NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418

U.S. NATIONAL COMMITTEE
ON TUNNELING TECHNOLOGY

(202) 334-3136

November 28, 1984

Mr. Naiem S. Tanious
Engineering Branch
Division of Waste Management
Mail Stop 623 SS
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Tanious:

I am pleased to transmit comments on the Draft GTP, "In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories." The comments were solicited from the members of the U.S. National Committee on Tunneling Technology, as requested in your letter of October 18, 1984.

As you know, these comments reflect the individual opinions of the respondents. Therefore, they may not be considered to constitute an official position by either the National Research Council or the committee.

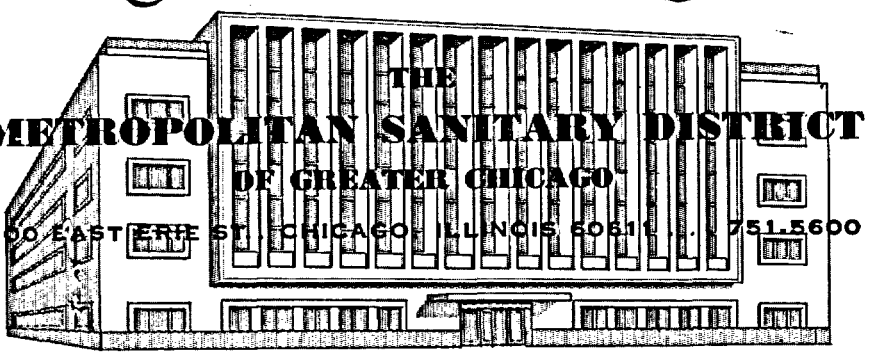
We appreciate the opportunity to assist the Nuclear Regulatory Commission in this activity.

Sincerely,

Susan V. Heisler
Acting Executive Secretary

Enclosures

NICHOLAS J. MELAS
PRESIDENT



November 21, 1984

Ms. Susan V. Heisler,
Acting Executive Secretary
National Research Council
Commission on Engineering and
Technical Systems
2101 Constitution Avenue
Washington, D.C. 20418

Dear Ms. Heisler:

Subject: Draft Generic Technical Position: "In-Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories"

The subject technical position has been reviewed by the Metropolitan Sanitary District of Greater Chicago's Engineering Department.

The document presents a comprehensive coverage of the topic. However, we feel that Section 4.4, Scale of Testing, should be expanded to discuss possible requirements for variable depths at which in-situ tests will be performed. A possible need to sink the exploratory shafts deeper, in order to adequately characterize a potential nuclear waste disposal site, should be addressed.

In general, we concur that a thorough site investigation is highly essential.

Very truly yours,

Frank E. Dalton
Chief Engineer

FED/sb

NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418

U.S. NATIONAL COMMITTEE
ON TUNNELING TECHNOLOGY

(202) 334-3136

TELEPHONE RESPONSES TO: Susan V. Heisler

SUBJECT: Draft GTP, "In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories"

From Z.T. Bieniawski: I have no substantive issues to raise with respect to the draft GTP.

From C.A. Baskerville: I have not gone into any of the references but have read the draft GTP and believe it looks reasonable.

From W.H. Hansmire: I concur with need for in situ testing--it is essential. However, coupled interaction testing is described in generic ways that may leave the technical personnel wondering where to go. Also, it leads to an "open" situation for designing research projects that may be unproductive or unnecessary. Focus and objective should be sharpened.

UNIVERSITY OF MISSOURI—ROLLA

School of Mines and Metallurgy

Department of Geological Engineering

Allen W. Hatheway, Ph.D., P. Geol., P.E.
Professor of Geological Engineering

125 Mining Building
Rolla, Missouri 65401-0249
Telephone (314) 341-4867

17 November 1984

Ms. Susan V. Heisler
Acting Executive Secretary
U.S. National Committee on
Tunneling Technology
National Research Council
2101 Constitution Avenue, NW
Washington, DC 20418

Subject: Review of USNRC Draft Generic Technical Position
In Situ Testing During Site Characterization for
High-Level Nuclear Waste Repositories

Dear Susan:

Here are my comments relating to the above-cited U.S. Nuclear Regulatory Commission Draft Generic Tecnical Position paper, as received here on 8 November 1984. It has been a pleasure to assist you in the review effort.

