98 East Naperville Road
Westmont, IL 60559-1595

ENGINEERS INTERNATIONAL, INC.

Telephone: 312/963-3460
Telex: 9106511931
Cable: ENGINT

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High Level Waste Technical Development Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Attention: Mr. John Buckley, Mail Stop 623-SS

Subject: NRC Review of the DOE Letter Response to NRC Concerns on ES Construction and Sealing Methods

Ladies and Gentlemen:

Please find enclosed one (1) copy of our comments on the subject draft review. Our comments largely arise out of our reviews of the documents referenced in the DOE letter; as such, we have suggested additions, deletions, and changes in wording.

If there are any comments or questions, please don't hesitate to call.

Sincerely,

ENGINEERS INTERNATIONAL, INC.

Robert A. Cummings
Project Engineer

RAC/ko

Enclosure

1421

103/104/JJP/84/06/20/0

Mr. J. O. Neff
Salt Repository Program Manager
U.S. Department of Energy
National Waste Terminal Storage
Program Office
505 King Avenue
Columbus, OH 43201

Dear Mr. Neff:

The NRC staff has reviewed the DOE January 11, 1984 letter providing information on exploratory shaft construction and sealing. This material was provided in response to our letter of June 15, 1983.

The two broad areas of concern considered in our review are: 1) that the site characterization activities (e.g., construction of an exploratory shaft) will not compromise subsequent long-term isolation and containment capabilities of the repository; and 2) that plans for construction of the exploratory shaft will not preclude the acquisition of adequate information for site characterization. These two concerns are raised early (i.e. well in advance of license application) so that DOE commitments to construction techniques can be examined thoroughly prior to implementation.

Our June 15, 1983 letter, identifies information needs of construction and the NRC pertaining to six broad areas associated with exploratory shaft construction and sealing: 1) shaft and seal design considerations, 2) construction plans and procedures, 3) sealing and grouting plans and

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NAME	:JJPeshel:jec	:MSNataraja	:	:	:	:	:
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procedures, 4) construction testing and inspection plans and procedures, 5) plans and procedures for gathering specific information related to site characterization, and 6) quality assurance for all of the above. Specific NRC comments related to the DOE response associated with each of the above six areas are addressed in Attachment 1. NRC consultants' comments on the DOE response are provided for your information in Attachments 2, 3, and 4.

Our review has identified major concerns regarding the design of and research and testing needs for long-term sealing performance of the repository when blind drilled shaft construction is used. Related to that is the NRC concern regarding the potential use of the exploratory shaft for site characterization data gathering. These concerns are discussed in Attachment 1.

Based on the limited information provided in the DOE documents, the NRC staff has not identified any major adverse safety-related effects which might result from the exploratory shaft construction. However, additional information is needed as discussed in Attachment 1 of this letter.

We understand that DOE is considering a second exploratory shaft. Any changes or additions to the DOE program as described in your letter of January 11, 1984 which would result from this program modification would be subject to our future review when details are provided.

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NAME	:JJPeshel:jec	:MSNataraja	:	:	:	:	:
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If you have any questions covering the attached material, please contact John T. Greeves at (301) 427-4032.

Sincerely,

Engineering Branch
Division of Waste Management

Attachments:

1. NRC Comments on DOE response of January 11, 1984 to NRC June 15, 1983 letter.
2. Review of attachments to DOE letter of January 11, 1984 by Sandia National Laboratories.
3. Review of attachments to DOE letter of January 11, 1984 by Dr. J. Daeman, University of Arizona.
4. Review of attachments to DOE letter of January 11, 1984 by Engineers International, Inc.

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Attachment 1

NRC Comments On Doe Response of January 11, 1984 to

NRC June 15, 1983 Letter

I. Shaft and Seal Design Considerations

A. DOE states that the potential effects of shaft construction on the shaft-wall rock mass, which could adversely effect its long term sealing capability are 1 stress redistribution and excavation damage. Of these DOE considers the first to be more important. DOE further states that decommissioning seals can be designed to overcome the rock disturbance induced by these phenomena (per DOE references 7, 9, 10).

While NRC concurs that these two effects identified by DOE are indeed potentially significant and merit consideration, the NRC staff would like to suggest other potential phenomena that also merit consideration:

including block failures as well as squeezing or swelling ground, and flowing sand, for all potentially susceptible formations

- Shaft-wall collapse, and
- Rock mass disturbance, including flushing out of filling materials, ~~from the rock mass~~ when the liner is removed for decommissioning seal placement.

