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ITASCA
Consulting Group, Inc.

18 March 1986

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 the trip report for Itasca's attendance at the NRC update meeting on 26-27 February 1986.

Sincerely,

Roger D. Hart

Roger D. Hart
Program Manager

cc: J. Greeves, Engineering Branch
Office of the Director, NMSS
E. Wiggins, Division of Contracts
DWM Document Control Room

Encl.
rdh/ks

WM Record File WM-RES
D1016
Itasca

WM Project 10, 11, 16
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2910

ITASCA TRIP REPORT

DATES: 26-27 February 1986

LOCATION: Nuclear Regulatory Commission
Silver Spring, Maryland

PURPOSE:
(1) To update the consultants on the current status of NNWSI Conceptual Design (as presented at the DOE meeting in Albuquerque on 2/11/86)

(2) to discuss Engineer's International point papers on NNWSI conceptual design and exploratory shaft

(3) to solicit comments on conceptual design, ESTP, and information needs.

ITASCA ATTENDEES: L. Lorig
J. Daemen (University of Arizona)
K. Wahi (Consultant)

PREPARED BY: J. Daemen, K. Wahi, and L. Lorig

SUMMARY

The meeting was attended by between 7 and 12 persons (attendance varied over the two days). The primary participants are listed in the attached agenda. The comments which follow are given in order of the major agenda items.

CONCEPTUAL DESIGN

The following notes are based on the presentation by D. Gupta at the DOE meeting held on 11 February 1986 in Albuquerque. Each consultant was given a copy of a DOE handout which included outlines of issues, drawings of facility design for surface and underground structures, and information on design basis for waste package, thermal design, thermomechanical analyses, sealing concepts, equipment design for emplacement hole drilling/lining and emplacement/retrieval equipment. Perhaps the most notable among the handout material was a list of eleven items related to underground facilities design basis (copy attached).

SURFACE FACILITIES — FLOODING

Flooding could have a significant impact on repository operations and performance for several reasons, in particular:

(1) surface facilities are partially located in low-lying areas (washes?);

(2) shafts are within, or close to, low-lying areas (washes?); and

(3) floods can cause preferential infiltration (e.g., along faults).

A reasonable estimate is needed of the risk of flash flooding, associated discharge rates, and debris caused by floods. Consideration also should be given to design of surface facilities with respect to the 500-year flood, including the type of fence to be used around the secured facility.

UNDERGROUND FACILITIES DESIGN BASIS — SEISMIC HAZARDS

Seismic hazard analysis of underground facilities appears to be missing. On the other hand, detailed accounts of seismic effects apparently have been included in the surface facility design. The underground facility design needs to consider seismic effects (earthquakes, NTS tests) and fault displacements. Fault displacements might be particularly important for the long horizontal hole emplacement design option if it is possible that such holes might be intersected by faults. Equally important would be an assessment of the possibility that faults might be preferential flow paths.

Another question raised during discussion concerned the "Ghost Dance" fault, which was not shown on the repository drawings but which has been included in other drawings.

UNDERGROUND FACILITIES DESIGN BASIS — DUAL INDEPENDENT VENTILATION SYSTEMS FOR EMPLACEMENT AND CONSTRUCTION

The basic design objective in separating the two air streams is to continuously maintain a higher pressure throughout the construction system and thereby ensure that any leakage will be from the construction to the emplacement ventilation systems. However, as soon as waste is emplaced, the thermal effects will start to influence air flow patterns. Analysis will need to confirm that thermal effects will not induce leakage from emplacement to construction ventilation systems. This analysis is likely to be complicated given the unsaturated flow conditions.

NNWSI is proposing to use a non-reversible ventilation system. The justification given appears to be that this would prevent accidental reversing of the ventilation circuits and, hence, an accidental promotion of the nuclide migration (leakage) from the emplacement to the construction system. If this indeed is the only reason for justifying the installation of non-reversible fans (and this needs to be confirmed before any action is taken), it must be considered as a marginally-acceptable argument, at best. Air flow reversal in mining is required as a fundamental safety approach to underground operations, particularly in the case of underground fires. Admittedly, the risk of fire in a repository appears small. Nevertheless, diesel equipment will be present, as well as explosives, fuel supplies, belt conveyors, hydraulic oil and other combustibles. It would appear that the installation of non-reversible fans and ventilation circuits might significantly reduce the available response options in case of a fire. In seems that prevention of a ventilation circuit reversal could be readily ensured by less drastic means since it would be detected almost instantaneously.

