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Level of Design Detail Necessary for the License Application for Construction Authorization

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LEVEL OF DESIGN DETAIL NECESSARY FOR THE LICENSE APPLICATION FOR CONSTRUCTION AUTHORIZATION

OBJECTIVE

The objective of this paper is to establish the criteria and framework for discussions with the U. S. Nuclear Regulatory Commission and Project personnel regarding the Level of Design Detail necessary and sufficient for inclusion in the License Application (LA) and as supporting documentation for the LA.

PURPOSE

The purpose of this paper is to present criteria for the necessary and sufficient technical content and associated level of design development for the design information for the engineered Structures, Systems and Components (SSCs) contained in and available to support LA for Construction Authorization. The LA will contain information other than design information, such as quality assurance, testing, operations, performance confirmation, technical specifications, site descriptions, and performance assessment. This paper does not cover this other information. The level of design detail in the LA submittal will provide the information required to:

1. Ensure the protection of the public health and safety.
2. Ensure the protection of worker health and safety
3. Demonstrate compliance with the regulatory requirements.
4. Submit a docketable License Application for a repository at Yucca Mountain.

REGULATORY REQUIREMENTS

The repository licensing process for waste emplacement consists of two steps: a construction authorization (CA), and a license to receive and possess waste. Each step requires a NRC safety determination, which will be based on the LA submittal for CA and on the update to the LA for a license to receive and possess waste.

Submittal of only the amount of design information in the LA that is necessary and sufficient for the NRC to make a safety determination for a CA, followed by an update with the updated design for the license to receive and possess waste, is consistent with NRC licensing precedents and current regulations.

IMPLEMENTATION FRAMEWORK

The licensing process for the repository is a two step process that consists of a submittal for a CA and an updated submittal for a license to receive and possess waste. The LA will include a description of the systems that are required to protect the health and safety of the public from Design Basis Events and those engineered SSCs that are required to meet postclosure performance objectives. The LA will also include a description of systems that process radwaste, provide fire protection, and protect required safety SSCs from interactions from nonsafety SSCs. In addition, the LA will identify design features that protect the health and safety of the worker. Because those SSCs that are important to waste isolation have no regulatory precedent, it is assumed that more information will be required on the design bases and analytical methods employed for them than for those SSCs important to radiological safety. Since the design process for systems important to waste isolation uses project-specific analytical methodologies and models developed utilizing project-specific testing, or applies industry codes and standards in a unique way, additional information is needed in the records system, and summaries of this information shall be included in the LA. The updated submittal for a license to receive and posses waste will incorporate, as appropriate, the updated designs and results of the analyses for all safety systems.

The information in the LA submittal will be based on and supported by various design products that will reside in the records center. The design products themselves will not be in the LA, but portions and summaries of these products may be. The design products that provide the basis for the content of the LA must be fully defensible and traceable. The information contained in this document will be used to develop the Technical Guidance Document (TGD) for LA preparation. Appendix A contains explanations and examples for the terms used in this document for developing the TGD and the LA.

CRITERIA FOR DESIGN INFORMATION NEEDED IN THE LA SUBMITTAL FOR CA

Basis for SSCs to be Discussed in the LA

Since the purpose of the LA is to present the safety case for a repository, it must demonstrate that a repository will meet the preclosure and postclosure performance objectives. To demonstrate that a repository can meet the preclosure safety objectives, potential hazards are identified, design basis events are analyzed, and the SSCs are identified that are required to meet preclosure safety objectives. As such, the LA shall include representative discussions of the following:

Identification of Potential Hazards

- Perform hazards analysis
- Determine potential Design Basis Events (DBEs)

Analysis of DBEs

- Develop event scenarios, including methods of analysis, key assumptions, and design features
- Prepare analytical models which include engineered SSCs design features and performance characteristics
- Perform consequence analysis
- Compare results to the design criteria

Identification of SSCs Required to Meet Preclosure Safety Objectives

- Identify SSCs required to prevent or mitigate DBEs
- Develop SSC safety classification / Q-List

To demonstrate that a repository can meet postclosure performance objectives, a Total System Performance Assessment (TSPA) is performed. The LA shall include a summary of the Total System Performance Assessment, including a discussion of the models, inputs, and assumptions that are used to demonstrate compliance with the postclosure performance objectives, representative discussions of the features, events, and processes (including disruptive events) that drive postclosure performance, and summaries of the engineered barriers' contribution to the overall performance.