Yours truly,

Member, USNCTT

encl. Comments

17 November 1984

COMMENTS IN REVIEW OF USNRC DRAFT GENERIC TECHNICAL POSITION

IN SITU TESTING DURING SITE CHARACTERIZATION FOR HIGH-LEVEL NUCLEAR WASTE REPOSITORIES

Dr. Allen W. Hatheway
125 Mining Building
University of Missouri-Rolla
Rolla, Missouri 65401

1. General Comment: The content of the Position is generally clearly stated and easily understood. A considerable degree of latitude in the planning and design of the required in situ testing is afforded to USDOE and its contractors.

2. page 5, par 4, line 2: Suggest addition of "...and the current deficiency

3. page 5, par 4, line 7: Suggest addition of "...by certain analytical extrapolation models."

4. page 6, par 1, line 1: Suggest addition of "...limitation on applicability and are sensitive....".

5. page 6, par 1, line 1: Suggest addition of "...used as input parameters, as well as to the constituative relationships chosed to relate interrelate these parameters....".

6. page 6, par 1, line 3: Suggest addition of "...volumes of rock, to detect possible spatial variations, and employing....".

7. page 6, par 1, line 4: Suggest addition of: "...spatial variation of engineering , chemical, and hydraulic properties ...."

8. page 6, par 1: Comment: It is not apparent that this paragraph takes into consideration the need to define rheologic (time-dependent, non-linear) behavior.

9. page 6, par 3, line 6: This Figure number is actually labeled "1A" in the attachment to the document

10. page 6, par 3, line 6: This statement about Figure 1 (1A) should be clarified (perhaps on the Figure) as to who chooses (The President?) the site and that this scheme is applicable to both the first Presidential site selection (from bedded salt, salt domes, basalt, or tuff) in 1987, and to the second site selection (1990) in crystalline rock.

11. page 7, par 2, line 5: Here and throughout the remainder of the Position, the word capability might better be replaced by containment integrity to better portray the intent of containment measures (unless the writing is constrained by wording of the NWPAct).

12. General comment: It is good to see that the specific methods of in situ, subsurface access are specified. Those of us who worked hundreds of hours on the ONWI proposals were originally told (by USDOE) that exploratory/test shafts would not be constructed in the site characterization phase. At the time many of us felt that the USDOE position was short-sighted. USDOE, of course, reversed that position after awarding the ONWI Permian Basin contract.

13. page 9, par 2, line 3: Suggest addition of "... prior to design, construction and waste emplacement....".

14. page 9, par 2, lines 5 & 6: Suggest reordering the sequence of test/observational procedures to more clearly group them: "...geochemical characteristics, thermal conductivity, distribution of discontinuities, and geologic structure....".

15. page 10, par 2, line 3: Suggest addition of "....size of the rock specimen or rock mass tested;....".

16. page 10, par 3, line 3: Suggest replacement of "geologic features" with Geologic discontinuities, in order to be more consistent with present-day usage and with the previous paragraphs of the Position.

17. page 10, par 3, line 7: Suggest addition of "...and therefore attempt to test the rock....".

18. page 10, par 4, sentence 2: This sentence should include consideration of expected non-linear behavior until shown otherwise.

19. page 10, par 5, line 4: Suggest addition of "...the only means to calibrate surface geophysical surveys, and to assess the thickness....".

20. page 10, par 6: Suggest addition of a new second sentence: Host rock variability should be related to the presence of three-dimensional geologic structural domains, within the candidate repository near-field rock mass.

21. page 11, item 5: The term "Geoengineering" is not well accepted in the United States (at least); suggest replacing it with Geotechnical.

22. page 11, item 6: Suggest begining the sentence with Subsurface geologic mapping.

23. page 12, item A(1): Suggest addition of: "Examination and full-face geologic mapping of all exposed rock surfaces...."

24. page 12, item A(4), line 3: "gama" is misspelled (gamma).

25. page 13, par 1, line 4: Suggest replacement of "fractures" with discontinuities as a more definitive an accepted term.

26. page 13, item C(2), line 1: This statement needs to be clarified; suggest replacement of "from" with due to construction of.

27. page 13, item D(1): "migration" should be replaced with contamination migration, as the present wording suggests "migration of the bedrock", which, of course, is not the case.

