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RESOURCE CONSERVATION AND RECOVERY ACT
DRAFT HAZARDOUS WASTE FACILITY PERMIT

WASTE ISOLATION PILOT PLANT (WIPP)

ATTACHMENTS:

Volume IV of IV

EPA I.D. Number: NM4890139088

U.S. Department of Energy (DOE); and
Westinghouse Electric Corporation,
Waste Isolation Division (WID)

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Engineering drawings for this project
are identified as CAPE- 3069
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**RESOURCE CONSERVATION AND RECOVERY ACT
DRAFT HAZARDOUS WASTE FACILITY PERMIT**

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**] VOC MONITORING PLAN FOR BIN-ROOM TESTS
(WP 12-6)**

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VOC Monitoring Plan for Bin-Room Tests

Cognizant Department: ENVIRONMENT, SAFETY AND HEALTH

Approved By: Leslie L. Reed

VOC MONITORING PLAN FOR BIN-ROOM TESTS

WP 12-6, Rev. 0

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Change History

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None

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VOC MONITORING PLAN FOR BIN-ROOM TESTS

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List of Acronyms

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BFB - 4-Bromofluorobenzene
CH - Contact Handled
CMS - Central Monitoring System
DOE - Department of Energy
EPA - Environmental Protection Agency
GC/MS - Gas Chromatograph/Mass Spectrometer
NIST - National Institute of Standards and Technology
NMEID - New Mexico Environmental Improvement Division
PLC - Programmable Logic Controller
ppbv - Parts Per Billion by Volume
ppmv - Parts Per Million by Volume
psig - Pounds Per Square Inch Gauge
QA - Quality Assurance
QAPJP - Quality Assurance Program Plan
QAPM - Quality Assurance Program Manual
QAPP - Quality Assurance Project Plan
QC - Quality Control
RCRA - Resource Conservation and Recovery Act
RH - Remote Handled
RSD - Relative Standard Deviation
SNL - Sandia National Laboratories
SOP - Standard Operating Procedure
SWB - Standard Waste Box
TRU - Transuranic
VOC - Volatile Organic Compound
VOST - Volatile Organic Sampling Train
WID - Waste Isolation Division
WIPP - Waste Isolation Pilot Plant
WP - WIPP Procedure

1.0 INTRODUCTION

D R A F T

The DOE's plan for monitoring VOCs emitted from the WIPP during the test phase is described in this document.

The monitoring program is designed to demonstrate that there will be no migration of hazardous chemicals from the WIPP in concentrations exceeding health-based criteria. The monitoring plan includes an overview of the WIPP test program, a description of waste sources, the monitoring design, and justification of the design. The plan also includes a description of sampling and analysis procedures, QA objectives, and reporting activities.

1.1 BACKGROUND

The WIPP facility is constructed in a massive salt bed formation, with its design characterized as a "room and pillar" arrangement, allowing containerized solid or solidified waste to be placed in the excavations. Waste, equipment, and personnel enter the underground through designated shafts.

Initially, waste will be placed underground only for the purpose of conducting tests to determine more precisely the impacts of the waste on the long-term performance of the repository. During the test phase, the gas generation rate and changes in the gas composition in bins will be examined, as will simulation of the interactions between the waste and the surrounding salt. The results of these and other tests will determine what additional measures, if any, are needed to meet the long-term performance objectives of the facility. These objectives are derived from 40 CFR Parts 191 and 268 and are directed at permanently isolating the waste from the biosphere.

The WIPP No-Migration Variance Petition (DOE, 1990a) is intended to fulfill the requirements of 40 CFR 268.6, which allows the disposal of wastes prohibited from land disposal only if a demonstration can be made that, to a reasonable degree of certainty, there will be no migration of hazardous constituents from the disposal unit for as long as the wastes remain hazardous. To verify continued compliance with this requirement, a monitoring program must be implemented which is capable of detecting gaseous releases of hazardous constituents beyond the unit boundary at the earliest practicable time.

This monitoring plan describes the sampling and analysis program that will be implemented during the initial test phase and is aimed at quantifying VOC emissions in air that may potentially enter the exhaust shaft. Other media are not considered viable contaminant transport pathways during the test phase and will not be specifically monitored under this program.

This conclusion is based on the following factors. The low annual precipitation in the region and the lack of any significant surface water drainage features within the vicinity of the WIPP site preclude the need for surface water monitoring. Surrounding soils will not be impacted by releases, because all waste handling activities will occur within the Waste Handling Building and underground; further, air emissions will be filtered to remove particulates, which eliminates the potential for their deposition upon the soil. With regard to groundwater, the salt of the Salado Formation, in which the excavations are located, is highly impermeable, contains virtually no circulating fluids, and is itself situated between two confining formations. Thus, no mechanism exists for wastes to migrate via groundwater, and monitoring would be infeasible. It

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should be noted, however, that the DOE has and will continue to conduct other environmental monitoring at and around the WIPP site.

This plan addresses the following information requirements, set forth by the EPA in both the final No-Migration Determination (EPA, 1990) and the associated notice of proposed decision:

a. Rationale for the design of the monitoring program, based on:

- Mobility and persistence of hazardous constituents managed at the unit
- Possible migration pathways from the unit, both during the active life of the facility and through the postclosure phase
- Operations at the unit
- Strength of engineered and natural material components of the unit and any weak points in the unit design
- Optimum location of the monitoring stations to detect any migration of hazardous constituents at the earliest practicable time

b. Descriptions of specific elements of the monitoring program, including:

- The type of monitoring conducted
- The location of the monitoring stations
- The monitoring interval
- The specific hazardous constituents monitored
- The implementation schedule for the monitoring program
- The equipment used at the monitoring stations
- Sampling and analytical techniques employed
- Data recording/reporting procedures

The results of the experiments conducted during the test phase will be used, in part, to refine the monitoring programs that will be established for the planned operational phase, during which full-scale waste emplacement activities will occur. Environmental monitoring currently anticipated during both the operational and postclosure phase is described in Volume 1 of the petition (DOE, 1990a).

1.2 TEST PROGRAM

The WIPP project was authorized by Congress to provide a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from national defense activities and programs. To meet this objective, the WIPP facility initially will serve as an experimental pilot plant, and tests will be performed during this phase to collect, interpret, and refine data necessary for the performance assessment required for radioactive waste disposal by the EPA in 40 CFR Part 191. The data will also be evaluated to determine if any additional measures are necessary to ensure that no migration of hazardous constituents will occur beyond the unit boundary. The test program is described in DOE/WIPP 89-011, Waste Isolation Pilot Plan Test Phase Plan: Performance Assessment.

During the test phase, all waste emplaced in the repository will be readily retrievable. If the results of evaluations indicate that the WIPP facility is

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not the appropriate location for the permanent isolation of these wastes, they can be retrieved with minimal risk. The DOE has submitted plans to the EPA that describe the requirements for retrieval of waste from the underground and the activities that will be undertaken during the test program (Section 8.0 of the Addendum to the petition provides a summary of the test program). The WIPP facility will enter full-scale operations upon successful completion of the test phase, the EPA and NMEID approval, and demonstration of compliance with 40 CFR 191 and other regulatory requirements.

Bin-scale tests will be performed underground. The bin-scale tests are designed to provide information concerning gas production, gas composition, and gas depletion rates from actual CH TRU wastes. Some of the CH TRU waste may be mixed with salt, backfill, brine, and backfill additives to simulate conditions to which the waste will be exposed within the repository during the operational phase and/or in the long term. The waste used will be representative of the general CH TRU waste inventory. All CH TRU waste can be divided into four groups based on gas-generation potential: newly generated high organic, retrievably stored ("old") high organic, low organic, and processed sludges. The low organic waste and processed sludges can be either newly generated or old waste.

The waste will be tested under a variety of conditions, including aerobic and anaerobic environments that simulate potential scenario conditions anticipated during the operational and postoperational phases. The interactions of the waste with various compositions of brines will be examined, as well as waste interactions with salt, backfill additives that absorb gases, and steel. Finally, experiments will be conducted to provide information about the production of gas by wastes in various modes (including saturation, compaction, bacterial actions, and degradation product contamination).

The WIPP bin-scale tests involve testing of repackaged CH TRU waste in specially designed, transportable sealed bins after a series of detailed characterization and examination steps. The bin is a metal box with sampling ports and instrumentation. Each bin accommodates the equivalent of four to six 55-gallon drums of CH TRU waste. Each bin will be prepared and filled at the generator facility with CH TRU waste mixed with backfill and/or salt. The test bin will fit within a TRUPACT-II SWB for transportation to the WIPP.

All test bins will have a carefully sealed internal environment that will be accessed by gas sampling ports, pressure gauges, and control systems, as well as temperature monitors. Some bins will also have ports for brine injection and sampling. Additional detail is provided in Molecke (1990) and Molecke and Lappin (1991).

At the conclusion of the test phase, the DOE will decide whether, based upon a performance assessment, the WIPP facility has complied with 40 CFR Part 191, Subpart B. If there is a determination of compliance, the DOE will initiate full-scale operations with EPA and EID approval. If there is a determination of noncompliance, a number of alternatives will be considered, including engineered modifications to the facility or the waste itself. Full-scale disposal operations will not commence until compliance with all regulatory requirements is demonstrated.

1.3 OBJECTIVES OF THE VOC MONITORING PLAN

VOCs could potentially be released from waste containers located in the WIPP underground during the test phase of the project. This plan describes how VOCs

will be monitored to demonstrate that the concentrations of emissions at the WIPP unit boundary will not exceed health-based criteria. This plan is responsive to requirements of 40 CFR 268.6 and addresses waste management activities during the WIPP test phase only. Prior to the initiation of the WIPP operational phase, a second plan will be developed.

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2.0 WASTE DESCRIPTIONS

D R A F T

The wastes proposed to be emplaced in the WIPP are described in both Section 3.0 and Appendix B (Waste Analysis Plan) of DOE/WIPP 89-003, No-Migration Variance Petition; they are also described in Section 2.0 of the Addendum to the petition. Approximately 60 percent of the waste proposed to be emplaced in the WIPP during the entire lifetime of the facility is classified as mixed waste, which consists of waste that contains both radioactive and RCRA-regulated hazardous chemical components.

Generator knowledge of the wastes and the processes by which they are generated, in addition to available analytical data (Clements and Kudera, 1985), indicate that the VOCs most commonly present in the wastes are:

- 1,1,1-Trichloroethane
- Carbon tetrachloride
- 1,1,2-Trichloro-1,2,2-trifluoroethane
- Methylene chloride
- Trichloroethylene

2.1 SOURCES OF VOC EMISSIONS

During the test phase, VOCs potentially may be emitted from several sources, including test bins. Other activities not related to waste management may also lead to VOC emissions.

Bins. Test bins will be emplaced in the WIPP underground during the test phase in Rooms 1 and 2 of Panel 1 (Figure 2-1).

Each bin will be equipped with a one-way pressure-relief valve which will allow the escape of gases when bins become pressurized. Thus, each bin represents a potential source for the release of VOCs to the atmosphere in the WIPP underground.

