability. Off-normal events and conditions are similar to Design Event II in ANSI/ANS 57.9. The DSS and DSF SSCs are expected to experience off-normal events and conditions without permanent degradation of capability to perform its full function (although operations may be suspended or curtailed during off-normal conditions) over the full storage term (the license period for a specific license facility or the storage period equivalent to the certificate term for a DSS). Off-normal events or conditions are referred to as anticipated occurrences in 10 CFR 72.104, “Criteria for Radioactive Materials in Effluents and Direct Radiation from an ISFSI or MRS.”

Overpack. A heavy-walled concrete, metal, or combined concrete and metal structure designed to store SNF, HLW, or reactor-related GTCC in canisters. The overpack provides physical protection of canisters and radiological shielding, while allowing passive cooling. For the purposes of this SRP, the term overpack will be used generically in the horizontal, vertical, and underground storage of canisters.

Pinhole Leak. A minor cladding defect that will not permit significant release of particulate matter from the SNF rod and therefore present a minimal ALARA concern during fuel-handling operations.

Preferential Loading. A non-uniform loading configuration of SNF assemblies within a DSS that typically is specified by assigning a fuel zone designation to each basket cell and specifying limiting nuclear and physical parameters of SNF assemblies that can be loaded into each zone. Preferential loading is often used as a means to optimize allowable SNF parameters (e.g., burnup, cooling time, decay heat) while satisfying the shielding, criticality, and thermal performance objectives of the storage container or system.

Qualification Test. A test, or series of tests, conducted at least once for a given manufacturing process and set of material specifications to demonstrate the quality and durability of the component, such as neutron absorber product, over the licensed/certified service life of the facility/storage container.

Rad. The special unit of absorbed dose, which is defined in 10 CFR 20.1004, “Units of Radiation Dose.”

Ready Retrieval. The ability to safely remove SNF, reactor-related GTCC waste, or HLW from storage for further processing or disposal.

Real Individual. Any individual who lives, works, or engages in recreation or other activities close to the DSF for a significant portion of the year. The requirements in 10 CFR 72.104 include annual dose limits for real individuals located beyond the controlled area boundary. For the purposes of these limits, doses to nuclear or radiation workers while they are working are excluded.

Recovery. The capability of returning the stored radioactive materials from an accident to a safe condition without endangering public health and safety or causing significant or unnecessary exposure to workers. Any potential release of radioactive materials during recovery operations must not result in doses or radiation exposures that exceed the limits in 10 CFR Part 20, "Standards for Protection Against Radiation." Doses during recovery operations are included in the dose estimates for accidents, the total of which must not exceed the limits in 10 CFR 72.106, "Controlled Area of an ISFSI or MRS."

Restricted Area. An area to which access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted areas do not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area (10 CFR 20.1003).

Retrievability. See *Ready Retrieval*. Storage systems must be designed to allow ready retrieval of SNF, HLW, and reactor-related GTCC waste for further processing or disposal (10 CFR 72.122(l)).

Safety Analysis Report (SAR). In the context of this SRP, the report submitted to the NRC staff by an applicant for a CoC for a DSS, or for a specific license for a DSF, to present information related to the design and operations of the system or facility. The SAR provides the justification and analyses to demonstrate that the design meets regulatory requirements and acceptance criteria (10 CFR 72.24, "Contents of Application: Technical Information," 10 CFR 72.230(a)). The SAR is submitted to obtain approval for the DSF or DSS. The final SAR is defined in 10 CFR 72.48(a)(5).

Safety Evaluation Report (SER). In the context of this SRP, the report prepared by the NRC staff that describes the basis for the NRC's approval and issuance of a specific license for a facility or a CoC for a DSS. The SER also identifies the recommended license/CoC conditions and technical specifications ("operating controls and limits" or "conditions of use") and the bases for those conditions and technical specifications.