The results of the preclosure and postclosure safety analyses provide the basis for the safety classification of engineered SSCs; i.e., Quality Level I, II, III, or nonsafety. The level of design detail needed in the LA to demonstrate that a repository will not adversely impact the health and safety of the public and workers is commensurate with the resultant safety classification, as reflected in the following sections.

SSCs to be Discussed in the LA

For Quality Level I SSCs, the following information should be included in the LA for the particular SSC to support the regulatory design basis:

- Applicable Codes and Standards
- Design Criteria and Regulatory Design Bases
- General System Description
- Piping and Instrumentation Diagrams (P&IDs)
- Electrical One Line Diagrams
- General Arrangement Drawings
- Handling Diagrams

For Quality Level II SSCs, the following information should be included in the LA for the particular SSC, as it supports the regulatory design basis:

- Applicable codes and standards
- Design criteria
- General system description

For Quality Level III SSCs, the following information should be included in the LA

- Design criteria
- General system description

Non Safety SSCs Discussed in the LA

A general description of nonsafety SSCs will be included in the LA that is sufficient to demonstrate the nonsafety classification.

Summary

The focus of the LA submittal for CA is to provide documentation to the NRC that substantiates the conclusion that the repository can be constructed, operated, and eventually closed without unreasonable risk to the health and safety of the public and workers. This documentation includes the design, design processes, and controls of the repository. Submittal of the information listed above, in the LA, will enable the NRC to make this determination.

CRITERIA FOR DESIGN PRODUCTS NEEDED TO SUPPORT THE LA SUBMITTAL FOR CA

The set of design products needed to support the LA submittal include the development of the safety analyses, the design products to support the development of the safety analyses, the design bases, and a general system description.

The development of the safety case for a repository is an iterative process - an initial concept is developed, safety analyses are performed, SSCs are classified, codes and standards are identified, and design criteria are developed. As the design evolves these steps may be repeated, as appropriate, to optimize the design based on additional design detail and to remove unnecessary conservatism while maintaining consistency with the safety case.

The design products required to support the safety analyses are process flows (for systems involving the handling of radioactive materials), general arrangement diagrams, general system descriptions, and concepts of operations. The first iteration of the safety analysis process has already begun and is based on the Viability Assessment design. The results of the safety analysis for LA provide the basis for the safety classifications of SSCs. The level of design detail for each SSC in the LA and supporting documentation is commensurate with the safety significance of the SSC, as determined by the safety analysis.

For those SSCs to be described in the LA, the regulatory design basis (applicable codes and standards, design criteria), and the general system descriptions shall be based on the information contained in Section 1 of the System Description Documents (SDDs). The additional information needed in the LA for systems that are required to meet preclosure or postclosure safety objectives is the information needed to support the safety analyses (or can be readily derived from them). For SSCs that have no safety significance, the only information needed in the records system is the information necessary to support the non-safety classification (i.e., the general design description of the system captured in section 1 of the SDD.) This regulatory design basis information will be contained in Section 1 of the SDDs.

FUTURE CONSIDERATIONS

The licensing approach described above will guide the Project through the LA submittal to be used as a basis for the Construction Authorization. In addition, this paper provides a framework to be followed for the development of the updated LA. This framework will need to be expanded in the near future to capture all of the design effort that will be required to be completed to defend the commitments that will be made in the LA submittal with regard to constructing a repository. The amount of design work to adequately procure the equipment and materials and ultimately construct the repository is significantly greater than that required for the LA, and should not be underestimated.

APPENDIX A

DEFINITIONS

DEFINITIONS

Applicable Codes and Standards

Applicable industry codes and standards are those codes and standards applicable to the design of the SSCs (provided in Section 1 of the SDDs).

Examples:

1. The system shall comply with the applicable provisions of 29 CFR 1910, Occupational Safety & Health Standards.[1]

2. The system shall comply with the applicable provisions of ASME N509-1989, Nuclear Power Plant Air-Cleaning Units and Components.[1]

3. The design of concrete radiation shielding shall comply with ANSI/ANS 6.4 and ACI 349 when it provides a critical confinement or structural function.

4. In accordance with 10 CFR 20.1101(b) and to the extent practicable, facility procedures and engineering controls shall be based upon sound radiation protection principles to achieve occupational and public doses that are ALARA.

