(91)

DOCKET NUMBER PROPOSED RULE PR-60 (46 FR 35280)

DOCKETED USNRC

'82 OCT 29 P4:13

OFFICE OF SECRETARY DOCKETING & SERVICE BRANCH

Department of Energy
Washington, D.C. 20585

OCT 29 1982

MEMORANDUM FOR Honorable Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

On July 29, 1982, the Department of Energy met with the NRC staff in an open meeting to discuss the proposed final draft of 10 CFR Part 60. Others who had participated in the rulemaking proceeding were also invited to this meeting.

Draft copies of the final Rule and "Rationale for Performance Objectives in 10 CFR Part 60" were distributed. Based upon those documents and discussions at that meeting, it is clear that a number of basic Department concerns are not being adequately addressed by the NRC staff as it proceeds with the development of the Rule. Accordingly, I am writing to advise the Commission directly that the Department has serious difficulties with certain aspects of the Rule as now written, despite extensive discussions with NRC staff management and the apparent accommodations of our concerns.

The Department's major concern with the proposed Rule, which has been noted in our comments and in those of other reputable reviewers, is the inclusion of ad hoc numerical design requirements for subsystems (individual barriers). Because the degree to which a repository contains radionuclides over time is the ultimate test of its adequacy, we believe the Rule should be based on and derived from an overall system performance objective, as were the curie release limits which have been proposed by EPA in their draft Standard. Instead, the Rule centers on the imposition of performance requirements for individual components that are neither derived from nor related to an overall system performance objective.

Further, inclusion in the Rule of numerical performance requirements for individual barriers will, because of the difficulties in demonstrating compliance, significantly complicate the licensing process and add needless expense of the disposal of high-level waste. The NRC has issued drafts for public review and comment twice, first on May 13, 1980, and again on July 8, 1981. In response, the Department and other concerned parties have expressed reservations about the NRC's approach. These comments, however, have not been fully addressed by the NRC staff, perhaps partially because of a failure to appreciate the potential licensing pitfalls involved.

In its current form the Rule still contains rigid, numerical requirements for individual components that are not justified. For example, the Rule states in section 60.113(a)(1)(ii)(A):

> "Containment of HLW within the HLW waste package will be substantially complete for a period of 1,000 years after permanent closure of the geologic repository, or such other period as may be approved or specified by the Commission."

DS10
add: Frank Arsenault 1130 SS
J. Wolf 9604 N 3B

The NRC staff position is that the phrase "or such other period as may be approved or specified by the Commission" sufficiently addresses the Department's concern that the 1,000-year period constitutes a firm requirement. We, however, cannot agree. As a practical matter, case-by-case approvals of deviations from specific nume. cal requirements are almost never granted, require extensive litigation, and, accordingly, are not a realistic alternative to compliance with specific numerical criteria.

We are seriously concerned over the numerical requirements prescribed in 60 113 for components in the Rule for three reasons. First, we believe that the need to demonstrate compliance will unnecessarily complicate and prolong the licensing process. Simply determining the requirements necessary for demonstrating a 1,000-year waste package, for example, is likely to consume considerable time. Secondly, the requirements in the Rule are not technically justifiable. For example, as discussed in our previous comments on the proposed Rule, a long lived (1,000-year) waste package makes no measurable contribution toward protecting the health and safety of the public. The third reason for concern is that of unnecessary cost. The cost of a very long-lived waste package--and exotic, very low release rate waste forms, which also appear to be required by the Rule--would needlessly add to the expense of the disposal of the Nation's waste.

In addition, we have found that the NRC staff's "Rationale" document, which accompanies the draft Rule and sets forth the staff's bases for the requirements it contains, does not, in fact, support the specific requirements in the Rule. During their presentation to the Commission on the proposed Rule, the NRC staff acknowledged that the imposition of the numerical values will not in and of themselves ensure that the proposed EPA Standards will be met. The geologic conditions in the repository must provide a measure of protection from premature radionuclide release. In assessing the effectiveness of the geology, however, minimal credit was allowed because of assumed conditions which were seriously flawed compared to geologic options the Department is investigating.

Enclosed are excerpts from the comments of others on the NRC Rule. You can see that the Department is not alone in taking a position against the specific design requirements included in the proposed Rule. Even one of the NRC staff's principal contractors, Sandia National Laboratories, has stated "If a constant release rate and a groundwater travel time greater than approximately 500 years is assumed, then the presence of (a) canister has little effect on releases."

We understand that on November 2, 1982, the NRC staff is scheduled to brief the Commission on alternative procedures to finalize the technical criteria portion of 10 CFR 60. Given our concerns with the requirements of the Rule as presently drafted, we urgently request an opportunity to present to the Commission our concerns and to suggest alternatives which we believe will significantly improve the Rule. Unfortunately, senior members of DOE management will be out of the country on November 2. Consequently, we request that the Commission reschedule the NRC's staff presentation to a mutually convenient time. Additionally, we request that the Commission defer any action on this matter until we have had an opportunity to present our concerns to the Commission.

Thank you for your consideration of our request. I am sure that we can work together to develop a useful, technically sound rule.

Sincerely,

Shelby T Brewer
Assistant Secretary
for Nuclear Energy

Enclosure

cc:
John F. Ahearne, Commissioner
James Asselstine, Commissioner
Victor Gilinsky, Commissioner
Thomas Morgan Roberts, Commissioner

Enclosure

SUMMARY OF OTHER PARTICIPANTS' COMMENTS

I. SYSTEMS APPROACH

Many commentors supported the systems approach to performance assessment and suggested elimnation of subsystem performance requirements. A few of these comments are quoted below.

