D1016 PDR-1
LPDR- Wm-10 (2)
Wm-11 (2)
Wm-16 (2)

ITASCA
Consulting Group, Inc.

29 June 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 our review of the document "Final Preliminary Design Report, Permian Basin, Texas" by Parsons Brinkerhoff/PB-KBB (ES-225-01, March 1986). Please call me if you have any questions.

Sincerely,

Roger D. Hart

Roger D. Hart
Program Manager

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

WMRES

Encl.
rdh/ks

'87 JUL -6 A10:01

WM Record File D1016
WM Project 10, 11, 16
Docket No.
x PDR ✓
x LPDR ✓ (B, N, S)
Distribution:
Tiktinsky
Ballard
(Return to WM, 623-SS)

8709040219 870629
PDR WMRES EECITAS
D-1016 PDR

87225735
WM Project: WM-10, 11, 16
PDR w/encl
(Return to WM, 623-SS)
WM Record File: D1016
LPDR w/encl

H

Suite 210 • 1313 Fifth Street SE • Minneapolis, Minnesota 55414
Telephone: (612) 623-9599 • Telex: 201682

3900

ITASCA DOCUMENT REVIEW

File No.: 001-02-36

Document Title: "Final Preliminary Design Report, Permian Basin, Texas" by Parsons Brinkerhoff/PB-KBB (ES-225-01, March 1986)

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

Approved: Roger D Hart

Date Approved: 6/29/87

Significance to NRC Waste Management Program

The ES shafts provide a permanent and major penetration through two major aquifers overlying the host salt formation. Exceptional control over the groundwater flow into these structures must be maintained to prevent potential salt dissolution at the repository horizon. These shafts will become part of the licensed facility, and NRC must have concerns over the construction methods (CFR 60.31, .32, .72, .74, .131, .133) and plans for shaft sealing (60.134 and .140) and performance monitoring (60.141 and .142).

The ES shaft and underground facilities are governed by the 10 CFR 60 regulations given in Appendix A.

Summary

The document describes the preliminary design of the Exploratory Shaft (ES) facility proposed for Deaf Smith County, Texas. The recent Title II, 30% ES Design Meeting (Itasca, 1987) has shown that few changes have occurred from this preliminary design. Therefore, this document describes present shaft specifications fairly accurately.

The facility consists of two shafts (roughly 20' OD, 12' ID) and several thousand feet of subsurface excavations for in-situ testing. The shaft must pass through two major aquifer systems: the Ogallala, which occurs in surficial sediments to a depth of approximately 360 feet; and the Dockum, a group of approximately 600 feet of variably-indurated siltstones, sandstones and shales below the Ogallalla. The subsurface facility is to be located in the

lower San Andres Unit 4 salt at a depth of roughly 2500 feet. The salt sequence is 150 feet thick and interbedded with thin mudstones and shales.

The upper sediments and the Dockum group present excavation difficulties due to (1) weak strata, and (2) excessive water. Grouting methods will not be effective, and ground freezing will be used. A series of 28 freeze holes are to be drilled on a 33'2" circle circumscribing the shaft excavation. These holes are to be 1,000 feet in length and angle slightly to the exterior of the freeze circle. Three interior temperature monitoring and one central water relief hole are also to be drilled. The ground is frozen by circulating brine at -13°F at 1270 gpm through the freeze holes. Progression of the freeze front will be monitored by cross-hole ultrasonics as well as the temperature holes and central water relief hole. Freezing is expected to require 80 days, at which time shaft sinking is to begin.

Sinking will be accomplished by standard drill and blast and spading methods. Unsupported wall heights of no greater than six feet are anticipated in the frozen earth.

The shaft liner must be water tight in the non-salt zones above 1100 feet to prevent water ingress and salt dissolution. Two lining types are used—a preliminary and final lining. The preliminary lining consists of cast-in-place concrete or concrete blocks (pre-cast). The final lining will consist of a double steel cylindrical ring with stiffening concrete and bitumen water seal. Below the aquifers, the bitumen seal may be replaced with periodic chemical seal rings and cementitious grout. The shaft will be over-excavated in salt and the liner backfilled with a compressible resin or bitumen to avoid liner overstressing from salt creep.

Instrumentation proposed to monitor the shaft includes primarily closure and near-field extensometry as well as liner strain monitoring.