NRC review of the references quoted by DOE indicates that the references do not substantiate the conclusion that the decommissioning seals can be designed to overcome these disturbances. Rather, ~~it is the opinion of the~~ the NRC staff interprets ~~that the basic conclusion of~~ these references ~~can best be~~ as basically ~~summarized by~~ stating that further generic and site-specific in situ

testing of the seal designs presented in the references is required (as recommended by the designees themselves). Furthermore, the designs appear to be inconsistent with some of the latest principles of bulkhead design, (Auld, 1983). This reference, in fact, raises NRC concern as to the viability of the bulkhead design technique as selected by DOE. Some of these concerns are as follow:

° To key the bulkhead into the shaft wall requires more excavation which introduces further destressing. That could extend and create additional possible leakage paths through a larger area of the strata. This raises doubts as to whether the bulkheads should be keyed into the shaft walls at all.

° The length (vertical dimension) of the bulkhead should be substantial. The necessary length ~~and it~~ is governed by leakage resistance around the sides and through the surrounding rock. The longer length required for leakage sealing also ~~ensures low~~ minimizes shearing or bearing stresses at the concrete to rock interface. These design considerations are site-specific and require in situ testing.

° The optimum location of the bulkheads is of utmost importance and is decided on detailed knowledge of the ~~site-specific~~ geologic and hydrogeologic conditions, to be encountered in the shaft. The design should contain the flexibility to relocate or add seals as necessary to meet actual shaft conditions.

The NRC staff considers that these and other concerns about the design of the decommissioning shaft seals can best be answered by accomplishing a planned program of site exploration and in-situ testing and monitoring. The rationale for the design of bulkheads should be substantiated before further development is performed.

B. DOE states that the blind-hole drilling method in itself does not reduce uncertainties in long-term sealing, but states that there are advantages to the method as follow: "In comparison to conventional drill and blast methods, it can reduce the damage caused during excavation, and supports the shaft wall through the use of weighted drilling fluids."

The NRC staff notes that reference 7 given by DOE ~~presents~~ describe data needs and construction factors that underscore several disadvantages of the blind-hole drilling method (p. 53, p. 92, p. 98, 120), ~~as does DOE reference 6 (p. 4 and 5)~~. It appears to the NRC staff that ~~the disadvantages identified require~~ is warranted consideration of additional efforts on the part of DOE to offset the disadvantages and uncertainties of blind hole drilling, in assuring that long-term sealing can be effectively accomplished.

DOE Reference 6 (pp. A-4 to A-5) describes data critical to long-term sealing that cannot be collected directly from a blind-bored shaft; Reference 6 goes on (p. A-5) to indicate that the seals are intended only to protect against inundation.

C. DOE states that the DOE ES design specifications dealing with factors affecting sealing concern the short-term operation seals. The NRC staff considers that the ES design specifications should also address factors related to the long-term seals. Some of the seals placed at the time of ES construction will have to perform on a long-term basis (unless they are removed and replaced, which introduces further hazard and disturbance to the rock mass.), Also, the activities associated with the placement of short-term seals must take into account the potential long-term implications. The NRC staff suggest that some decommissioning seal designs be considered for construction of short-term seals. Advantage could then be taken of the oportunity to test the decommissioning seals during the operation of the repository, or ADT facility.

D. DOE describes the design and materials for operational and decommissioning seals. The NRC staff considers that although the WES-PSU developed materials and mix designs may have the sealing properties claimed, it has not been demonstrated that the seal systems constructed using these materials will provide sufficient sealing for the desired time periods.

The industry experience with the CSR is only limited to the last 20 years, and the experience (was not gained under conditions similar to a repository) ~~did not involve similar circumstances~~ (i.e. large diameter shaft, high temperatures, surrounded by water/brines). The DOE plan to manually place seals only at the base of the final casing will

not offset the lack of long-term experience. The NRC staff suggest that DOE considers placing long-term seals at additional locations.

E. DOE states that an EDBH will be drilled to obtain design and site characterization data. However, ~~no~~ available information ~~is presented as to the type of data that can be gathered nor is the location of the EDBH specified~~ as to the location of the EDBH or the data to be gathered from it do not confirm that the information from it will substitute for shaft-wall exposures. NRC request that DOE from this source identify the proposed location of this hole, ~~to show if it is coaxial with the future shaft or at some distance from it~~ with the shaft, If the drillhole is not coaxial, a discussion of how the EDBH is to be sealed should be provided. It appears that DOE does not intend that the EDBH will provide any characterization of the disturbed zone.