NRC Advisory Committee on Reactor Safeguards

". . . we believe that the licensee should be given a greater degree of flexibility for compliance with the overall safety goal. One approach would be to emphasize the fact that the NRC will be evaluating the anticipated performance of the total waste repository as a system, in contrast to the performance of its individual components. Since we foresee only one or two repositories being built within the next several decades, we believe that each should be evaluated in relation to overall performance on a case-by-case basis."

American Nuclear Society

". . . ANS strongly recommends that all subsystem numerical performance requirements be deleted in favor of more general statements permitting system trade-offs to achieve the desired overall system or repository performance. Specifically, the following values should be deleted:

1000-Year Waste Package Life (Section 60.111(b)(2))
10[illegible] Long-Term Release Rate (Section 60.111(b)(2)(ii)(A))
1000-Year Undistrubed Water Travel Time (Section 60.112(c))
50-Year Retrieval Time (Section 60.111(a)(2))"

"It is our concerted view that overly restrictive and specific performance standards are not necessary, and that such standards in regulation form are likely to add to the overall cost of waste disposal without achieving any degree of benefit to the public health and safety. Instead, using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. The application of such a single performance standard would not only coincide with the Environmental Protection Agency's recommended approach of the systems concept, but would permit repository designers to optimize the repository as a system of both natural and engineered barriers for differing site and geologic medium characteristics."

Utility Nuclear Waste Management Group

". . . the NRC barrier performance objectives approach, as embodied in the current proposed regulations, can only be viewed as the arbitrary imposition, on individual system components, of special-value standards that are without scientific or other technical support."

". . . we cannot agree that the inclusion of such component requirements will increase the ability to show compliance with an overall system performance requirement (e.g., EPA protection standards), since such a showing will necessarily involve the use of mathematical models independent of specific component performance requirements."

"UNMWG is firmly of the view that overall repository performance should be addressed directly by means of the systems approach. Utilization of an overall performance standard would correctly serve to focus attention on total repository performance. In addition, it would provide for appropriate design flexibility; something which is important in order to both be able to take advantage of new developments, as this new undertaking proceeds, and to accommodate and effectively utilize the specific characteristic of individual sites."

National Research Council/National Academy of Sciences

"The BRWM (Board on Radioactive Waste Management) questions the adequacy of the proposed numerical criteria to accomplish these (their) purposes." . . . "Specifically, our conclusions regarding the proposed numbers are as follows:

1. NRC has not presented adequate evidence that these numerical criteria can "support a finding of no unreasonable risk to the health and safety of the public" . . .

2. NRC has not shown that these numerical criteria are either necessary or sufficient to meet the "EPA Standard." . . .

3. It has not been shown that adoption of the numerical criteria will simplify the licensing process . . .

4. No attempt has been made to demonstrate the technical validity of the proposed criteria. . .

5. NRC has not shown how the proposed numerical criteria for the waste package can be verified . . ."

". . . we recommend that precise numerical criteria for major elements of the repository system be eliminated."

II. 1000-YEAR WASTE PACKAGE

The NRC received many technical comments questioning the validity of the 1000-year waste package containment requirement. A few of the comments are quoted below.

Lawrence Livermore Laboratory

"The zero-released containment limit as proposed by the Commission is not necessary because more reliance can and should be placed on the other barriers . . ." "In addition, it should be recognized that small releases are not intolerable, in view of the vast inventory of naturally-occuring radionuclides in the earth's crust . . ." "The containment time proposed by the Commission is not reasonable because the function of the waste package should be to provide containment primarily during handling and shipping, including possible retrieval, not long-term containment."

American Nuclear Society

"The requirement for a 1,000-year containment period by engineered barriers is grossly excessive and unsupported by scientific fact." "NRC claims that the basis for the choice of 1,000 years is mainly that the heat induced by the waste in the geologic medium will increase the waste package leachability and reduce the near-field transport time, with the net result that the radiological source term from the "distrubed zone" increases. NRC does not argue that the 1,000-year containment period is necessary to reduce the overall radiological releae to man's environment to an acceptable level."

It is agreed that the postulated release from the underground facility would be accelerated due to resulting higher temperatures in the geologic medium but, generally, the calculational models used do not take credit for any holdup or delay of radionuclides in the region of relatively higher temperatures. Rather, the radiological source term for the far-field transport models are derived directly from the waste package release rate as if the heated geologic medium region or "distrubed zone" did not exist. Thus, any acceleration of release from the underground facility due to temperature effects has already been discounted and, therefore, should not be used to penalize the waste package design."

Dr. T. H. Pigford, University of California at Berkeley

Dr. Pigford has prepared a detailed analysis of the NRC's proposed 1,000-year waste package containment period. Seven areas were analyzed: (1) the NRC's purpose; (2) the importance of 1,000-year containment to overall performance; (3) temperatures assumed by the NRC; (4) temperature effects; (5) extrapolation from current knowledge; (6) compliance verification; and (7) cost estimate.

Dr. Pigford summarizes:

"The above analysis shows that NRC's proposed criterion that the radionuclides be confined within the waste package for 1,000 yr is without adequate or valid technical foundation, is based upon questionable assumptions, and may not be important to long term public health and safety. There is no showing by NRC that the proposed criterion is necessary or sufficient for NRC's stated purposes."

Environmental Protection Agency

"Although we strongly support the multiple barrier approach, we think that the 1000 year waste package requirement may be excessive. Studies published by the Electric Power Research Institute (EPRI) and confirmed by EPA indicate that in almost all situations improvements in canister life are less important for reducing long-term risks than improvements in waste form or careful selection of site characteristics. If the waste package lasted only a few hundred years, it would guard against uncertainties during the period of greatest heat generation; however, the 1000-year life requirement for the waste package could necessitate the use of very expensive or exotic materials (such as titanium) for waste canisters. The supporting documentation for the rule does not consider the potential cost of this requirement. In light of the relatively small benefits and possible high cost, we believe the Commission should reexamine this requirement."

