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SANDIA NATIONAL LABORATORIES

NNWSI PROJECT

DEPARTMENT 6310 OPERATING PROCEDURE

REVIEWING, APPROVING, AND ISSUING TECHNICAL INFORMATION DOCUMENTS

Page	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	App A	App B	App C	App D	App E
Revision	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Author: Carl Mora — Date: 1/8/87

Approved: Division Supervisor — Date: 1/14/87

Approved: SNL QA — Date: Jan 20, 1987

Approved: T. O. Hunter, SNL TPO — Date: 1/20/87

SNL NNWSI DEPARTMENT 6310
CONTROLLED DOCUMENT
Issued to: M.D. COTTER, SAIC.
Copy Number: #073
RETURN TO 6310 RECORDS CENTER
WHEN NO LONGER NEEDED.

DEPARTMENT OPERATING PROCEDURE FOR REVIEWING, APPROVING, AND ISSUING NNWSI TECHNICAL INFORMATION DOCUMENTS

PURPOSE

The purpose of this procedure is to detail the method for reviewing, approving, and issuing official technical information documents produced by Department 6310, by its contractors, and by other Sandia organizations for Department 6310. Such documents include SAND reports, abstracts, conference papers, journal articles, and letter reports (SLTRs). Other types of documents are covered separately in other QAPs and DOPs.

SCOPE

The procedures herein apply to all such documents to be distributed outside of Sandia National Laboratories. This procedure (DOP 6-2) supersedes entirely QAP III-1, adopted in May 1983 and QAP VI-2, November 1985.

DESCRIPTION

Section 1.0, "Documents Authored by Department 6310 Personnel," provides a detailed description of the method of reviewing, approving, and issuing formal technical documents written by members of Department 6310.

Section 2.0, "Documents Authored by Other Sandia Organizations for Department 6310," provides a detailed description of the method of reviewing, approving, and issuing formal technical documents for the NNWSI Project written by Sandia employees outside of Department 6310.

Section 3.0, "Contractor Documents for Department 6310," provides a detailed description of the method of reviewing, approving, and issuing formal technical documents written by outside firms under contract to Department 6310.

Section 4.0, "Letter Reports (SLTRs)," defines what a letter report is and describes the method of reviewing, approving, and issuing it.

Section 5.0, "Records Management," identifies which of the documents mentioned in this DOP are QA records and specifies by file designators where they are entered in the Records Management Systems.

Section 6.0," Definitions," explains key terms used in this DOP.

REQUIREMENTS

In the case of documents authored by Department 6310 personnel, it is the responsibility of the primary author to see that the procedure is

followed and that the document receives complete review and approval before it is printed and/or distributed. In the case of documents authored by contractors and by other Sandia organizations, the department 6310 employee assigned to monitor the work has that responsibility.

No abstract, conference paper, or journal article covered by this DOP (see PURPOSE) can be submitted outside of Sandia unless it has been reviewed and approved by Dept. 6310, NVO/WMPO, and Sandia according to the procedures outlined in this procedure. To be processed, such documents must be submitted for review and approval no later than 15 working days (for abstracts) and 30 working days (papers and articles) before they are due. These requirements apply to both Sandia personnel and all contractors.

1.0 Documents Authored by Department 6310 Personnel (Figure 1)

1.1 Editorial Review

Author sends three copies of draft document to Department 6310 technical reports editor (hereafter "editor," c/o Division 6311), who will conduct, or arrange for, an editorial review, examining it to determine if it is complete, in the proper format, and otherwise ready for review. If not, draft will be returned to the author for modifications.* (Note: Author's division supervisor has the authority to waive editorial review requirement if there is a compelling reason to do so. The Manuscript Review Sheet contains a signature block for this.)

1.2 Technical Review

When editor has an acceptable draft, author will ask his/her division supervisor to select two independent technical reviewers who are qualified** and available to technically review the document. The editor then sends a copy of the draft document and Department 6310 Manuscript Review Sheet (Appendix A) to each independent technical reviewer (one reviewer and one referee).

1.3 Technical reviewers return written review comments and manuscripts to the author and initial the Manuscript Review Sheet. Author resolves problems and questions, incorporates changes into a revised draft, and sends document to the editor.

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*Writing and rewriting assistance is available through the Department 6310 technical reports editor.

**See Section 6.0, "Definitions" for qualifications.

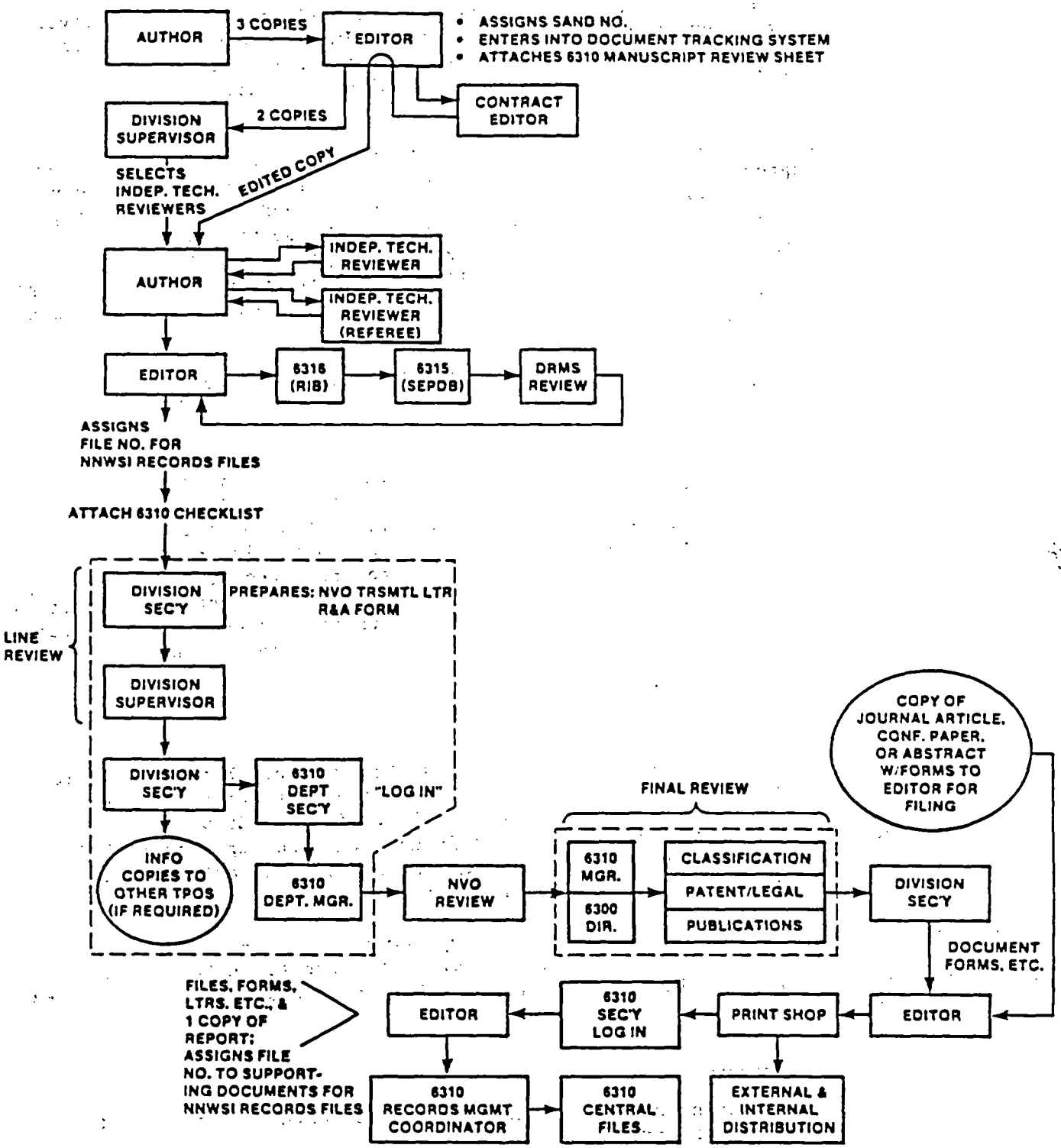

Figure 1. Documents Authored by 6310 Personnel.

1.4 Author works with technical and editorial reviewers and gets final approval signatures on Manuscript Review Sheet from technical and editorial reviewers.* The author will enter technical review and editorial review comments for documents resulting from Quality Level I and II activities into the Records Management System. Author sends two copies of revised manuscript to the editor, along with the Manuscript Review Sheets completed by reviewers.

1.5 The editor sends the draft to Division 6316 for examination. If draft sent to the 6316 representative contains the appendix for the Reference Information Base (RIB) comparison and the latter is acceptable, the representative will sign the Department 6310 Manuscript Review Sheet, and the draft and sheet will be returned to the editor. If draft is unacceptable from this standpoint, the 6316 representative will work with the author to solve the problems and produce an acceptable draft.

1.6 The editor sends draft to Division 6315 to ensure that appendices identifying candidate information for the Site and Engineering Properties Data Base (SEPDB) are considered for future entry. If draft sent to the 6315 representative contains the appendix for the SEPDB comparison and the latter is acceptable, the representative will sign the Department 6310 Manuscript Review Sheet, and the draft and sheet will be returned to the editor. If draft is unacceptable from this standpoint, the 6315 representative will work with the author to solve the problems and produce an acceptable draft.

1.7 The editor will forward a copy of the document to the Department 6310 Data Records Management System (DRMS) representative who will review the document and appropriate DRMS data set notebooks to determine if all data and supporting documents for the reported data have been placed in the DRMS. If the DRMS data set notebooks are incomplete relative to the data, the representative will so inform the author. The author will provide to the DRMS representative the required documents to complete the DRMS notebook. The representative will sign the 6310 Manuscript Review Sheet when all the data and supporting documents are placed into the appropriate DRMS data set notebook. The representative then returns the draft document and review sheet to the editor.

1.8 The editor, after ascertaining that the manuscript is ready for line review, attaches the Department 6310 Technical Publication Checklist, (Appendix C) and sends the packet to the author's division secretary who

* If differences cannot be resolved between the author and a reviewer, the author's division supervisor may sign in lieu of the reviewer. If supervisor does this, he must document the unresolved differences and how he handled them; a copy must be sent to the Department 6310 QA Coordinator and the reviewer involved.

prepares the transmittal letter** to the Department of Energy's Nevada Operations Office (NVO) and the SNL Review and Approval form (SF 1003) (Appendices D and E) that accompanies the document through the remainder of the Sandia review process. The secretary gives Manuscript Review Sheet, Review and Approval form, and manuscripts to division supervisor.

1.9 The division supervisor completes his review. After any problems are resolved with author and an acceptable draft document exists, the supervisor signs Review and Approval form. The supervisor determines if the document has direct application to other NNWSI Project participant organizations. If so, the supervisor sends an information copy of the document to the TPO at appropriate organization(s).

1.10 Supervisor has secretary send two copies of the draft document, Manuscript Review Sheet, Review and Approval form, and transmittal letter to Department 6310 secretary who "logs in" the document, files copies of the abstract and Manuscript Review Sheet, and gives document and all forms to Department 6310 manager.

1.11 Department 6310 manager examines the document. If it is satisfactory, he has department secretary send one copy of the draft document and transmittal letter to NVO for "policy review."

1.12 NVO performs policy review and returns any comments to Department 6310 manager. Department secretary updates log and files a copy of NVO comments and/or approval letter. Comments requiring resolution are forwarded to author.

1.13 After NVO comments are resolved and a revised draft is prepared (if necessary), reviews are conducted by department manager and 6300 director. The document, together with the Review and Approval form, is sent through the remaining steps in the final review process--classification, patent/legal, and publication policy reviews.

1.14 Document and forms are returned to appropriate division secretary who notifies author that document has final approval. Secretary forwards copies of all QA records to the Department 6310 Records Management System staff for filing, then forwards original manuscript and all forms and letters to editor to arrange for printing, if document is to be published by Sandia. If document is a journal article, conference paper, or abstract, secretary forwards original manuscript and copies of forms to author who submits manuscript to appropriate place; at the same time secretary sends a copy of the manuscript and original forms to editor who files them in editorial archives.

1.15 Department 6310 secretary notes in log when a printed copy of a document is received.

1.16 Original copy of SAND reports and all forms and letters are filed in the SNL RMS.

** If applicable, the transmittal letter to NVO shall include the sentence: "This draft document satisfies Milestone # _____."

2.0 Documents Authored by Other Sandia Organizations for Department 6310 (Figure 2)

2.1 Author has draft document reviewed by the independent technical reviewers (one reviewer and one referee). (Department 6310 contact's* division supervisor selects two qualified independent technical reviewers.** At least one reviewer should be a Department 6310 staff member.) At the same time, author should send a draft to the Department 6310 contact who will forward a draft to the Department 6310 technical reports editor (c/o Division 6311), hereafter referred to as "editor," who will conduct, or arrange for, an editorial review and get a SAND number assigned if the author has not done so. (Note: if author expects considerable suggestions and changes from the peer reviewers, author may choose to have the editorial review done after peer review comments have been resolved and incorporated into a revised draft. Monitor's division supervisor has the authority to waive editorial review requirement if there is a compelling reason to do so. The Manuscript Review Sheet contains a signature block for this.)

2.2 Technical and editorial reviewers return written review comments and manuscripts and initial the Manuscript Review Sheet. Author resolves problems and questions and incorporates changes into a revised draft.

2.3 Author works with technical and editorial reviewers and gets final approval from them.*** Reviewer signatures are required on the Department 6310 Manuscript Review Sheet to indicate final approval. The technical and editorial review comments for documents resulting from Quality Level I and II activities must be entered into the Records Management System.

2.4 Author sends two copies of revised manuscript to the editor, along with the Manuscript Review Sheets. The editor sends the draft to Division 6316 for examination. If draft sent to the 6316 representative contains the appendix for the RIB comparison and the latter is acceptable, the representative will sign the Department 6310 Manuscript Review Sheet (Appendix A), and the draft and sheet will be returned to the editor. If draft is unacceptable from this standpoint, the 6316 representative will work with the 6310 contact to solve the problems and produce an acceptable draft document.

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*In most cases, a Sandia author outside Department 6310 will have been assigned a contact within 6310. The author should work closely with the contact and keep him/her informed about the status of the document throughout the review process.

**See Section 6.0, "Definitions," for qualifications.

***If differences cannot be resolved between the author and a reviewer, the author's division supervisor may sign in lieu of the reviewer. If supervisor does this, he must document the unresolved differences and how he handled them; a copy must be sent to the Department 6310 QA Coordinator and the reviewer involved.

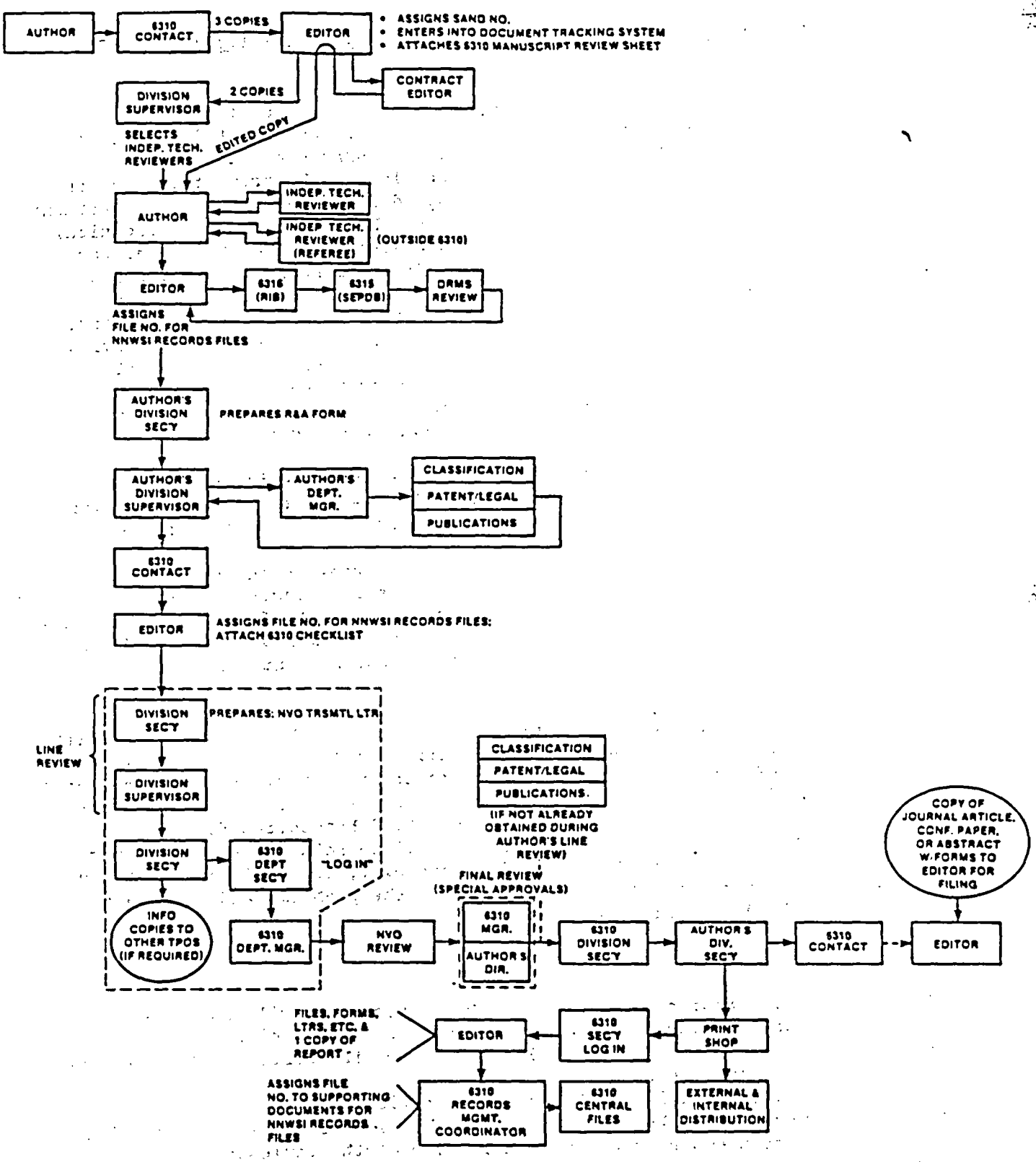

Figure 2. Documents Authored by other Sandia Organizations for Department 6310.

2.5 The editor sends draft to Division 6315 to ensure that appendices identifying candidate information for the SEPDB are considered for future entry. If draft sent to the 6315 representative, contains the appendix for the SEPDB comparison and the latter is acceptable, the representative will sign the Department 6310 Manuscript Review Sheet (Appendix A), and the draft and sheet will be returned to the editor. If draft is unacceptable from this standpoint, the 6315 representative will work with the 6310 contact to solve the problems and produce an acceptable draft.

2.6 The editor forwards a copy of the document to the Department 6310 Data Records Management System (DRMS) representative, who will review the document and appropriate DRMS data set notebooks to determine if all data and supporting documents for the reported data have been placed in the DRMS. If the DRMS data set notebooks are incomplete relative to the data, the representative will so inform the 6310 contact (through the Department 6310 contact). The author will provide to the DRMS representative the required documents to complete the DRMS notebook. The representative will sign the 6310 Manuscript Review Sheet when all the data and supporting documents are placed into the appropriate DRMS data set notebook. The representative then returns the draft document and review sheet to the editor.

2.7 The editor then sends two copies of the manuscript to the author's division secretary, along with the Manuscript Review Sheets completed by reviewers. Author's division secretary prepares Review and Approval form (SF 1003) (Appendices D and E) that accompanies the manuscript through remainder of Sandia review process. Secretary gives Manuscript Review Sheet, Review and Approval form, and both copies of the manuscript to author's division supervisor.

2.8 Author's division supervisor and department manager conduct their reviews. After any problems are resolved with author, the supervisor and manager sign the Review and Approval form. The manuscripts and forms are sent to the author's Department 6310 contact, who will ensure that everything is in order and complete. The contact sends two copies of the revised manuscript to the editor, along with the Manuscript Review Sheet completed by reviewers. The editor, after ascertaining that the manuscript is ready for line review, attaches the Department 6310 Technical Publication Checklist (Appendix C) and sends the packet to the contact's division secretary.

2.9 The division supervisor completes his review. After any problems are resolved with author (through the Department 6310 contact) and an acceptable draft document exists, the supervisor signs Review and Approval form under "Special Approvals." The Supervisor determines if the document has direct application to other NNWSI Project participant organizations. If so, the supervisor sends an information copy of the document to the TPO at appropriate organization(s).

2.10 Division supervisor's secretary prepares transmittal letter* to Nevada Operations Office (NVO) and sends the two copies of the document, Manuscript Review Sheets, review and approval form, and transmittal letter to department 6310 secretary who "logs in" the document, files copies of the abstract and manuscript review sheets, and gives document and all forms to Department 6310 manager.

2.11 Department 6310 manager examines the document. If it is satisfactory, he has department secretary send one copy of the draft document and transmittal letter to NVO for "policy review."

2.12 NVO performs policy review and returns comments to department 6310. Secretary updates log and files a copy of NVO comments and/or approval letter. Comments requiring resolution are forwarded to author.

2.13 After NVO comments are resolved and a revised draft is prepared (if necessary), reviews are conducted by 6310 Department Manager, who signs under "special approvals." The document, together with the Review and Approval form, is then sent through remaining steps in the final review process--classification, patent/legal, and publication policy reviews (if author's organization has not already obtained these approvals prior to sending R & A form to 6310 monitor). If author's organization is to arrange for printing, the packet is returned to author; if publication is to be done by Department 6310, the packet is forwarded to the editor.

2.14 Document and forms are returned to author who forwards copies of all QA records to the Department 6310 Records Management System staff for files. Author then forwards original manuscript and all forms and letters to editor to arrange for printing, if document is to be published by Sandia. If document is a journal article, conference paper, or abstract, author submits manuscript to appropriate place; at same time author sends a copy of the manuscript and original forms to editor to file for archives.

2.15 Department 6310 secretary notes in log when a printed copy of the document is received.

2.16 Original copy of SAND reports and all forms and letters are filed in SNL RMS.

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*If applicable, the transmittal letter to NVO shall include the following sentence: "This draft document satisfies Milestone # _____."

3.0 Contractor Documents for Department 6310 (Figure 3)

3.1 Contractor conducts internal review of draft document, updates and submits five copies of typed, double-spaced document to Department 6310 employee assigned to monitor contract. The 6310 monitor examines draft to determine if it is acceptable.

3.2 When monitor is satisfied with draft, he or she should send three copies to Department 6310 technical reports editor (hereafter, "editor") who will assign a SAND number (7000 series). The editor will work with the monitor to ensure that the document is in the proper format and condition for independent technical review. The editor will then forward the draft to the appropriate division 6310 supervisor, who examines it to determine if it is ready for review. If not, draft is returned to monitor, who works with contractor to get an acceptable draft. After division supervisor determines that draft is ready, he selects the qualified independent technical reviewers and returns manuscript to monitor.* Monitor sends a copy of the draft and a copy of the Department 6310 Manuscript Review Sheet (Appendix A) to each independent technical reviewer (one reviewer and one referee). At same time, monitor sends a draft to editor, c/o Division 6311, who will conduct, or arrange for, an editorial review. (Note: monitor's division supervisor has the authority to waive editorial review requirement if there is a compelling reason to do so. The manuscript review sheet contains a signature block for this.)

3.3 Technical and editorial reviewers return written review comments and manuscripts and initial the Manuscript Review Sheet. Monitor resolves problems and questions and incorporates changes into a revised copy.

3.4 The monitor returns the revised copy to the contractor for necessary revisions to the manuscript and artwork. Contractor makes revisions and, if document is a technical report, provides the following to the monitor: one unbound "camera-ready" copy of the document (now single-spaced) and a set of tapes or disks containing the complete text of the document. (The tapes or disks should be compatible with Sandia's word-processing equipment in case Sandia needs to make adjustments to the final copy.)

3.5 Monitor checks manuscript and gets final approval signatures on Manuscript Review Sheet from technical and editorial reviewers. The technical and editorial review comments for documents resulting from Quality Level I and II activities must be entered into the Records Management System. The monitor sends two copies of the revised manuscript to the editor, along with the Manuscript Review Sheets completed by reviewers.

3.6 The editor sends the document to the Division 6316 representative who examines it to see if data and assumptions agree with the Department 6310 Reference Information Base (RIB). If draft sent to the 6316

*See Section 6.0, "Definitions," for qualifications.

representative contains the appendix for the RIB comparison and the latter is acceptable, the representative will sign the Department 6310 Manuscript Review Sheet (Appendix A), and the draft and sheet will be returned to the editor. If draft is unacceptable from this standpoint, the 6316 representative will work with the 6310 contact to solve the problems and produce an acceptable draft document.

3.7 The editor sends draft to Division 6315 to ensure that appendices identifying candidate information for the SEPDB are considered for future entry. If draft sent to the 6315 representative contains the appendix for the SEPDB comparison and the latter is acceptable, the representative will sign the Department 6310 Manuscript Review Sheet, and the draft and sheet will be returned to the editor. If draft is unacceptable from this standpoint, the 6315 representative will work with the monitor to solve the problems and produce an acceptable draft.

3.8 The editor forwards a copy of the document to the Department 6310 Data Records Management System (DRMS) representative, who will review the document and appropriate DRMS data set notebooks to determine if all data and supporting documents for the reported data have been placed in the DRMS. If the DRMS data set notebooks are incomplete relative to the data, the representative will so inform the monitor. The monitor will provide to the DRMS representative the required documents to complete the DRMS notebook. The representative will sign the 6310 Manuscript Review Sheet when all the data and supporting documents are placed into the appropriate DRMS data set notebook. The representative then returns the draft document and review sheet to the editor.

3.9 The editor, after ascertaining that the manuscript is ready for line review, attaches the Department 6310 Technical Publication Checklist (Appendix C) and sends the packet to the monitor's division secretary.

3.10 Secretary prepares Review and Approval form (SF 1003) (Appendices D and E) that accompanies the document through remainder of Sandia review process and the transmittal letter* to the Department of Energy's Nevada Operations Office (NVO). Secretary gives review sheets, Review and Approval form, and document to division supervisor.

3.11 Division supervisor completes his review. After any problems are resolved with monitor and an acceptable draft document exists, supervisor signs Review and Approval form. Supervisor determines if the document has direct application to other NNWSI Project participant organizations. If so, the supervisor sends an information copy of the document to the TPO at appropriate organization(s).

3.12 If differences cannot be resolved between the monitor and a reviewer, the monitor's division supervisor may sign in lieu of the reviewer. If supervisor does this, he must document the unresolved differences and how he handled them; a copy must be sent to the Department 6310 QA coordinator and the reviewer involved.

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*If applicable, the transmittal letter to NVO shall contain the sentence: "This draft document satisfies Milestone # _____."

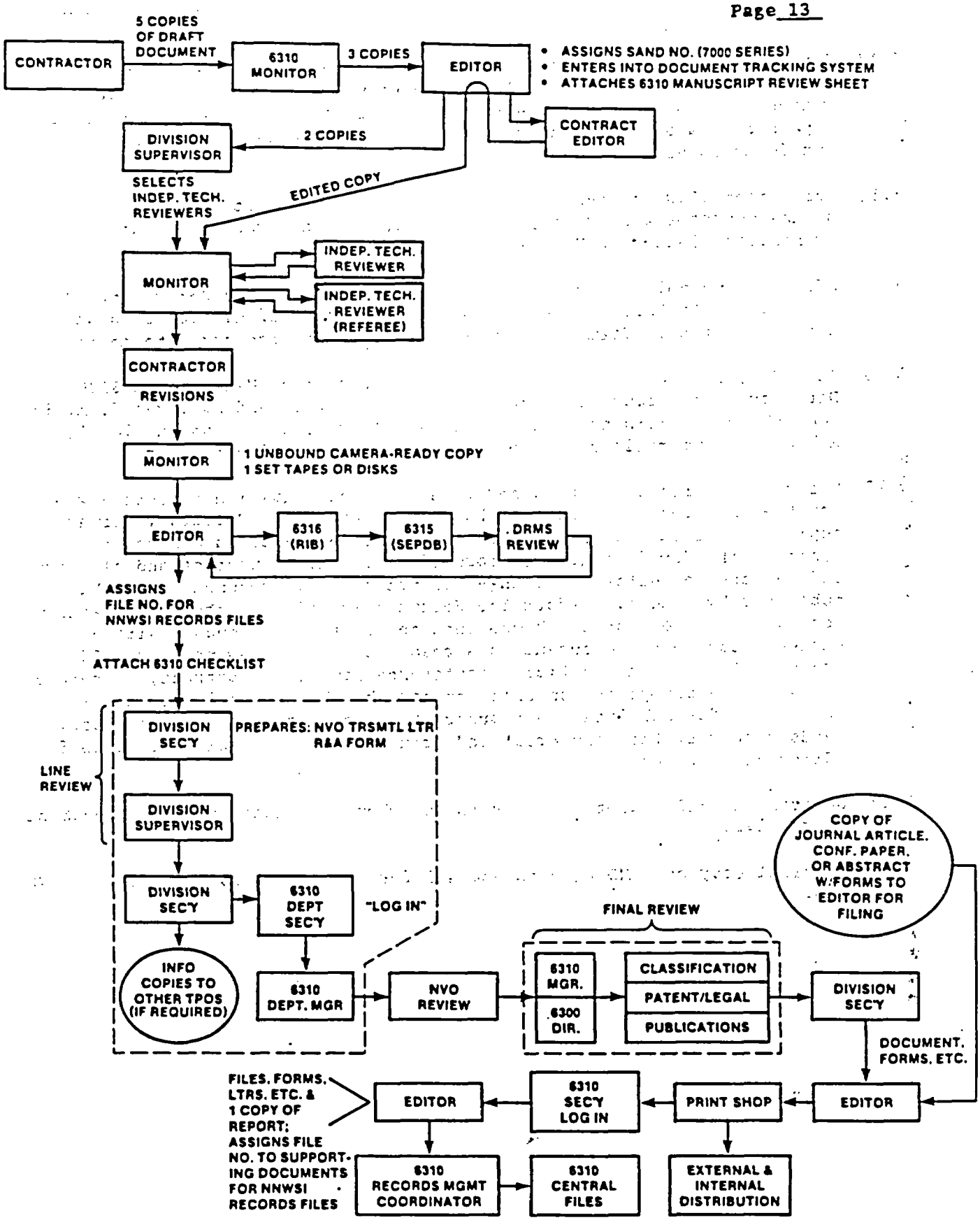

Figure 3. Contractor Documents

3.13 Supervisor has division secretary send two copies of the document, Manuscript Review Sheet, review and approval form, and transmittal letter to Department 6310 secretary who "logs in" in the document, files copies of the abstract and manuscript review sheets, and gives document and forms to 6310 manager.

3.14 Department 6310 manager examines the document. If it is satisfactory, he has department secretary send one copy of the draft document and transmittal letter to NVO for "policy review."

3.15 NVO performs policy review and returns any comments to Department 6310 manager. Secretary updates log and files a copy of NVO comments and/or approval letter. Items requiring resolution are forwarded to monitor.

3.16 In order, reviews are conducted by 6310 Department Manager and 6300 Director. The document, together with the Review and Approval form, is sent through remaining review steps -- classification, patent/legal, DOE Albuquerque Operations Office, and publication policy reviews.

3.17 Document and forms are returned to appropriate division secretary who notifies monitor that document has final approval. Secretary forwards copies of all QA records to the Department 6310 Records Management System staff for filing, then forwards original manuscript and all forms and letters to editor to arrange for printing, if document is to be published by Sandia. Before the document is printed, the editor will work with the monitor to ensure that the contractor concurs with all changes made to the document as a result of the review process. If document is a journal article, conference paper, or abstract, secretary forwards manuscript to contract monitor who then sends it to the contractor for submittal to appropriate place; at same time secretary sends a copy of the manuscript and original forms to editor to file for editorial archives.

3.18 Department 6310 secretary notes in log when a printed copy of a document is received.

3.19 Original copy of SAND reports and all forms and letters are filed in SNL RMS.

4.0 Letter Reports (SLTRs)

4.1 A Letter Report (SLTR) is miscellaneous documentation that must be formally entered into the Records Management System and be made available expeditiously to NNWSI Project personnel and their contractors without going through the longer review and publication process required for SAND reports. SLTRs may be in various formats: engineering memos, correspondence, test data, etc., and should represent results of NNWSI Project activities such as design, analysis, or planning activities and/or other technical work.

4.2 SLTRs will be assigned numbers and logged by the Department 6310 Records Manager.

4.3 An SLTR must have two independent technical reviewers chosen by the author with the division supervisor's approval. The independent technical reviewers and the division supervisor will sign the Department 6310 Letter Report Review Sheet (Appendix B). An editorial review is not required.

4.4 SLTRs will be archived in the Department 6310 Records Management Center, together with the Letter Report Review Sheet and any other supporting documentation.

4.5 SLTRs are not referenceable in SAND documents.

5.0 Records Management

QA documents identified in this DOP are: (1) The Department 6310 Manuscript Review Sheet (Appendix A), (2) the Department 6310 Letter Report Review Sheet (Appendix B), (3) the SAND or SLTR document itself, (4) technical reviewer comments, and (5) the Review and Approval forms (Appendices D and E). All are filed with the documents they accompany and come under the coding index for that document per the Master Index for Department 6310 Records Management System.

6.0 Definitions

Independent Technical Reviewer: Any individual who is knowledgeable in the technical area to be reviewed but who did not perform the original work that resulted in the report. The author's supervisor can be an independent technical reviewer only if the supervisor is the only technically competent, certified individual available and that fact is documented by the 6310 Department Manager per DOP 6-2. For technical documents resulting from QA Level I activities, the independent technical reviewers must also be certified in accordance with DOP 2-6 in the technical area to be reviewed.

SLTR: A letter report containing results of NNWSI Project activities. It is assigned a log number by the Records Management staff and entered into the Records Management System. An SLTR is non-referenceable in SAND reports.

7.0 Appendices

Appendix A	Department 6310 Manuscript Review Sheet
Appendix B	Department 6310 Letter Report Review Sheet
Appendix C	Department 6310 Technical Publication Checklist
Appendix D	Review and Approval for Release/Distribution of Official Sandia Reports
Appendix E	Review and Approval Journal Articles, Conference Papers, Presentations (Oral or Written)

Appendix A

DEPARTMENT 6310 MANUSCRIPT REVIEW SHEET

Appendix A
to DOP 6-2
(Revised 11/03/86)

SAND _____ Date _____
Title _____

Author(s) and Organization(s) _____

If contractor report, name of Sandia contract monitor and organization _____
If author from outside 6310, name of Dept. contact _____

Type of Manuscript:
( ) SAND Report
( ) Journal Article _____
(name of journal)
( ) Conference/Meeting Abstract or Paper _____
(name of conf./meeting)

Please review the attached manuscript for each of the following:

___ 1. Organization, clarity, and conciseness of the material.
___ 2. Correctness of any assumptions.
___ 3. Validity of data, including statistical significance.
___ 4. Adequacy of the discussion of variables.
___ 5. Validity of conclusions and recommendations.
___ 6. Adequacy of illustrations, graphs, tabular data, etc.
___ 7. Appropriate acknowledgment of contributors and referenced material.
___ 8. Consistency of information with program baseline and reference information, required appendices are present (RIB & SEPDB).
___ 9. Format, grammar, spelling, punctuation (editorial reviewer).

Attach any comments you have, initial below, and return the package to the author/contract monitor by _____. If you cannot complete your review by that date, please contact the author/monitor as soon as possible. Do not complete the signature block until your comments and suggestions are resolved to your satisfaction; your signature indicates your final approval.[a]

[b] Reviewer name _____ Org. _____ Initials _____
Signature (final approval): _____ Date: _____

[c] Referee name _____ Org. _____ Initials _____
Signature (final approval): _____ Date: _____

[d] Editorial reviewer _____ Org. _____ Initials _____
Signature (final approval): _____ Date: _____

( ) Editorial review not required _____
Division supervisor signature

The manuscript has been reviewed and approved for conformance with Reference Information Baseline, and identification of candidate information for the SEPDB.

6315 Signature: _____ Date: _____ 6316 Signature: _____ Date: _____

The manuscript has been reviewed by a Data Records Management System (DRMS) representative. All appropriate data and testing information have been provided to and placed into the DRMS.

Data Set ID _____ Signature: _____ Date: _____

Records Management System (RMS) index code _____

[a] If differences cannot be resolved between the primary author/contract monitor and the reviewer, referee, or editorial reviewer, the division supervisor of the author/monitor may sign in lieu of reviewers.
[b] To be chosen by author/monitor, with concurrence of division supervisor.
[c] To be chosen by division supervisor and should be someone outside of the division whenever possible.
[d] Send copy for editorial review to C. Mora, Div. 6311, before copies are sent to reviewer and referee. Division supervisor of primary author/monitor has the authority to waive editorial review requirement by so indicating and signing.

Note: Neither the reviewer nor the referee should have been directly involved with the acquisition or interpretation of data reported in the manuscript.

Appendix B

DEPARTMENT 6310 LETTER REPORT REVIEW SHEET

Appendix B
to DOP 6-2
(Revised 10/22/86)

SLTR[a] _____ Date _____

Title _____

_____

Author(s) and Organization(s) _____

_____

PI/Contract Monitor (if applicable) _____

Attach any comments you have, initial below, and return the package to the author/contract monitor by _____. If you cannot complete your review by that date, please contact the author/monitor as soon as possible. Do not complete the signature block until your comments and suggestions are resolved to your satisfaction; your signature indicates your final approval.[b]

[c] Reviewer name _____ Org. _____ Initials _____

Signature (final approval): _____ Date: _____

[d] Referee name _____ Org. _____ Initials _____

Signature (final approval): _____ Date: _____

Division Supervisor _____ Org. _____ Initials _____

Signature (final approval): _____ Date: _____

This Letter Report has been reviewed and approved for conformance with Reference Information Baseline, and identification of candidate information for the SEPDB.

6315 Signature: _____ Date: _____ 6316 Signature: _____ Date: _____

This Letter Report has been reviewed by a Data Records Management System (DRMS) representative. All appropriate data and testing information have been provided to and placed into the DRMS.

Data Set ID _____ Signature: _____ Date: _____

[e] Records Management System (RMS) index code _____

[a] To be assigned by Dept. 6310 Records Manager.
[b] If differences cannot be resolved between the primary author/PI/contract monitor and the reviewer, or referee, the division supervisor of the author/monitor may sign in lieu of reviewers.
[c] Should be PI, contract monitor, or designee (for externally generated reports).
[d] To be chosen by division supervisor and should be someone outside of the division whenever possible.
[e] To be assigned by author/PI/contract monitor.

Note: Neither the reviewer nor the referee should have been directly involved with the acquisition or interpretation of data reported in the manuscript.

Appendix C

DEPARTMENT 6310 TECHNICAL PUBLICATION CHECKLIST

TO: 1. _____, 63___ SAND_____
2. Tom Hunter, 6310
FROM:
DATE:

I have examined the technical report or other publication attached. It appears to be ready for your action. The following are noted:

_____ SAND number is correct.

_____ Is logged into the 6310 document tracking system.

_____ Peer review signoff sheets included.

_____ Correct review and approval form is included.

_____ Includes two appendices for RIB and SEPDB.

_____ A representative of Division 6316 has reviewed the document for consistency with the RIB.

_____ A representative of Division 6315 has reviewed the appendix for candidate information for the SEPDB.

_____ Has received an editorial review.

_____ Latest NNWSI standard distribution list enclosed, along with other distribution required by Sandia and suggested by author or monitor.

_____ If 6310 has seen the publication previously and requested changes, a copy of the request is included, and the current version of the document with all changes incorporated is included.

_____ Author/monitor has been consulted to determine if the document represents a milestone. The document does - does not (circle one) represent a milestone. If it does, the milestone number is _____ and the number has been noted on the NVO policy letter.

_____ An NNWSI data set is - is not documented. If so, the data set identification is _____, B. M. Schwartz (6313) has been added to the distribution list, and all appropriate information has been provided to and accepted into the Data Records Management System.

THE FOLLOWING ITEMS SHOULD BE COMPLETED BY SUPERVISOR BEFORE SENDING TO DEPARTMENT 6310 MANAGER:

_____ Policy review letter to NVO is included. (If abstract or conference paper, state name, dates, and location of conference. If journal article, include name of journal.) Send information copies w/cy of transmittal letter to Max Blanchard and Larry Skousen. For milestone documents, include copy of milestone sheet and add following to NVO policy review letter: "This document satisfies Milestone No._____."

_____ The division supervisor named at the top of this form has examined the document to determine if it has direct application to other NNWSI participant organizations. It _____ does not have such application, and no information copies have been sent. It _____ does have such application, and an information copy has been sent to the TPO at the following organizations:

_____ LANL, _____ LLNL, _____ USGS, _____ SAIC, _____ other _____

Appendix D

SF 1003 (4-84)

Do not enter Classified Information

REVIEW AND APPROVAL FOR RELEASE/DISTRIBUTION OF OFFICIAL SANDIA REPORTS

Use yellow form SF 1003-MF for journal articles conference papers and presentations.

1. IDENTIFICATION

Control Number _____ DOE Distribution Category Number _____ Case No. _____ Date _____

Unclassified Title _____

2. CLASSIFICATION LEVEL, CATEGORY AND EXTRA MARKINGS (To be completed by originating organization)

Title _____ Abstract _____ Total Report _____ Authorized Classifier _____

(Check when applicable) ☐ NWD ☐ Sigma ___ ☐ CNWDI Org. _____ Date _____

(Complete when applicable) ☐ NSI Declassify/Downgrade on _____

3. SPECIFIC CONTENTS REQUIRING ADDITIONAL APPROVALS *(see instructions on back of form)*

Unclassified controlled access information ☐ No ☐ Yes

Unclassified computer software ☐ No ☐ Yes

4. LIMITATIONS ON DISTRIBUTION State reason for limitation: _____

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In my judgment the unlimited release of the information in this document is not detrimental to the best interests of the United States.

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5. LINE SIGNATURES/APPROVALS THROUGH DIVISION

Author	E No.	Division Supervisor	Org.	Date

6. CLASSIFICATION REVIEW 3180 (8265)

Signature/Initials _____ Date _____

7. PATENT/LEGAL REVIEW 4031

Patent Interest: ☐ no ☐ yes Signature/Initials _____ Date _____

8. PUBLICATION POLICY REVIEW 3151 (8265)

Signature/Initials _____ Date _____

9. LINE DEPARTMENT AND DIRECTOR APPROVAL

Department	Org.	Date	Department	Org.	Date

Director	Org.	Date	Director	Org.	Date

10. SPECIAL APPROVALS/CHECKS

11. COMPLETED FORM — In Albuquerque, return completed form to Division 3151 so that DOE reporting can be processed. In Livermore, include this form with the copies sent to 8265.

Appendix E

Do not enter classified information.

Review and Approval
Journal Articles, Conference Papers, Presentations (Oral or Written)

1. IDENTIFICATION

Control Number _____ Case Number _____ Date _____

Send 3 Copies of Unclassified "C" suffixed material to Division 3151

Unclassified Title _____

Proposed for Publication in _____ (Name of Journal)

Proposed for Presentation at _____ (Name of meeting, conference or symposium)

Date of Meeting _____ Location _____ Sponsoring Org. _____

2. CLASSIFICATION LEVEL, CATEGORY AND EXTRA MARKINGS (To be completed by originating organization)

Title _____ Abstract _____ Manuscript _____ Authorized Classifier _____

(Check when applicable) ☐ NWD ☐ Sigma ___ ☐ CNWDI Org. _____ Date _____

(Complete when applicable) ☐ NSI Declassify/Downgrade on _____

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5. LINE SIGNATURES/APPROVALS THROUGH DIVISION

Author	E No.	Division Supervisor	Org.	Date

6. CLASSIFICATION REVIEW 3180 (8265)

Signature/Initials _____ Date _____

7. PATENT/LEGAL REVIEW 4031

Patent Interest: ☐ no ☐ yes Signature/Initials _____ Date _____

8. DEPARTMENT AND DIRECTOR APPROVAL

Department	Org.	Date	Department	Org	Date

Director	Org	Date	Director	Org	Date

9. SPECIAL APPROVALS/CHECKS

Signature _____ Date _____

10. TECHNICAL PUBLICATIONS REVIEW 3151 (8265)

☐ Abstract Release ☐ Full Paper Release

(If full paper is prepared, it must be approved and reviewed before release)

Initials _____ Date _____

11. COMPLETED FORM — Return completed form to Division 3151 (8265)

NNA.880122.0038

UNCONTROLLED

SNL NNWSI PROJECT

DEPARTMENT OPERATING PROCEDURE

PROCUREMENT PLANNING

Page	1	2	3	4	5	6	7	8	9	10
Rev.	0	0	0	0	0	0	0	0	0	0

Author: R. R. Richards — 4/17/87 Date

Reviewed: D. L. Brockman — 4/17/87 Date

Approved: N/A Division Supervisor — Date

Approved: Quality Assurance — 4/17/87 Date

Approved: Department Manager — 4/20/87 Date

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PROCUREMENT PLANNING

1.0 Purpose

To specify those actions necessary to prepare for and plan procurement of materials, items, and services for the NNWSI Project.

2.0 Scope

This procedure applies to all procurements for the NNWSI Project initiated within the Sandia NNWSI Project Department, regardless of Quality Assurance Level, except for requests for stock items within the "Just-in-Time" system. This procedure does not replace or supersede any Sandia Laboratories Instructions or Purchasing Instructions relating to procurement activities.

3.0 Definitions

3.1 "Catalog, off-the-shelf" item - An item of material or equipment which can be fully identified by a catalog, part, or model number and which is made not to Sandia specifications but to the manufacturer's or vendor's specifications.

3.2 Requester- The individual who initiates a procurement, via a Purchase Requisition.

4.0 General

4.1 In the broadest sense, organizational responsibilities and methods for procurement activities have been established by Sandia management and expressed in various Sandia Laboratories Instructions (see References).

4.2 Within the SNL NNWSI Project, the documents which guide and integrate the procurement process (in addition to the SLIs mentioned in para. 4.1 and instructions on the Purchase Requisition form) are:

4.2.1 DOP 7-1 (this procedure), "Procurement Planning." This DOP describes the actions necessary to accomplish the planning of a procurement. This procedure should be used PRIOR to filling out the Purchase Requisition form.

4.2.2 DOP 4-1, "Procurement Document Requirements." This DOP specifies the content required in Purchase Requisitions (PRs) and the reviews and approvals required of these PRs.

4.2.3 DOP 4-2, "Changes to Procurement Documents." This DOP specifies the actions necessary to plan and initiate changes to existing procurement documents via the Purchase Requisition Change Notice.

4.2.4 DOP 7-2, "Evaluation for Acceptance of Purchased Items or Services." This DOP specifies the actions necessary to evaluate purchased items or services to determine their conformance to requirements.

5.0 Responsibilities

All activities specified in this procedure are to be carried out by the requester.

6.0 Requirements

6.1 Overall Procurement Planning Process: In general, procurement planning should begin with a clear determination of the items or services to be provided. The process then proceeds through determination of specific technical or performance requirements, the Quality Assurance requirements applicable, reporting requirements and schedule, how to evaluate vendor performance or item acceptability, planning for bid evaluation and, optionally, development of a list of potential bidders. Note that SLI 6600-1, "Acquisition Planning," specifies additional actions applicable to high-cost procurements (over $500,000).

6.2 Commercial, "catalog, off-the-shelf" items. For such items, the procurement planning process consists of the following actions:

6.2.1 Clearly identify the items to be procured. If "equivalent" items will fulfill the need, indicate what constitutes "equivalence."

6.2.2 Determine the method for verifying acceptability of the item. Complete form "QA Requirements for Purchase Requisitions" (NNWSI) Appendix A to indicate what the item is, its QA level and associated WBS, and "Method for Evaluation for Acceptance." Receiving Inspection is the minimum required evaluation. Other methods may be considered; see paragraphs 6.3.5.2.1, 6.3.5.2.2, and 6.3.5.2.4.

6.3 Other Items or Materials and Services. For "non-catalog" items or services the following detailed procurement planning actions must be carried out (see Figure 1 for a graphic representation of this process).

6.3.1 Materials or Services Needed

Determine specifically what materials or services the procurement is intended to provide. This will be the basis for the "Description of Materials/Services" or Statement of Work in the resulting procurement documents. This answers the question, "What is to be done/provided?"

4.3.3 Data Processing

4.3.3.1 This task is accomplished by 7111 Personnel and is described in detail in TP-82 (Section IV and Appendix A). The digitized data is run through a series of programs (SAND87-XXXX). This includes removal of obvious noise spikes, calculation of the power spectra, filtering noise from the data, performing first and second integrations of the data and calculation of psuedo relative velocity response spectra. All information generated during the conduct of this task will be filed in the "Event Data Book".

4.3.4 Data Storage and Retrieval

4.3.4.1 This task is accomplished by 7111 Personnel and is described in TP-82 (Section V and Appendix A). The detailed storage procedures are contained in TP-89. In addition, 7111 Personnel will perform the necessary activities to make backup copies of the digitized data and keep detailed records to ensure that contents of the various digitized data tapes are fully known.

4.4 Records Control

4.4.1 DRMS Data-Set ID Assignment

The file guide portion of the Data-Set ID assignment for this work is F08.

4.4.2 Records Transmittal

4.4.2.1 The records generated in this work consist of two distinct groups. The first group consists of records that will be forwarded to the 6311 PI for insertion into the DRMS in Department 6310. The records in this group consist of an annual listing of all data in the WTSI data base, microfiche listing of the contents of the digitized data tapes and written verification from the 7111 PI that all other experiment records are complete and archived in the Division 7111 archives. The second group consists of records that are to be maintained in Division 7111. This group consists of analog data tapes, digital data tapes, field data records and all paper data records produced from the digital data tapes. The procedures which discuss storage of these records are given in TP-89. This

6.3.2 Technical or Performance Requirements

Given the specific materials or services to be procured, identify or develop the applicable technical or performance requirements. This may be done by either:

- Developing the requirements and standards that the requester wishes to impose, when no other standards exist.

- Selecting the applicable and appropriate specifications, drawings, design or site investigation bases, regulatory requirements, or standards.

This answers the question, "How well or to what extent is the work to be done or what technical constraints are there on the product?"

6.3.3 Quality Assurance Requirements

Determine the QA requirements that are either necessary, appropriate, or desirable for the procurement. These requirements will be primarily based on the nature of the item or service and the QA Level of the item or WBS task with which the procurement is associated. The form "QA Requirements for Purchase Requisitions (NNWSI)" can serve as a worksheet for developing these QA requirements. (This form must be completed to accompany the Purchase Requisition itself, see DOP 4-1.) When available, Generic Procurement Quality Requirements for such activities as laboratory data collection, design, and software development may be utilized to specify QA requirements. Specific QA requirements include:

6.3.3.1 Contractors for QA Level I or II procurements will be required to have a documented QA Program consistent with the SNL NNWSI QA Program and appropriate to item or service being procured. Such QA Program documents must be reviewed and approved by SNL prior to initiation of activities specified by the contract.

6.3.3.2 Contractor personnel participating in QA Level I activities are to be certified as being qualified, in accordance with DOP 2-6, prior to initiation of work. Contractor personnel whose activities are considered to affect the quality of NNWSI Project product will be required to complete a NNWSI Familiarization Program per QAP 2-5.

6.3.3.3 Contractors will be required to extend appropriate QA Program requirements to sub-tier contractors.

6.3.3.4 Procurement documents will specify contractor's responsibilities for recording and reporting nonconformances and SNL authority for approving disposition of nonconformances.

5.6 Set-up and Adjustment TM Control Box (PFTU) -- TP-87 - This TP lists the procedures necessary to set-up and adjust the PFTU control box. TBD

5.7 Ground Motion Gage Operation Verification -- TP-88 -- This TP list the procedures necessary to verify the satisfactory operation of the ground motion gages in conjunction with the entire measurment system prior to installation in the ground. TBD

5.8 Procedures for Storing and Retrieving UNE Ground Motion Data Used for the NNWSI Project -- TP-89 -- This TP lists the procedures used in storing and retrieving the ground motion data obtained for the NNWSI project. TBD

6.0 References of SNL NNWSI QA Documents

6.1 DOP 2-6, "Qualification and Certification of Project Personnel"

6.2 DOP 6-2, "Reviewing, Approving and Issuing Technical Information Documents"

6.3 DOP 11-2, "Requirements for Experiment and Equipment-Test Logbooks"

6.4 DOP 12-1, "Calibration Program"

6.5 QAP 15-1, "Nonconformance Reporting and Controls"

6.5 QAP 16-1, "Corrective Action Requirements"

7.0 General References

7.1 Sanders, M. L., Description of Ground Motion Data Processing Codes, SAND87-XXXX, In preparation.

unacceptable upon receipt. This method is best used when the items procured are complex, the shipping process itself is complicated due to the nature of the items, or the requester is concerned with critical steps of the vendor's process. This method involves the establishment of one or more Mandatory Hold Points in the vendor's process beyond which they are not to proceed without approval by a Sandia representative (normally the requester). Mandatory Hold Points can be specified in the Statement of Work or the vendor can be required to submit for approval a manufacturing process control document, into which Mandatory Hold Points can be inserted. A minimum of one Mandatory Hold Point is required once the finished product is ready for shipping. At this Mandatory Hold Point, the vendor will be required to perform a final shipping inspection for release of their product(s). This inspection will be closely overviewed by a Sandia representative.

6.3.5.2.2 Certificate of Conformance

In this case, the vendor's signed certification of the acceptability of his product is taken as evidence of that acceptability. This is generally a poor substitute for direct physical inspection or testing, and it will not be used as the only indicator of acceptability by the SNL NNWSI Project. Requiring a Certificate of Conformance can be a means of heightening a vendor's concern for the quality of product he provides to Sandia. When a Certificate of Conformance is called for, the vendor will be required to include the following information:

- a brief description (name) of the procured material,
- reference to the SNL Purchase Order number,
- identification of the specific procurement requirements met by the purchased material or equipment (such as standards, specifications, drawings, etc.), including changes, waivers, or approved deviations to those requirements,
- a signature attesting to the above, of a person responsible for the vendor's quality assurance function, whose function and position are described in their QA Program document.

DOP 7-2 specifies actions necessary to verify adequacy of Certificates of Conformance.

6.3.5.2.3 Receiving Inspection

Receiving inspection to verify acceptability will be accomplished in accordance with DOP 7-2 and SLI 6640-1. These procedures call for final determination of material acceptability to be

Procurement Planning Process

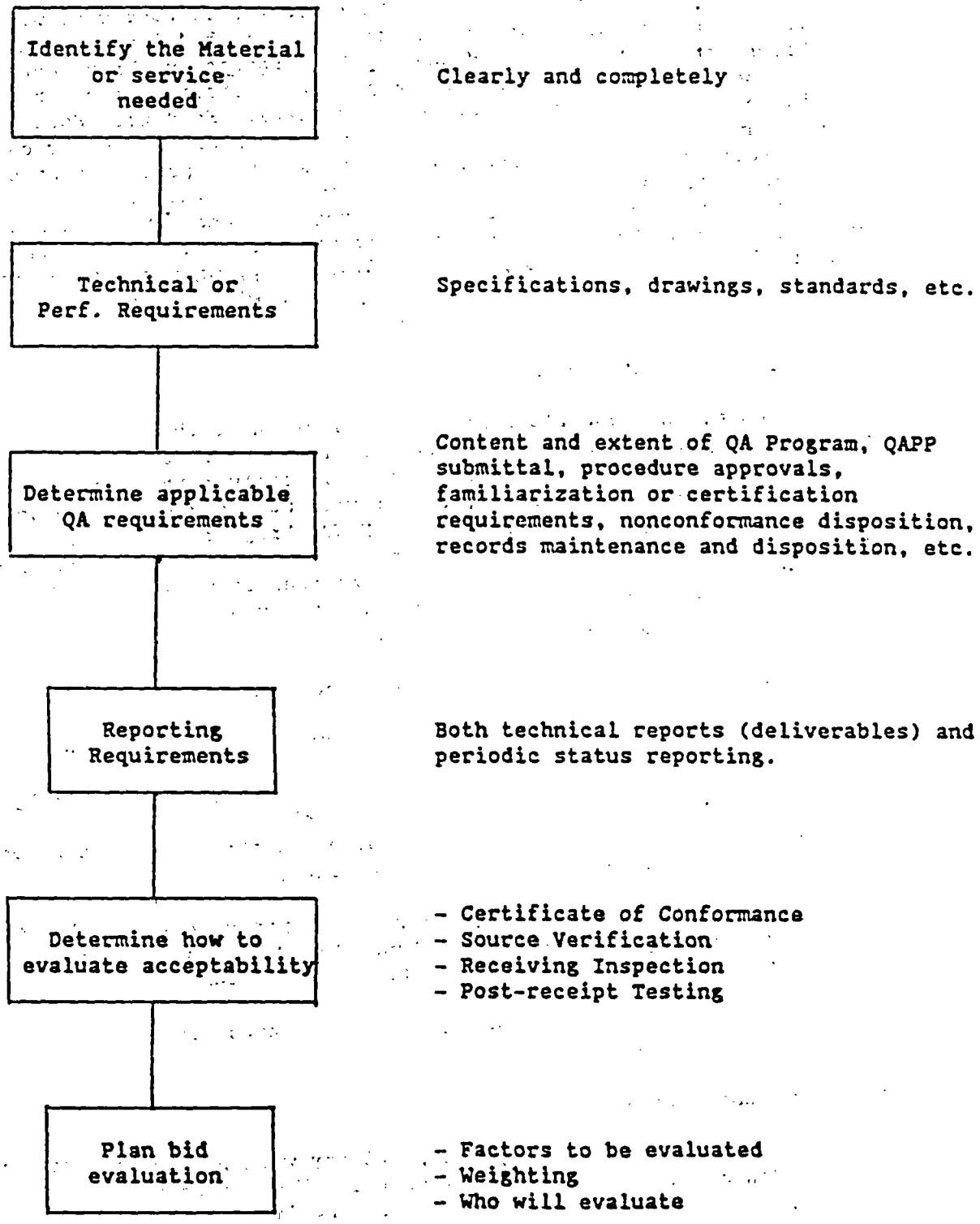

Figure 1

8.0 References

DOP 2-6, Qualification and Certification of Project Personnel

DOP 4-1, Procurement Document Control

DOP 4-2, Changes to Procurement Documents

DOP 7-2, Evaluation for Acceptance of Purchased Items and Services

DOP 11-1, Experiment and Equipment Test Procedure Requirements

QAP 2-5, NNWSI Project Training and Familiarization Procedures

SLI 6600-1, Acquisition Planning

SLI 6640, Approvals Required for Payment of Acquisition

SLI 6640-1, Receipt and Inspection of Material

NVO 196-17, NNWSI Quality Assurance Plan

9.0 Appendices

A. Form "QA Requirements for Purchase Requisitions (NNWSI)"

6.3.3.5 Procurement documents will specify contractor responsibilities for QA records identification, maintenance, safeguarding, and turn-over to this organization.

6.3.3.6 Procurement documents will clearly state acceptability criteria for purchased items or performance criteria applicable to purchased services.

6.3.3.7 Contractors for QA Level I or II procurements will be required to verify and document, prior to offering items or services for acceptance, that the item or service being furnished complies with the procurement requirements.

6.3.4 Reporting Requirements and Schedule

For procurement of services, determine the reports or other deliverable documents to be provided and when they are due. For items or materials, determine when they are to be provided. In either case, determine if periodic status reporting is necessary.

6.3.5 Vendor Performance/Product Acceptance

Given the items or services to be procured and the requirements placed on them, determine the method(s) to be used to determine the acceptability of the product.

6.3.5.1 For services, requester will evaluate the adequacy of performance of the contractor by either:

- technical verification of data produced or
- review of objective evidence, such as the results of the work itself (reports, documents) for conformance to procurement document requirements.

Although feedback concerning this performance should be frequently provided from the requester to the contractor, as well as to the Sandia Contracting Representative (buyer) and the QA Coordinator, final acceptance of services is documented by the requester in accordance with SLI 6640.

6.3.5.2 For items and materials, the following methods for determination of acceptability are available:

6.3.5.2.1 Source Verification

In this case, the acceptability of the product is determined at the vendor's location, thereby avoiding the delays and costs involved in returning items or materials to the vendor if they were found

accomplished by the requester. They also provide for the requester to obtain necessary information to make that determination by designating certain evaluations to be performed by other Sandia organizations by specifying inspection codes (e.g., C for instrument calibration, D for detailed mechanical inspection, etc.). Notes: Code Z must be designated for all QA Level I or II items or materials, unless otherwise designated by the QA Coordinator. This results in a documented receiving inspection report to be made a part of the procurement record. Receiving inspection of Q-List items must be performed by an inspector qualified in accordance with Appendix C of NVO 196-17.

6.3.5.2.4 Post-Receipt Testing

In addition to any of the above methods, performance testing of equipment after its installation or assembly may be used to verify its acceptability. In such cases, test requirements and acceptance documentation will be established, on a case-by-case basis, by the requester, in coordination with the QA Coordinator, vendor, and buyer. Either Equipment Test Procedures, in accordance with DOP 11-1, or vendor-developed check-out procedures would be required.

6.3.6 Bid Evaluation Planning

For procurements which are to be competitively bid, determine how the vendor proposals will be evaluated to determine the vendor to be selected. This may include factors to be evaluated, weighting of the factors, and the personnel to perform the evaluation. For QA Level I procurements, the QA Coordinator will specifically be included in the bid evaluation plan to evaluate bidder's QA programs.

6.3.7 Potential Sources

Develop a list of potential sources for the items or services. (This action is optional, not mandatory.)

7.0 Records Management

The QA Records identified in this procedure, and their Records Management System locations are:

- Completed form "QA Requirements for Purchase Requisitions (NNWSI)" - filed with the procurement documents for the particular contract in the 21 or 22 series.

EVALUATION FOR ACCEPTANCE OF PURCHASED ITEMS OR SERVICES

DOP 7-2

1.0 PURPOSE

1.1 The purpose of this Department Operating Procedure is to define requirements for a system of performing acceptance evaluations and/or inspections of purchased items and services by Department 6310 personnel or other organizations (Purchasing, Shipping & Receiving, etc.) and used in support of the Nevada Nuclear Waste Storage Investigations Project. These measures are intended to ensure that items and services conform to the procurement documents.

2.0 SCOPE

2.1 This DOP applies to all items or services procured via regular purchasing channels and used in support of the NNWSI project, as well as those stock items within the Sandia National Laboratories "Just-in-Time" ordering system. This DOP does not replace or supersede any Sandia National Laboratories Instructions or governing documents related to procurement activities. Criteria noted in this document will be used to ensure that evaluation and/or inspections are made as to the acceptability of purchased items or services used in support of this project.

3.0 DEFINITIONS

3.1 Item: An all inclusive term used in place of any of the following: appurtenance, assembly, component equipment, material, module, part, structure, subassembly, system, unit, and prototype hardware. This term includes magnetic media, and other materials that retain or support data.

3.2 Services: The performance of activities that include, but are not limited to, design fabrication, investigation, inspections, surveillances, audits, etc.

3.3 Supplier: Any individual or organization under contract to provide items or services to Sandia National Laboratories

Appendix A

QA Requirements for Purchase Requisitions (NNWSI)

PR# _____ C/N# _____ Requester _____

Description of Procurement: _____

Commercial, "catalog" item(s)? YES ___ NO ___

WBS # _____ WBS Title _____

WBS Act/Task _____ Act/Task Name _____

QA Level: I ___ II ___ III ___ NQ ___

Rationale: _____

Q-list item? YES ___ NO ___

SNL NNWSI Familiarization Program Required ___ Not Required ___

Vendor's QA Program Requirements:

____ PQR-1 (lab ____ PQR-4 (design services)

____ PQR-2 (field) ____ PQR-5 (analysis)

____ PQR-3 (fabric.) ____ PQR-6 (software)

____ None ____ Other; describe _____

Method of Evaluation for Acceptance:

____ Services-requester evaluates

____ Certificate of Conformance

____ Source (field) Verification (hold points specified?)

____ Receiving Inspection: Code ____

____ Post-Receipt Testing

Requester: _____ QA Coordinator: _____

Date: _____ Date: _____

4.2.2 Source Verification

4.2.2.1 Quality inspections are normally performed at the time the property or material is received. When "at source" is specified on Form SF 6430-RD, "Purchase Requisition" (PR), the inspection is performed before receipt at the supplier's location.

4.2.2.2 The objectives of the source verification shall be stated in the Purchase Requisition (PR) or other contractual agreement, including all necessary parameters as noted by the requester.

4.2.2.3 The requester or designated person responsible for the Quality Assurance function shall perform source verification activities at intervals that are consistent with the importance and complexity of the item or service. Such source verification shall be implemented to monitor, witness, or observe activities related to the material or services procured.

4.2 .4 Identification of individuals providing source verification shall be noted by means of memos, fabricated forms (PR's, etc.), or other contractual documents.

4.2.2.5 Persons who conduct source verification shall do so in accordance with prepared plans to perform these activities at predetermined points.

4.2.2.6 Upon requester acceptance or rejection of items or services during source verification, documented evidence of acceptance or rejection shall be furnished to the receiving destination of the item or service, to the requester or his designee, the Sandia Contracting Representative, and to the supplier.

4.2.2.7 Documentation of all source verification activities, including all deviations from established procedures as established in sections 4.2.2.2 through 4.2.2.6 of this DOP, shall be made using fabricated forms, memos, letters, or by the generation of a Nonconformance report (NCR) per DOP 15-1 (Nonconformance Reporting and Controls) if applicable. All documentation shall be placed in the appropriate contract file maintained by the Department 6310 Financial Assistant, as well as the 20-Series in the SNL NNWSI Records Management System.

4.2.3 Receiving Inspections

WA.880122.0039

SNL NNWSI PROJECT

DEPARTMENT OPERATING PROCEDURE FOR EVALUATION FOR ACCEPTANCE OF PURCHASED ITEMS OR SERVICES

Page	1	2	3	4	5	6	7
Revision	0	0	0	0	0	0	0

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Author: J. T. George, 6313 — Date: 10/1/87

Reviewed by: T. E. Blejwas, 6313, Division Supervisor — Date: 10/1/87

Approved by: R. R. Richards, 6310, QA Coordinator — Date: Oct 5, 1987

Approved by: T. O. Hunter, 6310, Department Manager — Date: 10/5/87

SNL NNWSI DEPARTMENT 6310
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4.4.5.1.3 Code "E" used for the inspection of: development electrical and electronic items and conducted by Org. 7474-3 (Electronic Fabrication).

4.4.5.1.4 Code "X" used for the inspection of: standard items and services, general stores items, and special design test material(s). Inspection of "X" coded items is to be conducted by the requester.

4.4.5.1.5 Code "Z" used for the inspection and assessment of: purchased items or materials to verify quantity and identify as stated in the PR. Inspection of "Z" coded items are to be conducted by Org. 3428 (Shipping & Receiving). Materials and items purchased by Department 6310 and shipped directly to the Nevada Test Site for use in the NNWSI Project will be inspected by Org. 7135 (Field Support and Logistics Division).

4.4.6 Should receiving inspections reveal irregularities concerning, or deviations from, the requirements and procedures listed above, an NCR shall be initiated by the requester and the material shall be withheld from acceptance.

4.4.7 Once the results of the quality inspections referred to above are available to the requester, the requester will make a determination of the acceptability of the item. If the items or materials do not meet procurement document requirements, an NCR will be initiated (as stated in 4.4.6) and resolved. Also, for deviating material, the requester will initiate Sandia Form (SF) 6891-S, "Deviation From Requirements/Return of Warranted Material Report" and forward it to the buyer.

4.4.8 The requester shall see to it that documentation of all receiving inspection activities, including NCR's generated as a result of such activities, be placed in the appropriate contract file maintained by the Department 6310 Financial Assistant, as well as the 20-Series in the SNL NNWSI Records Management System.

4.5 Post-Receipt Testing and Acceptance

When post-receipt testing and acceptance is used, the post-receipt test requirements and acceptance documentation shall be established mutually by both the purchaser or his designee and the supplier.

4.5.2 Post-receipt testing and acceptance activities shall be conducted in accordance with parameters established in the

in support of NNWSI Project activities. Synonymous with "contractor."

3.4 Requester: The individual who initiates a procurement, either for items and/or services, via a Purchase Requisition. (Sandia Form (SF) 6430 - RD "Purchase Requisition" (PR).

4.0 REQUIREMENTS AND PROCEDURES

4.1 Methods used to accept an item or related service from a supplier shall be any one or combination of the following: certificate of conformance, source verification, receiving inspection or post-receipt testing and acceptance. Requirements and procedures applicable to these methods of acceptance and/or inspection are as follows:

4.2 Certificate of Conformance

4.2.1.1 When the PR specifies a certificate of conformance is to be provided by the supplier, the following minimum criteria shall be checked by the requester upon receipt of the document and item or service.

- The certificate identifies specific procurement requirements met by the purchased material or equipment such as codes, standards, or other specifications. This may be accomplished by including a list of the specific requirements or by providing at the point of receipt, a copy of the purchase order and the procurement specifications or drawings, together with suitable approved changes, waivers, or deviations applicable to the subject material or equipment.

- The certificate is attested to by a person who is responsible for this Quality Assurance function and whose function and position are described in the supplier's QA program.

4.2.1.2 The requester shall see to it that documentation of all activities conducted in the acquisition of a certificate of conformance, including deviations from criteria established in section 4.2.1.1 above, be placed in the appropriate contract file maintained by the Department 6310 Financial Assistant, as well as the Department 6310 NNWSI Data Records Management 20-Series files.

5.3 It is the responsibility of the requester to determine the acceptability of items and services procured in support of the NNWSI Project, by seeing that they conform to the procurement documents, or, if not, that deviations are documented and resolved.

5.4 Records Management

5.4.1 In all cases, the requester shall see to it that records pertaining to the acceptance of items or services procured in support of the NNWSI Project, including: receiving reports, Nonconformance Reports, fabricated forms or memos pertaining to such practices as set forth in this DOP or other governing document be placed in the 20-Series in the SNL NNWSI Records Management System.

6.0 REFERENCES

Sandia Laboratories Instruction (SLI) 6640-1 "Receipt and Inspection of Property and Materials"

Sandia Laboratories Instruction (SLI) 6640-2 "Receipt of Services"

Sandia Form (SF) 6430-RD "Purchase Requisition" (PR)

Sandia Form (SF) 6891-S "Deviation from Requirements/ Return of Warranted Material Report"

Sandia Form (SA) 9511-L "Invoice Action"

DOP 4-1 - "Procurement Document Requirements"

DOP 7-1 - "Procurement Planning"

DOP 11-1 - "Experiment - Equipment Test Procedures"

DOP 15-1 - "Nonconformance Reporting & Controls.

4.4.1 When receiving inspections are used, purchased items shall be inspected as necessary to verify their conformance to specified requirements, by taking into account source verification, audit documentation and the demonstrated quality performance of the supplier.

4.4.2 Receiving inspections shall be performed to verify by objective evidence such features as proper configuration; identification; dimensional, physical, and other characteristics; freedom from shipping damage; and cleanliness.

4.4.3 Receiving inspections shall be coordinated with review of supplier documentation when procurement documents require such documentation to be furnished prior to receiving inspections.

4.4.4 When receiving inspections are to be implemented, they will be conducted in accordance with Sandia Laboratories Instruction (SLI) 6640-1 and the following guidelines shall be used.

4.4.5 Inspection codes are included on the PR to specify who should perform the quality inspection for the property or material ordered. When the PR form is not the appropriate means for ordering property or material (i.e., general stores orders, "Just-in-Time" orders, etc.), the requester is responsible for the quality inspection (correct items, correct quantity, freedom from damage, correct operation, etc.).

4.4.5.1 Following are listed the most commonly used inspection codes and organizations performing those inspections for materials or supplies ordered by Department 6310 and used in support of the NNWSI Project.

4.4.5.1.1 Code "C" used for the inspection of: commercial measuring equipment, scales, and laboratory balances. Inspections of commercial equipment are performed by Org. 7243 (Measurement Standards Lab), while scales and balance inspections are conducted by Org. 3424 (Instrument Service/ Equipment Pool), or in certain cases, certified third party vendors.

4.4.5.1.2 Code "D" used for the inspection of: development mechanical items and conducted by Org. 7485-3 (Mechanical Measurements & Calibration).

NNA.880122.0040

SNL NNWSI PROJECT

DEPARTMENT OPERATING PROCEDURES

Sample Identification and Handling Requirements

Page	1	2	3	4	5	6	7	8	9	10	App.1
Rev.	A	A	A	A	A	A	A	A	A	A	A

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equipment test plan per DOP 11-1 (Experiment-Equipment Test Procedures).

4.5.3 Documentation of all post-receipt testing and acceptance activities, including deviations from the established procedures defined in sections 4.5.1 and 4.5.2 of this DOP, shall be placed in the appropriate contract file maintained by the Department 6310 Financial Assistant, as well as the 20-Series in the SNL NNWSI Records Management System.

4.6 Acceptance of Services

4.6.1 In cases involving procurement of services only, such as third party inspections, engineering, and consulting; and installation, repair, overhaul, or maintenance work, the requester shall accept the service by any, or any combination, of the following methods:

4.6.2 Technical verification of data produced.

4.6.3 Surveillance, audit, or both, with regard to the activity.

4.6.4 Review of objective evidence for conformance to the procurement document requirements, such as certifications, stress reports, etc.

4.6.5 Acceptance of services will be carried out in accordance with SLI 6640-2, "Receipt of Services," and documented on Sandia Form (SA) 9511-L, "Invoice Action."

4.6.6 The requester shall see to it that documentation of all activities regarding the acceptance of services, including deviations from the established procedures as referenced in 4.6.1 through 4.6.5 of this DOP, be placed in the appropriate contract file maintained by the Department 6310 Financial Assistant, as well as the 20-Series in the SNL NNWSI Records Management System.

5.0 RESPONSIBILITIES

5.1 The requester and Division Supervisors shall see to it that all requirements of this DOP are observed to the extent necessary to assure an effective program for the acceptance of items and services.

5.2 It is the responsibility of the requester to determine the applicable methods used to accept items or services procured in support of the NNWSI Project.

4.1.2 Samples Originating as a Result of SNL Activities

Procedures for identification of samples originating as a result of SNL activities will be the same as those described in Section 4.1.1 except that assignment of original sample identifications will be performed by the SNL PI or by a designated representative. The requirements for these identifications are listed in Section 5.1.2, with responsibility for the identifications discussed in Section 6.0.

4.2 Sample Handling and Shipping

The procedures for sample handling and shipping are the same regardless of sample origination with the exception that samples collected by an organization other than SNL (or SNL's designated representative) will be handled and shipped according to the procedures of that organization until the time that the sample(s) become SNL's responsibility (i.e., when the sample(s) are in physical custody by the SNL PI or of the designated representative thereof).

Sample handling and shipping will be performed in a manner that will minimize the possibility for damage to, or deterioration of, the samples. If necessary for particular samples, special protective environments (e.g., inert gas atmospheres, specific moisture contents, temperatures) will be provided. Procedures for the creation and/or maintenance of such environments will be written as technical procedures when required, and in such cases will be written before handling or shipping occurs.

Handling and shipping of samples of natural materials will be subject to chain-of-custody requirements, as discussed in Section 5.2.2. The principal procedure associated with these requirements is the maintenance of a custody record for each sample in which the physical location and/or custody of the sample is documented continuously throughout the sample history up to and including disposal.

5.0 Requirements

5.1 Sample Identification

5.1.1 Samples Originating as the Result of Non-SNL Activities

5.1.1.1 Responsibility

Assignment of the sample identification is the responsibility of the organization collecting the sample in association with the SCF. Maintenance of the sample identification throughout the time in which the sample is in SNL custody is the responsibility of the SNL PI or of any personnel handling the sample.

Additional sample collection requirements may be defined in appropriate technical procedures. Such requirements might be the provision of specific sample collection report forms tailored to the specific experiment and type of sample(s).

Once assigned, the sample identification must be maintained throughout the sample history up to and including disposal. If a sample is subdivided, each subsample will retain as part of its identification the original sample identification, with additional unique identification appended as necessary (see Section 5.1.2.3). Documentation linked to individual subsamples will be initiated at the time of creation of the subsamples. After subdivision, all subsamples will be subject to the same requirements as original samples.

Physical identification will be used to the extent possible, either by marks on the sample or by physical attachment of the identification to the sample. The relevant EP or Technical Procedures (TP) will describe procedures to be followed in cases in which physical identification is impractical or would compromise the sample for intended use.

Provisions will be made for the control of sample identification consistent with the planned duration of shipping, handling, and storage. Provisions also will be made for maintenance or replacement of markings and identification records if damage resulting from handling or aging occurs. At no time should physical identification, if used, be obliterated or hidden by surface treatment or coating unless other means of identification are substituted consistent with criteria in this section.

5.1.2.3 Format of Sample Identifications

5.1.2.3.1 Samples in Category (1) of Section 3.0

The format of identifications for samples in this category will be as follows:

kkk mmm-nn-ppp-q-r-s-... .

where:

kkk is the collection locality, which can include drill holes, core holes, shafts, ramps, drifts, outcrops, or surface locations;

mmm is the distance of the sample location from the zero-point of the collection locality (i.e., ground surface for surface-based drill holes, core holes, and shafts; starting points for underground drifts or core holes; etc.);

1.0 Purpose

The purpose of this Department Operating Procedure (DOP) is to state the minimum requirements for identification, handling, shipping, and temporary storage of samples for SNL activities of all QA levels for the NNWSI Project.

2.0 Scope

This DOP defines the requirements for identification, handling, shipping, and temporary storage of samples for the NNWSI Project for periods of time in which SNL staff or contractors thereto are responsible for the samples. Specifically excluded from this DOP are handling and shipping of samples at times when they are the responsibility of the Sample Curatorial Facility (SCF) as well as the initial assignment of sample identifications when samples are collected under technical procedures of the SCF or of other NNWSI Project participants. Also excluded is storage of samples in the SNL NNWSI Core Library, the operation of which is covered by DOP 8-2.

3.0 Definitions

Sample 1) As defined in the SNL-NNWSI-QAPP, Section 8.2.1.1; this category also includes cultural artifacts if pertinent; and

2) Materials used for calibration of, or for calibration checks on, testing apparatuses to be used in support of experiments or equipment tests.

4.0 Procedures

4.1 Sample Identification

4.1.1 Samples Originating at the SCF or Other NNWSI Project Participants

Samples originating at the SCF or with other NNWSI Project participants should arrive at SNL with a sample identification already assigned. Each such identification will be unique, and will either be physically attached to, or marked on, the sample, or alternatively maintained by physical separation, procedural control, or other identification deemed to be appropriate according to the procedures of the SCF or of the other Project participants. Once received by SNL, identifications of individual samples will be maintained throughout processing, testing, and storage up to and including disposal. The Principal Investigator (PI) or other personnel handling the sample(s) will be responsible for maintaining the identifications. Documentation of additions to sample identifications (see Section 5.0) will be initiated by the person making the additions at the time of such additions and will be maintained throughout the subsequent sample history.

MI = mechanical, intact rock;

MF = mechanical, fracture;

TC = thermal conductivity;

TE = thermal expansion;

THC = heat capacity;

HI = hydrologic, intact rock;

HF = hydrologic, fracture;

and y = is an Arabic numeral in sequence beginning with 1.

If for any reason a sample in this category is subdivided, assignment of identifications will use the designators q-r-s-t- etc. as described in Section 5.1.2.3.1.

Assignment of identifications for these samples is the responsibilty of the SNL PI or the designated representative thereof.

5.2 Sample Handling and Shipping

5.2.1 Maintenance of Samples During Handling and Shipping

The requirements for sample handling and shipping are the same regardless of sample origination with the exception that samples collected by an organization other than SNL (or SNL's designated representative) will be handled and shipped according to the requirements of the other organization until such time as the sample(s) become SNL's responsibility (i.e., when the sample(s) is in the physical custody of the SNL PI or of the designated representative thereof).

Provisions will be made that prevent damage or deterioration during sample shipping and handling. When necessary for particular samples, special protective environments such as inert gas atmospheres, specific moisture content levels, and temperature levels will be provided and maintained. Procedures for the creation and/or maintenance of such environments will be written as TPs when necessary, and in such cases will be written before handling or shipping occurs.

Samples of liquids will be contained in non-metallic containers, preferably glass jars with screw-on lids for small quantities and lined 55-gallon drums for larger amounts. These containers should be cleaned before use as sample containers, even if new, including a rinse with distilled water in addition to any other cleaning method employed. Appropriate sample identification will be clearly marked on the exterior

5.1.1.2 Description

Samples originating as the result of activities of organizations other than SNL will arrive at SNL with an identification already assigned. This identification will be maintained throughout the subsequent sample history up to and including disposal. The identification will be traceable to documents including, but not limited to, logs, test records, inspection documents, and nonconformance reports. Additional requirements are the same as those described in Section 5.1.2 with the exception of assignment of original sample identification.

5.1.2 Samples Originating as the Result of SNL Activities

5.1.2.1 Responsibility

Assignment of the sample identification is the responsibility of the SNL PI, or of the designated representative thereof, in association with the SCF. Assurance that the sample identifications are unique will be attained by interaction between the SNL PI and the SCF. Maintenance of the sample identification throughout the time in which the sample is in SNL custody is the responsibility of the SNL PI or of any personnel handling the sample.

5.1.2.2 Description

The first requirement for samples originating as the result of SNL activities is the assignment of a sample identification. This identification will be unique and will be traceable to documents including, but not limited to, logs, test records, inspection documents, and nonconformance reports. In addition, the sample identification will be linked to a sample collection report that will include the following minimum information:

- the Experiment Procedure (EP) number and Revision for which the sample is being collected
- unique sample identification(s) (see Section 5.1.2.3)
- sampling location(s), including map or trench coordinates (if available), hole identification and position within hole (if relevant)
- sampling date and time
- purpose of sampling
- field observations
- references to relevant maps, photographs, or logs
- name and signature of collector

sample changes custody, the transfer will be documented by the signature(s) of the sender and of the receiver together with the date(s) and time(s) of transfer. After each transfer is made and the chain-of-custody form is signed and dated, the form will be photocopied and the copy will be transmitted to the SNL PI for subsequent transmittal to the SNL Data Records Management System (DRMS). (If transfers are sufficiently numerous that more than one page are required to document custody, only the page bearing the most recent signature and date must be photocopied and transmitted at the time of sample transfer.) The original form(s) will remain in the same location as the sample at all times until the sample is subdivided or until final disposal of the sample occurs. In either eventuality, the completed original form(s) will be transmitted to the SNL PI for transmittal to the DRMS.

If a sample needs to be subdivided, a new chain-of-custody form will be initiated for each new subsample, and notation of the new sample IDs will be made on the original form. The original form then will be complete and the original will be returned to its originator.

Samples will remain in appropriate containers at all times other than:

- when being machined,
- when being described for the purposes of post-test interpretation of data,
- when being tested,

or - when being prepared for any of the above.

If a sample is composed of material that could be easily contaminated or replaced (e.g., powder, soil, water, etc.), then the containers will be closed in a manner that will permit determination of unauthorized entry to the containers. For most containers, a gummed paper seal may be used, attached in such a way that the container cannot be opened without breaking the seal. Provisions will be made that the seals will remain intact (if not intentionally broken) for as long as the sample is the responsibility of SNL.

If a container must be sealed, the seal will include, at least, the following information:

- "NNWSI SNL Sample"
- sample identification

nn — is the number of the "sample" taken from location kkk mmm. For this designator, a "sample" could be an individual piece of arbitrary size or could be a collection of pieces within a single container, with the container bearing the nn designator;

ppp — is the organization to which "sample" nn or a subsample thereof is assigned. If "sample" nn is subdivided, then this designator will include an Arabic numeral at the end (e.g., nn-LA13 would indicate that the piece is the 13th piece that Los Alamos has received from "sample" nn);

q-r-s-t-q... — are sequential designators to be used when subdividing samples. The sequence of subdivision is as follows:

q = capital letters in sequence A through Z (and continuing AA through ZZ if necessary);

r = Arabic numerals in sequence beginning with 1;

s = lower case letters in sequence a through z (and continuing aa through zz if necessary);

t = Arabic numerals in sequence beginning with 1.

Any subsequent subdivision would begin with capital letters again and follow the sequence outlined above.

Assignment of designators kkk, mmm, nn, and ppp will be the combined responsibility of the collector of the sample and of the SCF. The SCF will ensure that all designators kkk are unique.

Assignment of designators q and following will be the responsibility of the SNL PI or the designated representative thereof.

5.1.2.3.2 Samples in Category (2) of Section 3.0

The format of identifications for samples in this category will be as follows:

C-SNL-xx-y

where

C indicates calibration-related sample;

SNL indicates that the responsible organization is SNL;

xx indicates the type of test for which the sample will be used, as follows:

DOP 8-1
Rev. A
Appendix 1

NNWSI-SNL Chain-of-Custody Form

Page ____ of ____
Date _____

Sample Number: _____
Sample Originator _____ _____
Printed Name Signature

Relinquished by:		Received by:	
Signature	Date/Time	Signature	Date/Time
Printed Name	Company	Printed Name	Company
Signature	Date/Time	Signature	Date/Time
Printed Name	Company	Printed Name	Company
Signature	Date/Time	Signature	Date/Time
Printed Name	Company	Printed Name	Company

Change of Sample-Container Seal (if applicable)

Seal Removal		Seal Replacement	
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time

If sample is subdivided, numbers of resulting subsamples: _____

of the container in a manner ensuring durability of the marking (e.g., indelible ink, gummed label secured by transparent tape, etc.). Provisions will be made during shipping and handling of glass jars to prevent breakage and resulting loss of samples.

Samples of rocks will be contained in clear plastic jars with screw-on lids (if sufficiently small), in heavy canvas or plastic bags, or in wooden crates. Appropriate sample identification will be clearly marked on the exterior of the jar, bag, or crate in a manner ensuring durability of the marking (e.g., indelible ink, gummed label secured by transparent tape, etc.). Provisions will be made during shipping and handling to prevent breakage of the plastic jars and to prevent damage to samples contained in bags or wooden crates. During shipping and handling, rock samples will not be exposed to any abnormal environmental conditions (e.g., freezing, excessive heat, submersion in liquid, etc.) unless such exposure is specified in a TP that explicitly supersedes this prohibition. Assurance that samples have not been subjected to such abnormal conditions is the responsibility of the SNL PI or the designated representative thereof.

Soil samples will be placed in containers that have been cleaned in the manner described earlier for liquid samples. The nature of the container (e.g., glass, plastic, etc.) will be consistent with the intended use of the sample; if a container of a specific size and composition is required, specification will be made in the appropriate TPs. Additional requirements for shipping and handling of soil samples are as specified earlier for rock samples.

5.2.2 Chain-of-Custody Requirements

The physical location and/or custody of all samples will be documented throughout the sample history from initial collection up to and including disposal. Provisions will be made to minimize the possibility of unauthorized access to samples. The requirements outlined in this section are consistent with practices necessary to ensure chain-of-custody as outlined by various government and law-enforcement agencies (e.g., U.S. Environmental Protection Agency, 1985). Custody of samples obtained as the result of non-SNL activities will be maintained and documented according to the requirements outlined below or those of the originating organization (e.g., the SCF), whichever requirements are more stringent. Selection of the appropriate requirements is the responsibility of the SNL PI.

A chain-of-custody form (Appendix 1) will be initiated by the SNL PI or by a designated representative thereof either when a sample is collected (SNL origination) or when a sample becomes the responsibility of SNL (non-SNL origination). This form will accompany the sample throughout the sample history up to and including disposal. Each time that a

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SNL NNWSI PROJECTS DEPARTMENT
Department Operating Procedure

Experiment and Equipment-Test Procedure Requirements

Page	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	App. 1
Rev	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B

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Seals will be attached to the container at the time that the sample is placed in the container. Each time that a sample is removed from its container and then replaced, a new seal will be attached to the container with the appropriate information as described above. Each time that a seal is broken or replaced, notation will be made on the relevant chain-of-custody form.

6.0 Records Management

6.1 Responsibility

The SNL PI is responsible for ensuring that all records relevant to sample identification and handling as described in Section 6.2 are submitted to the DRMS. A representative designated by the SNL PI also may submit records directly to the DRMS.

6.2 Description

The following records must be submitted to the DRMS by the SNL PI or a designated representative thereof:

- original sample collection report(s)
- original chain-of-custody form(s) and photocopies of the form(s) after each sample transfer
- related nonconformance report(s), if any.

These records must be in a physical form acceptable to the DRMS as specified in DOP 11-3.

7.0 References

Other DOP's to which this DOP relates are the following:

DOP 8-2 Department Operating Procedure for Operation of the NNWSI Core Library

DOP 11-3 Data Records Management System Interaction Requirements

Other references mentioned in the DOP are as follows:

U. S. Environmental Protection Agency, 1985, Update Number II to Test Methods for Evaluating Solid Waste - Physical/Chemical Methods -; SW-846 (Second Edition, Revised).

8.0 Appendices

Appendix 1: Example of Chain-of-Custody Form

1.0 Purpose

The purpose of this SNL NNWSI Project Department Operating Procedure (DOP) is to state procedures for writing, approving, revising, and using Experiment Procedures (EPs) and Equipment-Test Procedures (ETPs). EPs and ETPs state requirements to ensure that work is performed in accordance with written procedures, that all prerequisites have been met, that adequate instrumentation is and used, that work is performed under suitable environmental conditions, and that results are documented.

2.0 Scope

This DOP applies to SNL NNWSI Project EPs and ETPs. Conformance to all sections in this DOP are required when work supports QA Level 1 or 2 activities. EPs and ETPs which support QA Level 3 activities must adhere to as a minimum, the following criteria:

a. Control of revisions, per section 4.2
b. Format, per section 4.3
c. Review and Approval, per section 4.4
d. Safety, per sections 5.4.6.1 and 5.5
e. DRMS Data-Set ID assignment, per section 5.6.1

For Experiment and Equipment-Test activities which are joint efforts between NNWSI Project participants, primary responsibility for format and content of implementing procedures rests with the NNWSI Project Principal Investigator. To meet SNL NNWSI Project requirements, only criteria c, d, and e must be addressed.

In addition, good scientific practice suggests that the method(s) of performing and documenting the work be addressed.

3.0 Definitions

3.1 Activity - A specific data acquisition or sample/site preparation effort, one or more of which comprise an EP or ETP.

3.2 Equipment Test - Data gathering activities which demonstrate that structures, systems, and components perform satisfactorily in service or which determine functional characteristics. These activities include:

- Functional tests (proof tests prior to installation and preoperational tests).
- Operational tests (during repository operation) of structures, systems, and components that are important to safety.
- Prototype qualification tests (including acceptance tests).

3.3 Experiment - Data gathering activities conducted to establish characteristics or values not previously known.

3.4 Experiment and Equipment-Test Procedures - Documents which provide detailed written requirements and provide primary control for implementation. EPs and ETPs may involve more than one activity and may be prepared by contractors, or SNL employees outside of the SNL NNWSI Projects Department, subject to approval per section 4.4 of this DOP.

4.3.2 Each page of an EP and ETP will bear the following header, located in the upper right hand side of the page:

EP or ETP B
REV C
Page #

where:
EP stands for Experiment Procedure and

ETP stands for Equipment-Test Procedure.

where B is:
An Arabic numeral, e.g. 1, which is a unique identifying code assigned by the SNL NNWSI Project Records Management staff.

where C is:
the latest revision, starting with 0 (for "original") and then proceeding alphabetically (A, B, C...). Revisions will be consistent for each page of the EP and ETP, i.e., changes to EPs and ETPs will result in all pages having the latest revision.

4.3.3 If Appendices are included in EPs or ETPs, the page number on the cover sheet will have App. followed by the Appendix designator. Each page of appendices will have a page count with the header, in the form of "page # of #", in addition to the EP or ETP Identifier and Revision.

4.4 Review and Approval Requirements

The persons listed below will review and approve original and subsequent versions of EPs and ETPs and provide a dated signature on their cover sheet.

- The author of the EP and ETP, if different from the PI.
- The PI.
- An Independent Technical Reviewer.
- Other independent Technical Reviewers (as determined necessary by the PI or Division Supervisor of the PI).
- SNL NNWSI Project QA Coordinator, or delegate.
- SNL Division Supervisor of the PI, or delegate.
- SNL NNWSI Project Department Manager
- DOE/WMPO (For version 0 of QA Level 1 ETPs and subsequent revisions of a technical nature only.)

5.0 Content of EPs and ETPs

EPs and ETPs will include but are not limited to:

5.1 General Information

A. Table of Contents
B. Scope - A description of the extent of its application.
C. Definitions - Those items needing a specific description to avoid ambiguity.
D. Objective - The objective of the work, i.e., the type of information that is expected, stated concisely.
E. Reference to applicable EP Study Plan, if any.

TABLE OF CONTENTS

Section		Page
1.0	Purpose	3
2.0	Scope	3
3.0	Definitions	3
4.0	Requirements	4
4.1	Personnel	4
4.2	Control	4
4.3	Format of EP and ETP Cover Sheet	4
4.4	Review and Approval Requirements	5
5.0	Content of EPs and ETPs	5
5.1	General Information	5
5.2	Description of Work	6
5.2.1	Management	6
5.2.2	Experiment and Equipment-Test Configuration	6
5.2.3	Experiment and Equipment-Test Methods	6
5.2.4	Measuring and Operating Equipment	6
5.2.5	Sample Custody and Sample/Site History	7
5.2.6	Sample/Site Preparation	7
5.2.7	Use of Logbooks	7
5.2.8	Analyses	7
5.2.9	Related Experiments and Equipment Tests	8
5.3	Quality Assurance (QA)	8
5.3.1	QA Levels	
5.3.2	Surveillances and QA Audits	
5.3.3	Shipping, Handling and Receiving	
5.4	Operations	8
5.4.1	Prerequisities	9
5.4.2	Postrequisites	9
5.4.3	Technical Procedures	9
5.4.4	Data Acquisition System (DAS)	9
5.4.5	Interactive Procedures	12
5.4.6	Deviations and Changes to Procedures During Use	13
5.5	Safety	13
5.6	Records Control	14
5.7	Data Reports	14
5.8	Personnel Training	14
5.9	Nonconformance/Corrective Action	14
5.10	Acceptance or Rejection of Equipment (Equipment Tests Only)	14
6.0	References	15

5.2.5 Sample Custody and Sample/Site History (if applicable)

1. EPs and ETPs will specify sample/site identifications and require that they (or an accepted cross reference) be utilized during all work. The instructions will ensure that the requirements stated in SNL NNWSI Project DOP 8-1 are met. EPs and ETPs will also describe how activities affecting sample/site history will be performed (or reference appropriate TPs) and documented.

2. EPs and ETPs will address the effects of any prior activities on the sample/site including reference to other EPs, ETPs and TPs which describe those activities.

5.2.6 Sample/Site Preparation

EPs and ETPs will either specify the quantity, dimensions, and tolerances for sample preparation and/or criteria for site preparation, or it will reference any TPs which contain the requirements.

5.2.7 Use of Logbooks

The EP and ETP will require that Logbooks be maintained consistent with the requirements in SNL NNWSI Project DOP 11-2. EPs and ETPs will also define any information to be recorded in addition to those requirements.

5.2.8 Analyses

1. Analyses Supporting Design of Data Gathering Activities

EP and ETPs will briefly describe analyses that are performed to support the design of the data gathering activitiy.

a. Completed Analyses - For analyses that are complete at the time of writing of the EP and ETP, a description or reference to the analyses results will be made so that the reader may evaluate the approach and configuration of the data gathering activity. The interpretation of results with respect to the adequacy of the data gathering design will be addressed, if appropriate.

b. Planned or Ongoing Analyses - For analyses that are planned or ongoing at the time of writing of the EP or ETP, the EP or ETP will state the general requirements of the analyses. The EP or ETP will describe the planned approach to using the results of analyses to verify or modify the data gathering design. When the analytical results are available, EPs and ETPs will be revised to describe the results as prescribed above.

2. Model Validation

For data gathering supporting a model validation activity, EPs and ETPs will briefly describe the model to be validated and the planned use of the data gathering activitiy results in the validation activity. If the general requirements for the data gathering activitiy are stated in a Problem Definition Memo (PDM), EPs and ETPs will reference the PDM.

3.5 Interactive Procedure - Interim procedure used in scoping and preliminary investigations.

3.6 Technical Procedures (TPs) - Detailed implementing procedures that define technical requirements, constraints, and procedural steps in support of EP and ETPs. They may include requirements for measuring devices and other data acquisition equipment. TPs may be prepared by contractors or SNL employees outside of the SNL NNWSI Projects Department, subject to review and approval requirements defined in SNL NNWSI Project DOP 5-2.

4.0 Requirements

4.1 Personnel

4.1.1 It is the responsibility of the SNL NNWSI Project Principal Investigator (PI) to ensure that:

- o EP and ETPs are written for all data acquisition efforts, and to ensure they are written in conformance with this DOP.
- o SNL NNWSI Project Records Management System (RMS) staff are provided a distribution list for controlled issuance.
- o Users of the EPs and ETPs are familiarized, trained and certified in the use of all necessary procedures prior to the conduct of QA Level 1 or 2 work on the EP, and that documentation is provided to the SNL NNWSI Project QA Coordinator and the following SNL NNWSI Project file:

  6310 90/1293/TNG/QA Level, where QA Level is either Q1, Q2, or Q3.

- o A Task Definition Statement (TDS) has been completed and filed in the SNL NNWSI Project RMS prior to work being performed by SNL employees outside of the SNL NNWSI Project Department.

4.1.2 It is the responsibility of SNL NNWSI Project Records Management Staff to maintain unique identifying codes for EP and ETPs, including revisions, and to distribute EPs and ETPs as controlled documents.

4.1.3 It is the responsibility of the users of EPs and ETPs to adhere to the content of them.

4.2 Control

Revisions cannot be made to EPs and ETPs except by the provisions stated in section 4.4 of this DOP.

4.3 Format of EP and ETP Cover Sheet

4.3.1 The format of the cover sheet will follow that of page one of this DOP with "Experiment Procedure" or Equipment-Test Procedure" in place of "Department Operating Procedure", followed by the appropriate title.

3. General

The PI for the data gathering activity and the PI for an associated analyses may be the same individual but, in general, will not. When PIs can not agree on the approaches to related experiment and analytical activities, the division supervisors of the PIs will determine the approaches. In such situations, the supervisor of the data gathering PI will have authority for the data gathering and analyses that support data gathering design and the supervisor of the analysis PI will have authority for analyses and data gathering that support model validation.

5.2.9 Related Experiments and Equipment Tests

EPs and ETPs will describe how their activities relate to other planned or ongoing efforts, including reference to applicable Study Plans.

5.3 Quality Assurance (QA)

5.3.1 QA Levels

QA-Level Assignment(s) consistent with SNL NNWSI Project Work Plans/QALAS will be stated. If the QA Level(s) have not been approved, this information will be stated. If, when QA-Level approval is received from SNL NNWSI Project QA personnel, the level(s) are different from those stated in the EP or ETP, the EP or ETP will be revised prior to the start of work.

5.3.2 Surveillances and QA Audits

EPs and ETPs will specify that the PI reserves the right to perform technical surveillances in accordance with SNL NNWSI Project QAP 10-1, and that the SNL NNWSI Project QA organization reserves the right to perform QA audits.

5.3.3 Shipping, Handling, and Receiving of Items, Materials, and Samples

Shipping and handling of items, materials and samples will conform with the requirements in SNL NNWSI Project DOP 13-1. Specific requirements can be stated in the EPs, ETPs or TPs or under separate cover. For any of these options, the requirements will be transmitted to the necessary persons prior to the respective shipment. When appropriate, the SNL PI may request to be notified if shipped items, materials, or samples have been damaged or impaired so as not to be able to perform their intended function. The request should state any requirements for reporting such problems.

5.4 Operations

EPs and ETPs will specify the procedural steps of the activities and operations to be performed, unless already stated in referenced TPs. Procedures specified in the EP and ETP will be written as a series of steps to be followed in a regular, definite, sequential order and include details of the prerequisites and postrequisites for each operational phase. Prerequisites ensure that critical items and/or conditions will be checked prior to starting a process, while postrequisites ensure that critical items and/or conditions will be checked for completion during the closing down phase of a process. EPs and ETPs will also delineate interaction between other EPs and ETPs and in referenced TPs, and if more than one TP is referenced, between each TP.

5.2 Description of Work

Provide the rationale for the activities to be performed, in sufficient detail to provide reasonable understanding of the technical objectives, unless already provided in the applicable Study Plan. A description of each activity will include the following:

5.2.1 Management

1. State how each activity is going to be performed.
2. List the participants, i.e., the positions that individuals will occupy, their affiliation, and their responsibilities.
3. Define contract numbers and/or TDSs pertaining to activities defined in EPs and ETPs written for work to be performed by person(s) outside of the SNL NNWSI Projects Department.

5.2.2 Experiment and Equipment-Test Configuration

1. A schematic and/or written description of equipment set-up.

5.2.3 Experiment and Equipment-Test Methods

1. Define the parameters (e.g., strain rates, heating rates, confining pressures) for each process, or for individual samples, as necessary.

