Rec'd with Letter dtd 10/29/97

MINUTES OF THE SEPTEMBER 10, 1997
U.S. DEPARTMENT OF ENERGY/U.S. NUCLEAR REGULATORY COMMISSION
HIGH-LEVEL RADIOACTIVE WASTE QUARTERLY TECHNICAL MEETING

On September 10, 1997, U.S. Nuclear Regulatory Commission staff met with staff from the U.S. Department of Energy (DOE) and DOE's contractor to discuss items of mutual interest regarding DOE's site characterization programs. The items discussed included updates on the status of some of the scientific studies at the site, including alcove testing within the Exploratory Studies Facility (ESF). In addition, DOE also presented some preliminary information on its engineering design programs.

This meeting was another in a continuing series of periodic quarterly technical meetings. The meeting was held via a three-way videoconference at the NRC office in Rockville (Maryland); DOE's office in Las Vegas (Nevada); and the Center for Nuclear Waste Regulatory Analyses (CNWRA) office in San Antonio (Texas). Representatives from the State of Nevada; Clark County and Nye County, Nevada; the U.S. Geological Survey (USGS); and the U.S. Nuclear Waste Technical Review Board (NWTRB) also attended. The agenda is in Attachment A. Attachment B contains the list of attendees.

In the first major series of presentations, DOE provided an update of the status of its scientific investigations, including some of its testing programs. The following three testing activities were discussed: (1) thermal testing; (2) ESF moisture studies; and (3) other new investigations that are part of the enhanced repository block characterization. The briefing materials reviewed are contained in Attachment C (pages 4 through 10). For each of the testing programs, DOE presented its preliminary findings, to the extent that the information was available. The following points were noteworthy:

- *Drift-Scale Heater Test*: Overall, activities related to this particular test were reported to be on schedule. The scheduled turn-on date for the heater is currently sometime in early December 1997. Testing duration is expected to be 4 to 8 years with warm-up and cool-down phases.

- *Single-Element Heater Test*: DOE reported that this particular test, being performed by Sandia National Laboratory staff, is in an shake-down phase in which the testing instrumentation is being calibrated. Thus far, the shake-down phase is proceeding as planned and is on schedule. Some limited data have been collected and analyzed, and although they are preliminary, a comparison of the predicted versus measured data for this particular test to date are in good agreement. In response to a question regarding the availability of test results, DOE noted that test results will be reported quarterly after they are analyzed.

- *Large Block Tests (LBT):* The LBT heater was initially turned on in February 1997 and was scheduled to run for six months. Thus far, DOE has reported a good correlation between results and predicted data. However, it was noted that southern portions of Nye County, including the Yucca Mountain site, recently received excessive amounts of

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precipitation[1] which unexpectedly resulted in a cooling-down of the LBT. As a result, DOE noted that it may have to run the test a little longer than first envisioned in order to collect the data that was lost during the precipitation-induced cool-down.

The second scientific investigations topic concerned an update on DOE's ESF moisture studies. The intent of these studies is to better understand the behavior of moisture (liquid water) within the ESF. DOE reported on the progress of the following four studies: (1) ESF moisture balance; (2) Paintbrush non-welded tuff (PTn) moisture monitoring; (3) role of fault systems in unsaturated zone flow; and (4) ESF niche tests (see Attachment C, pages 11 through 23). In reporting its preliminary findings, DOE announced the following:

- The ESF moisture-balance studies thus far suggest that moisture removal by ventilation is less than the volume of construction water introduced into the ESF, suggesting that there is drainage from the ESF drift.

- Instrumentation in the North and South ESF Ramps suggest that the PTn is "wetter" than previously thought.

- Pneumatic testing results from Alcove 6 suggest the possible importance of microfractures in water content and flux.

Overall, it was noted that despite the availability of some preliminary test results (some of which are contradictory), additional testing will be necessary (i.e., niche studies, Alcove 7) before the behavior of moisture within the Yucca Mountain block can be fully explained. As part of the question and answer period, a representative for Nye County asked whether DOE was attempting to differentiate between pore water and drilling water found in the various instrumentation boreholes. DOE responded that it was using a lithium-bromide tracer to allow its scientists to differentiate between the two.

Following the update on thermal test activities, DOE provided an overview of other investigations and testing activities as part of the enhanced repository block characterization. The briefing materials that were relied on in this portion of the discussion are also contained in Attachment C (see pages 25 and 26). In this series of presentations, the following points were noteworthy:

- *Surface-Based Drilling:* DOE plans four new boreholes as part of its enhanced repository block characterization. Two boreholes, designated WT-24 and SD-6, are planned in order to better understand the large hydraulic gradient to the North and West of the repository block. It was noted that Borehole WT-24 recently encountered problems when a drill bit became lodged in the borehole (the drill bit has since been recovered). Drilling is now at a depth of 110 meters. Construction of the drilling pad for SD-6 and access road are currently underway. Two additional boreholes, designated SD-11 and SD-13, are planned to provide additional data on perched-water, mineralogy, and rock properties beyond the repository foot print as part of enhanced repository block characterization.

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[1] For example, 5½ inches of rain was reported in Pahrump, Nevada, in a 24-hour period.

- *Cross-Drift*[2]: DOE's current plans call for commencement of construction sometime in Spring 1998. DOE will provide the staff with a revised construction schedule. In response to NRC questions about previously-raised NWTRB issues on the impact of the cross-drift on waste isolation and the creation of preferential pathways for radionuclide transport, DOE responded that the preferential pathway issue had been resolved through a *Determination of Importance Evaluation* (DIE) and that additional DIEs, evaluating the potential significance of other issues, will be made prior to the excavation of the cross-drift starter tunnel. DOE also indicated that their evaluations of some of these issues would be presented to the NWTRB at its October 1998 meeting.

The second major agenda item was a series of presentations on certain aspects of DOE's engineering design program. Four areas were addressed: (1) the status of binning of geologic repository structures, systems, and components (SSCs); (2) the *Engineering Compliance Program*; (3) the use of concrete ground support; (4) the level of design detail to appear in the license application. The first engineering design program item to be discussed was an update on DOE's "binning" of geologic repository SSCs into one of three bins[3] (see Attachment D). DOE presented the results from a detailed analysis that was just completed, including a brief explanation of the basis for the binning assignments. Based on an initial review of SSCs for a *Mined Geologic Disposal System* — MGDS (this analysis being designated as "Revision 1"), 18 SSCs were listed as Bin 1; 22 SSCs were listed as Bin 2; and 18 SSCs were listed as Bin 3. DOE is currently reviewing Revision 1, including the background documentation that describes the basis for binning decisions, and it should be publicly available sometime in November 1997. At that time, it will be provided to the NRC for its review and comment. NRC's review comments will be needed by the Spring of 1998. During the course of the presentation and discussion that followed, NRC noted that it would be useful for DOE to identify all of the engineering design products the Department would like the NRC to review prior to the submittal of a potential license application. Second, in response to NRC questions on the quality assurance (QA) pedigree of the binning exercise (and the possible need for one), DOE noted that the binning exercise was simply a management tool intended to help the Department rank and prioritize its workload. Moreover, DOE noted that the binning exercise was being conducted in parallel to: (1) the re-classification for items currently on the "Q-list;" and (2) its design-basis event work, and that the results of these various exercises would be compared and any differences between them reconciled before they are used as design inputs to a potential license application.

The second agenda item in the engineering design area concerned *DOE's Engineering Compliance Program* (ECP) for the MGDS. The briefing materials that were relied on in this portion of the discussion are contained in Attachment E. In the absence of comprehensive design guidance for the MGDS, the ECP represents DOE's attempt to identify and incorporate

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2 Formerly referred to as the "East-West Drift."

3 DOE has defined the three SSC bins as follows: Bin 1 SSCs are believed to have no impact on public health and safety. Bin 2 SSCs are believed to potentially affect public health and safety; however, in DOE's estimation, there exists adequate guidance and/or previous engineering precedent that can be followed when preparing (and reviewing) a design. Bin 3 SSCs are believed to potentially affect public health and safety; however, in DOE's estimation, there is no previous licensing precedent that could be followed when preparing (and reviewing) a design.

applicable NRC regulations and accepted industry codes and standards into the design of the MGDS. When completed, the ECP process will: (1) identify criteria that, when met, are expected to demonstrate compliance with NRC's 10 CFR Part 60 regulation for a geologic repository; and (2) represent a controlled process for maintaining and evaluating possible changes to MGDS design criteria. Accordingly, DOE noted that the ECP process would be performed under a QA procedure. Following this presentation, NRC noted its overall favorable impression with the ECP process. Moreover, to the extent that it could agree with the results of DOE's analyses, it would attempt to adopt the results. There were several questions from the NRC staff. In a question related to timing, the staff questioned whether DOE should wait until the binning exercise had been completed before implementing the ECP process. In response, DOE noted that both processes were intended to be iterative and as such, the two activities could be performed in parallel. Next, NRC noted that SSCs designated Bin 3 where not unlike the Type 4 or 5 *Key Technical Uncertainties*[4] (KTUs) first identified in its *License Application Review Plan* (NUREG-1323). However, because of budgetary limitations, the staff had no immediate plans to develop the needed regulatory framework to review Bin 3 SSCs. Thus, the staff were interested in hearing if DOE expected specific regulatory guidance for Bin 3 SSCs. In response, DOE noted that it was not expecting the development of NRC guidance, at this time. DOE's expectation was that existing regulations, codes, and standards could be identified and applied, albeit in new applications. Finally, DOE inquired as to the general availability of electronic versions of NRC *NUREGs* and *Regulatory Guides*. The staff noted that it would make the necessary inquiries and if DOE was interested in electronic versions of specific documents, it should identify these to the staff.

Next, DOE presented an overview of its plans to use concrete liners as ground support in the geologic repository. DOE's current VA designs call for full-circle, pre-cast liners in all emplacement drifts. This design may be augmented by steel sets and lagging, as necessary. DOE's presentation included the following: (1) a discussion of the technical basis and reasoning behind the decision to use pre-cast concrete; (2) an overview of the lining design; (3) concrete property testing programs at Lawrence Livermore National Laboratory; and (4) performance testing of the concrete liner within the drift scale heater test alcove. The briefing materials reviewed are contained in Attachment F. In the question and comment period that followed, the following points of clarification were provided:

- Issues related to the long-term (i.e., post-closure) stability of the concrete liner are the subject of future investigations and analyses, including some analyses in the context of total-system performance.

- In the context of repository performance, DOE is determining what pH levels can be tolerated in the near-field owing to the presence of concrete.

- Although 200 degrees Centigrade (at the drift face) is the maximum design temperature for the repository, instrumentation and testing within the drift scale heater test alcove (over an eight-year period) is expected to provide insight into the performance of the concrete lining at higher temperatures.

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[4] Types 4 or 5 KTUs were regarded potentially as the most difficult to resolve and thus would require some limited independent staff analytical capability.

- The *Materials Testing Institute* at the Pennsylvania State University will be conducting additional tests of the proposed concrete liner design to evaluate the effects of creep on the stability of the concrete liners.

- A DIE for the ESF already exists and will be expanded to evaluate the effects of lining the emplacement drifts with concrete.

The final presentation of the day was discussion related to the overall level of design detail that DOE would provide to the staff in any geologic repository license application. The briefing materials that were used to support this presentation are contained in Attachment G. Moreover, DOE displayed copies of preliminary engineering drawings for selected portions of the MGDS as examples of the concepts it was proposing. Overall, DOE's level of detail design concept is twofold in its objectives. First, it will provide sufficient information to demonstrate that there is an adequate safety basis underlying its proposed repository designs. Second, because the concept is tied to the binning and ECP processes (discussed previously in Attachments C and D, respectively), the NRC should have sufficient information to make necessary (affirmative) findings, documented in its *Safety Evaluation Report* that would be prepared following a review of a potential DOE license application, that DOE's designs are adequate to meet NRC's regulations. As noted above, DOE presented specific examples of the level of detail it expected to provide for both Bin 2 and Bin 3 SSCs to illustrate its concepts.[5] In the question and comment period that followed, DOE noted that it intended to include the same level of design detail, to the extent that it is available, in the VA. In response to a comment from Nye County that the 10 CFR Part 960 siting requirement related to a minimum waste emplacement depth of 200 meters did not appear as a design criterion for the MGDS, DOE noted that the Part 960 requirements were interpreted as **guidelines** to the Department and not requirements *per se*, as is the case with the Part 60 regulations.

In summary, in response to a DOE request on the staff's preliminary views regarding DOE's overall approach to its engineering design program, the staff noted that it was favorably impressed with the level of details presented. Moreover, based on the information displayed thus far during this Quarterly Technical Meeting, the staff welcomed the ECP concept and noted that DOE was moving ahead prudently and responsibly to address regulatory matters in the engineering area despite fewer NRC design resources as a result of an overall reduced Congressional appropriation. In view of the fact that DOE plans to move aggressively in the design area (as stated earlier in the meeting), the staff believes that it would be useful for future planning purposes for the Department to identify the types and kinds of design documents it plans to prepare and for which it will seek NRC reviews.

At the end of the presentations, DOE provided the audience with advance copies of the second revision to the *Reference Design Description* — RDD (dated September 1997). Copies of the RDD will be made available to DOE stakeholders and other interested parties through its standard distribution process for such documents.

At the close of these discussions, the staff representing the State of Nevada and Clark

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[5] Because these designs are preliminary, they were displayed for illustrative purposes only and thus were not intended to be included in the meeting record.

County , Nevada, were invited to make some closing comments. Neither participant had comments.

Michael P. Lee
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards
U.S. Nuclear Regulatory Commission

Christian E. Einberg
Regulatory Coordination Division
Office of Civilian Radioactive
Waste Management
U.S. Department of Energy

AGENDA FOR THE
QUARTERLY NRC-DOE TECHNICAL
VIDEOCONFERENCE

September 10, 1997
9:00 a.m. — 2:00 p.m. (PST)

DOE Location:
Blue Room, Summerlin, 1551 Hillshire Drive, Las Vegas, Nevada 89134

NRC Location:
Two White Flint North, 11555 Rockville Pike, Room T2B5
Rockville, Maryland 20852

Time	*Item*	*Lead (s)*
12:00 p.m. (EST)	Opening Remarks	DOE, NRC, State, AUG
12:10	Scientific Studies Update - Thermal Testing Update - Program Enhancement Update (including Surface-Based Drilling) - Additional work in the Exploratory Studies Facility - Status of Alcove Construction - East-West Drift	DOE
12:50	Engineering Design Program - Level of Design Detail - Engineering Compliance Program Description - Design Binning Update - Use of Concrete Ground Support	DOE
3:45	Closing Remarks and Additional Discussion	DOE, NRC, State, AGU
4;00	Adjourn	

ENCLOSURE, ATTACHMENT A

LIST OF ATTENDEES
AT THE QUARTERLY DOE-NRC
HIGH-LEVEL RADIOACTIVE WASTE
TECHNICAL VIDEOCONFERENCE

September 10, 1997

Booz, Allen, & Hamilton
J. York

Center for Nuclear Waste Regulatory Analyses
A. Chowdhury R. Green L. McKague
W. Patrick B. Sagar

Clark County, Nevada
E.V. Tieseshausen

IBEX
R. Sweeney

Nye County, Nevada
M. Murphy N. Stellavato

State of Nevada
J. Grubb

U.S. Department of Energy (DOE)
A. Gil C. Einberg W. Boyle P. Harrington T. Hawe M. Tynan D. Williams

DOE Management and Operating Contractor
K. Ashe S. Dana B. Fish R. Fitzgerald A. Haghi P. Hammond
K. Iyengar H. Minwalla A. Segrest R. Stambaugh

U.S. Geological Survey
R. Wallace

U.S. Nuclear Regulatory Commission (NRC)
M. Bell B. Belke T. Carter K. Chang C. Glen G. Gnugnoli
L. Hamden A-B Ibrahim P. Justus M. Lee M. Nataraja K. Stablein
S. Wastler R. Weller

NRC Advisory Committee On Nuclear Waste
A. Campbell L. Deering

U.S. Nuclear Waste Technical Review Board
R. McFarland

ENCLOSURE, ATTACHMENT C

YUCCA
MOUNTAIN
PROJECT

Studies

Yucca Mountain Project Scientific Studies Update

Presented to:
DOE/NRC Quarterly Technical Meeting

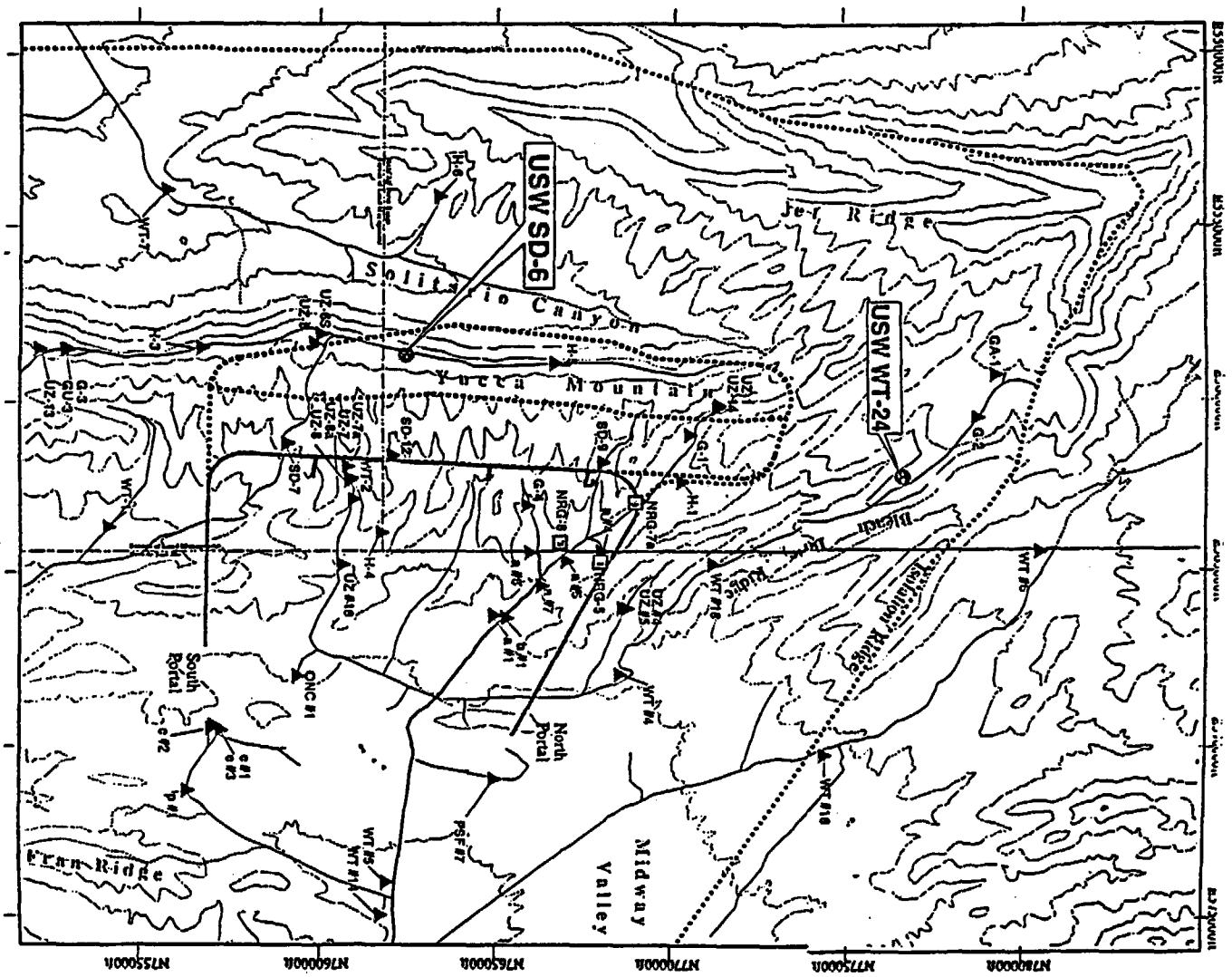
Presented by:
William J. Boyle
Team Leader for Performance Confirmation
Yucca Mountain Site Characterization Office

September 10, 1997

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

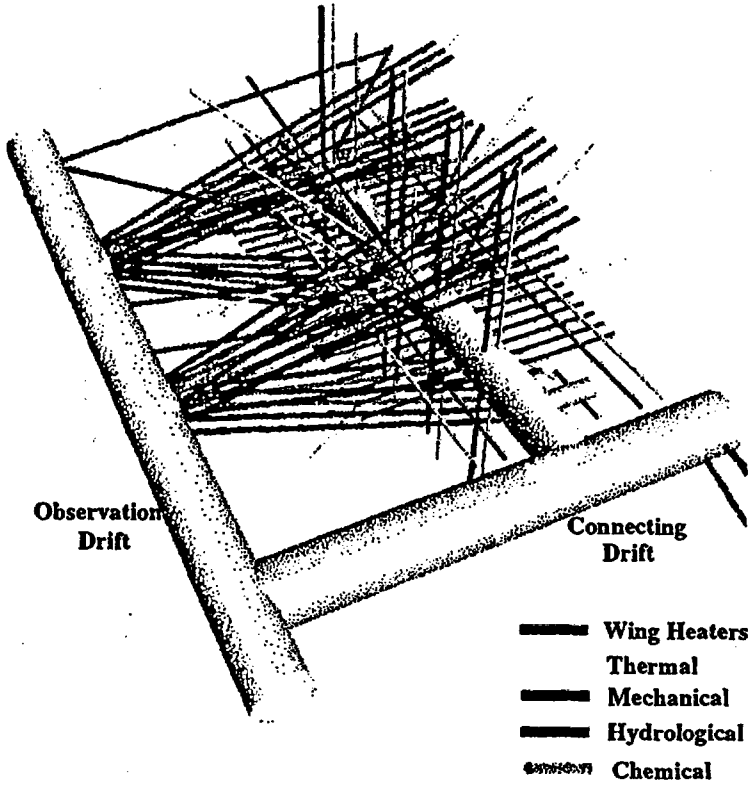
Overview

- **Thermal Studies**
  - Drift Scale Test (ESF)
  - Single Heater Test (ESF)
  - Large Block Test (Fran Ridge)
- **ESF Moisture Studies**
  - Moisture Balance Study
  - PTn monitoring
  - Fault characteristics
  - Niche studies
- **Other Studies**
  - WT-24 and SD-6 boreholes
  - Enhanced Characterization