Any emissions of gases from test bins will be controlled by a specially designed manifold ducting system which will direct emitted gases from the bins to the sampling system. Gases in the ducting system will be directed through a carbon sorption system designed to remove VOCs from the gas stream prior to discharge to the underground atmosphere. The manifold will discharge gases from a single point (for each room) into the panel accessway. The design characteristics of the bin-room ducting system and the carbon sorption bed are given in Engineering Design Specification D-0077 (Westinghouse, 1991).

Other Sources. The bin manifold system will include a carbon sorption system designed to mitigate the release of VOCs from the manifold into the underground atmosphere. The sorption system will be periodically replaced; any used carbon sorption beds will be capped and emplaced in the derived waste storage area. In addition, the sampling and analyses of bins will generate some wastes, such as potentially contaminated equipment and protective clothing. These materials will be drummed and emplaced in the derived waste storage area.

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Nonwaste-related sources of VOCs include background concentrations found in the ambient air drawn into the underground. Also, lubricants, solvents, paints, and other materials not related to wastes are used in the WIPP underground and may also donate VOCs to the repository atmosphere. An additional potential source is the exhaust emissions from the operation of diesel-powered equipment, such as forklifts and haul trucks, in the WIPP underground.

2.2 MIGRATION PATHWAY

The only pathway for migration of hazardous constituents to the unit boundary during the test phase is via airborne transport. Any volatiles released from waste sources in the underground would become entrained in the underground air ventilation flow. The underground ventilation air exits the underground through the exhaust shaft (Figure 2-1). The unit boundary of concern for this pathway is the uppermost extent of the Salado Formation in the exhaust shaft. For monitoring purposes, the top of the exhaust shaft will be considered the facility unit boundary.

3.0 MONITORING DESIGN

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The detailed design features of the VOC monitoring program are presented in this section. The monitoring program uses commercially available sampling and analysis techniques to measure VOC concentrations. The bin-room monitoring system (VOC-10) uses a specially-designed sampling system. All other monitoring stations use standard VOC canister sampling equipment. The purposes of this program are:

- To demonstrate that there is no migration of specific VOC target compounds above any health-based criteria in the ventilation exhaust airstream
- To provide data for validation of the proposed monitoring method

3.1 SAMPLING LOCATIONS

VOC samples will be collected at multiple locations at the facility to measure concentrations at both the point of potential release in the underground and at the point of emission into the atmosphere. The most intensive sampling will occur near the bin-scale experimental areas. Sampling locations are shown in Figure 2-1. Additional detail for each location is presented below.

3.1.1 Bin-Scale VOC Sampling

The bin-scale tests will be performed in the Panel 1 rooms. The bins in each room will be vented to a common gas manifold system, equipped with both a HEPA filter and a carbon sorption system to remove radioactive particulates and VOCs from the gas discharge stream. A discussion of the sorption system is provided in Section 5.1. VOC samples will be taken at the downstream side of the gas discharge systems, downstream of the HEPA filters and the sorption system (Stations VOC-10 and VOC-11). Since two bin experimental rooms are proposed during the test program, samples will be collected from the gas discharge system in each room. A conceptual diagram of this sampling configuration is shown in Figure 3-1. A detailed schematic of the VOC monitoring system is shown in Figure 3-2. More detail on the bin-scale tests can be found in Molecke (1990).

3.1.2 Panel Intake and Outlet Sampling

One sampler (Station VOC-8) will be deployed in the Panel 1 ventilation air intake passageway, and an additional VOC sampler (Station VOC-9) will be deployed in the air outlet passageway. All airflow to Panel 1 will be in one direction only. The downstream station (Station VOC-9) will monitor VOC emissions potentially released from any leaks in the bin ducting systems, gases released from the manifold system in the test rooms, and concentrations of VOCs entering Panel 1. The difference in the VOC concentrations, Stations VOC-8 and 9, will represent the amount of VOC emitted from the Panel 1 area.

3.1.3 Unit Boundary and Background Sampling

Two additional sampling stations will be deployed. One sampler (Station VOC-1) will be deployed at existing "Station A," which has been established near the top of the exhaust shaft as part of the radioactive particulate monitoring programming place at the facility. This VOC sampler will be integrated into the existing sampling system to measure detectable levels of the VOC target compounds

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FIGURE 3-1 CONCEPTUAL DIAGRAM OF BIN GAS DISCHARGE SAMPLING

FIGURE 3-1. Conceptual Diagram of Bin Gas Discharge Sampling

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FIGURE 3-2 DETAILED SCHEMATIC DIAGRAM OF THE BIN-ROOM VOC MONITORING SYSTEM

FIGURE 3-2. Detailed Schematic Diagram of the Bin-Room VOC Monitoring System

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n in the exhaust airstream. The location of this station is shown in Figure 2-1.
or For the purposes of this monitoring program, this station represents the unit
ou boundary, since it is not possible to monitor at the top of the Salado Formation
n in the exhaust shaft.

nd Another VOC sampling system (Station VOC-2) will be deployed at the air intake
ha shaft as depicted in Figure 2-1. The purpose of this system will be to measure
et detectable quantities of the target compounds in the ambient air drawn into the
nd underground facility.

.1 3.2 ANALYTES TO BE MONITORED

on Concentrations of five target VOC compounds will be routinely quantified. They
re are: carbon tetrachloride; methylene chloride; trichloroethylene; 1,1,1-tri-
hl chloroethane; and 1,1,2-trichloro-1,2,2-trifluoroethane. Other compounds may
ls also be present in the wastes; the analytical method selected will allow semi-
ua quantitative evaluation of these compounds. If other compounds are detected on
r a regular basis at concentrations greater than one ppm, they will be added to the
is list of target compounds for routine quantitation.

.1 3.3 SAMPLING METHOD AND SCHEDULE

he The method selected for sampling and analysis is EPA Compendium Method TO-14
EP (EPA, 1988a) using 6-liter canisters. SUMMA[®] passivated stainless-steel can-
st isters will be used to collect an integrated sample at all locations except where
ra grab samples will be obtained. Generally, the samplers will be operated in the
re pressurized mode. In this mode, air is pumped into an initially evacuated can-
st ister by the sampler, which regulates the rate and duration of the sampling. At
he the end of each sampling period, the canisters will be pressurized to about two
tm atmospheres.

DC VOC sampling will commence approximately 30 days prior to the beginning of the
in bin-scale tests at station VOC-1 in the exhaust shaft. Samples will be collected
n on a frequency at each location as shown in Table 3-1. Not all samplers will be
pe operated on the same schedule, nor will sampling begin at each location at the
am same time. Initial samples will be taken at the Panel 1 air intake (Station
DC VOC-8), Panel 1 air outlet (Station VOC-9), the exhaust shaft (Station VOC-1),
nd and the air intake shaft (Station VOC-2) prior to the receipt of waste. Sampling
t at the bin gas discharge systems (Station VOC-10 and Station VOC-11) will begin
ri prior to emplacement of bins within a room.

.1 3.3.1 Provisions for Sampling Frequency Reduction

he When data from sampling events at a particular sampling location indicate little
ar variation over a designated time period, sampling frequency will be reduced.
he These reductions will follow the strategy outlined below and in Table 3-2.

ai Daily sampling for all stations with the exception of the air intake shaft and
he the exhaust shaft must be performed for a minimum of 30 days after initiation
f of a test phase system. If the RSD for any targeted compound is greater than
5 25 percent, or if the RSD for any compound identified (quantified) in a GC/MS
ib library search is greater than 35 percent, then no reduction in sampling fre-
ue quency will occur for the next 15 days. After 15 days, the 30-day test will be

Table 3-1

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Sampling Schedule

Sampling Location	Station Number	Sampling Frequency ⁽¹⁾	Sampling Duration/Type
Bin Gas Discharge Systems	VOC-10, VOC-11	Daily	24-hr/Integrated
Panel 1 Air Intake	VOC-8	Daily	24-hr/Integrated
Panel 1 Air Outlet	VOC-9	Daily	24-hr/Integrated
Exhaust Shaft	VOC-1	Weekly	24-hr/Integrated
Air Intake Shaft	VOC-2	Weekly	24-hr/Integrated

⁽¹⁾Frequencies subject to change based on monitoring results.

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performed again, starting 15 days later than the previous evaluation. The pass/fail criteria (RSD of 25 percent and 35 percent, as above) will be applied again. If the data fail the criteria, the system will continue to be evaluated using the same algorithm. If the data pass the criteria, the sampling frequency will be reduced to one sample per week. At no time will the sampling frequency be reduced to less than one sample per week for any sampling station. Also, in no event shall the monitoring frequency be reduced to less than 20 percent of the minimum time required for the consumption of the total working capacity of the carbon sorption system (see Section 5.1).

Sampling frequencies may be increased as well. Increases in frequency require approval of the VOC project management staff only. These increases will follow the strategy outlined below and in Table 3-2. Increases in sampling frequency will be motivated by large excursions from previous data values. These excursions can be in the form of transient excursions or be indicative of trends. In either case, the requirement will be an RSD of greater than 75 percent for the targeted compounds or greater than 100 percent for the compounds identified and quantified during GC/MS library searching functions. If the data evaluated over each contiguous four-month period fail the criteria (greater than 75 percent and greater than 100 percent, as listed above), then the sampling frequency may be increased to once per day.

Sampling frequency may also be increased if the conditions in Panel 1 change, such as the addition of new bins to the test rooms.

3.4 SAMPLE ANALYSES

The analysis system that will be used with the canister samples is GC/MS operating in the SCAN mode. Initially, detailed analysis and definitive quantitation will be obtained for the five target VOC compounds: carbon tetrachloride; methylene chloride; trichloroethylene; 1,1,1-trichloroethane; and 1,1,2-trichloro-1,2,2-trifluoroethane. As part of the routine GC/MS/SCAN analyses for all canister samples, semi-quantitative results will be reported for all identifiable VOC compounds. Additional compounds will be added to the target list if they are detected at average concentrations greater than one ppm over any four-month period.

3.5 MIGRATION CALCULATION AT THE UNIT BOUNDARY

The results of the GC/MS/SCAN analyses will be combined with exhaust ventilation flowrate data, and the gas flow rates in the bin gas discharge systems to calculate the equivalent concentrations of the target compounds passing the facility unit boundary. As described in Section 3.3.2.3.6 of WP 02-9, WIPP Final Safety Analysis Report, the CHS at the facility is designed to continuously monitor the underground exhaust airflow rate.

The equation for these calculations is the same for all compounds. For a given set of analytical results, the calculated concentration of compound "i" at the unit boundary is:

$$X_{ui} = \left(\sum_{b=1}^N X_{bi} \cdot Q_b \right) + Q_E$$

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Table 3-2

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Criteria for Determining Sampling Frequency Changes

Criteria		Action	Frequency of Verification
<u>Target Compounds</u>	<u>Library Search Compounds</u>		
RSD > 75 %	RSD > 100 %	Increase sampling frequency one level, where possible	Verify daily if sampling is daily; verify weekly if sampling is weekly.
75 % > RSD > 25 %	100 % > RSD > 35 %	No reduction or increase in sampling frequency	Verification by increase and decrease checks.
RSD < 25 %	RSD < 35 %	Reduce sampling frequency one level, where possible	Verify every 15 days if sampling is daily; verify every six weeks if sampling is weekly.