UNDERGROUND FACILITIES DESIGN BASIS — RAMP ACCESS

What additional or unique requirements might be associated with a ramp (as a substitute for a vertical shaft) used to transport waste packages to the underground facility?

UNDERGROUND FACILITIES DESIGN BASIS — THERMAL DESIGN OF UNDERGROUND FACILITY

The 1983 unit evaluation study (Johnstone et al, 1984) remains a major reference in support of repository design. It would be highly desirable to perform an independent thermomechanical sensitivity analysis of the results obtained therein. This would also be helpful in the review of on-going preliminary far-field and near-field studies as listed below.

(1) <u>Near-Field Thermal Design</u>

The large variation in initial container output is to be noted, confirmed independently and, if confirmed, to be treated as an essential input variable in sensitivity analyses—particularly with regard to near-field response (e.g., previously mentioned 1983 unit evaluation study, also input for previously shown Parsons Brinckerhof Horizontal shorthole configurations, etc.). It is to be noted that local temperatures (275°C on hole wall, 200°C one meter inside rock) are listed as design constraints.

(2) <u>Horizontal Emplacement Borehole Wall Temperature</u>

Is the analysis conservative? In particular, is the thermal input conservative (in light of the preceding comments, viewgraph)? Should it be conservative?

(3) <u>Scope of Work to Date</u>

Clearly, the work to date has been extensive. Do we have access to it? Has it been reviewed in light of its implications for ESTP (i.e., does ESTP address critical uncertainties identified by the analysis)?

(4) <u>Past-Calculations Applicable to Current Design</u>

The extensive set of available results, deserves, at a minimum, spot-checking, starting with a check of all input parameters in light of most up-to-date information on those parameters.

(5) <u>Vertical Emplacement Reference Thermomechanical Calculations</u>

Rock strength input parameters seem high. These need to be checked. These values have implications for design, constructability, and test design (ESTP). Sensitivity analysis is highly desirable and should be made a high priority.

It would not require much of a scaling factor of laboratory to field rock strength for the crown stress to exceed the strength within 35 years after emplacement.

(6) <u>Parameter Uncertainty, Thermomechanical Sensitivity and Data Requirements</u>

A rational approach to the identification of information needs and, hence, guidance for ESTP would be to perform thermomechanical sensitivity analyses, taking into account present parameter uncertainties, including comingling of wastes.

UNDERGROUND FACILITIES DESIGN BASIS — SEALING

This appears relatively unchanged from earlier reports. Uncertainties identified in earlier reviews remain:

- grout curtain effectiveness
- drainage effectiveness (i.e., long-term maintenance of necessary permeability)
- shaft in-flow calculations
- damaged zone calculations (properties, extent)
- multiple in-flow sources
- main uncertainties (hydrology)
- fault sealing

POINT PAPER ON NNWSI CONCEPTUAL DESIGN BY S. BATTACHARYA

Time limitations prevented anything but a highly preliminary superficial review; only a few items are highlighted.

STABILITY OF OPENINGS

Analyses seen to date can be considered as highly preliminary only and are probably based on optimistic assumptions (rock strength, thermal input). Particularly needed are sensitivity thermomechanical analyses (experimental data on rock strength as a function of extended exposure to high temperature/steam/ air-water circulation/high stresses/ gradients), and data on reinforcement/support performance as a function of environment.

The repository area is surrounded by faults and it is possible that the repository block is intersected by faults. Although "fault" is a well-defined geologic concept, its geomechanical implications are highly uncertain (i.e., mechanically, the influence of a fault can be entirely insignificant yet, at the extreme, faults can entirely dominate the behavior of underground structures and hence have a major implication for design, construction, retrievability, containment and isolation). It therefore is essential that the site characterization provide sufficient information about the faults to allow an assessment of their engineering implication. This requires, as a minimum, fault locations, geometry (e.g., from surface to water table), descriptive information (width, in-filling, etc.) and, preferably, mechanical properties.

