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MASTER

**Test Plan - Potash Core Test
WIPP Experimental Program
Borehole Plugging**

Charles L. Christensen

Sandia Laboratories

MASTER

Rev. 10-1-78

8 011-03700-00000-1

POTASH CORE TEST

WIPP EXPERIMENTAL PROGRAM

BOREHOLE DRILLING

SANDIA LABORATORIES

ALBUQUERQUE, NEW MEXICO

SAND79-1306

Prepared by: C. L. Christensen
C. L. Christensen, Project Leader

Date

Reviewed by: R. G. Hogan
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Date

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D. W. Powers, Reviewer

Date

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T. O. Hunter, Project Supervisor

Date

Reviewed by: J. T. Henderson
J. T. Henderson, QA Chief

Date

Approved by: W. D. Weart
W. D. Weart, Project Manager

Date

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TEST PLAN ABSTRACT

POTASH CORE TEST - PCT

SANDIA LABORATORY

WIPP EXPERIMENTAL PROGRAM

BOREHOLE PLUGGING - POTASH CORE TEST (PCT)

FIRST REPORT THIS SUBJECT

Activity 7-3b (revised)

LOCATION: Potash Exploration Well P-11

Section 18, T22S, R31E

Zone IV, WIPP Site

T.D. 1576', Emplaced 9/17/76

Lea County, New Mexico

OBJECTIVE: To obtain an in-situ cured plug of known mix constituents for determination of bench scale properties for comparison to Plug 217.

DESCRIPTION: The Potash Core Test will utilize a WIPP emplaced plug to obtain samples of an in-situ cured plug of known mix constituents for bench scale testing. An earlier effort involved recovery at the salt horizon of Plug 217, a 17 year old plug in a potash exploration hole for bond testing, but the lack of particulars in the emplacement precluded significant determination of plug performance (see Appendix B).

4. INTRODUCTION

A. Background

A necessary part of the Borehole Plugging Program (BHP) is to investigate the in-situ performance of existing plugs. Since existing plugs were emplaced prior to a concern for documented performance, the capability to test these plugs in situ is severely limited, and testing must be done by removal (overcoring) from the environment to provide bench scale samples for laboratory testing.

Such an effort was undertaken as a part of the BHP in that a 17-year-old plug (Plug 217) was mined through at the salt horizon in a southeastern New Mexico (SENM) mine during mine development. A three foot (3') cube of salt containing this plug at about the 1048' level was obtained, cut into nominal 12"-thick sections, and shipped to A. D. Buck and J. Boa at the Waterways Experiment Station (WES) Vicksburg, MI, and D. M. Roy at the Pennsylvania State University (PSU) Materials Research Laboratory, University Park, PA, for evaluation. While the results of preliminary testing indicated that the plug/salt bond was tight, the high (>.7) water/cement (w/c) ratio had gas permeabilities on the order of 50 m darcy and compressive strengths on the order of 400 psi (see Appendix B and B. E. Scheetz, et al., unnumbered ONWI report, draft July 1979, by the Materials Research Laboratory, PSU (to be published). The current cement technology program being conducted by Sandia in coordination with WES indicates that much lower permeabilities (~.1 m darcy) and higher compressive strengths can be achieved with the high strength, low w/c (~.3) ratios now planned as plugging materials.

The results to date of the laboratory tests indicate that cementitious materials will be adequate for plugging wellbores. To validate and verify these tests however requires that actual emplaced plugs of known composition be tested for comparison, since the in-situ environment is different from the

laboratory. The Potash Core Test will provide the opportunity to test an in-situ cured plug, of known constituents, for verification of the laboratory test program.

The test plan contains the procedures for the recovery and testing of the P-13 plug. The location of the proposed selected site is shown in Figure 1, and Figure 2 shows the generic plug components.

The planning operation for removal of the P-13 plug must contain a definition of the disturbed zone, that portion of the native rock which may have been affected by the drilling and plugging operation, to permit bond evaluation. With an 8"-dia-plug, a nominal 12"- to 18"-dia-overcore barrel must be used, so that once the plug is recovered a minimum 12"-diameter wellbore will be available. This is approximately the size required for the Diagnostic Test Hole (DTH), which is another test planned in the Borehole Logging Program (BHP). Thus, this wellbore may be suitable for the DTH test and following possible hydrologic testing in other WIPP site evaluation programs. Approval to use this wellbore for the DTH will be pursued during the development of the PCT Test Planning.

