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Mr. George E. Niewiadomski
U. S. Bureau of Mines
Division of Minerals Health
and Safety Technology
2401 E. Street, NW
Washington, DC 20241

Dear Mr. Niewiadomski:

Attached for your consideration is the NRC's comments on your proposal "State-of-the-art feasibility study of large diameter horizontal boreholes".

As we discussed during our phone conversation on May 2, 1983, after you have considered the NRC's comments, a meeting will be set up to further discuss the proposal.

The action taken by this letter is considered within the scope of the current interagency agreement (NRC-02-80-075). No changes of costs or delivery of contracted products are authorized. Please notify me immediately if you believe this letter would result in changes to costs or delivery of contracted products. I can be reached on (301) 427-4131.

Sincerely,

"ORIGINAL SIGNED BY"

David H. Tiktinsky
High-Level Waste Technical
Development Branch
Division of Waste Management

Attachment:
NRC's Comments

cc: H. Nichols (BOM)
C. Fleenor (TACB)

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PDR WMRES EUSDOIMI
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comments to Bom from NRC on project proposal

PROJECT PROPOSAL

STATE-OF-THE-ART ~~FEASIBILITY STUDY~~ assessment

OF

LARGE DIAMETER HORIZONTAL

NUCLEAR WASTE EMPLACEMENT HOLES

Prepared by: U.S. BUREAU OF MINES

For: THE NUCLEAR REGULATORY COMMISSION

I Introduction

The Nuclear Waste Policy Act of 1982 establishes a schedule and procedures for the disposal of nuclear waste in mined repositories by the mid-1990's. The Nuclear Regulatory Commission, as the licensing agency for nuclear waste repositories, must have ~~conclusive evidence~~ reasonable assurance that technical approaches proposed for ~~use~~ waste retrieval in repositories ~~truly~~ represent proven state-of-the-art technology that can meet the required retrieval performance objectives. A key element of ~~this entire program~~ the repository design proposed by DOE centers around the ability to drill and maintain the integrity of large diameter, long horizontal boreholes in which the waste packages will be placed. ~~For this reason~~ To determine if this approach is valid, it is essential that the NRC know the current proven state-of-the-art pertaining to drilling and maintaining the integrity of long, large diameter emplacement holes. These emplacement holes will be from 2 to 4 feet in diameter and from 200 to 700 feet in length. They may be open-ended holes which are drilled with a small diameter bit, then backreamed with a large diameter borer, or they may be dead-ended and require blind boring of the total diameter throughout the h le length. These emplacement holes will be large enough to allow from 3 to 6-ir..nes of backfill to be placed around the canister. This approach has been proposed by DOE at hard rock sites (Basalt and Tuff) for depths between 1000 and 4000 feet.

A ~~Another~~ required characteristic of the emplacement holes is that they must be capable of maintaining their integrity over long periods of time. ~~up to 100 years~~. According to the Code of Federal Regulations 10 CFR 60, it is necessary to have canister retrieval capabilities for up to 50 years after initial emplacement. These capabilities should be maintained up until the time when a decision is made to decommission and seal the repository. Retrieval ~~would~~ could be initiated ~~only~~ in the event that repository storage failed to meet established public health and safety performance objectives. Retrieval capability is highly dependent upon maintaining the shape of the emplacement hole.

~~Originally~~ The concept of vertical emplacement holes ~~was~~ is considered in some designs. However, vertical emplacement would require significantly higher emplacement rooms. These are the airways from which the emplacement holes are drilled and from which the canisters are emplaced in the holes. Higher emplacement rooms generate unfavorable stress conditions around the rooms when horizontal stresses are high, as in the case of a deep repository. Also, as much as four times more mining of emplacement rooms is needed for vertical emplacement than for horizontal emplacement. This is because the vertical holes would be much shorter than the horizontal holes and many more holes would be needed.