Safety Functions. The functions that DSS and DSF SSCs important to safety (see 10 CFR 72.3) are designed to maintain, perform, or both, include the following:

- protection against environmental conditions
- content temperature control
- radiation shielding
- confinement
- subcriticality control

Shallow Dose Equivalent (H_S). See 10 CFR 20.1003.

Spent Nuclear Fuel. See 10 CFR 72.3.

Spent Fuel Storage Cask. See 10 CFR 72.3.

Standby Power. The power supply that is chosen to furnish electric energy to select electrical equipment that is not important to safety when the primary (i.e., normal) power supply is not available. Standby power cannot be used interchangeably with emergency power.

Storage Container. The generic term used to refer to the containers of radioactive materials for which the DSS or DSF is certified or licensed for storage. This term covers canister-based and non-canister-based DSSs. For canister-based DSSs, it can be used to refer to the canister alone or the configuration of the canister in an overpack or transfer cask. The term also refers to non-DSS SNF storage containers, storage containers for GTCC waste, and storage containers for HLW. If storage of these wastes involves canister-based designs that include transfer casks and overpacks, the term is applied in the same manner as for canister-based DSSs.

Structures, systems, and components important to safety. See 10 CFR 72.3.

Subcritical. The state of a fissile material system where the rate of production of neutrons, from fission and other sources, is less than the rate of loss, from absorption and leakage. A system that is subcritical will have a decreasing population of neutrons.

Supplemental Cooling. Additional temporary external forced cooling (circulating water or air flow) of a DSS or DSF storage container during loading operations or during transfer operations.

Supplemental Shielding. Shielding that is not an integral part of DSS or DSF SSCs used to handle, transfer, or store SNF, GTCC waste, or HLW. There are three general types of supplemental shielding. The first type consists of engineered features, such as earthen berms or shield walls that are used to ensure compliance with the 10 CFR Part 72 dose limits. The second type consists of items that are used in operations for ALARA purposes but are generally not credited in the SAR dose rate and dose analyses. These items include, for example, lead blankets. The third type consists of items that are necessary for personnel to safely perform storage activities and meet relevant dose limits and which are credited in the SAR dose rate and dose analyses. Examples of storage activities for this third type include canister welding and decontamination. These items include, for example, thick steel shields that surround the transfer cask during activities to prepare the canister for storage or to transfer the canister to the storage overpack. The SRP may also refer to the second and third types as temporary shielding.

Thimble Plug Assembly. An assembly of short rods inserted into the assembly's guide tubes to restrict the flow of coolant through a fuel assembly. This component is designed for operations within the fuel assembly envelope and, when stored with SNF, fits within that envelope.

Total Effective Dose Equivalent. See 10 CFR 20.1003.

Undamaged Spent Nuclear Fuel. Any fuel rod or fuel assembly that can meet the pertinent fuel-specific or DSS-related regulations. Undamaged SNF rods may contain pinholes or hairline cracks, but may not contain gross breaches. Undamaged SNF assemblies may have assembly defects if able to meet the pertinent fuel-specific or DSS-related regulations.

Unrestricted Area. An area to which access is neither limited nor controlled by the licensee (10 CFR 20.1003).

Validation. See Benchmarking.

Volume Percent. The percent of a mole of the material that is present in a volume equal to the standard volume for the material as a gas; the volume occupied by 1 mole of the material as a gas at standard conditions for gases (760 millimeters of mercury (760 torr) for pressure and 0 degree Celsius (32 degrees Fahrenheit) for temperature).

