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2nd Draft

MONITORED RETRIEVABLE STORAGE FACILITY

DESIGN CRITERIA POLICY DOCUMENT

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REVISION DESCRIPTION SHEET

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1.0 INTRODUCTION

The Design Criteria Policy Document will provide guidance on the types of Design Events, Design Basis Accidents, and Design Criteria for Important To Radiological Safety Systems, Structures, and Components (SSCs) to be assumed during the design of the MRS facility. Definitions of key terms associated with Design Events are also included with this document. Appropriate combinations of Design Events and criteria is identified. This information will significantly affect both the design and cost of MRS SSCs and thus, should become input to the MRS design, cost, and licensing documents.

Guidance on design criteria to be assumed for the specification of equipment is provided in section 4 of this document. Design criteria to be assumed for the various QA classifications of SSCs is provided in section 5.

Note that this document references only those documents produced by the NRC or referenced in NRC documents and considered to be potentially part of the licensing basis for the MRS facility. This approach is consistent with the Regulatory Policy Document produced by the M & O, which is currently in draft form (Reference 23).

Additional detail will be included with this document as the design of the MRS facility progresses beyond conceptual design. Eventually, this information should be documented in Design Basis specifications. These will be a special group of design specifications at the same level as Configuration Item specifications. In the short term there will probably be only one specification (this document will probably be converted into a specification).

2.0 DEFINITIONS

Following are key terms used in this document. These definitions will be adopted across MRS Design for use in discussing Design Events, General Design Criteria, and Design Basis Accidents (DBAs).

1. Important To Radiological Safety (IRS) - As defined in 10CFR72.3 (Reference 1), Structures, Systems, and Components whose function is:

(1) To maintain the conditions required to store spent fuel safely,

(2) To prevent damage to the spent fuel during handling and storage, or

(3) To provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

Undue risk will be interpreted to mean radiation exposure to an individual (whole body or any organ) located on or beyond the nearest boundary of the controlled area being greater than 5 rem

(Reference 18).

It appears that at least several classes of IRS may be necessary for the MRS facility. The highest class of IRS may be those SSCs whose failure would present an offsite dose problem following a DBA. An effluents analysis will be necessary in order to determine if any SSCs fall into this category. See section 5 for additional information on the subclasses of IRS.

Note that IRS does NOT mean safety-related as it applies to nuclear power plants. Nuclear safety-related SSCs are subjected to an extremely large number of conservative design requirements unlike those requirements recommended for IRS SSCs at the MRS facility.

General Design Criteria - Design criteria for MRS facility SSCs that are Important To Radiological Safety as referenced in 10CFR72 Subpart F (Reference 6). IRS SSCs are QA Classification 1A per reference 24.

Design Events - Occurrences which need to be considered in the design of SSCs. They are categorized according to their frequency of occurrence and provide a means of establishing design requirements to satisfy operational and safety criteria of the MRS facility. The four categories are defined as follows.

Note that these definitions were derived from ANSI standards (References 2 and 3) that were written for the design of Independent Spent Fuel Storage Installations (ISFSIs) assuming both dry and wet storage. The NRC staff has reviewed these ANSI standards and found them to be acceptable subject to some conditions as described in Regulatory Guides 3.49 and 3.60 (References 4 and 5). It is reasonable to assume that these standards and guides will apply to the MRS facility. NRC and DOE concurrence will have to be obtained.

Design Event I - Those events that are expected to occur regularly or frequently in the course of normal operation. Examples are:

(a) Cask receipt, inspection, loading, unloading, and maintenance.

(b) Spent Nuclear Fuel (SNF) transfer from shipping cask to storage and vice-versa.

(c) Handling of radioactive waste.

The General Design Criteria do not apply to SSCs that only function during normal operation.

Design Event II - Events that although not occurring regularly, can be expected to occur with moderate frequency or on the order of once during any calendar year of operation.

Examples are:

(a) A loss of external power supply for a limited duration. (Comment: The length will need to be defined).

(b) Minor mechanical failure of the SNF transfer mechanism during operation.

(c) Minor leakage from flanged piping or component connections.

Design Event III - Those events that could reasonably be expected to occur once during the lifetime of the MRS facility.

Examples are:

(a) A loss of external power supply for an extended interval. (Comment: Again, the length will have to be defined).

(b) A credible passive failure of a radioactive liquid retaining boundary.