USW SD-6
USW WT-24
Solitario Canyon
Yucca Mountain
Jet Ridge
Midway Valley
North Portal
South Portal
Fran Ridge
Dune Wash
Busted Butte
Station Ridge
Ridge
NRG-6
NRG-7
NRG-5
ONC #1
WT-24
WT-7
WT-2
WT-10
WT-12
WT-14
WT-18
WT-19
WT-23
WT-24
SD-6
SD-7
SD-9
SD-12
UZ-14
UZ-16
UZ-23
UZ-25
UZ-26
UZ-30
UZ-37
UZ-38
UZ-45
UZ-46
UZ-7
H-1
H-3
H-4
H-5
G-1
G-3
G-4
G-6
GA-1
GU-3
NTS5000N
NT6000N
NT6500N
NT7000N
NT7500N
NT8000N

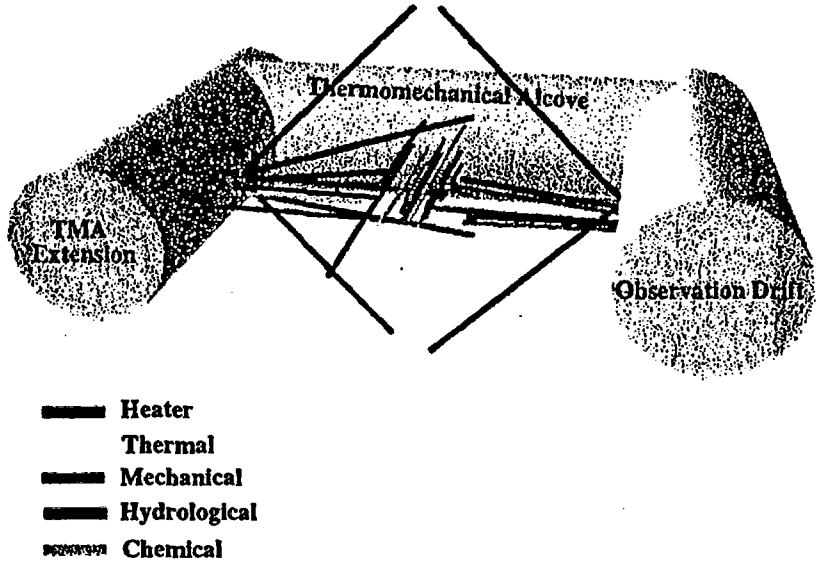
Thermal Studies Update
Drift-Scale Test Status

- The test will provide information regarding coupled effects essential to design and performance assessment of the repository system
- Baseline conditions established
- All wing heaters installed
- First canister heater emplaced
- On schedule to begin December 8

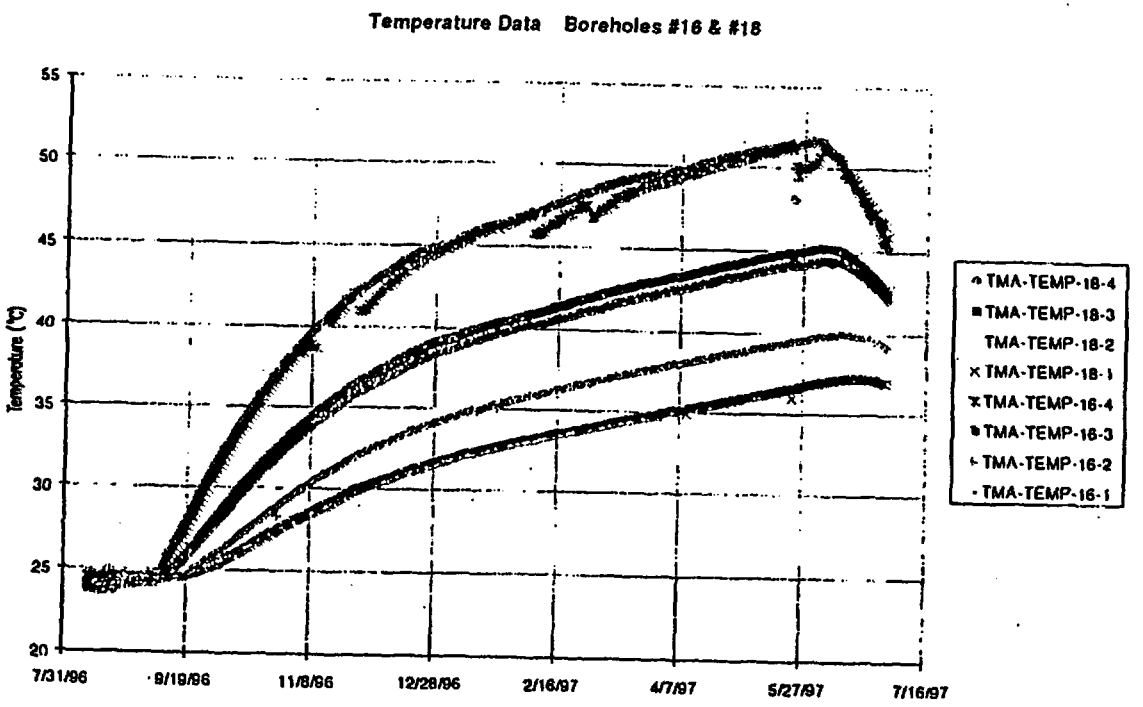


Thermal Studies Update
Single Heater Test Status

- The test provides shakedown of instrument performance and logistics for the Drift Scale Test
- Also provides data regarding rock mass response and properties at intermediate scale
- Heating phase has been completed; results provide useful constraints on thermal and hydrologic parameter sets
- Cooling phase underway, rock response being monitored

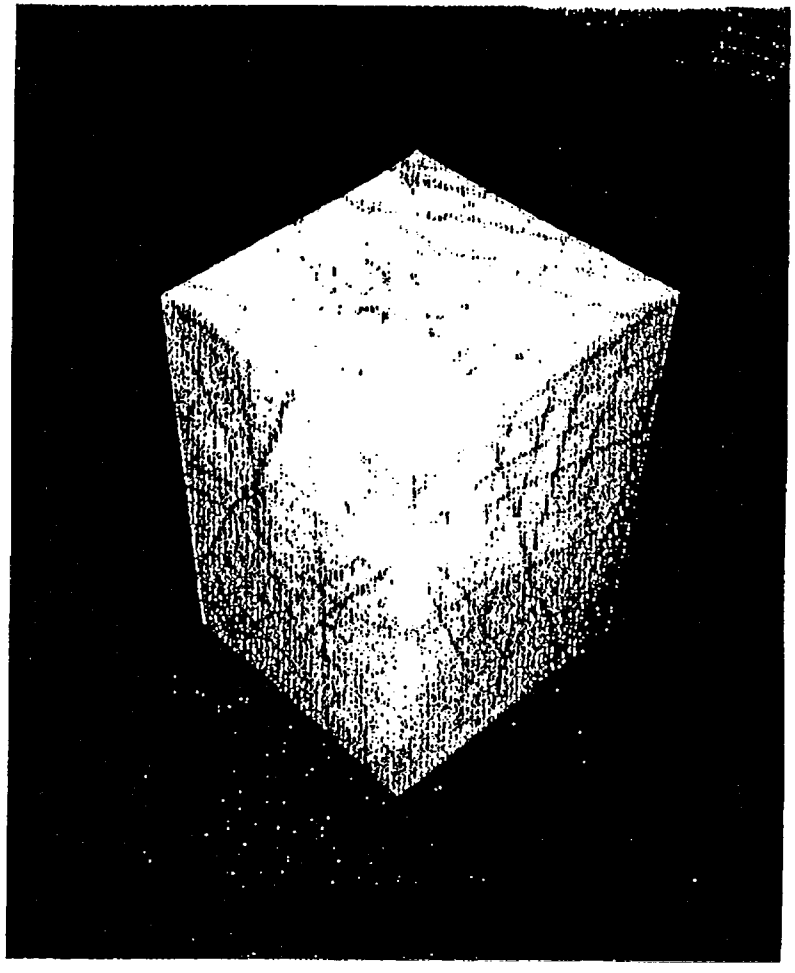


Single Heater Test--Temperatures In Cooling Phase



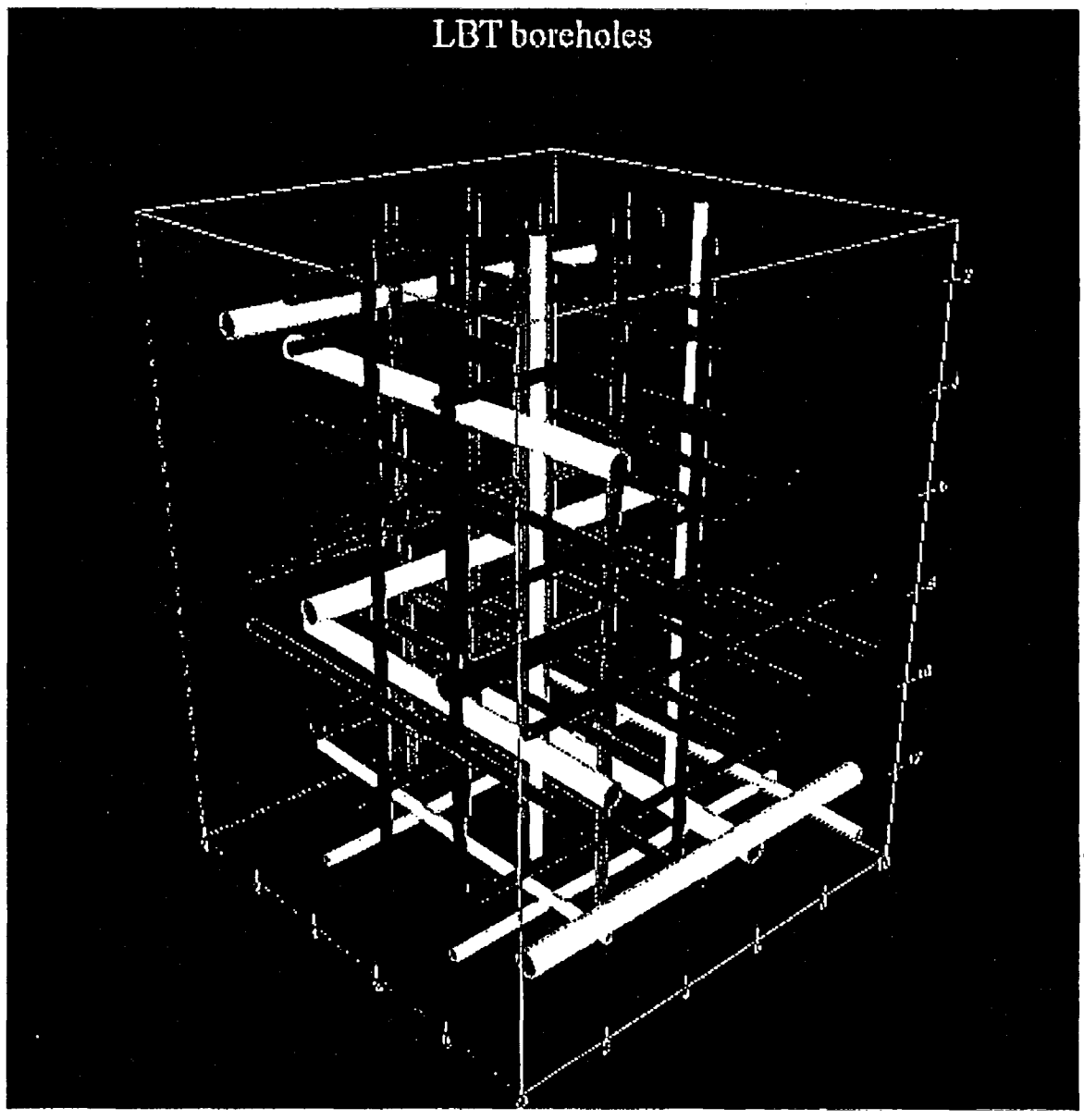
Thermal Studies Update
Large Block Test Status

- Test provides information regarding thermal effects under conditions that are well defined and controlled
- Tests conceptualizations of these effects to support models that will be applied to the field
- Heating phase underway, cooling phase to begin January 98.

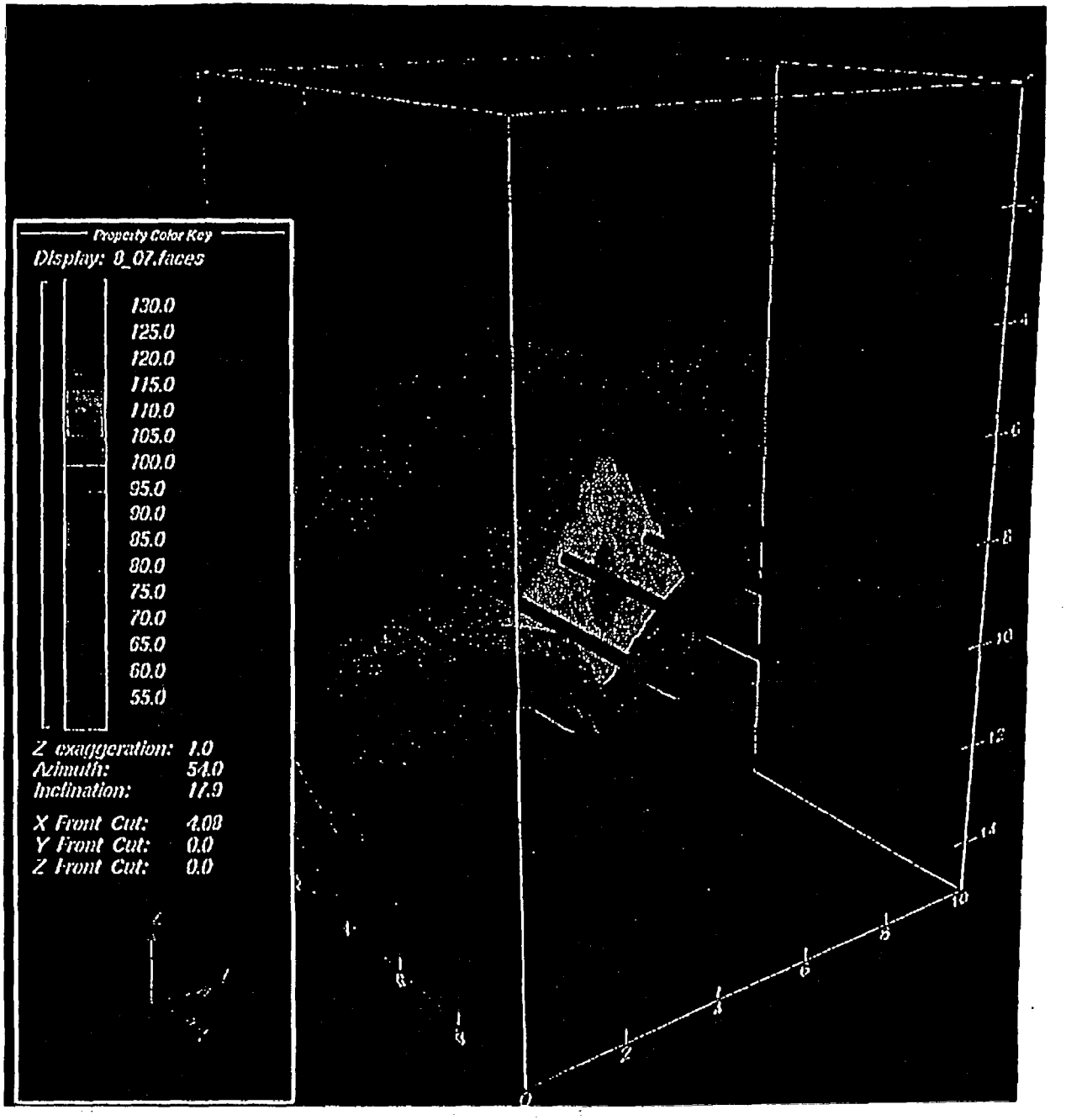


Large Block Test

Blue = Hydrology
Yellow = MPBX
Green = Neutron
Red = Heater
White = Observation
Brown = Temperature

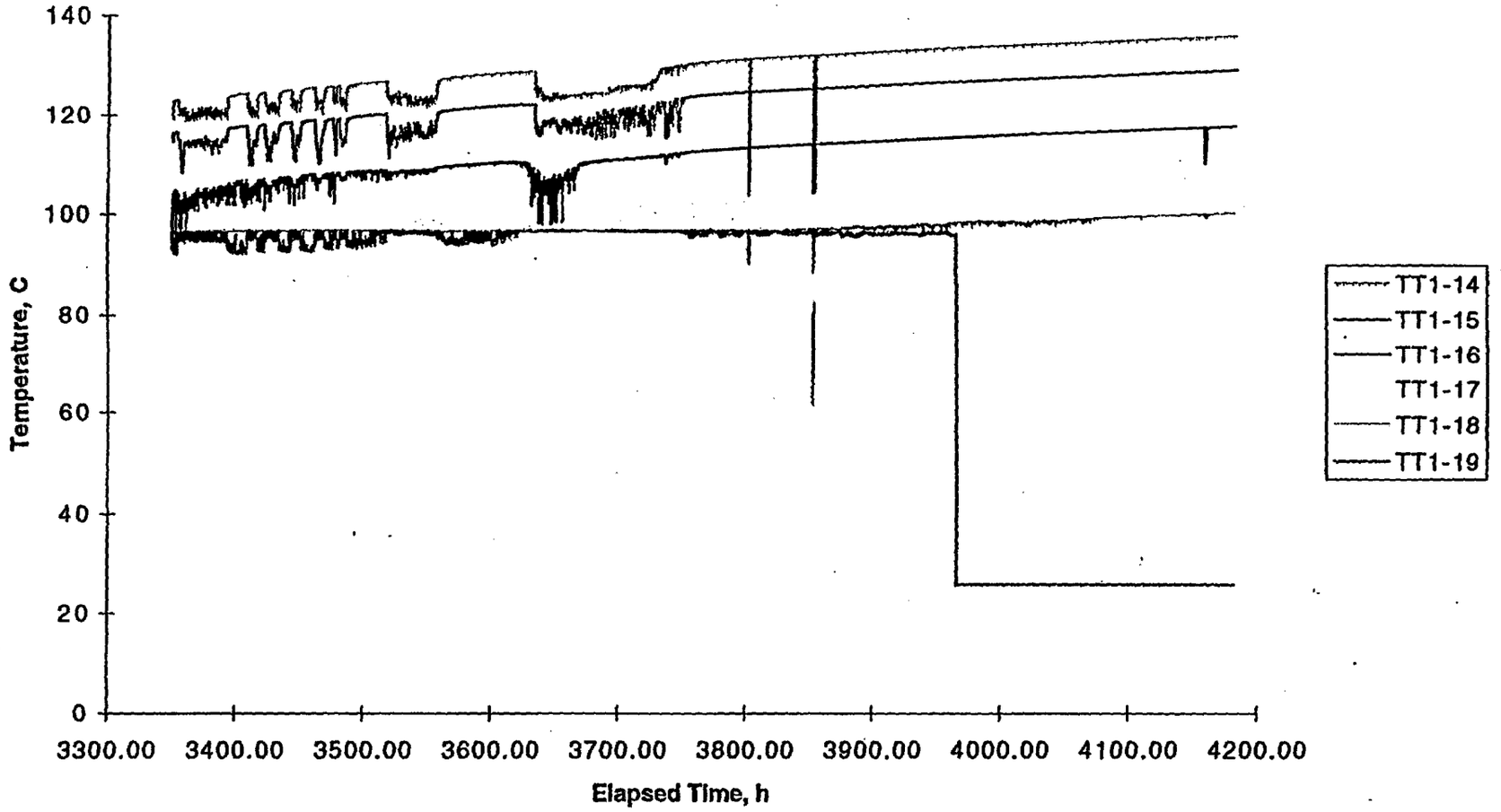


Large Block Test Temperatures



Large Block Test Temperatures

Temperatures at TT1-14 to TT1-19 from 7/18/97 to 8/21/97.



ESF Moisture Studies Update
Status of Moisture Balance Study

- Testing is evaluating removal of moisture by ventilation, water potential of the rock, and other aspects related to moisture balance in drifts
- Results suggest moisture removal by ventilation is less than volume of introduced construction water
- May suggest percolation drainage from drift; studies are continuing to evaluate potential for drainage into and seepage out of host rock

ESF Moisture Studies Update
Status of PTn Monitoring

- Testing will evaluate flow through PTn, potential for diversion at PTn
- 21 2-m holes in North Ramp to detemine water retentions, properties, and contrasts of PTn layers
- PTn holes in South Ramp focus on features (e.g., faults, contacts). 37 of 41 holes cored so far.
- Monitoring is ongoing. Preliminary analyses indicate PTn is significantly wetter than previously thought.

ESF Moisture Studies Update
Status of Fault Studies

- Testing in Alcoves 6 and 7 examining basic role of faults in UZ flow system, complementing surface-based testing
- In addition, air-injection, temperature, pneumatic, gas chemistry, fracture fill and isotope measurements underway to evaluate host rock characteristics
- Alcove 6 (North GDF) completed; fault crossed and evaluated; ongoing pneumatic suggests possible importance of microfractures in water content and flux
- Alcove 7 (South GDF) under construction; splay crossed; some testing has been conducted.
- Considering bulkheading off Alcove 7 (and Alcove 1) to monitor potential effects during El Niño wet year

ESF Moisture Studies Update
Niche Studies Status

- Test principal models for percolation, seepage, and transport in host rock
- Niche 3566 drilled, tested, and bulkheaded
- Niche 3650 drilled, tested, and excavated. Bulkheading underway.