Engineered Barriers — Items that need to be addressed in this area include:

- longevity of hole liners
- rock deterioration
- probability of faults intersecting emplacement holes
- consequences of shear displacements along such faults

Shaft and Borehole Seals — Items that need to be addressed in this area include:

- performance requirements for holes below repository
- seal materials
- installation
- fault sealing
- dam floor sealing
- grout curtains
- reliability of long-term floor drainage

Waste Retrieval — Items that need to be addressed in this area include:

(a) for emplacement holes,

- liner corrosion (longevity)
- liner deformation (faults, joints, rock fracture)
- rock (deterioration, deformation)

(b) for emplacement rooms

- maintenance or re-establishment of access
- rock conditions at end of retrieval period (i.e., after prolonged heating, stressing, steam circulation)
- support/reinforcement condition

DESIGN FLEXIBILITY AND ALTERNATIVE DESIGN CONCEPTS

This is a critical issue at NNWSI, probably requiring a major site characterization (where are the faults, lithophysae?) and rock mechanics effort (How significant are the faults?) What are their properties? How wide a range of properties (e.g., lithophysae content) is acceptable? What is the tuff variability?

It appears likely that a repository at this site might have to be built in rocks with a fairly wide range of properties. This logically suggests testing/characterizing a fairly wide range of rocks, with accompanying design and sensitivity analyses.

CONTROL OF WATER AND GAS

What is meant by "control of water and gas" at Yucca Mountain? This might become a topic of discussion between NNWSI and NRC. Elements which may have to be considered are:

- fault in-flow estimates and control (e.g., diversion, sealing, grouting)
- perched water table occurrences
- flow patterns subsequent to waste emplacement (i.e., thermally-driven flow)
- NNWSI proposed sealing methodology (largely diversion)
- reliability of free-draining floor conditions

EXCAVATION TECHNIQUES

The applicable requirement, 10CFR60.133 (f), as amended for the unsaturated zone, states that the "design of the underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for groundwater to contact the waste packages or radionuclide migration to the accessible environment." Several aspects related to this requirement might have to be addressed by NRC staff and, hence, require a position. These aspects include the question: Is blasting damage around emplacement beneficial or detrimental (e.g., does damage enhance or reduce free drainage, does damage enhance or reduce the potential for radionuclide migration?) Input from hydrologists would be desirable to establish engineering/design/construction criteria. These questions might need to be raised for emplacement holes, all drifts and shafts, and might need to be considered in two different directions (i.e., what is beneficial for preventing water contact with the packages? what is beneficial for preventing radionuclide migration?).

Waste Retrieval System — Areas of concern related to the waste retrieval system include:

(1) emplacement holes

What type of hole inspection is to be performed prior to lining emplacement? The following may be suggested as a minimum.

- alignment, deviations
- caliper logs, dimensions
- water in-flow
- faults/joints/rock fracturing
- camera/geophysical inspection

One applicable precedent for the acceptability inspection can be found in the regulations for drilled rock caisson foundations for cooling towers of nuclear power plants. Before the concrete and reinforcing are introduced into the drilled holes, an inspection, consisting of the items listed above, is made.

(2) liner installation

- Will liner be grouted?
- If yes, how, and with what?

(3) Is the liner expected to endure for the duration of the retrieval period? If so, then corrosion and deformation criteria may need to be specified.

(4) What is the methodology for determination?

- Will the criteria be in place for the decision-making process as to whether or not to accept a particular hole for emplacement?

- How will rejected holes be treated (i.e., are such holes potential preferential migration paths? If so, what measures will be implemented to preclude a detrimental impact on repository performance?)?

POINT PAPER ON EXPLORATORY SHAFT BY S. BATTACHARYA

Only a very brief overview has been given of the point paper, with rather limited discussion. Major concerns that have been identified (once again) include:

- representativeness (e.g. lithophysae)
- extent of drifting/drilling needed (the widest drifts in the test plan do not appear long enough to get away from end effects)
- approaches to be used (geostatistics, judgement)
- fault characterization (Some suggestions for fault behavior monitoring and in-situ fault property determination were given; presumably these will to be detailed in subsequent discussions)
- adequacy of the extent of drifting, of the direction in which drifting is to be done

RECOMMENDATIONS FOR STUDIES TO BE PERFORMED IN PREPARATION OF DOE DOCUMENT REVIEWS — ROCK MECHANICS AND REPOSITORY DESIGN

1. Representativeness Studies of ESTP and Site Characterization

   Based on an integrated analysis of all presently available site geology, assess the representativeness of the information that will be obtained from site characterization and in-situ testing.