2. Define the units of measurement to be used during data acquisition.

5.2.4 Measuring and Operating Equipment

1. Define the type of measuring and operating equipment that will be used in the preparation and/or inspection of samples/sites, or acquisition of data. If operating procedures are dependent on the make and model of the equipment, the make and model will be specified in the EP or ETP or a referenced TP. If make and model information is unavailable, an identifier will be assigned to the equipment.

2. Describe experiment events or physical environments that are expected to influence selection of gages and measuring equipment, e.g., anticipated motions that would influence the required range of transducers.

3. Specify (or reference the appropriate TP) the type, range, engineering units, and accuracy of all measuring equipment that will be used to acquire data, taking into account the effect of the physical and test environment on these parameters. If any of these are unknown at the time of EP or ETP preparation, the EP or ETP will state the methods that will be used in their definition and specify the criteria. If the precision (repeatability) of gages and measuring equipment needs to be known, criteria to determine it should be defined.

4. Define calibration requirements for measuring devices, including calibration to nationally recognized standards, operational or calibration checks and the use of standard reference material, consistent with the requirements of SNL NNWSI Project DOP 12-1. This requirement does not apply to EPs and ETPs where the requirements are addressed in referenced TPs.

EPs and ETPs will also delineate interaction between procedures defined in the EPs or ETP and those in referenced TPs, and if more than one TP is referenced, between each TP.

5.4.1 Prerequisites Include Checking that (as applicable):

- Necessary personnel familiarization, training, and certification are complete and that required personnel are available.
- Current revisions of implementing procedures (the EP or ETP, TPs, DOPs, etc.) are being used.
- Any necessary hold points have been defined and that systems are in place to ensure they will be made.
- All equipment/items are present and ready.
- Applicable initial conditions exist, e.g., calibration of instruments, verification of application software, sample identification and custody, preparation of samples and/or sites, use of logbooks, etc.

5.4.2 Postrequisites Include Checking that (as applicable):

- All necessary information has been collected or recorded.
- All sign-offs have been made to logbooks and other records.
- Applicable closing conditions have been taken care of, e.g. post-test calibration check of instruments, etc.
- All samples/sites, standards and data have been identified, custody has been documented, data collected (and prepared for transmittal) and hardcopy records and computer media backups made.
- Provisions exist for the return of items, materials and samples (and excess sample material).

5.4.3 Technical Procedures (TPs)

TPs will be prepared to control data acquisition and sample/site preparation activities supporting EPs and ETPs. EPs and ETPs will contain a list of TPs, even if a TP is not yet written. The list will include the title, scope, unique identifier and a brief description of the TP. When nationally recognized procedures are used in lieu of detailed step-by-step TPs, they will be included as an appendix to the EP and ETP. Minor changes to nationally recognized procedures can be documented in the EP or ETP. Major changes to a nationally recognized procedure will be documented by the writing of a TP per SNL NNWSI Project DOP 5-2. When a TP which is referenced in an EP or ETP is revised, no revision of the EP or ETP is required.

5.4.4 <u>Data Acquisition System (DAS)</u>

EPs and ETPs will either contain the requirements defined in this section, or contain reference to TPs and/or other documents in which they are included.

5.4.4.1 <u>Computer Hardware</u>

The description of the data acquisition hardware will include the following:

A. A list and description of all hardware to be used. Hardware will be identified consistent with requirements within SNL NNWSI Project DOP 13-1.

B. Diagram(s) showing the interface between the DAS and measuring equipment and gages used.

C. Assurance that the hardware is compatible with the required measuring equipment and gages (gage output, type of data, and rates of acquisition) and that the hardware and software is compatible. Reference should be made to section(s) of the EP or ETP and any TPs which define the type of data and rates of acquisition.

5.4.4.2 Software

This section defines the requirements for use of application software. Application software is non-operating-system software which supports or controls data acquisition. There is no distinction between commercial and non-commercial software except for proprietary constraints discussed in section 5.4.4.2.6.

5.4.4.2.1 Identification of Application Software

A. Description of Software

Application software used will be described using U.S. Governmnent Form Standard Form 185 (Appendix 1 of this DOP) for submittal to the SNL NNWSI Project Data Records Management System (DRMS). The form will be updated when information contained on it changes. The form may be completed by the SNL PI or by a designee of the PI.

B. Identification

1. Application Software Program Files

Application software program files stored on computer media will bear a label defining the software manufacturer, title, version number and date copied. In cases of non-commercial software, the manufacturer may be the name and affiliation of the originator(s) of the software. This requirement only applies to floppy disks or other computer media which can be separated from the computer hardware. Hard copies of program files must contain the same information as the computer media.

2. Application Software Data Files

Application software data files stored on computer media will bear a label defining the software manufacturer, title, version number, EP or ETP ID and revision, and computer file names containing the data. The EP or ETP logbook must contain a cross reference of file names and sample IDs as well as other information concerning the activity. Hard copies of data files must contain the same information as the computer media.

5.4.4.2.2 Operating Characteristics

The following operating characteristics will be described:

A. The expected rates of and volume of data to be collected, and the engineering units of the data.

B. Provisions for alphanumeric identification of data channels and identification of data (headers and/or trailers on rows and columns). The method of cross reference of channel identification to computer logging files and/or logbooks will be defined.

5.4.4.2.5 Instructions for Use of Application Software

Instructions may take the form of a users manual included in (or referenced by) the EP and/or associated TPs. The instructions may be developed by the users, subject to review and approval by the PI. As a minimum, instructions will include:

A. Installation and users instructions.

B. The function and invocation of each major option.

C. The input data, including formats of individual records and the structure and format of overall input data, names of variables into which the data are read and any units of these data, and any known limits of the input data values.

D. The output data, including any normalization, units, output variable names, graphical capabilities of the software, and the effects of input options on output formats.

5.4.4.2.6 Listings of Application Software

When using non-proprietary software, computer-readable and hardcopy listings of all versions of the software used in the conduct of workwill be transmitted to the SNL PI for inclusion in the DRMS. All computer media will be labeled in accordance with section 5.4.4.2.1.B of this DOP and will be provided in duplicate.

5.4.4.2.7 Errors

The user of the software will report errors discovered in the software or software instructions to both the originator of the software and the SNL PI.

5.4.4.2.8 Computer Media Maintainance

Define the type of computer media used to archive program and data files, including the format of programs and data, definition of the operating system, and requirements for the method and frequency of back-up of computer media.

5.4.5 Interactive Procedures (Experiments only).

This section defines requirements for generating a procedure interactively, i.e., during the time the Experiment is being performed.

5.4.5.1 Applicability of Interactive Procedures

Interactive procedures may only be used when existing procedures are determined to be insufficient to adequately define or control experiments, and it is determined that additional experiments or efforts are necessary to provide such information, or where a review of the results of a process is needed prior to proceeding to the next step.

5.6 Records Control

5.6.1 DRMS Data-Set ID Assignment

The EP and ETP will define the SNL NNWSI Project DRMS Data-Set ID. The PI will use the Data-Set ID in the transmittal of records to the DRMS.

5.6.2 Records Transmittal

EPs and ETPs will define the requirements of format (e.g., hard copy, computer media, microfiche, etc.) content, and frequency of record transmittal from the user of the EP or ETP to the PI (where appropriate). If records are to be provided in a computerized format to the SNL NNWSI Project DRMS, documentation must be provided which defines the number of copies and the requirements for access of the records, consistent with the requirements in section 5.4.4 of this DOP. Due to problems of fading, the EP and ETP should state that thermal and electrostatic paper are not acceptable media for records.

5.7 Data Reports

The EP and ETP will define the number, scope, and the unique identifier(s) of all SNL Letter Reports (SLTR) and SAND Reports. SNL NNWSI Project Records Management staff issue SLTR numbers and the SNL NNWSI Project Publication Coordinator issues SAND Document numbers.

5.8 Personnel Training

In addition to SNL NNWSI Project familiarization and certification, any specific training necessary for implementation of EPs, ETPs and associated TPs will be defined.

5.9 Nonconformances/Corrective Action

A. The EP and ETP will request that the user(s) of the EP and ETP report nonconformances to the PI as soon as possible verbally, and within 5 working days of evidence of the nonconformance. The PI will then document the nonconformance and describe any corrective actions per the requirements of SNL NNWSI Project QAP 15-1.

5.10 Acceptance or Rejection of Equipment (Equipment Tests Only).

For Equipment Tests developed to determine acceptability (proof tests prior to installation, preoperational tests, and operational tests after installation) of repository systems or components important to safety:

- Persons performing Equipment Tests will be qualified according to criteria defined in Appendix C of NNWSI Project QA Plan.

C. Sample, standard reference material, and site identifications will be consistent with that in the EP or ETP and/or sample custody forms.

D. List of equations used in the software. This is only required when verification is only performed using the method in section 5.4.4.2.3.B, and where the equations are not protected by proprietary agreement.

5.4.4.2.3 Verification of Application Software

Application Software Verification is defined as confirmation that it correctly performs the mathematical and logical operations included in the software. One or more of the following three software verification methods (A1, A2, B) must be performed and documented prior to data acquisition. Software verification is considered to be a prerequisite of data acquisition. Therefore, the EP or ETP will define the method of documentation of verification and state that the PI must provide the user of application software written approval of the verification results prior to use of the application software in QA level 1 or 2 activities.

A. Empirical Methods

1. If the transformation performed by the software can be represented by analytic expressions, these expressions will be defined. Input a specific numeric value into the software and compare the output with the corresponding hand calculations corresponding to the equation(s).

2. Perform a calibration check using standard reference materials or input known values from calibrated equipment into the application software.

For both of the above methods, acceptance criteria, in the form of upper and lower bounds will be defined. Verification will be performed for more than 1 point for each mathematical manipulation within the software. If verification is performed using only 1 point for each mathematical manipulation, an explanation will be included. In either case, the input will be within a range consistent with that expected during data acquisition.

B. Descriptive Method

This method of verification involves documentation of the application-software history. The information should show that the specified version of the selected software is appropriate for the intended use. This will be done by documentation that the software has a proven record of performing both qualitatively and quantitatively, the functions expected of it. The documentation should include reference to previous successfull use of the software including any reports and journal articles. The approximate length of time the version of the software being proposed for use has been in service should be defined.

5.4.4.2.4 Validation

Validation pertains to interpretation of data using a model and does not fall under the scope of EPs or ETPs. If data interpretation using models is required, the models must be validated prior to usage, in accordance with SNL NNWSI Project DOP 3-2.

APPENDIX 1

FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

01. Summary date (Yr / Mo / Day)

02. Summary prepared by (Name and Phone)

03. Summary action: New ☐ Replacement ☐ Deletion ☐

Previous Internal Software ID

04. Software date (Yr / Mo. / Day)

05. Software title and revision

06. Short title

07. Internal Software ID

08. Software type: ☐ Automated Data System ☐ Computer Program ☐ Subroutine/Module

09. Processing mode: ☐ Interactive ☐ Batch ☐ Combination

10. Application area — General: ☐ Computer Systems Support/Utility ☐ Scientific/Engineering ☐ Bibliographic/Textual ☐ Management/Business ☐ Process Contr ☐ Other — Specific

11. Submitting organization and address

12. Technical contact(s) and phone

13. Narrative

14. Keywords

15. Computer manufr and model

16. Computer operating system

17. Programming language(s)

18. Number of source program statements

19. Computer memory requirements

20. Tape drives

21. Disk/Drum units

22. Terminals

23. Other operational requirements

24. Software availability: Available ☐ Limited ☐ In-house only ☐

25. Documentation availability: Available ☐ Inadequate ☐ In-house only ☐

26. FOR SUBMITTING ORGANIZATION USE

5.4.5.2 Control of the Interactive Procedure Process

When it has been determined (and documented in the EP or ETP) by the PI that an interactive procedure is necessary, the PI will generate a procedure (containing as much detail as possible) defining the known portions of the process. The procedure will either be included in the EP or ETP, or it will be written and controlled in a manner consistent with TPs. In either case, the procedure will be clearly labeled as an interactive procedure. Documentation requirements for work performed under interactive procedures are the same as that for other procedures, i.e. logbooks and transmittal to the SNL NNWSI Project DRMS with the following addition:

Data gathered using interactive procedures will be clearly marked as to the circumstance of the data collection.

5.4.6 Deviation From and Changes to Procedures During Use

Deviations from EPs, ETPs, and TPs are allowed only under circumstances described in the following subsections. If deviations have an effect on either the quality of the data or on its intended use, documentation of the event(s) will be in accordance with SNL NNWSI Project QAP 15-1.

5.4.6.1 Irretrievable Loss of Data or Unsafe Operation

The EP and ETP may instruct the user that in situations where irretrievable loss of data or an unforeseen unsafe operation will occur if the EP and ETP or referenced TP is followed, justification exists for the user of the procedure to deviate from it. Documentation of the event will be in accordance with SNL NNWSI Project DOP 11-2. If the EP and ETP and/or TP needs revision to reflect changes in future operation, it will be done as soon as resolution of the situation is made, and must be prior to subsequent use of the EP and ETP and/or TP.

5.4.6.2 Typographical Errors

Documentation of typographical errors found at the time of use of a procedure will be documented in accordance with SNL NNWSI Project DOP 11-2. The intent of the word(s) in question will be clarified by the PI, whenever possible, prior to implementation by the user. EPs, ETPs and TPs will be revised prior to subsequent use to correct typographical errors when the intent of the procedure is ambiguous because of the error.

5.5 Safety

Safety should be of primary concern in all aspects of work. Procedures for safe operation of activities (other than those normally encountered in a facility) will either be included in the EPs and ETPs or referenced TPs. In either case, the following unusual safety aspects will be addressed:

A. A description of potential hazards and the means by which the hazards will be eliminated or mitigated.

B. Definition of procedure(s) to handle or mitigate each potentially hazardous situation.

- The provisions of SNL NNWSI Project DOP 14-1 will apply for indication of the accept/reject status of tested equipment before, during, and after testing.
- Acceptance criteria and results of tests will be defined in the EP and ETP for Equipment Tests, except for prototype qualification tests. When prototype qualification tests are performed with the purpose of developing criteria for future acceptance tests, a disposition of acceptance or rejection of the equipment is not required.
- Documentation in the form of sign-off will be generated for indication of acceptance or rejection of test equipment.

6.0 References

- DOP 2-6, "Qualification and Certification of Project Personnel"
- DOP 3-2, "Software Quality Assurance"
- DOP 5-2, "Technical Procedure Requirements"
- DOP 8-1, "Sample Identification and Handling Requirements"
- DOP 8-2, "Operation of the SNL NNWSI Project Core Library"
- DOP 11-2, "Requirements for Experiment and Equipment-Test Logbooks"
- DOP 12-1, "Calibration Program"
- DOP 13-1, "Identification, Handling, Shipping, and Storage Procedures for Items"
- DOP 14-1, "Status Indication of Items"
- QAP 15-1, "Nonconformance Reporting and Controls"
- QAP 16-1, "Corrective Action Requirements"
- NVO 196-17, "NNWSI QA Plan"

1.0 Purpose

1.1 The purpose of this SNL NNWSI Project Department Operating Procedure (DOP) is to establish requirements for format, content, and use of Experiment and Equipment-Test logbooks. Logbooks are maintained to document activities defined in Experiment Procedures (EPs), Equipment-Test Procedures (ETPs) and Technical Procedures (TPs).

2.0 Scope

This DOP is mandatory for documentation of data/information acquired during Quality Assurance (QA) Level 1 and 2 Experiments and Equipment Tests performed in support of the SNL NNWSI Project. Good scientific judgement suggests that this DOP be followed for the maintenance of logbooks used in QA Level 3 Experiments and Equipment Tests. This DOP is supplemental to SNL guidelines pertaining to the use of laboratory notebooks by SNL employees.

3.0 Definitions

Corrective Action: Measures taken to rectify conditions adverse to quality and, where necessary, to preclude repetition.

Deviation: A departure from established procedures.

Documentation: Information that details the conduct of laboratory and/or field experiment/equipment tests.

Nonconformance: A deficiency in a characteristic, documentation, or adherence to procedure that renders the quality of a service, item, or activity unacceptable or indeterminate.

Experiment and Equipment-Test Logbook: A compilation of notes in a log which provides continuity of documentation before, during, and after the performance of Experiments and Equipment Tests.

Unusual Occurrence: A significant, unplanned event that does not meet the definition of nonconformance but is deemed appropriate for reporting.

4.0 Responsibility

It is the responsibility of the SNL NNWSI Project Department Principal Investigator (PI) to see that this procedure is followed. Transmittal and evaluation of logbooks (or copies of logbooks), including any photographs to the SNL NNWSI Project Data Records Management System (DRMS) is also the responsibility of the PI.

INSTRUCTIONS

01. Summary Date. Enter date summary prepared. Use Year, Month, Day format: YYMMDD.

02. Summary Prepared By. Enter name and phone number (including area code) of individual who prepared this summary.

03. Summary Action. Mark the appropriate box for new summary, replacement summary or deletion of summary. If this software summary is a replacement, enter under "Previous Internal Software ID" the internal software identification as reported in item 07 of the original summary, and enter the new internal software identification in item 07 of this form; complete all other items as for a new summary. If a software summary is to be deleted, enter under "Previous Internal Software ID" the internal software identification as reported in item 07 of the original summary, complete only items 01, 02, 03 and 11 on this form.

04. Software Date. Enter date software was completed or last updated. Use Year, Month, Day format: YYMMDD.

05. Software Title. Make title as descriptive as possible.

06. Short Title. (Optional) Enter commonly used abbreviation or acronym which identifies the software.

07. Internal Software ID. Enter a unique identification number or code.

08. Software Type. Mark the appropriate box for an Automated Data System (set of computer programs), Computer Program, or Subroutine/Module, whichever best describes the software.

09. Processing Mode. Mark the appropriate box for an Interactive, Batch, or Combination mode, whichever best describes the software.

10. Application Area.
General: Mark the appropriate box which best describes the general area of application from among:

Computer Systems Support/Utility	Process Control
Management/Business	Bibliographic/Textual
Scientific/Engineering	Other

Specific: Specify the sub area of application, e.g.: "COBOL optimizer" if the general area is "Computer Systems Support/Utility"; "Payroll" if the general area is "Management/Business", etc. Elaborate here if the general area is "Other."

11. Submitting Organization and Address. Identify the organization responsible for the software as completely as possible, to the Branch or Division level, but including Agency, Department (Bureau/Administration), Service, Corporation, Commission, or Council. Fill in complete mailing address including mail code, street address, city, state, and ZIP code.

12. Technical Contact(s) and Phone: Enter person(s) or office(s) to be contacted for technical information on subject matter and/or operational aspects of software. Include telephone area code. Provide organization name and mailing address, if different from that in item 11.

13. Narrative. Describe concisely the problem addressed and methods of solution. Include significant factors such as special operating system modifications, security concerns, relationships to other software, input and output media, virtual memory requirements, and unique hardware features. Cite references, if appropriate.

14. Keywords. List significant words or phrases which reflect the functions, applications and features of the software. Separate entries with semicolons.

15. Computer Manufacturer and Model. Identify mainframe computer(s) on which software is operational.

16. Computer Operating System. Enter name, number, and release under which software is operating. Identify enhancements in the Narrative (item 13).

17. Programming Language(s). Identify the language(s) in which the software is written, including version; e.g., ANSI COBOL, FORTRAN V, SIMSCRIPT II.5, SLEUTH II.

18. Number of Source Program Statements. Include statements in this software, separate macros, called subroutines, etc.

19. Computer Memory Requirements. Enter minimum internal memory necessary to execute software, exclusive of memory required for the operating system. Specify words, bytes, characters, etc., and number of bits per unit. Identify virtual memory requirements in the Narrative (item 13).

20. Tape Drives. Identify number needed to operate software. Specify, if critical, manufacturer, model, tracks, recording density, etc.

21. Disk/Drum Units. Identify number and size (in same units as "Memory"—item 19) needed to operate software. Specify, if critical, manufacturer, model, etc.

22. Terminals. Identify number of terminals required. Specify, if critical, type, speed, character set, screen/line size, etc.

23. Other Operational Requirements. Identify peripheral devices, support software, or related equipment not indicated above, e.g., optical character devices, facsimile, computer-output microfilm, graphic plotters.

24. Software Availability. Mark the appropriate box which best describes the software availability from among: Available to the Public, Limited Availability (e.g.: for government use only), and For In-house Use Only. If the software is "Available", include a mail or phone contact point, as well as the price and form in which the software is available, if possible.

25. Documentation Availability. Mark the appropriate box which best describes the documentation availability from among: Available to the Public, Inadequate for Distribution, and For In-house Use Only. If documentation is "Available", include a mail or phone contact point, as well as the price and form in which the documentation is available, if possible. If documentation is presently "Inadequate", show the expected availability date.

26. For Submitting Organization Use. This area is provided for the use of the organization submitting this summary. It may contain any information deemed useful for internal operation.

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e. Data or reference to any data recorded elsewhere including type of observation (if not stated in procedures defined in 5.1.1.a).
f. Deviation(s) from EP or ETP and TPs.
g. Notation of unusual occurances or unexpected results.
h. Nonconformances and corrective action efforts (successful and unsuccessful) keyed to the unusual occurrence or nonconformance.
i. Dates and reasons for significant Experiment or Equipment-Test downtime or delays (covering gaps as appropriate).
j. Name(s) of person(s) performing Experiment or Equipment Test and making entry (printed and signed, including date and time).

5.1.3 The following entries are required for Equipment Tests that are defined as acceptance/rejection tests in the ETP. Entries are made by the PI, or designee of the PI.

a. Indication of acceptance or rejection of the equipment, as measured against performance criteria defined in the ETP.
b. Name of the individual making the evaluation (printed and signed; including date and time).

5.2 Method of Logbook Entry

The required method of recording logbook entries is by means of black, indelible ink with the exception of colored entries as specified in section 5.1.1.e of this DOP.

5.3 Corrections to Logbook Entries

Entries in existing logbooks that are incorrect may be corrected by providing the following documentation in the logbook:

- Draw a single line through the incorrect entry (without completely obliterating the incorrect entry).
- Insert the correction above or adjacent to the incorrect entry.
- Initials of the person making the correction.
- Date of correction.

6.0 References

DOP 11-1, "Experiment and Equipment-Test Procedure Requirements"
DOP 11-3, "Data Records Management System Interaction Requirements"

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SNL NNWSI PROJECT DEPARTMENT
Department Operating Procedure

Requirements for Experiment and Equipment-Test Logbooks

Page	1	2	3	4
Rev	B	B	B	B

UNCONTROLLED

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SNL NNWSI PROJECTS
DEPARTMENT 6310 OPERATING PROCEDURE

Data Records Management System Interaction Requirements

Page	1	2	3	4
Rev	A	A	A	A

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5.0 Requirements

5.1 Experiment and Equipment-Test Activity Documentation

Experiment and Equipment-Test logbooks may be comprised of either unbound data sheets or bound notebooks or a combination of both (i.e., items not documented on unbound data sheets must be documented in bound notebooks). Each page of unbound data sheets and bound notebooks will be numbered sequentially. In cases where both data sheets and bound notebooks are used, there must be adequate cross reference between the two so that corresponding records are clearly identified. Experiment documentation includes, but is not limited to, sections 5.1.1, and 5.1.2. Equipment-Test documentation includes, but is not limited to, sections 5.1.1, 5.1.2, and 5.1.3.

5.1.1 The following entries are to be made before the start of Experiment and Equipment Tests and whenever changes dictate:

a. Title or identifier and revision of EP or ETP and TPs.
b. Title and version number of application software used in data acquisition or reduction.
c. Activity location (company name, address, building, room, or specific field location).
d. List of items to be used (including traceability information such as manufacturer name and lot number, make, model, serial number, or unique identifier of items traceable to calibration records).
e. Sketch or photographs of equipment hookup, installation, and samples/sites. Photographic media will contain reference to the date the picture was taken and the negative/slide identifier. The subject ID, (e.g., sample/site) will be documented, and as necessary, the location, direction, scale, and time of day the picture was taken. All photographs (B&W and color) and other records which are provided in a color other than black such as colored drawings and field notes, and plots using colored pens will be provided to the DRMS in duplicate.
f. Name of person(s) performing the Experiment and Equipment Test and making entry (printed and signed, including date and time).

5.1.2 The following entries are made to ensure complete documentation of an activity and should be recorded at least daily when work is performed on the activity:

a. Procedure steps worked on or reference to specific section(s) of procedures defined in 5.1.1.a.
b. Item, sample and/or site identification (consistent with EP or ETP and TPs).
c. Equipment settings such as range, gain, heating rate, time base, etc.
d. Observations of conditions (environment, power, etc.) that might affect Experiment and Equipment-Test results.

5.0 Specific Requirements

5.1 The PI will fill out a DRMS Index and Tracking Sheet when revision 0 of an Experiment and Equipment-Test Procedure (EP) is approved and provide it to DRMS staff.

5.2 When information documented on the DRMS Index and Tracking Sheet changes, i.e., activity description, scope, sampling, location, etc., the PI will provide an updated Index and Tracking Sheet to the DRMS staff. The exception is status of progress (planned, ongoing, completed) which is updated quarterly.

5.3 When (EP's) and referenced Technical Procedures (TP) are written or revised, the PI is responsible for coordinating with SNL NNWSI Records Management Staff to ensure that the DRMS is on distribution for the documents.

5.4 Transmittal of records to the DRMS

a. Documentation requested in or generated by implementation of EP's and TP's and data reports are the type of records that are transmitted to the DRMS.

b. Records provided to the DRMS will contain reference to the DRMS data-set ID(s).

c. Records originating from persons outside of the SNL NNWSI Projects Department will be evaluated and accepted by the PI (or designee of the PI). Acceptance is designated "as is" or "as noted" and includes a signed acceptance date. Transmittal of records to the DRMS should be made in stages commensurate with the completion of work. When transmission of record(s) to the DRMS is delayed, the PI is responsible for ensuring that duplicate records are maintained at separate locations.

d. Records which are difficult to reproduce via xerography, e.g., photographic media (negatives, prints and slides) and microfiche, should be provided to the DRMS in duplicate.

e. Thermal and electrostatic paper are not acceptable media for record transmittal to the DRMS due to problems with fading.

1.0 Purpose

1.1 The purpose of this Department Operating Procedure (DOP) is to state the requirements for interaction with the SNL Department 6310 NNWSI Data Records Management System (DRMS).

2.0 Scope

This DOP applies to SNL-sponsored data gathering activities of all Quality Assurance (QA) levels in support of the NNWSI Project.

3.0 Definitions

Data Gathering Activities - work performed as a part of Experiments or Equipment Tests.

Data Records Management System (DRMS) - the 50 series of the SNL Department 6310 NNWSI Record Center, which archives records pertaining to SNL-sponsored data gathering activities in support of the NNWSI Project.

Data-Set Identification (ID) Number - A unique identifier assigned to an individual DRMS data-set notebook. The identifier is based on a file-guide number that designates the type of activity and the sign-off date of revision 0 of the Experiment or Equipment Test Procedure (EP).

4.0 General Responsibilities

4.1 It is the responsibility of the SNL Principal Investigator (PI) to see that the requirements pertaining to initial definition, status updates, and submittal of records stated in this DOP are met.

4.2 It is the responsibility of the SNL 6310 Publication Coordinator to include DRMS Data Set ID's ("in care of" the SNL PI) on distribution of reports whenever DRMS data-set ID's are defined on Department 6310 Manuscript Review Sheets.

4.3 It is the responsibility of the DRMS staff to follow the SNL NNWSI DOP 17-2, which defines operational requirements for the DRMS.

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SNL NNWSI PROJECT
DEPARTMENT OPERATING PROCEDURE

Identification, Handling, Shipping, and Storage Procedures for Items and Material

Page	1	2	3	4
Rev.	0	0	0	0

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5.5 When the PI determines that the data gathering activity is complete (or if the Data Set has been cancelled) the PI will request that the DRMS Records Administrator begin the "closing" process for that DRMS data set (unless the PI requests that the closing process be delayed. In these cases, the PI will document the reason for the delay). The PI shares in the responsibility to close data sets by reviewing comments made by DRMS staff and SNL NNWSI Quality Assurance Coordinator pertaining to the content of the DRMS data set.

6.0 References

DOP 17-2 Data Records Management System (DRMS) Operating Procedure.

4.1.2 Maintenance of identification - The identification will be maintained throughout the period of usage of items and material up to and including disposal. All personnel using, moving, or handling identified items are responsible for maintaining that identification. The identification will be traceable to documents including but not limited to logs, test records, inspection documents, and nonconformance reports. ID markings will be applied or transferred to each part of an item to be subdivided. Surface treatments shall not obliterate or hide the markings without re-marking the item(s).

4.2 Limited Life Items - Items determined to have a limited useful life (e.g., some elastomers and adhesives) will be controlled to preclude their use after expiration of their useful life. This control will be exercised by the individual responsible for the items or material and may be manifested by labeling as to shelf life and periodic checks to remove expired items. Items whose shelf life has expired will not be used.

4.3 Handling and Shipping - In addition to the requirements below, see SLI's 6950 and 6951 concerning the administrative actions necessary to move or ship items. See also DOP 8-1 regarding samples.

4.3.1 Packaging - When necessary for particular items and material, special protective environments designed to maintain the characteristics of the items and material (e.g., inert gas atmosphere, moisture-impermeable coatings, temperature, etc.) shall be specified by the PI or requester and the existence of such environments will be verified by the recipient. Individuals shipping items or materials may confer with Packaging Engineers in the SNL Shipping and Receiving Division for advice on proper packaging. Aspects that may be considered in determining if specific packaging instructions are appropriate include:

- Orientation - must the item be maintained upright, horizontal, etc. during shipment
- Protection from moisture/wetness
- Protection from temperature extremes, such as freezing
- Protection from deceleration/shock

These instructions shall be specified on the "Shipper" form (SF-6951-AE) and/or the "Shipper Continuation Form" (SF-6951-AEA).

4.3.2 Handling - When determined by the PI or requester to be necessary to ensure safe and adequate handling, special handling tools will be utilized by operators certified in their use.

4.3.3 Shipping - The PI or requester, as appropriate, will ensure that items and material will be shipped in a manner that will protect the characteristics or functions of the items and material, as well as the identification.

1.0 Purpose

This Department Operating Procedure (DOP) defines the requirements and methods for identification, shipping, and storage of items and material. The objective of this DOP is to preclude damage, loss, deterioration by environmental conditions, or substitution of items and material.

2.0 Scope

This DOP applies to items or material determined to be important to safety, waste isolation, retrievability, or site characterization in the NNWSI Project when these items or material are the responsibility of the SNL staff and contractors. Instructions herein supplement existing SNL procedures, such as SLI's.

3.0 Definitions

3.1 Items and Material - A term used in place of any of the following: appurtenance, assembly, component, equipment, module, part, sample, structure, subassembly, subsystem or unit. Documents are specifically excluded.

4.0 Procedure

Compliance with this DOP will provide for the identification, packaging, handling, shipping, preservation, and storage of items and material important to safety, waste isolation, retrievability, or site characterization. The PI is responsible for preparing specific instructions for above activities.

4.1. Identification: This section applies only to those items or materials used in QA Level I activities that, by their nature, application, need for traceability or because of codes or specifications applicable to the item or material, require unique identification. However, this section does not apply to samples. (See DOP 8-1.)

4.1.1 For such items or materials, the PI or other individual responsible for the item or material (e.g., requester of purchased material) will devise a unique identifier and apply that identifier to the item or material. Physical identification will be used to the extent possible, either by indelible marks on the items and material or by physical attachment of the identification to the items and material. In cases in which physical identification is either impractical or insufficient, or would compromise the items and material for intended use(s), then physical separation, procedural control or other appropriate identification will be employed.

Status Indication of Items

1.0 PURPOSE

The purpose of this Department Operating Procedure (DOP) is to define requirements for a system of indicating the current status (i.e., present condition) of specific items, whose status must be evident when used in support of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. This DOP also applies to activities that include an organized sequence of actions that must be verified, such that individual verification steps are not by-passed.

This DOP will also define measures intended to ensure that required evaluations or verification activities, of equipment, components, materials, geologic or environmental samples etc., are performed at the time or point of processing defined by the applicable governing document, and that the acceptability of such items or activities has not been compromised. This DOP implements the requirements in Section 14.0 "Inspection and Test Status," in the SNL NNWSI QAPP.

2.0 SCOPE

This DOP applies to specific items and activities (to include laboratory and/or field (in situ) experiments) used or conducted in support of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project by Sandia National Laboratories or its contractors. Criteria noted in this DOP will be used to ensure that the status of such items or activities is known throughout all operations.

Items covered by this DOP are those whose status with regard to specific inspections or tests must be evident before, during, or after the conduct of an activity as defined by procurement, equipment test, experiment or technical procedures.

3.0 DEFINITIONS

3.1 Item: An all-inclusive term used in place of any of the following: appurtenance, assembly, component, equipment, material, module, part, service, structure, subassembly, subsystem, system, unit, sample (geologic or environmental), and prototype hardware.

3.2 Acceptability: The suitability of an item for its intended use, determined by an evaluation of the item for any departure from established baseline characteristics or parameters.

3.3 Verifications: The act or process of confirming or substantiating.

3.4 Evaluation: An objective determination based on selected technical requirements, constraints, and acceptance limits.

4.4 Storage - See SLI 6970 concerning adminstrative actions necessary to place items or materials in storage.

4.4.1 Individuals responsible for items or materials covered by this procedure will ensure that such items placed in storage will be adequately protected to ensure their preservation and functioning. This applies to temporary storage in project work areas as well as long-term storage governed by SLI 6970.

5.0 Records Management There are no specific QA Records called for by this procedure.

6.0 References

SLI 6950, "Shipment and Handcarry of Property and Material"
SLI 6951, "Moving Property and Material"
SLI 6970, "General Storage of Property and Material"
DOP 8-1, "Sample Identification and Handling Requirements"

4.5 Records of the status of items, evaluations, qualifying routines, or verifications shall be maintained through the use of: test logbook notations, segregation of unacceptable items, labeling, stamps, tags, indelible marking pen, or other means deemed appropriate.

5.0 RESPONSIBILITIES

5.1 It is the responsibility of the Principal Investigator (PI) or his designee to determine the quality, degree, and timing of specific tests and/or inspections conducted on items used in support of the NNWSI Project. The PI shall also determine which items require the control expressed in this DOP and designate them in the controlling document.

5.2 It is the responsibility of the Principal Investigator or his designee to see to it that all requirements of this DOP are implemented to the extent necessary in governing documents (e.g., Experiment, Technical, or Equipment Test Procedures) to assure that the current status of designated items is evident in laboratory, field testing, or experimentation. This may include written instructions in those documents to apply or change labels or tags, to make specific logbook entries, to change the physical location of items, or it may involve standard procedures such as DOP 8-1.

5.3 It is the responsibility of the Principal Investigator or his designee to see to it that, for activities requiring verification of a sequence of events (prototype hardware checkout, receiving inspections, etc.), the governing documents (Experiment, Technical, or Equipment Test Procedures) contain adequate controls on the process and that appropriate documentation (logbook entries, data collection forms) is called for.

5.4 It is the responsibility of the SNLA/NNWSI Quality Assurance Coordinator to ensure that appropriate controls for identification of inspection or test status is addressed, as applicable, in the procedures pertinent to activities affecting quality.

5.5 In the event that the current status of an item is found to be either unacceptable or questionable, the Principal Investigator or his designee will evaluate and document the validity of previous inspection, test, or experiment results obtained with the subject device and of items previously inspected or tested. The Nonconformance Report shall be used to initiate this evaluation.

5.6 Any change in an item's status (from unacceptable to acceptable) resulting from a reevaluation for possible inclusion in further testing shall be documented via the Nonconformance Report.

NNWSI 880122.0045

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NNWSI PROJECT

DEPARTMENT 6310 OPERATING PROCEDURE

STATUS INDICATION OF ITEMS

Page	1	2	3	4	5
Rev.	0	0	0	0	0

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3.5 Laboratory Experiments: Experiments normally carried out within the confines of a building or structure specifically identified for experimental studies in science or for testing and analysis.

3.6 Field Experiments: Experiments normally conducted within a region or area in which the effects under study or observation are naturally resident.

3.7 Nonconforming: A deficiency in characteristics, documentation or procedure, making the quality of an item unacceptable or indeterminate.

3.8 Test Logbook: A compilation of records that provides continuity of test documentation during the performance of a test or procedure.

3.9 Segregation: The separation of items from a large group for special treatment or observation, to include the detachment or seclusion of items via removal from the immediate area (physical separation).

3.10 In situ: Occurring in the natural or original position.

3.11 Governing Document: Documents which define or implement procurement activities, equipment tests, experiment or technical procedures and which exercise control, authority, or decisive influence.

Examples of governing documents are: purchase requisitions (RFQ's)(DOPs 4-1 and 7-1), technical procedures (DOP 5-2), experiment or equipment test procedures (DOP 11-1), and engineering drawings (DOP 3-1).

4.0 REQUIREMENTS AND PROCEDURES

4.1 Items, equipment or components (including those in situ) that are to undergo specific tests, or inspections shall be designated in the applicable governing document.

4.2 The quality, degree, timing, and methodologies of specific tests and/or inspections shall be defined in the applicable governing document and shall be consistent with the criticality of the item, allowing continued judgement as to the type and level of evaluation required.

4.3 The applicable governing document will specify the conduct of activities requiring verification of an organized sequence of events (prototype hardware checkout, research and development activities, receiving inspections etc.).

4.4 Items or components subject to evaluation shall be physically marked, tagged, or labeled as to their acceptable condition or, in the unacceptable case, to be so marked as to prevent their inadvertent inclusion in continued testing. All markings used to indicate an item's current status shall be separate and distinct from those used for item identification.

RECORDS MANAGEMENT SYSTEM

1.0 PURPOSE AND SCOPE

1.1 This procedure establishes the method to maintain, safeguard, and retrieve SNL NNWSI Project records and to interface with the NNWSI QA Records Management System and Information Management System. This procedure implements requirements of the SNL NNWSI QA Program Plan, section 17.0 and NNWSI-SOP-17-01 regarding QA records. In addition, this procedure specifies actions to be followed in managing non-quality records.

1.2 The scope of this procedure includes those completed documents generated by SNL and its contractors designated as QA records which provide documentary evidence of SNL NNWSI Project activities or items assigned Quality levels I, II, or III, documents generated in support of or documenting non-quality activities or items, as well as documents received from other NNWSI participants determined by SNL to be needed to maintain the continuity or integrity of an SNL set of records.

2.0 APPLICABILITY

2.1 This procedure applies to all NNWSI Project records, regardless of the QA level designation assigned to such records, generated by SNL and its contractors.

3.0 DEFINITIONS

3.1 Document - Hardcopy of written evidence (report, letter, memorandum, procedure, drawing, or other information) describing, defining, reporting, or certifying activities, requirements, procedures or results pertaining to the NNWSI Project.

3.2 Document Type List - A list of types of QA records identified by QA Procedures (QAPs), Department Operating Procedures (DOPs) and other instructions, which forms the basis for the QARMS data base. The list contains the names of documents which will be processed individually and those which will be processed as a package. (See Appendix A.)

3.3 Information Management System (IMS) - A records management system for receipt and processing of all quality and non-quality project records to be used in the licensing application process.

3.4 Master Index for the SNL Department 6310 NNWSI Records Management System - The structured listing of all SNL Department 6310 NNWSI Project records with designated codes developed for efficient and accurate indexing, data entry and retrieval.

3.5 One-of-a-Kind-Records - QA records for which duplicates do not exist and which cannot be reproduced by xerography or microfilming are considered one-of-a-kind records. These may include photographs, negatives, radiographs, multi-colored maps, map overlays, and laboratory/field notebooks containing material which is not microfilmable.

6.0 REFERENCES

DOP 8-1 - "Sample Identification and Handling Requirements"
QAP 15-1 - "Nonconformance Reporting and Controls"
SNL NNWSI QA PROGRAM PLAN, SLTR 86-0001
DOP 3-1 - "Preparing, Reviewing, Approving and Issuing Engineering Drawings"
DOP 4-1 - "Procurement Document Requirements"
DOP 5-2 - "Technical Procedures Requirements"
DOP 7-1 - "Procurement Planning"
DOP 11-1 - "Experiment and Equipment Test Procedure Requirements"

4.1.1 It is the responsibility of the SNL Department 6310 NNWSI project personnel to ensure the completeness and acceptability of a document as a record (as specified in 5.1.1) according to appropriate procedures (QAPs, DOPs, etc.) and to submit the document to the SNL RMS identified with appropriate index codes from the Master Index. The submission of documents to the SNL RMS will be performed as soon as possible after records completion, not to exceed 30 days.

5.0 PROCEDURE

5.1 Generation of Records - SNL Department 6310 NNWSI project personnel will submit records generated for the NNWSI Project as specified by the applicable specifications, procurement documents, procedures, plans, or other documents. These records or documents are listed in the Document Type List outlined in Appendix A, and may be collected as original documents or as reproduced copies.

5.1.1 SNL Department 6310 NNWSI project personnel will ensure that documents designated as records are completed in permanent, indelible black ink (unless otherwise specified) and will be legible, accurate, complete, reproducible, microfilmable, and appropriate to the work accomplished.

5.1.2 SNL Department 6310 NNWSI project personnel shall identify each document with at least one index code from the Master Index for the SNL Department 6310 NNWSI Records Management System.

5.2 Validation of Records - SNL Department 6310 NNWSI project personnel will ensure the validation of records before submittal to the SNL RMS. Validation of records includes the dating and stamping, initialing or signing of the document by authorized personnel.

5.2.1 Authorized Personnel List - The SNL Records Coordinator will maintain a list by general document categories containing the signature and initials of project personnel authorized to validate records.

5.3 The SNL Records Coordinator will process all records regardless of the quality level designation of the document in the following manner:

5.3.1 Receipt Control and Processing - Documents will be reviewed for meeting requirements stated in 5.1.1 and 5.2 above and will be processed according to steps outlined in Implementing Procedure 1 (see Appendix B). Records processing activities will begin when the RC receives and accepts the records and will continue until the RC completes the transmittal of reproducible records either to the MASSF or to the SNL archival facility and transmits one-of-a-kind records to the MASSF.

5.3.2 QA Records Storage and Protection - The RC will provide dual storage facilities for all reproducible records according to SNL QAPP, Section 17.3.9 and will protect accepted QA records from loss or damage during records processing activities and prior to transmittal to the MASSF and/or to the SNL archival facility.

5.3.2.1 The RC will protect accepted QA records until they are transferred to the MASSF to prevent damage to records from hazards including, but not limited to, fire, water, vandalism, vermin, and extreme fluctuations in temperature and humidity by placing them in binders, folders, or envelopes and storing them on steel shelving or in steel cabinets within an enclosed room which is protected with a fire

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DEPARTMENT OPERATING PROCEDURE

RECORDS MANAGEMENT SYSTEM

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Page	1	2	3	4	5	6	7														
Rev.	0	0	0	0	0	0	0														
APP A	1	2	3	4	5	6	7	8	9	10	11	12	13	14							
	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
APP B	1	2	3	4	5	6	7														
	0	0	0	0	0	0	0														
APP C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
APP D	1	2	3	4	5	6	7	8	9	10											
	0	0	0	0	0	0	0	0	0	0											
APP E	1	2	3	4																	
	0	0	0	0																	

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5.4.7 Ensure that the records sent to the MASSF are completely and correctly processed (see Appendix E) by reviewing the diazo microfilm copies of the QA records filmed by the MASSF.

5.4.8 Document the review and acceptance or rejection of the microfilm by completing the acceptance/rejection portion of the Microfilm Transmittal form (see Appendix D) and returning it to the MASSF. Resolve any microfilm discrepancies with the MASSF through the Records Administrator to obtain acceptable microfilm.

5.5 Correction of Information in Records - Records that are controlled or baseline documents requiring correction shall be corrected in accordance with written procedures that provide for appropriate review or approval by the originating organization. Minor corrections to other documents shall be made by drawing a single line through the information to be changed, writing the change adjacent to the lined through text and initialing and dating by the person authorized to issue such correction. A brief explanation for correction may be placed in the margin when appropriate.

5.6 Safekeeping - Measures to be specified in a separate Department Operating Procedure shall be taken to provide for determination of the loss of or irreparable damage to a record and for the provision of its replacement, restoration or substitution within 90 days following that determination.

5.7 Historical File - The records management staff shall maintain a historical file of all records which are officially revised or superseded, and shall mark appropriate records as superseded, replaced by, etc. and shall add the document title and date of the document which supersedes that record.

5.8 Record Retention Period - All Quality Level I and Quality Level II records shall be retained for the NNWSI Project Record retention period. The NNWSI Project record retention period is defined as lifetime. A lifetime retention period begins when the document is complete and ends at the date the repository has been decommissioned. This covers the time period required for repository siting, site characterization, repository construction, operation and decommissioning. Quality Level III and non-quality records will be assigned retention periods at a later date.

6.0 <u>REFERENCES</u>

6.1 NVO-196-17, NNWSI Quality Assurance Plan.

6.2 NNWSI-SOP-02-01, QAPP Requirements for Participating Organizations and NTS Support Contractors.

6.3 NNWSI-SOP-03-03, Acceptance of Data or Data Interpretation Not Developed Under the NNWSI QA Plan.

6.4 SNL NNWSI QA Program Plan, Section 17.0.

6.7 NWSI-SOP-17-01, Rev 0, NNWSI Quality Assurance Records Management

3.6 Project Records Center (PRC) - The PRC is the physical facility where records-relat-i functions are performed by the WMPO Records Administrator, the NNWSI Records Coordinator, and the Microfilm and Archival Storage Service Facility (MASSF), which collectively process QA records received from the Project participants for the entire NNWSI Project and maintain the NNWSI QA Records Database and file.

3.7 Quality Assurance (QA) Record - A QA record is any completed document that furnishes evidence of the quality of items or activities that affect quality. It must be prepared in accordance with applicable procedures, specifications, or instructions and stamped, initialed, or signed and dated by authorized personnel.

3.8 Quality Assurance Records Management System (QARMS) - The QARMS of the NNWSI Project encompasses the administrative activities performed on completed NNWSI Project QA Records designated as Quality level I and II records. Administrative activities, performed in accordance with NNWSI-SOP-17-01 include specifying the records to be generated by completing the QA records list, validating the records, preparing an index of the records, retrieving the records, identifying the records, retaining the records, and providing for a controlled method of records correction. The QARMS includes resources such as the procedures, computer database, microfilming and archival storage facilities. At SNL, the QARMS is considered to be a subsytem of the SNL RMS.

3.9 Quality Assurance Records Management System Database - A digital record of all indexed NNWSI Project QA Records stored in the NNWSI QA Records Database and file.

3.10 Retention Period - The retention period is the period of the time a record must be kept according to legal, regulatory or NNWSI Project requirements.

3.11 Record - A document or one-of-a-kind item that is listed on the document type list or is given special designation for processing into the records management system for utilization in the licensing application process.

3.12 SNL Records Coordinator - The person or persons (also referred to as the records management staff) charged with the function of developing and/or implementing the activities of the SNL Department 6310 NNWSI Records Management System.

3.13 SNL Department 6310 NNWSI Records Management System (SNL RMS) - Involves the coordination of several data-gathering systems and provides a method for the collection, indexing, storage and retrieval of NNWSI Project records generated by SNL and its contractors.

4.0 <u>RESPONSIBILITIES</u>

4.1 It is the responsibility of the SNL Records Coordinator (RC) to implement the processing of records as outlined in section 5.0 of this procedure.

APPENDIX A

SANDIA NATIONAL LABORATORIES

DEPARTMENT OPERATING PROCEDURE

RECORDS MANAGEMENT SYSTEM

DOCUMENT TYPE LIST

Table of Contents of Appendix A

Page

Documents Indexed Individually A-1

Documents Indexed as Packages A-12

will reduce the possibility of damage to those records which are being processed.

5.3.2.2 The RC will protect QA records from unauthorized access by placing them in a locked area and will monitor the use of that area. In addition, the RC will maintain a list of authorized project personnel and will provide a check-out system, consisting of a logbook and a tickler file, for the utilization of records.

5.3.2.3 The RC will protect one-of-a-kind records by storing them in a two-hour fire rated cabinet which meets NFPA ratings.

5.3.3 Preservation - As stated in Section 5.3.2, records will be stored in binders, folders or envelopes which are placed on steel shelving or in steel file cabinets and placed in a well-controlled environment. In addition, records submitted to the SNL RMS which require special processing, such as radiographs, photographs, and magnetic material will be placed in a two-hour fire rated cabinet as specified in 5.3.2.3. Magnetic material will be kept in appropriate containers.

5.4 Records Processing for the QARMS - The SNL Records Coordinator and other members of the Records Management staff will perform the following activities in support of the QARMS as directed in NNWSI-SOP-17-01 for records assigned a quality level designation of Q1 or Q2:

5.4.1 Develop and maintain a QA Document Type List (see Appendix A) based upon the documents identified in the QAPs and DOPs. Coordinate the addition or deletion of document types with the WMPO Records Administrator or designee.

5.4.2 Collect QA records designated as quality level I or II which are submitted to the SNL RMS.

5.4.3 Attempt to minimize of delays between record completion and storage by training SNL Department 6310 NNWSI project personnel on the submission of records to the SNL RMS.

5.4.4 Perform the following tasks regarding QA records designated as quality level I or II documents: receipt inspection for legibility, identification and retrieval information (see Appendix B), records indexing and information entry into the QARMS Database (see Appendix C), and QA records transfer (both hardcopy and digital indexing information) to the MASSF (see Appendix D).

5.4.5 Maintain the current local QARMS Database and database system codes and tables providing the Records Administrator with any changes as requested (see Appendix E).

5.4.6 Ensure that complete reproducible copies of all QA Records are available prior to transferring them to the MASSF by processing these records into the SNL RMS and filing of the copies in the SNL Records Center. In this way, the RC shall protect documents during shipping and microfilming in accordance with Implementing Procedure 3, "Document and Digital Record Preparation and Transmittal" (see Appendix D).

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Conference/Telecon Notes, Form EPI XVII-3	Part of a Package	PDM Procurement Package Data Set Notebooks Request for Quotation Software Documentation	QAP III-3 EPI XVII-3
Configuration Management System for Development of Software	Individual and/or Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Contract, Purchase Order	Part of a Package	Procurement Package	EPI IV-2
Contractor Internal Review	Individual and/or Part of a Package	Procurement Package	EPI VI-3
Contractor Monthly Report	Part of a Package	Procurement Package	EPI IV-2
Controlled Document Transmittal Form	Individual		DOP 6-1
Core Sample	Individual		QAP II-13 QAP XVII-4
Corrective Action Request	Individual		QAP 16-1
Corrective Action Request Log	Individual		QAP 16-1
Correspondence Not Directly Related to a Contract	Individual		
Correspondence Related to a Contract	Part of a Package	Procurement Package	EPI IV-2
Correspondence - Request for Quotation	Part of a Package	Request for Quotation	EPI IV-2
Cost Estimate Studies	Package	Procurement Package	
Data Collection Notebooks	Individual		Test & Calibration Procedure
Design Calculations -- Records of Verification	Package	DIM Design Package	DOP 3-4 DOP 3-5

7.0 APPENDICES

7.1 APPENDIX A -SNL NNWSI Records Management Document and Package Types

7.2 APPENDIX B -Implementing Procedure 1, Receipt Control

7.3 APPENDIX C -Implementing Procedure 2, Indexing

7.4 APPENDIX D -Implementing Procedure 3, Document and Digital Record Preparation and Transmittal

7.5 APPENDIX E -Implementing Procedure 4, Review of Microfilm and Database Update

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Geophysical Logs, Only those Originated by SNL Personnel	Individual		
Geophysical Surveys, Gravimetric, Magnetic, etc. Only those Originated by SNL personnel	Individual		
Geotechnical Field Test Data, Only those Initiated by SNL Personnel	Individual		
Geotechnical Field Test Reports, Only those Initiated by SNL Personnel	Individual		
Hydrologic Logs	Individual		
IGIS Job Log	Individual		IGIS Proc.
IGIS Product Management Procedures	Individual		
Inspection Reports -- Other	Individual and/or Part of a Package	Procurement Package Data Set Notebooks	EPI VII-4
Inspection Reports -- Receiving/Source	Part of a Package	Procurement Package	EPI IV-2 EPI VI-3 EPI VI-4 EPI VII-4
Lab Data, Index and Tracking Sheets	Part of a Package	Data Set Notebooks	QA XI-13
Lab Experiment Test -- Equipment and Material List	Part of a Package	Data Set Notebooks	QAP XI-13
Lab Experiment -- Equipment and Material Purchase Records	Part of a Package	Procurement Package	QAP XI-13
Letter of Criteria	Part of a Package	Data Set Notebooks	QAP XI-13
Letter of Criteria Amendments	Part of a Package	Data Set Notebooks	QAP XI-13

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Notification of Quality Assurance Audit	Part of a Package	Quality Assurance Audit Report	QAP 18-1
Administrative Procedures Manual	Individual		
Analysis and/or Calculational Study Report (Final Report)	Individual and/or Part of a Package	PDM Data Set Notebooks Procurement Package PDM	DOP 3-3 DOP 2-4 DOP 6-1
Authorization to Proceed Memorandum	Part of a Package	PDM	DOP 3-3
Equipment Test Procedures	Individual		
Test Reports	Individual		
Calibration Records	Individual and/or Part of a Package	Data Set Notebooks Procurement Package	DOP 12-1
Certified Personnel Roster	Individual and/or Part of a Package	Procurement Package	EPI II-1 DOP 2-6 EPI IV-3 EPI IV-4
Change Control Board Records	Individual		
Change Requisitions	Part of a Package	Procurement Package	EPI IV-2
Code Notebooks	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Computer Code Control Procedures, Library Control and Records Retrievability	Individual and/or Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Computer Code Validation	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Conceptual Task Definition	Individual		
Conference Documents Related to a Contract	Part of a Package	Procurement Package	EPI IV-2

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Problem Definition Memo	Individual and/or Part of a Package	PDM	QAP III-3
Procedure Qualifications	Individual		EPI IX-1
Purchase Requisition	Part of a Package	Procurement	EPI IV-2
Quality Assurance Audit	Part of a Package	QA Audit Report	EPI XVIII-1
Quality Assurance Audit Notification Letter	Part of a Package	QA Audit Report	EPI XVIII-1
Quality Assurance Audits of Contractors (by Contractors)	Part of a Package	Procurement Package	EPI VI-3
Quality Assurance Audit Plan	Part of a Package	QA Audit	EPI XVIII-1
Quality Assurance Audit Record of Completion	Part of a Package	QA Audit	EPI XVIII-1
Quality Assurance Audit Replies	Part of a Package	QA Audit	EPI XVIII-1
Quality Assurance Audit Report	Package	QA Audit	EPI XVIII-1
Quality Assurance Audit Schedule	Individual		EPI XVIII-1
Quality Assurance Level Assignment Sheet	Package		SOP 02-02
Quality Assurance Procedures	Individual and/or Part of a Package	Data Set Notebooks Procurement Package Software Documentation	QAP XI-13 QAP IV-1 EPI IV-2 EPI VI-3 EPI VI-4
Quality Assurance Program Plan	Individual and/or Part of a Package	Procurement Package Software Documentation	EPI XVII-1 EPI IV-1 EPI IV-2 EPI VI-2 EPI VI-3 EPI VI-4 EPI XIX-1

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Design Information Memos	Individual and/or Part of a Package	Procurement Package	DOP 6-1
Design Report	Package	Design Package	EPI III-2
Design Review Checklist	Package	Design Package	EPI III-2
Design Review Minutes	Package	Design Package	EPI III-2
Design Review Reports	Package	Design Package	EPI III-2
Deviation from Requirements Reports, Form SA 7571-1	Individual or Package	Procurement Package	
Discrepancy Reporting and Corrective Action System, Software	Part of a Package	Software Documentation	EPI VI-2 XIX-1
Documentation of Software Bugs	Part of a Package	Software Documentation	EPI VI-2 XIX-1
Drawings, Marked Prints, Sketches	Individual and/or Part of a Package	PDM Data Set Notebooks Procurement Package	DOP 3-1 DOP 3-9
Drill Hole Logs, <u>Only</u> those <u>Originated</u> by SNL	Individual		
Design Change Request	Individual		DOP 3-6
Design Change Request Log	Individual		DOP 3-6
Equipment Development Plan	Individual		
Equipment Test Procedures	Individual and/or Part of a Package	Data Set Notebooks Procurement Package	DOP 11-2
Experiment/Equipment Logbook	Individual		DOP 11-2
Exploratory Shaft Plan	Individual		
Familiarization Programs	Individual		DOP 2-5
Engineering Calculation Notebooks	Individual or Package	PDM Design Package	DOP 3-10

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
SAND Report Peer Review	Individual and/or Part of a Package	PDM Data Set Notebooks Software Documentation	QAP VI-2 EPI VI-2 EPI XIX-1
Sandia Letter Report	Individual and/or Part of a Package)	PDM Data Set Notebooks Software Documentation Design Package	QAP III-3 QAP XI-13 EPI III-2 EPI XIX-1
Sandia Letter Report Peer Review	Individual and/or Part of a Package	PDM Data Set Notebooks Software Documentation	QAP III-3 QAP XI-13 EPI III-2 EPI XIX-1
Sealing Plan	Individual		
Serial Number Sheet Form SC 6890-AB or Equivalent	Individual		EPI VII-1
Site Characterization Plan	Individual		
SNL Department 6310 Operating Procedures	Individual		DOP 6-1
Software Problem Report Form	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Software Specification and Design	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Source Code, Paper or Tape	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Standard Lab Instrument Record Form SA 7571-1	Individual		EPI VI-2
Statement of Work	Part of a Package	Request for Quotation	EPI IV-1

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Material Analysis	Individual		EPI VI-3
Modifications to Software	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Nonconformance Report	Individual and/or Part of a Package	PDM Data Set Notebook Procurement Package	QAP I-2 QAP III-3 QAP XI-2 EPI VI-4
Nonconformance Report Log	Individual		SOP 15-01
Experiment or Equipment Test	Part of a Package	Data Set Notebooks	DOP 11-1
PDM Calculations	Part of a Package	PDM	QAP III-3
PDM Change Forms	Part of a Package	PDM	QAP III-3
PDM Correspondence	Part of a Package	PDM	QAP III-3
PDM Data Forms	Part of a Package	PDM	QAP III-3
PDM Letter of Transmittal	Part of a Package	PDM	QAP III-3
Performance Assessment Plan	Individual		
Personnel Certification QA, Form QAP2-6(1)	Individual		DOP 2-6 EPI II-1
Personnel Qualifications (Includes Training Course Certification	Individual and/or Part of a Package	Procurement Package	EPI II-2 DOP 2-6 EPI IV-3
Personnel Training	Individual and/or Part of a Package	Procurement Package Training	EPI II-1 EPI IV-3
Personnel Training Attendance Records	Package	Training Event Package	QAP 2-5

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
SEP Data Base Operations Logbook	Individual		
SEP Data Base Operations Procedures Manual	Individual		
Tuff Data Base Quarterly Review	Individual		
Users Manual -- Computer Code	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Verification of Test Run Results	Part of a Package	Software Documentation	EPI VI-2 EPI XIX-1
Work Plans	Individual		
Work Stoppage Correspondence	Individual		QAP I-3
Work Stoppage Rescinded	Individual		QAP I-3

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Quality Requirements for Purchase Requisition Form	Part of a Package	Procurement	EPI IV-2
Quality Verification Report, Form SA 6890A	Individual		EPI VII-1 EPI VII-4
Reference Information Base Computer Tapes on Design Configurations	Individual		
Reference Information Base Computer Tapes on Performance Assessment Results and Methods and Backups	Individual		
Reference Information Base-Computer Tapes on Site Characterization and Backups	Individual		
Repository Design Plan	Individual		
Request for Design Definition Services, Form SA 5460-5	Individual		EPI III-9
Request for Quotation	Part of a Package	Procurement	EPI IV-2
Request for Quotation Technical Evaluation	Part of a Package	Procurement	EPI IV-2
Return of Warranted Material, Form SF 6891-SW	Individual		
Roster of Qualified Lead Auditors	Individual		EPI II-1
Sample Log	Part of a Package	Data Set Notebooks	QAP XI-2
Sample Preparation Sheets	Part of a Package	Data Set Notebooks	QAP XI-13
Sandia National Laboratories Formal Report -- SAND Report	Individual and/or Part of a Package	PDM Data Set Notebooks Software Documentation Procurement Package	QAP III-3 QAP XI-13 EPI III-2 EPI VI-2 EPI VI-3 EPI VI-4

DOCUMENT TYPE LIST

Documents Indexed in Packages

Description	Contents
Problem Definition Memo	- Problem Definition Memo (PDM) PDM Change Forms - PDM Data Forms - Task Acceptance Memorandum - Authorization to Proceed Memorandum - Conference/Telecon Note - Subcontractor Reports - Correspondence - Letters of Transmittal - Calculations - Study Reports - Peer Reviews - Nonconformance Reports - Test/Analysis Procedures - Drawings, Marked Prints, Sketches

Procurement Package, Purchase Order File	- Storage Inventory and Issuance Record
	- Supplier Inspection Procedure
	- Supplier Inspection Program
	- Supplier Inspection Report
	- Supplier QA Capabilities Evaluation
	- Supplier QA Program Plan
	- Supplier QA Procedures
	- Supplier Test Data
	- Purchase Order
	- Correspondence
	- Change Requisitions
	- Inspection Reports, Receiving/Source
	- Conference Documents
	- Monthly Report
	- Conference/Telecon Notes
	- Contractor Internal Review
	- Drawings, Marked Prints, Sketches
	- Deviation from Requirements Report
	- Personnel Qualifications
	- Personnel Training
	- QA Audit of Subcontractors by Contractors
	- Original Reports
	- Peer Reviews
	- Surveillance Reports
	- Request for Quotation
	- RFQ Technical Evaluation
	  - Correspondence
	  - Statements of Work
	  - Purchase Requisition
	  - Quality Requirements for Purchase Requisitions
	  - Conference/Telecon Notes

DOCUMENT TYPE LIST

Documents Indexed Individually

Description	Index Method	Document Package	Ref Proc.
Supplier Inspection Program	Part of a Package	Procurement Package	EPI IV-2 EPI VI-3 EPI VI-4
Supplier Inspection Procedures	Part of a Package	Procurement Package	EPI IV-2 EPI VI-3 EPI VI-4
Supplier Inspection Report	Part of a Package	Procurement Package	EPI IV-2 EPI VI-3 EPI VI-4 EPI VII-4
Supplier Inventory and Issuance Report	Part of a Package	Procurement Package	EPI IV-2
Supplier QA Capabilities Evaluation	Part of a Package	Procurement Package	EPI IV-2 EPI VI-3 EPI VI-4 EPI VII-65
Surveillance Reports	Individual and/or Part of a Package	Procurement Package Data Set Notebooks	EPI VII-7
Systems Engineering Management Plan	Individual		
Task Acceptance Memo	Part of a Package	PDM	DOP 3-3
Task Definition Statement	Individual		DOP 2-1
Technical Procedures (Experiments, Equipment Test of Sample, Site Preparation)	Individual and/or Part of a Package	Data Set Notebooks Procurement Package PDM	DOP 5-2 EPI VI-3 EPI VI-4
Data Sheets	Part of a Package	Data Set Notebooks Procurement Package	QAP III-3 QAP XI-13 DOP 11-2
Training Summary Sheet	Package	Training Event Package	

APPENDIX B

SANDIA NATIONAL LABORATORIES

DEPARTMENT OPERATING PROCEDURE

RECORDS MANAGEMENT SYSTEM

IMPLEMENTING PROCEDURE 1 - RECEIPT CONTROL

Table of Contents of Appendix B

Page

1.0 PURPOSE B-2

2.0 PROCEDURE B-2

2.1 Receipt Inspection B-2

2.2 Document Acceptance B-3

2.3 Document Rejection B-4

2.4 Preparation of Indexing B-4

Figures

B-1 SNL RMS Transmittal Stamp B-6

B-2 Records Rejection Memo B-7

DOCUMENT TYPE LIST

Documents Indexed as Packages

Description	Contents
Data Set Notebook	- Letter of Criteria (LOC) - Letter of Criteria Amendments - Sample Log - Sample Custody Forms - Sample Call Report - Lab Data Index and Tracking Sheet - Telecons Relating to Data Acquisition/Evaluation Activities - Correspondence - Sample Preparation Sheets (also called Sample Preparation Records, Sample Preparation Data Sheets and Sample Saturation Reports) - Technical Procedure(s) - Experiment/Equipment Test Procedures - Nonconformance Reports - Data Sheets - Equipment and Material List/Purchase Records - Reports - Peer Reviews - Calibration Records - Drawings, Marked Prints, Sketches - Inspection Reports - Surveillance Reports - Test/Analysis Procedures - Calibration Records - Certified Personnel Roster - Equipment Test Procedures - Nonconformance Reports
Design Investigation Memo	- Design Investigation Memo (DIM) - DIM Change Forms - DIM Data Forms - Task Acceptance Memo - Authorization to Proceed Memo - Conference/Telecon Note - Subcontractor Reports - Correspondence - Letters of Transmittal - Calculations - Study Reports - Peer Reviews - Nonconformance Reports - Test/Analysis Procedures - Drawings, Marked Prints, Sketches - Design Report (see DOP 3-5) - Design Review Records (see DOP 3-5) - Calculation Notebook (see DOP 3-5)

2.1.5 Document is completed in black ink, is legible, and is of the highest possible quality to produce a microfilm record copy that is archivally sound and retrievable for its entire retention period (see reference in 2.5).

2.1.6 Document can be processed (that it is not damaged in a manner precluding processing), this includes preparing "slip sheets" (see Appendix D, section 2.2) for items not suitable for microfilming.

2.1.7 Document meets the requirements of the records management system as set forth in the appendices of this DOP.

2.2 Document Acceptance

2.2.1 If the document meets the receipt inspection criteria and is designated as a quality level 1 or 2 record (hereafter referred to as Q1/Q2), the Records Coordinator accepts it and continues processing as follows:

2.2.1.1 Determines whether the document is processed individually or as part of a package. (See Section 2.4 below.)

2.2.1.2 Assigns the next available "RMS number" to the document. (For an explanation of the numbering system, see Section 4.6 of the QA RMS Database User's Guide.)

2.2.1.3 Marks the first page of the document with START stamp and the RMS number. Notes the RMS number in an RMS number assignment logbook. The START stamp indicates the first page to be microfilmed for the microfilm camera operator.

2.2.1.4 Indexes the document per Implementing Procedure 2, "Indexing."

2.2.1.5 Places the document in a protected, secure holding area for temporary storage prior to completion of processing.

2.2.1.6 The RC maintains a sequential log of RMS numbers used to ensure that duplicate RMS numbers are not assigned.

2.2.1.7 If the document is a one-of-a-kind item which cannot be marked with an identifying RMS number (such as a three dimensional object) then the RC affixes a tag or a label showing the RMS number to the item or its container.

2.2.2 If the document meets the receipt inspection criteria and is not designated as a Q1/Q2 record, the RC accepts it and continues processing as follows.

2.2.2.1 Determine whether the document is processed individually or as a part of a package using the Document Type List.

2.2.2.2 Enter document information into QARMS Database as specified in Section 2.1.2 if the document supports a Q1/Q2 document.

DOCUMENT TYPE LIST

Documents Indexed in Packages

Description	Contents
Quality Assurance Audit Package	- Audit Notification Letter - Audit Plan - Audit Checklist - Audit Report - Audit Replies - Audit Record of Completion - Audit Closeout Letter
Software Documentation	- Software Specification - Software Design Document - Source Code (Paper or Tape) - Original Reports - Peer Reviews - Documentation of Bugs - Software Modifications - Software Summary Form, SF 185 - Verification Test Run Results - Code Notebooks - Users Manuals - Software Problem Report Form - Software QA Plan - Software QA Procedures - Configuration Management System (Plan) - Code Validation - Discrepancy Reporting and Corrective Action System - Computer Code Control Procedures - Conference/Telecon Notes
Training Event Records Package (QAP 2-5)	- Training Summary Sheet (Form QAP 2-5()) - Attendance List - Training Plan - Lesson Plan
DOP Review Records	- QA Review Checklist (Form DOP 5-3(2)) - Review Comments
Modified Work Plan	- Modified Work Plan
QA Level Assignments	- QALAS

- Intended for individual reference or distribution.
- The direct output of a WBS sub-level task or it is in response to an action item or is otherwise indicated to be an individual and discrete unit of work.

2.4.3 Documents Processed as Packages - A package is defined as a collection of documents which supports an activity for the issue of a report, study, evaluation or assessment. The documents in the package provide a history of the activity and are more meaningful and useful in the context of the collection than they would be individually. The documents are typically filed and retrieved as a unit. The QA RMS maintains this characteristic by processing documents in the package as a unit.

2.4.4 Additional criteria for determining whether a document will be indexed as a package are listed below. If the document is:

- The backup data which supports a specific report or document.
- A collection of documents that is created, filed or referenced collectively.
- A collection of documents representing raw, backup or supporting data.
- A series of documents recording an activity which takes place over time.

2.4.5 If there is no document type on the list that corresponds with the document, the RC contacts the NNWSI Records Administrator. They together identify a document type, its acronym or code, whether it is processed individually or as a package, and coordinate adding the document type to the QA RMS database.

2.4.6 Continues records processing activities as specified in Appendix C.

2.5 Reference.

2.5.1 AIIM (NMA) MS-23-1983, Practice for Operational Procedures/Inspection and Quality Control of First-Generation, Silver-Gelatin Microfilm of Documents.

Implementing Procedure 1
Receipt Control

1.0 PURPOSE

1.1 This procedure describes how the SNL Department 6310 NNWSI Records Coordinator (RC) receives documents, reviews them for eligibility for processing, and completes their initial indexing.

2.0 PROCEDURE

2.1 Receipt Inspection

2.1.1 The RC receives documents from the SNL Department 6310 NNWSI project personnel and reviews them to ensure the following:

2.1.2 Document contains the required information for indexing as specified below.

- Originator name
- Document identification number (if applicable)
- Document date
- Title or subject
- Document type
- Applicable technical data (for example, instrument serial numbers, stratigraphic unit)
- Quality level
- WBS number
- Index code from the Master Index for the SNL Department 6310 NNWSI Records Management System either on the records stamp (see Figure B-1) of incoming documents or in the distribution listing of outgoing documents.
- The records stamp must contain the initials of the recipient (member of the SNL Department 6310 NNWSI project personnel)and must be dated when accepted or not accepted.

2.1.3 Document is in agreement with transmittal information and is the document designated in the transmittal form and is complete (that all the pages which should be included are included, with attachments, appendices, etc., as indicated in the document).

2.1.4 Document is dated and stamped, initialed or signed, or otherwise authenticated as required by type of document.

RECORDS REJECTION MEMO

Date:

To:

From: SNL Department 6310 NNWSI Records Coordinator

Subject: Receipt Inspection of NNWSI QA Record(s):

_____

_____

We have inspected the enclosed document(s) and determined that it (they) is (are) not acceptable for further processing and inclusion in the NNWSI QA Records (which will be transmitted to the Project Records Center in Mercury, NV) for the reason(s) marked below.

- o Incomplete (pages or attachments missing).
- o Not properly authorized (required signatures, authentication missing).
- o Required transmittal form missing.
- o Incomplete data available for document indexing.
- o Document quality is poor. Will not provide adequate microfilm image.

Please take the appropriate corrective action and return the document to the Records Center. The Records Coordinator is available to assist you in preparing documents for processing.

Figure B-2

2.2.2.3 File according to the index code assigned by the SNL Department 6310 NNWSI project personnel, either as an individual document or as part of a package, into binders and place in the SNL NNWSI Records Center.

2.2.2.4 Use QARMS Database to list incomplete packages and send listings to appropriate SNL Department 6310 NNWSI project personnel to determine accuracy of listings and modifications to expected dates for completion of packages.

2.2.2.5 When packages are complete, enter completion date into QARMS Database.

2.2.2.6 Transmit records to the SNL Archival facility according to the retention schedule developed for records with quality level designations of Q3 and NQ.

2.3 Document Rejection

2.3.1 If the document is not acceptable, the RC documents the reasons for rejection and returns document, transmittal form (if available) and rejection memo (see Figure B-2) to the document sender for corrective action. In some cases it may be possible to correct the document by calling the responsible individual to obtain the missing information, which the RC then uses to correct the document in accordance with Section 5.5 of this procedure.

2.3.2 If the document is not suitable for filming, due to poor document quality, the RC must attempt to find a suitable copy. If no better copy of the document is available, the RC writes the action taken to obtain a better copy on the comments section of the indexing sheet and places the "Best Available Copy" slip sheet in front of the document or marks it "Best Available Copy." (See Implementing Procedure 3, Section 2.2.)

2.4 Preparation for Indexing

2.4.1 After accepting QA Records, the RC determines the document type using the Document Type List and whether to process each document individually, as part of a package, or both.

2.4.2 Documents Processed Individually - The criteria for determining whether a document will be individually indexed are listed below. If the document is:

- A one-of-a-kind item (the storage location of one-of-a-kind items is part of the digital record and consequently there must be a separate index record for each. This is important because the one-of-a-kind items are not suitable for microfilming and thus will not have that location).

- Referenced in a formally published report for which the participating organization is responsible for rocessing.

Appendix C

Implementing Procedure 2
Indexing and Data Entry

1.0 PURPOSE

1.1 This procedure describes how the Records Coordinator (RC) initially indexes documents for entry into the automated Quality Assurance Records Management System Database (QARMS Database) and how the RC performs data entry. Indexing is the process of transcribing pertinent information from accepted documents to index sheets that used as data entry forms. The utilization of these sheets is optional when the person performing data entry activities is familiar with the process. In this case, the data are input directly into the computer QARMS Database as outlined in Section 3.0 of this Appendix.

2.0 PROCEDURE for Indexing

2.1 Indexing

2.1.1 The RC obtains the indexing information from the transmittal form or the document itself and writes it on the index sheets (see Figure C-1) according to the following guidelines:

- o Complete one set of indexing sheets per accepted document type (package or individual).
- o Not all data elements on the indexing sheets will be pertinent to each document type.
- o Complete only as many parts of the form as apply.
- o Sign or initial and date the indexing sheets.

2.2 Index Sheet Types

2.2.1 There are two types of QARMS database index sheets:

- o Package Indexing Sheet, pages 1-6.

  "#PKGS.CRE" - This set of sheets was developed to match the packages.create screen of the QARMS database.

- o Documents Indexing Sheet, pages 1-6.

  "#DOCS.CRE" - This set of sheets was developed to match the documents.create screen.

2.2.2 The RC determines which index sheet to use as follows:

2.2.2.1 Use the "#PKGS.CRE" set of indexing sheets to record data from documents to be indexed as a "package."

SNL RMS TRANSMITTAL STAMP PLACED ON INCOMING DOCUMENTS

```
-----------------------------------------------------------
|Accepted                                   |  No File #  |
| As is: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _|             |
|                                           |             |
|Accepted                                   |             |
|As Noted: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _|_ _ _ _ _ _ _ |
|                                                         |
|Date Accepted: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ |
|                                                         |
|Dept. File 6310 10- _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _|
|                                                         |
|             |        6310 RECORDS FILE        |         |
|---------------------------------------------------------|
|6310 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _|
|                                                         |
|6310 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _|
|                                                         |
|6310 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _|
-----------------------------------------------------------
```

Figure B-1

Screen 3. HOW THE DOCUMENT IS PROCESSED BY THE RECORDS COORDINATOR
Indexing Sheet, pages 4 and 5
Field Numbers 13-23

Screen 4. OTHER DESCRIPTIVE INFORMATION
Indexing Sheet, pages 5 and 6
Field Numbers 13-17

2.4.3 In all cases, the field number of the indexing sheet corresponds to the field number of the data entry screen. More information about each field (data element) is found in the Data Element Dictionary.

2.4.4 #DOCS.CRE Indexing Sheet Fields

Field Number	#DOCS.CRE Indexing Sheet 1 Description "*" - required field, mv - multivalue.
01-05	Leave blank. These fields are automatically completed by the database when the screen is accessed.
06*	Doc Type: A four letter code to indicate the document type. Example: For Audit Report the standard code is QARD (Quality Assurance Record "D"). Note: If indexing a document type for which there are no matching document types on the list, the RC must add a document type. See the User's Guide for the procedure on updating the document type list. Table lookup available.
07*	Doc Date: The date of the document being indexed, in this format: MM-DD-YY, where MM - month; DD - day; and YY - year. Example: 01-05-86. The Data Element Dictionary requires that the date be entered in the following format, Month, Day and Year, separated by hyphens. It will not accept as a valid date anything else. If the document does not have a date, or if the date of the document does not include a day (only month and year) the following conventions are used: No Date: If during receipt inspection the RC has attempted to find the date of a document and has been unsuccessful, use the date of indexing the record. In the comments field note that the date was missing from the record. Month and Year Only: Use the first day of that month. For example, if the document is date "September 1985," index it as "09-01-85." Year Only: Use the first day of that year. Multiple Dates If the document contains several dates, use the most recent date. If this is not acceptable, select which date the organization will use (oldest date, date of most important document, etc.) and always use this date. Be consistent.

APPENDIX C

SANDIA NATIONAL LABORATORIES

DEPARTMENT OPERATING PROCEDURE

RECORDS MANAGEMENT SYSTEM

IMPLEMENTING PROCEDURE 2 - INDEXING AND DATA ENTRY

Table of Contents of Appendix C

Page

1.0 PURPOSE C-2

2.0 PROCEDURE C-2

2.1 Indexing C-2

2.2 Index Sheet Types C-2

2.3 Determining Indexing: Individually or as Package C-3

2.4 Index Sheet Fields C-3

2.4.4 #DOCS.CRE Indexing Sheet Fields C-4

2.4.5 #EPKGS.CRE Indexing Fields C-8

3.0 Procedure for Data Entry C-8

3.1 Enter Data C-8

3.2 Verify Data C-8

Figure

C-1 Indexing Sheet for QA RMS Database #PKGS.CRE C-9

C-2 Indexing Sheet for QA RMS Database #DOCS.CRE C-15

17 Dual Document ID: Another number (other than RMS or Accession number) assigned to the document as a second identifier. For example, if a document is originated by a subcontractor and assigned a number by the subcontractor, then transmitted to a Participating Organization and assigned another number there, the first number is the dual document ID and the second is the document ID.

Field #DOCS.CRE Indexing Sheet 2

18* Document Title: Full text field. Be careful in using abbreviations or acronyms as they can mean different things to different database users. Any abbreviations or acronyms used, must be documented in the Acronym and Abbreviations List, an appendix of the User's Guide. If abbreviations or acronyms are used, supply a "translation" list. For example, NNWSI - Nevada Nuclear Waste Storage Investigations, or SFT - Spent Fuel Test. Be consistent!

19 Vendor ID: A code for vendors, subcontractors, suppliers, or other contractors, if the document was prepared by an organization other than the indexing organization.

20 Purchase Requisition Number: Use for relevant purchase requisition or purchase order number.

21 Contract Number: Same comment as #20.

22* Originating Organization: A two-character code for the Participating Organizations: SL - Sandia National Laboratories, SA - Science Applications, GS - USGS, etc., MV field. Table lookup capability available.

This field and Fields 23-29 are Multi-value fields. There can be many entries in this field. The indexing sheet provides for 4 entries, but the RC is not limited to that in the database.

23* Originator Last Name: The complete last name of the originator, if present. MV field.

24 Originator First Initial: First letter of first name.

25 Originator Middle Initial: First letter of middle name.

26 Receiving Organization: See #22. MV field. Table lookup available.

27-29 See #23-#24 above.

Field #DOCS.CRE Indexing Sheet 3

14* WBS Number: Enter the WBS number in the format "1.2.n.n.a." Don't forget the alpha suffix to the WBS number which identifies the participating organization, if this is applicable. MV field. Table lookup available.

2.2.2.2 Use the "#DOCS.CRE" set of indexing sheets to record data from documents to be indexed as "individual" documents.

2.2.2.3 If any documents are indexed as both, indicate on the "#DOCS.CRE" set of indexing sheets which package it is also indexed under.

2.3 Determining Indexing: Individually or as Package

2.3.1 A "Package" is defined as a collection of documents which supports an activity or the issue (publication) of a report, study, evaluation or assessment. The documents in the package provide a history of the activity and are more meaningful and useful in the context of the package than they would be individually. The documents are filed and retrieved collectively. The QARMS maintains this characteristic by processing documents in a package as a unit.

2.3.2 The criteria for determining whether a document is indexed as a package are:

- o A collection of documents, such as data sheets or raw data, which is created filed and referenced collectively.
- o A collection of documents representing raw, backup or supporting data.
- o A series of documents which document an activity taking place over a period of time (such as daily log sheets).

2.3.3 If the documents do not meet these criteria, they are indexed individually. See Implementing Procedure 1 for further discussion.

2.4 Index Sheet Fields

2.4.1 Following is a description of each field for individual documents and for documents which are a part of packages along with the field number as it appears on the data entry screen, the type of information to be entered, and a description of the field.

2.4.2 There are six pages of indexing sheets, but only four "pages" of the data entry screens in the QARMS Database on the computer. This may cause some confusion when indexing or performing data entry. For example, the four data entry screens categorize the information about a package as follows:

Screen 1. HOW THE DOCUMENT IS IDENTIFIED
Indexing Sheet, pages 1 and 2
Field Numbers 1-29

Screen 2. HOW THE DOCUMENT IS DESCRIBED
Indexing Sheet, pages 3 and 4
Field Numbers 13-18

Field #DOCS.CRE Indexing Sheet 6

14 Instrument/Serial Number: The identification of any instruments that may be noted in the document.

15 Instrument Name: The type or description of the instrumentation used.

16 Abstract: See the comment on use of keywords.

17 Release Date: The date a document can be released outside the participating organization.

18 Review Date: The date a document will be reviewed for possible release outside the participating organization.

2.4.5 #EPKGS.CRE Indexing Fields

The RC completes the #PKGS.CRE indexing sheet in the same manner as the #DOCS.CRE indexing sheet. The one difference is that on #PKGS.CRE page 1, field number 14 is "Indiv. Doc. Acc. No." Leave it blank, as it will be updated automatically if an individual document is linked to a package. The field numbers in the #PKGS.CRE indexing sheet are slightly different than those on #DOCS.CRE, however, they match the data entry field in the database.

3.0 Procedure for Data Entry

3.1 Enter Data

The RC enters (types in) data from the indexing sheets or directly from the accepted documents into the database according to the procedures described in the Section 4.0 of the QARMS Database User's Guide.

3.2 Verify Data

The RC prints a hardcopy report periodically in order to proofread and correct the data. The RC notes any errors (typographic, omission or transcription errors) and corrects them by entering accurate data into the computer. See the User's Guide for instruction on updating or deleting existing records.

The database cannot use the format described above for documents with dates before January 1, 1930. For those documents the year must be entered as 4 digits instead of 2. The format is: MM-DD-YYYY, where MM = the month; DD = the day; and YYYY = the year. Example: 06-05-1929. The RC must contact the Records Administrator to ensure data entry for these documents.

08* RMS Number: The unique, sequential Records Management System number which the RC assigns to each accepted document or package indexed. The RMS format is: AAnnnnnn. For example: WM000027, for the 27th document indexed. The "WM" indicates that this is a document for which WMPO is responsible. The RC keeps track of the numbers assigned in an RMS Number Assignment Log to ensure that the same number is not assigned to two different documents or packages. The database does not allow the same RMS number to be assigned to different documents. However, it does not check for consecutive assignment of numbers.

09 Package Account Number: The accession number of the package in which the individual document is physically located. This field is only completed if the individual document is part of a package. It will not always be completed.

10* Quality Level: Enter "1", "2", "3", "NQ", or "PFC" (prior to final classification, in other words, to be determined). MV field. Table lookup capability available.

11* Page Count: The number of pages of the document. If the document includes pages with information on both sides, the page counts as 2.

12 Sheet: The sheet number of the document (use this for drawings oretches if they are indexed, controlled or revised individually only).

13 Revision ID: The number or letter revision, *e.g., Rev. 1 or Rev. A). Use this only for document types which are controlled by revision issues, for example procedures, drawings, change orders.

14 Revision Type: The type of revision, e.g., "amendment," "addendum," "change order," "interim," etc.

15 Transmittal ID: The number or other identification of the transmittal letter or other device which accompanied the document. Do not confuse this field with the transfer box number field.

16 Document ID: The number of the document if applicable. this number is assigned by the originating or receiving organization. Do not cc· use this number with the RMS or Accession numbers. If applicable, this identifying number will be on the document when it arrives for processing.

18 Doc Title (T): AUDIT REPORT NUMBER 85-21 SITE GEOLOGY ACTIVITIES FOR YUCCA MOUNTAIN

19 Vendor ID:

20 Purchase Req No.:

21 Contract No.:

22 Orig Org (mv):
23 O Last Name:
24 O First Init:
25 O Middle Init:

1) WM JONES J J

2) SA SMITH S S

3) GS JOHNSON J J

4)

Recv Org (mi):
R Last Name:
R First Init:
R Middle Init:

1)

15 Keyword: These fields are included at this time to provide for more complete description of a QARMS record. However, it is recommended that RC's not use the keyword, phrase, or abstract fields, as these require special indexing expertise to complete consistently and correctly. MV field.

Field #DOCS.CRE Indexing Sheet 4

16 Issue Number: The NNWSI Issues Hierarchy number. MV field.

17 Stratigraphic Unit: If there is any pertinent stratigraphic information, write the name of the unit in this multi-value field. MV field. Table lookup capability available.

18 Borehole ID: Enter the borehole (or drill hole) number. MV field. Table lookup capability available.

19 Phrase: See #15 above. MV field.

Field #DOCS.CRE Indexing Sheet 5

14 File Location: Use this to describe the location of the one-of-a-kind (non-microfilmable) items, or of the file copy to be maintained by the participating organization.

15 Transfer Box Number: The number on the box being sent to the MASSF. The format is AA*3nnnn. For example, WM*30001 is the first transfer box number assigned by WMPO and WM*30025 is the twenty-fifth transfer box number assigned.

16 Supercedes Accession Number: Use to record the accession number of the document that is superceded by the document being indexed.

17 Superceded by Accession Number: Leave blank. The database will automatically update this field.

18 Reference Document ID: Use for the document identification (not the accession number) of documents attached to correspondence.

19 Revision ID: The revision of the document in field #18.

20 Revision Date: The revision date of field #18.

21 Comments: This is a full text edited field. The RC enters remarks about the document or its use.

22 Cart/Frame: Leave blank. This field is completed by the MASSF.

23 Storage Box: Leave blank. This field is completed by the MASSF, if applicable.

24 Film Other: Enter the identification of microfilm sent by the RC to the MASSF, if microfilm is sent instead of hardcopy.

15 Issue

(mv) ;

1)	1.1.3
2)	1.1.6
3)	
4)	
5)	
6)	
7)	
8)	
9)	
10)	

16 Stratigraphic Unit

(mv) ;

1)	PAINTBRUSH TUFF
2)	JACKASS FLATS
3)	
4)	
5)	

17 Bore Hole

(mv) ;

1)	
2)	
3)	
4)	
5)	

18 Phrase

(mv)

1)	
2)	
3)	
4)	
5)	

13 File Location: WM-BLDG 100 RM 5

14 Transfer Box No.: WM*30001

15 Supercedes Acc No.: *

16 Superceded By Acc No.: *

DOp 17-1
Rev. 0
Appendix C

Figure C-1

dexing Sheet for QA RMS Database #PKGS.CRE 1

Indexing Org *	WH *
Accession No. *	100001
Rec Stat *	WA
Index Date *	04-16-86
Compl Date *	04-16-86
Doc Type *	QARI
Doc Date (H)	11-05-85
RMS Number (H)	WH000012
Quality Level (H) ;	2
Page Count (H)	52
Sheet	
Revision ID No.	
Revision Type ; (C)	
Index Doc. Acc. No. *	*
Transmittal No.	
Doc ID	85-21
Dual Doc ID (C)	

LEGEND:

* = Automatically completed by database
(H) = Mandatory (required) field, all others are optional
; = Cross-Reference Table Look-Up
(mv) = multi-value field
(C) = conditional
(T) = Full text edited field

ndexing Sheet for QA RMS Database #PKGS.CRE 6

5 Abstract

(T)

3 Release Date

7 Review Date

2)

3)

4)

13 WBS Number

; (mv)

(H)

1)	1.2.3.2.1.1.4
2)	1.2.3.2.1.2.4
3)	
4)	
5)	
6)	
7)	
8)	
9)	
10)	

14 Keyword

; (mv)

1)
2)
3)
4)
5)
6)
7)
8)
9)
10)

Indexing Sheet for QA RMS Database #DOCS.CRE 2

18 Document Title (T): CALIBRATION OF MEASURING DEVICE

19 Vendor ID:

20 Purchase Req No.:

21 Contract No.:

22 Orig Org (MW): 1) WM
23 O Last Name: CLARK
24 O First Init: C
25 O Middle Init: C

2)

3) WM
DAVIS
D
D

4)

26 Recv Org (MW): 1)
27 R Last Name:
28 R First Init:
29 R Middle Init:

17 Reference Doc (mv)
1)
2)
3)
4)
5)

18 Reference Doc Revision ID (mv) (C)
1)
2)
4)
5)

19 Reference Doc Revision Date (mv) (C)
1) - -
2) - -
3) - -
4) - -
5) - -

20 Comments (T)

THIS AUDIT REPORT IS INCOMPLETE. AWAITING RECEIPT OF FINAL AUDIT CLOSEOUT

21 Cart/Frame
22 Storage Box

Leave Blank

23 Film Other

13 Inst Serial No.

14 Instrument Name

Indexing Sheet for QA RMS Database #DOCS.CRE 4

16 Issue No. (mv) ;	1)	1.2.1
	2)	1.5.2.W
	3)	
	4)	
	5)	
	6)	
	7)	
	8)	
	9)	
	10)	
17 Stratigraphic Unit (mv) ;	1)	
	2)	
	3)	
	4)	
	5)	
18 Bore Hole No. (mv) ;	1)	
	2)	
	3)	
	4)	
	5)	
19 Phrase (mv)	1)	
	2)	
	3)	
	4)	
	5)	

Indexing Sheet for UA RMS Database #DOCS.CRE

1

01 Indexing Org *	WM
02 Accession No. *	100012
03 Rec Stat *	UA
04 Index Date *	04-01-86
05 Completion Date *	04-02-86
06 Doc Type * (M) ;	CALA
07 Doc Date (M)	01-07-85
08 RMS Number (M)	WM00002O
09 Package Acc No.	WM*100027
10 Quality Level (M) ;	2
11 Page Count (M)	1
12 Sheet No.	
13 Revision ID No.	
14 Revision Type ; (C)	
15 Transmittal No.	
16 Document ID	WMP001A72-3-1245
17 Dual Document ID (C)	

Legend :

* = Automatically completed by database
(M) = Mandatory (required) field, all others optional
; = Cross-reference Table Look-up
(mv) = Multi-value Field
(C) = Conditional Field
(T) = Full Text Edited Field

Indexing Sheet for QA RMS Database #DOCS.CRE 6

14 Inst/Serial No. DOE-12750

15 Instrument Name MEASURING DEVICE

16 Abstract

(T)

17 Release Date

18 Review Date

2)

3)

4)

14 WBS Number

1) 1.2.6.9.2.3
2) 1.2.1.4
3) 1.2.2.4
4)
5)
6)
7)
8)
9)
10)

15 Keyword

1)
2)
3)
4)
5)
6)
7)
8)
9)
10)

Appendix D

Implementing Procedure 3
Document and Digital Record Preparation and Transmittal

1.0 PURPOSE

1.1 This procedure describes how the RC prepares documents designated as quality level 1 or 2 (Q1/Q2) for microfilming and transmits them to the NNWSI Microfilming and Archival Storage Services Facility (MASSF). The microfilming function is currently assigned to the Holmes & Narver. Engineering Records Library located in Building 310 at the Nevada Test Site, Mercury, NV 89023.

2.0 PROCEDURE

2.1 Transfer Tasks Performed on the QARMS Database

2.1.1 The RC performs data and documents transfer activities to the MASSF and data transfer activities to the PRC. The RC accesses the QARMS Database (see Section 5.0 of the User's Guide for instructions) to perform the following activities:

- o Prints out the "Inventory List" and checks it against the contents of the transfer box to ensure that the actual contents match the "digital" contents of the box.
- o Prints out the "Packing List" for the transfer box to be used as a transmittal device for the documents sent to the MASSF.

2.1.2 Two copies are automatically printed out.

- o Distributes the copies as follows:
  - a) Enclose Copy 1 in the transfer box being shipped to the MASSF.
  - b) File Copy 2.
- o Creates a Transfer Box floppy diskette for transmittal to the MASSF.
- o Sends the diskette separately from the hardcopy QA Records to MASSF in a proper protective floppy diskette mailer with a Diskette Receipt Acknowledgement form. (See Figure 3-1.)

2.2 Transfer of Digital Records to the PRC - There are three separate transfers of data via diskette from the Participating Organization database (%ESI):

- o To the MASSF with each shipment.
- o To PRC one-time.
- o Monthly transfer to PRC.

Indexing Sheet for QA RMS Database #DOCS.CRE

14 File Location: WM RECORD LIBRARY

15 Transfer Box No.: WM*30001

16 Supercedes Acc. No: *

17 Superceded By Acc No.: *

18 Reference Doc ID (mv): 1) 2) 3) 4) 5)

19 Reference Doc Revision ID (mv) (c): 1) 2) 3) 4) 5)

20 Reference Doc Revision Date (mv) (c): 1) 2) 3) 4) 5)

21 Comments (T)

22 Cart/Frame

23 Storage Box

} Leave Blank

24 Film Office

- Signs (initials) packing list.

- Places packing list in transfer box with documents. Seals with heavy duty (shipping, strapping or filament) tape. Ships to Microfilming and Archival Storage Services Facility, Mercury, NV.

2.3 Transfer of Records

2.3.1 The RC transfers the hardcopy to the MASSF for microfilming when the documents have been prepared as described above. The transfer box has been specified to provide a standard unit of transfer. It is not however required that the RC send only full boxes. A "box" may be an envelope of microfiche QA records, a tube of drawings for filming, or other containers. The unit of transfer is not important. It is however vital, that the RC maintain a one-to-one correspondence between a digital "box" and the physical unit transferred to the MASSF.

2.4 One-of-a-Kind Items

2.4.1 If a one-of-a-kind item is part of a document or package that has had a digital record created for it, it should be represented on the microfilm record by a cross reference slip sheet (see Figure D-6). The RC completes the slip sheet with the identification of the one-of-a-kind item and its permanent storage location. Until such time as WMPO has a facility appropriate for storing large volumes of one-of-a-kind items, they shall remain under the protective care of the SNL RC.

APPENDIX D

SANDIA NATIONAL LABORATORIES
DEPARTMENT OPERATING PROCEDURE
RECORDS MANAGEMENT SYSTEM

IMPLEMENTING PROCEDURE 3 - DOCUMENT AND DIGITAL RECORD PREPARATION AND TRANSMITTAL

Table of Contents for Appendix D

Page

1.0 PURPOSE D-2

2.0 PROCEDURE D-2

2.1 Transfer Tasks Performed on the QARMS Database D-2

2.2 Transfer of Digital Records to the PRC D-2

2.3 Document Preparation D-3

2.4 One-of-a-Kind Items D-4

Figures

D-1 Diskette Receipt Acknowledgement Form D-5

D-2 Project Records Center Data and Documents Flow Diagram D-6

D-3 Two-Sided Copying D-7

D-4 Sub-Standard Quality D-8

D-5 Oversize Document D-9

D-6 Cross Reference Slip Sheet D-10

Project Records Center Data and Documents Flow Diagram

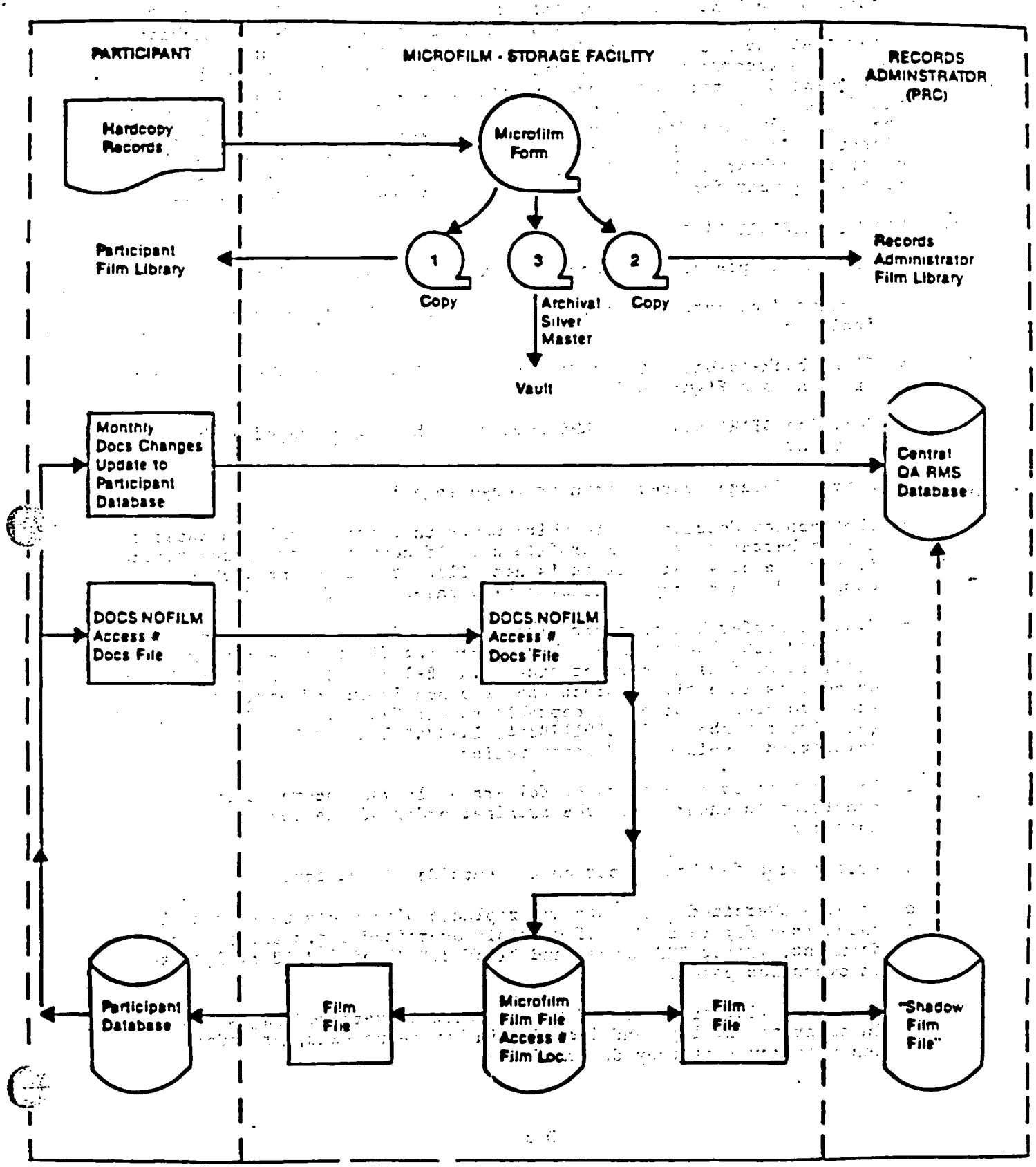

FIGURE D-2

2.2.1 These transfers are detailed in the QARMS User's Guide. The RC establishes a baseline set of information in the central database in Las Vegas, NV, through a one-time transfer of the SNL QARMS database. After that the Records Coordinator is responsible for transferring data on changed records to the central database by the first of each month, as requested by the NNWSI Records Administrator. Transfers are made via diskette in accordance with he procedures found in Section 5.0 of the QARMS Database User's Guide. The transfer of data, documents and microfilm is depicted in Figure D-2. The RC sends a diskette to the central database each month with a participate diskette receipt acknowledgement form unless the database has not been used at all.

2.3 Document Preparation

2.3.1 The RC prepares documents for microfilming as follows:

- Reviews documents to ensure all pages and all attachments are included.
- Flags back-to-back (two-sided) sheets. Places slip sheet in front of each (see Figure D-3).
- Verifies START stamp and RMS number at the beginning of each document.
- Repairs damaged pages (torn or rough edges).
- Photocopies documents onto white paper that are on colored paper to obtain better copy for microfilming. If copy is better, substitutes it for the original. If it is not, flags the document with a completed "best copy available" slip sheet (see Figure D-4).
- Place transfer box on short (12" W) end. Places document in standard box, lowest RMS-numbered document first, face forward, START stamp facing to right side. The 8-1/2" x 11" sheet should be on edge as in a file cabinet when the box is turned upright. Uses standard archive boxes, acceptable to the Federal Records Center (GSA Order Number: 8115001178344, 14-3/4" L x 12" W x 9-1/2" D), reinforced double walled construction.
- Leaves records in binders or folders or leaves documents in "bound" condition to ensure that the original order of the documents is maintained.
- Writes transfer box number on the outside of the box.
- Removes oversized documents and replaces with cross reference slip sheet (see Figure D-5). If multiple oversized pages exist within a document, writes RMS number and "1 of 3," "2 of 3," "3 of 3," etc., on oversized pages.
- Creates a list of oversized pages. Places oversized pages and list in separate envelope and includes in box being sent, or under separate cover if they do not fit.

