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Consulting Group, Inc.

9 April 1987

David Tiktinsky - SS623
U.S. Nuclear Regulatory Commission
Division of Waste Management
Washington, D.C. 20555

"NRC Technical Assistance for Design Reviews"
Contract No. NRC-02-85-002
FIN D1016

Dear David:

Enclosed is Itasca Review No. 001-02-33, "Task V, Engineering Study No. 5, Shaft Optimization" by RKE/PB (Rockwell Hanford Operations SD-ES-016 (Rev. 0), August 1984). Please call me if you have any questions.

Sincerely,

Roger D. Hart

Roger D. Hart
Program Manager

cc: J. Greeves, Engineering Branch
Office of the Director, NMSS
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ITASCA DOCUMENT REVIEW

File Number: 001-02-33

Document: "Task V, Engineering Study No. 5, Shaft Optimization", by Raymond Kaiser Engineers, Inc. and Parsons Brinckerhoff Quade and Douglas, Inc. (SDI-BWI-ES-016 (Rev. 0), August 1984)

Reviewer: Itasca Consulting Group, Inc. (Mark Board)

Date Approved: Roger Hart 4/9/87

Date Review Completed: 9 April 1987

Significance to NRC Waste Management Program

This document is the initial RKE/PB study to define the BWIP repository shaft diameters, number of shafts, drilling, and casing methods. The conclusions drawn here have effects on worker safety in that the lining method must be waterproof for the full hydrostatic load at repository depth. The number of shafts effects the required ventilation load, as well as the means for controlling repository air flow and isolation. The analysis presented here, therefore, inpacts the radiologic safety in the event that a canister breach (or other means of contamination) occurs during the pre-closure phase.

Summary

The purpose of this report is to examine the specification of the shafts for the BWIP repository. Analyses are presented in the following areas:

(1) shaft functional requirements for various repository design concepts;

(2) shaft diameter;

(3) number of shafts required;

(4) drilling methods* and components; and

(5) casing method.

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*Shaft sinking methods other than drilling are not seriously considered in this report.

The ultimate goal is to determine the development testing program required to establish the deep shaft technology required for this site. As a basis for this study, the Shaft Decision Memorandum (BWIP, 1983), and the Conceptual System Design Description (CSDD) [RKE/PB, 1983] were used. In the CSDD, five shafts were proposed, all within the shaft pillar area. Since the issuance of this report, another study, "Task V, Engineering Study No. 9 — Underground Repository Layout" (PKE/PB, 1985), has been released which sets the number of shafts to nine, places some shafts at the repository perimeter, and alters the ventilation pattern to allow separate intakes for the waste and non-waste panels.

The primary conclusions this report reaches are as follow.

1. A design using five shafts requires a minimum inside shaft diameter of 12 feet (3.7m). A 14-ft (4.3m) ID shaft is the most flexible design.

2. Steel and composite steel and concrete casings for these shafts are possible alternatives as lining methods. For 10-ft or greater ID shafts, the composite liner arrangement is slightly more economic.

3. RKE/PB judges that the largest diameter shaft which can confidently be drilled with existing technology is 14 feet (4.3m). It is felt by RKE/PB that technology can be developed which would allow 20-ft (6.1m) holes to be drilled. Single-pass drilling is preferred over multi-pass methods.

RKE/PB further suggests a field testing program to examine the conclusions and recommendations of this study. This program consists of a test shaft approximately 15 feet (4.8m) in diameter to a depth of 800 to 1,000 feet (240 to 300m) on the Hanford site. This program would test cutter and bit types and mud circulation methods. The objective is to develop technology capable of a 20 ft/day (6m/day) drilling rate.

Deficiencies, Problems, Limitations

This document provides a detailed examination of the existing shaft drilling and casing technology. The ventilation requirements obtained from the CSDD are used to estimate the minimum shaft diameter (finished) required for the assumption of five shafts. The conclusion reached is that a minimum diameter (finished) of 12 feet is required for ventilation purposes. The report details the calculations for design of a stiffened steel liner (either 50 or 100 ksi strength) as well as a composite steel-concrete-steel liner. This latter alternative reduces the required steel thickness, thereby somewhat reducing costs.

Several problems and deficiencies were noted in the above studies; these are described below.

