WM S/F 3106.9
WMRP r/f
NMSS r/f
CF
REBrowning
MJBell
JBunting
PAltomare
MRKnapp
LBarrett
LBHigginbotham
HJMiller
RRBoyle
SCoplan
JLinehan
JKennedy
LCasey
TVerma
SGrace & r/f
RLJohnson
PDR

AUG 14 1984

Mr. Jefferson O. Neff
Program Manager
Salt Repository Project Office
U. S. Department of Energy
505 King Avenue
Columbus, Ohio 43201-2693

Dear Mr. Neff:

SUBJECT: NRC ROCK MECHANICS DATA REVIEW MEETING

With respect to the subject meeting scheduled for the week of August 20th, I am including several enclosures. Enclosure 1 is a clarification of the proposed agenda highlighting what we would like to see discussed under each agenda section. Enclosure 2 is our list of expected attendees (please note that two are not U. S. citizens).

Enclosure 3 is a list of general data questions and Enclosure 4 is a list of the references from Draft 4 of the Environmental Assessments that we do not currently have. As was done in the hydrology data review, we would like these documents available during the data review so that our staff can review them and decide if copies are needed. Also included in Enclosure 4 is a list of the documents from the ONWI catalogue that we want copies of.

Enclosure 5 is our draft data inventory sheets. We intend to develop them further with the results of our data review together with detailed reviews of additional documents, the draft EA's and the information sheets. It would be very useful to us if your staff could point out omissions or corrections in our summary data inventory and address our data questions. In this way we would develop a better understanding of the available data from all sources.

Also enclosed is Enclosure 6, a copy of our draft rock mechanics data review checklist.

WM Record File
WM Project
Docket No.
PDR
LPDR
Distribution:
(Return to WM, 623 SS)

8410030652 840814
PDR WASTE
WM-16 PDR

We appreciate the preparations and the staff arrangements you are making for this data review and look forward to a mutually beneficial exchange.

Sincerely,

[redacted]

John Linehan, SALT Section Leader
Repository Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures:
1. NRC Additions/Clarifications to DOE Proposed Agenda
2. List of NRC Attendees
3. General data questions
4. List of references
5. Draft summary data inventory sheets
6. Draft rock mechanics data review checklist

cc: L. Casey, DOE/SRPO
T. Verma, NRC

OFC	:WMRP:ejc	:WMRP	:WMRP	:	:	:	:
NAME	:SGrace	:RJohnson	:JLinehan	:	:	:	:
DATE	:8/14/84	:8/ /84	:8/ /84	:	:	:	:

See folder for Mtg
& Neff Ann. Location
8-14-84

Enclosure 1

NRC ADDITIONS/CLARIFICATIONS TO DOE PROPOSED AGENDA

Rock Mechanics
Data Review
Salt Repository Project (SRP)

Purpose

Provide opportunity for NRC to find out what data is available and to determine the reliability of data used in geotechnical engineering analysis for the SRP (i.e. technical accuracy and adequate documentation).

Objectives

1) Orient NRC to the various types of rock mechanics and geotechnical engineering data from all sources (e.g., SRP, WIPP, SPR, foreign, etc.).

   a) Identify what types of data exist.
   b) Identify the amounts of the various types of data that exist.
   c) Identify where the various types of data are located.

2) Familiarize NRC with data used in geotechnical engineering analysis for the SRP.

   a) Provide overview of contributing organizations to Paradox, Permian and Gulf Coast projects (short discussion).
   b) Identify and present field and laboratory exploration and test data conducted by program related sources.

3) Allow NRC to understand how data was obtained and documented.

   a) Understand test sample selection procedure and representativeness.
   b) Review test methods used to collect data.

   c) Obtain an understanding of how data collection procedures and activities have been documented.

4) Allow NRC to identify and obtain (on a selective basis) data to be analyzed by NRC at a later date.

   a) Provide examples of test records which contain the data.
   b) Provide available unpublished (raw) data for NRC review.
   c) Identify current location of unpublished data.

DOE PROPOSED AGENDA

ROCK MECHANICS DATA PRESENTATION
Project Management Center (Room 13-4160)

AGENDA

August 21, 1984

8:30 - 8:45	*1	NRC/DOE/ONWI Introductions	J. Sherwin (SRPO)
8:45 - 9:30	*2	Rock Mechanics Overview	S. Versluis (ONWI)
9:30 - 10:00		Scope of Rock Mechanics Data and Sources	E. Lindner (ONWI) H. Hume (ONWI)
10:00 - 10:15		Break	
10:15 - 10:45	*3	Data Management	M. Golis (ONWI)
10:45 - 11:30	*4	Thermal Properties Data	E. Lindner (ONWI) W. Durham (LLNL)
11:30 - 1:00		Lunch	
1:00 - 1:30		Elevated Temperature/Pressure Data	P. Senseny (RE/SPEC)
1:30 - 2:00		Site Characterization Data	H. Hume (ONWI) T. Lamb (SWEC)
2:00 - 2:30		Previous Laboratory Efforts	S. Versluis (ONWI)
2:30 - 2:45		Break	
2:45 - 3:15	*5	Field Testing at Avery Island-Asse	A. Coyle (ONWI)
3:15 - 3:45		Field Testing - Permian Basin	T. Lamb (SWEC)
3:45 - 4:00		Field Testing - Paradox Basin	R. Nelson (WOODWARD-CLYDE)
4:00 - 4:15		Field Testing - Gulf Region	H. Hume (ONWI)
4:15 - 4:45		Questions and Answers	

*(See next page, under First day)

ROCK MECHANICS DATA REVIEW
AUGUST 21-24, 1984

I. First Day Footnotes to DOE's proposed agenda.

*1) NRC Introduction R. Johnson/ J. Pearring

- o NRC's purpose of the data orientations/review
- o NRC organization

*2) Provide a summary of the contributing organizations and their responsibilities in data collection:

- o field investigations
- o office investigations
- o laboratory investigations
- o Q/A
- o data analysis
- o data presentations

*3) Provide a summary review of ONWI/DOE documentation control including a brief overview of document hierarchy and traceability. Discuss where the data is located.