28. page 14, item D(3): Suggest addition of "Petrographic and chemical analyses....".

29. page 14, item D(4): Redox is generally capitalized in the literature of geochemistry and environmental engineering.

30. page 16, par 2, line 4: "...falls...." should be changed to fall.

31. page 19, par 1, line 3: Suggest changing "credit" to credit-dependence to achieve the proper meaning. If so, "credit" appears again in line 6.

32. page 19, par 1, next to last line: "near-field" needs to have some range of distance values, and is such to be measured from the accesss shaft of the repository, or from the furthest placement of waste in the respository?

33. page 20, par 2, item 7: the word "delineate" refers to the act of defining a linear or line-type relationship or feature. Suggest replacement with identify or define.

34. page 20, par 2, item 9: The word "credit" applies to comment number 31, above.

////////////////////////////////END OF COMMENTS ////////////////////////////////

Crimmins, Samuels & Associates, Inc.

CONTRACTORS AND CONSULTANTS

REUBEN SAMUELS, PRESIDENT
KEVIN B. CRIMMINS, VICE PRESIDENT
ALLAN J. GALE, SECRETARY-TREASURER

205 EAST 42ND STREET
NEW YORK, N.Y. 10017
(212) 687-6226

November 7, 1984

MEMORANDUM

TO: Susan V. Heisler
U.S. National Committee on Tunneling Technology

FROM: Rube Samuels

SUBJECT: Comments - NRC Draft GTP
"In-situ testing during site characterization
for high level Nuclear Waste Repositories"

These comments are from a limited background, very often conversational, of what some of the constraints for the design, construction and operation of the repositories will or should be. Also, I assume that NRC 10 CFR 60 is not a necessary item for background.

- The applicability of oil well drilling (offset holes, etc.) and logging* procedures should be explored. That industry's logging together with T.V. and borehole cameras offer a potential of good information within existing technology. *many of the data--physical, chemical characteristics are standard.

- Questions must be asked and answered re:
  - must all properties be investigated in-situ
  - what specifically will be done with the test data.
  - is there a significant range of variation in characteristics and properties; can a conservative assumption be made without distortion of analysis and predictions.

- There should be a separation of testing for physical characteristics that would affect the construction of the shafts, tunnels and openings as opposed that characteristics that affect the containment performance of the rock with the high level nuclear waste installed.

- This draft is generic and is so stated; would it be possible to generate a site specic technical position as an hypothetical example?

REUBEN SAMUELS

Conoco Inc.
P.O. Box 2197
Houston, TX 77252

November 20, 1984

U.S. National Committee on Tunneling Technology
Commission on Engineering and Technical Systems
National Research Council
2101 Constitution Avenue
Washington, DC 20418

Attention: Susan V. Heisler, Acting Executive Secretary

Dear Ms. Heisler:

Subject: Draft Generic Technical Position on In-Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories

Pursuant to your request, I have reviewed the Nuclear Regulatory Commission's draft generic technical position on in-situ testing during site characterization for high-level nuclear waste repositories.

The document appears to be quite comprehensive in its coverage for the need, plan, duration and amount of testing.

My own expertise lies in the construction of the exploratory shaft as opposed to the required testing necessary to define the suitability of a geologic repository for high level nuclear waste. Therefore, I have no recommendations to contribute to the draft document on in-situ testing.

Yours very truly,

Hassell E. Hunter
Senior Staff Engineer
(Member, USNCTT)

mrr

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JOHN J. REED

MARYLAND OFFICE
510 PERPETUAL BUILDING
7401 WISCONSIN AVENUE
BETHESDA, MARYLAND 20814
(301) 986-9688

November 21, 1984

Ms. Susan V. Heisler
Acting Executive Secretary
National Research Council
Commission on Engineering and
Technical Systems
2101 Constitution Avenue
Washington, DC 20418

Re: Draft Generic Technical Position: "In-Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories"

Dear Susan:

I have reviewed the referenced draft relating to nuclear waste repositories and can only offer the very limited comment that it seems that the analysis is thorough and well structured. Since the subject is a highly technical one dealing with some rather esoteric geological concepts, I do not feel qualified to comment on the technical side.

If I can be of any further assistance, however, with respect to collation of other comments, please feel free to contact me. This is obviously a very important, specific problem, and I can readily understand the importance of input from the Committee.

