REGULATORY BACKGROUND
OF
10 CFR PART 60.113(a)(2)
GROUNDWATER TRAVEL TIME

PRESENTATION TO
PANEL ON HYDROGEOLOGY AND GEOCHEMISTRY
NUCLEAR WASTE TECHNICAL REVIEW BOARD

LAS VEGAS, NEVADA
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REGULATORY APPROACH

- Foundation of 10 CFR Part 60 is a defense-in-depth regulatory approach

- Implementation of defense-in-depth regulatory approach

  - Use of multiple barriers

  - It was determined appropriate to include reasonable, generic requirements [for individual barriers] that, if satisfied, would ordinarily contribute to meeting standards

  - Quantitative measures were considered important in conveying the degree of confidence that the NRC expected must be achieved in order to be able to make the required licensing decisions

  - Performance of individual barriers evaluated separately and independently of overall system performance so as to increase confidence in predictions of system performance

BACKGROUND

- Some reviews and compilations, related to the geologic disposal of high-level radioactive wastes, that influenced NRC staff early on in the development of the performance objective for the geologic setting

1. *Site Selection Factors for Repositories of Solid High-Level and Alpha-Bearing Wastes in Geological Formations*, Technical Reports Series No. 177, International Atomic Energy Agency, Vienna, 1977.

2. *Report to the American Physical Society by the Study Group on Nuclear Fuel Cycles and Waste Management*, Reviews of Modern Physics, Vol. 50, No. 1, Part II, January, 1978.

3. *Geologic Disposal of High-Level Radioactive Wastes--Earth-Science Perspectives*, Geological Survey Circular 779, US Geological Survey, 1978

4. *Geological Criteria for Repositories for High-Level Radioactive Wastes*, National Research Council, National Academy of Sciences, 1978

ASSUMPTIONS ABOUT SITE SUITABILITY THAT INFLUENCED DEVELOPMENT OF THE DRAFT RULE

- The most likely process (only important medium, most probable method, etc.) for moving radioactive waste from the repository to the biosphere is transport by groundwater (Ref 1; p. 20, Ref 2; p. S120, Ref. 3; p. 7, Ref 4; p. 2)

- The principal criterion for geological disposal is to use either a dry formation or one where there is little or no movement of groundwater (Ref. 1; p.20)

- Criteria for the amount of groundwater migration which may be considered negligible must be worked out separately for each individual site in relation to the specific disposal system proposed for that site (Ref. 1; p. 20)

- A properly designed repository in a suitable site has hydrological properties that can be predicted with reasonable assurance for about 1,000 years. This is about 30 half-lives of the critical beta, gamma-emitters, strontium-90 and cesium-137 (Ref. 4; p. 3)

- Combinations of hydrologic factors can slow transport between the repository and the biosphere. Factors tending to lengthen the transport time include (Ref. 3; p. 8):

    - Low permeability of the media
    - High effective porosity of the media
    - Low gradient of hydraulic head
    - High sorption capacity of the media
    - Long flow path
    - Low rate of release of solutes by the wastes to the transporting fluids

PRELIMINARY CONCLUSIONS

- Groundwater transport most probable release pathway

- Establishing a criterion based on amount of groundwater flow is a site and design specific problem (need a source term, establishing a dependency on the engineered system)

- Long-term performance of the geologic setting will likely depend on the specific geochemical environment

- Many combinations of permeability, effective porosity, gradient and flow path length can result in long transport times. In addition, it was not considered practical to establish a discrete value for these parameters as a quantitative performance measure for the geologic setting because of their variability in space

- Early focus of the staff was on establishing a minimum travel time as an independent measure of performance of the geologic setting

ALTERNATIVES CONSIDERED DURING DEVELOPMENT OF THE DRAFT PERFORMANCE OBJECTIVE FOR THE GEOLOGIC SETTING

- Require the geologic setting to provide whatever margin is needed to complement the engineered barriers to ensure that the overall performance criterion for the disposal system is met
- Minimum radionuclide travel time from the underground facility to the accessible environment under repository conditions
- Minimum groundwater travel time for the undisturbed geologic setting

ALTERNATIVE 1

- Require the geologic setting to provide whatever margin is needed to complement the engineered barriers to ensure that the overall performance criterion for the disposal system is met

  - Already an implicit performance requirement because this would always be required

  - Requires complex models to predict the behavior of the flow system and the geochemical system under the thermal field of the repository, and of the far field geochemical system, thus, is subject to many of the same types of uncertainties that modeling of the entire disposal system involves. Therefore, was not considered an approach suitable to enhancing confidence in predictions of system performance

ALTERNATIVE 2

- Minimum radionuclide travel time from the underground facility to the accessible environment under repository conditions

  - Requires complex models to predict the behavior of the flow system and the geochemical system under the thermal field of the repository, and of the far field geochemical system, thus, is subject to many of the same types of uncertainties that modeling of the entire disposal system involves. Therefore, was not considered an approach suitable to enhancing confidence in predictions of system performance.

ALTERNATIVE 3

- ♦ Minimum groundwater travel time for the undisturbed geologic setting

  - Relatively simpler. As indicated in the statements of consideration for the draft rule, this alternative avoids the need to model the thermal effect on the hydrologic system and the geochemical impacts of nuclide transport. Thought to require only the measurement of parameters and modeling of aquifer flow that is commonly done in water resource analyses.