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where:

X_{ui} = Calculated concentration at the unit boundary for VOC i ($\mu\text{g}/\text{m}^3$)

X_{bi} = Measured concentration from bin gas discharge system b for VOC i ($\mu\text{g}/\text{m}^3$)

Q_b = Measured gas flow rate from the bin discharge system b ($\text{m}^3/\text{min.}$)

Q_e = Measured ventilation exhaust flow rate ($\text{m}^3/\text{min.}$)

This equation will be used to calculate the results for each daily sample collected from the bin gas discharge systems. The determination of migration at the unit boundary and the EPA reporting requirements are discussed in detail in Section 9.4.4 of WP 12-7, VOC Monitoring Quality Assurance Program Plan.

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4.0 MONITORING DESIGN JUSTIFICATION

The previous sections present a plan for conducting air monitoring to quantify VOC concentrations related to the bin-scale test activities at WIPP. This section presents the rationale and justification for the selected design.

1 4.1 SAMPLING LOCATIONS

The proposed sampling locations were selected based on a number of operational and analytical considerations. Operationally, there are a number of different potential sources of release for VOCs: bins, support operations, and the intake air into the underground facility. In addition, due to the ventilation requirements of the underground facility, any VOCs that are released from the waste bins may be difficult to detect with current commercially available analytical techniques. The primary analytical consideration for this plan is the detection limit achievable with current technology as discussed below.

1 4.1.1 Detection Limits

According to data provided by the EPA, the current health-based standard for carbon tetrachloride, one of the five target compounds, is $0.03 \mu\text{g}/\text{m}^3$ (to one significant figure). Values for the other compounds are: methylene chloride, $0.3 \mu\text{g}/\text{m}^3$, and trichloroethylene, $0.3 \mu\text{g}/\text{m}^3$. The EPA has not specified similar low values for the other target compounds (1,1,1-trichloroethane ($10,000 \mu\text{g}/\text{m}^3$) and 1,1,2-trichloro-1,2,2-trifluoroethane ($30,000 \mu\text{g}/\text{m}^3$)). At present there are no commercially available sampling and analysis methods that allow for quantitation of multiple VOC compounds at such low levels. Since the health-based standards apply at the unit boundary, it would be desirable to measure the concentrations of these compounds at this point. However, it is unlikely that detectable quantities of the target compounds contributed by the waste and above background can be quantified at this sampling point.

1 4.1.2 Panel 1 Air Outlet (Station VOC-9)

Initially, all of the waste will be stored underground in Panel 1. Air leakage from bin rooms 1 and 2 and the exhaust from the bin gas discharge systems will all exit into the exhaust drift. A sampling station has been established in the exhaust drift from Panel 1 to determine if detectable quantities of VOCs above background can be found at this point and to verify measurements made further upstream. Initially, this sampler will be operated on a daily basis.

1 4.1.3 Bin Gas Discharge Systems (Stations VOC-10 and VOC-11)

Because it is anticipated that concentrations of VOCs above background will not be detected in the Panel 1 air outlet, samples will be collected at the next upstream point of potential release, the bin gas discharge systems. The bin gas discharge systems are equipped with carbon sorption systems designed to mitigate any releases from the experimental bins. Initially, samples will be collected daily from each system, starting prior to the day that any bins are connected to the systems. The purpose of the sampling at this point is to demonstrate that no migration of VOCs occurs, not to characterize and quantify VOC releases from the bins. The bin-scale test plan (Molecke, 1990) is designed to do this.

The bin gas discharge system is the point of maximum potential concentration for gas released from the bins (after sorption) and represents the point with the

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greatest likelihood of detecting the target compounds if they are present in the discharges from the bin ducting system. Because two bin experimental rooms are proposed during the test program, samples will be collected from the gas discharge system prior to waste emplacement in each room. If either of the discharge systems were to leak, any potential discharges would be detected by the sampler directly downstream in the Panel 1 air outlet drift (Station VOC-9).

4.1.4 Exhaust Shaft (Station VOC-1)

The EPA has directed that sampling be performed at the facility unit boundary to confirm sampling performed in the underground. From a practical standpoint, it would be difficult to take air samples in the exhaust shaft 850 feet below ground level, at the unit boundary. Consequently, samples will be taken at the top of the exhaust shaft (Station VOC-1). All ventilation air is exhausted at this point, and VOC concentrations in the exhaust air at the surface are expected to be the same as those at the unit boundary (850 feet down this shaft). Weekly samples will be taken at Station VOC-1.

4.1.5 Background Interferences

Sources of the target VOC compounds may not be restricted to the wastes emplaced at WIPP. For example, 1,1,1-trichloroethane is a constituent of some cleaners/lubricants. Also, methylene chloride is found in some paint strippers. Various other sources of VOCs exist in any facility. Consequently, measurements of target VOC compounds in the ventilation air may include a contribution from sources other than the emplaced wastes. These sources may be located either within the facility (above or below ground) or beyond the facility boundaries.

4.1.6 Air Intake Shaft (Station VOC-2)

The WIPP is located in the general vicinity of potash mining and processing facilities and oil and gas wells. Ambient air may contain some or all of the target compounds or other interfering compounds. In addition, the air intake shaft is located immediately adjacent to a parking lot. Automobile emissions include a variety of VOCs.

As part of this monitoring program, it will be important to determine any contribution of VOCs to the samples within the ventilation airstream from aboveground sources. To this end, a sampler will be established in the vicinity of the air intake shaft (Station VOC-2) to quantify detectable levels of VOCs in the intake air. Weekly samples will be taken at this location for a period of time (up to a year). If no detectable quantities of target VOCs are found, sampling at the site may be eliminated.

4.1.7 Panel 1 Air Intake (Station VOC-8)

To quantify detectable levels of VOCs entering Panel 1, another sampler will be established in the air intake drift to Panel 1. This sampler also will be operated on a daily basis. Results from this monitoring station will allow detectable background quantities of target VOCs in the ventilation air entering panel to be distinguished from any target VOCs emanating from the emplaced waste.

4.2 ANALYTES TO BE MONITORED

Based on process knowledge and previous analytical data (Clements and Kudera, 1985), the VOCs that are expected to occur in the waste most commonly are:

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carbon tetrachloride; methylene chloride; trichloroethylene; 1,1,1-trichloroethane; and 1,1,2-trichloro-1,2,2-trifluoroethane. Concentrations of these compounds in all of the samples collected will be quantified. Other compounds may also be present in the wastes. These may be identified as part of the bin and experiments. As part of the analytical evaluations, the presence of other compounds will be investigated. The laboratory performing GC/MS/SCAN analyses for this program have implemented SOPs that will provide positive identification of the following compounds if detected during the forward spectral library search as discussed in Section 4.4: perchloroethylene, chloroform, bromoform, dichloroethane, dichloroethylene, toluene, and chlorobenzene.

4.3 SAMPLING METHOD AND SCHEDULES

4.3.1 Sampling Method

Given the need to be able to accurately identify and quantify not only the five target compounds but also other VOCs in the bin rooms, ambient air, and ventilation air, a flexible sampling method is required that is not specific to particular compounds. Another consideration is the desire to use commercially available EPA-approved or recommended methods that are presently in use.

The two methods evaluated were the use of solid adsorbents (e.g., charcoal, Tenax) and canister sampling. Canister sampling provides several advantages over the solid adsorbents: ability to collect all VOCs nonpreferentially; grab-sampling capability; convenient integration of samples over a specific time period (e.g., 24 hours) at adequate flow rates; elimination of the concern of compound breakthrough (eliminating the need for multiple samples); and ease of sample storage and shipping. In addition, this method permits collection of sufficient sample volume to assess measurement precision and to permit analysis of samples by several analytical systems, as required. The method also facilitates multiple dilutions and analyses to define the relative order of magnitude of the concentrations in a gas sample.

EPA Compendium Method TO-14 sampling technique uses 6-liter passivated stainless steel canisters to collect integrated or grab samples. This method will be used to collect all samples. The samples will be analyzed using a GC/MS/SCAN.

The field sampling systems will be operated in the pressurized mode. In this mode, air is drawn through the sampling system with a pump. The air is pumped into an evacuated SUMMA[®] passivated canister by the sampler, which regulates the rate and duration of sampling.

The passivation process forms a pure chrome-nickel oxide on the interior surfaces of the canisters. This type of container has been used many times in the past and has demonstrated sample storage stability for the target compounds selected for this monitoring program (EPA, 1988a).

During the analysis, the VOCs in the air sample are separated by gas chromatography and measured by mass spectroscopy. It will require some experimentation to define the analytical conditions appropriate for quantitation, since the range of measured concentrations may be very broad. This sampling system lends itself well to this type of process, since a large sample is collected. The limits of detection for the method are less than one ppbv, so extremely low concentrations can be defined. On the other hand, the sample can be diluted many times if high concentrations are encountered.

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Method TO-14 is an EPA-recognized sampling procedure for VOC sampling and speciation. The method can provide 24-hour integrated sampling (or grab samples) and detection limits appropriate for a broad range of concentrations. Laboratory analyses can be expanded to include other compounds if analytical results indicate a need to quantify additional compounds. The sampling system can be operated unattended but requires detailed operator training.

4.3.2 Schedules

Initiation of the monitoring program will occur approximately 30 days prior to receipt of the first waste at WIPP. This will allow a "shakedown" of the entire system and an opportunity to characterize background concentrations. Samplers will be deployed as discussed below.

4.3.3 Exhaust Shaft (Station VOC-1) and Air Intake Shaft (Station VOC-2)

The samplers at the exhaust shaft (Station VOC-1) and the air intake shaft (Station VOC-2) will be installed and operational at the beginning of the program. Samples will be collected on a weekly basis to verify the results of the underground monitoring and to quantify aboveground concentrations of contaminants.

4.3.4 Panel 1 Intake and Outlet (Stations VOC-8 and VOC-9)

The sampler at the Panel 1 intake (Station VOC-8) and outlet (Station VOC-9) will be installed and operational at the beginning of the program. Daily samples collected at these locations will allow any unforeseen problems associated with monitoring in the salt-laden underground environment to be identified and addressed. Data from these two stations will also allow quantification of existing VOC background levels.

4.3.5 Bin Gas Discharge Systems (Stations VOC-10 and VOC-11)

Sampling of bin emissions from any of the gas discharge systems will begin after emplacement of bins within one of the rooms. The waste generation sites will perform an analyses of the waste prior to shipment to WIPP. The WID will not perform analyses until waste shipments are in the underground. At that time stations VOC-10 and 11 will be activated.

4.4 SAMPLE ANALYSES

The analytical strategy for Method TO-14 involves using a GC coupled to a GC detector. The proposed analysis system for the canister sampling involves the use of a specific detector system, GC/MS/SCAN. Since the five target compounds have been specified, the sensitivity of the analysis system can approach that of the multidetector GC, while providing positive compound identification. This system can also resolve coeluting peaks.