INTRODUCTION

Purpose of the Standard Review Plan

This Standard Review Plan (SRP) is intended to provide guidance to the U.S. Nuclear Regulatory Commission (NRC) staff for reviewing safety analysis reports (SARs) for the following:

- Certificate of Compliance (CoC) for a dry storage system (DSS) for use at a nuclear power reactor authorized to possess or operate under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, “Domestic Licensing of Production and Utilization Facilities,” or 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants”

- specific license for a dry storage facility (DSF) that is either an independent spent fuel storage installation (ISFSI) or a monitored retrievable storage installation (MRS)

This SRP does not apply to wet storage ISFSIs or MRSs (e.g., GE Morris), but does have information related to pools for repackaging at a DSF. Refer to NUREG-1567, “Standard Review Plan for Spent Fuel Dry Storage Facilities,” for information regarding the review of wet pools (such as for spent fuel repackaging, loading, un-loading).

Note that the guidance for specific license applications is intended to cover all specific license DSFs, including those co-located with 10 CFR Part 50 and 10 CFR Part 52 facilities and those that are not co-located with these other facilities. For specific license DSFs that are co-located with 10 CFR Part 50 and 10 CFR Part 52 facilities, technical discipline reviews should appropriately factor this condition into the evaluation. The applicant may refer to documents submitted to the Commission in connection with applications for a license under 10 CFR Part 50 or 10 CFR Part 52, as long as the applicant can demonstrate that the information is applicable to the requirements in 10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste” and still be factual.

This introduction provides an overview of DSSs and DSFs along with the function of the SAR in the review process to assist the NRC project manager coordinate the review effort. It is also intended to assist individual technical reviewers understand how specific evaluations should be coordinated and integrated across disciplines to produce a comprehensive safety evaluation report (SER). In accomplishing their evaluations, the reviewers should coordinate their efforts to achieve a determination of the sufficiency of the application.

This SRP may be revised and updated as the need arises on a chapter-by-chapter basis to clarify the content, correct errors, or incorporate modifications approved by the Director of the Division of Spent Fuel Management. Comments, suggestions for improvement, and notices of errors or omissions should be sent to and will be considered by the Director, Division of Spent Fuel Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

Types of Licenses for Use of Dry Storage Systems and Dry Storage Facilities

A license is required for the receipt, handling, storage, and transfer of spent nuclear fuel (SNF), high-level radioactive waste (HLW), and reactor-related greater-than-Class-C (GTCC) waste. There are two types of ISFSI licenses: specific and general. An MRS license is a specific license.

The regulations in 10 CFR Part 72 also provide for issuance of a Certificate of Compliance (CoC) for use with the general license.

A specific license authorizes a person (see the definition in 10 CFR 72.3, "Definitions") to receive, handle, store, and transfer SNF, and reactor-related GTCC. A specific-license ISFSI may be co-located with a reactor facility or may be located away from a reactor facility.

A specific license for an MRS (see the definition in 10 CFR 72.3) authorizes DOE to construct and operate a DSF to receive, transfer, package, possess and safeguard SNF, HLW, and reactor-related GTCC waste. HLW is only authorized for storage in an MRS and not in a specifically licensed or generally licensed ISFSI (see 10 CFR 72.2, "Scope").

The second type of ISFSI license is a general license. A general license authorizes storage of SNF in an ISFSI at power reactor sites to persons authorized to possess or operate a power reactor under 10 CFR Part 50 or 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (see 10 CFR 72.210). A general licensee may construct and operate an ISFSI and store SNF using NRC-approved DSSs (see 10 CFR 72.210 and 10 CFR 72.212, "Conditions of General License Issued Under § 72.210"). The NRC approves the DSSs through the issuance of a CoC to the vendor of the systems, which allows the general licensee to use the systems (see 10 CFR 72.214, "List of Approved Spent Fuel Storage Casks"). A general license provided in 10 CFR 72.210 is effective without the filing of an application with the Commission or the issuance of a licensing document to a particular person.

The safety review conducted for a specific license or CoC is primarily based on the information the applicant provides in a SAR to show that the design and operation meet the appropriate requirements in 10 CFR Part 72. Note that 10 CFR 72.13, "Applicability," states which regulations apply to a specific licensee, general licensee, and a CoC holder. Each application for approval and issuance of a CoC for a DSS design or a specific license for a DSF must include an accompanying SAR (see 10 CFR 72.230, "Procedures for Spent Fuel Storage Cask Submittals," and 10 CFR 72.24, "Contents of Application: Technical Information," respectively).