(c) A major mechanical malfunction involving the SNF transfer mechanism during operation (no loss of shielding but retrieval of fuel required).

(d) Loss of shielding optical oils in a transfer cell viewing window.

Design Event IV - Events that are postulated because their consequences will result in the maximum potential impact on the health and safety of the public. Their consideration establishes a conservative design basis for certain IRS system, structures, and components. These events are man-induced low probability events called Design Basis Accidents (DBAs). See section 3 for additional information on DBAs.

Natural Phenomena - These are natural events that include earthquakes, tornadoes, lightning, hurricanes, floods, tsunami, and seiches. Some of these events may occur simultaneously with Design Events and DBAs. See section 3 for additional information.

3.0 DESIGN BASIS

The significant Design Events (levels III and IV) and Design Basis Accidents that can be identified at this point in the conceptual design are described in this section. Guidance on how to apply General Design Criteria (Reference 6) to the design of SSCs that are IRS is also included.

The underlying rationale for the guidance provided in this document is based on the following:

(a) Short-lived radionuclides, particularly some of those of Iodine and Xenon, are no longer present in significant quantities in SNF that has decayed for more than one year since discharge from the reactor core.

(b) The storage of SNF is a relatively low hazard-potential activity (when compared to the potential hazards associated with nuclear power plants). Very little of the radioactivity present is available in a dispersible form and there is no mechanism (such as a rapid depressurization and uncovering of a reactor core) present to cause the release of radioactive quantities from the MRS facility.

3.1 SINGLE FAILURE CRITERIA

A single failure is an occurrence which results in the loss of capability of a component to perform its intended IRS function. Systems and Components shall be designed to perform their IRS functions following a single failure (Reference 7). Multiple failures resulting from a single occurrence are considered to be a single failure.

Designing systems to meet single failure criteria not only helps protect the health and safety of the public but also prevents failures of important equipment from affecting operations and throughput.

Single failures can be either active or passive and can occur at anytime during which the component is required to perform its IRS function. Only one failure will be assumed for the duration of the occurrence. An active failure is the failure of a powered component, such as a piece of mechanical equipment, component of the electrical supply system, or instrumentation and control equipment to perform its intended IRS function. A passive failure is the failure of a static component, such as piping, which limits that component's effectiveness in carrying out its intended IRS function.

Spurious actuation of equipment (e.g., a powered valve opening on its own) or operator errors are not considered single failures. SSCs will not be required to perform their IRS functions following spurious actuation or operator errors.

Single failure criteria does not apply to structural components. Rationale is that these types of components do not experience failures as frequently as valves, piping, electrical components, etc. Conservatism in loads and acceptance criteria applicable to structures provide assurance that the structures will perform their intended function in the event of a single failure of systems or components for which support is provided.

Spent fuel handling, packaging, transfer, and storage systems must be designed to ensure that upon a single failure, nuclear criticality is not possible (Reference 19).

3.2 LOSS OF EXTERNAL POWER (LOEP)

A LOEP is classified as a Design Event III. In the event of a LOEP, an onsite power system will be required in order to meet the requirements of redundant power systems that serve that IRS functions (Reference 7).

Note that these systems are NOT required to be Class 1E. This class applies to safety-related power systems on nuclear power plants.

No other Design Events (or DBAs) will be assumed to be concurrent with the LOEP. However, there are natural phenomena, i.e. tornadoes, that can initiate a LOEP.

3.3 FIRES AND EXPLOSIONS

Structures, systems, and components that are IRS must be designed and located so that they are capable of performing their safety functions effectively under credible fire and explosion exposure conditions (Reference 8).

Design criteria for fire events can be referenced in NUREG-0800 section 9.5.1 (Reference 26).

Design bases of the fire protection system will include consideration of maximum fires that may develop in local areas assuming no manual, automatic, or other fire fighting measures have been started and the fire has passed flashover and is reaching its peak burning rate before fire fighting can start (section 4.3.8 of References 9 and 10).

The effect of explosions on transportation routes and at industrial facilities near the MRS facility will be analyzed per the criteria of Regulatory Guide 1.91 (Reference 11). This guide is applicable to the design of ISFSIs per Reference 12. It is reasonable to assume that it will apply to the MRS facility. Any effects resulting from these analyses will be considered in the design of MRS SSCs.