For this study, each sample will be analyzed with GC/MS/SCAN to quantify the five target compounds. In addition, the SCAN option coupled with a spectral library search will allow other significant peaks to be evaluated in a semi-quantitative manner. Any significant peaks will be evaluated further and can be included as part of the routine quantification, if necessary. For the purpose of this evaluation, significant peaks will be defined as chromatographic peaks of compounds identified in samples during library search routines at a frequency of at least ten percent of the samples collected. The samples must also have an

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average concentration greater than one ppmv during any four-month period, and not be primary or secondary alcohols.

A commercial laboratory has been selected for the analytical effort, and detailed analytical SOPs and QAPjPs have been prepared. As the sampling and analysis systems and SOPs were developed, the recommendations and requirements in Method TO-14 were followed.

In addition, detailed canister and sampling system cleaning and certification SOPs and QAPPs were prepared. These procedures will be consistent with the recommendations and requirements detailed in Method TO-14.

4.5 Unit Boundary Concentration Calculations

As discussed in Section 3.5, VOC concentrations in the exhaust shaft will be calculated based on VOC measurements from the bin room gas discharge systems. There are no commercially available sampling and analysis methods for measuring all of the target VOCs in the facility exhaust airstream at the levels required to confirm compliance with the health-based criteria suggested by EPA. Since monitoring in the exhaust shaft cannot be used for the compliance determination, it is more appropriate to sample at the points of potential VOC release (the bin-manifold systems). The analytical results can then be combined with measured flow rates and mine ventilation rates to calculate equivalent concentrations at the unit boundary. An equation for this calculation is presented in Section 3.5. Example calculation for three of the compounds for which EPA has provided health-based concentration values, carbon tetrachloride ($0.03 \mu\text{g}/\text{m}^3$), methylene chloride ($0.3 \mu\text{g}/\text{m}^3$), and trichloroethylene ($0.3 \mu\text{g}/\text{m}^3$)--are presented below to demonstrate the application of this method.

For the purposes of these calculations, it is assumed that there is no carbon sorption control device installed and that there are two bin rooms containing waste. Further, it is assumed that an approximately equivalent mass of VOCs is released from each location. The concentration values shown below are simply assumed values and may not actually be measured as part of the experiment. Lower concentrations are expected. Inputs to the example equation are as follows:

- Bin gas discharge flow volume: $670 \text{ liters/bin/year} = .140 \text{ m}^3/\text{day}$.

$$670 \text{ liters/bin/year} \times 76 \text{ bins} \div 365 \text{ days/year} = 139.5 \text{ liters/day} \\ = .140 \text{ m}^3/\text{day}$$

The actual volume will be measured and recorded using a calibrated mass-flow meter and strip chart recorder.

- Assumed concentration of VOCs in the bin gas discharge system for each bin room (two total):

Carbon tetrachloride: $1,850,000 \mu\text{g}/\text{m}^3$
Methylene chloride: $470,000 \mu\text{g}/\text{m}^3$
Trichloroethylene: $699,000 \mu\text{g}/\text{m}^3$

Assumed concentrations are for the purpose of example calculation only and are taken from Table 5-1.

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- Mine ventilation rate: 425,000 ft³/min. = 17,332,000 m³/day. The actual ventilation rate is monitored and will be obtained for each sample day.

The resulting concentrations are:

Exhaust shaft concentration of carbon tetrachloride ($\mu\text{g}/\text{m}^3$) =

$$[(1,850,000 \mu\text{g}/\text{m}^3 \times .140 \text{ m}^3) \times 2] \div 17,332,000 \text{ m}^3 = 0.0299 \mu\text{g}/\text{m}^3$$

Exhaust shaft concentration of methylene chloride ($\mu\text{g}/\text{m}^3$) =

$$[(470,000 \mu\text{g}/\text{m}^3 \times .140 \text{ m}^3) \times 2] \div 17,332,000 \text{ m}^3 = 0.0076 \mu\text{g}/\text{m}^3$$

The concentration calculation for trichloroethylene is identical to that for methylene chloride.

This example demonstrates that source concentrations well above analytical detection limits would result in concentrations in the exhaust shaft less than the health-based criteria provided by the EPA.

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5.0 SAMPLING AND ANALYSIS PROCEDURES

5.1 SAMPLING EQUIPMENT

The sampling equipment that will be used during the study includes: 6-liter stainless steel canisters, VOC canister samplers, and modified VOST tubes. A discussion of each of these items is presented below. The justification for the design of the carbon sorption bed is also presented.

5.1.1 SUMMA® Canisters

Six-liter, stainless steel canisters with SUMMA® passivated interior surfaces will be used to collect and store all ambient air and gas samples for VOC analyses collected as part of the monitoring processes. These canisters must undergo rigorous cleaning and certification procedures, both prior to their use as required by Compendium Method TO-14. A SOP describing this process in detail has been prepared by the analytical laboratory. Compendium Method TO-14 was used as a guidance document in the preparation of this SOP.

5.1.2 VOC Canister Samplers

A conceptual diagram of a VOC sample collection unit is provided in Figure 5-1.

Initially, 13 VOC sampling systems have been purchased, with the provision for additional systems if required. Two systems will be dedicated to bin testing (Stations VOC-10 and VOC-11), one for monitoring at the Panel 1 intake (Station VOC-8), one for the Panel 1 exhaust (Station VOC-9), one at the exhaust shaft (Station VOC-1), one at the air intake shaft (Station VOC-2), and the last seven will be utilized as back-up systems. Each sampling system includes a gas sample collection unit and sufficient collection canisters so that any delays due to laboratory turnaround time and canister cleaning and certification will not result in canister shortages.

The system consists of a sample pump, flow-controlled sample inlet line, mass flow sensor, vacuum/pressure gauge, electronic timer, inlet purge vent, and two sampling ports. Knowledge of sampler flow rates and duration of sampling will allow calculation of sample volume. The set point flow rate will be verified on a daily basis by monitoring the mass flow sensor. Prior to use and at periodic intervals, the sample collection units including inlet line will be tested and certified to demonstrate that they are free of contamination. Verification of cleanliness will be initiated prior to their use. UHP humidified zero air will be pumped through the sampling unit and collected in previously certified canisters. Prior to the initiation of sampling, an SOP describing in detail the cleaning and certification (certification will include pressure testing and target compound recovery evaluation) procedure for samplers will be prepared.

5.1.3 Carbon Sorption Media

The current design of the VOC air monitoring system for the bin rooms includes a carbon sorption system to ensure no migration of hazardous constituents beyond the unit boundary above health-based limits.

A sampling system for the carbon bed sorption unit utilized in the bin-scale monitoring systems has been installed (see Figure 3-2). The purpose of the

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FIGURE 5-1 CONCEPTUAL DIAGRAM OF VOC SAMPLING SYSTEM CONFIGURATION

FIGURE 5-1. Conceptual Diagram of VOC Sampling System Configuration

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carbon sorption sampling system is to allow experimental determination of the carbon bed efficiency and lifetime as related to the waste being tested. Gases emitted from bins generally will be directed through the manifold to the main carbon sorption system during routine canister sampling. The conceptual design of the carbon sorption system is provided in Figures 3-1 and 3-2.

The capacity of the main carbon sorption unit has been determined through calculation of the total mass of target VOCs expected to be emitted annually from the experimental bins during the test phase at WIPP. The validity of this calculation is to be confirmed by use of the carbon bed sampling loop (modified VOST tubes) included in the system design.

The sampling loop will include three modified VOST tubes. These tubes will be used and analyzed in a manner based on a modification of the EPA Test Method 0030, as described in SW-846. The VOST tubes will be loosely packed (26 lbs/ft³) with approximately eight grams of 6x16 mesh calgon type BPL granular carbon or equivalent, the identical carbon to be packed in the main sorption unit. The sorption system has been configured so that flow may be directed through the main carbon unit or through the sampling loop. During operation of the system, flow will be directed through the sampling loop for a specified test period. The duration of the test period will be specified based on the quantity of carbon in the tube and the quantity of gas anticipated to flow through the loop during the test. At the end of the test, flow will be redirected through the main unit. The three VOST tubes will then be removed from the system and sent to the laboratory for analyses of the quantity of VOCs sorbed onto the carbon within each tube.

The analytical data from VOST tube sampling experiments, coupled with the system mass flow data during the test period, will provide a basis for estimating the lifetime of the carbon in the main sorption unit. Once the analytical data are received and evaluated, this test will be repeated, probably at a modified test duration. This iterative process will continue until the lifetime of the main unit can be predicted.

The calculated life of each carbon-filled VOST tube is approximately 12.8 hours at the anticipated full gas discharge rate (139.5 liters/day). Three VOST tubes in series would give an estimated time of 38.4 hours before breakthrough. This anticipated tube life will be used to design the initial sampling experimental program. The sampling system is constructed in a parallel flow path to the main carbon unit (Figure 3-1). Valving will allow manual switching from the main sample flow path to the sampling loop without interruption to the overall system operation.

5.1.4 Carbon Sorption Bed Design Specifications

The maximum quantities of VOCs measured in the headspace of waste drums and potentially released from the bins was used to design the capacity of the carbon sorption system. The concentrations of the five target compounds measured in headspace of the drums (Clements and Kudera, 1985) are summarized in Table 5-1. These data represent the only headspace gas composition data available.

The present design of the bin-scale tests calls for 76 bins in a room. Eight of these bins will be empty and used as controls for the gas generation experiments (Molecke, 1990). The carbon sorption system for each room, which was based on an earlier test plan, was designed to contain any releases of VOCs from 116 bins.

Table 5-1

Average Concentration of Selected Hydrocarbons in the
Headspace of TRU Waste Drums

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Average Concentration
(grams per liter)

H	Hydrocarbon	
C	Carbon tetrachloride	1.85×10^{-3}
N	Methylene chloride	0.47×10^{-3}
T	Trichloroethylene	6.99×10^{-4}
1.	1,1,1-Trichloroethane	13.2×10^{-3}
1.	1,1,2-Trichloro-1,2,2-trifluoroethane	1.22×10^{-3}

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Source: Clements and Kudera, 1985

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A gas generation rate of five moles per drum per year was used to estimate the maximum potential release. Based on experimental data and the fact that the processes that may generate gas (i.e., radiolysis, microbial degradation, and corrosion) will compete for available water and oxygen; this rate is considered a credible maximum rate. The majority of the gas will consist of hydrogen, methane, carbon dioxide, and nitrogen.

Assuming this rate of gas generation, a total of 670 liters of gas per bin per year potentially may be released. To estimate a quantity of VOCs that may be present within this 670 liters of gas, it is assumed that the average concentrations of VOCs found in drums from the Rocky Flats Plant (Clements and Kudera, 1985) are continuously present.

It should be noted that the rate of volatilization of VOCs and the concentrations of VOCs present in the headspace of bins over time cannot be estimated from the rate of generation of hydrogen or other gases. During the bin-scale tests, headspace gas samples will be collected to determine the concentrations of VOCs that are present in the bins over time (Molecke, 1990).