Drift Seepage Test in Niche

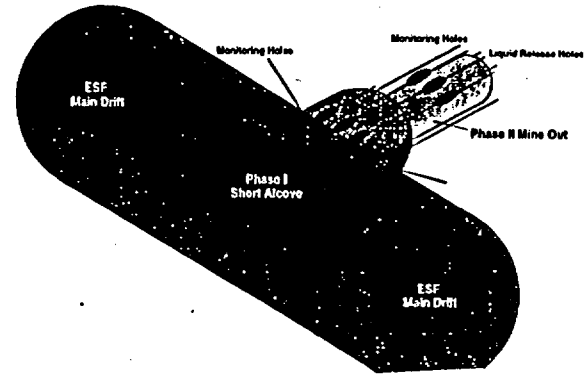
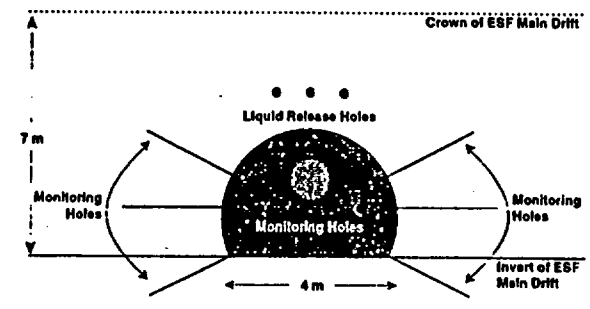
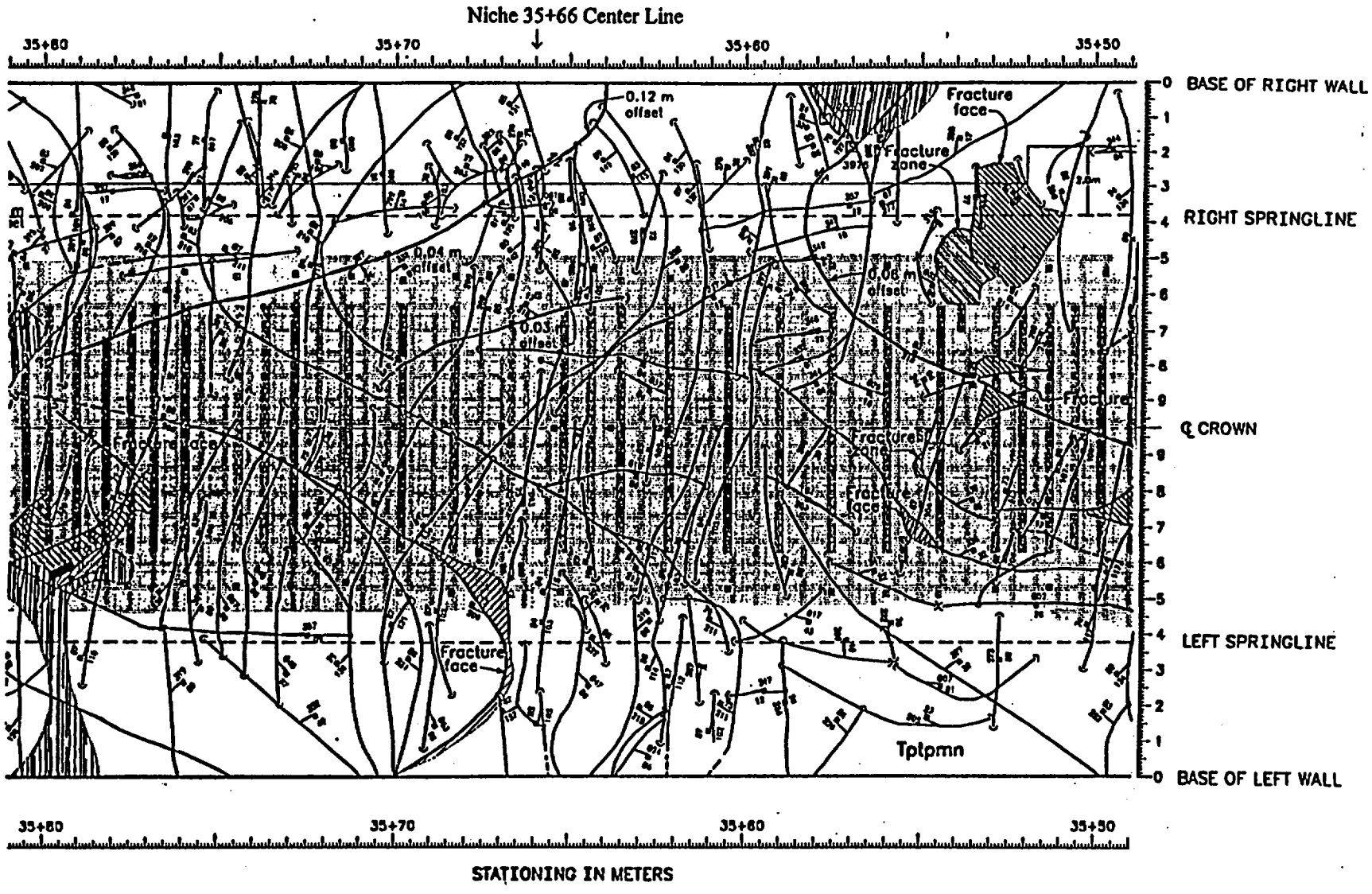


Figure 1(a)

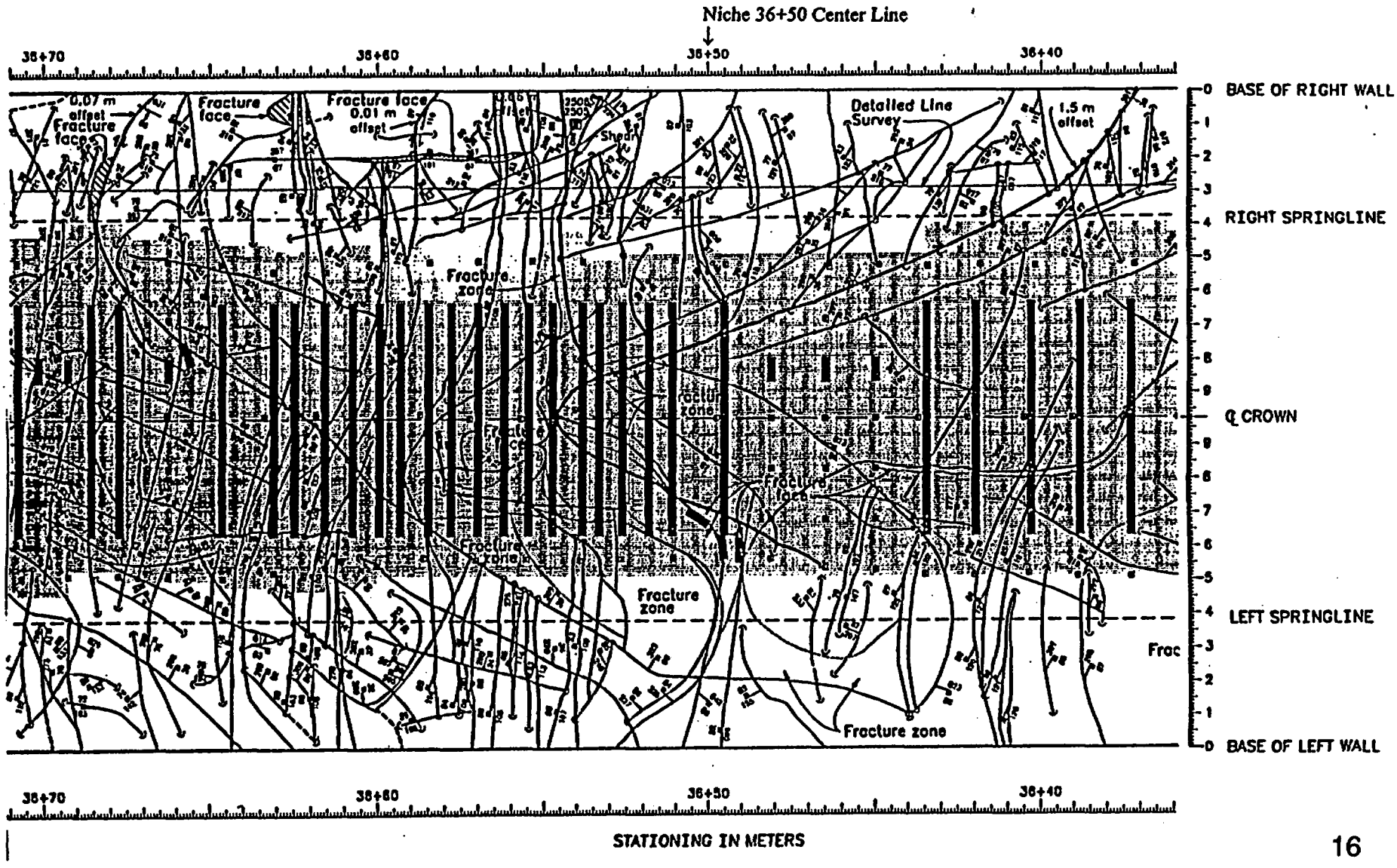
Parallel to the Main Drift:



