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NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Ticket for
Bell
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MEMORANDUM FOR: John B. Martin, Director, Division of Waste Management, NMSS

FROM: I. Craig Roberts, Assistant Director for Siting Standards, SD

SUBJECT: DRAFT PAPER ON REGULATORY APPROACH TO HLW DISPOSAL IN GEOLOGIC REPOSITORIES

Attached, as promised in our November 15, 1979, meeting, is a draft paper setting forth for your consideration a regulatory approach to HLW disposal which is intended to form the basis for discussions with EPA on their HLW standard and to underlie the technical criteria being developed for 10 CFR Part 60. Please provide your comments to Pat Comella by Thursday, November 29, so that she can quickly turn around a revised paper.

Patricia A Comella for
I. Craig Roberts, Assistant Director
for Siting Standards
Office of Standards Development

Enclosure:
As stated

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A. A Question of Demonstrability

Demonstrability is the quintessential element of any finding connected with the licensing of a geologic repository for disposal of high-level radioactive waste. In establishing the approach which will underlie NRC's regulations governing the licensing of such a repository, a key question which must be satisfactorily answered is the following:

- Is it possible to license a geologic repository that relies on the geologic setting alone to contain and isolate the waste from the biosphere for the periods of time required to protect the public health and safety and the environment?

We - along with the technical community - believe that at this point in time and for the foreseeable future the answer to this question must necessarily be "No," but not because geology alone is incapable of isolating the waste. Rather, earth science cannot demonstrate conclusively that for all wastes in all credible conditions for the time periods involved, isolation has been achieved. The uncertainties which generate the lack of confidence arise from the limitations of our ability to fully understand and quantitatively model all the complex hydrogeologic, chemical, and mechanical processes which will or can be supposed to take place in a geologic repository. In fact, we really can't quantitatively separate the credible processes from the incredible. Because of this we turn to engineering - in the broadest sense of anything used to effect a purpose - as something in which we can secure a high confidence (even in understanding its practical limits) as a potential means of compensating for the uncertainties of earth science models.

B. Simplifying the Problem

The confidence we may have in engineered systems arises in part from experience in designing and building all variety of systems and structures and in part from ability to conduct controlled tests and experiments to verify the performance of design and construction. But this same experience and experiment tells us the limitations of engineering and, in this particular case, that we cannot rely on engineering to isolate all nuclear wastes until they are no longer hazardous. What role does engineering play? Basically, engineering can be used to compensate for the uncertainties associated with the geology and hydrology by narrowing the scope of geologic processes which need to be addressed in the "demonstration." By narrowing the scope of processes considered, we mean using engineering to provide mechanisms to insulate the wastes from the potential effects of certain geologic processes until such time or in such a way as to make the effect of such process understandable and predictable or, at minimum, boundable at some acceptable level.

Whether the specific scheme of engineering is a super waste canister, selected backfill to retard especially troublesome isotopes, geometric layout of waste emplacement to minimize potential effects of inadverdent human intrusion, or whatever, engineering must be assisted by prudent site selection. Citing once again the limitations of geologic and hydrologic models, obviously the more stable and simple - understandable - the site, the less is demanded of both the geologic models and the engineering. Similarly, the more compatible with the geology and insensitive to geologic processes the engineering, the fewer the demands that will be placed upon the site, and, hence, the greater the overall confidence.

C. Thrust of Technical Criteria

In light of the discussion above, it would appear that the direction the technical rule should lead is toward sites which are stable and relatively easily understood and to engineered systems which are compatible with and make the least adverse impact upon the geologic and hydrologic characteristics of the site, and, to the greastest extent possible, are insensitive to changes in those characteristics.

D. Multiple Barriers

How is this direction to be realized in the regulations? To answer this question, it is important to realize that for high-level waste: first, that the radiologic hazards of the waste diminish with time and that because, after about 1,000 years, fewer isotopes dominate the hazard, our understanding of the behavior of decayed waste is much greater than our understanding of the behavior of the original "hot" waste; second, that the less we understand of the behavior of the "hot" wastes independent of geologic setting, the less we can understand of the interactions between the "hot" waste and the geology, hence, the greater the uncertainty of demonstrating containment and isolation without reliance of some sort on engineering; third, that the period of greatest complexity and thus of uncertainty with respect to the behavior of the waste is on the order of 1,000 years; fourth, that it is possible to demonstrate with reasonable assurance that a set of engineered barrier(s) can be designed to function for such a period of time; fifth, that the definitions and descriptions of the barriers must fit with how the real world is organized, that is, the persons engaged in identification of appropriate geologic settings will have different backgrounds from those who are engaged in the civil engineering of the repository or in the waste form and packaging.