Before submitting an SAR, the applicant should have evaluated the DSS or DSF in sufficient detail to conclude that it can be properly fabricated, constructed, and safely operated without endangering the health and safety of the public. The SAR is the principal document in which the applicant provides the information on the design and operations and their associated technical bases and demonstrates that the design meets all the applicable requirements in 10 CFR Part 72. The NRC reviewers should understand the facility design and operations and their technical bases, including but not limited to the selection of materials and geometries, mathematical models and equations used, and computer models and calculated results, in order to draw conclusions that the DSS or DSF does in fact meet the regulatory requirements in 10 CFR Part 72.

This SRP is divided into 17 chapters, several of which also include appendices. This SRP discusses regulatory requirements, staff positions, industry codes and standards, acceptance criteria, and other information.

Technical Review Oversight

CoC holders are responsible for demonstrating that the DSS design and fabrication meet the requirements in 10 CFR Part 72, Subpart L, "Approval of Spent Fuel Storage Casks," (see 10 CFR 72.234(a)). Licensees are responsible for the safety of the DSF design and for DSS and DSF construction, safe operation, and for complying with appropriate regulations. The mission of the NRC as the regulator is to certify, license, and provide inspection oversite on the operation of each DSS and DSF to ensure adequate protection of public health and safety and the environment.

The staff's review should evaluate the proposed DSS or DSF design, contents, operations, and, for a DSF only, the proposed site to ensure that the application provides reasonable assurance that the design and operations meet the regulations in 10 CFR Part 72. In addition to the requirements in 10 CFR Part 72, an application for a DSF must also address other pertinent regulations, such as the standards for protection against radiation in 10 CFR Part 20, "Standards for Protection Against Radiation." Chapter 10A, "Radiation Protection Evaluation for Dry Storage Facilities (SL)," describes the evaluation approach regarding the 10 CFR Part 20 requirements, including the use of dose assessments in the applicant's SAR.

The NRC review team uses its independent expertise to identify and resolve potential design or operational deficiencies, analytical errors, significant uncertainties or non-conservatisms in design approaches, or other issues which might hinder the review team's ability to ensure compliance with the regulations. If otherwise left unchecked by the CoC holder or licensee and the regulator, these issues could potentially lead to the unsafe or noncompliant use or operation of the DSS or DSF.Several considerations may influence the depth of review that is needed for a reasonable assurance determination that the applicable regulations have been met. These include, but are not limited to, the uniqueness of the design (as compared to existing designs), safety margins, operational experience, defense-in-depth, and the relative risks that have been identified for normal operations and potential off-normal conditions (or anticipated occurrences) and accident conditions. Reviewers should also consider the design parameters and methods the applicant describes in the SAR and their possible use, upon approval of the DSS or DSF design (i.e., issuance of a CoC or specific license) in subsequent 10 CFR 72.48(c) changes to the design or procedures by the CoC holder or licensee. Any aspect of the design or procedures that the NRC determines should not be changed by the CoC holder or licensee, without NRC approval beforehand, must be placed in the CoC or license conditions or the technical specifications of the CoC or license.

Review Process

The reviews are performed by members of the NRC review team with expertise in the technical areas described in this SRP. Because of the dependencies in the technical information in different chapters of the SAR, reviewer coordination among the different disciplines is important to ensure a comprehensive, consistent, uniform, and quality review. Each chapter includes a flow chart that diagrams the technical issues that cross disciplines; as such, many reviews rely on input from multiple areas.

