U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

A Proposed Graded Approach for Dry Cask Storage

Donald Chung, PhD
US Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
October 28, 2016

NMSS
Division of Spent Fuel Management

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

What is Graded Approach?

- Rating of review procedures in the Standard Review Plan* (SRP) evaluation areas for dry cask storage systems (DSS)s, and
- guidance for regulatory reviewer on the relative level of effort that typically should be applied in implementing the review based on the ratings of high, medium and low.

*NUREG-1536, Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility

NMSS Division of Spent Fuel Management

Current Objectives

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Focus regulatory efficiency efforts on storage (10 CFR 72) at this time
- Propose a graded-approach framework that
  - Considers results of previous PRA studies, and safety functions and defense-in-depth
  - Improve guidance for casework activities by focusing regulatory evaluation on areas that impact safety
  - Increase efficiency of licensing actions while maintaining appropriate margins of safety and security

NMSS
Division of Spent Fuel Management

10 CFR 72.236 Specific requirements for spent fuel storage cask approval and fabrication

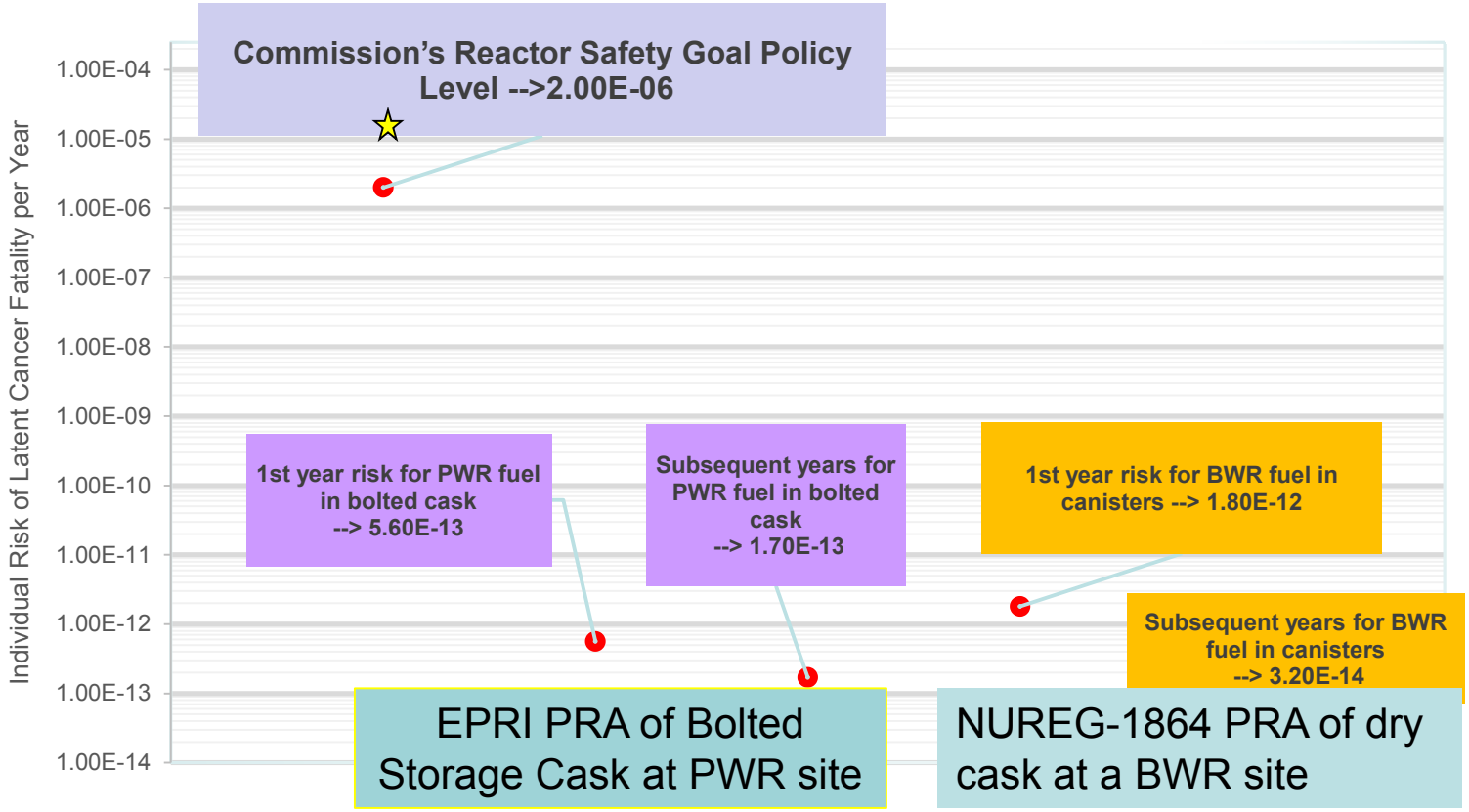
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