Based on these realizations, we conclude that the following descriptions and statements of purpose for the multi-barriers are appropriate:

1) Geologic barrier description: its purpose is to prevent - in the sense of the EPA standard - the wastes from reaching the biosphere;

2) Set of Engineered barrier(s) description: its purpose is to make the geologic problem tractible thereby increasing confidence that 1) above is realized. This is accomplished by designing the engineering to a) prevent the wastes from coming into contact with the geologic barrier at least during the period of greatest radiologic hazard (a period on the order of 1,000 years) and b) limit releases to the geologic barrier thereafter.

E. Specific Effects of the Limitation of Models

Considerations of the state-of-the-art in modeling over the next several years dictate in large part the characteristics of the barriers as follows: first, demonstration of whether the geologic setting at a particular site can fulfill the stated purpose of the geologic barrier relies fundamentally on the predictive power of the particular transport model appropriate to that site; second, the more complex the site geologically and hydrologically, the less reliable the transport model as a description of the steady-state; third, the less stable the site over time with respect to geologic and climatologic processes, the greater the uncertainty of any prediction; fourth, the more complex or less stable the site, the greater the difficulty in modeling behavior at the interface between the geologic barrier and the set of engineered barriers; fifth, because the lifetime of the set of engineered barriers transcends the normal lifetime of engineered systems, demonstration of meeting performance objectives on the engineering (necessarily a modeling exercise) is inherently more difficult than demonstration of meeting engineering design criteria, which may rely on consensus of the technical community. In light of these considerations, the regulatory approach underlying 10 CFR Part 60 will reflect a minimal reliance - to the extent possible - on modeling to demonstrate the capability of the geologic repository to contain and isolate waste from the biosphere.

Further, the regulatory approach will require - to the extent possible - the selection of "simple," "stable" sites in order to improve the reliability of the transport models. The set of engineering barriers will be compatible - to the extent possible - with the geology and hydrology of the site in order to simplify the boundary value model; and will minimize - to the extent possible - the sensitivity of the repository to changes in geologic setting. Lastly, requirements on the set of engineered barriers will be stated - to the extent possible - as design criteria rather than as performance objectives in order to insulate the demonstration process from reliance on modeling.

F. Development of Specific Criteria

For the same reasons that it is desirable to structure 10 CFR Part 60 so as to minimize reliance on modeling in the licensing process, it is desirable to specify technical criteria associated with the regulatable elements in such a manner as not to require the results of modeling as part of their technical justification. Further, to assure the workability and practicability of the regulation, it is important that the technical criteria reflect the way the world is organized. Thus, technical criteria will be largely developed through the consensus process in much the same manner as present-day industrial standards.

The consensus process is particularly appropriate to development of criteria for which neither experience nor recourse to experimental verification exist to provide the basis for the criteria. Through the best considered judgment of experts in the field, airing their views and technical reasoning in a public forum, a satisfactory if imprecise margin of safety for site characteristics and engineering design will be realized. When combined with models to compare and rank sites and designs, as well as to develop a scheme for comparison and ranking, the result will not only be the best technical effort of the NRC but represent the soundest technical judgment available from the scientific community.

G. Relation to EPA Standard

If our understanding of the earth sciences were sufficiently quantitative so that we could predict the result of the complex geological, hydrological, chemical, and mechanical processes which will govern the behavior of a repository for eons, then, literally we could plug in the numbers characteristic of the site and the wastes to be emplaced and grind out a simple yea or nay on whether to allow the wastes to be disposed of at the site. Predicting the risk (probability time consequence) of emplacing the wastes in a repository is really no different, although the manner by which the result of a risk assessment is stated might be more easily grasped by the general public or at least might appear so. The precise prediction of the evolution of the repository in time, considering all "credible" perturbations and changes to the hydrogeologic environment, is the key, regardless of whether a curie limit or a complementary cumulative distribution function is used to assess the results. However, we are not in a position to have any confidence in that sort of analyses for particular sites, let alone generically. Hence, we are constrained to implement the EPA standard not with a risk assessment, but rather by considering a few selected scenarios - some expected, some not - indicative of the kinds of "failures" which might occur at a repository and developing the site criteria and design criteria to assure that those conditions will be avoided or their consequences mitigated through site selection and engineering. Similarly, in applying the technical criteria to a review of a proposed repository or application to receive wastes, the potential effect of those selected scenarios on the proposed facility will be examined to determine whether an adequate margin of safety is provided.

The margin of safety, defined through the concensus process cited above, will be the determination of whether the EPA standard has been met.