

Defense-in-Depth Philosophy In Proposed Regulations for HLW Disposal at Yucca Mountain



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Total System Performance Assessment for Yucca Mountain

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OUTLINE

- **Definition of Defense-in-Depth Concept**
- **High-Level Waste Regulation (Proposed Part 63)**
- **Requirements for Multiple Barriers**
- **Quantitative Approaches**

DEFENSE-IN-DEPTH

“Risk-Informed and Performance-Based Regulation” (Commission White Paper, issued 3/11/99) defined the concept of defense-in-depth as follows:

(Emphasis added)

“Defense-in-depth is an element of the NRC’s Safety Philosophy that employs successive compensatory measures to prevent accidents or mitigate damage if a malfunction, accident, or naturally caused event occurs at a nuclear facility. The defense-in-depth philosophy ensures that safety will not be wholly dependent on any single element of the design, construction, maintenance, or operation of a nuclear facility. The net effect of incorporating defense-in-depth into design, construction, maintenance, and operation is that the facility or system in question tends to be more tolerant of failures and external challenges.”

POST-CLOSURE REPOSITORY PERFORMANCE OBJECTIVES

Part 63

- **25 mrem annual dose limit**
 - **performance assessment (PA) must include analysis of uncertainty in dose estimates**
- **demonstration of the capability of multiple barriers (both engineered and natural).**
- **stylized calculation of human intrusion**

PART 63 REQUIREMENTS FOR MULTIPLE BARRIERS

- **No quantitative requirements for individual barriers**
- **Barrier is defined as any material or structure that prevents or substantially delays movement of water or radioactive materials.**
- **Requires DOE to:**
 - 1) **identify those design features of the engineered barrier system, and natural features of the geologic setting, that are considered barriers important to waste isolation;**
 - 2) **describe the capability of these barriers to isolate waste, taking into account uncertainties in characterizing and modeling the barriers; and**
 - 3) **provide the technical basis for the description of the capability of these barriers.**
- **Affords DOE flexibility to identify barriers important to waste isolation and select approach for demonstrating their contribution.**
 - **DOE has the responsibility to identify and demonstrate their capability to isolate waste**

DEMONSTRATION OF MULTIPLE BARRIERS

- 1) **Barriers should be representative of distinct features, characteristics or attributes of the repository system, for example:**
 - **engineered barriers, unsaturated zone, alluvium of the saturated zone**

- 2) **Barrier capability should be explained in terms of preventing or substantially delaying the movement of water or radioactive materials, for example:**
 - **waste package delays releases for many years**
 - **unsaturated zone “shields” repository from water, deep percolation only a small fraction of annual precipitation**
 - **unsaturated zone limits the number of wetted packages, and, thereby limiting amount of radioactive waste available for release to ground water**
 - **alluvium in saturated zone significantly delays movement of many radionuclides by sorption**

- 3) **Rigor of needed technical basis for a barrier’s capability proportional to its importance to performance, for example:**
 - **laboratory and field measurements**
 - **analog studies**

USING QUANTITATIVE APPROACHES

- **Many quantitative techniques are available that can provide additional insights, support explanation of the barrier's capability, and illustrate barrier's relationship to performance, for example:**
 - **sensitivity analysis**
 - **importance analysis**
 - **“one-off” analysis**
 - **analysis beyond 10,000 years**

- **NRC is open to any approach that:**
 - 1) **makes PA and capability of multiple barriers more transparent, and**
 - 2) **supports more informed licensing decisions**