a) Specifications: fuel type, max initial enrichment, min. acceptable cooling time, max. heat output, max. fuel load limit, fuel condition, required inerting atmosphere.
b) Design bases and design criteria for SSCs important to safety.
c) Cask must be designed and fabricated so that the spent fuel is maintained in subcritical condition under credible conditions.
d) Radiation shielding and confinement features must be sufficient to meet 70.104 and 72.106.
e) Storage cask must provide redundant sealing of confinement systems.
f) Cask must provide adequate heat removal capacity without active cooling system.
g) Designed to store the spent fuel safely for the term proposed in the application, and permit maintenance as required.
h) Cask must be compatible with wet or dry spent fuel loading and unloading facilities.
i) Cask must be designed to facilitate decontamination to the extent practicable.
j) Cask must be inspected to ascertain that there are no…defects that could significantly reduce its confinement effectiveness.
k) Cask must be conspicuously and durably marked: model number, id number, empty weight.
l) Cask and its systems important to safety must be evaluated by appropriate tests or other means acceptable to the NRC, to demonstrate that they will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions.
m) Compatibility with removal of the stored spent fuel from a reactor site, transportation, and ultimate disposition by the DOE.
n) Safeguards Information shall be protected against unauthorized disclosure…

Background

Comparison of EPRI and NRC PRA Studies
Dry Cask Spent Fuel Storage
Latent Cancer Fatality Risk per Cask