Regulatory Design Bases

The NRC's proposed 10 CFR 63 defines "design bases" as follows:

> Design bases means that information that identifies the specific functions to be performed by a structure, system, or component of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be restraints derived from generally accepted "state-of-the-art" practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which a structure, system, or component must meet its functional goals. The values for controlling parameters for external events include:
>
> (1) Estimates of severe natural events to be used for deriving design bases that will be based on consideration of historical data on the associated parameters, physical data, or analysis of upper limits of the physical processes involved; and
>
> (2) Estimates of severe external human-induced events, to be used for deriving design bases, that will be based on analysis of human activity in the region, taking into account the site characteristics and the risks associated with the event.

The regulatory design bases are those restraints that are part of the licensing basis and form the foundation for the NRC staff's safety judgement (safety functions described or implied in LA Chapters 7 & 8 or specific requirements imposed by NRC as a basis for its approval). The regulatory design basis is that information that identifies the specific functions to be performed by

[1] (from Waste Handling Building (WHB) ventilation system SDD)

a structure, system, or component of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be constraints derived from generally accepted "state-of-the-art" practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which a structure, system or component must meet its functional goals (from 10 CFR 60.2 and the NRC staff draft of 10 CFR 63.2) (provided in Section 1 of the SDDs). The design basis may be evaluated by applying the guidance provided in documents developed by the NRC (e.g., regulatory guides, Staff Technical Positions, Branch Technical Reports, or SERs on Topical Reports).

It should also be noted that the entire set of design constraints that are implemented for the Monitored Geologic Repository (MGR) also includes those that are not part of the regulatory design basis as defined above but are implemented to achieve certain economies of operation, maintenance, procurement, installation, or construction. These additional design constraints are part of the engineering design basis for the MGR but are not included in the LA.

Examples:

1. During the preclosure period, the disposal container, while in a horizontal orientation, shall be designed to withstand a drop from a height of 2.4 m (7.9 ft.) without breaching. [2]

2. The transport system design shall prevent an uncontrolled descent. The frequency of an uncontrolled descent by the transportation system shall be shown by analysis to be less than 6×10^{-4}/yr.[2]

3. The system shall exhaust all airflow from the confinement areas through air cleaning units equipped with 90% ASHRE pre-filters and 99.97% HEPA filters.[1]

4. Two 225-ton capacity bridge cranes are provided in the [spent fuel] transfer facility, allowing simultaneous SNF [spent nuclear fuel] handling operations in various areas of the transfer facility and providing redundancy of cask handling equipment in the event that one crane is out of service....The capacity of the crane is sized to allow handling of the heaviest transportation and storage cask designs specified in the design basis, which is bounded by the 195-ton Westinghouse concrete storage cask....The overhead bridge cranes and associated cask lifting equipment are supplied in accordance with the guidelines specified in the following:

   - NUREG-0612
   - NUREG-554
   - ASME NOG-1
   - ANSI-N14.6

   Applicable loading conditions for crane design are identified in Section X.Y. During site-specific design, the crane design will be shown to meet the minimum safety factors, requirements for load path and safety feature redundancy, and other design criteria set forth in

[2] (from the uncanistered spent nuclear fuel and waste emplacement SDDs)

the above referenced documents. This also ensures that the cranes will be designed, installed and operated to preclude collision and that the loads on the two cranes will be stable during seismic or other events.... All crane components are designed to be fail-safe in the event of loss of power, so that the load cannot be dropped or inadvertently moved. Thus, power to the cranes is not required to be QA1. The cranes are designed to withstand the effects of the generic site earthquake. Since a large number of casks are handled in the transfer facility on a continuous basis, the design assumes that an earthquake occurs while a crane is lifting a cask. As such, the overhead bridge cranes are designed to accommodate seismic loading while both of the cranes are fully loaded with the heaviest cask included in the design basis. In addition, assurance is made that the cranes will remain on their rails and functional after the earthquake has subsided.[3]

Design Criterion

A design criterion is a standard or rule against which a design can be judged (provided in Section 1 of the SDDs). The NRC defines "principle design criterion" in 10 CFR 50 Appendix A as follows: "Principle design criteria establish the necessary design, fabrication, construction, and performance requirements for SSCs important to safety..."