Institute of Electrical and Electronics Engineers

"The 1000-year requirement for Waste Package integrity would probably be unduly restrictive in cases where engineered barriers are available and/or groundwater travel times are longer than 1000 years. In addition, it may be prohibitively difficult and expensive to fabricate waste packages that will remain intact for 1000 years, and impossible to provide assurance that the requirement will be met."

III. RELEASE RATE REQUIREMENT

The NRC proposed release limit of one part in 100,000 per year was also disputed by most of the technically qualified commentors.

Dr. T. H. Pigford, University of California at Berkeley

"The numerical specification of a fractional release rate of 10^{-5}/yr is of questionable importance to long-term safety and is proposed without a technically valid basis and with invalid assumptions of existing technology and cost if such a numerical criterion were adopted, compliance could probably not be verified. It would be more appropriate for NRC to state the considerations which may help guide DOE in its development and proof of the waste package as one of the possible barriers that may aid in meeting whatever safety standards that emerge."

Dr. H. P. Ross, Geophysical Consultant

"The one part in 100,000 release requirement for the engineered system again will be impossible to verify and ignores the positive features of a good geologic site to contain or delay transport of radionuclides. The requirement as stated requires engineering overkill for a single component of the system which will be unnecessarily costly and still impossible to verify. Sorption, long travel paths, and dilution all tend to offset the effects of release from the engineered system."

IV. 1,000-Year Groundwater Travel Time

Several commentors disagreed with the 1,000-year groundwater travel time requirement.

Dr. T. H. Pigford, University of California at Berkeley

"NRC has not shown need or adequate technical basis for its proposed numerical criterion for water travel time. It would be more appropriate for NRC to state its considerations of water travel time as a contributor to overall safety performance. It would be appropriate for DOE to have the flexibility to select sites with water travel times sufficient so that, in combination with the other properties of the site and of the engineering design, there will be reasonable assurance that a regulatory specified overall performance standard will be achieved."

Institute of Electrical and Electronics Engineers

"Placing the requirement on water travel time, rather than on radionuclide travel time, may, in effect, result in focusing on an implicit assumption that no retardation occurs. This is another compounding conservatism."

V. INTERNATIONAL COMMENTS

Agencies from two countries, the Netherlands and the United Kingdom, were concerned about the performance criteria proposed by the NRC.

Netherland Energy Research Foundation

" . . . there should be only one approach for setting performance criteria for a high-level waste repository. That approach should be the prescription of a single performance standard for the overall disposal system." . . . "It is only by means of an iterative process of safety assessment and repository system improvement that the relative importance of the different components to the overall system can be evaluated."

"At least for a carefully designed HLW-repository in salt the waste package is therefore not a key component of the overall engineered system . . ."

"The restrictive containment or confinement of the radioactive waste to its waste package is an irrational requirement. The boundary of confinement can easily be shifted more outward without any consequences from the point of view of radiological hazard to man and his environment."

Department of the Environment, United Kingdom

"Document 10 CFR 61 illustrates the setting of overall performance objectives whilst allowing some flexibility in designing and operating each individual repository, whereas document 10 CFR 60 appears to set acceptance criteria not always justified by technical evidence."

"The rule has been developed in the absence of raidological protection criteria (environmental standards), for disposal of high-level wastes; the proposed technical criteria are, therefore, arbitrary. This approach to setting technical criteria is incorrect in principle. It leads to criteria which are inflexible because, since they have no clear basis, there can be no basis for changing them. In addition the approach is very likely to lead to criteria which are too restrictive, thus causing more expenditure on high-level waste disposal than is warranted by radiological protection consideration."

"The rule does not define in any detail the means by which compliance with performance objectives is to be demonstrated. As a consequence the proposed performance objectives have little meaning and it is very difficult to decide whether they are appropriate or achievable."

". . . the proposed rule is unsatisfactory and should not be adopted in its present form. It would be preferable to leave the rule in "proposed" form until the EPA standards have been published and until there is sufficient information available to derive technical criteria from these standards. The rule should then be revised."

"We feel that too many firm numbers are being laid down without sufficient experimental and theoretical justification. Particularly if disposal will not take place for many years it is better to set overall dose limits to define the required performance of the multiple barrier. It is then up to designers to optimize the individual elements in the system as models and experimental data are improved over the years. The proposed rule would freeze options too soon."

, that in a
the public
ether towards
gulations.
agencies and

ASSESSMENT OF TECHNICAL CRITERIA OF 10CFR60 FOR GEOLOGIC DISPOSAL OF HIGH-LEVEL WASTE

M. S. Y. Chu
N. R. Ortiz
R. E. Pepping
M. D. Siegel

Fuel Cycle Risk Analysis Division
Sandia National Laboratories

The Environmental Protection Agency (EPA) has issued a draft standard (40CFR191)[1] which specifies permissible radionuclide release limits from a repository for high-level waste to the accessible environment. The U. S. Nuclear Regulatory Commission (NRC) has published a proposed rule (10CFR60)[2] which specifies technical criteria for geologic disposal of high-level waste designed to facilitate compliance with the EPA draft standard. One of the purposes of the rule is to enhance NRC's confidence that the EPA standard will be met. NRC has requested support from Sandia National Laboratories (SNLA) in the assessment of the 10CFR60 technical criteria and their relation to the EPA draft standard. The assessment includes but is not limited to:

1) Evaluating the effect of the 10CFR60 numerical-technical criteria on reducing the risk and/or uncertainties associated with meeting the EPA draft standard.
2) Identifying potential modifications of 10CFR60 to further reduce the risk and/or uncertainties of meeting the EPA draft standard.
3) Identifying possible interpretations of the numerical criteria and their impact regarding compliance with the EPA draft standard.
4) Identifying the state of the art for assessing compliance with the 10CFR60 numerical criteria.
5) Assessing the impact of the non-quantitative criteria in 10CFR60 on the risk to the public.