*4) Provide a summary review of ONWI/DOE/other ('other' includes WIPP, SPR and foreign) geotechnical engineering testing data related to surface and subsurface soil and rock material, including discussion of the method of sampling and representativeness of the sample.

*5) Provide a summary presentation, by area of data availability (including a summary of types, amounts and representativeness of data for each area) for:

- o Palo Duro
- o Paradox
- o Gulf States areas

II. Second Day — Review of Data Not Previously Available to NRC.

- o ONWI/DOE makes data available in reports and in other forms to allow NRC observations of data.
- o NRC review to include
  - o type of data
  - o method of collection (field vs laboratory)
  - o method of sampling
  - o representativeness of sample
  - o method of test
  - o description of non-standard test condition
  - o test equipment used
  - o Q/A applied
  - o method of analysis
  - o completeness of documentation
- o ONWI will provide facilities for copying any of the documented data examined excepting draft data analysis.

III. Subsequent Days

Continue data reviews as required
PM of last day: Meeting summary (optional if desired by DOE)
- o Preliminary observations
- o Follow-up discussions

Enclosure 2

LIST OF NRC ATTENDEES
DOE ROCK MECHANICS DATA REVIEW
AUGUST 21-24, 1984

John Linehan	NRC
Robert Johnson	NRC
Scott Grace	NRC
Jerome Pearring	NRC
John Peshel	NRC
Steve Symkowski	NRC
John Trapp	NRC
Banad Jaganaugh	NRC
Robert Cummings	EI
Roger Hart	EI
Adrian Brown	EI *
Jaak Daemen	SANDIA *
Krishan Wahi	SANDIA
Edward Hollop	Bureau of Mines
Lindsey Mundell	Bureau of Mines

*note: not U. S. Citizens

GENERAL DATA QUESTIONS

1) What is the basis for core sample selection for laboratory intact rock tests? How representative are the samples of the ranges of observed geologic conditions? How is sample disturbance evaluated?

2) What laboratory testing has been accomplished on rock and overburden material for each site study area (type, number, testing standard, testing equipment, Q/A, etc.)?

3) What in situ testing has been accomplished on rock and overburden materials at site study areas or at other locations (heater, block creep, extensometry, flatjack, borehole and shaft seal test, in situ shear test, in situ thermal property tests, etc.)?

4) Are laboratory tests being accomplished using standard or recommended rock testing methods of such organizations as the American Society of Testing and Materials, the International Society of Rock Mechanics, or the U.S. Bureau of Reclamation? Provide the rationale for any testing variance from standards if appropriate.

5) How are the rock mass elastic moduli, creep, and strength properties of the proposed repository horizons, for the various proposed repository locations being estimated for both ambient and repository induced conditions?

6) Will rock mechanics data be added to the composite drilling data charts to provide a ready reference to rock mechanics/geology/geophysical data for significant borings at each potential site?

Enclosure 4

List of References

This is a list of the references from draft number 4 of the SALT Environmental assessments that NRC does not currently have and a list of documents from the ONWI catalogue that NRC wants to receive.

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DOE/ONWI CATALOG

Cycle/Catalog Number and Title

0-1302 - Toms Handbook - 2nd Edition

0-1141 - Transient Creep of Repository Rocks, Mechanistic Creep Laws for Rocksalt

0-1279 - First Test Report - Draft

0-1280 - Second Test Report

0-1354 - Exponential-Time Creep Law For Avery Island Salt: First Revision

0-1213 - Summary of the Avery Island Field Testing Program

0-1276 - Site C Heater Test Report - Avery Island Salt Mine: Unanalyzed Data

0-1305 - Final Report on Corejack Tests

0-1307 - Updated Geochemical Test Conditions

0-1121 - Seismic Reflection, Gravity and Aeromagnetic Studies of Geologic Structure in the Gibson Dome Area, Southwestern Paradox Basin

0-1100 - Seismicity of the Paradox Basin and the Coloradd River Plateau

0-1179 - High-Resolution Seismic Reflection Study - Vacherie Dome

0-1256 - Mississippi Seismic Interpretation Status Report

0-1258 - Vacherie Geophysical Surveys Report

0-1259 - G. J. Long Report Revised Per ONWI Comments

0-1260 - Vacherie Geophysical Surveys Activity Plan

O-1299 - Regional Seismicity Status Report

O-1247 - Well Completion Report for the Detten No. 1 (PD-6) Well, Palo Duro Basin: Unanalyzed Data

O-1253 - Well Completion Report for the J. Friemel No. 1 (PD-9) Well, Palo Duro Basin: Unanalyzed Data

O-1140 - Constitutive Parameters for Salt and Non-Salt Rocks from the Detten, G. Friemel, and Zeeck Wells in the Palo Duro Basin

O-1266 - J. Friemel Unconfined, Triaxial and Velocity Test Report

O-1267 - Harman Unconfined, Triaxial and Velocity Tests Report

O-1268 - Zeeck Unconfined Tests Report

O-1269 - J. Friemel In-House Tests Report

O-1272 - Well Lithologic Property Logs - Zeeck

O-1273 - Well Lithologic Property Logs - G. Friemel

O-1274 - Well Lithologic Property Logs - Detten

O-1275 - Revised Deaf Smith Geotechanical Profile

O-1318 - Permian Cycle 4 Salt Core Test Data Report

O-1146 - Microseismic Recording In Palo Duro Basin: Unanalyzed Data

O-1335 - Letter Report on Status of Seismic Program

O-1336 - Field Acquisition of Seismic Data

O-1339 - Letter Report on Integration of Seismic and Geologic Interpretations

O-1338 - Summary of Petrographic and Chemical Data for Palo Duro Basin Samples Examined by Bendix Field Engineering Corp., Grand Junction, CO, as of April 29, 1983

O-1343 - Identification of Sites within the Palo Duro Basin

K-0143 - Thermal Conductivity and Diffusivity of Permian Basin Bedded Salt at Elevated Pressure and Temperature

O-1089 - Well Completion Report, G. Friemel No. 1, Deaf Smith County Texas: Unanalyzed Data

O-1263 - Mansfield Oetten Tests Report

O-1248 - Well Completion Report for the Zeeck No. 1 (PD-7) Well, Palo Duro Basin: Unanalyzed Data

O-1131 - Geoengineering Evaluation of Intermediate Shaft Seal

O-1261 - Friemel Triaxial Tests Report

Enclosure 5

Draft summary data inventory sheets

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Thermal property laboratory tests/ thermal conductivity

Data Documented: ORNL/TM-6809: Morgan, M.T., Thermal Conductivity Of Rock Salt from Louisiana Salt Domes; Oak Ridge National Laboratory, Oak Ridge, Tennessee, June, 1979.