The deep facility is to consist of several thousand feet of drifting for in-situ testing purposes. Drift cross-sections will vary between 14' wide by 8' high to 20'wide by 20' high and 20' wide by 24' high (the current plan for repository waste emplacement rooms). Construction instrumentation will include closure, extensometry, and rockbolt load measurements.

The report also details the various mechanical and electrical systems for the facility, including ventilation, hoisting, compressed air, electrical supply, pumping and communications.

Problems, Limitations, Deficiencies

The shaft design, as presented, is approximately that used in standard mining practice in salt and potash. In salt, the excavated penetrations to the repository horizon provide primary pathways for radionuclide transport. It is, therefore, essential that these shafts be subjected to detailed performance analysis at this time. As stated, the design presented in this document is essentially the same as what will become the Title II 60% design. At this stage, detailed specification is conducted. The following major limitations are given, keeping in mind that the shaft design is well advanced.

(1) Performance Analysis — The document does not discuss, nor does it reference, a performance analysis of the following:

(1) construction effects on rock mass performance (including ground freezing)

(2) a performance analysis of the lining method—in particular,

(a) the liner's ability to remain watertight over the stated 100-year life

(b) the ultimate fate of the linings—will they be left in, will they be removed, will they interfere with the permanent lining systems, etc.?

(c) if the linings are removed, how will this be accomplished—e.g., by removal of seal rings, additional ground freezing, etc.?

We feel that, at this advanced stage, a thorough performance assessment is essential. This should have been (if it has not) completed in advance of specification of construction and lining methodology. The document takes a strictly construction viewpoint —i.e., it assumes the standard liner is adequate and approaches the problem as one of mining construction.

(2) Freeze Design and Monitoring — The use of freezing for the upper 1000 feet of the stratigraphic column presents several potential problems in performance. First, a detailed analysis of the effects of freezing and thawing on the performance of the rock mass needs to be conducted and referenced in this document. It must be recognized that the act of freezing and thawing will sub-

ject the rock mass directly around a primary potential pathway to far greater strain and temperature change than will be induced by the proposed repository loading. This is particularly true considering the volumetric expansion and contraction upon freezing and thawing. To our knowledge, the effects of this action on performance have not been addressed and could prove to be extremely important.*

The freeze design specified in the document is non-standard, involving angled holes which must be drilled in a highly-accurate fashion. This represents a possibility of problems in the freezing process. A standard, vertical overlapping hole arrangement would seem advisable.

There appears to be inadequate measures taken to monitor the effects of the freezing and thawing on rock mass performance. There is no reference to supporting instrumentation studies.

(3) Shaft Liner Design — The calculations for the design of the shaft liner were not included or referenced in the document. Several assumptions have been made which could affect liner performance:

(a) It has been assumed that, in salt sections, the salt will be over-excavated and backfilling placed between the salt and liner. This backfilling is to be compressible and is to be designed to take all of the creep of the salt without loading the liner. Therefore, the liner has been designed for no rock loading at salt sections. It is highly probable that some load will be applied to the liner—the extent of which is uncertain since no calculations are presented. Additional sources of load have been ignored in the calculations, including

(i) swelling of water-sensitive clays and shales; and

(ii) point loading at boundaries of salt/non-salt interfaces.

---

*In fact, at the May 4-7 ES Design Meeting in Houston, DOE stated that the shaft is considered to be unimportant to waste isolation; therefore, ground freezing has no isolation importance to them.

It would appear that the most conservative liner design would be for full lithostatic loads in salt sections.

(4) Monitoring Instrumentation — We can see no instrumentation plan which attempts to define a hydrological and mechanical baseline prior to shaft sinking and to determine changes from this baseline upon freezing, sinking and thawing. Moreover, the instrumentation does not clearly indicate how performance is to be established and verified.

(5) The Bitumen Liner — The placement of the bitumen liner is an important aspect of producing a watertight lining; yet, there appear to be no reasonable specifications for placement of this material at great depth in the shaft. The only specification quoted is a standard highway paving specification.

(6) Shaft and Monitoring Life — The document states that the shaft and accompanying monitoring is to last for 100 years. It comes across in the document that this technology is based on empirical evidence. In fact, however, a shaft in a viscous material lasting for this time period is unprecedented, particularly the complex liner specified here. The document does not appear to recognize that a breach in liner integrity, allowing water into the shaft, could be a problem in waste isolation (retrievability and containment) as well as safety. Instrumentation in a shaft will likely last no more that ± five years. There is no discussion on how cast-in-place instruments will be maintained.

