To: NRC, WMES
Attn: N. Tanious
From: J. Daemen JD
Re: Retrievability
- Notes for a DOE/NRC meeting
- Comments on a generic NRC position
Date: 6-4-85

1. <u>Introduction: definition of 10 CFR 60 retrievability requirements</u>
   - quote applicable sections of the rule, in particular
     §60.21(c),(12):
       License Application
       §60.21 Content of application
       (c) The Safety Analysis Report shall include:
           (12) A description of plans for retrieval and alternate storage of the radioactive wastes should the geologic repository prove to be unsuitable for disposal of radioactive wastes.
     §60.111,(b):
       Performance Objectives
       §60.111 Performance of the geologic repository operations through permanent closure
       (b) Retrievability of waste
           (1)
           (2)
           (3)
     §60.132,(a); §60.133,(c):
       Design Criteria for the Geologic Repository Operations area.
       §60.132 Additional design criteria for surface facilities in the geologic repository operations area.
       (a)
       §60.133 Additional design criteria for the underground facility.
       (c) Retrieval of waste.

- quote in full or at least extensively the discussions on retrievability requirements from NUREG-0804.

In order to be able to come to a common NRC/DOE understanding on retrieval, it is essential to clearly and unambiguously identify the NRC position on retrieval. This can be accomplished most effectively by assembling in one place all the relevant rule requirements as well as the appropriate Staff Analysis (NUREG-0804) sections.

Quoting the rule as per above makes it immediately clear that the License Application must include retrieval plans, that the Repository Performance Objectives include Retrievability, and hence that the Design Criteria must address Retrievability.

The second item of point 1. of the 5/10/85 Draft of "Generic Retrievability Issues" is "Conditions for Retrieval." Does this mean conditions under which the Commission will require retrieval to be done, i.e., reasons for retrieval, or does it mean conditions under which retrieval will have to be conducted, i.e., in situ conditions during retrieval? This needs to be clarified.

In NUREG-0804, p. 10 (also Federal Register, Vol. 48, No. 120, June 21, 1983), it is explicitly stated " . . . that it would be imprudent to limit the Commission's discretion by specifying in advance the particular circumstances that would make it necessary to retrieve wastes." This is clear and explicit. Unless an NRC position change has taken place, the generic technical position is <u>not</u> to specify the conditions that will require retrieval.*

This leaves only the second interpretation, i.e., "conditions for retrieval" means conditions (the overall in situ repository situation) under which retrieval must be conducted. This could be a fairly complex and comprehensive topic, including design, operations, maintenance, etc. It is recommended to make this an entirely separate topic, and to limit point 1 of the agenda for the NRC-DOE meeting to an exposition of the NRC retrievability

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*It is equally clear that the Commission considers as the fundamental situation requiring retrieval " . . . should the geologic repository prove to be unsuitable for disposal of radioactive wastes" (10 CFR 60, §60.21,(c),(12)). This is further clarified by " . . . if the Commission no longer had reasonable assurance that the overall system performance objective would be met" (NUREG-0804, p. 10), and " . . . the option to retrieve the wastes must be preserved long enough to complete a program of monitoring and verification of repository performance" (NUREG-0804, p. 534), " . . . the option to retrieve should be preserved for the time necessary to emplace all of the wastes, complete a performance confirmation program, ..." An NRC decision on retrieval will be based on the conclusion that overall repository containment or isolation performance objectives cannot be satisfied, i.e., that a radiological safety hazard might exist or develop. If an identification is required of the conditions that might require retrieval, they must be developed on the basis of the above quotes from the Rule and from the Staff Analysis. This would require a major effort.

requirements, i.e., a comprehensive detailed presentation of the relevant sections in 10 CFR 60 and NUREG-0804. Point 2 might then be an exposition by DOE of the DOE position on retrievability.

2. Demonstration of Retrievability

DOE is required to provide, in the License Application, reasonable assurance that the retrievability option will be maintained. In order to provide this reasonable assurance, DOE will have to provide a detailed plan of how retrieval can be accomplished, thus demonstrating that the repository design accommodates the retrievability requirement.