In summary, the PCT will

1. Provide an in-situ cured plug of known constituents for evaluation of plug properties
2. Expand plug performance data base
3. Correlate existing laboratory data
4. Permit additional hydrologic evaluation of WIPP site if required
5. Provide a candidate wellbore for the Diagnostic Test Hole

B. Calculations

There are no calculations required for the recovery of the P-13 plug in the PCT.

IMMEDIATE AREA WIPP SITE DRILL HOLE STATUS

Sandia Laboratories

SEPTEMBER 1978

LEGEND

- WELP PRODUCTION SAYS
- + ABANDONED WELL
- ⊕ WELP & ABANDONED
- POTASH DRILL HOLES
- GEOPHYSICAL HOLES
- ⊖ HYDROLOGICAL HOLES
- ⊙ 100% POTASH DRILL HOLES
- LAND WITHDRAWAL BOUNDARY
- U.S. POTASH CO. WASSICAMP POTASH
- DOTS OVAL CORP
- INTERPOLITICAL BOUNDARY
- PP PERMANENT POTASH
- 1 DRILL (100 MILES)

NOTES

- 1 ONLY THOSE HOLES WITHIN A 5 MILE GRID NORTH AND SOUTH AND EAST AND WEST OF T22S R31E ARE SHOWN WITH THE EXCEPTION OF THE ERDA/WIPP SPONSORED HOLES INDICATED
- 2 DRILL HOLES NOT SHOWN TO SCALE

Figure 2

II. POTASH CORE TEST QUALITY ASSURANCE PROGRAM

A. Description

The PCT will be conducted in accordance with Waste Management Procedure (WMP) appropriate for a Quality Level III (Minor) Task, as defined in the WIPP Quality Assurance Program Plan (QAPP)*. Specific guidance is included in this section to identify the significant aspects of the PCT test and the application of the WIPP-QAPP to these activities.

The starting point for applying these procedures will be those activities necessary for the P-13 plug recovery, such as:

- o preservation of the interface between the plug and disturbed zone
- o core handling post recovery

The preservation of the plug-disturbed zone interface constitutes the most significant aspect of the PCT. Accordingly, a concentrated effort must be exercised to obtain a minimum of two inches and preferably four inches outside the plug radius (4"). Thus an 18"-diameter core barrel will be used if available, with a minimum of 12" as an acceptable alternate. During recovery, maximum effort must be exerted to keep the core barrel centered around the selected plug zones. Admittedly, this may be beyond the current drilling state of the art, but field efforts to achieve this capability should be developed since it will be required in many of the planned BHP tests.

Once the core is recovered, it will be checked and logged against the known stratigraphy, labeled, photographed and double bagged for distribution.

*WIPP Quality Assurance Program Plan (QAPP) dated April 24, 1978, submitted to ORNL on May 7, 1979. Limited distribution.

2. ~~Introduction~~

2.1. Technical Classification

The ERM included in this report has been developed as a tool for (1) monitoring and controlling the progress of software development, (2) providing a means of communication between the development team and the management, and (3) providing a means of communication between the development team and the customer.

2.2. Objectives of the ERM

2.2.1. General Objectives

2.2.2. Specific Objectives

2.3. Description of the ERM

The ERM is a tool for monitoring and controlling the progress of software development. It is a tool for providing a means of communication between the development team and the management, and between the development team and the customer. The ERM is a tool for providing a means of communication between the development team and the management, and between the development team and the customer. The ERM is a tool for providing a means of communication between the development team and the management, and between the development team and the customer. The ERM is a tool for providing a means of communication between the development team and the management, and between the development team and the customer.

2.4. Organization

Figure 1 contains the project organization chart for the ERM and the organizational chart of the QA organization.

FORM C-100 (12-84)

1. FIELD OPERATIONS

The organizational structure shown in Figure 3 designates responsibility within the JJA program and the operational portion of the PCT. R. D. Statler will prepare a Field Test Plan for review and approval in accordance with the WILCAPB and maintain a Field Test Notebook containing a chronological record of the activities.

The following details are contained herein:

A. Organization

1. Technical direction will originate within Sandia Laboratory, STAG Division 4512. The Project Leader is G. L. Christensen.
2. Field Operations will be the responsibility of the Senior Field Engineer R. D. Statler and will include:

Administrative support provided by P. D. Seward (113)

Engineering support provided by J. W. Schwarz (1123) and

W. C. Wilson (113)

Porehole and formation characterization and technical

support provided by C. L. Jones, USGS Special Projects, and

H. W. Mercer, USGS WRD

Well head services will be provided and administered on

behalf of Sandia by W. E. Cunningham, Pentac & Sons (P&S).