The Bureau of Mines, with its extensive mining experience, is in a unique position to conduct state-of-the-art paper studies on drilling and maintaining emplacement holes, as well as comment on methods of backfilling these holes. Furthermore, the Bureau has the ability to conduct investigations or demonstrations, either in-house or through its contractors, to verify the reliability of drilling methods and backfill techniques, and to evaluate the long term integrity of emplacement holes.

II Objective

To evaluate technology relevant to drilling, maintaining, and backfilling long (up to 700 feet), large diameter (up to 4-feet) horizontal emplacement holes for underground storage of nuclear wastes, and to provide evidence to NRC as to whether or not technical approaches being proposed for use in repositories truly represent proven state-of-the-art technology that can meet the required structural performance objectives.

III Proposed Work Plan

This work will address four independent but related areas associated with the use of large diameter horizontal emplacement holes. These are:

1. Drilling of Emplacement Holes.
2. Maintaining Integrity of Emplacement Holes.
3. Backfilling Emplacement Holes.
4. Retrieving Waste Canisters from Emplacement Holes.

The work will consist of a paper state-of-the-art ~~feasibility study~~ assessment of each of the above four areas of interest. Also included will be a determination of whether technology proposed in DOE nuclear waste repository reports is in line with the findings of this state-of-the-art study, and whether technology exists which will satisfy the requirements of 10 CFR 60. All of this work will be done as a paper study.

STATEMENT OF WORK

STATE-OF-THE-ART ~~FEASIBILITY STUDY~~ assessment

1.0 Drilling of Emplacement Holes

1.1 A study will be done to establish the current state-of-the-art of drilling long, large-diameter horizontal boreholes. The required borehole characteristics will be :

A. Diameters from 2 to 4 feet.

B. Lengths from 200 to 700 feet.

C. Open-ended and dead-ended.

D. Hole deviation of no more than 6-inches in 100 feet and no more than 12 inches of total deviation.

Both back-reaming and blind boring technology well be reviewed. This state-of-the-art investigation of drilling techniques will include but not be limited to:

A. A review of directional drilling techniques with an emphasis on down hole motors. Equipment manufacturers and operators will be contacted to obtain the most up to date information on directional drilling techniques.

B. A review of tunnel boring techniques. Again equipment manufacturers and users will be contacted for information. Consideration will be given to the "pilot tube principle" incorporated into tunnel boring equipment.

C. A review of work done by federal agencies (BOM, OSM, and DOE) in the area of horizontal borehole drilling.

D. A review of vertical borehole drilling techniques that might be applicable to horizontal hole drilling.

E. A review of auger mining techniques. Consideration will be given to the concept of adding high pressure water jets to the auger head as a means of reducing the thrust required on an auger and thus improving the steering of the auger head.

In this state-of-the-art study each method of drilling will be looked at in terms of its:

1. Reliability
2. Alignment accuracy
3. Associated problems
4. Portability
5. Constraints and operational capabilities

1.2 A study will be done to establish the state-of-the-art of horizontal borehole trajectory control. The study will include but not necessarily be limited to:

A. Measurement while drilling techniques (hard wire systems)

B. Telemetric techniques

C. Conventional wire run techniques

D. Laser techniques as were used on a blind shaft boring machine as part of a Bureau project.

E. Steering correction devices

1.3 A state-of-the-art review of cuttings removal systems will be done. This will consider:

A. Fluid flushing systems

B. Air flushing systems

C. Mist flushing systems

D. Vacuum removal

E. Mechanical flushing systems.

1.4 A review of DOE nuclear waste repository reports will be done to determine if drilling technology proposed in these reports is in line with findings of the state-of-the-art study proposed in sections 1.1, 1.2, and 1.3.

1.5 An evaluation will be made as to whether or not horizontal borehole drilling technology exists which ~~will~~ can help satisfy the retrieval requirements of 10 CFR 60.