This paper presents preliminary results and observations related to item (1) above. The other issues will be addressed before completion of the project which is scheduled for September 1982.

The impacts of the following three numerical-technical criteria on compliance with the EPA draft standard were examined:

1) Waste package containment of at least 1,000 years.
2) Control release rate of at most 10^{-5} part/year from the underground facility.
3) Groundwater travel time of at least 1,000 years to the accessible environment.

In this study all the calculations are limited to the post-closure period and only transport by groundwater is considered. The waste containment period is considered synonymous to canister lifetime, and radionuclide release from the underground facility begins immediately after the waste containment period. The preliminary results of the analysis are expressed in terms of a "release ratio" (RR). This ratio is defined as $\sum Q_i/(RL)_i$ where Q_i is the cumulative release of radionuclide i over 10,000 years; $(RL)_i$ is the release limit for radionuclide i from 1,000 metric tons of heavy metal (MTHM) as specified in the EPA draft standard.

The analysis consists of three sets of parametric calculations:

1) Generic parametric analysis.
2) Parametric analysis including geochemical retardation for basalt.
3) Parametric analysis for a hypothetical basalt site.

In the first set, a simple model with point value estimates of input parameters was specified. No assumptions about the variability or uncertainty in input parameters were made and no credit for retardation of radionuclides by geomedia was considered. In the second set of analyses, ranges of input values for groundwater travel times and radionuclide retardation factors representative of basaltic host rock were sampled. In these calculations the effect of the uncertainty in input data upon the uncertainty in the release ratio was assessed. In the third calculation, release ratios for a hypothetical basalt site were calculated.

Generic Parametric Analysis

In this study, an inventory of 46,800 MTHM of spent fuel was assumed. For releases occurring with a probability greater than 10^{-2}, a release ratio of less than 46.8 indicates compliance with

the EPA standard. Integrated discharges over 10,000 years for radionuclides were calculated with the following assumptions:

1) All canisters fail at the end of the waste containment period t_c.
2) Release rate (τ $yr.^{-1}$) is a constant and is set at a specified fraction of the inventory present at time t_c.
3) Dispersion is neglected in transport.
4) Radionuclides in the inventory are divided into two groups. Group I consists of ^{99}Tc, ^{14}C, ^{129}I, ^{90}Sr, ^{135}Cs and ^{137}Cs which are assumed to be unretarded by all geomedia. Group II consists of all actinides and ^{126}Sn, which are assumed to be retarded by the same factor.

The DVM (Distributed Velocity Method) computer code developed at Sandia[3] was used to calculate the discharges of radionuclides with decay chains. Analytical closed-form solutions were used to describe the transport of single member radionuclides. Figure 1 shows release ratio for Group I (unretarded) radionuclides as a function of groundwater travel time and release rate. For example, with a release rate of 10^{-4} yr^{-1}, the EPA standard is violated by these radionuclides alone for sites with groundwater travel time less than ~7600 years. Figure 2 shows the results of similar calculations for the Group II (retarded) radionuclides. We calculated a set of "residual" release ratio curves (Fig. 3) for the radionuclides in Group II as $(46.8 - RR_{I,\tau_i})$, where RR_{I,τ_i} is the release ratio curve for the τ_i release rate in Fig. 1. We can estimate the amount of radionuclide retardation necessary to ensure compliance from these data. The minimum radionuclide migration time associated with a particular release rate that is needed to ensure compliance with the EPA standard is found at the intersection of appropriate RR curve for Group II radionuclides (Fig. 2) and the corresponding residual RR curve (Fig. 3). The minimum retardation factor for radionuclides in Group II is the ratio of this radionuclide migration time to the groundwater migration time. Table I summarizes the results of these calculations. The numbers in parentheses are results for a 1,000 year canister lifetime.

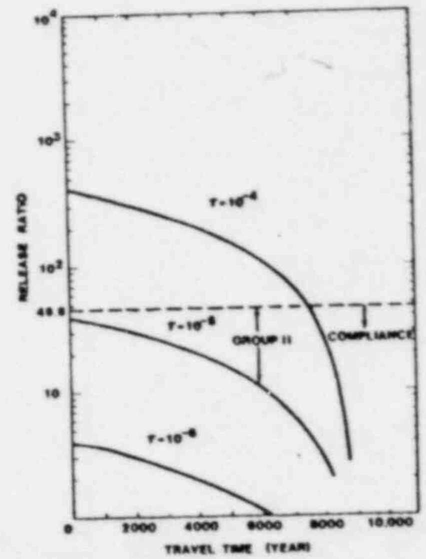
Table I. For Spent-Fuel Inventory.

For an Engineered System with:		And a Site with:	Need Minimum Retardation for "all other" RN's
Canister	Release Rate	Groundwater Travel Time	
300 (1,000)y.	10^{-3}/y.	9300 y. (8600)	Violation of EPA STANDARD
	10^{-4}/y.	8300 y. (7600)	Violation of EPA STANDARD
	10^{-5}/y.	500 y.	20 (18.2)
		1000 y.	9.9 (9.0)
		2000 y.	4.9 (4.5)
		3000 y.	3.3 (3.0)
		5000 y.	1.9 (1.8)
		8000 y.	1.2 (1.1)
	10^{-6}/y.	500 y.	18.5 (17.0)
		1000 y.	9.3 (8.5)
		2000 y.	4.6 (4.3)
		5000 y.	1.7 (1.7)
	10^{-7}/y.	1000 y.	7.7 (7.1)
		2000 y.	3.8 (3.6)
		5000 y.	1.5 (1.4)

The effect of different canister lifetimes (t_c, years) on the release of nuclides in Group I is shown in Fig. 4. Note that if a constant release rate and a groundwater travel time greater than ~ 500 years is assumed, then the presence of canister has little effect on releases.