Other support will be provided, as required, from source within Sandia or by contract with outside agencies.

B. Operational

Field operations will be directed by the Senior Field Engineer, R. D. Statler, and will involve direction of the overall field effort in meeting the test objectives. P-13 will be rotary drilled to

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10/1/79

Task	Start Date	End Date	Duration (Days)
Prepare Test Plan	10/1/79	10/11/79	10
Select Site	10/11/79	10/21/79	10
Prepare Field Test Plan	10/21/79	10/31/79	10
Procure Drilling Contractor	10/31/79	11/10/79	10
Procure Core Barrel	11/10/79	11/20/79	10
Commence Overcore	11/20/79	12/10/79	10
Core Distribution	12/10/79	12/20/79	10
Petrographic Reports	12/20/79	1/10/80	10
Final Results Report	1/10/80	1/20/80	10

3rd Qtr FY80

4th Qtr FY80

POSTED FOR SCHEDULE

IV. REPORTS AND PERMITS

The required reports and permits for the PCT are listed below:

- A. Permits and Drill Notices: R. D. Statler will obtain permits and issue drill notices as required per New Mexico statutes.
- B. Daily Drill Hole Status: R. D. Statler will obtain daily reports on drill-hole activities.
- C. Hole History Summary/Drilling Completion Report: R. D. Statler will assemble and provide to the WIPP Central Files all pertinent logs and records obtained during the course of the PCT and prepare the Hole History Summary and Drilling Completion Report.
- D. Test Plan/Final Results: C. L. Christensen will prepare the PCT Test Plan and the Final Results Reports.
- E. Petrograph Reports: Petrographic reports will be prepared by the core recipients and will be forwarded to C. L. Christensen, Sandia Laboratories, Albuquerque, NM, for inclusion in the Final Results Report. Specific procedures utilized in the laboratory test will be included along with a summary of results and conclusions.

Sandia Laboratories

Dec. 16, 1979

: W. D. Weart, 4510

Thru: " " color, 4-12
" " " " " " 4-13

1. The first group of people who are interested in the study of the history of the United States are the people who are interested in the history of the United States.

© 2004 Potash Corp. of Canada

Ref: a) M. Ltr dtd 1/14/74, same subject (attached)
b) Your Ltr dtd 2/23/79, same subject (attached)

1. It is requested that P-4 be deleted as the candidate for the PCT and P-13 substituted instead for the following reasons.

- a) P-13 is located in Zone IV versus Zone III for P-4;
- b) H-6 is within about 250' of P-13 which may be useful if the BTH is employed in the overcored P-13;
- c) The interesting strata occurs at shallower depths (~200') in P-13 than in P-4 thus saving drilling costs;
- d) The P-13 plug is only 20 days younger than the P-4 plug which will have no impact on the PCF test results.

2. Specifics on P-13 are:

- a) Plugged 9/17/76; age at time of overcoring (November, 1979) 3 years;
- b) T.D. 1576; location Sec. 18, T22S, R31E;
- c) Within WIPP project jurisdiction;
- d) Use of P-13 is acceptable to the subsidence study group.

3. Approved - Provisions of Reference 8 apply

Disapproved

W. D. Weart, Manager
Department 4510

CLC: 4512: rmf

Copy to:
1133 R. D. Statler
1133 C. W. Gulick
4511 S. J. Lambert
4512 C. L. Christensen

APPENDIX A

Sandia Laboratories

March 23, 1979

C. L. Christenser, 4512

W. D. Weart, 4510

Potash Overcore Test

I have no objection to using P-1 for the test described in your memo dated 3/14/79 on the referenced subject. This assumes that the hole, P-4, can eventually be plugged with the same (or greater) confidence as the other potash holes existing within the Zone III boundary and that no tests which could lead to breaching of geologic integrity (hydrofrac) are conducted.

Also, provision for obtaining hydrostatic head data from the Rustler should be considered should information of this nature be desired.

WTW:4510:rmf

Copy to:
4511 L. E. Hill
4512 T. O. Hunter

Sandia Laboratories

March 14, 1979

Mr. J. C. ...
...

W. D. Weart - 4510
D. R. Hill - 4511
E. O. Hunter - 4512

D. Christensen - 4513

Re: Concrete Test (HOT)

At the PHP program review meeting on March 1, 1979, one action item highlighted was the deferral of the Charley Hole Test (CHT), immediately with a substitute event requiring the recovery of a previously installed plug with known mix characteristics.