2.0 <u>Maintaining Integrity of Emplacement Holes</u>

2.1 A study will be done to establish the state-of-the-art of technology applicable to maintaining the integrity of emplacement holes. For purposes of possible retrieval it is essential that these holes maintain their established original configuration. Closure of these holes could make retrieval extremely difficult. This study will have to take into account:

A. Rock mechanic stresses over long periods (>50yrs). When designing underground openings it is essential to have an accurate prediction of the behavior of the rock mass that is affected by the opening. Before an underground opening is formed, the rock mass is in equilibrium under action of the existing or virgin stresses. When an opening is made and is unsupported, redistribution of stresses occur around the excavation and some closure of the opening results. To evaluate the reponse of rock stresses to an underground opening, it is essential to evalute the virgin stresses, redistribution, displacements, and energy changes.

B. Effects of water and steam

C. Effects of heat (up to 400°C).

D. Effects of dynamic influences such as earthquakes or volcanic activity.

E. Effects of gamma radiation on the host rock.

2.2 Significant consideration will be given to methods of hole casing as this appears the most viable way of maintaining the integrity of the holes. Areas of consideration are:

A. Methods of casing - this will take into account technology for concrete slip forming and jacking in steel liners as well as methods, of casing holes as the drilling progresses.

B. Casing materials - The casing material itself must take into account several factors. The material must ~~be corrosion proof,~~ maintain its strength characteristics over a fifty year period ~~the life expectancy of a repository and it would be desirable if the material also acted as a barrier against water inflow and as a radiation shield.~~

2.3 Consideration will also be given to methods of improving emplacement hole integrity by chemically or structurally strengthening the surrounding rock. The concept of using grouts to tie together factured rock mass and to add strength to the borehole perimeter will be investigated. Consideration will have to be given to whether or not technology is available to force grouts into holes 700 feet long with enough pressure to force the grout into fractures in the host rock.

2.4 A review will be made of DOE nuclear waste repository reports to determine if the technology proposed in these reports to insure emplacement hole integrity is in line with the findings of the state-of-the-art study proposed in sections 2.1, 2.2, and 2.3.

2.5 An evaluation will be made as to whether or not emplacement hole integrity can be maintained to satisfy the critical requirements of 10 CFR 60.

3.0 Backfilling of Emplacement Holes

3.1 A study will be done to establish the state-of-the-art of technology to backfill long boreholes. The backfill must ~~completely~~ fill an empty borehole space which consists of the space between waste canisters and the annular spaces between the canisters and the borehole wall. Concepts to be looked at include, but are not limited top:

A. Pneumatic conveying systems.

B. Hydraulic conveying systems.

C. Mechanical ram techniques.

3.2 An evaluation will be done of various types of materials which could be used as backfill in the emplacement holes. Various types of grouts, tight-packing solids, and slurries will be looked at. Special emphasis will be put on materials which have a tendency to swell and fill voids after they are in place. Other favorable characteristics of these materials are:

A. They should be unaffected by temperatures in the 400°C range.

B. They should act as barriers against water flow.

C. They should act as radiation shields.

D. They should add structural integrity to the emplacement hole.

E. They should have good thermal conductivity.

3.3 A study will be conducted to determine if there are existing methods to insure that the backfilling of a borehole is complete and that no void spaces exist. Methods to be looked at would include:

A. Geophysical techniques.

B. Volume measurement techniques where a comparison is made between the borehole volume and the volume of backfill being fed in.

3.4 A review will be made of DOE nuclear waste repository reports to determine if the technology proposed in these reports concerning backfilling of emplacement holes is in line with the findings of the state-of-the-art study proposed in sections 3.1, 3.2, and 3.3.

3.5 An evaluation will be made as to whether or not backfilling of emplacement holes can be done so as to satisfy the release rate requirements of 10 CFR 60.