2. Thermomechanical Analysis

   - emplacement holes
   - drifts
   - intersections
   - shafts

3. Flooding Risk Assessment

   • surface facilities
   • shafts
   • fault in-flow

4. Ventilation Analysis

   Determine risk of thermally-driven (waste emplacement) air flow through rock from emplacement holes to construction circuit. (This may not be an issue if holes are lined —i.e., if no nuclides are released to rock around holes)

5. Rock Bolt/Reinforcement Studies

   Rock bolts (as well as grout, mesh, shotcrete) will be exposed to a hostile environment for an extended period of time.

   Uncertainty about performance could be reduced partly by an experimental (comprehensive and full-scale, or even preliminary, scoping, with limited tests) investigation of systems likely to be used.

6. Determination of Rock Properties as a Function of Time, Temperature and Saturation (e.g., water/steam)

   The data base on "rock strength" remains very narrow, and it is unclear whether this will change soon.

7. Analysis of the Implications of Variability in Thermal Input

   Indications have been given that extreme uncertainty exists with regard to the actual thermal loads that might be imposed on the repository, as compared to the nominal design loads. This might have significant impact on temperatures, thermal gradients, liner loads, etc. If interactions with the HLW package people confirm the variability and can provide estimates thereof, it would seem desirable for the design/rock mechanics group to evaluate the potential impact on repository performance.

RECOMMENDATION FOR STUDIES TO BE PERFORMED
IN PREPARATION OF ESTP REVIEW

1. Comprehensive Readily-Accessible Document File

   - include ESTP/EA references
   - include related documents (e.g., all SANDIA, LASL, USGS documents related to NNWSI whether or not referenced in DOE documents)

2. Comprehensive Readily-Accessible Rock Mechanics/Structural Geology Data File

3. Mechanical Analysis of ES Excavations (including sensitivity analyses)

   - assess predictability of rock mass response to excavation
   - assess adequacy of proposed instrumentation for defining rock mass response

4. Thermomechanical Analysis of Proposed Experiments (including sensitivity analyses)

   Objective: to allow an analysis-based NRC decision as to whether proposed experiments will provide NRC with the necessary information

5. Development of an Independent NRC SCP/ESTP

   Based on presently available site information, what should be included in an NRC-developed SCP and ESTP. This could form the basis for an evaluation of DOE plans—i.e., how much of NRC information needs will be satisfied by DOE proposals?

6. Observational (Field) Study of Potential Impact of Faults

   Visit mines in the same structural domains as Yucca Mountain and inspect impacts of faults for, as examples,

- evidence of deterioration since opening mines(s)
- evidence of intensified support requirements

With all recognized limitations (e.g., shallow, small excavations, different rock types), this still would provide a qualitative indication about the potential impact of faults.

7. <u>Engineering Review of Available Geological/Hydrological/ Geochemical/Seismic Information</u>

Review by design/rock mechanics group of NRC, DOE, and other literature. It is not clear whether past time limitations have allowed such an integration effort for NRC staff, but it certainly has not been possible for the consultants.

REFERENCES

Johnstone, J. Keith, Ralph R. Peters, and Paul F. Gnirk. Unit Evaluation at Yucca Mountain, Nevada Test Site: Summary Report and Evaluation. SAND83-0372. June 1984.

10 CFR 60 (Code of Federal Regulations), Title 10. "Energy", Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories." U.S. Gov't. Printing Office, Washington, D.C.

Respectfully submitted,

Loren J. Lorig

Loren J. Lorig
Itasca Consulting Group, Inc.

attach
ljl/ks

MEETING NOTICE

U.S. Nuclear Regulatory Commission meeting with Engineers International and Itasca to discuss the Conceptual Design and the Exploratory Shaft Test Plan for NNWSI.