Data Collection Location:

(a) Areal Location: Avery Island and Jefferson Island Salt Domes, Southern Louisiana

(b) Subsurface Location: From Floor of mine, level &/or depth not specified.

Method of Data Collection/Analyses: Cores 2 and 2 1/8 inch diameter taken from mine floors. Samples prepared, and thermal conductivities measured using a Dynatech TCFCM-20 comparative thermal conductivity instrument.

Amount of Data: Thermal conductivities given for 15 samples at 100°C & plotted against density measured at 25°C. Rock salt impurities & their specific heat also given.

Data Sources: Core specimens, laboratory testing

Data Interpreted by: M. T. Morgan, ORNL

Data Storage Location: Oak Ridge, Tennessee 37830

Data Related Uncertainties: Uncertainty in thermal conductivity, using Pyroceram 9606 as a reference material, is reported as ± 5% at room temperature and ± 10% at higher temperatures. Cummulative error estimated within 20%, and precision within 10%. Data is definitive for stated conditions and uncertainties.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Creep property laboratory tests/ triaxial compression creep experiments.

Data Documented: ONWI-401: Mansen, F.D. & K.D. Mellegard; Creep of 50-mm Diameter Specimens of Dome Salt from Avery Island, Louisiana; prepared by RE/SPEC, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, August, 1980.

Data Collection Location:

(a) Areal Location: Avery Island, Louisiana

(b) Subsurface Location: 500' Level of Avery Island Mine

Method of Data Collection/Analysis: Samples collected from three 16 inch diameter heater holes and many smaller instrument holes. 50 mm diameter samples were recored from field samples using a vertical milling machine, a thin-walled diamond-impregnated bit, and saturated brine solution.

Laboratory experimentation includes triaxial compression and data for time, temperature, axial stress, confining pressure, axial displacement, and volumetric displacement. Specimen was subjected to some axial stress (most more than one stress, or temperature) and allowed to creep. A constitutive law for transient creep is derived. Strain data were fitted to constitutive law in form

$$\varepsilon = kt^{n}\Delta\sigma^{m}T^{p}$$

Amount of Data: 40 tests on 20 specimens with varying conditions. Numerous plots and tables showing summary of data, test parameters, results, comparisons, stress-strain plots of stress difference application, axial strain as a function of time, total transient axial strain as a function of temperature, and others. Creep law parameters and derivation included.

Data Sources: Avery Island Mine specimens and laboratory tests

Data Interpreted by: Hansen & Mellegard, RE/SPEC, Inc.

Data Storage Location: RE/SPEC, Inc.

Data Related Uncertainties: Raw data-minor, Derived-model dependent, possibly major. Possible flaws are mentioned, though no specific uncertainties are reported. The report states that "there are several weaknesses in the constitutive laws...and they should be further evaluated and perhaps modified." Raw data may be considered definitive, and modelling, preliminary.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Thermal Property field tests/ heater tests

Data Documented: ONWI 190(1): Sambeek, Leo L., Avery Island Heater Tests: Temperature Measurements for the First 300 Days; prepared by RE/SPEC, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, October, 1980.

Data Collection Location:

(a) Areal Location: Avery Island Salt Dome, Louisiana

(b) Subsurface Location: 550 ft. below mean sea level

Method of Data Collection/Analyses:

- a heated borehole was surrounded by monitoring holes.
- measurement of temperature and moisture were made in each hole.

Amount of Data: Several plots of temperature vs. days of heating, and temperature vs. radial distance. Several tables showing heater temperatures for initial 32 hours, and tables and plots of temperatures at specific periods of heating for 3 heater tests. Considerable data contained in appendices.

Data Sources: ONWI, RE/SPEC

Data Storage Location: RE/SPEC, Inc., Rapid City, SD
ONWI, Columbus, OH

Data Related Uncertainties: Attached Table gives source & magnitude of potential errors in temperature measurement. Data is definitive.

TABLE 2

SOURCE AND MAGNITUDE OF POTENTIAL ERRORS
IN TEMPERATURE MEASUREMENT

	RTD's on Site A Sleeve	Thermocouples in Heater Assemblies	Thermocouples in the Salt
Source of Error	Magnitude of Error		
Sensor Accuracy	±0.9°F 0°<T<212°F ±1.8°F 212°<T<392°F ±3.6°F 392°<T<752°F --- ±(0.3° + 0.6%)	± 0.4% T>530°F	±2°F T<530°F
Lead Wire Compensation/ Signal Conversion-Interpolation	±1.2°F @ 200°F ±3.8°F @ 750°F --- ±(0.3° + 0.5%)	±2.1°F @ 200°F ±2.9°F @ 750°F --- ±(1.8°F + 0.2%)	
Installation Technique	±5%	±5%	±(0.015%(T-100°F)T)
Assigning Radial Location	included in installation technique error	included in installation technique error	±(0.02 + 0.5%Z) ΔT/ΔR

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Geomechanical Property field tests/ displacement and stress measured during heater tests.

Data Documented: ONWI-190(2); Sambeek, Leo L., Randall G. Stickney & Keith B. DeJong: Avery Island Heater Tests: Displacement and Stress Data for the First 300 Days; prepared by RE/SPEC, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, June, 1981.

Data Collection Location:

(a) Areal Location: Avery Island Salt Dome - Louisiana

(b) Subsurface Location: 550 ft. below mean sea level

Method of Data Collection/Analyses:

- Vertical and inclined extensometers for displacement/strain.
- Anchored bolts referenced to series of permanent bench marks beyond expected zone of influence for floor heave.

Amount of Data: Numerous plots and tables present data including displacements at 6 depth intervals per extensometer, 13 extensometers, and 17 time intervals over 300 days for 3 sites; days of heating vs. strain; floor heave data for 13 array pins at 3 sites, at various temperatures and time intervals. Detailed temperature data reported elsewhere (ONWI-190(1)). Also Roof to floor & Pillar Expansion measurements & borehole closure measurements.