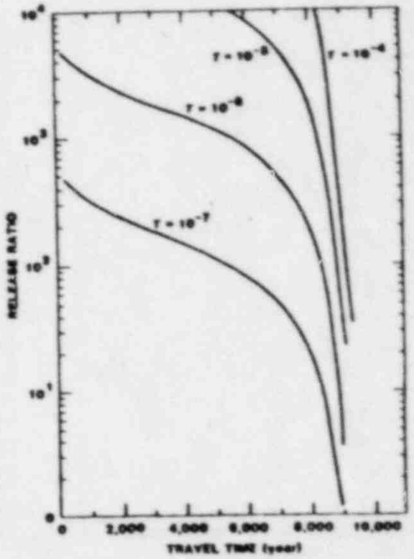
Temperature dependence of the release rate of radionuclides from waste form has been demonstrated in laboratory studies[4]. This temperature dependence can be converted to a time dependence. In Fig. 5 the results of similar calculations on the effect of canister lifetimes are shown when a time-dependent release rate is used. For our calculations we arbitrarily assumed a release rate of 10^{-1} yr^{-1} from 0 to 100 yr. after closure of the repository, 10^{-3} yr^{-1} between 100 yr. and 400 yr., and 10^{-5} yr^{-1} thereafter. When this release behavior is assumed, the significance of canister lifetime becomes apparent. Effort is underway to collect realistic data for time (temperature) dependent release rates.

Fig. 1



Release Ratio Curves for Group I Radionuclides. τ = Release Rate (Yr^{-1}), Canister Lifetime = 1,000 Yr.

Fig. 2



Release Ratio Curves for Group II Radionuclides. τ = Release Rate (Yr^{-1}), Canister Lifetime = 1,000 Yr.

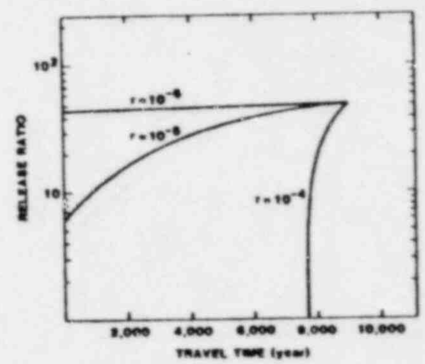


Fig. 3 "Residual" Release Ratio Curves for Group II Radionuclides.

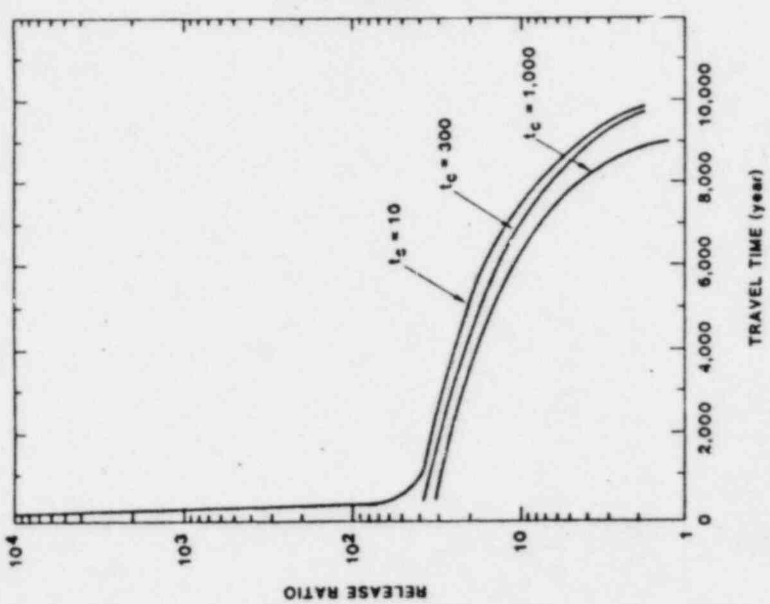


Fig. 4 Effect of Different Canister Lifetimes (t_c). Release Rate = 10^{-5} Yr^{-1}.

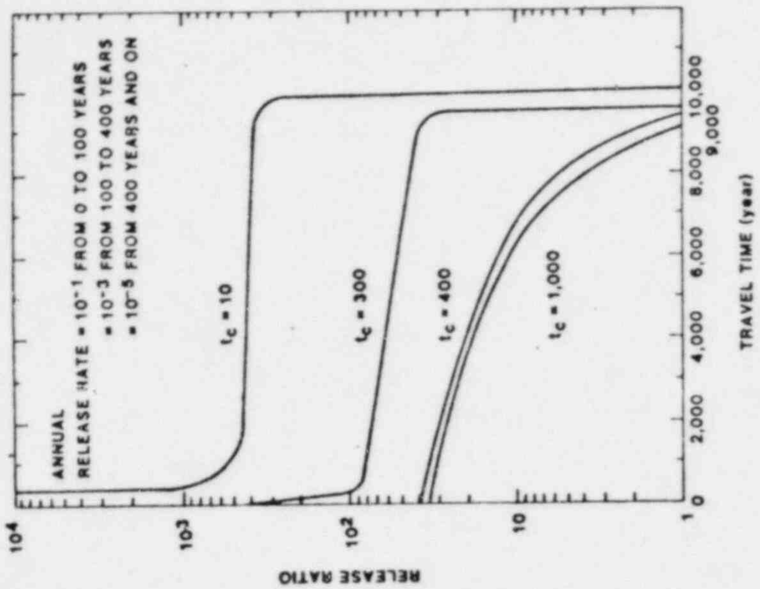


Fig. 5 Effect of Different Canister Lifetimes (t_c) for a Time-Dependent Release Rate.