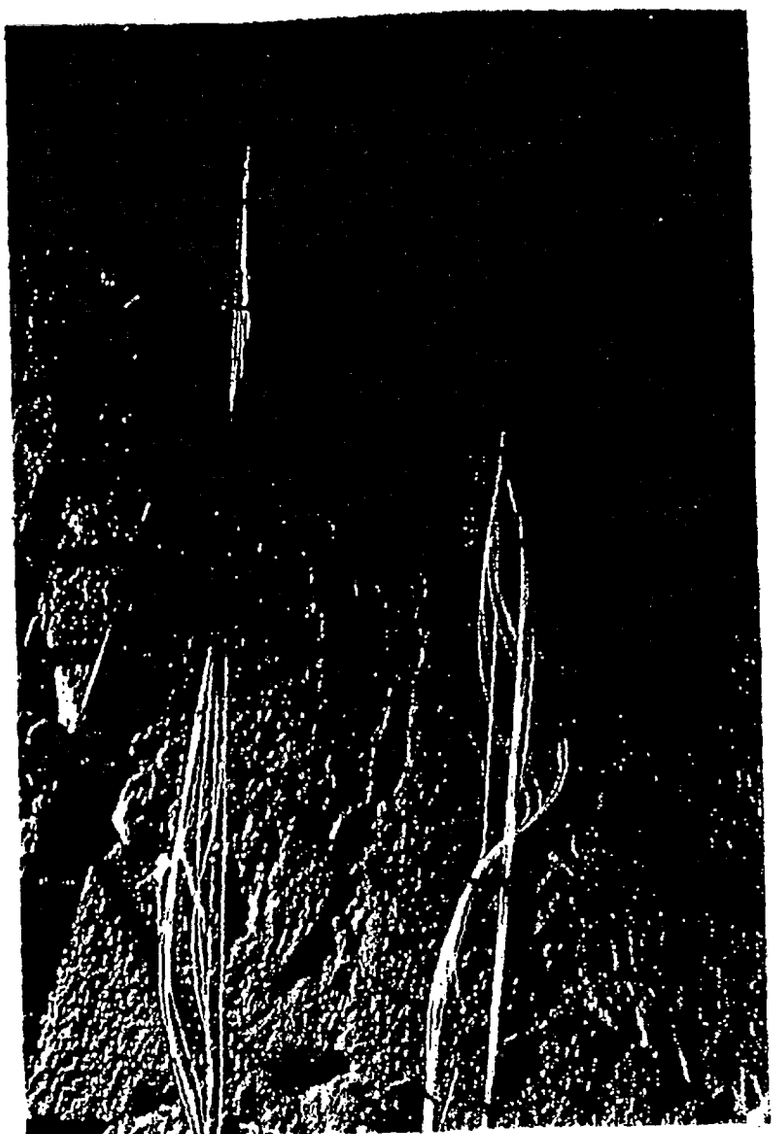
Selecting Niche #1 Location



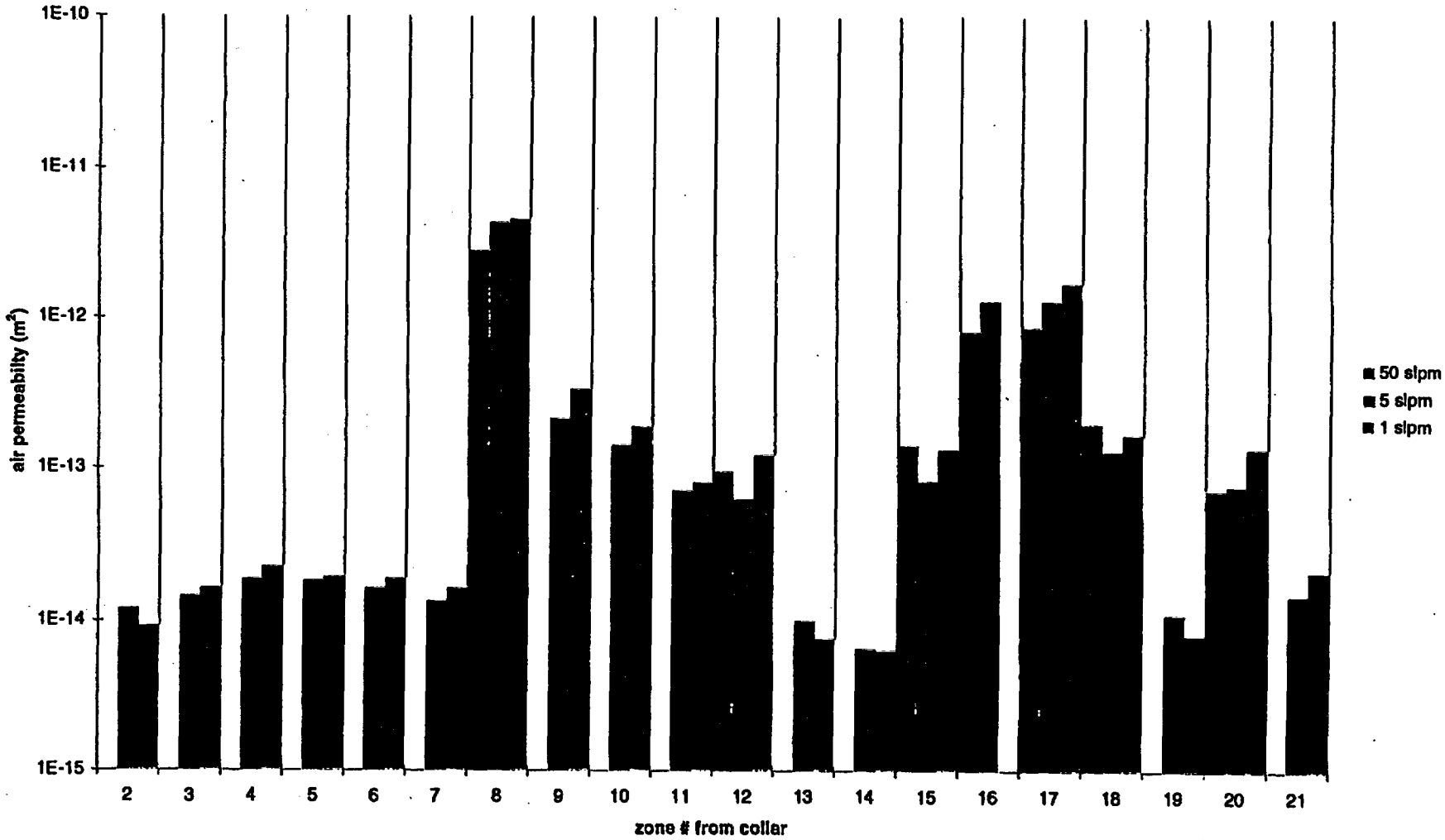
Selecting Niche #2 Location



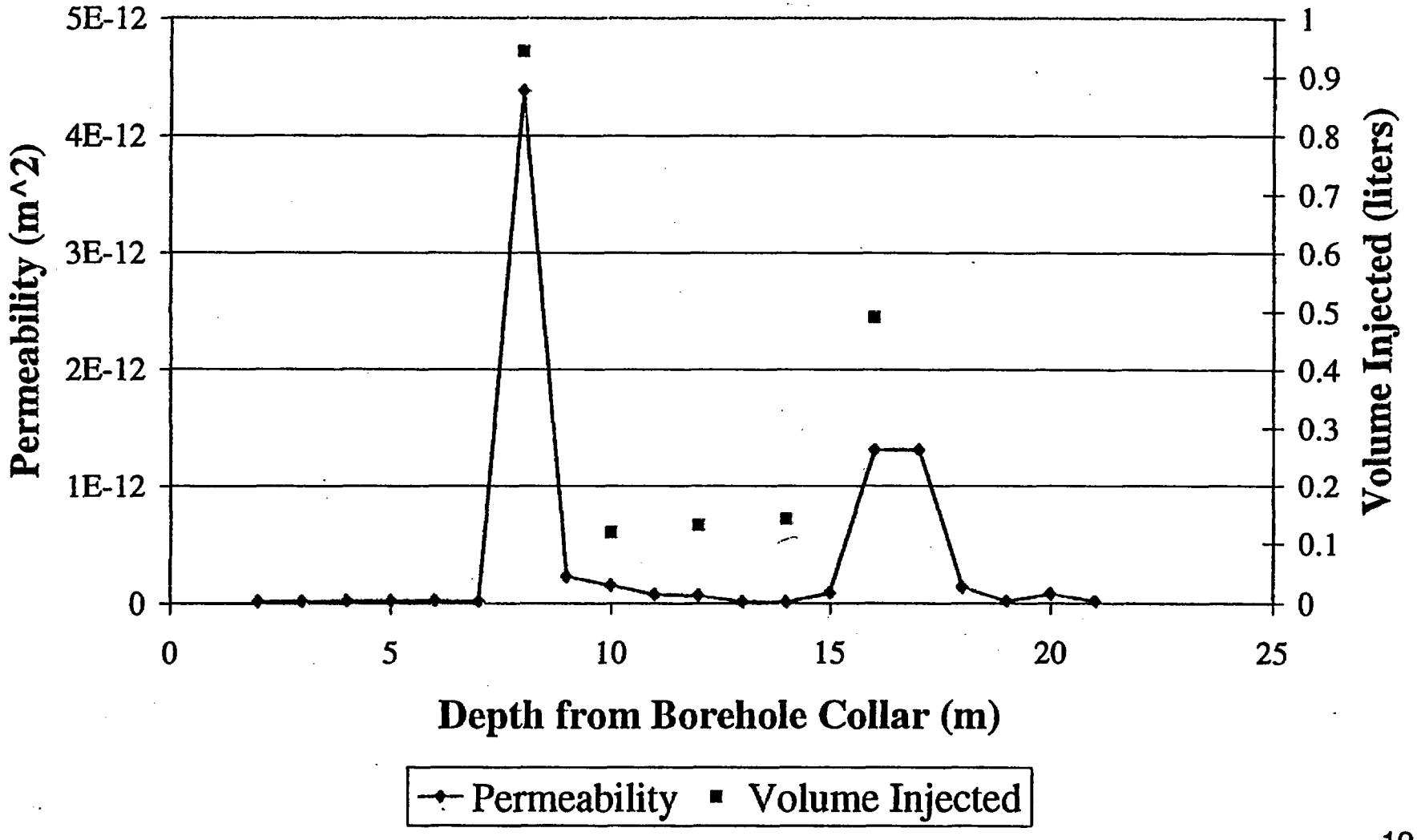
Niche #1 (CS 3566) Boreholes



Niche 3566--Location of Fractures

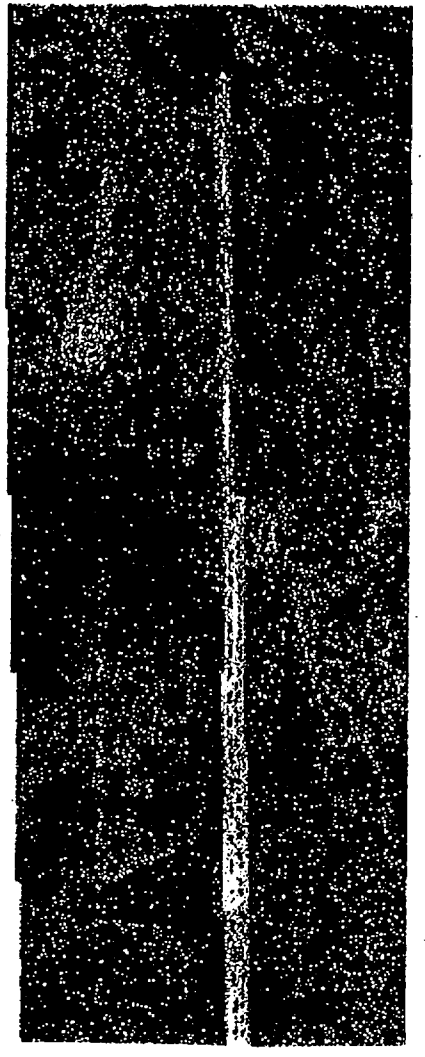


Niche 3566--Dyed Water Intervals



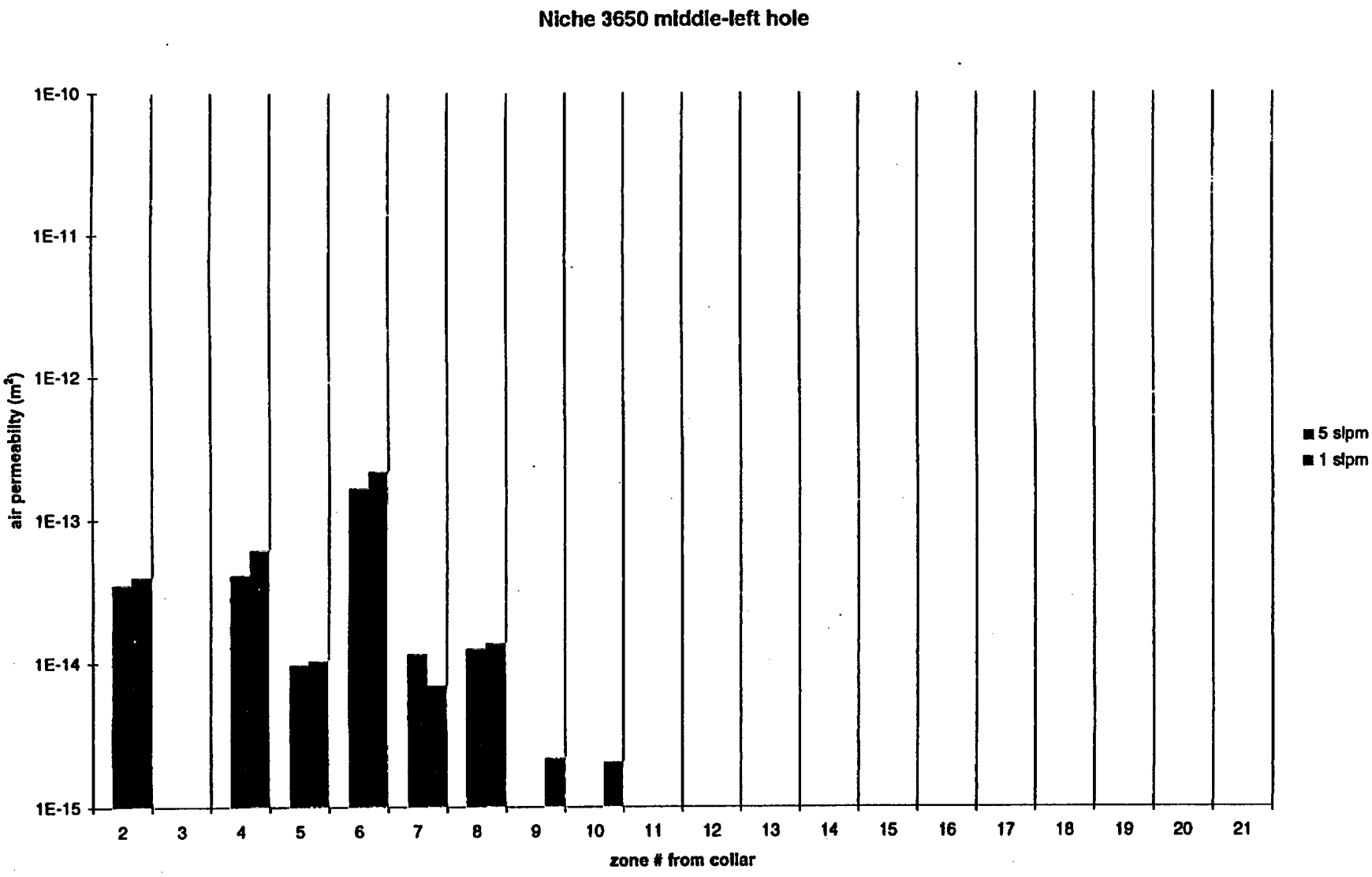
Niche 3566--Results at 3 m

Niche 3566--Results at 5 m



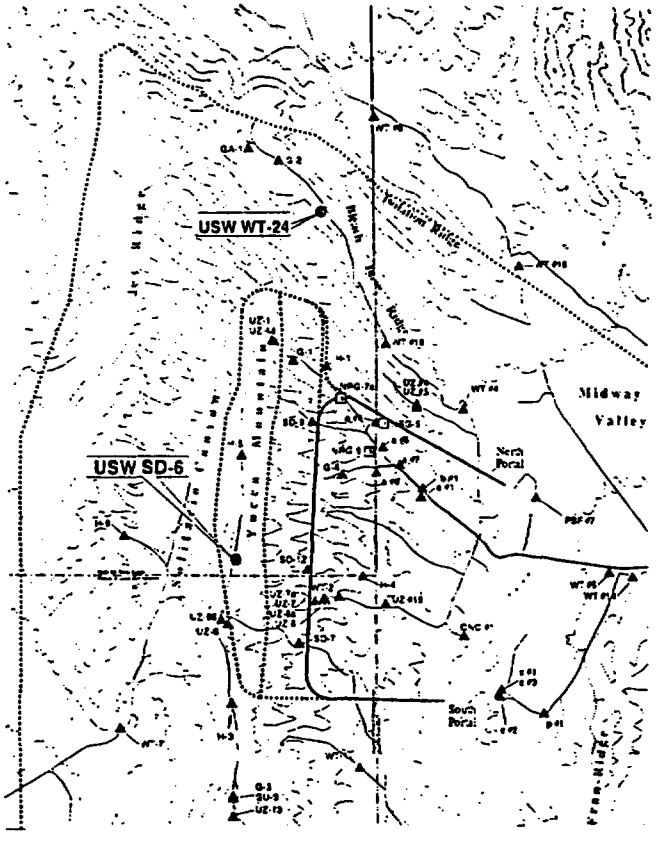
Niche 3566--Breccia Feature at 10 m

Niche 3650--Location of Fractures



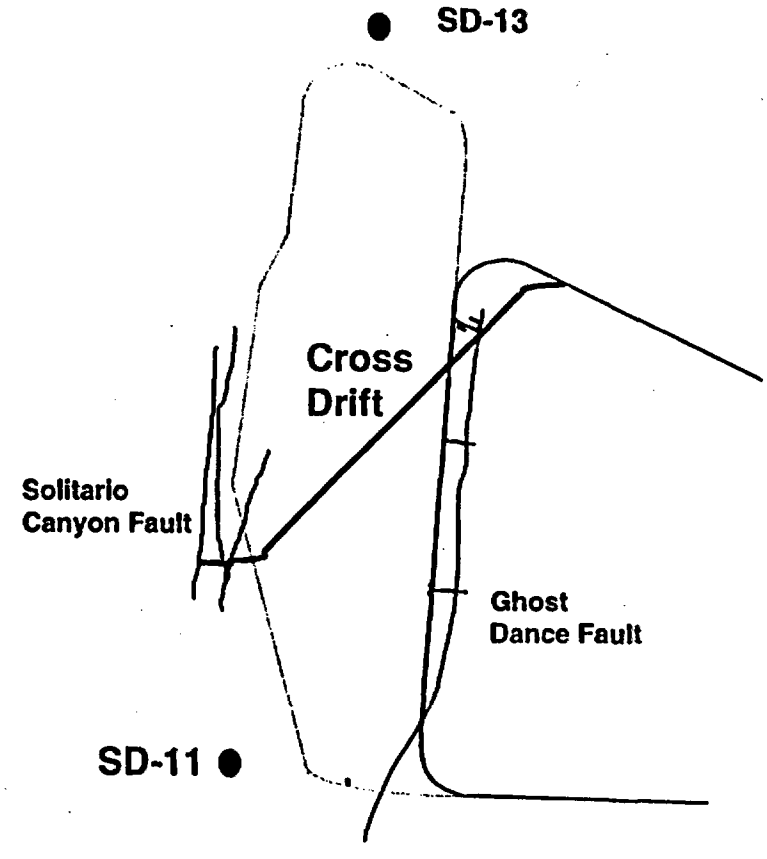
Status of WT-24 and SD-6

- Purpose of WT-24 and SD-6 is to obtain stratigraphic, hydrologic, and rock properties data to the north and from the western portion of the proposed repository block
- Perching, saturated zone, and large apparent hydraulic gradient will be investigated in WT-24
- Solitario Canyon fault will be investigated in SD-6
- WT-24 has reached 110 m (perched zone at 450 m)
- SD-6 pad and access road under construction



Status of Enhanced Characterization Effort

- Effort involves Cross Drift, two additional boreholes (SD-11, SD-13)
- Exploration in proposed repository block, will complement and enhance characterization from existing surface-based testing and ESF
- Effort just approved; plan to begin excavation Spring 1998, reach Solitario Canyon fault late Summer



Testing in Enhanced Characterization Effort

- Perched water, mineral distributions, rock properties in SD-11, SD-13 boreholes
- Testing in Cross Drift
  - Fracturing and faulting
  - Gas pressure and flow, rock moisture, and temperature
  - Moisture balance
  - Chloride concentrations and Cl isotopic compositions
  - Abundance and distribution of calcite and opal
- Hydrologic alcoves at cross-over of ESF, crest of Yucca Mountain, and Solitario Canyon Fault
- Single Heater Test

ENCLOSURE, ATTACHMENT D

YUCCA
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Studies

MGDS SSC Prioritization (Binning)

Presented to:
DOE - NRC Quarterly Technical Meeting
Rockville, Maryland

Presented by:
Paul Harrington
Assistant Manager for Licensing/
Licensing Application Team Leader
September 10, 1997

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

SSC Prioritization ("Binning")

- Management tool to prioritize design development and level of detail for License Application
- Categorizes SSCs into "Bins" based on:
  - importance to radiological safety or waste isolation
  - availability of applicable licensing/design precedent
  - other items of regulatory significance (management judgement may apply more conservative bin number on basis of regulatory significance not strictly associated with radiological safety or waste isolation)

SSC Prioritization ("Binning")

- Results presented at SDD level
  - Some SSCs evaluated (binned) at lower levels of detail, depending on maturity of design
  - SDDs assigned a bin number based on highest bin number of subordinate SSCs
- Re-prioritization will occur periodically as design evolves (e.g., in support of annual planning)

Binning Status

- Revision 1 in progress
  - Evaluating some SSCs at lower levels of detail (based on design detail)
  - Restructuring based on evolving SSC/SDD architecture
  - Work being performed by DBE/QA classification staff: validate earlier conclusions against in-progress classification results

Binning Status (continued)

- Procedure development
  - Captures rationale for binning conclusions
  - Provides for documentation in "backup sheets" for each SDD/SSC evaluated
  - Provides for updates/revisions as design and architecture evolves

Results of In-Progress Revision

- Results currently in internal DOE review
- Changes in conclusions limited to specificity in SSCs and minor changes in SSC architecture
- Draft document (with results to date) available for review at this meeting
- Anticipate completion of DOE review by 1-Nov

Bin 3

- Highest priority for design development
  - SSCs important to radiological safety, waste isolation , or other significant regulatory concern
  - little or no regulatory guidance exists
  - may also apply where no appreciable regulatory guidance exists in a given application
- Proposed changes result in 18 SDDs at Bin 3
- Examples:
  - Engineered Barrier & Disposal Containers
  - Waste Emplacement System
  - Subsurface Ventilation System

Bin 2

- Second highest priority for design development
  - SSCs important to radiological safety, waste isolation , or other significant regulatory concern
  - significant regulatory guidance and/or design precedent exists
- Proposed changes result in 22 SDDs at Bin 2
- Examples:
  - Site-Generated Radwaste Handling System
  - Waste Handling Facility Electrical Systems
  - Safeguards & Security Systems

Bin 1

- Lowest priority for design development
- SSCs not important to radiological safety or waste isolation
- Proposed changes result in 18 SDDs at Bin 1
- Examples:
  - General Site Transportation
  - Off-Site Utilities System

ENCLOSURE, ATTACHMENT E

YUCCA
MOUNTAIN
PROJECT

Studies

Engineering Compliance Program

Presented to:
DOE - NRC Quarterly Technical Meeting
Rockville, Maryland

Presented by:
Roberta Stambaugh
Engineering Standards & Compliance Manager
September 10, 1997

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

OBJECTIVES OF THIS PRESENTATION:

- Provide an overview of the Engineering Compliance Program (ECP)
- Describe how the ECP is integrated with and prioritized to support other programs
- Describe the ECP process
- Describe the value of the ECP for License Application

ECP OVERVIEW

- The ECP is a formal program to assess regulatory guidance documents, and industry codes and standards, to determine their applicability to the design for the MGDS.

- The ECP will assist in the development of criteria that when met, will comply with the requirements in 10 CFR Part 60.

- This applicability determination, along with supporting rationale, will be documented in ECP Guidance Packages.

ECP OVERVIEW (Cont.)

- ECP Guidance Packages will be used as an input to the System Description Documents (SDDs) upon which the MGDS design will be based.

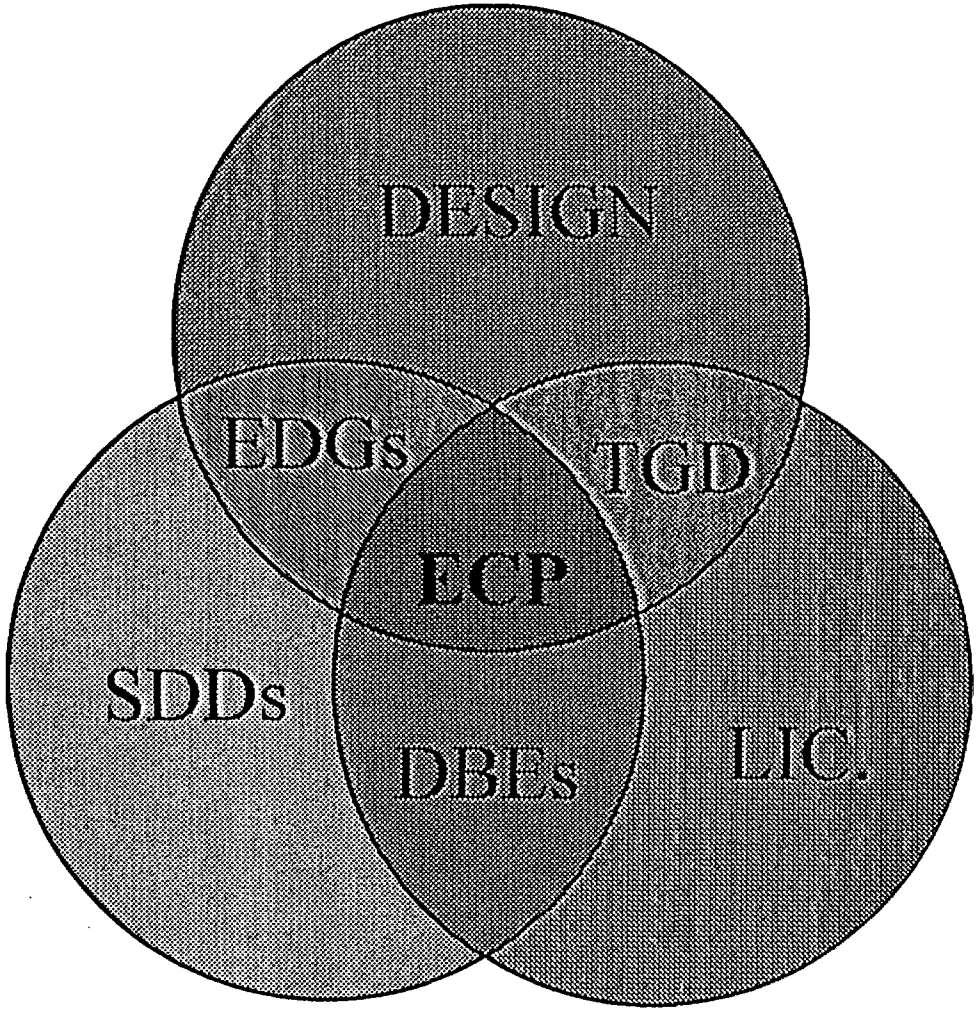
- Conformance of the design with the regulatory guidance provided in the ECP Guidance Packages will ensure that the design is consistent with established regulatory precedent, where applicable.

ECP OVERVIEW (Cont.)

- Consistency with established regulatory precedent will facilitate the licensing process for a geologic repository at Yucca Mountain (should the site be found to be suitable).

- ECP Guidance Packages will also be used as input to Engineering Design Guides (EDGs), Design Basis Event (DBE) analyses, and future revisions of the *Technical Guidance Document for License Application Preparation* (TGD).

ECP INTEGRATION/PRIORITIZATION



ECP INTEGRATION/PRIORITIZATION (Cont.)

- ECP is at the nexus of the design, licensing and SDD development activities

- ECP process requires day-to-day coordination and interface with all three organizations

ECP PRIORITIES ARE DRIVEN BY THE DESIGN:

- Prioritization supports "design phases"
- Structures, Systems, and Components (SSCs) are assigned to one of three "bins"
- "Bin 3" SSCs to receive highest priority for FY98

ECP PROCESS

- Assign development of ECP Guidance Packages based on priority.
- Review available SSC background information.
- Derive a list of potentially applicable regulatory guidance documents and industry codes and standards.
- Check against NUREG/CR-5973 for information regarding NRC review and acceptance.

ECP PROCESS (Cont.)

- Review the potential guidance for each of twelve criteria categories.

- Extract applicable guidance; document as design criterion statements suitable for direct transcription into SDDs.

ECP GUIDANCE PACKAGE CRITERIA CATEGORIES

Environmental	Site and Natural Systems
Physical Structures	Nuclear Safety
Systems Design	Operations
Maintenance	Surveillance & Testing
Quality Assurance	Repository Programs
Performance Confirmation	Performance and Safety Assessment

ECP PROCESS (Cont.)

- Document review on ECP Guidance Sheet.

- Check/review of ECP Guidance Package per process-specific procedure.

Note: The ECP is a Quality Process; this provides confidence that the process is adequately controlled and that the results are reliable.

ECP PROCESS (Cont.)

- Three "prototype" Guidance Packages have been prepared to test the procedure.

- Process will be improved based on lessons learned from prototype packages.

- Additional efficiency improvements are expected; procedure will be revised accordingly.

REQUESTS FOR SPECIFIC DESIGN GUIDANCE

- ECP procedure includes mechanism to request specific review for regulatory design guidance.

- Documented and tracked for later inclusion into appropriate ECP Guidance Package.

VALUE OF THE ECP FOR LICENSE APPLICATION

- Maximizes use of regulatory precedents.
- Ensures sufficient rationale and documentation supports design/licensing bases.
- Independently assures that regulatory requirements and guidance are incorporated into the licensing process.
- Provides early identification of potential deviations and exceptions to NRC and industry guidance.
- Supports completeness and thoroughness of the LA, minimizing review time and uncertainties.

CONCLUSIONS

- Provides a robust process to evaluate, document, and incorporate applicable regulatory and industry guidance into design.

- Performs an integral role in supporting design and licensing activities (MGDS Design, SDDs, TGDs, EDGs).

- Maintains a controlled process for identifying any changes to existing criteria, as well as evaluating future criteria or possible deviations.

- Assures a more thorough and technically comprehensive LA, thus facilitating NRC's review.

PRELIMINARY FY 1998 SDD LIST
(All Bin 3)

SDD Title and Primary SSCs	No. Of Subordinate SSCs
Subsurface Ventilation System (SS05)	
Development Ventilation System	7
Operations Ventilation System	6
Uncanistered SNF Disposal Canister (WP01)	
21 PWR Disposal Container, No Absorber Plates	3
21 PWR Disposal Container, with Absorber Plates	3
12 PWR Disposal Container, No Absorber Plates	3
12 PWR Disposal Container, with Absorber, STP Fuel	3
44 BWR Disposal Container, No Absorber Plates	3
44 BWR Disposal Container, with Absorber Plates	3
24 BWR Disposal Container, with Thick Absorber Plates	3
Canister Transfer System (SU11)	
Small Canister Hoist System	1
Large Canister Hoist System	1
Canister Lag Storage System	1
DC Canister Transfer Line Systems	2
Ground Control System (SS03)	
Perimeter Mains	1
Ventilation Openings	1
Performance Confirmation Openings	1
Support Openings and Cutouts	1
Accesses	1
Emplacement Area	1

PRELIMINARY FY 1998 SDD LIST (Cont'd)
(All Bin 3)

SDD Title and Primary SSCs	No. Of Subordinate SSCs
DHLW Disposal Container (WP03)	
5 DHLW Co-Disposal Disposal Container	4
5 DHLW Co-Disposal Hanford Disposal Container	4
Waste Emplacement System (SS17)	
Emplacement Rail System	3
Emplacement Drift Access	3
Emplacement Maintenance System	3
Assembly Transfer System (SU10)	
Pool Systems	3
Cask/Canister Handling System	4
SFA Pool Transfer Systems	3
SFA Dry Transfer Systems	2
DC Assembly Transfer Line Systems	5
Engineered Barrier System (SS02)	
Carrier/Cask Handling System (SU09)	
Carrier Bay Crane System	1
Canister Transfer Line Cask Systems	6
Assembly Transfer Line Cask Systems	5
Subsurface Closure & Seal System (SS19)	
Canistered SNF Disposal Container (WP02)	
Boiling Water Reactor Disposal Container	3

PRELIMINARY FY 1998 SDD LIST (Cont'd)
(All Bin 3)

SDD Title and Primary SSCs	No. Of Subordinate SSCs
Performance Confirmation System (SS14)	
Borehole Monitoring System	1
Emplacement Drift Monitoring System	1
General Subsurface Performance Confirmation System	6
General Surface Performance Confirmation System	1
Waste Package Remediation Container (SU12)	
DC Crane System	1
DC/Canister Opening System	1
DC Non-Destructive Examination System	1
Sampling System	1
DC Welding System	1
Decontamination System	1
Filler Material Addition System	1
DOE Waste Forms Disposal Container (WP04)	
Intact Oxide Disposal Container	1
Disrupted Fuel Disposal Container	1
Zirconium Hydride Disposal Container	1
Uranium Oxide Disposal Container	1
Uranium Metal and Alloy Disposal Container	1
Thorium Oxide Disposal Container	1
Aluminum Based Disposal Container	1
Uranium Carbide Disposal Container	1
Waste Retrieval System (SS21)	
Waste Retrieval Equipment System	3
Waste Retrieval Transport Equipment System	1

PRELIMINARY FY 1998 SDD LIST (Cont'd)
(All Bin 3)

SDD Title and Primary SSCs	No. Of Subordinate SSCs
Disposal Container Handling System (SU13)	
Empty DC Receiving System	1
DC Welding/Inspection Systems	4
DC Storage and Handling Systems	3
DC Emplacement Preparation Systems	4
Backfill Emplacement System (SS18)	
Seal System	3
Borehole Sealing System	2