Retrieval requires gaining access to the canister, removing the canisters from the repository, and surface storage or removal of the canisters. It will have to be demonstrated with reasonable assurance that each one of these phases can be accomplished, and can be accomplished under conditions expected throughout the retrieval period.

A retrieval plan will have to include a detailed assessment of what the conditions in situ are likely to be at the time when retrieval might have to be executed. Many conditions will affect retrievability, and need to be identified and described, e.g.:
- thermal environment
- canister, overpack, rock, backfill temperatures
- cooling loads, requirements, plans, if any

- canister location, position, orientation.
For any emplacement method or medium which might result in significant canister movement (e.g., emplacement in salt, or with a thick soft (clay) overpack), reasonable assurance will have to be provided either that the canisters will not be subjected to significant displacements, or that it will be possible to relocate the canisters with sufficient precision to allow retrieval.

- mechanical condition (strength) of the canisters.
An analysis will have to be provided of the mechanical condition (strength) of the HLW packages throughout the retrievability period. Such an analysis will have to include canister corrosion estimates under the expected repository environment (i.e., including thermal, hydrological, chemical and mechanical effects). The mechanical condition of the canisters could significantly influence whether certain retrieval schemes are technically feasible and radiologically safe (e.g., how much force can be applied to a canister to pull it out of a hole?).

- mechanical condition (stability) of emplacement holes.

By the end of the retrievability period the hole wall rock will have been exposed to high temperatures, high thermal gradients, high stresses, high stress gradients, etc., for several decades. The condition of the hole will determine whether some retrieval procedures are feasible or not. It therefore will be necessary, at the time of license application, to provide reasonable assurance that canisters can be removed from the emplacement holes after the emplacement holes have been subjected to repository conditions for several decades. This will require predicting hole deformations, especially if hole wall failures are likely to occur, and canister loads likely to result from such deformations.

- stability of emplacement rooms, access drifts, and shafts.

If the retrieval plans call for access to the canisters through previously mined repository excavations it will have to be demonstrated that the stability of these excavations can be maintained throughout the retrievability period, or that it will be feasible to re-establish stability of such excavations. Similarly, if retrieval plans were to call for new excavations, it would have to be demonstrated that technology will be available to excavate and stabilize the necessary openings under the in situ conditions likely to exist at the time of retrieval.

- mechanical equipment for removal from hole, hauling to shafts, hoisting to surface.

It is clear that demonstration of retrievability involves a complex sequence of events under a complex set of in situ conditions. The complete retrievability analysis and demonstration is very similar to the containment performance analysis. Although it covers a shorter period of time, it includes a number of additional features specific to retrieval. Uncertainties for all repository performance objectives have to be reduced through a program of in situ testing, and this also holds true for retrievability.

Relationship to in situ testing program

Retrievability will be affected by in situ conditions, examples of this are outlined above. It can be expected therefore that any in situ testing which will provide information about the repository host rock response, canister response, overpack response, etc., to waste emplacement conditions, actual or simulated, also will provide considerable insight into retrievability conditions. Hence, a first relationship between retrievability and in situ testing is that it would appear highly desirable for DOE to make a separate explicit interpretation of all results obtained during in situ testing in light of their potential

assistance in clarifying retrieval issues. This would concern in particular all those in situ conditions, examples of which have been listed earlier, that will impact retrievability.

A second aspect of the relationship between retrievability and in situ testing is that in situ testing should address key uncertainties that are specific to retrievability only or to retrievability primarily. Immediate examples of this might be removal of canisters from long horizontal holes, canister loading due to salt deformation at elevated temperatures and stresses, etc.

Time Frame for Demonstration

Reasonable assurance of the feasibility of retrieval must be provided in the license application. Hence the retrieval plans provided in the license application must demonstrate comprehensively, i.e., with inclusion of solutions to all probable retrieval difficulties, that the retrieval option will be retained for the required retrieval period. It is recognized that a true physical demonstration of retrievability, i.e., removal of canisters from holes and repository locations exposed to true in situ conditions for several decades is not possible. It is expected, therefore, that the required demonstration will include comprehensive analyses, predictions of rock and canister response, etc.

3. Basic Design Considerations

10 CFR 60, §60.111,(b)(1): "The geologic repository operations area shall be designed to preserve the option of waste retrieval . . . ."