The rationale behind this change in emphasis is that in the CHT, access is necessarily restricted to the plug top and at the salt horizon only. Freezing at one end, with heaters and monitoring at the other end, could take an inordinate time for tracer migration and produce little insight regarding the migration path. From the petrographic analysis efforts on the 17-year-old plug 217, comparison of the cements then used with water/cement (w/c) ratios lower than .7 to the current high-strength plug program utilizing w/c ratios of approximately .7 is not meaningful. The conclusion at the meeting was that more meaningful data regarding the current migration plans could be obtained by studying a plug having the low w/c ratio, even though the benefit of aging may not be realized. Accordingly, given the limited data potential of the top and the poor comparison of Plug 217 to current efforts, a Fresh Concrete Test (FCT) should be substituted for the CHT. The purpose of this memo is to outline initial planning and scheduling required to accommodate this substitution.

Review was conducted by W. D. Statler, C. W. Gulick, and J. W. Powers. The meeting indicated that a suitable plug is available and that the location for the substitution was:

P-4 does not play a role in the subsidence studies now in progress by Powers.

The mix used is known and is consistent with the current plans.

The locale of P-4 is convenient and accessible.

March 14, 1979

- o P-4 is located in Zone III of the WIPP site but does not penetrate the proposed repository horizon and will not compromise existing WIPP requirements.
- o Bench scale core samples could be available prior to the end of FY79.

The specifics on P-4 are:

- 1. Plugged 8/27/76, age at time of overcoring - 2 years.
- 2. T.D. 1457', location R31F, T22S, Sect 28 in Zone III.
- 3. Within WIPP project jurisdiction.
- 4. Subsidence study benchmark is located approximately 55' from the wellbore. When P-4 is re-plugged, a new subsidence benchmark will be included.

If approval is granted to utilize P-4 for the POT, the re-coring operation could begin in approximately June or July, with completion prior to FY80. No adverse budget impacts are anticipated.

Comments and concurrence regarding this plan are requested.

CLD:4512:jg(1503A)

Copy to:

1133 R. D. Statler

4521 E. R. Hill

4512 T. O. Hunter

SKCF (BHP)

4512 C. L. Christensen

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surface of the slice from Section 1 were designated C and D for petrographic examination while the other samples from this surface were E (grout) and F (grout-rock contact). The upper surface of the slice was used because there had been less opportunity for the grout to carbonate in this fresher surface.

5. According to a USGS log of the hole, the rock in samples B-1, B-2, C, and D is from the Salado Formation of Tertiary Age.*

Test procedure

6. The upper surface of the slice from the bottom of Section 1 is shown in Figure 1. Samples of grout, rock, and their contact were obtained by taking small cores about 1/2 in. in diameter from this surface with a small diamond core drill. A small amount of lubricating water was used during the drilling.

7. X-ray diffraction examinations. X-ray diffraction examinations were made with an X-ray diffractometer using nickel-filtered copper radiation.

a. Grout. The grout samples were examined as tightly packed powders in a static nitrogen atmosphere using either a beaker of hot barium hydroxide solution or a sponge saturated with this solution to minimize carbonation and dehydration.

(1) Sample A. Sample A was ground and examined.

(2) Sample E. A core of sample E was vacuum-dried about 18 hr in an oven at 60°C. Part of it was then ground and examined.

b. Rock. Portions of samples B-1 and B-2 from the loose rock at core samples C and D from Section 1 were ground to pass a 45- μ m (No. 40) sieve and were examined as back-packed powders to minimize preferred orientation. Samples C and D came from opposite sides of the grout plug and each was about 2 in. away from the plug. Sample C was reddish clayey rock while sample D was lighter colored rock. Portions of each of the four rock samples were dissolved in distilled water; the solution was then filtered and dried. The precipitated water-soluble material from each sample was then examined as a tightly packed powder. The water-insoluble residues of clayey samples B-1 and C were slurried onto glass slides and allowed to dry; these films were then examined air-dry, after saturation with glycerol or ethylene glycol or both (separate slides), and after heating for 1 hr at 350°C. The heated slides were examined in a static nitrogen atmosphere to prevent rehydration. The water-insoluble residue from the lighter colored rock sample B-2 was dried, ground, and examined as a back-packed powder.

c. Small slender transparent crystals were present on the surface of the light colored rock sample B-2. Some of these were hand-picked, ground in alcohol, slurried on a glass slide and examined after drying. Some of the crystals were also examined as grain immersion mounts with a polarizing microscope.