4.0 Retrieving Waste Canisters from Emplacement Holes

4.1 A study will be done to determine if state-of-the-art technology exists to reliably and safely retrieve canisters from the emplacement holes in the event that repository storage fails to meet established public health and safety performance objectives. In the event that backfilling of the emplacement hole has not yet taken place and the hole has maintained its integrity to the extent that the annular space between the canisters and the hole is still open, then retrieval should be a simple matter if hole integrity has been maintained. However, if backfilling of the hole has taken place or if the hole has closed to the extent that no annular space exists between the canisters and the hole, then retrieval becomes much more difficult. It is this latter situation which will be addressed in this state-of-the-art study. While all related technology will be considered, it appears that overcore drilling of the emplacement hole is the most likely approach. Areas of special consideration should be:

A. How to avoid drill damage to the canisters during overcore drilling.

B. How to guarantee overcore drilling will follow the emplacement hole. One way would be to overcore the casing or liner if in place.

C. How will the core containing the canister be removed after overcoring.

In this state-of-the-art study each method of canister retrieval considered will be evaluated in terms of its:

1. Reliability
2. Safety features
3. Associated problems

4.2 A review will be made of DOE nuclear waste repository reports to determine if the technology proposed in these reports concerning the retrieval of canisters from backfilled emplacement holes or from emplacement holes which have lost their integrity is in line with the findings of the state-of-the-art study proposed in section 4.1.

4.3 An evaluation will be made as to whether or not canister retrieval technology exists which will satisfy the requirements of 10 CFR 60.

5.0 Report to NRC

At the completion of this work a formal report will be submitted to the Nuclear Regulatory Commission by the Bureau of Mines. This report ~~will be in~~ two parts.

A. Part 1 will be a summary of all the state-of-the-art information assembled by the Bureau of Mines during this study. To the extent possible, the Bureau will determine if state-of-the-art technology is available to drill, maintain, and backfill the long, large diameter horizontal emplacement holes proposed for the underground storage of nuclear waste. The BOM will summarize their comments on the ability of the proposed DOE design to meet the retrieval performance object

B. Part 2 will be a list of investigations which the Bureau of Mines believes would be beneficial for NRC to pursue in order to confirm the reliability of certain technologies which appear viable but still have some question of uncertainty surrounding their use in nuclear waste repositories. These investigations would not deal with equipment development. Rather, their purpose will be to confirm the applicability of existing technologies to repositories.

6.0 Period of Performance

A report will be submitted to NRC eight (8) months after the award date of this work.

7.0 NRC - BOM Meeting

After NRC has had adequate time to review the report, a meeting between the Bureau of Mine and NRC will be held in Washington, D.C. The purpose of this meeting will be to discuss any aspects of the report which are of special interest to NRC.

ENGINEERING COST PROPOSAL

LABOR COSTS

TASK	MAN-HOURS	RATE	COST
1.1	800	E*	$ 25,000.00
1.2	80	E	2,500.00
1.3	80	E	2,500.00
1.4	144	E	4,500.00
1.5	40	E	1,250.00
2.1	680	E	21,250.00
2.2	120	E	3,750.00
2.3	200	E	6,250.00
2.4	144	E	4,500.00
2.5	40	E	1,250.00
3.1	244	E	7,625.00
3.2	120	E	3,750.00
3.3	80	E	2,500.00
3.4	144	E	4,500.00
3.5	40	E	1,250.00
4.1	160	E	5,000.00
4.2	144	E	4,500.00
4.3	40	E	1,250.00
5.0	160	E	5,000.00
	96	C**	1,049.28
7.0	48	E	1,500.00
		Total Labor Cost	$ 110,674.28

ENGINEERING COST PROPOSAL (CONTINUED)

	Total Labor Cost	$ 110,674.28
COMPUTER INFORMATION SEARCHES		
6 searches @ $500 per search		3,000.00
	Total	113,674.28
Bureau of Mines Washington Office overhead rate (15%)		$ 17,051.14
	Total Project Cost	130,725.42

* E represents Bureau of Mines engineering labor cost of $31.25/hr. which includes all Bureau overhead charges except a Washington Office overhead of 15%.

** C represents Bureau of Mines clerical labor cost of $10.93/hr. which includes all Bureau overhead charges except a Washington Office overhead of 15%.