The total grams of each of the five target VOCs in the headspace of the bins (Table 5-2) were calculated using the following equation:

$$\frac{\text{Average headspace}}{\text{Gas concentration (g/m}^3\text{)}} \times \frac{116 \text{ bins}}{\text{room}} \times \frac{670 \text{ liters}}{\text{bin-year}} = \frac{\text{g VOC}}{\text{room-year}}$$

The volumetric air flow through the underground facility is 12,035 m³/min. (425,000 ft³/min.) or 1.73 x 10⁷ m³/day. The estimated maximum concentration of VOCs at the unit boundary assuming a complete failure of the carbon sorption system is provided in Table 5-3.

The total activated carbon requirements were calculated from the partial pressures of each of the five target VOCs, monitoring system air flow velocity, VOC loading, and the carbon efficiencies from Calgon-BPL isotherms. Based on this evaluation, the calculated activated carbon requirement to achieve a VOC sorption efficiency of greater than 95 percent was 24.98 grams of carbon per bin per year. The following calculation was used to define the total carbon requirements for each room per year:

$$(24.98 \text{ g carbon/bin/yr}) (116 \text{ bin/room}) = 2898 \text{ g carbon/room yr for 100 percent over design criteria (calgon recommendation)}$$

$$(2898 \text{ g}) (1.0) + 2898 \text{ g} = 5796 \text{ g carbon/room/yr.}$$

The specific design for the carbon sorption system uses 12 kg of carbon/room/yr for an additional factor of two conservatism in the design. The design using 12 kg of carbon/room/yr represents an overdesign of 400 percent for an experimental design having 116 test bins.

The following information on the activated carbon was used to determine the volume of the carbon sorption unit:

- 26 lbs/ft³
- 6 x 16 mesh
- Calgon type BPL

Table S-2

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**Total Quantity of Volatile Organic Compounds
Available for Release from the Bin-Scale Experiments**

	Chemical	Total Quantity (grams/room/year)
ii	Carbon tetrachloride	144
.1	1,1,1-Trichloroethane	1,026
le	Methylene chloride	37
.1	1,1,2-Trichloro-1,2,2-trifluoroethane	95
rii	Trichloroethylene	54
	Total	1356

Table 5-3

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Maximum Daily Concentration of Volatile Organic
Compounds at the Unit Boundary
Assuming No Carbon Sorption System

Chemical	Concentration ($\mu\text{g}/\text{m}^3$)
Carbon tetrachloride	0.023
1,1,1-Trichloroethane	0.162
Methylene chloride	0.006
1,1,2-Trichloro-1,2,2-trifluoroethane	0.015
Trichloroethylene	0.009

D R A F T

 $26 \text{ lb/ft}^3 \text{ ---- } > 416.48 \text{ kg/m}^3$
$$\frac{(12 \text{ kg carbon})}{(416.48 \text{ kg/m}^3)} = 0.0288 \text{ m}^3 = 28,813.00 \text{ cm}^3 = 28.81 \text{ liters}$$

(size of sorption unit)

All spent carbon material from the VOC sorption system will either be stored underground or be regenerated or reactivated by a process that minimizes the release of organics to the atmosphere or is disposed of in full compliance with federal and state regulations. If the carbon is regenerated or reactivated, a signed certification demonstrating compliance with these requirements will be maintained in the facility operating record and will be available for review by EPA.

5.2 SAMPLE COLLECTION PROCEDURES

Sample collection procedures are described in the following sections.

5.2.1 Bin Manifold Sampling

Gas will be directed from the bins through stainless steel riser tubing connected to a common manifold. The manifold system is a pressure-balanced system, maintained at atmospheric pressure, consisting of a positive pressure inert gas supply and a canister sampler. An air-actuated ball valve is controlled by a PLC, which will open the valve to allow the inert gas to fill the manifold in the event of an underpressurized system. The effluent line is fitted with a sampler controlled by the PLC that operates and samples in the event of an overpressurized system. In this way, bin room pressure and manifold pressure can be maintained at approximately the same level, and no large pressure gradient will exist across the system (Figure 3-2). As an added precaution, prior to the installation of the bins, the system has undergone a static pressure test at 20 psig.

After pressure testing is successfully completed and prior to the installation of the bins, a 24-hour composite sample will be collected to determine background levels in the manifold system. This sample will be collected down-flow from the carbon bed filtration unit.

The VOC canister sampler will sample the manifold gas on a schedule programmed into a PLC. The PLC will direct the sample pump to turn on at a frequency of once every 30 minutes and run for one minute. The unit will sample at a flow rate of 250 milliliters per minute for the 24-hour sample period. This will yield a final sample volume of approximately 12 liters. Flow rates may be modified as necessary to meet the data quality objectives.

Twenty-four-hour composite samples will be taken on a daily basis. This sampling process will continue until sufficient data are available to determine average VOC concentrations. When average concentrations are known, sampling frequency may be reduced. Any large excursions from average rates will, however, require a subsequent increase in sampling frequency (see Section 3.3.1).

Samplers are now dedicated to sampling the entire flow stream. A system flow meter, up-flow of the sampling station and down-flow of the carbon sorption unit, will record total system flow rates. As the sampler flow rate becomes known, the percentage of the entire flow monitored will be known as well. Analytical results and system flow measurements will allow the calculation of the total target VOCs in the effluent.

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Flow controllers on the sampling equipment will be checked daily by monitoring with an in-line mass flow meter dedicated to the sampler. These meters are initially factory-calibrated and specify a typical accuracy of better than 4 percent full scale. Additionally, the bin mass flow meters and the system mass flow meter will be calibrated using a NIST primary flow standard on a quarterly basis, either by the manufacturer or by the on-site WIPP Calibration Laboratory. The WIPP Calibration Laboratory currently performs routine calibration of mass flow meters. Existing SOPs will be revised to address the specific calibration requirements of the VOC monitoring equipment.

Duplicate field samples will be taken at a frequency of ten percent. Original and duplicate samples will be taken concurrently (see Section 6.1). This design will require the doubling of the sampling frequency for the duplicate sampling period (every 15 minutes).

5.2.2 Shaft and Panel Sampling

Samples taken at the Panel 1 intake and outlet (Stations VOC-8 and VOC-9) can potentially represent transient environments; therefore, 24-hour integrated samples will be collected. Prior to the installation of any waste in the Panel, background samples will be collected and characterized. Samples taken at the Air Intake and exhaust shafts may represent transient environments as well, and 24-hour composite samples will be collected at these two locations to characterize the background concentrations. Due to the potential for airborne particulate contamination at the Panel 1 intake and outlet and the exhaust shaft sampling stations, the collection of background samples at these locations can be utilized as a "shakedown" test for sampler performance. The results of these tests may require modifications to the filtration capabilities of the samplers.

Initially, Panel 1 samples (Stations VOC-8 and VOC-9) will be taken daily, with the potential for sampling reduction to weekly based on analytical results (see Section 3.3). Air Intake shaft (Station VOC-2) and exhaust shaft (Station VOC-1) samples will be taken on a weekly basis.

Samples taken at the exhaust shaft and panel locations should represent the same matrix type, that is, elevated levels of salt aerosols. To verify the matrix similarity, duplicate samples will initially be collected from the panel and shaft sampling station (Station VOC-8, -9, -1, and -2) at a frequency of ten percent (see Section 6.1). The duplicate sampling at these locations will continue until at least three duplicate data sets are reported for each sampling station. The duplicate sampling at these stations may be eliminated if the duplicate precision values for the samples differ by no more than ten percent. If compounds cannot be identified in the samples collected at these stations, making calculations of precision unattainable, the duplicate sampling at these stations will be eliminated.

5.2.3 Method Relative Accuracy Sampling

Method relative accuracy will be evaluated by spiking canister samples with a known volume of a gaseous standard. As a first step in this process, concurrent duplicate samples of the matrix gas (i.e., mine air or gas from the bin manifold) will be collected in standard sample canisters through the sampling system. The sampling duration for these samples will be approximately 22 hours, and approximately 11 liters of matrix gas will be collected in each of the two sample canisters.

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The second step will be to connect the gaseous standard cylinder to the sampling system and purge the entire flow path with the gaseous standard to remove all of the matrix air. The gaseous standard will be injected into the inlet of the sampling system. Only the gaseous standard will be injected. No matrix air will be introduced with the standard.

The third step will be to spike one of the duplicate canisters with one liter of the gaseous standard. The sampling system will be used to add this additional volume to the canister designated as the matrix spike sample. The final sample volume of the matrix spike will be approximately 12 liters. The final volume of the duplicate sample will be approximately 11 liters.

After removing the matrix spike and matrix duplicate samples from the samplers, the fourth step of the process will be to disconnect the gaseous standard from the inlet to the sampling system and to purge the system with either matrix gas or zero air. This purge cycle will remove all of the gaseous standard from the sampling system. Finally, both the matrix spike and the matrix sample will be sent to the laboratory for analysis.

The gaseous standard may be prepared by the analytical laboratory, obtained from the EPA, or purchased from a commercial supplier. The standard will contain known concentrations of the five target compounds in a pressurized cylinder. The concentration of the target compounds in the cylinder will be evaluated before use and on a regular basis thereafter. Using a standard sample canister, an initial sample of the gaseous standard will be obtained directly from the cylinder and analyzed by the laboratory. Samples will be collected from each cylinder prior to use and on a semiannual basis thereafter.

This procedure will be conducted on a rotational basis at each sampling location. Method relative accuracy will be tracked at each location through the use of control charts. The matrix spike and concurrent matrix duplicate will be collected and analyzed on a frequency of ten percent. After data are received for ten method relative accuracy samples at each sampling location, accuracy windows and outlier criteria will be determined. Additional information is provided in WP 12-7. Data quality objectives for the measurement of method relative accuracy are presented in Section 6.

5.2.4 VOST Tube Sampling

Accurate VOC concentrations and bin off-gas flow rates and frequencies are presently unknown. For these reasons, carbon bed absorption efficiency and lifetime must be determined experimentally. The proposed design of the bin-scale sampling manifold provides for a carbon bed sampling loop (Figure 3-2). By changing the gas flow direction to the sampling loop, VOCs off-gassing from the bins may be trapped in staged, carbon-filled VOST tubes and analyzed in the laboratory by thermal desorption GC/MS. These tubes may be changed out and analyzed periodically without any interruption to the effluent monitoring effort. A separate SOP for carbon sorption sampling will be completed after the finalization of the manifold design specifications.

After carbon bed lifetime has been determined, additional VOST tube sampling will not be necessary unless there is an increase in gas flow rates or the quantity of VOCs determined through canister sampling, or wastes from new sources/processes are added to the experiments.

DRAFT**5.3 SAMPLE MANAGEMENT**

Field sampling data sheets will be used to document the conditions under which each sample is collected. These data sheets have been developed specifically for this study. The individuals assigned to collect the specific samples will be required to fill in all of the appropriate sample data and to maintain this record in field notebooks. The program supervisor will review these forms on a weekly basis.

All samples will be maintained and shipped at ambient temperatures. Completed samples will be shipped in individual shipping containers biweekly. Prior to leaving the unit boundary, all sample containers/tubes must undergo radiological screening. The results of the screening must be submitted to the receiving laboratory prior to or with the samples.

Additional QA requirements for sample management contained in WP-13 will be followed as appropriate. Chain-of-custody procedures required by WP-13 will be followed closely, and additional requirements imposed by the laboratory for sample analysis will be included as necessary.