Data Sources: ONWI/RE/SPEC

Data Storage Location: RE/SPEC, Inc., Rapid City, SD
ONWI, Columbus, OH

Data Related Uncertainties: "Extensometer propable error ± 0.002 inches. Floor heave measurements - random error of ± 0.05 inches." Data is definitive for specific conditions.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Thermal Property/Field Test variations in hydraulic conductivity with temp.

Data Documented: ONWI-190(3) Nitrogen Gas Permeability at Avery Island Blankenship, PA and Stickney, Randall G., RE/SPEC Inc., Battelle Memorial Institute, Columbus, OH, 1983.

Data Collection Location:

(a) Areal Location: Gulf Coast Salt Domes, Avery Island

(b) Subsurface Location: Heater Site C

Method of Collection/Analyses: Mechanical Pucker with constant pressure and falling head measurements 1½" ϕ hole, 6 ft. section, nitrogen as the permeant.

Amount of Data: 10 Falling head tests
8 constant pressure tests

Data Sources: ONWI, RE/SPEC

Data Storage Location: RE/SPEC Rapid City, SD or
ONWI, Columbus, OH

Data Related Uncertainties: Probable errors for hydraulic conductivities were calculated. Probable errors are a function of:

- tested length
- effective radius
- borehole radius
- time
- pressure difference
- well pressure

Due to the small values of k the errors approach the calculated values of k.

Data is definitive for conditions stated.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Thermal Property/Field Tests

Data Documented: ONWI-190(4) Avery Island Brine Migration Tests: Installation, Operation, Data Collection, and Analysis, Krause, W.B. RE/SPEC, Battelle Memorial Institue, Columbus, OH, 1984.

Data Collection Location:

(a) Areal Location: Gulf Coast Salt Domes - Avery Island

(b) Subsurface Location: Upper level of Avery Island Salt Mine 500 ft. deep (169 m).

Method of Collection/Analyses:

- a heated borehole was surrounded by monitoring holes.
- measurement of temperature and moisuture were made in each hole.

Amount of Data: Two complete sets of data for natural and synthetic brine movement and temperature with time & a control test at ambient temperature conditions.

Data Sources: ONWI, RE/SPEC

Data Storage Location: ONWI, Columbus, OH
RE/SPEC, Rapid City, SD

Data Related Uncertainties: Large inclusions lead to highly increased migration and permeability rates.

Problems were reported for:

- long term operation of pneumatic packers.
- maintaining pressurization and fluid level indication in brine (monitoring) borehold.
- attachment of floor sealing ring.
- thermocouples attachment for long term monitoring.
- emplacement of glass beads to provide a collecting medium.

Due to redundancy or correction these problems did not significantly affect data quality.

Data is definitive for conditions and uncertainties as given.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Thermal Property/Field Tests

Data Documented: ONWI 190(5) Avery Island Heater Tests, Measured Data for 1,000 Days of Heating, Van Sambeck, L.L., Stickney, R.G., DeJong, K.B., RE/SPEC, Inc. Battelle Memorial Institute, Columbus, OH, 1984.

Data Collection Location:

(a) Areal Location: Gulf Coast Salt Domes - Avery Island

(b) Subsurface Location: ∿ 500 feet deep (169 m) upper level of Avery Island Salt Mine.

Method of Collection/Analyses:

- thermocouples in boreholes ((EX), 1½ ϕ), salt back filled at various distances.

Amount of Data: Considerable in Appendices A-F and text plots with distance from heater and time.

Data Sources: ONWI, RE/SPEC

Data Storage Location: ONWI, Columbus, OH
RE/SPEC, Rapid City, SD

Data Related Uncertainties: Report uncertainties include the following:

The uncertainties are minimized by the internal consistency and smooth and uniform plots with time.

Occasionally temperature measurements at the heater were inconsistent due to recrystallized salt in the annulus around the sleeve.

The data are only as certain as the thermocouple location due to high gradients.

Data is definitive for the stated conditions and uncertainties.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Geomechanical Property/Field Tests

Data Documented: ONWI190(5) Avery Islant Fleater Tests: Measured data for 1,000 days of heating, Van Sambeek, L. L., Stickney, R. G., and DeJong, K. B., RE/SPEC, Inc., Battelle Memorial Institute, Columbus, OH, 1983.

Data Collection Location:

(a) Areal Location: Gulf Coast Salt Domes - Avery Island

(b) Subsurface Location: approx. 500 ft deep (169 m) upper level of Avery Island Salt Mine

Method of Collection/Analysis: Extensometers in the pillars and floor and ceiling. Stressmeters in borehole around heated hole.

Amount of Date: Considerable in Appendices G-L. Plots with distance from heater and fume.

Data Sources: ONWI Re/SPEC

Data Storage Location: ONWI, Columbus, OH; RE/SPEC, Rapid City, SD.

Date Related Uncertainties: Uncertainties were reported as follows: No complications of the stress measurement or displacement measurement were noted. The anchor depths for floor extensometers may not have been deep enough to measrue all the displacement. The anchor depth for horizontal pillars was ½ the pillar width but this assumes the pillar is expanding the same in all directions which is unlikely due to the thermal gradient. Data is definitive for the reported conditions and uncertainties.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics/Creep Property/Laboratory Tests

Data Documented: ONWI-250, Quasi Static Strength and Creep Characteristics of 100-mm-Diameter Specimens of Salt from Avery Island, Louisiana, Mellegard, K.D., Senseny, P.E., Hansen, F.D., RE/SPEC, Inc., Battelle Memorial Institute, 1983.

Data Collection Location:

(a) Areal Location: Avery Island

(b) Subsurface Location: 500 ft. deep, (169 m) upper level Avery Island Salt mine.

Method of Collection/Analyses: Volumetric changes during heated triaxial testing of 100 mm ϕ samples.