When reviewing an amendment to, or a new application for, a DSS or DSF, the NRC review team should consult the SERs of previous amendments, as well as the SERs for similar, approved DSSs and DSFs to understand past NRC determinations regarding analyses affecting or similar to those in the SAR under review. The staff should also consult other relevant sources, such as generic communications, on issues that describe the staff's current position(s) on an issue(s) pertinent to the DSS and DSF review. The staff also relies on published industry standards to support its review. The guidance in this SRP, along with any regulatory guides that endorse industry standards, identifies industry standards that are acceptable to the staff and, where needed, the specific version(s) of the standards the staff finds acceptable. While some of these standards have been withdrawn, they may still be appropriate to use. In some cases, no suitable replacement has been issued for a withdrawn standard.

For amendments, the staff should review the entire amendment to ensure that the applicant has identified all of the proposed changes. Amendments may range from minor changes in the DSS or DSF design, contents, or operations to adding new major component designs or contents. Some amendments are based on the design and methods previously reviewed by the NRC for that same DSS or DSF. Evaluations of amendment changes are often based on the performance of the DSS or DSF as an integrated system. As a result, the staff may examine portions of previously approved components, contents, or methods in the SAR to assess the impact on the proposed amendment.

If the information provided in the SAR does not demonstrate that the new or revised DSS or DSF design meets the regulations, the staff may develop and then forward to the applicant a request for additional information, which contains questions requesting clarification of technical issues. The staff should refer to the updated SAR when reviewing the applicant's response to the request for additional information, for acceptability. The process is repeated as necessary (i.e., additional requests for information and applicant responses), until the SAR shows that the design meets the requirements in 10 CFR Part 72, or until the review is closed by the NRC or the applicant.

For review and issuance of a CoC, once the technical review of a DSS is complete, the NRC prepares a draft SER that summarizes the results of the review. If the NRC intends to authorize use of a new or amended CoC, the NRC staff prepares the *Federal Register* notices for a direct final rule and a companion proposed rule. The rulemaking notices identify the Agencywide Documents Access and Management System (ADAMS) Accession numbers for the draft CoC, technical specifications, and SER. During the rulemaking process, stakeholders and members of the public are allowed to comment on the draft CoC, technical specifications, and preliminary SER. If there are no significant adverse comments, the NRC publishes a notice of confirmation of the effective date of the rulemaking in the *Federal Register*. If the NRC receives a significant adverse comment, then the staff will withdraw the direct final rule and address the public comment in the companion proposed rule process. After addressing the comment, the NRC staff will either modify the proposed CoC, technical specifications, and preliminary SER, if necessary, and publish a final rulemaking in the *Federal Register* or withdraw the rulemaking. The rulemaking, when completed, leads to an update of 10 CFR 72.214 to add the new or amended CoC to the list of approved cask designs.

For review and issuance of a license for a DSF, if no adjudicatory hearing is requested and granted, the technical review of a DSF is complete when the staff issues the license (and associated technical specifications), and an SER documenting the results of the safety review and the staff's findings of compliance. The staff must also issue an environmental assessment (or environmental impact statement) that identifies the environmental impacts of the proposed licensing action. The NRC regulations require that a *Federal Register* notice be published upon issuance of the license and the publishing of the environmental assessment. NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," provides guidance to staff on conducting an environmental review for a DSF.

<u>Safety Evaluation Report and Content</u>

The SER documents the results of the staff's evaluation. The structure typically follows the applicant's SAR or this SRP and contains the following information:

- a general description of the system or facility, operational features, and content specifications

- a summary of the approach the applicant used to demonstrate compliance with the regulations, and a description of the reviews the NRC staff performed to confirm compliance

- a comparison of systems, components, analyses, data, or other information important in the review analysis for comparison with the acceptance criteria, in addition to conclusions regarding the acceptability, suitability, or appropriateness of this information to provide reasonable assurance the acceptance criteria have been met; the staff should clearly state its basis for approval or acceptance of the applicant's design, analyses, results, and conclusions