Individuals collecting samples will be responsible for the initiation of custody procedures. The chain of custody will include documentation as to the canister certification, location of sampling event, time, date, and duration of sampling. Samples will be collected in accordance with written sampling SOPs; deviations from a SOP will be considered a variance. Variances must be preapproved by the project manager and recorded in the project files. Unintentional deviations, sampler malfunctions, and other problems are nonconformances. Nonconformances must be documented and recorded in the project files. All field logs/data sheets must be incorporated into WIPP's document control process.

More detailed documentation of sample management is presented in WP 12-7.

5.4 SAMPLER MAINTENANCE

Routine sampler maintenance will be the responsibility of the sampling personnel. This maintenance will include but not be limited to replacement of damaged or malfunctioning parts, filter changes, leak testing, and minor cleaning. Major cleaning and sampler cleanliness certification will be the responsibility of the contracted laboratory. Additionally, complete spare units will be maintained on the site to minimize downtime due to sampler malfunction. A spare parts inventory will be maintained at the site as well. A sampler preventative maintenance schedule will be developed and included in the QAPP. At a minimum, samplers will be certified for cleanliness on a quarterly basis, after any parts that are included in the sample flow path are replaced, or any time analytical results indicate potential contamination. All sample canisters will be certified prior to each usage.

5.5 ANALYTICAL PROCEDURES

Analytical procedures used in the analysis of VOC samples from canisters are based on recommendation in Compendium Method TO-14. Analysis of carbon sorption media will be performed using a modification to the analytical procedure for the analysis of VOST tubes (EPA, 1986). Analytical SOPs will be in place prior to the analysis of any samples.

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5.5.1 Analysis of Samples from SUPMA[®] Canisters

Sample Preparation

As canisters will be pressurized during the sampling procedure, laboratory pressurization will not be necessary for analyses. Pressures of canisters will be verified when they are received, however, to confirm that losses did not take place during shipping and storage.

Analytical System Requirements

The analytical system will consist of three major components: the sample introduction system, analyte separation system, and the analyte detector system.

- **Sample Introduction System for Canisters:** The sample introduction system will include a thermostated unit (oven) to allow canisters (samples and standards) to be evacuated at a constant temperature. It will include a Nafion[®] drying tube to remove moisture from the gas stream. One or more cryogenic traps may be used to focus and desorb trapped material. Transfer lines within the introduction unit must be heated so that volatile compounds are not actively absorbed. Valves and solenoids should be heated and be of a low dead volume type. The introduction system will have an in-line mass flow controller. The introduction unit will be capable of introducing internal standards directly into the sample flow path.
- **Some modifications may have to be made to the introduction system if relatively large amounts of salt aerosols are present in the samples. Problems of this type will be investigated during the analysis of background samples.**
- **Analyte Separation:** Analyte separation will be achieved by gas chromatography. The GC will be capable of subambient temperature programming. The capillary column used will be a 30 meter x 0.53 millimeter I.D., J&W DB-624 with a 3-micron film thickness, or equivalent.
- **Detection System:** Analyte detection will be accomplished by full scanning quadrupole mass spectrometry. The mass spectrometer must be capable of scanning from 40-260 m/z in one second or less, be fitted with a gas jet separator, a data system capable of storing all raw data, and a computer algorithm for analyte quantitation and forward library searching. All raw and processed GC/MS data must be stored on magnetic tape or disk and kept for the duration of this project.

Standard Preparation

Primary standards will be prepared for the five target compounds as well as the internal standards. Secondary standards will be prepared from dilution of the primary standards. Analytes that are gases at STP will be prepared in a static gas dilution bottle. For analytes that are liquids or solids at STP, a mixture will be made and loaded directly into a standard preparation cylinder. These standards will be checked against EPA audit cylinders to verify the accuracy of their concentrations.

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Calibration Procedures

Prior to the analysis of a standard curve, the GC/MS system must undergo a mass calibration check. This check is performed by injecting 50 ng of BFB directly onto the capillary column. The requirements (criteria) for relative ion abundances, listed in Table 5-4, must be met before analyses may proceed. BFB requirements must be met for each 12 hours of operation.

Quantitative standards for the five target analytes, to be determined in the canisters, will be analyzed at five concentration levels. These levels should define the linear range of the instrument for these five compounds; however, if some nonlinearity exists, concentration may be determined through curve fitting or physical plotting of data. One standard concentration level should be at or near a concentration corresponding to the detection limit for the method. Relative response factors will be generated for each target compound. These response factors must meet the requirements listed in the QA objectives section. As discussed above, if low concentration standards do not meet the linearity requirement, then a curve-fitting routine may be used. The method used for quantification of the data must be reported with the analytical results.

Library Searches

In every sample analyzed, a forward search of the NIST library of mass spectra must be performed for all chromatographic peaks greater than ten percent of the nearest internal standard.

Data Reporting

Sample target analyte concentrations will be quantified using the mid-range calibration standards and will be reported in ppbv. Other sample contaminants identified by NIST library searches will be reported as tentatively identified compounds, and concentration calculations will be based on response factors of the nearest internal standard. The relative response factor used for quantitation as well as copies of spectra, with the library search results (purity and fit), will be submitted with the results. A table listing the run sequence with the corresponding internal standard area counts must be reported with the analytical results. A narrative describing any problems with sample analysis must be included. Any nonconformances must be included with the reporting of the data.

5.5.2 Analysis of VOST Tubes

The objective of the analysis of the VOST tubes is not to determine the nature of the waste stream, although library searching may aid in this function, but to determine the effective lifetime of the carbon bed absorbent. As over-design criteria were applied to the carbon bed absorbent, extremely accurate quantitative results are not required. For this reason, the analytical effort and the level of quality control will be somewhat lower than the level that is applied to the emissions monitoring program.

Sample Preparation

VOST tubes do not require any special sample preparation.

Table 5-4

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**4-Bromofluorobenzene Key Ions and
Ion Abundance Criteria**

Mass	Ion Abundance Criteria
50	15 to 40% of mass 95
75	30 to 60% of mass 95
95	Base Peak, 100% Relative Abundance
96	5 to 9% of mass 95
173	<2% of mass 174
174	>50% of mass 95
175	5 to 9% of mass 174
176	>95% but <101% of mass 174
177	5 to 9% of mass 176

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Analytical System Requirements

- **Sample Introduction System for VOST Tubes:** The sample introduction system for the VOST tubes will consist of a thermal desorption oven, heated transfer lines, and mixed sorbent focusing trap; it will be capable of introducing internal standards directly into the flow path. All valving should be heated and be of a low dead volume type.
- **Analyte Separation:** Analyte separation will be achieved by gas chromatography. The GC will be capable of subambient temperature programming. The capillary column used will be a 30 m x 0.53 mm I.D., J&W DB-624, with a 3- μ m film thickness, or equivalent.
- **Detection System:** Analyte detection will be accomplished by full-scanning quadrupole mass spectrometry. The mass spectrometer must be capable of scanning from 40-260 m/z in one second or less, be fitted with a gas jet separator, a data system capable of storing all raw data, and a computer algorithm for analyte quantitation and forward library searching.

Calibration Procedures

Prior to the analysis of a standard curve, the GC/MS system must undergo a mass calibration check. This check is performed by injecting 50 ng of BFB directly onto the capillary column. The requirements (criteria) for relative ion abundances, listed in Table 5-4, must be met before analyses may proceed. BFB requirements must be met for each 12 hours of operation.

Three liquid instrument calibration standards will be used for the analysis of VOST tubes. Thermal desorption efficiencies will be determined once for all compounds on the EPA Contract Laboratory Program, Target Compound List for Volatile Organic Compounds (EPA, 1988b) and Freon-113. After this determination is complete, standard curves will be prepared by a direct injection technique. Relative response factors will be generated based on the total nanograms of analyte and internal standard injected.

Library Searches

In every sample analyzed, a forward search of the NIST library of mass spectra will be performed for all chromatographic peaks greater than 20 percent of the nearest internal standard.

Data Reporting

Sample target analyte concentrations will be quantified using the mid-range calibration standard and will be reported as total nanograms. Other sample contaminants determined by NIST library searches will be reported as tentatively identified compounds and concentration calculations will be based on a response factor for the nearest internal standard. Copies of spectra, with the library search results (purity and fit), will be submitted with the results. A table listing the run sequence with the corresponding internal standard area counts must be reported with the analytical results. A narrative describing any problems with sample analysis must be included. Any nonconformances must be included with the reporting of the data.

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5.6 LABORATORY SELECTION

Measures shall be taken, in accordance with the current Westinghouse Waste Isolation Division (WID) procurement policies and procedures, to ensure that procured services conform to specified requirements. These measures will generally include one or more of the following: evaluation of the supplier's capability to provide services in accordance with requirements, including a history of providing similar services; evaluation of objective evidence of conformance, such as submittals; and examination of delivered services.

5.7 LABORATORY PROCEDURES

The contracted laboratory is required to develop and prepare the following SOPs:

- Canister cleaning and certification procedures
- Sampler cleaning and certification procedures
- Analysis of VOCs from SUPMA[®] canisters
- Analysis of carbon tubes by thermal desorption GC/MS
- Project-specific data verification procedures.

The contracted laboratory is also required to develop and prepare QAPJP for cleaning and certification of samplers and for laboratory analysis of canister and VOST tube samples. The laboratory will also be required to review and approve WP 12-7.

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6.0 QUALITY ASSURANCE OBJECTIVES

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Many quality objectives for the VOC monitoring plan have been addressed in Sections 4.0 and 5.0. For example, sample collection procedures are discussed, including justification of sampling location selection. Additional topics include discussions of sampling program operations, preparation of sampling equipment and sample containers, redundancy in sampling equipment and sample containers (including canister certification), a general sample management/control scheme, and the selection of analytical procedures. More detailed descriptions of these functions, as well as additional quality-related objectives, are addressed in WP 12-7. This QAPP has been prepared in accordance with the Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (EPA, 1983) and the criteria listed in Table 6-1. This section addresses the methods to be used to evaluate the components of the measurement system and how this evaluation will be used to establish data quality objectives. In addition, project activities will be performed in conformance with quality assurance requirements described in WP 12-7.

6.1 QA OBJECTIVES FOR THE MEASUREMENT OF PRECISION, ACCURACY, SENSITIVITY, AND COMPLETENESS

- **Precision**: For the duration of this project, precision will be defined and evaluated by the RPD between field, as well as laboratory duplicate samples.

$$RPD = \frac{A - B}{[(A + B)/2]} \times 100$$

where:

A = Original sample result
B = Duplicate sample result.

- **Accuracy**: Analytical accuracy will be defined and evaluated through the use of analytical standards. Because recovery standards cannot reliably be added to the sampling stream, overall system accuracy must be based on analytical instrument performance evaluation criteria and sampler accuracy. This will include performance verification criteria for daily quantitation standard evaluation, internal standard area evaluation, and the percent relative accuracy as defined in Method TO-14. These criteria will constitute the verification of accuracy for the quantitative effort. Evaluation of standard ion abundance criteria for BFB will be used to evaluate the accuracy of the analytical system in the determination of targeted analytes, as well as the evaluation of unknown contaminants (qualitative accuracy).
- **Sensitivity**: Sensitivity will be defined by the Limit of Quantitation (LOQ). The LOQ represents the lowest analytical value that can reliably be quantified.
- **Completeness**: Completeness will be defined as the percentage of the ratio of the number of valid sample results received versus the total requested. Completeness may be affected, for example, by sample loss or destruction during shipping and laboratory sample handling errors.