*** SUB-STANDARD QUALITY ***

THE FOLLOWING DOCUMENT IS THE
BEST AVAILABLE COPY

This document type does not meet document quality standards. it is included in the QA Record as the best available copy of this document.

RMS Number: _____

Document ID Number: _____

Title: _____

Comment/Initials/Date: _____

_____

_____

Figure D-4

DISKETTE RECEIPT ACKNOWLEDGEMENT FORM

Date:

To: NNWSI Microfilming and Archival Storage Services Facility
Holmes & Narver Engineering Records Library, Bldg. 310
Nevada Test Site
Mercury, NV 89023

From: SNL Department 6310 NNWSI Records Coordinator

Subject: Receipt of QARMS Diskette(s) Labeled:

_____

_____

_____

_____

I have received the QARMS Diskette(s) identified above.

Name	Title	Date

Distribution:
Records Coordinator
PRC File

Return completed copy to: SNL Department 6310 NNWSI Records Center
M. Tang, Division 6316
Sandia National Laboratories
Albuquerque, NM 87185

Figure D-1

Cross Reference Slip Sheet

This slip sheet replaces the item that was orignally filed or referenced in this document. The item is not suitable for microfilming and has been stored in its original state or format in an archival storage facility. See database for physical location of this item.

RMS Number: _____

Document ID Number: _____

Title/Description: _____

_____

_____

Figure D-6

ATTENTION CAMERA OPERATOR

Two-Sided Copying

The following document(s) contains information on the front and back of each page. Please ensure that both sides are recorded.

Figure D-3

Implementing Procedure 4
Review of Microfilm and Database Update

1.0 PURPOSE

1.1 This procedure describes how the Records Coordinator (RC) receives digital information from the Microfilming and Archival Storage Service Facility (MASSF) and processes the information into the SNL Records Center.

2.0 PROCEDURE

2.1 Microfilm Location Designation

After the MASSF has completed microfilming the documents designated as quality level 1 or 2 (Q1/Q2) sent from the SNL Records Center and has entered the appropriate microfilm location into the Microfilm File of the QARMS database, the MASSF sends the location information to the SNL Records Coordinator with a copy(ies) of the microfilm as requested. Additionally, the MASSF sends the microfilm location information to the central database. Processing the microfilm and database information are described separately below.

2.2 Microfilm Review

2.2.1 The RC receives the copy of the microfilm and reviews it to ensure that the documents sent to the MASSF have been completely and correctly microfilmed. The MASSF performs quality checks on the microfilm before returning it. The review of the film should be a "spot check" of approximately 5% of the microfilm. The RC reviews the microfilm as follows:

- o Places the microfilm in a microfilm viewer and scans it slowly to see if there are any documents that have been improperly filmed or if the microfilm image is illegible.
- o Resolves any problems with the NNWSI Records Administrator to obtain acceptable microfilm. If corrections of the microfilm are required, the MASSF will also need to provide a new diskette. Therefore, the RC should not proceed to load data from the diskette into the database.
- o Completes the acceptance portion of the microfilm transmittal/ acceptance form (see Figure 4-1) and returns it to the MASSF.
- o Places the accepted microfilm in the microfilm library.

2.3 Database Update

2.3.1 The RC receives the diskette from the MASSF and, if the microfilm is accepted, updates the QARMS database (see Section 5.0 o the User's Guide for instructions) as follows:

OVERSIZE DOCUMENT

THE DOCUMENT ORIGINALLY FILED HERE HAS BEEN REMOVED

RMS Number: _____

Document ID Number: _____

Title: _____

_____

_____

This document is an oversize document and will be microfilmed or stored separately in a format appropriate to the original medium.

Figure D-5

Microfilm Transmittal/Acceptance Form

Microfilm Transmittal Number _____ Page _____ of _____

Date:

From: MASSF

To:

Transmittal Contents:

Film Format	Microfilm Identification
Cartridge	
Microfiche	
Aperture Cards	

********* ********** *********

Microfilm Acceptance Certificate

I have reviewed the microfilm listed above and accept the microfilm images as true reproduction of the QA records this organization transmitted to the MASSF for microfilming. My signature below releases the hardcopy records for further appropriate disposition by the MASSF.

_____	_____	_____
Name	Title	Date

Figure E-1.

APPENDIX E

SANDIA NATIONAL LABORATORIES

DEPARTMENT OPERATING PROCEDURE

RECORDS MANAGEMENT SYSTEM

IMPLEMENTING PROCEDURE 4 - REVIEW OF MICROFILM AND DATABASE UPDATE

Table of Contents of Appendix E

Page

1.0 PURPOSE E-2

2.0 PROCEDURE E-2

2.1 Microfilm Location Designation E-2

2.2 Microfilm Review E-2

2.3 Database Update E-2

Figure

E-1 Microfilm Transmittal/Acceptance Form E-4

NNA.880122.0046

SNL NNWSI PROJECTS DEPARTMENT
DEPARTMENT OPERATING PROCEDURE

Operation of the SNL NNWSI Project Data Records Management System (DRMS)

Page	1	2	3	4	5	6	7	8	9	10
Rev	A	A	A	A	A	A	A	A	A	A

App	A	B	C	D	E	F	G	H	I	J	K
Rev	A	A	A	A	A	A	A	A	A	A	A

UNCONTROLLED

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SNL NNWSI DEPARTMENT 6310
CONTROLLED DOCUMENT
Issued to: M. D. COHER/SAIC
Copy Number: #010
RETURN TO 6310 RECORDS CENTER
WHEN NO LONGER NEEDED.

- Completes the MASSF Diskette Receipt Acknowledgement Form and returns it to the MASSF.

- Logs on to the QARMS Database and proceeds to the appropriate menu for transferring data from the MASSF into the local database.

- Places the diskette returned from the MASSF into the appropriate drive (usually drive "A") in the computer and updates the database with the microfilm location.

DRMS Coordinator (DC)
SNL NNWSI Project individual(s) having overall responsibility for the operation of the DRMS.

File Guide Number
An alphanumeric code incorporated into Data-Set IDs to define a specific type of data-gathering activity.

Index Sheet (Form 5008)
A form used to initiate a Data-Set ID.

Records Administrator (RA)
The person or persons (also referred to as the DRMS staff) responsible for the operation of the DRMS through implementation of this DOP.

Reference Notebook
A single or multivolume notebook that contains multipage documents (typically 50 or more pages in length) that are to be filed in multiple Data Sets.

Status of DRMS Data Sets
The status of DRMS Data Sets is either:

Planned - Data acquisition has not been initiated.
Ongoing - Data acquisition has been initiated.
Completed - Data acquisition was initiated and is now terminated.
Cancelled - EP was issued with work terminated prior to data acquisition.
Closed - Data-Set Notebook has been through the process defined in Section 5.4 of this DOP. The Data-Set Notebook will be submitted within 10 working days from closure to the SNL NNWSI Project RMS.

System Notebook
A single or multivolume notebook that contains general information pertaining to the entire DRMS.

Table of Contents (TOC)
A listing of records contained in each Data Set generated from the DRMS Computer Index.

4.0 Responsibilities
4.1 DRMS Records Administrator (RA)

A. It is the responsibility of the RA to implement the processing of DRMS records as defined in this DOP and the DRMS Computer Index Users Manual.

4.2 SNL NNWSI Project DRMS Coordinator (DC)

A. It is the responsibility of the DC to ensure that this DOP is understood and followed by the RA. It is also the responsibility of the DC to ensure that the RAs are familiarized in the use of this DOP and other procedures pertaining to operation of the DRMS. Familiarization records are QA records and the DC will distribute them to the SNL NNWSI Project QA Coordinator and the QA training file.

B. It is the responsibility of the DC to provide SNL NNWSI Project RMS staff with updates of the structure of the 50 series for input into the Department 6310 Master Coding Index.

5.2.1 Building A Data Set

A. Assigning Data-Set ID Number

The RA checks the Data-Set ID against existing Data Sets to prevent duplicates.

B. Initiating Computer Index for Data Set

In order to establish the computer index for the new Data Set and to input changes to the Index and/or Tracking Sheets, a Document Transfer Sheet is prepared and attached to them.

C. Constructing Data-Set Notebook

1. Construct the new Data-Set Notebook in duplicate.

2. One copy (the master-set) is added to the DRMS facility at SNL. The master-set notebook will be sent to SNL within 10 working days of its construction. Master-set notebook removal from SNL to the work location of the RA are subject to the following requirements:

   A. A maximum of ten notebooks (or the contents of 1 Data Set) may be removed from either records location. The exception is during the closing process, at which time the working-set notebooks will be permanently removed.

   B. Notebooks will be returned to their original location within 10 working days of the removal date. The exception is for Notebooks being reviewed for closing and for notebooks which are closed and submitted to the SNL NNWSI Project RMS.

3. The second copy (working-set) is added to the DRMS facility maintained at the work location of the RA.

5.2.2 Sorting Records

A. Assign Records Location in DRMS Notebooks

1. Records are not accepted into the DRMs if they do not have a Data-Set ID assigned to them.

2. Records originating from persons not in SNL NNWSI Project Department will not be accepted into the DRMS without a dated notation indicating acceptance by the PI.

3. Originals of poor quality (which cannot be reproduced legibly) are flagged and returned to the PI with a request for a better copy. If a legible copy is not provided, the RA will make the following notation on the record;

"BEST AVAILABLE COPY"

4. The correct section for filing in Data-Set Notebooks is determined.

1.0 Purpose

1.1 This Department Operating Procedure (DOP) defines the methods of maintaining records provided to the SNL NNWSI Project Data Records Management System (DRMS). The DRMS contains records of data gathering activities performed by SNL in support of the NNWSI Project.

2.0 Scope

This DOP applies to the receipt, filing, storage, preservation, and safekeeping of records provided to the DRMS, as well as maintenance of a Computer Index of the records, regardless of the QA level of the records. Requirements for providing records to the DRMS are defined in SNL NNWSI Project DOP 11-3. This DOP also defines the requirements for transmitting "closed" Data-Set Notebooks to the SNL NNWSI Project Records Management System (RMS) where they are handled per the requirements defined in SNL NNWSI Project DOP 17-1.

3.0 Definitions

Cross-Reference Sheet (Form 5005)
A form used to define the location of a record common to more than one Data Set.

Data Catalog
A compilation describing all Data Sets which is generated from the DRMS Computer Index data base.

Data Records Management System (DRMS)
The 50 series of the SNL Department 6310 NNWSI Project Records Management System, which archives records pertaining to SNL-sponsored data-gathering activities in support of the NNWSI Project. The DRMS is comprised of Data-Set Notebooks, system notebooks, reference notebooks, and a computerized index. The DRMS is a dual-facility operation, with records maintained at the work location of the RA and at SNL.

Data-Set Closing Sheet (Form 5000)
A form used to document the process of assigning a status of "closed" to a Data Set.

Data-Set Identification (ID)
A unique identifier assigned to an individual Data-Set Notebook. The identifier is based on a file-guide number that designates the type of data-gathering activity and the date of the implementation document.

Data-Set Notebook
A single or multivolume binder that contains the records generated for a Data Set.

Document Transfer Sheet (Form 5004)
A form used to describe a record and track its handling through the DRMS.

DRMS Computer Index
Computer data base containing information describing records in the DRMS.

5.2.6 Placement of Records in DRMS Notebooks

Records will be filed in DRMS Notebooks within 10 working days of receipt by the RA. When originals are provided, they will be filed in the working-set notebooks. If microfiche masters are provided, they will be filed in master-set notebooks.

A. Data-Set Notebooks

1. Records are filed in their corresponding section, i.e., data are filed in the data section. Within a section, records are filed in a logical order.

2. Records will be filed in the working and master Data-Set Notebooks after computer input is complete.

3. Computer-generated Index and Tracking Sheets are filed in Data-Set Notebooks; handwritten Index and Tracking Sheets are kept in a convenience file at the work location of the RA.

B. Reference Notebooks (R series)

R01 In the Procedures Notebook, records are filed alphabetically, with subsections under a single laboratory facility ordered chronologically.
R02 In the Reports Notebook, the documents are ordered by the type of report and then in a numerical sequence according to the report number.
R03 In the Sample Custody Notebook, records are ordered consistent with how they are provided.
R04 In the Analysis of Results Notebook, records are ordered chronologically.
R05 In the calibration notebook, records are ordered chronologically.

C. System Notebooks (S series)

S01 In the Data Catalog Notebook, records are ordered chronologically.
S02 In the DRMS-Computer-Index-User's Manual Notebook, records are ordered chronologically.
S03 In the Document-Transfer Sheet Notebook, records are ordered chronologically.
S04 In the DRMS-Procedures Notebook, records are ordered chronologically.
S05 In the Lithologic Log Notebook, records are ordered alphabetically by location, and then chronologically.
S06 In the Notebook-Log Notebook, records are ordered chronologically.
S07 In the Table of Contents Notebook, records are ordered by Data-Set ID.

D. General Filing Provisions

1. Document Transfer Sheets that have the "Permanent File" block marked are filed in the Document Transfer Sheet Notebook (50/S05 of the DRMS System Notebooks).

C. It is the responsibility of the DC to maintain the DRMS master set logout/return forms and, at the end of each month, to send the originals of the completed forms to the RA for filing in the DRMS System Notebook for Logout and Return of Notebooks.

D. It is the responsibility of the DC to provide the working set copy of each closed Data-Set Notebook to SNL NNWSI Project RMS staff within 10 working days of its closed date.

5.0 Operations

5.1 The following measures will be followed at the DRMS facility located at the working location of the RA:

A. The facility will be clearly marked as the SNL NNWSI Project Data Records Management System (DRMS).

B. Records will be maintained in a facility equipped with locking doors. When not occupied by an RA, the facility will be locked. The RAs are the only people having unattended access rights to the DRMS. Safety and security personnel are exempt from this requirement.

C. There will be no smoking, eating, or drinking in the DRMS, and signs will be posted to note these restrictions.

5.1 Receipt of Records at the work location of the RA

When the RA receives records with a transmittal sheet from the DC, the RA will initiate Document Transfer Sheets for each record, answer all questions on the transmittal sheet, and return the transmittal sheet to the DC within 10 working days of receival. When the RA receives records without a transmittal sheet from the DC, the RA will provide the DC with a copy of the completed Document Transfer Sheet within 10 working days of receival. If the volume of records received is large enough so that records cannot be processed within this time period, the RA may request an extention from the DC.

5.2 Filing of Records

Filing of records into the DRMS consists of the following operations to be performed by the RA:

1. Building a Data Set
2. Sorting the records
3. Copying records
4. Screening records
5. Making entries in the DRMS Computer Index
6. Filing records into DRMS Notebooks

All records are stored in duplicate, with one set called the DRMS working set (the set located at the location of the RA) and the other called the master set (the set at the location of the SNL NNWSI Project Department)

C. Back-ups will be provided to the DC on a bi-monthly basis. A records count will be made before performing the back-up. After the back-up is created, the restore function will be performed and a second records count made. The RA will compare the count to ensure records were not lost during the back-up/restore process. The RA will provide a notation of the number of counts to the DC with the back-ups.

5.3.5.2 DRMS Program Files

A. DRMS program files will be backed up daily on days which changes have been made to the program files, with two copies stored at the working location of the RA. Two copies will also be provided to the DC, who will file one of the copies in a metal file cabinet in the DRMS located at SNL.

5.4 Closing DRMS Data Sets

The RA performs steps described in Section 5.4.A of this DOP for all Data Sets. Sections 5.4.B and 5.4.C are performed only after the RA receives a written request from the PI or DC to close the Data Set.

A. Locate Outstanding Records for a Data-Set

1. When the status of a Data Set changes from ongoing to completed, or to cancelled, as indicated by the PI on the Tracking Sheet, the RA generates a current Table of Contents (TOC) for inclusion in the working and master Data-Set Notebooks. The RA will update the TOC as necessary.

2. RA processes all new acquisitions and supplies the PI with updated comments.

B. Perform DRMS Review of Data-Set Notebook

1. The DRMS review will be performed by the:

   a. RA (from 5001)
   b. DC (form 5002)
   c. PI (form 5003)
   d. SNL NNWSI Project QA coordinator, who examines the DRMS review sheets from the RA, DC, and PI; the QA Coordinator makes the final decision as to the status of the Data Set.

2. SNL NNWSI Project QA Coordinator supplies a closing date for the Data Set, enters it on form 5000 (Data Set Closing Sheet), and returns the form to the DRMS RA.

3. The RA enters the closing date into the DRMS Computer Index.

C. Final Check of Data-Set Notebooks by RA and DC

1. RA makes a written request of the DC to define which cross-references will be provided in full text form as part of the closing process.

2. RA and DC verify that the content of the working and master Data-Set Notebooks match.

B. Prepare Document Transfer Sheet for Each Record

1. Initiate a Document Transfer Sheet for each record by completing all sections on the sheet.

2. When input from Document Transfer Sheets results in a change to the Data Catalog, mark the "Permanent File" block to ensure it will be filed in the DRMS System Index Document Transfer Sheet Notebook.

3. Attach the Document Transfer Sheet to the document until the record is filed.

5.2.3 Copy Records

A. Review Records for Quality of Copy

Instructions for copying which are necessary to guard against loss of information will be found on the Document Transfer Sheet.

B. Generate Required Number of Copies

The "Number of Copies" block on the Document Transfer Sheet is initialed when the required number of copies are made.

5.2.4 Screen Records

A. The Document Transfer Sheet

1. The Document Transfer Sheet is reviewed for correct dates, number of pages, spelling and grammar, and clarity of comments.

2. When the record is acceptable for entry into a DRMS notebook, initial and date the "Reviewed for Completeness" block on the Document Transfer Sheet.

B. The Record

Original records returned to the sender will be identified using a label dot containing the Data-Set ID(s), the initials of the RA, and the date. The originals should be returned in the same order and condition in which they were received. Originals are to be returned to the sender within 10 working days unless the DC or PI gives a time extension in writing.

5.2.5 Making Entry into the DRMS Computer Index

A. Input into the DRMS computer index will be made using the computer located at the workplace of the RA.

1. Determine if the record is entered in the DRMS Computer Index.

2. Enter information from the Document Transfer Sheet to the Computer Index following the procedures in the DRMS Computer Index User's Manual.

3. After the entry, check the input and initial and date the "Input in Computer" block on the Document Transfer Sheet.

SNL DEPARTMENT 6310 DATA RECORDS MANAGEMENT SYSTEM (DRMS) DATA-SET CLOSING SHEET

U.S. DEPARTMENT OF ENERGY
OCRWM
OGR
Nevada Nuclear Waste Storage Investigations PROJECT
YUCCA MOUNTAIN

DATA-SET ID _____

COMMENTS ATTACHED

DRMS REVIEWED (RA) _____ _____ DATE ☐

DRMS REVIEWED (DC) _____ _____ DATE ☐

DRMS REVIEWED (PI) _____ _____ DATE ☐

ACCEPTED BY _____ _____ DATE CLOSED ☐
6310 QA COORDINATOR

NUMBER OF VOLUMES IN THIS DATA SET: _____

CLASSIFICATION REVIEW 3180

Signature/Initials _____ Date _____

PATENT/LEGAL REVIEW 4121

Patent Interest: ☐ no ☐ yes

Signature/Initials _____ Date _____

PUBLICATION POLICY REVIEW 3151

Signature/Initials _____ Date _____

2. Document Transfer Sheets which are not filed in the "Permanent File" are maintained in chronologic order in locked metal file cabinets at the working location of the RA for 6 months after a record is filed. Document Transfer Sheets can be discarded after 6 months from the date the record is filed.
3. Thermal paper is not to be filed in any DRMS notebook; make additional copies as needed.
4. Immediately after filing the record in a DRMS working-set notebook, the RA will date and initial the "Filed in working set" block on the Document Transfer Sheet.
5. Immediately after filing the record in a DRMS master-set notebook, the RA will date and initial the "Filed in master-set" block on the Document Transfer Sheet.

5.3 Computer-Record Maintenance

5.3.1 Type of Computer Media
The computer media may be either a Bernoulli Box cartridge or double sided (ds), double density (dd) 5 1/4 in. floppy disks.

5.3.2 Labeling of Computer Media
Computer media will contain a label to identify the type of records contained in it. The label will also contain the words "SNL NNWSI DRMS" as well as the date and time of record transfer and the initials of the RA.

5.3.3 Storage of Computer Media
Backups will be stored in metal file cabinets at the work location of the RA and the DC. The file cabinet at the working location of the RA will be in a different room than the DRMS computer system. The DC file cabinet will be in the DRMS at SNL. These file cabinets will be locked when not in use.

5.3.4 Back-up Log
A back-up log will be kept by the RA indicating the type of computer media, the date and the time of back-up, and the initials of the RA performing the back-up. A log entry will be made (in black indelible ink) each working day for data files and whenever the DRMS computer program is changed for program files. If no changes to data files are made during the day, a back-up is not made, however the log will contain a statement that no changes were made. The log will be kept in the same file cabinet as the back-ups at the working location of the RA. A copy of the logbook page(s) containing records of the past 2 weeks will be provided to the DC with the bi-monthly back-up of the DRMS data files. The log will clearly distinguish data-file entries from program-file entries.

5.3.5 Types of Files

5.3.5.1 DRMS Data Files

A. DRMS data files will be backed up daily on all days when additions or changes have been made to the files. These back-ups will be kept for one week.

B. Weekly back-ups will be made on the last working day of the week and kept for 1 month at the working location of the RA.

SNL NNWSI PROJECT DRMS REVIEW SHEET

(to be completed by DRMS Coordinator)

Data Set ID _____

DRMS Coordinator _____ DIV _____

Start/Complete Date _____

---

1. Does the Table of Contents accurately index the records in the Data-Set Notebook?

2. Are implementing procedures (including all revisions) complete and properly filed?

3. Are sample chain-of-custody records requested in the implementing procedures? If yes, are they complete?

4. Are data adequately identified per instructions in the implementing procedures? If not, list the inconsistencies.

Reviewer's Comments: (Attach additional sheets as necessary)

3. RA inserts the Data-Set Closing Sheet (form 5000) into the front of both the master and working Data-Set Notebooks and provides the working-set to the DC within 5 working days of the closing date.

6.0 References

6.1 SNL NNWSI Project DOP 17-1, Records Management System
6.2 SNL NNWSI Project DOP 11-3, DRMS Interaction Requirements

7.0 Appendices

The current DRMS forms are included as Appendices (APP).

APP A	- DRMS form 5000	Data-Set Closing Sheet
APP B	- DRMS form 5001	Data-Set Closing Review Sheet, RA
APP C	- DRMS form 5002	Data-Set Closing Review Sheet, DC
APP D	- DRMS form 5003	Data-Set Closing Review Sheet, PI
APP E	- DRMS form 5004	Document Transfer Sheet
APP F	- DRMS form 5005	Cross-Reference Sheet
APP G	- DRMS form 5006	Information Sheet
APP H	- DRMS form 5007	DRMS Notebook Log In/Log Out Sheet
APP I	- DRMS form 5008	Data-Set Index Sheet
APP J	- DRMS form 5009	Data-Set Tracking Sheet
APP K	- DRMS form 5010	Supplemental DRMS Tracking Sheet for Samples

DOCUMENT TRANSFER SHEET

DATE RECEIVED _____ SENT BY _____

NOTEBOOK

DATASET ID _____
SECTION
(TAB DIVIDERS) _____
SUBDIVISION
(CARD STOCK DIVIDERS) _____

DESCRIPTION

TITLE _____

DATE WRITTEN

AUTHOR	DIV.
RECIPIENT	DIV.

NUMBER OF PAGES

COMMENTS _____

QA

ID AND SECTION CORRECT		REVIEWED FOR COMPLETENESS		INPUT IN COMPUTER		FILED IN WORKING SET		FILED IN MASTER SET	

SPECIAL INSTRUCTIONS: _____

NUMBER OF EACH COPY		SAMPLES DATA-BASE			PERMANENT FILE (SYSTEM NOTEBOOK 505)

FORM 5004 REV03/03/87

SNL NNWSI PROJECT DRMS REVIEW SHEET

(to be completed by DRMS Records Administrator)

Data Set ID _____

DRMS Records Administrator _____

Start/Complete Date _____

---

1. Does the Table of Contents accurately index the records in the Data-Set Notebook?

2. Are implementing procedures (including all revisions) complete and properly filed?

3. Are sample chain-of-custody records requested in the implementing procedures? If yes, are they complete?

4. Are data adequately identified per instructions in the implementing procedures? If not, list the inconsistencies.

Reviewer's Comments: (Attach additional sheets as necessary)

DRMS
INFORMATION SHEET

DATASET:

SECTION:

SUBJECT:

BY:

DATE:

SNL NNWSI PROJECT DRMS REVIEW SHEET

(To be Completed by the Principal Investigator)

Data Set ID _____

Principal Investigator (PI) _____

PI's Organization _____

Start/Complete Date _____

---

1. In reviewing the Data-Set Notebook, have you noticed any discrepancies or omissions in the documentation? If yes, resolve them.

2. Do you concur with the review comments of the DRMS Records Administrator (RA) and the DRMS Coordinator (DC)? If no, please explain.

3. Do you know of any published reports, not included in this Data Set, that document data acquired from these experiments or tests?

4. If there are no further changes to the records in this Data Set Notebook, it will be given given a designation of "closed". Is there any reason this Data Set should not be closed at this time?

Reviewers Comments: (attach additional sheets as necessary)

DRMS DATA-SET INDEX SHEET

DATA-SET ID	FILE NAME
DESCRIPTION	
EP IDENTIFIER	SIGN-OFF DATE OF EP
EP TITLE	
ACTIVITY #1	
	QA Level / # OF SAMPLES
ACTIVITY #2	
	QA Level / # OF SAMPLES
ACTIVITY #3	
	QA Level / # OF SAMPLES
ACTIVITY #4	
	QA Level / # OF SAMPLES
ACTIVITY #5	
	QA Level / # OF SAMPLES
ADDITIONAL DATA SETS TO BE GENERATED FOR THIS EP? YES NO (IF YES, LIST THEM BELOW)	
DATA-SET ID_____	DATA-SET ID_____
DATA-SET ID	DATA-SET ID
SNL PI	DIVISION
SUBMITTED BY	DIVISION / DATE

Comments

DRMS Form 5008 Rev 4/4/87

NNWSI
DATA SET CROSS-REFERENCE SHEET

INFORMATION ENTITLED: _____

_____

_____

FROM: _____ DATED: _____

TO: _____

FOR:
DATA SET NOTEBOOK _____
SECTION _____

CAN BE FOUND IN:
DATA SET NOTEBOOK _____
SECTION _____

SUBMITTED BY _____
DATE _____

SUPPLEMENTAL DRMS TRACKING SHEET FOR DATA SETS WITH SAMPLES

DATA-SET ID	
SUBMITTED BY	DIV

THE STATUS OF EACH SAMPLE IN A DRMS DATA SET IS EITHER:
Planned (P) - Data acquisition not yet initiated.
Ongoing (O) - Data acquisition has been initiated.
Completed (C) - Data acquisition completed.
Work Cancelled (W) - Work cancelled prior to acquisition of data.

ACTIVITY NUMBER	SAMPLE ID	STATUS OF SAMPLES AS OF			

IS THIS LIST CONTINUED ON ANOTHER SHEET? YES NO (circle one)

DRMS Form 5010, Rev 10/8/87

LOG-OUT/LOG-IN OF DRMS NOTEBOOKS

REMOVED FROM: _____

NEW LOCATION: _____

NOTEBOOK ID: _____

VOLUME(S): _____

REMOVED BY: _____

DATE REMOVED: _____

INITIALS OF DC (FOR LOG-OUT OF MASTER-SET NOTEBOOKS)
OR
INITIALS OF RA (FOR LOG-OUT OF WORKING-SET NOTEBOOKS) _____

COMMENTS: _____

_____

_____

_____

DATE RETURNED: _____ RETURNED BY: _____

VOLUME(S): _____

INITIALS OF DC (FOR LOG-IN OF MASTER-SET NOTEBOOKS)
OR
INITIALS OF RA (FOR LOG-IN OF WORKING-SET NOTEBOOKS) _____

COMMENTS: _____

_____

_____

RETURN COMPLETED FORMS TO THE SNL DRMS COORDINATOR (DC)

DRMS FORM 5007, Rev 4/4/87

UNCONTROLLED

NNA.880126.0002

SNL NNWSI PROJECTS DEPARTMENT
EXPERIMENT PROCEDURE
SEISMOTECTONIC FIELD STUDIES FOR REPOSITORY SURFACE FACILITIES, NNWSI

e	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38									
v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
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APPENDIX A

ge	1	2	3	4
ev	0	0	0	0

Approved by:

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C. V. Subramanian, SNL Division 6311 — Date
Independent Technical Reviewer

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Leo W. Scully — Date
SNL Division 6311 Supervisor

R. Richards — JAN 14, 1987
Robert R. Richards — Date
SNL 6310 Department QA

Thomas O. Hunter — 1-29-87
Thomas O. Hunter — Date
SNL Department 6310 TPO

SNL NNWSI DEPARTMENT 6310
CONTROLLED DOCUMENT
Issued to: M. D. COHER, SAIC
Copy Number: #012
RETURN TO [illegible] RECORDS CENTER
WHE[illegible] NO LONGER NEEDED.

DRMS DATA-SET TRACKING SHEET FOR FIELD EXPERIMENTS AND EQUIPMENT TESTS

DATA-SET ID	
SUBMITTED BY	DIV

THE STATUS OF EACH ACTIVITY IN A DRMS DATA SET IS EITHER:
Planned (P) - Data acquisition not yet initiated.
Ongoing (O) - Data acquisition has been initiated.
Completed (C) - Data acquisition completed.
Work Cancelled (W) - Work cancelled prior to acquisition of data.

Date _____ Status of Activity #1 _____ Status of Activity #2 _____ Status of Activity #3 _____ Status of Activity #4 _____ Status of Activity #5 _____ Initials of person making entry _____	Date _____ Status of Activity #1 _____ Status of Activity #2 _____ Status of Activity #3 _____ Status of Activity #4 _____ Status of Activity #5 _____ Initials of person making entry _____
Date _____ Status of Activity #1 _____ Status of Activity #2 _____ Status of Activity #3 _____ Status of Activity #4 _____ Status of Activity #5 _____ Initials of person making entry _____	Date _____ Status of Activity #1 _____ Status of Activity #2 _____ Status of Activity #3 _____ Status of Activity #4 _____ Status of Activity #5 _____ Initials of person making entry _____

____ CHECK TO INITIATE CLOSING OF DATA SET. DATE REQUESTED _____

PART A: FIELD EXPERIMENT PROCEDURE
(Concluded)

	Page
6.0 QA Implementation	31
6.1 Audits/Surveillance	31
6.2 Personnel Qualifications	31
6.3 Calibration	32
6.4 Nonconformances/Corrective Action	32
7.0 Documentation	33
7.1 Logbooks	33
7.2 SNL 6310 Data Records Management System (DRMS)	33
8.0 Safety	34
9.0 Reports	35
9.1 Data Report Requirements	35
10.0 Nevada Test Site Operations	36
10.1 Overall Responsibilities	36
10.2 Personal	36
10.3 Logistical Support	37
10.4 Security	37
10.5 Environmental Clearances	37
11.0 References	38
Appendix A, Daily Log	1
Figure 1 Map of the Surface Geological and Faults in the Vicinity of Exile Hill	7
Figure 2 Principal Organization Interfaces and Functions	11
Table 1 Special Efforts	14

PART B: TECHNICAL PROCEDURES

1. Surface Geologic Mapping, TP-0068
2. Trench Mapping, TP-0069
3. Sample Collection and Control, TP-0070
4. Geologic Age Dating, TP-0071
5. Soil Property Investigations (To be added later)

Excavation - Any manmade cavity or depression in the earth's surface, including its sides, walls or faces, formed by earth removal and producing unsupported earth conditions by reason of the excavation. In general, the depth is less than the width. If installation of forms or similar structures reduce the depth to width relationship, an excavation may become a trench (1926.653(n)).

1.4 Activity Objective

To characterize the site for repository surface facilities with respect to material properties and tectonic history, especially faulting, and to identify a location for waste-handling facilities that is free of faults or, if faults exist, that has a history of movement which is very old and has not exceeded 10^{-4} cm/yr in the last 10^{5} -10^{6} yr.

1.5 Study Plan

The detailed rationale and description of this activity is contained in the following study plans:

SP-0001 - Study Plan for Conduct of Geologic Field Studies for Repository Preclosure Facilities

SP-0002 - Study Plan for Conduct of Surface Fault Rupture Studies for NNWSI Repository Surface Facilities

The principal initial activity involves the Study Plan 0002. As the work evolves, this EP will be revised to reflect the work contained in SP-0001.

PART A: FIELD EXPERIMENT PROCEDURE

1.0 GENERAL INFORMATION

1.1 Table of Contents

	Page
Approvals	1
1.0 General Information	2
1.1 Table of Contents	2
1.2 Scope	4
1.3 Definitions	4
1.4 Activity Objective	5
1.5 Study Plan	5
2.0 Description of Work	6
2.1 General Description	6
2.2 Management	10
2.3 Experiment/Equipment Test Configuration	13
2.4 Experiment/Equipment Test Methods	15
2.5 Equipment Used	16
2.6 Sample Traceability	16
2.6.1 Sample Storage and Disposition	16
2.7 Sample/Site Preparation	17
2.8 Use of Logbooks	17
2.9 Related Analysis/Experiments	17
3.0 Quality Assurance Levels	18
4.0 Operations	19
4.1 Technical Procedures	19
4.2 Description of Sequence and Interaction of Experiment/ Equipment Test Procedures and Technical Procedures	21
4.3 Experiment Prerequisites	24
4.4 Experiment Postrequisites	25
4.5 Deviation From and Changes to Procedures During Use	26
4.5.1 Irretrievable Loss of Data or Unsafe Operation	26
4.5.2 Typographical Errors	27
4.6 Revision of Field Experiment Procedures and Technical Procedures	27
5.0 Data	28
5.1 Data Acquisition System/Instrumentation	28
5.2 Data Reduction/Analysis/Interpretation	28
5.3 Supporting Analysis	29
5.4 Records Maintenance	30

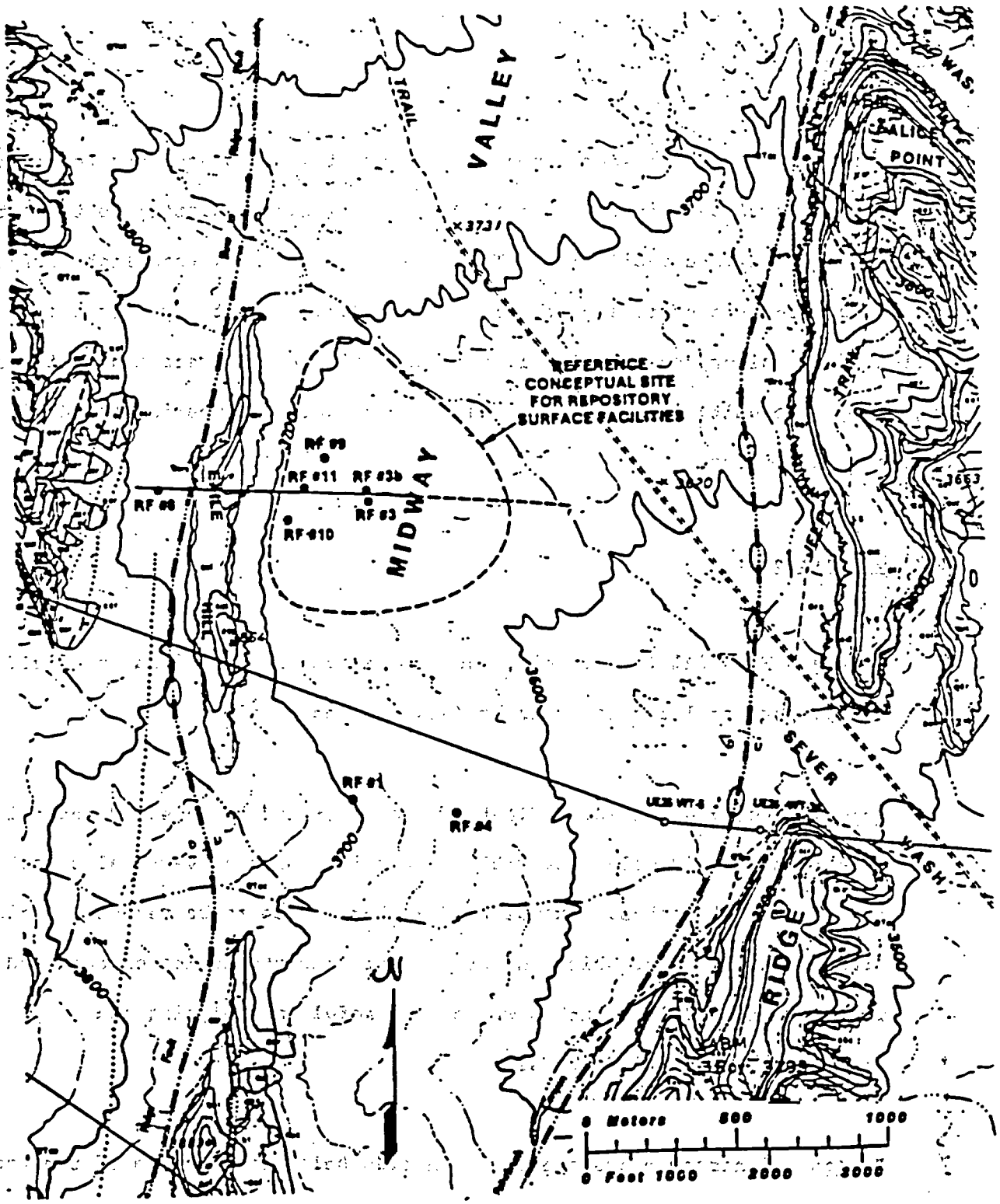

Figure 1. Map of the Surface Geology and Faults in the Vicinity of Exile Hill.

Source: Scott and Bonk, 1984.

1.2 Scope

This experiment procedure specifies activities and procedures to be used in the conduct of seismic-tectonic field investigations relating to the siting of repository surface facilities. The investigations will establish surface and subsurface geotechnical properties and conditions that may affect the safe siting of repository surface facilities, and will lead to recommenda- tions regarding site suitability, with emphasis on seismic engineering for design of critical facilities.

1.3 Definitions:

Sample - Material (e.g., soil, rock, artifact) removed from the field for the purpose of later analysis or detailed description

Trench mapping - The identification and recording of selected geologic data that are directly observable on vertical or near-vertical exposures in excavated trenches. Examples of geologic data to be recorded include lithologic, stratigraphic, and structural characteristics of rock and sediment exposed in trenches which are useful in analyzing the neotectonic setting of the site.

Trench - A narrow manmade excavation made below the surface of the ground by earth removal and producing unsupported earth conditions by reason of the excavation. In general, the depth is greater than the width, but the width of a trench is not greater than 15 feet (1926.653(n)).

Failure to adequately characterize Quaternary faulting near structures important to safety could result in the necessity of relocating surface facilities at the time of construction, causing significant delay to the completion of the project. Failure to avoid a condition of Quaternary faulting at the location of these structures would likely, at a late date, require extensive geologic investigations to adequately characterize the faults which in turn could result in uncertainty and/or delays in licensing, and an unknown but probably significant additional expense.

To define the design basis vibratory ground motion for the surface facility structures, characteristics of earthquake sources, and information on their recurrence, maximum magnitudes, and ground motion attentuation at the site must be determined. Failure to obtain a reasonable vibratory ground motion characterization of the site, or failure to address a wide enough range of possible earthquake sources, recurrence statistics, and other elements of a complete characterization, would result in piecemeal reexamination of seismic design input and design technique during licensing and could cause delay in facility completion.

Performance of the foundation of structures is dependent on the properties of the undisturbed and compacted material underlying the foundation. Such properties include, but are not limited to, gradation, density, moisture content, permeability, compressibility, bearing strength, shear strength, and shear modulus. With regard to response to ground motion from earthquakes, foundation performance is also dependent on the shear and compression wave velocities and dynamic moduli of soil and rock and their

2.0 DESCRIPTION OF WORK

2.1 General Description

The work involves field and laboratory efforts aimed at determining the seismotectonic environment present at the reference conceptual site. Geologic mapping is required to establish the nature and age of surficial alluvium and bedrock. The age of the alluvial units will enable estimates to be made of surface fault offset (amount and rate), if present. The nature and type of materials underlying the site area is required for establishing foundation and tunneling conditions. The work also includes the activities that support the technical work, including excavation, surveying, and photography.

The reference conceptual site east of Exile Hill (Figure 1) overlies the zone of close spaced normal faulting (Scott and Bonk, 1984), but it is not known if any of these faults penetrate the overlying alluvium. Whether any of these faults have moved during the Quaternary is unclear, but this information is needed to establish the nuclear safety aspects for the siting of the waste handling facilities, especially regarding the potential for surface fault rupture.

The site is also adjacent to several major faults - Bow Ridge, Paintbrush Canyon, and Midway Valley. These major fault systems have large (hundreds of feet) vertical displacements but the displacements' histories are not known. They may be capable of disrupting nearby facilities, either through ground motion during earthquakes, or by ground cracking and surface rupture.

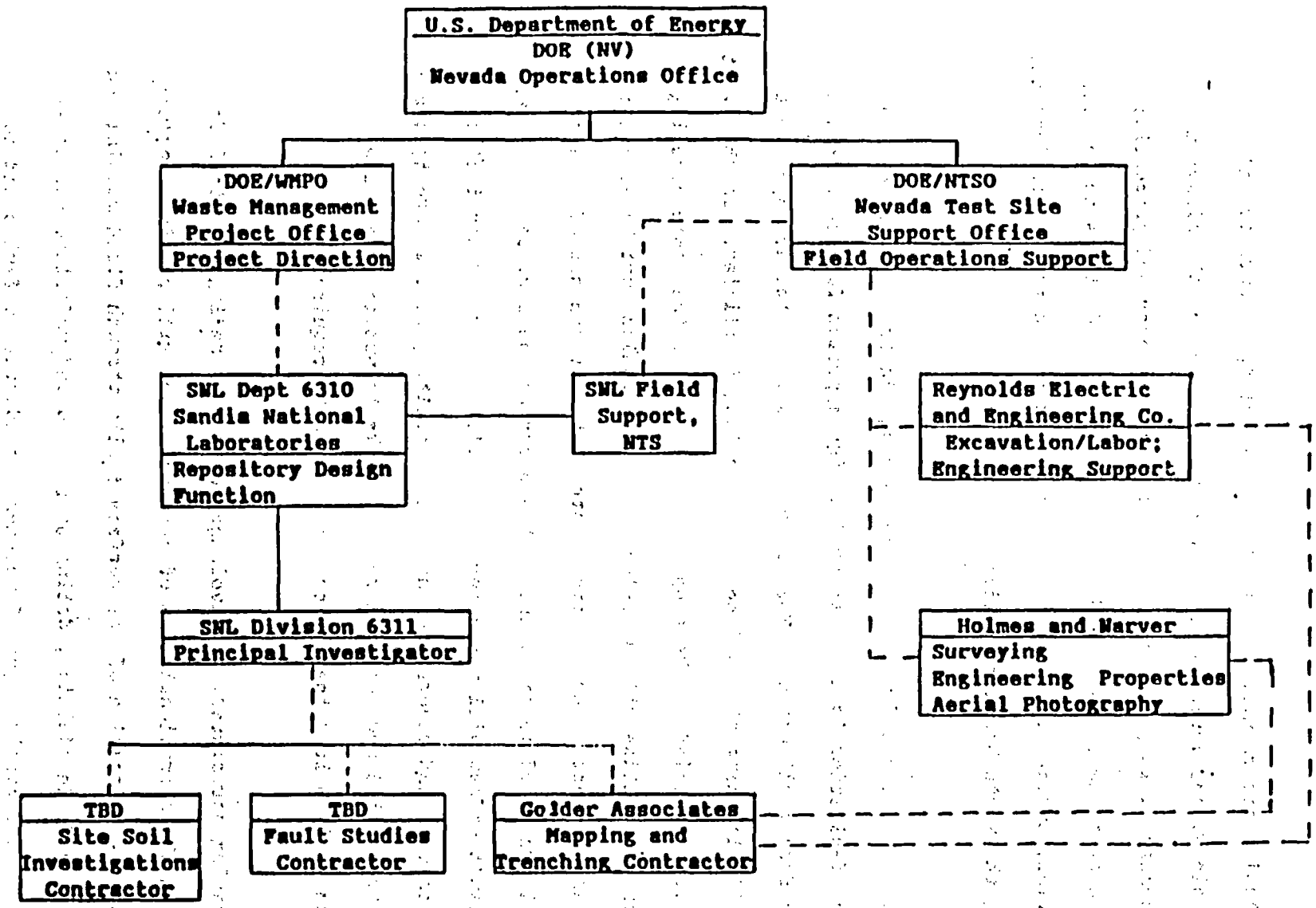

Figure 2. Principal Organization Interfaces and Functions.

Field studies are required to obtain data relating to surface and subsurface geology, particularly geologic structure, age of the alluvium, fault displacement history and rates, and soil stratigraphy and properties. Interpretation of these features and data will enable predictions to be made of ground motion, surface rupture, and foundation strength for use in locating and designing the waste-handling facilities.

Avoidance of tectonic faults of Quaternary age in the location of the waste handling facilities is the preferred design approach for negating the effects of surface fault offset. Therefore, faults of Quaternary age are to be avoided while locating the surface waste-handling facilities. In the event such faults are identified at the proposed locations for the waste handling facilities, the facilities will be relocated or the faults must be adequately investigated and characterized to demonstrate that they are not capable or have very small rates of movement and with appropriate design, any resulting (but small) fault offset will not compromise public safety. Determination of displacement amounts and recurrence interval of faulting will ensure that a WH facility can be located and designed so that risks to public safety due to seismic events will be less than or commensurate with requirements.

When locating structures, the avoidance of faults having potential for movement during the operational life of the facilities will require conclusive determination of the location of any surface faults through field mapping and selected trenching. In addition, dating of faulted and unfaulted strata will be necessary to characterize ages of movement on identified faults and to assess the possibility of future offset and the effects on design.

11. Laboratory material property determined (per TP-TBD, to be developed).

12. Incorporation of all data into Data Records Management System, File #F12 A.A-TBD, F12 B.A TBD.

13. Reporting of results by SNL P.I.

This experiment procedure specifies field and laboratory activities to be conducted under WBS 1.2.3.2.1.1, Site Geology. These activities relate to geotechnical information required for repository engineering efforts supporting Advanced Conceptual Design and License Application Design and are further described in Study Plan SP-0002. This procedure applies to contractual and Sandia National Laboratories efforts and includes mapping, sampling, drilling, trenching, geophysics, photography, testing and analyses. Specific efforts are listed in Table 1, below:

Formal dissemination of experiment procedures to all users will be by way of transmittal in Statements of Work (for contractors), and Letters of Criteria (for NTS support services).

2.3 Experiment/Equipment Test Configuration

Trench and sample test pit configurations are highly individualized and site specific. Lengths, depths, and details of mapping are discussed in Technical Procedures for trench-wall mapping (TP-0069). Plans for individual

damping, on variations of these properties vertically with depth and with respect to strain , and on depth-to-rock, particularly where there is a large variance of depth below large buildings.

Thus, a verifiable tectonic history and material properties are prerequisites to a design that will be acceptable to demonstrate public health and safety. Sufficient effort will be expended on these investigations to demonstrate with reasonable assurance that uncertainty in defining these parameters has been reduced to acceptable levels.

2.2 Management

The activities under this experiment procedure will be accomplished through contract with in-house (SNL) oversight (but not supervision). Principal organization interfaces and functions are shown on Figure 2. Contractor's data reports will be used as primary inputs to SAND reports which synthesize data and present interpreted information. The general sequence to be followed is:

1. Planning activities, including base map preparation, airphoto acquisition and interpretation, and reference examination. This responsibility is the joint responsibility of the Principal Investigator and contractors.

2. Daily go-ahead and procedural checks by SNL representative, at beginning and end of day, including completion and sign-off of Daily Log (Appendix A).

trenches will be described in contractors recommendation to SNL, to be documented and presented in writing prior to start of work on each trench. Test configurations for soil investigations will be described in appropriate technical procedures (to be developed).

2.4 Experiment/Equipment Test Methods

Standard methods of trench-wall mapping are described in "Trenching as an Exploratory Method," Geological Society of America Reviews in Engineering Geology, V. IV, 1979. Methods are further described in TP-0069, Technical Procedures for Trench Mapping.

Age dating of geological materials is the primary use of samples and is described in "Dating Techniques in Fault Investigations," same volume as above; TP-0071, Geologic Age Dating, details technical procedures.

Measurements will be taken in S.I. units (with parenthetic English units, when appropriate) unless specified otherwise in contract SOWs. Angular measurements in trenches will be by pocket transits, compasses, and hand levels; linear measurement will be made by tapes, generally to 0.5 cm accuracy, except where required otherwise. Photographs of trench walls will contain centimeter scales in the view and photo ID number. Captions for photos will be written in field notes at time of taking. Two copies of every photo are required for DRMS records (Reference Daily Log (Attach #1) and TP-0069, Part B).

3. Surface mapping by contractor (Golder Associates) per TP-0068, following contractor's Statement of Work.

4. Recommendation of trench locations by Golder Associates (per contract Statement of Work, and written report prior to start of individual trench work).

5. Written approval of trench locations by SNL Principal Investigator (per contract Statement of Work).

6. Excavation by REECO support personnel; support services, e.g., surveying by H & N, per letters of criteria.

7. Mapping of trench walls by Golder Associates (per TP-0069), following contractor's Statement of Work.

8. Standby for safety, quality assurance, or security inspections as required. In each case, duly appointed representatives of these functions may stop work as required, as these functions take precedence over technical work.

9. Sampling (per SNL DOP 8-1 and TP-0070) as required (by Golder Associates or other contractor).

10. Laboratory age dating per TP-0071 as required (by Golder Associates and/or other contractor), following contractor's Statement of Work.

2.7 Sample/Site Preparation

Samples will be collected in a manner that ensures noncontamination, i.e., fresh exposure with no infall from above or from the excavation process. The exposure face being sampled will be cleaned by scraping away any questionable material, prior to collection, which will be accomplished immediately after cleaning. Specific details regarding individual sample treatment are discussed in Technical Procedures TP-0070, including attachments thereto, e.g., Specific Work Instructions.

2.8 Use of Logbooks

Logbooks will be maintained consistent with the requirements in SNL NNWSI DOP 11-2. Completion of the Daily Log (Appendix A) as a means of compliance is further discussed in Section 4, Operations, and in the Technical Procedures.

2.9 Related Analyses/Experiments

Similar fault investigations are being performed by U. S. Geological Survey scientists. These are related primarily to understanding regional tectonics and seismicity as it relates to postclosure repository performance. Several trenches, e.g., No. 14 and 14a, are located on Exile Hill. The results of these studies are being coordinated with participating individuals. Although the application is somewhat different, much of the same information is relevant to the preclosure performance period.

TABLE 1

Specific Efforts

Participant and Responsibility	Procedural Controls	QA Requirements
1. Mapping and Trenching (surface faulting) (Contract 95-9505; Golder Associates)	a) Contract Statement of Work (SOW) b) Field Experiment Procedures (herein) c) Technical Procedures (TPs 68-71; Part B)	Contractor's QA Plan
2. Mapping and Trenching FY87 Contract (TBD)	a) Contract SOW b) Field Experiment Procedures (herein) c) Technical Procedures (TPs-68-71; Part B)	Contractor's QA Plan
3. Site Soil Investigations FY87 Contract (TBD)	a) Contract SOW b) Field Experiment Procedures (herein) c) Technical Procedures (to be developed)	Contractor's QA Plan
4. Excavation and Support (REECO)	a) Letter of Criteria (LOC) b) Field Experiment Procedures (herein)	REECO QAPP
5. Surveying (H&N)	a) Letter of Criteria b) Field Experiment Procedures (herein)	H&N QAPP
6. Aerial Photography (through H&N vendor)	a) Letter of Criteria b) Field Experiment Procedures (herein)	SNL Field Experiment Procedures & LOC
7. Contract Monitoring (SNL)	a) Field Experiment Procedures b) Dept. 6310 policy	a) SNL Field Experiment Procedures b) SNL NNWSI QAPP

4.0 OPERATIONS

4.1 Technical Procedures

Technical Procedures to be used and a brief description are listed below; the complete procedures are included in Part B.

(A)	Surface geologic mapping	TP-0068
(B)	Trench mapping	TP-0069
(C)	Sample collection and control	TP-0070
(D)	Geologic age dating	TP-0071
(E)	Soil property investigations	TPs-XXXX-...N

(A) The technical procedure for surface geologic mapping (TP-0068) describes the complete sequence and range of activity, including preliminary mapping and location selection for test pits, unit identification and correlation, base map preparation and synthesis of remotely sensed data, traverse spacing vs. scale, note keeping (per SNL DOP 11-2), equipment, and sampling for age dating.

(B) The technical procedure for trench mapping (TP-0069) describes the complete sequence and range of activity, including location selection, excavation, cleaning, shoring, gridding, photography, map

2.5 Equipment Used

Brunton pocket transits will be used for determining pebble orientations and preliminary strikes of faults, if present. Altimeters will be used to measure relative surface elevation differential, along with hand levels. All three of these instruments are field devices and not meant to be highly accurate. Precise measurements, where needed, will be by professional surveyors. Calibration requirements are included in Technical Procedures for surface geologic mapping and trench mapping (TPs 0068 and 0069). All calibration and handling of equipment will be consistent with SNL DOPs 12-1 and 13-1.

2.6 Sample Traceability

Samples must be accounted for and site information documented per SNL DOP 8-1, and Technical Procedure, TP-0070. Accountability is achieved through use of the NNWSI-SNL Chain-of-Custody Form.

All records relating to samples must be clearly identified with appropriate markings, consistent with SNL DOP 8-1 and TP-0070. Sample collection reports will be made for each sample and incorporated in the Daily Log.

2.6.1 Sample Storage and Disposition

Archival samples will be permanently stored at Dept. 6310/NNWSI core library and will be subject to QA procedures used at this facility and by the NNWSI Sample Overview Committee, where applicable. Sample chain of custody will follow DOP 8-1 and TP-0070.

4.2 Description of Sequence and Interaction of Experiment/Equipment Test Procedures and Technical Procedures:

The technical procedures described above and included as Part B detail the contractor's (or SNL in-house personnel) responsibilities in carrying out the technical activity. They do not discuss management activity by SNL, or NTS operating considerations, which are detailed in subsequent sections. In general, the sequence to be followed was specified in Section 2.2, Management.

The technical work builds upon both site-specific (e.g. Scott and Bonk, 1984) and general (e.g. Compton, 1985) references for field investigations. The initial data assessment tacitly assumes that some differences in professional opinion will exist and that revisions and refinements will be made as work progresses. This may result from increasing (refining) the mapping detail (scale), but also in the evolution of concepts regarding the particular area being investigated.

The airphoto acquisition will provide a visual record of the area at a scale close to the map scale. Stereoscopic viewing will enable the mapping specialist to observe field features in three-dimensions in ways and from a vantage that is not possible in the field. This viewing enables the geologist to conceptualize the processes and the distribution of mappable units. Principles and practice of remote sensing are described in Colwell (1983).

The field mapping involves the correlation of airphoto units and the mappable units that can be identified in the field. Age or lithologic distinctions are often manifested in reflectance variations on the airphotos. Usually, but not always, these variations are discernible in the field.

3.0 QUALITY ASSURANCE LEVELS

All technical activity has been approved as QA Level I; field support work, e.g. excavation, is Level III.

Quality level assignments were approved in Work Plan WP No. 123211-86, dated 9/19/86.

in a manner such that spoil does not obliterate or cover material in its natural state. There has not been any problem at Yucca Mountain thus far in the excavation of more than 25 trenches; nonetheless the oversight function during excavation will be maintained. The overseeing person may stop the excavation at any time if thought to be necessary, and for any reason.

Mapping of trenches will begin only after all excavating machinery has stopped and been removed from the trench. The decision regarding trench wall stability is a joint responsibility of the persons doing the mapping, the SNL representative, and the NTS safety representative. All must agree regarding stability; otherwise mapping will not begin. If any subsequent slumping, sloughing, or caving occurs, mapping will cease and the trench will be re-evaluated with respect to stability and safety.

Trench mapping involves a similar subjective approach as with the field geologic mapping. Considerable study and reflection is required prior to the actual placement of symbols on trench logs. The identification of map units may require collaboration by numerous individuals and consultants; agreement by all may not necessarily result. Horizons may be sampled for age dating and this may take several weeks or even months for results. These dates then may resolve conflict, or may require additional collaboration and re-examination. The explanation of trench features is generally evolutionary and time is needed to reach understanding and consensus.

During mapping, standby for safety, security, or quality assurance reasons may be required; these functions will take precedence over technical work in every instance.

scale, technical equipment, note keeping (per SNL DOP 11-2), sketching, and sampling for age dating (to be detailed in (3) and (4) below.

(C) The technical procedure for sample collection and control (TP-0070) describes the detailed procedures involved in the acquisition, handling, archiving, accountability, and shipment of samples. The procedure considers use of the sample, as not all samples require the same handling or redundancy requirements. Reference SNL DOP-8-1, and Sample Collection Report requirements.

(D) The technical procedure for geologic age dating (TP-0071) describes the controls necessary to ensure that laboratory measurements will provide reliable information for licensing. While the preceding technical procedure discusses acquisition and control of sampling, this procedure addresses the controls necessary in identifying the laboratory accomplishing the dating, usually a subcontractor. In particular, sample treatment history and documentation requirements are necessary elements.

(E) Multiple procedures will be developed for soil property investigations, including adoption of existing ASTM procedures/standards.

- Verification that current revisions of implementing procedures (the EP, TP's, DOP's, QAP's, etc.) are being used. Signature by SNL representative in the Daily Log constitutes verification that current revisions of implementing procedures are being used.
- Verification that any necessary hold points have been defined and that systems are in place to ensure they will be made. Daily verification of necessary hold points are signed off by the SNL representative in the Daily Log at the beginning and the end of the day.
- Verification of applicable initial conditions, e.g., identification of samples and sites, calibration of instruments, provisions for data acquisition, etc. The Daily Log and attendant signatures are used to document these aspects.

These verifications will be noted in the Daily Log and field notebooks.

4.4 Experiment Postrequisites

- Verification that all necessary information has been collected or recorded. This is accomplished daily, and signed off by the P.I. or his representative.
- Verification that all sign-offs have been made. This is the responsibility of the SNL representative and is verified at the end of each day in the Daily Log.

The process of field mapping involves much judgment and interpretation. Much time at the outset is often spent establishing mappable units. In mapping alluvial units, test pits may be required to establish continuity of surface units with depth. A conceptual framework of mappable units is formulated which accounts for the distribution of map units in space and time, including the origin. The actual mapping involves the filling in of details, and the explanation of nuances. The process of geologic mapping involves much time and skill on the part of the mapper(s). Seldom are simple field situations observed, and when reported sometimes reflect the shallow depth of skill of the interpreter. Increasing detail in mapping scale invariably will produce increased complexity in understanding, especially relating local details to regional concepts.

The selection of trench locations will be based on the relative age of map units, and the dating of alluvium where possible. Much of this involves extrapolation from known ages at other locations and relies on substantial skill on the part of the interpreter. In this respect, procedures for accomplishing these subjective skills cannot be defined precisely because there is no prescribed means for doing so. The requirement to specify locations in writing, and to approve the locations in turn (also in writing) creates a formal mechanism to create dialogue if necessary and to document the decision point.

Excavation by support personnel is generally straightforward and will be overseen (but not supervised) by contract technical workers. The reason for this is to ensure that features or artifacts (if uncovered) can be observed in real time, and preserved if necessary. The excavation is to be accomplished

DOP 11-2. If the EP and/or TP needs revision to reflect future operation, it will be done as soon as resolution of the situation is made, and prior to subsequent use of the EP and/or TP.

4.5.2 Typographical Errors

Typographical errors found at the time of use of a procedure will be documented in accordance with SNL NNWSI DOP 11-2. The intent of the word(s) in question will be clarified by the PI, whenever possible, prior to implementation by the user. The EP and/or TP will be revised prior to subsequent use to correct typographical errors when they may prove significant in the conduct of work, e.g., a confining pressure of 80 psi is inadvertently written as 800 psi.

4.6 Revision of Field Experiment Procedures and Technical Procedures

These operating procedures shall be revised only under the control and approval of the responsible PI or his designee. In parallel with the recommended change, the reason for and the circumstances leading to the change shall be recorded in the appropriate logbook and Daily Log, including dates. Revisions cannot be made to this EP except by provisions and control requirements stated in SNL NNWSI DOP 6-1.

Sampling is almost never routine and requires individualized attention. Consequently a sample collection report is required for every sample, and every sample requires specialized work instructions. Each sample requires accontability, i.e. chain-of-custody traceability. Each of these requirements is documented on a form per TP-0070 and DOP8-1.

Geologic age dating can be accomplished by numerous commercial laboratories that have been performing this service for as much as 30 years. Theory is well established as a result, but procedures will vary from laboratory to laboratory because of equipment differences. Not all age dating laboratories perform the same services, and some services (e.g. uranium trend dating) are performed by a single laboratory at substantial cost. Some samples require elaborate mechanical separation, such as hand separation of mineral grains and fragments under a microscope. Because of the highly individualized services required of the dating laboratories, the selection of the laboratory is an important aspect of ensuring quality work. Procedures are detailed in TP-0071.

4.3 Experiment Prerequisites

- Verification that all equipment/items are present and ready. This aspect is signed off on the Daily Log by both the Project Manager and the P.I.
- Verification that necessary personnel training and qualification has been completed and approved, and that required personnel are available. Verification is established in Daily Log by way of signature of contractor's project geologist.

9. Geochemical analyses of datable horizons for correlation purposes
10. Petrographic analyses of datable horizons for correlation purposes
11. Geophysical measurements across faults

These types of data are recorded at reduced scale on geologic maps and cross-sections, with the interpretation being recorded in the legend, i.e., the representation. The scale is determined by the detail needing to be represented and is strongly influenced by the complexity of the features present in the exposures being mapped. For example, if fault displacements are judged to be absent after a detailed examination of a trench by experienced geologists and geophysicists, then descriptions and photographs will be taken to verify conclusively that that condition exists. On the other hand, if displacements exist, that condition will be thoroughly documented and mapped at a greater level of detail, because the amount and recurrence rates of offset are crucial to the placement of the waste handling facilities. Data are recorded on map sheets, logbooks, and the Daily Log (Attach. 1). Supplementary photography and samples comprise additional data.

5.3 Supporting Analysis

The interpretations of fault displacement will often depend on supporting data such as ages of geologic samples taken from specific horizons, geochemical analysis of specific horizons, or in geophysical measurements.

These supporting analyses are described further in Part B, Technical Procedures and in references contained therein.

- Verification that all samples/sites and data have been identified and data collected per the instructions in the EP. Sample collection reports are required per TP-0070 and DOP 8-1; completion of these forms are noted in the Daily Log and certified by the SNL representative at the end of the day.
- Statement and verification of existence of applicable closing conditions, e.g. post-experiment calibration check of instruments, etc. Normally this does not apply, but if necessary, the Daily Log will be used for this purpose.
- Verification of return of samples and excess material to the NNWSI core repository, consistent with requirements in SNL NNWSI DOP 8-2. These verifications will be noted in the Daily Log and post-experiment summary of collected data to be entered into the DRMS.

4.5 Deviation From and Changes to Procedures During Use

Deviations from this EP and TP's are acceptable when circumstances described in the following subsections occur. If deviations have an effect on either the quality of the data or on its intended use, the event(s) will be documented in accordance with SNL NNWSI QAP 15-1.

4.5.1 Irretrievable Loss of Data or Unsafe Operation

When irretrievable loss of data, or an unforeseen unsafe operation will occur if the EP or referenced TP is followed, the user of the procedure may deviate from it. The event will be documented in accordance with SNL NNWSI

6.0 QA IMPLEMENTATION

6.1 Audits/Surveillances

Periodic, selective audits of experiment activities shall be instituted by the contractor QA manager. Continuing surveillance of contractor activities is the responsibility of the Sandia on-site representative. Daily surveillance and documentation is achieved by way of completing the Daily Log.

6.2 Personnel Qualifications

Qualifications for technical personnel are detailed in the technical procedures listed herein (Part B). Certification requirements for NNWSI project personnel are discussed in SNL DOP 2-6; certification documents are retained as lifetime QA records in SNL Department 6310 file 90/1293/CRT/QI.

Contractor personnel are required to satisfy qualification requirements as stated in Technical Procedures 0068, 0069, 0070, 0071, which are incorporated in the Contract Statement of Work (SOW). In addition the SOW requires that the contractor submit a Quality Assurance Plan and that this be approved by the Department 6310 Quality Assurance Coordinator prior to start of work. The contractor certifies that personnel qualification requirements are met, and in addition will certify in writing that familiarization training regarding all relevant Experiment and Technical Procedures is accomplished for project personnel.

5.0 DATA

5.1 Data Acquisition System/Instrumentation

A data acquisition system is not required in the conduct of this work.

Geophysical instrumentation may be used by Golder Associates or other contractors as an adjunct to mapping and trench location. Procedures associated with this activity are described in SNL Technical Procedures (TP's-0068-69).

5.2 Data Reduction/Analysis/Interpretation

The following types of data will be collected during the conduct of this work:

1. Areal distribution of mappable geologic units
2. Attitude of units, e.g., strike, dip, orientation
3. Description of properties, e.g., weathering, fracturing, composition, gradation
4. Location, orientation, description of tectonic features, e.g., faults, fractures
5. Samples of units for archiving
6. Samples of horizons for age dating
7. Dates on samples
8. Material properties (laboratory)

7.0 DOCUMENTATION

7.1 Logbooks

Field logbooks for mapping and geologic observations will follow SNL DOP 11-2. A Daily Log (Appendix A) is maintained; completion of the Daily Log is a joint responsibility of the Principal Investigator and the Project Geologist.

7.2 SNL 6310 Data Records Management System (DRMS)

All original data and logbooks will be entered into the DRMS, including two copies of all photography. All data will be entered by the P.I., following requirements of SNL DOP 11-3. Computer media and thermographic or electrostatic paper are unacceptable for entry into DRMS.

The interpreted data is used by seismologists in their analyses and predictions of surface fault rupture and ground motion. These procedures are described in SAND85-7104 and SAND86-7013. Engineering designers then apply these data to their facility designs. Safety Analyses are then conducted, applying these specific designs to site-specific conditions.

5.4 Records Maintenance

Data obtained in support of this effort are to be maintained at SNL Department 6310, Bldg. 823, Kirtland AFB East under NNWSI Data Indexes (i.e., Site Data for Surface Facilities, Trenching (F12 A.A-TBD); Site Data for Surface Facilities, Surface Mapping (F12 B.A-TBD). Logbooks are maintained in accord with SNL DOP 11-2 and the Daily Log (Appendix A) custody rests with the SNL Principal Investigator.

9.0 REPORTS

Contractors will provide reports for activities as specified in their individual contracts. The principal SNL document will be SAND85-0816, "Fault and Tectonic Environment at the Reference Conceptual Site for Repository Surface Facilities." This will provide interpretations of the salient data that are obtained.

9.1 Data Report Requirements

All data reports which are produced, shall contain reference to:

(a) The unique identifier and revision number of the Field Experiment Procedure and Technical Procedure(s) used to acquire data.

(b) Names of persons performing work and author(s) of the report.

(c) The SNL PI responsible for the activity.

(d) Units (e.g., S.I.) data are to be reported in are usually the same as the units used during data acquisition.

(e) Date that the report(s) are due. The requirement can be stated as a time interval from the completion of the performance period, i.e., 30 days from the completion of testing.

6.3 Calibration

Periodic adjustments are made in Brunton pocket-transits, hand levels, and other equipment as required. These adjustments and calibrations are described in Technical Procedures TP-0068-69.

6.4 Nonconformances/Corrective Action

Nonconformances to this experiment procedure and associated technical procedures will be documented per SNL QAP-15-1. Corrective actions will be taken and documented per SNL QAP 16-1.

10.3 Logistical Support

Contractor personnel will not be provided with support services. Emergency support may be requested through the SNL on-site representative, e. g. for vehicle repair, etc.

10.4 Security

All participants will be badged and adhere to all NTS security requirements, including wearing the badge at all times. Photography is not permitted without permit. Contractor photography will be arranged through the SNL on-site representative, who will possess an NTS Photographer's Permit.

10.5 Environmental Clearances

The SNL on-site representative is responsible for coordinating these permits with the NTS Support Office.

8.0 SAFETY

All NTS safety requirements will be followed. Requirements specific to this test procedure include wearing of hard hats and safety shoes in unstable, unshored trench walls. Safety glasses/goggles are worn when hammering rocks or when sand and dust is being generated from the cleaning of trench walls. The determination of trench stability is a joint responsibility of the SNL PI, the contractor's site manager, and the NTS safety representative. Additional safety practices are described in TP-0069.

Total field working time, including commuting time, of more than 12 hours per day will not be permitted.

Off-road-vehicle travel is not allowed, unless special permission has been obtained from NTS Operations Office. Fire extinguishers will be contained in all field vehicles. First-aid kits will be kept in each field vehicle, and/or in the personal possession of the vehicle operator.

Field operations will cease when electrical storms approach closer than two miles. This will be determined by observation of a ten-second delay in thunder following lightning.

Trenches will be roped off according to NTS safety practices.

All Entries in Ball-Point Ink (Black)
Loose Leaf Notebook

DATE_____

DAILY LOG

Contractor_____
Contract #_____
NNWSI _____

Part I - ACTIVITY IDENTIFIERS

Activity and Technical Procedure Identification:

FEP-0001 Field Experiment Procedure for Seismotectonic Field Studies for Repository Surface Facilities, NNWSI

TP-_____

TP-_____

TP-_____

Activity Location:

RSF Site, Yucca Mountain, Nevada

Instrumentation/Equipment: (include manufacturer, model & serial number and other unique I. D.)

Sketch or Photograph of Set Up (if warranted): Attach to separate page (in duplicate, for DRMS)

Investigators:

Name	Title	Signature*

Verification by SNL Representative:

Signature**	Title and Division	Date and Time of Activity Start

*Signature by Project Geologist constitutes verification that training and qualification has been completed and documented by contractor, as specified in EP-0001.

**Signature by SNL Representative constitutes verification that current revisions of implementing procedures are being used.

10.0 NEVADA TEST SITE OPERATIONS

10.1 Overall Responsibilities

Primary responsibility for the conduct of investigations and the execution of the field test procedures rests with the SNL Principal Investigator or alternate designated by the SNL Div. 6311 supervisor. Secondary responsibilities for test execution rest with contractor and support personnel. Supervisory control for Reeco, H & N, and other contract personnel does not extend to the SNL Principal Investigator. Changes to work statements are made formally through established procedures with the SNL Purchasing Department, and/or the NTS Support Office. Nonconformances are handled by immediate remedial action where appropriate, and by formal reporting (SNL QAP 15-1). Contractor field investigations will be conducted only when an SNL representative or designated alternate is present. No exceptions will be made to this procedure.

10.2 Personal

Individual participants will make housing and other personal arrangements through the SNL on-site representative. Assistance may be obtained through the SNL field office at Mercury, NV (702) 295-6200 or FTS 575-6200.

DATE_____

Deviations From Experiment/Equipment Test Procedures or Technical Procedures:

Unusual Occurrences or Unexpected Results:

Nonconformances and Corrective Action Efforts:

Separate Report Required per QAP-15-1

Downtime - State reasons:

11.0 REFERENCES

1. Colwell, R. N., editor, (1983). "Manual of Remote Sensing" (in 2 volumes), 2nd edition: Amer. Soc. Photogrammetry, Falls Church, VA, 2440 pp.

2. Compton, R. R., (1985). Geology in the Field, John Wiley and Sons, New York, 398 pp.

3. Hatheway, A., and F. B. Leighton, (1979). Trenching as an Exploratory Method, Geol. Soc. Amer., Reviews in Engineering Geol., v. IV, pp. 169-195.

4. Murphy, P. J., J. Briedis, J. Peck, (1979). Dating Techniques in Fault Investigations, Geol. Soc. Amer., Reviews in Eng. Geology, v. IV, pp. 153-168.

5. SAND85-7104, "Ground Motion Evaluations at Yucca Mountain, Nevada, With Applications to Repository Conceptual Design and Siting."

6. SAND86-7013, "Technical Basis and Parametric Study of Ground Motion and Surface Rupture Hazard Evaluation at Yucca Mountain, Nevada," (in review).

7. Scott, R. B., and J. Bonk, (1984). "Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections," U. S. Geol. Survey, Open File Report 84-494.

8. (1926.653(n)) OSHA Trenching and Shoring Standards.

9. SNL NNWSI QA Documents

- DOP 2-6, "Qualification and Certification of Project Personnel"
- DOP 5-2, "Technical Procedure Requirements"
- DOP 6-1, "Document Control"
- DOP 8-1, "Sample Identification and Handling Requirements"
- DOP 8-2, "Operation of the SNL NNWSI Core Library"
- DOP 11-2, "Requirements for Experiment and Equipment-Test Logbooks"
- DOP 11-3, "Data Records Management System Interaction Requirements"
- DOP 12-1, "Calibration Program"
- DOP 13-1, "Identification, Handling, Shipping, and Storage Procedures for Items"
- QAP 15-1, "Nonconformance Reporting and Controls"
- QAP 16-1, "Corrective Action Requirements"

DATE_____

PART II - DOCUMENTATION OF ACTIVITY

Procedure Steps Worked On: Comments

_____

_____

_____

_____

Item/Sample/Site Identification:

_____

_____

_____

_____

Equipment/Instrumentation Settings:

Conditions That Might Affect Experiment/Test Results:

Data or Reference to Other Data:

Copies of field notes will be attached to separate page herein
(notebook and page #'s _____;_____)
(note sketch #'s _____)

TABLE OF CONTENTS

Section		Page
1.0	General Information	4
1.1	Scope	4
1.2	Objective	4
1.3	Applicable Study Plan	5
2.0	Description of Work	5
2.1	Management	6
2.2	Experiment Configurations	6
2.3	Experiment Methods	9
2.3.1	Activity A	9
2.3.2	Activity B	9
2.3.3	Activity C	9
2.3.4	Activity D	11
2.3.5	Units of Measurement	11
2.4	Measuring and Operating Equipment	11
2.4.1	Identification, Handling, Shipping, and Receiving of Items, Materials, and Samples	14
2.4.2	Calibration of Equipment	17
2.4.3	Calibration Checks	20
2.5	Sample Traceability and History	22
2.5.1	Sample Identification and Custody	22
2.5.2	Effects of Prior Activities on Samples	24
2.6	Sample Preparation	24
2.6.1	Machining of Rock Samples	24
2.6.2	Inspection for Dimensions and Tolerances	24
2.6.3	Drying and Saturation of Samples	25
2.7	Use of Logbooks	25
2.8	Related Analyses	27
2.9	Related Experiments	27

Person Making Entry:

Certification by SNL Representative at End of Day:

Name	Time Original Notes Received	Approval (Signature, Time)

Remarks by SNL Representative:

1.0 GENERAL INFORMATION

1.1 Scope

This Experiment Procedure (EP) describes experiments to be performed by New England Research (NER) under SNL Contract 95-8399. The EP describes requirements for:

- sample handling, identification, and control;
- pre-experiment activities such as equipment calibration and sample preparations;
- experiment activities, including data acquisition;
- post-experiment activities such as calibration checks, data reduction, sample storage and shipment, and reporting requirements;
- documentation requirements at all stages.

It is intended that this EP and Referenced Technical Procedure (TPs) embody the applicable portions of the SNL NNWSI Quality Assurance Program Plan (QAPP) and its associated procedures. Therefore, this EP and the referenced TPs form the Quality Assurance Plan that the contractor, NER, should follow.

1.2 Objective

The objective of the work described in this EP is to obtain mechanical property data on samples of welded, devitrified Topopah Spring Member for three different experiment conditions:

- Strain rate of 10^{-8} s^{-1} at 250°C;
- Strain rate of 10^{-9} s^{-1} at 25°C;
- Constant differential stress of 80 MPa (creep test) at 250°C.

The data to be collected are axial load, axial displacement, lateral displacement, pressure, and temperature. These data will be used to analyze the mechanical response of the rock to high temperatures and/or low strain rates.

880126.0003

SNL NNWSI PROJECT EXPERIMENT PROCEDURE

EFFECTS OF VARIABLE ENVIRONMENTAL CONDITIONS ON COMPRESSIVE MECHANICAL PROPERTIES - HIGH TEMPERATURE/LOW STRAIN RATE EXPERIMENTS

Approved by:

Francis B. Nimick, 6313
Author — Date: 9/21/87

Ronald H. Price, 6313
Author and PI — Date: 9/21/87

Stephen J. Bauer, 6314
Independent Technical Review — Date: 9/21/87

Barry H. Schwartz, 6313
Independent Technical Review — Date: 9/21/87

R. R. Richards, 6310
QA Coordinator — Date: Sep 21, 1987

T. E. Blejwas, 6313
Division Supervisor — Date: 9/22/87

T. O. Hunter, 6310
Department Manager — Date: 9/22/87

SNL NNWSI DEPARTMENT 6310
CONTROLLED DOCUMENT
Issued to: M. D. CUTTER, SAIC
Copy Number: #006
RETURN TO 6310 RECORDS CENTER
WHEN NO LONGER NEEDED.

All experiments governed by this EP will be performed on samples provided to NER by SNL. Experiments will be run on equipment of sufficient load capacity (approximately 1×10^6 N) to achieve sample failure in compression, and of sufficient stability to maintain constant temperature ($\pm 3°C$) and applied load for long periods of time. Constant-strain-rate experiments will be run until sample failure is achieved; whereas constant stress experiments will run until either sample failure occurs or a pre-established time limit is reached, whichever occurs first.

2.1 Management

The SNL Principal Investigator (PI) for this work is Ronald H. Price (SNL Division 6313), who is responsible for providing technical and quality-assurance guidance for the experiments, for ensuring that relevant documentation is completed, and for submitting the documentation to the SNL Data Records Management System (DRMS). The SNL PI or designee will have the right to perform surveillances and QA audits of NER or approved subcontractors during any work covered by this EP. At NER, the lead scientist will be responsible for overseeing all technical work at NER, implementing all QA activities, and for ensuring that all requirements specified by SNL are met. The experiments will be performed by NER technicians with interaction from the NER lead scientist.

This work is to be performed under SNL Contract 95-8399. The pertinent DRMS Data-Set ID is 51/L02-4/6/87.

2.2 Experiment Configurations

The general test configuration is shown in Figure 1. The furnace that is shown in the figure will be used for Activities A, B, and D. The configuration for the radial linear variable differential transformer (LVDT) is shown in Figure 2 as it will be used for Activity C. For Activities A, B,

3.0 QA Level 27

4.0 Operations 27

4.1 Prerequisites 28

4.1.1 Personnel Qualification and Training 29
4.1.2 Procurement 29
4.1.3 Current Procedures 29
4.1.4 Hold Points 29

4.2 Postrequisites 30

4.3 Technical Procedures 31

4.4 Data Acquisition System 31

4.4.1 Hardware 31
4.4.2 Application Software 33
4.4.3 Data Acquisition and Storage 34

4.5 Deviation From and Changes to EP or Associated TPs During Experiments 35

5.0 Nonconformances and Corrective Actions 36

6.0 Safety 36

7.0 Records Control 36

7.1 DRMS Data-Set ID 36

7.2 Records Transmittal 36

7.3 Return of Samples 37

8.0 Data Reports 38

9.0 Personnel Qualification and Training 39

10.0 References 41

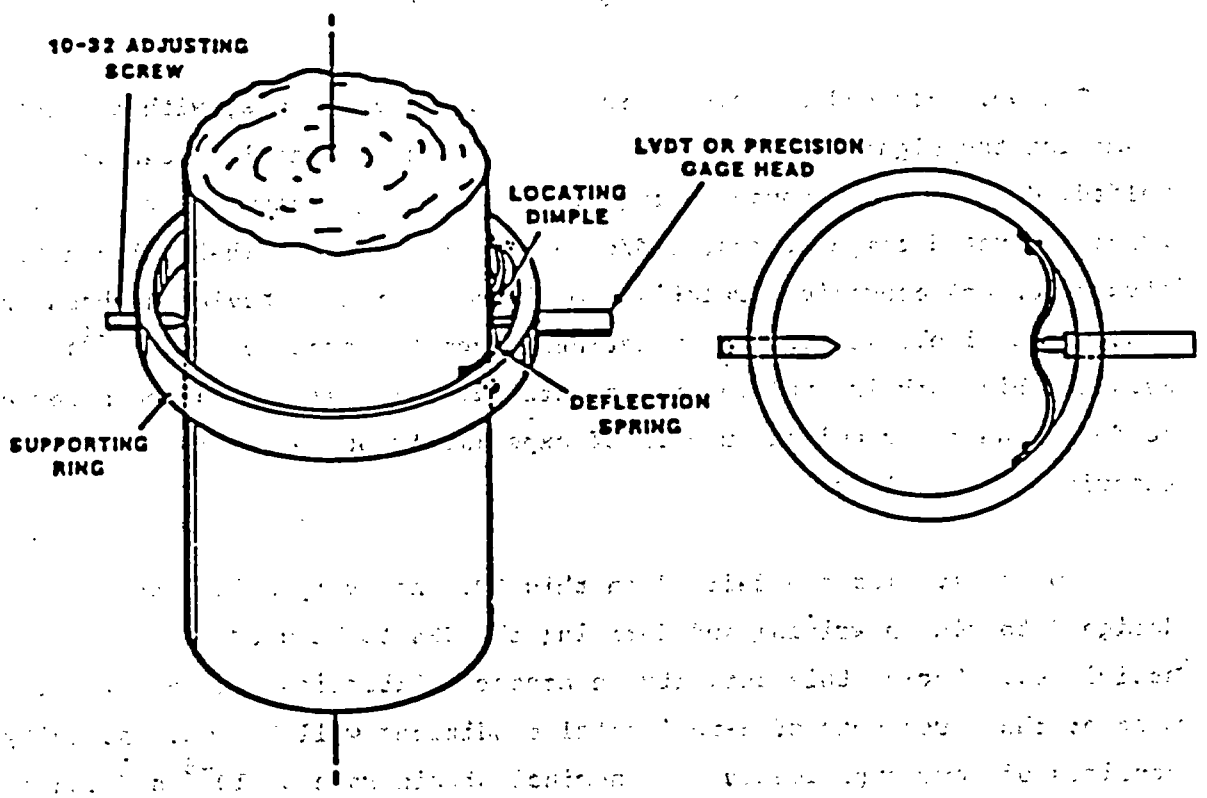

Figure 2. Schematic drawing of radial LVDT displacement gage (after Holcomb and McNamee, 1984)

1.3 Applicable Study Plan

The Study Plan to which this EP relates is SP-4, entitled "Laboratory Determination of the Mechanical Properties of Intact Rock." This Study Plan is presently scheduled to be completed in August 1987 and submitted to the Department of Energy for submittal to the Nuclear Regulatory Commission with the Site Characterization ongoing Plan. Work described in the EP is considered a part of our ongoing work in mechanical testing of intact rock and may be initiated prior to approval of the Study Plan.

2.0 DESCRIPTION OF WORK

The work covered by this EP is exploratory in nature, with the intent of examining the significant changes, if any, in the mechanical behavior of the welded, devitrified Topopah Spring Member that might occur at very low strain rates, elevated temperatures, and/or under long-term, high-level constant stress (creep) conditions relative to the mechanical behavior at baseline test conditions (i.e., saturated, unconfined, room temperature, 10^{-5} s^{-1}). Because this work is exploratory, no statistical analysis has been performed to determine the required numbers of experiments or to aid in defining experiment conditions.

Four activities are defined in this EP. Activity A is scoping in nature, designed to aid in writing and defining the TPs to be used in the other three activities. During this activity, a heater calibration and one experiment at each of the three sets of experimental conditions will be run. Activity B consists of four experiments at a nominal strain rate of 10^{-8} s^{-1} and a temperature of 250°C. In Activity C, three samples will be tested at 10^{-9} s^{-1} and room temperature. Activity D consists of constant stress experiments at 250°C.

Activity A must be performed first; however, NER may perform Activities B, C, and D in any order they deem appropriate. Following Activity A, NER must meet certain requirements (see Section 4.1.4.1) before continuing on to Activity B, C, or D.

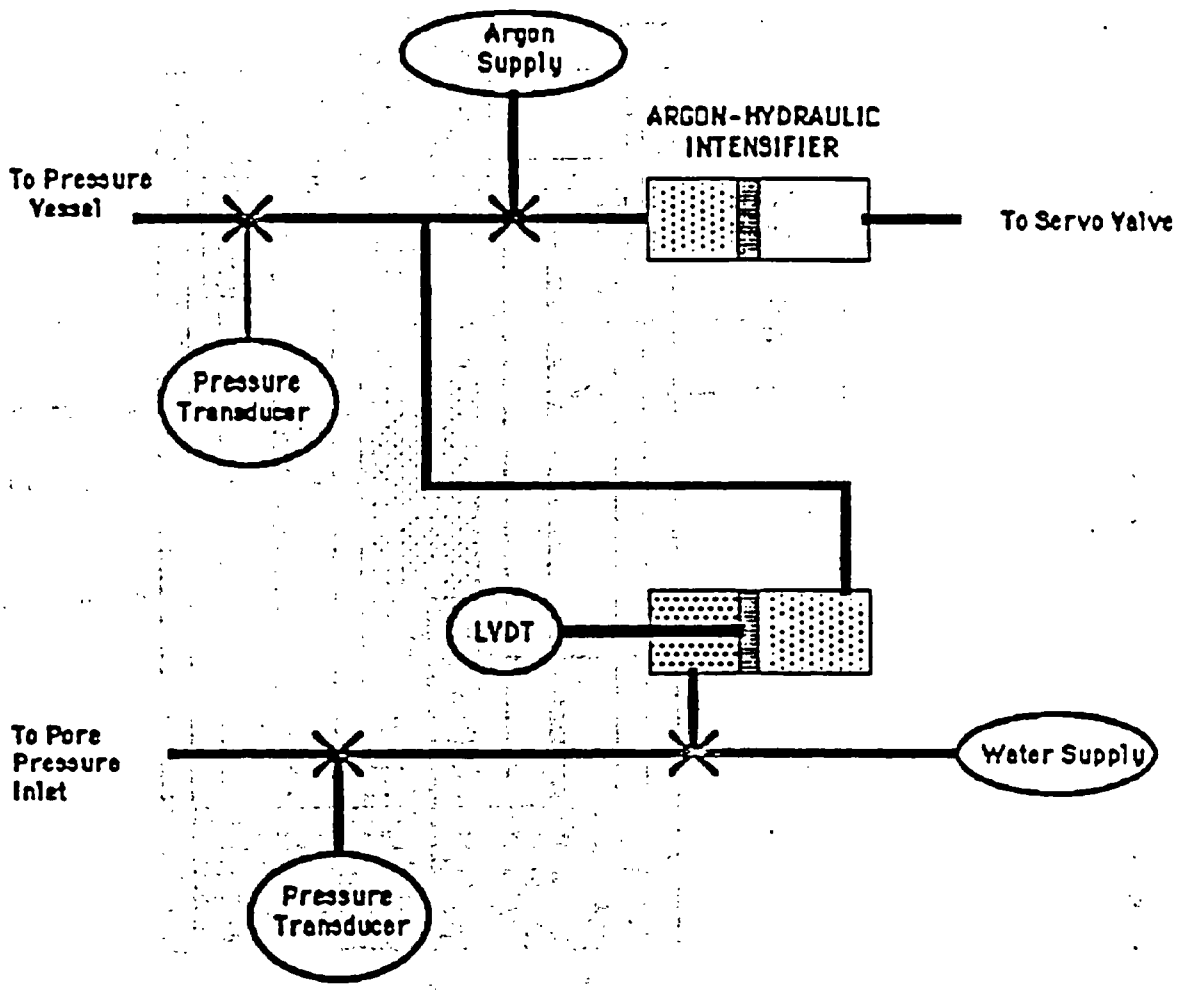

Figure 3. Schematic diagram of the servo-control system for the confining pressure and pore pressure.

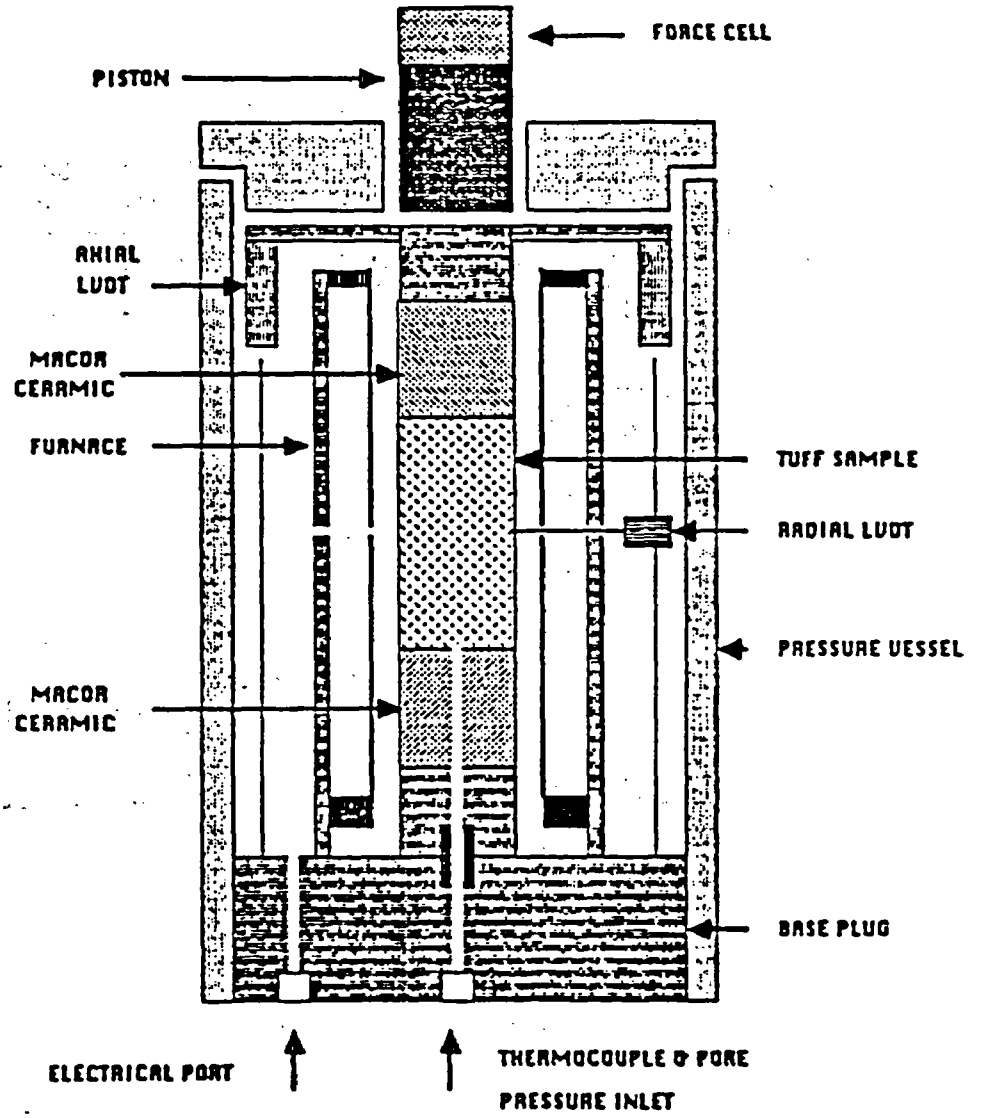

Figure 1. Schematic diagram of sample assembly, furnace and pressure vessel for high temperature experiments on tuff.

TABLE 1

Equipment to be Entered Into the SNL Calibration-Recall System

Equipment	Serial Number	Cal. Freq.	SNL Cal. Div.
Omega sheathed thermocouple, Type J. Model TJ36-ICCS-116G.	#1	52 weeks	7243
Omega sheathed thermocouple, Type J. Model TJ36-ICCS-116G.	#2	52 weeks	7243
Omega sheathed thermocouple, Type J. Model TJ36-ICCS-116G.	#3	52 weeks	7243
Omega Trendicator Degrees C. Model 4000 BIA-02-C	5005089	52 weeks	7243
Data Instruments Pressure Transducer (0-1000 psi), Model AB	B28448	52 weeks	7545
Data Instruments Pressure Transducer (0-2000 psi), Model AB	B22798	52 weeks	7545
BLH load cell (0-100,000 lb) Model CXX	K758	52 weeks	7544 (1)
NER load cell (0-200,000 lb) Model 200-J-86	#1	52 weeks	7544 (1)
Lancing Research Micrometer Head, 0.010 in. stroke, no model #	NER-010-86	52 weeks	7485-3
Fluke Digital Voltmeter (true RMS) Model 8060A	4135099	26 weeks	7243

and D, rods will extend through the furnace to connect the deflection spring and the adjusting screw to the sample surface. A schematic of the servo-control system of the confining and pore pressure system is provided as Figure 3.

2.3 Experiment Methods

All samples will be nominally 50.8 mm in diameter and 101.6 mm in length, obtained from a large block of welded, devitrified Topopah Spring Member collected from Busted Butte on the Nevada Test Site. Sample dimensions as determined by SNL should be used in all calculations unless a written notification to the contrary is received from the SNL PI.

2.3.1 Activity A

Four samples will be tested, one at each set of conditions as described in Activities B, C, and D and one heater calibration experiment. These experiments are defined as scoping, in order for the draft TPs relevant to the other activities to be refined.

2.3.2 Activity B

Four samples will be tested at a temperature of 250°C and a nominal axial strain rate of 10^{-8} s^{-1}. Pore pressure will be sufficient to prevent boiling of pore water at 250°C (approximately 4.5 MPa), and confining pressure will be maintained at 10/9 of the pore pressure by the intensifier shown in Figure 3. Application of confining pressure will be at $\leq$0.3 MPa/s, and temperature will be applied at $\leq$0.02°C/s. Verification of these rates should be provided as part of the documentation in the experiment logbook.

2.3.3 Activity C

Three samples will be tested at a nominal axial strain rate of 10^{-9} s^{-1}. The samples will be water-saturated at the beginning of testing. Confining pressure, pore pressure, and temperature will be ambient laboratory values.

TABLE 2

Equipment Not Entered Into the SNL Calibration-Recall System
(Concluded)

Equipment	Serial Number	Type of Operation
Validyne Model MC 170 Signal Conditioning Module	**	LVDT Excitation and Amplification
A/D Converters	**	For LVDTs (In the DAS)
Analog Devices Model 2B31 Signal Conditioning Module	**	Load Cell Amplification
A/D Converters	**	For Load Cells (In the DAS)

* = To be determined.
** = None, entry will be made in logbook if changed during conduct of work under this EP.

elevated pressures during Activities A and B. The effect of the pressure on these pieces of equipment will be accounted for as described in the relevant Technical Procedures (TP). The TPs to be used in connection with this EP are listed in Table 3. These TPs address the type, range, and accuracy of each piece of measuring equipment; specify the calibration procedures for individual pieces of equipment; and also include procedures for calibration checks.

2.4.1 Identification, Handling, Shipping, and Receiving of Items, Materials, and Samples

For items, materials, and samples at NER or NER subcontractors, it is the responsibility of the NER lead scientist to ensure that the requirements of this section are met. For items, materials, and samples at SNL it is the responsibility of the SNL PI, or designee of, to ensure that the requirements of this section are met.

2.3.4 Activity D

Three samples will be tested at a constant differential stress of 80 ± 1 MPa and 250 ± 3°C. No confining pressure or pore pressure will be applied, but samples will be jacketed to provide controlled boundary conditions for sample saturation. Samples initially will be water-saturated, but will be allowed to dry naturally through a pore-pressure inlet in the lower end-cap during the experiment. The heating rate will be ≤0.02°C/s, and axial load will be applied at ≤0.25 MPa/s. Verification of these rates will be provided as part of the documentation in the experiment logbook.

2.3.5 Units of Measurement

The following units of measurement will be used during data acquisition:

Temperature: °C
Stress and Pressure: MPa
Length and Displacement: mm
Strain: milli
Time: s
Force: N

In many cases, data actually will be acquired as voltages and will be converted to the units given above using computer software. Requirements for verification and validation of such software are given in Section 4.4.

2.4 Measuring and Operating Equipment

Tables 1 and 2 list the equipment to be used for the activities covered by this EP. All equipment has been selected as suitable for the experiments to be performed. The only equipment in the tables to be subjected to conditions other than ambient during the experiments are the LVDTs, thermocouples, and furnace, all of which will be subjected to elevated temperatures during Activities A, B, and D. In addition, the LVDTs, thermocouples, furnaces, and pressure transducers will be subjected to

2.4.1.1 Identification of Items

Documentation of work in support of this EP (including shipping, receiving and handling, as well as data gathering activities) will utilize item identifications consistent with Tables 1 and 2 of this EP. NER will provide the SNL PI (prior to data gathering work being performed) all equipment identifications from Tables 1 and 2 which are not yet defined as of revision 0 of this EP.

2.4.1.2 Identification of Materials and Samples

NER will provide unique identifiers of materials (such as the aluminum standards discussed in section 2.4.3) to the SNL PI prior to their use. These unique identifiers will be treated like a sample ID (i.e., notations on data, logbook, and diskettes).

2.4.1.3 Handling and Shipping

It has been determined that no special protective environments are necessary during shipping and handling of the items, materials, and samples defined in this EP.

Shipping

Items, materials, and samples will be shipped so that the characteristics or functions of the items and materials, as well as their identification are not compromised. As a minimum, the conditions specified on the form (Appendix A) will be verified.

The shipping form (shipper) will request that the outer shipping container be constructed of wood, be labeled "fragile," and the top of the shipping container be defined, e.g., "this side up." In addition, the handler/carrier should be instructed (in writing) of the following:

TABLE 2

Equipment Not Entered Into the SNL Calibration-Recall System

Equipment	Serial Number	Type of Operation
Scale, *	*	Weight
Miller Machine Co. Intensifier, no model #	986	Pressure limiting Device
NER Furnace, no model #	1H	Heats Sample inside Compressive Cell
Research Inc., Model 639B Temperature Controller	30323-60	Temperature Control for Above Furnace
Schaevitz Eng. 100 MHR Series LVDT	4722	Axial Displacement
Schaevitz Eng. 100 MHR Series LVDT	4723	Axial Displacement
Schaevitz Eng. 005 MHR Series LVDT	2017	Radial Displacement
IBM-XT Model 268	2133847	Computer
Validyne Model MC308	108060	Signal Conditioning
Hewlett Packard Power Supply Model 6253A	1140A02557	Pressure Transducer Excitation Source
Analog Devices Model 2B31J card	**	NER Load Cell Excitation Source
Lambda Power Supply Model L2S-10	**	BLH Load Cell Excitation Source
Lambda Power Supply Model L2S-10	**	Piston Displacement Excitation Source
Validyne Model BA 172 Buffer Amplifier	**	Pressure Transducer Amplifier
A/D Converters	**	For Pressure Transducers (In the DAS)
Hewlett Packard LVDT Model 7 DCDT-100	**	Displacements for Strain Rate Measurements

The measuring equipment will be entered in the SNL calibration recall system for the duration of work under this EP, with calibration stickers placed on all measuring equipment. SNL calibration certificates will be provided from the SNL calibration labs to SNL Division 6313 personnel, for transmittal to the SNL NNWSI Project Data Records Management System (DRMS). The SNL PI (or designee) will transmit copies of the calibration certificates to NER, for use in performing system calibrations using the Data Acquisition System (DAS). NER is responsible for the shipment of measuring equipment that will be calibrated at SNL. SNL is responsible for return of such measuring equipment to NER.

Thermocouples and Furnace

The output reading from each thermocouple is measured using the trendicator and compared with the readout from the DAS. The furnaces will be calibrated in accordance with Technical Procedure TP-95.

Pressure Transducers

The voltage output from each pressure transducer is measured using the digital voltmeter, and compared to the output on the DAS. The pressure measuring system will be calibrated in accordance with Technical Procedure TP-96.

Load Cells

The voltage output from each load cell is measured using the digital voltmeter and is also compared to the values measured using the DAS. The force measuring system will be calibrated in accordance with Technical Procedure TP-93.

LVDTs

LVDTs will be calibrated at NER using a micrometer head, in accordance with Technical Procedure TP-94.

TABLE 3

Technical Procedures Relevant to Activities for EP-0002

Title	Number	Activity or Activities
Procedure for the Preparation and Inspection of Rock Core Specimens Used in Mechanical Tests	TP-51	B, C, D
Procedure for Vacuum Saturation of Geologic Core Samples	TP-64	A, B, C, D
Procedure for Drying Geologic Core Samples to Constant Weight	TP-65	A, B, C, D
Confined Compression Experiments at 250°C and a Strain Rate of 10^{-8} s^{-1}	TP-90	B
Low-Pressure Confined Compression Experiments at a Strain Rate of 10^{-9} s^{-1}	TP-91	C
Constant Stress (Creep) Experiments at 250°C	TP-92	D
Load Cell Calibration at New England Research	TP-93	B, C, D
LVDT Calibration at New England Research	TP-94	B, C, D
Furnace Calibration at New England Research	TP-95	B, D
Pressure Transducer Calibration at New England Research	TP-96	B

Power Supplies

Power supplies that provide excitation voltages to transducers will have their output checked using the fluke digital voltmeter, in accordance with the respective TP for each type of transducer that uses the power supply.