SPONSOR: U.S. Nuclear Regulatory Commission (NRC)
Division of Waste Management
Engineering Branch

CHAIRMAN: Dinesh Gupta, WMEG

DATE/TIME: February 26-27, 1986
8:30AM - 4:00PM

LOCATION: 1st Floor Conference room, February 26th,
11th Floor Conference room, February 27th
Willste Building
Silver spring, Maryland

PURPOSE: To discuss issues related to the Conceptual Geologic Reposiroty Design and the Exploratory Shaft Test Plan

PARTICIPANTS:

NRC	EI	ITASCA	BOM
D. Gupta	S. Bhattacharya	J. Daemen	D. Conover
D. Tiktinsky		L. Lorig	
J. Peshel			
M. Nataraja			
K. Stablein			

AGENDA ITEMS:

2/26/86

8:30AM INTRODUCTION, D. Gupta

9:00AM Presentation of information on conceptual design presented at the design review meeting in Albuquerque, NM on February 11, 1986, D. Gupta

9:45AM Discussion of DOE Handout from the Design Review Meeting
- -Facilities Design Presentation, Design Philosophy/Control
- -Facilities Design Presentation, Repository Setting
- -Surface Facilities, Design Basis
- -Surface Facilities, Current Concepts
- -Underground Facilities, Design Basis
- -Underground Facilities, Current Concepts
- -Underground Facilities, Design Analyses
- -Underground Facilities, Sealing

-Equipment Design Philosophy/Control
-Equipment Design, Emplacement Hole Drilling/Lining
-Equipment Design, Waste Emplacement/Retrieval Equipment
-Equipment Design, Future efforts

12:00PM Lunch

1:00PM Discussion continues

2:00PM Presentation of Point Paper on Conceptual Design,
S.Bhattacharya, Engineers International

2:45PM Discussion of point paper
-Conceptual Design Information and Level of Detail needed in the SCP

4:00PM Preparation of meeting notes

2/27/86

8:30AM Presentation of point paper on the Exploratory Shaft Test Plan,
S. Bhattacharya

9:30AM Discussion of issues related to the ESTP and the point paper
- DOE's Draft ESTP, September, 85
-Issues related to construction of ES drifts and Insitu test plans
-Amount of drifting, DOE proposals
-Types of Tests and Test Location (Interference)
-Representativeness, (including Kim's Report)
-Key Rock Mechanics/Design Parameters needed for Representativeness
-Constructability
-Sealing and Performance Analysis
-Information needed for Evaluation of ESTP

12:00PM Lunch

1:00PM Discussion continues

3:00PM Preparation of meeting notes detailing the groups perspective on (a) representativeness, (b) key Rock Mechanics Design parameters and (c) work needed in preparation for review of the DOE ESTP.

4:30PM Adjourn

UNDERGROUND FACILITIES DESIGN BASIS

Sandia National Laboratories

1. Waste types: spent fuel/DHLW/WVHLW
2. All waste types will be comingled
3. Reference emplacement orientation is vertical
4. Horizontal emplacement is alternative
   - 350 foot long borehole
   - 100 foot standoff
5. Ramp for waste delivery to underground
6. Areal power density for emplacement = 57 kilowatts per acre
7. Dual, independent ventilation systems for emplacement and construction
8. Guaranteed access for retrieval
   - Emplacement and access drifts stable for retrieval period
   - Temperature in vertical access drift and horizontal emplacement drifts less than 50° C in 50 years
9. Underground haulageway slopes not to exceed 10 percent
10. Exploratory shafts used in the repository design
11. Exploratory shaft facility in the repository plane

COST BREAK-OUT

Labor

J. Daemen	16 hrs @ $57.75/hr	$ 924.00
L. Lorig	18 hrs @ $19.95/hr	359.10
K. Wahi	15 hrs @ $55.00/hr	825.00
	TOTAL LABOR	$ 2,108.10

Actual Expenses

Travel	
Airfare (to WDC)	
Daemen	$ 390.00
Lorig	580.00
Miscellaneous Travel Expenses (taxis, buses)	27.70
Motel	
Daemen	$ 42.35
Lorig	42.35
Wahi	40.65
Meals	
Daemen	68.17
Lorig	31.26
Wahi	65.00
Miscellaneous Expenses	
Lorig (telephone)	$ 39.72
Wahi (telephone)	5.70
TOTAL EXPENSES:	$ 1,332.90