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Table 6-1

Data Quality Objectives for Accuracy, Precision, Sensitivity, and
Completeness for the VOC Monitoring Program

Compound	Relative Accuracy (Percent)	Precision (RPD)	Sensitivity (ppbv)	Completeness (Percent)
Carbon tetrachloride	± 10	15	0.5	> 90
Methylene chloride	± 10	15	0.5	> 90
Trichloroethylene	± 10	15	0.5	> 90
1,1,1-Trichloroethane	± 10	15	0.5	> 90
1,1,1-Trichloro-1,2,2- trifluoroethane	± 10	15	0.5	> 90

These data quality objectives have been prescribed for this program by EPA and are formally presented in the Final No-Migration Determination (EPA, 1990).

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6.1.1 Evaluation of Laboratory Precision

Laboratory duplicates will be used for the evaluation of laboratory precision. Typical values of laboratory precision are listed in Table 6-1. These values will be appropriate for the evaluation of samples with little or no matrix effects. Due to the potentially high level of salt-type aerosols in the WIPP underground environment, analytical precision may be quite different. Laboratory duplicate values will be tracked through the use of control charts, specific to a type of sampling area (e.g., bin-scale). After 20 laboratory duplicate data points have been collected, control values will be established for each sampling area type. These control values will be reevaluated after every ten additional laboratory duplicate analyses. Laboratory duplicates will be analyzed at a frequency of ten percent. Precision windows and outlier criteria will be addressed in WP 12-7.

6.1.2 Evaluation of Field Precision

Duplicate field samples will be taken at a frequency of ten percent for all monitoring locations. Field duplicate values will be tracked through the use of control charts specific to the type of sampling area. After 20 field duplicate data points have been collected, control values will be established for that type of sampling area. Control values will be reevaluated after every ten field duplicate analyses. The difference between the laboratory duplicate and the field duplicate results represents the precision of the sampling event. Precision windows and outlier criteria will be addressed in the QAPP. Data quality objectives for the measurement of duplicate field sample precision are presented in Table 6-1.

6.1.3 Evaluation of Laboratory Accuracy

Quantitative analytical accuracy will be evaluated through performance criteria based on relative response factors generated during instrument calibration and recovery of compounds from audit cylinders. The criteria for the initial calibration (5-point calibration) is that any single relative response factor for a particular target compound can differ by no more than 25 percent from the average of the five. After the successful completion of the 5-point calibration, it is sufficient to analyze only a midpoint standard for every 12 hours of operation. The midpoint standard must pass the 25 percent difference acceptance criteria before sample analysis may begin. Internal standard areas will be monitored as a verification of stable instrument performance. In the absence of any unusual interferences, areas should not change by more than 25 percent over a 12-hour period. Deviations larger than 25 percent are an indication of a potential instrument malfunction. If the internal standard areas in a sample change by more than 25 percent, the sample must be reanalyzed. If the 25 percent criterion is not achieved during the reanalysis, the instrument must undergo a performance check and the midpoint standard reanalyzed to verify proper operation.

6.1.4 Evaluation of Method Accuracy

Percent relative accuracy (as defined in Method TO-14) will be evaluated by sampling standard mixtures from a cylinder containing known concentrations of the target compounds through the sampling system and into a standard sample canister (matrix spike). This procedure will be conducted on a rotational basis, so that the measurement of percent relative accuracy will reflect all of the sampling stations. An EPA audit cylinder is not available that contains the five project-specific target compounds. Laboratory-prepared audit cylinders may be used.

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These audit cylinders will be verified against the EPA audit cylinders (group 5 and group 3) and may not be prepared with the same standards used to manufacture calibration solutions. Verification must be documented and the original submitted to the project file. Alternatively, cylinders may be obtained from a commercial supplier. Percent relative accuracy is expressed as:

Method relative accuracy will be determined for each target compound based on the relative difference between the concentration of the target compound in the gaseous standard cylinder and the concentration of the target compound recovered from the matrix spike sample. The computation of the concentration recovered from the sampler will be adjusted for the actual background concentration measured in the matrix duplicate sample at the time the matrix spike was collected. The sample volumes of matrix air and gaseous standard also must be considered in the calculation. Method relative accuracy is calculated as follows:

$$A = \frac{C_s - C_t}{C_s} \times 100$$

$$C_t = \frac{[C_r(V_s + V_m) - (C_d \times V_m)]}{V_s}$$

where,

A = Relative accuracy, percent

C_s = Concentration of the target VOC in the gaseous standard, ppb

C_r = Concentration of the target VOC recovered from the matrix spike, ppb

C_d = Concentration of the target VOC recovered from the matrix duplicate, ppb

C_t = Calculated true concentration of the target VOC in the matrix spike, ppb

V_m = Sample volume of matrix gas collected, liters

V_s = Sample volume of the gaseous standard collected, liters.

To correct for potential effects from matrix or background concentrations of the target compounds, matrix duplicate samples will be collected concurrently with the collection of a matrix spike sample.

Percent relative accuracy will be tracked through the use of control charts. After data are received for ten accuracy samples, accuracy windows and outlier criteria will be determined. These control values will be reevaluated after every ten additional accuracy sample analyses. Gas from standard cylinders will be sampled through the systems at a frequency of ten percent. Additional information is provided in WP 12-7. Data quality objectives for the measurement of percent relative accuracy are presented in Table 6-1.

6.1.5 Evaluation of Qualitative Accuracy

Qualitative accuracy will be evaluated by the relative ion abundance criteria established for 8FB. For each 12 hours of sample analysis, a 50 ng injection of

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BFB must be made, and the requirements listed in Table 6-1 must be met before the instrument may be used to analyze samples.

6.1.6 Evaluation of Sensitivity

Typical values for sensitivity (LOQ) are listed in Table 6-1. These values are based on the evaluation of samples with little or no matrix effects. There is the potential at the exhaust shaft and background locations in the drift for sampling and analytical interferences, due to airborne salt in the form of an aerosol. The sampling manifold for the bin-scale test is sufficiently protected from the underground environment, and this type of interference should not occur during the bin-scale tests. Prior to the initiation of bin, exhaust shaft, and Panel 1 intake/outlet testing, it will be necessary to determine if these airborne aerosols will affect method sensitivity. Partially filled standard cylinders of known concentration will be diluted with a metered volume from a bin-scale monitoring system, a location near the Panel 1 outlet, and from the exhaust shaft. These cylinders will be analyzed to determine if target concentration can be achieved in the presence of the aerosol. Salt aerosol impact on method sensitivity will be reevaluated annually.

6.1.7 Completeness

The expected completeness for this project is greater than 90 percent. Data completeness will be tracked and will be evaluated after every ten quality control analyses.

6.2 SAMPLE HANDLING AND CUSTODY PROCEDURES

Sample packaging, shipping, and custody procedures are addressed in the QAPP (see Section 5.3).

6.3 CALIBRATION PROCEDURES AND FREQUENCY

Calibration procedures and frequencies for analytical instrumentation are listed in Section 5.5. When samplers are in operation, flow rates will be verified on a daily basis.

6.4 ANALYTICAL PROCEDURES

Analytical procedures are outlined in Section 5.5.

6.5 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction and validation are addressed in the WP 12-7. A brief description of data reporting is given in Section 5.5; more detail on data reporting is provided in WP 12-7.

A dedicated log book will be maintained by the operators. This log will contain documentation of all pertinent data for the sampling. Sample collection conditions, maintenance, and calibration activities will be included in this log. Additional data collected by other groups at WIPP, such as temperature, pressure, etc., will also be obtained to document the sampling conditions, as necessary.

Data validation procedures will be specified in the monitoring program QA protocols. As a minimum, all field data forms and the sampling log book will be

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checked for completeness and other relevant information. Sample custody and analysis records will be routinely reviewed by the laboratory supervisor.

Data will be reported to the EPA annually within 60 days of the end of the calendar year. Data summaries will include daily results for each sample for the target compounds as well as overall statistical summaries. Graphical summaries will be included to aid in the evaluation of trends.

In addition, in accordance with the requirements of 40 CFR 268.6(e)(f)(2), if the data indicate average target VOC concentrations in the exhaust shaft above EPA-specified criteria during any three-month period, the DOE will notify the EPA within ten days.

6.6 PERFORMANCE AND SYSTEM AUDITS

System audits will initially address start-up functions for each phase of the project. These audits will consist of on-site evaluation of materials and equipment, review of canister and sampler certification, review of laboratory qualification and history, and may, at the request of the contracting officer, include an on-site audit of the laboratory facilities. The function of the system audit is to verify that the requirements for project initiation, as discussed in this Monitoring Plan and the QAPP, have been met. System audits will be performed prior to the initiation of the monitoring program and semiannually thereafter.

Performance audits will be accomplished through the evaluation of analytical quality control data in the form of control charts and reports by performing periodic site audits throughout the duration of the project and the introduction of audit cylinders (laboratory blinds) into the analytical sampling stream. Control charts for precision and percent relative accuracy are maintained for the duration of the project. Performance audits will also include a bimonthly surveillance/review of all data associated with canister and sampler certification, a semiannual project-specific technical audit of field operations, and an annual laboratory performance audit. Field logs, notebooks, and data sheets will be reviewed weekly. Blind-audit cylinders will be introduced at a frequency of 1 in every 100 samples (initially, this will be about twice a month). Details concerning scheduling, personnel, and data quality evaluation are addressed in WP 12-7.

6.7 PREVENTATIVE MAINTENANCE

A brief description of sampler maintenance is described in Section 5.4. Maintenance of analytical equipment will be addressed in the analytical SOPs.

6.8 CORRECTIVE ACTIONS

Corrective actions may be responses to variances or nonconformances. A variance is an intentional modification to an established protocol or procedure. A variance may include technical modifications to field/laboratory procedures, a change in administrative details (for example, a change in personnel or a specified reporting format), or may constitute a change in the scope of work. Nonconformances are unintentional errors that can result from faulty or broken equipment or operational errors. In the case of a variance, corrective actions must be reviewed and approved by project management personnel including appropriate government agencies. Corrections to nonconformances may be initiated in

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the field or laboratory. Documentation of variances/nonconformances and the associated corrective actions must be integrated into the project file.

6.9 QUALITY ASSURANCE REPORTS TO MANAGEMENT

As part of the quality assurance function, a semiannual QA report will be submitted to project management. This report will include semiannual control charts for relative percent accuracy, field/analytical precision and completeness, system audit results, and identification of QA problems and recommended solutions. Individual(s) responsible for this function will be identified in the WP 12-7. All monitoring data will be kept on file at the WIPP site.

7.0 REFERENCES

D R A F T

40 CFR 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Radioactive Waste

40 CFR 268, Land Disposal Restrictions

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Molecke, M.A. Test Plan: WIPP Bin-Scale CH TRU Waste Tests. Sandia National Laboratories, Albuquerque, New Mexico.