Examples:

1. The waste package shall have a long lifetime to contain the waste throughout the thermal period.

2. Provisions shall be made so that, if there is a loss of the primary electric power source or circuit, reliable and timely emergency power can be provided to instruments, utility service systems, and operating systems, including alarm systems, important to safety.

3. The facility design shall comply with the ALARA criteria of 10 CFR 20 and NRC Regulatory Guide 8.8

4.

Table 1.2-1. Summary of CISF Principal Design Criteria[4]

Design Parameter	Design Criteria	Condition	Applicable Codes, Standards, & Bases
Seismic (Ground Motion)	Design response spectra anchored at horizontal acceleration of 0.75g	Accident	NRC RG 1.60 (Ref. 3.3-1)
Seismic (Surface Faulting)	No surface faulting	Accident	10 CFR100, App. A (Ref. 3.3-8)

[3] Example from the DOE Centralized Interim Storage Facility (CISF) Topical Safety Analysis Report (TSAR), Rev. 1, September 30, 1998, pp.4.2-4 to 4.2-6.
[4] Example from the DOE Centralized Interim Storage Facility (CISF) Topical Safety Analysis Report (TSAR), Rev. 1, September 30, 1998, p. 1.2-2.

Electrical One Line Diagrams

Electrical One Line Diagrams are diagrams of single lines showing the electrical power sources, distribution busses, major loads, and associated circuit breakers. Electrical one line diagrams may be generated based on the general system description and the design information required to perform the safety analyses, such that no additional supporting information will be required.

General Arrangement Drawings

General Arrangement drawings provide an overall view of a structure, component, or area showing the arrangement of major structural features and major equipment. Only overall dimensions are included. General arrangement drawings may be generated based on the general system description and the design information required to perform the safety analyses such that no additional supporting information will be required.

General System Description

A general system description provides a summary of the system functions, operations, the system design, concept of operations, and a description of system interfaces, such as in Section 1 of the SDDs. This description should include a discussion on any special construction or fabrication techniques, unique testing programs or special design and analysis procedures used for the SSCs, as applicable.

Examples:

1. The Waste Handling Building (WHB) Ventilation System provides heating, ventilation, and air conditioning for the confinement and non-confinement areas of the Waste Handling Building. In the non-confinement areas, the ventilation system maintains the proper environmental conditions for equipment operation and personnel comfort. In the confinement areas, in addition to maintaining the proper environmental conditions for equipment operation and personnel comfort, the ventilation system directs potentially contaminated air away from personnel in the WHB and confines the contamination within HEPA filtration units. The confinement areas ventilation system creates airflow paths and pressure zones that minimize the potential for spreading contamination within the building. Through confinement of airborne contamination and exhausting the air to the environment through a stack equipped with radiation monitors, the Waste Handling Building Ventilation System protects the personnel outside of the WHB and the public from radiation exposure.

   The WHB Ventilation System is designed to performs its safety functions under all conditions resulting from natural and induced events such as earthquakes, fires, and loss of electric power. Additional system design features, such as independent subsystems, minimize the potential for cross contamination within the WHB. The system provides status of important system parameters and equipment operation, and provides audible and/or visual indication of off-normal conditions or equipment failures.

   The WHB Ventilation System confines the radioactive and hazardous material within the building such that the release rates are within the regulatory limits. The system operations and maintenance activities incorporate the ALARA principles in order to maintain personnel radiation exposures within regulatory limits and as low as is reasonably achievable (ALARA).

The WHB Ventilation System interfaces with the Waste Handling Building System by maintaining specific pressure differentials between the building confinement zones during all waste handling operations. The system interfaces with the WHB Radiological Monitoring System and the WHB Fire Protection System for detection and alarm or action in the presence of hazardous conditions such as radiological release or smoke.