Balance

Calibration of the balance used in weighing samples during sample drying and vacuum saturation (TP-64 and TP-65) will be the responsibility of NER. These calibrations need to be performed on-site, because shipping and handling of the balance would render calibration invalid. Calibration of the balance is to be performed on a 26 week interval. Documentation requirements for the balance include the following:

- A copy of the calibration records for the instruments of the calibration facility and standards certifying that traceability to national standards exists.

- A calibration report, containing the following:

  - type and identification of device being calibrated,
  - identity of the standards used (if any),
  - a statement of traceability to nationally recognized standards,
  - a table or plot of the indicated versus the actual value,
  - a statement certifying that the device is accurate within a specified tolerance over a specified range,
  - the identity of the person performing the calibrations, and
  - the dated signature of the same person or their supervisor.

- A sticker attached to the instrument (or directly referenced thereto if physical attachment would interfere with use of the instrument) bearing the following information:

  - the identification of the instrument, consistent with the permanent identification marking on the instrument,

- The contents shall have a moisture barrier around them.

- The contents should be packed with sufficient packing material to keep the contents from contacting other contents in the box or the box itself.

- The contents should be properly oriented, consistent with the "this side up" marking on the outer shipping container.

- The shipping container should not be exposed to freezing temperatures or direct sunlight for prolonged periods of time.

2.4.1.4 Inspection

Inspections will be performed at the time shipments are received. The SNL PI should be notified verbally as soon as possible and in writing within 5 days from when it has been determined that items, materials, or samples have been damaged during shipment.

2.4.2 Calibration of Equipment

All equipment that will be performing a measurement function must be calibrated before use. Two options are available for calibration. The first option is that such equipment can be calibrated at SNL by an SNL calibration organization. The second option is that NER can obtain calibrations independently. In the latter case, which applies to the balance only, calibrations must be documented as traceable to the National Bureau of Standards or other nationally recognized standard. For both options, periodic calibrations will be required. Table 1 lists the measuring equipment that will be calibrated at SNL under SNL Engineering Release ER-SIER 871197SC. Prior to the calibrations, NER will define the following for all equipment in Table 1:

- Appropriate units of measurements,
- Range of use,
- Excitation voltage (if applicable),
- Desired accuracy,
- Environmental conditions other than ambient (if any).

performing a least-squares linear fit to stress and strain data obtained between 10% and 50% of the maximum applied stress.

If the preexperiment series check is out-of-specification, the source(s) of error must be identified and eliminated to the extent possible, then the calibration check must be performed again. This process is to be repeated until an in-specification check is obtained. Appropriate entries in the experiment logbook (Section 2.7) must be made for all calibration checks, whether they are in or out of specification.

If a check other than the first is out-of-specification, this fact should be clearly noted on all data records from the mechanical experiments on tuff samples performed since the preceding calibration check.

Four calibration checks should be performed for Activity C. One calibration check using the aluminum sample should be made before experiments on tuff samples. Tuff sample experiments and calibration checks then should alternate with the last run being a final calibration check. Each calibration check should be run using the following conditions: a strain rate of 10^{-5} s^{-1}, room temperature (approximately 25°C), and no confining pressure. All other stipulations for these calibration checks are as given for Activity B.

Calibration checks for Activity D will take two forms. Standard checks as described above for Activity C will be performed alternately with tuff samples, beginning after the first tuff experiment is completed. The last run in Activity D will be a calibration check.

Before the first tuff experiment for Activity D, the aluminum sample should be subjected to the following sequence:

1. Increase the temperature of the aluminum at $\leq$ 0.02°C/s to 250 $\pm$ 3°C.
2. Maintain temperature for 15 $\pm$ 1 min. (900 $\pm$ 60 s) to ensure thermal equilibrium.
3. Raise the axial stress at $\leq$ 0.25 MPa/s to 80 $\pm$ 1 MPa.

All samples are right-circular cylinders with nominal diameters of 50.8 mm (20. in) and lengths of 101.6 mm (4.0 in). These identifications will be used throughout the period of work, and either will be physically attached to the sample, or the sample(s) will be in container(s) marked with the identification(s), or both. Sample custody will be documented using Chain-of-Custody forms supplied by the SNL PI with one form (or more, if necessary) for each sample in Activities B, C, and D.

The remainder of the instructions in Section 2.5.1 apply only to samples used in Activities B, C, and D.

Samples will be provided to NER in transparent, plastic jars with screw-on lids. Sample identifications will be marked on the side of each sample and on each plastic jar. It is the responsibility of NER to ensure that the samples are not exposed to any abnormal environmental conditions (e.g., unusual temperature variations, excessive vibrations, etc.) while samples are in the custody of NER. If exposure to abnormal conditions occurs or is suspected to have occurred, documentation in the experiment logbook should be made, and the SNL PI should be notified as soon as possible. Samples thought to have been exposed to abnormal conditions should not be tested without written approval from the SNL PI.

Samples will be kept in the plastic jars at all times other than:

- when being described before testing for the purposes of post-test interpretation of data,
- when being prepared for testing,
- when being tested,
- or when being described after testing.

Each time that a sample changes custody, the transfer will be documented on the chain-of-custody forms by the signatures of the sender and of the receiver together with the date(s) and time(s) of transfer. After each transfer is made and the chain-of-custody form is signed and dated, the form will be photocopied and the copy will be sent to the SNL PI. The original forms will remain in the same location as the samples at all times. Original forms will be returned to the SNL PI when the samples are returned.

- the date of the most recent calibration,
- the due date of the next calibration,
- the signature of the person that performed the calibrations, and
- the identity of the organization or company that performed the calibration.

Timing Device

Times recorded during all data gathering activities will be derived from the IBM computer system internal clock.

2.4.3 Calibration Checks

Calibration checks of the entire test system must be made for each activity, using a sample of 2024 T351 aluminum of the same nominal dimensions as the rock samples. Documentation of the sample(s), unique ID, traceability, and history of the aluminum should be provided to the SNL PI before experiments on rocks are initiated, together with documentation of the elastic properties and of the yield strength of the material. The SNL PI should be notified of any out-of-specification calibration checks (deviations of more than 5% of the accepted values). Experiments on rock samples should not begin following an out-of-specification check without the approval of the SNL PI. If such approval is given verbally, written confirmation will be sent as soon as possible.

Three calibration checks should be performed for Activity B. One calibration check should be made using the aluminum sample before experiments on tuff samples, a check should be run after the first two tuff samples have been tested, and the final check after all tuff experiments are complete. Each calibration check should be run using the following conditions: a nominal strain rate of 10^{-6} s^{-1}, a temperature of 250°C (achieved at a heating rate of $\leq$ 0.02°C/s), and no confining pressure. The maximum axial stress applied during these checks should not exceed 50% of the yield strength of the material. Axial load, axial displacement, radial displacement, and time should be recorded during the calibration checks. Values for Young's modulus and Poisson's ratio should be calculated for the material by

of any of these curves is significantly nonlinear then the cause of this nonlinearity will be investigated and the situation resolved prior to Activites B, C, and D.

Rock and Aluminum Samples

The rock and aluminum samples to be used in Activities B, C, and D will be inspected by the SNL Measurements Division in accordance with the requirements in TP-51.

2.6.3. Drying and Saturation of Samples

After the rocks have been machined by NER and inspected at SNL, NER will dry the rock samples to constant weight per the requirements of TP-65. After oven drying, NER will vacuum saturate the rock samples per the requirements of TP-64, using distilled water of their own choice. After saturation is complete, NER will store the samples in distilled water at ambient pressure and temperature until they are tested, reweighing them immediately prior to jacketing and testing. The estimated weight of each dried rock sample is 450 g, while each saturated sample should weigh about 500 g.

2.7 Use of Logbooks

An experiment logbook must be maintained to document work for all Activities in this EP. The logbook may be in the form of unbound data sheets, a bound notebook, or both. Whichever type is selected, pages must be numbered sequentially for each form separately. If both types are used together, adequate cross reference must be provided.

Entries to be made in the logbook include, but are not limited to the following:

Before start of activities, and whenever changes are required:

a. Name, identifier, and revision of EP and TPs.

4. Maintain the sample at the nominal values of 250°C and 80 MPa for 24 ± 0.25 hours ($8.64 \times 10^4 \pm 900$ s).

5. Reduce the axial stress to ambient pressure at approximately 0.25 MPa/s.

6. Allow the sample to cool to room temperature.

7. Calculate Young's modulus and Poisson's ratio by least-squares linear-fits using data for stresses between 8 to 40 MPa and the corresponding strains, both for loading and unloading. Compare the calculated values to "ideal" values for the elevated temperature condition. If the values are in specification, proceed with the first tuff experiment. If not, follow the requirements for an out-of-specification check before proceeding.

2.5 Sample Traceability and History

2.5.1 Sample Identification and Custody

The following rock samples, acquired from a large block from Busted Butte on the NTS, will be used in the work for this EP:

Activity A	10-AE-5Y
	10-AE-23W
	10-AE-31X
	10-AE-37Z
Activity B	10AE-11Z
	10AE-22Y
	10AE-32Z
	10AE-51W
Activity C	10AE-6Y
	10AE-36Z
	10AE-49W
Activity D	10AE-5X
	10AE-11Y
	10AE-24Z

All entries in the logbook must be made using black, indelible ink. Corrections may be made by providing the following documentation in the logbook:

- Draw a single line through the incorrect entry (without completely obliterating the incorrect entry).
- Insert the correction above or adjacent to the incorrect entry.
- Initials of the person making the correction.
- Date of correction.

2.8 Related Analyses

No analyses related to these experiments have been performed, and no future analyses are planned.

2.9 Related Experiments

As mentioned earlier this EP is a supporting document for SP-4, "Laboratory Determination of the Mechanical Properties of Intact Rock." Within SP-4, there will be several other EPs related to environmental effects on the compressive mechanical properties of intact rock. However, these other EPs will not be directly linked to EP-0002 and so are not listed here.

3.0 QA LEVEL

The work defined in Activity A has been assigned a QA Level of 3. The work in the other three activities was assigned a QA Level of 1 on August 8, 1986. The work described in this EP all pertains to task A.6 for WBS 1.2.4.2.1.3.

4.0 OPERATIONS

The work for this EP will be conducted in the following general sequence (applicable to all Activities):

2.5.2 Effects of Prior Activities on Samples

These samples were cored from a large block of welded tuff, then cut and machined to present dimensions. They were sent from SNL to RE/SPEC, Inc. in Rapid City, SD in April of 1984 as part of a larger experiment program. They were returned, untested, to SNL in August of 1986. No part of this sample history is expected to have altered the properties to be measured during activities for EP-0002.

2.6 Sample Preparation

2.6.1 Machining of Rock Samples

Rock samples have been core drilled and ground before transmittal to NER. Inspection of the samples at SNL showed that the ends of most of the samples would need further grinding in order to meet the requirements for the sample ends being flat to $\pm 1.0 \times 10^{-2}$ mm ($\pm 4.0 \times 10^{-4}$ in) with both ends of the samples perpendicular to the longitudinal axis of the core to $\pm 5.1 \times 10^{-2}$ mm ($\pm 2.0 \times 10^{-3}$ in) in 51 mm (2 in) of sample length. Currently samples are flat to within $\pm 2.0 \times 10^{-2}$ mm ($\pm 8.0 \times 10^{-4}$ in) and the ends are perpendicular to the longitudinal axis to within $\pm 3.6 \times 10^{-1}$ mm ($\pm 1.4 \times 10^{-2}$ in). In order to minimize changes to the L/D ratio, the amount of material removed from the ends of the sample should be minimized. Grinding of the rocks will be performed by NER or their subcontractor in accordance with TP-51.

2.6.2 Inspection for Dimensions and Tolerances

Bearing Surfaces

NER personnel will perform a preliminary check of the condition of all bearing surfaces of the testing machine. The results from this check should be noted in the experiment logbook.

The test of the load column alignment will involve careful examination of the calibration-check axial stress-axial strain curves. If the early portion

4.1.1 Personnel Qualification and Training

Before technical work in Activities B, C, and D is performed, the forms verifying the familiarization, training, and qualification of all NER personnel involved must be completed. The details of the appropriate actions are discussed in Section 9.0.

4.1.2 Procurement

The instructions in this section pertain to materials, items, and services which effect technical quality.

Items and services procurement requests by NER in support of this EP, after the issuance of REV 0, must be reviewed and approved in writing by the SNL PI. It is the responsibility of the SNL PI to assure that the procurement procedures and documents conform to the appropriate SNL NNWSI Project DOPs.

4.1.3 Current Procedures

Verification must be made that current revisions of all implementing procedures (EP, TPs) are being used before technical activities begin.

4.1.4 Hold Points

4.1.4.1 Required

A required hold point will occur following Activity A. Prior to starting work on activities B, C, and/or D, NER must wait until all the relevant TPs (Table 3) have been signed off and receive written approval to procede from the SNL PI.

4.1.4.2 Voluntary

Voluntary hold points for this work are limited to those related to out-of-specification calibration checks (Section 2.4.3) and those during establishment of environmental parameters for experiments (Section 4.0). Documentation of voluntary hold points should be made in the logbook.

b. Activity location (company name, address, building, room, or specific field location).

c. List of items to be used (including traceability information such as manufacturer name and lot number, make, model, serial number, or unique identifier of items traceable to calibration records).

d. Sketch or photographs of equipment hookup, installation, and samples/sites. Photographic media provided to SNL must be provided in duplicate. Photographic media will contain reference to the sample/equipment ID, the date the picture was taken, the location in which photographs were taken, and the scale of the photograph(s). The negative/slide identifier and the subject of the photographs will be documented in the logbook.

e. Name of person(s) performing the experiment and making entry (printed and signed, including date and time).

f. Title and revision number of application software.

At least daily when work is being performed:

a. Procedure steps worked on or reference to specific section(s) of procedures defined in (a) above.

b. Sample identification (consistent with Section 2.5.1).

c. Equipment identification and settings such as range, gain, heating rate, time base, etc.

d. Observations of conditions (environment, power, etc.) that might affect experiment results.

e. Data or reference to any data recorded elsewhere including type of observation (if not stated in procedures defined in (a) above).

f. Deviation(s) from EP and/or TPs.

g. Notation of unusual occurrences or unexpected results.

h. Nonconformances and corrective action efforts (successful and unsuccessful) keyed to the unusual occurrence or nonconformance.

i. Dates and reasons for significant experiment downtime or delays (covering gaps as appropriate).

j. Name(s) of person(s) performing experiment and making entry printed and signed, including date and time).

- Chain-of-custody forms have been completed properly.

- All pertinent documentation, as defined in Section 7.2, has been transmitted to the SNL PI.

4.3 Technical Procedures

All TPs pertinent to this work are listed in Table 3. Relevant nationally recognized procedures are referenced in TPs where appropriate.

4.4 Data Acquisition System

4.4.1 Hardware

The computer hardware to be used in data acquisition is a Turbo-M 20 megabyte unit, with MSDOS 3.0 as an operating system. Figure 4 shows the interfaces between the data acquisition system and all devices or gauges used in the experiments.

The data to be acquired are the following:

- temperature,
- confining pressure,
- pore pressure,
- axial load,
- axial displacement,
- radial displacement.

The hardware described here is compatible with the measuring equipment (Tables 1 and 2), the application software, and the rates of data acquisition as defined in Section 4.4.3.

- grinding of rock samples,
- drying and vacuum saturation of samples,
- calibration check of system,
- experiment on rock samples.

The second and third steps may occur in parallel. Operation of measuring systems and control of experiment conditions are described in relevant TPs, listed in Table 3.

For Activities B and D, environmental parameters (confining pressure, pore pressure, temperature) will not be ambient. Changes of these parameters will be made in the following sequence for each experiment in an Activity:

Activity B: Raise confining pressure at $\leq$0.3 MPa/s to 5.0 MPa. Hold constant ($\pm$0.1 MPa) for 30 $\pm$ 3 minutes (1800 $\pm$ 180 s) to check for jacket leaks. Raise pore pressure to 4.5 MPa at $\leq$0.3 MPa/s. Hold for 30 $\pm$ 3 minutes (1800 $\pm$ 180 s) to check for stability. Open valve connecting pore pressure intensifier to servo-control system. Raise temperature at $\leq$0.02°C/s to 250 $\pm$ 3°C while keeping pore pressure constant ($\pm$0.1 MPa). Hold for 1 $\pm$ 0.1 hour (3600 $\pm$ 360 s) to ensure stability. Begin applying differential load.

Activity D: Apply axial stress at $\leq$0.25 MPa/s to 80 MPa. Hold constant ($\pm$1 MPa) for 168 $\pm$ 4 hours. Raise temperature at $\leq$0.02°C/s to 250 $\pm$ 3°C. Hold both axial stress and temperature constant at the nominal values of 80 MPa and 250°C for 1246 $\pm$ 4 hours or until sample failure occurs.

4.1 Prerequisites

Before performance of technical procedures in Activities B, C, and D in this EP, a number of prerequisites must be verified. Specific technical prerequisites are discussed in relevant TPs. Prerequisites applicable to more than one activity are discussed in the remainder of this section.

4.4.2 Application Software

Application software is non-operating system software which supports or controls data acquisition.

4.4.2.1 Identification

The following is a description of the software to be used in data acquisition:

Authors:	D. J. Holcomb, SNL, 6232
	R. J. Martin, Jr., NER
Title:	DATAVG
Version:	1.1
Documentation:	Holcomb and Jones, 1983

The SNL PI will complete U.S. Government Standard Form 185 as required by SNL NNWSI Project DOP 11-1. In addition, all application software computer media (i.e., floppy disks) will be labeled with the identification information listed above.

Instructions for the use of the application software appear in the document noted above. Any changes to this program and a listing of the program must be supplied to the SNL PI prior to any QA Level 1 data acquisition.

4.4.2.2 Equations

The calibration of each gage will provide the equation for conversion of the electronic output of the gage into a physical unit to be used in data acquisition and reduction. The only other equations to be used are standard rock mechanics equations. Engineering stress will be calculated by dividing the load cell readings by the original cross-sectional area of the sample. Similarly, engineering strain will be calculated by dividing the displacements by the original gage (or measurement) length. In addition, standard

4.1.4.3 Involuntary

Involuntary hold points may result from temporary power outages, failure of individual pieces of equipment, or temporary unplanned absence of personnel. In all such cases, the SNL PI should be consulted to determine the appropriate steps to take before continuation of technical work. Documentation of involuntary hold points also should be made in the experiment logbook.

4.2 Postrequisites

Following completion of Activity A, the following postrequisites must be verified:

- Informal presentation of results to SNL PI.
- Write, revise, and finalize all TPs relevant to the remaining activities.

After technical work in Activities B, C, and D is completed, the following postrequisites shall be verified:

- All necessary information defined in the relevant TPs has been recorded.
- All pertinent observations have been made in the logbook and have been signed and dated.
- Sample identifications on samples are still legible and samples have been returned to appropriate jars with seals reapplied. (If sample identifications on samples are not legible following an experiment, notation to that effect should be made in the logbook).
- All instructions in EP have been followed, or that nonconformance procedures (Section 5.0) have been followed if deviations have occurred.
- Required post-experiment calibration checks were performed (Section 2.4.3).

For each experiment, these constraints should result in approximately 1000 data records, or less.

Data should be stored on an IBM-XT microcomputer. As data are acquired, they should be written immediately to the hard disk. In addition, the current contents of the data file should be copied to floppy diskette(s) at intervals no longer than every two days (1.7×10^5 s). The diskette(s) should be labeled, at a minimum, with the EP ID and revision number, and the sample ID(s). In addition, the diskettes should be stored in a separate location from the IBM-XT microcomputer.

All data must be identified clearly with the associated parameters (e.g., temperature, strain, etc.) by use of headers and/or trailers on rows and/or columns. Data should be stored on computer media and on hard copy in the units specified in Section 2.3.5.

4.5 Deviation From and Changes to EP or Associated TPs During Experiments

In situations in which irretrievable loss of data or an unforeseen unsafe operation will occur if EP-0002 or associated TPs are followed, NER may deviate from established procedures. Documentation of such an event must be made in the experiment logbook, and the SNL PI must be notified by phone as soon as practicable and in writing within five working days. If the EP or TP from which deviation was made needs revision to reflect necessary changes in future operations, changes will be made as soon as resolution of the situation has been accomplished, and must be made before subsequent use of the affected procedure(s).

Errors discovered in the software or software instructions will be documented, by NER personnel and provided to the originator of the software and to the SNL PI for documentation in the DRMS.

Typographical errors discovered at the time of use of the procedures should be documented in the experiment logbook. If any possibility exists that the intent of the procedure is ambiguous because of the error, the intent must be clarified by the SNL PI before the procedure is implemented. If

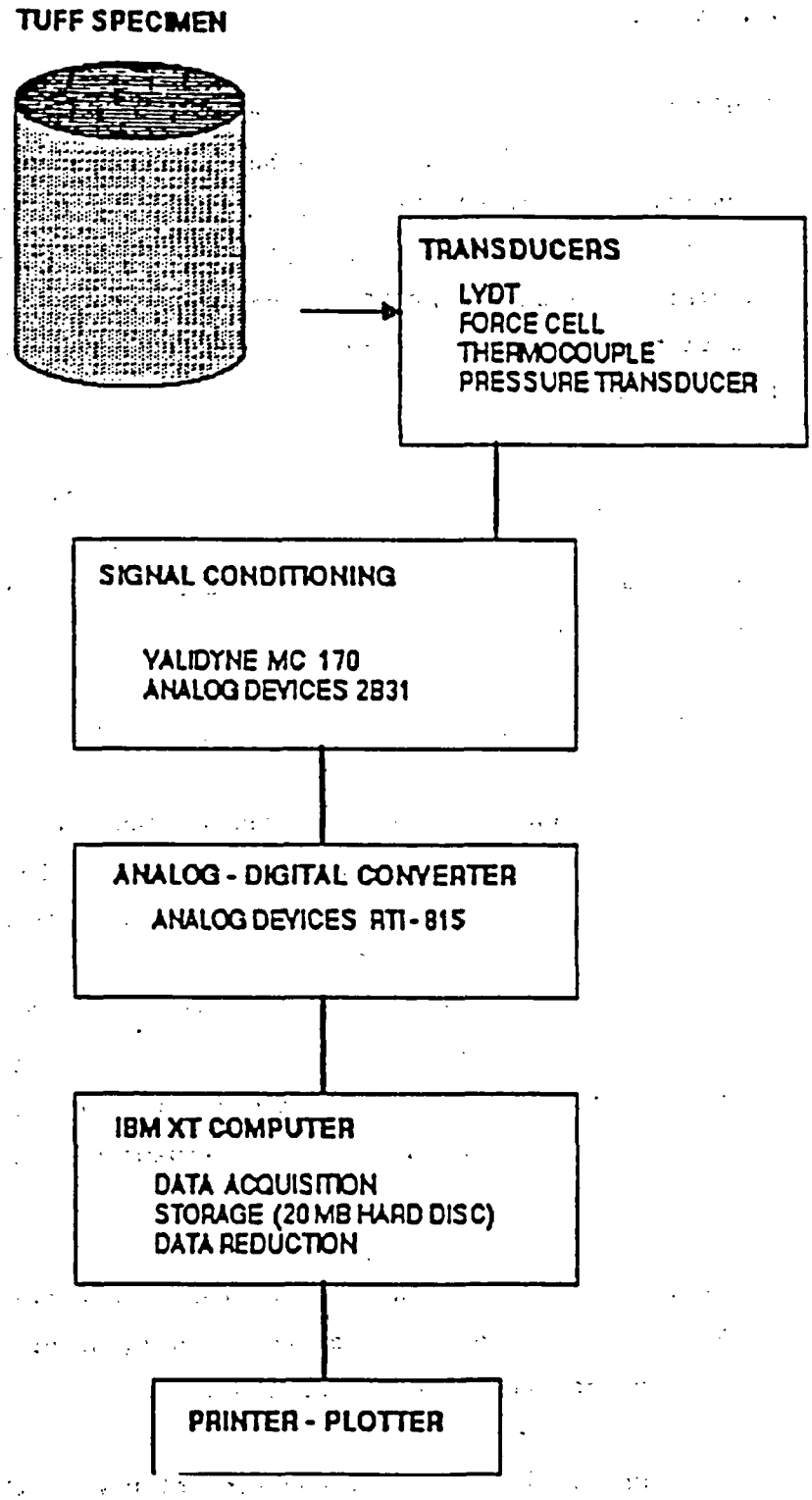

Figure 4. Flow diagram for the acquisition, storage and reduction of data obtained during the deformation of tuff during compressional testing.

b. procurement documents for items and services: following acceptance of item or satisfactory completion of service;

c. documentation of standard materials: before use of materials in technical activities;

d. data from calibrations and calibration checks: with data from associated experiments;

e. data from experiments: at conclusion of relevant Activity;

f. logbook: one copy at conclusion of all Activities;

g. sample drying and vacuum-saturation data sheets: one copy for each sample at conclusion of sample saturation.

h. certification forms to be provided by SNL PI: before work described in EP-0002 begins, and whenever a change in personnel occurs; also, once a year from the date of previous certification if necessary.

The SNL PI also may request preliminary copies of data at intervals during ongoing Activities. These requests may be transmitted verbally or in written form. Data supplied by NER for these informal requests will not be the records to be formally submitted to the SNL PI for entry into the DRMS. Sets of data for the DRMS will be those specified in the preceding list.

Any photographs should be provided to SNL in duplicate, following requirements outlined in Section 2.7.

7.3 Return of Samples

After completion of each experiment in Activities B, C, and D, each sample should be returned to the jar bearing the relevant sample ID. Sets of samples should be returned to the SNL PI at the conclusion of all experiments in a given Activity.

techniques should be used to calculate least-squares linear fits of axial stress as a function of axial strain and of transverse strain as a function of axial strain. The slopes of these fits will provide Young's modulus and Poisson's ratio, respectively. The range of data to be used in these fits is specified to be those data relating to stress values from 10 to 50% of the sample's ultimate stress.

4.4.2.3 Verification

The application software has been verified following the descriptive method of verification described in Section 5.4.4 of SNL NNWSI Project DOP 11-1. This has been accomplished through the successful use of the program in several previous studies (e.g., Price, et al., 1985; Price, 1986; Price, Connolly, and Keil, 1987).

In addition, the software will be verified several times throughout this test series following the second empirical method of verification (Section 5.4.4, DOP 11-1). This will be achieved by the calibration checks with an aluminum standard using the range of input and acceptance criteria described in Section 2.4.3.

4.4.3 Data Acquisition and Storage

4.4.3.1 Rate of Data Acquisition

The rate of data acquisition will be governed by the rate of change of measured parameters. Data should be recorded at least each time one of the following changes (from the previous data record) occurs:

Time:	1800 s
Axial Strain:	0.1 millistrain
Radial Strain:	0.05 millistrain
Differential Stress:	5 MPa
Temperature:	3°C
Pressure:	0.5 MPa

The following plots (Y/X) also should be included for each sample:

- differential stress/axial strain (Activities B, C, and D),
- radial strain/axial strain (Activities B, C, and D),
- axial strain/time (Activities B and C),
- differential stress/time (Activity D),
- differential stress/volumetric strain ($\varepsilon_{ax} + 2\varepsilon_{rad}$) (Activities B, C, and D),
- confining pressure/volumetric strain (Activity B),
- axial strain/temperature (Activity B and D).

9.0 PERSONNEL QUALIFICATION AND TRAINING

According to the definitions in SNL DOP 2-6, all NER staff associated with this work are considered to be supporting staff. As such, the following qualifications for the work must be documented:

- Each person must have an academic background in a technical area that provides the basic concepts of mathematics, engineering, and the physical sciences.

- Each person must have appropriate technical experience for the tasks being performed.

- Each person must have read the EP, associated TPs, and other general aspects of the NNWSI Project QA program relevant to the work to be performed, and must document familiarity with the procedures by completing, signing, and dating the SNL NNWSI Project familiarization forms. The actual forms will be transmitted to NER personnel under separate cover.

All NER staff also must be familiarized with the NNWSI QA program before work begins on QA Level 1 work, and a certification document provided by the SNL PI must be completed for each individual performing work for this EP. Collectively, these documents will be permanent QA records in the DRMS data

corrections would be significant to subsequent use of the procedure, they must be made before the procedure is implemented.

5.0 NONCONFORMANCES AND CORRECTIVE ACTIONS

Nonconformance of items and/or processes must be reported to the SNL PI verbally as soon as possible and in writing within five working days. The SNL PI is responsible for documenting nonconformances and corrective actions per the requirements defined in the SNL NNWSI Project QAP 15-1. NER must also document the nonconformances in the experiment logbook.

6.0 SAFETY

Procedures for safe operation of activities will be included in the TPs associated with this EP.

7.0 RECORDS CONTROL

7.1 DRMS Data-Set ID

The data-set ID to which this work is related is 51/L02-4/6/87.

7.2 Records Transmittal

Data and related documentation (e.g., chain-of-custody forms, evidence of calibration and software verification, logbooks or copies thereof, etc.) must be transmitted to the SNL PI by NER as hard copy. NER will maintain a copy of all records listed below for a period of no less than six months following completion of data gathering activities as defined in Section 2.3. Thermal and electrostatic (non-xerographic) paper are not acceptable. The following transmittal frequencies apply to Activities B, C, and D:

a. chain-of-custody forms: one copy after each new signature for change of custody, original form to be returned to the SNL PI with samples;

10.0 REFERENCES

Holcomb, D. J., and Jones, A. K., 1983. "Data Acquisition for the Rock Mechanics Lab," SAND83-0646, Sandia National Laboratories, Albuquerque, NM.

Holcomb, D. J., and McNamee, M. J., 1984. "Displacement Gage for the Rock Mechanics Laboratory," SAND84-0651, Sandia National Laboratories, Albuquerque, NM.

Price, R. H., 1986. "Effects of Sample Size on the Mechanical Behavior of Topopah Spring Tuff," SAND85-0709, Sandia National Laboratories, Albuquerque, NM.

Price, R. H., Connolly, J. R., and Keil, K., 1987. "Petrologic and Mechanical Properties of Outcrop Samples of the Welded, Devitrified Topopah Spring Member of the Paintbrush Tuff," SAND86-1131, Sandia National Laboratories, Albuquerque, NM.

Price R. H., Nimick, F. B., Connolly, J. R., Keil, K., Schwartz, B. M., and Spence, S. J., 1985. "Preliminary Characterization of the Petrologic, Bulk, and Mechanical Properties, of a Lithophysal Zone Within the Topopah Spring Member of the Paintbrush Tuff," SAND84-0860, Sandia National Laboratories, Albuquerque, NM.

8.0 DATA REPORTS

One month after the completion of each of Activities B, C, and D, a letter report must be submitted to the SNL PI. The report should summarize the experiment results and should include discussion of significant features of the results. Supporting data, as defined in Section 7.2 may be part of these letter reports or may be submitted separately from (but no later than) the letter reports. If submitted separately, appropriate cross-references should be made.

The letter reports must be numbered and titled as follows:

Activity B: SLTR 87-3001, Results of Compressive Experiments on Welded Topopah Spring Samples at 10^{-8} s^{-1} and 250°C.

Activity C: SLTR 87-3002, Results of Compressive Experiments on Welded Topopah Spring Samples at 10^{-9} s^{-1}.

Activity D: SLTR 87-3003, Results of Compressive Creep Experiments on Welded Topopah Spring Samples at 80 MPa and 250°C.

Each report should contain a table summarizing the following for each sample:

- differential stress at failure (MPa),
- Young's modulus (GPa),
- Poisson's ratio,
- axial strain at failure (millistrain).

For Activities B and C, Young's modulus and Poisson's ratio should be calculated using least-squares linear fits to stress and strain data that are between 10 and 50% of the differential stress at failure and the strains associated with those stresses. For Activity D, Young's modulus and Poisson's ratio should be calculated using stresses between 8 and 40 MPa (and associated strains) for the loading portion of each experiment.

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NNWSI PROJECT

Experiment Procedures for Acquiring, Digitizing, Processing, Storing and Retrieving Ground Motion Data from Underground Nuclear Explosions

Page	1	2	3	4	5	6	7	8	9	10	11	12
Rev	0	0	0	0	0	0	0	0	0	0	0	0

Approved by:

J. S. Phillips — Date: 4/6/87
Author, SNL Div 7111

L. J. Vortman — Date: 4/6/87
Author, SNL Div 7111

C. V. Subramanian — Date: 4/6/87
Independent Technical Review, SNL Div 6311

J. R Banister — Date: 4/6/87
Division Supervisor, 7111

Division Supervisor, 6311 — Date: 4/7/87

R. R. Richards — Date: 4/6/87
Q/A Coordinator, 6310

T. O. Hunter — Date: 4/7/87
Department Manager, 6310

SNL NNWSI DEPARTMENT 6310
CONTROLLED DOCUMENT
Issued to: M. D. COTTER, SAIC
Copy Number: #010
RETURN TO 6310 RECORDS CENTER WHEN NO LONGER NEEDED.

set listed in Section 7.1 and in SNL NNWSI file 6310 90/1293/TNG/Q1. As such, the documents should be completed using black indelible ink, and the documents (including updated forms at 12 month intervals) should be submitted to the SNL PI as soon as practicable. Technical work on Activities B, C, and D should not begin until these documents are approved by the SNL PI in writing.

The job performance of personnel involved in work for this EP should be evaluated by the NER lead scientist after each Activity. The evaluation will determine the need for retraining or replacement.

4.0 Description of Work

4.1 General

4.1.1 The nature of this work is such that the procedures described are not unique to gathering ground motion data from any one UNE. Rather, they are general and therfore applicable to all UNEs conducted. The work described herein is divided into four distinct subcategories. These are data acquisition (which involves mostly field activities at NTS), data digitizing, data processing, data storage and retrieval (these are computer intensive activities and are performed at SNLA). All tasks described in this EP have been designated at level I by Department 6310.

4.1.2 As stated above, this EP relates to all UNEs for which ground motion data are collected for the NNWSI Project. These UNEs are conducted in two primary testing areas. These are Pahute Mesa and Yucca Flat. Recording stations have been set up at various locations in the Yucca Mountain area. Figure 1 shows the relation of the two primary testing areas and Yucca Mountain. Figure 2 shows an expanded view of the Yucca Mountain and the recording station locations. The stations currently in use at Yucca Mountain are W25 (surface/downhole pair), W26 (surface only), W28 (surface/downhole pair), W29 (surface/downhole pair) and W30 (surface/downhole pair). During a typical UNE, the motions measured at the Yucca Mountain stations are telemetered to the Fire Station (Fig. 1) where they are recorded. Upon preliminary field checks, the data tapes are sent to SNLA for digitizing and processing.

4.1.3 The generalized configuration of the data acquisition system and the processing system is shown in Figure 3. The measurement portion of the diagram represents a single station which is representative of the five Yucca Mountain stations. The detailed information on the setup, calibration and ranging of the system as well as an inventory list of all equipment is presented in referenced TPs and will not be repeated here. The data is recorded in electrical units in the field and converted in the processing to the CGS unit system. All digitized data are stored in this system of units.

the measurement system (gages, amplifiers, TM boxes, receivers, tuners and recorders) will be field checked as outlined in TP-82 (Section II.4.3.6 and Section A.III) and in TP-83 through TP-87. Setting the ranges of the canisters for the expected ground motion levels at the TM box is described in TP-82, Appendix A, Section A.II, and TP-86 and TP-87. These tasks are performed by 7125 Personnel. Note that all actions performed by the 7125 Field Personnel require a set of data/log sheets (TP-82, Appendix A, Exhibits B-F) to be filled out, signed and dated. These records are maintained in the field during the Pre-shot phase and forwarded to SNLA at the end of field activities.

4.3.1.5 Event Recording -- This subtask involves all steps necessary to record the ground motion at Yucca Mountain from the UNE. The procedure is outlined in TP-82 (Section II.4.1 and Appendix A, Section A.IV). This is performed by 7125 Personnel.

4.3.1.6 Post-shot Activities -- This involves inspection of the paper playbacks from each channel of recorded data to identify any obvious problems, completion of all field records on the UNE and the transmission of all field records and analog data tapes to SNLA. In addition, the information from the field data records is entered into the Weapons Test Seismic Investigations (WTSI) data base which resides on the SNL Central Computing Facility open Network Operating System (NOS) computer. This work is performed by both 7125 and 7111 Personnel.

4.3.2 <u>Data Digitizing</u>

4.3.2.1 This task is accomplished by 7522 and 7111 Personnel and is described in detail in TP-82 (Section III and Appendix A). In general, the tasks to be performed are creation of an "Event Data Book" (per NNWSI DOP 11-2) which contains all field records as well as the subsequent digitizing records, preparation of an "Event Summary Sheet", visual inspection of paper playbacks of the analog tapes to determine any digitizing problems, digitizing of the data, visual inspection of the digitized data, creation of engineering unit tapes and transmission of the analog tapes, paper playbacks and the "Event Data Book" to Division 7111.

1.0 **Objective**

1.1 The objective of this Experiment Procedure (EP) is to state the procedures and requirements for obtaining, processing and storing ground motion data from Underground Nuclear Explosions (UNE). Appropriate Technical Procedures (TPs) and 6310 Department Operating Procedures (DOPs) will be referenced as required. The end product of the work described herein is digitized ground motion data for use in various seismic analyses.

2.0 **Scope**

2.1 This EP applies to all activities involved in gathering ground motion data from UNEs. These activities include data acquisition, digitizing, processing, storage and retrieval.

2.2 The tasks described in this EP are covered in Work Plan 12412-87, Task D.1.

3.0 **Requirements**

3.1 Personnel

3.1.1 All personnel involved in the work covered by this EP will be certified in accordance with NNWSI DOP 2-6. In addition, all personnel will review this EP and all applicable referenced TPs and DOPs to familiarize themselves with the requirements of the tasks described. Upon completion of this review, the form included in Appendix A will be signed, dated and returned to the 7111 PI, who will forward these documents to the 6311 PI.

3.1.2 All personnel are required to follow the procedures discussed in this EP and all referenced TPs and DOPs for data collection from all UNEs of interest to the NNWSI project. If situations arise in which these procedures cannot be followed, a "Non-conformance Report" (per the requirements of QAP 15-1) will be filled out and sent to the 7111 PI. Corrective action will be undertaken and documented following the requirements of QAP 16-1.

3.1.3 In the event that gages need to be replaced, the replacement gages will be calibrated in accordance with the procedures described in TP-82 and TP-88.

dichotomy exists because of the volume of material generated as well as classification problems.

4.5 **Data Reports**

Individual data reports for specific UNEs are not written for this project. Data analysis reports, which include data from a suite of experiments, are written periodically. The content and timing of these reports are a function of the Statment of Work agreed upon between departments 6310 and 7110 for a particular fiscal year. When these reports are written they will be published as "SAND" reports and follow the review and approval process outlined in DOP 6-2.

5.0 **Technical Procedures**

5.1 Procredures for Acquiring, Digitizing, Processing, Storing and Retrieving Ground Motion Data from Underground Nuclear Explosions -- TP-82 --This TP covers the overall operation of the data gathering activity for UNEs. This includes procedures for all aspects listed in the title as well as calibration procedures for ground motion gages and the list of equipment used for the operation.

5.2 Verification of PNE Amplifier Gains and Frequency Response, -- TP-83 -- This TP lists the procedures necessary to verify the gains and frequency responses of the PNE Amplifier. (To be written--TBD)

5.3 Verification of Tamarac-B Amplifier Gains and Frequency Response, -- TP-84 -- This TP lists the procedures necessary to verify the gains and frequency responses of the Tamarac-B amplifier. -- TBD

5.4 Verification of PFTU Amplifier Gains and Frequency Response, -- TP-85 -- This TP lists the procedures necessary to verify the gains and frequency response of the PFTU amplifier. --TBD

5.5 Set-up and Adjustment TM Control Box (PNE Seismic) -- TP-86 -- This TP lists the procedures necessary to set-up and adjust the PNE TM control box. TBD

4.2 Management

4.2.1 Division 7111 has overall responsibility for this work. The field activities required by the data acquisition task are performed by Supporting Staff in Division 7125. The data digitizing task is performed by Supporting Staff in Division 7522. The data processing and data storage and retrieval tasks are performed by Supporting Staff in Division 7111. All Supporting Staff report to the 7111 Principal Investigator (PI, J. S. Phillips; Alternate, J. W. Long) who reports to the 6311 PI.

4.3 Tasks

4.3.1 Data Acquisition

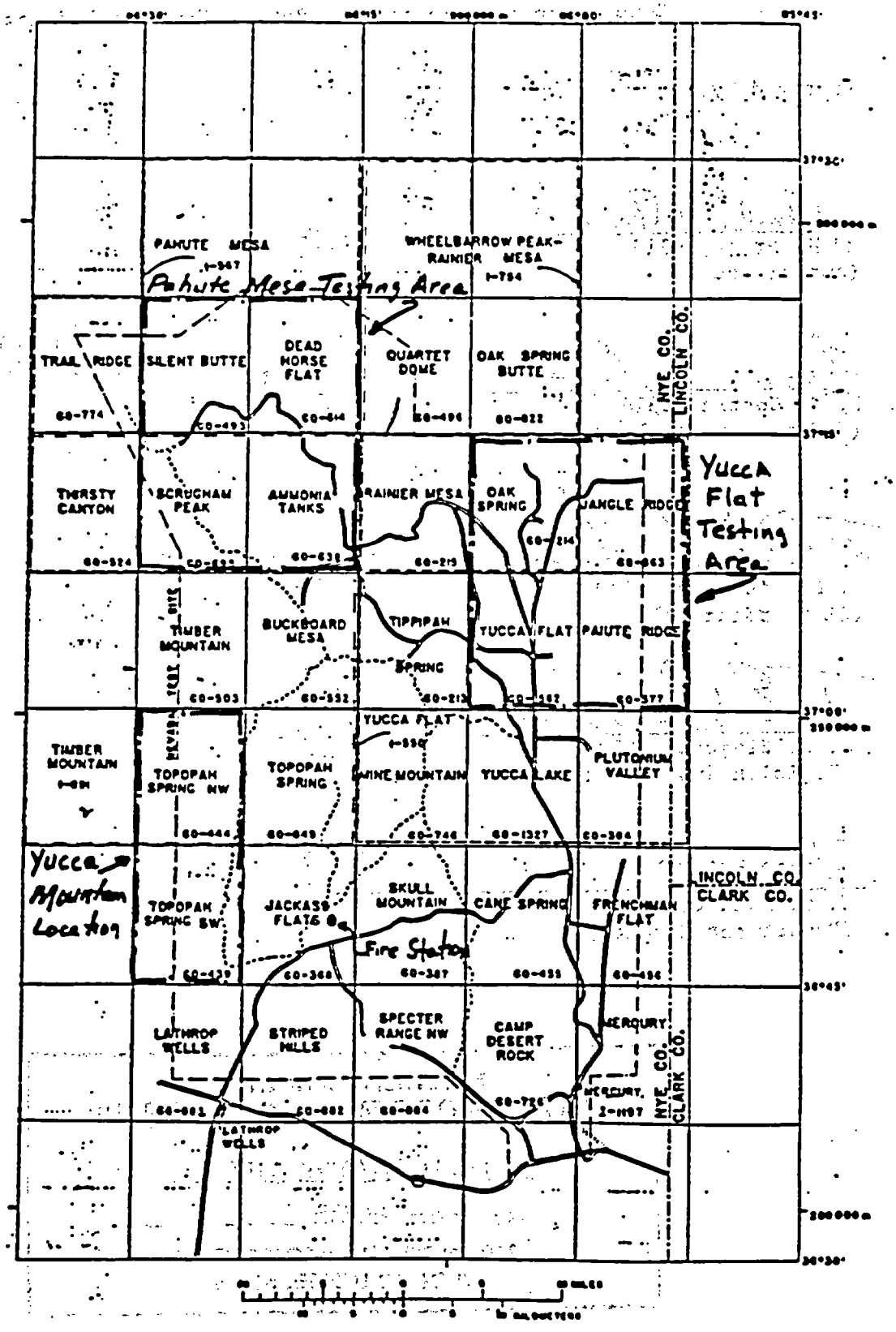
4.3.1.1 The Data Acquisition task consists of five subtasks. These are described in detail in TP-82 (Section II and Appendices A and B) and will only be summarized below. Equipment used to measure, telemeter and record ground motion is listed in TP-82 Appendix C.

4.3.1.2 Event Selection -- This involves choosing an event from the "NV (Department of Energy, Nevada Operations) Master Test Schedule", determining which stations to operate and notifying field personnel of their need to participate. The decisions required for this subtask are a function of the yield and location of the UNE. The 7111 PI makes these decisions based on the judgement that the data acquired will contribute to the objectives of the NNWSI project.

4.3.1.3 Determination of Canister Settings -- This involves empirical prediction of expected ground motions and determining the settings for the canisters accordingly. The settings for the canisters are determined by an automated alogrithm described in TP-82 (Section II.4.2 and Appendix A, Section A.II) These settings are reviewed by the 7111 PI, signed and dated, then forwarded to the 7125 Field Personnel.

4.3.1.4 Pre-shot Preparation -- The first requirement of this subtask involves notifying the appropriate Fielding Agency (either Los Alamos National Laboratories or Lawerence Livermore National Laboratories) of the intent to participate in the UNE. All components of

Figure 1. Approximate locations of the testing areas and Yucca Mountain



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SNL NNWSI PROJECT EXPERIMENT PROCEDURE

Fracture Properties Testing: Comparison of Triaxial and Rotary Shear Techniques

Approved by:

Ronald H. Price — 2/16/88
R. H. Price, 6313 — Date
(Author and PI)

Lawrence S. Costin — 2/17/88
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R. R. Richards — Feb 23, 1988
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T. E. Blejwas, 6313 — Date
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T. O. Hunter, 6310 — Date
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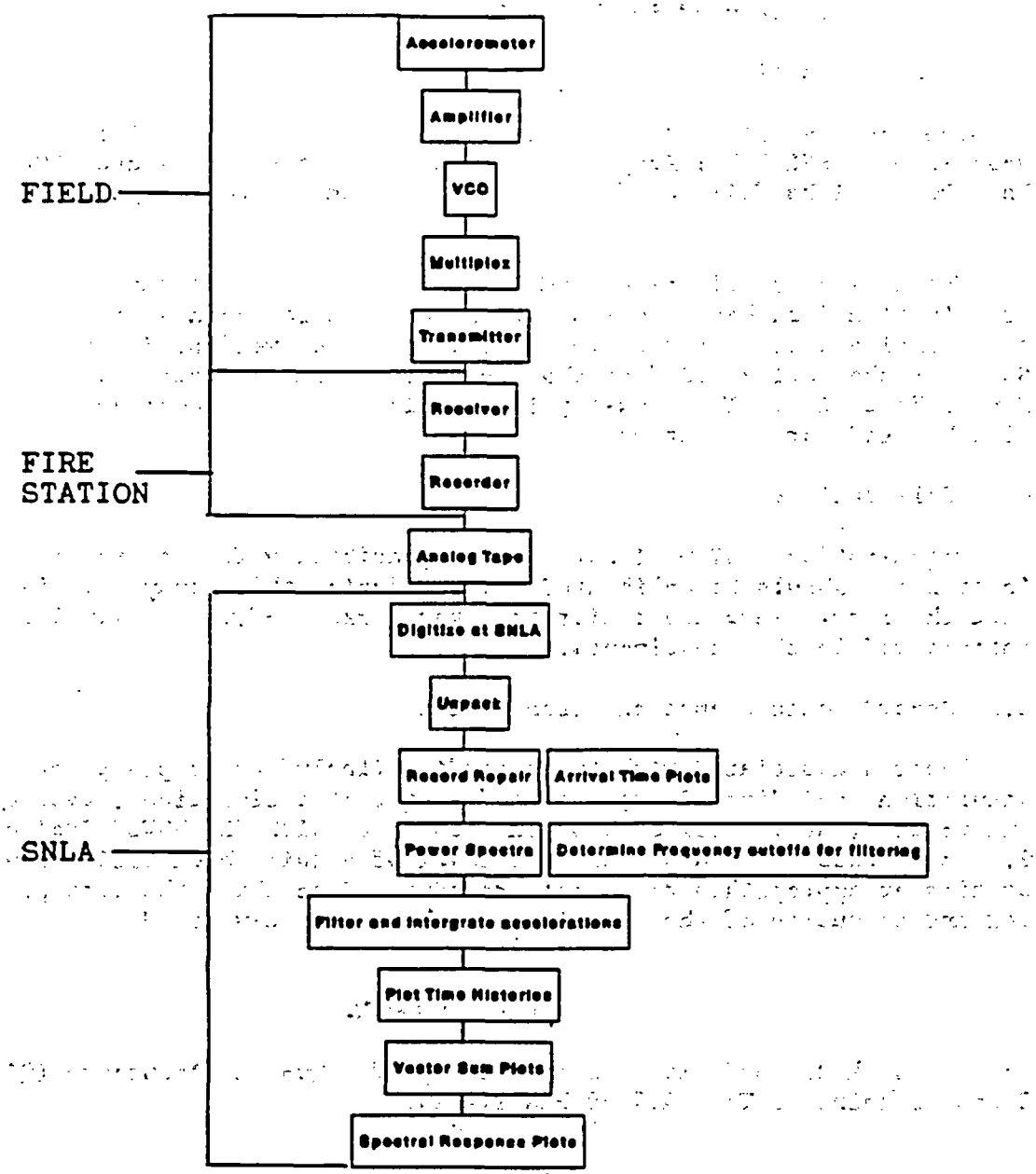
Figure 3. Configuration of Data Acquisition and Processing



2.2 Planned Experiments

The work covered by this EP is designed to be exploratory, with the intent of examining results from triaxial and rotary friction tests on Topopah Spring Tuff samples containing saw cuts. The data from experiments performed with each technique at similar test conditions will be compared. These comparisons will form the basis for determining the appropriate test technique(s) to be used in the QA Level 1 experiments.

2.3 Sample Handling

The requirements for identification (ID) and custody of test samples are described in SNL NNWSI Project Department Operating Procedure (DOP) 8-1. This DOP will be followed for all samples used in these experiments.

The nominal sample sizes and tolerances will be determined by Organization 6232 based on what is appropriate for each experiment type. The tuff samples were obtained from a large block of welded, devitrified Topopah Spring Member collected from the southeast flank of Busted Butte on the Nevada Test Site. The rock-physics machines in the Geomechanics Laboratory will be used for this study.

2.4 Calibrations

Organization 6232 will have the responsibility for determining which instruments should be calibrated for use during this study. It is important that the instruments are calibrated over a range of values similar to those anticipated in the experiments.

2.5 Records Maintenance and Transmittal

Records associated with these studies (including sample preparation, saturation, and dimensions; pre- and post-test calibrations; test conditions and results, etc.) will be kept in accordance with SNL NNWSI Project DOP 11-2. These records should include a level of detail which will allow the writing of appropriate technical procedures describing the same preparation for and execution of the experiment technique(s) developed.

3.0 QA LEVEL

The work defined here has been assigned a Quality Assurance (QA) Level of 3 and pertains to Task A.9 of WBS 124213.

5.0 SAFETY

Safety procedures to be followed during these experiments are included in the Safe Operating Procedures (SOPs) for each machine in the Geomechanics (SNL Division 6232) laboratory.

6.0 NONCONFORMANCE/CORRECTIVE ACTION

Nonconformance of items and/or processes must be reported to the PI verbally as soon as possible and in writing within five working days. The 6232 Division Supervisor is responsible for ensuring that nonconformance are documented and that corrective actions are determined per the requirements defined in the SNL NNWSI Project QAP 15-1.

7.0 REFERENCES

Holcomb, D. J., and Jones, A. K.
Data Acquisition for the Rock Mechanics Lab, Sandia National Laboratories Report, SAND83-0646, Albuquerque, NM, 1983.

NNWSI PROJECTS DEPARTMENT

NNWSI GEOTECHNICAL PROJECTS DIVISION

EXPERIMENT PROCEDURE: PROTOTYPE THERMAL STRESS TESTING

WBS 1.2.6.9.4.3.2

Sandia National Laboratories
Albuquerque, NM

Prepared by

Roger M. Zimmerman
NNWSI Geotechnical Projects Division

Prepared as part of

NNWSI Project Exploratory Shaft Prototype Testing

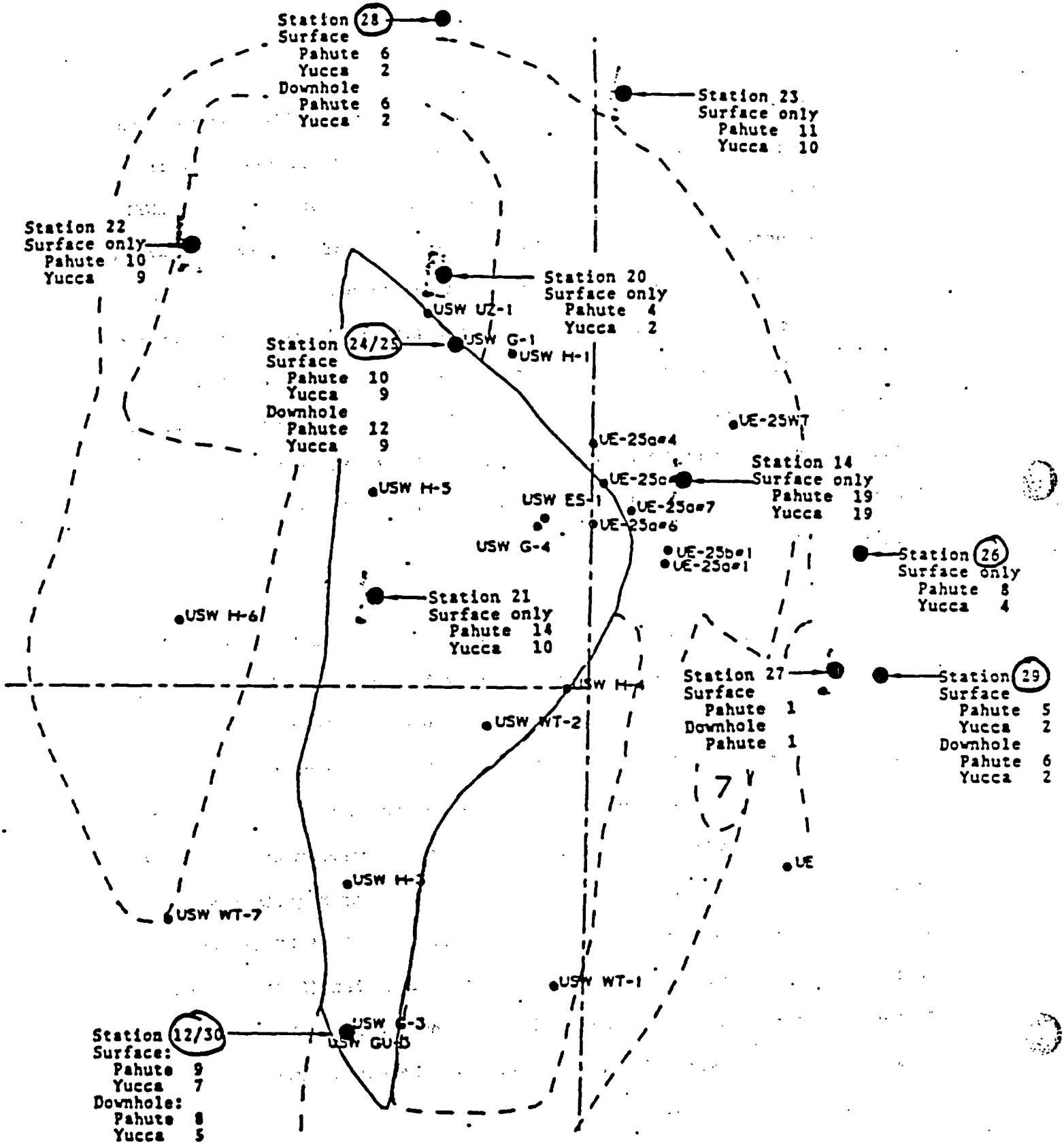
1.0 GENERAL INFORMATION

1.1 Purpose

The Nevada Nuclear Waste Storage Investigations (NNWSI) project was established to evaluate the potential for storing radioactive waste in geologic formations on or adjacent to the Nevada Test Site (NTS). NNWSI has chosen Yucca Mountain as the potential site and site characterization studies are underway. Until in situ data collection can be started in exploratory shaft (ES) studies at Yucca Mountain, field scale studies are being conducted at G-Tunnel, which is located some 40 km away on the NTS. Welded tuffs, with similar properties and in situ stress states as tuffs present in Yucca Mountain (Zimmerman and Finley, In Prep), are located in a portion of G-Tunnel, called the G-Tunnel Underground Facility (GTUF).

The purpose of prototype thermal stress testing is to develop the technique and demonstrate the technical feasibility of developing and measuring thermal stresses up to 30 MPa on approximately 2 m^3 of a jointed rock mass, which is included in a heated volume over 36 m^3, so that an established technique can be available for current model evaluations and future exploratory shaft (ES) studies. Measurements of thermal stresses (increases over the in situ stresses) of this magnitude are needed to satisfy performance allocation goals as part of NNWSI Issue Resolution Strategies (IRS) [Site Characterization Plan (SCP), 1987]. Success in this prototype testing will mean that thermal stress measurements can be scheduled and achieved in the short time period available for ES data collections.

Figure 2. Yucca Mountain ground motion stations (Active stations are circled)



1.3.4 Measurement Equipment: Sensors and related data acquisition system used to convert physical changes in the rock to data describing the changes.

1.3.5 Operational Equipment: Control systems used to regulate displacement parameters for experiments.

1.3.6 Experiment: Data gathering activities conducted to establish characteristics or values not previously known.

1.3.7 Test: Process of exposing an item of hardware to some defined parameter change or operational sequence to determine its acceptability or its operational characteristics.

1.3.8 Analyses: Calculations or other evaluations needed to assess site characteristics, support design activities, or to support experiment designs and evaluations.

1.3.9 Technical Procedure: Documents specifying detailing actions in order to perform certain functions (e.g., operating experiment equipment as part of experiments or tests).

1.4 Objectives

a. Measure tangential stresses in roof and rib (wall) of demonstration drift using the flatjack cancellation method.

Appendix A: Personnel Acknowledgement Form

I have read EP-004 and all referenced TPs, QAPs, and DOPs, as checked below, that directly apply to my work for this project. I understand and will follow the procedures as described.

____ TP-82, "Procedures for Acquiring, Digitizing, Processing, Storing and Retrieving Ground Motion Data from Underground Nuclear Explosions"

____ TP-83, "Verification of PNE Amplifier Gainsand Frequency Response"

____ TP-84, "Verification of Tamarac-B Amplifier Gains and Frequency Response"

____ TP-85, "Verification of PFTU Amplifier Gains and Frequency Response"

____ TP-86, "Set-up and Adjustment TM Control Box (PNE Seismic)"

____ TP-87, "Set-up and Adjustment TM Control Box (PFTU)"

____ TP-88, "Ground Motion Gage Operation Verification"

____ TP-89, "Procedures for Storing and Retrieving UNE Ground Motion Data used for the NNWSI Project"

____ DOP 2-6, "Qualification and Certification of Project Personnel"

____ DOP 6-2, "Reviewing, Approving and Issuing Technical Information Documents"

____ DOP 11-2, "Requirements for Experiment and Equipment-Test Logbooks"

____ DOP 12-1, "Calibration Program" (when issued)

____ QAP 15-1, "Nonconformance Reporting and Controls" (when issued)

____ QAP 16-1, "Corrective Action Requirements" (when issued)

_____ _____

Signature Date

to (a) show compliance with the postclosure design criteria of 10 CFR 60.133, and (b) provide information to support resolution of the performance issues?

Information Need 1.11.6: Predicted thermal and thermomechanical response of the host rock, surrounding strata, and ground-water system.

Issue 4.4: Are the repository construction, operation, closure and decommissioning technologies adequately established to support resolution of the performance issue?

Information Need 4.4.7: Design analyses, including those addressing impacts of surface conditions, rock characteristics, hydrology, and tectonic activity.

Within the IRS statements in the SCP, there are certain products that are needed. In the case of IN 1.11.6, one of the desired products is a definition of the areal power density (APD), a quantity used in the design of a repository to define the spacing of the heat generating canisters. The APD relates to spacings of emplacement holes and surrounding access drifts. Thermal and thermomechanical analyses are needed to establish the allowable APD. In situ rock mass thermomechanical properties are needed for these analyses.

The principal products expected from the IRS as applied to IN 4.4.7 are design support studies, sensitivity studies, reference calculations,

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SNL NNWSI PROJECTS DEPARTMENT

EXPERIMENT PROCEDURE: PROTOTYPE THERMAL STRESS TESTING

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Approved by:

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thermal stress measurements up to 30 MPa. This magnitude was selected after a review of both analytical efforts dealing with anticipated stress buildups in a repository environment (St. John, In Prep.) and physical limitations to testing which are expressed as design parameters in Section 2.4. St. John performed finite element calculations for ventilated and unventilated drifts of vertical and horizontal emplacement concepts. The results are summarized as follows:

	100 yr Total Stress		100 yr Total Stress	
Emplacement	Ventilated Condition		Unventilated Condition	
Concept	Crown	Mid-wall	Crown	Mid-wall
Vertical	11.6 MPa*	5.8 MPa	54.3 MPa	-3.8 MPa
	(30.0°C)**	(30.0°C)	(108.5°C)	(109.0°C)
Horizontal	30.9 MPa	-8.8 MPa	36.2 MPa	-5.2 MPa
	(30.0 °C)	(30.0°C)	(58.3°C)	(58.3°C)

*increase in compression is assumed as positive

**temperatures ( ) are those at drift locations at 100 yr

St. John stated that the predicted results may be higher than encountered in practice due to limitations and assumptions in modeling. The design value of 30 MPa for the thermal stress testing is about the same as the crown (top of drift) induced stresses for the horizontal emplacement concept. For the vertical concept the value of 30 MPa is less than the maximum crown value predicted (54.3 MPa), but it is

Table of Contents

		Page
APPROVALS		
1.0	GENERAL INFORMATION	4
1.1	Purpose	4
1.2	Scope	5
1.3	Definitions	5
1.4	Objectives	6
2.0	DESCRIPTION OF WORK	7
2.1	Management	12
2.2	Experiment Configuration	13
2.3	Experiment Methods	22
2.4	Operational and Measurement Equipment	26
2.5	Field Preparations	33
2.6	Related Analyses and Experiments	36
3.0	QA LEVEL	39
4.0	OPERATIONS	39
4.1	Sequence of Activities	39
4.2	Operational Stages	41
4.3	Prerequisites	41
4.4	Postrequisites	43
4.5	Technical Procedures	44
4.6	Interactive Procedures	45
4.7	Changes in Experimental Procedures	45
5.0	DATA ACQUISITION SYSTEM	45
5.1	Data Acquisition System Description	45
5.2	Data Storage	50
6.0	PERSONNEL QUALIFICATIONS	51
7.0	NONCOMFORMANCE ACTIONS	52
8.0	DOCUMENTATION	52
8.1	Logbooks	52
8.2	SNL Data Records Management System	53
9.0	SAFETY	53
10.0	REPORTS	54
11.0	REFERENCES	56
11.1	Program References	56
11.2	Technical References	57

In summary, the G-Tunnel prototype testing program will be the stepping stone to planned in situ thermal stress experiments that will be conducted at Yucca Mountain, where the following INs will be addressed:

(1) IN 1.11.6: Experiments will provide measurements of in situ thermomechanical behavior at relatively high stresses with applications for evaluating the in situ thermomechanical properties.

(2) IN 4.4.7: Experiments will provide for in situ evaluations of repository-design oriented thermomechanical codes at relatively high stresses.

2.1 Management

Prototype thermal stress testing consists of three major components: (1) laboratory measurements, (2) analyses, and (3) field experiments. Some of the laboratory effort is the preparatory work that is necessary before the field work can be started. Laboratory work initially focuses on instrumentation selection and preparation and control system development and shakedown. Later work includes instrument calibration and equipment preparation. The analyses start with scoping calculations necessary for the design of the experiments and then are focused on the description of the details of the experiments for the model evaluation exercise. Field experiments consist of site preparation, measurement and operational equipment installation, data system operation and management, and experiment evaluations. Data output from the laboratory and field experiment components are stored in the SNL Data Records Management System (DRMS) through unique data set identifications.

1.2 Scope

This prototype testing effort is designed as a development effort that is to be conducted in the GTUF. This experiment procedure (EP) describes the activities including the preparation, execution, and documentation of this development effort. The work being performed under this effort is conducted under the general heading of prototype testing because of the developmental nature. Using the definitions listed in Section 1.3, the work can best be described by the definition of two experiments, which are data gathering activities that occur in the roof and side wall of a drift in the GTUF. Throughout this document prototype testing or testing will refer to the developmental effort and experiments will refer to the data gathering activities.

1.3 Definitions

1.3.1 Prototype testing: Exploratory shaft preparation work conducted under Work Breakdown Structure (WBS) 1.2.6.9.4. Prototype testing involves the preparation and conduction of experiments, tests, and field trials of proposed ES efforts to verify or validate procedures, methods, equipment, designs, and performance under simulated ES conditions.

1.3.2 Flatjack Cancellation Method: Method defined by Mayer et al. (1951) for measuring tangential stresses in underground openings using flatjack pressures to represent in situ stresses.

1.3.3 Flatjack Effective Area: Actual pressurized area of flatjack bearing on rock surface.

FIGURE 1

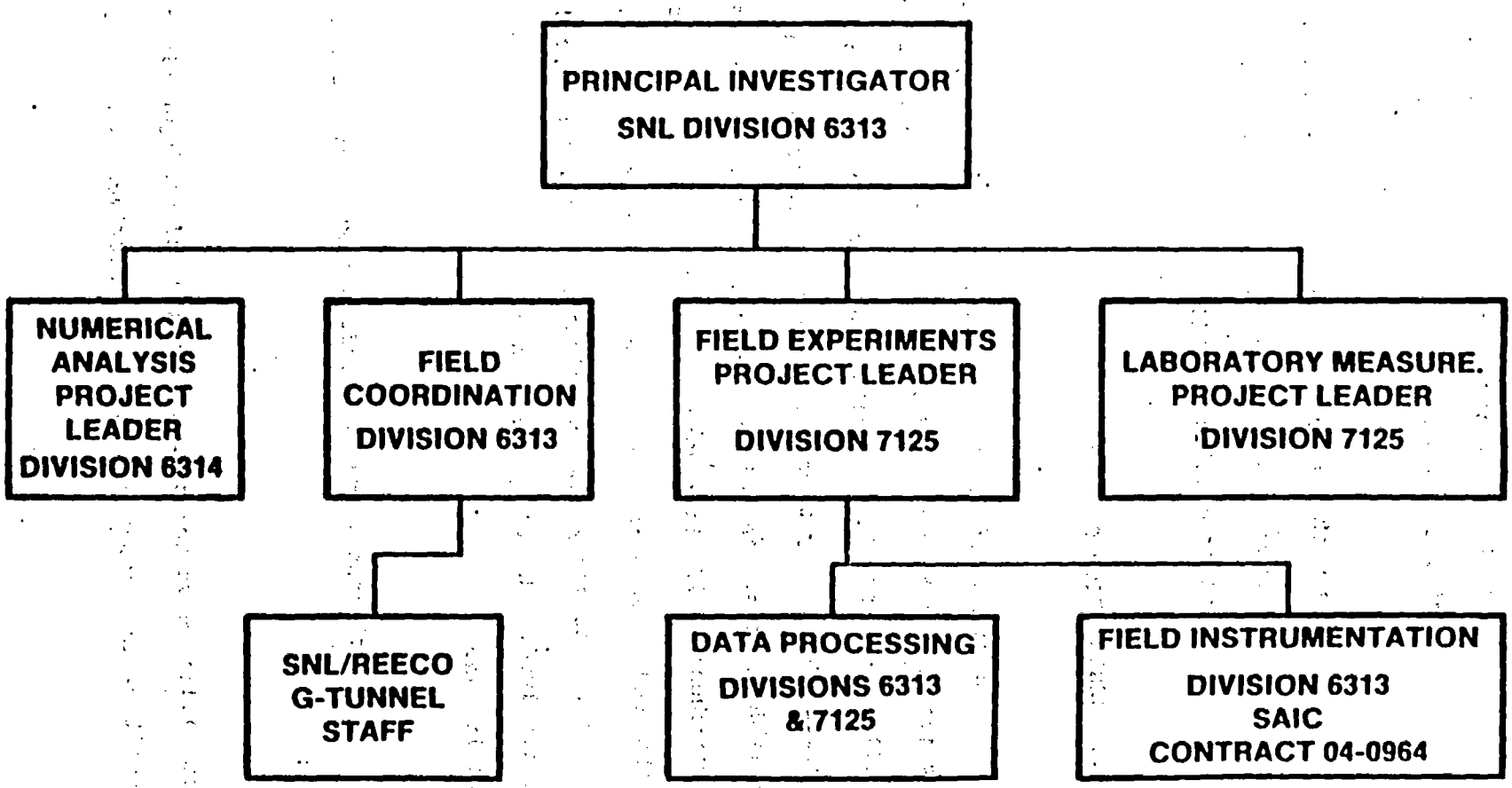

Figure 1. Organizational Responsibilities

b. Generate and measure thermal stress increases up to 30 MPa in roof and rib using a new thermal stress measurement technique that incorporates a flatjack as the measurement sensor.

c. Relate thermal stress changes to thermomechanical displacements and temperature changes in surrounding rock to improve numerical model prediction capabilities.

2.0 DESCRIPTION OF WORK

The rationale for this prototype effort stems from overall NNWSI project needs that are reflected in the IRS, which is part of the SCP (1987). The SCP is a mandatory document required to be submitted to the Nuclear Regulatory Commission (NRC) for repository license considerations. An issues hierarchy is used in the SCP to provide a comprehensive identification of all questions or issues that need to be addressed. For each issue, information needs (INs) are identified that represent necessary and sufficient information required for an issue to be resolved. The IRS provides a strategy to address the INs and resolve the issues.

The pertinent issues and information needs related to this testing are:

Issue 1.11: Have the characteristics and configurations of the repository and repository engineered barriers been adequately established

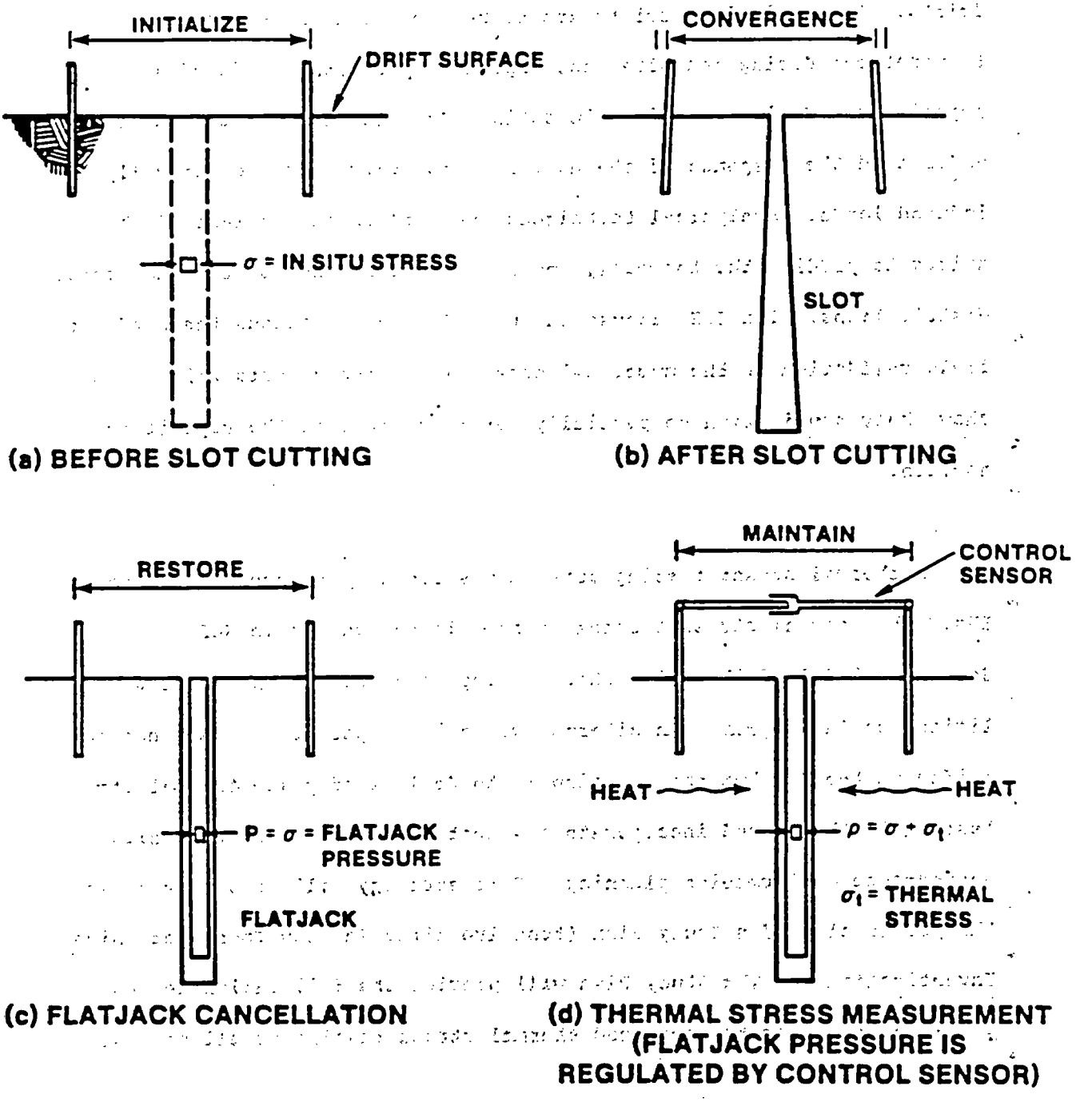

Figure 2. Thermal Stress Measurement Concept

and, where necessary, calculations to verify or validate the design approaches being used. This IN deals with shafts, ramps, and access drifts. In particular, drifts are to be subjected to increased temperatures during and after the expected operational life of a repository. Goals identified in satisfying this IN indicate the need to understand the response of the host rock to excavation and thermally induced loads. Analytical techniques are used in the designs of the drifts to predict the thermally induced stresses based on the temperature distributions. The IRS discussion under IN 4.4.7 mentions the need for field validation of the numerical codes, where the efforts will be to show their application on partially saturated tuff at the repository horizon.

A thermal stress testing program was created in response to these INs. The thermal stress testing program is called for in SCP Section 4.7.2.7 of the SCP. This developmental effort addresses a limited scale program. An alternative is to prepare full-scale heated drifts in the ES, but the SNL plan is to do limited-scale thermal stress testing in the ES and incorporate the heated room into later in situ performance confirmation planning. This strategy will be discussed in the preparation of a Study Plan (tenative title-In Situ Thermomechanical Investigations). The Study Plan will provide the full rationale and justifications for the proposed thermal stress testing at all scales.

There are certain design goals that have been established in this limited-scale testing in order to satisfy the perceived intents of the statements in the SCP. The stated purpose of this testing calls for

direction. St. John (In Prep.) showed that tensile stresses were predicted for the ribs in the horizontal emplacement concept. While we cannot measure tensile stresses with the flatjack concept, we can measure the unloading of the rock during the cooling and this additional information should be helpful to designers who are concerned about the initial unloading phenomena associated with the horizontal emplacement concept.

Figure 3a shows a section view through the drift illustrating the relative locations of the experiments. The slots with the flatjacks are to be constructed parallel to the longitudinal axis of the drift so that stresses tangential to the curved surface may be measured. This orientation will allow measurement of the largest surface stress buildup and will relate to repository design considerations. The heat will be provided by 12 line heaters, located in two planes of six heaters parallel to each flatjack and displaced 1.2 m from the flatjack. The heater and flatjack arrangement is shown in Figure 3b. Line heaters located sufficiently close together and arranged in parallel planes provide a uniform heat flow in regions between the planes (Zimmerman, et al., 1986).

The overall strategy is to create a one-dimensional heat flux between the two planes of heaters and measure the thermal stress buildup between the planes. The maximum temperature expected in the rock is 300°C with this arrangement. The one-dimensional heat flux was used in the Heated Block Experiment and similar temperatures were reached near the heaters (Zimmerman et al., 1986). The maximum temperature was

somewhat higher than the minimum (11.6 MPa) and appears to be a reasonable compromise. The design value of 30 MPa differs somewhat from the mid-wall values and is only comparable to the mid-wall case for the vertical concept and unventilated condition. The measurement of tensile (negative) stresses is beyond the scope of this testing, but thermo-mechanical measurements in the wall during a cooldown period can be used to document the actual behavior. Relative tensile stresses are induced in the rock as a result of cooldown, but the overall compressive stresses remain in compression. The results of these measurements will be used to guide model predictions. St. John pointed out that the tensile stresses in the side-walls were somewhat localized and should present no threat to drift stability that could not be controlled with proper ground support design. A basic technical concern that needs to be evaluated is understanding the extent of a correlation between numerical model predictions and in situ measurements in a jointed rock.

The objective in the development of the thermal stress testing program is to provide a means to measure high thermal stresses in a short period of time in a rock mass of sufficient size so that necessary thermomechanical evaluations can be conducted. The time constraint was imposed because of anticipated tight schedules in Exploratory Shaft testing and the desire to get limited scale information as early as possible. The size selected for each experiment (heated volume ~736 m^3) was the maximum that could be comfortably defined using knowledge extrapolated from other unpublished research efforts in G-Tunnel and that would incorporate a number of joints in the volume of rock influenced by the heating process. This prototype testing is the developmental effort in preparing for thermal stress measurements in the ES.

selected because of knowledge that the rock would be stable at these temperatures (Zimmerman and Finley, In Prep.) and concern about using hydraulic fluids at temperatures above this value. It is noted that this temperature is higher than the drift surface temperatures defined by St. John (In Prep.), but higher temperatures are necessary for limited scale testing to achieve the desired level of thermal stress. The maximum temperature sets the limit of the maximum thermal stress that can be obtained in this testing. Zimmerman and Finley (In Prep.) recommended average values to describe the welded tuff properties in G-Tunnel. These are: modulus of deformation (E_d), 16,000 MPa; coefficient of thermal expansion (α), 8x10-6°K-1. An estimate for thermal stress could be approximated as follows:

$$\sigma_t = E_d \times \alpha \times \Delta T$$

Substitution of design values in this equation for a temperature differential of 280°C results in a stress increase of 35.8 MPa. The partial confinement of the rock around the heated area in a drift provides restraint to a heated region and preliminary calculations using the above values indicate that drift surface stresse changes on the order of 30 MPa can be achieved at the design temperature. If E_d increased with temperature due to closure of joints, a reasonable assumption (Zimmerman and Finley, in preparation), the predicted thermal stresses could be higher.

The instrumentation arrangement is shown in all three views in Figure 3. Figure 3a shows the major instrumentation for measurements

A feature in the design of this development effort is that this EP is prepared before all decisions are made as to the selections of the final instrumentation and operational equipment that are to be used in the field; a revised version of the EP will be issued when initial laboratory and modeling evaluations are complete and the field experiment activities are to be initiated.

Figure 1 shows the organizational responsibilities for this prototype testing. The work is performed under the direction of the Principal Investigator (PI), who has overall responsibility for the experimental effort. The field experiment effort is the most complex and involves G-Tunnel personnel support, data processing and field instrumentation activities. Current SNL Division assignments are shown. Also identified in the figure is a key contract participant. Activities and responsibilities of key SNL and contract personnel are described within the body of this document. Key SNL personnel are the PI, the Field Project Leader (FPL) (7125), the Field Coordinator (FC) (6313), and the Numerical Analysis Project Leader (NPL) (6314).

2.2 Experiment Configuration

This new prototype thermal stress measurement concept that is described in the following paragraphs has evolved from available techniques and unpublished field testing efforts in the GTUF. The measurement concept is shown in four diagrams in Figure 2. Figure 2a

Figure 3c shows the physical details of the instrumentation arrangement for a single experiment. Twenty two holes, 38 mm in diameter, are to be diamond drilled into the rock. For each experiment location, 12 heater holes, 6 distance measuring, and 4 thermocouple (TC) holes will be drilled. Depths of the holes are indicated in the other diagrams. The holes for the two MPBXs are to be rotary drilled with a tri-cone bit. These holes, nominally 76 mm in diameter, will be 15 m long. The short holes (10cm) for the 4 monitoring pins (control sensor) will be drilled with a heavy duty hand-held rock drill.

TCs are shown in the three diagrams. TCs are to be placed in special TC holes and are to be attached to the flatjack and LGDX instrumentation. The number of TC holes have been kept to a minimum to help minimize the discontinuities in the rock mass included in the thermomechanical evaluations. TCs will also be located at the collar and at all anchors for the MPBXs.

2.3 Experiment Methods

2.3.1 Control Parameters

The control system for this testing consists of: (1) heaters operating at a fixed wattage and (2) a flatjack pressure regulation system that is based on displacement measurement control.

Heater wattage is to be manually set to a specified level for each line heater and that wattage is to be kept constant through the heating

shows the surface of a drift in an underground setting. The drift concentrates the in situ stress in the rock mass to produce a surface stress (σ). The flatjack cancellation method (Mayer et al., 1951) involves a three step process. First, short-metal pins are placed in the drift surface in planes parallel to a plane in which the normal stress is to be measured. In this first step, the distances between the pins are measured. In step 2, the slot is cut in the region between the pins and the in situ stress causes the rock to converge slightly (Figure 2b). In step 3, a flatjack is inserted in the slot and pressurized to the extent that the pins are restored to their original configurations (Figure 2c). In the flatjack concellation method, it is assumed that the flatjack pressure (p) is equal to the surface stress (σ) acting normal to the slot prior to the cutting of the slot. This assumption is supported by measurements and studies reported by Hoskins (1966).

The concept proposed for the measurement of thermal stresses is illustrated in Figure 2d. If heat is added to the rock and (1) there is proper confinement of the slot due to the surrounding rock and (2) the pressure buildup due to the thermal expansion of fluid in the flatjack is controlled, the width of the slot could be held nearly constant and the stresses normal to the slot would increase. The increased pressure (σ_t) in the flatjack over the reference pressure referred to as the surface stress (σ), is caused by expansion of the heated rock and resistance by the cooler-surrounding rock mass and is assumed to represent the thermal stress added to the rock. The process in the

c. Displacement (mm)

d. Angle(?) (°)

e. Wattage (W)

f. Time (day,hr,min,sec)

g. Voltage (V)

Temperature measurements are needed to monitor the actual response of the rock and the test equipment to the heating, and results are used in the thermomechanical evaluations.

Flatjack pressure measurements are used to define the in situ stress under ambient conditions and the thermal stress under the heated conditions.

The LGDXs are used to measure the rock mass responses caused by the heating. The LGDXs involve measurement of displacement changes of anchor ends located outside the rock surface. These measurements are converted to rock displacements at the bottom of the anchors, which are located in the rock. Since the displacement measurements are perpendicular to the anchors, angle changes of the embedded anchors must be considered to ensure that the rock translation and rotation components are adequately accounted for. Zimmerman et al., (1986) showed that rotational components are important in making long gage length measurements. Based on this experience, provisions are made in this experiment to measure the rotational component of the LGDX anchors. The angle measurement is shown with a (?) because alternate methods are being considered and possibly the angular component can be handled with additional displacement sensors.

thermal stress measurements is to maintain the initial distance between the pins by controlling the flatjack pressure while heat is added. Flatjack pressure is regulated to ensure that the prescribed pin distance is maintained during heating.

Figure 3 shows the application of the thermal stress measurement concept to a repository sized drift. The physical arrangement is modular in form and can be conducted in any orientation. Two experiments are defined utilizing the measurement concept. Experiments are defined and planned for the roof (R) and side wall (W) for two reasons. The first reason is that there is need for a learning experience in this developmental type testing. It is planned that the thermal stress measurements be conducted at one location and then that an assessment be made before starting the heating of the second so that necessary changes in experimental procedures can be accomplished. The second reason deals with obtaining useful information. The first experiment is to be located in the roof of the Demonstration Drift, which is the only repository sized drift in G-Tunnel that is located in welded tuff. The Demonstration Drift is shaped to represent the horizontal emplacement concept. The first experiment is to be located in the roof because of the concern for buildup of thermal stresses in the roof of a repository. The second experiment is to be located in the right rib of the same drift, not necessarily at the same station along the drift as the roof experiment. Both experiments will have to be located in rock where slots can be successfully cut. The second experiment is located in the rib so that: (1) the thermomechanical behavior can be evaluated in a vertical orientation and (2) cooldown phenomena can be studied in the vertical

measure output voltages for sensors so that they can be stored in raw form in the data acquisition system (DAS). These measurements provide backups to converted measurements in case algorithms need to be checked and also provide a vital backup in case the converted data are not properly calculated and stored within the DAS.

2.4 Operational and Measurement Equipment

2.4.1 Operational Equipment

a. Heaters - Two-meter immersion type heaters that can be fitted within 3.2-cm- diameter stainless steel tubing are to be fabricated. The heaters are to be rated to at least 1000 W and operate at 220 V. Heaters are to be designed to operate up to 400°C.

b. Flatjacks - Stainless steel flatjacks are to be specially fabricated for this testing. The flatjacks are to be 0.8 m x 0.8 m x "t" cm. The overall size of the flatjack (0.8 x 0.8 m) is smaller than the size of the slot to allow for surface irregularities of the rock. It is important that the flatjack be fully contained within the slot. The dimension "t" is the flatjack thickness and falls in the range of 0.9 to 1.5 cm. The final thickness will be established after the slot dimensions are established. The flatjack will be designed to operate up to pressures of 40 MPa. Hydraulic fluids must be capable of operating at temperatures up to 300°C.

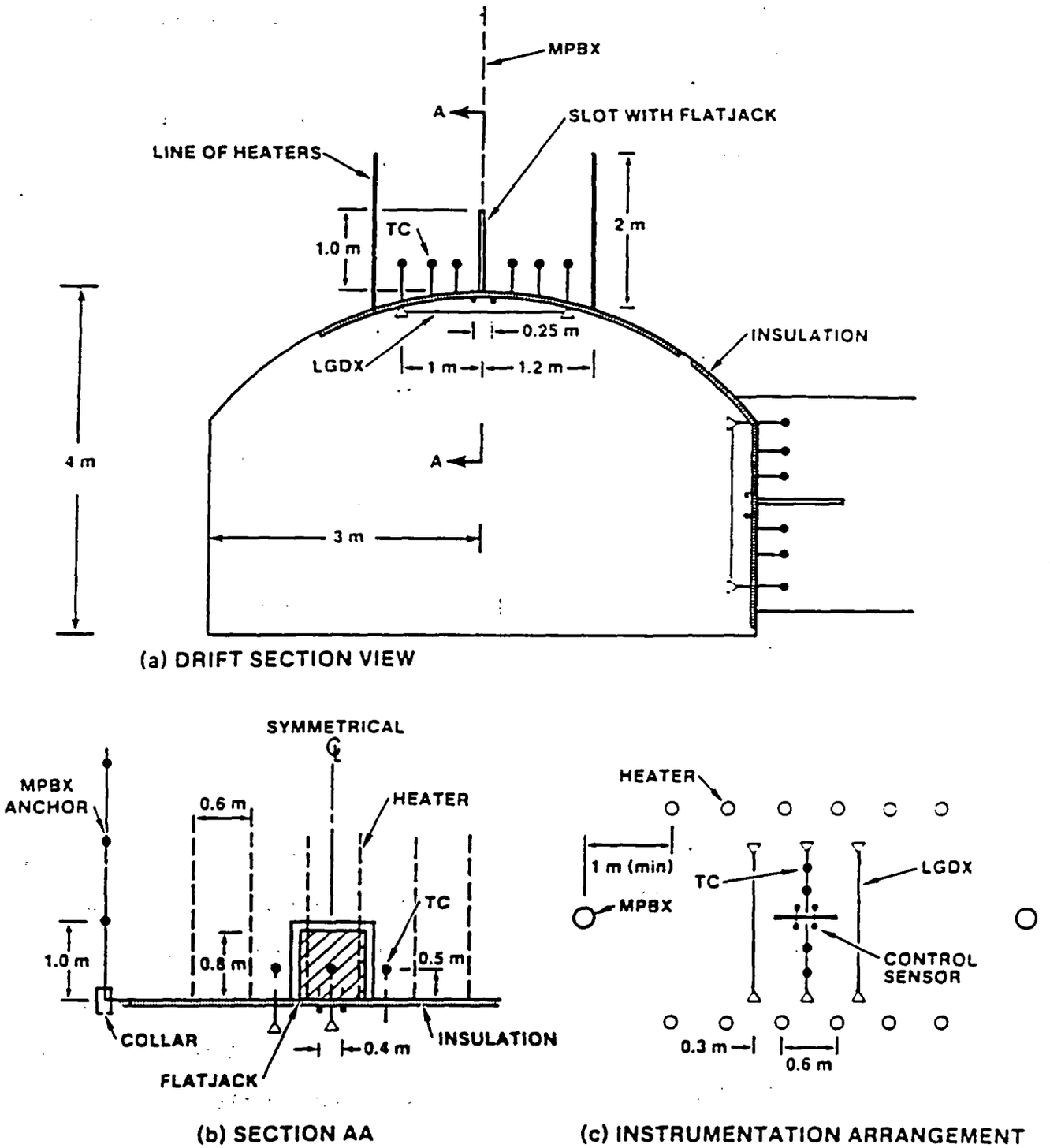

Figure 3. Prototype Thermal Stress Testing Concept

2.4.2 Measuring Equipment

2.4.2.1 Expected Instrumentation Requirements

The design requirements for the instrumentation are:

a. Maximum Temperature - 400°C for heaters, 300°C for rock outside 0.2 m of the heaters, 200°C for the control sensors and 100°C for the LGDX and MPBX instrumentation.

b. Maximum Pressures - 40 MPa for flatjack and supporting hydraulic system. As a safety consideration, the pressure control system must be designed with a "fail safe" pressure release valve to prevent pressures from exceeding this value.

2.4.2.2 Sensors Required

a. Thermocouples - Type E Chromel-Constantan with Inconel sheaths. Nominal accuracy is 1.5°C.

b. Pressure - Pressure transducers are needed to operate up to 50 MPa at temperatures up to 300°C. The transducers should have a resolution of 500 kPa with appropriate temperature compensation.

c. Displacement - Measurement resolution for the MPBXs, linear portion of LGDXs, and control sensors should be within

planned in a direction normal to the slot. The pins next to the slot are to be used for the experiment control, i.e., they are the pins used in the feedback system to control the flatjack pressure. A long gage displacement extensometer (LGDX) measurement system is used to monitor the thermomechanical behavior of the jointed rock over a distance of 2 m. The objective of LGDX measurements is to correlate displacement measurements across a line located within the jointed rock with temperature and stress buildups for purposes of numerical model comparisons. The displacements are taken across a distance smaller than the distance between the heater planes to avoid the thermal stress concentrations in the immediate vicinity of the heaters. Figure 3c shows a plan view of the instrumentation, heaters, and flatjack. The heater and LGDX arrangement define a volume of rock having dimensions of 2 x 1.2 x 0.8 m for a volume of 1.9 m^3. This volume is large enough to contain several joints so that the thermal stress buildup can be evaluated on a jointed-welded tuff.

Two multi-point borehole extensometers (MPBXs) are to be located near the outside planes of the heaters as shown in Figure 3c. These MPBXs are to measure the thermal expansion parallel to the heaters. The MPBXs are located on the periphery of the heated area to minimize high temperatures and possible loss of function of the electronic sensors. Each MPBX will have a collar located at the surface and grouted anchors located at distances of 1,2,3, and 14 m. The three anchors nearest the collar will define the thermal expansion of the heated region and the furthest anchor will be used as a reference anchor. The heated volume included in the MPBX arrangement as shown would be 5 x 2.4 x 3 m for a total volume of 36 m^3.

f. Time - Time is normally an internal component of the DAS. It is a design feature that the heating period extend for a minimum of 90 days.

g. Voltage - Excitation and output voltages should be measurable to μV to achieve the resolution needed for the DC-LVDTs.

2.4.2.3 Calibration Requirements

Calibration practices shall follow SNL DOP 12-1. Special requirements are:

a. TCs-TCs are manufactured according to ANSI Standard Code C96.1, "Limits of Error for Thermocouples." The nominal error can be reduced with laboratory calibration procedures, which consist of placing TCs in an oven that contains a precise resistance temperature device (RTD) capable of measuring to 0.1°C. The measured temperatures, as determined with the ANSI methods, are compared with the RTD measurements and only those TCs that fall within a ±1°C band will be used in further measurements.

b. Pressure - Pressure devices must be calibrated in the laboratory under the expected operating conditions. The hydraulic fluid in the flatjack may have to operate to temperatures of 300°C. The sensor will be calibrated in the laboratory for temperatures and pressures within the full design range. The calibration procedure will consist of comparing the sensor output with

portion of the thermal stress testing. Wattage is the parameter that will be monitored for the heater system. The wattage level will be established after the completion of the scoping calculations.

The flatjack pressure control system requires engineering design because this system has not been used in other GTUF experiments. The basic concept of the system requires a feedback loop between the displacement based control sensor and the flatjack pressure regulation system. Therefore, there are two parameters involved: displacement and pressure. Both of these need to be monitored in the DAS. Output from the external control system used to convert the control sensor measurements to pressure changes must be monitored as well.

A third control parameter is the passive thermal insulation of the rock surface. The heat must be kept in the rock around the heaters and test area in order to attain the desirable thermal stresses. This means that effective insulation must be placed on the rock. A design specification is to have insulation that has a thermal conductivity of 0.05 W/m°C or less. This is the value that was used in the heated block testing (Bellman et al., in preparation). Studies will be made to determine the best insulation that can be applied in the underground situation.

2.3.2 Measurement Parameters

The following types of measurements are required:

a. Temperature (°C)

b. Pressure (MPa)

effective area and it must be determined experimentally. It is useful to know the effective areas of flatjacks so that measurements from flatjacks fabricated with different designs can be compared. The flatjack is to be placed in a testing frame and the effective area determined by comparing known forces in the testing machine and the measured flatjack pressures. Flatjacks can be tested up to 7 MPa in this manner with equipment readily available at SNL. Experience in testing flatjacks in G-Tunnel has shown that seating (plastic deformations) of flatjacks occurs at stresses less than 3 MPa. Thus the full activated area is achieved at this lower stress. These determinations will be made for various flatjack thicknesses near the design slot dimension "t."

Standard calibration procedures will apply for:

a. Wattmeter - A wattmeter will be calibrated by the SNL Calibration Laboratory prior to use.

b. Time - The timing device for the DAS will be calibrated in the SNL Calibration Laboratory.

c. Voltage - The voltage standard used as a reference for the digital voltmeter (DVM) in the DAS will be calibrated by the SNL Calibration Laboratory. This is the prime voltage reference for DAS operations and its accuracy is essential. Calibration of voltage references will follow provisions specified in SNL DOP 12-1.

Angle measurements are not needed for the control sensor because the pins are used as position sensors and movements are eliminated through flatjack pressure controls. The control sensor design concept is based on the assumption that the distance between the short pins remain fixed in space during the heating and that the relative positions of the surfaces of the slot remain a constant. Control sensor movements are kept small so that all rotational aspects should have occurred in the ambient temperature flatjack cancellation phase.

The displacements measured with the MPBXs are parallel to the MPBX boreholes. Each anchor is connected to an individual sensor with rods and the measurement represents the change in distance between the collar and the anchor. Thus, relative changes in rock distances over significant lengths are measured. These measurements provide an important second dimension to the overall displacement measurement system.

Wattage monitoring is needed for completeness in defining the control system parameters. Wattage is measured on each of the line heaters.

Time is needed to provide a common reference for all measurements. Time is expressed by hour, min, and sec in Julian days (J-days), which are sequential countings of days starting with the first of each year.

Voltages are measured for two purposes. First, most instrumentation must be energized in order to operate. G-Tunnel research has shown that it is vital to monitor excitation voltages for sensors so that any variations can be factored into measurements. It is also important to

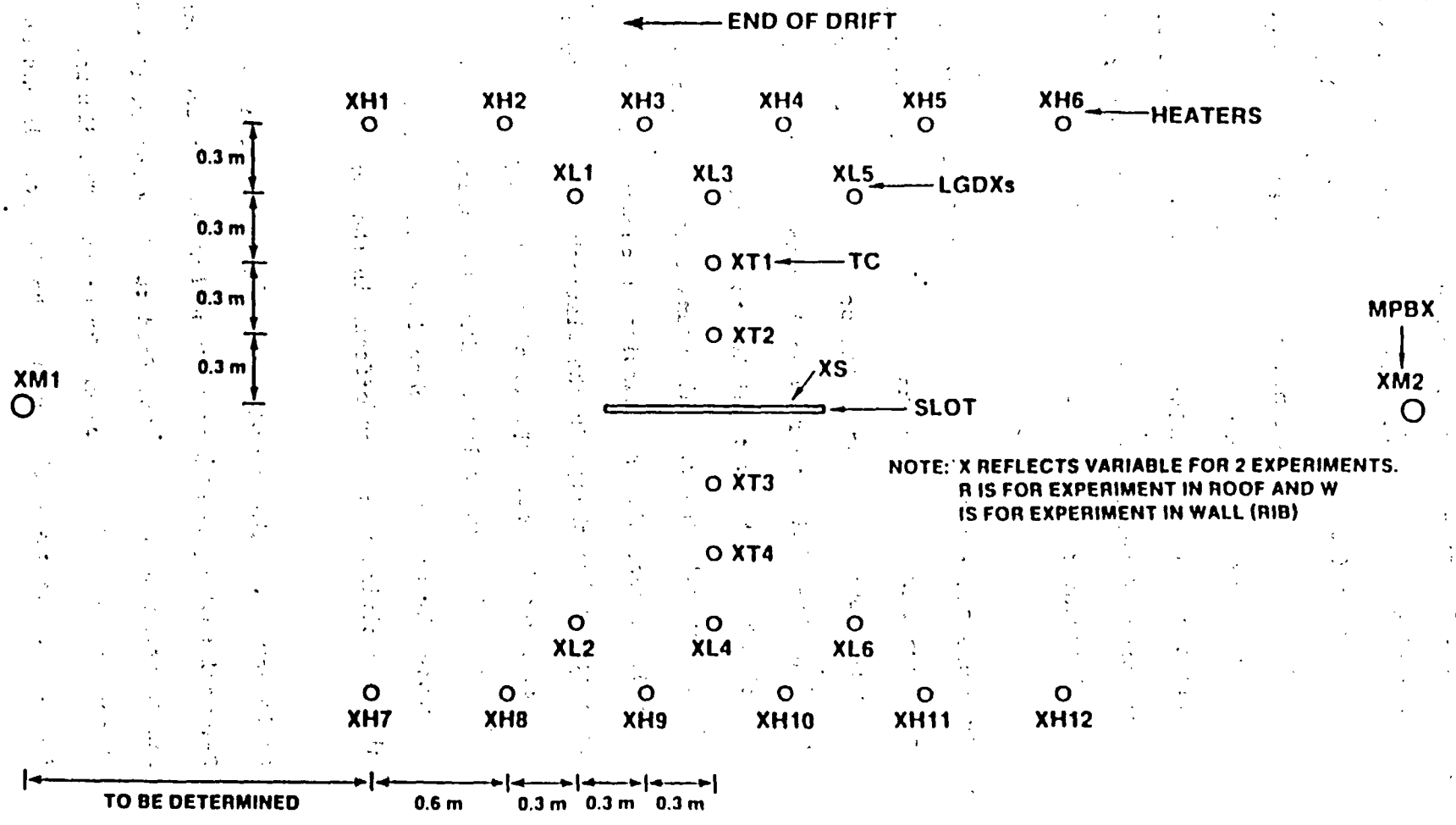

Figure 4. Layout and Identification of Drill Holes

c. Control Sensor - A control sensor will be designed. It could consist of a direct current-linear variable displacement transformer (DC-LVDT), which has been successfully used in G-Tunnel testing (Zimmerman et al., 1986). This unit can have a resolution of 0.001 mm with precise and constant voltage excitation. Other similar instruments will be evaluated before selection of the final control device. The sensor should have a displacement range of 4 mm.

d. Pressure Control System - A key component is design of the pressure control system that translates displacement information from the control sensor to the pressure control. During heating, the fluid and rock will expand. The volume of fluid in the flatjack is to be regulated to maintain the desired position of the control sensor. This means that a small change in the control sensor, either extension or compression, must translate to a corrective change in the flatjack volume of fluid. The volume control system should be responsive to displacement changes of 0.03 mm or less. When the volume is changed, the pressure change increment should be kept in within ± 150 kPa per min to minimize transient effects in the system.

e. Chain-saw - A chain saw with a 1.1 m bar has been used in G-Tunnel testing and is to be used for cutting the slots. The saw mounting needs to be modified to allow for cutting of slots at the roof and side (rib) of the drift. The diamond tips used with the chain saw will regulate the flatjack dimension "t."

g. Complete installation of the measurement equipment. Personnel from SAIC will install the MPBX and LGDX systems under direction from the FPL. SNL personnel will install the TCs.

h. Complete installation of anchor pins for Whittemore measurements and later control sensor. Personnel from SAIC will install the pins and perform the measurements under direction of the FPL.