The DOE statement that there are no plans for testing the decommissioning seal components in the exploratory shaft is unfortunate and should be reconsidered (as explained in "C" above).

II. Construction Plans and Procedures

A. DOE indicates that acceptance criteria for construction of exploratory shafts will be developed in late FY 84 or early FY 85. These criteria need to address the requirements of 10 CFR 60 10.d(1) "to limit adverse

effects on the long-term performance of the geologic repository" by the shaft construction. Reference 8 does address these requirements only to the extent of very broad recommendations.

B. DOE states that damage to the rock mass can be minimized by the use of multiple liners and a controlled mud program. Our concern is how successfully the mud density can be maintained optimally throughout the shaft sinking process, so as to prevent shaft-wall ~~collapse~~ failure on the one hand and prevent hydrofracturing on the other. Mud records may not always be able to indicate occurence of hydrofracturing. It should be stressed that apart from taking all possible precautions to prevent strata damage, the DOE should outline procedures to mitigate damage that may occur. In large diameter shafts, large block failures may also occur (because more fractures will daylight in the shaft. Thus, stability must be addressed in all formations, not just those that caused hole stability problems in exploratory boreholes.). Oil well drilling experience with small diameter holes may not be fully indicative of all types of failure modes significant to the protection of the isolation capability of the site.

C. Since multiple liners are planned, ~~to be used~~, considerable attention needs to be devoted to complete grouting behind the liners to ensure that no voids are left. NRC recommends that DOE document the methods that are planned to positively locate any voids behind the steel lining and the procedures planned to adequately seal them.

The NRC staff is also concerned about seal problems associated with mud contamination of the shaft walls and the surrounding rock mass, and of mud contamination of the cement grout. It is requested that DOE provide an analysis of considerations affecting mud contamination and sealant performance. NRC also considers that an explanation is needed on how the proper precise locations for placement of the chemical seal rings behind the steel lining will be determined when placing the CSR's at the aquifer/aquatard and fresh water/brine interfaces.

III. Sealing and Grouting Plans and Procedures

A. DOE indicates that discussions of long-term seal performance are given in DOE references (7, 13, and 14). However, the documents do not give any research plans for work on mortars and concretes needed for sealing. It is the NRC staff's opinion that research is required to include studies on the strength and elastic properties of cement-based materials at elevated temperatures. The test program indicated for the CSR also needs to be conducted, including thermal stability of the long-term case.

B. DOE appreciates the problems to be expected because of voids in the grout behind the lining and indicates that these will be detected by bond logs. Due to the complex arrangement of ~~the~~ grout and vent pipes, this needs further

discussion, as explained in Section VI, Quality Assurance of this Attachment 1.

C. DOE states that a major inundation is not a credible event, however it must be recognized that inundations of salt shafts have happened (DOE reference 7).

The procedures presented to detect and to rectify seepages at any point in the shaft require further discussion. The NRC staff would like to know how seepage along liner-grout, pipe-grout and rock-grout interfaces will be detected; especially between the lowest aquifer above the salt formation and the top of the repository salt horizon. A temporary stoppage with grouting, without ascertaining the cause of the seepage, would leave the potential for the recurrence of the leak during the post-closure period.

IV. Construction Test Plans And Procedures

A. DOE states that test and inspection procedures used during excavation will be tailored to be compatible with the "blind-hole" drilling method. DOE has identified requirements to ensure that shaft diameter and verticality are maintained, stratigraphic information

required for verification of design is obtained, and that loss zones are identified. NRC is in basic agreement that both direct and nondirect inspection and test techniques compatible with the "blind-hole" drilling method are available to verify with sufficient precision shaft diameter and verticality. However, NRC harbors considerable doubt that sufficiently precise stratigraphic information can be obtained using the methods identified by DOE in the letter as compatible with "blind hole" drilling for verification of shaft and sealing design parameters. In particular, NRC has considerable doubt about the precision of the visual inspection of drill cuttings testing for confirmation of formation composition or for conformation of anticipated performance even when supplemented with the other drilling data identified by DOE. NRC recommends that DOE consider alternate ways of obtaining stratigraphic information including hydraulic conductivities, rock mass strength and characteristics of anomalies which may exist and document the consideration together with an analysis of advantages and disadvanatages of each approach.

