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Consulting Group, Inc.

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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 our review of the document "Task V. Engineering Study No. 6, Tunnel Optimization," by Raymond Kaiser Engineers, Inc. and Parsons, Brinkerhoff, Quade and Douglas, Inc., (SD-BWI-ES-015, Rev. 0, May, 1984). Please call me if you have any questions.

Sincerely,

Roger D. Hart
Program Manager

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ITASCA DOCUMENT REVIEW

File No.: 001-02-34

Document Title: "Task V, Engineering Study No. 6, Tunnel Optimization," by Raymond Kaiser Engineers, Inc. and Parsons, Brinkerhoff, Quade and Douglas, Inc., (SD-BWI-ES-015, Rev. 0, May, 1984)

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

Approved: Roger D. Hart

Date Approved: July 3, 1987

Significance to NRC Waste Management Program

This study provides the background evaluation of various repository layouts, drift sizes, shapes and rock support methods which have fed into the present conceptual design of the repository at Hanford. The document therefore provides the background details which are necessary in reviewing the Conceptual Design Report.

Summary

This document is a re-evaluation of the physical layout, excavation methods and rock support techniques which were specified in the 1983 Conceptual System Design Description (CSDD) (RKE/PB, 1983). This re-evaluation is based on additions to the geomechanical date base in the year since the 1983 study was completed.

The two primary objectives of this document are:

(1) to examine drift shapes and sizes, excavation methods, rock support methods, and repository layouts in order to provide a basis for concept selection for the "upgraded" conceptual design (i.e., the re-evaluation of the 1983 CSDD); and

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(2) to examine the availability of current technology in order to determine if development or testing is needed or warranted for repository construction objectives, based on performance requirements for design and construction, and to provide data for decisions to use and develop new or improved technology.

This study still does not center design efforts on the Cohassett flow alone, even though it had been selected at the time of the report preparation. Therefore, the study is not site specific, although the rock properties and initial conditions are very near the laboratory values for the Cohassett.

The drift dimensions were determined from the functional requirements (i.e. size of expected equipment and services), which are derived from ventilation, equipment to be used, utilities and safety considerations. Other considerations used are rock mass stress and strength and flexibility of the method. It is determined that an elliptic horseshoe shape aligned with the maximum stress is optimum.

Three methods of excavation are examined:

(1) drill-and-blast;

(2) tunnel boring machine (TBM); and

(3) partial face borers (PFB).

Although the TBM disturbs the rock mass less, it is restricted to circular geometries of large cross-section with a very large turning radius. The large turning radius results in a much increased areal extent of the repository if used for all excavation. The PFB can excavate non-circular cross-sections while resulting in less rock disturbance; however, it is, in general, less economical than standard drill-and-blast. Additionally, mechanical cutting of hard rock such as basalt is feasible—but with a small experience base.

The following three basic waste emplacement configurations are examined in this study.

- horizontal long-hole and short-hole in a number of variations, including symmetric and asymmetric arrangements along the drift length

- emplacement in angled and vertical boreholes

- emplacement in the drift in a shielded mode or in a trench in the drift floor

For the three excavation methods and the above variations in emplacement scheme, a parametric evaluation is conducted to determine the optimum combination. The judging of the alternatives is based on economic, technical and safety criteria. The following conclusions have been reached from this study.

Excavation Technology

No one method is well suited to all repository openings due to the varied nature of the development and rock mass. Drill-and-blast is chosen as the best method for drifts within the shaft pillar area as well as for waste emplacement panels. Here, varying drift shapes and flexibility in excavation directions is needed, effectively precluding the TBM. PFBs can, theoretically, perform a similar function to drill-and-blast but is essentially untested. TBMs are well suited for panel entry mains, which are long, straight drifts.

Waste Emplacement

The study shows the long horizontal emplacement scheme is preferred, primarily from an economic standpoint. This scheme allows placement of three or four waste packages per hole in a .8 meter ± diameter, 138m blind-drilled hole. The hole is lined with an ungrouted pipe to prevent cave-ins from impairing retrieval. Although drilling equipment for such large diameter, long horizontal holes have not been constructed and tested. The report authors feel there are no particular difficulties in this area. The repository panels are sized to hold five years of receipts.

Rock Reinforcement

The suggested rock reinforcement methods are grouted rockbolts with shotcrete. This design agrees well with Barton's 1986 report to BWIP regarding ground support requirements for the Cohassett flow.

Testing and Development

Testing is suggested for most unproven components. In particular, the performance of rockbolts and resin grouts as well as various metal components are suggested for testing under repository conditions. Further development and testing of a drill for long, horizontal boreholes is also suggested.

Problems, Limitations and Deficiencies

1. The geologic data base used is not specific to the Cohassett flow, although the laboratory properties suggested are not widely different from flow to flow. There is no specific discussion of the lateral or vertical variability of the Cohassett and how this may affect the repository design.

2. There is no discussion of the possible effects of site seismicity on the design. There is abundant evidence of seismicity of $4M_{L}\pm$ at depth within the site (Kim, et al., 1986) which need to be addressed in the design.