Detailed Comments

p. 13 The effects of mudstone/shale seams on the visco-plastic behavior of salt is unknown and not factored into design. Basal dolomite and anhydrites have yielded brine waters.

Zones below Dockum may yield significant water to the shaft from fractures.

Note that there are significant drilling problems of hole collapse in Ogallala and Dockum.

pp. 13-15
Plastic and water-sensitive shales are found to exist in the lower Dockum or within Dewey Lake. Swelling and sloughing may be evident.

p. 15 Note that the design data base is small and not site-specific—i.e., a "synthetic data base".

Concerning the statement that "Radial displacement due to salt creep was estimated to be much less than 2.0 ft . . .", even a 2-foot radial displacement is a 4-foot shaft closure—this is obviously not acceptable.

Note that the lower San Andres Unit 4 salt contains occasional zones of poor to very poor quality shales; yet, these potential slip planes were not factored into the design.

General Comment — There are no references as to place from which data were taken.

p. 16 There is no reference given for the table.

p. 17 Under the discussion of "Subsurface Pressures", there are numbers given for angle of friction for intact rock, apparent cohesion, and in-situ stress. First, the type of rock is not given and the values given cover a range for nearly all types of rock. No site-specific data is given for in-situ stress. In effect, this section states that we know nothing of the data but will choose a wide variation of average rock properties. Also, the properties given allow the assumption that we are dealing with an elastoplastic rock, whereas we have a viscoplastic rock mass.

The assumption of over-excavation and non-lithostatic loading is bothersome. We basically have no data presented here for salt creep, little in-situ stress data, and no analysis of the amount of creep. Additionally, there is no data regarding the "compressible backfill material". So, there is no possible means of judging the applicability of these assumptions. It seems the most conservative method would be to compare the design for the full lithostatic load. Here, the load is expected to be zero.

No consideration is given to non-uniform loading resulting from swelling of clay layers.

Note: Is it possible for long-term creep to compress material to the point of loading the liner? Also, what about the non-uniform loading resulting from the excavation itself?

p. 18 No reference on the earthquake magnitude and method of calculating induced stresses are given.

No calculations of static and dynamic conveyance loads are given.

Swelling potential and slake durability are not listed as data requirements.

It must be realized that the shaft design may change significantly on the basis of the EDBH data.

p. 28 Nine surface buildings are to have a five-year design life. [Question: What role are shafts to play in the final repository?]

p. 34 Concerning the shaft seal functional criteria,

(a) watertight composite shaft liner — what exactly does this mean? Watertight over what areas and for how much time?

(b) designed to prevent vertical migration of groundwater — What are the specifications? What does prevent mean?

(c) 100-year life—i.e., through pre-closure — Will they be torn out? What will happen to salt zones, water seal rings?

(d) If shaft buildings have a five-year life, how will maintenance be performed to 100 years?

p. 35 We are given no specifications on damage or performance to freezing. How will instrumentation over a short period demonstrate adequate ability to seal the shaft or other penetrations?

A major point—the Functional Criteria for Design (FCD) is that the shaft minimize damage to the site and, yet, there is no analysis presented which shows what potential damage may occur and how it will be minimized.

It is stated that excavations must be functional over ES life — What is ES life?

p. 48 It should say 12-foot finished diameter.

p. 69 Typo for # gallons water

p. 70 Overbreak will be greater, in many cases, than 6" radial.

p. 98 Hydrologic testing is not to be performed below Dockum so, at this time, it is unknown what exists there. The assumption, however, is that insufficient water exists there to require freezing. There is no data given on creep of salt and the amount of over-excavation required. What is the type of compressible material to be used in the over-excavated salt?

Statements like "calculated ground pressures are less that 30% of the total design pressure" are totally unsubstantiated in this report. The above refers to rock below the Dockum.

p. 99 The criteria for design given in Table 2.4-1 are really not design criteria for stability. They refer only very loosely to performance criteria.

Also, the statement is made that too little data is currently in hand to allow an accurate technical analysis of methods and dimensions—yet we are currently at 30% Title II design.