  - Staff clearly recognized there would be some uncertainty in predictions of groundwater travel time due to parameter uncertainty but assumed uncertainty would be less when compared to measuring geochemical parameters and modeling radionuclide transport

  - Staff recognized the potential use of environmental tracers as an independent indicator of groundwater travel time

  - This alternative was selected as the performance measure for the geologic setting

ESTABLISHING A DISCRETE VALUE FOR GWTT

- In developing the draft rule, travel times of 100, 1,000 and 10,000 years were considered

- Locating sites with a minimum travel time of 100 years was considered readily achievable in a variety of hydrogeologic environments, but thought to be of little benefit (i. e., considerable reliance on the geochemical system)

- A 10,000 year travel time was considered sufficient for many shorter-lived nuclides to meet the system's overall performance objectives with no reliance on geochemistry. Staff was uncertain to what extent such a groundwater travel time was achievable (i. e., variety of hydrogeologic environments exhibiting this characteristic)

- Travel times of 1,000 years were thought to be achievable in many hydrogeologic systems. It was thought that for a groundwater travel time of 1,000 years, sorption equilibrium coefficients of 100 ml/g or less would be sufficient to prevent most of the principal contributors to dose from reaching the accessible environment (low end of laboratory estimates)

TRANSITION TO THE FINAL RULE

- Linkage of GWTT to the disturbed zone as defined in 10 CFR 60.2. Thus, GWTT from the disturbed zone to the accessible environment was considered a parameter that is not dependent upon the effects of waste emplacement

- A sensitivity analysis of system performance as a function of release rate and GWTT, for a variety of hydrogeologic environments, was developed to support GWTT. It was concluded that a 1,000 year GWTT can be of significant value in providing reasonable assurance that the assumed standard [EPA] can be met without placing an undue reliance on the ability of the underground facility to minimize release rates, and is readily achievable (NUREG-0804). In other words, if the EBS release rate meets the 10^{-5} performance objective that, for a variety of environments (not necessarily all), groundwater travel times in excess of 1,000 years yielded a higher percentage of cases that met the assumed standard.

ALTERNATIVE NUMERICAL PERFORMANCE OBJECTIVES UNDER 10 CFR PART 60.113(b)

- The language of 10 CFR 60.113(b) affords the Commission the flexibility to adjust the subsystem performance objectives to reflect site-specific conditions and designs:

  On a case-by-case basis, the Commission may approve or specify some other radionuclide release rate, designed containment period or pre-waste-emplacement groundwater travel time, provided that the overall system performance objective, as it relates to anticipated processes and events, is satisfied.

- Under this provision, the Commission may specify new numerical values for the subsystem criteria but may not alter the three criteria themselves. Among the factors that the Commission may take into account in setting alternative numerical values are:

  - Any generally applicable environmental standard for radioactivity established by the U.S. Environmental Protection Agency

- The age and nature of the waste, and the design of the underground facility, particularly as these factors bear on the time during which the thermal pulse is dominated by the decay heat from the fission products

- The geochemical characteristics of the host rock, surrounding strata, and groundwater

- Particular sources of uncertainty in predicting the performance of the geologic repository

♦ Staff views on implementation of this provision of the rule was provided to DOE (letter from J. Holonich to R. Milner; dated August 23, 1994)

EXPANSION OF SCOPE OF 10 CFR PART 60 TO INCLUDE DISPOSAL OF HLW IN THE UNSATURATED ZONE

- One issue concerning the proposed rule, addressed by commenters, was the NRC decision to restrict applicability of the provisions of 10 CFR Part 60 to geologic repositories sited within the saturated zone

- In general, these commenters, including the U.S. Department of Energy, the U.S. Department of the Interior, and separately, the U.S. Geological Survey, requested the proposed rule be made equally applicable to geologic repositories in the unsaturated zone

- NRC staff recognized the merit of the request and amended the rule to ensure the provisions of Part 60 were equally applicable to disposal within the saturated and unsaturated zones.

- NRC staff recognized that most provisions of the rule, generic in nature, already applied equally well in either the saturated or unsaturated zones. Action taken included new definitions of the terms "groundwater" and "unsaturated zone", modification of some existing favorable conditions and addition of some new favorable and potentially adverse conditions (NUREG-1046)

ONGOING INTERACTIONS

- DOE has provided basic elements of a proposed approach for demonstrating compliance with GWTT to NRC (letter of June 10, 1994)
- DOE has indicated that their proposed approach should not require changes in the text of either 10 CFR Part 60 or Part 960
- NRC has provided initial feedback on the proposed approach to DOE (letter of August 23, 1994)
  - NRC staff generally believes -- as, it appears, does DOE -- in the appropriateness of developing and evaluating a distribution of water particle travel times as part of a compliance demonstration
  - NRC staff believes -- as, it appears, does DOE -- that uncertainty in the estimate of GWTT needs to be addressed in the compliance demonstration

- More detailed exchanges on a number of technical items are needed

    - methods for assessing uncertainty

    - physical and chemical properties germane to delineating the disturbed zone

    - criteria to be used to decide where resultant changes in those properties may have a significant effect on the performance of the geologic repository

    - method and appropriateness of incorporating dispersion and matrix diffusion into the analysis

    - summing estimates of GWTT in the saturated and unsaturated zones

- ♦ NRC/DOE technical exchange planned for week of November 28, 1994