§60.133,(c): "The underground facility shall be designed to permit retrieval of waste in accordance with the performance objectives of §60.111."

NUREG-0804, p. 9: "The Commission adheres to its original position that retrievability is an important design consideration."

p. 533: ". . . a license application that contains a detailed design and an analysis of the performance of the repository based on the site specific information . . . ."

p. 534: ". . . the option to retrieve the waste must be preserved long enough. . . . The design must also ensure that the option is preserved . . . ."

"For example, the thermal loading . . . will affect the temperature of the host rock and the stability of the underground structures . . . ."

It is clear that the design analysis presented with the license application must include a design analysis which will provide reasonable assurance that the retrieval option will be maintained for the period required by the Commission. This will require that DOE present an analysis of its repository design in terms of retrieval, i.e., DOE has to demonstrate, by means of detailed retrieval plans and designs, that any or all waste can be retrieved from the repository as designed. This will require in particular for the DOE to demonstrate that its design will provide reasonable assurance that

- access to all emplaced waste will be maintained or can be re-established.
- waste can be removed from its emplaced configuration, and from the repository.

In order to provide the Commission with reasonable assurance that the retrievability option is maintained, the DOE retrievability plans, analysis and design will have to address all factors that can reasonably be expected to complicate retrieval. Examples of such factors, and of their direct and indirect effects, include:

- thermal loading in the emplacement area, and consequences for retrievability:
  - temperature of the host rock in the emplacement area
  - temperature of waste and overpack
  - temperature of the backfill, if any, along the entire access routes to the waste emplacement holes
  - stability of access routes to and within emplacement area
  - stability of emplacement holes
  - stability, deformation, and expected corrosion of waste emplacement hole liners, if any
  - rock loads, if any, that might develop on canisters
  - ventilation requirements during retrieval
- technology requirements
  - gaining access to emplacement rooms, e.g., backfill removal, access route remedial stabilization
  - canister removal from emplacement holes

The retrieval design analysis must include a number of basic design considerations, for example:

- <u>Waste Emplacement Scheme</u>

Emplacement in short vertical holes would, in the present state of the art and based on demonstrations already performed,

provide much more assurance of the feasibility of removing waste from the holes than would emplacement in long horizontal holes. For the latter configuration much more detailed plans and designs might be required. Included will have to be reasonable assurance that the holes will remain stable, hence access easy, or alternative procedures for regaining access to the canisters.

- Thermal Effects

It is probable that thermal effects are among the most significant causes of likely difficulties to be encountered in retrieval. It will be expected therefore that the DOE retrieval design analysis will include predictions of the expected thermal regime in the repository area, and of its consequences (e.g., rock deformation and deterioration, backfill changes, water movement, steam generation, corrosion). These consequences in turn must be addressed in the retrieval plans.

In addition to the influence of thermal loading on in situ conditions, thermal effects on actual retrieval operations need to be considered. Consideration of the thermal situation during retrieval make it immediately obvious that retrieval is not simply an emplacement operation in reverse (NUREG-0804, p. 537). Retrieval design, in order to provide reasonable assurance of its feasibility, will have to address explicitly how retrieval operations will be designed to cope with the thermal loads generated by the emplaced waste.

- Use of Backfill in Emplacement Holes and Rooms.

The Commission explicitly recognizes that the retrievability requirement does not preclude backfilling (10 CFR 60, §60.111,(b),(2)). The staff requires that the retrievability design analysis include trade-off studies for backfilling (NUREG-0804, pp. 536/7). Hence, a repository design calling for backfilling prior to the end of the retrievability period must be accompanied by a retrieval design which demonstrates the feasibility of removing or remining backfill as required for regaining access to the waste. These retrieval plans will have to consider the temperature of the backfill, and the effects of its removal on room and hole stability.

- Performance of Liners

If the DOE retrieval plans call for access to the waste and removal of the waste through excavations and holes opened during repository construction, reasonable assurance will have to be provided that such openings will remain accessible, i.e., stable. Given the harsh environment, especially with regard to corrosion,

and the extended period of time for which the liners will have to be maintained, retrieval analysis and design will have to address in detail, with convincing evidence, a liner design that will perform as required to maintain stability throughout the retrievability period. Specific items that need to be included are liner temperature, liner stresses, liner corrosion (hydro-geochemical interactions at elevated stresses and temperatures).