- a summary of aspects of the review that were selected or emphasized, aspects of the design or contents that the applicant modified, aspects of the design that deviated from the criteria stated in the SRP, and the bases for any deviations from the SRP

- summary statements for evaluation findings at the end of each chapter

<u>Content of SRP</u>

Each chapter of the SRP is organized into the following sections:

- Review Objective
- Applicability
- Areas of Review
- Regulatory Requirements and Acceptance Criteria
- Review Procedures
- Evaluation Findings
- References

<u>Review Objective</u>. This section provides the purpose and scope of the review and establishes the major review objectives for the chapter. The reviewer should obtain reasonable assurance during the review that the objectives are met.

<u>Applicability</u>. This section describes the scope of each chapter in terms of whether a chapter, or a portion of a chapter, is applicable to the review of SARs for both DSSs and DSFs, or only DSSs, or only DSFs.

<u>Areas of Review</u>. This section lists the areas of review. Each area of review encompasses systems, components, analyses, data, or other information. This section provides the organizational structure for the rest of the chapter.

<u>Regulatory Requirements and Acceptance Criteria</u>. This section summarizes the regulatory requirements pertaining to the review and specifies either regulatory or self-imposed acceptance criteria. Generally, the requirements for a given SAR chapter will be in 10 CFR Part 72, but the chapter can also list other significant regulatory requirements, such as those in 10 CFR Part 20. The reviewer should refer to the regulations to ensure the SAR addresses all relevant requirements. Sections of 10 CFR Part 72 that are applicable to the review of an application for a new or an amendment to a DSF specific license or a DSS CoC are listed in 10 CFR 72.13(b) and (d), respectively. The reviewer should read the complete language of the current version of 10 CFR Part 72 to determine the proper set of regulations for the section being reviewed for the application (CoC or specific license).

The acceptance criteria portion of this section addresses the design criteria and, in some cases, addresses specific analytical methods that NRC staff reviewers have found to be acceptable for meeting the regulatory requirements that apply to the given SAR chapter. Most chapters organize the acceptance criteria in accordance with the review areas established in the "Areas of Review" section of the specific chapter and identify the type and level of information that should be in the SAR.

This section typically sets forth the solutions and approaches that staff reviewers have previously determined to be acceptable for demonstrating compliance with the regulations and addressing specific safety concerns or design areas that are important to safety. These solutions and approaches are discussed in the SRP so that the reviewers can implement consistent and well-understood positions as similar safety issues arise in future cases. These solutions and approaches are acceptable to the staff, but they are not the only possible method for meeting the regulations.

Substantial staff time and effort has gone into developing these acceptance criteria. Consequently, a corresponding amount of time and effort may be required to review and accept new or different solutions and approaches. Thus, applicants proposing new solutions and approaches to safety issues or analytical techniques other than those described in the SRP may experience longer review times. An alternative for the applicant is to propose new methods on a generic basis, independent from a CoC or license application, possibly as a topical report.Review Procedures. This section presents a general approach that reviewers should typically follow to establish reasonable assurance that the applicable regulations have been met. As an aid to the reviewer, this section may also provide information on what has been found acceptable in past reviews. This section identifies standards that have been found acceptable in particular reviews, or that are desirable but not specifically identified in existing regulatory documents. Since many of the reviews are interdisciplinary, the reviewers should coordinate with each other, as necessary, to identify issues in other SAR chapters. The section includes a flow chart to depict the coordination across disciplines that may be necessary to conduct reviews. In addition, the reviewer may identify conditions of the approval. In these cases, the reviewer should include a discussion of each condition and the reasons for the addition of the condition in the relevant sections of the SER.

Evaluation Findings. This section provides example evaluation findings and summary statements to be incorporated into the SER. The reviewer prepares the evaluation findings based on how satisfactorily the application meets the regulatory requirements. The NRC publishes the findings in the SER.

References. This section lists the NRC documents, codes, specifications, standards, regulations, and other technical documents referenced in the chapter.