Sincerely yours,

Andrew F. Dempsey, Jr.

AFD:jeg

November 19, 1984

Susan V. Heisler, Act. Exec. Secretary
U.S. National Committee on Tunneling Technology
2101 Constitution Avenue
Washington, D.C. 20418

SUBJECT: Review of Draft Generic Technical Position: "In-Situ Testing During Site Characterization for High Level Nuclear Waste Repositories"

Dear Susan:

My comments are made from the viewpoint of a party selected to make a proposal for accomplishing the Site Characterization Plan.

Page 8, para. (a) (6) The last word "etc." should be removed or should be specific.

Para. (c) (1) (ii) where are paragraphs (A) through (D) in this document? Entire paragraph is confusing, needs to be rewritten to clarify.

Page 9 - Second paragraph - Remove the etc. at end of sentence (1) or be more specific. Second paragraph sentence headed (2), is this something to be done initially or will it be accomplished after results of in-situ tests are analized?

Page 11 - Under 1. Development of an in-situ testing program should consist of: Why the word "and" after the sentence numbered by the 4th dot down? Eliminate the and or complete the sentence. Item 6 - After word lateral add, and vertical extent to assess---------. Item 7 - eliminate the last word and for the same reasons given above.

Page 12 - Under section 3.2.1.. A. - Geological - Geophysical: (2) after end of this sentence add: "and to determine lateral variation of host rock." Para. (3) leave off word and or complete the sentence.

Page 13 Geomechanical: (1) Omit the word and or complete the sentence. (2) and to arrive at a better estimate change "a better" to "the best".

Page 14 - Under item (4) Add the requirement for tests to determine the age of the groundwater. Is it "conate" water, or, "recent water?" An estimate of the rate of movement of the water can be approximated by determining the age of the groundwater. (5) remove the etc., or be specific also the and is useless here, unless the writer has something to add.

Page 18 - Top of page, any planned long term--------. The word any implies that long term monitoring activities may not be required. Word any should be replaced by the word all. Second paragraph under 4.7 Amount of Testing. The last sentence, (For all tests important to the performance assessment a general guidance is that testing should continue or be repeated until confidence in the results is established by an independent peer review.) This sentence is lost here on page 18, and should be placed "up front" in the document to alert the reader early-on in his planning.

Page 19 - 4.9 Sufficiency Criteria. This paragraph has sentences that might tend to create "Loop-holes" for parties accomplishing work. Last sentences refering to the need for coupled testing should be stated in a positive form rather than the present negative form, so that contractor will be prepared to perform coupling tests and that non-testing would be an exception to the requirement.

Page 20 - 5.0 Summary. As in the previous comment, recommend that testing will be a requirement unless otherwise determined not to be necessary by the governing agency or the peer review.

Page 23 - Fig. 1A. The text is difficult to follow because it is not clear when certain activities listed on the left hand side of the chart are to be accomplished. It is suggested that paragraph numbers in the text which pertain to the specific activities should be listed on figure F 1A, next to or along the line representing the required activity. This would help the parties interested in accomplishing the program to plan their activities in accordance with the time requirements or milestones shown on the bar graph with the specific paragraphs in the text.

Page 24 - Figure 2, Where is the line, representative of reduction of uncertainties, located percentage wise? It is suggested that a scale of 1 to 10 be shown on the ordinate of this chart to indicate approximately what NRC's goal is for reducing uncertainties.

Sincerely yours,

"Spike"

Lloyd B. Underwood

LBU:kmu

DEPARTMENT OF CIVIL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139

ROOM 1-330 PHONE: (617) 253- 3598

November 9, 1984

Ms. Susan V. Heisler
National Research Council
Commission on Engineering and Technical Systems
2101 Constitution Avenue
Washington, D.C. 20418

Dear Susan:

I just received the NRC Draft Generic Technical Position on situ testing and I have two comments:

(1) In Section 3.2.1 quite a few tests are discussed. This may cause problems because there may be other equally or better suited tests that can replace some of those mentioned as well as additional tests that should be run. Although the draft mentions that the extent of testing may vary between sites, there is a danger in being so specific with regard to test types. It would in my opinion, be much better to state what characteristics of the host rock, of the facility and of the host rock - facility interaction NRC would to have examined. It should have to also be emphasized that some of these extant characteristics may be model dependent and are not defined as yet.