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



Three Phases of Operation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

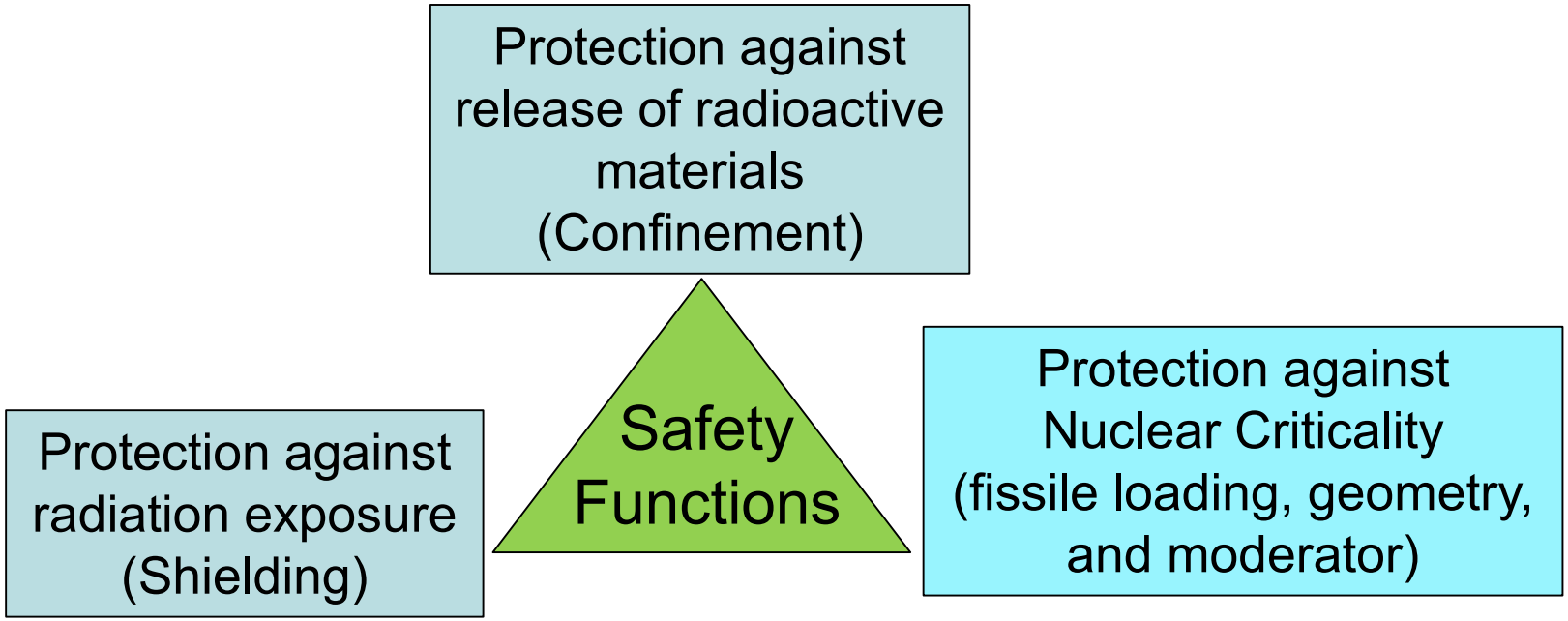
Canister Loading

On-site Transfer to ISFSI

Storage in ISFSI

NMSS
Division of Spent Fuel Management

Dry Storage System Safety Functions



Defense-in-Depth

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Level 1, Prevention
(10CFR72, SRP, AMP, MAPS)
- Prevent criticality
- Prevent release of radioactive material
- Limit radiation exposure

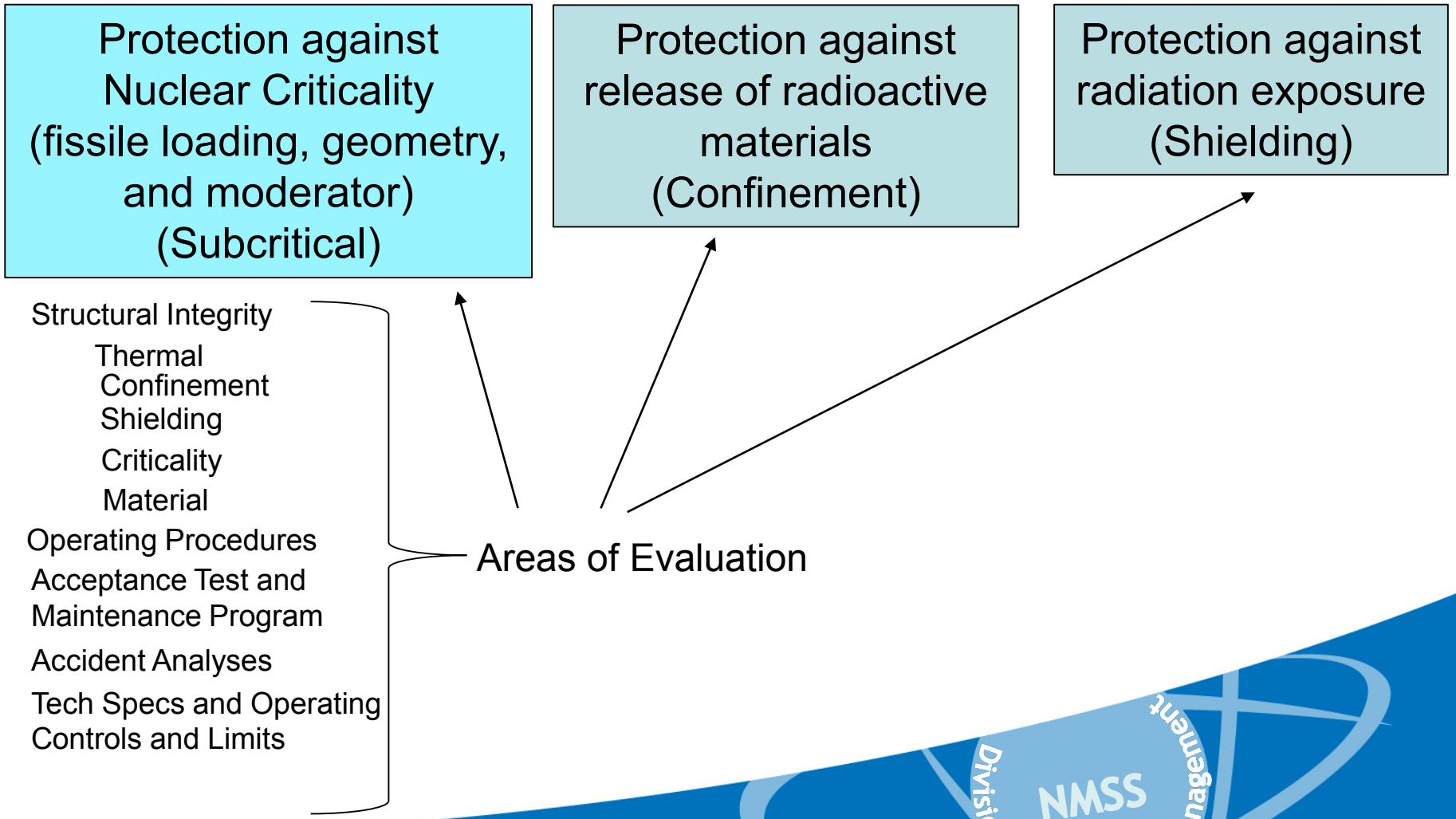
Level 2, Mitigation
- Assessment of failures
- Perform remedial actions
- Perform repair