No other Design Events will be assumed to be concurrent with fires and explosions.

3.4 LOSS OF CONTROL ROOM/AREA

Capability will be provided to allow the MRS facility to be put into a safe condition if any IRS control room or control area is removed from service (section 5.5 of References 9 and 10).

No other Design Events will be assumed to be concurrent with a loss of control room/area.

3.4 CONTROL ROOM/AREA HABITABILITY

IRS control rooms and control areas of the MRS facility will be appropriately protected from radiation and hazardous chemicals that may be discharged as a result of equipment failures, operator errors, or events and conditions outside the control of the facility. Radiation exposure limits for the control room need to be determined. (Comment: the control room limit prescribed for nuclear power plants is 5 rem whole body. This is the same as the offsite limit for the MRS facility. This may be appropriate for the control room at the MRS). Design criteria for protection from hazardous chemicals is in Reference 13 which is applicable to ISFSIs (and thus the MRS facility).

3.6 ENVIRONMENTAL QUALIFICATION

IRS systems, structures, and components must be designed to withstand the harsh environmental conditions resulting from normal operations and Design Events (Reference 20). These conditions will include at least radiation, temperature, pressure, and humidity.

3.7 NATURAL PHENOMENA

Systems, structures, and components that are IRS must be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, hurricanes, floods, tsunami, and seiches, without impairing their capability to perform safety functions (Reference 20).

Some Design Basis Accidents will be assumed to occur concurrently with natural phenomena. It is anticipated that earthquakes will be assumed to be concurrent with DBAs. However, based on a discussion in Regulatory Guide 1.117 (Reference 15), very low probability natural phenomena such as tornadoes will not be assumed to be concurrent with DBAs.

Seismic classification criteria contained in Regulatory Guide 1.29 (Reference 14) is applicable to the design of ISFSIs (and thus MRS SSCs that are IRS) per Reference 12. In addition, seismic design criteria listed in section 3.2.3 of References 9 and 10 will be applied to the design of the MRS facility.

IRS SSCs will be designed against the effects of tornado wind loads. These loads are described in Regulatory Guide 1.76 (Reference 16), as prescribed in Reference 12. Additional guidance of the analysis to be performed is described in section 3.2.1 of References 9 and 10. Designing against the effects of negative pressure associated with a tornado will also be considered for IRS SSCs.

IRS SSCs will also be designed against the effects of missiles, including tornado-generated and other types of missiles. Missiles created by large rotating machinery will be considered, as necessary. Additional information on the analysis to be performed is described in section 3.2.1 of References 9 and 10.

Flood protection will also be provided for IRS systems, structures, and components at the MRS facility. As prescribed in Reference 12, Regulatory Guides 1.59 and 1.102 (References 16 and 17) contain criteria for designing against the effects of floods.

SSCs that are Important To Radiological Safety will also be designed against the effects of lightning. The lightning protection system for the MRS facility will be designed in accordance with NFPA No. 78-1986 (Reference 21). This standard is referenced in ANSI/ANS-57.7-1988 (Reference 2).

IRS SSCs will also be evaluated for the potential effects of hurricanes, tsunamis, seiches, and ice flooding. Section 2.4 of References 9 and 10 contain additional information on the analysis to be performed for these natural phenomena. Hurricanes, tsunamis, and seiches are applicable to those MRS facility sites near coastal areas.

3.8 DESIGN BASIS ACCIDENTS

Design Basis Accidents (DBAs) are those postulated Design Events with an extremely low probability of occurrence but which may result in the maximum potential radiation exposure to the public. The limiting exposure is 5 rem at the controlled area boundary (Reference 18).

These DBAs are postulated to result in the rupture of a number of fuel assemblies based on conservative accident analyses and the subsequent release of their gaseous (and a portion of their particulate) radioactive fission products. They can be categorized as cask handling accidents and fuel handling accidents. These DBAs are further categorized into dry and wet handling types.

During dry handling, the shipping cask will be opened in a transfer facility. The outer lid will be removed outside of the transfer cell. At this point the cask could be dropped or overturned and cause all of the assemblies within the shipping cask to rupture outside of the transfer cell in either a cask preparation area (inlet side) or a storage cask discharge area (outlet side). A low probability fuel handling accident can also be postulated. With the cask completely open (both lids removed) and in the transfer cell, an assembly could be dropped into the cask and cause all of the assemblies within the shipping cask to rupture.