(2) Uncertainty

The draft includes an illustrative preshaft curve (Fig. 2) on how uncertainty should be reduced as one goes from pure shaft to closure. The title of Figure 2 mentions "uncertainty about compliance with 10 CFR60 performance requirements".

This is an important issue which should be more methodologically approached in the draft. The performance uncertainty is affected by geologic uncertainty, test uncertainty, test interpreration uncertainty and model uncertainty. It should be an integral part of the testing program to specifically identify and determine these uncertainties. This will create a sound basis of information for whoever will have to assess the performance uncertainties.

The generic technical position should emphasize the necessity for such a systematic and specific treatment of uncertainties.

I hope my comments are of some use and I would be glad to discuss these in more detail with NRC staff if they so desire.

Sincerely yours,

Herbert H. Einstein
Professor of Civil Engineer

HHE:pph

WOODWARD - CLYDE CONSULTANTS
1300 Piccard Drive
ROCKVILLE, MARYLAND 20850

(301) 258-9780

LETTER OF TRANSMITTAL

DATE	21 NOV 84
JOB NO.	
ATTENTION	Susan V. Heisler
RE:	USNC/TT Comments on NRC Repository In Situ Testing Paper (Sept. 84)

TO USNC/TT
NRC
2101 Constitution Ave
Washington DC 20418

GENTLEMEN:

WE ARE SENDING YOU ☐ Attached ☐ Under separate cover via _____ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications
☐ Copy of letter ☐ Change order ☒ hand written comments

COPIES	DATE	NO.	DESCRIPTION

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REMARKS Susan,
I apologize for the lack of typed comments, but timing and a broken down word processor foiled my best efforts. Call me if you need an interpreter.
In addition to the attached specific comments my people had two general comments
(1) The paper is pretty well thought out
(2) The insitu testing program should serve as the base line data for on-going performance monitoring through repository life.

COPY TO AEG file

SIGNED: Ron
RE Smith

FORM 240-3 Available from NEBS Inc., Townsend, Mass. 01470 *If enclosures are not as noted, kindly notify us at once.*

RJE/RAN
11/19/84

REVIEW OF NRC DRAFT GTP ON INSITU TESTING DURING SITE CHARACTERIZATION, SEPTEMBER 1984

PAGE NO.	PARAGRAPH	COMMENT
5	2	"In-situ testing", as defined in the GTP, necessarily includes at-depth tests conducted in surface-drilled boreholes. Examples are in-situ stress, packer testing, borehole closure tests, and geophysical testing. GTP gives the impression that useful testing can only be performed from at-depth test facility.
5	3	"... which will [be used] to assess the suitability ..." (INSERT)
6	1	"... to account for ~~possible~~ spatial [and inherent] variation ..."
6	3	The GTP refers to an "application made for a license", which is then followed by construction authorization. The NWPA, dated 1/7/83, Section 114.(b), references the "application for a construction authorization", which is then followed by construction authorization. Is GTP's license application (LA on Fig. 1) the same as NWPA's construction authorization application (which is referred to often by DOE as the "CAA"). Recommend that LA be explained to include the CAA.
8	last para.	"... the responsibility to establish [(a) the volume of rock subject to exploration and insitu testing, and (b) the representativeness of that volume] to the repository block volume." (Note: NRC should address the possibility that the time frame allocated for SCP in-situ testing activities may be insufficient to assess the "representativeness". NRC should give more attention to continued at-depth testing and/or exploration during periods: (a) following LA, and continuing until the first emplacement of waste, and (b) during repository operation until permanent closure.)
9	1	Reference Figure 2. If the clarity of the Y-AXIS label is an indication of NRC's logical reasoning ..., we're in for a long haul. How about changing label to "Level of Confidence".