ENGINEERING COMPLIANCE PROGRAM GUIDANCE SHEET

1. ECP Guidance Package Document Identifier (DI) Number (include revision number):

2. SSC Name:
3. Rev. No. or Date of SSC Source Listing:
4. SSC Description:

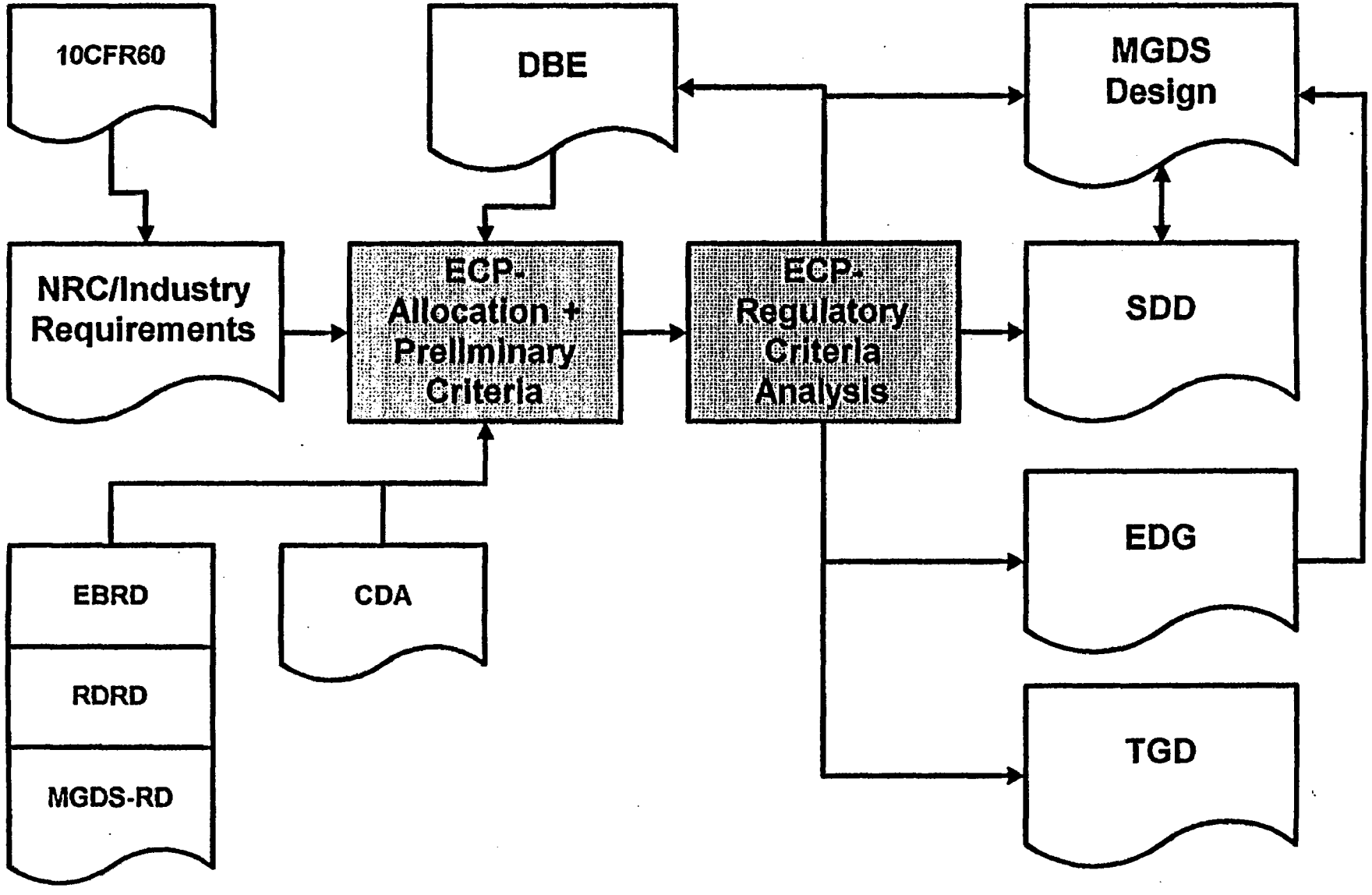
5. Associated SDD Title:	
6. Rev. No. or Date of SDD or SDD Source Listing:	
7. Bin Allocation:	8. QA Classification:

9. ECP Guidance for Criteria Category (obtain from Attachment V):
10. Specific Guidance:
10.1. Assumptions Used:
10.2. List of Applicable Regulatory Guidance including Licensing Precedent(s):
10.3. List of Applicable Industry Codes & Standards:
11. Guidance Applicable to the MGDS Design:
12. Rationale for Applicability of Guidance:

ECP GUIDANCE SHEET (CONT.)

13. Unresolved Issues (yes/no):	14. To Be Verified Activities (yes/no):
15. Provide Details and Method to Control/Disposition:	
16. Identify Appendices and Attachments:	

ECP Process


10CFR60
DBE
MGDS Design
NRC/Industry Requirements
ECP- Allocation + Preliminary Criteria
ECP- Regulatory Criteria Analysis
SDD
EDG
TGD
EBRD
RDRD
MGDS-RD
CDA

ENCLOSURE, ATTACHMENT F

YUCCA
MOUNTAIN
PROJECT

Studies

Use of Concrete Ground Support

Presented to:
DOE - NRC Quarterly Technical Meeting
Rockville, Maryland

Presented by:
Alden M. Segrest
MGDS Development Manager
CRWMS M&O

Septemeber 10, 1997

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

VA Reference Design
Ground Support

- Emplacement drift ground support
  - full-circle precast concrete segmental lining
  - installed in one pass.
- If needed for additional geologic mapping
  - emplacement drifts may be lined
    - with a two-pass lining
    - using cast-in-place concrete.
- Other repository openings
  - mainly final linings of cast-in-place concrete

Additional VA Ground Support Options

- Cast-in-place concrete linings
  - used in any emplacement drifts where geologic mapping is needed.
- Steel sets and steel lagging
  - can be used if concrete is found unacceptable for postclosure use

Why Fully-Lined Emplacement Drifts?

- Tuff rock mass
  - although moderately strong and largely self-supporting
    - has variable ground conditons
    - especially joint frequency and orientation
  - full-perimeter lining
    - completely confine and stabilize the jointed rock
      - regardless of joint orientations
      - for both ambient and thermal loading conditions

Why Fully-Lined Emplacement Drifts? (cont.)

- Emplacement drifts
  - must remain accessible
    - allow for monitoring and inspection during preclosure period
- Full-perimeter lining
  - provides ground stability throughout the period of retrievability
  - allows access and transport for waste packages

Why Fully-Lined Emplacement Drifts? (cont.)

- Maintenance is minimized with a robust, full-circle lining system.
- Regular maintenance will be precluded by
  - elevated temperatures up to 200 C
  - high radiation levels

Why Fully-Lined Emplacement Drifts? (cont.)

- Personnel safety
  - during construction and emplacement operations
- Backfill operations, if needed
  - facilitated by robust long-lasting linings
    - decrease the probability of disruptive events

Why Precast Concrete Linings?

- One-pass precast lining system
  - installs rapidly
  - minimum disruption to repository operations
  - construction and schedule economies.
- Precast concrete manufacture
  - high degree of quality
    - materials and construction tolerances
  - provides needed longevity and material characteristics
    - accommodates requirements

Why Precast Concrete Linings? (cont.)

- Maintenance minimized
  - durable, uniform, relatively clean concrete surface.
- Longitudinal joints between segments
  - structural flexibility
  - can reduce lining stress

What's Needed for Lining Design

- Design analysis
  - Properties
    - strength, elastic modulus, creep/relaxation
      - for anticipated ranges of temperature, loads, and concrete mixes
- Materials design
  - Concrete mix design
    - to meet performance requirements
      - durability, strength, stress-strain behavior, workability, and chemical reactivity.

What's Needed for Lining Design (cont.)

- Postclosure compatibility
  - concrete chemistry appropriate for longterm waste isolation.

Analytical Approach

- Pre-emplacement
  - ambient conditions
    - In situ and seismic loads imposed
    - Linear-elastic concrete material model
      - computes lining stresses
      - compared with ultimate concrete compressive strength
- Post-emplacement
  - elevated temperature conditions
    - Thermal and seismic loads imposed
    - Creep/relaxation model
      - computes lining strains
      - compared with ultimate concrete compressive strain

Concrete Properties Testing

- Objective
  - To provide engineering data for confimation of values used for VA and to provide a basis for LA design
- Test Plan
  - Determine compressive strength, elastic modulus and creep/stress-relaxation of concrete at temperatures at least to 200 C.
  - candidate mix designs represent concrete in current heated drift test and for potential repository.
- Three-year test duration

Status of Properties Testing

- A statement of work has been prepared
- The procurement process has begun
  - talks are being held with prospective testers
- Consultation with industry experts
  - has provided help in arranging a modeling and testing strategy to finalize the statement of work

Concrete Chemistry Testing

- Objective
  - To provide an estimation of organic contents in concrete as a function of time and thermal conditions
- Test Plan
  - Concrete specimens will be heated to 200 C to decompose and volatilize organic admixtures and release CO2 gas
    - The CO2 and the concrete pore solution pH will be monitored.
- Results provide input
  - for a PA study of postclosure conditions

Status of Chemistry Testing

- Penn State University
  - Materials Research Laboratory has initiated this work
  - Cement and admixture
    - materials have been obtained
    - test apparatus is being assembled
  - Preliminary supporting tests and calibrations have commenced
- Results
  - available December 1997 to January 1998

Waste Package Concrete Program at LLNL

- The major objective is to determine the changes in water chemistry contacting waste packages due to the presence of a concrete emplacement drift liner.
- A secondary objective is to understand the morphological changes to the concrete as a result of the thermal pulse.
- Experiments to study the hydrothermal alteration have been initiated with concrete samples obtained from cores of ESF invert material.

Performance Testing: Drift Scale Test

- Objective
  - examine performance of concrete lining similar to what is envisioned for the repository.
- Concrete lining
  - Installed
    - About 12 m of 200-mm thick
    - includes 4 m with steel fibers

Performance Testing: Drift Scale Test (cont.)

- Heater startup
  - scheduled December 8, 1997
  - test duration 4 years
    - 2-year heatup to about 200 C
    - 2-year cooldown,
      - instruments will be remotely monitored
      - camera observations will be made
- Concrete specimens
  - tested before and after
  - lab tests will be done on same mix

Performance Testing: Drift Scale Test (cont.)

- Measurements will be taken in surrounding rock mass
  - temperature, moisture, and displacement
- Lining strain and drift closure will be monitored.
- Data will provide:
  - information for current concrete lining analysis
  - inputs for developing criteria for license application design

ENCLOSURE, ATTACHMENT G

YUCCA
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Studies

Level of Design Detail, MGDS Design

Presented to:
DOE - NRC Quarterly Technical Meeting
Rockville, Maryland

Presented by:
Alden M. Segrest
MGDS Development Manager
CRWMS M&O

Septemeber 10, 1997

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Level Of Design Detail

- Repository Design Strategy Background - 2/6/97 Meeting
  - What We Said We Plan to Do
- Repository Design Strategy Status Update Since 2/6/97 Meeting
  - Where We are Today
- Specific Examples of Level of Design Detail

Repository Design Strategy Background

- Conceptual, Preliminary, and Detailed
- SSCs Classified into "Bins" for Design Development; Bins 1, 2, 3
  - Specific Examples of Bins 2 & 3
- Design detail sufficient for NRC to Act in 2 Stages
  - License Application (LA) for Construction Authorization
  - Amended LA for Waste Emplacement (WE)

Repository Design Strategy Background (Continued)

- LA Design
  - Varying levels of design detail
    - based on system binning.
- WE Design will have mostly detailed design

Repository Design Strategy

- Provide design detail necessary for NRC staff to have reasonable assurance that radioactive material can be disposed of in the proposed repository without unreasonable risk to public health & safety
- Strategy recognizes that a different level of design detail is needed for construction authorization than is required for waste emplacement

Repository Design Strategy (Continued)

- Design strategy is similar to that used for commercial nuclear reactors (PSAR/FSAR)
- LA Design level of detail will include conceptual, preliminary, and some detailed design information
  - sufficient to demonstrate adequate safety basis
- LA to be amended as design progresses to support construction authorization & license to emplace waste

Typical Level of Design Detail Considerations

- The level of design detail for SARs depends upon:
  - Safety classification of the SSC
  - Regulatory & licensing precedents
  - SSC complexity and interfaces with other SSCs
  - The type of license or authorization
    - e.g., Part 50, 60, or 72;
    - Construction Permit or Operating License
  - NRC review & acceptance criteria

Level of Design Detail for "Bin 2" SSCs

- Applicable to SSCs that are important to safety or interface with important to safety SSCs, and have regulatory and licensing precedent
- Design will be developed to preliminary design level, comparable to what was normally provided in a Part 50 PSAR
- Existing technology, NRC licensed designs, and NRC guidance documents will be used extensively

Level of Design Detail for "Bin 3" SSCs

- Applicable to SSCs that are important to safety or waste isolation and that have little or no NRC licensing precedent
- Design will be developed to a level of detail comparable to what was normally provided in a Part 50 FSAR
- SAR level of detail should be sufficient for NRC to conclude there is reasonable assurance that expected performance of SSCs will not constitute an unreasonable risk to public health & safety

Specific Examples

- Bin 2 SSC
  - Waste Handling Building
  - Air Filtration System for Potential Radioactive Releases
- Bin 3 SSC
  - Ground Control System
  - 21 PWR Uncanistered Disposal Container

Design Criteria

- Requirements are stated in the CFRs
  - 10 CFR 20 Standards for Protection Against Radiation.
  - 10 CFR 60 Disposal of High-Level Radioactive Waste in Geological Repository.
  - 10 CFR 960 General Guidelines for Recommendation of Sites for Nuclear Waste Repositories.
  - 40 CFR 191 (Remanded) Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste.

Bin 2
Waste Handling Building

SSC Description: Waste Handling Building

- Function
  - Provide a structure to house and support the waste handling operations
- Current Design Concept
  - Multi-level facility with about 500,000 ft^2 of floor space includes hot cells, fuel handling pools, and hot and cold support areas
- Current Design Status
  - Analyses and drawings are in preparation to document a conceptual design for VA

Design Criteria

- RDRD
  - provides the current requirements
  - mostly derived from:
    CDR, MGDSRD, 10 CFR 60, 10 CFR 960, 10 CFR 20
- Section 1 of the SDDs
  - will replace the RDRD in FY98 to provide requirements for LA
  - SDDs are expected to incorporate criteria derived from NUREGs and NRC Reg. Guides
- CDA
  - provides controlled assumptions

Design Criteria Example

- RDRD 3.5.1.3
  - derived from 10 CFR 961.11,IV,B,(2)(c)
- Indicates:
  - The surface facilities shall be capable of inspecting casks for contamination, and radiation, decontaminating casks surfaces, cleaning casks following unloading, and providing special tooling to perform incidental cask maintenance.

Design Addressing RDRD 3.5.1.3

- *Surface Nuclear Facilities Space Program Analysis* (draft)
  - provides minimum space requirements and general arrangement drawings
  - includes space for decontamination, cask preparation, and tooling storage
- Mechanical Flow Diagrams
  - for waste handling operations
  - show the sequence of operations to inspect, prepare, decontaminate and clean casks
  - show the major equipment and tooling

Design Addressing RDRD 3.5.1.3 (Cont.)

- Assembly and Canister Transfer System Analyses (draft)
  - provide greater detail than shown on the Mechanical Flow Diagrams
  - develop conceptual designs for equipment, facilities and tooling
- *Secondary Waste Treatment Analysis*
  - provides an estimate of the LLW generated from cask decontamination operations

Summary

- Conceptual design of Bin 2 Waste Handling Building and waste handling systems are in development to support VA.
- Design is based on requirements from RDRD, which were partially developed from DOE orders. LA design will be based on more detailed SDD criteria.
- Examples of developing designs for VA that incorporate criteria derived from DOE orders were provided. Further design iterations will be based on criteria from Reg. Guides, NUREGs and licensing precedent.

Bin 2
Air Filtration System for Potential Radioactive Releases

SCC Description
Air Filtration System

- To limit release of radioactive particulates and gases to the surface environment from a breached waste package
- High Efficiency Particulate Air (HEPA) Filters are Bin 2
  - NRC precedence exists for HEPA filter usage in nuclear facilities
  - Specific Regulatory Guidance available for design of filters

Analyses supporting design of subsurface HEPA filter system

- *Accident Analysis for a Nonmechanistic Waste Package Failure (Subsurface)*
  - BCA000000-01717-0200-00001
- *Air Filtration System For Potential Radioactive Releases*
  - BCAD00000-01717-0200-0004
- *Overall Development and Emplacement Ventilation System*
  - BCAD00000-01717-0200-00005
- *Emplacement Drift Air Control System*
  - BCAD00000-01717-0200-00005

Criteria

- 10CFR60.111(a) - Protection against radioactive exposure and releases of radioactive material
  - The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and release of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in part 20 of this chapter and such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency.

Design criteria

- Dose limits used in *Accident Analysis for a Nonmechanistic Waste Package Failure (Subsurface)*, which in turn provided input to the *Air Filtration System For Potential Radioactive Releases* analysis:
- Category 1 Dose Limits - Public
  - 10CFR20.1301 "Dose Limits for Individual Members of the Public"
    - *...(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 Rem (1 mSv) in a year,...*
    - *...(2) the dose in an unrestricted area from external sources does not exceed 0.002 Rem (0.02mSv) in any one hour.*

Design criteria (cont.)

- Category 1 Dose Limits - Personnel
  - 10CFR20.1201 "Occupational Dose Limits"
    - *...The total effective dose equivalent being equal to 5 Rem (0.5 Sv); or*
    - *...The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 Rem (0.5 Sv).*
    - *...An eye dose equivalent of 15 Rem (0.15 Sv)*
    - *...A shallow-dose equivalent of 0.5 Rem (0.5 Sv) to the skin or to any extremity.*

Design criteria (cont.)

- Category 2 Dose Limits
  - 10CFR60.136 "Preclosure controlled area"
    - *(b): "The geologic repository operations area shall be designed so that, for Category 2 design basis events, no individual located on or beyond the nearest boundary of the preclosure controlled area will receive the more limiting of a total effective dose equivalent of 0.05 Sv (5 Rem), or the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) of 0.5 Sv (50 Rem). The eye dose equivalent may not exceed 0.15 Sv (15 Rem), and the shallow dose equivalent to skin may not exceed 0.5 Sv (50 Rem)."*

Design criteria (cont.)

- Category 2 Dose Limits (cont.)
  - Standard Review Plan for Dry Cask storage Systems, USNRC, NUREG 1536, Draft Report for Comment, February 1996
  - Provided release fractions for *Accident Analysis for a Nonmechanistic Waste Package Failure (Subsurface)* and the *Air Filtration System For Potential Radioactive Releases* analysis.

Results of analyses

- *Accident Analysis for a Nonmechanistic Waste Package Failure (Subsurface)*
  - concluded that Category 2 regulatory limits not exceeded for non-mechanistic release event at 100 m from the release point without taking credit for mitigating effect of HEPA filters
- *Air Filtration System For Potential Radioactive Releases*
  - analysis recommends use of HEPA as a safeguard against release to the public and for protection of site personnel

Results of analyses (cont.)

- HEPA filter and adsorption units remove particulates and radioiodine
- Overall ventilation system designed to limit potential exposure to personnel and releases to the public

Current design concept

- Air filtration system consists of pre-filters, HEPA filters, and gas adsorption units
- Exhaust air from emplacement drifts carried in steel ducts from emplacement drift to subsurface HEPA filter banks
- Under normal operating conditions emplacement drift exhaust air by-passes filters
- Air diverted through filters only in event radioactive release indicated

Current design concept (cont.)

- Airflow through HEPA grade filter unit limited to 1,500 cfm
- Airflow through each filter bank limited to 30,000 cfm
- HEPA filter systems located underground - provides protection against potential missile damage and minimizes spread of contamination into exhaust air shaft.

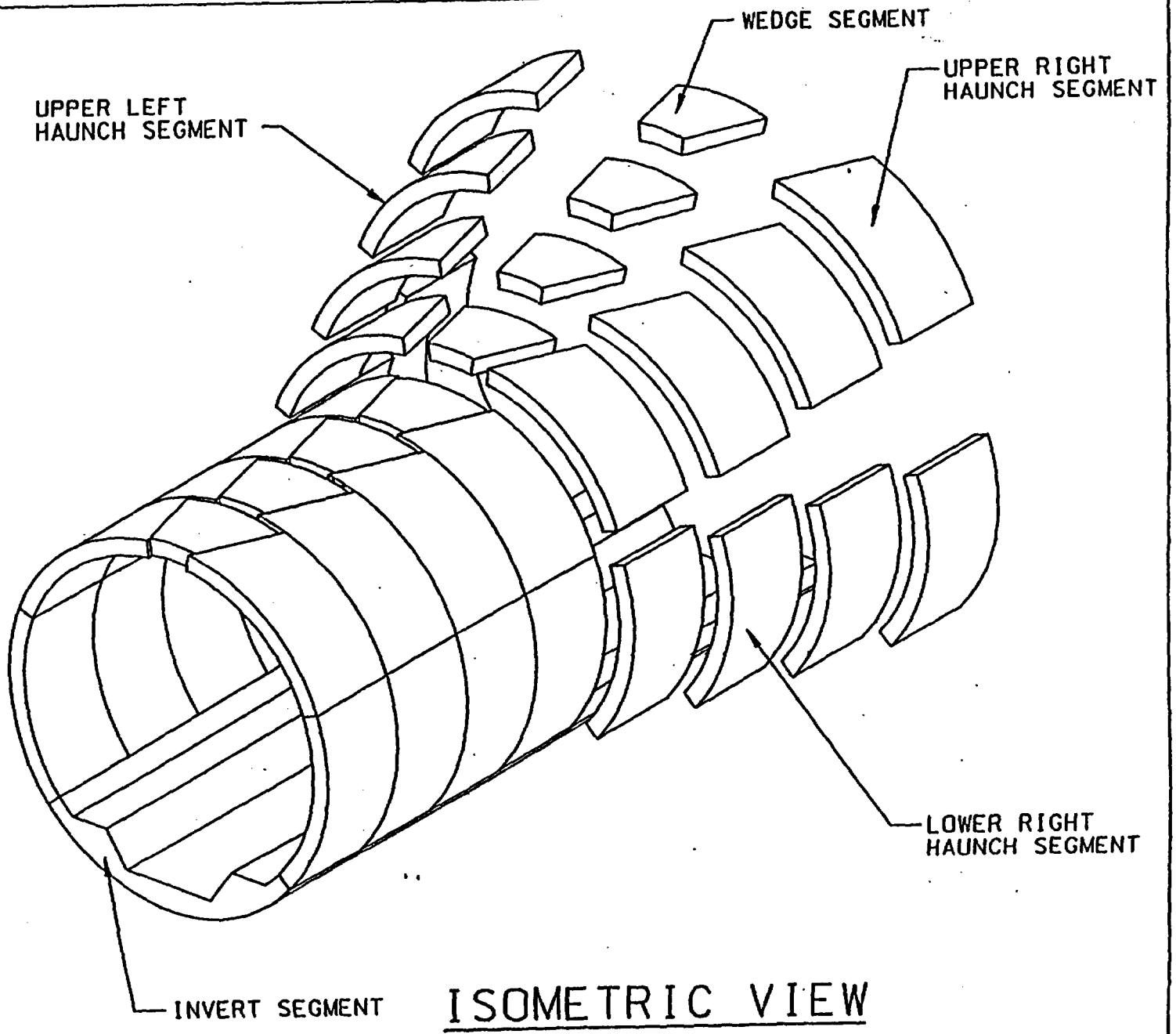
Bin 3
Ground Control System

Ground Support Emplacement Drifts

- Three options
  - precast concrete segmental lining
    - reference design for VA design
  - cast-in-place concrete lining
    - provides geologic mapping of drift walls
  - steel set/steel lagging lining
    - alternative material
    - if concrete is unacceptable for postclosure

Precast Concrete Segmental Lining

- Full ring of five segments plus a wedge
  - 200 mm thick and 1.5 meters wide
- Installation in one operation
  - segments erected beneath tail shield of TBM
    - invert segment placed first
  - ring expanded against excavated rock
    - uses the wedge as TBM moves forward.
- Contact grouting
  - relatively weak sand-cement grout
    - fill any voids between exanding ring and rock
    - provide for more uniform lining



ISOMETRIC VIEW

LINING SEGMENT ASSEMBLY

Requirements

- Underground Openings [10 CFR 60.133(i)]
  - The underground facility shall be designed so that the performance objectives will be met taking into account the predicted thermal and thermomechanical response of the host rock, and surrounding strata, and groundwater system.
    - [MGDS-RD 3.7.3.4.C][RDRD 3.7.5.E.7]
- Thermal Analysis [RDRD 3.2.6.1.I]
  - The design of structures shall include the effects of stresses and movements resulting from variations in temperature, including the effect of emplaced waste packages.