1. Shaft Minimum Size — The CSDD establishes the number of shafts to be five*. For the expected ventilation load during backfilling (maximum load), a minimum finished shaft diameter of 12 feet is necessary. This results in peak air velocities of 3,500 ft/min (17.8m/sec) in the confinement air intake. The primary problem with this arrangement appears to be separation of the confinement and development ventilation system as well as the reversibility of the air flow and filtering of the exhaust and intake (confinement) air from either shaft using HEPA filters. This problem has been corrected in a revision of the underground design presented in RKE/PB (1985). In this later design, the number of shafts has been increased to nine. The capability for ventilation reversal and filtering at the confinement intake has been added. The confinement and development systems have been made into totally separate systems as well. The addition of four shafts has also allowed the reduction of air velocity in the service shaft to 2,000 ft/min (10.2 m/sec). Based on this new design, the 12-ft minimum ID appears reasonable from a ventilation standpoint.

2. Shaft Drilling Technology — The report indicates that a 14-ft drilled diameter, single-pass shaft is the maximum size which can be confidently drilled at the Hanford site with existing technology. There is some confusion in the report since a 16 to 17-ft drilled diameter shaft is necessary to produce a finished 12-ft diameter shaft as suggested in the present document as well as in RKE/PB (1985). All previously drilled shafts were examined as a basis

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*The five shafts are: (1) confinement air exhaust; (2) waste transport; (3) confinement air intake; (4) service shaft; and (5) basalt transport.

for this conclusion. In particular, there were only eight shafts of radius 10 feet or greater which have been drilled beyond 2,000 feet in depth. Of these, only two were larger than 11 feet. Only a few shafts have been drilled in rock as hard as that found at Hanford.

In our opinion, the importance of the in-situ stress state at the Hanford site has been largely ignored and may have significant implications regarding the difficulty in shaft drilling. The high magnitude, highly deviatoric stresses (see Kim et al, 1986) will likely result in some form of instability of the shaft walls or bottom during drilling. The confining pressure exerted by the drilling mud will reduce the deleterious effects of the stress, but problems such as rockbursting at the bit and in the walls and hole wall sloughing along an East-West line appear probable. The effects of these phenomena on the drilling performance are unknown at this time.

3. <u>Shaft Casing Design</u> — Calculations were presented for the design of stiffened-steel and composite steel-concrete-steel liners. In this document, the loading provided to the liner is simply the weight of the liner and the hydrostatic water pressure applied the liner exterior. The liner is to be designed and installed to QA Level 1 specifications as a result of the serious worker safety implications in the event that formation water leakage occurs as a result of liner failure. Several additional sources of loading have been ignored in the analysis. These are:

   (a) seismic loading from earthguake or microearthquake activity;

   (b) loading due to non-linear (plastic or viscous) response of the rock mass upon dewatering of the shaft;

(c) loading due to sloughing of the wall rock, resulting in possible point-loading of the liner*;

(d) expansive grout pressures; and

(e) loading from shaft conveyance.

Of the above, the first three may be significant and result in a change in the casing design. These factors have been recognized in a recent design study (RKE/PB, 1986), however, calculations have not been presented which verify the design presented in the subject report. At a minimum, we believe calculation should be presented for the rock loads provided to the liner for the most conservative in-situ stress conditions and rock properties.

Finally, the report states that the liner and grout will be removed upon closure of the repository. Therefore, the liner itself plays no role in isolation.

Recommendations

No further recommendations are necessary at this time.

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*Ample abundance of core-disking and hole wall sloughing from small diameter holes is reviewed in Kim et al (1986).

References

BWIP. "Shaft Decision Memorandum", Rockwell Hanford Operations SD-BWI-PD-001, March 1983.

RKE/PB. "Conceptual System Design Description, Nuclear Waste Repository in Basalt (CSDD)", Rockwell Hanford Operations SD-BWI-SD-005, 1983.

RKE/PB. "Engineering Study Number Nine, Underground Repository Layout", Rockwell Hanford Operations SD-BWI-ES-023, January 1985.

Kim, K., S. Dischler, J. Aggson, and M. Hardy. "The State of In Situ Stresses Determined by Hydraulic Fracturing at the Hanford Site", Rockwell Hanford Operations RHO-BW-ST-738, February 1986.