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MRS ROLE IN REDUCING TECHNICAL UNCERTAINTIES IN GEOLOGICAL DISPOSAL

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MRS Role in Reducing Technical Uncertainties in Geologic Disposal

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A high-level nuclear waste repository has inherent technical uncertainty due to its first-of-a-kind nature and the unprecedented time over which it must function. Three possible technical modifications to the currently planned US high-level nuclear waste system are reviewed in this paper. These modifications would be facilitated by inclusion of an MRS in the system.

The modifications are 1) an underground MRS at Yucca Mountain, 2) a phased repository, and 3) a "cold" repository. These modifications are intended to enhance scientific confidence that a repository system would function satisfactorily despite technical uncertainty.

Underground MRS at Yucca Mountain. From a purely technical viewpoint, the most conservative approach to establishing whether Yucca Mountain is suitable for a permanent repository would be to construct a facility with the waste emplaced in a retrievable manner, and then to monitor the performance for decades before application is made for a disposal license. These words describe underground monitored retrievable storage.

The concept of an underground MRS at Yucca Mountain integrates three independent observations. *First*, as pointed out by Carter[2], *there is little difference at Yucca Mountain between an underground MRS and the initial 50-year mandated retrievability period during operation of some repository conceptual designs.*

Second, because of drying of the fractured, unsaturated rock at the repository horizon in response to heat from the emplaced waste, it is expected that the near-field rock and emplaced waste at Yucca Mountain can be kept dry for hundreds of years, with little corrosion of containers and no aqueous dissolution of waste[3, 4, 5]. Although supported by theory and calculations[6], laboratory studies[7], and field testing away from Yucca Mountain[8], *these phenomena must be demonstrated full-scale underground at Yucca Mountain.*

Third, spent fuel has to be stored somewhere until a repository is licensed. During the time of storage, the output of heat from radioactive decay declines. Because of the thirty year half-life of the principal heat-contributing radionuclides, *the ability of the waste to dry nearby rock is reduced if there are decades of delay in the repository schedule.*

Constructing an underground MRS as part of the determination of suitability of Yucca Mountain for a repository solves both the problems of where to store fuel and of how to demonstrate the concept of constructive use of decay heat in repository design. Calculations assuming emplacement of 10-year-old spent fuel indicate that near-field rock temperatures would peak 10 to 20 years after emplacement[9]. Therefore, phenomena related to maximum temperatures at Yucca Mountain would be observable within the design life of an MRS.

While the underground MRS concept has many technical benefits, it faces numerous political, perceptual, and legal obstacles, including specific prohibitions and limitations in Waste Management legislation. However, a less-controversial phased repository that would rely on a non-co-located MRS also could reduce some of the uncertainty for technical issues.

Phased Repository. Friendly critics have called for a more experimental, evolutionary, and flexible program that approaches permanent disposal in incremental steps[2,10,11]. Although a repository is a first-of-a-kind facility, current policy is to obtain a full capacity operating license prior to emplacing any waste. By contrast, with more than 100 nuclear reactors licensed in the US, the current reactor licensing approach is to proceed through low-power testing stages before granting the full-power, 40-year operating license.

The phased repository concept would approach licensing of a repository in a similar manner, emplacing successively more waste until a decision is made at some point to proceed with complete loading. Emplacement of a small panel of waste [~ 10 MTHM as authorized in Sec 113(c)(2) of the Waste Management Policy Act of 1982] could even be included as part of site characterization.

Despite the capability to test laboratory specimens and make computer analyses, "proof" of satisfactory performance of a Yucca Mountain repository may require construction, operation, and monitoring for decades of a large portion of the potential repository. Specific issues for which the resolution would be aided by emplacing actual waste at Yucca Mountain include:

Shorter term issues

1. radiolysis effects from emplaced waste
2. determination of whether water drains away from the repository horizon by gravity flow in fractures as the rock dries
3. the effect of repository ventilation on removal of water from the repository horizon
4. the degree and effect of spatial variability of rock at the repository horizon

Longer term issues

5. long-term variability in mass flux of water from the ground surface
6. hydraulic and chemical effects on near-field rock from elevated temperatures that peak 10 to 20 years after emplacement
7. how and when water returns to the dried rock as the temperature declines.

Currently planned or even greater amounts of surface and underground site characterization and computer modeling will not equal the impact of experimental emplacement of even a few containers of actual high level waste. In addition to addressing the above technical questions, a phased repository provides early demonstration of disposal technology, allows continual incorporation of improved technology and site information, and maintains momentum and focus in the repository program.

"Cold" repository. This concept deals with decay heat from nuclear waste in a fundamentally different way than the constructive use of heat underlying the two preceeding concepts. Most nuclear nations plan for a long period of interim storage of spent reactor fuel or high level waste prior to disposal in a repository. A commonly cited technical rationale is to enhance isolation of radionuclides by storing waste until heat output falls below some limit. For repository designs in saturated granite with bentonite backfill or in salt, reduction of heat provides clear technical benefits.

Eriksson and Pentz[12] recommend this approach for a repository at Yucca Mountain. The essence of their argument is that analyses required to demonstrate meeting the regulations are simplified by keeping the repository temperature lower than the boiling point of water. With no other design changes, delay of about 50 years beyond the present schedule would assure that rock temperatures remained below boiling at Yucca Mountain.

The purpose of this paper is not to review the technical merits of constructive use versus avoidance of heat, but rather to point out that the implementation of either concept would be facilitated with an MRS in the waste management system. An MRS introduces technical flexibility into the system. It thus aids consideration of new concepts as well as modifications to the authorized system, alleviates time constraints for designers and regulators, and thereby reduces technical uncertainty in geologic disposal.

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