2.6 Related Analyses and Experiments

2.6.1 Laboratory Activities

This EP shall serve as the principal document describing the scope of laboratory activities. When laboratory related concerns arise that are not covered in this document, the PI and appropriate personnel will meet, resolve the concerns, and document the decisions in the laboratory logbook. Outputs from laboratory activities are discussed in Section 10.0.

a. Preliminary activities - Laboratory related activities directed towards the final experiment design include:

- o Definition of displacement measurement devices and evaluate as necessary
- o Develop and evaluate instrumented flatjack pressure control system for field use

0.002 mm. The LGDXs should have a measurement range of 8 mm and should be designed to operate in temperatures up to 100°C. Note, the LGDX sensors are to be placed further from the insulation to reduce temperature buildups. The MPBXs should have a displacement range of 12 mm and a 100°C maximum operating temperature. The measurement range for the control sensor should be within 4 mm and the operable temperature range should be up to 200°C.

For ambient temperature testing, a Whittemore strain gage is used for measurements used to determine the in situ tangential stress using the flatjack compensation technique. The strain gage has a nominal resolution of 0.0025 mm, but the actual accuracy is on the order of ±0.025 mm because of manual reading limitations.

d. Angle - In the event that tiltmeters are used on LGDXs, they should have a nominal resolution of 2 arc seconds. The range for the tiltmeters should be ±1°. Tiltmeters should be capable of operating up to temperatures of 100°C and appropriate temperature compensation techniques should be applied.

e. Wattage - Power for each of the heaters is monitored and recorded. The transducer should have a resolution of 5 W and a range of at least 1200 W. The power transducer can be operated at ambient temperatures.

2.6.2 Numerical Analyses

Numerical calculations will follow SNL DOPs 2-4 and 3-3, consistent with Quality Level III requirements. Problem Definition Memorandums (PDMs) will be written by the PI to describe the intended analytical efforts. The PI will obtain an analysis number from the SNL NNWSI Project Department records management staff and will be responsible for transmitting analytical results to the DRMS. The activities related to preparations and reviews of PDMs and actual analyses supervision will be handled by the numerical analysis project leader (NPL). Planned analytical work includes:

a. Scoping Calculations - Scoping calculations are needed to effectively design these experiments. Important considerations are determinations of the heater power levels and resulting temperatures required to achieve the design thermal stress of 30 MPa. Calculations are to be used to predict the temperature distributions and thermal stresses in the rock mass for the two configurations shown in Figure 3. Scoping calculations will provide the final design arrangement for the heaters and instrumentation. These calculations will define heater power levels and the time parameters required to achieve the design thermal stress.

b. Numerical Model Evaluations - The experiment is designed to assist in thermomechanical model development. Two-dimensional displacements parallel and perpendicular to the planes of the heaters, temperature distributions, and thermal stresses become

outputs from devices that have been approved by the SNL Calibration Division for such use. Pressure-temperature relationships as used in the DAS will be corrected to account for the temperature corrections found in the laboratory measurements.

c. Displacement - Displacement transducers for LGDXs and MPBXs will be calibrated in the laboratory under the expected temperature environments in a manner similar to the pressure transducers. The objective will be to determine any temperature corrections that are needed for measurement equipment used in the DAS so that correct values are outputted in real time during the conduction of the experiment. Whittemore strain gages are operated manually under ambient temperatures and have reference calibration bars that are used in the measurement process.

d. Angle - The tiltmeter used in the heated block testing and proposed for use with the LGDXs had a known thermal drift of 0.003°/°C (Zimmerman et al., 1986). Studies are underway to try to remove dependence on tiltmeter measurements for this reason. In the event that tiltmeters are needed, they will be subjected to calibration studies in the laboratory in a manner similar to the pressure transducer calibrations.

e. Flatjack - The flatjack pressurizes a finite area in a slot that is somewhat less than the area defined by the outside dimensions of the flatjack. The actual pressurized area is called the

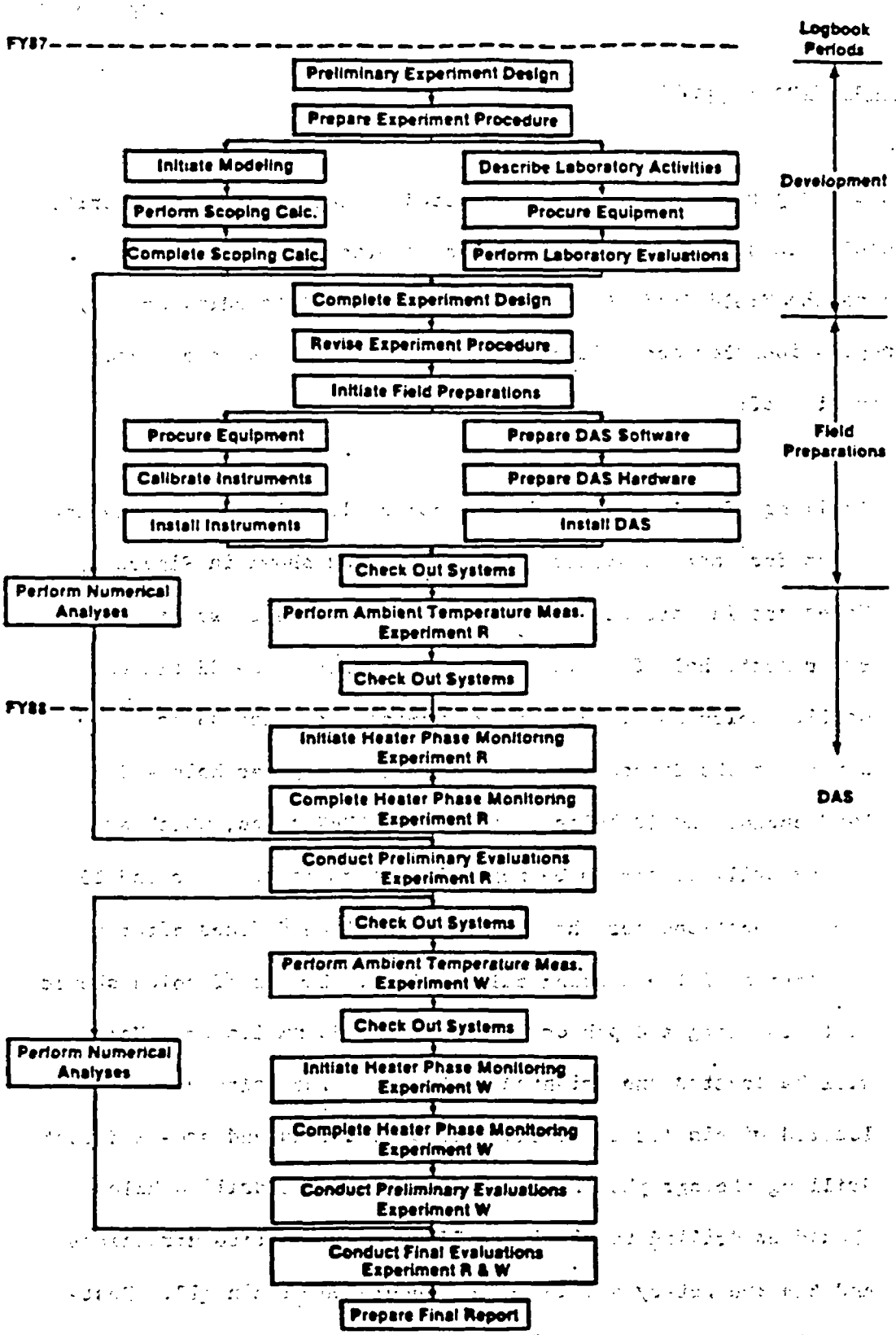

Figure 5. Sequence of Major Activities

2.5 Field Preparations

The two experiments are to be conducted in the Demonstration Drift of the GTUF. These activities are conducted with responsibilities assigned to the Field Project Leader (FPL) and Field Coordinator (FC). Field preparations for each, identified as experiments R (roof) and W (wall), consist of:

a. Drilling of holes of specified depths, locations, and orientations for instrumentation installation as shown in Figure 4. Holes are identified by an Alphanumeric sequence starting with experiment, hole function, and hole number. The 22 diamond drilled holes shall be EX size, nominal diameter 38 mm. The depths of the diamond drilled holes are: heater holes- 2 m, LGDX anchor and TC holes- 0.5 m. The MPBX holes, which are rotary drilled, are to be nominally 76 mm in diameter and 15 m deep. Locations for the MPBX holes will be defined after the completion of the scoping calculations. Depths of holes should be to the target depth or not more than 25 mm longer. Holes will be located and oriented by the PI. The holes should be located within 1.2 cm of the marked locations and pre- and post-drilling photographs shall be taken. Diamond drilled holes should be drilled to within $\pm 0.5°$ of the specified directions and the two rotary drilled holes should be within $\pm 1°$. Post-drilling bearings will be measured. REECo personnel shall do the drilling, in consultation with the FC.

first slot. The heater phase can commence when the heater equipment and pressure control systems have been installed and thoroughly checked out in the DAS. It is intended that the heaters and control systems be installed and checked out so that the heat in experiment R can be turned on in 1987.

c. Instrumentation Readiness - The ambient temperature phase requires that the displacement pins be properly set and the distances initialized prior to the slot cutting. Starting the heater phase requires that all sensors be calibrated, installed, and checked out in the DAS. Instrumentation checkout includes continuity, signal stability, and when possible field calibrations. DAS checkout includes certification that calibration files are accurate and that all software is functioning properly. One of the features of the instrumentation checkout is to assure that the sensors are properly described within the software and that the DAS output can be matched against individual sensor changes. This is in-effect a DAS system check.

d. Pretest Hold Points - Pretest hold points are those controls that are imposed to assure that all requirements are satisfied before the next step in testing occurs. The following hold points are defined:

(1) End of Development Period: Determination by the PI that:

(a) the instrumentation selection is complete

(b) the control system development is complete

b. Setup and cutting of slots with 1.1-m diamond tipped chain saw. The slots, identified by experiment R or W as shown in Figure 4, will be located by the PI and the plane of the slot shall be parallel to the plane of the heater holes within ±3°. Personnel from SNL will do the cutting with support from REECo, under the general direction of the FC.

c. Application of specified thermal insulation over test region. REECo shall do the work using specified materials in coordination with the FC with acceptance by the PI.

d. Installation of 220 V power at test region. Power up to 12 kW should be available at each experiment location and total power variations should be controlled to within ±1%. REECo shall do the work with acceptance by the FPL.

e. Complete field geological mappings of the regions within 5 m of the test areas. Maps should include descriptions of fractures and inhomogeneities. When possible, drill holes should be used to check surface based fracture projections. SNL will obtain the services of a geologist to perform the work. The FC will coordinate the activities.

f. Complete installation of the operational equipment. This equipment will be installed under the direction of the FPL. SNL personnel will perform the tasks.

experiment (W). The heater phase will be complete when the heat has been turned off after experiments have been conducted both in the roof (Experiment R) and rib (Experiment W) of the Demonstration Drift. Appropriate entries will be placed in the DAS logbook.

b. Completion of Testing - The prototype testing will be complete when the heat has been turned off for the second of the two thermal stress experiments, the heated area has cooled to 30°C or below, and the appropriate instrumentation has been removed and subjected to post-measurement calibrations. Appropriate entries will be placed in the DAS logbook.

4.5 Technical Procedures

Formal Technical Procedures (TPs) are not required for QA Level III work, but some procedures are necessary to ensure satisfactory results. Safe Operating Procedures (SOPs) as necessary are defined in Section 9.0. The following TPs will be prepared and/or utilized:

a. Measurements with a Whittemore Strain Gage (SAIC)

b. Operation of the DAS (SNL)

c. Operation of heater wattage controls (SNL)

The investigators will use available Technical Procedures developed in related SNL activities as models for field practices.

- Subject thermal insulation to confirming laboratory measurements

The major effort in the preliminary laboratory activities is focused on development of the pressure control system. The requirements for the design of control sensors and pressure control system are defined in Section 2.4.1. The details for the design of the system are being formulated and there may be several small scale trials before the final system is defined. A concept involving incorporating displacement feedback from the DAS is technically feasible, as an alarm system was developed for the Heated Block Experiment that utilized calculated feedback from one type of sensor to cause actuation of an automated telephone alarm. The intent of the laboratory effort is to develop and demonstrate viability of a pressure control system for later field use. Included in the demonstration will be validation of any software used.

b. Pre-field activities - Laboratory related activities starting after the final experiment design are:

- Calibrate flatjacks in full scale pressure measurements as described in Section 2.4.2.3.

- Calibrate TCs, pressure transducers, displacement transducers, and tiltmeters (as appropriate)

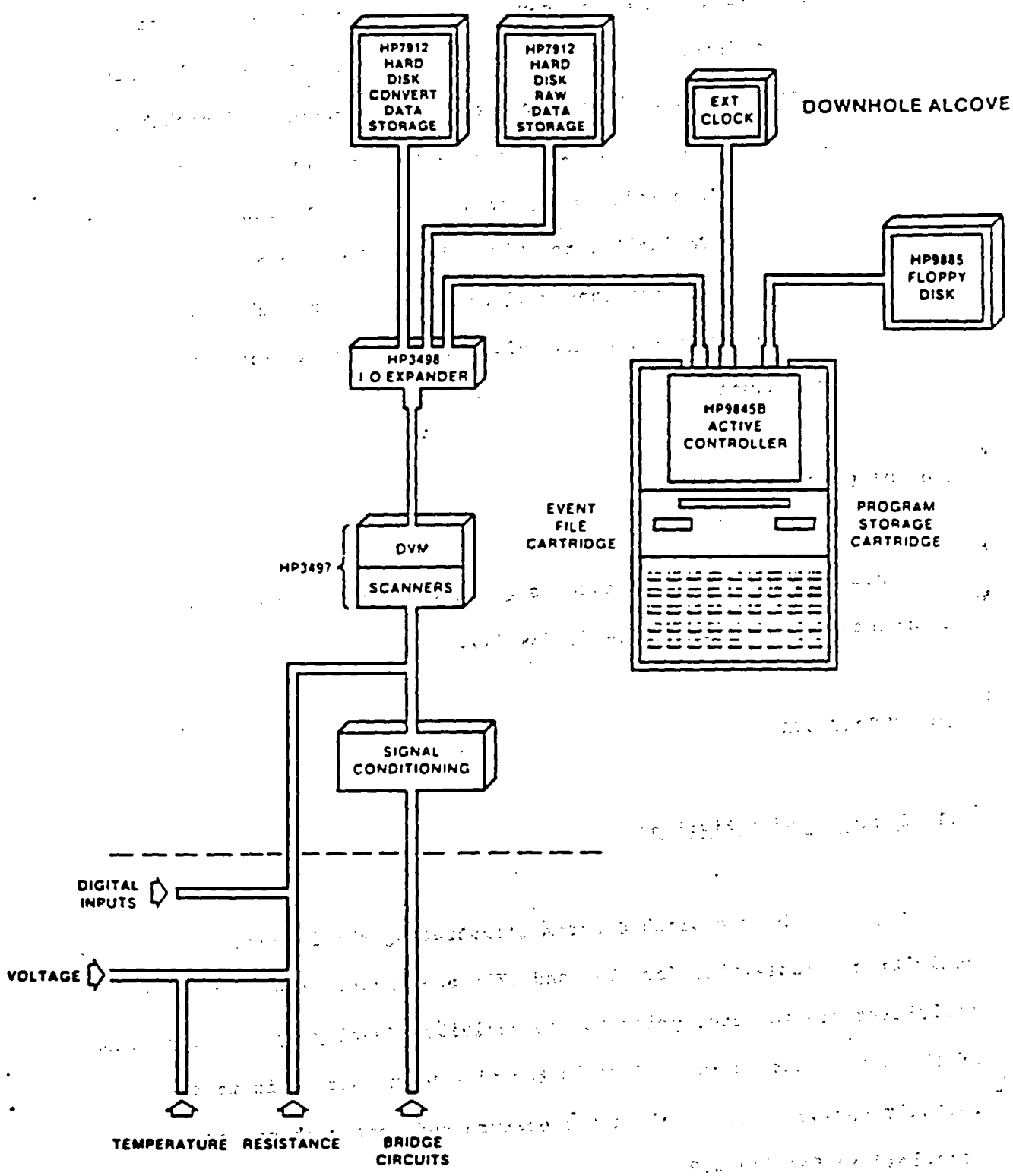

Figure 6. Block Diagram Showing Data Acquisition System Functions

part of the data sets used for measurement-numerical analysis comparisons. In this development effort, the goal is to compare the predictions and measurements in order to check the extent of agreement. Any differences can be determined and probable causes assessed. It is expected that experimental procedures and/or models will be adjusted in future efforts to improve the results. To facilitate this effort, the thermal stress experiment in the roof will be conducted and subjected to preliminary evaluations before the second experiment in the rib is conducted.

3.0 QA LEVEL

This work has been approved as Quality Assurance (QA) level III in accordance with NNWSI-SOP-02-02, Rev (1).

4.0 OPERATIONS

4.1 Sequence of Activities

Figure 5 shows a block diagram illustrating the intended sequence of activities. Activities for FY87 and FY88 are shown. The development activities are to occur prior to the activity identifying the completion of the experiment design. This is the time when this EP is to be formally revised. The ambient temperature and heater phases are described in Section 4.2.

and any revisions will be recorded in the DAS logbook. In the DAS, sensors are uniquely identified in wiring diagrams that correspond to HP 3497 scanner channels. There are two types of channels; scanner channels and data channels. Software algorithms cause the computer to automatically map the scanner channel data to the data channels for storage, processing, and reviewing. Upon initiating a scan, the computer activates the scanner and raw voltages for all channels are measured and stored in a raw data file. The computer then converts the raw data to engineering units and performs appropriate corrections, such as temperature, etc. The converted data are stored in the converted data file. After all data are stored, the computer identifies the scan by time, raw and converted file numbers, and the calibration file used. This information is printed out on the line printer signifying completion of a scan. This means that all data and/or file information can be identified by channel number and time.

5.1.4 Basic Equations

The basic equations used in the data processing are summarized in Table 1.

5.1.5 Software Validation

It is expected that software will need to be prepared for the pressure control system used in the heating phase. Software for this will be validated in laboratory preparation efforts.

4.2 Operational Stages

The field portion of thermal stress testing is to be conducted in two phases, ambient temperature and heater. The ambient temperature phase consists of the measurements of the in situ tangential stress using the flatjack cancellation method (Figure 1). The objective of this phase is to measure the reference pressure prior to the addition of thermal stresses. After the in situ stress is determined at both the roof and wall locations, the same pins that were used in the measurements will be fitted with the control sensors so that the heater phase can be initiated.

The heater phase consists of adding heat to the rock and monitoring the stress, temperature, and displacement changes during the heating and cooldown periods at the two locations. During the heater phase, personnel will periodically monitor the DAS output to ensure that all control functions are operating properly and that measurement systems are operating as expected.

4.3 Prerequisites

a. Overall - The day to day operations associated with the measurement activities in this EP will be documented in logbooks (See Section 8.1). Various readiness activities discussed in this section will be documented in the logbooks.

b. Equipment Readiness - The ambient temperature phase can be started when the chain saw is in position and ready to cut the

Software validation in the GTUF is accomplished in stages. First, there are checks on accuracies of sensor lead connections by comparing changes in individual sensors with changes in voltage in the DVM/ Scanner. This can be done manually. Next, the individual sensors are actuated under controlled conditions and the signal is processed through the DAS to provide output that can be checked. This is a field calibration and can be done for TCs, pressure transducers, LVDT type displacement sensors, tiltmeters, wattmeters, and voltage. Results are entered into the field preparation logbook. Verification that the output is as expected completes the software validation process.

5.1.6. Data Collection Rate

Data are normally collected in 1-hr intervals for the heating phase. The system can be operated up to 2 min intervals if necessary, but it is expected that the changes will be slow and that the 1-hr frequency will provide an adequate record of the changes.

5.2 Data Storage

5.2.1 Manual Data Storage

Data obtained in the ambient temperature testing phase will be manually recorded. This is necessary because of the slot cutting operation. Data consist of pin displacement and flatjack pressure records. These will be recorded on special forms and completed copies will be distributed by the PI to the Data Records Management System

(c) the thermal insulation testing is complete

(d) the scoping calculations are complete

(e) the revision of this EP is complete

(2) End of Field Preparation Period: Determination by the PI that:

(a) calibrations are complete

(b) ambient temperature equipment and instrumentation readiness is complete

(c) heater phase equipment and instrumentation readiness is complete

(d) DAS is installed and operating properly

(3) LANL Readiness Approval for Ambient Temperature Phase: Required before beginning of ambient temperature measurement phase for experiment R. Approval documentation will be entered in the DAS logbook.

(4) LANL Readiness Approval for Heater Phase: Required before beginning of heater measurement phase for experiment R. Approval documentation will be entered in the DAS logbook.

4.4 <u>Postrequisites</u>

a. Completion of Phases - The ambient temperature phase will be complete when the surface stress has been measured in the second

could be shown to have the appropriate technical experience necessary for the tasks planned.

7.0 NONCONFORMANCE ACTIONS

Nonconformance of Quality Level III items or processes will be documented per the requirements of SNL NNWSI QAP 15-1.

8.0 DOCUMENTATION

8.1 Logbooks

Three logbooks will be used to document the day by day activities in this testing. Sequential books in each of the categories need to be identified. The three logbooks are:

a. Laboratory Logbook - Logbook used to document laboratory testing activities and significant results. Records of calibrations activities will be identified.

b. Field Preparation Logbook - Logbook used to describe field preparations for each experiment and those activities leading to first system checkout listed in Figure 5.

c. DAS Logbook - Logbook used in the field data acquisition activities. The book is to be started at the end of the first system checkout listed in Figure 5 for each experiment and

4.6 Interactive Procedures

Interactive procedures are used when it is evident that additional experiments or efforts are necessary to reach the desired objectives. This is a development effort and such occurrences may arise. If so, criteria for interactive procedures discussed in SNL DOP 11-1 will be followed.

4.7 Changes in Experimental Procedures

This experimental procedure is prepared in accordance with SNL DOP 11-1. The initial issue is Revision (0). The approval sheet identifies the persons who review and approve Revision (0). Upon changing this document, the PI will draft the necessary changes and go through the same approval process. A revised document will be issued and distributed to those involved. Note a revision is planned after the development period shown in Figure 5.

There may be occasions where there may be irretrievable loss of data if this EP is followed. SNL DOP 11-1 will be followed in this case.

5.0 DATA ACQUISITION SYSTEM

5.1 Data Acquisition System Description

5.1.1 Block Diagram

Figure 6 is a block diagram showing the major components of the DAS.

SNL Safe Operating Procedures (SOP) exist for cutting of slots. The existing 1.1-m saw needs to be modified slightly for this testing. The SOP will be modified and approved according to SNL policies.

The pressure control system involves pressures up to 40 MPa and temperatures up to 300°C and is to be operated with pressure control system. There is potential for excessive pressure buildup, flatjack failure, and spontaneous combustion of the hydraulic fluid due to the increased temperatures and pressures. The flatjack will be shielded to prevent accidental spraying of high temperature hydraulic fluid on personnel or equipment. The high temperature pressure system will be defined and the operation will be reviewed and approved by SNL's Safety Department. A SOP will be prepared if required.

SOPs will stand alone or become appendices of appropriate TPs as they are made available and used.

10.0 REPORTS

Output from these testing activities will be reported in a number of forms. These include:

a. SNL Technical Letter Reports (SLTR) - Results from the following activities will be prepared in SLTRs:

   - Pressure control system development

   - Ambient Temperature measurements for Experiments R and W

5.1.2 Hardware

Equipment for the DAS exists as a result of earlier SNL testing efforts (Zimmerman, et al., 1986). Selected hardware will be identified, for record keeping purposes, assembled, and utilized in the DAS. Once selected, the equipment will be described in the DAS logbook. The following types of equipment are available for use in the DAS:

a. Hewlett Packard (HP) 9845 active controller digital computer with graphics cathode-ray tube, a printer-plotter, dual tape cartridges, and clock.

b. Hewlett Packard 3498 Input/Output Expander

c. Hewlett Packard 7912 Hard Disk Storage (one for raw and one for converted data)

d. Hewlett Packard 9885 Floppy Disk (for calibration file)

e. Hewlett Packard 3497 DVM-Scanner

5.1.3 Software

Software will be written in the BASIC language. Software will be prepared under the guidance of the FPL. The software used in DAS activities in G-Tunnel will be identified when entered into the computer

11.0 REFERENCES

11.1 Program References

a. DOP- 2-4, "Analysis Control and Verification"

b. DOP- 3-3, "Analysis and Calculation Control"

c. DOP- 5-2, "Technical Procedure Requirements for Data Acquisition Activities"

d. DOP-11-1, "Experiment and Equipment-Test Procedure Requirements"

e. DOP-11-2, "Requirements for Experiment and Equipment-Test Logbooks"

f. DOP-11-3, "Data Records Management System Interaction Requirements"

g. DOP-12-1, "Calibration Program"

h. QAP-15-1, "Nonconformance Reporting and Controls"

Table 1

Typical Software Conversion Equations

Measurement	Equations	Explanation
Temperature	$T = B4*VCORR^4 + B3*VCORR^3 + B2*VCORR^2 + B1*VCORR$ $VCORR = V + VREF - VOFF$	T = Temperature (°C) B1-B4 = TC Constants VCORR = Corrected Voltage V = TC Output Voltage VREF = Reference Junction Voltage VOFF = Initial TC Voltage
Pressure	$P = (VCORR*VP-VOP)*CFP$ $VCORR = 5/VEXCIT$	P = Pressure (MPA) VCORR = Corrected Voltage VP = Sensor Output Voltage VOP = Initial Sensor Voltage CFP = Unit Conversion Factor (MPA/V) VEXCIT = Excitation Voltage
Displacement	$D = (VCORR*VD-VOD)*CFD$ $VCORR = 10/VEXCIT$	D = Displacement (MM) VCORR = Corrected Voltage VD = Sensor Output Voltage VOD = Initial Sensor Voltage CFD = Unit Conversion Factor (MM/V) VEXCIT = Excitation Voltage
Angle	$A = (VCORR*VA-VOA)*CFA$ $VCORR = 15/VEXCIT$	A = ANGLE (°) VCORR = Corrected Voltage VA = Sensor Output Voltage VOA = Initial Sensor Voltage CFA = Unit Conversion Factor (°/V) VEXCIT = Excitation Voltage

Zimmerman, R. M. and Finley, R. E., In Preparation, "Summary of Geomechanical Measurements Taken in and Around the G-Tunnel Underground Facility, NTS," SAND86-1015, Sandia National Laboratories, Albuquerque, NM.

Department of Energy, Draft January 15, 1987, "Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada," Office of Civilian Radioactive Waste Management, Washington, DC.

(DRMS) in accordance with SNL DOP 11-3. Occurrences of manual measurement activities will be recorded in the DAS logbook.

5.2.2. DAS Recorded Data Storage

Data for the heated phase of the testing will be recorded in the DAS. Data from active channels and monitoring channels are stored on the HP 7912 hard disks in raw and converted form at the GTUF. Periodically (no greater than two week intervals) these data, calibration records, and computing software are transferred to tape cassettes and the cassettes are hand delivered to Albuquerque for transfer to a master HP 7912 hard disk located at SNL. Data analyses are performed in Albuquerque from this master data set. Data are processed under the supervision of the FPL or the PI. Data from this master set are transferred by the PI to the DRMS in accordance with SNL DOP 11-3.

5.2.3 Data Identification

Data obtained manually and recorded on the DAS will be identified by type of measurement, sensor identification, and time for DRMS storage. A data history showing converted data in specified units will be provided for each sensor. Appropriate comments and calibration records will be provided as well.

6.0 PERSONNEL QUALIFICATIONS

Quality Level III work does not require formal certification of project personnel; nevertheless, the personnel involved in this testing

NNA.880126.0006

SNL NNWSI PROJECT EXPERIMENT PROCEDURE

CHARACTERIZATION OF THE MINERALOGY AND PETROLOGY OF MECHANICAL TEST SAMPLES

Page	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Rev.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Page	27	28	29	30	31	32	33	34	35	App. A	App. B
Rev.	0	0	0	0	0	0	0	0	0	0	0

Approved by: Francis B. Nimick — 10/15/87
Francis B. Nimick, 6313 — Date
Principal Investigator

Approved by: Barry M. Schwartz — 10/19/87
Barry M. Schwartz, 6313 — Date
Independent Technical Review

Approved by: C A Rautman — 10/15/87
Chris Rautman, 6315 — Date
Independent Technical Review

Approved by: R R Richards — Oct 16, 1987
Robert R. Richards, 6310 — Date
QA Coordinator

Approved by: Thomas E Blejwas — 10/19/87
Thomas E. Blejwas, 6313 — Date
Division Supervisor

Approved by: Thomas O. Hunter — 10/19/87
Thomas O. Hunter, 6310 — Date
Department Manager

SNL NNWSI DEPARTMENT 6310
CONTROLLED DOCUMENT

Issued to: M. D. COTTER, SAIC
Copy Number: #005

RETURN TO 6310 RECORDS CENTER

should continue through the completion of field measurements. All activities pertaining to manual or computed based measurements should be described.

Requirements for logbook entries are described in DOP 11-2. The PI has the responsibility to assure that the laboratory and field project leaders and the field coordinator have copies of the DOP and that appropriate logbooks are being used. On approximately one month intervals, the FC will make copies of the current logbooks and transmitt them to the PI for delivery to the DRMS. When logbooks are completed, they will be transmitted to the PI for disposition within the DRMS.

8.2 SNL Data Records Management System

Manual and DAS data will be identified by a unique DRMS number. The number is F13.A-TBD. The TDB will become the date that Rev (0) of this EP is signed by the SNL Department Manager. From then on, all data will be referenced to that number. The data will be transmitted to the DRMS in a manner acceptable to the DRMS. Manually obtained data will be transmitted by hard copy and data stored in the DAS will be transmitted in a form acceptable for permanent storage.

9.0 SAFETY

There are two potential hazards associated with this testing outside of normal underground operations. The first is the use of the diamond tipped chain saw in cutting the slots and the second is the hydraulic pressure system, operating at a high temperature.

1.0 GENERAL INFORMATION

1.1 Contents

Page

Section

1.0 General Information 2
1.1 Contents 2
1.2 Scope 4
1.3 Objective 4
1.4 Applicable Study Plan 5

2.0 Description of Work 5
2.1 Management 5
2.2 Experiment Configurations 6
2.3 Experiment Methods 6
2.4 Measuring and Operating Equipment 7
2.4.1 Calibration of Equipment 9
2.4.2 Calibration Checks 11
2.4.2.1 X-ray Diffraction 12
2.4.2.2 Bulk Chemical Analysis 13
2.4.2.2.1 X-ray Fluorescence 13
2.4.2.2.2 Atomic Absorption 15
2.4.3 Identification, Handling, Shipping, and Storage 16
2.4.3.1 Identification 16
2.4.3.2 Handling and Shipping 16
2.4.3.2.1 Handling 16
2.4.3.2.2 Shipping 16
2.4.3.3 Inspection 16
2.5 Sample Traceability and History 17
2.5.1 Sample Identification and Custody 17
2.5.2 Effects of Prior Activities on Samples 19
2.6 Sample Preparation 19
2.7 Use of Logbooks 20
2.8 Related Analyses 22
2.9 Related Experiments 23

3.0 Quality Assurance 23
3.1 QA Level 23
3.2 Surveillances and Audits 23

4.0 Operations 23
4.1 Prerequisites 24
4.1.1 Personnel Training and Qualification 24
4.1.2 Procurement 24
4.1.3 Current Procedures 24
4.1.4 Hold Points 24
4.2 Postrequisites 25
4.3 Technical Procedures 25

o Heater phase monitoring results for Experiments R and W.

b. Monthly Reports - SAIC will provide monthly reports to the PI for activities relating to this testing. Reports will include documentation of activities and provide results of any measurements. Copies of monthly reports will be transmitted to the DRMS by the PI.

c. SNL Internal Memoranda - Formal communications between the PI and project leaders will become part of the records and copies will be filed with the DRMS.

d. SAND report. It is planned that the results and final interpretations of this work will be published in a SAND report.

e. Technical procedures - One of the major outputs of this prototype testing effort will be the establishment of Technical Procedures that can be used in later ES testing. Technical Procedures will be prepared for the activities related to the control and measurement parameters defined in Section 2.3.

f. Other - It is expected that there will be a number of papers submitted to technical and professional proceedings and journals covering various aspects of this work. These will be submitted as appropriate.

1.2 Scope

This SNL NNWSI Project Experiment Procedure (EP) describes work to be performed by personnel at the Department of Geology/Institute of Meteoritics (IM) of the University of New Mexico (UNM) under SNL Contract 01-9156. This EP supersedes the Letter of Criteria from Nimick to Keil dated 2/21/86. The EP describes requirements for:

- sample handling, identification, and control;
- pre-analysis activities such as equipment calibration and sample preparations;
- analysis activities, including data acquisition;
- post-analysis activities such as calibration checks, data reduction, sample storage and shipment, and reporting requirements;
- documentation requirements at all stages.

It is intended that this EP and referenced SNL NNWSI Project Technical Procedures (TPs) embody the applicable portions of the SNL NNWSI Quality Assurance Program Plan and its associated procedures. Therefore, this EP and the TPs referenced herein form the quality assurance plan that the contractor (UNM, Dept. of Geology/IM) should follow.

1.3 Objective

The objective of the work described in this EP is to obtain mineralogic, petrologic, and chemical data on samples of tuff from Yucca Mountain to allow refined interpretation and correlation of existing mechanical property data and similar data gathered in the future. Data to be collected under the EP are mineralogic abundances, and distributions; textural information, including

11.2 Technical References

Bellman, R. P., W. C. Thompson, M. P. Board, M. D. Voegele, M.D., and M. E. Hall, In prep., "Instrumentation Preparations and Calibrations for the G-Tunnel Heated Block Experiment," Science Applications International Corporation Contractor Report to Sandia National Laboratories.

Hoskins, E. R., 1966, "An Investigation of the Flatjack Method of Measuring Rock Stress," Int. J. Rock Mech. Min. Sci. Vol. 3, Pergamon Press, Great Britain.

Mayer, A., P. Habib, and R. Marchand, 1951, "Underground Rock Pressure Testing," Proceedings of the International Conference on Rock Pressure and Support in Workings;" Liege, France.

St. John, C. M. In Preparation, "Reference Analyses of the Design of Drifts for Vertical and Horizontal Emplacement of Nuclear Waste in a Repository in Tuff," SAND86-7005, Sandia National Laboratories, Albuquerque, NM.

Zimmerman, R. M., R. L. Schuch, D. S. Mason, M. L. Wilson, M. E. Hall, M. P. Board, R. P. Bellman, and M. P. Blanford, May 1986, "Final Report: G-Tunnel Heated Block Experiment," SAND84-2620, Sandia National Laboratories, Albuquerque, NM.

The SNL Principal Investigator (PI) for this work is Francis B. Nimick (SNL Division 6313), who is responsible for providing technical and quality assurance requirements for the work, for ensuring that these requirements are met and that relevant documentation is completed, and for submitting the documentation to the SNL Data Records Management System (DRMS). At the IM, the Director will be responsible for overseeing all work at the IM and will serve as QA coordinator for the work. The project research scientist at the IM will be responsible for overseeing or performing all data acquisition activities and for ensuring that all requirements specified by SNL are met. Personnel to be involved in bulk chemical analyses, production of thin sections, photographing of thin sections, and crushing of samples into powder also will be familiarized and certified per requirements in Section 9.0.

This work is to be performed under SNL Contract 01-9156. The pertinent DRMS Data-Set-ID is 51/L04-2/21/86.

2.2 Experiment Configurations

Samples for this work originally will be in the form of post-test (broken), mechanical test samples which will be made into thin sections and powder for analysis (see Section 2.5.1 for a list of samples). All analyses of these samples will be performed using accepted techniques and equipment. For work involving equipment (e.g., X-ray diffraction, bulk chemistry), descriptions of equipment are provided in relevant TPs. A list of TPs applicable to the work for this EP is provided in Section 2.4.

2.3 Experiment Methods

All samples that have been provided to the IM have been broken in compressive mechanical tests. The characterization of these samples for this EP should be performed in the sequence given in the following paragraphs. Where appropriate, cross-references to relevant TPs are provided.

The first step is a hand-sample (mesoscopic) description of each sample. Each sample should be described as received, with attention paid to identifiable mesoscopic features. Fractures induced during mechanical testing need not be described unless they are obviously related to a preexisting inhomogeneity. Estimation of modal proportions should be made following procedures outlined in TP-59.

Table 1

Equipment to be Used in Work for EP-0007

Type of Equipment	Identifier	Related Technical Procedures
Binocular Microscope	UNM ID# 36545	TP-59
Research Microscopes	UNM ID# 104825	TP-59, TP-60
	UNM ID# 144592	TP-59, TP-60
Micrometer Eyepieces	IM - ME1	TP-59
	IM - ME2	TP-59
Bulk Chemical Equipment		
Rigaku 3064M X-ray Fluorescence Spectrometer	DR12035	TP-61
Hokuswa R1130-2-H114-030-090 Strip Chart Recorder	5B7086A0110K	TP-61
OHAUS G-110 Balance	5050	TP-61
Mettler H16 Laboratory Balance	124904	TP-61
Precision Scientific Co Thelco Oven	13-U-1	TP-61
Lindberg 51848 Laboratory Box Furnace	777433	TP-61
Perkin Elmer 303 Atomic Absorption Spectrophotometer	34872	TP-61
Hitachi 165-0045 Strip Chart Recorder	K216649	TP-61
X-ray Diffraction System	Scintag Pad V	TP-62, TP-102

Table 2

Technical Procedures Relevant to Activities for EP-0007

Title	Number
Procedures for Laboratory Sample Petrologic Determination	TP-59
Procedures for Preparation of Polished Thin Sections	TP-60
Procedure for Laboratory Sample Bulk Chemistry Determination	TP-61
Laboratory Procedures for Mineralogic Analysis by X-ray Powder Diffraction, Part 1: Data Gathering	TP-62
Laboratory Procedures for Mineralogic Analysis by X-ray Powder Diffraction, Part 2: Data Analysis	TP-102

Section | Page

4.4 Data Acquisition/Reduction Systems 26
4.4.1 Equipment 27
4.4.1.1 Hardware 27
4.4.1.1.1 X-ray Diffraction 27
4.4.1.1.2 X-ray Fluorescence 27
4.4.1.1.3 Atomic Absorption 27
4.4.1.2 Software 27
4.4.1.2.1 X-ray Diffraction 29
4.4.1.2.2 X-ray Fluorescence 29
4.4.1.2.3 Atomic Absorption 29
4.4.2 Equations 29
4.4.3 Verification and Validation 29
4.4.3.1 X-ray Diffraction 29
4.4.3.2 X-ray Fluorescence..... 30
4.4.4 Data Acquisition and Storage 30
4.5 Deviations From and Changes to EP or Associated TPs During Work 30

5.0 Nonconformances and Corrective Actions 31

6.0 Safety 31

7.0 Records Control 31
7.1 DRMS Data-Set ID 31
7.2 Records Transmittal 31
7.3 Return of Samples 33

8.0 Data Reports 33

9.0 Personnel Qualification and Training 34

Appendix A NNWSI-SNL Chain-of-Custody Form

Appendix B Form EP-0007-T1. Certification for NNWSI Project Personnel

in which such software is used. The details of calibration checks are given in the following subsections. For standards used in calibration checks, documentation as to source, sample history, sample purity, and relevant known properties (e.g., mineralogy and associated x-ray pattern, bulk chemistry, etc.) must be provided to the SNL PI and approved in writing before software verification or data acquisition begins.

2.4.2.1 X-ray Diffraction (XRD)

Calibration checks of the entire system used in X-ray diffraction must be made at the beginning and end of each separate data collection session. A calibration check consists of performing an X-ray diffraction analysis of a material of known properties and comparing the measured results with known values. For this work, the reference material is a pressed disk of silicon powder, calibrated against a sample of unconsolidated silicon powder (NBS SRM-640). Details of the calibration checks using the disk are provided in TP-62, including definitions of in- and out-of-specification runs and procedures to be followed in the latter case.

Before any routine data-gathering begins, the unconsolidated silicon powder (NBS SRM-640) should be subjected to five consecutive XRD analyses (removing and reloading powder in sample holder between analyses) to obtain an estimate of the precision of the peak locations and relative intensities. Accuracy of peak locations also should be checked against Joint Committee on Powder Diffraction Standards (JCPDS) Card 27.1402.

After the unconsolidated silicon powder has been analyzed, the pressed disk of silicon powder should be analyzed by XRD five times. These analyses will provide an estimate of the precision of data determined on the disk. In addition, comparison of the resulting XRD data with those obtained on the unconsolidated powder and on JCPDS Card 27.1402 will allow determination of the accuracy of data for the disk. Documentation of the data for the 10 XRD analyses must be maintained in the experiment logbook. In addition, the documentation, together with a brief discussion of precision and accuracy, must be transmitted in a letter to the SNL PI. Verbal acceptance by the SNL PI of such documentation must be obtained before routine data gathering begins.

abundances of lithic fragments, lithophysae and phenocrysts, types and percentages of matrix, and characterization of rock fabric(s); and whole-rock chemical analyses.

1.4 Applicable Study Plan

The study plan to which this EP relates is 8.3.1.15.1.3, entitled "Laboratory Mechanical Properties of Intact Rock." This study plan is presently scheduled to be completed in September of 1987 and submitted to the Department of Energy for submittal to the Nuclear Regulatory Commission with the Site Characterization Plan. Work described in this EP is considered to be a part of ongoing work in interpretation of mechanical properties of tuff and may be initiated before approval of the Study Plan.

The work covered by this EP is intended to provide information on mineralogic, petrologic, and chemical characteristics of tuff samples. The information will be combined with porosity, grain density, and bulk density data to determine an optimal set of characteristics with which mechanical properties can be correlated. The ultimate goal is to enable estimation of mechanical properties from characteristics that can be measured on small, irregularly shaped samples or that can be measured more quickly and less expensively than the mechanical properties could be measured.

Correlation of mechanical properties with physical characteristics will be performed at Sandia National Laboratories (SNL), and so is not covered by this EP. No statistical analyses were performed to determine the required numbers of analyses or to aid in defining types of analyses.

2.0 DESCRIPTION OF WORK

2.1 Management

All work performed for this EP will be done on samples provided to the IM by SNL. Hand-sample and thin-section descriptions will be made, X-ray diffraction analyses will be run, and bulk chemical compositions will be measured.

obtained by a chemical titration, and the results are used to correct the LOI data to obtain the true content of volatiles. The accuracy of both of these measurements is checked using standard MRG-1 [Mount Royal Gabbro; standard of the Canadian Certified Reference Materials Project (an equivalent NBS material is not available)].

Before routine data-gathering begins, standard MRG-1 should be used to perform a titration in each of the burets that will be used in work for this EP. (The burets should be marked so that their identities are separable). Successful replication of the Fe^{2+} amount (within ±3% of the accepted value) is required before a buret is used for routine data-gathering, and documentation of the successful replications should be maintained in the log-book and also should be made in a letter to the SNL PI. Verbal acceptance by the SNL PI of such documentation must be obtained before routine data gathering begins.

The purity and grade of all chemicals used in the titration are stated in TP-61, and supporting documentation must be maintained by the IM.

An additional check of the quality of chemical analyses obtained using XRF, LOI, and the titration for amount of Fe^{2+} is the analytic total for each sample. The total must be within the bracket of 99.0% to 100.5% to be acceptable. If the total is not within these limits, then a sequence of additional analyses may be necessary. First, the SiO_2 content will be determined using a classical gravimetric method (described in TP-61), and the analytic total will be recalculated using the gravimetric SiO_2 content with the other XRF, LOI, and titration data. If the analytic total still is outside the required bracket, atomic absorption (AA) analysis will be used (Section 2.4.2.2.2). Elements that are present in the sample in amounts that deviate most from amounts in calibration samples will be the first to be analyzed by AA. After each such element is analyzed by AA, the result will be used in recalculating the analytic total for the sample. The process will continue until the analytic total is within the required bracket. If the bracket is not satisfied after all elements have been analyzed by AA, the SNL PI will be consulted to reach a resolution of the problem.

After the mesoscopic description of a sample is complete, the sample will be examined by the project research scientist in conjunction with the SNL PI or the designee thereof to determine whether material suitable for representative bulk property measurements is available. If so, the material will be taken by the SNL PI and bulk density measurements will be made; these measurements will be governed by EP-0010 ("Bulk Property Measurements on Post-Test Mechanical Samples"). Any material taken by the SNL PI will be returned to the IM after bulk density measurements have been completed. All sample movements must conform to the requirements of sample identification and custody (Section 2.5.1).

The next step to be performed by the IM is a description of thin sections prepared from each sample. Selection of material suitable for thin sections will occur after the SNL PI removes material for bulk density measurements or after it is determined that no material is suitable for such measurements. Two thin sections should be made for each sample following the procedures presented in TP-60, and descriptions should be performed following the procedures given in TP-59. For point counting, a grid spacing of 1-mm-by-1-mm should be used unless otherwise specified (in writing) by the SNL PI. The SNL PI should be consulted before point counts are made on thin sections containing individual components with a maximum dimension greater than approximately 1 mm.

After powdering the remaining material from each original sample following the procedures in TP-59, perform an X-ray diffraction analysis of each sample (TP-62 and TP-102). The X-ray analysis should be supplemented with a bulk chemical analysis of the major oxide composition (TP-61) of each sample. Results of the sample descriptions, X-ray and bulk chemical analyses should be used to produce an estimate of proportions of mineral phases present, reported as either weight or volume percentages or constituent phases.

2.4 Measuring and Operating Equipment

Table 1 lists the equipment to be used for the work covered by this EP. The table also provides an identifier for each piece of equipment [either a serial number, if available, or an identifier assigned by UNM or by the IM (if

The standard(s) to be used in the calibration checks will be identified by the IM in conjunction with the SNL PI. Documentation of each standard must include the information listed in Section 2.4.2 and must be provided to the SNL PI and accepted verbally before routine data-gathering by AA is performed.

2.4.3 Identification, Handling, Shipping, and Storage

For items, materials, and samples at UNM, it is the responsibility of the project research scientist to ensure that the requirements of this section are met. For items, materials, and samples at SNL, it is the responsibility of the SNL PI, or designee thereof, to ensure that the requirements of this section are met.

2.4.3.1 Identification

Documentation of work in support of this EP (including shipping, receiving and handling, as well as data gathering activities) will utilize item identifications consistent with Table 1 of this EP. UNM will provide the SNL PI (before work begins) all equipment identifications from Table 1 that have not been defined as of Revision 0 of this EP.

2.4.3.2 Handling and Shipping

2.4.3.2.1 Handling

It has been determined that no special protective environments are necessary during shipping and handling of the items, materials and samples defined in this EP.

2.4.3.2.2 Shipping

Items, materials, and samples will be shipped so that the characteristics or functions of the items, materials, and samples, as well as their identification are not compromised.

2.4.3.3 Inspection

Inspections (also referred to as receiving inspections) will be performed each time items, materials, or samples are received. The SNL PI should be

assigned by the IM the identifier must remain attached to the equipment for the duration of the work)]. The identifier must be referenced on all data sheets and log books provided to the SNL PI per the requirements for documentation (Section 7.2).

The TPs to be used in connection with this EP are listed in Table 2. These TPs address the type, range, and accuracy of each piece of data-measuring equipment. The TPs also specify the calibration procedures, if necessary, for individual pieces of equipment.

2.4.1 Calibration of Equipment

Any equipment that is to be used primarily for quantitative or semi-quantitative data acquisition must be calibrated before use. Procedures for calibration are provided in relevant TPs. Appropriate documentation of the calibrations should be transmitted to the SNL PI for transmittal to the SNL DRMS before subsequent measurements begin. The documentation requirements for calibrations are as follows:

- Copies of (1) the calibration records for the instruments of the calibration facility; and (2) documentation of the standards used for calibration certifying that traceability to national standards exists.

- A calibration report, containing the following:

  - type and identification of device being calibrated,

  - identity of the standards used (if any),

  - a statement of traceability to nationally recognized standards,

  - a table or plot of the indicated versus the actual value,

  - a statement certifying that the device is accurate within a specified tolerance over a specified range,

These identifications will be used throughout the period of work, and either will be physically attached to the sample(s), or the sample(s) will be in container(s) marked with the identification(s), or both. Sample custody will be documented using Chain-of-Custody forms (Appendix A) with one form for each sample.

Rock samples have been provided to the IM either in plastic bags or in plastic or glass jars. In most cases, the samples are still enclosed in the polyolefin jackets in which mechanical tests were conducted. Sample identification is marked on the bag or jar in which the sample is located, and in some cases also is marked on the sample.

Samples or subsamples (see Section 2.6 for description of expected subsamples) must be kept in appropriately labeled containers at all times other than:

- when being described,
- when being subdivided or otherwise being prepared for analysis,
- when being analyzed,
- or when being described after analysis.

For subsamples that are powders, the containers must be sealed in a way that the container cannot be opened without breaking the seal. The seal will include, at least, the following information:

- "SNL NNWSI sample"
- sample identification

Seals will be attached to the container at the time that the sample is placed in the container. Each time that a sample is removed from its container and then replaced, a new seal will be attached to the container with the appropriate information as described above. Each time that a seal is broken or replaced, notation will be made on the relevant Chain-of-Custody form. Provisions will be made that seals remain intact (if not intentionally broken) for as long as the sample is the responsibility of UNM/IM.

- the identity of the person performing the calibrations, and

- the dated signature of the same person or their supervisor.

- A sticker attached to the instrument (or directly referenced thereto if physical attachment would interfere with use of the instrument) bearing the following information:

  - the identification of the instrument, consistent with the permanent identification marking on the instrument,

  - the date of the most recent calibration,

  - the due date of the next calibration,

  - the initials of the person that performed the calibrations, and

  - the identity of the organization or company that performed the calibration.

Two types of equipment must be calibrated periodically for this work: thermocouples used for determination of furnace temperatures and balances. The calibration interval for both is here defined to be 12 months (6 months for thermocouples if output uses LED readout). Calibration should be performed by an organization that has a QA Plan approved by SNL Department 6310 and the documentation requirements listed previously must be satisfied. Any procurement by the IM for calibration services must conform to the requirements of Section 4.1.2 of EP-0007.

2.4.2 Calibration Checks

Calibration checks of entire measurement systems must be made to ensure that the systems are working properly. These checks also will be used to satisfy verification requirements on data acquisition software in situations

Preparation of thin sections should follow procedures provided in TP-60. Grinding of material for XRD and XRF analyses should follow procedures given in TP-59.

Assignment of sample IDs to subsamples will be the joint responsibility of the project research scientist and the SNL PI. The format of these IDs will be in conformance with the format for subsample IDs described in SNL NNWSI Project DOP 8-1 and in TP-59.

If a complete sample ID cannot be physically attached to a sample (i.e., in the limited space available for scribing on a thin section), the project research scientist may assign "short form" identifications to such samples. These "short form" IDs must be unique, and must be traceable to the complete sample ID. Specifically, cross-reference between the two IDs must be noted on the appropriate Chain-of-Custody form.

2.7 Use of Logbooks

An experiment logbook must be maintained to document work for this EP. The logbook may be in the form of unbound data sheets, a bound notebook, or both. Whichever type is selected, pages must be numbered sequentially for each form separately. If both types are used together, adequate cross reference must be provided.

Entries to be made in the logbook include, but are not limited to the following:

Before start of activities, and whenever changes are required:

a. Name, identifier, and revision of EP and TPs.

b. Activity location(s) [company name, address, building(s), room(s), or specific field location(s)].

c. List of items to be used [including traceability information such as manufacturer name and lot number, make, model, serial number, (or other unique identifier) of items traceable to calibration records and to other records generated in support of the EP].

During routine data gathering, calibration checks will be made using the silicon disk. As long as each analysis of the disk satisfies the specifications outlined in TP-62 (peak locations within ± 1% of those on the JCPDS Card 27.1402), no additional analyses of the unconsolidated silicon powder are required. If the specification on peak locations is not met, the unconsolidated powder should be analyzed again to ascertain whether the failure to meet specifications is attributable to the disk or to the XRD equipment.

During the routine gathering of XRD data on rock samples, five replicate analyses (removing and reloading powder in sample holder between analyses) should be made on one sample of each mineralogic type (devitrified, vitric, zeolitized). The data from these replicate analyses will allow an estimate of the precision of XRD data for the rock samples.

2.4.2.2 Bulk Chemical Analysis

2.4.2.2.1 X-ray Fluorescence (XRF)

The set of internally stored calibration curves for the elements of interest (described in TP-61) should be checked with each group of four samples by performing an analysis of one of two NBS standards [either NBS SRM-278 (obsidian) or NBS SRM-688 (basalt)] and an analysis of basalt standard BCR-1. Comparison of the analysis of standard BCR-1 with earlier analyses will provide a correction factor to be applied to each calibration curve in data reduction for the group of four samples plus the NBS standard. The analysis of the NBS standard then should be checked against the composition provided by NBS for the standard. The analysis for each constituent of the NBS standard should agree within ±3% of the accepted value for each constituent that comprises more than 1% of the sample. For constituents that comprise between 0.1% and 1.0% of the samples, the values should agree within ±5%. For constituents that comprise less than 0.1% of the sample, the values should agree within ±30%.

Two additional measurements are made that contribute to the bulk chemical analysis. Loss on ignition (LOI) determines the total volatile (assumed to be H_2O) content of a sample, including weight changes caused by oxidation of iron in the sample. The relative proportions of Fe^{2+} and Fe^{3+} are

d. Observations of conditions (environment, power, etc.) that might affect experiment results.

e. Data or reference to any data recorded elsewhere, including type of observation (if not stated in procedures defined in (a) above).

f. Deviation(s) from EP and/or TPs.

g. Notation of unusual occurrences or unexpected results.

h. Nonconformances and corrective action efforts (successful and unsuccessful) keyed to the unusual occurrence or nonconformance.

i. Dates and reasons for significant experiment downtime or delays (covering gaps as appropriate).

j. Name(s) of person(s) performing experiment and making entry (printed and signed, including date and time).

All entries in the logbook must be made using black, indelible ink. Corrections may be made by providing the following documentation in the logbook:

- Drawing of a single line through the incorrect entry (without completely obliterating the incorrect entry).
- Insertion of the correction above or adjacent to the incorrect entry.
- Initials of the person making the correction.
- Date of correction.

2.8 Related Analyses

No analyses related to design of this work have been performed, and no future analyses related to design of the work are planned.

If gravimetric determination of SiO_2 in a tuff sample is necessary, one of the two NBS standards (SRM-278 or SRM-688) should be used as a check on the accuracy of the method. The SiO_2 content of the NBS standard should be within ±3% of the accepted value before the first measurement on a tuff sample is made.

2.4.2.2.2 Atomic Absorption (AA)

This method will be used only if the XRF analyses fail to meet the acceptability criterion described in the preceding section. The AA system is calibrated for each set of samples. Calibration is performed using in-house (UNM Dept. of Geology) standard solutions based on up to five rock standards:

Basalt (BCR-1)
Granite (G-2)
Peridotite (PCC-1)
Dunite (DTS-1)
Andesite (AGV-1)

(Sample ID's in parentheses are those assigned and used by UNM).

The calibration must be checked before analyzing any tuff samples.

The calibration check will be performed using a solution of a standard material (the choice of standards is discussed below). For a successful calibration check, the analysis of each constituent that comprises more than 1% of the standard must be within ±3% of the accepted value. For constituents that comprise between 0.1% and 1.0% of the sample, the values should agree with ±5%. For constituents that comprise less than 0.1% of the sample, the values should agree within ±30%. If one or more values for the constituents fail to meet this criterion, no data will be gathered on tuff samples until the reasons for the discrepancies are identified, the problem is resolved and an in-specification calibration check is obtained.

4.1 Prerequisites

Before performance of technical activities for this EP, a number of prerequisites must be verified. Technical prerequisites are discussed in relevant TPs. Other prerequisites are discussed in the remainder of this section.

4.1.1 Personnel Training and Qualification

All personnel involved in the work must be trained and qualified for the work, as discussed in Section 9.0. Before technical work is performed, documentation of training and qualification must be transmitted to the SNL PI.

4.1.2 Procurement

The instructions in this section pertain to items and services that affect technical quality.

Procurement requests by UNM for items and services in support of this EP must be reviewed and approved in writing by the SNL PI if such requests are initiated after issuance of Revision 0 of the EP. The SNL PI is responsible for ensuring that the procurement procedures and documents conform to the appropriate SNL NNWSI Project DOPs or to the SNL NNWSI Project Quality Assurance Program Plan.

4.1.3 Current Procedures

Verification must be made that current revisions of all implementing procedures (EP, TPs) are being used before technical activities begin. At the time that this EP or a revision thereof is issued, the SNL PI will transmit a list of the current revisions of all other implementing procedures to UNM. In addition, the SNL PI will verify that copies of the current revisions of the EP, associated TPs, and other documents relevant to the technical activities (e.g., User's Manuals for software) are filed in the pertinent portion of the DRMS.

4.1.4 Hold Points

The only voluntary hold point planned for this work is one following the mesoscopic description of the samples. The hold point will allow selection of suitable material for bulk property measurements (see Section 2.3).

notified verbally as soon as possible and in writing within five working days from the time that it has been determined by personnel at the IM that items, materials, or samples have been damaged or that identifications have been obliterated during shipment to the IM.

2.5 Sample Traceability and History

2.5.1 Sample Identification and Custody

The following rock samples, originally acquired from core stored in the U.S. Geological Survey core library in Mercury, Nevada, will be used in the work for this EP. (The cores were controlled under an undetermined QA level before initiation of this EP.)

Sample ID*	DRMS Data-Set ID of Related Mechanical Test
A1-212.7	51/L02-3/1/80
G1-1487.4-SLA1	51/L02-10/1/81
G1-1550.4-SLA28	51/L02-10/1/81
G1-1551.1-SLA29	51/L02-10/1/81
G1-1784.8-SLA19	51/L02-10/1/81
G1-1785.6-SLA20	51/L02-10/1/81
G1-2276-SF	51/L02-7/30/81
G1-2589-SD	51/L02-7/30/81
G1-2699.1-SLB	51/L02-12/1/81
G1-2996.9-SLB	51/L02-12/1/81
G1-3102.3-SLD	51/L02-12/1/81
G1-3498.4-SLB	51/L02-12/1/81
GU3-760.9/4A	51/L02-2/11/83
G4-742.75-E	51/L02-10/12/83
G4-742.75-G	51/L02-10/12/83
G4-965.2-D	51/L02-10/12/83
G4-1001.9-A	51/L02-10/12/83
G4-1369.1-E	51/L02-10/12/83
G4-1400.6-H	51/L02-10/12/83

*A1 = core hole UE-25a#1; G1 = core hole USW G-1; GU3 = core hole USW GU-3; G4 = core hole USW G-4; numbers following core hole identifiers are depths in feet.

4.3 Technical Procedures

All TPs pertinent to this work are listed in Table 2.

4.4 Data Acquisition/Reduction Systems

The data to be acquired, listed by type of description of analysis, are the following:

1. mesoscopic (hand-sample) description
   - color(s)
   - texture(s)
   - clast type(s), including size(s) and sorting characteristic(s)
   - modal proportions of fragments/constituents larger than about 5 mm.

2. thin-section description
   - grain size(s)
   - fragment type(s), size(s), shape(s)
   - degree of welding
   - texture(s)
   - degree and type of devitrification
   - modal proportions of components

3. X-ray diffraction analysis
   - identity of constituents (e.g., mineral(s) or glass)
   - semi-quantitative to quantitative estimates of abundances of constituents

4. bulk chemical analysis
   - weight percentages of SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, H_2O^+, and H_2O^-.

The remainder of Section 4.4 discusses the acquisition and storage of the data.

The Chain-of-Custody forms will serve as records of sample custody throughout sample history. Each time that a sample changes custody, the transfer will be documented by the signatures of the sender and of the receiver together with the date(s) and time(s) of transfer. After each transfer is made and the Chain-of-Custody form is signed and dated, the form will be photocopied and the copy, accompanied by a transmittal letter, will be sent to the SNL PI. The original forms will be maintained by the person having custody of the samples. Original forms will be returned to the SNL PI when the samples are returned, when subdivision of samples occurs (see Section 2.6), or when work on the EP is completed (applicable to standards only).

2.5.2 Effects of Prior Activities on Samples

All samples to be characterized for this EP originated as core from deep core holes at Yucca Mountain. They were cut and machined to prescribed dimensions for compressive mechanical testing. After saturation with water from well J-13, they were loaded in uniaxial compression at ambient temperature until brittle failure occurred. After failure, they were stored in the jars or bags in which they presently are located.

None of the activities mentioned in the preceding paragraph are expected to have altered the characteristics being analyzed for this EP. The hydration state of any hydrous phases (e.g., zeolites, clay) that may be present in the samples undoubtedly has changed significantly during sample history. However, it is the presence or absence of such minerals that is important for this work; a specific hydration state is not relevant.

2.6 Sample Preparation

Samples as provided to the IM should be suitable for mesoscopic description. After such description is complete, portions for preparation of thin sections and for bulk property testing at SNL should be selected as described in Section 2.3. The latter piece should be transmitted to SNL before additional subsample preparation occurs. When a sample is subdivided, a new Chain-of-Custody form will be initiated for each subsample, and notation of the new sample IDs will be made on the original form. The original form then will be complete and will be returned to the SNL PI.

All application (data acquisition) software will be described using U.S. Government Standard Form 185 for submittal to the DRMS. The form(s) (to be provided under separate cover) will be completed by the project research scientist, and will be transmitted to the SNL PI before data-gathering using the software begins. The form(s) will be updated whenever information on the form(s) changes.

Application software program files stored on computer media will bear a label defining the software manufacturer, title, version number, and date copied. (This requirement only applies to floppy diskettes or other computer media that can be separated from the computer hardware). Hard copies of program files must contain the same information as the computer media.

All data, whether on hard copy or computer media, must be identified clearly with associated parameters (e.g., 2θ angle, intensity, etc.) by use of headers and/or trailers on rows and/or columns. Such headers and/or trailers must either include units or must reference the location in the logbook where units are defined.

Computer-readable and hard-copy listings of all versions of nonproprietary application software used in the conduct of work for this EP will be transmitted to the SNL PI for inclusion in the DRMS. All computer media will be labeled as described above and will be provided in duplicate. For application software that is proprietary, the SNL PI must be notified in writing that copies of such software cannot be provided.

The user of any application software, or the project research scientist, will report errors discovered in the software both to the originator of the software and (in writing) to the SNL PI. In addition, the errors should be documented in the logbook.

REFLEX database software (Borland International Corp.), Version 1.1, will be used for tabulation and reporting of data for the EP, but will not be involved in data acquisition. LOTUS 1-2-3 spreadsheet software (Lotus Development Corp.) will be used for some data manipulation and analysis, and the program's INPUT and CIPW (Rock Doc Programs, Inc.) will be used to calculate CIPW norms from chemical data. In addition PC-FILE+, Version 1.0 (Button ware) may be used for some data tabulation and reporting.

d. Sketch or photographs of equipment hookup, installation, and samples/sites. (If photographs or sketches of permanently installed equipment are presented in a TP used for the work described in this EP, only a cross-reference needs to be entered in the logbook.) Photographic media provided to SNL must be provided in duplicate. Photographic media will contain reference to the date the picture was taken, the location in which photographs were taken and the scale of the photograph(s). The negative/slide identifier and the subject of the photographs will be documented in the logbook.

e. Name of person(s) performing the experiment and making entry (printed and signed, including date and time).

f. Title(s) and revision(s) of any application software used in data acquisition. If the version number of any software changes during the period of work for this EP, any changes to the software that may affect the outcome of the work should be described in the logbook.

g. Settings of all gauges and dials that are not to be changed by the UNM project research scientist, but may be changed by other UNM staff as part of equipment maintenance or updating of a measurement system by original vendor.

At least daily when work is being performed:

a. Procedure steps worked on or reference to specific section(s) of procedures defined in (a) above.

b. Sample identification (consistent with Section 2.5.1).

c. Equipment identification and settings such as range, gain, heating rate, time base, etc.

4.4.3.2 X-ray Fluorescence

The discussion provided in Section 4.4.3.1 for X-ray diffraction applies for this section as well, except that calibration checks (Section 2.4.2.2), description of software and instructions for the use thereof are provided in TP-61 and associated documents.

4.4.4 Data Acquisition and Storage

For most work for this EP, the rate of data acquisition is unimportant. For X-ray diffraction analysis, acquisition rates are defined in TP-62. The X-ray diffraction data are stored as they are collected on the hard disk of the Data General Computer. After each X-ray diffraction data collection session, newly acquired data must be copied to 5 1/4" floppy diskette(s) as specified in TP-62. The diskette(s) should be labeled, at a minimum, with the software manufacturer, title and version number, the EP number and revision, the names of all files on the diskette(s), and the date on which the analyses were performed. A cross reference to the page number(s) of associated logbook entries also must be included. An additional copy of all raw data files should be made on a separate diskette and should be maintained in a location physically separated from the location of the first copy. Hard copies of the data must contain the same information as is required on the labels for diskettes.

For X-ray fluorescence, data acquisition rate is unimportant. The X-ray fluorescence data will be output to paper (hard copy) as they are collected. These hard copies should be photocopied within 24 hours of completion of the analyses and the photocopies should be stored in a separate location from the original hard copies.

4.5 Deviations From and Changes to EP or Associated TPs During Work

In situations in which irretrievable loss of data or an unforeseen unsafe operation will occur if EP-0007 or associated TPs are followed, the IM may deviate from established procedures. Documentation of such an event must be made in the experiment logbook, and the SNL PI must be notified as soon as practicable. If the EP or TP from which deviation was made needs revision to

2.9 Related Experiments

This EP is a supporting document for Study Plan 8.3.1.15.1.3, "Laboratory Mechanical Properties of Intact Rock." Other EPs describing additional compressive testing and characterization of samples used for such testing also will support this study plan. However, these other EPs will not be directly linked to EP-0007 and so are not listed here. Bulk properties of the samples provided to UNM will be determined under the guidance of EP-0010, "Bulk Property Measurements on Post-Test Mechanical Samples," as discussed in Section 2.3.

3.0 QUALITY ASSURANCE

3.1 QA Level

This work has been assigned a QA Level of II as of August 8, 1986. The work described in this EP pertains to task B-1 for WBS 1.2.4.2.1.3.

3.2 Surveillances and Audits

The work performed in this EP will be subject to periodic surveillances and audits. The frequency and timing of such activities will be defined by SNL, and performance will be the responsibility of SNL.

4.0 OPERATIONS

The work for this EP will be conducted in the following general sequence:

1. mesoscopic description
2. thin-section description
3. X-ray diffraction analysis
4. bulk chemical analysis

The second, third, and fourth steps need not occur in series, as the relative timing is not important. Procedures for data acquisition for these steps are provided in relevant TPs, listed in Table 2.

diskettes, etc.) must be transmitted to the SNL PI by the IM as hard copy. Thermal and electrostatic (nonxerographic) paper are not acceptable. The following transmittal frequencies apply:

a. Chain-of-Custody forms: one copy after each new signature for change of custody, original form to be returned to the SNL PI with samples or after subdivision of samples;

b. documentation of standard materials: before use of materials in technical activities;

c. logbook: one copy at conclusion of all work for this EP;

d. familiarization forms: before work described in EP-0007 begins, and whenever a change in personnel occurs; also, at 12-month intervals if work becomes a multi-year effort;

e. certification forms (Appendix B): before work described in EP-0007 begins, and whenever a change in personnel occurs; also, at 12-month intervals if work becomes a multi-year effort;

f. results of application software verification: as soon as practicable after obtaining the results, and before data acquisition begins;

g. data demonstrating precision and accuracy of properties of standards used in XRD and bulk chemical analysis: before routine gathering of associated data begins.

In addition, copies of data from calibration checks not previously submitted as software verification results should be submitted together with data from sample analyses by the last business day of each month. These submittals need to include only those data obtained during the preceding month. The transmission of data that contains the final information for work on this EP should contain a statement to that effect.

Involuntary hold points may result from failure of individual pieces of equipment, temporary unplanned absence of personnel, or an inability to obtain a successful calibration check. In such cases, the SNL PI should be consulted to determine the appropriate steps to take before continuation of technical work. Documentation of involuntary hold points also should be make in the experiment logbook.

4.2 Postrequisites

After technical work is completed, the following postrequisites shall be verified:

- All necessary information has been recorded, as defined in this EP and in relevant TPs.
- All pertinent observations have been made in the logbook(s) and have been signed and dated.
- Sample identifications on samples and containers are still legible and samples have been returned to appropriate containers. (If sample indentifications on samples are not legible following an analysis notation to that effect should be made in the logbook).
- All instructions in EP have been followed, or that nonconformance procedures (Section 5.0) have been followed if deviations have occurred.
- Required post-analysis calibration checks were performed (Section 2.4).
- Chain-of-Custody forms have been completed properly.
- All pertinent documentation has been transmitted to the SNL PI.

The report should contain, at a minimum, the following information for the samples:

- a reference to EP-0007,
- a summary of the mesoscopic (hand-sample) descriptions,
- a summary of the thin-section descriptions,
- a table containing the results of the X-ray diffraction analyses, and
- a table containing the results (in weight percent) of the bulk chemical analyses.

When applicable, two copies of the floppy diskette(s) containing a tabular summary of all quantitative data (e.g., X-ray analyses) also should be submitted with the letter report. These diskettes should be labeled consistent with the minimum requirements stated in Section 4.4.4.

9.0 PERSONNEL QUALIFICATION AND TRAINING

According to the definitions in SNL NNWSI Project DOP 2-6, all staff in the IM or the UNM Department of Geology who are associated with this work are considered to be supporting staff. As such, the following qualifications for the work must be documented:

- Each person must have an academic background in a technical area that provides the basic concepts of mathematics, engineering, and the physical sciences.

  <u>or</u>

- Each person must have appropriate technical experience for the tasks being performed.

- Each person must have read the EP and associated TPs relevant to the work to be performed, and must document familiarity with the procedures and general aspects of the SNL NNWSI Project QA program by completing, signing, and dating the SNL NNWSI Project familiarization forms. The actual forms will be transmitted to UNM under separate cover.

4.4.1 Equipment

Equipment used in data acquisition is described in the relevant TPs. A summary of computer hardware and software is provided below.

4.4.1.1 Hardware

4.4.1.1.1 X-ray Diffraction

The computer hardware to be used in data acquisition for X-ray diffraction analysis is a Data General Desktop Model 20 computer with 256 kilobytes of RAM, and a 15 megabyte Winchester hard disk. The operating-system software is Data General's RDOS dual-user operating system with a Fortran IV compiler. All of this hardware is an integral part of the Scintag Pad V XRD system.

Data tabulation and analysis will be performed on one or both of the computers described in this paragraph. (1) A Zenith ZF-158-42 microcomputer (IBM-PC/XT compatible) with a 20-megabyte hard disk and 640 kilobytes of RAM, operating under MS-DOS (Version 3.1). (2) A Zenith ZF-248 microcomputer (IBM-PC/AT compatible) with a 40-megabyte hard disk and 512 kilobytes of RAM, operating under MS-DOS (Version 3.2).

4.4.1.1.2 X-ray Fluorescence

The computer hardware to be used in data acquisition for X-ray fluorescence is a Digital Equipment Corporation (DEC) Micro PDP-11/73 with DEC RX02 8 1/2" dual-floppy disk drive housed in a DEC 11V03-L cabinet and equipment rack. The computer has 512 kilobytes of RAM and a 30-megabyte hard disk. The computer is connected to a DEC Decwriter III terminal. The operating system for the DEC PDP-11/73 is DEC's RT-11 (Version 3).

4.4.1.1.3 Atomic Absorption

No computer hardware is required for atomic absorption measurements.

4.4.1.2 Software

Data acquisition software is used in X-ray diffraction and X-ray fluorescence measurements. Requirements common to the two types of measurement are summarized in this section, and requirements or information specific to each measurement type are provided in following subsections.

NNWSI-SNL Chain-of-Custody Form

Page ____ of ____
Date _____

Sample Number: _____ (_____)
Short Form (if applicable)

Sample Originator _____ _____
Printed Name Signature

Relinquished by: Received by:

Signature	Date/Time	Signature	Date/Time
Printed Name	Company	Printed Name	Company
Signature	Date/Time	Signature	Date/Time
Printed Name	Company	Printed Name	Company
Signature	Date/Time	Signature	Date/Time
Printed Name	Company	Printed Name	Company

Change of Sample-Container Seal (if applicable)

Seal Removal		Seal Replacement	
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time

If sample is subdivided, numbers of resulting subsamples: _____

4.4.1.2.1 X-ray Diffraction

Data acquisition software for X-ray diffraction analysis is the system software (Version 1) provided by Scintag with the Scintag PAD V XRD system.

4.4.1.2.2 X-ray Fluorescence

Data acquisition software for X-ray fluorescence is Rigaku/USA, Inc., 3064 Dataflex (Version 3-1). The software is used for equipment control, data gathering, data reduction, and output.

4.4.1.2.3 Atomic Absorption

No software is used in data acquisition for atomic absorption.

4.4.2 Equations

No equations are required for use in data acquisition or reduction other than those specifically listed in relevant TPs.

4.4.3 Verification

Verification of application software must be performed and documented before data acquisition begins and each time that a new version of the software is installed. The SNL PI must provide written approval of the verification results before the software is used in data acquisition.

4.4.3.1 X-ray Diffraction

The data acquisition software for the Scintag PAD V XRD system cannot be verified by input of a specific numeric value and comparison with output. Therefore, the system calibration checks described in Section 2.4.2.1 and in TP-62 will serve as verification of the software.

Description of the software and instructions for the use thereof are provided in TP-62 and associated documents ("Step-By-Step Procedures for Operation of the Scintag PAD V X-ray Diffraction Systems" and the Scintag User's Manual for the PAD Diffraction System). As such, no specific instructions are included here.

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SNL NNWSI PROJECT EXPERIMENT PROCEDURE

Bulk-Property Measurements on Posttest Mechanical Samples

Approved by:

B. M. Schwartz, 6313 Author	5/4/88 Date
F. B. Nimick, 6313 Principal Investigator	5/5/88 Date
E. A. Klavetter, 6313 Technical Review	5/6/88 Date
R. R. Richards, 6310 QA Coordinator	5/6/88 Date
T. E. Blejwas, 6313 Division Supervisor	5/13/88 Date
T. O. Hunter, 6310 Department Manager	5/13/88 Date

SAIC/T & MSS
MAY 23 1988
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reflect necessary changes in future operations, changes will be made as soon as resolution of the situation has been accomplished, and must be made before subsequent use of the affected procedure(s).

Typographical errors discovered at the time of use of the procedures should be documented in the experiment logbook. If any possibility exists that the intent of the procedure is ambiguous because of the error, the intent must be clarified by the SNL PI before the procedure is implemented. If corrections would be significant to subsequent use of the procedure, they must be made before the procedure is implemented.

5.0 NONCONFORMANCES AND CORRECTIVE ACTIONS

Nonconformance of items or processes with the requirements of this EP or any associated TP must be reported to the SNL PI verbally as soon as practicable, and in writing within five working days. The SNL PI is responsible for deciding on additional documentation of the nonconformance and on any corrective action to the nonconformance, and must document the corrective action in writing.

6.0 SAFETY

Procedures for safe operation of activities will be included in the TPs associated with this EP.

7.0 RECORDS CONTROL

7.1 DRMS Data-Set ID

The data-set ID to which this works related is 51/L04-2/21/86.

7.2 Records Transmittal

Data and related documentation (e.g., Chain-of-Custody forms, evidence of calibration, logbooks or copies thereof, copies of the data stored on floppy

2.2 Planned Experiments

2.2.1 Saturated Bulk Density

Saturated bulk density will be measured on all samples (devitrifed, zeolitic, and vitric) after the samples have been vacuum saturated to constant weight either following the procedures in SNL NNWSI Project TP-64, "Procedure for Vacuum Saturation of Geologic Core Samples," or following a modification of the procedure that makes it appropriate for this activity. When the saturated bulk-density measurements are completed, the samples will be transferred to personnel at the University of New Mexico, for continuation of work under the SNL NNWSI Project EP-0007, entitled "Characterization of the Mineralogy and Petrology of Mechanical Test Samples."

2.2.2 Grain Density

Grain density will be measured using the water immersion technique, similar to the procedure entitled "Test and Calibration Procedures for Grain Density Measurements Using a Water Pycnometer," dated January 28, 1983. The methods used to prepare and test samples will depend on the sample type. The following constraints are in effect:

Devitrified samples: Samples should be ground to about 100 mesh (0.015-cm particle size) and then heated to a temperature between 105 and 115°C, either in air or under vacuum conditions.

Zeolitic or vitric samples: Methods to minimize dehydration of these powders during both grinding and sample handling need to be developed to measure grain-density while the sample is saturated. Samples should be ground to about 100 mesh (0.015-cm particle size). The grain density should be measured without heating these samples other than through exposure to ambient laboratory conditions. Methods need to be developed to saturate the powders without the formation of mold or bacteria, which has been observed in previous attempts.

2.2.3 Dry-Bulk Density

Because of concerns about drying the samples before continuing work under SNL NNWSI Project EP-0007, dry bulk-density measurements will not be made on the samples listed in Section 2.3 of this EP. However, because technical procedures will be developed as part of the work in this EP, other samples may be used, if approved, in accordance with Section 2.3.

Any photographs should be provided to SNL in duplicate, following requirements outlined in Section 2.7(d).

A copy of all records pertinent to work for this EP must be maintained by the IM for one year after completion of the work or for a shorter time interval if authorized to dispose of the records by written instruction from the SNL PI.

7.3 Return of Samples

After completion of each stage of work, the sample or subsample should be replaced in the container bearing the relevant sample ID. All samples and subsamples should be returned to the SNL PI at the conclusion of work for this EP. If mailed, the samples should be sent to the SNL PI at the following address:

Div. 6313--Bldg. 823/Rm. 4466
Sandia National Laboratories
1515 Eubank SE
Albuquerque, NM 87123

Whether the samples are mailed or hand-carried, they must be processed through SNL Receiving/Inspection.

8.0 DATA REPORTS

One month after the completion of the work, a letter report must be submitted to the SNL PI. The report should summarize the results of the work and should include discussion of significant features of the results. Supporting data as discussed in Section 7.2 may be part of this letter report or may be submitted separately from (but no later than) the letter report. If submitted separately, appropriate cross-references should be made.

The letter report must be numbered and titled as follows:

SLTR 87-7004, Mineralogy, Petrology, and Whole-Rock Chemistry of Selected Mechanical Test Samples of Yucca Mountain Tuffs.

2.6 Records Maintenance and Transmittal

B. M. Schwartz is also responsible for maintaining data and supporting information (sample preparation, calibration certificates, results of calibration checks, logbook entries, sample custody forms, etc.) in accordance with DOP 11-2. These records should include a level of detail that allows appropriate technical procedures for sample preparation, testing, and calibration to be developed. Commensurate with the progress of work, records shall be transmitted to the PI.

The PI is responsible for transmitting these records to the DRMS in accordance with the SNL NNWSI Project DOP 11-3.

3.0 QA LEVEL

The work defined here has been assigned a QA Level of 3 and pertains to Tasks 1.3 (Development of Technical Procedures and Analytic Techniques for Bulk Properties) and 5.3 (Development of Technical Procedures and Analytic Techniques for Mechanical Properties) of WBS 1.2.4.2.1.3.S.

4.0 OPERATIONS

4.1 Prerequisites

o All Organization 6310 staff associated with the work under this EP must be familiarized and trained in general and specific aspects of the NNWSI Project QA program. Completion of this process must be documented in the SNL NNWSI Projects Local Records Center (LRC) before any technical work begins.

o Instruments and devices must be calibrated, and the calibration must be traceable to the SNL Calibration Laboratories or to the National Bureau of Standards. The exception is devices used for indication only. These devices will be marked "for indication only," and a notation will be made in a logbook documenting the identity of these instruments or devices.

All UNM staff involved in work for this EP also must be familiarized with the SNL Project. A certification document EP-0007-T1 (Appendix B) must also be completed for all UNM staff performing work for this EP before work begins. Collectively, these documents will be permanent QA records in the DRMS data sets listed in Section 7.1 and in SNL NNWSI Project file 6310 90/1293/TNG/Q1. As such, the documents should be completed using black indelible ink, and the documents (including updated forms at 12-month intervals) should be submitted to the SNL PI as soon as practicable. Technical work should not begin until these documents are approved by the SNL PI in writing.

Form EP-0007-T1

Certification for NNWSI Project Personnel
Employer: University of New Mexico, Dept. of Geology, Institute of Meteoritics

Name: _____

Job Title	WBS Element	Activity	Task No.	Name of Task
Supporting Staff	1.2.4.2.1.3	Laboratory Property Measurement	B.1	Development of empirical relationships between porosity and mechanical properties.

Restrictions: _____

Basis for Certification:
Education and Experience Applicable to Job Function

Education: _____

Experience: _____

Training: The subject individual has been familiarized in the purpose, scope, technical objectives, and requirements of the activities to be performed and has been instructed in the SNL NNWSI QA Program.

_____ _____
SNL Principal Investigator Date

_____ _____
SNL Division Supervisor Date

Based on the above record and information described in DOP 2-6, _____ is certified to perform or to verify activities that affect quality, including conducting independent technical reviews, participating in design verification, and performing surveillances.

_____ _____
SNL Department Manager 6310 Date

Date Certification Expires_____

INTRODUCTION

The work described in the Experiment Procedure (EP) was initiated in January 1986 well before the issuance of DOP 11-1. Nevertheless, we are complying with DOP 11-1 by reissuing the original letter of criteria (LOC) dated January 8, 1986, as an EP. The quality assurance level of this work is QA Level 3.

The work described in the attached LOC is correct with the following exceptions:

1) Item 7. Reporting and Documentation. Replace the last paragraph with the following:

   "Complete all testing prior to June 30, 1988 . By this time, a final letter report (SLTR) should be submitted to SNL which contains the results from the laboratory testing. Because the primary focus here is the development of a technical procedure on the combined hydraulic conductivity and consolidation testing of crushed tuff in a large consolidation apparatus, the newly developed, technical procedure should also accompany the experimental results which are reported in the SLTR.

   The progress of the testing should be reported in monthly reports by the 25th of the month in which the work is performed."

2) Item 8. Quality Assurance. Replace the first sentence with the following:

   "The level of quality assurance associated with this work described in the EP is Level 3."

3) Item 9. Quality Assurance. Add the following to the first paragraph:

   "The appropriate sections of the following Department Operating Procedures (DOPs) will be followed in performing the work described in this experiment procedure (EP) 0012."

   - DOP 5-2 "Technical Procedure Requirements"
   - DOP 8-1 "Sample Identification and Handling Requirements"
   - DOP 11-2 "Requirements for Experiment and Equipment-Test Logbooks"
   - DOP 11-1 "Experiment and Equipment-Test Procedure Requirements" (to support the use of DOP 5-2),
   - DOP 13-1 "Identification, Handling, Shipping, and Storage Procedures for Items and Materials," (to support the use of DOP 5-2).

4) Use the current version of published ASTM standards for all testing with modifications as noted in this EP.

NOTE: The existing sample identification numering scheme will continue to be used. We are using the existing numbering scheme because some samples have been designated according to this numbering scheme and to change at this point would be potentially confusing to others using this data or transferring this data to the appropriate SNL data systems.

---

*The appropriate sections to be used in each DOP are checked; whereas, the sections not appropriate are crossed out.

1.0 GENERAL INFORMATION

1.1 Scope and Objective

This Experiment Procedure (EP) describes a group of experiments to be performed by Sandia National Laboratories (SNL) Organization 6313 for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. These experiments will investigate techniques for obtaining bulk-property data.

The objective of the work described in this EP is twofold: (1) to measure saturated bulk density and grain density of posttest mechanical samples and (2) to analyze the results to determine the appropriate techniques to be used in Technical Procedures (TPs) for Quality Assurance (QA) Level 1 or 2 work for devitrified, zeolitic, and vitric samples and select standard reference materials and appropriate techniques for use as calibration checks.

1.2 Applicable Study Plan

This EP relates to Study Plan 8.3.1.15.1.1, entitled "Laboratory Thermal Properties," submitted to WMPO on March 17, 1988, and Study Plan 8.3.1.15.1.3, entitled "Laboratory Determination of the Mechanical Properties of Intact Rock," submitted to WMPO on February 8, 1988. Work described in this EP is scoping in nature, with a QA level of 3. The results of these experiments will support future experiments conducted to support the repository license application (i.e., QA Level 1 or 2 experiments).

2.0 DESCRIPTION OF WORK

2.1 Management

The Principal Investigator (PI) for this work is F. B. Nimick, 6313, who is responsible for providing technical and quality assurance guidance for these experiments, for ensuring that relevant documentation is completed, and for submitting the documentation of data and supporting information to the SNL NNWSI Project Data Records Management System (DRMS). The DRMS Data-Set ID to which this work is related is 51/L03-5/2/88.

B. M. Schwartz is responsible for performing the bulk-property measurements in accordance with this EP and for writing draft TPs necessary to support future QA Level 1 or 2 bulk-property experiments. The draft TPs should be written in accordance with SNL NNWSI Project DOP 5-2.

Activities associated with the testing program are defined below.

(a) X-Ray diffraction, chemical analysis, and optical microscopy (thin section) of the bulk rock as received from SNL shall be performed prior to any crushing or testing of the rock. The sample analyzed should be a composite sample representative of the entire rock shipment. The procedures to be used include ASTM C:295-85 including comments and the NNWSI Chemical Analyses procedure using guidance provided in ASTM C:114.

(b) Crushing of the bulk rock as received from SNL shall be performed according to item 3 of this LOC. The NNWSI Crushing Procedures will be used.

(c) Following the crushing and sieving of the welded tuff, the following will be performed.

- a description (includes noting angularity, shape, weathering effects, friable or intact nature, color and grain size) of particles retained on the sieve sizes given in ASTM D422. For particles passing the #200 sieve, the hydrometer analysis contained in EM 1110-2-1906, Appendix V, shall be used. A complete description will be given for the crushed tuff after it is passed through the jaw crusher having an opening of 1.5 in. and after a subset of the crushed tuff passes through the jaw crusher having an opening of 3/8 in.

- X-Ray diffraction and chemical analyses shall be performed on the particles passing the #100 sieve.

(d) Establish the relative density and the maximum and minimum densities and void ratios for sample group.

Any drying of the tuff should be achieved using the procedures defining in this LOC as Attachment 2.

Record the humidity of the testing room. No compaction other than vibratory compaction of the sample shall be performed to achieve the relative, dry bulk density. The following procedures shall be used: ASTM D:4254-83 for determining the minimum index density and relative densities and ASTM D: 4253-83 for determining the maximum index density.

2.3 Sample Identification, Description, and History

The 19 posttest mechanical samples listed below will be tested following the procedures in this EP. The sample history is described in SNL NNWSI Project EP-0007, which defines requirements for work under DRMS Data-Set 51/L04-2/21/86.

SAMPLE ID	DESCRIPTION
A1-212.7-B	VITRIC/ZEOLITIC(?)
G1-1487.4-SLA1-B	ZEOLITIC
G1-1550.4-SLA28-B	ZEOLITIC
G1-1551.1-SLA29-B	ZEOLITIC
G1-1784.8-SLA19-B	ZEOLITIC
G1-1785.6-SLA20-B	ZEOLITIC
G1-2276-SF-B	ZEOLITIC
G1-2589-SD-B	ZEOLITIC
G1-2699.1-SLB-B	ZEOLITIC
G1-2996.9-SLB-B	DEVITRIFIED
G1-3102.3-SLD-B	ZEOLITIC
G1-3498.4-SLB-B	ZEOLITIC
GU3-760.9/4A-B	DEVITRIFIED
G4-742.75-E-B	DEVITRIFIED
G4-742.75-G-B	DEVITRIFIED
G4-965.2-D-B	DEVITRIFIED
G4-1001.9-A-B	DEVITRIFIED
G4-1369.1-E-B	ZEOLITIC
G4-1400.6-H-B	ZEOLITIC

If additional samples are needed for this work, the PI shall submit written authorization for their removal to the SNL NNWSI Project Samples Library.

2.4 Sample Handling

Samples will be maintained in accordance with SNL NNWSI Project DOP 8-1.

2.5 Calibrations

B. M. Schwartz is responsible for determining which instruments should be calibrated (including details such as the range of calibration), and for selecting and procurement (if necessary) of calibration standards and procedures necessary to support future QA Level 1 or 2 experiments.

Testing of sample groups 1 to 6 will be performed in the large-scale consolidometer. Testing of sample group 7 will be performed in the small-scale consolidometer. At the end of the consolidation test the hydraulic conductivity of the specimen shall be determined as indicated in Table 1.*

(Note: As indicated in Section 1.5 of ASTM D4253-83, impact compaction rather than vibration may give a more appropriate maximum index density for materials having 5 to 15% fines.)

(g) Each sample set should go through the testing sequence defined in Table 1. It is therefore necessary that we discuss the status of this testing program (at least weekly) to determine if redirection of the testing program is needed. Samples 7a through 7d can be performed in a smaller consolidometer than that used in testing the samples in sample sets 1 through 6. Testing for sample set 7 can be performed concurrently with the testing of samples defined in sample sets 1 to 6. The testing order for sample sets 1 to 6 is given on Table 1. All samples shall be emplaced in the consolidation cells in ambient dry conditions. No additional moisture shall be added to the sample to achieve the needed compaction.

(h) Following the testing of each sample, the moisture content of the crushed tuff shall be determined using the over-drying procedure provided in Attachment 2.

(i) Grain size distribution will be determined for the material following each consolidation test. Particle size distribution of materials smaller than 75µm (No. 200 sieve) will be determined using a hydrometer analysis. The hydrometer analysis defined in EM 1110-2-1906, Appendix V, shall be used. Care should be taken not to create additional fines when removing the sample from the consolidometer or performing a gradational analysis.

---

*Before any testing is initiated the large-scale consolidometer shall be tested with no samples contained within it to determine the largest possible hydraulic conductivity measurement. Discussions should take place, following this system measurement, between SNL and WES, to determine if design changes to the testing apparatus are necessary.

4.2 Postrequisites

When activities described in this EP have been completed, the following postrequisites will need to be verified:

- The complete set of records associated with this study have been transmitted to the PI within 4 weeks after the testing has been completed. This includes completed Data Compilation Forms (DCFs).

- New or revised drafts of TPs relevant to bulk-property measurements have been submitted to the PI. The draft TPs should be submitted to the PI by November 1, 1988.

5.0 SAFETY

There are no specific safety requirements. Standard laboratory procedures should be followed when using ovens and vacuum pumps.

6.0 NONCONFORMANCES AND CORRECTIVE ACTIONS

Nonconformances of items and/or processes must be reported to the PI orally as soon as possible and in writing within five working days. B. M. Schwartz is responsible for ensuring that nonconformances are documented and that corrective actions are determined in accordance with SNL NNWSI Project QAP 15-1 and 16-1.

7.0 REFERENCES

All documents referenced in this EP can be obtained from the SNL NNWSI Project LRC.

-- The fifth set of samples will incorporate 40% by weight of fine-sized particles (passing the #100 sieve) with the samples formulated using the results from the first crushing (CL-40-G-5 (5a to 5d))

-- The sixth set of samples will incorporate 55% by weight of fine-sized particles (passing the #100 sieve) with the samples formulated using the results from the first crushing (CL-40-G-5 (6a to 6d))

-- The seventh set of samples will be comprised of the fine-sized particles passing the #100 sieve) only (CL-40-G-5 (7a to 7d))

- Four samples will be tested in each sample group as indicated in Table 1.

- The rocks as shipped have received no special treatment because they are to simulate excavated materials from the repository that have been placed at the surface for some unspecified period.

3. Sample Preparation Requirements:

- The samples are to be developed by crushing the Topopah Spring Member tuff from the Busted Butte outcrop. Two-step reduction of the tuff should be used to develop the gradation curves. The openings for the jaw crusher should be 1.5 in. and 0.375 in. The gradation curves obtained following the crushing at 1.5 in. and 0.375 in. jaw openings will define the grading of the samples to be tested for sample groups one and two. Maximum particle sizes shall be documented.

  To assure an accurate gradation of the crushed tuff, it will be necessary to crush all of the rocks received from SNL passing the material through the jaw crusher having an opening of 1.5 in. (first step in the reduction operation). All materials shall be weighed before and after the crushing operations to assure that no (or little) material is lost during the crushing operation. To avoid chemical contamination, it will be necessary to clean (or vacuum) all apparatus used in the crushing and sieving operations prior to and after usage. Following the single pass through the jaw crusher, it will be necessary to take a sufficient amount of crushed tuff having an identical gradation of the material originally passed through the jaw crusher, and pass this material through the jaw crusher with an opening of 0.375 in. (second step in the crushing operation).

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SNL NNWSI PROJECTS DEPARTMENT

Experiment Procedure

Alteration of the Consolidation Behavior and Hydraulic Conductivity of Crushed Tuff Due to the Presence of Fine-Sized Particles

Page	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rev.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Page	App A	App B	App C	App D	App E	App F	App G
Rev.	A	A	A	A	A	A	A

J. A. Fernandez, 6314, Author and PI — Date 3/3/88

T. E. Hinkebein, 6314, Independent Technical Review — Date 3/4/88

R. R. Richards, 6310, QA Coordinator — Date Mar 4, 1988

J. R. Tillerson, 6314, Division Supervisor — Date 3/4/88

T. O. Hunter, 6310, Department Manager — Date 3/8/88

SAIC/T&MSS

MAR 23 1988

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5. Calibration and/or Calibration Checks

- A listing of all measuring and test equipment used in the acquisition of data and in sample treatment should be provided to me prior to testing. Model and serial number of the measuring and test equipment should also be included.

- The measuring and test equipment should be calibrated, and the calibration should be traceable to the National Bureau of Standards or to other recognizable physical standards. The measuring and test equipment calibration system should be controlled by means of a recall system.

- Calibration checks of all measuring and test equipment should be made prior to and following all sample preparation and testing. If the sample preparation or testing is not continuous, i.e., interrupted by testing not associated with this letter of criteria, then calibration should be performed prior to resuming testing. Measurements made on standards shall also be recorded. All calibration efforts should be consistent with Section 2.6 of your QA manual.

6. Detailed Test Procedures

- The attached procedures shall be used (Attachments 1, 2, and 3).

7. Reporting and Documentation

- The results should be sent to me via letter reports. The letter reports should include, for each sample analyzed:

  - initial height of sample in consolidation apparatus

  - a plot of decrease in sample height versus load imposed on the sample

  - initial void ratio and associated porosity

  - void ratio at each consolidation pressure and the corresponding porosity

  - saturated hydraulic conductivity for each sample at 8,000; 32,000; 90,000; and 190,000 lb/ft^2

Sandia National Laboratories

Albuquerque, New Mexico

January 8, 1986

Mr. G. Sam Wong
Waterways Experiment Station
Corps of Engineers
3909 Halls Ferry Road
P.O. Box 631
Vicksburg, Mississippi 39180

Dear Sam:

Re: Letter of Criteria to Define the Alteration of the Consolidation Behavior and Hydraulic Conductivity of Crushed Tuff Due to the Presence of Fine-Sized Particles

This letter of criteria (LOC) is a revision of the LOC dated July 15, 1985 on the same subject. As agreed, the testing and sample preparation procedures that will be used during testing are attached to this LOC. Where test options are given in these procedures, the option selected should be documented. No deviations from the agreed to procedures are permissable. If variations are necessary SNL shall concur with the change prior to it being implemented into the existing procedure.

1. Description of Test:

- This work is to be performed under Contract #37-5031.
- The influence of fine-sized particles (from crushed tuff) on the hydraulic conductivity of backfill material in shafts, ramps, and drifts will be investigated. Basic properties of consolidated crushed tuff will also be measured and computed.
- The controlling factors for the laboratory analyses will be the gradation curves developed from crushing Topopah Spring Member tuff obtained from the Busted Butte outcrop. The backfill samples will be consolidated at varying loadings. The primary test parameters will be moisture content, relative density, loading, and void ratio.

- All post-test samples should be individually packaged, identified using the numbering scheme identified in section 2 of this LOC, and sent to me following all testing. The material should be shipped to:

  Joseph A. Fernandez/Barry Schwartz
  Sandia National Laboratories
  Division 6314
  Building 823
  Room B-100
  Albuquerque, New Mexico 87185

  Additionally, a copy of this LOC should accompany the returned shipment.

- All samples should be placed in containers that will protect the sample from further crushing due to handling. The samples should be properly identified using the sample identification numbers defined in this LOC.

Sincerely,

Joseph A. Fernandez
Geotechnical Design
Division 6314

JAF:6314:pcg
0005G/19

Attachment 1. Sample Preparation Data Sheet
Attachment 2. Oven-Drying Procedures
Attachment 2a. Sample/Test Tracking Form
Attachment 3. Testing Procedures

a. Rock Crushing (EP 0012, Appendix A)
b. Petrographic Examination (EP 0012, Appendix B)
c. Chemical Analysis (EP 0012, Appendix C)
d. Particle-Size Analysis (EP 0012, Appendix D)
e. Relative Density (EP 0012, Appendix E)
f. One-Dimensional Consolidation Properties of Crushed Rock (EP 0012, Appendix F)
g. Hydraulic Conductivity (EP 0012, Appendix G)

(e) At this point an appropriate method for preconsolidation of the crushed tuff shall be determined for use in preconsolidating all the samples. Three samples shall be preconsolidated to 85% of the relative density each by a different technique. The gradation to be tested is that defined by sample group 1, i.e., the gradation following the 1.5 in. jaw crushing. The preconsolidation techniques to be used are:

1. hammer compaction using two lifts
2. hammer compaction using three lifts
3. static compaction (one lift) using the loading machine.

After 85% of the relative density is achieved (assuming an initial, sample height of 6.0± 0.1 in.), the samples shall be removed from the consolidation cell and a sieve analyses shall be performed on each sample using D 422-63 (Reapproved 1972). For particles passing the #200 sieve, the hydrometer analysis contained in EM 1110-2-1906, Appendix V, shall be used. Distribution of particle sizes smaller than 75µm shall be determined using a hydrometer. Because the preconsolidation procedures defined above are not standard, the interactive, procedure, generation form accompanying EPI V-1 shall be used.

Based on the results obtained from the preconsolidation efforts, SNL, through consultation with WES, will determine the appropriate preconsolidation procedure to be used to achieve the appropriate preconsolidation for all of the samples tested.

(f) Establish the relative density and the maximum and minimum densities and void radios for all sample groups (see section 2 of this LOC). Following the determination of these values for each sample group, preconsolidate each sample to at least 85% (do not exceed 90%) of the relative density using the accepted technique established in step "e". Once the sample is preconsolidated the consolidation test should be initiated according to the following loading schedule.

Loading lb/ft^2 x 1000: 1,2,4,8,16,32,90,140,190

Loading Time: Each load increment shall be applied until secondary consolidation is reached. The approach that will be used to determine when secondary consolidation is reached shall be defined in your MFAC prior to testing.

ATTACHMENT 1

SAMPLE PREPARATION DATA SHEET

CONTRACT OR P.R. #: DATE OF CONTRACT:

OPERATOR NAME:_____ OPERATOR SIGNATURE:_____

OPERATOR LOCATION: USAE, WES

SAMPLE NO. _____ COMPLETION DATE:

CONCRETE TECHNOLOGY DIVISION DESIGNATED SAMPLE IDENTIFICATION FOR THIS ITEM #:

---

1. MATERIALS USED:

---

2. EQUIPMENT USED:

(j) Two photographs (black and white) should be taken for each sample group before the samples are preconsolidated. The photograph should be of loose material divided into four groups by size: all material passing the No. 200 sieve, all material passing the No. 4 sieve but retained on the No. 200 sieve, all material less than 0.50 inch but being retained on the No. 4 sieve, and all material greater than 0.50 inch. Therefore, there should be seven photographs, one for each sample group. A scale should be included in each photograph.

Following each consolidation test, each sample will be removed carefully to prevent disaggregation. Once the sample is removed from the consolidation apparatus, it shall be photographed. Two copies of the photographs (black and white) shall be taken on post-test samples. Negatives of all photographs shall also be provided to SNL.

2. Sample Identification and History:

- The samples are to be fabricated from the crushed tuff that has been supplied from SNL (SNL Shipper Number 934981). The samples are all densely welded Topopah Spring float samples removed from the Busted Butte outcrop. The rock shipped from SNL shall be designated by the identification number CL-40-G-5. Because of the different gradations that will be tested, an identification will be required for each sample tested. Seven sets of laboratory testing will be implemented:

  -- The first set of samples will represent the gradation of crushed tuff following the first crushing with the jaw crusher set at 1.5 inches (CL-40-G-5 (1a to 1d)). In order to pass the rock through the jaw crusher at 1.5 in., the rock must be reduced to 3 in. to 6 in.