•[MGDS-RD3.2.6.1.J][DOE Order 6430.1A, 0111-2.8.4]

Requirements (cont.)

- Natural Conditions [RDRD 3.2.6.1.A]
  - Natural phenomena and environmental conditions at the GROA considered in the design shall include events and conditions such as earthquakes, tornados, wind, lightning, floods, precipitation, humidity, temperature, sand and dust, and fungus, bacteria, and algae.
    - [MGDS-RD 3.2.6.1.A][CRD]

Requirements (cont.)

- Combinations [RDRD 3.2.6.1.B]
  - The design bases shall reflect appropriate considerations of the most severe conditions reported for the site and surrounding area and appropriate combinations of the normal and accidental conditions and the effects of natural phenomena, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated.
    - [MGDS-RD 3.2.6.1.B][CRD 3.2.6.1.B]

Analytical Approach for Lining Design

- As stated in the requirements, for the analysis of ambient and elevated temperature conditions for repository emplacement drifts, appropriate combinations of in situ, seismic, and thermal loads are used with elastic and elastic-plastic rock models and with elastic and inelastic concrete property models to calculate stresses and strains in drift linings.
- These results are compared with concrete limit state values (e.g., compressive strength, peak compressive strain) to determine the adequacy of performance.

Data Used To Compute Design Loads

- In situ rock loads [CDA TDSS 001]
  - Vertical stress = 10 Mpa
  - Horizontal stress = 0.3 to 1.0 times the vertical
- Thermal loads [CDA Key 019]
  - Areal mass loading = 80 to 100 MTU per acre
  - upper bound of 100 MTU/acre used for analysis.

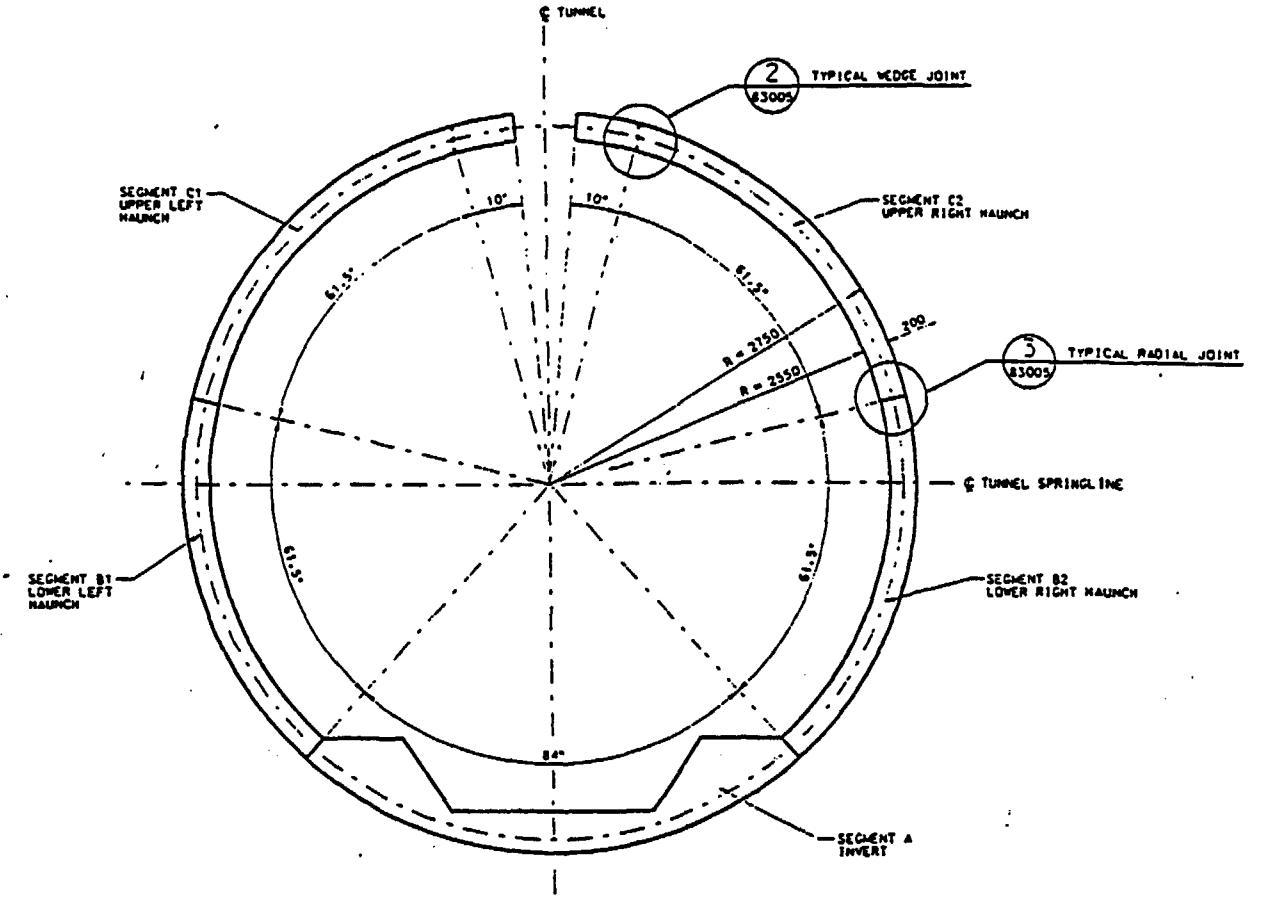
•MTU = metric tons of uranium

Data Used To Compute Design Loads (cont.)

- Thermal loads (cont.)
  - Drift and Waste Package Spacings analysis uses
    - drift spacing of 22.5 m
    - package spacing of 16.08 m are used in the analysis.
    - drift spacing of 28 m has also been considered.
  - Initial rock temperature of 26° C based on surface temperature and thermal gradient information.
  - Waste stream and heat decay values found in CDA Key Assumptions 003 and 004

Data Used To Compute Design Loads (cont.)

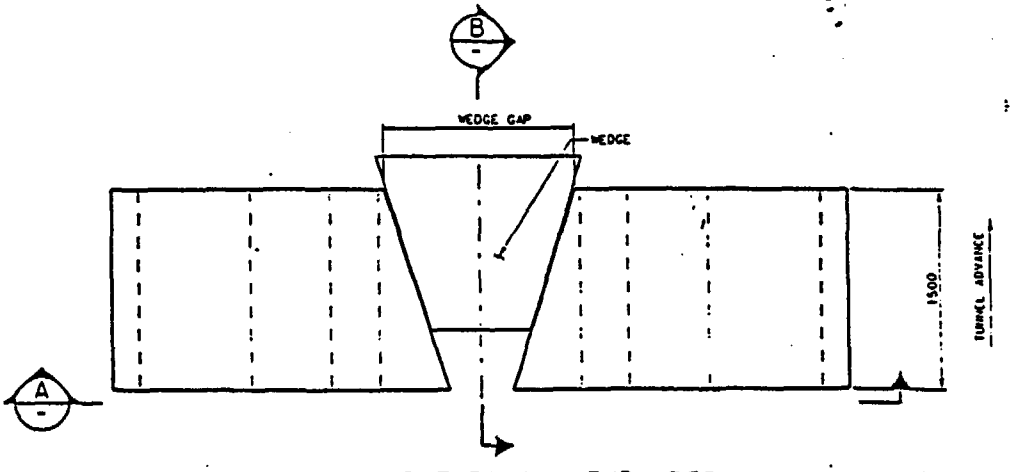
- Seismic loads [CDA Key 064]
  - Seismic design shall include design for vibratory ground motion and fault displacement, based on "*Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain*" (YMP/TR-003-NP).
  - Based on NRC Frequency-Category-1
    - mean annual exceedence probability of 1 x 10-3
    - mean peak horizontal acceleration of 0.27g
    - mean peak horizontal velocity of 16 cm/sec.



TYPICAL SEGMENT RING-UNEXPANDED

SECTION A

SCALE: 1:25



TYPICAL SEGMENT RING-UNEXPANDED

PLAN VIEW

SCALE: 1:25

ALL DIMENSIONS ARE SHOWN IN MILLIMETERS UNLESS OTHERWISE NOTED

GRAPHIC SCALE

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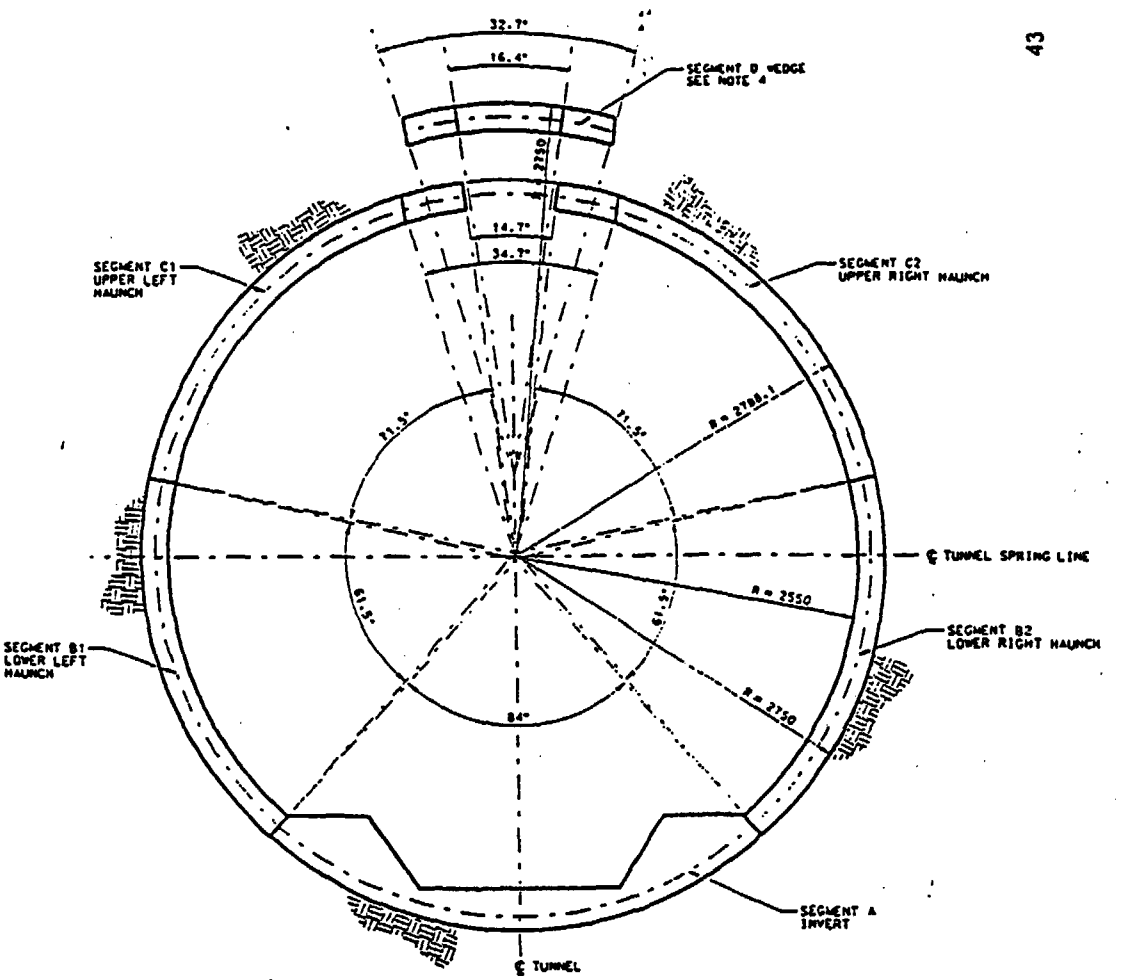
1 : 25



TYPICAL SEGMENT RING-EXPANDED AGAINST ROCK

SECTION (A)

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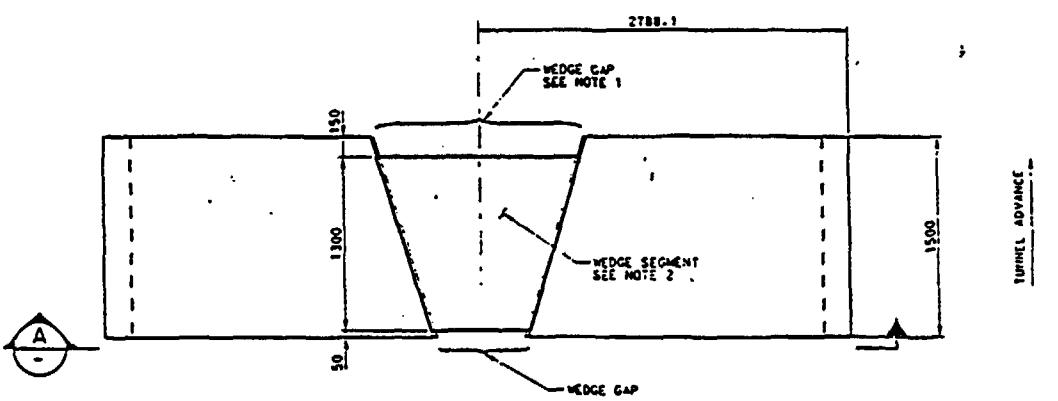

TYPICAL SEGMENT RING-EXPANDED

PLAN VIEW

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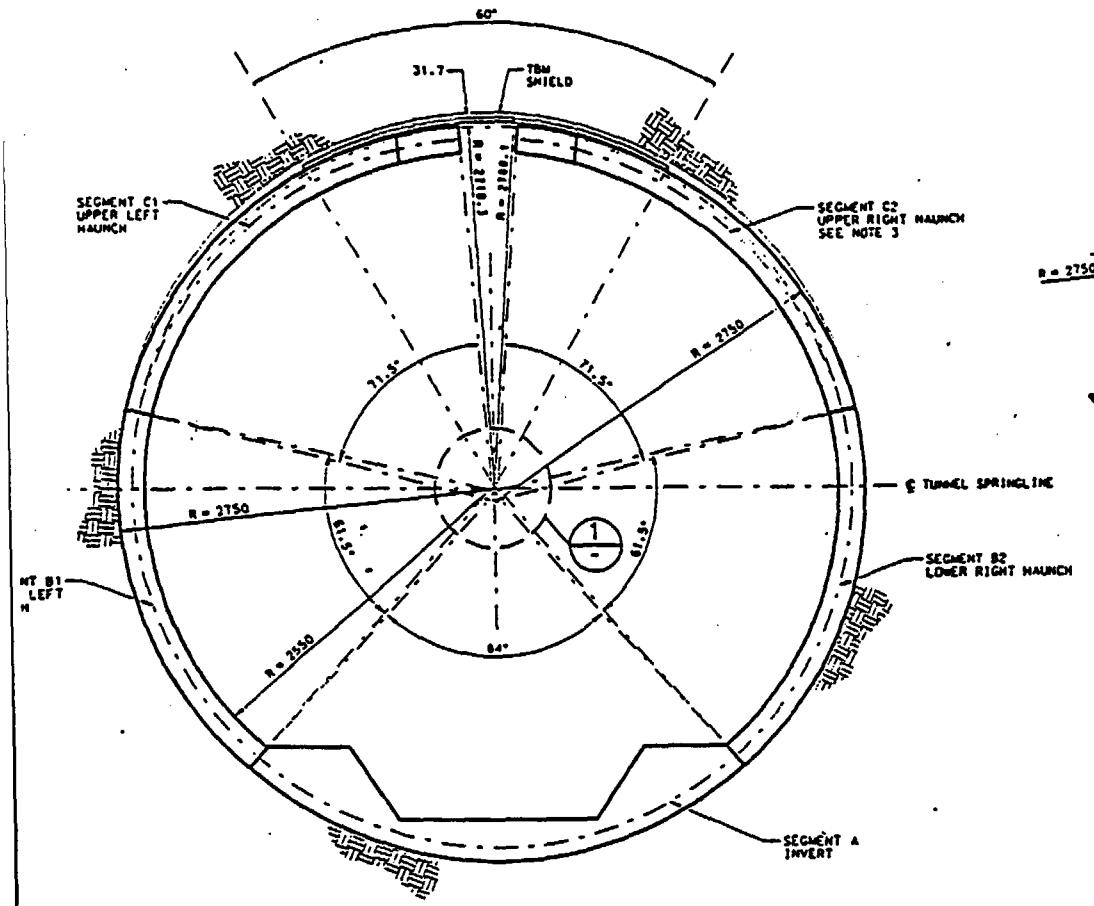
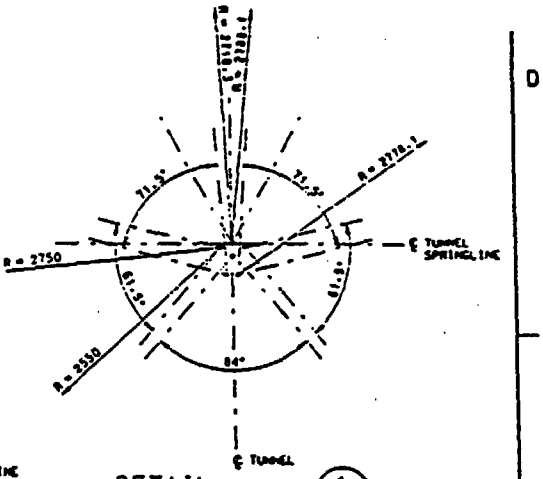


TYPICAL SEGMENT RING-ASSEMBLED BENEATH 60° SHIELD

SECTION A
SCALE: 1:25



DETAIL 1
NO SCALE

EXPANDED DETAIL OF TUNNEL GEOMETRY AS SHOWN ON SECTION A

NOT TO SCALE

NOTES:

1. WEDGE IS SHOWN IN WEDGE GAP WHEN TBM GAGE CUTTERS ARE NEWLY INSTALLED SO THAT THE CUT RADIUS OF THE TUNNEL IS 2.7881 m. AS THE GAGE CUTTERS WEAR DOWN, THE CUT RADIUS DECREASES TO 2.7754 m. THIS CLOSES THE WEDGE GAP SLIGHTLY.
2. AS THE WEDGE GAP CLOSES WITH BIT WEAR, THE WEDGE POSITION MUST CHANGE. THE WEDGE MOVES UPWARD IN THE TYPICAL PLAN VIEW SUCH THAT THE WIDE END OF THE WEDGE APPROACHES THE END OF THE SEGMENT RING WITH THE WIDE WEDGE GAP.
3. THE SEGMENT RING ASSEMBLED BENEATH THE SHIELD REPRESENTS THE MAXIMUM EXPANSION OF THE RING POSSIBLE. DURING TUNNEL ADVANCE, THE UPPER HAUNCH SEGMENTS MUST LIE SLIGHTLY BELOW THE SHIELD WHEN THE SHIELD IS PULLED FORWARD.

THIS DRAWING IS PRELIMINARY AND NOT INTENDED FOR CONSTRUCTION, PROCUREMENT OR FABRICATION.