Amount of Data: 1) 30 creep tests at $\sigma_1-\sigma_2$ from 5.4-20.7 MPa
$\sigma_2=\sigma_3$ from 0.7-30.7 MPa
T=24°-200°C
100 mm and samples

2) Quasi Static Strengths @ $\dot{\varepsilon}^{\circ} = 0.002$ σ = 0-20.7 MPa

Data Sources: ONWI, RE/SPEC

Data Storage Location: ONWI, Columbus, OH
RE/SPEC, Rapid City, SD

Data Related Uncertainties: Uncertainties were reported as follows:

The interaction of activation energy and temperature may lead to uncertain results. The calculations assumed activation energy was independent of temperature.

The transient strain equation is empirical derived from a "best fit" for lab size samples. Comparison between 50-mm and 100-mm samples indicate they are statistically different in their behavior.

Raw data is definite. Modelling for laboratory creep is considered preliminary.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Thermal Property Field Tests/ Bottom hole temperature, geothermal analysis

Data Documented: ONWI-289: Law Engineering Testing Company; Geothermal Studies of Seven Interior Salt Domes; prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, June, 1983.

Data Collection Location:

(a) Areal Location: Eight selected Gulf Coast salt domes in the Gulf Interior Region of Mississippi, Louisiana and Texas.

(b) Subsurface Location: Various, ranging from 500 to 20,000 feet.

Method of Collection/Analysis: Bottom hole temperatures, and electrical logging runs which occurred within six hours of circulation, from oil and gas exploration wells, were plotted and corrected to estimate actual geothermal environment.

Law Engineering - analysis, modelling, and interpretation of data.

Amount of Data: More than 700 temperature readings from 317 well logs. One well log for Cypress Creek; 45 for Richton, and 79 for Vacherie.

Data Sources: Oil and gas well logs from petroleum industry.

Data Interpreted by: Law Engineering Testing Company

Data Storage Location: Law Engineering Testing Company, Marietta, GA.

Data Related Uncertainties: Temperature estimates, after data correction reported as "probably accurate within 10°F for depths down to 5,000 feet." Data is definitive for stated conditions and uncertainties.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Creep property field tests/short term borehole creep

Data Documented: ONWI-400: Nelson, R.A., J.G. Kocherhaus, M.R. Schnapp; In Situ and Laboratory Geotechnical Test Results from Borehole GD-1 in Southeast Utah; prepared by Woodward-Clyde Consultants for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, November, 1982.

Data Collection Location:

(a) Areal Location: GD-1 Borehole, Gibson Dome, San Juan County, Utah

(b) Subsurface Location: Five depth intervals-160 ft @ 4785-4945 ft; 160 ft @ 360-3320 ft; 100 ft @ 3928-4028 ft; 100 ft @ 3575-3675 ft; and 70 ft @ 4245-4315 ft

Method of Data Collection/Analysis: Evaluated during minimum unloading pressure when nitrogen pressure was zero in Geotechnical Drill Stem Tests (GDST). Measured by downhole triple quartz-crystal pressure transducers (TQCT). Volumetric strain values obtained from direct measurements of fluid level & from precise measurements of test zone pressure.

Slopes of pressure versus time plots for 3 tests (GDST-1, 2 & 4) were converted to volumetric & radial logarithmic strain rates. Slope calculated as $\epsilon r = \frac{1}{2}\epsilon v = \Delta p/\Delta t \times TC/FG \times Vo$.

Woodward-Clyde Consultants-analysis and interpretation of data

Amount of Data: Plots for creep versus time. Three tests reported, only one with adequate fluid level change (GDST-1). Radial strain creep rate given for GDST-1, 2 & 4.

Data Sources: GD-1 Borehole, Geotechnical Drill Stem Tests

Data Interpreted by: Woodward-Clyde Consultants

Data Storage Location: Woodward-Clyde Consultants, San Francisco, CA

Data Related Uncertainties: Raw data - "TQCT pressure sensor with drift of ± 1kPa (0.2 psi) was able to record fluid levle changes as small as ± 0.09 m (0.3 foot)." Converting maximum pressure change into fluid level change gives...a value close to the directly measured value." Data considered definitive for stated conditions and uncertainties.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Geomechanical property field test/ unloading stress-strain

Data Documented: ONWI-400: Nelson, R.A., J.G. Kocherhaus, M.R. Schnapp; In Situ and Laboratory Geotechnical Test Results from Borehole GD-1 in Southeast Utah; prepare[d] by Woodward Clyde Consultants for Office of Nuclear [W]aste Isolation, Battelle Memorial Institute, Columbus, OH, November, 1982.

Data Collection Location:

(a) Areal Location: GD-1 Borehole, Gibson Dome, San Juan County, Utah

(b) Subsurface Location: Five depth intervals - 160 ft @ 4785-4945 ft; 160 ft @ 3160-3320 ft; 100 ft @ 3928-4028 ft; 100 ft @ 3575-3675 ft; and 70 ft @ 4245-4315 ft.

Method of Data Collection/Analysis: Primary data-downhole pressures recorded above drilling fluid pressure, within and below test zone at one- to five-minute intervals per test, during each unloading geotechnical drill-stem test (GDST). Fluid level data measured by dunking pressure transducer or shorting-type electrical sensor on electric cable wireline.

Data translated info unloading pressure versus volumetric strain values, by Volumetric Strain = $\Delta V/Vo$, and radial strain $\Delta V/Vo$, and radial strain $\Delta r/ro = 0.5\ \Delta V/Vo$.

Woodward-Clyde Consultants-analysis and interpretation of data.

Amount of Data: 70 fluid level measurements for GDST-1, 8 for GDST-2; 21 for GDST-4. Pressure graphs for GDST 1, 2 & 4 showing pressures in and below test zone, and drilling fluid pressures. Five tests-two successful, one partially successful, and two unsuccessful, are reported.

Data Sources: GD-1 Borehole, Geotechnical Drill Stem Tests

Data Interpreted by: Woodward-Clyde Consultants

Data Storage Location: Woodward-Clyde Consultants, San Francisco, CA

Data Related Uncertainties: Possibly major. "Refinements of equipment will improve accuracy of unloading fluid level data...," "Equipment malfunctions during this test (GDST-2) could have yielded anomalous measurements..." No uncertainties reported. Uncertainty in raw data minor. Data definitive for stated conditions; preliminary considering possible large uncertainties.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Creep Property Laboratory Tests/ creep at various temperatures.