Again, no reference is given for hydrology of zones below Dockum, and yet 40-50 gpm max down to 10 gpm after one year is projected.

p. 104 In one instance, it is stated that the freeze hole casing will be removed; in another, it is stated that the casing will be perforated and injected with cement slurry. It will prove very difficult to remove any casing, especially if soil creep occurs when thawing.

pp. 104-105
General Note: The freeze hole design is non-standard, employing non-vertical holes which cannot likely be drilled with sufficient geometrical accuracy. There is apparently no consideration of the effect of freezing and thawing on performance of the rock mass surrounding the shaft. The discussion cannot, therefore, be considered adequate for Title II design purposes.

p. 108 Note that water collection rings may be embedded in the concrete liner. The water collected is directed to the shaft sump for pumping. Hydrologic connections are thus probable between the rock mass and the shaft interior.

A one-foot (on radius) creep allowance is given for unlined shaft sections. No supporting creep calculations are given or referenced.

p. 111 There is no conventional shaft technology that will last for 100 years—particularly in salt or potash mines. In particular, there is no established technology for long-lasting water rings, water seals or bitumin.

p. 113 Again, a constant 200 psi pressure is assumed on the preliminary lining. There are no supporting calculations given. This ignores water pressure above salt, possible swelling pressures, etc. The concrete blocks provide a rather complex liner to examine structurally. No analysis is given of the loading of the liner as the rock mass is frozen. No past experience is cited.

p. 114 No information is given on the method of connection of the inner steel membrane to the concrete blocks.

p. 117 The shaft liner design basis appears to be non-conservative.

(1) The horizontal stress in non-salt layers is assumed to be equal to the vertical pressure.

(2) The salt is to be over-excavated not to load the liner. The excavation backfill is to be bitumin or resin foam. No data are given to indicate the liner loading resulting from the salt creep against these backfills. This is a critical point because the liner is to remain watertight.

p. 119 It is impossible to judge the adequacy of design calculations in table 3.3-3 since no background calculations are given.

p. 122 A demonstration of seal performance for design verification over the shaft life (100 years) is to be made. No detail on a demonstration which could verify a 100-year design life is given.

p. 123 Chemical seal rings are planned at 2460 and 1045 feet. These seals have not been demonstrated to last 100 years and must be confined to avoid dissolution. Also, the bitumin layer requires certain temperature and composition specifications at emplacement. To our knowledge, the only specification quoted for liner installation here is a standard asphalt paving specification. This is obviously insufficient. No discussion is given as to how it will be demonstrated that bitumin seals will last for 100 years and how it will be serviced if found to be inadequate.

p. 125 The document states that a behind-the-liner fluid detection system is required but does not discuss it.

p. 128 Several mechanisms for additional liner loading are given. However, there is no indication that these have been accounted for in the design. Many of the items are ambiguous, such as "excess salt creep". Several items (such as swelling of water-sensitive sediments and loading from differential strains) have not been accounted for.

p. 130 Instrumentation of a liner over time periods of up to 100 years is treated as standard practice. In fact, experience indicates that life of less than two years in a shaft environment can be expected.

p. 142 The concept of factor of safety has little to do with excavation in a visco-plastic material like salt. Pillar analysis by the Wilson method was developed for hard rock and has little application to salt. It appears that a cursory stability analysis was used for the at-depth facility.

p. 146 The geomechanics and NGI classification methods do not apply to viscous rocks.

p. 147 There is no discussion of performance monitoring of the freeze zone and the associated rock damage. Remember: freezing will subject the rock mass to far greater thermal strain than the repository heating.

Conclusion

There appear to be several crucial issues, including

(1) performance analysis of the liner, freeze design, and the shaft in relation to the repository;

(2) calculations concerning liner design; and

(3) freeze design (construction and monitoring).

which need to be addressed in this document but are not. A very bothersome point is the general lack of reference to any previous performance analysis.

Action Items

1. Obtain ONWI performance analysis of ES shafts and review.

2. Obtain the Shaft Design Guide and Review.

REFERENCES

Itasca Consulting Group, Inc. Trip Report, ES Title II 30% Design Review, (22-24 April), Hyatt Regency West Hotel, Houston, Texas; submitted to NRC, 27 April 1987.