2. Two 225-ton capacity bridge cranes are provided in the [spent fuel] transfer facility, allowing simultaneous SNF [spent nuclear fuel] handling operations in various areas of the transfer facility and providing redundancy of cask handling equipment in the event that one crane is out of service. Either crane can service any part of the transfer facility. The service area covers the entire floor area of the transfer facility, with setback allowances from the edges and sides due to hook approach restrictions.... Both cranes run on a common set of rails, which provide a crane span of approximately 70 feet and a travel distance of approximately 230 feet. Each crane has a 25-ton capacity auxiliary hoist for handling of impact limiters, personnel barriers and other ancillary equipment. The main hook hoist blocks swivel to accommodate cask rotation. Platforms and ladders are provided for crane maintenance. The cranes are remotely operated using computer-assisted controls from a crane operating room located along one side of the transfer facility, to ensure crane operator personnel radiation dose is kept ALARA. Cameras are provided on the crane and throughout the transfer facility to aid crane operators in observing crane activities.[5]

Handling Diagrams

Handling diagrams depict major handling paths and sequence of operations at a summary level (e.g., fuel movement in the Waste Handling Building). Handling diagrams may be generated based on the general system description and the design information required to perform the safety analyses, such that no additional supporting information will be required.

Process & Instrumentation Diagrams (P&ID)

P&IDs are diagrams showing only major flow paths, equipment, and instrumentation (pumps, tanks, ion exchangers, major valves, instrumentation used for operation, etc.). Interfaces with other systems and seismic and quality interfaces shall be included on the P&ID. These P&IDs may be generated based on the general system description and the design information required to perform the safety analyses, such that no additional supporting information will be required.

Quality Levels

Quality Level is a measure of quality assurance commensurate with a SSC's safety significance that is evaluated in a classification analysis. The quality level is used to establish controls on design, procurement, construction, and maintenance requirements which will be applied to permanent items using a graded approach.

[5] Example from the DOE Centralized Interim Storage Facility (CISF) Topical Safety Analysis Report (TSAR), Rev. 1, September 30, 1998, p.4.2-4 to 4.2-5.

Quality Level I

Quality Level I SSCs are those whose failure could directly result in a condition adversely affecting public health. SSCs classified as Quality I include:

SSCs required to provide waste package containment or criticality control

SSCs required to prevent or mitigate off-site dose from a Category 1 design basis event to below 100 mrem TEDE (Total Effective Dose Equivalent)

SSCs required to prevent or mitigate off-site dose from a Category 2 design basis event to below 5 rem TEDE

SSCs required to meet the annual longterm waste isolation performance objective of 25 mrem TEDE for the first 10,000 years after permanent closure

SSCs required to perform a waste isolation function by forming a part of the natural barrier or engineered barrier system or which are part of the performance assessment system

Quality Level II

Quality Level II SSCs are those whose failure or malfunction could indirectly (i.e., multiple failures) result in a condition adversely affecting public health or SSCs whose failure could directly result in consequence in excess of normal operational offsite limits. SSCs classified as Quality Level II include:

SSCs that function to provide control and management of site-generated liquid, gaseous, or solid low-level or mixed radioactive waste

SSCs that provide fire detection, fire suppression, or otherwise protect Quality Level I SSCs from the hazards of a fire

SSCs that do not have a Quality Level I function but whose failure during a design basis event could prevent Quality Level I SSCs from performing their required functions

SSCs required to prevent or mitigate off-site dose from a Category 1 design basis event to below 25 mrem TEDE

SSCs, in conjunction with an additional SSC or administrative control, required to prevent or mitigate off-site dose from a Category 1 design basis event to below 100 mrem TEDE

SSCs, in conjunction with an additional SSC or administrative control, required to prevent or mitigate off-site dose from a Category 2 design basis event to below 5 rem TEDE

SSCs that do not have a Quality Level I function but whose failure could result in the inability of a Quality Level I engineered barrier to perform its intended functions, long term changes to the hydrological characteristics of the natural barriers, introduction of fluids or other materials that could adversely affect the long-term geomechanical characteristics of the natural barriers, or compromises the ability of the natural barriers to isolate waste.

Quality Level III

SSCs that do not meet the definition of Quality Level I or II, but provide discernible public and worker safety benefits, are classified as Quality Level III. SSCs classified as Quality Level III include:

SSCs required to limit worker doses from normal operations and Category 1 design basis events

SSCs that alarm to warn of significant increases in radiation levels or concentrations of radioactive material

SSCs that monitor variables to verify that operating conditions are within technical specification limits

SSCs used in emergency responses to provide for or initiate prompt evacuation of personnel, or to monitor variables used in helping to determine the causes or consequences of design basis events (during post-accident investigations)

SSCs that are part of the radiological, meteorological, or environmental monitoring systems required to assess radionuclide release or dispersion following a design basis event

SSCs that keep levels of radioactive material in effluent to unrestricted areas as low as practical during normal operations

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