Level 3, Emergency Actions
(10CFR72.32, Emergency Plan)
- Accident detection/assessment
- Notification
- Protective response

NMSS Division of Spent Fuel Management

Dry Storage System Safety Functions - continued

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



NMSS Division of Spent Fuel Management

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Graded Approach for Reviewing Licensing Action (casework)

NMSS
Division of Spent Fuel Management

Regulatory Review Guidance for Dry Storage System

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

	Consequence			Phase of Operation		
Areas of Evaluation (NUREG-1536)	**Confinement**	**Shielding**	**Prevent Criticality**	**Loading**	**On-site Transport**	**Storage**
Structural	TBD	TBD	TBD	X	X	
Thermal	TBD	TBD	TBD	X		
Confinement	TBD	TBD	TBD		X	
Shielding	TBD	TBD	TBD	X	X	
Criticality	TBD	TBD	TBD	X		
Material	TBD	TBD	TBD	X		X
Operating Procedures	TBD	TBD	TBD	X	X	
Acceptance Test and Maintenance Program	TBD	TBD	TBD	X		X
Radiation Protection	TBD	TBD	TBD	X	X	
Accident Analyses	TBD	TBD	TBD	X	X	
Technical Specifications and Operating Controls and Limits	TBD	TBD	TBD	X	X	
Quality Assurance	TBD	TBD	TBD	X	X	X

EXAMPLE

Review Procedures in Evaluation Areas

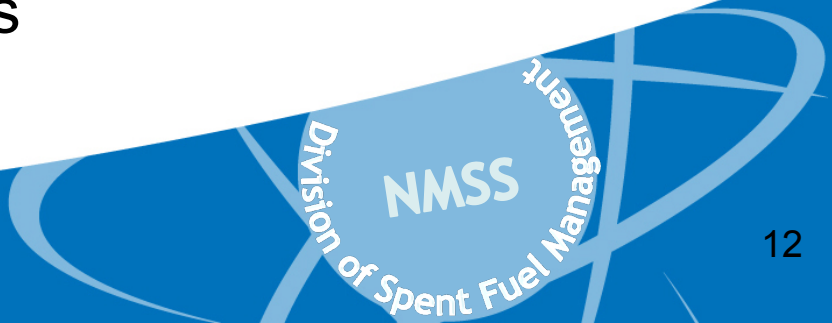
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulatory Review Guidance could also assign Grades for Review Procedures in a Evaluation Area

7. Criticality Evaluation

7.5 Review Procedures

- 7.5.1 Criticality Design Criteria and Features
- 7.5.2 Fuel Specification
- 7.5.3 Model Specification
- 7.5.4 Criticality Analysis
- 7.5.5 Burnup Credit



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Proposed Methods for Assigning Grades to Review Procedures
(DRAFT)

1. Informed by results from existing PRAs
2. Safety function, defense-in-depth (DiD), and impact of noncompliance
3. Expert knowledge from panel of experts (insights from technical reviewers and dry storage system vendors)

NMSS
Division of Spent Fuel Management

Method for Assigning Grade to Review Procedures

by PRA Data or Consequence* (NUREG-1536)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- High
  - Qualitative: Likely to occur or significant consequences.
  - Quantitative: >10^{-3}/yr. or >25 rem to worker or > 1 rem to public per year.
- Medium
  - Qualitative: May occur or moderate consequences.
  - Quantitative: <10^{-3}/yr. but >10^{-5}/yr. or 5-25 rem to worker or 0.1 rem to public per year.
- Low
  - Qualitative: Occurrence improbable or minimal consequences.
  - Quantitative: < 10^{-5}/yr. or less than 5 rem to worker or 0.1 rem to public per year. (10 CFR 20 dose limits)

* NUREG-1536, Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility, Appendix B.