B. DOE states that since the steel liner is designed to take the structural loads, the mechanical properties of the cement grout are not significant. Although NRC agrees that the liner can be designed to take the standard loads, NRC nevertheless considers it essential

that the cement possess adequate strength to resist failure induced by both static and dynamic loading conditions as failure of the cement could provide a path for water to flow. If any pipes are embedded in this grout, the problem becomes even more acute, since these act as stress raisers. (Jeffrey, 1980)

NRC also requests that DOE provide additional informtion regarding the long-term performance capabilities of the CSR materials. NRC recognizes the proprietary nature of the chemical, but nevertheless would appreciate all relevant data. We suggest that DOE consider placement of the manual long-term CSRs at several horizons, and not only near the bottom of the shaft above the repository horizon.

C. An explanation should be included to show what remedial action DOE contemplates if the bond logs reveal a low density cement.

D. DOE states that a Quality Assurance Program Plan and Manuals will identify management system requirements to satisfy anticipated licensing documentation needs, i.e., ANSI/ASME NOA-1. DOE also states that procedures will be progressively developed as definitive information becomes available by design documents and by site selection.

The NRC staff state that a description of the quality assurance program to be applied to the design, fabrication, construction, and testing should satisfy 10 CFR, Part 50, Appendix B as applicable. That should include information pertaining to the managerial and administrative controls to be used.

V. Plans and Procedures for Gathering Specific Information Related to Site Characterization

DOE states that it is their intention to obtain equivalent geologic information from sources other than the shafts. However no specific ~~information~~ plan is presented. The NRC staff request that DOE provide information as to what sources are to be used and how the information is to be obtained. The NRC considers it desirable for DOE to obtain a full suite of conventional logs from the ES prior to floating in the liner because drill penetration rates and cuttings provide only limited information. It would be desirable to obtain very specific information as to what other sources will be used to obtain this information, for example:

The continuity of strata conditions from place to place may or may not be reliable enough to establish conditions at untested critical localities.

° Rock Characterization of shaft walls (e.g. disturbed zone permeability; vertical joint spacing, frequency, continuity, and aperature).

° Groundwater Inflow

o Location and Condition of Instruments.

° Shaft Shape

o Unexpected Conditions

It is also recommended that DOE consider developing procedures for gathering data related to the capability of the site to accept the proposed grout and to the method for placing grout for sealing.

VI. Quality Assurance (QA)

DOE identifies the line of responsibility for implementing QA procedures down to and including the Construction Manager. DOE also identified the procedures to be used.

The NRC staff has identified some special quality assurance problems when blind drilling technique is used for the shaft construction and sealing:

° Any voids in the grout behind the shaft lining need to be detected, their effect on the shaft and seal integrity assessed, and remedial action taken. DOE states that "very large" voids will be treated remedially. The NRC staff is concerned that remedial methods should ~~be~~ described how to positively locate any voids behind the steel lining and how to adequately seal them.

Information is needed on what performance assessment techniques will be used to ascertain the void size below which no remedial action is required.

° Remedial action if shaft diameter is not maintained during construction should be described.

° The NRC staff is concerned about the potential for mud contamination of the shaft walls, surrounding rock mass and mud contamination of the cement grout. The drilling mud can affect the quality of bondage between the cement grout and the rock of the shaft walls. The mud can fill the voids in the surrounding rock and prevent an adequate seal by cement grout. Also any contamination of the cement grout by the drilling fluids will decrease the strength and other important qualities of the sealing grout. It is requested that DOE provide a

description of methods ~~how~~ to control this problem and what remedial action is proposed. The NRC is also concerned about similar effects on chemical sealing agents.

A discussion of the Geotechnical Quality Control Program for the design and construction phases of the exploratory shaft construction and sealing should be presented in the Quality Assurance Program. Areas to be addressed should include the 18 criteria of Appendix B, Part 50. Emphasis should be placed on identifying the geotechnical engineering parameters that are significant in design, identifying items to be controlled during construction, methods of testing and frequency of testing, verification efforts to insure that the design site characteristics and soil and rock engineering properties are met or exceeded during the construction phase; and timeliness of corrective actions as appropriate.

References

Auld, F. A. (1983), Design of Underground Plugs, Intl. Joul. Mng. Eng., v. 1, p. 189-228.

Jeffrey, University of Arizona (1980), Report to NRC