RJE/RAN
11/19/89

PAGE NO.	PARAGRAPH	COMMENT
9	3	NRC recognizes in the last sentence that SCP testing will not be sufficient by itself. This contradicts the last line of page 8, and supports our comment on that page.
10	4	The ability to assess coupled processes in sufficient detail to support design and/or performance assessment issues within the SCP time frame is questionable. Suggest that most of this type of testing will be appropriate for the long-term performance monitoring test phase.
10	5	If the only means to assess extent of repository host rock is from within the expl. shaft excavations at depth, then NRC's suggestion of 1,000 feet as being adequate for at-depth testing (see p. 17, para. 1) is grossly inadequate. Furthermore, the time frame provided for SCP testing would also be grossly inadequate. Suggest that NRC recognize the value of boreholes (with core) located outside the boundaries of the repository together with reasonable lengths of exploration adits (these boreholes are already a component of site characterization activities).
10	6	NRC should recognize that a "satisfactory" design may also need to be a flexible design, from the standpoint of varying support requirements, opening sizes and orientations, locations and dimensions of emplacement room pillars and barrier pillars, etc. Ground conditions may vary sufficiently within a several thousand acre footprint to warrant modifications to the design. Such modifications should be anticipated, and appropriate implementation procedures provided, prior to construction.

PAGE NO.	PARAGRAPH	COMMENT
12	3	"Coupled thermal-mechanical-hydrological-geochemical tests" may be a figment of someone's imagination. The practical limitations of conducting such tests in sufficient numbers and with the necessary control may exceed existing technology. To rely on the results of such complex, multi-variable tests as bases for repository design and performance prediction may be impractical. Use of simpler, one- or two-variable test programs may prove more feasible to develop, conduct, duplicate, interpret, and apply.
12	6 (3.2.1.A(3))	Should read: "Logging of cuttings and cores obtained ... underground excavations, for lithologic variations and discontinuity characterization"
12	7 (3.2.1.A(4))	"... distribution of geological units [,] ~~and~~ discontinuities [, and anomalies,]
13	5 (C(1))	"(e.g., block tests [, pillar tests]) to predict...
13	7 (C.(3))	"... emplacement, [backfill,] and retrievability [(e.g., excavation methods/disturbance, roof support systems, stress-relief techniques, backfilling procedures and timing, trafficability of equipment, waste package transport, etc.)]
13	Add (C(4))	Create item (4): "Observations of underground openings, pillars, and backfill by means of full-scale testing (e.g., multiple parallel rooms, mine-by tests, etc.)"
14	8 (E.)	See comments from page 12, para. 3 regarding coupled testing.
14	9 (3.3)	NRC should provide additional insight as to their definitions of "key issues" and "key tests".
15	1	Suggest different title for Figure 3: "Relationship of Repository and In-Situ Tests to Accessible Environment"

PAGE NO.	PARAGRAPH	COMMENT
15	2	Does NRC expect a separate document presenting "rationale" for testing, or will this be covered in the test plan or other SCP documentation?
16	1	Change "medium" to "media"
16	2	"In situ testing programs [, including deep boreholes and at-depth test facilities,] fall into this category."
16	3	"... are crucial to [(a) verify assumed design conditions, (b) confirm predicted repository behavior, and (c) provide bases for design modifications.]"
16	5	"... should consider ~~the~~ estimated range[s] of parameter~~s~~ [values] to be measured. The data ... should ~~reduce~~ [increase the confidence in selected parameter values for design input].
17	1	A test facility consisting of 1,000 feet of tunnels appears inadequate for the range of tests perceived by NRC in this document. Suggest excluding a minimum required length of tunnels.
17	3	What does NRC envision as "fundamental test results"? Are these related to "key issues" or "key tests", as discussed on page 14, para. 9?
18	4	The NRC appears to agree with our concern that performance of complex, multi-variable tests may be impractical. Yet this is contradictory to their inference on page 10 that the testing of coupled processes is, in part, "an essential element of site characterization and rational design of the repository". Also in this paragraph, NRC alludes to radiation testing during site characterization. We understand that radiation testing will not be performed at-depth during this time frame.

PAGE NO.	PARAGRAPH	COMMENT
19	1	Reference the acronym "THMC". Here we go again... does NRC think these tests are necessary, or are they willing to provide us with numerous acceptable excuses for not doing the tests in the first place?
20	5 (5.0)	Item 10, "analyses discussion", does not appear to be discussed in any detail in this document. Recommend that NRC provide a section in the main body of report to amplify.

The following are unique features that make in situ tests an essential element of site characterization and rational design of the repository.

1. Size Effects can be Minimized: - It has been shown through numerous laboratory and in situ tests that many of the measured rock properties are influenced by the size of the rock specimen tested; for example, compressive strength and permeability. In highly jointed rocks, the dependence could be more pronounced. In situ tests which measure crucial design parameters clearly minimize the size effect as a source of error.