DESIGN INPUTS
SEE DRAWING INPUTS LIST

CHECK

CAD	
J COGAN	
D TANG	
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R HOLTING	
K BHATTACHARYYA	

U.S. DEPARTMENT OF ENERGY
Yucca Mountain Site Characterization Project
M&O Civilian Radioactive Waste Management System MANAGEMENT & OPERATING CONTRACTOR

REPOSITORY DESIGN
PRECAST CONCRETE LINING ASSEMBLED AND EXPANDED SECTIONS

D DOCUMENT IDENTIFIER: BCAA00000-01717-2700-83002-004
SCALE 1:25 | 1.2.4 | RIGED:83002

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00A	ISSUE FOR DISCIPLINE CHECK					N/A			

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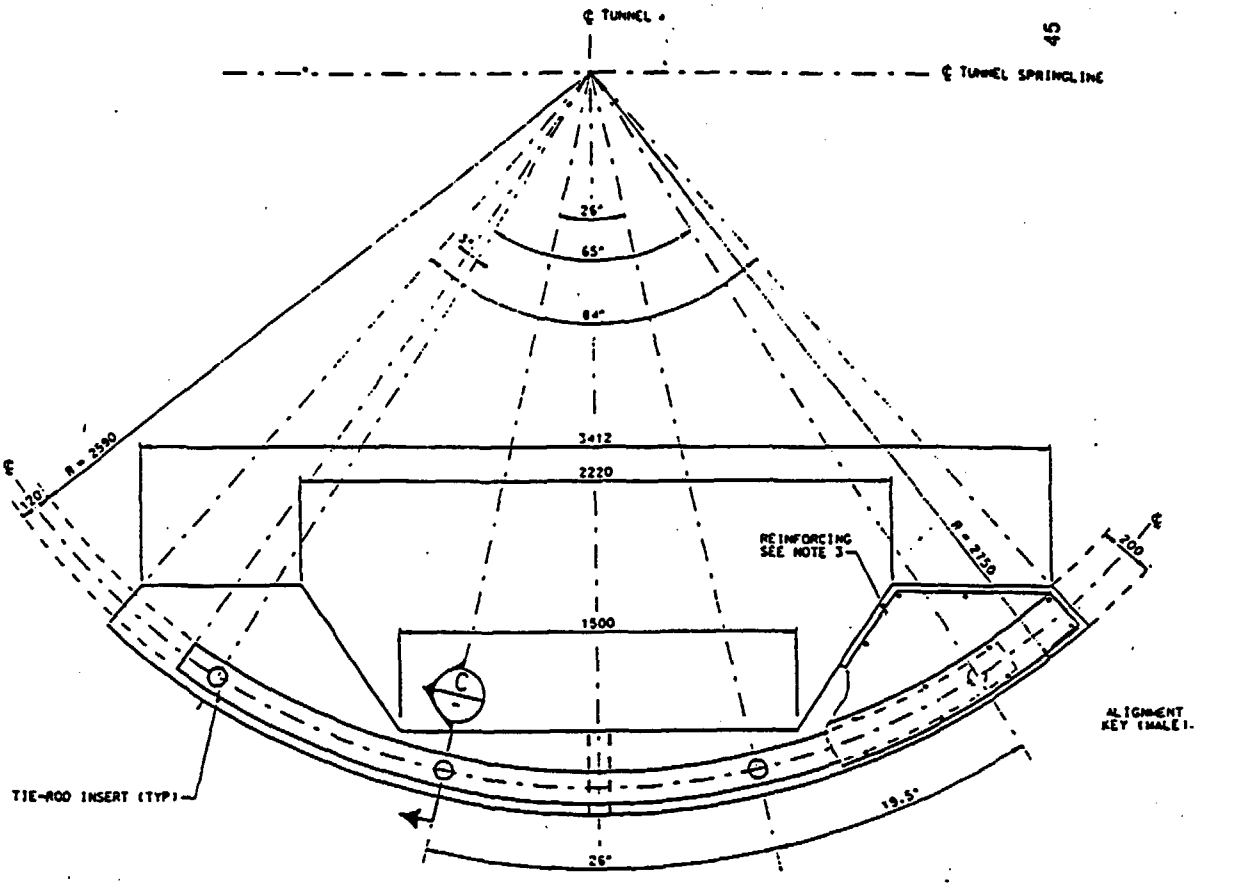
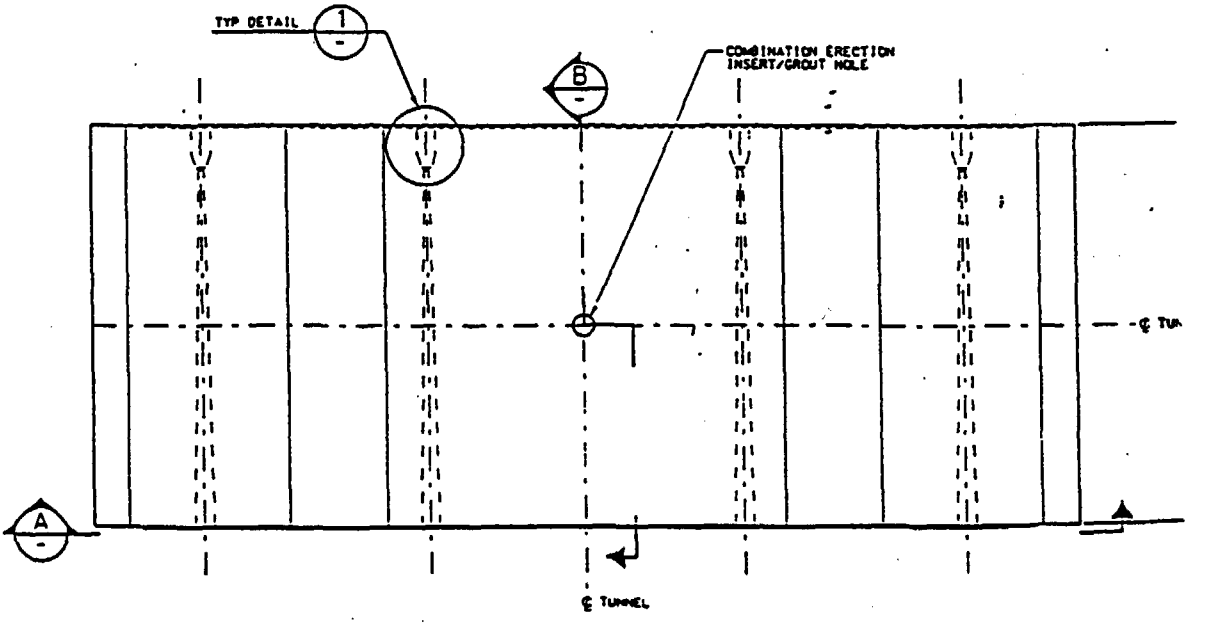


SEGMENT A-INVERT

SECTION A

SCALE: 1:12.5



SEGMENT A-INVERT

PLAN VIEW

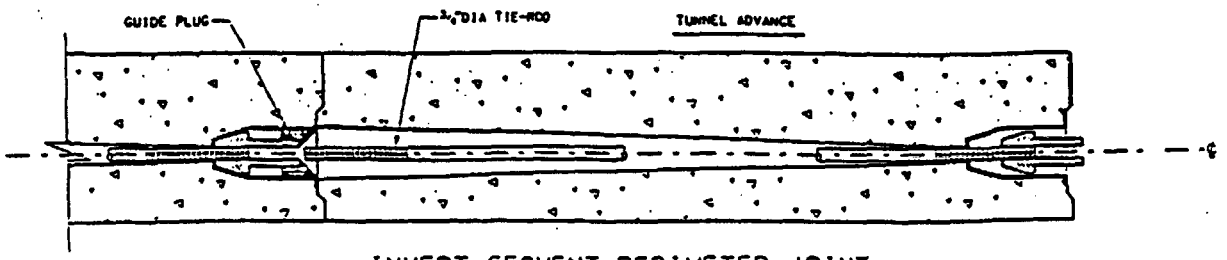
SCALE: 1:12.5 mm

GRAPHIC SCALE

0 50 100 200 300 400 mm

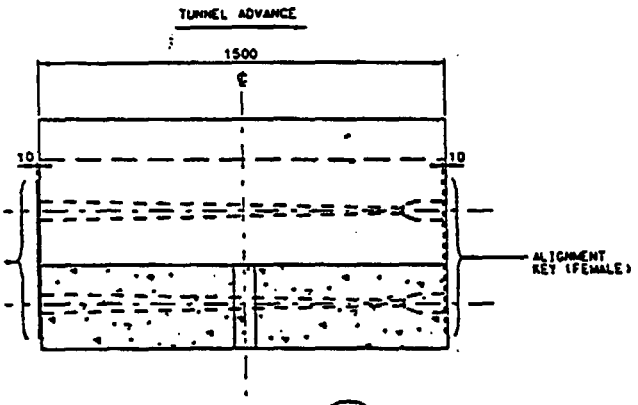
1 : 5

ALL DIMENSIONS ARE SHOWN IN MILLIMETERS UNLESS OTHERWISE NOTED

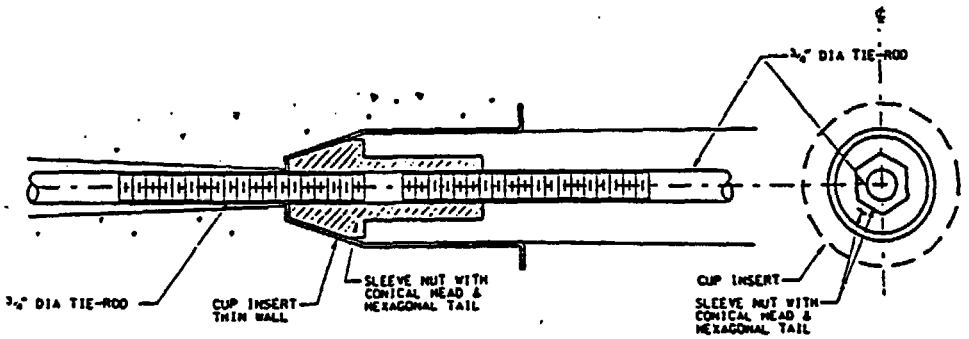


INVERT SEGMENT PERIMETER JOINT

SECTION C
SCALE: 1:5



SECTION B
SCALE: 1:12.5



SIDE VIEW PLAN VIEW

TYPICAL TIE-ROD ASSEMBLY

DETAIL 1
NO SCALE

1500 TUNNEL ADVANCE

NOTES:

1. ALIGNMENT KEYS ARE CAST INTO THE CIRCUMFERENTIAL JOINT OF EACH INVERT SEGMENT. A FEMALE KEY ON THE SIDE FACING THE TBM AND A MALE KEY ON THE SIDE FACING AWAY FROM THE TBM. THE MALE KEY ON ONE SEGMENT FITS INTO THE FEMALE KEY ON THE ADJACENT SEGMENT.
2. EACH INVERT SEGMENT IS TIGHTLY BOLTED TO THE ADJACENT SEGMENT USING THE BARS. THE REMAINING SEGMENTS OF THE RING ARE NOT BOLTED ACROSS THE CIRCUMFERENTIAL JOINT WITH THE ADJACENT RING.
3. REINFORCING IS SHOWN FOR INFORMATION ONLY. IT WILL BE DESIGNED TO PREVENT CRACKING AND FAILURE OF SEGMENTS DURING HANDLING.

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CHECK

GRAPHIC SCALE
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CAD	
J COGAN	
D TANG	
N/A	
R HOLTING	
K BHATTACHARYYA	

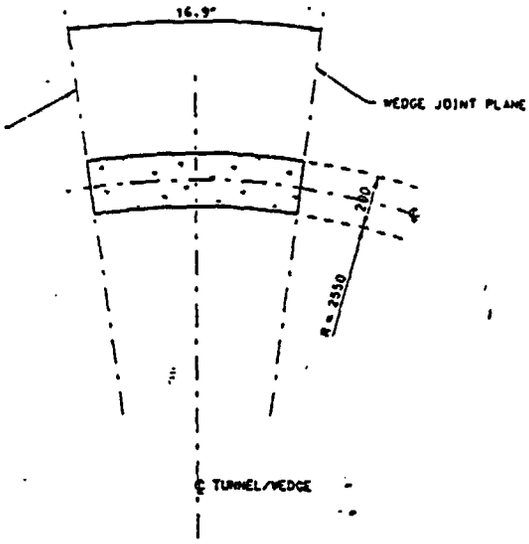
U.S. DEPARTMENT OF ENERGY
Yucca Mountain Site Characterization Project
M&O Civilian Radioactive Waste Management System MANAGEMENT & OPERATING CONTRACTOR

REPOSITORY DESIGN
PRECAST CONCRETE LINING
CONCRETE INVERT SEGMENT

D DOCUMENT IDENTIFIER: BCAA00000-01717-2700-83003-00A

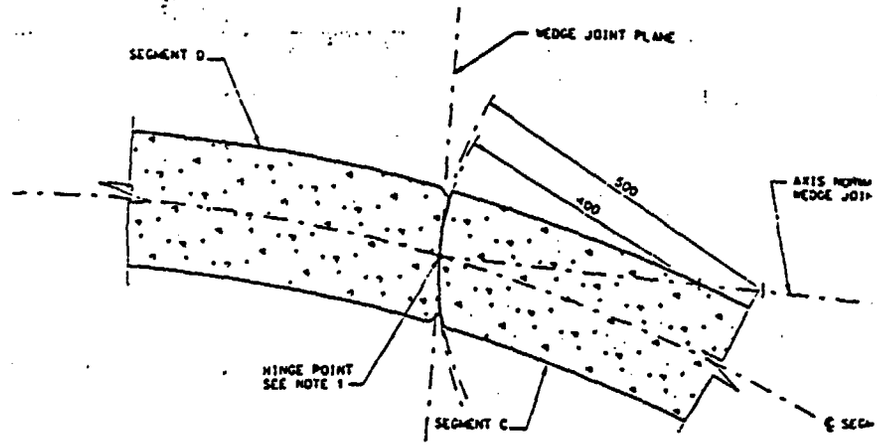
SCALE AS NOTED | 1.2.4 | RIGEO:83003

RECORD DESIGNATOR DAI



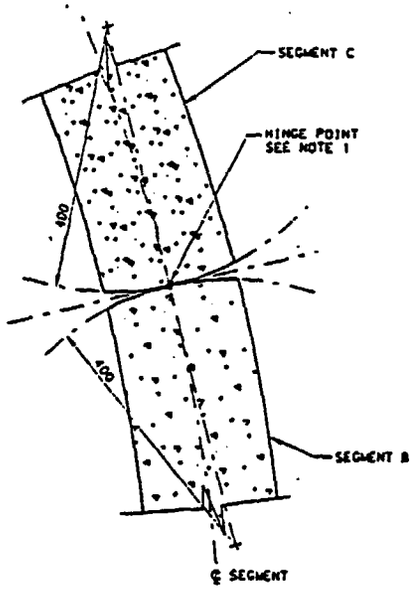
SEGMENT D-WEDGE

SECTION B
SCALE: 1:12.5



CONCAVE/CONVEX JOINT

DETAIL 2
SCALE: 1:5 mm
83001



CONVEX/CONVEX JOINT

DETAIL 3
SCALE: 1:5 mm
83001

NOTES:

1. THE POINT OF CONTACT BETWEEN SEGMENTS AT EACH JOINT IS CALLED THE "HINGE POINT". WITH PERFECT ALIGNMENT OF THE J THE HINGE POINT IS LOCATED AT THE CENTER OF EACH SEGMENT.
2. THE WEDGE IS DESIGNED WITH FLAT JOINT PLANES. THESE PLANE PASS THROUGH THE CENTER LINE DEFINING THE ARC OF THE WEDG SEGMENT. EACH PLANE PASSES THROUGH THE JOINT HINGE POINTS AT THE NOSE OF THE WEDGE. ONE PLANE TO THE LEFT AND THE O TO THE RIGHT.
3. REINFORCING IS SHOWN FOR INFORMATION ONLY. IT WILL BE DES TO PREVENT CRACKING AND FAILURE OF SEGMENTS DURING HANDLI
4. ALL CONCRETE IS FIBER REINFORCED CONCRETE.

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DESIGN IN SEE DRAWING

CHECK

GRAPHIC SCALE
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1 : 12.5

00A	ISSUE FOR DISCIPLINE CHECK							N/A					
REV	DESCRIPTION	DATE											

CAD
J COGAN
D TANG
N/A
R NOLTING
K BHATTACHARYYA

U.S. DEPARTMENT OF
Yucca Mountain Site Characterizat
M&O Civilian Radioactive Waste Mana MANAGEMENT & OPERATING
REPOSITORY DESIGN
PRECAST CONCRETE L
WEDGE AND JOINT DE

REV D | DOCUMENT IDENTIFIER: BCAA00000-01717-27
SCALE AS NOTED | 1.2.4 | SHEET PIECE

Bin 3
21 PWR Disposal Container

Disposal Container Function

- 21 PWR Disposal Container to meet requirements for:
  - Preclosure Criticality
  - Postclosure Criticality
  - Thermal Limits (Drift Wall, Cladding, etc.)
  - Waste Containment/Isolation
  - Handling, Emplacement, Retrieval Loads

Current Design Concept

- Commercial Spent Nuclear Fuel
  - Uncanistered Spent Nuclear Fuel Waste Container and Waste Package (21 PWR)
    - Corrosion allowance and corrosion resistant barriers
    - Carbon steel tube basket structure
      - Load bearing, heat removal, long term performance as it degrades (displaces moderator, retards radionuclides)
    - Performance based neutron absorbing material
      - Corrosion resistant stainless steel-boron
      - Non-structural, in compliance with NRC guidance
    - Thermal shunt, ensures cladding temperature limit is kept

Current Design Status

- Preliminary design completed
- Materials identified
- Welding process demonstrated
- Supporting evaluations completed
- Toleraning in process

Criteria

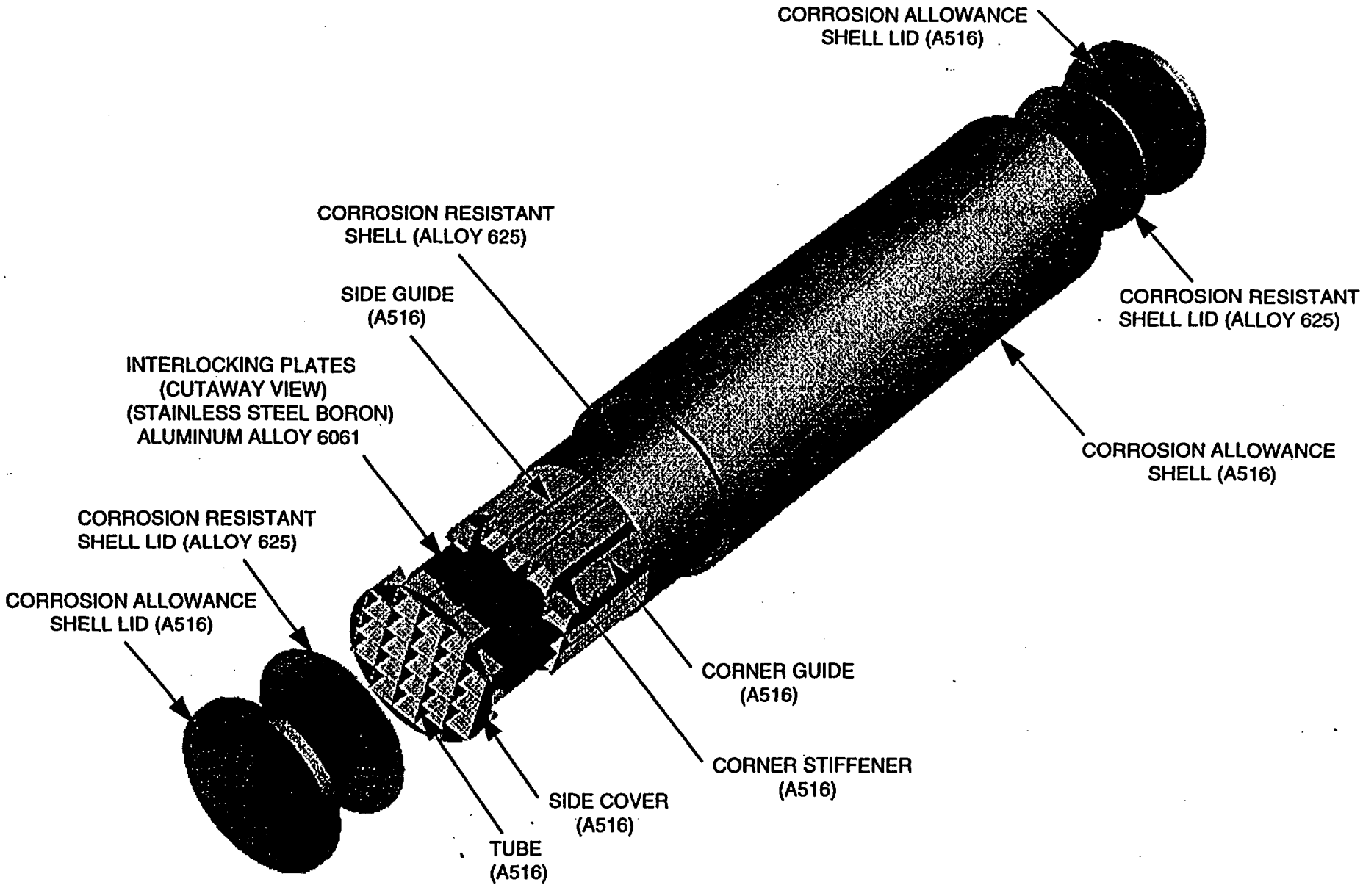
- 10 CFR 60.135(a)(1) - High-level-waste package design in general.
  - Captured by MGDS-RD 3.7.3.2.D, MGDS-RD 3.7.3.3.A, EBDRD 3.7.1.A, EBDRD 3.7.1.2.C, and EBDRD 3.7.1.2.G
  - Post containment release <1 part in 105 per year of inventory of each radionuclide at 1000 years
- 10 CFR 60.135(b)(3) - Specific criteria for HLW package design. Handling.
  - Captured by MGDS-RD 3.7.3.3.E and EBDRD 3.7.1.E
  - Maintain waste containment during transportation, emplacement, and retrieval

Criteria

- 10 CFR 60.113(a)(1)(ii)(A) - Containment of HLW
  - Captured by MGDS-RD 3.7.3.2.C, EBDRD 3.7.1.I, and EBDRD 3.7.1.2.B, CDA EBDRD 3.7.1.I / CDA EBDRD 3.7.1.2.B / CDA KEY 074
  - Containment of the waste for at least 3,000 years (program requirement, NRC 300 to 1,000 years)
- 10 CFR 60.131(h) - (Formerly 60.131(b)(7) Criticality Control.
  - Captured by MGDS-RD 3.2.2.6.A and EBDRD 3.7.1.3.A, CDA KEY 039
  - Preclosure, prevent criticalities during operations
  - Postclosure, prevent criticality with very low likelihood and insignificant consequences during isolation period