Parametric Analysis Including Geochemical Retardation for Basalt

There are large uncertainties associated with many of the input parameters used in modeling the performance of a real waste isolation system. In our models, these uncertainties are treated by:

1) Assigning a probability distribution to the range of values for each parameter.
2) Dividing the input parameter ranges into finite intervals of equal probability.
3) Computing the consequence (using DVM code) for combinations of input values selected by the Latin-Hypercube Sampling technique (LHS)[5].

With this scheme, the uncertainties of input are reflected as a range of output values (consequences). The results are presented in a plot which shows the fraction of calculations with release ratio greater than some value.

In this analysis three sets of calculations were performed for an inventory of 1,000 MTHM of spent-fuel. Each set of calculation involves a parametric variation of one of the performance objectives of 10CFR60. Ranges of all other parameters were divided into 25 intervals and sampled by LHS. A computation was performed to calculate the release ratio for each combination of input variables. Ranges of retardation for each radionuclide in the inventory were chosen from the published data to represent the range of chemical retardation in a reducing basalt environment. The detailed geologic properties of a basalt site are not considered. Calculations were performed for several values of the groundwater travel time from the underground facility to the discharge location. The dispersivity was sampled over a range of 50-500 ft. The release rate was constant with respect to time for each calculation. The input data for each set of calculations are summarized in Table II.

TABLE II

SET	CANISTER LIFETIME (yr)	RELEASE RATE (yr^{-1})	GROUNDWATER TRAVEL TIME (yr)
1	100 300 500 1,000	(10^{-7} - 10^{-3})	(10^2 - 10^4)
2	300	(10^{-7} - 10^{-3})	200 500 1,000 5,000
3	300	10^{-3} 10^{-4} 10^{-5} 10^{-6}	(10^2 - 10^4)

Figures 6 through 8 presents the results of these calculations. In these figures, the curves indicate the fraction of calculation results in release ratios greater than the value on the abscissa. In Fig. 5 it can be seen that the waste containment period has little effect on compliance. Longer groundwater travel times and slower release rates result in a reduction in release as demonstrated by the shifting of the curves to the left in Figs. 7 and 8.

Parametric Analysis for a Hypothetical Basalt Site

These calculations were based on a hypothetical basalt site with the stratigraphy shown in Fig. 9. Ranges of hydraulic properties and retardation factors for radionuclides were assigned to each unit based on its postulated lithology and mineralogy respectively. Figures 10 and 11 show the two scenarios considered in this analysis. The first scenario is a base case (routine release) scenario; the second scenario involves fracturing the dense basalt unit that contains the underground facility. In these calculations 100 combinations of input values were sampled from the data ranges, producing 100 consequences for each scenario. Two canister lifetimes (300 and 1,000 yrs.) and two release rate

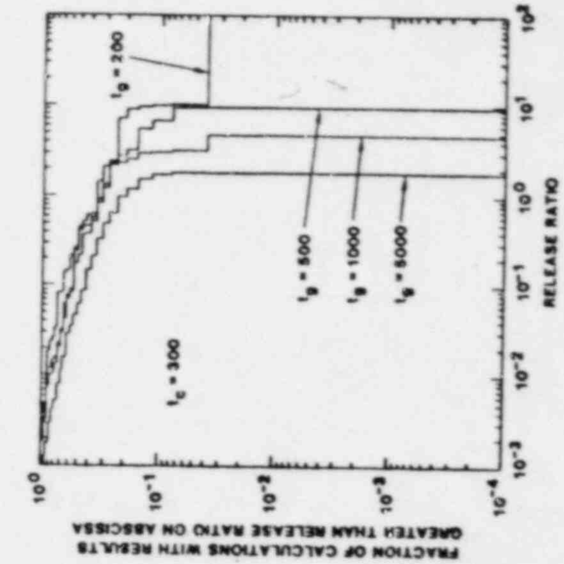


Fig. 7

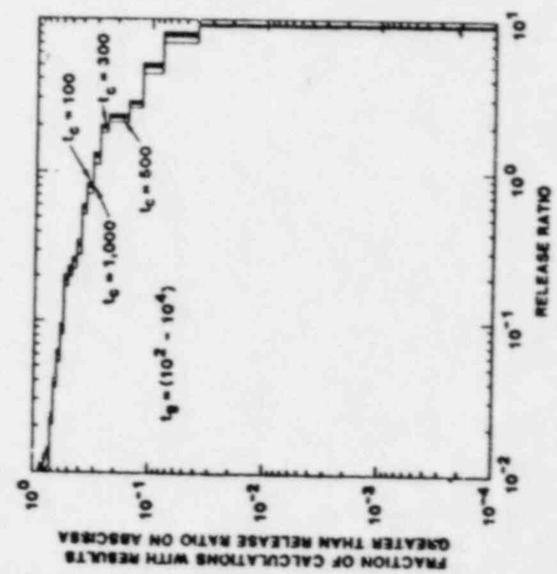


Fig. 6

Fraction versus Release Ratio Curves for a Generic Basalt Site.
t_c = Canister Lifetime (Yr), τ = Release Rate = (10^{-7} - 10^{-3}) Yr^{-1},
t_g = Groundwater Travel Time (Yr).

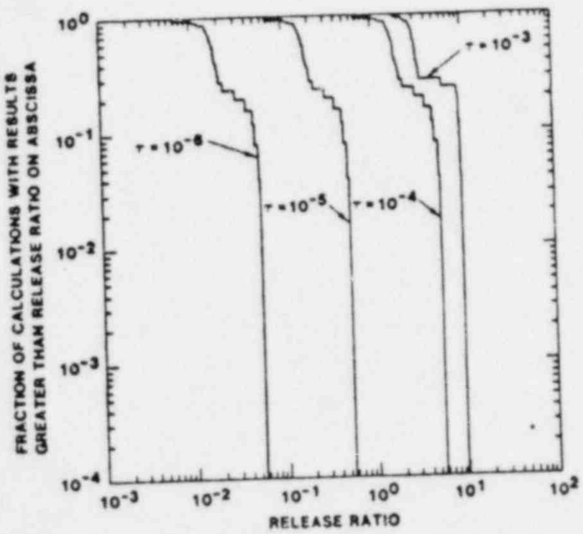


Fig. 8 Fraction versus Release Ratio Curves for a Generic Basalt Site. Canister = 300 Yr., τ = Release Rate, t_g = Groundwater Travel Time.