APPENDIX A

10 CFR 60 REGULATIONS
APPLICABLE TO THE ES CONSTRUCTION AND TESTING

60.15 — Site Characterization

At-depth testing is required at waste emplacement locations (also, Section 113 of NWPA) and inclusion of the following provisos:

- must limit adverse effects on long-term performance
- number of boreholes and shafts to be limited to the extent practical
- shafts to be located in large pillars or where other shafts/boreholes are located
- underground excavation/testing to be planned and coordinated with the repository design and construction

60.16 — Site Characterization Plan

Sinking of shafts is deferred until NRC comments have been solicited and considered.

60.17 — Contents of SCP

Of importance to the ES plan are the following:

- description of planned excavations
- plans for testing
- plans for investigations which may affect isolation capability of site
- plans to control adverse effects of site characterization

60.21 — Content of License Application

(i)(b)(5) — a description of site characterization work

(i)(c)(1)(B) — description of potential pathways for radionuclide transport

(ii)(e) — analysis of major design structures, systems and components

(ii)(f)(2)(3) — discussion of surface and subsurface

(ii)(f)(2)(4),(14) — design components, including information on construction and issues important to safety

(ii)(f)(15)(v),(vi) — discussion of components which require research and development to confirm adequacy of design; normal maintenance activities; permanent closure plans

60.31 — Construction Authorization

(a)(i) — reasonable risk to public health and safety

(a)(i)(1)(iii) — description of principal architectural and engineering criteria

(a)(i)(1)(iv) — construction procedures which may affect site isolation capability

60.32 — Conditions of Construction Authorization

(b)(2) — DOE will furnish any data obtained during construction which are not within predicted limits

(b)(3) — any adverse deficiencies in construction

60.51 — Permanent Closure

(1) — method for post-closure monitoring

(4) — results of tests, experience, analyses regarding shaft sealing

Subpart D

60.72 — Construction Records

(1) — survey control, geologic mapping, construction practice, etc.

60.74 — Testing of Structures, Systems and Components

Subpart E

60.111 — Performance Objectives

(a) — control of release prior to permanent closure

(b) — retrievability of waste up to 50 years after emplacement

60.112 — Overall System Performance After Permanent Closure

- EPA standard

60.113 — Performance of Particular Barriers After Closure

(ii)(B) — release rate; 1 part in 100,000 per year of the inventory calculated at 1,000 years

(2) — geologic setting; 1,000-year fastest path travel time from disturbed zone

60.122 — Siting Criteria

potentially adverse conditions:

(20) — rock or groundwater conditions requiring complex engineering measures in the design and construction or in-sealing of shafts/boreholes

60.131 — General Design Criteria for the Geologic Repository Operations Area

(b) — structures, systems, components important to safety

(b)(3) — fire
(b)(6) — inspection, testing maintenance
(b)(8) — instrumentation
(b)(9) — mining regulations
(b)(10) — hoists

60.133 — Additional Criteria

(a)(1) — geometry/layout of facility

(b) — flexibility of design accommodation of specific site conditions

(d) — control of water and gas

(e)(2) — prevention of deleterious rock movement

(f) — incorporate excavation methods which preclude formation of pathways

60.134 — Design of Seals for Shafts and Boreholes

(a) — designed so that they don't become pathways and affect the ability to meet performance objectives

(b) — selection of materials and placement methods; reduce to the extent possible

(b)(1) — potential to create a preferred pathway

(b)(2) — for radionuclide migration through existing pathways

60.140 — Performance Confirmation

provide data on:

(a)(1) — actual subsurface conditions are within limits assumed in licensing review

(a)(2) — natural or engineered systems functioning as assumed

(b) — monitoring started at site characterization and carried on through permanent closure

(c) — in-situ monitoring/testing

(d) — program does not:

(d)(1) — adversely affect natural or engineered barriers

(d)(2) — provide baseline data on natural processes and construction activities effects

(d)(3) — monitors changes from baseline

(d)(4) — feedback/implementation of appropriate action

60.141 — Confirmation of Geotechnical/Design Parameters

(a) — continuing program of monitoring/surveillance

(c) — rock deformation, changes in rock stress/ strain, rate/location of water inflow

(d) — comparison of the above to design assumptions

(e) — thermomechanical response measurement to permanent closure

60.142 — Design Testing

(a) — in-situ testing of design shaft seals
(b) — tests as early as practical
(d) — tests of borehole/shaft seals

Subpart G

60.151 — Applicability

60.152 — Implementation