  -- The second set of samples will represent the gradation of crushed tuff following the second crushing with the jaw crusher set at .375 inch (CL-40-G-5 (2a to 2d))

  -- The third set of samples will incorporate 10% by weight of fine-sized particles (passing the #100 sieve) with the samples formulated using the results from the first crushing (CL-40-G-5 (3a to 3d))

  -- The fourth set of samples will incorporate 25% by weight of fine-sized particles (passing the #100 sieve) with the samples formulated using the results from the first crushing (CL-40-G-5 (4a to 4d))

ATTACHMENT 2

OVEN DRYING PROCEDURE

The temperature of the oven shall have been brought to 230 $\pm 9^{\circ}$ F (110 $\pm 5^{\circ}$C). Dry the samples at the specified temperature until constant weight has been achieved. Constant weight will be considered to have been achieved when weight loss is less than 0.1% of sample weight after at least 4 hours of drying.

From ASTM C 88-83, paragraph 8.2

Fine-sized particles (passing the #100 sieve) will be added to the crushed tuff (first set) in varying proportions. If insufficient fine-sized particles are available, it may be necessary to crush extra rock (using the rod mill) until sufficient materials are available to develop the samples in sample groups 3 through 7. Fine-sized particles should be removed following each crushing and the crushing repeated to obtain more fine-sized particles if necessary. This operation should continue until all excess rocks are crushed to the fine-sizes. The weight of the material, before and after the crushing operation, shall be recorded to assure no (or little) material is lost.

- A sample preparation sheet (Attachment 1) shall be prepared for each sample group formulated. There should be a total of 7 sample preparation sheets with a table and graph defining each final gradation for each sample preparation sheet.

- It is recognized that a widely accepted consolidation procedure for crushed rock currently does not exist. Therefore, the consolidation test method developed for soils in ASTM D2435-80 should be adopted when practicable to test the crushed rock. The initial dimensions of the specimen should tentatively be 6.0±0.1 in. (height) x 12 in. (diameter).

- Document serial numbers and types of equipment used in sample preparation.

4. Sample Treatment Prior to Testing

- All test samples will be preconsolidated to a specific relative density prior to consolidation testing. The samples should be preconsolidated to a state that is reasonably achievable in the field. The samples should be preconsolidated to 85% (but not greater than 90%) of the relative dry bulk density unless another value is agreed to in writing. To preconsolidate the samples to 85% of the relative density, it will be necessary to establish the relative, dry bulk density. Following all testing the moisture content and dry bulk density of the tested samples should be determined. The tuff should be dried according to Attachment 2--Oven Drying Procedures (notes the two changes in the procedures).

Attachment 3

NNWSI Testing Procedures

- bulk density of each sample at each load, gm/cm^3
- compression index and the consolidation curve (void ratio versus pressure (lb/sq. ft.)) for each sample (including table of values used to develop the consolidation curve)
- time consolidation curve (settlement versus time) for each sample (including table of values used to develop the time consolidation curve)
- initial and final gradation curves for each sample
- the sample preparation sheets for each sample
- relative, dry bulk density (gm/cm^3) for each sample tested and the density achieved prior to and following consolidation of the samples
- dimensions of each consolidometer and a table cross-referencing the consolidometer with the sample tested
- the data sheets developed for all aspects of testing
- the results from the petrographic and chemical analyses

- Complete initial testing and submit interim letter report by March 26, 1986. This should include the results from all testing completed to that point in time. A final letter report should be submitted by June 23, 1986. Available results should be reported in the monthly reports due by the 25th of each month. All results should be reported to me including those results which are aborted because of problems during testing.

8. Quality Assurance

- The level of quality assurance associated with this contract is level III WES should provide documentation of conformance to the requirements of this letter of criteria and "Quality Assurance (QA) Manual--U.S. Army Engineer Waterways Experiment Station-Structures Laboratory" when requested by SNL.

- Any nonconformance to this letter of criteria should be submitted to me within 5 working days following the nonconformance.

NNWSI CRUSHING PROCEDURES

1. Purpose. The purpose of this document is to describe the processes and methods used by the U.S. Army Engineer Waterways Experiment Station (WES) to break down cubic foot size samples of tuff for use in testing required by Sandia National Laboratory (SNL) as part of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project.

2. Scope. This procedure applies to samples provided by SNL for study in conjunction with NNWSI Project.

3. Procedures.

3.1. All test equipment will be cleaned to insure that there is no contamination from previous use of jaw crusher, rod mill, or sieving equipment. The sieves (Gilson screens) used for particle analysis and particle size separation will be taken apart to remove possible debris hidden in the frame. The work area around the jaw crusher, rod mill and sieve shaker will be maintained to assure a contamination free sample production.

3.2. Samples larger than a nominal 6-in. are initially reduced in size manually by striking the rock using a sledge hammer. Once the particles are reduced to sizes between 3 and 6 in. in size, further particle size reduction will be made mechanically using a laboratory jaw crusher. The jaw crusher opening is checked after each charge of material of 500 lb. The jaws will be adjusted as described in the Letter of Criteria (LOC). The reduction steps will also be specified in the LOC. Crushed material will be sieved through the appropriate sieve size to insure appropriate particle size reduction. Particles not meeting the specific requirements of the last revised LOC will be reprocessed until the appropriate size criterias are met.

3.3. Once all of the rock has been crushed to the appropriate size, all of the crushed material will be blended together to provide a homogeneous mixture. Blending is accomplished by placing all of the material in a pile and moving the material at the edge of the pile to the center working around the edge of the pile until visually the pile appears uniformly mixed.

3.4. A representative sample of the blended material is then taken for gradation determination. Approximately 50 lb of material will be obtained for gradation determination according to "Standard Methods for Reducing Field Samples of Aggregate to Testing Size", ASTM C 702-80, Method B-Quartering. The overall gradation can be adjusted by removing portions of certain sieve sizes or through additional crushing.

3.5. Crushing to produce finer material passing the 150 µm (No. 100) sieve (which conforms to ASTM E 11-81) will be accomplished using a rod mill. An appropriate amount of material from the crushed gravel material will be obtained for further reduction. A 10-lb charge of material will be ground in a laboratory rod mill for approximately an hour depending on how much time

Table 1. Testing Sequence for Letter of Criteria--Fernandez to Wong, 1-8-86

Sample Group	Sample ID	Testing Order	Loading Sequence Following Preconsolidatic lb/ft^2 x 1000								
			1	2	4	8	16	32	90	140	190
1	CL-40-G-5,1a	11	x	x	x	x	x	x	x	x	y*
1	CL-40-G-5,1b	18	x	x	x	x	x	x	y		
1	CL-40-G-5,1c	19	x	x	x	x	x	y			
1	CL-40-G-5,1d	12	x	x	x	y					
2	CL-40-G-5,2a	9	x	x	x	x	x	x	x	x	y
2	CL-40-G-5,2b	17	x	x	x	x	x	x	y		
2	CL-40-G-5,2c	20	x	x	x	x	x	y			
2	CL-40-G-5,2d	10	x	x	x	y					
3	CL-40-G-5,3a	7	x	x	x	x	x	x	x	x	y
3	CL-40-G-5,3b	16	x	x	x	x	x	x	y		
3	CL-40-G-5,3c	21	x	x	x	x	y				
3	CL-40-G-5,3d	8	x	x	x	y					
4	CL-40-G-5,4a	5	x	x	x	x	x	x	x	x	y
4	CL-40-G-5,4b	15	x	x	x	x	x	x	y		
4	CL-40-G-5,4c	22	x	x	x	x	x	y			
4	CL-40-G-5,4d	6	x	x	x	y					
5	CL-40-G-5,5a	3	x	x	x	x	x	x	x	x	
5	CL-40-G-5,5b	14	x	x	x	x	x	x	y		
5	CL-40-G-5,5c	23	x	x	x	x	x	y			
5	CL-40-G-5,5d	4	x	x	x	y					
6	CL-40-G-5,6a	1	x	x	x	x	x	x	x	x	y
6	CL-40-G-5,6b	13	x	x	x	x	x	x	y		
6	CL-40-G-5,6c	24	x	x	x	x	x	y			
6	CL-40-G-5,6d	2	x	x	x	y					
7	CL-40-G-5,7a	1a	x	x	x	x	x	x	x	x	y*
7	CL-40-G-5,7b	2a	x	x	x	x	x	x	y	x	y
7	CL-40-G-5,7c	3a	x	x	x	x	x	y	y	x	y
7	CL-40-G-5,7d	4a	x	x	x	y	x	y	y	x	y

NOTE: *A "y" designation indicates that the saturated hydraulic conductivity of the tested sample, should be made following the designated loading.

In all cases the procedure defined in EM 1110-2-1906 should be used to measure the hydraulic conductivity of the sample. When the hydraulic conductivity of the sample becomes $>10^{-3}$ cm/s, the hydraulic conductivity of the sample should be measured by the constant-head technique in addition to the falling-head test. Implementation of the constant-head technique will be dependent on the ability to fabricate the appropriate test apparatus to conduct this test.

Following the determination of the saturated hydraulic conductivity for these samples, measure the gradation of the sample to determine if additional fines are created.

Extreme care should be taken not to create additional fines within the tested sample following the consolidation test. ASTM D422 should be used to determine the gradation of the sample. Hydrometer tests shall be conducted on the particles <75µm.

SAMPLE PREPARATION DATA SHEET

CONTRACT OR P.R. #: DATE OF CONTRACT:

OPERATOR NAME: _____ OPERATOR SIGNATURE: _____

OPERATOR LOCATION: USAE, WES

SAMPLE NO. _____ COMPLETION DATE:

CONCRETE TECHNOLOGY DIVISION DESIGNATED SAMPLE IDENTIFICATION FOR THIS ITEM #:

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1. MATERIALS USED:

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2. EQUIPMENT USED:

SAMPLE PREPARATION DATA SHEET (CONTINUED)

CONTRACT OR P.R.#: DATE OF CONTRACT:

SAMPLE NO. _____

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3. GENERAL DESCRIPTION OF PROCESS STEPS:

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4. DEVIATION FROM SPECIFICATIONS:

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5. ADDITIONAL COMMENTS:

STRUCTURES LABORATORY TEST PROCEDURE

PETROGRAPHIC EXAMINATION

The attached documents describe the test procedure for petrographic examination of Nevada Nuclear Waste Storage Investigations crushed tuff rock.

Approved By:

PROJECT LEADER	13 Jan 1986 DATE
M&CA GROUP CHIEF	13 Jan 1986 DATE
CT DIVISION CHIEF	1/13/86 DATE
QA OFFICER	13 J. 86 DATE
PROJECT MANAGER SNL	1-15-86 DATE

ATTACHMENT 2A

SAMPLE/TEST TRACKING FORM

Project: Crushed Tuff Consolidation Test

Reference Document: No. 37-5031

Sample No._____

Test Sequence	Test	Operator Date
_____	Drying	_____
_____	Relative Density	_____
_____	Consolidation	_____
_____	Saturation*	_____
_____	Constant Head Hydraulic Conductivity	_____
_____	Falling Head Hydraulic Conductivity	_____
_____	Photograph and Observation	_____
_____	Drying to Constant Weight	_____
_____	Particle Size Analysis	_____
_____	Sieve	_____
_____	Hydrometer	_____
_____	Return Sample to Sam Wong	_____

---

*W_s weight of consolidated sample _____gm. Refer to the Hydraulic Conductivity test procedure to compute volume of water needed to saturate sample.

This form is to accompany the designated sample illustrating the testing required for the sample. When the test has been completed the operator should date and initial the form prior to moving the sample on to the next test. All samples should eventually be returned to Mr. Sam Wong, Concrete Technology Division, Structures Laboratory.

Paragraph No.	Description of Deletion
8.1	All
8.2	All
8.3	All
8.4	All
8.4.1	All
8.4.1.1	All
8.4.1.2	All
8.4.1.3	All
8.4.1.4	All
8.4.1.5	All
8.4.1.6	All
8.4.1.7	All
8.4.1.9	All
8.4.2	All
9.1	All
9.1.1	All
9.1.2	All
11.1	All

Test Equipment Listing:

Equipment	Serial or Model No.
Polarizing Microscope	Leitz-Orthoplan
X-ray diffraction	GE 700
Refractometer	B&L Refractometer 33-45-02-01
Stereo Microscope	B&L SKV-105

Data Sheets:

(1) Shape Classification Worksheet (attachment 2)

(2) Petrographic Examination Data Worksheet (attachment 3)

Quality Assurance:

(1) Petrographers and qualified technicians will perform the analyses.

(2) Calibration

A. X-ray Diffraction.

1. A standardization procedure has been written for X-ray diffraction and is in effect. This is a daily check made using an external standard (permaquartz) to permit adjustment of X-ray tube voltage and amperage

STRUCTURES LABORATORY PROCEDURE

ROCK CRUSHING

This document describes the procedures for crushing tuff rock and generation of fines for Nevada Nuclear Waste Storage Investigations Project.

Approved By:

PROJECT LEADER	13 Jan 1986 DATE
M&CA GROUP CHIEF	13 Jan 1986 DATE
CE DIVISION CHIEF	1/13/86 DATE
QA OFFICER	13 Jan 86 DATE
PROJECT MANAGER SNL	1-15-86 DATE

Standard Practice for PETROGRAPHIC EXAMINATION OF AGGREGATES FOR CONCRETE[1]

This standard is issued under the fixed designation C 295; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice[2] outlines procedures for the petrographic examination of samples representative of materials proposed for use as aggregates in concrete. The specific procedures employed in the petrographic examination of any sample will depend to a large extent on the purpose of the examination and the nature of the sample. In most cases the examination will require the use of optical mineralogy. Complete petrographic examinations for particular purposes and to investigate particular problems may require examination of aggregates or of selected constituents by means of additional procedures, such as X-ray diffraction analysis, differential thermal analysis, infrared spectroscopy, or others; in some instances, such procedures are more rapid and more definitive than are microscopical methods. Petrographic examinations are made for the following purposes:

1.1.1 To determine the physical and chemical characteristics of the material that may be observed by petrographic methods and that have a bearing on the performance of the material in its intended use.

1.1.2 To describe and classify the constituents of the sample.

1.1.3 To determine the relative amounts of the constituents of the sample, which is essential for proper evaluation of the sample, when the constituents differ significantly in properties that have a bearing on the performance of the material in its intended use, and

1.1.4 To compare samples of aggregate from new sources with samples of aggregate from one or more sources, for which test data or performance records are available.

1.2 Identification of the constituents of a sample is usually a necessary step towards recognition of the properties that may be expected to influence the behavior of the material in its intended use, but identification is not an end in itself. The value of any petrographic examination will depend to a large extent on the representativeness of the samples examined, the completeness and accuracy of the information provided to the petrographer concerning the source and proposed use of the material, and the petrographer's ability to correlate these data with the findings of the examination.

1.3 This practice does not attempt to describe the techniques of petrographic work since it is assumed that the practice will be used by persons who are qualified by education and experience to employ such techniques for the recognition of the characteristic properties of rocks and minerals and to describe and classify the constituents of an aggregate sample. It is intended to outline the extent to which such techniques should be used, the selection of properties that should be looked for, and the manner in which such techniques may best be employed in the examination of samples of aggregates for concrete. These objectives will have been attained if engineers responsible for the application of the results of petrographic examinations to the evaluation of aggregate materials for use in concrete construction have reasonable assurance that such results, wherever and whenever obtained, may confidently be compared.

1.4 The rock and mineral names given in Descriptive Nomenclature C 294 should be used insofar as they are appropriate in reports prepared according to this practice.

1.5 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[3]

C 117 Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing[3]

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates[3]

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates[3]

C 702 Methods for Reducing Field Samples of Aggregate to Testing Size[3]

C 823 Practice for Examination and Sampling of Hardened Concrete in Constructions[3]

C 856 Practice for Petrographic Examination of Hardened Concrete[3]

D 75 Practice for Sampling Aggregates[3]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]

E 883 Practice for Metallographic Photomicrography[4]

3. Planning

3.1 It is assumed that the examination will be made by persons qualified by education and experience to operate the equipment used and to record and interpret the results obtained. In some cases, the petrographer will have had experience adequate to provide detailed interpretation of the materials' performance with respect to engineering and other consequences of the observations. In others, the interpretation will be made in part by engineers, scientists, or others qualified to relate the observations to the questions to be answered.

3.2 This practice may be used by a petrographer employed directly by those for whom the examination is made. The employer should inform the petrographer, as much in detail as necessary, of the purposes and objectives of the examination, the kind of information needed, and the extent of examination desired. Pertinent background information, including results of prior tests, should be made available. The petrographer's advice and judgment should be sought regarding the extent of the examination.

3.3 This practice may form the basis for establishing arrangements between a purchaser of a service and a petrographic service and the petrographer. In such a case, the purchaser and the consultant should together determine the kind, extent and objectives of the examination and analyses to be made, and should record their agreement on an writing. The agreement may stipulate specific observations to be made, observations to be omitted, limits to be adjusted, or a combination of these or other conditions.

4. Significance and Use

4.1 Petrographic examination of aggregates is considered for use in hydraulic cement concrete in one aspect of the evaluation of aggregates. Petrographic examination is also used for many other purposes as listed below. It may not be used for all of these purposes every time a petrographic examination is made, and there may be other purposes not listed below. Petrographic examinations provide identification of types and varieties of rocks present in potential aggregates. However, as noted above, identification of rock and mineral present in an aggregate may not be required.

4.2 The petrographic examination should establish whether the aggregate contains harmful amounts of unstable materials such as soluble sulfates, soluble sulfides that may form sulfates, and or cracks in concrete exposed to high temperatures during service, or volumetrically unstable materials such as varieties (also known as the quartz-monzonite-syenite group of materials or varieties) of quartz. Specifications may limit the quartz content of aggregates for use in concrete that may be subject to high temperatures (purposefully or incidentally) because of the conversion to beta quartz at 573°C (1063°F), with accompanying

[1] This practice is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C 09.02 on Petrography of Concrete and Concrete Aggregates.

Current edition approved Feb. 8, 1985. Published April 1985. Originally published as C 295 - 54. Last previous edition C 295 - 79.

[2] This practice is based on the "Method of Petrographic Examination of Aggregates for Concrete" by Kathleen Mather and Bryant Mather, Proceedings ASTM, ASTM A, Vol 50, 1950, pp 1299-1312.

[3] Annual Book of ASTM Standards, Vol 04.02.

[4] Annual Book of ASTM Standards, Vol 14.01.

is required to reduce the material to 90 percent passing the No. 100 sieve, as measured according to ASTM C 117-84 (Standard Test Method for Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing), modified to use 150 µm (No. 100) sieve instead of a 75 µm (No. 200) sieve. At 30 min a sample of the material will be taken and the amount passing the No. 100 sieve will be determined. If 90 percent of the material passes the No. 100 sieve the material is discharged and a new charge is introduced for grinding. If the reduction is less than 90 percent passing the No. 100 sieve the material is ground for another 15 min at which time the material is again tested for the amount passing the No. 100. This is repeated until 90 percent of the material passes the No. 100 sieve.

3.6. When the appropriate amount of fines has been produced as outlined by the test matrix required by the LOC, then the material is blended using a twin shell dry blender. The blender is operated per manufacturer's recommendation, as follows: The blending chamber is loaded to the recommended capacity through the discharge opening. The blender is rotated at 22-26 revolutions per min for at least 6 min.

3.7. All procedures are documented on Sample Preparation Data Sheet (attachment 1).

Equipment List

Equipment	Model No.	Serial No.
Jaw Crusher	Laboratory	None
Gilson Shaker Sieve	TM-4	T1316
Balances	Mettler PE 3600	SNE01221E12883
Rod Mill	12 X 24 Marcy Mill	374

4. Quality Assurance.

4.1. Only qualified personnel shall be allowed to perform this work.

4.2. Balance is calibrated by Allometric Balance Systems, Baton Rouge, LA, annually.

4.3. Sieve screens will be checked according to Appendix X1 "Methods of Checking Wire-Cloth Sieves to Determine Whether or Not They Conform to Specifications" found in "Standard Specifications for Wire-Cloth Sieves for Testing Purposes" ASTM E 11-81.

plied by means of cores drilled through the entire depth expected to be exploited. Drilling of such cores should be in a direction that is essentially perpendicular to the dominant structural feature of the rock. Massive material may be sampled by CNX (54 mm (2") in diameter) cores. Thinly bedded or complex material should be represented by cores not less than 100 mm (4 in.) in diameter. There should be an adequate number of cores to cover the limits of the deposit proposed for the project. The entire footage of the recovered core should be included in the sample and accurate data given as to elevations, depths, and core losses.

6.1.2 *Operating quarries and operating sand and gravel deposits*, in which stock piles of the material produced are available, should be represented by not less than 45 kg (100 lb) or 100 pieces, whichever is larger, of each size of material to be examined. Samples from stock piles should be composed of representative portions of larger samples collected with due consideration given to segregation on the piles.

6.1.3 *Exposed faces of nonproducing quarries*, where stock piles of processed material are not available, should be represented by not less than 2 kg (4 lb) from each distinctive stratum or bed, with no piece weighing less than 0.5 kg (1 lb), or by a drilled core as described above.

6.1.4 *Underlayed sand and gravel deposits* should be sampled by means of test pits dug to the anticipated depth of future economic production. Samples should consist of not less than the quantities of material indicated in Table 1, selected so as to be representative of the deposits.

NATURAL GRAVEL AND SAND

7. Selection of Samples for Examination

7.1 Samples of gravel and natural sand for petrographic examination should be dry sieved in accordance with Method C 136 to provide samples of each sieve size. In the case of sands an additional portion should then be tested in accordance with Test Method C 117, with the wash water being saved and removed by drying in order to provide a sample of the material passing the 75-µm (No. 200) sieve. The results of the sieve analysis of each sample made in accordance with Method C 136 should be provided to the petrographer making the examination and used in calculating results of the petrographic examination. Each sieve fraction should be examined separately, starting with the largest size available. Rocks are more easily recognized in larger pieces. In the fabrication of a heterogeneous type present in the larger sizes may have provided particles of several apparently different types in the smaller sizes. Some important and easily confused types may be recognizable using the stereoscopic microscope if they are first recognized and separated in the larger sizes, but may require examination using the petrographic microscope if they are first encountered in the smaller sizes.

7.2 The number of particles of each sieve fraction to be examined will be fixed by the required precision of determination of the less abundant constituents. Assuming that the field sampling and laboratory sampling procedures are accurate and reliable, the number of particles examined, identified, and counted in each sieve fraction will depend on the required accuracy of the estimate of constituents present in small quantities. The numbers given in this method are minimal. They are based on experience and on statistical considerations.[6] It is believed that at least 150 particles of each sieve fraction should be identified and counted in order to obtain reliable results. Precise determinations of small quantities of an important constituent will require counts of larger numbers of particles. If the sample of a sieve fraction contains many more particles than need to be identified, the sample shall be reduced in accordance with one of the procedures in Methods C 702, so as to contain a proper number of particles for examination.

8. Examination of Natural Gravel

8.1 *Coatings*—The particles should be examined to establish whether external coatings are present. If they are, it should be determined whether the coatings consist of materials likely to be deleterious in concrete (opal, gypsum, easily soluble salts, organic matter). It should also be determined qualitatively how firmly the coatings are bonded to the particles.

8.2 *Rock Types*—The sieve fraction should be sorted into rock types by visual examination. If all or most of the groups present are types easily identifiable on hand specimen by examination of a natural or broken surface, and by scratch and acid tests, no further identification may be needed. Fine grained rocks that cannot be identified macroscopically or that may consist of or contain constituents known to be deleterious in concrete should be checked by examination with the stereoscopic microscope. If they cannot be identified by that means, they should be examined by means of the petrographic microscope. The amount of work done on identifying fine-grained rocks should be adapted to the information needed about the particular sample. Careful examination of one sure of a sample, or study of information from previous examination of samples from the same source, will usually reveal the amount of additional detailed microscopical work required to obtain information adequate for the purpose. In some instances, petrographic methods other than microscopy, such as X-ray diffraction, may be required or might most rapidly serve to identify fine-grained rock materials.

8.3 *Condition*—The separated groups belonging to each rock type should be examined to determine whether a further separation by physical condition is necessary. If all of the particles of a rock type are in a comparable condition, that fact should be noted. More frequently, particles in several degrees of weathering will be found in a group. They should be sorted into categories based on condition and on the expectation of comparable behavior in concrete. The types of categories intended are: (*1*) fresh, dense; (*2*) moderately weathered; (*3*) very weathered; or (*1*) dense; (*2*) porous (or porous and friable). It usually is not practicable to recognize more than three conditions per rock type, and one or two may be sufficient. An important constituent present on larger quantities may sometimes require separation into four groups by condition. The commonest example is chert when it is the major constituent of a gravel sample. It may be present as dense, unfractured chert; as vuggy chert; as porous chert; and as dense but highly fractured chert. The determination of which of these four conditions characterizes a particle may be expected to have an important influence on prediction of the behavior of the particle in concrete.

8.4 *Record*.

8.4.1 Notes should be taken during the examination. Each rock type should be described; the relevant features may include the following:

8.4.1.1 Particle shape.

8.4.1.2 Particle surface texture.

8.4.1.3 Grain size.

8.4.1.4 Internal structure (including observations of pore space, packing of grains, cement of grains).

8.4.1.5 Color.

8.4.1.6 Mineral composition.

8.4.1.7 Specific gravity (if determined).

8.4.1.8 Mineral physical condition of the rock types in the sample.

8.4.1.9 Coatings or incrustations, and

8.4.1.10 Presence of constituents known to cause adverse chemical reaction in concrete.

8.4.2 Particle counts should be recorded so that tables can be made for inclusion in the report. When the examination has been completed, the notes should contain enough information to permit the preparation of tables and descriptions. Tables should be prepared showing the composition and condition of the sample by sieve fractions, and the weighted average composition, based on the grading of the sample as received and on the distribution of constituents by sieve fractions. Descriptions of constituent groups should be prepared containing the salient features among those enumerated on the preceding list.

9. Examination of Natural Sand

9.1 The procedure for the examination of natural sand is similar to that for the examination of gravel, with the modifications necessitated by the differences in particle size.

9.1.1 *Sieve Coarser than 600 µm (No. 30)*—Each sieve fraction percent that is coarser than the 600-µm (No. 30) sieve should be subdivided in accordance with one of the procedures in Methods C 702 until a split or splits containing at least 150 particles are obtained. The reduced sample of each sieve fraction should be examined, and its constituents identified and counted, using the stereoscopic microscope. It is convenient to spread out the sample on a flat bottom glass dish such as a Petri dish and manipulate the grains with a forceps and dissecting needle. The identification of grains on the coarser sand sieves is easier when the grains are just submerged in water. The submergence lessens reflection from the outer surfaces and may show diagnostic features that cannot be seen when the grains are dry. There are exceptions to this generalization. Where identification is difficult, the examination includes examination of the natural surface (if

[6] Simpson, G. G., and Roe, A., *Quantitative Zoology*, McGraw-Hill Co. Inc., New York, NY, 1939, pp. 182-185.

Dixon, W. J., "Accuracy in Percentage Representation of Thin Sectional Frequencies," *Proceedings*, 11 Nat. Acad. Sciences, Vol. 19, No. 9, Sep. 1933, pp. 916-920.

SAMPLE PREPARATION DATA SHEET (CONTINUED)

CONTRACT OR P.R.#: DATE OF CONTRACT:

SAMPLE NO. _____

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3. GENERAL DESCRIPTION OF PROCESS STEPS:

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4. DEVIATION FROM SPECIFICATIONS:

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5. ADDITIONAL COMMENTS:

scribed above, calculate the percentage in the whole sample of that constituent in that size group (percentage of constituent in size fraction Table 3) It is convenient to calculate and record these percentages to tenths

14.1.4 By adding the weighted percentages of each constituent in each sieve fraction obtain the weighted percentage of each constituent in the whole sample (see under weighted composition of sample in Table 2)

14.1.5 Construct a table to show the composition of each sieve fraction and the weighted composition of the whole sample Report values to the nearest whole number Report constituents amounting to 0.5 % or less of a sieve fraction or of the whole sample as traces Table 3 is an example constructed from the data obtained in Table 2 As a convention, the total in each sieve fraction and the total in the whole sample shall each be 100 % without the traces Difficulties in dealing by this convention can usually be avoided by grouping minor constituents of little engineering importance It is preferable to tabulate constituents known to react deleteriously in concrete so that their distribution will be apparent from inspection of the table, even though the amount in the whole sample or in any fraction is very small.

15. Report

15.1 The report of the petrographic examination should summarize the essential data needed to identify the sample as to source and proposed use, and include a description giving the essential data on composition and properties of the material as revealed by the examination The report should record the test procedures employed, and give a description of the nature and features of each important constituent of the sample, accompanied by such tables and photographs as may be required The findings and conclusions should be expressed in terms likely to be intelligible to those who must make decisions as to the suitability of a material for use as concrete aggregate.

15.2 When the sample has been found to possess properties or constituents that are known to have specific undesirable effects in concrete, these properties or constituents should be described qualitatively and, to the extent practicable quantitatively The undesirable effects that may be expected to occur in concrete should be mentioned When appropriate, it should be stated that a given sample was not found to contain any undesirable features When such is the case it may also be appropriate, especially if the report of the petrographic examination is not accompanied by reports of results of physical and chemical tests for which tentative limits may be applicable, to add that the material appears acceptable for use provided the applicable acceptance tests are made and the results are within the appropriate limits The report should not, however contain conclusions other than those based upon the finding of the examination unless the additional data to support such conclusions are included in or with the petrographic report and the petrographer has been authorized to analyze the other relevant nonpetrographic data

15.3 The petrographic report should include recommendations regarding any additional petrographic, chemical, physical, or geological investigations that may be required to evaluate adverse properties that are indicated by the petrographic examination that has been performed Supplementary petrographic investigations might include qualitative or quantitative analyses of the aggregate or of selected portions thereof by X ray diffraction, differential thermal methods, or other procedures that are directed to identification and description of the constituents of the aggregate.

16. Precision and Bias

16.1 There test methods that are used in connection with this practice that have been standardized in ASTM are subject to having precision and bias statements Those that have not been standardized will each be provided with such a section, if and when standardized None of the nonstandardized procedures mentioned for optional use in this practice are used in ways that lend themselves to the preparation of precision and bias statements

TABLE 1 Minimum Sizes for Samples from Fine and Coarse Sand and Gravel Deposits

Sieve Size	Quantity		
	kg	lbs	Pieces
Larger than 150 mm (6 in)			1
75 to 150 mm (3 to 6 in)			Test[a]
37.5 to 75 mm (1½ to 3 in)	100	200	
19.0 to 37.5 mm (¾ to 1½ in)	50	100	
9.5 to 19.0 mm (No. 4 to ¾ in)	15	30	
4.75 to 9.5 mm (No. 4 to ⅜ in)	5	10	
Less than 4.75 mm (No. 4)[b]	20	40	

[a] Not less than one piece from each apparent type of rock

[b] Fine aggregate

TABLE 2 Calculation of Results of Petrographic Examination[a]

Individual Percentage Retained on Sieve	Composition of Fractions Retained on Sieves Shown Below							
	19.0 mm (¾ in)		12.5 mm (½ in)		9.5 mm (⅜ in)		4.75 mm (No. 4)	
	114		326		295		305	
Constituents[b]	Number of Particles	%	Number of Particles	%	Number of Particles	%	Number of Particles	%
A_1	350	30.0	300	40.0	150	50.0	90	30.0
A_2	50	10.0	100	20.0	125	25.0	100	20.0
A_3	30	2.0	50	10.0	35	11.0	100	20.0
B_1	307	21.4	30	14.0	62	12.6	32	6.4
B_2	36	15.2	33	10.6	19	5.6	57	11.6
B_3	..	..	20	4.0	41	8.6	95	19.2
C_1	3	1.0	5	1.0	20	4.0	20	4.0
C_2	2	0.4	2	0.4	6	1.2	10	2.0
C_3	..	..	..	..	..	..	5	1.0
Totals	500[c]	100	500[c]	100	500[c]	100	500[c]	100

	Weighted Percentages of Constituents in Each Sieve Fraction				Weighted Composition of Sample
	19.0 mm (¾ in)	12.5 mm (½ in)	9.5 mm (⅜ in)	4.75 mm (No. 4)	
A_1	8.7	13.0	8.9	2.1	32.7 (0.4 to 1.1 and 4)
A_2	4.7	6.5	7.6	4.1	23.0
A_3	0.4	3.3	4.4	4.1	12.2
B_1	3.7	4.6	3.7	1.5	13.5 (0.8 to 1.1 and 4)
B_2	2.6	2.5	1.1	1.6	8.0
B_3		1.3	2.5	5.9	9.7
C_1	0.2	0.3	1.2	0.6	2.3 (0.1 to 1.1 and 4)
C_2	0.1	0.1	0.3	0.1	0.6
C_3	..	..	..	0.2	0.2
Total on sieve fractions	17.4	32.6	29.5	20.5	
Total on sample, constituent A					68.0
Total on sample, constituent B					31.4
Total on sample, constituent C					0.6

[a] The table indicates a convenient method of setting up a work sheet for recording results and calculations. The results discussed here are covered in the form indicated by Table 3 Table 3 is included in the petrographic report Table 2 is not

[b] Letters (A, B, C) refer to the various constituents found, subscript numbers (1, 2, 3) refer to the various conditions in which each constituent has been found, such as relative degree of weathering

[c] The minimum volumes containing the number of particles to be counted has been met the selection of 500 particles per fraction for the example is to illustrate the calculations it is not intended to suggest that a predetermined number of particles per fraction should be selected

Standard Practice for Petrographic Examination of Aggregates for Concrete ASTM-C 295-85 Including Deletions.

Background: This Standard Practice is used for the petrographic analysis of aggregate for use in concrete but the general procedure is also useful in the examination of rock for general engineering usage. The procedure is modified for the NNWSI project to exclude the portions of the standard practice in which tests or examinations are biased solely for concrete purposes or in which examination is for natural sands or natural gravel since no natural sand or natural gravels will be examined for this phase of testing.

Procedure Modification from ASTM-C 295-85 (attachment B-1).

The following paragraphs and subparagraphs will be excluded from this testing program:

Paragraph No.	Description of Deletion	Reason for Deletion
4.3	Beginning with sentence No. 2 to end of of paragraph	Rock will not be used for aggregate in which it will be subject to freezing and thawing.
4.4	Beginning with sentence No. 2 to end of paragraph	Rock will not be evaluated for use in concrete.
4.5	All	Rock will not be evaluated for use in concrete.
4.6	All	Rock will not be evaluated for use in concrete.

The samples to be tested are rocks processed in the laboratory. The following paragraphs deal with field sampling procedures and are not applicable to the current testing and will be excluded:

Paragraph No.	Description of Deletion
6.1	All
6.1.1	All
6.1.2	All
6.1.3	All
6.1.4	All

The following paragraphs describe the examination of natural sand, natural gravels and ledge rock which are not applicable to the current testing and will be excluded:

SHAPE CLASSIFICATION WORKSHEET

w width
t thickness
l length

Operator _____
Sample _____

Date _____
Job No. _____
Memo No. _____

Particle Size														
Particle Shape	Pcs	%	Pcs	%	Pcs	%	Pcs	%	Pcs	%	Pcs	%	Pcs	%
Cubic														
Blocky														
Spherical														
Ellipsoidal														
Pyramidal														
Tabular (w:t=(3:1)														
Irregular														
Elongated(l:w>3:1)														
Flat (w:t>3:1)														
Lenti														
Spindle														
Total														

Particle Shape	Individual % Retained								Wt Avg of Sample, %
Cubic									
Blocky									
Spherical									
Ellipsoidal									
Pyramidal									
Tabular (w:t=(3:1)									
Irregular									
Elongated(l:w>3:1)									
Flat (w:t>3:1)									
Lenti									
Spindle									
Total									

to achieve a predetermined intensity level. Other settings are then made to verify that this intensity occurs at the proper location on the X-ray chart. The intent of this procedure is to permit X-ray diffraction patterns made at different times with the same unit to be comparable.

2. Peak resolution is used to verify that the combined effects of X-ray tube alignment and goniometer alignment are satisfactory. One procedure is to examine the resolution into $K\alpha_2$ and $K\alpha_2$ components of an X-ray peak of metal. This is described on page 18 of Directions 116930, "SPG X-ray. Spectrogoniometer for Diffraction and Emission Techniques (Installation, Operation, Maintenance)" in the General Electric (now Diano) XRD-7 Instruction Manual. Another procedure is the test for resolution of five lines of quartz within one degree at about 68 degrees 2θ; this is described on pages 392-393 of Klug, H. P., and Alexander, L. E., "X-ray Diffraction Procedures," 2nd Edition, 1973. The procedure at WES is to check the $K\alpha_1$-$K\alpha_2$ peak resolution on a monthly basis. If the resolution should decrease significantly, then the cause would be found and corrected.

3. The proper angular location of a diffraction peak has been checked by the use of a 4.26A peak of permaquartz. The general validity of this positioning is checked daily as part of the standardization procedure when the location of this peak is found for the intensity check. However, since peak position may change with the type of sample preparation that is used, an internal standard of powdered quartz is added to a sample when peak position is a major concern.

B. The index oil used in preparing grain immersion specimens for examination using a polarizing microscope is checked using a refractometer prior to using the oil. Index oils are stable in storage over extended periods of time and do not need to be checked more often than monthly when used routinely. Laboratory stock index oil with an index of 1.544 is checked monthly.

STRUCTURES LABORATORY TEST PROCEDURE

CHEMICAL ANALYSIS

This document describes the test procedures for chemical analysis of Nevada Nuclear Waste Storage Investigations crushed tuff. Modifications to the original test procedure were made as follows:

Approved By:

PROJECT LEADER	27 May 86 DATE
M&CA GROUP CHIEF	27 May 86 DATE
CT DIVISION CHIEF	27 May '86 DATE
QA OFFICER	27 May 86 DATE
PROJECT MANAGER SNL	5-30-86 DATE

volume change.

4.3 Petrographic examination should identify the portion of a sample of aggregate that is composed of weathered or otherwise altered particles and the extent of that weathering or alteration, whether it is severe, moderate, or slight, and should determine the proportion of each such type in each condition. If the concrete in which the aggregate may be used will be exposed to freezing and thawing in a critically saturated condition, finely porous and highly weathered or otherwise altered rocks should be discriminated because they will be especially susceptible to damage by freezing and thawing and will cause the aggregate portion of the concrete to fail on freezing and thawing, which will ultimately destroy the concrete because such aggregates cannot be protected by adequately air-entrained sound mortar. Finely porous aggregates near the concrete surface are also likely to form popouts, which are blemishes on pavements and walls.

4.4 Petrographic examinations may also be used to determine the proportions of cubic, spherical, ellipsoidal, pyramidal, tabular, flat, and elongated particles in an aggregate sample or samples. Flat, elongated, and thin chip-like particles in aggregate increase the mixing water requirement and decrease concrete strength.

4.5 Petrographic examination should identify and call attention to potentially alkali-silica reactive and alkali-carbonate reactive constituents, determine such constituents quantitatively, and recommend additional tests to confirm or refute the presence in significant amounts of aggregate constituents capable of alkali reaction in concrete. This practice is referred to in the Appendix of Specification C 33. Alkali-silica reactive constituents found in aggregates include opal, cristobalite, tridymite, siliceous and some intermediate volcanic glass, chert, glassy to cryptocrystalline acid volcanic rocks, synthetic siliceous glasses, some argillites, phyllites, metamorphic graywackes, rocks containing highly metamorphic quartz such as graywackes, phyllites, schists, gneisses, gneissic granites, semi-quartz, quartzite, and sandstone. Criteria are available in the mineralogic literature for identifying the minerals in the list above by optical properties or X-ray diffraction or both, and in petrographic and petrologic literature for identifying the rocks in the list by mineral composition and texture in thin section, sometimes assisted by X-ray diffraction for mineral composition. Potentially alkali-carbonate reactive rocks are usually calcareous dolomites or dolomitic limestones with clinos insoluble residues. Some dolomites consistently free of clay and some calcitic limestones free of clay and with minor insoluble residue mostly quartz, are also capable of some alkali-carbonate reactions, however such reactions have not yet been found alkali-reactive.

4.6 Petrographic examination may be directed specifically at the possible presence of contaminants in aggregates, such as synthetic glass, cinders, clinker, or coal ash, magnesium oxide, calcium oxide, or both, and hydrocarbons, chemicals that may affect the setting behavior of concrete or the properties of the aggregate, animal excrement, plants or rotten vegetation, and any other contaminant that may prove undesirable in concrete.

5. Apparatus and Supplies

5.1 The apparatus and supplies listed below comprise a selection that will permit the use of all of the procedures described in this practice. All specific items listed have been used in connection with the performance of petrographic examinations by the procedures described herein; it is not however, intended to imply that other items cannot be substituted to serve similar functions. Whenever possible the selection of particular apparatus and supplies should be left to the judgment of the petrographer who is to perform the work so that the items obtained will be those with the use of which he has the greatest experience and familiarity. The minimum equipment regarded as essential to the making of petrographic examinations of aggregate samples are those items or equivalent apparatus or supplies that will serve the same purpose, that are indicated by asterisks in the lists given below.

5.1.1 *Apparatus and Supplies for Preparation of Specimens:*

5.1.1.1 *Rock Cutting Saw,*[a] preferably with 150-mm or larger diamond blade, and automatic feed.

5.1.1.2 *Horizontal Grinding Wheel,*[a] preferably 400 mm in diameter.

5.1.1.3 *Polishing Wheel,* preferably 200 to 300 mm in diameter.

5.1.1.4 *Abrasives*[a]—Silicon carbide grit No. 100 (122 μm), 220 (63 μm), 320 (31 μm), 400 (16 μm), and 800 (12 μm), alumina M-305 (5 μm).

5.1.1.5 *Geologist's Pick or Hammer.*

5.1.1.6 *Microscope Slides,*[a] clear, nonconcave, 25 by 45 mm or size.

5.1.1.7 *Canada Balsam,*[a] neutral, in xylene, or suitable low-viscosity epoxy, or Lakeside 70.

5.1.1.8 *Xylene*[a].

5.1.1.9 *Mounting Medium,*[a] suitable for mounting rock slices for thin sections.

5.1.1.10 *Laboratory Oven*[a].

5.1.1.11 *Plate-Glass Squares,*[a] about 300 mm on an edge for thin section grinding.

5.1.1.12 *Sample Splitter* with pans[a].

5.1.1.13 *Micro Cover Glasses*[a] nonconcave, square, 12 to 18 mm, 25 mm, etc.

5.1.1.14 *Plastic Mortar.*

5.1.2 *Apparatus and Supplies for Examination of Specimens:*

5.1.2.1 *Polarizing Microscope,*[a] with mechanical stage, low-, medium-, high-power objectives, and objective-centering devices; eyepieces of various powers; full- and quarter-wave compensators, quartz wedge.

5.1.2.2 *Microscope Lamp*[a] (preferably including a sodium arc lamp).

5.1.2.3 *Stereoscopic Microscope,*[a] with objectives and oculars to give final magnifications from about 6x to about 150x.

5.1.2.4 *Magnet,*[a] preferably Alnico, or an electromagnet.

5.1.2.5 *Needle-holder and Probe*[a].

5.1.2.6 *Dropping Bottle,* 60-mL capacity.

5.1.2.7 *Petri Culture Dishes.*

5.1.2.8 *Forceps,* smooth, straightpointed.

5.1.2.9 *Lens Paper*[a].

5.1.2.10 *Immersion Media,*[a] $n = 1.410$ to $n = 1.785$ in steps of 0.005.

5.1.2.11 *Counter.*

5.1.2.12 *Photomicrographic Camera and accessories.*

5.2 The items under Apparatus and Supplies include those used to make thin sections. Semi-automatic thin section machines are now available, and there are several thin-section makers who advertise in *Geotimes*, the *American Mineralogist*, and other mineralogical or geological journals. Laboratories may find it reasonable to buy a thin-section machine or use a commercial thin-section maker. Remotely located laboratories have more need to be able to make their own thin sections.

[a] The values given in parentheses are the approximate sizes of grit or grit size of commercial silicon carbide grit or the designated size of the item.

5.3 It is [illegible] that in data for a field or the petrographic [illegible] which the rock or mineral of the immersion media. If a quantitative determination of minerals is to be attempted, as for example the differentiation of quartz and alkali feldspars, or the differentiation of lime from intermediate volcanic glass, the indices of refraction of the media need to be known with accuracy. Media will not be stable for very long periods of time and are subject to considerable variation due to temperature changes. In laboratories not provided with close temperature control, it is often necessary to establish immersion media several times during the course of a single day when accurate identifications are required. The equipment needed for checking immersion media consists of an Abbé refractometer. The refractometer should be equipped with compensating prisms to read indices for sodium light from white light, or it should be used with a sodium arc lamp.

5.4 A laboratory that undertakes any considerable amount of petrographic work should be provided with facilities to make photomicrographic records of such features as cannot adequately be described in words. Photomicrographs can be taken using standard microscope lamps for illumination, however it is recommended that whenever possible a sodium arc lamp be provided for this purpose. For illustrations of typical apparatus, reference may be made to the paper by Mather and Mather,[7] and manufacturers of microscopes equipped with cameras and photomicrographic equipment may be consulted. Much useful guidance regarding photomicrography, especially using reflected light, is found in Practice E 883.

6. Sampling

6.1 Samples for petrographic examination should be taken by or under the direct supervision of a geologist familiar with the requirements for random sampling of aggregates for concrete and in general following the requirements of Practice D 75. The exact location from which the sample was taken, the geology of the site, and other pertinent data should be submitted with the sample. The amount of material actually studied in the petrographic examination will be determined by the nature of the examination to be made and the nature of the material to be examined, as discussed below.

6.1.1 *Individual quarries* should be sam-

performed to ensure the quality of the analysis. 1) To ensure that the operating parameters of the instrument have not shifted during the course of an analysis, for example due to the warming of some components from the flame or accidental disturbance of the wavelength control during operation, standard solutions are read (i.e. the absorbance measured) before and after the unknown solutions are read. If the two readings do not agree to within the tolerances expected for that analysis (see para. 3.3.4. for a discussion of the precision and accuracy expected), then the operating parameters of the instrument are checked and the analysis repeated. 2) To ensure that the analysis is being performed within a linear operating range and as an indicator that standards are accurate (see para. 3.3.3. below), a regression analysis of concentration of analyte on absorbance is performed with data from readings of the standard solutions. If any of the points on the standard curve deviate from the linear fit by more than the tolerances for that analysis allow, then the analysis is discontinued until the source of the problem is identified and corrected. 3) All analyses are performed in duplicate. If the duplicates agree to within the tolerances established for that analysis, then a mean is reported. If the duplicates do not agree, then additional replicates are performed, as necessary, to identify the outlying datum, which is then discarded, and a mean of the remaining data reported.

3.3.3. United States Geologic Survey rock standards, prepared in the same way as the tuff samples, are used as atomic absorption standards. The elemental composition of these standards is well characterized. Because the elemental composition of these standards is similar to that of the tuff samples, these materials provide a convenient way of eliminating analysis problems which often arise in atomic absorption analysis due to interactions among the chemical species present in the sample. Standard solutions prepared with these materials have been found to be unstable after several weeks. This becomes evident when linear regression analysis indicates a poor fit of the absorbance values of the standards to the known elemental content, as indicated in 3.3.2. above.

3.3.4. The maximum tolerable differences between duplicate analyses are listed in Table 1. If these differences are exceeded, then additional replicates are performed until this level of reproducability is achieved. The values in this table are also used to evaluate the equality of the standard curves used for calculating results from atomic absorption analyses. If absorbance for any standard solution deviates from the regression line calculated from all of the standards by a sufficient amount to result in an inaccuracy (difference between the measured value and accepted value of that standard) greater than the value reported in the following table, then the analysis is discontinued until the problems are identified and corrected.

and wet) examination of a broken surface (dry and wet) and scratch and acid tests. Only after all of these steps have been taken and the grain is still unidentified should the petrographic microscope be used. Grains that cannot be identified using the stereoscopic microscope, or that are suspected of consisting of or containing substances known to react deleteriously in concrete, should be set aside to be examined with the petrographic microscope. If the question of reaction with the alkalies (sodium and potassium) of portland cement paste is important in the examination of the sample, certain additions to the procedure are indicated. If the coarser sand sizes contain fine-grained, partially glassy igneous rocks, several typical particles of each variety of such rocks should be selected for more thorough examination. The petrographer should determine the presence or absence of glass by crushing typical grains and examining them in immersion media, using the petrographic microscope. In difficult or especially important cases, it may be necessary to break suspected grains and to make immersion mounts of part of the grain and a thin section of another part. Where the sand contains chert and the potential reactivity of the chert is an important consideration, a number of chert particles from the fractions retained on the 600-µm (No. 30) sieve should be set aside for determinations of the index of reactivity.

9.1.2 *Sieve finer than 600 µm (No. 30)*—The sieve fractions finer than the 600-µm (No. 30) sieve should each be reduced to a sample splitter or by quartering to about 4 or 5 g. The volume will usually be less than a level teaspoonful. In some gradings the fractions retained on the 150-µm (No. 100) and 75-µm (No. 200) sieves may be present in such small amounts that reduction is unnecessary. These splits should be further reduced on a miniature sample splitter or by coning and quartering with a spatula on a clean sheet of paper. The examination may be conducted as in 9.1.1. As required, the petrographic microscope should be used. For this purpose, a representative portion of each reduced split should be mounted in immersion oil on a clean glass slide and covered with a clean cover glass. No entirely satisfactory method of reducing a split to a predetermined number of grains is known. The reduced split can be sampled by spreading it in a thin layer on glass or clean [illegible] and transferring the grains [illegible] to the needle to a drop of immersion oil on a clean slide. If this is done carefully, a fairly representative sample will be obtained. If the dissecting needle is made of magnetized steel, a concentration of magnetic minerals may result. It is usually necessary to make several mounts of the 600-µm (No. 30) and 150-µm (No. 100) sieve fractions to obtain at least 100 grains of each. The index of the immersion oil should be selected to make the identification of the important constituents as easy and as definite as possible. The use of an immersion oil with an index of or just below the lower index of quartz (1.544) is recommended. The slide should be mounted on a petrographic microscope equipped with a mechanical stage. Several traverses should be made, and each grain that passes under the cross hair should be identified and counted. Care should be taken to move the slide on the north-south adjustment between traverses so that no grain will be counted twice. Each sieve fraction passing the 600-µm (No. 30) and retained on the 75-µm (No. 200) sieve should be examined. Ordinarily, the material passing the 75-µm (No. 200) sieve is mounted on a slide following the procedure described above, examined by means of the petrographic microscope, and its composition estimated. If an unusually large amount of this size is present, or if it contains constituents that may be expected to have an important effect on the suitability of the aggregate for the intended use, it should be counted. In this event, it is suggested that the fraction passing the 75-µm (No. 200) sieve be washed over the 45-µm (No. 325) sieve before being counted.

10. Examination of Drilled Core

10.1 Each core should be examined and a log prepared showing footage of core recovered, core loss and location, location and spacing of fractures and parting planes, lithologic type or types, alternation of types, physical conditions and variations in consistence, toughness, hardness[9], coherence, obvious porosity, grain size, texture, variations in grain size and texture, type or types of bedding, and presence of constituents capable of deleterious reaction in concrete. If the size of the core permits, the probability that the rock will make aggregate of the required maximum size should be considered. If the surface of the core being examined is vertical, it is usually easier to recognize signals and features and changes on bedding. Most of the information usually required can be obtained by careful visual examination, scratch and acid tests, and hitting the core with a hammer. In the case of fine-grained rocks, it may be necessary to examine parts of the core, using the stereoscopic microscope, or to prepare thin sections of selected portions. Some considerations and procedures are more applicable to particular rock types than to others. Ordinarily, the layered rocks considered for concrete aggregate will be limestone, and occasionally metamorphic rocks, such as phyllite, gneiss, or schist. One of the most important questions arising in the examination of limestone is that of the presence, type, and distribution of argillaceous impurities. Limestones that contain interbedded thin beds of soft shale may make suitable sources of aggregate if the shale is so distributed that it does not prevent manufacture of the required maximum size, and if the shale can be eliminated or reduced in processing. Where argillaceous impurities are present, it should be determined whether they actually consist of clay minerals or of other minerals in clay sizes. If they do consist of clay minerals, it should be established whether the clay minerals include swelling clays (that is, smectites, also known as the montmorillonite-saponite group of minerals).[9] X-ray diffraction analysis is especially valuable in identification and quantitative determination of clay minerals. In the examination of fine-grained igneous rocks, particular attention should be directed to the nature of the ground-mass. This examination should include determination of the presence or absence of opal, chalcedony, natural glass, and swelling clays; if any of these are found the amount should be estimated; if natural glass is found the type should be determined.

11. Examination of Ledge Rock

11.1 The procedure used in examination should be the same as for core samples to the extent that the spacing of samples and size of the individual pieces allow. If the sample consists of a relatively large quantity of broken stone produced by blasting, it is desirable to inspect the whole sample, estimate the relative abundance of each types or [illegible] and sample each type by four further [illegible] procedure should be the same as given below for crushed stone.

12. Examination of Crushed Stone

12.1 The procedure for examination of crushed stone should be similar to that for core except that necessary quantitative data should be obtained by particle counts of the separated sieve fractions obtained as described in the section on Natural Gravel and Sand.

13. Examination of Manufactured Sand

13.1 The examination procedure should be similar to that for natural sand, with particular emphasis on the amount and extent of fracturing and the amount and nature of rock dust created by the milling operations. If a sample of the rock from which the sand was produced is available, examination of it will provide useful information.

CALCULATIONS AND REPORT

14. Calculations

14.1 Calculate the composition of each sieve fraction of a heterogeneous sample and the weighted average composition of the whole sample as follows:

14.1.1 If sieve the composition of each sieve fraction by summing the total number of particles of that fraction counted, and calculating each constituent in each condition as a percentage of the total amount (as number of particles or percent, in each sieve fraction). It is convenient to calculate and record the percentages to tenths at this stage. An example of these calculations is given in the upper half of Table 2.

14.1.2 Obtain the weight percent of the sieve fraction in the whole sample (individual percentages retained on consecutive sieves) from the grading of the sample as determined by Method C 136.

14.1.3 By multiplying the percentage of the constituent in the sieve fraction, determined as described above, by the percentage of the sieve fraction in the whole sample, obtained as de-

[9] Bonjiglio, G. J. "Evaluation of Damage to the Volume of Concrete," Bull. Prelim. Vol 14, No. 6, March 17, 1958, pp 20-30.

3.3.5. The Inductively Coupled Plasma (ICP) analysis will be performed as outlined in "User's Manual Model 3510 ICP Spectrometer", Manual No. 145986-83B1. The general procedure for analysis is as described for atomic absorption Section 3.3.2. and 3.3.3. Standards will be run, as discussed in these sections, to verify the performance of the ICP spectrometer.

3.4. Silicon dioxide will be determined on a separate sample by gravimetric method as described in "Standard Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete", ASTM-C 311-85 as outlined in paragraphs 13.1 through 13.4.

3.5. Total sulfur content.

3.5.1. This procedure involves use of a combustion-titrimetric apparatus for determining sulfur content.

3.5.2 The total sulfur in the sample is converted to SO_2 by heating the sample in a stream of oxygen. The SO_2 is reacted with iodine in an acidified starch-iodide solution and titrated with a standard potassium iodate solution.

3.5.3. Apparatus and reagents.

3.5.3.1. Furnace. Any electric tube furnace equipped with an automatic temperature controller and capable of continuous operation at 1425°C and intermittent operation at temperatures up to 1670°C is suitable. The combustion zone should be approximately 20 to 25 cm in length. A LECO induction furnace capable of operating in these temperature ranges is used. The apparatus also provides automatic titration giving readings in percent sulfur (S).

3.5.3.2. Ceramic filter. A tightly fitting, porous ceramic filter is placed in the combustion tube in such a position as to be in the hot zone of the furnace. Such filters serve to remove metallic oxide fumes from the gas stream and can be constructed from porous insulating firebrick capable of withstanding the operating temperatures. For induction furnaces, glass wool shall be placed in the constricted end of the combustion tube.

3.5.3.3. Combustion boats, crucibles, and covers. Refractory boats, crucibles, and covers of very low sulfur content, resistant to molten oxide, are used. The boats shall be 8.7 to 10.2 cm in length, and the crucibles shall have inside dimensions of approximately 20 mm in diameter and 20 mm in height. The crucibles, which are used for induction heating furnaces, shall be designed in order to retain the oxide dust formed during the combustion of the sample.

3.5.3.4. Gas supply. Compressed oxygen shall be supplied to the apparatus through a pressure regulating and reducing valve at a set pressure within the range 0.14 to 0.7 kg/cm^2.

Standard Specification for LIQUID MEMBRANE-FORMING COMPOUNDS FOR CURING CONCRETE[1]

This standard is issued under the fixed designation C 309; the number immediately following the designation indicates the year of original adoption, or in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This specification covers liquid membrane-forming compounds suitable for application on horizontal and vertical concrete surfaces to retard the loss of water during the early hardening period and, in the case of the white-pigmented compound, to also reduce the temperature rise in concrete exposed to radiation from the sun. The compounds covered by this specification are suitable for use as curing media for fresh concrete, and may also be used for further curing of concrete after removal of forms or after initial moist curing.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 The following types of compounds are included:

1.3.1 *Type 1*, clear or translucent without dye,

1.3.2 *Type 1-D*, clear or translucent with fugitive dye, and

1.3.3 *Type 2*, white pigmented.

1.4 The vehicle shall be one of the following classes:

1.4.1 *Class A* – No restrictions on vehicle solids material, or

1.4.2 *Class B* – Vehicle solids restricted to all resin[2] material.

2. Applicable Documents

2.1 *ASTM Standards*:

C 156 Test Method for Water Retention by Concrete Curing Materials[3]

D 869 Method of Evaluating Degree of Settling of Paint[4]

D 1309 Test Method for Settling Properties of Traffic Paints During Accelerated Storage[4]

D 1611 Test Methods for Nonvolatile Content of Varnishes[4]

E 97 Test Method for 45/0 Diffuse Reflectance Factor of Opaque Specimens by Broad-Band Filter Reflectometers[5]

3. Ordering Information

3.1 The purchaser shall include the following information on the purchase order when applicable:

3.1.1 Type of compound and class of vehicle to be furnished,

3.1.2 Rate of application to be used to determine conformance to this specification. If not specified, the curing material shall be applied at the rate of 200 ft²/gal (0.2 dm²/m²) for testing purposes.

NOTE 1 – The rate of application to be used to determine conformance to this specification should be specified by the purchaser and may be based on the recommendation of the manufacturer. The 200-ft²/gal (0.2 dm²/m²) application rate, to be used for evaluation of the compound when another rate is not stated, is the application rate most commonly used in the industry. The application rate used for testing may, or may not, be the same as the rate to be used for field application. Many operators use the same rate for field application on relatively smooth surfaces as the rate used for testing, while requiring a substantially greater field application rate on deeply textured surfaces.

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[1] This specification is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.01.07 on Methods of Testing and Specifications for Materials Used in Curing Concrete.

Current edition approved April 30, 1981. Published June 1981. Originally published as C 309 – 53 T. Last previous edition C 309 – 74 (1980).

[2] For the definition of "resin," refer to ASTM Definitions D 883, Terms Relating to Plastics, 1981 Annual Book of ASTM Standards, Vol 08.01.

[3] Annual Book of ASTM Standards, Vol 04.02.

[4] Annual Book of ASTM Standards, Vol 06.01.

[5] Annual Book of ASTM Standards, Vol 11.02.

3.5.3.5. Metal accelerators. Iron chips and tin containing a low carbon and sulfur content are used to increase and control the temperature of the sample when the sample is heated in an induction furnace. Copper rings are used to reduce splashing of the metals in the crucible. Copper strips are used to control the heating process in a resistance furnace.

3.5.3.6. Starch-KI solution. Transfer 2 g of soluble (or arrowroot) starch to a beaker, add 50 ml of water, and stir until a uniform slurry is obtained. Pour this mixture slowly into 150 ml of boiling water, stirring constantly. Cool to room temperature, add 6-g of KI, and stir until the KI is dissolved.

3.5.3.7. Standard potassium iodate solution (1 ml = 0.0002 g S). Dissolve 0.4450 g of reagent grade KIO_3 in 900 ml of water, and dilute to 1 l in a volumetric flask (Notes 1 and 2).

Note 1. The sulfur equivalent for the KIO_3 solution is based on the following reactions:

$$KIO_3 + 5KI + 6HCl = 3I_2 + 6KCl + 3H_2O$$

$$SO_2 + I_2 + 2H_2O = H_2SO_4 + 2HI$$

On the basis of 100 percent conversion of sulfur to SO_2, the solution should contain 0.4450 g of KIO_3 per liter.

Note 2. The standardization of the KIO_3 solution is made using potassium alum in determination of the furnace constant.

Hydrochloric acid solution. Hydrochloric acid with a 0.174N concentration. Dilute 15 ml of HCl (36% HCl) to 1 l with deionized water.

Potassium alum, reagent grade ($AlK(SO_4)_2 \cdot 12H_2O$) (1 g = 0.1350 g S).

3.5.4. End-point adjustment. The temperature of the furnace is adjusted to 1425°C or higher (Note 3). HCl solution, described in Section 3.5.3.7. is added to the titration vessel. The amount of HCl used should be sufficient to half fill the vessel. Then add 5 ml of starch-KI solution to the titration vessel. Pass oxygen through the system at a rate of one l/min. Next add a small amount of KIO_3 solution until the intensity of the blue color is that which is to be taken as the end point of the final titration (Note 4). Turn off the oxygen.

Note 3. Induction heating, when the furnace is properly adjusted to give the specified temperature or higher, has given satisfactory performance.

Note 4. The end point need be adjusted only at the beginning of a series of determinations when the automatic titrator is used.

Date: _____

Operator: _____

Sample _____

Job No. _____

Memo No. _____

Particle Size																	
Mineral Name	Pcs		Pcs	%	Pcs	%	Pcs	%	Pcs	%	Pcs	%	Pcs		Pcs	%	
Totals																	

Individual % Retained

Mineral Name									Wt Avg of sample
Total									

USAE,

Attachment 3

3.5.10. Calculate the percentage of sulfur as follows:

$$S \text{ percent} = \frac{F(B - C)(0.02)}{D}$$

where F,B,C,0.02 = definition in Section 3.5.9
D = weight of sample, g

4. Quality Assurance.

4.1. Only qualified personnel shall be allowed to perform this work.

4.2. Instrument calibrations are made using commercially available standards (American Chemical Society (ACS) reagent grade chemicals). These standards are checked by a chemist for compliance of the standards to the test requirements. The standards are used to standardize and adjust instrumentation to assure proper operation. Standards are run before and after testing a series of samples, with a standard being run at least after every eight samples.

4.3. Three U.S. Geological Survey silicate rock standards BCR-1, GSP-1, and AGV-1 are used to reference the techniques utilized by WES to demonstrate the validity of test results. The U.S.G.S. silicate rock standards are used due to the lack of appropriate NBS standards. These standards provide ranges in the elemental composition of silicate rock materials. The samples were identified by Flanagan [5] as follows:

BCR-1	Basalt
GSP-1	Granodiorite
AGV-1	Andesite

NNWSI CHEMICAL ANALYSIS

1. The purpose of this document is to describe the processes and method used by the U.S. Army Waterways Experiment Station (WES), to perform chemical analysis of tuff rock from the Nevada Test Site (NTS) for study by Sandia National Laboratories as part of the Nevada Nuclear Waste Storage Investigations (NNWSI) project.

2. Scope. This procedure applies to rock samples provided by SNL for study in conjunction with NNWSI project.

3. Procedure.

3.1. A representative sample for testing is obtained as described in Standard Practice for Petrographic Examination of Aggregate for Concrete, ASTM-C 295-85.

3.2. Equipment used for this analysis is as follows:

Equipment	Model No.	Serial No.
Atomic Absorption Spectrophotometer	Perkin Elmer 306	102 905
LECO Combustion Furnace & Titration Apparatus	532-000,521-003	1181,2667
Inductively Coupled Plasma Spectrometer	Applied Research Laboratories 3510 ICP	147
Analytical Balance	Sartorius Type 1702	3504112
Analytical Balance	Sartorius Type 1801	35100099

3.3.1. Samples will be ground to pass a 150 µm (No. 100) sieve. They will then be ignited at 1000°C to a constant weight and an ignition loss determined. A 0.250±.0005-g sample will then be weighed into a carbon crucible with 1-g of lithium metaborate and fused at 1000°C for 15 min. The melt will be dissolved in 5 ml of concentrated HCL solution (11.6 N) and diluted to 50 ml with deionized H_2O. The solution is transferred to a volumetric flask and diluted to 500 ml with deionized water. The solution can be used for atomic absorption analysis. The solution is filtered through a medium filter paper (41 Whatman Ashless) for ICP analysis. The solution will be analyzed by atomic absorption spectrophotometry for Fe_2O_3, Na_2O, K_2O, MgO, Al_2O_3, Mn_2O_3, CaO and SrO with TiO_2, BaO and P_2O_5 analysis made using a ICP spectrometer.

3.3.2. Atomic absorption analysis is performed according to procedures described in "Analytical Methods For Atomic Absorption Spectrophotometry", document 303-0152, Perkin-Elmer Co., 1973. Several additional practices are

STRUCTURES LABORATORY AND SOILS TEST FACILITY (GEOTECHNICAL LABORATORY) TEST PROCEDURE

PARTICLE - SIZE ANALYSIS

This document describes the test procedures for use to determine the particle size analysis of crushed tuff, Nevada Nuclear Waste Storage Investigations Project.

Approved By:

PROJECT LEADER	DATE 13 Jan 1986
SOILS TEST FACILITY CHIEF	DATE 1/13/86
MECA GROUP CHIEF	DATE 13 Jan 1986
QT DIVISION CHIEF	DATE 1/13/86
QA OFFICER	DATE 13 J[illegible]
PROJECT MANAGER SNL	DATE 1-15-86

TABLE 1

Limits of Chemical Analysis Using Atomic Absorption Spectrophotometry*

Analysis	Maximum Difference Between Duplicates %
SiO_2	0.50
Al_2O_3	0.50
Fe_2O_3	0.20
CaO	0.20
MgO	0.20
SO_3	0.10
Na_2O	0.20
K_2O	0.20
TiO_2	0.05
P_2O_5	0.03
SrO	0.05
BaO	0.05

*Limits of analysis based on WES Laboratory experience using equipment indicated.

Quality Assurance:

1. Only qualified personnel shall be allowed to perform this work.

2. Calibration: The Concrete Technology Division, Structures Laboratory, is inspected every 2 years by Cement and Concrete Reference Laboratory (CCRL) at the National Bureau of Standards. As part of this inspection CCRL inspects the mechanical sieving apparatus, sieves, and scales used in sieve analysis testing. Balances are calibrated as outlined by Structures Laboratory QA Manual dated 1 June 1980.

3. Sieve analysis data will be recorded on WES Form No. 2213 (Attachment 2) modified to omit sieve size 1/2-in., No. 3, No. 6, No. 8, No. 16, No. 30, No. 50, No. 70 and No. 100 sieves and No. 60 will be added to coincide with sieves used in the test procedures.

4. Hydrometer data will be recorded on WES Form No. 2213 (Attachment 2).

results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry. When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the air for dispersion purposes.

3.3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3.4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in. (457 mm) in height and 2½ in. (63.5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36 ± 2 cm from the bottom on the inside.

3.5 *Thermometer*—A thermometer accurate to 1°F (0.5°C).

3.6 *Sieves*—A series of sieves, of square-mesh woven-wire cloth, conforming to the requirements of Specification E 11. A full set of sieves includes the following (Note 6):

3-in. (75-mm)	No. 10 (2.00-mm)
2-in. (50-mm)	No. 20 (850-µm)
1½-in. (37.5-mm)	No. 40 (425-µm)
1-in. (25.0-mm)	No. 60 (250-µm)
¾-in. (19.0-mm)	No. 140 (106-µm)
⅜-in. (9.5-mm)	No. 200 (75-µm)
No. 4 (4.75-mm)	

NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)	No. 16 (1.18-mm)
1½-in. (37.5-mm)	No. 30 (600-µm)
¾-in. (19.0-mm)	No. 50 (300-µm)
⅜-in. (9.5-mm)	No. 100 (150-µm)
No. 4 (4.75-mm)	No. 200 (75-µm)
No. 8 (2.36-mm)	

3.7 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4. In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessary.

3.8 *Beaker*—A beaker of 250-mL capacity.

3.9 *Timing Device*—A watch or clock with a second hand.

4. Dispersing Agent

4.1 A solution of sodium hexametaphosphate (sometimes called sodium metaphosphate) shall be used in distilled or demineralized water, at the rate of 40 g of sodium hexametaphosphate/litre of solution (Note 7).

NOTE 7—Solutions of this salt, if acidic, slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive action. Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them.

4.2 All water used shall be either distilled or demineralized water. The water for a hydrometer test shall be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath, or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room. The basic temperature for the hydrometer test is 68°F (20°C). Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed.

5. Test Sample

5.1 Prepare the test sample for mechanical analysis as outlined in Method D 421. During the preparation procedure the sample is divided into two portions. One portion contains only particles retained on the No. 10 (2.00-mm) sieve while the other portion contains only particles passing the No. 10 sieve. The mass of air-dried soil selected for purpose of tests, as prescribed in Method D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

5.1.1 The size of the portion retained on the No. 10 sieve shall depend on the maximum size of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
¼ (9.5)	500
¾ (19.0)	1000
1 (25.4)	2000
1½ (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sand soils and approximately 65 g for silt and clay soils.

5.2 Provision is made in Section 5 of Method D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm), 2-in. (50-mm), 1½-in. (37.5-mm), 1-in. (25.0-mm), ¾-in. (19.0-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 10 sieves or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.

3.5.5. Induction furnace. Transfer 0.100 g ±.0005 g the sample to a ceramic crucible. Add 1 g of iron chips, 1.5 g of tin, and 1/2 of a copper ring (Note 5). Place a cover on the crucible, and raise the crucible and contents into the geometric center of the induction coils. Close the combustion tube, start the furnace, and initiate the flow of oxygen at a rate of 1 l/min.

Note 5. The accelerators can be added volumetrically.

3.5.6. Titration. As the stream of gas begins to bubble through the absorption solution, the blue color will fade. Record the initial burette reading, and titrate continuously with the KIO_3 solution at such a rate as to maintain, as nearly as possible, the initial intensity of the blue color. Near the end of the combustion period (Note 6), cautiously add the KIO_3 solution until the intensity of the blue color is that taken initially (Section 3.5.4.). Read the burette, and record the reading. The difference between this reading and the initial reading is the volume of KIO_3 solution required for titration of the sample.

Note 6. The length of combustion period is 5 min for the induction furnace. The time is measured by automatic timer, beginning when the sample begins to be fired.

3.5.7. Blank. A blank determination shall be made following the procedures specified in Sections 3.5.4 and 3.5.6, omitting the sample. Checks of the blanks are made when a new shipment of crucibles, crucible covers, or accelerators is used.

3.5.8. Furnace factor. All of the sulfur in the sample is not driven off during the heating period. A determination of a furnace factor (F) is therefore necessary. Follow the procedure using 3 different SRM cements in place of the sample. The F factor shall be checked each day for very accurate work. For routine determinations, F factor should be checked once a week. A new factor is calculated whenever new solutions are made, sample and accelerator weights are changed, or with any changes in the operation of the furnace or combustion time.

3.5.9. Calculation of F value. The furnace factor F is calculated as follows:

$$\frac{13.52A}{(0.02)(B-C)} \qquad F = \frac{A \times D}{B - C}$$

where
F = furnace factor (dimensionless number)
A = weight of SRM, g
B = volume of KIO_3 solution required for titration of SRM, ml
C = volume of KIO_3 solution required for titration of blank, ml
D = assigned value of SRM%

drometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/l). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil - water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil - water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil - water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica need be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil - water slurry to the sedimentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil - water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns. Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position.

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem, since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading take the
of the suspension by inserting the
into the suspension.

11. Sieve Analysis

11.1 After taking the final hydr
ing, transfer the suspension to a No
sieve and wash with tap water un
water is clear. Transfer the materia
200 sieve to a suitable container, dr
at 230 ± 9°F (110 ± 5°C) and m
analysis of the portion retained, us
sieves as desired, or required for the
upon the specification of the materia

CALCULATIONS AND REP

12. Sieve Analysis Values for
Coarser than the No. 10 (2.00-m

12.1 Calculate the percentage pas
10 sieve by dividing the mass passing
sieve by the mass of soil originally
No. 10 sieve, and multiplying the re
To obtain the mass passing the N
subtract the mass retained on the N
from the original mass

12.2 To secure the total mass of
the No. 4 (4.75-mm) sieve, add to
the material passing the No. 10 sieve
the fraction passing the No. 4 sieve a
on the No. 10 sieve. To secure the to
soil passing the ⅜-in. (9.5-mm) sieve
total mass of soil passing the No. 4
mass of the fraction passing the ⅜-in.
retained on the No. 4 sieve. For the
sieves, continue the calculations in
manner.

12.3 To determine the total perce
ing for each sieve, divide the total m
(see 12.2) by the total mass of sample
tiply the result by 100.

13. Hygroscopic Moisture Correction

13.1 The hydroscopic moisture corr
tor is the ratio between the mass of
dried sample and the air-dry mass befo
It is a number less than one, except w
is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of
in the hydrometer analysis by multip
air-dry mass by the hygroscopic moistu

REFERENCES

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ing to Stokes' law:

$$D = \sqrt{[30\eta/980(G - G_1)] \times L/T}$$

where:

D = diameter of particle, mm,

η = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),

L = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (Table 2)),

T = interval of time from beginning of sedimentation to the taking of the reading, min,

G = specific gravity of soil particles, and

G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

NOTE 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows:

$$D = K\sqrt{L/T}$$

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of L is divided by T using the A- and B-scales, the square root being indicated on the D-scale. Without ascertaining the value of the square root it may be multiplied by K, using either the C- or CI-scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.2), and the result divided by 100.

16.2 Calculate next the total mass passing the No. 200 sieve. Add together the fractional masses retained on all the sieves, including the No. 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 Calculate next the total masses passing each of the other sieves, in a manner similar to that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total mass of sample (as calculated in 14.2), and multiply the result by 100.

17. Graph

17.1 When the hydrometer analysis is performed, a graph of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an arithmetic scale as the ordinate. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional, since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph repre
gradation of the sample tested. If particles la
those contained in the sample were remove
testing, the report shall so state giving the am
maximum size.

18.2 For materials tested for compliar
definite specifications, the fractions calle
such specifications shall be reported. T
tions smaller than the No. 10 sieve shall
from the graph.

18.3 For materials for which compliar
definite specifications is not indicated ar
the soil is composed almost entirely of
passing the No. 4 (4.75-mm) sieve, the
read from the graph may be reported as

(1) Gravel, passing 3-in. and retained on No. 4 sieve
(2) Sand, passing No. 4 sieve and retained on No. 200 sieve
  (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve
  (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve
  (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve
(3) Silt size, 0.074 to 0.005 mm

STANDARD METHOD FOR PARTICLE-SIZE ANALYSIS OF SOILS, ASTM-D 422-63 (REAPPROVED 1972) AND DELETIONS

Background: ASTM-D 422-63 (Reapproved 1972) (Attachment D-1)is like test procedure Grain Size Analysis, Appendix V described in EM 1110-2-1906 used by the U.S. Army Corps of Engineers for particle size analysis. The following options and omissions in ASTM-D 422 were made to coincide with the EM 1110-2-1906 and requirements of Nevada Nuclear Waste Storage Investigations testing.

Paragraph Number	Description of Options and Deletions
3.6	Option of Note 6 to include additional sieves will not be implemented.
18.1.3	Not performed because information provided by petrographic examination made in other testing.
18.1.3.1	Not performed because information provided by petrographic examination made in other testing.
18.1.3.2	Not performed as part of particle size analysis procedures.
18.1.4	Not performed as part of particle size analysis procedures.

Equipment: Two balances will be used for the sieve analysis testing. The larger capacity balance will be used for coarse aggregate analysis while the smaller capacity balance will be used in the analysis of material passing the 4.75 mm (No. 4) sieve. The Gilson mechanical sieve shaker will be used to sieve the material retained on the 4.75 mm (No. 4) sieve, while the Ro-tap mechanical sieve shaker will be used to sieve material passing the 4.75 mm (No. 4) sieve. The specific equipment to be used in the program are listed below:

Equipment	Model	Serial No.
Balance	Mettler PE1600	E39125
Balance	Mettler P10	192547
Mechanical Sieve Shaker	TM-4 (Gilson)	T1316S
Mechanical Sieve Shaker	Ro-tap	3353

TABLE 1 Values of Correction Factor, a, for Different Specific Gravities of Soil Particles[a]

Specific Gravity	Correction Factor[a]
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

[a] For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[a]

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth L, cm	Actual Hydrometer Reading	Effective Depth L, cm	Actual Hydrometer Reading	Effective Depth L, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5

TABLE 2 Continued

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth L, cm	Actual Hydrometer Reading	Effective Depth L, cm	Actual Hydrometer Reading	Effective Depth L, cm
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

[a] Values of effective depth are calculated from the equation

$$L = L_1 + \frac{1}{2}(L_2 - L_1/A)$$

where

L = effective depth, cm,

L_1 = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,

L_2 = overall length of the hydrometer bulb, cm,

V_b = volume of hydrometer bulb, cm³, and

A = cross-sectional area of sedimentation cylinder, cm².

Values used in calculating the values in Table 2 are as follows:

For both hydrometers, 151H and 152H:

L_2 = 14.0 cm

V_b = 67.0 cm³

A = 27.8 cm²

For hydrometer 151H:

L_1 = 10.5 cm for a reading of 1.000

= 2.3 cm for a reading of 1.031

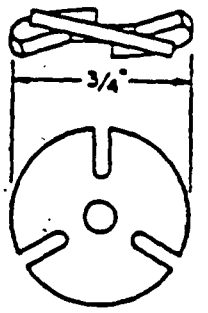
For hydrometer 152H:

L_1 = 10.5 cm for a reading of 0 g/litre

= 2.3 cm for a reading of 50 g/litre

TABLE 3 Values of K for

Temperature, °C	2.45	2.50
16	0.01510	0.01505
17	0.01511	0.01486
18	0.01492	0.01467
19	0.01474	0.01449
20	0.01456	0.01431
21	0.01438	0.01414
22	0.01421	0.01397
23	0.01404	0.01381
24	0.01388	0.01365
25	0.01372	0.01349
26	0.01357	0.01334
27	0.01342	0.01319
28	0.01327	0.01304
29	0.01312	0.01290
30	0.01298	0.01276



(a)

in
mm

... g for sandy soils and approxi-
... .ll and clay soil for particle-size

ple for Soil Constants

ate the remaining portion of the ma-
g the No. 10 (2.00-mm) sieve into
means of a No. 40 (425-µm) sieve.
fraction retained on the No. 40 sieve.
tion passing the No. 40 sieve for the
on of the soil constants.

alidity of any patent rights asserted in connection
ed that determination of the validity of any such
ssibility

mittee and must be reviewed every five years and
for revision of this standard or for additional
receive careful consideration at a meeting of the
ment have not received a fair hearing you should
iladelphia, Pa 19103

Standard Method for PARTICLE-SIZE ANALYSIS OF SOILS[1]

This standard is issued under the fixed designation D 422; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

NOTE—Section 2 was added editorially and subsequent sections renumbered in July 1984.

1. Scope

1.1 This method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 µm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 µm is determined by a sedimentation process, using a hydrometer to secure the necessary data (Notes 1 and 2).

NOTE 1—Separation may be made on the No. 4 (4.75-mm), No. 40 (425-µm), or No. 200 (75-µm) sieve instead of the No. 10. For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided: (1) a high-speed mechanical stirrer, and (2) air dispersion. Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20-µm size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20 µm.

2. Applicable Documents

2.1 *ASTM Standards*

D 421 Method for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

E 100 Specification for ASTM Hydrometers[4]

3. Apparatus

3.1 *Balances*—A balance sensitive to 0.01 g for weighing the material passing a No. 10 (2.00-mm) sieve, and a balance sensitive to 0.1 % of the mass of the sample to be weighed for weighing the material retained on a No. 10 sieve.

3.2 *Stirring Apparatus*—Either apparatus A or B may be used.

3.2.1 Apparatus A shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate not less than ¾ in. (19.0 mm) nor more than 1½ in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

3.2.2 Apparatus B shall consist of an air-jet dispersion cup[5] (Note 3) conforming to the general details shown in Fig. 3 (Notes 4 and 5).

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft³/min; some small air compressors are not capable of supplying sufficient air to operate a cup.

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

Current edition approved Nov. 21, 1963. Originally published 1935. Replaces D 422 – 62.

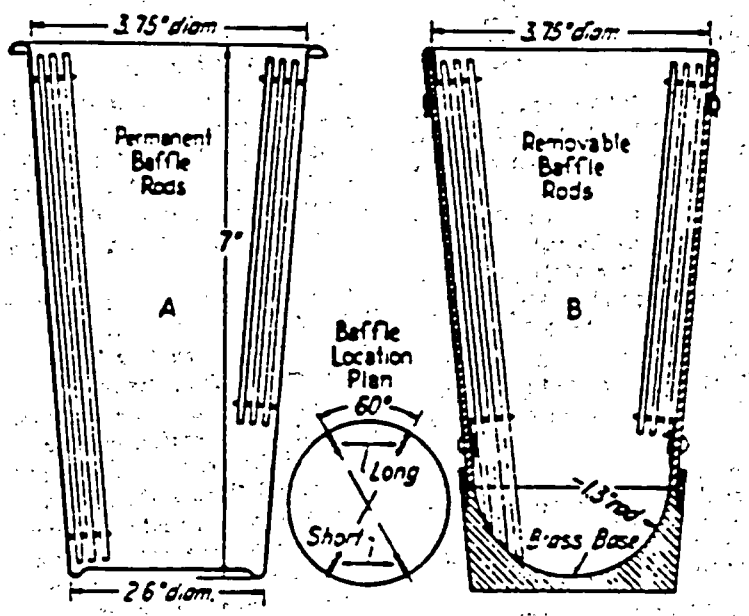
[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 14.01.

[5] Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103. Order Adjunct No. 12-404220-00.

attachment 2



Metric Equivalents

in	1.3	2.6	3.75
mm	33	66	95.2

FIG. 2 Dispersion Cups of Apparatus

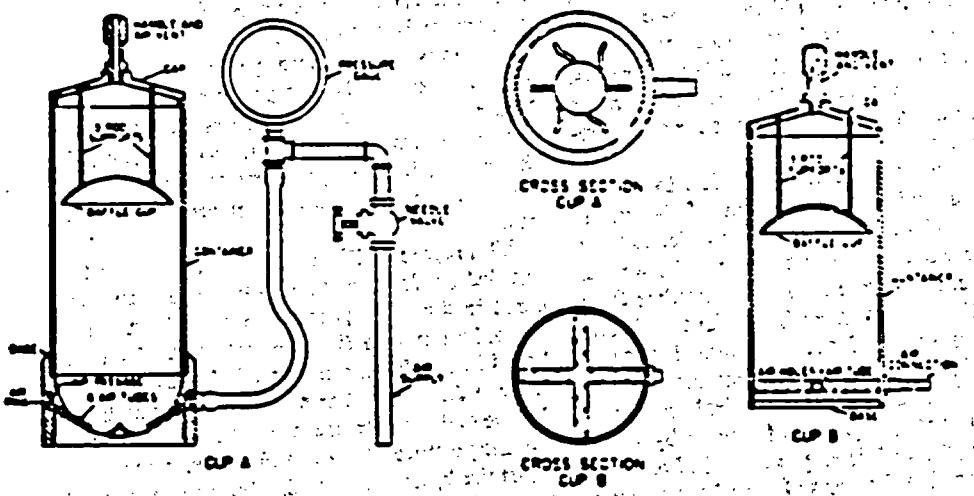


FIG. 3 Air-Jet Dispersion Cups of Apparatus B

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
1 (25.4)	2000
1½ (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

5.2 Provision is made in Section 5 of Method D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm), 2-in. (50-mm), 1½-in. (37.5-mm), 1-in. (25.0-mm), ¾-in. (19.0-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 10 sieves, or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3.1. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

7. Determination of Composite Correction for Hydrometer Reading

7.1 Equations for percentages of soil remaining in suspension, as given in 14.3, are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

7.1.1 Both soil hydrometers are calibrated at 68°F (20°C), and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

7.1.2 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

7.1.3 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

7.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

7.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in a sedimentation cyclinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 151H the composite correction is the difference between this reading and one; for hy-

COMPUTER DATA SHEET FOR GRAIN-SIZE ANALYSIS

TITLE

JOB NUMBER

BORING	SAMPLE	DEPTH ELEV	DATE

LL	PL	GS	OPT	TOTAL WEIGHT	PARTIAL WEIGHT	NAT MC

CLASSIFICATION

REMARKS

SIEVE ANALYSIS

STANDARD SIEVE SIZE OR OPENING	CODE	WEIGHT IN GRAMS
3 IN	C	
2 IN	D	
1-1/2 IN	E	
1 IN	F	
3/4 IN	G	
1/2 IN	I	
3/8 IN	J	
No 3	K	
No 4	L	
No 6	M	
No 10	N	
No 16	O	
No 20	P	
No 30	Q	
No 40	R	
No 50	S	
No 70	T	
No 100	U	
No 140	V	
No 200	W	

HYDROMETER ANALYSIS

NUMBER	DIFFERING COEF.	MENISCUS COEF.

CLOCK TIME	ELAPSED TIME	TEMP C.	PERCENT
	1 MIN		
	2 MIN		
	4 MIN		
	15 MIN		
	30 MIN		
	1 HR		
	2 HR		
	4 HR		
	24 HR		

WEIGHT OF -4 PAN _____

WEIGHT OF -200 PAN _____

Operator: _____

WES Form 2213

over cap on the cup and open
ve until the gage pressure is 20
perse the soil according to the
:.

	Dispersion Period, min
	5
	10
	15

arge percentages of mica need
nly 1 min. After the dispersion
gage pressure to 1 psi prepar-
f soil - water slurry to the sed-
er.

Test

ely after dispersion, transfer the
to the glass sedimentation cyl-
stilled or demineralized water
ume is 1000 mL.
palm of the hand over the open
er (or a rubber stopper in the
the cylinder upside down and
d of 1 min to complete the
urn (Note 11). At the end of 1
e. convenient location and
readings at the following inter-
asured from the beginning of
r as many as may be needed.
sample or the specification for
r test: 2, 5, 15, 30, 60, 250, and
controlled water bath is used,
cylinder should be placed in
the 2- and 5-min readings.

umber of turns during this minute
ately 60, counting the turn upside
o turns. Any soil remaining in the
er during the first few turns should
rous shaking of the cylinder while
osition.

s desired to take a hydrometer
insert the hydrometer about 20
reading is due to approximately
ave when the reading is taken.
ding is taken, carefully remove
and place it with a spinning
ate of clean distilled or demin-

portant to remove the hydrometer
ch reading. Readings shall be taken
eniscus formed by the suspension
since it is not possible to secure
on of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75-μm) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at 230 ± 9°F (110 ± 5°C) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the ⅜-in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the ⅜-in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hygroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W' in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = [(100\,000/W') \times G/(G - G_1)](R - G_1)$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W') \times 100$$

where:

a = correction faction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1).

P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension.

R = hydrometer reading with composite correction applied (Section 7),

W' = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,

G = specific gravity of the soil particles, and

G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for R is based on a value of one for G_1.

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. Accord-

STANDARD TEST METHODS FOR MAXIMUM INDEX DENSITY OF SOILS USING A VIBRATORY TABLE, ASTM-D 4253-83 AND STANDARD TEST METHODS FOR MAXIMUM INDEX DENSITY OF SOILS USING VIBRATORY TABLE, ASTM-D 4253-83

Background: These standard test methods ASTM-D 4253-83 and ASTM-D 4254-83 are similar to the U.S. Army Engineers test procedure "Relative Density" described in appendix XII of EM 1110-2-1906. The procedures need no modification for use in determining the relative densities of crushed tuff for the NNWSI project. It should be noted that the term soils used in the test method will for this project refer to the crushed tuff. Options within each test method selected in advance of the testing are described below:

ASTM-D 4253-83 (Attachment E-1)

Paragraph No.	Description of Options With Changes
1.2	Method 1.A will be used for this testing program. Methods 1.B, 2.A and 2.B will not be used.
11.1.2	Addition to this paragraph. Tape will be placed around the surcharge plate to minimize escape of fines into the atmosphere.
11.1.5	Add to this section that a gasket will be placed between the guide sleeve and the mold to prevent loss of fines. The seam between the sleeve and mold will also be taped to insure a good seal.
11.1.6.2	Deleted as the paragraph pertains to method 2.A.
11.1.10	The second sentence in this paragraph is changed to read: The reweighed mass M_s is determined after the removal of material above and around the surcharge. The mass of the removed material is determined along with the mass of the mold plus the crushed tuff. M_s is determined by subtracting the weight of the mold determined in paragraph 9.2 from the weight of the mold plus the crushed tuff. Relative Density Supplemental Data Sheet will be used to record the above data.
11.2 to 11.2.7	Deleted as these paragraphs pertain to method 2.A and 2.B.

have been retained on the
ot been removed. This mass
percentage retained on the
hus total percentage passing)
he total sample represented
used (as calculated in 14.2),
d by 100.
at the total mass passing the
ogether the fractional masses
ieves, including the No. 10
his sum from the mass of the
ulated in 14.2).
ext the total masses passing
eves, in a manner similar to

st the total percentages pass-
total mass passing (as calcu-
he total mass of sample (as
and multiply the result by

hyd- meter analysis is per-
he results shall be made.
rs of the particles on a loga-
abscissa and the percentages
rresponding diameters to an
the ordinate. When the hy-
not made on a portion of
ion of the graph is optional.
secured directly from tabu-

hall include the following:
size of particles.
passing (or retained on)
y be tabulated or presented
h (Note 16),
of sand and gravel parti-

bunded or angular.
—hard and durable, soft, or

ivity, if unusually high or

ty in dispersing the fraction
2.00-mm) sieve, indicating
and amount of dispersing

ion device used and the
n period.

NOTE 16—This tabulation or graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

(1) Gravel, passing 3-in. and retained on No. 4 sieve %
(2) Sand, passing No. 4 sieve and retained on No. 200 sieve %
  (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve %
  (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve %
  (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve %
(3) Silt size, 0.074 to 0.005 mm %
(4) Clay size, smaller than 0.005 mm %
  Colloids, smaller than 0.001 mm %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.	
2-in.	
1½-in.	
1-in.	
⅜-in.	
⅛-in.	
No. 4 (4.75-mm)	
No. 10 (2.00-mm)	
No. 40 (425-μm)	
No. 200 (75-μm)	

HYDROMETER ANALYSIS

0.074 mm	
0.005 mm	
0.001 mm	

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-μm) sieves may be substituted for No. 10 and No. 40 sieves.

Data Sheet: Relative Density, WES Form No. 728 (Attachment E-3).

Quality Assurance:

(1) Only qualified personnel shall be allowed to perform this work.

(2) Calibration of equipment shall be made as described in test method.

(3) All scales are calibrated by Allometric Balance Systems, Baton Rouge, LA.

(4) Dial gage used for this project will be calibrated using calibration bars traceable to NBS standards.

LE 2 Continued

Hydrometer 152 H			
Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm

depth are calculated from the equation

$L_e = \frac{1}{2}[L_1 - (V_b/A)]$

m.

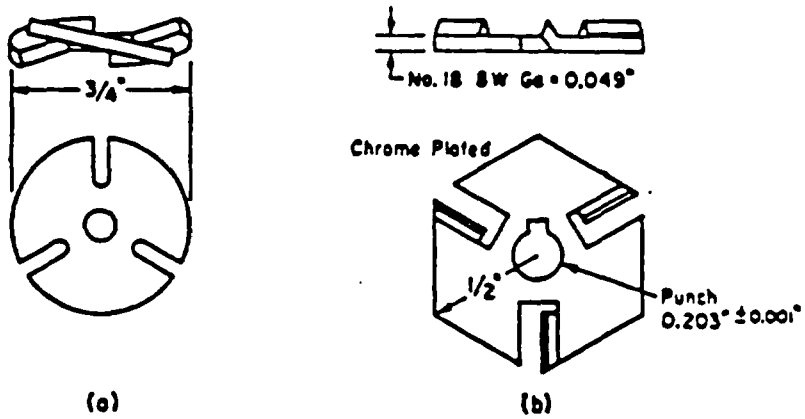
e stem of the hydrometer from the top
e mark for a hydrometer reading, cm
the hydrometer bulb, cm.
meter bulb cm³, and
m of sedimentation cylinder, cm³
ng the values in Table 2 are as follows
1f 1 152H

ding of 1 000
ding of 1.031

ding of 0 g/litre
ding of 50 g/litre

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature, °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149



Metric Equivalents

in	0.001	0.049	0.203	½	¾
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Sorting Paddles

amount of degradation (particle breakdown) of the soil. When degradation occurs, typically there is an increase in the maximum index density obtained, and comparable test results may not be obtained when different size molds are used to test a given soil.

2. Applicable Documents

2.1 *ASTM Standards*

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[7]

D 422 Method for Particle-Size Analysis of Soils[1]

D 653 Terms and Symbols Relating to Soil and Rock Mechanics[1]

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[1]

D 854 Test Method for Specific Gravity of Soils[1]

D 1557 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop[1]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[1]

D 2487 Test Method for Classification of Soils for Engineering Purposes[1]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

D 4254 Test Methods for Minimum Index Density of Soils and Calculation of Relative Density[1]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[8]

E 319 Methods of Testing Single-Arm Balances[8]

E 380 Metric Practice[9]

3. Summary of Methods

3.1 The maximum index density of a given free-draining soil is determined by placing either oven-dried or wet soil in a mold, applying a 2-lb/in.^{2} (14-kPa) surcharge (dead mass) to the surface of the soil, and then vertically vibrating the mold, soil, and surcharge. Use either an electromagnetic, eccentric, or cam-driven vibrating table having a sinusoidal like time-vertical displacement relationship at a double amplitude of vertical vibration (peak-to-peak) of about 0.013 in. (0.33 mm) for 8 min at 60 Hz or about 0.019 in. (0.48 mm) for 10 min at 50 Hz. The maximum index density is calculated by dividing the oven-dried mass of the densified soil by its volume (average height of densified soil times area of mold).

4. Significance and Use

4.1 For many cohesionless, free-draining soils, the maximum index density is one of the key components in evaluating the state of compactness of a given soil mass that is either naturally occurring or placed by man (fill).

4.1.1 Relative density and percent compaction are commonly used for evaluating the state of compactness of a given soil mass. Density index is also sometimes used. See Section 5 for descriptions of terms.

4.2 It is generally recognized that either relative density or percent compaction is a good indicator of the state of compactness of a given soil mass. However, the engineering properties such as strength, compressibility, and permeability of a given soil, compacted by various methods to a given state of compactness can vary considerably. Therefore, considerable engineering judgment must be used in relating the engineering properties of soils to the state of compactness.

4.3 An absolute maximum density is not necessarily obtained by these test methods.

NOTE 2—In addition, there are published data to indicate that these test methods have a high degree of variability.[9] However, the variability can be greatly reduced by careful calibration of equipment, including the vibrating table, and careful attention to proper test procedure and technique.

4.4 The double amplitude of vertical vibration has been found to have a significant effect on the density obtained.[9] For a particular vibrating table and mold assembly, the maximum index density of a given material may be obtained at a double amplitude of vibration other than the double amplitude of 0.013 ± 0.002 in. (0.33 ± 0.05 mm) at a frequency of 60 Hz or 0.019 ± 0.003 in. (0.48 ± 0.08 mm) at 50 Hz required in the method, that is, dry density may initially increase with increasing double amplitude of vibration reach a peak, and then decrease with further increases in double amplitude of vibration. Furthermore, the relationship between the peak density and optimum double amplitude of vibration (double amplitude of vibration where peak density occurred) can vary with various soil types and gradations. For this reason, these methods allow the use of double amplitudes of vibration other than that described above, on special circumstances as provided in 11.1.6.3.

4.5 The use of the standard molds (6.1.1) has been found to be satisfactory for most soils requiring maximum index-density testing. Special molds (6.1.2) shall only be used when the test results are to be applied in conjunction with design or special studies and there is not enough soil to use the standard molds. Such test results should be applied with caution as maximum index densities obtained with the special molds may not agree with those that would be obtained using the standard molds.

5. Descriptions of Terms Specific to This Standard

5.1 *maximum index density*, ρ_{max}—the reference dry density of a soil in the densest state of compactness that can be attained using a standard laboratory compaction procedure that minimizes particle segregation and breakdown.

5.2 *minimum index void ratio*, e_{min}—the reference void ratio of a soil at the maximum index density.

5.3 *minimum index density*, ρ_{min}—the reference dry density of a soil in the loosest state of compactness at which it can be placed using a standard laboratory procedure which prevents bulking and minimizes particle segregation.

5.4 *maximum index void ratio*, e_{max}—the reference void ratio of a soil at the minimum index density.

5.5 *given void ratio*, e—the in situ or stated void ratio of a soil deposit or fill.

5.6 *dry density*, ρ_d—the dry density of a soil deposit or fill at the given void ratio.

5.7 *relative density*, D_R—the ratio, expressed as a percentage, of the difference between the maximum index void ratio and any given void ratio of a cohesionless, free-draining soil; to the difference between its maximum and minimum index void ratios. The equation is as follows:

$$D_R = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

or, in terms of corresponding dry densities,

$$D_R = \frac{\rho_{max}(\rho_d - \rho_{min})}{\rho_d(\rho_{max} - \rho_{min})} \times 100$$

5.8 *percent compaction or relative compaction*, R_c—the ratio, expressed as a percentage, of the dry density of a given soil to its maximum index density. The equation is.

$$R_c = \frac{\rho_d}{\rho_{max}} \times 100$$

5.9 *density index*, I_D—the ratio, expressed as a percentage, of the difference between any given dry density and the minimum index density of a given cohesionless soil to the difference between its maximum and minimum index densities. The equation is:

$$I_D = \frac{\rho_d - \rho_{min}}{\rho_{max} - \rho_{min}} \times 100$$

6. Apparatus

6.1 *Mold Assembly*—An example of a typical mold assembly is shown in Fig. 1. Individual components and accessories shall be as follows:

6.1.1 *Standard Molds*—Cylindrical metal molds having nominal volumes of 0.100 ft^3 (2830 cm^3) and 0.500 ft^3 (14 200 cm^3). The molds shall conform to the requirements shown in Fig. 2. The actual volume of the molds shall be within ±1.5 % of the specified nominal volume.

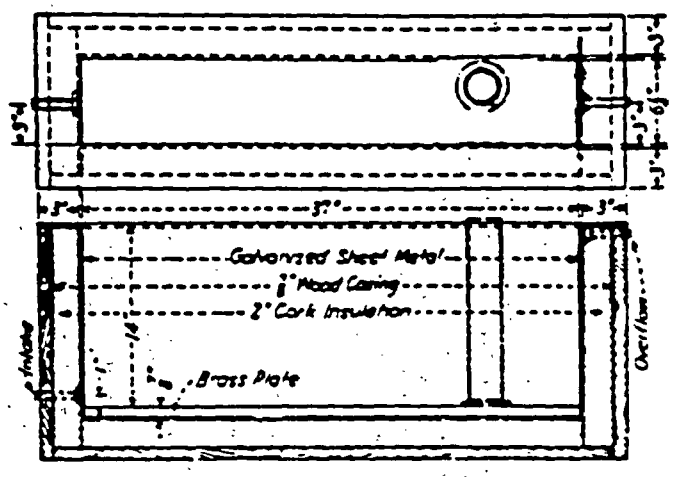
6.1.2 *Special Molds*—Cylindrical metal molds having a capacity less than 0.100 ft^3 (2830 cm^3), an inside diameter equal to or greater than 2¾ in. (70 mm) but less than 4 in. (100 mm) and conforming to the design methodology presented in Fig. 3. Such molds may only be used when the test results are to be used in conjunction with design or other special studies or both, and there is not enough soil to use the 0.100 ft^3 (2830 cm^3) mold.

6.1.3 *Guide Sleeves*—One guide sleeve with clamp assembly, or other suitable attachment devices (see Fig. 4(a)), for each size mold. For easy centering of the guide sleeve above the mold, two of the three set screws on the clamp assembly should be provided with lock nuts.

6.1.4 *Surcharge Base Plates*—One surcharge base plate for each standard size mold, conforming to the requirements of Fig. 5.

6.1.5 *Surcharge Weights*—One surcharge weight for each size mold. See Fig. 5 for inter-

[1] Annual Book of ASTM Standards, Vol 04.08.
[7] Annual Book of ASTM Standards, Vol 04.02.
[8] Annual Book of ASTM Standards, Vol 14.02.
[9] E. J. Yoder and R. B. J. Witczak, "Evaluation of Relative Density and its Role in Geotechnical Projects Involving Cohesionless Soils," STP 523, ASTM, 1973.



Metric Equivalents

in	1/8	1	3	6¼	14	37
mm	22.2	25.4	76.2	158.2	356	940

FIG. 4 Insulated Water Bath

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

not been changed. As required, adjust the dial gage or repetitom the calibration (10.4). Alternatively, a reference bracket (similar to that shown in Fig. 6) may be used and, if required, adjust the dial gage to the reference bracket reading.

10. Calibration

10.1 The following calibrations of test apparatus should be performed before initial use and at intervals not exceeding each 1000 tests, or annually, whichever occurs first.