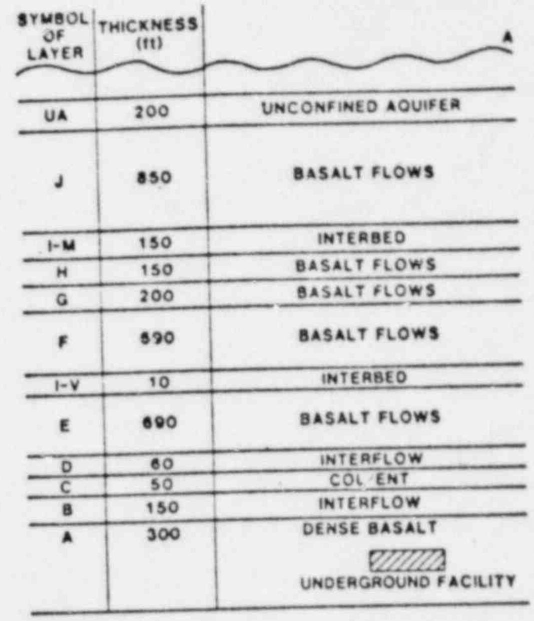


Fig. 9 Stratigraphic Cross-section of Hypothetical Repository in Basalt.

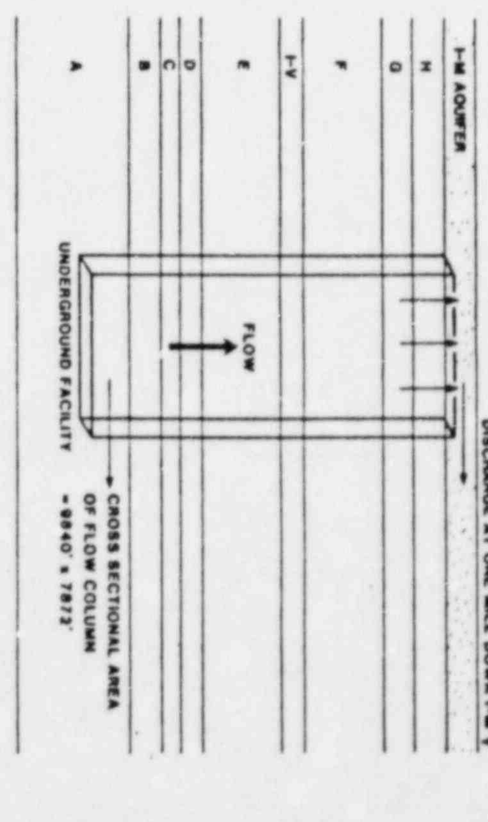


Fig. 10 Routine Release Scenario in a Hypothetical Basalt Site.

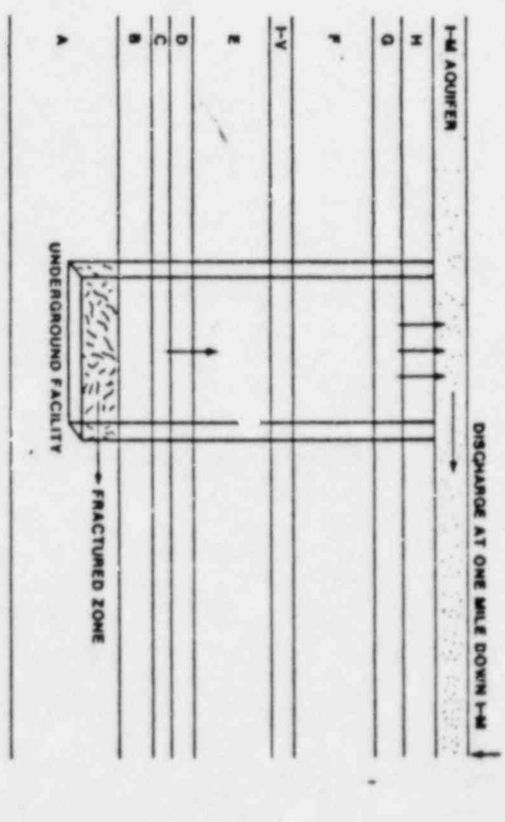


Fig. 11 Fractured Dense Basalt Scenario in a Hypothetical Basalt Site.

ranges (10^{-7} - 10^{-3} and 10^{-7} - 10^{-5} yr^{-1}) were considered. Figures 12 and 13 show the results of these calculations for Scenarios I and II respectively. These results are similar to those obtained from the generic parametric analyses. It can be seen that varying the lifetime of the canister has a minor effect on the shape or position of the fraction-release ratio curves when a temperature independent release rate is assumed. Variations in the groundwater travel time caused by choice of scenario or variability in hydraulic or geochemical parameters significantly affect the curves. Variation in the range of sampled release rates also has a strong effect on these curves. The shifting of these curves to the left could be interpreted as an increase in the safety margin with respect to compliance.

Summary and Comments

In these preliminary analyses, the ability of the three numerical criteria in 10CFR60 to facilitate compliance with the EPA draft standard was examined. It was found that the waste containment period had minor importance in assisting compliance with the EPA draft standard, if the release rate of radionuclides is independent of time (temperature). However, the waste containment period will have a significant impact if the release rate changes significantly with time (temperature). In the latter case, the regulation of the waste containment period, or the temperature at which radionuclide release could occur, may have a significant impact in meeting the EPA draft standard.