- Stability of Openings

Retrieval would require that repository access routes be maintained in a stable condition, or that their stability can be re-established, or that new stable access routes can be driven. For all of these cases the influence of prolonged exposure to elevated temperatures and stress concentrations, possibly large displacements and hydro-geothermal chemical reactions poses unusual problems in assessing the stability of openings. This is true both with regard to the behavior of the rock itself and with regard to the performance of any support or reinforcement systems used to stabilize the rock. Providing reasonable assurance that the retrieval option will be maintained will require that the retrieval design analysis indicates how the stability will be maintained, i.e., how the rock will perform, how any reinforcement or support will perform, and how the interaction between the two will assure the stability required at the time of retrieval.

4. Media-Specific Issues*

The fundamental retrievability requirements specified in 10 CFR 60 are generic, i.e., they apply to any HLW repository, regardless of its particular site specific conditions. It is recognized that many if not most specific details of retrieval plans and designs will be site specific, because so many factors influencing retrievability are site-specific, e.g., opening stability, thermal loads, emplacement configuration, geochemical-corrosion effects, etc. (This strong site dependency helps explain the need for a close relationship between in situ testing and demonstration of retrievability.) Based on presently selected media and sites for site characterization, a number of media and site specific issues can be identified as being of particular concern with regard to the required retrievability demonstration.

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*The title of this section is media-specific issues, however, two of the three subtopics are highly site-specific, and even design-specific (e.g., long horizontal holes). The title/content needs consistency: is it the intention of NRC staff, in this section, to be media-specific, site-specific, design-specific, or all of these?

- SALT

It is widely believed in the technical community that retrieval of waste from a salt repository might prove extremely difficult. This places a particularly severe burden on the DOE to demonstrate through its detailed plans and designs for retrieval from a salt repository, backed up by at depth demonstrations, that reasonable assurance exists that waste can be retrieved from a salt repository. Examples of technical issues that need to be addressed are creep, opening stability and deformations, brine migration and its effects on canisters, overpack, and emplacement hole liners, if any, etc.

Creep affects many aspects of retrieval, e.g., canister location and orientation, canister loads at the time the retrieval option might need to be exercised, overpack deformation, emplacement hole closure, emplacement room closure, etc. Retrieval plans will have to provide credible predictions of expected creep along the entire access and removal routes, taking into account thermal and stress redistribution effects, and designs for maintaining or re-establishing access to the waste.

Opening stability, especially of emplacement holes and rooms, at the time of retrieval is of particular concern, because of the substantial strength loss suffered by salt when exposed to elevated temperatures.

- BWIP

The presence of high-yield aquifers under high pressure in close proximity to the repository level raises concern about the potential of repository flooding prior to permanent closure. It will be expected that retrieval plans address this concern, e.g., by providing reasonable assurance that any water inflows that can be expected to occur can be controlled or prevented, by demonstrating that retrieval from a flooded repository will be possible without creating radiological hazards, etc.

Core discing and borehole wall spalling suggests the likelihood of emplacement hole instabilities, of emplacement room and access drift instabilities, etc. Long term stability (e.g., throughout the retrievability period) of the repository will be of particular concern. The retrievability plans and designs will have to provide substantial evidence that access can be maintained or can be re-established.

Emplacement in long horizontal holes raises several issues. The feasibility of removing canisters from long horizontal holes has not been demonstrated. The stability of long horizontal

holes in a rock mass in which vertical joints might be frequent needs to be demonstrated.

- Yucca Mountain

Any design calling for emplacement in deep horizontal holes raises concerns about canister removal from such holes.

Intense fracturing of the rock mass at the repository level raises concern about stability of emplacement holes, especially so for long horizontal holes, and of the access routes.

The potential presence of geochemically very reactive rock and of extensive water (steam)--moist air flow raises concerns about corrosion of waste canisters, hole liners, and any rock reinforcement and opening support. If opening stability, and hence retrieval access, depends on any such measures it will be of particular concern to see the longevity aspects discussed in detail in retrieval plans and designs.