10.2 *Molds*—Determine the volume of each mold by either the direct measurement method or the water-filling method as provided in 10.2.1 and 10.2.2. The volume obtained by either method should be within ± 1.5 % of the nominal value. It is recommended that both the direct-measurement and water-filling methods be used. If the difference between the volumes calculated from the two methods exceeds 0.5 % of the nominal value of the mold being calibrated, then the calibration should be repeated. Failure to obtain agreement between the two calibration methods within the stated tolerances, even after several trials, is an indication that the mold is badly deformed and should be replaced. If both calibration methods are performed, the volume obtained by the water-filling method should be assigned to the mold (as this method more accurately reflects the conditions over the entire mold).

10.2.1 *Direct Measurement Method*—The volume of the mold is calculated from the average of at least three internal diameter and three height measurements, evenly spaced throughout the mold, made to the nearest 0.001 in. (0.025 mm). Calculate and record the cross-sectional area, A_m, (ft² or cm²) and volume, V_m, (ft³ or cm³) to four significant digits (in accordance with Practice E 380).

10.2.2 *Water-Filling Method*—Completely fill the mold with water. Slide a glass plate carefully over the top surface (rim) of the mold as to ensure that the mold is completely filled with water. A thin film of grease or silicone lubricant on the rim of the mold will make a watertight joint between the glass plate and rim of the mold. Determine the mass and temperature of the water required to fill the mold. The temperature should be determined to the nearest degree Celsius. The mass of the water must be determined to at least the nearest 0.01 lb (5 g) for the 0.100 ft³ (2830 cm³) mold and to the nearest 0.1 lb (50 g) for the 0.500 ft³ (14 200 cm³) mold. From Table 2 obtain the unit volume of water in milliliters per gram at the observed temperature. Calculate and record the volume of the mold (ft³ or cm³) to the appropriate number of significant digits as follows:

10.2.2.1 *For mass measurements in grams*, the calculated volume in cubic feet is obtained by multiplying the mass of water, in grams, used to fill the mold by the unit volume of water, from Table 2, and dividing the result by 28 320 mL/ft³.

10.2.2.2 *For mass measurements in pounds*, the calculated volume in cubic feet is obtained by multiplying the mass of water, in pounds, used to fill the mold by the unit volume of water, from Table 2, and dividing the result by 62.41 lb/ft³.

10.2.2.3 To convert the calculated volume in cubic feet to cubic centimeters multiply 28 320.

10.2.2.4 If only the water-filling method is used to determine the volume of the mold, then the cross-sectional area of the mold must be calculated by dividing its measured volume (10.2.2) by its measured height (10.2.1).

10.3 *Surcharge-Base Plate*—Calculate and record the average thickness of the surcharge base plate (t_p) to the nearest 0.001 in. (0.025 mm) from at least four measurements using a vernier or micrometer caliper.

10.4 *Initial Dial Reading*—This value may be obtained using the calibration bar, as provided in 10.4.1 or without the bar, as provided in 10.4.2, if the contact area between the mold guide bracket and the collar of the dial gage holder (Figs. 2 and 4) has been machined level or made level by the use of brass inserts.

10.4.1 *Initial Dial Reading with Calibration Bar*—Determine the thickness of the calibration bar to 0.001 in. (0.025 mm) using a micrometer. Place the calibration bar across a diameter of the mold along the axis of the guide brackets. Insert the dial-indicator gage holder on each of the guide brackets on the mold with the dial gage stem on top of the calibration bar and on the axis of the guide brackets. The dial gage holder should be placed in the same position in the guide brackets each time by notches or marks on the guide brackets and the holder. Obtain six dial indicator readings, three on each the left and the right sides, and average these six readings. To compute the initial dial reading, R_o, for clockwise reading dial indicators, subtract the thickness of the calibration bar from the average of the six dial indicator readings. To compute counterclockwise reading dial indicators, R_o, add the thickness of the calibration bar to the average of the six dial indicator readings.

10.4.2 *Initial Dial Reading Without Calibration Bar*—Insert the dial indicator gage holder in each of the guide brackets with the dial gage stem in contact with the rim of the mold (at its center) on both sides of the guide brackets. Obtain six sets of dial indicator readings, three on each side of each guide bracket. The average of these twelve readings is the initial dial gage reading, R_o.

10.5 *Vibrating Table*—The calibration shall consist of determining, under simulated test conditions and for each mold size being used, the required rheostat, eccentric, or cam setting for the electro-magnetic, eccentric, or cam-driven table, respectively, such that the mold has a double amplitude of vertical vibration of 0.013 ± 0.002 in. (0.33 ± 0.05 mm) at 60 Hz or 0.019 ± 0.003 in. (0.48 ± 0.08 mm) at 50 Hz. The double amplitude of vibration should be measured on the mold to the nearest 0.0005 in. (0.015 mm). It is recommended that during each calibration a relationship between the double amplitude of vertical vibration versus the rheostat, eccentric, or cam setting be established.

10.5.1 While there are many different equipment configurations that can be used to measure the double amplitude of vibration, it is not easily measured unless one has considerable experience. Typical calibration procedure and equipment requirements have been given in the *Geotechnical Testing Journal*.*

10.5.2 In addition to the calibration frequency recommended in 10.1, the vibrating table should also be calibrated before reuse after any event (including repairs) which might affect its operation and whenever the test results are questionable.

11. Procedure

11.1 *Dry Method*—Method 1.A or 2.A.

11.1.1 Mix the oven-dried sample to provide as even distribution of particle sizes; that is, having as little segregation as possible.

11.1.2 Fill the mold with soil and level the surface of the soil, using methods that minimize segregation. A scoop or pouring device (funnel) should be used to place the soil in the mold. The sides of the mold may be struck a few times using a metal bar, rubber hammer, or similar item to settle the soil so that the surcharge base plate can be easily placed into position and there is no surge of air from the mold when vibration is initiated.

NOTE 5—If the maximum index density is also being performed, the soil shall be placed in accordance with the appropriate method specified in Methods D 4254. The mass of the mold plus soil shall also be determined and recorded.

11.1.3 Place the appropriate surcharge base plate on the surface of the soil and twist it slightly several times so that it is firmly and uniformly in contact with the surface of the soil. Remove the surcharge base plate handle.

11.1.4 Attach the mold to the vibrating table.

11.1.5 Firmly attach the guide sleeve to the mold and lower the appropriate surcharge weight onto the surcharge base plate.

11.1.6 Setting for double amplitude of vibration.

11.1.6.1 *Method 1.1*—Set the vibrator control (rheostat) at the setting determined in 10.5 for the mold assembly being used to obtain a double amplitude of vertical vibration of 0.013 ± 0.002 in. (0.33 ± 0.05 mm) at 60 Hz or 0.019 ± 0.003 in. (0.48 ± 0.08 mm) at 50 Hz.

11.1.6.2 *Method 2.1*—Set the eccentric or cam at the setting determined in 10.5 for the mold assembly being used to obtain a double amplitude of vertical vibration of 0.013 ± 0.002 in. (0.33 ± 0.05 mm) at 60 Hz or 0.019 ± 0.003 in. (0.48 ± 0.08 mm) at 50 Hz.

11.1.6.3 As stated in 4.4, there is a relationship between density and double amplitude of vibration, and the peak density occurs at an optimum double amplitude of vibration which may not be the same as the maximum index density obtained at the double amplitude of vibration prescribed in 11.1.6.1 and 11.1.6.2. Therefore, this method allows the use of a double amplitude of vertical vibration other than those prescribed in 11.1.6.1 or 11.1.6.2 if the following conditions are met:

11.1.6.3.1 Test results are to be used in con-

* Kochanov, E. P., Strickland, F. A., and Bonaparte, A. A., "Suggested Method for the Calibration of Vibrating Tables for Maximum Index Density Testing," *Geotechnical Testing Journal*, GTJODJ, Vol 2, No. 3, Sept 1979, pp. 152-157.

D 4253

SOILS TESTING FACILITY (GEOTECHNICAL LABORATORY) TEST PROCEDURE

RELATIVE DENSITY (Modification A)

This document describes the test procedures for use to determine the Maximum and Minimum Index Densities of Crushed Tuff, Nevada Nuclear Waste Storage Investigations Project. Modifications to the original test procedure were made as follows:

Modification A: 20 May 1986 (See paragraph 11.1.2, 11.1.5, 11.1.10, 12.1, 9.2.3.1 and "Relative Density Supplemental Data Sheet.")

Approved By:

PROJECT LEADER	2 June 86 DATE
SOILS TEST FACILITY CHIEF	2 Jun 86 DATE
QA OFFICER	2 Jun 86 DATE
PROJECT MANAGER, SNL	9/14/86 DATE

11.1.4 Double amplitude of vertical vibration used if different from that specified in 11.1.6.1 or 11.1.6.2.

11.1.5 The maximum index density, ρ_{max}, in lb/ft³ (kg/m³) to three significant digits (in accordance with Practice E 380).

11.1.6 Any abnormalities such as loss of material, segregation, excessive tilting of base plate, etc.

14. Precision and Accuracy

14.1 Criteria for judging the acceptability of maximum-index density test results are given in Table 3.

14.1.1 *Variations Between Laboratories (Reproducibility)*

14.1.1.1 The standard deviation, S, is calculated from the equation:

$$S^2 = \frac{1}{N-1}\sum_{i}^{N}(x_i - A)^2$$

where:

N = number of determinations,
x_i = individual value of each determination, and
A = numerical average of the determinations.

14.1.2 *Variations Between Duplicate Tests (Repeatability)*

14.1.2.1 The combined standard deviation, S^c, is calculated from the equation:

$$S^{c2} = \frac{1}{2K}\sum D^2$$

where:

D = difference between duplicate tests and
K = number of pairs of duplicate tests.

TABLE 1 Required Mass of Specimen

Maximum Size of Sand Particle in Sample	Mass of Specimen to be Required, lb (kg)	Size of Mold to be Used, ft³ (m³)
3 (75)	25 (11)	0.500 (0.014 200)
[illegible]	25 (11)	0.500 (0.014 200)
[illegible]	25 (11)	0.100 (0.028 3)
[illegible]	25 (11)	0.100 (0.028 3)
No. 4 (4.75) or less	25 (11)	0.100 (0.028 3)

TABLE 2 Volume of Water per Gram Based on Temperature[A]

Temperature °F	Temperature °C	Volume of Water, mL/g
32	0.0	1.000 040
34	1.1	1.000 071
36	2.2	1.000 103
38	3.3	1.000 136
40	4.4	1.000 172
42	5.5	1.000 210
44	6.6	1.000 250
46	7.8	1.000 290
48	8.9	1.000 333
50	10.0	1.000 377
52	11.1	1.000 423

[A] Values other than shown may be obtained by referring to the *Handbook of Chemistry & Physics*, Chemical Rubber Publishing Co., Cleveland, Ohio.

TABLE 3 Precision of Maximum-Index Density Test Results[A]

	Standard Deviation, S, lb/ft³ (kg/m³)	Combined Standard Deviation, S^c, lb/ft³ (kg/m³)	Acceptable Range of Two Results Expressed as Percent of Mean Value[B]
Modified-density gravel			
fine to medium sands	0.14 (0.38)		81
gravelly sands	0.43 (0.72)		110
Single-operator gravel			
fine to medium sands		0.08 (0.13)	33
gravelly sands		0.14 (0.22)	41

[A] All values shown in this table are based on average test results on a limited variety of different soils of nominal 3-in. and any subject to human error.

[B] This column indicates a limiting range of values that shall not be exceeded by the difference between any two results, expressed as a percentage of the average value. Approximately 95% of the test results from the comparative test programs do not exceed the limiting acceptable ranges shown (assuming normally distributed data).

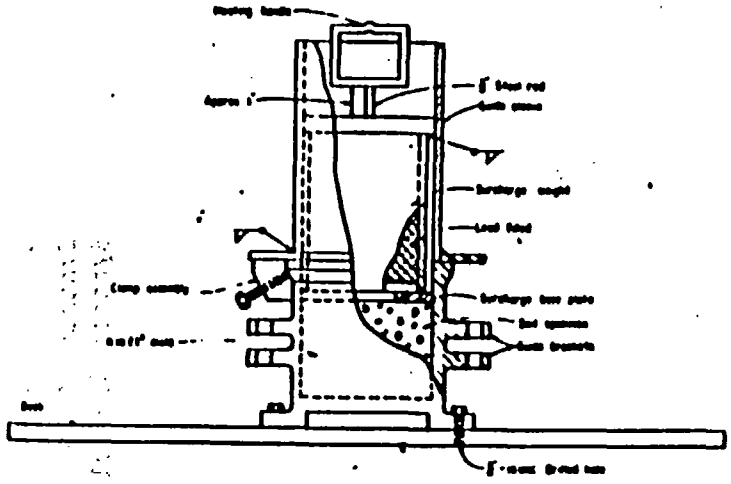


FIG. 1 Schematic Drawing of a Typical Mold Assembly

12.1 Definition of M_s is modified to say M_s = mass of the dry specimen, (kg), as determined by reweighing the mold following vibration and removal of material above and around the surcharge.

ASTM-D 4254-83 (Attachment E-2).

1.2 Method A will be used for this testing program. Method B and C will not be used.

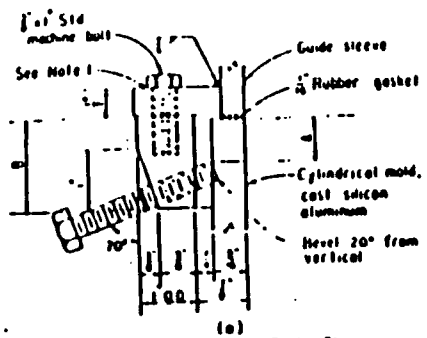
6.3.5 to 6.4.3 Deleted as these paragraphs pertain to methods B and C.

9.2.3.1 The surface preparation technique will be changed to reflect the technique described in EM-1110-2-1906, Appendix XII, for relative density determination, Paragraph 5.a.4. The method described in the EM-1110-2-1906 is better suited for the materials used in the current testing program where an abundance of fines is present.

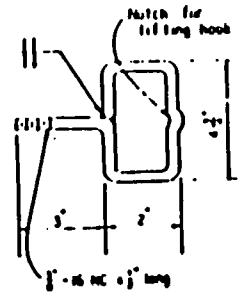
9.3 to 9.4.3 Deleted as these paragraphs pertain to methods B and C.

Test Equipment Listing:

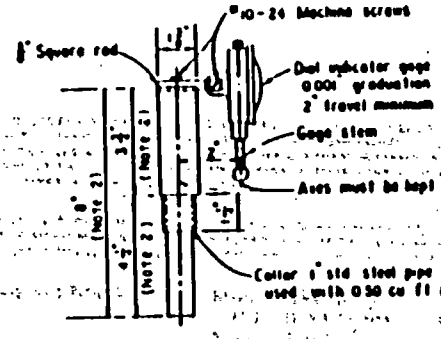
Equipment	Model No.	Serial No.
Scale	Mettler PS-30	79 1037
Vibrating Table	Syntron VB240	31 24 69
Dial Gage	Syntron Controller G4	B 5 4409



(a)
Typical Clamp Assembly for Guide Sleeve for Guided Surcharge Weights.



(b)
Surcharge Base Plate Handle
(1 Required)



(c)
Holder for Dial Indicator Gage

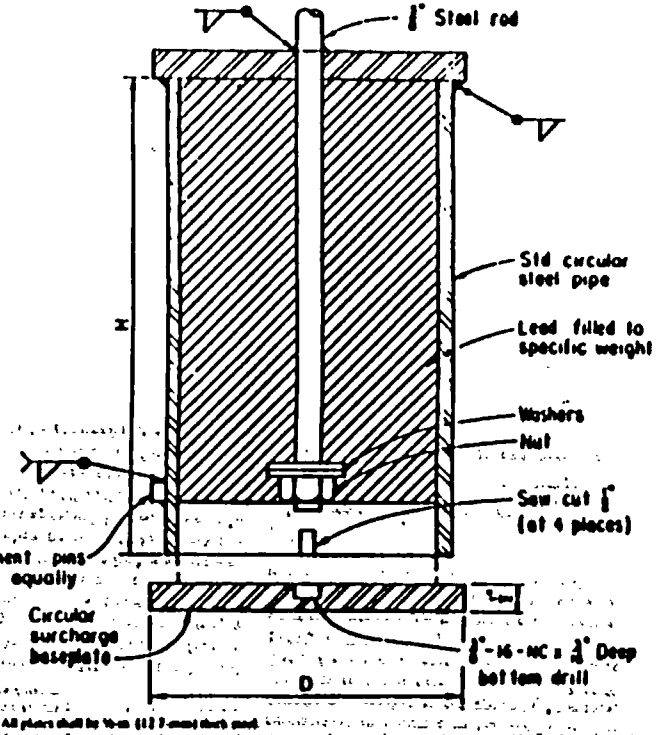
Note 1—This piece shall be a section (3 by 3 in (76 by 76 mm)) of a length necessary to position the sides and downward from the crown of the guide sleeve. Weld three clamp assemblies to the guide sleeve at equal spacing.

Note 2—These dimensions may be changed to fit the dial gage sides and used.

Note 3—Dimensions are in inches (mm) unless otherwise noted.

Size Mold ft³ (m³)	A in (mm)	B in (mm)	Guide Sleeve
[illegible]	[illegible]	[illegible]	Steel tubing, [illegible] in (150 mm) [illegible] in (6.4 mm) wall, [illegible] in long ([illegible] mm)
[illegible]	[illegible]	[illegible]	Steel pipe, [illegible] in (200 mm) [illegible] in (9.5 mm) wall, [illegible] in (200 mm) long

FIG. 4 Details of Apparatus (Components)



Note 1—All plates shall be [illegible] (12.7-mm) thick steel.

Note 2—Lap plates for weights may be notched, but edges must be ground as smooth as practicable. Surcharge base plates must be machined to the specified diameter.

Note 3—Housing handles shall have the same shape as the surcharge base plate handle (See Fig. 4 (b)).

Size Mold ft³ (m³)	D in (mm)	H in (mm)	Standard Pipe, in (mm)	Total Weight Required lb (kg)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FIG. 5 Circular Surcharge Weight and Base Plate

11.1.1.2 Place the entire batch in the mold and spade the mixture vigorously with a spatula or a trowel 15 times around the perimeter and 10 times over the interior.

11.1.1.3 Remove the collar and smooth the surface to a slightly rounded shape.

11.1.1.4 Replace the collar and place the mold assembly on the compaction pedestal in the mold holder and apply 50 blows with the compaction hammer.

11.1.1.5 Remove the mold from the mold assembly, invert, and replace it.

11.1.1.6 Apply 50 blows with the compaction hammer to the face of the inverted specimen.

11.1.1.7 Remove the specimen from the mold by means of an extrusion jack or other device and place on a smooth flat surface. The number of blows may be varied depending upon intended service, or as called for in the method to be used subsequently.

11.1.2 *Number of Specimens*—For emulsified asphalt mixtures, the specimens can be prepared by the above procedure over a range of fluid contents for each of the trial mixes, provided that the mixing fluid content is first used to prepare the mix and a reduction in fluid content is accomplished by controlled evaporation of water. The number of specimens of any given proportion of soil, asphalt, water are to be as required in the method to be used. For cutback asphalt mixtures, the specimens can be fabricated for each of the trial mixes in the numbers required in the method to be used.

12. Report

12.1 *Soil*

12.1.1 Results of wash and grading analysis on Sieve Nos. 4, 8, 1[illegible] 100 and 200.

12.1.2 Oil ratio value, centrifuge kerosene equivalent test.

12.2 *Emulsified Asphalt*—All soil emulsified asphalt specimens fabricated by the procedures of 10.1 and 11.1 shall have the following information reported:

12.2.1 Emulsified asphalt content as percent of dry mass (weight) of soil.

12.2.2 Mixing fluids content (emulsified asphalt content plus water content plus added water content) as percent of dry mass (weight) of soil.

12.2.3 Compaction fluids content (after aeration and immediately prior to compaction) as percent of dry soil.

12.2.4 Number of tamps in kneading compactor or on Marshall compactor.

12.2.5 Static pressure and, if applicable, time to exudation.

12.2.6 Height of specimen to nearest 0.01 in. (0.2 mm), and

12.2.7 Dry unit mass (weight) of compacted specimen to nearest 0.10 lb/ft³ (16 kg/m³).

12.3 *Cutback Asphalt*—All soil cutback asphalt specimens fabricated by the procedures of 10.2 or 11.1 shall have the following information reported:

12.3.1 Cutback asphalt content added to soil as percent of dry mass (weight) of soil.

12.3.2 Loss in mass (weight) during oven curing as percent of dry mass (weight) of soil.

12.3.3 Number of tamps in kneading compactor or in Marshall compactor.

12.3.4 Height of specimen to the nearest 0.01 in. (2 mm), and

12.3.5 Unit mass (weight) to the nearest 0.10 lb/ft³ (16 kg/m³).

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

(attached 1)

Standard Test Methods for MAXIMUM INDEX DENSITY OF SOILS USING A VIBRATORY TABLE[1]

This standard is issued under the fixed designation D 4253; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

These test methods have been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 These test methods cover the determination of the maximum index density of cohesionless, free-draining soils using a vertically vibrating table.

1.2 Four alternative procedures are provided to determine the maximum index density, as follows:

Method 1.A Using oven-dried soil and an electromagnetic, vertically vibrating table.

Method 1.B Using wet soil and an electromagnetic, vertically vibrating table.

Method 2.A Using oven-dried soil and an eccentric or cam-driven, vertically vibrating table.

Method 2.B Using wet soil and an eccentric or cam-driven vertically vibrating table.

1.3 The test method to be used should be specified by the individual assigning the test.

1.3.1 The type of table to be used (Method 1 or 2) is likely to be decided based upon available equipment.

NOTE 1—There is considerable evidence to show that electromagnetic tables yield slightly higher values of maximum index density.

1.3.2 It is recommended that both the dry and wet methods (Methods A and B) be performed when beginning a new job or encountering a change in soil types, as the wet method can yield significantly higher values of maximum index density for some soils. Such a higher maximum index density, when considered along with the maximum index density, will be found to significantly affect the value of the relative density (5.7) calculated for a soil encountered on the field. While the dry method is often preferred because results can usually be obtained more quickly, as a general rule the wet method should be used if it is established that it produces maximum index densities that would significantly affect the use/application of the value of relative density.

1.4 These test methods are applicable to soils in which 100 %, by dry weight, of soil particles pass a 3-in. (75-mm) sieve and which may contain up to 15 %, by dry weight, of soil particles passing a No. 200 (75-µm) sieve, provided they still have cohesionless, free-draining characteristics; and 30 %, by dry weight, of soil particles retained on a 1½-in. (37.5-mm) sieve (Nominal sieve dimensions are in accordance with Specification E 11).

1.4.1 Soils, for the purpose of these test methods, shall be regarded as naturally occurring cohesionless soils, processed particles, or composites or mixtures of natural soils, or mixtures of natural and processed particles, provided they are free draining.

1.5 These methods will typically produce a higher maximum dry density for cohesionless, free-draining soils than that obtained by impact compaction in which a well-defined moisture-density relationship is not apparent. However, for some soils containing between 5 and 15 % fines, the use of impact compaction (Methods D 698 or D 1557) may be useful in evaluating what is an appropriate maximum index density.

1.6 For many types of free-draining, cohesionless soils, these methods cause a moderate

[1] These test methods are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.01 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved May 27, 1983. Published July 1983.

Standard Test Methods for MINIMUM INDEX DENSITY OF SOILS AND CALCULATION OF RELATIVE DENSITY[1]

This standard is issued under the fixed designation D 4254; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

These test methods have been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 These test methods cover the determination of the minimum index density of cohesionless, free-draining soils.

1.2 Three alternative procedures are provided to determine the minimum index density, as follows:

Method A Using a funnel pouring device or a hand scoop to place material in mold

Method B Depositing material into a mold by contacting a soil filled tube.

Method C Depositing material by inverting a graduated cylinder

1.3 The test method to be used should be specified by the individual assigning the test. If no test method is specified, the provisions of Method A shall govern. Method A is the preferred procedure for determining minimum index density as used in conjunction with the procedures of Test Methods D 4253. Methods B and C are provided for guidance of testing used in conjunction with special studies especially where there is not enough material available to use a 0.100 ft³ (2830 cm³) or 0.500 ft³ (14 200 cm³) mold as required by Method A.

1.4 These test methods are applicable to soils that may contain up to 15 %, by dry weight, of soil particles passing a No. 200 (75 µm) sieve, provided they still have cohesionless, free-draining characteristics (Nominal sieve dimensions are in accordance with Specification E 11).

1.4.1 Method A is applicable to soils in which 100 %, by dry weight, of soil particles pass a 3-in. (75-mm) sieve and which may contain up to 30 %, by dry weight, of soil particles retained on a 1½-in. (37.5-mm) sieve.

1.4.2 Method B is applicable to soils in which 100 %, by dry weight, of soil particles pass a ⅜-in. (9.5-mm) sieve.

1.4.3 Method C is applicable only to fine and medium sands in which 100 %, by dry weight, of soil particles pass a ⅜-in. (9.5-mm) sieve and which may contain up to 10 %, by dry weight, of soil particles retained on a No. 10 (2.00-mm) sieve.

1.4.4 Soils, for the purposes of these test methods, shall be regarded as naturally occurring cohesionless soils, processed particles, or composites or mixtures of natural soils, or mixtures of natural and processed particles, provided they are free-draining.

2. Applicable Documents

2.1 *ASTM Standards*

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[2]

D 422 Method for Particle-Size Analysis of Soils[3]

D 653 Terms and Symbols Relating to Soil and Rock Mechanics[3]

D 854 Test Method for Specific Gravity of Soils[3]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[3]

D 2487 Test Method for Classification of Soils for Engineering Purposes[3]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[3]

D 4253 Test Method for Maximum Index Density of Soils Using a Vibratory Table[3]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]

E 319 Methods of Testing Single Arm Balances[4]

E 380 Metric Practice[4]

3. Summary of Methods

3.1 The minimum index density represents the loosest condition of a cohesionless, free-draining soil that can be attained by a standard laboratory procedure, which prevents bulking and minimizes particle segregation. Any particular procedure selected will consist of determining the density of oven-dried soil placed into a container of known volume in such a manner that prevents bulking and particle segregation, and minimizes compaction of the soil.

4. Significance and Use

4.1 The density of a cohesionless soil may be determined by various in-place methods in the field or by the measurement of physical dimensions and masses by laboratory soil specimens. The dry density of a cohesionless soil does not necessarily, by itself, reveal whether the soil is loose or dense.

4.2 Relative density expresses the degree of compactness of a cohesionless soil with respect to the loosest and densest conditions as defined by standard laboratory procedures. Only when viewed against the possible range of variation, in terms of relative density, can the dry density be related to the compaction effort used to place the soil in a compacted fill or indicate volume change and stress-strain tendencies of soil when subjected to external loading.

4.3 An absolute minimum density is not necessarily obtained by these test methods.

NOTE 1—In addition, there are published data to indicate that these test methods may have a high degree of variability.[5] However, the variability can be greatly reduced by careful calibration of equipment and careful attention to proper test procedure and technique.

4.4 The use of the standard molds (6.3.1) has been found to be satisfactory for most soils requiring minimum index density testing. Special molds (6.3.2) shall only be used when the test results are to be applied in conjunction with design or special studies and there is not enough soil to use the standard molds. Such test results should be applied with caution as minimum index densities obtained with the special molds may not agree with those that would be obtained using the standard molds.

5. Descriptions of Terms Specific to This Standard

5.1 *minimum index density*, ρ_{min}—the reference dry density of a soil in the densest state of compactness that can be attained using a standard laboratory compaction procedure that minimizes particle segregation and bulking.

5.2 *minimum index void ratio*, e_{min}—the reference void ratio of a soil at the minimum index density.

5.3 *maximum index density*, ρ_{max}—the reference dry density of a soil in the loosest state of compactness in which it can be placed using a standard laboratory procedure that prevents bulking and minimizes particle segregation.

5.4 *maximum index void ratio*, e_{max}—the reference void ratio of a soil at the maximum index density.

5.5 *given void ratio*, e—the in situ or stated void ratio of a soil deposit or fill.

5.6 *dry density*, ρ_d—the dry density of a soil deposit or fill at the given void ratio.

5.7 *relative density*, D_R—the ratio, expressed as a percentage, of the difference between the maximum index void ratio and any given void ratio of a cohesionless, free-draining soil to the difference between its maximum and minimum index void ratios. The equation is:

$$D_R = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

or, in terms of corresponding dry densities:

$$D_R = \frac{\rho_{max}(\rho_d - \rho_{min})}{\rho_d(\rho_{max} - \rho_{min})} \times 100$$

5.8 *density index*, I_D—the ratio, expressed as a percentage, of the difference between any given dry density and the minimum index density of a given cohesionless soil to the difference between its maximum and minimum index densities. The equation is:

$$I_D = \frac{\rho_d - \rho_{min}}{\rho_{max} - \rho_{min}} \times 100$$

[1] These test methods are under the jurisdiction of ASTM Committee D-18 on Soil and Rock, and is the direct responsibility of Subcommittee D18.03 on General Properties, Classification and Identification of Soils.

[2] Annual Book of ASTM Standards, Vol 04.02

[3] Annual Book of ASTM Standards, Vol 04.08

[4] Annual Book of ASTM Standards, Vol 14.02

[5] E. T. Selig and B. S. Ladd, eds., Evaluation of Relative Density and its Role in Geotechnical Projects Involving Cohesionless Soils, ASTM STP 523, Am. Soc. Testing Mats., 1973.

(AR, Amd 2)

ances related to the 0.100-ft³ (2830-cm³) and 0.500-ft³ (14 200-cm³) molds. For special molds, similar tolerances should be maintained. The total mass of the surcharge base plate and surcharge weight shall be equivalent to a surcharge pressure of 2.00 ± 0.02 lb/in.² (13.8 ± 0.1 kPa) for the mold being used. For special molds the surcharge weight can be composed of a single solid mass of metal.

6.1.6 *Surcharge Base Plate Handle*—A device used to initially place and then to remove the surcharge base plate upon completion of densification. An example of such a handle is given in Fig. 4(b); however, any convenient hooking device may be used.

6.2 *Dial Indicator Gage Holder and Dial Indicator*—A device used in conjunction with the guide brackets, to measure the difference in elevation between the top surfaces of the mold and surcharge base plate after densification (Fig. 4(c)). The dial indicator shall have a 2-in. (50-mm) or greater travel, with 0.001-in. (0.025-mm) graduations and mounted so that the dial stem is parallel with the vertical axis of the mold. The dial indicator may be of the clockwise-movement type where the dial pointer reads zero when the stem is extended, or of the counterclockwise type where the dial pointer reads zero when the stem is all the way in.

6.3 *Balance(s)*, of sufficient capacity to determine the total mass of the specimen and mold, having sufficient accuracy that the mass of the soil is determined to the nearest 0.1 %. Examples of balances capable of satisfying these requirements for most conditions have specifications as follows:

6.3.1 For 0.500-ft³ (14 200-cm³) molds, use a platform or similar balance of at least 40-kg capacity, readable to 5 g, having a precision (standard deviation) of 0.02 % of the test load, and an accuracy of 0.05 % of the test load at any point between 10 kg and capacity.

6.3.2 For 0.100-ft³ (2830-cm³) molds, use a platform or similar balance of at least 15-kg capacity, readable to 1 g, having a precision (standard deviation) of 0.02 % of the test load, and an accuracy of 0.05 % of the test load at any point between 2 kg and capacity.

6.3.3 For special molds, use a balance of at least 20000-g capacity, readable to 0.1 g, having a precision (standard deviation) of 0.02 % of the test load, and an accuracy of 0.05 % of the test load at any point between 200 g and capacity.

NOTE 1—See [illegible] 119 for explanations of terms relating to balance performance. Additional standards for evaluating the performance of balances are being prepared by ASTM Subcommittee E 41.06 on Weighing Devices.

6.4 *Hoist*—A rope, chain, or cable hoist of at least 300-lb (136-kg) capacity when either the 0.100-ft³ (2830-cm³) or 0.500-ft³ (14 200-cm³) size molds are being used.

6.5 *Drying Oven*, thermostatically controlled, preferably of the forced draft type, capable of maintaining a uniform temperature of 230 ± 9°F (110 ± 5°C) throughout the drying chamber.

6.6 *Sieves*, 3-in. (75-mm), 1½-in. (37.5-mm), ¾-in. (19-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 200 (75-µm) sieves conforming to the requirements of Specifications E 11.

6.7 *Calibration Bar*, metal, about 3 by 12 by ⅜-in. (75 by 300 by 6-mm) (optional) (see 10.4).

6.8 Other equipment such as mixing pans, a large metal scoop, a hot bristled drying brush, a timing device indicating minutes and seconds, a micrometer with at least a 1-in. (25-mm) travel and with 0.001-in. (0.025-mm) graduations, and a metal straight edge (for trimming excess soil after it has been placed in the mold, if the maximum index density by Methods D 4254 is being determined).

6.9 *Vibrating Table*, shall be mounted to a concrete floor or mass of sufficient size and configuration that excess vibrations are not transmitted to other testing areas. The vertically vibrating deck of the table shall be of sufficient size and rigidity that the mold assembly being used can be attached and rigidly supported during the test. The table shall be capable of vertically vibrating the mold assembly with a sinusoidal time-vertical displacement relationship at an average double amplitude (peak-to-peak displacement) of 0.011 ± 0.002 in. (0.13 ± 0.05 mm) at a frequency of 60 Hz or 0.019 ± 0.001 in. (0.48 ± 0.08 mm) at 50 Hz under test conditions. The table shall have the capability for adjustment of the frequency of vibration (between about 0 to 60 Hz) or double amplitude of vibration, or both, between about 0.005 in. (0.13 mm) and 0.013 in. (0.33 mm) at 60 Hz or about 0.007 in. (0.20 mm) and 0.019 in. (0.48 mm) at 50 Hz for use with Methods 1 B and 2 B (11.2.3). The table shall have the capability for adjustment of the double amplitude of vibration between about 0.008 in. (0.20 mm) and 0.025 in. (0.64 mm) at 60 Hz or about 0.012 in. (0.30 mm) and 0.036 in. (0.91 mm) at 50 Hz for use in conjunction with design or other special studies (11.1.6.3).

6.9.1 Use one of the following table types:

6.9.1.1 *Electromagnetic Vibrating Table*—A steel table conforming to the requirements of 6.9 with a vertically vibrating, cushioned steel deck generally about 30 by 30 in. (760 by 760 mm), actuated by an electromagnetic vibrator of the solid impact type with a net mass over 100 lb (45 kg). The table shall be mounted to a concrete floor or slab of mass weighing about 1000 lb (450 kg).

6.9.1.2 *Electric or Cam-Driven Vibrating Table*, conforming to the requirements of 6.9. The mass required to support cam-driven tables and eliminate vibrations to other areas may be as large as 10 000 lb (4500 kg).

NOTE 4—See Footnote 5 for examples of electromagnetic and cam-driven vibratory tables.

7. Precautions

7.1 *Safety Precautions*—Use of vibratory tables in certain acoustic environments may produce noise levels above those considered acceptable. In areas where such conditions are known to exist or where acoustic monitoring surveys have not been conducted, suitable hearing protection devices shall be used. In addition, testing personnel should also adhere to any additional personal safety requirements in accordance with individual laboratory policies.

8. Sampling and Test Specimen

8.1 Prior to testing,[7] the sample should be stored in a manner to prevent freezing, contamination with other matter, loss of soil, or loss of identification.

8.2 The required size of the test specimen and mold is a function of the maximum particle size contained in the sample and the particle-size distribution (gradation) of the sample (see Table 1).

8.2.1 Using a visual method or Method D 422 (depending upon the complexity of the gradation of the sample and operator experience), determine the percentage of particles retained on the 3-in. (75-mm), 1½-in. (37.5-mm), ¾-in. (19.0-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 200 (75-µm) sieves.

8.2.2 The determination of the maximum index density should [illegible] performed in accordance with this test [illegible] unless the requirements of 1.4 are met. If these conditions are met, then the mold size and specimen mass required can be determined according to the maximum particle size as presented in Table 1.

8.2.3 When it is applicable to use special molds, 100 % of the sample shall pass the ¾-in. (19.0-mm) sieve and have less than 10 % retained on the ⅜-in. (9.5-mm) sieve.

8.2.3.1 The selected test specimen shall have a mass not less than that determined using the following equation:

$$M_s = 0.0024\,V_m$$

where:

M_s = mass required in kg, and
V_m = volume of mold in cm³.

8.3 Select a representative specimen of soil that meets the requirements of 8.2, using a splitter, riffle, or other method such as quartering.

8.4 If Methods 1 A or 2 A are being performed, dry the specimen in the drying oven, maintained at 230 ± 9°F (110 ± 5°C) to a constant mass. It is often desirable to obtain the water content of the field sample. If this is the case, determine the water content in accordance with Method D 2216.

8.4.1 After drying, thoroughly break up the weakly cemented aggregations as to avoid reducing the natural size of the particles.

9. Preparation of Apparatus

9.1 For a mold assembly in which the alignment of the guide sleeve on top of the mold is controlled by the position of the set screws, assemble the guide sleeve on top of the mold and tighten the clamp assemblies so that the inner wall of the sleeve is in line with the inner wall of the mold. Tighten the lock nuts on the two set screws to equipped. Loosen the set screw having no lock nut and remove the guide sleeve.

9.2 Determine and record the mass of the empty mold, using the appropriate balance specified in 6.3.

9.3 Check that the vibrating table is in good working condition and that parts are not loose or worn. Make any necessary adjustments or repairs.

9.4 Check that one set of initial dial readings is within ±0.005 in. (0.13 mm) of the value obtained in 10.4, that is, the dial gage zero has

8.1.2.7 For mass measurements in pounds, calculate the volume in cubic feet by multiplying the mass of water, in pounds, used to fill the mold by the unit volume of water from Table 2, and dividing the result by 62.43 lb/ft³.

8.1.2.3 To convert the calculated volume in cubic feet to cubic centimeters multiply by 28 320.

8.2 Determine and record the mass of the empty mold, using the appropriate balance specified in 6.3.3.

9. Procedure

9.1 The steps for performing Method A, the preferred procedure, shall be in accordance with 9.2. The Method B procedure is given in 9.3 and Method C in 9.4.

9.2 *Method A*

9.2.1 Mix the oven-dried specimen to provide an even distribution of particle sizes.

9.2.2 If the pouring device (as required in Table 1) are used, place the soil as loosely as possible in the mold by pouring the soil from the spout (Table 1) in a steady stream, holding the pouring device upright and vertical or nearly vertical. Continuously adjust the height of the spout to maintain a free fall of the soil of about ½ in. (13 mm) or just high enough to maintain continuous flow of soil particles without the spout contacting the already deposited soil. Move the pouring device in a spiral path from the outside to the center of the mold to form each layer of nearly uniform thickness. Spreading motion should be just sufficient to minimize particle segregation.

NOTE 3—Static electricity in dry sand can cause bulking similar to that produced by a trace of moisture on the particles. A static eliminating balance brush can be applied to the equipment in contact with the sand when this effect becomes bothersome.

9.2.2.1 Fill the mold approximately ½ in. (13 mm) to 1 in. (25 mm) above the top of the mold (or until all points of the soil surface are above the plane of the mold rim).

9.2.2.2 Screed off the excess soil level with the top by carefully trimming the soil surface with a straightedge. Great care must be exercised during filling and trimming operations to avoid jarring the mold or excessively disturbing the soil surface and causing rearrangement and settlement of the soil particles. Making one continuous pass with the straightedge, or if necessary, two passes has produced the most reproducible results.

9.2.3 If the scoop or shovel (as required in Table 1) are used, place the soil as loosely as possible by holding the scoop or shovel just above the soil surface to cause the material to slide rather than fall onto the previously placed soil. If necessary, hold large particles back by hand to prevent them from rolling off the scoop.

9.2.3.1 Fill the mold to overflowing but not more than 1 in. (25 mm) above the top. For soils where the maximum particle size passes the ¾ in. (19.0 mm) sieve, use the steel straightedge (and the fingers when needed) to level the surface of the soil with the top of the mold. For soils of large maximum particle size, use the fingers in such a way that any slight projections of the larger particles above the top of the mold shall approximately balance the larger voids in the surface below the top of the mold.

9.2.4 Determine and record the mass of the mold and soil. Calculate and record the mass of the soil filling the mold by subtracting the mass of the empty mold, as determined in 8.2, from the mass of the mold and soil. Calculate the maximum index density ρ_{max} in accordance with section 10.

9.2.5 Steps 9.2.1 through 9.2.4 should be repeated until consistent values of maximum index density (preferably within 1 percent) are obtained.

9.3 *Method B*

9.3.1 Mix the oven dried specimen to provide an even distribution of particle sizes.

9.3.2 Select the proper sized thin-walled tube in accordance with the requirements of 6.1.5.

9.3.3 Place the tube inside the mold. Place cohesionless soil into the tube with a pouring device, scoop, or spoon, being careful to minimize segregation of material during filling. Fill the tube within ¼ in. (3 mm) to ½ in. (6 mm) of the top.

9.3.4 Quickly raise the tube allowing the cohesionless material to overfill the mold.

9.3.5 Using procedures of 9.2.2.1 and 9.2.2.2 trim the soil surface level with the top of the mold.

9.3.6 Determine and record the mass of the mold and soil. Calculate and record the mass of the soil filling the mold by subtracting the mass of the empty mold, as determined in 8.2, from the mass of the mold and soil. Calculate the maximum index density ρ_{max} in accordance with Section 10.

9.3.7 Steps 9.3.1 through 9.3.6 should be repeated until consistent values of maximum index density (preferably within 1 %) are obtained.

9.4 *Method C*[6]

9.4.1 Place 1000 ± 1 g of sand in a 2000-mL graduated cylinder and place a stopper in the top of the cylinder. Tap the cylinder upside down, and then quickly tilt it back to the original vertical position.

9.4.2 Record the volume, V_c, of the graduated cylinder the sand occupies. Calculate the maximum index density in accordance with Section 10.

9.4.3 Repeat the procedure until three consecutive values of the maximum index density (preferably within 1 %) are obtained.

10. Calculations

10.1 For each trial, calculate the maximum index density, ρ_{max} in lb/ft³ (kg/m³) as follows:

$$\rho_{max} = M_s/V'$$

where:

M_s = mass of dry soil, lb (kg), and

V' = volume of soil, ft³ (m³).

For Methods A and B, $V' = V_c$, or calibrated volume of mold; and for Method C, $V' = V_c$ (see 9.4.2).

10.1.1 Calculate the average maximum index density, ρ_{max}, from the trials which agree within 1 %.

10.2 Calculate the maximum index void ratio, e_{min} as follows:

$$e_{max} = \frac{\rho_w G_{sb}}{\rho_{min}} - 1$$

where:

ρ_w = density of water equal to 62.4 lb/ft³ or 1000 kg/m³,

G_{sb} = weighted average specific gravity of soils composed of particles larger and smaller than the No. 4 (4.75-mm) sieve, or

$$G_{sb} = \frac{1}{\frac{R_1}{100G_1} + \frac{P_1}{100G_2}}$$

where:

G_1 = apparent specific gravity of the soil particles retained on the No. 4 (4.75-mm) sieve as determined by Method C 127,

G_2 = specific gravity of the soil particles passing the No. 4 (4.75-mm) sieve as determined by Method D 854,

R_1 = percentage of soil particles from the sample retained on the No. 4 (4.75-mm) sieve, and

P_1 = percentage of soil particles from the sample passing the No. 4 (4.75-mm) sieve, and

ρ_{min} is in units of lb/ft³ or kg/m³.

10.3 If the maximum index density, ρ_{max}, has been determined in accordance with Method D 4253 and the soil deposit or fill dry density, ρ_d, or void ratio, e, is known, the relative density, D_R, can be calculated as:

$$D_R = \frac{\rho_{max}(\rho_d - \rho_{min})}{\rho_d(\rho_{max} - \rho_{min})} \times 100, \text{ or}$$

$$D_R = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

11. Report

11.1 The report shall include the following information:

11.1.1 Origin of material used in the test.

11.1.2 Description of appearance of test specimen, based on Practice D 2488 (Test Method D 2487 may be used as an alternative).

11.1.3 The method (Methods A, B, or C) and size of mold used.

11.1.4 The maximum index density, ρ_{max} in lb/ft³ (kg/m³) to three significant digits (in accordance with Practice E 380), calculated in 10.1.1.

12. Precision and Accuracy

12.1 Criteria for judging the acceptability of maximum-index density test results, performed by Method A, are given in Table 3. No statement is made for the precision and accuracy of Methods B and C due to lack of sufficient data.

12.1.1 *Variations Between Laboratories (Reproducibility)*

12.1.1.1 The standard deviation, S, is calculated from the equation:

$$S^2 = \frac{1}{N-1}\sum(x - \bar{x})^2$$

where:

N = number of determinations,

x = individual value of each determination, and

[6] Bartholomew, J. J., "An Improvised Study of the Maximum and Minimum Densities of Sands," Proceedings, Second International Conference on Soil Mechanics and Foundation Engineering, Rotterdam, Vol 5, 1948, pp. 110–113.

junction with design or special studies or both, and

11.1.6.1.2 The double amplitude of vertical vibration used should be: (a) the optimum double amplitude of vertical vibration (see the Appendix for a recommended method to obtain the optimum double amplitude of vibration), (b) less than 0.025 in. (0.64 mm) at 60 Hz or 0.017 in. (0.94 mm) at 50 Hz, and (c) except when filling the mold for the wet method, 11.2.1) greater than 0.009 in. (0.20 mm) at 60 Hz or 0.012 in. (0.30 mm) at 50 Hz. In terms of nominal peak acceleration, these values are greater than about 1.5 g (14 m/s²) and less than about 4.8 g (45 m/s²).

NOTE 6—The nominal peak acceleration can be calculated using the following equation:

$$A_p = 0.0511\,(2)_d f^2$$

where:

A_p = nominal peak acceleration in g,
$2)_d$ = double amplitude of vertical vibration in inches, and
f = frequency in cycles per second, Hz.

11.1.7 Vibrate the mold assembly and specimen for 8 ± ½ min at 60 ± 2 Hz or for 12 ± ½ min at 50 ± 2 Hz. Remove the surcharge weight and guide sleeve from the mold. Check that the surcharge base plate is firmly and uniformly in contact with the surface of the soil; that is, does not wobble when pressed at the edges. If it wobbles, this should be noted on the report form (data sheet).

11.1.8 To obtain and record dial indicator gage readings on opposite sides of the surcharge base plate place the indicator gage holder on each of the guide brackets. Brush aside any fines that might have collected on the surcharge base plate where these readings will be taken.

11.1.9 Remove the surcharge base plate from the mold and detach the mold from the vibratory table. During this step, prevent (as much as possible) any fines that have collected on the surfaces of the surcharge base plate and the rim of the mold from entering the mold. If the mass of these fines is greater than about 0.2 % of the total mass of the specimen, determine this mass and note it on the report form (data sheet).

11.1.10 Determine and record the mass of the mold and soil using a balance meeting the requirements of 6.3. To calculate and record the mass of the soil filling the mold subtract the mass [illegible] mold from the mass of the mold

late the maximum index density, ρ_{max}, in accordance with Section 12.

11.1.11 Steps 11.1.1 through 11.1.10 should be repeated until consistent values of maximum index density (preferably within 2 %) are obtained. If excessive degradation (particle breakdown) of the soil is suspected, a sufficient quantity of representative soil sample should be provided (if possible), so that a single test specimen is not repeatedly subjected to step 11.1.7.

11.2 *Wet Method*—Method 1.B or 2.B

11.2.1 The wet method may be conducted on oven-dried soil to which sufficient water is added or, if preferred, on wet soil from the field. Mix the sample to provide an even distribution of particle sizes and moisture content with as little segregation as possible. If water is added to dry soil, allow a minimum soaking period of about 24 h. The amount of water added should be sufficient enough that free water does not accumulate in the mixing pan, and the specimen will become basically saturated during the densification process.

NOTE 7—The following equation can be used to estimate the amount of water required to be added to oven-dried soil or, usually, try about 1000 mL for every 4.5 kg (10 lb) of soil:

$$\Delta M_w = M_s[(\rho_w/\rho_d) - (1/G_s)]$$

where:

ΔM_w = mass of water in grams,
ρ_d = estimated dry density after initial placement in mold in lb/ft³ or kg/m³. This value typically ranges between 100 and 120 lb/ft³ or about 1600 and 1900 kg/m³,
M_s = mass of test specimen in grams,
ρ_w = density of water, 62.4 lb/ft³ or 1000 kg/m³, and
G_s = specific gravity of soil.

11.2.2 Attach the mold to the vibrating table.

11.2.3 With the vibrating table turned off, slowly fill the mold with wet soil using a scoop or shovel. After each increment of soil is added inspect to see if a small amount of free water has accumulated on the soil surface. If not, add sufficient amount of water by squeezing from a sponge, pouring from a small container, or other means. During this process, which should take 5 to 6 min, the double amplitude or frequency or both, of vibration must be adjusted to prevent excessive heaving and fluffing of soil. During and just after the final minute of vibration, any water appearing above the soil [illegible] minimal using pieces of

11.2.4 Assemble the surcharge base plate, surcharge weight, and guide sleeve as specified in 11.1.1 and 11.1.5.

11.2.5 Vibrate the mold assembly and specimen as specified in 11.1.6 through 11.1.7. After the vibration period, remove the surcharge weight and guide sleeve from the mold. Remove any free water appearing above, on, and around the surcharge base plate.

11.2.6 Obtain and record dial indicator-gage readings in accordance with 11.1.8.

11.2.7 Remove the surcharge base plate and detach the mold from the vibratory table in accordance with 11.1.9. If a determination of the specimen water content is desired, determine and record the mass of the mold and soil. Carefully remove the entire wet specimen from the mold, placing it in a pan of known mass for oven drying. Wash all particles clinging to the inside of the mold and bottom of the base plate into the pan. Dry the specimen in a drying oven, maintained at 230 ± 9°F (110 ± 5°C) to a constant mass (Method D 2216). Determine and record its oven-dried mass, using a balance meeting the requirements of 6.3.

12. Calculations

12.1 Calculate the maximum index density, ρ_{max}, in lb/ft³ (or kg/m³) as follows:

$$\rho_{max} = M_s/V$$

where:

M_s = mass of dry specimen, lb (or kg),
V = volume of densified specimen, ft³ (or m³);
= $V_c - A_c\,(\Delta H/12)$ in ft³
= $[V_c - A_c\,(\Delta H \times 10)] \times 10^{-6}$ in m³,
V_c = calibrated volume of mold, ft³ (or cm³),
A_c = calibrated cross-sectional area of mold, ft² (or cm²); and
ΔH = $R_i - R_f + T_p$ for clockwise-reading dial indicators or
= $R_f - R_i + T_p$ for counterclockwise-reading dial indicators,
R_i = initial dial gage reading, in. (or mm),
R_f = average of final dial gage readings on opposite sides of the surcharge base plate after completion of the vibration period, in. (or mm), and
T_p = thickness of surcharge base plate, in. (or mm).

12.1.1 Calculate the average maximum index density from the trials of the dry method which agree within 2 %. This value is to be reported as

the maximum-index density unless it is established that the wet method produces a maximum-index density higher than the dry method, which would significantly affect the use or application, or both, of maximum index density, in which case the result of the wet method should be used.

12.2 Calculate the minimum index void ratio, e_{min}, as follows:

$$e_{min} = \frac{\rho_w G_{avg}}{\rho_{max}} - 1$$

where:

ρ_w = density of water equal to 62.4 lb/ft³ or 1000 kg/m³, and
G_{avg} = weighted average specific gravity of soils composed of particles larger and smaller than the No. 4 (4.75-mm) sieve.

$$= \frac{1}{\frac{R_1}{100 G_1} + \frac{P_1}{100 G_2}}$$

G_1 = apparent specific gravity of the soil particles retained on the No. 4 (4.75-mm) sieve as determined by Method C 127,
G_2 = specific gravity of the soil particles passing the No. 4 (4.75-mm) sieve as determined by Method D 854,
R_1 = percentage of soil particles from the sample retained on the No. 4 (4.75-mm) sieve,
P_1 = percentage of soil particles from the sample passing the No. 4 (4.75-mm) sieve and ρ_{max} is in units of lb/ft³ or kg/m³.

12.3 If the minimum index density, ρ_{min}, has been determined in accordance with Method D 4254; and the soil deposit or fill dry density, ρ_d, or void ratio, e, is known, the relative density, D_R, can be calculated as:

$$D_R = \frac{(\rho_{max}/\rho_d) - (\rho_{min}/\rho_d)}{(\rho_{max}/\rho_d) - (\rho_{min}/\rho_d)} \times 100, \text{ or}$$

$$D_R = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

13. Report

13.1 The report shall include the following information:

13.1.1 Origin of material used in test.

13.1.2 Description of appearance of test specimen, based on Practice D 2488 (Test Method D 2487 may be used as an alternative).

13.1.3 The method (1.A, 1.B, 2.A, or 2.B) and size of mold used.

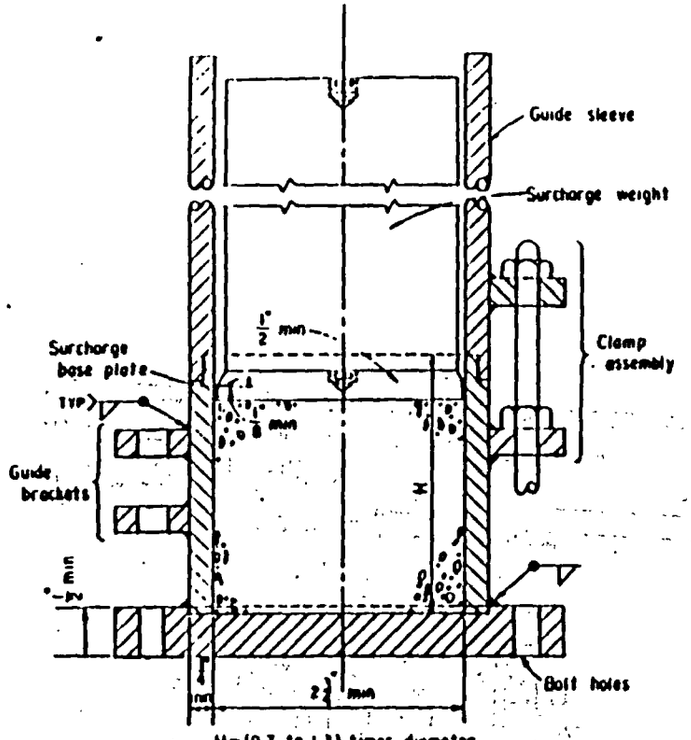


FIG. 3 Inverted Cylindrical Mold Details

Standard Test Method for LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS[1]

1. Scope

1.1 This test method covers the determination of the liquid limit, plastic limit, and the plasticity index of soils as defined in Section 3.

1.1.1 Four procedures for preparing test specimens and two procedures for performing the liquid limit are provided as follows:

A Multipoint test using a wet preparation procedure, described in Sections 10.1, 11, and 12.

B Multipoint test using a dry preparation procedure, described in Sections 10.2, 11, and 12.

C One-point test using a wet preparation procedure, described in Sections 13, 14, and 15.

D One-point test using a dry preparation procedure, described in Sections 13, 14, and 15.

The procedure to be used shall be specified by the requesting authority. If no procedure is specified, Procedure A shall be used.

NOTE 1—Prior to the adoption of this test method, a curved grooving tool was specified as part of the apparatus for performing the liquid limit test. The curved tool is not considered to be an improvement on the flat tool described in 6.2 since it does not control the depth of the tool in the liquid limit cup. However, there are some data which indicate that typically the liquid limit is slightly increased when the flat tool is used instead of the curved tool.

1.1.2 The plastic limit test procedure is described in Sections 16, 17, and 18. The plastic limit test is performed on material prepared for the liquid limit test. In effect, there are two procedures for preparing test specimens for the plastic limit test.

1.1.3 The procedure for calculating the plasticity index is given in Section 19.

1.2 The liquid limit and plastic limit of soils (along with the shrinkage limit) are often collectively referred to as the Atterberg limits in recognition of their formation by Swedish soil scientist, A. Atterberg. These limits distinguish the boundaries of the several consistency states of plastic soils.

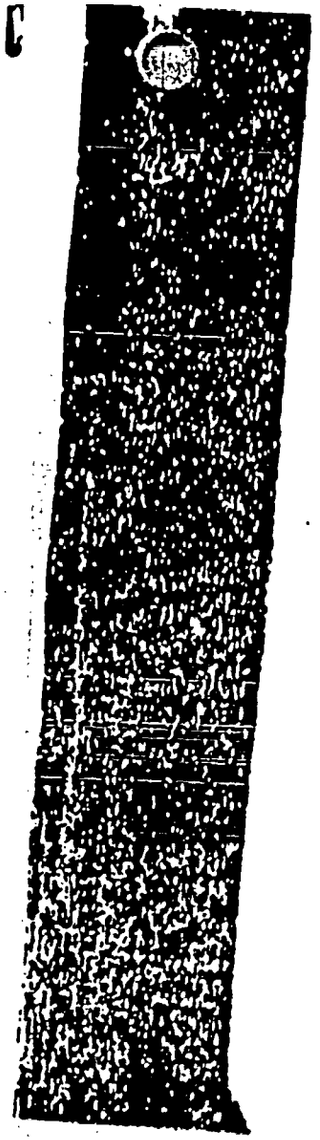
1.3 As used in this test method, soil is any natural aggregation of mineral or organic materials, mixtures of such materials, or artificial mixtures of aggregates and natural mineral and organic particles.

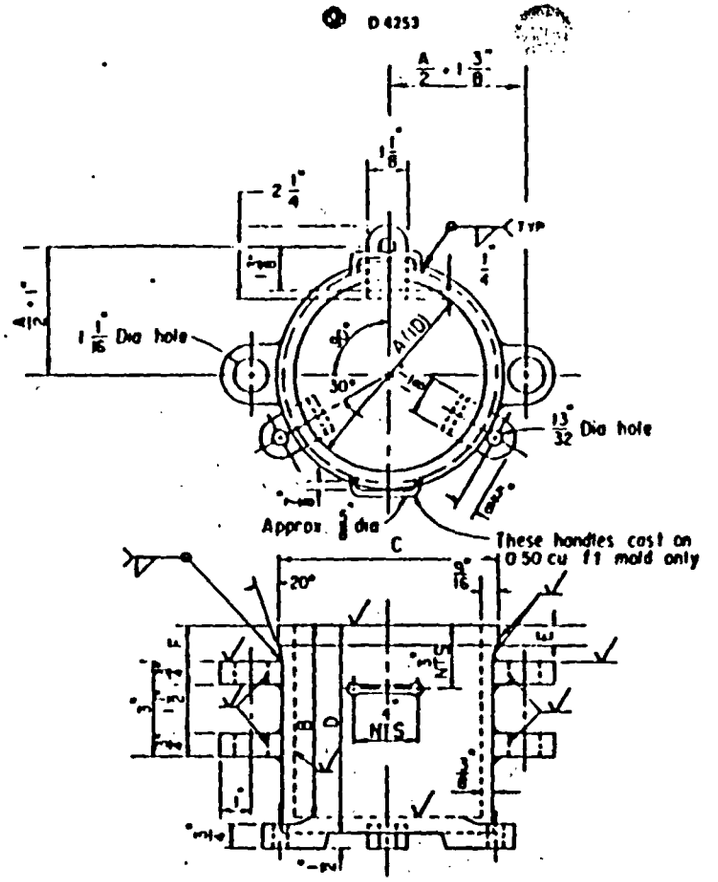
1.4 The multipoint liquid limit procedure is somewhat more time consuming than the one-point procedure when both are performed by experienced operators. However, the one-point procedure requires the operator to judge when the test specimen is approximately at its liquid limit. In cases where this is not done reliably, the multipoint procedure is as fast as the one-point procedure and provides additional precision due to the information obtained from additional trials. It is particularly recommended that the multipoint procedure be used by inexperienced operators.

1.5 The correlations on which the calculations of the one-point procedure are based may not be valid for certain soils, such as organic soils or soils from a marine environment. The liquid

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved Oct. 26, 1984. Published December 1984. Originally published as D 4318 – 83. Last previous edition D 4318 – 84.





Size Mold B[a] (cm³)	Dimensions, in (mm)					
	A (+0.015 in, −0.010)	B (+0.015 in, −0.010)	C	D	E	F
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FIG. 2 [illegible]

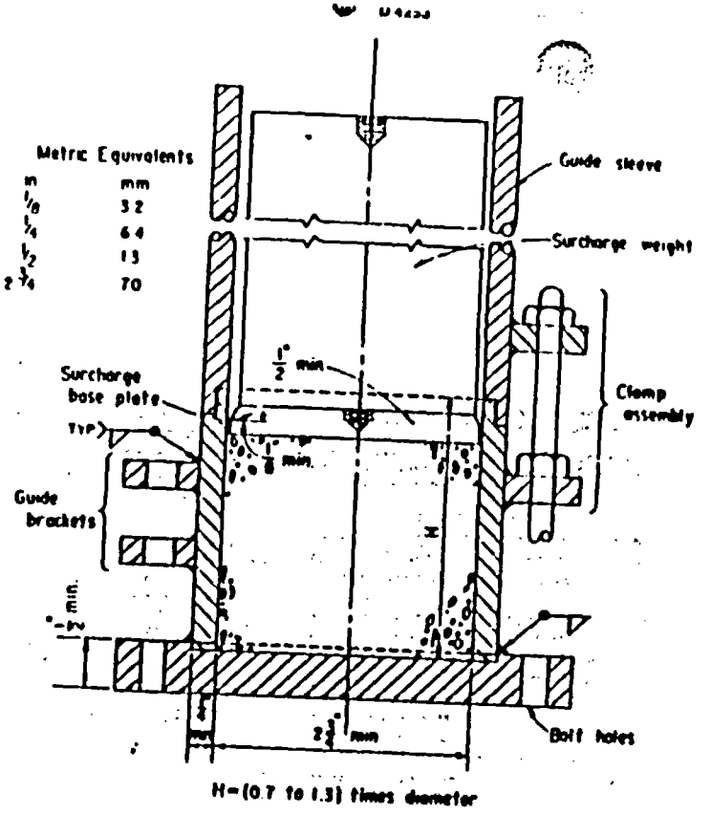


FIG. 3 [illegible]

Relative Density Supplemental Data Sheet*

Project: Crushed Tuff Consolidation Test — Date _____

(SNL Document No. 37-5031) — Operator _____

Sample No. _____

Maximum Dry Density

(Vibratory Table Method)

	Dry Method	
	Run 1	Run 2
Weight soil above Surcharge (W_A)	_____ g	_____ g
$W_2 = (W_1 - W_A)$	_____ g	_____ g

where W_1 is W_1 in WES Form No. 728

W_2 is W_2 in WES Form No. 728

*To be used with ASTM 4253 as modified in 11.1.10.

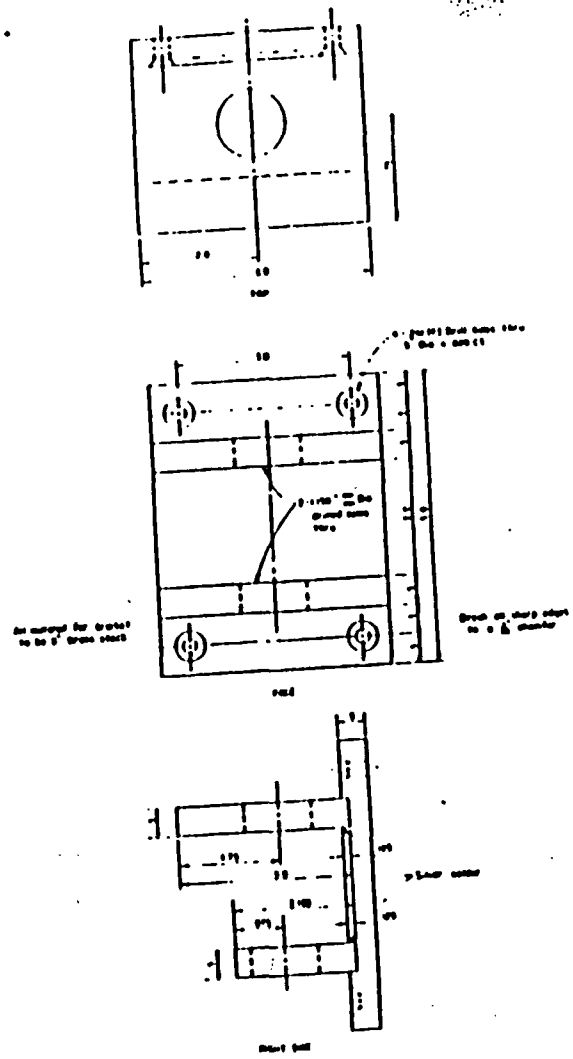


FIG. 6 [illegible]

APPENDIX

(Nonmandatory Information)

X1. RECOMMENDED METHOD TO OBTAIN THE OPTIMUM DOUBLE AMPLITUDE OF VIBRATION

X1.1 To reduce testing problems, the dry method (Method A) should be used. The size of mold used should be in accordance with 8.2.

X1.2 For the mold size and vibrating table being used, establish the relationship between the double amplitude of vertical vibration of the mold assembly, and the throw of eccentric, or cam acting under non-shock test conditions.

X1.3 Select between four and six test specimens from the sample using a splitter, riffle, or other method, such as quartering, and dry each specimen. An unused portion of material shall be used for each trial to eliminate any cumulative degradation effects of the test.

X1.4 Using the procedure outlined in Section 11 (except for 11.1.6) perform about four trials with the double amplitude of vibration varying between about 0.010 in. (0.2 mm) and 0.025 in. (0.64 mm) for 60 Hz. See Table X1 for a typical set of double amplitude of vibration values which may be used. If a peak dry density is not clearly defined (see X1.5) then additional trials using other values as indicated in Table X1 or between those already tried shall be used.

X1.5 From the data obtained in X1.4 plot the dry density values in ordinates with corresponding double amplitude of vibration values as abscissas. Draw a smooth curve connecting the plotted points. The double amplitude of vibration corresponding to the peak of this curve is termed the optimum double amplitude of vibration, while the peak dry density is termed the optimum index density.

X1.6 For soils susceptible to degradation, the optimum index density may not be clearly defined, that is, density may continue to increase with increasing double amplitude of vibration beyond a reasonable value of 0.025 in. (0.64 mm) at 60 Hz or 0.017 in. (0.43 mm) at 50 Hz. For this case, a selected optimum double amplitude value of 0.015 in. (0.38 mm) at 60 Hz or 0.022 in. (0.56 mm) at 50 Hz shall be used.

TABLE X1 Typical Set of Double Amplitude of Vibration Values

Frequency of Vibration	Double Amplitude of Vibration, in. (mm)					
60 Hz	0.012 (0.30)	0.017 (0.43)	0.022 (0.56)	0.025* (0.64)	0.030* (0.76)	0.035* (0.91)
50 Hz	0.014 (0.36)	0.021 (0.53)	0.015 (0.38)	0.018 (0.46)	0.021 (0.53)	0.025* (0.64)

* For some vibratory tables, double amplitudes of vibration of 0.025 in. (0.64 mm) and above may be limited by the vibration spacers. This can be checked by inserting a strip of paper between the vibratory table in accordance with the manufacturer's instructions.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF CRUSHED ROCK

Background: "Standard Test Method for One-Dimensional Consolidation Properties of Soils" ASTM-D 2435-80 (attachmentF-1) provides basic procedural guidance for consolidation testing of crushed tuff for the NNWSI program. The large consolidometer constructed at WES is designed to test samples approximately 6-in. in height and 12-in. in diameter. The consolidometer is of the fixed-ring type.

Scope: This procedure applies to rock samples provided by SNL for study in conjunction with NNWSI project.

Procedure: The use of the term soils in the test procedure ASTM-D 2435 for this test program will refer to samples of crushed tuff. Portions of this standard practice are not applicable to the current testing and will be excluded. The portions of the test method not applicable are as follows:

Paragraph No.	Description of Changes
5.2.2.	This paragraph describes specimen height for testing. The practical limits of a test device would be exceeded based on the criteria outlined in this paragraph for the materials being tested. The device constructed at WES for this test allows the testing of a specimen 6-in. in height and approximately 12-in. in diameter.
5.6	All of this paragraph will be deleted. Current material does not require trimming.
6.1	All of this paragraph will be deleted. Undisturbed samples are not included in current testing plans.
7.1, 7.2, and 7.3	These paragraphs will be deleted because the current material tested for this program does not require the steps outlined in these paragraphs
10.3	Loads to be used in this test program are described in Letter of Criteria and will be (lb x ft^2 x 1000) 1, 2, 4, 8, 16, 32, 90, 140, and 190
10.8	This paragraph will be deleted since no undisturbed samples will be tested for the current project.
12.1.5	Atterberg Limits will not be determined for current crushed tuff samples

6. *Apparatus*

6.1 *Apparatus for Methods A, B, and C*

6.1.1 *Drying Oven*—thermostatically controlled, preferably of the forced draft type, capable of maintaining a uniform temperature of 230 ± 9°F (110 ± 5°C) throughout the drying chamber.

6.1.2 Sieves—3 in. (75 mm), 1½ in. (37.5-mm), ½ in. (19 mm), ⅜ in. (9.5-mm), No. 4 (4.75 mm), No. 10 (2.00-mm), and No. 200 (75-µm).

6.2 The apparatus for determining the minimum index density of a cohesionless soil by Methods A and B is specified in 6.3. Apparatus required for Method C is specified in 6.4.

6.3 *Apparatus for Methods A and B*

6.3.1 *Standard Molds*—Cylindrical metal molds having nominal volumes of 0.100 ft³ (2830 cm³) and 0.500 ft³ (14 200 cm³). The molds shall conform to the requirements shown in Fig. 1. The actual volume of the molds shall be within ±1.5 % of the specified nominal volume.

6.3.2 *Special Molds*—Cylindrical metal molds having a capacity less than 0.100 ft³ (2830 cm³), an inside diameter equal to or greater than 2½ in. (70 mm) but less than 4 in. (100 mm) and conforming to the design methodology presented in Fig. 2. Such molds may only be used when the test results are to be used in conjunction with design or special studies, and there is not enough soil to use the 0.100 ft³ (2830 cm³) mold.

6.3.3 *Balance(s)*, of sufficient capacity to determine the total mass of the specimen and mold, having sufficient accuracy that the mass of the soil is determined to the nearest 0.1 %. Balances capable of satisfying these requirements for most conditions have specifications as follows:

6.3.3.1 For 0.500 ft³ (14 200 cm³) mold, use a platform or similar balance of at least 40 kg capacity, readable to 5 g, having a precision (standard deviation) of 0.02 % of the test load, and an accuracy of 0.05 % of the test load at any point between 10 kg and capacity.

6.3.3.2 For 0.100 ft³ (2830 cm³) mold, use a platform or similar balance of at least 15 kg capacity, readable to 1 g, having a precision (standard deviation) of 0.02 % of the test load, and an accuracy of 0.05 % of the test load at any point between 2 kg and capacity.

6.3.3.3 For special molds, use a balance of at least 2000 g capacity, readable to 0.1 g, having a [illegible] (standard deviation) of 0.02 % of the load at any point bet[illegible]g and capacity.

NOTE 2—See Methods E 319 for explanations of terms relating to balance performance. Additional standards for evaluating the performance of balances are being prepared by ASTM Subcommittee E41.06 on Weighing Devices.

6.3.4 *Pouring Devices*—The pouring devices are used in conjunction with the 0.100 ft³ (2830 cm³) standard mold with special molds. Pouring devices consist of relatively rigid containers having volumes about 1.25 to 2 times greater than the volumes of the molds used, and fitted with spouts or tubes about 6 in. (150 mm) long. Two pouring spouts are required: one having an inside spout diameter of 0.50 in. (13 mm) and another with an inside spout diameter of 1.0 in. (25 mm). A lipped brim, or other means, must be provided to securely connect the spout to the container that permits free and even flow of the soil from the container into the spout, and then into the mold.

6.3.5 *Rigid, Thin Walled Tubes*, for use with Method B. The size of the tubes is dependent upon the mold size selected. The volume of the tubes shall be between 1.25 and 1.50 times the volume of the mold. The inside diameter of the tube shall be about 0.7 times the inside diameter of the mold.

6.3.6 Other equipment such as mixing pans, a large metal scoop, a hair-bristled dusting brush, and a metal straightedge (for trimming excess soil after it has been placed in the mold).

6.4 *Apparatus for Method C*

6.4.1 *Glass Graduated Cylinder*, having a volume of 2000 mL, graduated to 20 mL, with about a 3 in. (75-mm) inside diameter.

6.4.2 *Balance*, of at least 1500-g capacity readable to 1 g, and otherwise consistent with 6.3.3.

6.4.3 Sieves, ⅜ in. (9.5-mm), No. 10 (2.00-mm), and No. 200 (75-µm) sieves conforming to the requirements of Specification E 11.

7. Sampling and Test Specimen

7.1 Sampling and test specimen requirements for Methods A and B are contained in the following paragraphs. Requirements for Method C begin at 7.4.

7.2 Prior to testing, the sample should be stored in a manner to prevent freezing, contamination with other matter, loss of soil, or loss of identification.

7.3 Size of the test specimen for mold is a function of the maximum particle size contained in the sample and the particle-size distribution (gradation) of the sample (see Table 1).

7.3.1 Using a visual method or Method D 422 (depending upon the complexity of the gradation of the sample and operator experience), determine the percentage of particles retained on the 3 in. (75-mm), 1½ in. (37.5-mm), ½ in. (19.0-mm), ⅜ in. (9.5 mm), No. 4 (4.75-mm), No. 10 (2.00 mm), and No. 200 (75-µm) sieves.

7.3.2 The determination of the minimum index density should not be performed in accordance with these test methods unless the requirements of 1.4 are met. If these conditions are met, then the mold size, pouring device, and specimen mass required can be determined in accordance with the maximum particle size as prescribed in Table 1.

7.3.3 When it is applicable to use special molds, 100 % of the specimen shall pass the ½-in. (19.0-mm) sieve and have less than 10 % retained on the ⅜-in. (9.5-mm) sieve.

7.3.3.1 The selected test specimen shall have a mass not less than that determined using the following equation:

$$M_s = 0.0834\ V_m$$

where:

M_s = mass required in kg, and
V_m = volume of mold in cm³.

7.4 Select a representative specimen of soil that meets the requirements of 7.3, using a splitter, riffle, or other method such as quartering. For Method C, the specimen should have a mass of about 1500 g.

7.5 Dry the specimen in the drying oven, maintained at 230 ± 9°F (110 ± 5°C) to a constant mass. Oven-dried sand, for use with Method C, shall be permitted to cool in an airtight container. It is often desirable to obtain the water content of the field sample. If this is the case, determine the water content in accordance with Method D 2216.

7.5.1 After drying, thoroughly break up the weakly cemented aggregations so as to avoid reducing the natural size of the particles.

8. Calibration

8.1 *Molds*—The volume and cross-sectional area of each mold should be calibrated before initial use and at intervals not exceeding each 1000 times the mold is used for testing, or annually, whichever occurs [illegible]. Determine the volume of each mold by [illegible] the direct measurement method or the water filling method as provided in 8.1.1 and 8.1.2. The volume obtained by either method should be within ±1.5 % of the nominal value. It is recommended that both the direct measurement and water filling methods be used. If the difference between the volumes calculated from the two methods exceeds 0.5 % of the nominal value of the mold being calibrated, then the calibration should be repeated. Failure to obtain agreement between the two calibration methods within the stated tolerances, even after several trials, is an indication that the mold is badly deformed and should be replaced. If both calibration methods are performed, the volume obtained by the water-filling method should be assigned to the mold (this method more accurately reflects the conditions over the entire mold).

8.1.1 *Direct Measurement Method*—The volume of the mold is calculated from the average of at least three internal-diameter and three height measurements, evenly spaced throughout the mold, made to the nearest 0.001 in. (0.025 mm). Calculate and record the volume, V_m (ft³ or cm³) to four significant digits (in accordance with Practice E 380).

8.1.2 *Water-Filling Method*—Completely fill the mold with water. Slide a glass plate carefully over the top surface (rim) of the mold so as to ensure that the mold is completely filled with water. A thin film of grease or silicone lubricant on the rim of the mold will make a watertight joint between the glass plate and rim of the mold. Determine the mass and temperature of the water required to fill the mold. The temperature should be determined to the nearest 1°C. The mass of the water must be determined to at least the nearest 0.01 lb (5 g) for the 0.100-ft³ (2830-cm³) mold and to the nearest 0.1 lb (50 g) for the 0.500-ft³ (14 200-cm³) mold. From Table 2 obtain the unit volume of water in milliliters per gram at the observed temperature. Calculate and record the volume of the mold (ft³ or cm³) to the appropriate number of significant digits, as follows:

8.1.2.1 For mass measurements in grams, calculate the volume in cubic feet by multiplying the mass of water, in grams, used to fill the mold by the unit volume of water, from Table 2, and dividing the result by 28 320 mL/ft³.

Consolidation Test Supplemental Data Sheet

Project: Crushed Tuff Consolidation Test — Date _____

(SNL Document No. 37-5031) — Operator _____

Sample No. _____

Compaction Phase

1. Initial height of sample caliper reading

#1	_____	in.
#2	_____	in.
#3	_____	in.
#4	_____	in.
Average (h_1)	_____	in.

2. Change in LVDT needed to get 6-in. sample

$3.515 - h_1 - \Delta h_1$
Strain sample Δh_1

3. Make four readings of compacted sample

#1	_____	in.
#2	_____	in.
#3	_____	in.
#4	_____	in.
Average (h_2)	_____	in.

4. Initial height of sample (h_3)

$3.515 - h_2 = \Delta h_2$
$\Delta h_2 + 6$ in. $= h_3$

h_3 _____

Consolidation Phase

5. Computer printout to include the following information:

   a. Date and load

   b. Elapsed time, min

   c. Deformation 10^{-3} in.

   d. Temperature °C _____ (recorded by technician)

6. Use Eng Form 2088 to define secondary consolidation for each load.

$\bar{D}$ = numerical average of the determinations

12.1.2 *Limitations Between Duplicate Tests (Reproducibility)*

12.1.2.1 The combined standard deviation, S', is calculated from the equation

$$S' = \frac{1}{2A}\Sigma D'$$

where:

D = difference between duplicate tests and

A = number of pairs of duplicate tests

TABLE 1 Required Mass of Specimen

Maximum Size of Soil Particle in (mm)	Mass of Specimen Required lb (kg)	Placement Device to be Used in Maximum Density Test	Size of Mold to be Used ft³ (m³)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

TABLE 2 Volume of Water per Gram Based on Temperature[A]

Temperature °F	Temperature °C	Volume of Water ml/g
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

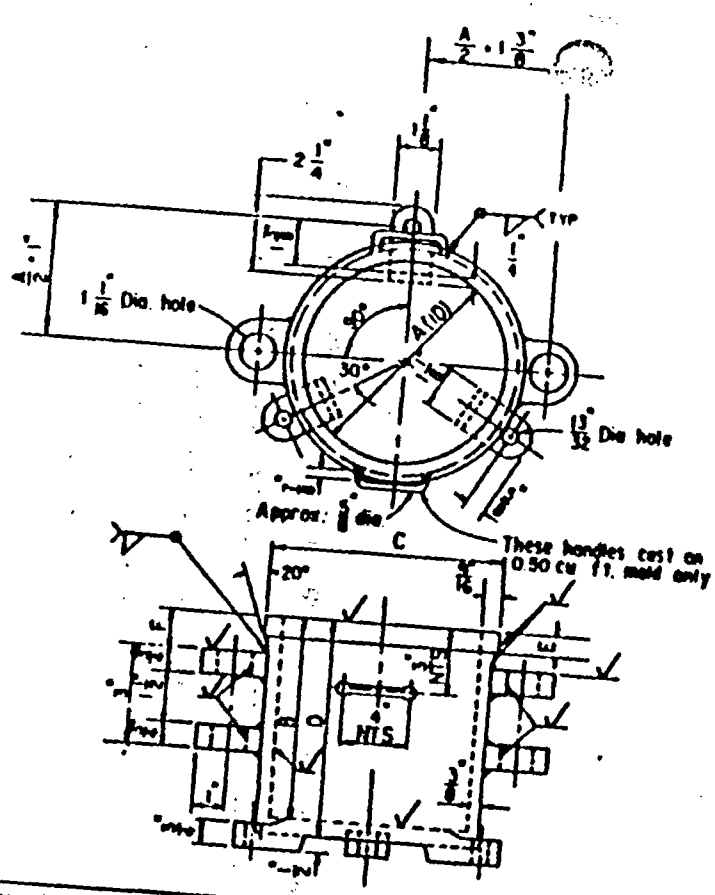
[A] Values other than shown may be obtained by referring to the *Handbook of Chemistry and Physics*, Chemical Rubber Publishing Co., Cleveland, Ohio.

TABLE 3 Precision of Maximum Index Density Test Results by Method A[A]

	Standard Deviation, S lb/ft³ (kg/m³)	Combined Standard Deviation, S', lb/ft³ (kg/m³)	Acceptable Range of Two Results Expressed as Percent of Mean Value[B]
Mechanical Density Procedure			
Two Operators	[illegible]		[illegible]
Laboratory	[illegible]		[illegible]
Simple Vibrator Procedure			
Two Operators		[illegible]	[illegible]
Laboratory		[illegible]	[illegible]

[A] All values shown in this table are based on average results on a limited variety of different soils (8 materials) [illegible] are subject to future revision.

[B] This column indicates a limiting range of values all should not be exceeded by the difference between any results expressed as a percentage of the average value. Approximately 95 % of the test results from the cooperative test program do not exceed the limiting acceptable ranges (assuming normally distributed data).



Size Mold ft³ (m³)	Dimensions, in. (mm)						
	A	B	C	D	E	F
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE — Tolerances are [illegible] unless otherwise noted.

FIG. 1 Details of Molds

in 1 less than the inside diameter of the sample tube if samples are extruded and trimmed.

5.2.2 *Minimum Specimen Height*—The minimum specimen height shall be 13 mm (0.5 in.) but shall be not less than 10 times the maximum particle diameter.

5.2.3 *Minimum Specimen Diameter-to-Height Ratio*—The minimum specimen diameter-to-height ratio shall be 2.5.

5.2.4 *Rigidity*—The rigidity of the ring shall be such that, under hydrostatic stress conditions in the specimen, the change in diameter of the ring will not exceed 0.03 % of the diameter under the greatest load applied.

5.2.5 The ring shall be made of a material that is noncorrosive in relation to the soil tested. The inner surface shall be highly polished or shall be coated with a low-friction material. Silicon grease is recommended or polytetrafluoroethylene for nonsandy soils.

5.3 *Porous Stones*—The porous stones shall be of silicon carbide, aluminum oxide, or metal that is not attacked by the soil or soil moisture. The grade of the stones shall be fine enough to prevent intrusion of soil into the pores of the stone. If necessary, a filter paper[4] may be used to prevent intrusion of the soil into the stones. However, the permeability of the stones, and filter paper, if used, must be sufficiently high to prevent retardation of the drainage of the specimen. The stones shall be clean and free of cracks, chips, and nonuniformities.

5.3.1 The diameter of the top stone shall be 0.2 to 0.5 mm (0.01 to 0.02 in.) less than that of the inside diameter of the ring. If a floating ring is used, the bottom stone shall have the same diameter as the top stone. The use of tapered stones is recommended, with the larger diameter in contact with the soil.

5.3.2 The stone thickness shall be sufficient to prevent breaking. The top stone shall be loaded through a corrosion-resistant plate of sufficient rigidity to prevent breakage of the stone.

5.4 *Storage*—Storage of sealed samples should be such that no moisture is lost during storage, that is, no evidence of partial drying of the ends of the samples or shrinkage. Time of storage should be measured, particularly when the soil or soil moisture is expected to react with the sample tubes.

5.4.1 *Sample Preparation Environment*—Test specimens shall be prepared in an environment whose soil moisture change during preparation does not exceed ± 2 % (A high humidity moisture room is usually used for this purpose.)

5.5 *Temperature*—Tests should be performed in an environment where temperature fluctuations are less than ± 4°C (± 2°F) and there is not any direct contact with sunlight.

5.6 *Trimmer*, or cylindrical cutter, for trimming the sample down to the inside diameter of the consolidometer ring with a minimum of disturbance. The cutter shall have a highly polished surface and be coated with a low-friction material.

5.7 *Balance*, sensitive to 0.1 g or to 0.1 % of the total mass of the test specimen.

5.8 *Drying Oven*, that can be maintained uniformly at 110 ± 5°C (230 ± 9°F). A forced-draft oven is recommended.

5.9 *Extensometer*, to measure change in height of the specimen with a sensitivity of 0.0025 mm (0.0001 in.).

5.10 *Miscellaneous Equipment*, including spatulas, knives, wire saws, used in preparing the specimen.

5.11 *Moisture Content Containers*, shall be in accordance with Method D 2216.

6. Sampling

6.1 Relatively undisturbed samples should be obtained and used for consolidation testing because the meaningfulness of the results diminishes greatly with sample disturbance. Methods D 1587 and D 3550 cover procedures and apparatus that may be used to obtain satisfactory samples for testing.

7. Specimen Preparation (Note 2)

7.1 Prepare the sample on an environment in accordance with 5.4.1. Trim the specimen to the inside diameter of the consolidometer, fitting it directly into the ring during trimming. Trim it flush with the plane surface of the ring. For soft to medium soils, a wire saw should be used for trimming the top and bottom of the specimen to minimize smearing. A straightedge with a sharp cutting edge may be used for the final trim after the excess soil has first been removed with a wire saw. For stiff soils, a sharpened straightedge alone may be used for trimming the top and bottom. If desired, the specimen height may be made less than the ring height by partial extrusion and trimming, provided the minimum specimen thickness requirements in 5.2.2 and 5.2.3 are met. A specimen ring with the cutting edge attached provides the most accurate fit in most soils.

NOTE 2—Precautions should be taken to minimize disturbance of the soil or changes in moisture and density during sample transportation and preparation. Vibration, distortion, and compression must be avoided.

7.2 For those soils, such as peat, and those soils that are easily damaged by trimming, may be transferred directly from the sampling tube to the ring provided that the ring has the same diameter as the sample tube.

7.3 Specimens obtained using a ring-lined sampler may be used without prior trimming, provided they comply with the requirements of Method D 3550 and this method.

7.4 Determine the mass of the specimen in the consolidation ring.

8. Calibration

8.1 Assemble the consolidometer with a copper or hard steel disk of approximately the same height as the test specimen and 1 mm (0.04 in.) smaller diameter than the ring in place of the sample. Moisten the porous stones. If filter papers are to be used (see 5.3), they should be moistened and sufficient time for the moisture to be squeezed from them should be allowed during the calibration process.

8.2 Load and unload the consolidometer as in the test and measure the deformation for each load applied.

8.3 Plot or tabulate the corrections to be applied to the deformation of the test specimen at each load applied. Note that the metal disk will deform also. However, the correction due to this deformation will be negligible for all but extremely stiff soils. If necessary, the compression of the metal disk can be computed and applied to the corrections.

9. Natural Moisture Content, Weight, Volume, Specific Gravity, Liquid and Plastic Limits, and Particle Size Distribution Determinations

9.1 Use the material trimmed adjacent to the specimen (see Section 7) to determine the natural moisture content in accordance with Method D 2216 and the specific gravity with Method D 854. Determine the initial wet mass of the specimen by subtracting the mass of the specimen ring from the combined mass of the specimen ring and the specimen. Determine the initial volume of the specimen from the diameter and height of the specimen. The value of moisture content determined from the trimmings is approximate but permits determination of the void ratio before the test is complete. The most accurate determination of the specimen dry mass and moisture content is found by drying the entire specimen at the end of the test. This procedure should be used unless a portion of the specimen is needed for index tests (see 10.9). The specific gravity can be estimated where an accurate void ratio is not needed.

9.2 The liquid limit, as determined in accordance with Method D 423, the plastic limit, as determined in accordance with Method D 424, and the particle size distribution, for soils with substantial granular material, as determined in accordance with Method D 422, are useful in identifying the soil and in correlating the results of tests on different soils. It is recommended that liquid and plastic limits be determined on the trimmings or on representative portions of the test specimen if the soil exhibits significant heterogeneity.

10. Procedure

10.1 The objective of the preparation of the stones and other apparatus prior to their contact with the specimen is to prevent change in moisture content of the specimen. Thus, very dry, highly expansive soils should be placed on dry stones but most partially saturated soils may be placed on stones that have simply been dampened. If the specimen is saturated and is believed not to exhibit a high affinity for water, the porous stones should be boiled after cleaning with a nonabrasive brush and kept saturated until the time of their contact with the specimen. Assemble the ring, specimen and porous stones. With the consolidometer assembled, enclose the specimen, ring, filter paper (when used), and porous stones with a moisture-fitting plastic or rubber membrane to prevent change in specimen volume due to evaporation. This step may be omitted if the specimen is to be inundated after the first load increment is applied as provided in 10.8.

[4] Use a hardened, fast filter paper.

RELATIVE DENSITY

MINIMUM AND MAXIMUM DENSITY DETERMINATIONS

DATE _____

PROJECT _____

BORING NO _____ SAMPLE NO _____

CLASSIFICATION

MOLD NO.	MOLD DIAMETER, IN. :	WEIGHT OF MOLD, w_m, LB :
VOLUME OF MOLD, V_m, CU FT :		END AREA OF MOLD, A_m, SQ FT :

MINIMUM DENSITY

			TRIAL NO	1	2	3	4
WEIGHT LB	MOLD (OR TARE) AND SOIL, DRY	w					
	MOLD (OR TARE)	w_m					
	SOIL, DRY	W_1					
MIN DRY DENSITY, LB/CU FT = w_s/V		γ_d					
MIN DRY DENSITY, AVERAGE				LB/CU FT			

MAXIMUM DENSITY

METHOD USED

			TRIAL NO	1	2	3	4
HEIGHT, IN	LEFT DIAL READING	h_L					
	RIGHT DIAL READING	h_R					
	AVERAGE DIAL = $(h_L + h_R)/2$	h_{avg}					
	INITIAL DIAL READING	h_o					
	HEIGHT CHANGE = $h_o - h_{avg}$	Δh					
VOL CU FT	VOLUME CHANGE = $(\Delta h/12) \times A_m$	Δv					
	VOLUME OF SOIL = $V_m - \Delta v$	V					
WEIGHT LB	MOLD (OR TARE) AND SOIL, DRY	w					
	MOLD (OR TARE)	w_m					
	SOIL, DRY	W_2*					
MAX DRY DENSITY, LB/CU FT = W_2/V		γ_d					
MAX DRY DENSITY, AVERAGE				LB/CU FT			

REMARKS _____

TECHNICIAN _____ COMPUTED BY _____ CHECKED BY _____

ENG FORM NO. 3858** PREVIOUS EDITION MAY BE USED (EM 1110-2-1906)
REV JUNE 1970

*From Relative Density Supplemental Data Sheet
**Replaces WES Form 728

of time method may also be used to obtain a value of t_{100} if desired.

11.7 Compute initial void ratio, water content, unit weight, and degree of saturation, based on the dry weight of the total specimen. Specimen volume is computed from measurements of the container ring height and diameter. Volume of solids is computed by dividing the dry weight of specimen by the specific gravity of the solids times the unit weight of water. Volume of voids is assumed to be the difference between the specimen volume and the volume of the solids.

11.8 Compute void ratio corresponding to 100 % primary consolidation (using corrected deformation readings) for each load. As an alternative, compute percent compression at 100 % primary consolidation for each load from the initial sample height. As a second alternative, compute void ratios (or values of percent compression) using the deformation values obtained after a selected time interval that shall include some portion of secondary compression, and such time interval shall be the same for each load increment. However, if the "equilibrium" value chosen is other than the 100 % primary consolidation point, a note to this effect should be included with the test results. It should be noted that the second alternative cited above will result in somewhat lower values of the preconsolidation pressure than are obtained when the 100 % primary consolidation points are used.

12. Report

12.1 The report shall include the following information:

12.1.1 Identification and description of the test sample, including whether soil is undisturbed, remolded, compacted, or otherwise prepared,

12.1.2 Initial and final moisture content,

12.1.3 Dry mass and initial and final wet unit weight,

12.1.4 Initial percentage saturation,

12.1.5 Specific gravity of solids or Atterberg Limit gradation data if obtained,

12.1.6 Specimen dimensions,

12.1.7 Condition of test (natural moisture or inundated, pressure at inundation),

12.1.8 Preparation procedure used relative to trimming, state whether specimen was trimmed, extruded directly into the ring, or tested directly in a ring from a ring lined sampler,

12.1.9 Plot of log of time or square root of time versus deformation, for those load increments where time rate readings were taken. For organic or highly micaceous soils, or other soils with appreciable secondary compression, it is highly desirable that log of time plots extending into the secondary compression region be included,

12.1.10 Plot of void ratio versus log of pressure curve or percent compression versus log of pressure curve,

12.1.11 In cases where time rate of consolidation readings have been taken for several load increments, a plot of coefficient of consolidation versus log of average pressure. As an alternative, a plot of log of coefficient of consolidation versus log of average pressure curve may be used. The method used for computing c_v should be noted. If time-rate readings were obtained for only two load increments, simply tabulate the values of c_v versus the average pressure for the increment,

12.1.12 All departures from the procedure outlined, including special loading sequences. For example, it may be desirable to inundate and load the specimen precisely in accordance with the wetting or loading pattern expected in the field in order to best simulate the response. Smaller than standard load increment ratios may be desirable for soils that are highly sensitive or whose response is highly dependent on strain rate.

13. Precision and Accuracy

13.1 Section 5 of this method specifies the sensitivity of the load and deformation measurements. The corresponding accuracy of the applied stress and resultant strain in the specimen can be computed from the specimen dimensions. The accuracy with which the test results can be applied to the field varies from case to case and depends on:

13.1.1 The quality of samples used,

13.1.2 The number of samples tested,

13.1.3 The vertical and horizontal distribution of the samples tested, and

13.1.4 The heterogeneity of the soil profile in the field.

13.2 A statistical analysis that includes both the sampling program and the laboratory test results is required to assess, in any meaningful way, the accuracy with which the test results apply to the field. In the absence of such an analysis, most engineers assess the applicability of the test results to the field qualitatively by looking at the variation in the test results and the variations on the boring logs. In general, it can be noted that the accuracy of settlement predictions based on consolidation tests increases (on a percentage basis) with the compressibility of the soil.

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SOILS TESTING FACILITY (GEOTECHNICAL LABORATORY) TEST PROCEDURE

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF CRUSHED ROCK (MODIFICATION A)

This document describes the test procedures for use in the consolidation testing for the Nevada Nuclear Waste Storage Investigations (NNWSI) Crushed Tuff project. The original procedure was modified as follows:

Modification A: 20 May 1986 (See data sheet and Consolidation Test Supplemental Data Sheet).

Approved by:

A. Burke for G. Wong PROJECT LEADER	5-27-86 DATE
Lessie C. Oldham SOILS TESTING FACILITY CHIEF	27 May 86 DATE
Joyce C. Ahlquist QA OFFICER	27 May 86 DATE
Roger A. Ewanowski PROJECT MANAGER SQR	5-30-86 DATE

SOILS TESTING FACILITY (GEOTECHNICAL LABORATORY) TEST PROCEDURE

HYDRAULIC CONDUCTIVITY (Modification (A)

This document describes the test procedures for use to determine the hydraulic conductivity of crushed tuff, Nevada Nuclear Waste Storage Investigations (NNWSI) Project. The original test procedure was modified as follows:

Modification A: 20 May 1986 (See Saturation Data sheet, paragraph 6.3, Hydraulic Conductivity Supplemental Data sheet, and Constant Head and Falling Head Hydraulic Conductivity Supplemental Data sheet).

Approved by:

A. Buck for G. Wong PROJECT LEADER	5-27-86 DATE
Leroy C. Olson SOILS TESTING FACILITY CHIEF	27 May 86 DATE
Joyce C. Wilson QA OFFICER	27 May 86 DATE
Joseph A. Dennis PROJECT MANAGER SWL	5-30-86 DATE

Equipment used for this test program will consist of the following:

Scales: (1) Toledo Model 2126
Serial No. 231-8614-2UL
250-lb cap.; readable to 0.1 lb

(2) Mettler PK 300
Serial No. A56081
300-g cap.; readable to 0.001 g

(3) Mettler P1600
Serial Nos. E39125; E39410; E39124
800-g cap.; readable to 0.1 g

(4) Mettler PE 1600
Serial No. E39131
1200-g cap.; readable to 0.01 g

(5) Mettler PE6000
Serial No. F35911
10-kg cap.; readable to 1 g

(6) Mettler PS-30
Serial No. 791037
30-kg cap.; readable to 1 g

Data Sheet: Eng Form 3848 will not be used due to changes in data recording. Compaction Data will be recorded on Consolidation Test Supplemental Data sheet. Consolidation test data will be recorded on a computer printout as described in the supplemental data sheet.

Eng Form 2088 is used by the technician during the consolidation test to plot time consolidation curve to determine secondary consolidation and termination of test. The form was modified to indicate testing installation with the addition of USAE-WES to the lower left corner of the form (attachment 3).

Quality Assurance: Only qualified personnel shall be allowed to perform this work.

Calibration: All scales are calibrated by Allometric Balance Systems, Baton Rouge, LA.

Displacement calibrations are made with precision micrometers/precision gage blocks.

Instrumentation is calibrated using precision voltage calibration units located in ISD and traceable to Bureau of Standards.

Hydraulic Conductivity Procedure. The procedure for determining hydraulic conductivity is as described in "Permeability Test", Appendix VII, EM 1110-2-1906 (attachment G-1) Procedure to determine hydraulic conductivity coupled with consolidometer is described in Section 8, "Permeability Tests" with consolidometer beginning on page VII-22. Sections of the "Permeability Tests", Appendix VII not applicable to the falling head test at it is coupled with a consolidometer are as follows:

Section	Reasons for Deletions
3	Section 3 provides description of constamt head permeability test
5	Section 5 describes permeability testing with sample tube which is not applicable to current testing
6 and 7	Sections 6 and 7 describes pressure chamber and back pressure testing not applicable to current testing

A list of the measuring equipment used for this testing is as follows:

Equipment	Description
Thermometer	0 to 50° C accurate to 0.1° C
Timing device	Reads to 0.5 seconds
Scale	Graduated in centimeters

Data Sheet: Data will be recorded on Eng Form 3844, Plate VII 2 and Eng Form 3845, Plate VII 2 of test procedure. The form is modified to add WES to the lower left corner of the form for identification of installation doing the work.

Quality Assurance:

6.1: Only qualified personnel shall be allowed to perform the work.

6.2: Calibration of applicable equipment will be performed as discussed in U.S. Army Engineer Waterways Experiment Station, Structures Laboratory, Quality Assurance (QA) Manual, 1980.

6.3: Measurement of the volume of water moving through the hydraulic conductivity sample will be measured by volume and by weight of water for both the hydraulic conductivity testing. The measurements for the constant head test and the falling head test will be recorded on Eng Form 3844 and 3845, respectively. A supplemental form has been provided to record weight of water corresponding to volume measurements made on Eng Form 3844 and 3845. The weight of the water in this testing program is used to verify volume measurements. If the two are in close agreement then the volume measurement will be used for the calculation of hydraulic conductivity.

PERMEABILITY TEST ON UNDISTURBED SOIL

Test No. — Date of Test

Location of Sample — Date Sampled — Report

Boring — Sample — Depth —

(a) Description of Soil _____

Materials Used _____

(b) Test Specimen Dimensions

Diameter D, cm — Height Before, H_1 — Weight Before, W_1

Area A, cm² — Height After, H_2 — Weight After, W_2

Length L, cm — Height Net, cm — Weight Net, g

Moisture Content (at start) _____

Dry Unit Weight γ_d, lb/ft³ _____

Void Ratio e _____

Relative Density, RD _____

(c) Permeability Test (Increasing Gradient)

Test No.	Measurements H_1	Measurements H_2	Head, cm	Q, cm³	i	Q/Ai	k/i	Temperature, °C	k, cm/s
1									
2									
3									
4									
5									
6									

FIG. 1 Permeability Test Data Sheet.

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Standard Test Method for ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS[1]

This standard is issued under the fixed designation D 2435; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers a procedure for determining the rate and magnitude of consolidation of soil when it is restrained laterally and loaded and drained axially.

NOTE 1—The values stated in SI units are to be regarded as the standard. The values stated in inch-pound units are approximate.

2. Applicable Documents

2.1 *ASTM Standards:*

D 422 Method for Particle-Size Analysis of Soils[2]

D 423 Test Method for Liquid Limit of Soils[2]

D 424 Test Method for Plastic Limit and Plasticity Index of Soils[2]

D 854 Test Method for Specific Gravity of Soils[2]

D 1587 Method for Thin-Walled Tube Sampling of Soils[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

3. Summary of Method

3.1 The method requires that an element of soil be restrained laterally and axially loaded in increments with a constant stress being applied until all of the excess pore water pressures have dissipated for each increment. During the compression process measurements of decrease in the sample height are made and these data are used to compute the parameters that describe the relationship between the effective stress and void ratio or strain and describe the rate at which compression can occur.