Data Documented: ONWI-400: Nelson, R.A., J.G. Kocherhaus, M.R. Schnapp; In Situ and Laboratory Geotechnical Test Results from Borehole GD-1 in Southeast Utah; prepared by Woodward-Clyde Consultants for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, November, 1982.

Data Collection Location:

(a) Areal Location: GD-1 Borehole, Gibson Dome, San Juan County, Utah.

(b) Subsurface Location: Salt Cycle 6, 6 samples: between 998 and 1,017 m (3,275 & 3,335 ft.) below drill rig datum.

Method of Data Collection/Analysis: Tests conducted on right circular cylinders of salt from salt cycle 6. Seven parameters monitored: axial stress, confining pressure, total axial displacement, axial strain, radial strain, temperature, and time. On samples with elevated temperatures, T was increased at 0.5°C (1°F) per minute to desired temperature. Samples isotropically compressed to desired pressure & allowed to equilibrate 24 hours, then quickly unbaded atrates between 7KPa/sec (1 psi/sec) and 140 KPa/sec (20 psi/sec), and data recorded every 30 sec.

Exponential-time creep law formed as $\Sigma = e_a (1-\exp(-\xi t)) t\Sigma^{\circ}_{ss} t$ and total axial strain values as calculated from LVDT measurements vs. elapsed time were fit to creep law.

Woodward-Clyde Consultants - analysis and interpretation of data.

Amount of Data: 18 strain vs. time plots, at various unloading stages for six samples tested. Tables and plots of creep law parameters. 15 tests on 6 samples at given temperatures and confining pressures.

Data Sources: GD-1 Borehole samples

Data Interpreted by: Woodward-Clyde Consultants

Data Storage Location: Woodward-Clyde Consultants, San Francisco, CA.

Data Related Uncertainties: It is reported that the "model sometimes overestimates the steady-state strain rate by about 10 percent." Various parameters reported and compared to work by others show considerable differences. Uncertainties probably major. Raw dat definitive for specific conditions, modelling is preliminary.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Geomechanical property laboratory tests/ strength

Data Documented: ONWI-400: Nelson, R.A., J.G. Kocherhaus, M.R. Schnapp; In Situ and Laboratory Geotechnical Test Results from Borehole GD-1 in Southeast Utah; prepared by Woodward-Clyde Consultants for Office of Nuclear Waste Isolation, Batelle Memorial Institute, Columbus, OH, November, 1982.

Data Collection Location:

(a) Areal Location: GD-1 Borehole, Gibson Dome, San Juan County, Utah.

(b) Subsurface Location: Salt cycle 6 between 998 and 1,017m (3,275 and 3,335 feet) below drill rig datum.

Method of Data Collection/Analysis: .9 m (3-foot) core lengths cut w/ diamond saw in 19 cm (7-5 inch) sample lengths. 4-inch diameter core, undercored to 3 inch diameter. Electrical resistance, foil-type strain gages affixed to sample. Testing was done using uniaxial compression, extension unload, compression load, compression unload, and extension load, using both uniaxial and triaxial testing.

Strain values from axial and circumferential gages calculated as $\varepsilon = 0.5_{abs}(S_\tau - S_o)$; total strain measured by linear-variable-displacement-transducer (LVDT) calculated as $\varepsilon_\tau = (LVDT_\tau - LVDT_o)/H_o$; and axial stress computed as $\sigma_{ax} = L - (A_p - A_\tau)P/A_\tau$.

Woodward Clyde Consultants-analysis and interpretation of data.

Amount of Data: 42 plots of Stress Difference vs. Strain; 32 results at maximum stress difference, showing values for bulk density, effective porosity, confining stress, axial stress, stress difference, and total (LVDT) strain.

Data Sources: GD-1 Borehole samples

Data Interpreted by: Woodward-Clyde Consultants

Data Storage Location: Woodward-Clyde Consultants, San Francisco, CA.

Data Related Uncertainties: Typical accuracy of strains is reported as ± 0.5 percent of recorded value for temperatures from 22° to 50°C (72° to 122°F) and 1/percent for 50° to 150°C (122° to 302°F), with a resolution to 40 microstrain. Accuracy of loading press VLDT is ± 0.5% of 2.5 cm (1.0 inch) full scale; resolution to .0025 mm (0.0001 inches); of loading press force transducer-.25% of 445KN (100,000 lb) full scale, resolution to 44N (10 lb); of confining pressure transducer-±0.3% of 69 MPa (10,000 psi) full scale, resolution to 7KPa (1 psi). Data is definitive.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Geomechanical property field tests/ loading/hydraulic fracture geotechnical drill stem tests (GDST)-in situ stress measurements.

Data Documented: ONWI-400: Nelson, R.A., J.G. Kocherhaus, M.R. Schnapp; In Situ and Laboratory Geotechnical Test Results from Borehole GD-1 in Southeast Utah; prepared by Woodward-Clyde Consulants for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, November, 1982.

Data Collection Location:

(a) Areal Location: GD-1 Borehole, Gibson Dome, San Juan County, Utah.

(b) Subsurface Location: GDST-9(3137 ft); GDST-4a(3630 ft); GDST-8(4177 ft); GDST-7(4577 ft); GDST-6A(4847 ft); and GDST-6(4887 ft).

Method of Data Collection/Analysis: Technique involves raising fluid pressure in inflated-packer-sealed segment of borehole until tensil fracture is induced. Continued pumping opens fracture & extends it away from hole. Whem pumping ceases, pressure in hole comes to equilibrium level as horizontal stress closes fracture. Subsequent analyses of pressure time history yields magnitudes of in situ principal stresses.

Stresses evaluated using breakdown pressure (P_B)= $3Sh-SH-P_p + T$ and fracture opening pressure (P_f^B)= $3Sh-SH-P_p^p$

Woodward-Clyde Consultants-analysis and interpretation of data.

Amount of Data: Plots of pressure vs. volume, surface pressure vs. time, and parameters for the six tests, including depth, test zone length; test zone temperature; P_B (breakdown pressure); P_F (fracture opening pressure); P_o (pore pressure); SH (maximum horizontal stress); ISIP (instantaneous shut in pressure); Sh (minimum horizontal stress); S_v (vertical stress); T_o (tensile strength); and S_u (maximum shear stress).