For wet handling, the DBAs are somewhat different. Fuel assembly rupture from cask and fuel handling accidents would occur under water. All fuel handling and storage would be under water. A fuel assembly could be dropped into an open cask and rupture all of the assemblies inside. Also, a cask could be dropped onto assemblies in the fuel pool, potentially rupturing a significant number of assemblies under water.

Sufficient IRS design features will be included with wet handling to preclude a significant loss of water from the pool for any Design Event. This is necessary to prevent significant damage to a large number of fuel assemblies.

Analysis will be performed to determine what the radiation exposure is to a hypothetical maximum exposed individual from these Design Basis Accidents (Reference 18). If the exposures are above the limits, then additional IRS features will be included in the design of the MRS facility to ensure compliance.

3.9 NUCLEAR CRITICALITY SAFETY CRITERIA

Spent fuel handling, packaging, transfer, and storage systems must be designed to be maintained subcritical and to ensure that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety (Reference 27). The design of handling, packaging, transfer, and storage systems must include margins of safety for the nuclear criticality parameters that are commensurate with the uncertainties in the data and methods used in calculations and demonstrate safety for the handling, packaging, transfer and storage conditions and in the nature of the immediate environment under accident conditions.

When practicable the design of an MRS must be based on favorable geometry, permanently fixed neutron absorbing materials (poisons) are used, the design shall provide means to verify their continued effectiveness.

Criticality monitoring system design criteria is also provided in Reference 27.

3.10 RADIOLOGICAL PROTECTION CRITERIA

SSCs at the MRS shall be designed to ensure that occupational radiation exposures are As Low As is Reasonably Achievable (ALARA) and that a high degree of integrity is obtained for the confinement of radioactive materials per the requirements of 10CFR72.126 (Reference 28). Applicable sections of Regulatory Guide 8.8 (Reference 29), which is referenced in 3.44 (Reference 9) and 3.48 (Reference 10), shall also be used.

The design must include means to:

1) Prevent the accumulation of radioactive material in those systems requiring access;

2) Decontaminate those systems to which access is required;

3) Control access to areas of potential contamination or high radiation with the MRS facility;

4) Measure and control contamination of areas requiring access;

5) Minimize the time required to perform work in the vicinity of radioactive components;

6) Shield personnel from radiation exposure.

Onsite personnel radiation exposure limits for normal operation are in 10CFR20 (Reference 30). Offsite normal operating radiation exposure limits are in 10CFR72.104 (Reference 31) and postaccident exposure limits can be found in 10CFR72.106 (Reference 32).

Radiation monitoring systems at the MRS facility shall be designed in accordance with criteria provided in References 28 and 29.

3.11 RADIOACTIVE WASTE STORAGE AND HANDLING CRITERIA

Per Reference 33, spent fuel storage and handling systems must be designed with:

1) A capability to test and monitor components that are IRS;

2) Suitable shielding for radioactive protection under normal and accident conditions;

3) Confinement structures and systems;

4) A heat-removal capability having testability and reliability consistent with its importance to radiological safety, and

5) means to minimize the quantity of radioactive wastes generated.

In addition, radioactive waste treatment facilities must be provided. Provisions must be made for the packaging of site-generated low-level wastes in a form suitable for storage onsite awaiting transfer to disposal sites. These SSCs must be designed per the guidance provided in Regulatory Guide 1.143 (Reference 25) which is applicable to the MRS per reference 12.

3.12 DECOMMISSIONING CRITERIA

The MRS must be designed for decommissioning (Reference 34). Provisions must be made to facilitate decontamination of structures and equipment, minimize the quantity of radioactive wastes and contaminated equipment, and facilitate the removal of radioactive wastes and contaminated materials at the time the MRS facility is permanently decommissioned.

4.0 EQUIPMENT SPECIFICATION DESIGN CRITERIA

NRC regulatory guidance for design criteria to be used for the purchase of equipment at the MRS can be taken from guides written for the development of Safety Analysis Reports for Independent Spent Fuel Storage Installations (ISFSIs). These regulatory guides and associated ANSI standards were written for both wet and dry storage type ISFSIs. For wet storage reference Regulatory Guide 3.44 and ANSI Standard 57.7 (References 9 and 2), and for dry storage use Regulatory Guide 3.48 and ANSI Standard 57.9 (References 10 and 3). From information in these ANSI standards it is evident that equipment for the MRS can be purchased per commercial or industrial grade codes and standards.