NMSS Division of Spent Fuel Management

Alternate Method to Assigning Grades to Review Procedures

by Safety Function, DiD and Impact to Safety
(Importance to Safety,* NUREG/CR-6407)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Category A – Critical to Safety High

  Category A items include structures, components, and systems whose failure could directly result in a condition adversely affecting public health and safety. The failure of a single item could cause loss of primary containment leading to release of radioactive material, loss of shielding, or unsafe geometry compromising criticality control.

- Category B – Major impact on Safety Medium

  Category B items include structures, components, and systems whose failure or malfunction could indirectly result in a condition adversely affecting public health and safety. The failure of a Category B item, in conjunction with the failure of an additional item, could result in an unsafe condition.

- Category C – Minor impact on Safety Low

  Category C items include structures, components, and systems whose failure or malfunction would not significantly reduce the packaging effectiveness and would not be likely to create a situation adversely affecting public health and safety.

*NUREG/CR-6407, Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety

NMSS Division of Spent Fuel Management

Guidance for Review*
(NUREG-1536)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- **HIGH** priority means the NRC staff review should ensure all items in the applicant's submittal are complete and correct as specified in the review procedure. This represents the most comprehensive review where many of the analytical methods, assumptions, and supporting references are evaluated. The reviewer may need to perform independent confirmatory analysis to validate the results of the safety analysis calculations.
- **MEDIUM** priority means the NRC staff should review the applicant's submittal for completeness and correctness in key areas. This represents a review in which key analytical methods, key assumptions, and key supporting references are checked and evaluated. It is expected a reviewer would spend approximately 30 percent of his or her review time focused n the medium review procedures.
- **LOW** priority means the NRC staff review should ensure that the applicant's submittal contains all of the requested information. A limited review of selected portions of the application for correctness would be performed. Given its relative significance, the reviewer should generally consider the applicant's analysis to be completed and accurate and forego independent confirmation, unless there is a reason to believe otherwise. However, if a problem is detected, the reviewer must thoroughly evaluate and resolve the issue.

*NUREG-1536, Standard Review Plan for Spent Fuel Dry Storage System at a General License Facility

Summary

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Graded-approach regulatory framework will rate review procedures in the SRP for each DSS design (or class of DSS designs).
- The rating will provide guidance to NRC reviewer regarding the relative level of effort typically applied for areas of review
- The review guidance from graded-approach will focus regulatory reviews at areas of higher safety importance
- The process will also identify regulatory requirements (low safety significant) that may not need to be included in the CoC.

NMSS
Division of Spent Fuel Management

Path Forward

- Kick off RIRP approach (Completed 7/22/2016)
- Develop the draft "Graded Approach" framework
  - Proposed draft guidance/basis for assigning grades to SSCs and NEI identifies pilot (10/28/2016)
  - Hold work shop with NEI, members of the public and industry (11/21/2016)
  - Revise the grade approach framework based on workshop feedback
- Provide internal NRC training for staff (2/7/2017)
- Receive pilot application based on the preliminary graded approach (3/17/2017)
- Complete safety review of pilot application (12/15/2017)
- Finalized framework (4/13/2018)
  - Incorporate lessons learned from the pilot (1/12/2018)
  - Engage stakeholders to solicit input (2/15/2018)
  - Issue finalize framework for graded approach (4/13/2018)
  - Receive NEI guidance document for endorsement (8/15/2018)
- Complete review of NEI guidance document (11/15/2018)
- Develop Staff Training (FY 2019)

References

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NUREG/CR-6407 Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety.
- NUREG-1536, Rev 1, Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility
- Regulatory Guide 7.10, Appendix A.
- Risk-Informed Decisionmaking for Nuclear Material and Waste Applications, Revision 1, February 2008.
- NUREG-1864, A Pilot Probabilistic Risk Assessment Of a Dry Cask Storage System At a Nuclear Power Plant.
- Probabilistic Risk Assessment (PRA) of Bolted Storage Casks: Updated Quantification and Analysis Report, EPRI, Palo Alto, CA: 2004. 1009691.

NMSS
Division of Spent Fuel Management

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Questions?

NMSS
Division of Spent Fuel Management