Data Sources: GD-1 Borehole, Geotechnical Drill Stem Tests

Data Interpreted by: Woodward-Clyde Consultants

Data Storage Location: Woodward-Clyde Consultants, San Francisco, CA.

Data Related Uncertainties: Major-"several potential sources of err.r...(1) uncertainty in determination of pre pressure (2) uncertainty of magnitude of tensile strength of salt, and (3) possibility that assumption of elastic response may not be strictly valid for salt in GD-1." Additionally at least 5 assumptions are made which may not all be valid. Data is definitive for conditions and uncertainties reported.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Creep Property Laboratory tests/ triaxial compression creep tests

Data Documented: ONWI-450: Pfeifle, T.W., K.D. Mellegard, P.E. Senseny; Preliminary Constitutive Properties for Salt and Nonsalt Rocks from Four Potential Repository Sites; prepared by RE/SPEC, Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, July, 1983.

Data Collection Location:

(a) Areal Location: Richton Dome - DOE Masonite MRIG-9
Vacherie Dome - LSU #1 (DOE-Smith #1 or DOE-V)
Permian Basin - Mansfield #1, Oldham County
#1 Rexwhite, Randall County
#1 Grabbe, Swisher County
Paradox Basin, Gibson Dome, GD-1

(b) Subsurface Location: Richton (MRIG-9) 35.9-386.7m (1177.4-1268.5 ft.)
Vacherie (LSU #1) 605.4-613.8m (1986.3-2013.8 ft.)
Permian (Mansfield #1) 446.1-451.6m (1463.7-1481.6 ft.)
Cycle 5
(#1 Rexwhite) 572.0-572.8m (1876-7-1879.3 ft.)
Cycle 4
(#1 Grabbe) 770.1-801.7 (2526.5-2630.2 ft.)
Cycle 4)
Paradox (GD-1) Carnalite - 971.7-974.8m (3187.9-3198.2 f
Salt Cycle 6 - 1010.8-1022.9m (3316.3-3356.0 f
Salt Cycle 7 - 1038.9-1042.8 (3408.4-3421.1 f

Method of Data Collection/Analysis: Specimens aquired by coring. Experiments on salt include triaxial compression creep tests, used to derive a creep law. Three creep experiments were performed at axial stress differences and temperatures of (SMPa, 100°C), (10 MPa, 100°C), and (5 MPa, 200°C), and all at a confining pressure of 15 MPa. A total of 19 tests were performed. Three tests for specimens at each depth investigated, except carnallite where only one was performed. All test durations were nominally 2.4×10^6 seconds, except for three which were terminated at shorter times.

Creep tests were fit to exponential-time creep law
$\varepsilon c = \varepsilon sst + ea(1-\exp(-\xi t))$

Amount of Data: Axial strain vs. time plots at 3 temperature/pressures. Axial strain vs. time as measured & as pedicted, for each site. Creep law parameters for each site.

Data Sources: Corehole samples & laboratory tests

Data Interpreted by: Pfeile, Melgard, Senseny-RE/SPEC, Inc.

Data Storage Location: RE/SPEC, Inc.

Data Related Uncertainties: "Predictive capability of creep law measured by its ability to reproduce data when appropriate fitting parameters were used. Steady-state strains are predicted very well. Transient portions of curves appear to account for most of deviations between measured and predicted response. Generally, the combinations of fitting parameters result in good fits to the data." No specific uncertainties reported. Raw data definitive, modeling preliminary.

SALT REPOSITORY PROJECT
SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Geomechanical property laboratory tests/elastic moduli and failure envelope at 20°C (salt) and elastic moduli, unconfined compressive strength & tensile strength at 24°C (nonsalt).

Data Documented: ONWI-450: Pfeifle, T.W., K.D. Mellegard, P.E. Senseny; Preliminary Constitutive Properties for Salt and Nonsalt Rocks from Four Potential Repository Sites; prepared by RE/SPEC, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, July, 1983.

Date Collection Location:

(a) Areal Location: Richton Dome - DOE Masonite MR16-9
Vacherie Dome - LSU #1 (DOE - Smith #1 or DOE - V)
Pennian Basin - Mansfield #1, Oldham County
#1 Rexwhite, Randall County
#1 Grabbe, Swisher County
Paradox Basin, Gibson Dome, GD-1

(b) Subsurface Location: Richton (MR16-9) 358.9-386.7 m (1177.4-1268.3 ft.)
Vacherie (LSU #1) 605.4-613.8 m (1986.3-2013.8 ft.)
Permian (Manisfield #1) 446.1-451.6 m (1463.7-1481.6 ft.) Cycle 5
(#1 Rexwhite) 572.0-572.8 m (1876.7-1879.3 ft.) Cycle 4
(#1 Grabbe) 770.1-801.7 m (2526.5-2630.2 ft.) Cycle 4
Paradox (GD-1) Carnallite - 971.7-974.8 m (3187.9-3198.2 ft.)
Salt Cycle 6 - 1010.8-1022.9 m (3316.3-3356.0 ft.)
Salt Cycle 7 - 1038.9-1042.8 m (3408.1-3421.1 ft.)

Method of Data Collection/Analysis: Specimens acquired by coring. Experiments on salt include quasi-static triaxial compression tests and Brazilian (indirect tension) tests. Four of six tests performed at 24°C and confining pressures of 0, 5, 10, and 15 MPa & Remaining two at 10 MPa and temperatures of 100°C and 200°C. Three Brazilian tests were performed at 24°C. All nonsalt experiments at 24°C.

Amount of Data: 6 failure envelopes in salt, one in carnalite
strength vs. temperature for 7 cases
7 failure criteria parameters
Axial strain vs. time under varied conditions
Voungs modulus & Poisson's Ration
31 samples-Elastic parameters & strength-nonsalt
42 Axial stress difference vs. strain plots
148 stress vs. lateral & axial strain for nonsalt

SALT REPOSITORY PROJECT

SUMMARY DATA INVENTORY SHEET

Type of Data: Rock Mechanics Data/Creep property laboratory tests/ triaxial creep experiments

Data Documented: SAND 79-0115: Wawersik, W.R. and D.W. Hannum; Interim Summary of Sandia Creep Experiments on Rock Salt from the WIPP Study Area, Southeastern New Mexico, Sandia laboratories, 1979.