Criteria

- Additional Criteria
  - EBDRD 3.7.1.2.D / CDA KEY 075
    - Protect waste from contact with seeping or dripping water for at least 10,000 years (program requirement)
  - CDA DCWP 001
    - Protect fuel rod cladding (temperature <350o C)
  - CDA KEY 031
    - Waste package containment barrier shielding to protect against radiation induced corrosion



21-PWR UCF
WASTE PACKAGE ASSEMBLY

Loads and Load Combinations - Materials

- Dual barrier design provides two independent failure mechanisms
  - –Corrosion-Allowance Barrier - 100 mm A516 carbon steel
    - General corrosion - permits performance prediction; thickness governs time to failure
    - Galvanic protection of corrosion-resistant material
    - Relatively low cost
  - –Corrosion-Resistant Barrier - 20 mm alloy 625 high-nickel alloy
    - Subject to localized corrosion
    - Random corrosion and failure - not thickness dependent

Design and Analysis Procedures - Engineering Development

- Multi-layer fabrication methods
  - Weld deposit
  - Shrink Fit
- Closure methods
  - Hot wire narrow gap welding
- NDE methods development of closure seams
  - Eddy current
  - Ultrasonic
- Waste package filler material
  - Tests indicate that iron SAE S230, 0.7mm and SAE S330, 1.0mm in diameter filled the SNF cell to about 95 % of available void space

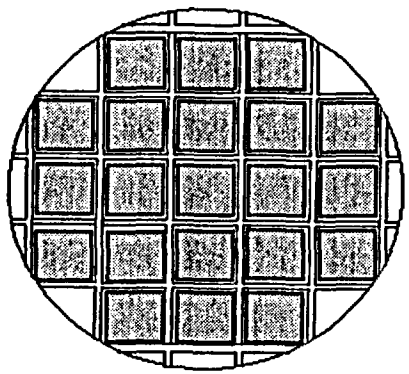
Design and Analysis Procedures-Criticality

- Analysis of criticality potential
  - Assumes moderator (water) present
  - Assumes principal isotope burnup credit
  - Determine credible configurations - degraded waste packages, in drift, in far-field
- Supplemental Neutron Absorber Material
  - Boron, gadolinium, hafnium, silver-indium-cadmium
  - Account for degradation over time

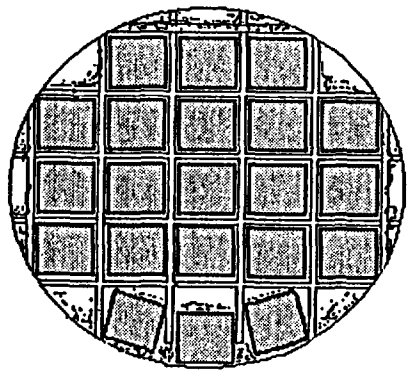
Design and Analysis Procedures-Risk Based

- Risk-based disposal criticality analysis methodology accounts for:
  - Probability of a criticality event occurring
  - Consequence of a potential criticality event
  - Risk = probability x consequence
- Probability of criticality event determined by Probabilistic Configuration Model
  - Estimates degradation of waste packages and neutron absorbing material
- Consequences determined by Total System Performance model with input from Neutronics Consequence Model
  - Determines power level and duration of criticality event
  - Estimates radionuclides produced and used

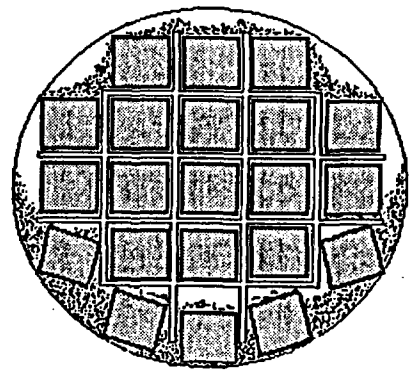
Waste Package Degraded Internal Configurations (Schematic)



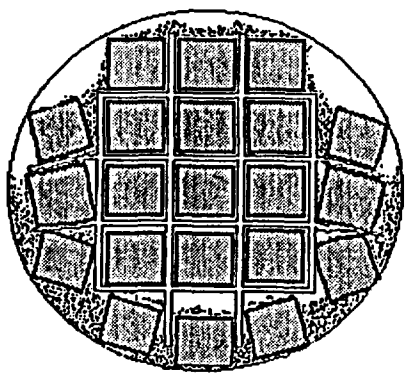
Initial Configuration



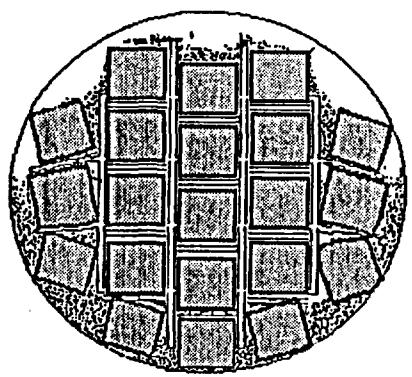
Side Guide Failure



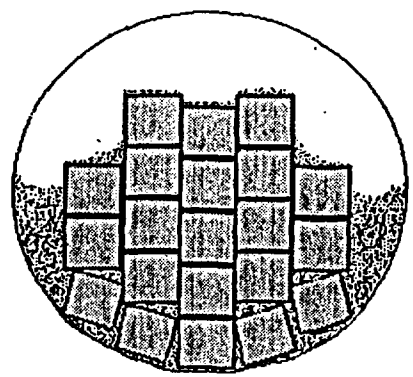
Corner Guide Failure



Long Criticality Control Plates Bend at Ends

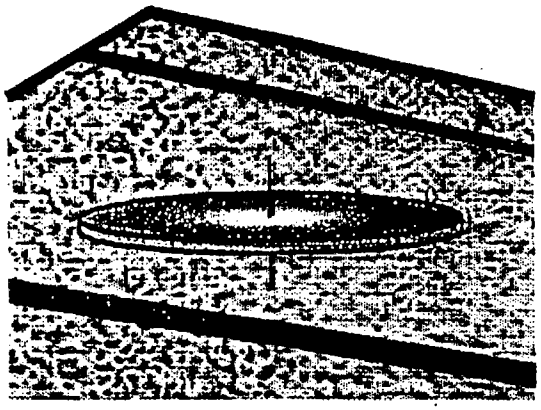


Fully Collapsed Basket with Partial Criticality Control Plate Degradation

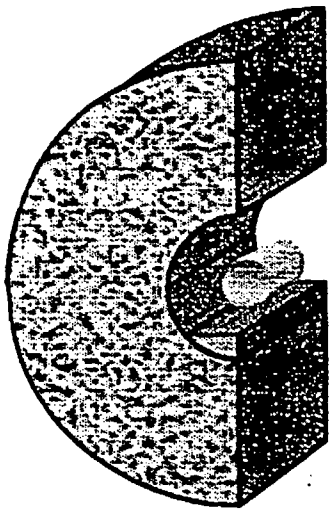


Fully Degraded Basket

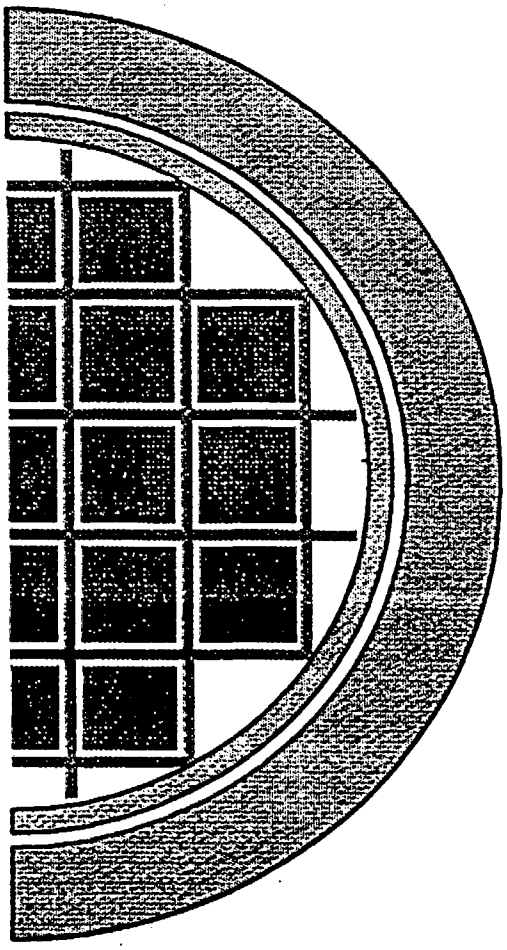
Four Model Thermal Analysis Approach

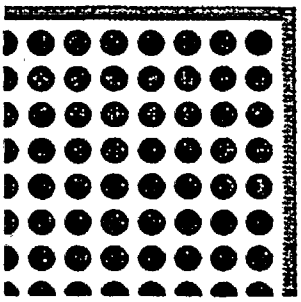


Repository Disk
Long-Term Response
Due to Thermal Loading



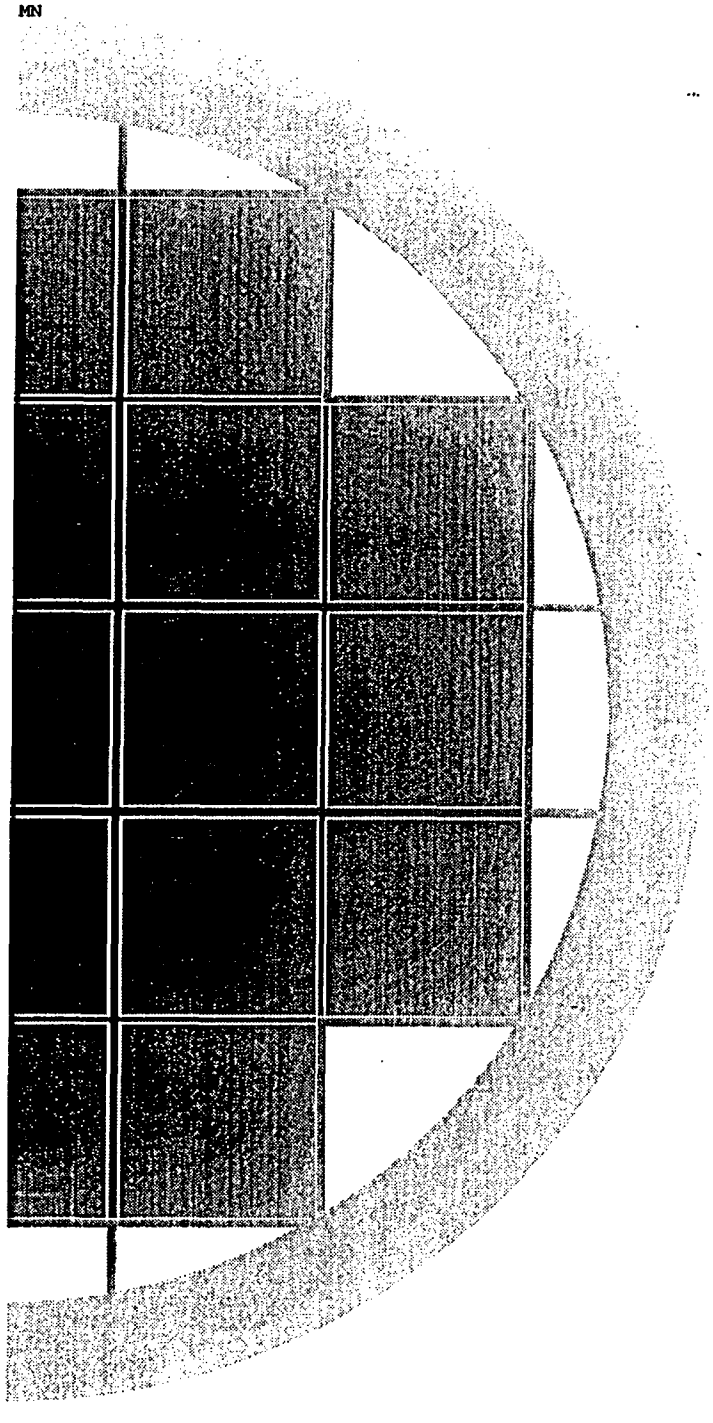
Drift Emplacement
Provide Time-Dependent
Boundary Conditions
for Near-Field





1/4 SNF Assembly
Peak Cladding Temperatures
(Effective Conductivity)

Waste Package
Incorporate Specific Materials
and Design Configuration



ANSYS 5.1
MAR 5 1997

Maximum
Cladding
Goal:
350 C

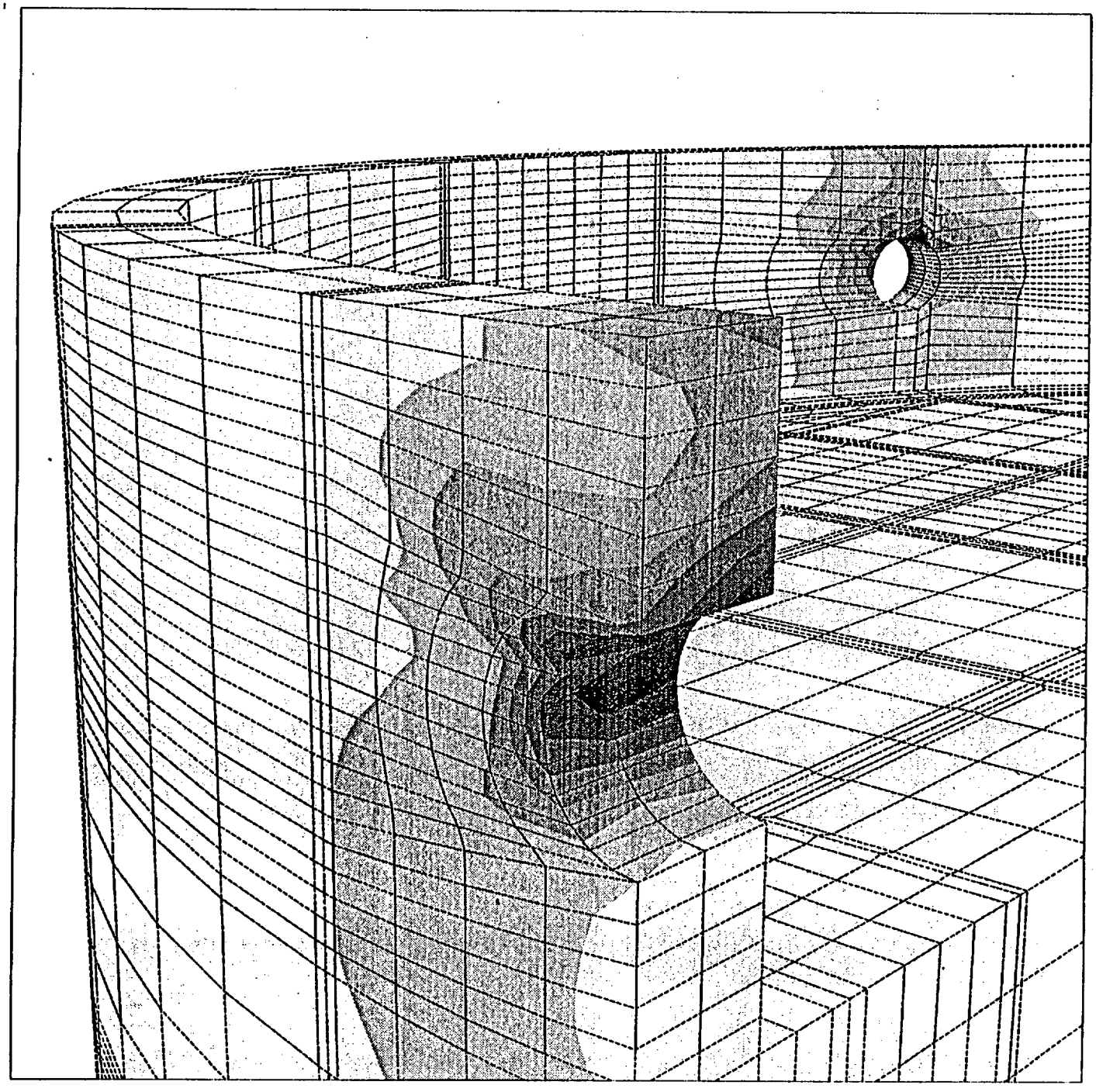
Temperature
Degrees C

175
183
190
199
206
214
222
230
237
246
253
261
269
277
284
293
300
308
316
323
332

21 PWR UCF/WP at Time of Peak Temp. (2 years)

Design and Analysis Procedures-Structural

- Preclosure
  - Surface Handling Load
    - Waste container lifting and moving
    - SNF loading and container closure loads
    - Surface to subsurface transport loads
    - In-Drift maintenance loads
    - Retrieval loads
  - Design Basis Events
    - Tip-over
    - Drops, vertical, horizontal, cg-over-center
    - Pin
    - Impact
    - In-Drift rock fall



ANSYS 5.1
SEP 2 1997

SEQV
NODAL SOLUTION
STEP=1
SUB =1

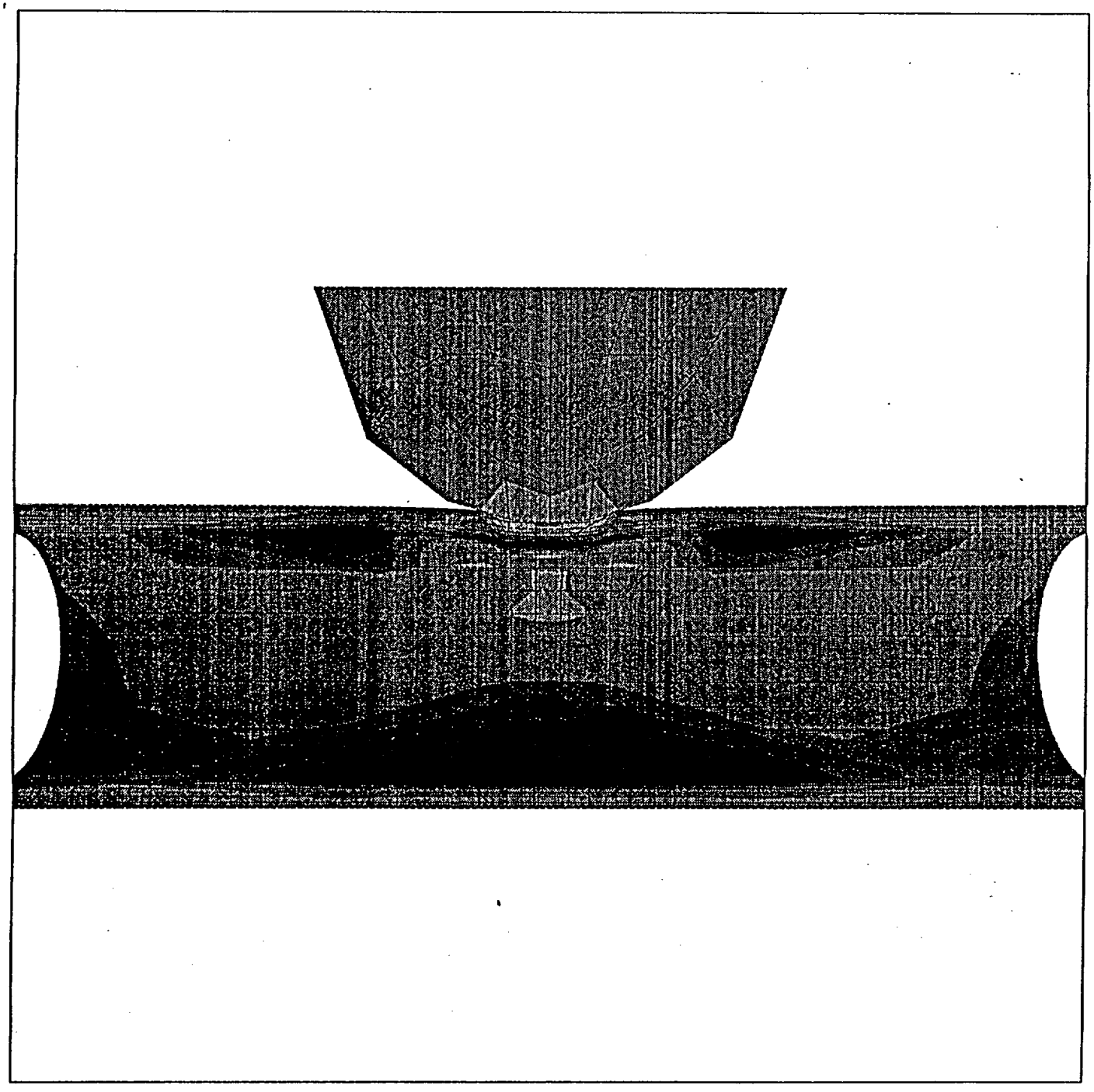
Limit = 225 MPa
Temp = 204C
MIN = 0.0432 MPa
MAX = 94.7 MPa
MAXB= 128 MPa

0.0432 MPa
10.6 MPa
21.1 MPa
31.6 MPa
42.1 MPa
52.6 MPa
63.1 MPa
73.7 MPa
84.2 MPa
94.7 MPa

21 PWR Disposal Container Lifting Analysis Results

Design and Analysis Procedures-Structural

- Postclosure
  - Post closure structural characteristics are coupled to material degradation, therefore waste package structural response will change with time.
    - Drift liner fall
    - In-Drift rock fall



ANSYS 5.0 A

STEP=3
SUB =17
TIME=1.319
S1 (AVG)

MIN = -344 MPa
MAX = 391 MPa

-344 MPa
-262 MPa
-181 MPa
-99 MPa
-18 MPa
64 MPa
146 MPa
227 MPa
309 MPa
391 MPa

TENSILE STRESS CONTOUR FOR ROCK FALL ONTO DISPOSAL CONTAINER (FOR ILLUSTRATION)

Summary

- Waste Package is robust/multibarrier providing containment for thousands of years, 'defense-in-depth' design philosophy.
- Criticality control options being evaluated for intact and degraded waste packages
- Thermal goals for waste forms and repository rock through time
- Design basis events (DBEs) for structural preclosure, long term performance for postclosure

Summary (Continued)

- Engineering Development Program ensures manufacturability of design(s)
- Materials selected on testing and environmental conditions
- Design based on CFRs, Engineered Barrier Requirements Document, Controlled Design Assumptions Document, System Design Descriptions (being developed)