3. The stress state assumed for this study may underestimate the in-situ stresses by as much as 20% to 25% from the most conservative case (Itasca, 1986). The conclusion reached regarding the optimum drift shape are still likely to be applicable, but the comparison of strength to stress for a given gross thermal loading may be in error due to this possible underestimate of stress.

4. RKE/PB recognizes the importance of geologic "anomalies" in the repository design. The principal types of anomalies considered to be of importance and their effects include:

   (1) flow top breccias, resulting in drift crown stability problems and water inflow;

   (2) pillow palagonite zones or other structures typical of flow bottoms, resulting in water inflow into drifts or potential invert instability;

   (3) spiracles, faults, shear zones or other major discontinuities traversing the basalt flow, with or without connection to the nearest aquifer(s), re-

sulting in potential water inflow or stability problems;

(4) vesicular or brecciated zones (sheet, columns or chimney) within the flow interior, resulting in possible water inflow or stability problems; and

(5) zones of rock of lower than expected strength, higher than expected stress levels, or otherwise adverse conditions, resulting in potential stability problems.

It is recognized that several of these types of anomalies could result in increased flow of water and/or methane to the workings. It is also stated that "From surface exposures of basalt flows, it appears that at least some of these types of anomalies might be encountered during repository construction."

5. The Hoek and Brown strength criteria material constants m,s are somewhat different than those given in the Site Characterization Plan, Draft Chapter 2.0. The values used in the present study are

$$m = 26.17$$
$$s = 0.05$$

whereas the SCP Chapter 2.0 uses

$$m = 22.34$$
$$s = 0.042$$

The strength envelope used in this report is therefore slightly less conservative than that presented in the draft SCP, Chapter 2.0.

6. The calculations of induced stress around the various openings are based on an elastic analysis. These stresses are used as input to the Hoek and Brown failure criteria to judge opening stability. This approach is reasonable for entry drifts which are not heavily influenced by heating, but it ignores failure mechanisms of possible importance for emplacement panels. This includes transient induced tension in drift walls resulting from the thermal expansion at the hole collars. This is covered in greater detail in Itasca (1987).

7. The rock properties in the opening design calculations are derived from the laboratory with the exception of Young's modulus which is an estimated 50% of the laboratory value. The limitation exists, therefore, that no field data has been applied to the design.

8. This document is based on a power per canister (PWR) of 1.65kw, whereas the most recent conceptual design is based on 2.2 kw per package.

9. TBMs are suggested for use in excavation of the main panel entries. RKE/PB expects no particular difficulties in their use. There may be significant problems, however, as there is little practical experience in the use of TBMs in hard rock.

10. The report suggests that rockbursts are predictable after an empirical data base has been developed. This is not true. Mining has shown that even years (roughly 15 in some instances) have not been sufficient for development of an empirical predictive base. Also, pre-fracturing (pp. 5-6) is not a suitable alternative for burst control in this case.

11. Many acute angle drift intersections occur which may have spans in excess of 9m. These spans and the rock promontory created may cause severe ground control problems including rockbursting and ground falls. Additional support including longer roof bolts and greater shotcrete thickness will be required here.

12. There is a misconception that the temperature gradients around the repository rooms will be small if the rooms are not ventilated. Actually, a gradient of several hundred degrees exists at early times between the heat source centerline and the drift wall. This gradient gives rise to significant transient tensions which will likely require additional wall support at the emplacement hole/drift intersections to prevent vertical splitting of the wall.

13. The potential problems associated with water inflow are covered fairly well in the report. If the mining intercepts an anomaly, high inflows of scalding water (>50°) could potentially flood the excavation. Probe holes and grouting are suggested methods for overcoming these problems; however, as the report states, grouting will be difficult. Grout must be injected at pressures exceeding the hydrostatic head (≈ 1400 psi) and flow-back must be prevented with blow-out preventers. Also, in hard rock with tight joints, chemical grouts are normally used, but may be jelly-like at the temperature and pressures expected in the Cohassett.

14. After examination of 11 waste emplacement options, horizontal long holes (400+ feet) in an asymmetrical orientation with multiple waste packages (up to 31) per hole was chosen as optimum. This differs from the present conceptual design which calls for short holes with one package per hole. The overall repository designs between this report and present conceptual designs vary significantly as a result of the difference between the long hole and short hole concepts.

15. The assumption is made (pp. 6-23) that geologic anomalies between emplacement drifts may be located by geophysical techniques prior to mining. Thus, geologic uncertainties will not limit the length of placement holes. It is the reviewer's opinion that it would be exceedingly difficult to define anomalous zones, particularly linear features such as a fault, using geophysical methods. Also, the drilling of large-diameter, 150m+ horizontal holes is not standard practice and will require considerable development.

16. The Construction cost extimate must be viewed with considerable skepticism due to the use of undeveloped technology such as TBMs and large-diameter, long-hole drilling.

Recommendations

This document is not a true representation of the present status of conceptual design. It would be worthwhile to obtain a draft copy of the conceptual design report to review prior to release of the SCP.

References

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