2. The Rock Mass in its Natural Conditions can be Tested: The natural conditions of the rock mass cannot be exactly duplicated in the laboratory. Examples are: a) geologic features such as joints, shear planes, etc.; b) hydrologic conditions such as hydraulic head, pore pressure; c) temperature; and d) the loading conditions such as the in situ stress field. The in situ tests, by definition, encompass the natural rock conditions, and therefore test the rock in its natural state.

3. Coupled Processes can be Directly Observed: Many coupled processes (i.e., thermal, hydrological, mechanical, chemical) are likely to occur in the host rock in which the nuclear waste will be disposed. In situ tests measure representative properties resulting from coupled processes, unlike most small scale laboratory tests. Furthermore, the in situ tests provide for measuring a possible non-linear behavior which is difficult to extrapolate from small scale laboratory experiments.

4. Host Rock Extent can be Estimated: Lateral extent and thickness of the repository host rock must be assessed during site characterization. Since there are restrictions (10 CFR 60.10 (d)(2)) against drilling many boreholes from the surface, the only means to assess the thickness and lateral extent is from within the exploratory shaft excavations at depth.

5. Host Rock Variability can be Evaluated: Variability in joint patterns and spacing, geology, and hydrologic and geochemical changes can only be directly assessed through in situ testing. Estimation of variability and assessment of ability to predict rock behavior in different parts of the repository are necessary for satisfactory design of the repository.

No mention is made of horizontal coring or exploratory drifting from the test facility to determine the lateral extent of the repository horizon.

3.2. General Guidance to In situ Testing

The in situ test program must be site-specific to account for local geologic conditions, the characteristics of the predictive models chosen for use at the site, and the key issues found relevant to the performance of the selected repository design. However, there are several features that are common to all in situ test programs. These features are discussed in the following general guidance:

1. Development of an in situ testing program should consist of:
   - Establishing the information needs for License Application based on performance requirements, and the acceptable level of uncertainties in repository performance prediction;
   - Assessing the capabilities and limitations of available tests and measurement methods;
   - Matching the capabilities of available tests to the perceived information needs;
   - Developing and validating tests, if necessary; and
   - Conducting the in situ test program under a well-developed quality assurance program.
2. The test program must be developed such that it has little or no adverse effects on long term repository performance;
3. The underground openings used for in situ tests must be of suitable layout and sufficient extent to properly assess host rock variability and to minimize or, if possible, avoid interference among tests.
4. Constructibility must be demonstrated in the proposed repository host rock;
5. Geoengineering input should be provided for retrievability demonstration.
6. Geologic mapping, geophysical testing and core drilling should be of sufficient lateral extent to assess the characteristics of the host rock and the variability of its properties;
7. Representativeness of in situ test location in comparison to the proposed repository location should be assessed; and

The emphasis of this statement should be reversed such that, "A well developed QA program must be developed by which to judge the insitu testing program". The emphasis on the absolute necessity of a strong QA program

4.0 DISCUSSION

4.1 Rationale for Testing

Isolation and containment of high-level nuclear waste in a geologic repository are provided by the following two systems: (a) the engineered barrier system and (b) the geologic setting. The NRC has defined the engineered barrier system as the waste package and the underground facility. The overall repository system provides different types of control on the release and migration of radionuclides from the repository to the accessible environment. A generic sketch showing the repository and the accessible environment is depicted in Figure 3.

Repository design and performance assessment require a knowledge of the input parameters many of which must be obtained from laboratory and in situ testing of different scales and duration. The amount of testing depends on the relative importance of the particular parameter being measured and on the significance of the component being designed to the overall performance of the repository. Therefore the type, amount, scale, and duration of testing will be guided by the specific site conditions and the expected performance of the various components of the repository system. A rationale for the testing should, therefore, be developed (by the Department of Energy) before a 'test plan' is developed for a site. The test plan should identify all important parameters, classify them according to their relative importance, and document their potential variability and the effect of that variability on design and performance. The test plan should also identify the measurement techniques and their reliability, and provide references to test procedures, quality control, and quality assurance. In summary, the test plan should identify; (a) all issues requiring resolution by in situ testing, and measurements (b) the information needs that must be satisfied in order to meet the performance criteria and regulatory requirements; and (c) the tests and their procedures, capabilities and limitations.