It was noticed that for relatively large release rates (>10^{-4}/yr.) and if some radionuclides were unretarded by the geo-media (e.g., ^{99}Tc and ^{14}C), these radionuclides alone could violate the EPA standard unless compensated by a good site (e.g., long groundwater travel time). For relatively smaller release rates (<10^{-5}/yr.) compliance with the EPA draft standard could be obtained if the site exhibited a minimum retardation factor for those radionuclides which could be retarded. In the present draft of 10CFR60, geochemical retardation of radionuclides is addressed only by non-quantitative (soft) requirements. In this study, minimum retardation factors were calculated for simple generic sites and for several combinations of groundwater travel time, release rate and canister lifetime.

The criterion on groundwater travel time showed a significant effect on compliance with the EPA draft standard. Sites with relatively long groundwater travel times will help in meeting the

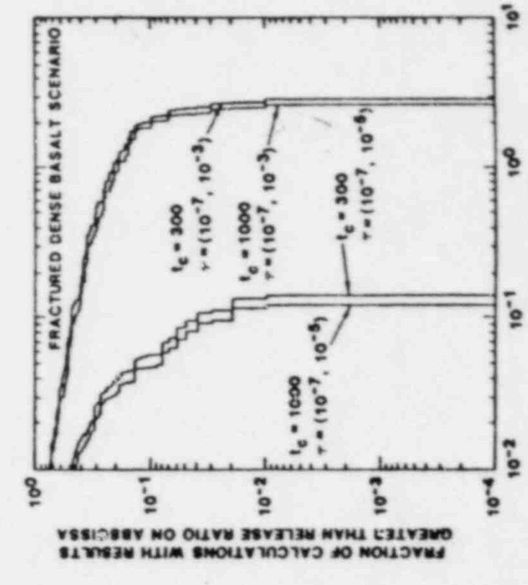


Fig. 13

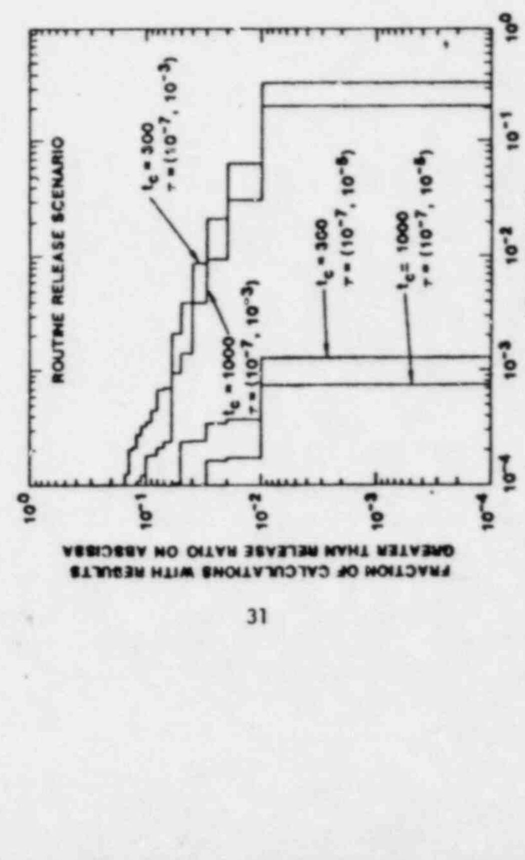


Fig. 12

Fraction versus Release Ratio Curves for a Hypothetical Basalt Site.
t_c = Canister Lifetime (Yr), τ = Release Rate (Yr^{-1}).

EPA draft standard. It is interesting to note that for very short waste containment periods (Figs. 4 & 5), the release ratio versus groundwater travel time curves show a large change in slope near 1,000 year groundwater travel time. This implies that in the event of premature failure of canisters, a site would have to have about 1,000 years groundwater travel time to prevent massive releases of radionuclides.

The 10CFR60 rule defines discrete minimum values for the performance objectives (technical criteria) in regulating the risk involved in HLW isolation. However, the characteristics of natural systems and the performance of engineered systems cannot be described without a degree of uncertainty. The calculations described in this paper demonstrate a method to estimate the impact on compliance with the EPA draft standard from uncertainties in the input data. Similar analyses can be performed to estimate the impact on compliance with the EPA draft standard from other interpretations of the performance objectives. For example, the values of the technical criteria may be set equal to the lower limit or the mean of a probability distribution which describes the engineered system performance or the natural variability of the site.

It is important to note that 10CFR60 also contains "soft" (non-quantitative) requirements described as favorable conditions and potentially adverse conditions for the geologic setting. These requirements shall be considered together with the numerical criteria in assessing the impact of 10CFR60 in reducing the risk and/or uncertainty in meeting the EPA draft standard. The above conditions intend to guide the applicant in selecting a site that protects the health and safety of the public. For example, compliance with these requirements could help to reduce the probability of having scenarios (e.g., faults, volcanic activity) which could lead to radionuclide releases to the accessible environment. An assessment of the impact of these requirements on compliance with the EPA draft standard will be performed.

REFERENCES

1. "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," 40CFR191, Draft #19, March 1981.

2. "Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Waste," 10CFR60, July 1981.

3. Campbell, J.E., et al., 1980, "Risk Methodology for Geologic Disposal of Radioactive Waste: The Distributed Velocity Method of Solving the Convective-Dispersion Equation," SAND80-0717, NUREG/CR-1376, Sandia National Laboratories, Albuquerque, NM.

4. Westik, J. and R. D. Peters, 1981. Scientific Basis for Nuclear Waste Management, Vol. 3: 356-362.

5. Iman, R. L., et al., 1980, "Latin-Hypercube Sampling (Program User's Guide)," SAND79-1473, Sandia National Laboratories, Albuquerque, NM.