5.0 QA CLASSIFICATION DESIGN CRITERIA

Design criteria appropriate to each QA condition as defined in QAP-2-3 (Reference 24) is described in this section.

Important to Radiological Safety (Classification 1A)

This classification can be further subdivided into three subclasses per the definition of Important to Radiological Safety in section 2. These subclasses will be called 1A.1, 1A.2, and 1A.3 and they correspond directly to the three parts of the definition of IRS. SSCs that are IRS can be bought to the criteria referenced in section 4 but must be designed to additionally meet the General Design Criteria specified in section 3. For example, IRS diesel generators can be bought to commercial or industrial standards but two are needed to meet single failure criteria.

It is possible that a different level of design criteria will be associated with each level of subclasses 1A.1, 2, and 3. Commercial grade codes and standards can be assumed for IRS SSCs. A somewhat higher degree of QA control, e.g. detailed material traceability, may be required for subclass 1A.3 SSCs.

Important to Radwaste (Classification 2)

This classification is defined in Reference 24. Design criteria for this classification can be taken from Reference 25. Again, commercial grade equipment can be bought for this classification.

Important to Fire Protection (Classification 3)

This classification is defined in Reference 24. Appropriate design criteria is defined in section 3 of this document. It is consistent with that specified in QAP-2-3.

Important to Seismic Category II (Classification 4)

Again, this classification is fully defined in Reference 24. Section 3 of this document contains additional information of the design criteria to be applied to this classification consistent with QAP-2-3.

Mission Critical (Classification 5)

See Reference 24 for the definition of this classification. QA Class 5 SSCs will be commercial grade and not subject to compliance with General Design Criteria.

6.0 REFERENCES

1. 10CFR72.3

2. "Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)." ANSI/ANS-57.7-1988, March 29, 1989.

3. "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," ANSI/ANS-57.9-1984, December 31, 1984.

4. "Design of an Independent Spent Fuel Storage Installation (Water-Basin Type)", Regulatory Guide 3.49, December 1981.

5. "Design of an Independent Spent Fuel Storage Installation (Dry Storage)", Regulatory Guide 3.60, March 1987.

6. 10CFR72, Subpart F.

7. 10CFR72.122(k).

8. 10CFR72.122(c).

9. "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Water-Basin Type)", Regulatory Guide 3.44, Rev.2, January 1989.

10. "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Dry Storage)", Regulatory Guide 3.48, Rev.1, August 1989.

11. "Evaluations of Explosions Postulated to Occur on Transportation Routes near Nuclear Power Plants", Regulatory Guide 1.91, Rev.1, February 1978.

12. "Applicability of Existing Regulatory Guides to the Design and Operation of an Independent Spent Fuel Storage Installation", Regulatory Guide 3.53, July 1982.

13. "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release", Regulatory Guide 1.78, June 1974.

14. "Seismic Design Classification", Regulatory Guide 1.29, Rev.3, September 1978.

15. "Tornado Design Classification", Regulatory Guide 1.117, Rev.1, April 1978.

16. "Design Basis Floods for Nuclear Power Plants", Regulatory Guide 1.59, Rev.2, August 1977.

17. "Flood Protection for Nuclear Power Plants", Regulatory Guide 1.120, Rev.1, September 1976.

18. 10CFR72.106(b).

19. 10CFR72.124(a).

20. 10CFR72.122(b).

21. American National Standard for Lightning Protection Code, NFPA 78-1986.

22. "Guidance for Defining Safety-related Features of Nuclear Fuel Cycle Facilities", ANSI N46.1-1980, July 16, 1981.

23. Regulatory Policy Document, NWMS M&O, draft dated 11/4/91.

24. "Establishing QA Program Controls (Classification and Grading), QAP-2-3, Rev.0.

25. "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants", Regulatory Guide 1.143, Rev.1.

26. NUREG-0800, section 9.5.1.

27. 10CFR72.124.

28. 10CFR72.126.

29. "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Plants Will be As Low As is Reasonably Achievable", Regulatory Guide 8.8, Rev. 3.

30. 10CFR20.

31. 10CFR72.104.

32. 10CFR72.106.

33. 10CFR72.128.

34. 10CFR72.130.