4.2. Type of Testing

Three categories of tests may be identified: (a) preliminary testing; (b) site characterization testing; and (c) performance confirmation testing. Site characterization and performance confirmation testing can be either of the two components of in situ testing program identified in Section 3.0 Paragraph 2; observation of host rock characteristics prior to construction and waste emplacement and host rock response after waste emplacement (see Section 3.0 for more detail).

(a) Preliminary Testing is basically all initial testing done to select a repository site for characterization. These preliminary tests can be of different scales and at any location. The results from such tests could be used for making certain preliminary assessments about site suitability

If there is a strong QA Program then any testing in (a) can be used in (b) and likewise (b) in (c) Need a strong QA program

and performance of the medium in general. Preliminary testing is outside the scope of this report and only mentioned here for completeness.

(b) Site Characterization Testing includes testing and measurements performed to gather data sufficient to characterize the site. Again, the testing could be of different scales and duration. In situ testing programs falls into this category. Traceability of test data and test procedures is very important because the results from in situ tests will be used to support a license application.

(c) Performance Confirmation Testing may start during site characterization and will continue until permanent closure as required by 10 CFR 60 Subpart F(§60.140,(b), (c)). However it should be noted that some of the performance confirmation tests will be a continuation of the testing started during site characterization as described in (b) above. The data from confirmation tests are crucial to verification of assumed design conditions and the predicted repository behavior. Discussions on performance confirmation tests are not provided in this GTP; these tests will be described in a subsequent GTP by the NRC.

The test plan should clearly identify the tests under the above categories and discuss how the data from different categories of tests will be used in repository design and performance assessment.

4.3. Planning of Testing

A certain level of variability is inevitable when dealing with geologic media, therefore, the planning and design of in situ testing should consider an estimated range of parameters to be measured. The data from actual testing should reduce variability of parameters and provide representative design input. For example, preliminary repository designs could be based on estimated ranges of in situ stresses and permeabilities. However, the actual range of design values of in situ stresses and field permeabilities of rock would be established by performing in situ experiments. Also, the standards for the quality of data to be produced for the in situ tests should be established from an appraisal of the overall design and performance requirements. More detail on general scope and nature of in situ testing can be found in NUREG/CR-3065 and NUREG/CR-2983 (see list of references).

4.4. Scale of Testing

Because of the complexities of designing and constructing an underground repository, testing will have to be performed at different scales. Laboratory testing on small specimens will provide useful information for preliminary

tests will continue after that. Any planned long-term monitoring activities should be identified and discussed in the test plan.

4.7. Amount of Testing

Decisions related to establishing the amount of testing should be made on a site and design-specific basis. The amount of testing can vary significantly depending on the objective, nature and scope of the tests. Several different tests can be used to obtain the same rock parameters. For example, the plate test, pillar test, and block test provide sufficient information to calculate the material modulus. For gathering the same set of data, there can be several test methods. Each test can be repeated a number of times depending on the required level of confidence. The same test may be repeated at a number of different locations to assess the variability of the measured parameter. Furthermore, tests may be conducted under a range of conditions to represent the extremes of the anticipated environment. For example, a range of temperatures and confining pressures can be applied to cover the anticipated repository conditions.

The in situ test plan should include criteria to determine whether an adequate amount of testing has been performed. For all tests important to performance assessment a general guidance is that testing should continue or be repeated until confidence in the results is established by an independent peer review.

4.8. Special Testing

Under this discussion "special tests" refer to the unconventional and/or nonstandard tests; for instance, accelerated tests to simulate long term effects in a short duration test period, and tests to assess interactions among different processes, such as, thermal-mechanical-hydrological-geochemical effects. These types of tests, if conducted could raise several difficult questions regarding their appropriateness, adequacy, and procedures. In order to minimize delays during licensing hearings, a careful and logical approach should be followed in identifying the need for such complex tests and defending the data obtained from them. One of the major difficulties that could arise would be the lack of confidence in the measuring techniques and instrument performance under adverse conditions of heat, moisture and radiation. The test plan should discuss the need for and the rationale behind such complex tests and present details on how the data will be used.

No unproven techniques/technology should be allowed during the test phase. If new, unproven techniques/technology are to be considered, they must be proven out elsewhere first.