4. Significance and Use

4.1 The compressibility of soils as determined from this test is one of the most useful properties that can be obtained from laboratory testing. The data from the consolidation test can be used to develop an estimate of both the rate and the amount of both differential and total settlement of a structure or a foundfill. Estimates of this type are often of key importance in first selecting a foundation type and secondly in evaluating its adequacy.

5. Apparatus

5.1 *Load Device*—A suitable device for applying vertical loads to the specimen. The device should be capable of maintaining specified loads for long periods of time with an accuracy of ± 0.5 % of the applied load and should permit application of a given load increment within a period of 2 s, without significant impact.

5.2 *Consolidometer*—A device to hold the specimen in a ring which is either fixed to the base or floating (supported by friction on periphery of specimen) with porous stones on each face of the specimen. The consolidometer shall also provide means for submerging the specimen, for applying a vertical load, and for measuring the change in height of specimen. The consolidometer ring shall conform to the following requirements:

5.2.1 *Minimum Specimen (Ring) Diameter*—The minimum specimen diameter shall be 50 mm (2.00 in.), and shall be at least 5 mm (¼ in.).

[1] This method is under the jurisdiction of ASTM Committee D 18 on Soil and Rock and is the direct responsibility of Subcommittee D 18.05 on Structural Properties of Soils.

Current edition approved Nov. 21, 1980. Published December 1980. Originally published as D 2435 – 65 T. Last previous edition D 2435 – 70.

[2] 1982 Annual Book of ASTM Standards, Vol 04.08.

Sample No. _____
Operator _____
Date _____

Hydraulic Conductivity Supplemental Data Sheet (Continued)
(Page 2 of 2)

Stand Pipe Reading(mm)

	Begin Reading A	End Reading B	Changes in Reading A - B = C	Volume In, C X D*	Cumulative Volume In, W_T	Volume Out	Cumulative Volume Out, W_D	Total Water In Sample, W_A**	Elapsed Time
1				ml	ml	ml	ml	ml	
2				ml	ml	ml	ml	ml	
3				ml	ml	ml	ml	ml	
4				ml	ml	ml	ml	ml	
5				ml	ml	ml	ml	ml	
6				ml	ml	ml	ml	ml	
7				ml	ml	ml	ml	ml	
8				ml	ml	ml	ml	ml	
9				ml	ml	ml	ml	ml	
10				ml	ml	ml	ml	ml	
11				ml	ml	ml	ml	ml	
12				ml	ml	ml	ml	ml	
13				ml	ml	ml	ml	ml	
14				ml	ml	ml	ml	ml	
15				ml	ml	ml	ml	ml	

*D = conversion of standpipe _____ml/mm (This value is taken from _____).

**W_A = Total water in sample and apparatus = W_T - W_D.

V_S = _____ (from page 1 of 2 of Hydraulic Conductivity Supplemental Data Sheet

10.2 Place the consolidometer in the loading device and apply a seating pressure of 5 kPa (100 lbf/ft²). Within 5 min after application of the seating load adjust the extensometer dial gage for the initial or zero reading. (For very soft soils a seating pressure of 2 or 3 kPa (about 50 lbf/ft²) or less is desirable.)

10.3 Place loads on the consolidometer to obtain pressures on the soil of approximately 5, 10, 20, 40, 80, etc., kPa (100, 200, 400, 800, 1600 etc., lbf/ft²), with each pressure maintained constant as required in 10.4. (Smaller increments may be desirable on very soft specimens or when it is desirable to determine the preconsolidation pressure with more precision.) Loading of the specimen should continue into the virgin compression region so that the slope and shape of the virgin compression curve may be assessed. Typically, a final pressure that is equal to or greater than four times the preconsolidation pressure of the sample is required for this assessment. In the case of overconsolidated clays in particular, it may be desirable to use an unloading-reloading cycle to better evaluate recompression parameters, but such a procedure is optional.

10.4 For at least two load increments (including at least one load increment after the preconsolidation pressure has been exceeded), record the height or change in height of the specimen before each pressure increment is applied and at time intervals of approximately 0.1, 0.25, 0.5, 1, 2, 4, 8, 15, and 30 min, 1, 2, 4, 8, etc., h, measured from the time of each incremental pressure application. These time-rate readings need be obtained only for saturated specimens. Readings should continue at least until the slope of the characteristic linear secondary compression portion of the thickness versus log of time plot is apparent (see 11.1), unless the method 11.6 is used, in which case the next loading may proceed as soon as 100 % consolidation is completed. (For soils that have slow primary consolidation, pressures should be applied for at least 24 h. In extreme cases, or where secondary compression must be evaluated, they should be applied much longer.) Then apply the next pressure increment. (For pressure increments where time versus deformation data are not required, the load should be left on the sample for essentially the same length of time as when time versus deformation readings are taken. Sufficient reading should be taken near the end of the pressure increment period to allow for any needed extrapolation of the time deformation curve.

10.5 If thickness versus square root of time plots are to be made, the time intervals may be adjusted to those that have easily obtained square roots, for example, 0.09, 0.25, 0.49, 1 min, 4 min, 9 min, etc.

10.6 *Rebound*—Where rebound or unloading characteristics are desired, unload soil by pressure decrements in reverse order. However, if desired, each successive load can be only one fourth as large as the preceding load. Record at time intervals as suggested in 10.4. Note however, that for most soils the rebound will be complete in less time than would be required for an increment of load during primary consolidation, but sufficient readings should be taken to verify that rebound is essentially complete.

10.7 An alternative loading, unloading, or reloading schedule may be employed that reproduces the construction stress changes, or obtains better definition of some part of the stress-deformation curve, or aids in interpreting the field behavior of the soil. This should be clearly indicated on the test results.

10.8 If the test is performed on an undisturbed sample that was either saturated under field conditions or obtained from below the water table, it should be inundated after the first load increment is applied. As inundation and specimen wetting occur, the load should be increased if required, to prevent the specimen from swelling, unless it tends to swell under the estimated in situ vertical stress. If the specimen compresses after inundation, simply record the amount of compression. Specimens also may be inundated at pressures that simulate future inundation under field conditions. In such cases, the pressure at inundation and any resulting effects, such as expansion or increased compression, should be noted in the test results.

10.9 To minimize swell during disassembly, the specimen should be rebounded back to a very small stress and dismantled quickly after releasing the final load on the specimen. Remove the specimen and the ring from the consolidometer and wipe the free water from the ring and specimen. Remove the specimen from the ring and determine its mass, oven dry it and reweigh it to obtain the dry mass of solids and the final water content. If the original soil sample is very heterogeneous, any index tests should be performed on a portion of the test specimen and the remainder can be used for a final water content measurement. Porous stones should be boiled clean after the test to prevent clay from drying on them and reducing their permeability.

11. Calculation

11.1 From those increments of load where time-rate readings are obtained, plot the deformation readings versus the log of time (in minutes) for each increment of load or pressure as the test progresses, and for any increments of rebound where time versus deformation data have been obtained.

11.2 Find the deformation representing 100 % primary consolidation for each load increment. First draw a straight line through the points representing the final readings and that exhibit a straight line trend and a flat slope. Draw a second straight line tangent to the steepest part of the deformation-log time curve. The intersection represents the deformation corresponding to 100 % primary consolidation. Correct the deformation at 100 % consolidation in accordance with the results of the calibration (see Section 8). Compression that occurs subsequent to 100 % primary consolidation is defined as secondary compression.

11.3 Find the deformation representing 0 % primary consolidation by selecting the deformations at any 2 times that have a ratio of 1 to 4. The deformation corresponding to the larger of the two times should be greater than ½ but less than ¾ of the total change in deformation for the load increment. The deformation corresponding to 0 % primary consolidation is equal to the deformation corresponding to the smaller time interval less the difference in the deformations for the two selected times.

11.4 The deformation corresponding to 50 % primary consolidation for each load increment is equal to the average of the uncorrected deformations corresponding to the 0 and 100 % deformations. The time required for 50 % consolidation under any load increment may be found graphically from the deformation-log time curve for that load increment by observing the time that corresponds to 50 % of the primary consolidation of the curve.

11.5 For each load increment for which time-rate readings were obtained, compute the coefficient of consolidation, c_v, as follows:

$$c_v = \frac{0.197H^2}{t_{50}}$$

where:

H = sample height in metres (feet) for a doubly drained sample at 50 % consolidation,

t_{50} = time for 50 % consolidation in years, and

c_v = coefficient of consolidation in m²/year (ft²/year).

If H is in millimetres and t in seconds or minutes, c_v will be expressed in mm²/s or mm²/min, respectively, and conversion to more convenient units is desirable.

11.6 An alternative procedure requiring a plot of deformation versus the square root of time in minutes may be used to determine the points of 0 and 100 % consolidation as well as the coefficient of consolidation for each load increment. The initial part of the curve is approximated by a straight line. The line is extrapolated back to $t = 0$. The corresponding deformation ordinate represents 0 % primary consolidation. A second straight line is drawn through this point so that the abscissa of this line is 1.15 times the abscissa of the straight line approximation of the initial part of the curve. The intersection of the new line with the deformation-square root of time curve corresponds to 90 % primary consolidation. The deformation at 100 % primary consolidation is ⅙ more than the difference in deformations between 0 and 90 % consolidation. Similarly, the deformation at 50 % consolidation is ⅗ of the difference between that at 0 and 90 %. The coefficient of consolidation can be found from the time of 90 % consolidation by the formula:

$$c_v = \frac{0.218H^2}{t_{90}}$$

where:

H = sample height for a doubly drained sample at 90 % consolidation, m (or ft),

t_{90} = time for 90 % consolidation, years, and

c_v = coefficient of consolidation, m²/year (ft²/year).

If H is in millimetres and t in seconds or minutes, the units of c_v will be mm²/s or mm²/min, respectively, and conversion to more convenient units is desirable. The square root

APPENDIX VII:

PERMEABILITY TESTS

1. **DARCY'S LAW FOR FLOW OF WATER THROUGH SOIL.** The flow of water through a soil medium is assumed to follow Darcy's law:

$$q = k\,i\,A$$

where q = rate of discharge through a soil of cross-sectional area A

k = coefficient of permeability

i = hydraulic gradient: the loss of hydraulic head per unit distance of flow

The application of Darcy's law to a specimen of soil in the laboratory is illustrated in Figure 1. The coefficient of permeability, k (often termed

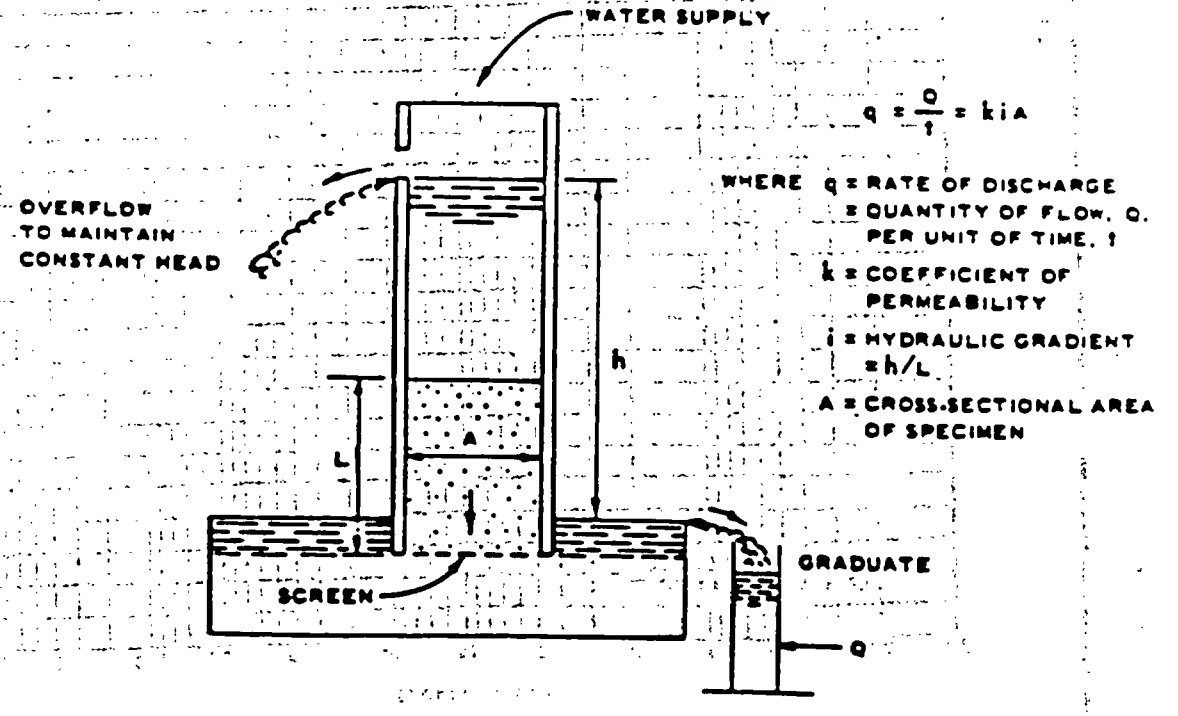
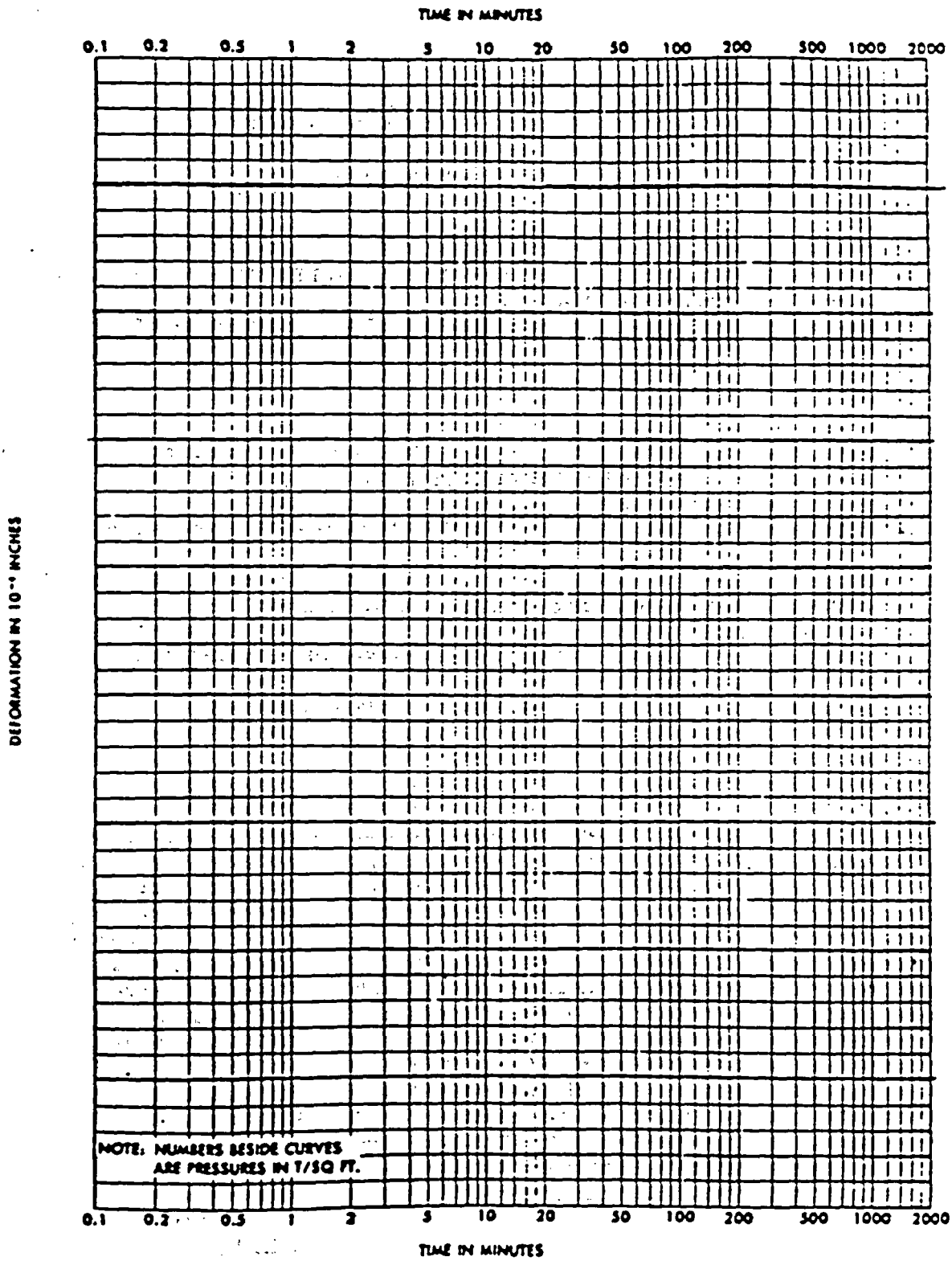


Figure 1. Flow of water through soil



PROJECT			
AREA			
BORING NO.	SAMPLE NO.	DEPTH EL	DATE

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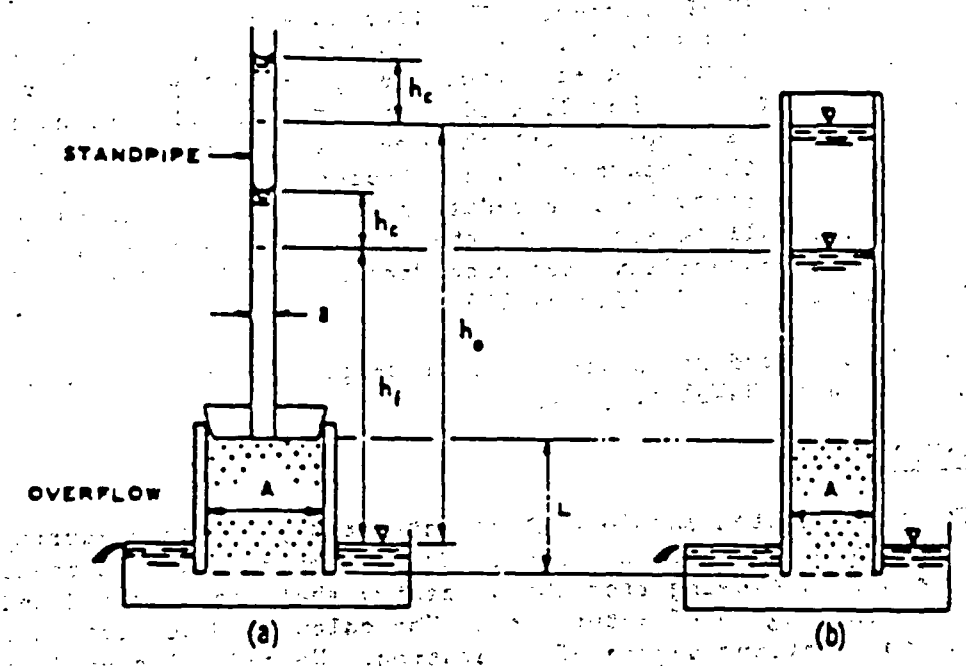
USAE-WES



USING SETUP SHOWN IN (a), THE COEFFICIENT OF PERMEABILITY IS DETERMINED AS FOLLOWS:

$$k = \frac{La}{At} \ln \frac{h_o}{h_f} = 2.303 \frac{La}{At} \log_{10} \frac{h_o}{h_f}$$

USING SETUP SHOWN IN (b), THE COEFFICIENT OF PERMEABILITY IS DETERMINED AS FOLLOWS:

$$k = \frac{L}{t} \ln \frac{h_o}{h_f} = 2.303 \frac{L}{t} \log_{10} \frac{h_o}{h_f}$$

WHERE: h_c = HEIGHT OF CAPILLARY RISE

a = INSIDE AREA OF STANDPIPE

A = CROSS-SECTIONAL AREA OF SPECIMEN

L = LENGTH OF SPECIMEN

h_o = HEIGHT OF WATER IN STANDPIPE ABOVE DISCHARGE LEVEL MINUS h_c AT TIME, t_o

h_f = HEIGHT OF WATER IN STANDPIPE ABOVE DISCHARGE LEVEL MINUS h_c AT TIME, t_f

t = ELAPSED TIME, $t_f - t_o$

Figure 2. Principle of falling-head test

HYDRAULIC CONDUCTIVITY WITH CONSOLIDOMETER

Purpose: The purpose of this document is to describe the test method used by the Soils Testing Facility, U.S. Army Engineer Waterways Experiment Station (WES), to perform hydraulic conductivity testing of crushed tuff for study by Sandia National Laboratories as part of the Nevada Nuclear Waste Storage Investigations (NNWSI) project. The procedure described by this document is for the falling head method as it is coupled with consolidation test apparatus. The constant head method used principally for hydraulic conductivities greater than 10×10^{-4} cm/sec currently has no standard test procedures as it is coupled with the consolidometer and will be developed interactively as the apparatus is constructed and tested. Guidance for hydraulic conductivity test procedure constant head as it is coupled with a consolidometer will be similar to the procedure described in Section 3 on Constant-Head Permeability Test with Permeameter Cylinder of "Permeability Test", Appendix VII, EM 1110-2-1906.

Scope: This procedure applies to rock samples provided by SNL for study in conjunction with NNWSI project.

SATURATION

The consolidated sample will be saturated prior to measuring the hydraulic conductivity of the test specimen. The amount of water introduced into the sample and that flowing from the apparatus shall be measured and used to calculate the degree of saturation. The calculated saturation will be used as a guide to determine degree of saturation. No hydraulic conductivity test shall be performed until full saturation is accomplished as indicated by water flowing from drain above the sample for at least 1 hr and where outflow is measured at $\geq$ 95 percent of inflow.

A small head of 1 psi shall be applied to facilitate saturation in those samples where added fines and consolidation pressures inhibit saturation of the sample. The head can be incrementally increased to a maximum of 10 psi if necessary to saturate the sample. Minimum pressure head should be applied to reduce particle migration and disruption of sample.

Water needed to saturate the test sample and to fill the consolidation apparatus to the drain (V_s) is calculated using the following equation:

$$V_s = 5438\ cm^3 + 455\ cm^2\ h_3 - \frac{W_s}{G_s}$$

where h_3 = height of sample (cm)

W_s = weight of sample (g)

G_s = specific gravity (g/cm^3)

3. CONSTANT-HEAD PERMEABILITY TEST WITH PERMEAMETER CYLINDER. a. Use. The constant-head permeability test with the permeameter cylinder shall in general be used for determining the permeability of remolded samples of coarse-grained soils such as clean sands and gravels having a permeability greater than about 10×10^{-4} cm per sec.

b. Apparatus. The apparatus and accessory equipment should consist of the following:

(1) A permeameter cylinder similar to that shown schematically in Figure 3a. The permeameter cylinder should be constructed of a transparent plastic material. The inside diameter of the cylinder should be not less than about 10 times the diameter of the largest soil particles, except when the specimen is encased in a rubber membrane as in the permeability test with pressure chamber, in which case the diameter of the cylinder should be at least six times the diameter of the largest soil particles.

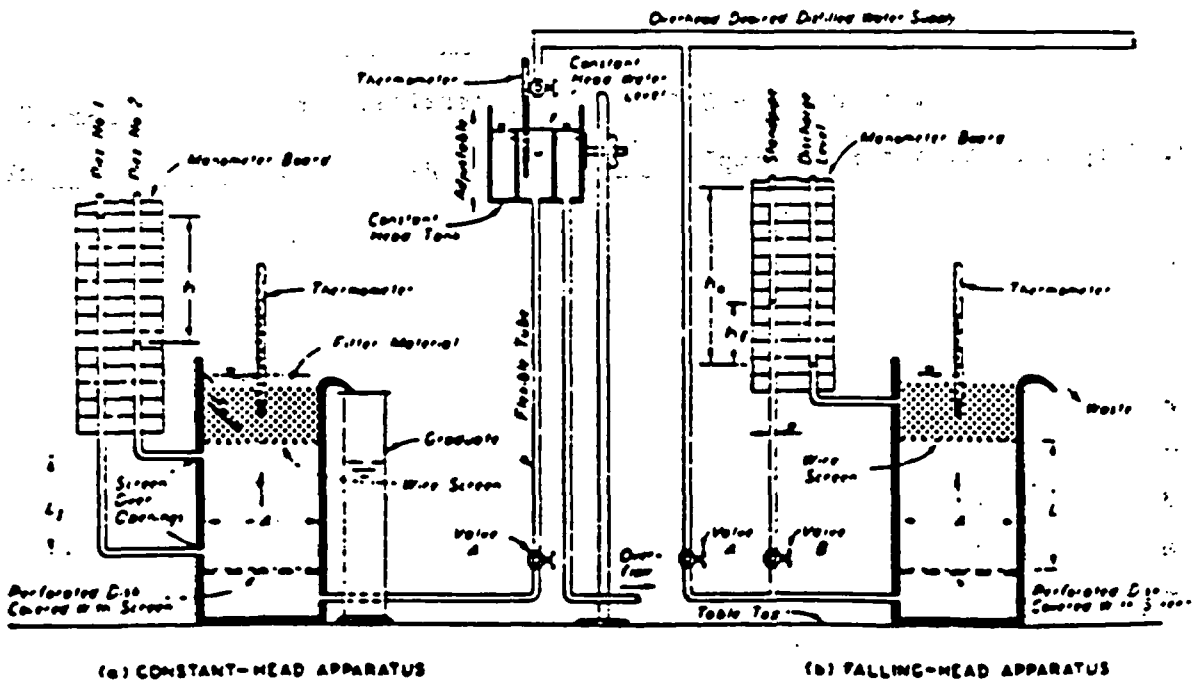


Figure 3. Schematic diagram of constant-head and falling-head permeability apparatus

Hydraulic Conductivity Supplemental Data Sheet
(Page 1 of 2)

Project: Crushed Tuff Consolidation Test Date _____

(SNL) Document No. 37-5031 Operator _____

Sample No. _____

SATURATION PHASE

Water required to saturate specimen and fill consolidation apparatus (V_s)

$$V_s = 5438\ cm^3 + 455\ cm^2\ h_3 - \frac{W_s}{G_s}$$

where

h_3 = height of sample (final height after creep)

W_s = weight of sample (dry) _____ gm

G_s = specific gravity (as determined for tuff) 2.50 g/cm^3

Head applied to saturate sample _____ psi V_s = _____ ml

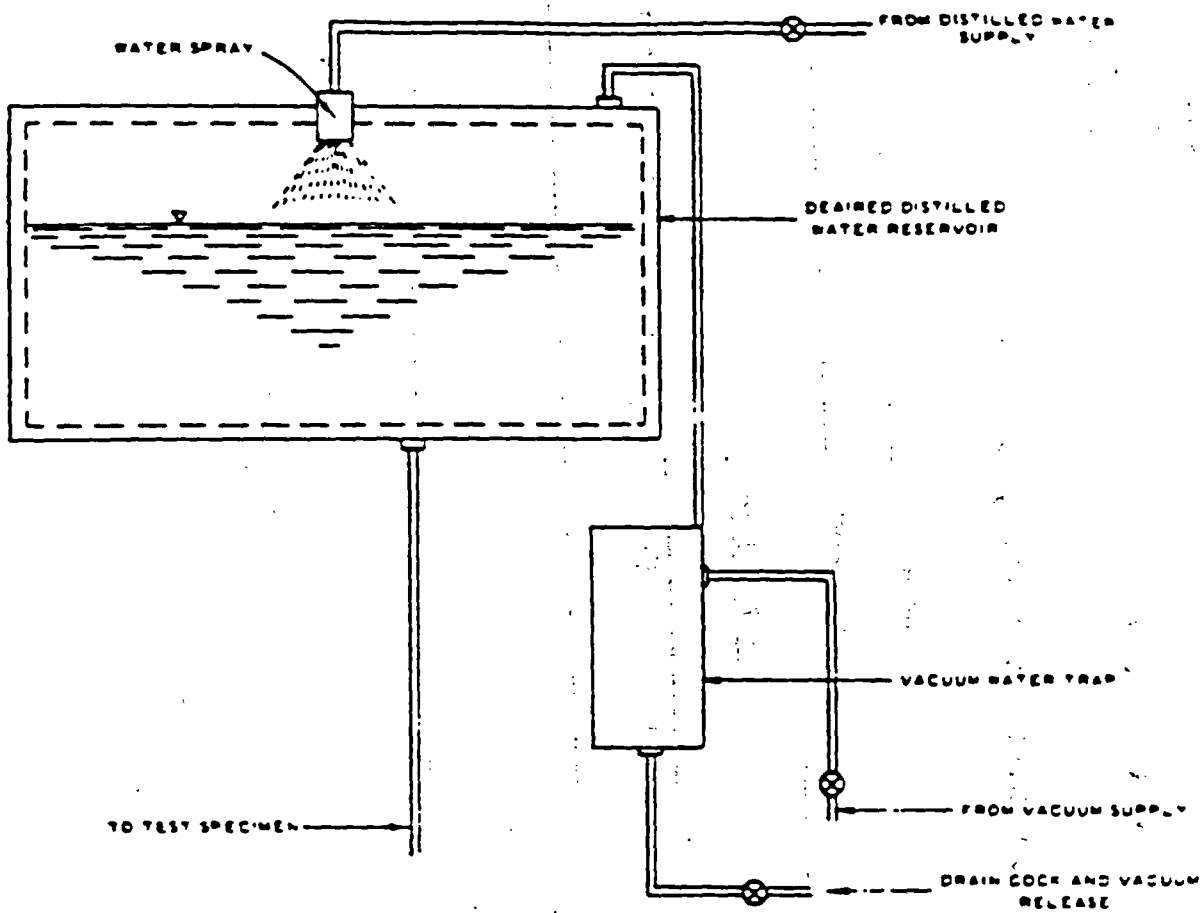


Figure 4. Schematic diagram of apparatus for preparing deaired distilled water

(7) Manometer board with tubing leading from the piezometer taps. If piezometer taps are not provided, equipment to measure the distance between the constant-head source and tailwater is required.

(8) Timing device, a watch or clock with second hand.

(9) Graduated cylinder, 100-ml capacity.

(10) Centigrade thermometer, range 0 to 50 C, accurate to 0.1 C.

(11) Balance, sensitive to 0.1 g.

(12) Oven (see Appendix I, WATER CONTENT - GENERAL).

Constant Head and Falling Head Hydraulic Conductivity Supplemental Data Sheet

Project: Crushed Tuff Consolidation Test
(SNL Document No. 37-5031)

Date: _____

Operator: _____

Sample No. _____

Constant Head*

Falling Head*

	Test 1a	1b	2a	2b	3a	3b
a. Dry weight of graduated cylinder, Wg (g)						
b. Weight of graduated cylinder and water, Wgw (g)						
c. Weight of water, Ww = Wgw - Wg (g)						
d. Quantity of Flow, cc**						

*Check one for appropriate test.

**Assume the density of water is 1g/cc.

spoon which permits the material to fall a constant height. The desired density may be achieved by vibrating the specimen to obtain a specimen of predetermined height. Compacting the specimen in layers is not recommended as a film of dust may be formed at the surface of the compacted layer which might affect the permeability results. After placement, apply a vacuum to the top of the specimen and permit water to enter the evacuated specimen through the base of the permeameter.

(7) After the specimen has been placed, weigh the excess material, if any, and the container. The specimen weight is the difference between the original weight of sample and the weight of the excess material. Care must be taken so that no material is lost during placement of the specimen. If there is evidence that material has been lost, oven-dry the specimen and weigh after the test as a check.

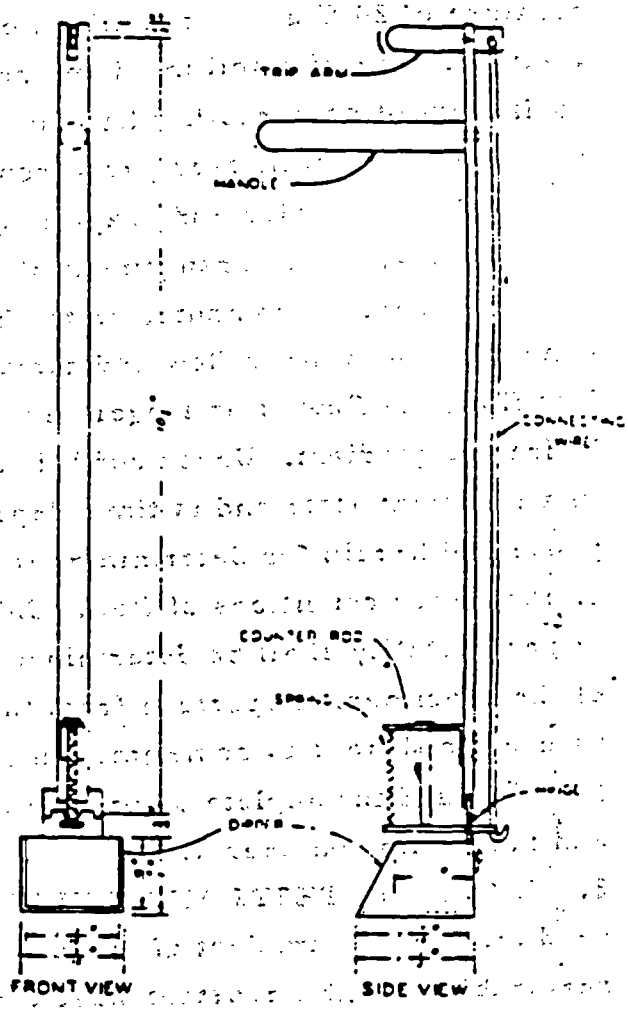


Figure 5. Spoon for placing cohesionless soils

(8) Level the top of the specimen, cover with a wire screen similar to that used at the base, and fill the remainder of the permeameter with a filter material.

(9) Measure the length of the specimen and inside diameter of the permeameter to the nearest 0.1 cm and record on the data sheet as initial height and diameter of specimen.

(10) Test the specimen at the estimated natural void ratio or

"permeability"), is defined as the rate of discharge of water at a temperature of 20 C under conditions of laminar flow through a unit cross-sectional area of a soil medium under a unit hydraulic gradient. The coefficient of permeability has the dimensions of a velocity and is usually expressed in centimeters per second. The permeability of a soil depends primarily on the size and shape of the soil grains, the void ratio of the soil, the shape and arrangement of the voids, and the degree of saturation.

Permeability computed on the basis of Darcy's law is limited to the conditions of laminar flow and complete saturation of the voids. In turbulent flow, the flow is no longer proportional to the first power of the hydraulic gradient. Under conditions of incomplete saturation, the flow is in a transient state and is time-dependent. The laboratory procedures presented herein for determining the coefficient of permeability are based on the Darcy conditions of flow. Unless otherwise required, the coefficient of permeability shall be determined for a condition of complete saturation of the specimen. Departure from the Darcy flow conditions to simulate natural conditions is sometimes necessary; however, the effects of turbulent flow and incomplete saturation on the permeability should be recognized and taken into consideration.

2. TYPES OF TESTS AND EQUIPMENT. a. Types of Tests. (1) Constant-head test. The simplest of all methods for determining the coefficient of permeability is the constant-head type of test illustrated in Figure 1. This test is performed by measuring the quantity of water, Q, flowing through the soil specimen, the length of the soil specimen, L, the head of water, h, and the elapsed time, t. The head of water is kept constant throughout the test. For fine-grained soils, Q is small and may be difficult to measure accurately. Therefore, the constant-head test is used principally for coarse-grained soils (clean sands and gravels) with k values greater than about 10×10^{-4} cm per sec.

(2) Falling-head test. The principle of the falling-head test is illustrated in Figure 2. This test is conducted in the same manner as

permeability, then the computed permeability is probably reliable. If there is a slight decrease in the permeability, then the permeability computed from the initial measurements, rather than the average, should be reported, so long as a plot of permeability versus time shows that the initial measurements are consistent with the subsequent measurements; a difference in permeability may result from a change in density caused by inadvertent jarring of the specimen in the permeameter. If there is any substantial decrease of the permeability with time, a prefilter should be used between the water reservoir and the permeameter (see paragraph 3b(6)). The criterion for judging whether a change in the computed permeability is "substantial" depends on the desired accuracy of the coefficient of permeability.

(7) If desired, reduce the void ratio as previously described and repeat the constant-head test.

e. Computations. The computations consist of the following steps:

(1) Compute the test void ratios in accordance with Appendix II, UNIT WEIGHTS, VOID RATIO, POROSITY, AND DEGREE OF SATURATION. The specific gravity shall be estimated or determined in accordance with Appendix IV, SPECIFIC GRAVITY.

(2) Compute the coefficient of permeability, k, by means of the following equation:

$$k_{20} = \frac{Q \times L \times R_T}{h \times A \times t}$$

where k_{20} = coefficient of permeability, cm per sec at 20 C

Q = quantity of flow, cc

L = length of specimen over which head loss is measured, cm. If piezometer taps are used, $L = L_1$ = distance between piezometer taps, cm

R_T = temperature correction factor for viscosity of water obtained from Table VII-1

h = loss of head in length, L, or difference in piezometer readings = $h_1 - h_2$, cm

A = cross-sectional area of specimen, sq cm

t = elapsed time, sec

the constant-head test, except that the head of water is not maintained constant but is permitted to fall within the upper part of the specimen container or in a standpipe directly connected to the specimen. The quantity of water flowing through the specimen is determined indirectly by computation. The falling-head test is generally used for less pervicus soils (fine sands to fat clays) with k values less than 10×10^{-4} cm per sec.

b. Equipment. The apparatus used for permeability testing may vary considerably in detail depending primarily on the condition and character of the sample to be tested. Whether the sample is fine-grained or coarse-grained, undisturbed, remolded, or compacted, saturated or nonsaturated will influence the type of apparatus to be employed. The basic types of apparatus, grouped according to the type of specimen container (permeameter), are as follows:

(1) Permeameter cylinders
(2) Sampling tubes
(3) Pressure cylinders
(4) Consolidometers

The permeability of remolded cohesionless soils is determined in permeameter cylinders, while the permeability of undisturbed cohesionless soils in a vertical direction can be determined using the sampling tube as a permeameter. The permeability of remolded cohesionless soils is generally used to approximate the permeability of undisturbed cohesionless soils in a horizontal direction. Pressure cylinders and consolidometers are used for fine-grained soils in the remolded, undisturbed, or compacted state. Fine-grained soils can be tested with the specimen oriented to obtain the permeability in either the vertical or horizontal direction. The above-listed devices are described in detail under the individual test procedures. Permeability tests utilizing the different types of apparatus, together with recommendations regarding their use, are discussed in the following paragraphs.

f. Presentation of Results. The coefficient of permeability shall be reported in units with coefficients of 1.0, 1×10^{-4}, and 1×10^{-9} cm per sec. The void ratio of the specimen shall be reported with all values of k. The coefficient of permeability, k, is logarithmically dependent upon the void ratio of the soil. Where k is determined at several void ratios, the test results shall be presented on a semilogarithmic chart as shown in Figure 6 in which k is plotted on the abscissa (logarithmic scale) and the void ratio is plotted on the ordinate (arithmetic scale).

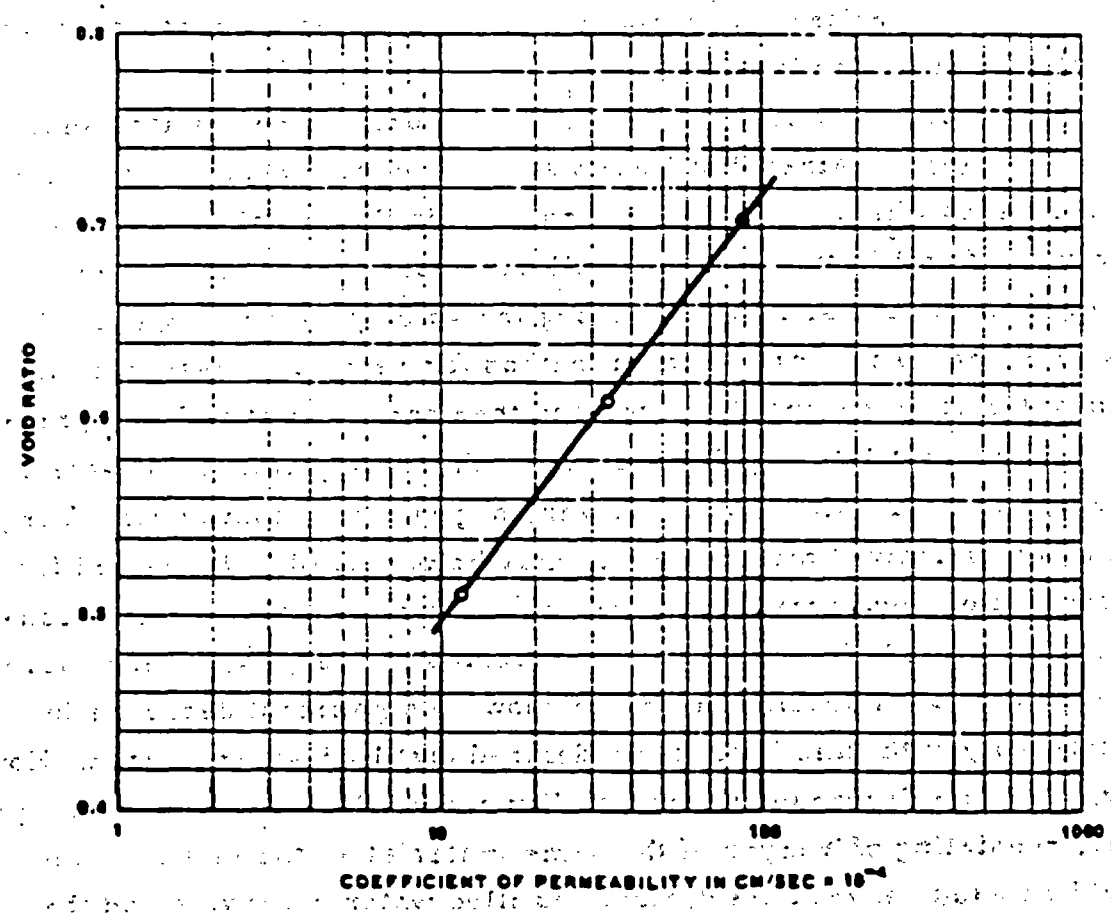


Figure 6. Relation between permeability and void ratio for cohesionless soils

4. FALLING-HEAD PERMEABILITY TEST WITH PERMEAMETER CYLINDER. a. Use. The falling-head test with the permeameter

Piezometer taps along the side of the permeameter within limits to be occupied by the sample are advantageous in that the head loss within the sample is always measured across a fixed distance and rapid determination of hydraulic gradient can be made.

(2) Perforated metal or plastic disks and circular wire screens, 35 to 100 mesh, cut for a close fit inside the permeameter.

(3) Glass tubing, rubber or plastic tubing, stoppers, screw clamps, etc., necessary to make connections as shown in Figure 3a.

(4) Filter materials such as Ottawa sand, coarse sand, and gravel of various gradations.

(5) A device for maintaining a constant-head water supply.

(6) Deaired distilled† water. Tapwater contains dissolved air and gases which separate from solution in the initial layers of a test specimen of soil in the form of small bubbles. These bubbles reduce the permeability of the soil by decreasing the void space available for the flow of water. The most common method for removing dissolved air from water is by boiling the water and then cooling it at reduced pressures. This method is applicable only with small quantities of water. Freshly distilled water also has a very negligible amount of air. Large quantities of deaired distilled water may be prepared and retained for subsequent use by spraying distilled water in a fine stream into a container from which the air has been evacuated (see Fig. 4). Permeability tests on saturated specimens should show no significant decrease in permeability with time if properly deaired distilled water is used. However, if such a decrease in permeability occurs during a test, then a prefilter, consisting of a layer of the same material as the test specimen, should be used between the deaired distilled water reservoir and the test specimen to remove the air remaining in solution.‡

† Demineralized water or tapwater when it is known to be relatively free of minerals may be used in place of distilled water.

‡ G. E. Bertram, An Experimental Investigation of Protective Filters, Soil Mechanics Series No. 7, Harvard University (Cambridge, Mass., January 1940, reprinted May 1959).

(10) Oven (see Appendix I, WATER CONTENT - GENERAL).

(11) Scale, graduated in centimeters.

c. Placement and Saturation of Specimen. Placement and saturation of the specimen shall be done as described in paragraph 3c. Identifying information for the sample and test data shall be entered on a data sheet similar to Plate VII-2.

d. Procedure. The procedure shall consist of the following steps:

(1) Measure and record the height of the specimen, L, and the cross-sectional area of the specimen, A.

(2) With valve B open (see Fig. 3b), crack valve A and slowly bring the water level up to the discharge level of the permeameter.

(3) Raise the head of water in the standpipe above the discharge level of the permeameter. The difference in head should not result in an excessively high hydraulic gradient during the test. Close valves A and B.

(4) Begin the test by opening valve B. Start the timer. As the water flows through the specimen, measure and record the height of water in the standpipe above the discharge level, h_o, in centimeters, at time t_o, and the height of water above the discharge level, h_f, in centimeters, at time t_f.

(5) Observe and record the temperature of the water in the permeameter.

(6) Repeat the determination of permeability, and if the computed values differ by an appreciable amount, repeat the test until consistent values of permeability are obtained.

e. Computations. The computations consist of the following steps:

(1) Compute the test void ratios as outlined in paragraph 3e(1).

(2) Compute the coefficient of permeability, k, by means of the following equation:

$$k = 2.303 \frac{a}{A} \frac{L}{t} \left(\log \frac{h_o}{h_f}\right) R_T$$

(13) Scale, graduated in centimeters.

c. Placement and Saturation of Specimen. Placement and saturation of the specimen shall be done in the following steps:

(1) Record all identifying information for the specimen, such as project, boring number, sample number, or other pertinent data, on a data sheet (Plate VII-1 is a suggested form).

(2) Oven-dry the specimen. Allow it to cool and weigh to the nearest 0.1 g. Record the oven-dry weight of material on the data sheet opposite W_s. The amount of material should be sufficient to provide a specimen in the permeameter having a minimum length of about one to two times the diameter of the specimen.

(3) Place a wire screen, with openings small enough to retain the specimen, over a perforated disk near the bottom of the permeameter above the inlet. The screen openings should be approximately equal to the 10 percent size of the specimen.

(4) Allow deaired distilled water to enter the water inlet of the permeameter to a height of about 1/2 in. above the bottom of the screen, taking care that no air bubbles are trapped under the screen.

(5) Mix the material thoroughly and place in the permeameter to avoid segregation. The material should be dropped just at the water surface, keeping the water surface about 1/2 in. above the top of the soil during placement. A funnel or a special spoon as shown in Figure 5 is convenient for this purpose.

(6) The placement procedure outlined above will result in a saturated specimen of uniform density although in a relatively loose condition. To produce a higher density in the specimen, the sides of the permeameter containing the soil sample are tapped uniformly along its circumference and length with a rubber mallet to produce an increase in density; however, extreme caution should be exercised so that fines are not put into suspension and segregated within the sample. As an alternative to this procedure, the specimen may be placed in the in the dry using a funnel or

the same as those described previously for each test.

6. PERMEABILITY TEST WITH PRESSURE CHAMBER. In the permeability test with a pressure chamber, see Figure 7, a cylindrical specimen is confined in a rubber membrane and subjected to an external hydrostatic pressure during the permeability test. The advantages of this type of test are: (a) leakage along the sides of the specimen, which would occur if the specimen were tested in a permeameter, is prevented, and (b) the specimen can be tested under conditions of loading expected in the field. The test is applicable primarily to cohesive soils in the undisturbed, remolded, or compacted state. Complete saturation of the specimen, if it is not fully saturated initially, is practically impossible. Consequently, this test should be used only for soils that are fully saturated, unless values of permeability are purposely desired for soils in an unsaturated condition. The permeability test with the pressure chamber is usually performed as a falling-head test.

The permeability specimens for use in the pressure chamber generally should be 2.8 in. in diameter, as rubber membranes and equipment for cutting and trimming specimens of this size are available for triaxial testing apparatus (see Appendix X, TRIAXIAL COMPRESSION TESTS). A specimen length of about 4 in. is adequate. (The dimensions of a test specimen may be varied if equipment and supplies are available to make a suitable test setup.) The pressure in the chamber should not be less than the maximum head on the specimen during the test. The other test procedure and computations are the same as those described for the falling-head test. The linear relation between permeability and void ratio on a semilogarithmic plot as shown in Figure 6 is usually not applicable to fine-grained soils, particularly when compacted. Other methods of presenting permeability-void ratio data may be desirable.

7. PERMEABILITY TESTS WITH BACK PRESSURE.

a. Description. Gas bubbles in the pores of a compacted or undisturbed specimen of fine-grained soil will invalidate the results of the

at a series of different void ratios, produced by increasing the amount of vibration after each permeability determination. Measure and record the length (height) of specimen in the permeameter prior to each determination. Permeability determinations at three different void ratios are usually sufficient to establish the relation of void ratio to permeability.

d. Procedure. The procedure shall consist of the following steps:

(1) Measure the distance, L_1, between the centers of the piezometer taps to the nearest 0.01 cm and record on the data sheet.

(2) Adjust the height of the constant-head tank to obtain the desired hydraulic gradient. The hydraulic gradient should be selected so that the flow through the specimen is laminar. The range of laminar flow conditions can be determined by plotting discharge versus hydraulic gradient. A straight-line relation indicates laminar flow, while deviations from the straight-line at high gradients indicate turbulent flow. Laminar flow for fine sands is limited to hydraulic gradients less than approximately 0.3. It is usually not practicable to achieve laminar flow for coarser soils, and the tests generally should be run at the hydraulic gradient anticipated in the field.

(3) Open valve A (see Fig. 3a) and record the initial piezometer readings after the flow has become stable. Exercise care in building up heads in the permeameter so that the specimen is not disturbed.

(4) After allowing a few minutes for equilibrium conditions to be reached, measure by means of a graduate the quantity of discharge corresponding to a given time interval. Measure the piezometric heads and the water temperature in the permeameter.

(5) Record the quantity of flow, piezometer readings, water temperature, and the time interval during which the quantity of flow was measured on the data sheet, Plate VII-1.

(6) Repeat steps (4) and (5) several times over a period of about 1 hr, and compute the coefficient of permeability corresponding to each set of measured data. If there is no substantial change in the

permeability tests described in the preceding paragraphs. It is known that an increase in pressure will cause a reduction in volume of gas bubbles and also an increased weight of gas dissolved in water. To each degree of saturation there corresponds a certain additional pressure (back pressure) which, if applied to the pore fluid of the specimen, will cause complete saturation. The permeability test with back pressure is performed in a pressure chamber such as that shown in Figure 8, utilizing equipment that permits increasing the chamber pressure and pore pressure simultaneously, maintaining their difference constant. The method is generally applicable to fine-grained soils that are not fully saturated. Apparatus and procedures have been described by A. Casagrande† and L. Bjerrum and J. Huder.‡

b. Procedure (see Fig. 8). The procedure shall consist of the following steps:

(1) After having determined the dimensions and wet weight of the test specimen, place it in the triaxial apparatus, using the same procedure as for setting up a specimen for an R triaxial test with pore pressure measurements except that filter strips should not be used (see para 7, APPENDIX X, TRIAXIAL COMPRESSION TESTS).

(2) Saturate the specimen and verify 100 percent saturation using the procedure described in paragraph 7b, APPENDIX X, TRIAXIAL COMPRESSION TESTS. Burette "A" is utilized during this operation.

(3) With the drainage valves closed, increase the chamber

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† Casagrande, A., "Third Progress Report on Investigation of Stress Deformation and Strength Characteristics of Compacted Clays," Soil Mechanics Series No. 70, Nov 1963, Harvard University, Cambridge, Mass., pp 30 and 31.

‡ Bjerrum, L. and Huder, J., "Measurement of the Permeability of Compacted Clays," Proceedings, Fourth International Conference on Soil Mechanics and Foundation Engineering, London, Vol 1, Aug 1957, pp 6-8.

Table VII-1

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temperature Degrees C	Tenths of Degrees									
	0	1	2	3	4	5	6	7	8	9
0.0	1.783	1.777	1.771	1.765	1.759	1.753	1.747	1.741	1.735	1.729
1.0	1.723	1.717	1.711	1.705	1.699	1.694	1.688	1.682	1.676	1.670
2.0	1.664	1.659	1.654	1.648	1.643	1.638	1.632	1.627	1.622	1.616
3.0	1.611	1.606	1.601	1.596	1.590	1.585	1.580	1.575	1.570	1.565
4.0	1.560	1.555	1.550	1.545	1.540	1.535	1.531	1.526	1.521	1.516
5.0	1.511	1.507	1.502	1.498	1.493	1.488	1.484	1.479	1.475	1.470
6.0	1.465	1.461	1.457	1.452	1.448	1.443	1.439	1.435	1.430	1.426
7.0	1.421	1.417	1.413	1.409	1.404	1.400	1.396	1.392	1.388	1.383
8.0	1.379	1.375	1.371	1.367	1.363	1.359	1.355	1.351	1.347	1.343
9.0	1.339	1.336	1.332	1.328	1.324	1.320	1.317	1.313	1.309	1.305
10.0	1.301	1.298	1.294	1.290	1.287	1.283	1.279	1.276	1.272	1.269
11.0	1.265	1.262	1.258	1.255	1.251	1.248	1.244	1.241	1.237	1.234
12.0	1.230	1.227	1.223	1.220	1.217	1.213	1.210	1.207	1.203	1.200
13.0	1.197	1.194	1.190	1.187	1.184	1.181	1.178	1.175	1.171	1.168
14.0	1.165	1.162	1.159	1.156	1.153	1.150	1.147	1.144	1.141	1.138
15.0	1.135	1.132	1.129	1.126	1.123	1.120	1.117	1.114	1.111	1.108
16.0	1.106	1.103	1.100	1.097	1.094	1.091	1.089	1.086	1.083	1.080
17.0	1.077	1.075	1.072	1.069	1.067	1.064	1.061	1.059	1.056	1.053
18.0	1.051	1.048	1.045	1.043	1.040	1.038	1.035	1.033	1.030	1.027
19.0	1.025	1.022	1.020	1.017	1.015	1.012	1.010	1.007	1.005	1.002
20.0	1.000	0.998	0.995	0.993	0.990	0.988	0.986	0.983	0.981	0.979
21.0	0.976	0.974	0.972	0.969	0.967	0.965	0.962	0.960	0.958	0.955
22.0	0.953	0.951	0.949	0.947	0.944	0.942	0.940	0.938	0.936	0.933
23.0	0.931	0.929	0.927	0.925	0.923	0.920	0.918	0.916	0.914	0.912
24.0	0.910	0.908	0.906	0.904	0.901	0.899	0.897	0.895	0.893	0.891
25.0	0.889	0.887	0.885	0.883	0.881	0.879	0.877	0.875	0.873	0.871
26.0	0.869	0.867	0.866	0.864	0.862	0.860	0.858	0.856	0.854	0.852
27.0	0.850	0.848	0.847	0.845	0.843	0.841	0.839	0.837	0.836	0.834
28.0	0.832	0.830	0.828	0.826	0.825	0.823	0.821	0.819	0.818	0.816
29.0	0.814	0.812	0.810	0.809	0.807	0.805	0.804	0.802	0.800	0.798
30.0	0.797	0.795	0.793	0.792	0.790	0.788	0.787	0.785	0.783	0.782
31.0	0.780	0.778	0.777	0.775	0.774	0.772	0.770	0.769	0.767	0.766
32.0	0.764	0.763	0.761	0.759	0.758	0.756	0.755	0.753	0.752	0.750
33.0	0.749	0.747	0.746	0.744	0.743	0.741	0.739	0.738	0.736	0.735
34.0	0.733	0.732	0.731	0.729	0.728	0.726	0.725	0.723	0.722	0.720
35.0	0.719	0.718	0.716	0.715	0.713	0.712	0.711	0.709	0.708	0.706
36.0	0.705	0.704	0.702	0.701	0.699	0.698	0.697	0.695	0.694	0.693
37.0	0.691	0.690	0.689	0.687	0.686	0.685	0.683	0.682	0.681	0.679
38.0	0.678	0.677	0.675	0.674	0.673	0.672	0.670	0.669	0.668	0.666
39.0	0.665	0.664	0.663	0.661	0.660	0.659	0.658	0.656	0.655	0.654
40.0	0.653	0.652	0.650	0.649	0.648	0.647	0.646	0.644	0.643	0.642
41.0	0.641	0.639	0.638	0.637	0.636	0.635	0.634	0.632	0.631	0.630
42.0	0.629	0.628	0.627	0.626	0.624	0.623	0.622	0.621	0.620	0.619
43.0	0.618	0.616	0.615	0.614	0.613	0.612	0.611	0.610	0.609	0.608
44.0	0.607	0.606	0.604	0.603	0.602	0.601	0.600	0.599	0.598	0.597
45.0	0.596	0.595	0.594	0.593	0.592	0.591	0.590	0.588	0.587	0.586
46.0	0.585	0.584	0.583	0.582	0.581	0.580	0.579	0.578	0.577	0.576
47.0	0.575	0.574	0.573	0.572	0.571	0.570	0.569	0.568	0.567	0.566
48.0	0.565	0.564	0.564	0.563	0.562	0.561	0.560	0.559	0.558	0.557
49.0	0.556	0.555	0.554	0.553	0.552	0.551	0.550	0.549	0.548	0.548

Computed from Table 170 - Smithsonian Physical Tables - 8th Edition
Correction factor, R_T, is found by dividing the viscosity of water at the test temperature by the viscosity of water at 20 C.

pressure to attain the desired effective consolidation pressure (chamber pressure minus back pressure). At zero elapsed time, open valves E and F.

(4) Record time, dial indicator reading, and burette reading at elapsed times of 0, 15, and 30 sec, 1, 2, 4, 8, and 15 min, and 1, 2, 4, and 8 hr, etc. Plot the dial indicator readings and burette readings on an arithmetic scale versus elapsed time on a log scale. When the consolidation curves indicate that primary consolidation is complete, close valves E and F.

(5) Apply a pressure to burette B greater than that in burette A. The difference between the pressures in burettes B and A is equal to the head loss h; h divided by the height of the specimen after consolidation, L, is the hydraulic gradient. The difference between the two pressures should be kept as small as practicable, consistent with the requirement that the rate of flow be large enough to make accurate measurements of the quantity of flow within a reasonable period of time. Because the difference in the two pressures may be very small in comparison to the pressures at the ends of the specimen, and because the head loss must be maintained constant throughout the test, the difference between the pressures within the burettes must be measured accurately; a differential pressure gage is very useful for this purpose. The difference between the elevations of the water within the burettes should also be considered (1 in. of water = 0.036 psi of pressure).

(6) Open valves D and F. Record the burette readings at any zero elapsed time. Make readings of burettes A and B and of temperature at various elapsed times (the interval between successive readings depends upon the permeability of the soil and the dimensions of the specimen). Plot arithmetically the change in readings of both burettes versus time. Continue making readings until the two curves become parallel and straight over a sufficient length of time to accurately determine the rate of flow (slope of the curves).

cylinder should in general be used for determining the permeability of remolded samples of cohesionless soils having a permeability less than about 10×10^{-4} cm per sec.

b. Apparatus. The apparatus and accessory equipment should consist of the following:

(1) A permeameter cylinder similar to that shown schematically in Figure 3b, or modified versions thereof. The permeameter cylinder should be constructed of a transparent plastic material. The inside diameter of the cylinder should be not less than about 10 times the diameter of the largest soil particles. The use of two piezometer taps, as shown by Figure 3b, connected to a standpipe and discharge level tube eliminates the necessity for taking into account the height of capillary rise which would be necessary in the case of a single standpipe of small size. The height of capillary rise for a given tube and condition can be measured simply by standing the tube upright in a beaker full of water. The size of standpipe to be used is generally based on experience with the equipment used and soils tested. In order to accelerate testing, air pressure may be applied to the standpipe to increase the hydraulic gradient.

(2) Perforated metal or plastic disks and circular wire screens, 35 to 100 mesh, cut for a close fit inside the permeameter.

(3) Glass tubing, rubber or plastic tubing, stoppers, screw clamps, etc., necessary to make connections as shown in Figure 3b.

(4) Filter materials such as Ottawa sand, coarse sand, and gravel of various gradations.

(5) Deaired distilled water, prepared according to paragraph 3b(6).

(6) Manometer board or suitable scales for measuring levels in piezometers or standpipe.

(7) Timing device, a watch or clock with second hand.

(8) Centigrade thermometer, range 0 to 50 C, accurate to 0.1 C.

(9) Balance, sensitive to 0.1 g.

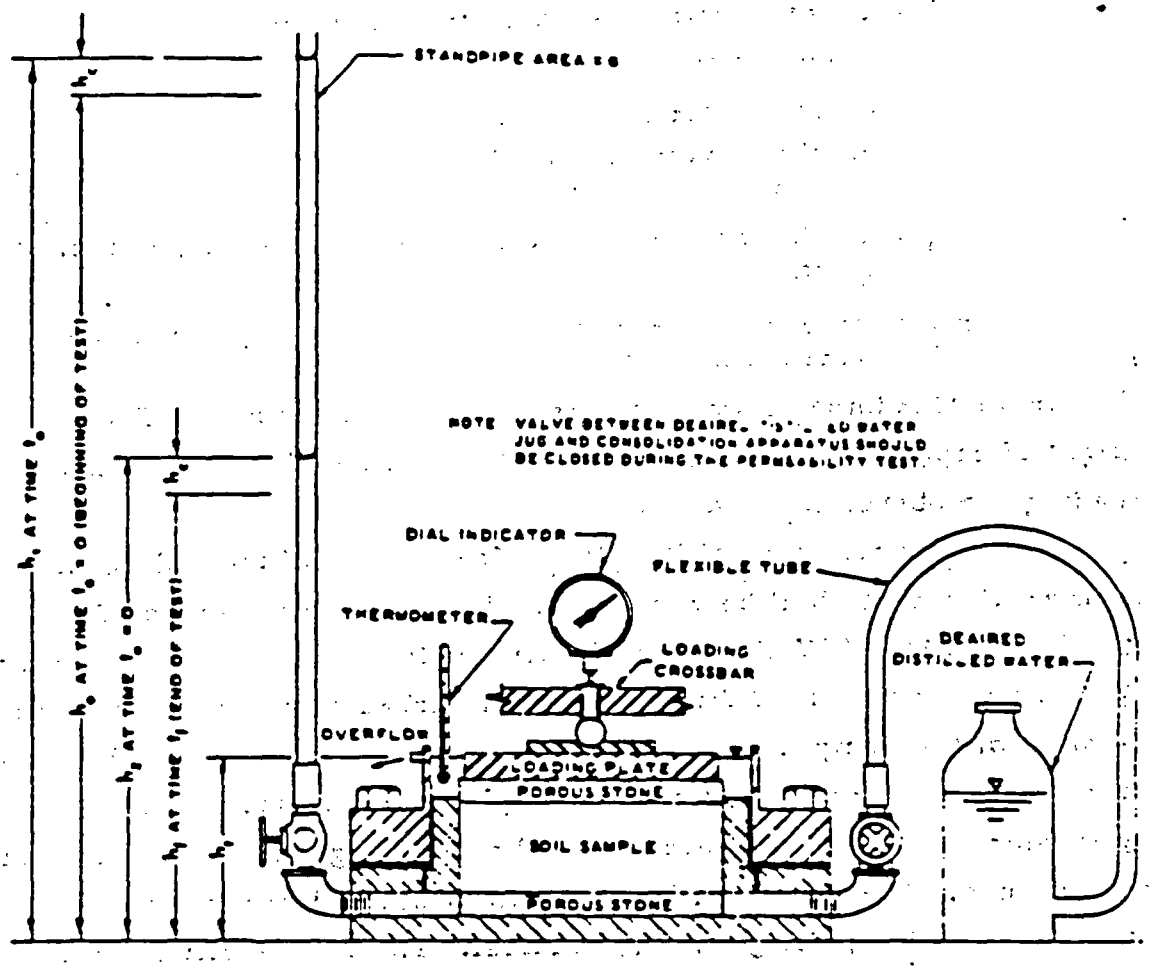

Figure 9. Schematic diagram of falling-head device for permeability test in consolidometer

net head on the specimen may be increased by use of air pressure; however, the pressure on the pore water should not exceed 25 to 30 percent of the vertical pressure under which the specimen has consolidated. Dial indicator readings are observed before and after consolidation to permit computation of void ratios. The determination of the coefficient of permeability may be made in conjunction with the consolidation test, in which case the test is performed at the end of the consolidation phase under each load increment. Computations are similar to those described for the

where a = inside area of standpipe, sq cm

A = cross-sectional area of specimen, sq cm

L = length of specimen, cm

t = elapsed time ($t_f - t_o$), sec

h_o = height of water in standpipe above discharge level at time t_o, cm

h_f = height of water in standpipe above discharge level at time t_f, cm

R_T = temperature correction factor for viscosity of water obtained from Table VII-1, degrees C

If a single standpipe of small diameter is used as shown in Figure 2, the height of capillary rise, h_c, should be subtracted from the standpipe readings to obtain h_o and h_f.

f. Presentation of Results. The results of the falling-head permeability test shall be reported as described in paragraph 3f.

5. PERMEABILITY TESTS WITH SAMPLING TUBES. Permeability tests may be performed directly on undisturbed samples without removing them from the sampling tubes. The sampling tube serves as the permeameter cylinder. The method is applicable primarily to cohesionless soils which cannot be removed from the sampling tube without excessive disturbance. The permeability obtained is in the direction in which the sample was taken, i.e. generally vertical. The permeability obtained in a vertical direction may be substantially less than that obtained in a horizontal direction.

Permeability tests with sampling tubes may be performed under constant-head or falling-head conditions of flow, depending on the estimated permeability of the sample (see paragraph 2a). The equipment should be capable of reproducing the conditions of flow in the constant-head or falling-head tests. It is important that all disturbed material or material containing drilling mud be removed from the top and bottom of the sample. The ends of the sample should be protected by screens held in place by perforated packers. The test procedure and computations are

CONSTANT-HEAD PERMEABILITY TEST

DATE _____

PROJECT _____

BORING NO. _____

Sample or Specimen No.

Tare plus dry soil			Diameter of specimen, cm	D	
Tare			Area of specimen, sq cm	A	
Dry soil	W_s		Initial height of specimen, cm	L	
Specific gravity	G		Initial vol of spec., cc = A·L	V	
Vol of solids, cc = $W_s \div G$	V_s		Initial void ratio = $(V - V_s) \div V_s$	e	

Distance between piezometer taps, cm L_1

Test No.		1		2		3	
Height of specimen, cm	L						
Void ratio = $(AL - V_s) \div V_s$	e						
		1a	1b	2a	2b	3a	3b
Reading of piez 1, cm	h_1						
Reading of piez 2, cm	h_2						
Head loss, cm = $h_1 - h_2$	h						
Quantity of flow, cc	Q						
Elapsed time, sec	t						
Water temperature, °C	T						
Viscosity correction factor(1)	R_T						
Coefficient of permeability,(2) cm/sec	k_{20}						
	Avg						

(1) Correction factor for viscosity of water at 20 C obtained from table VII-1.

(2) $k_{20} = \dfrac{Q \times L \times R_T}{h \times A \times t}$.

where L = height of specimen or distance between piezometer taps if used.

Remarks _____

Technician _____ Computed by _____ Checked by _____

ENG FORM 1 JUN 65 3844

PLATE VII-1

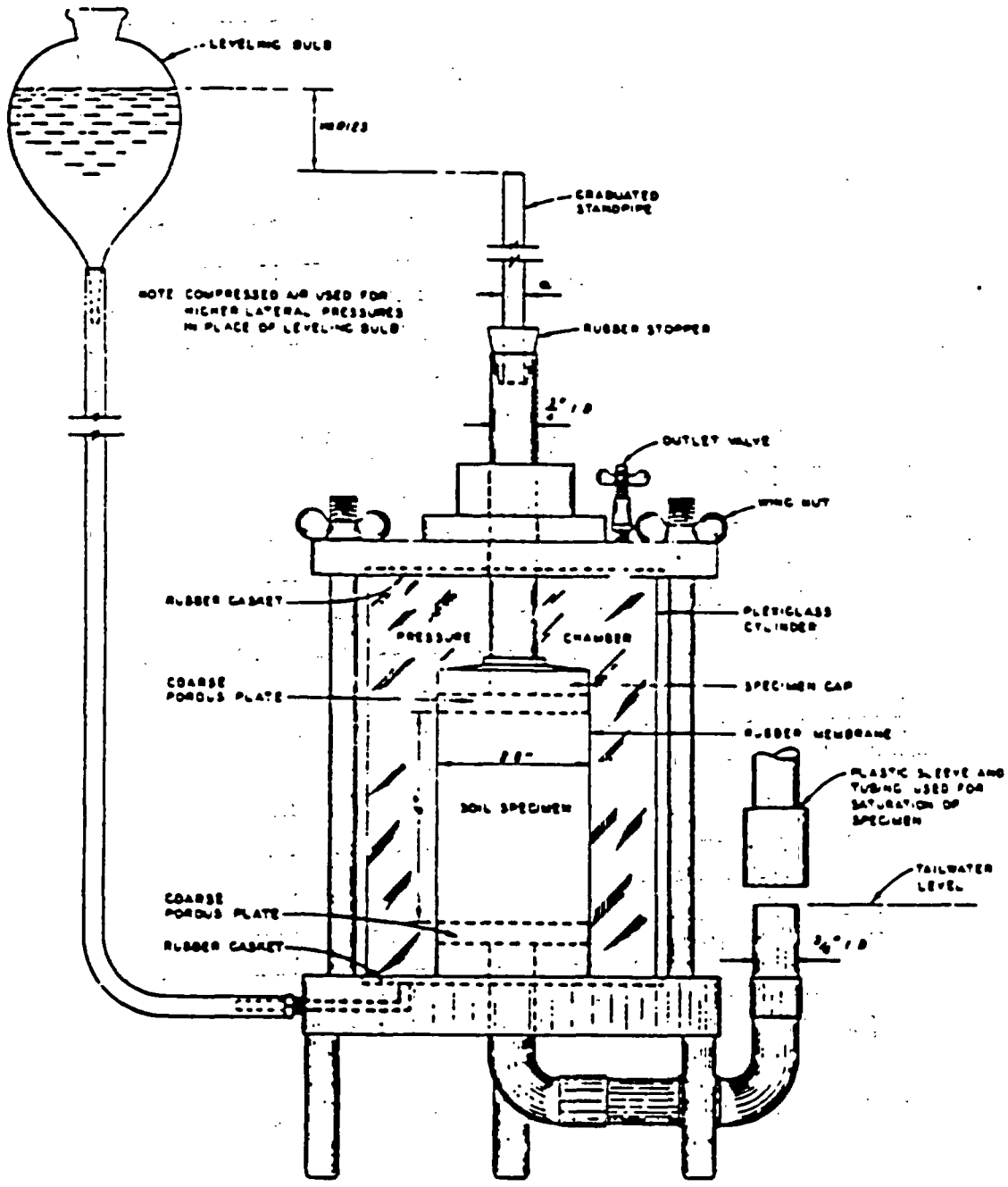

Figure 7. Pressure chamber for permeability test

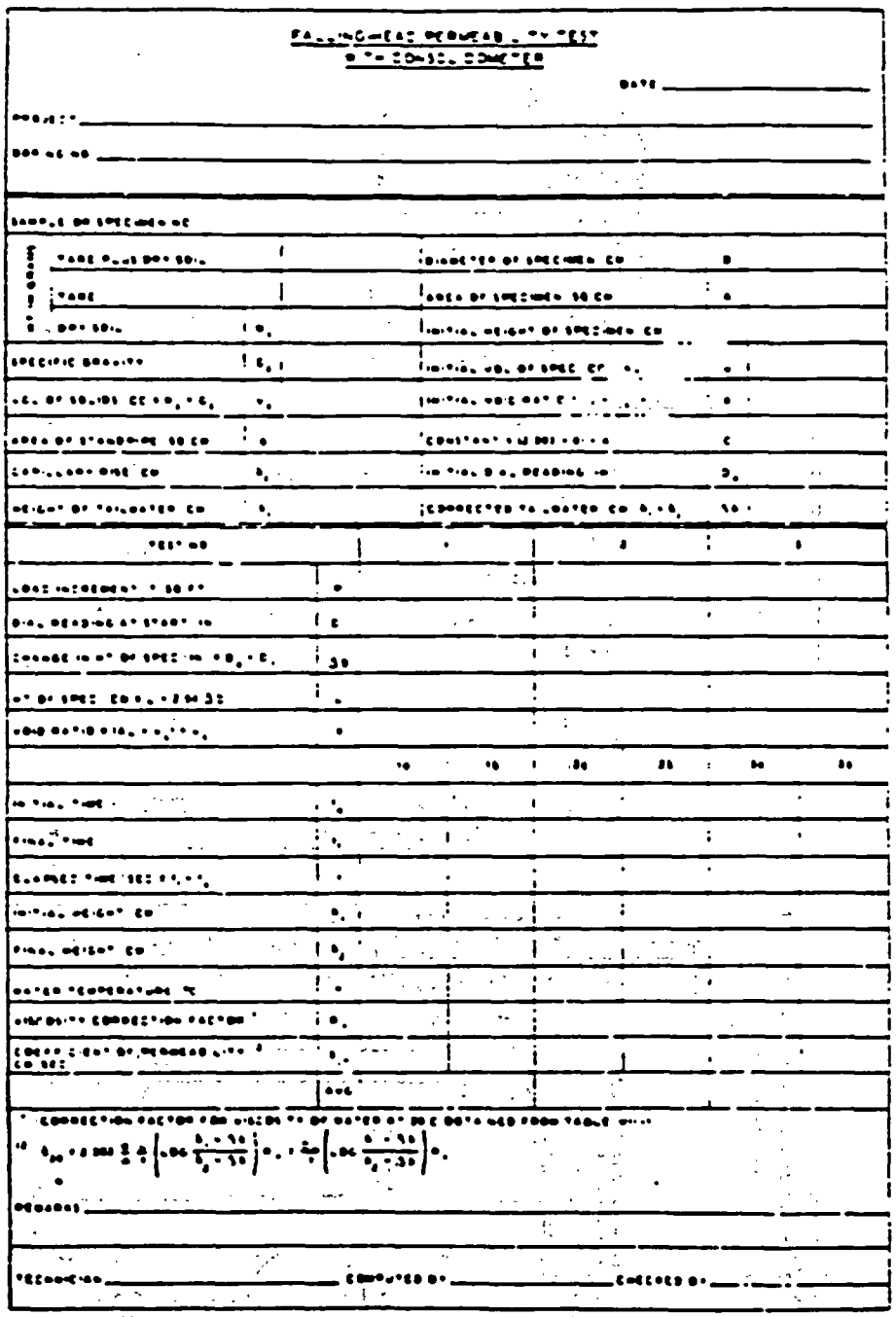

PLATE VII-3

WES

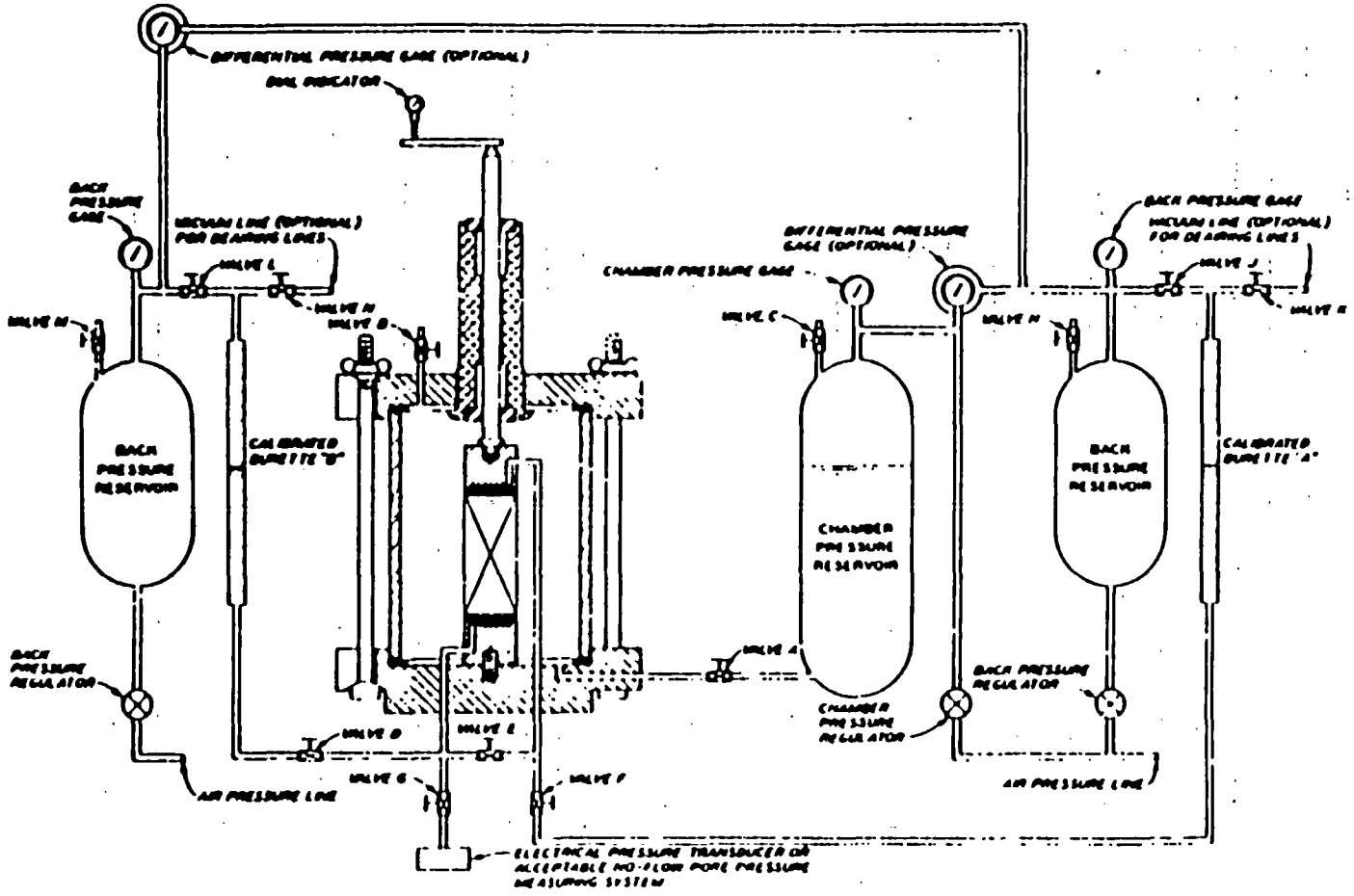

Figure 8. Schematic diagram of typical triaxial compression apparatus for permeability tests with back pressure

NNA.880129.0013

SNL NNWSI PROJECT EXPERIMENT PROCEDURE

Development of Tensile Strength Techniques in the Geomechanics Laboratory

Approved by:

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(7) If it is desired to determine the permeability at several void ratios, steps 3 through 6 can be repeated, using different consolidation pressures in step 3.

(8) At the end of the permeability determinations, close all drainage valves and reduce the chamber pressure to zero; disassemble the apparatus.

(9) Determine the wet and dry weights of the specimen.

c. Computations. The computations consist of the following steps.

(1) Compute the test void ratios as outlined in paragraph 3e(1).

(2) Computations of coefficients of permeability are the same as those described for the constant-head permeability test.

8. PERMEABILITY TESTS WITH CONSOLIDOMETER. A permeability test in a consolidometer (see Appendix VIII, CONSOLIDATION TEST) is essentially similar to that conducted in a pressure chamber, except that the specimen is placed within a relatively rigid ring and is loaded vertically. The test can be used as an alternate to the permeability test in the pressure chamber. The test is applicable primarily to cohesive soils in a fully saturated condition. Testing is usually performed under falling-head conditions.

A schematic diagram of the consolidation apparatus set up for a falling-head permeability test is shown in Figure 9. Identifying information for the specimen and subsequent test data are entered on a data sheet (Plate VII-3 is a suggested form). The specimen should be placed in the specimen ring and the apparatus assembled as outlined under Appendix VIII, CONSOLIDATION TEST. The specimen is consolidated under the desired load and the falling-head test is performed as previously described. The

In SNL Organization 6232, the Division Supervisor (Wolfgang R. Wawersik) will be responsible for overseeing all technical work in the Geomechanics Laboratory and for ensuring that all requirements specified by Department 6310 are met.

2.2 Planned Experiments

The work covered by this EP is designed to be exploratory, with the intent of examining what technique should be used for the QA level 1 tensile strength experiments. The techniques to be studied include direct-pull and Brazilian tests on saturated and unsaturated samples. The direct-pull experiments will be performed with and without metal-filled epoxy fillets. These fillets are conical shaped and would be placed at both ends of the samples, simulating a dogbone-shaped sample. In addition, some or all of the experiments will be performed on fully saturated samples.

2.3 Sample Handling

The requirements for identification (ID) and custody of test samples are described in SNL NNWSI Project Department Operating Procedure (DOP) 8-1. This DOP will be followed for all samples used in these experiments. When the unfinished samples are provided to Organization 6232, they will have the proper sample IDs and be accompanied by the appropriate sample custody forms.

All experiments on tuff governed by this EP will be performed on samples provided to Organization 6232 by Organization 6313. All samples will be nominally 50.8 mm in diameter and have been machined to this size; however, prior to testing, Organization 6232 will have to grind the sample ends flat and parallel. (The nominal lengths of the samples and tolerances for sample machining will be determined by Organization 6232 based on what is appropriate for a given experiment type). The tuff samples were obtained from a large block of welded, devitrified Topopah Spring Member collected from the southeast flank of Busted Butte on the Nevada Test Site. The rock-physics machines in the Geomechanics Laboratory will be used for this study.

2.4 Calibrations

Organization 6232 will have the responsibility for determining which instruments should be calibrated for use during this study. It is important that the instruments are calibrated over a range of values similar to those anticipated in the experiments.

falling-head test with the permeameter cylinder.

The permeability may also be determined indirectly from computations using data obtained during the consolidation test; however the assumptions on which the method is based are seldom satisfied, and consequently, the direct determination of permeability should be employed where reliable values of permeability are required.

9. POSSIBLE ERRORS. Following are possible errors that would cause inaccurate determinations of the coefficient of permeability:

a. Stratification or nonuniform compaction of cohesionless soils. If the specimen is compacted in layers, any accumulation of fines at the surface of the layers will reduce the measured coefficient of permeability.

b. Incomplete initial saturation of specimen.

c. Excessive hydraulic gradient. Darcy's law is applicable only to conditions of laminar flow.

d. Air dissolved in water. No other source of error is as troublesome as the accumulation of air in the specimen from the flowing water. As water enters the specimen, small quantities of air dissolved in the water will tend to collect as fine bubbles at the soil-water interface and reduce the permeability at this interface with increasing time. The method for detecting and avoiding this problem is described in paragraph 3d(6). (It should be noted that air accumulation will not affect the coefficient of permeability determined by the constant-head test if piezometer taps along the side of the specimen are used to measure the head loss.)

e. Leakage along side of specimen in permeameter. One major advantage to the use of the triaxial compression chamber for permeability tests (see paragraphs 6 and 7) is that the specimen is confined by a flexible membrane which is pressed tightly against the specimen by the chamber pressure.

The reported data should include all of the input parameters (in the appropriate units) needed for completion of the Data Compilation Forms (DCF) (A copy of the DCF is in Appendix A.) These forms are used for submitting laboratory mechanical properties data to the NNWSI Project Technical Data Base (TDB).

- Forward the complete set of records associated with this study to the PI within eight weeks of the completion of testing.

- Write, revise, and finalize (in accordance with SNL NNWSI Project DOP 5-2) the TPs relevant to the chosen tensile strength technique. The TPs should be submitted to the Department 6310 PI by September 1, 1988.

4.4 Data Acquisition System

The data acquisition system to be used for this study will be the same as that described by Holcomb and Jones (1983). If another system is deemed appropriate by the Organization 6232 staff, then documentation of the alternate data acquisition, application software will be provided to the Department 6310 PI. The documentation should be at least equivalent in detail to that in Holcomb and Jones (1983).

5.0 SAFETY

Safety procedures to be followed during these experiments are included in the Safe Operating Procedures (SOPs) for each machine in the Geomechanics (SNL Division 6232) laboratory.

6.0 NONCONFORMANCE/CORRECTIVE ACTION

Nonconformance of items and/or processes must be reported to the PI verbally as soon as possible and in writing within five working days. The 6232 Division Supervisor is responsible for ensuring that nonconformance are documented and that corrective actions are determined per the requirements defined in the SNL NNWSI Project QAP 15-1.

7.0 REFERENCES

Holcomb, D. J., and Jones, A. K.
Data Acquisition for the Rock Mechanics Lab, Sandia National Laboratories Report, SAND83-0646, Albuquerque, NM, 1983.

FALLING-HEAD PERMEABILITY TEST

DATE _____

PROJECT _____

BORING NO _____

SAMPLE OR SPECIMEN NO

WEIGHTS	TARE PLUS DRY SOIL			DIAMETER OF SPECIMEN CM	D
	TARE			AREA OF SPECIMEN SQ CM	A
	DRY SOIL	W_s		INITIAL HEIGHT OF SPECIMEN CM	L
SPECIFIC GRAVITY		G		INITIAL VOL OF SPEC CC = AL	V
VOL OF SOLIDS CC = W_s ÷ G		V_s		INITIAL VOID RATIO e = (V − V_s) ÷ V_s	e
AREA OF STANDPIPE SQ CM		a		CONSTANT a/2LD = C = a	C

TEST NO		1	2	3
HEIGHT OF SPECIMEN CM	L			
VOID RATIO e = (AL − V_s) ÷ V_s	e			

		1a	1b	2a	2b	3a	3b
INITIAL TIME	t_0						
FINAL TIME	t_1						
ELAPSED TIME SEC = t_1 − t_0	t						
INITIAL HEAD CM	h_0						
FINAL HEAD CM	h_1						
LOG (h_0 ÷ h_1)							
WATER TEMPERATURE °C	T						
VISCOSITY CORRECTION FACTOR**	η_T						
COEFFICIENT OF PERMEABILITY* CM/SEC	k_{20}						
	AVG						

** CORRECTION FACTOR FOR VISCOSITY OF WATER AT 20 C OBTAINED FROM TABLE VIII-1

* $k_{20} = 2.303 \frac{aL}{At} \log \frac{h_0}{h_1} \times \eta_T \times \frac{C_L}{t} \left(\log \frac{h_0}{h_1}\right) \eta_T$

REMARKS _____

TECHNICIAN _____ COMPUTED BY _____ CHECKED BY _____

ENG FORM 1836 1 JUNE 65

PLATE VII-2

1.0 GENERAL INFORMATION

1.1 Scope and Objective

This Experiment Procedure (EP) describes a group of experiments to be performed by Sandia National Laboratories (SNL) Organization 6232 (Geomechanics Division) for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. These experiments will investigate the magnitude of the mechanical anisotropy in the Topopah Spring Member of the Paintbrush Tuff, and were outlined in the SNL NNWSI Project Department 6310 Task Definition Statement for support work to be performed by SNL Department 6230 during Fiscal Year (FY) 1988.

The objective of the work described in this EP is to conduct a scoping study for determining the extent of the anisotropy in the elastic and strength properties of the welded, devitrified Topopah Spring Member. Mechanical property data will be collected from experiments on outcrop samples and the results will be analyzed to determine the appropriate approach and level of detail for the QA Level 1 experiments on site specific samples from the Exploratory Shaft Facility (ESF) at Yucca Mountain, Nevada. A secondary result of this investigation will be the development of the SNL NNWSI Project Technical Procedures (TPs) associated with the defined technique.

1.2 Applicable Study Plan

The Study Plan to which this EP relates is 8.3.1.15.1.3, entitled "Laboratory Determination of the Mechanical Properties of Intact Rock." This Study Plan is presently scheduled to be completed in February 1988 and submitted to the Department of Energy (DOE) for submittal to the Nuclear Regulatory Commission (NRC). Work described in this EP is scoping in nature, with a Quality Assurance (QA) level of 3. The results from these experiments will support future experiments defined to support the repository license application (i.e., QA level 1 experiments).

2.0 DESCRIPTION OF WORK

2.1 Management

The SNL NNWSI Project Department (6310) Principal Investigator (PI) for this work is Ronald H. Price (SNL Organization 6313), who is responsible for providing technical and quality assurance guidance for the experiments, for ensuring that relevant documentation is completed, and for submitting the documentation to the SNL NNWSI Project Data Records Management System (DRMS). The DRMS Data-Set ID to which this work is related is 51/L02-2/26/88.

1.0 GENERAL INFORMATION

1.1 Scope and Objective

This Experiment Procedure (EP) describes a specific group of experiments to be performed by Sandia National Laboratories (SNL) Organization 6232 (Geomechanics Division) for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. These experiments will investigate several techniques for obtaining tensile strength, and were generally defined in the SNL NNWSI Project Department 6310 Task Definition Statement for support work to be performed by SNL Department 6230 during Fiscal Year (FY) 1988.

The objective of the work described in this EP is to develop the technique for measuring the tensile strength of the welded, devitrified Topopah Spring Member of the Paintbrush Tuff, and for developing and writing the SNL NNWSI Project Technical Procedures (TPs) associated with the defined technique. Mechanical property data will be collected on outcrop samples using several techniques. The results will be analyzed to determine the appropriate technique for the QA Level 1 experiments on site specific samples from the Exploratory Shaft Facility (ESF) at Yucca Mountain, Nevada.

1.2 Applicable Study Plan

The Study Plan to which this EP relates is 8.3.1.15.1.3, entitled "Laboratory Determination of the Mechanical Properties of Intact Rock." This study is presently scheduled to be completed in December 1987 and submitted to the Department of Energy (DOE) for submittal to the Nuclear Regulatory Commission (NRC) with the Site Characterization ongoing Plan. Work described in this EP is scoping in nature, with a Quality Assurance (QA) level of 3. The results from these experiments will support future experiments defined to support the repository license application (i.e., QA level 1 experiments).

2.0 DESCRIPTION OF WORK

2.1 Management

The SNL NNWSI Project Department (6310) Principal Investigator (PI) for this work is Ronald H. Price (SNL Organization 6313), who is responsible for providing technical and quality assurance guidance for the experiments, for ensuring that relevant documentation is completed, and for submitting the documentation to the SNL NNWSI Project Data Records Management System (DRMS). The DRMS Data-Set ID to which this work is related is 51/L02-1/8/88.

3.0 QA LEVEL

The work defined here has been assigned a Quality Assurance (QA) Level of 3 and pertains to Task A.7 of WBS 124213.

4.0 OPERATIONS

4.1 Prerequisites

The only prerequisites relative to the work in this EP relate to personnel training. According to the definitions in SNL NNWSI Project DOP 2-6, all Organization 6232 staff associated with the work under this EP must be familiarized with general and specific aspects of the NNWSI Project QA program. Completion of this familiarization process must be documented and verified by the Department 6310 PI prior to any technical work beginning.

4.2 Technical Procedures

Technical Procedures (TPs) are not necessary for performing the experiments under this EP.

4.3 Postrequisites

At the completion of activities described in this EP, the following postrequisites will need to be verified:

- Present the results of the experiments in a memo to the PI within six weeks of the conclusion of testing. These results will include tabulated raw data (e.g., stresses, strains, time) and appropriate stress/strain, strain/strain, strain/time plots.

- Forward the complete set of records associated with this study to the PI within eight weeks of the completion of testing.

- Write, revise, and finalize (in accordance with SNL NNWSI Project DOP 5-2) the TPs relevant to anisotropy testing. The TPs should be submitted to the Department 6310 PI by November 1, 1988.

4.4 Data Acquisition System

The data acquisition system to be used for this study will be the same as that described by Holcomb and Jones (1983). If another system is deemed appropriate by the Organization 6232 staff, then documentation of the alternate data acquisition, application software will be provided to the Department 6310 PI. The documentation should be at least equivalent in detail to that in Holcomb and Jones (1983).

2.5 Records Maintenance and Transmittal

Records associated with these studies (including sample preparation, saturation, and dimensions; fillet composition and size; pre- and post-test calibrations; test conditions and results, etc.) will be kept in accordance with SNL NNWSI Project DOP 11-2. These records should include a level of detail which will allow the writing of appropriate technical procedures describing the same preparation for and execution of the experiment technique(s) developed.

3.0 QA LEVEL

The work defined here has been assigned a Quality Assurance (QA) Level of 3 and pertains to Task A.8 of WBS 124213.

4.0 OPERATIONS

4.1 Prerequisites

The only prerequisites relative to the work in this EP relate to personnel training. According to the definitions in SNL NNWSI Project DOP 2-6, all Organization 6232 staff associated with the work under this EP must be familiarized with general and specific aspects of the NNWSI Project QA program. Completion of this familiarization process must be documented and verified by the Department 6310 PI prior to any technical work beginning.

4.2 Technical Procedures

Technical Procedures (TPs) are not necessary for performing the experiments under this EP. The TPs describing the tensile strength technique(s) to be used in the future QA level 1 experiments will be developed and written as a result of this study.

4.3 Postrequisites

At the completion of activities described in this EP, the following postrequisites will need to be verified:

- Present the results of the experiments in a memo to the PI within six weeks of the conclusion of testing. These results will include tabulated raw data (e.g., stresses, strains, time) and appropriate stress/strain, strain/strain, strain/time plots.

APPENDIX A

DATA COMPILATION FORM

CONSTANT-STRAIN-RATE MECHANICAL EXPERIMENTS
DATA COMPILATION FORM FOR THE NNWSI PROJECT TECHNICAL DATA BASE

SAMPLE ID _____ SAMPLE ORIGIN _____

SAMPLE INTERVAL (ft) _____ TEST # _____ QA LEVEL _____

SNL NNWSI PROJECT DATA-SET ID _____

NAME AND NUMBER OF DATA REPORT _____

_____

EXPERIMENT TYPE _____ % SAMPLE SATURATION[1] _____ SAMPLE LENGTH [L] (mm) _____

SAMPLE DIAMETER [D] (mm) _____ SAMPLE L/D RATIO[1] _____ DRAINED OR UNDRAINED _____

TEMPERATURE[1] (DEGREES C) _____ CONFINING PRESSURE[1] (MPa) _____ PORE PRESSURE[1] (MPa) _____

STRAIN RATE[1] (1/s) _____

DRY SAMPLE MASS (kg) _____ SATURATED SAMPLE MASS (kg) _____ BULK MODULUS (GPa) _____

YOUNG'S MODULUS (GPa) _____ POISSON'S RATIO _____ ULTIMATE STRENGTH (MPa) _____

AXIAL STRAIN AT FAILURE (MILLISTRAIN) _____

---

1. Nominal value.

COMMENTS _____

_____

_____

_____

_____

1.0 GENERAL INFORMATION

1.1 Scope and Objective

This Experiment Procedure (EP) describes a group of experiments to be performed by Sandia National Laboratories (SNL) Organization 6232 (Geomechanics Division) for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. These experiments will investigate two techniques for obtaining fracture properties, and were outlined in the SNL NNWSI Project Department 6310 Task Definition Statement for support work to be performed by SNL Department 6230 during Fiscal Year (FY) 1988.

The objective of the work described in this EP is to compare two techniques for measuring the fracture properties of the welded, devitrified Topopah Spring Member of the Paintbrush Tuff, and for developing and writing the SNL NNWSI Project Procedures (TPs) associated with the two testing techniques. Mechanical property data will be collected from experiments on outcrop samples, and the results will be analyzed to determine the appropriate technique(s) for the QA Level I experiments on site specific samples from the Exploratory Shaft Facility (ESF) at Yucca Mountain, Nevada.

1.2 Applicable Study Plan

The Study Plan to which this EP relates is 8.3.1.15.1.4, entitled "Laboratory Determination of the Mechanical Properties of Fractures." This Study Plan is presently scheduled to be completed in June 1988 and submitted to the Department of Energy (DOE) for submittal to the Nuclear Regulatory Commission (NRC). Work described in this EP is scoping in nature, with a Quality Assurance (QA) level of 3. The results from these experiments will support future experiments defined to support the repository license application (i.e., QA level 1 experiments).

2.0 DESCRIPTION OF WORK

2.1 Management

The SNL NNWSI Project Department (6310) Principal Investigator (PI) for this work is Ronald H. Price (SNL Organization 6313), who is responsible for providing technical and quality assurance guidance for the experiments, for ensuring that relevant documentation is completed, and for submitting the documentation to the SNL NNWSI Project Data Records Management System (DRMS). The DRMS Data-Set ID to which this work is related is 51/L02-2/19/88.

In SNL Organization 6232, the Division Supervisor (Wolfgang R. Wawersik) will be responsible for overseeing all technical work in the Geomechanics Laboratory and for ensuring that all requirements specified by Department 6310 are met.

NNA.88.0002

SNL NNWSI PROJECT EXPERIMENT PROCEDURE

Preliminary Investigation of the Mechanical Anisotropy in Samples of the Topopah Spring Member

Approved by:

UNCONTROLLED

Ronald H Price — 2/16/88
R. H. Price, 6313 — Date
(Author and PI)

Ray E. Finley — 2/17/88
R. E. Finley, 6313 — Date
(Independent Technical Review)

R. R. Richards — Feb 23, 1988
R. R. Richards, 6310 — Date
(QA Coordinator)

T. E. Blejwas — 2/23/88
T. E. Blejwas, 6313 — Date
(Division Supervisor)

Thomas O. Hunter — 2/24/88
T. O. Hunter, 6310 — Date
(Department Manager)

SAIC/TRMSS
MAR 0 8 1988
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SNL NNWSI DEPARTMENT 6310
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Copy Number: #008
RETURN TO 6310 RECORDS CENTER
WHEN NO LONGER NEEDED.

4.0 OPERATIONS

4.1 Prerequisites

The only prerequisites relative to the work in this EP relate to personnel training. According to the definitions in SNL NNWSI Project DOP 2-6, all Organization 6232 staff associated with the work under this EP must be familiarized with general and specific aspects of the NNWSI Project QA program. Completion of this familiarization process must be documented and verified by the Department 6310 PI prior to any technical work beginning.

4.2 Technical Procedures

Technical Procedures (TPs) are not necessary for performing the experiments under this EP. The TPs describing the fracture testing techniques to be used in the future QA level 1 experiment will be developed and written as a result of this study.

4.3 Postrequisites

At the completion of activities described in this EP, the following postrequisites will need to be verified:

- Present the results of the experiments in a memo to the PI within six weeks of the conclusion of testing. These results will include tabulated (hardcopy or computer file) raw data (e.g., stresses, strains, time) and appropriate stress/strain, strain/strain, strain/time, etc. plots.

- Forward the complete set of records associated with this study to the PI within eight weeks of the completion of testing.

- Write, revise, and finalize (in accordance with SNL NNWSI Project DOP 5-2) the TPs relevant to fracture testing. The TPs should be submitted to the Department 6310 PI by November 1, 1988.

4.4 Data Acquisition System

The data acquisition system to be used for this study will be the same as that described by Holcomb and Jones (1983). If another system is deemed appropriate by the Organization 6232 staff, then documentation of the alternate data acquisition, application software will be provided to the Department 6310 PI. The documentation should be at least equivalent in detail to that in Holcomb and Jones (1983).

In SNL Organization 6232, the Division Supervisor (Wolfgang R. Wawersik) will be responsible for overseeing all technical work in the Geomechanics Laboratory and for ensuring that all requirements specified by Department 6310 are met.

2.2 Planned Experiments

The work covered by this EP is designed to be exploratory, with the intent of examining what experimental approach should be used for the QA level 1 anisotropy study. Sonic velocity measurements and quasistatic, compression experiments will be performed on samples cored with various orientations to the preferred rock fabric. In addition, at least some of the experiments will be performed on fully saturated samples.

2.3 Sample Handling

The requirements for identification (ID) and custody of test samples are described in SNL NNWSI Project Department Operating Procedure (DOP) 8-1. This DOP will be followed for all samples used in these experiments. When the unfinished samples are provided to Organization 6232, they will have the proper sample IDs and be accompanied by the appropriate sample custody forms.

All experiments on tuff governed by this EP will be performed on samples provided to Organization 6232 by Organization 6313. All samples will be nominally 50.8 mm in diameter and have an L:D ratio of 2:1. The tuff samples for this investigation were obtained from a large block of welded, devitrified Topopah Spring Member collected from the southeast flank of Busted Butte on the Nevada Test Site. The rock-physics machines in the Geomechanics Laboratory will be used for this study.

2.4 Calibrations

Organization 6232 will have the responsibility for determining which instruments should be calibrated for use during this study. It is important that the instruments are calibrated over a range of values similar to those anticipated in the experiments.

2.5 Records Maintenance and Transmittal

Records associated with these studies (including sample preparation, saturation, and dimensions; pre- and post-test calibrations; test conditions and results, etc.) will be kept in accordance with SNL NNWSI Project DOP 11-2. These records should include a level of detail which will allow the writing of appropriate technical procedures describing the same preparation for and execution of the experiment technique(s) developed.

5.0 SAFETY

Safety procedures to be followed during these experiments are included in the Safe Operating Procedures (SOPs) for each machine in the Geomechanics (SNL Division 6232) laboratory.

6.0 NONCONFORMANCE/CORRECTIVE ACTION

Nonconformance of items and/or processes must be reported to the PI verbally as soon as possible and in writing within five working days. The 6232 Division Supervisor is responsible for ensuring that nonconformance are documented and that corrective actions are determined per the requirements defined in the SNL NNWSI Project QAP 15-1.

7.0 REFERENCES

Holcomb, D. J., and Jones, A. K.
Data Acquisition for the Rock Mechanics Lab, Sandia National Laboratories Report, SAND83-0646, Albuquerque, NM, 1983.