* See footnote p 1.

[illegible]

 

1. The sample group was located at the residence of the informant, who stated that the informant was the owner of the property and that the informant was the owner of the property and that the informant was the owner of the property.

[illegible]

These results strongly suggest that the removal of the salt from the sample during sample preparation. The results of the freeze-drying experiments also suggest that the salt is removed from the sample during sample preparation. The results of the freeze-drying experiments also suggest that the salt is removed from the sample during sample preparation.

the fact that the β values of the model are not significantly different from zero. This indicates that the model is not capturing the true relationship between the variables. The model is therefore misspecified.

 

2. *How can we best understand the relationship between the individual and the community?*

1. The first series of experiments was conducted in 1961, 1962, and 1963. The results of these experiments are presented in Table 1. The data show that the rate of growth of the larvae was significantly higher in the presence of the hormone than in its absence. The effect of the hormone was more pronounced in the first two series of experiments than in the third. This may be due to the fact that the hormone was more active in the first two series of experiments than in the third.

[illegible]

It is important to note that the above results are based on the assumption that the data are stationary. If the data are non-stationary, the results may be biased. However, the results are robust to the assumption of stationarity, as shown in the results of the unit root tests.

Journal of Management Education 30(6)p.789-806
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[illegible]

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...the fact that the *in vitro* and *in vivo* results are in good agreement, and that the *in vivo* results are in good agreement with the results obtained from the *in vitro* studies.

the 1990s, the number of people in the United States who are 65 years of age or older has increased by 50% (U.S. Census Bureau, 2000). The number of people aged 65 and older is projected to increase to 20% of the total population by the year 2020 (U.S. Census Bureau, 2000). The number of people aged 65 and older is projected to increase to 20% of the total population by the year 2020 (U.S. Census Bureau, 2000). The number of people aged 65 and older is projected to increase to 20% of the total population by the year 2020 (U.S. Census Bureau, 2000).

References

- Forrest, J. B., Hartley, S. L., Shaffer, Sue Ellen, H.H., L. G.,
and others, editors, "Geologic Characterization Report, No.
10-1, Grand Plain (GNPP) Site, El Paso County, New Mexico," Vol. I, 16
pages, Dec. 1978, Albuquerque, N. Mex., and Livermore, Calif.

and

the following representation of the function $f(x)$:

$$f(x) = \sum_{k=0}^{\infty} a_k x^k$$

where a_k are the coefficients of the series, and x is the variable.

$f(x)$	x^0	x^1	x^2	x^3
$f(x)$	x^0	x^1	x^2	x^3
$f(x)$	x^0	x^1	x^2	x^3
$f(x)$	x^0	x^1	x^2	x^3
$f(x)$	x^0	x^1	x^2	x^3
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$f(x)$	x^0	x^1	x^2	x^3
$f(x)$	x^0	x^1	x^2	x^3
$f(x)$	x^0	x^1	x^2	x^3

where a_k are the coefficients of the series, and x is the variable.

Figure 1. Central portion of sawed surface from lower part of Section 1, X0.8. The circular area is the grout plug surrounded by rock salt. Note the uniformly tight contact of grout and rock salt.

Figure 2. Samples a (top, X230) and b (bottom, X2300) of grout side of grout to rock salt contact from Section 1 (Sample F), Duval Mine. The lower one is an enlargement of the mid portion of a; it is believed to show CSH, calcium hydroxide, possibly monochloroaluminate, and evaporated salt.

Figure 3. Grout samples E, X230. Both were vacuum dried before coating. The upper sample was then freeze-dried while the lower one was not. There is no detectable difference in the two samples.

Figure 4. Grout samples E, X2300. Upper sample was freeze-dried following vacuum drying while bottom one was not. There is no detectable effect of this difference. These are enlargements of the areas shown in Figure 3.

Figure 5. Grout sample E, X11,500. This is an enlargement of upper right of top sample in Figure 4. The thin upright films are believed to be salt (halite, sylvite) that precipitated as moisture evaporated during specimen preparation.

Figure 6. Grout sample 2, X1150. Massive calcium hydroxide is visible in upper left and left center. The main feature of interest is the large encapsulated grain in the center of the field. This may be calcium hydroxide (CH) or CH and CSH replacing an original cement grain.

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