Data Collection Location:

(a) Areal Location: WIPP study area near Carlsbad, New Mexico

(b) Subsurface Location: ERDA #9 Corehole
Upper Level 625-650 m (2000-2100 ft.)
Lower Level 810-875 m (2600-2800 ft.)

Method of Data Collection/Analysis: Specimens were collected from the ERDA #9 Corehole, and subjected to triaxial loading. 23 tests were subjected to principal stress differences between 930 psi (6.4 MPa) and 4800 psi (33.2 MPa), and confining pressures between zero (unconfined) and 3000 psi (20.7 MPa). Test temperatures were 22, 100 and 200°C.

Cross plots of data were prepared to explore effects of principal stress difference, temperature and confining pressure. For primary (transient) creep, axial strain-time data were fitted to $\Sigma p' = A \log (t)$ and $\Sigma p'' = ct^n$. Secondary creep was estimated from straight line portions of plots and that the slope r of plots in the space log (e total), log (t) increased with time from the value r = n during primary creep towards r = 1 when secondary creep becomes overriding. Tertiary creep measured in four experiments at 500 psi (3.5 UPa) confining pressure and T = 22°C and at T = 100°C with confining pressures of 0, 500 and 3000 psi (0, 35, 20.7 UPa).

Wawersik, Hannum - analysis and interpretation of data.

Amount of Data: 23 experiments - various tables giving max. principal stress difference, strain at maximum stress, minimum stress, temperature, direction of strain, and estimated secondary creep. 1 sample - 2 variations of principal stress difference with time (plot). 1 sample - plot of principal stress difference and confining pressure vs. time. 1 sample, axial creep vs. time plots, log/log plot, semi log plot, 3 secondary creep plots. 23 data tables showing principal stress difference over several time intervals.

Data Sources: WIPP core specimens, laboratory testing

Data Interpreted by: Wawersik, & Hannum - SNL

Data Storage Location: Sandia Laboratories, Albuquerque, NM.

Data Related Uncertainties: Major uncertainties in parameter n in primary creep power law. Raw data, minor, directly measure. Secondary creep estimated, possibly major uncertainties. Tertiary creep measured - moderate uncertainties. Uncertainties not specifically reported. Raw data should be definitive, however creep data can only be preliminary, based on laboratory data and creep laws.

SALT REPOSITORY PROJECT

SUMMARY DATA INVENTORY SHEET

Type of Data: Creep property laboratory tests/triaxial creep experiments

Data Documented: SAND 79-7030: Hansen, F.D. and K.D. Mellegard; Creep Behavior of Bedded Salt from Southeastern New Mexico at Elevated Temperature; by RE/SPEC, Inc., for Sandia Laboratories, Albuquerque, New Mexico, November, 1979.

Data Collection Location:

(a) Areal Location: WIPP Study Area, Southeastern New Mexico, ERDA No. 9 corehole.

(b) Subsurface Location: Depth interval of 2605 to 2679 feet.

Method of Data Collection/Analysis: Samples from corehole subjected to triaxial loading and data, including axial and lateral strain, axial and confining pressures, time and temperature were collected. Creep response was measured for temperatures of 24, 70 and 100°C under confinement pressures of 0, 1500, 2000, 2500, and 3000 psi, and differential axial stress levels of 1500, 3000, 4500 and 6000 psi. Test durations ranged from 15 minutes to over 500 hours. 14 specimens were tested.

Axial and Lateral Strain were plotted as a function of time and compared to previous results.

Hansen & Mellegard - analysis and interpretation of data.

Amount of Data: 14 specimens, 17 experiments, with numerous plots and tables showing test parameters and results, and resulting equation fitting axial creep data to a function of time, differential stress, and temperature. ($e_1 = 1.1\ (10\text{-}35)\ t^{0.4656}\ \sigma^{2.475}\ T^{8.969}$)

Data Sources: Core speciments, laboratory tests

Data Interpreted by: Hansen & Mellegard

Data Related Uncertainties: None reported. Raw measured data minor uncertainties. Modelling - major uncertainties. Raw data should be definitive, modelling, preliminary.

Enclosure 6

Draft rock mechanics data review checklist

Reviewer _____
Date _____

Draft Rock Mechanics Data Review Checklist
(Revision, August 6, 1984)

1. Name/type, identification number, and date of test.

1a. What is the overall objective of the test?

1b. What specific parameters are to be determined by the test?

1c. What criteria were used for test site (or sample) selection?

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1d. How is the rock at the test site characterized?

1e. How many of these tests have been performed?

1f. How many tests are planned?

1g. Comments.

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2. Is the procedure documented and complete, and is it in written form?

2a. Is it a standard (ASTM) procedure? If yes, provide reference.

2b. If non-"standard", how was the procedure developed, reviewed, documented, and approved? For example, COE, USBM, USBR, USGS, NBS, or other (internal) processes.

2c. Have there been revisions and how and when were the revisions reviewed, documented, approved, and implemented?

2d. How are any deviations from the established procedures that occur during testing documented?

2e. Comments.

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3. What instrumentation is used for the test?

3a. How were the reliabilities* of the instruments specified?

3b. Is there a calibration system and were calibrations systematically carried out according to approved procedure?

3c. Are the calibrations traceable to national or industrial standards?

3d. Comments.

* Reliability is defined as the probability of an instrument to perform a stated function under a stated environment for a stated time.

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4. What are the data collection, reduction, and presentation techniques involved in collecting analyzing and interpreting the data? (emperical, analytical, numerical)

4a. How can the raw numerical data be retrieved?

4b. Are the data presented in a complete and clear format? (Comment also on the utility of the presentation.)

4c. Are the data keyed to geological, environmental, and other experimental conditions?

4d. Comments.

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5. What are the acceptance/rejection criteria for the test data?

5a. Were these criteria established prior to test development?

5b. How are the criteria implemented? (Data handling, review procedure, corrective action.)

- Data Handling
- Review Procedure
- Corrective Action

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6. General comments (such as, relationship among different tests, impacts on interpretation, instrument redundancy, factors resulting in test closure, accuracy of measurements, limitations, additional uses of data, computer programs, and other miscellaneous comments).

7. Requested Test Data - (Identify all data and documentation that is needed for further review).