Westinghouse Electric Corporation, 1991. D-0077, Engineering Design Specification, for Volatile Organic Compound Sampling System for the Bin-Scale Experiment (VOC-10)

WP 02-9, WIPP Final Safety Analysis Report

WP 12-7, VOC Monitoring Quality Assurance Program Plan

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ATTACHMENT IV-3

**BIN EMISSION CONTROL AND VOC MONITORING
SYSTEM DRAWINGS**

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ECO 5565

USE BLUE BLACK INK

ENGINEERING CHANGE ORDER DRAFT

Page 1 of 2

1. E1. ECO No.: 5532

CC&D Review: [Signature]

Initials

Posted

2. Impact Level 1 ☐ 2 ☐ 3 ☒ 4 ☐

3. System: EM05/WH06 Equipment No.: 105-P-013 Building: 4/E Room 1

4. Associated Documents:

PWR M41816

ECP 1-WH-91-9

P.O. _____

Others DR 91-01, D-0077 REV B.

5. Document Type:

Drawing 52-L-001-W ☒

52-L-002-W ☐

Specification 105-H-005-W ☐

105-J-022-W ☐

Vendor Data 105-L-002-W ☐

105-F-013-W ☐

SDD 105-J-030-W ☐

Others _____

6. Title of Change: VOC 10 AS-BUILTS

7. C7. Originator: (print)

Ext. No.: _____ Department: _____

Date: _____

8. Cognizant Engineer: (print)

J.R.J.R. STROBLE

8374

ELEC. ENG.

6-22-91

J.R. STROBLE

9. D9. Description of Change:

Yes

☐

No

☒

Component indices change required
(if yes, attach sheets)

1. C. CHANGE VOC 10 DRAWINGS TO SHOW
A AS-BUILT CONFIGURATION AFTER
11 INSTALLATION AND TESTING.

2. 2. SUPERCEED ECO 5532.

☒ 9a Drawing Change Sheet attached

☐ 9b Design Documentation Sheet attached

☐ 9c Vendor Data Change Sheet attached

Yes No

☐

☒

MODIFICATION IN PROGRESS

Modification complete: _____

Signature

Date

ECO will be
incorporated after
M.I.P. signed complete

☐

Change drawing per as-built markup dated: _____

☐

Change drawing per ECO-provided data

☐

Temporary modification

Des Design Verification Requirements: (per WP 09-018)

EDT No.: _____

1. Requirements satisfied by review/approval of design document

2. Independent review

3. Alternate calculations

4. Development testing

5. Design review

6. Other: _____

Add Addendum Sheet added: 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, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100

ADDENDUM
1-10

Date

13. Justification

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1. TO SHOW AS-BUILT CONFIGURATION
2. ALL OF THE CHANGES IN ECO 5532
ARE AS-BUILT & INCLUDED IN THIS ECO.

14. Administrative Tracking

YES N/A

☒	☐	1. FSAR
☒	☐	2. Calibration Procedures
☒	☐	3. Maintenance Procedures
☐	☒	4. Computer Software
☒	☐	5. Operations Procedures

YES N/A

☐	☒	6. Startup/Acceptance Test
☐	☒	7. Test Requirement & Spec.
☐	☐	8. _____
☐	☐	9. _____
☐	☐	10. _____

15. Signature Requirements

KEY
A=APPR.
R=REVIEW
S=SIGN NEW
DRAWING

☒ A	Cog. Engineer	<u>J.R. Strolle 6-22-91</u>
☒ A	Cog. Eng. Mgr	<u>Jayme Davis 6/24/91</u>
☒ R	Startup	<u>1/1/91 - 6/21/91</u>
☒ R	QA	<u>H. Lee 6-26-91</u>
☐	DOE	_____
☐	Safety	_____
☐	Dept. Manager	_____
☐	Operations	_____
☐	Security	_____
☐	SNL	_____
☒ A		<u>See Administrative</u>
☐		_____
☐		_____

16. Distribute as Marked

☒	Maintenance (MANDATORY)	_____
☒	Ops. Support (MANDATORY)	_____
☐	Startup	_____
☐	Facility Operations	_____
☐	U/G Operations	_____
☐	Orig./Design Engr.	_____
☒	Cog. Engineer	<u>J.R. STROLLE</u>
☐	Others	_____
☒		<u>JERRY CAMP</u>
☐		_____
☐		_____
☐		_____
☐		_____

DRAFT 30F 29
JRS
6-24-91ECO 5565
30F 29
1736
MAY 27, 1991
4/24/91DOE ORDER 6430.1A DESIGN CRITERIA
CHECKLISTENGINEERING CHANGE ORDER (ECO) NO. 5565 DATE _____COG. ENGINEER J.R. StrableThe design requirements in DOE Order 6430.1A checked below
have been applied to this ECO.*[Signature]*

DIVISION	SUBDIVISION
☐ 1 General Requirements	☐ 0101 ☐ 0106 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☐ 2 Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0235 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0260 ☐ 0262 ☐ 0266 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0275 ☐ 0276 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☐ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☐ 3 Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☐ 4 Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☐ 5 Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☐ 0532
☐ 6 Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☐ 7 Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☐ 0721 ☐ 0722 ☐ 0724 ☐ 0727 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☐ 8 Doors and Windows	☐ 0800 ☐ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0836 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0870 ☐ 0880
☐ 9 Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0980 ☐ 0990 ☐ 0995
☐ 10 Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1055 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☐ 11 Equipment	☐ 1100 ☐ 1161
☐ 12 Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1260 ☐ 1270
☐ 13 Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☐ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☐ 1326 ☐ 1328
☐ 14 Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1460
☐ 15 Mechanical	☐ 1525 ☐ 1530 ☐ 1540 ☐ 1550 ☐ 1555 ☐ 1565 ☐ 1574 ☐ 1589 ☐ 1595
☐ 16 Electrical	☐ 1600 ☐ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1660 ☐ 1670 ☐ 1671 ☐ 1685 ☐ 1694

Note: A checked placed in the Division column signifies that the entire Division shall be applicable to the ECO, unless modified by checks indicated for specific Subdivisions.

☒ N/A

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

27
4 OF 29
113
M
6/24/91

1. Drawing: 52-L-001-W ECO Number: 5565

2. ECO Search List: 5532

3. Description of Change:

1. PRESSURE RELIEF VALVE (VC-534-RV-009):
 - A. MOVE TO UPSTREAM OF VALVES VC-534-TW-024 & 25
 - B. RUN OFF 3-WAY VALVE VC-534-TW-027 ON ONE PORT
 - C. PUT A 2-WAY VALVE & A CHECK VALVE ON OTHER PORT
 - D. TO ALLOW FOR MANIFOLD RELIEF DURING CLEANING & CERTIFICATION.

2. CHANGE QTY. FOR ITEMS:

4
9
14
16

3. CHANGE 15 MICRON FILTER IN ITEM 28 TO JUST HOUSING (NO FILTER).

4. CHANGE PART NUMBER FROM "0258C-⁰⁰⁰⁵⁰~~00500~~-SV" TO "0258C-00500-SV"
JRS 6-21-91

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: *[Signature]* Date: 6/24/91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

9a
DRAWING CHANGE SHEET **DRAFT**
(1 SHEET PER DRAWING)

29 JH
7 OF 29 6-24-91
HS
Mx
6/24/91

1. Drawing: 52-L-002-W2 ECO Number: 5565

2. ECO Search List: 5532 _____

3. Description of Change: SEE ATTACHED PAGES

1. CHANGE THE CONFIGURATION BETWEEN THE CARBON BED AND THE SAMPLER:

A. MOVE THE PRESSURE RELIEF VALVE TO JUST DOWNSTREAM OF BOTH THE CARBON BED & THE VOST TUBES.

B. HAVE A 3-WAY VALVE BEFORE THE PRV, TO ROUTE FLOW TO EITHER THE PRV OR THRU A CHECK VALVE & ISOLATION VALVE ADDED.

C. HAVE FLOW COME FROM EITHER THE CARBON BED OR THE VOST TUBES AS BEFORE.

2. ADD A NOTE TO READ:

ALL TUBING FROM THE MAIN CARBON BED OUTLET TO THE SAMPLER UNIT IS WRAPPED WITH HEAT TAPE (3.25 WATTS PER SQUARE INCH). THERE ARE OUTLETS FOR THIS TAPE ON THE SAMPLER RACK

3. ADD THE HEAT TAPE CONTROL BOX TO THE RACK.

4. MOVE THE "TEE" FOR THE OXYGEN GETTERING SYSTEM TO THE MANIFOLD FROM THE CARBON BED SIDE OF THE ROOM TO HELIUM SIDE OF THE ROOM.

4. Drawing Cog. Engineer Approval: *Ch. Hendricks* Date: 6/24/91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

Replaced by
 addendum
 7/10/89

EC0556
 80F 29
 43
 6/24

22 1 100 22

DRAFT

29
9 OF 29
113
MVR
6/24/91

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

1. Drawing: 52-L-002-W3 ECO Number: 5565

2. ECO Search List: 5532 _____

3. Description of Change:

SAME AS 1. AND 3. ON SHEET 9a OF DRAWING
52-L-002-W2 OF THIS ECO.

SEE ATTACHED PAGES

Drawing Cog. Engineer Approval: *Mr. W. R. [Signature]* Date: 6/24/91

Cover Sheet Block (CC&D Use Only)

Received from EFR: _____ Drafting Started: _____
Initials / Date Initials / Date

Date Assigned: _____ Drafting Completed: _____
Initials / Date Initials / Date

Assigned to: _____ Return to EFR: _____
(Same as data base entry) Initials / Date

DRAFT

ECO 5565
29 JPS
10 OF 29
H3
1/14/4
6/24/6

52 1 002 W3

Replace w/
addendum sheet
7/10/91

FIGURE 1 AS SHOWN

105-E-001

DRAFT

ECO 556.5
6-22-10 OF 29 JK
11 H3
26X
62W
/ 11

12 OF 29
27
113
ms
y2/ji

9a

DRAWING CHANGE SHEET **DRAFT**
(1 SHEET PER DRAWING)

1. Drawing: 52-L-002-W5 ECO Number: 5565

2. ECO Search List: 5532

3. Description of Change:

SAME AS 1. ON SHEET 9a OF DRAWING
52-L-002-W2 OF THIS ECO.

SEE ATTACHED PAGE

4. Drawing Cog. Engineer Approval: *M. W. [Signature]* Date: 6/24/91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

ECO 5500
13 OF 29
4/2/00
MUK
4/2/00

DRAWING CHANGE SHEET

(1 SHEET PER DRAWING)

DRAFT

14 OF ~~29~~²⁹
113
mll
6/24/21

2. ECO Search List: 5532

MOVE THE PRV AND TUBING TO 52-L-002-W5.
~~REPLACE TEE WITH A MALE CONNECTOR~~ JRS
6-24-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Date Assigned: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Drafting Started: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Return to EFR: _____
Initials / Date

CONTINUED ON
SHEET 7 OF 10
ZONE A7

52-L-002-W6

CONTINUED FROM
SHEET 5 OF 10
ZONE AB

MOVE THIS PRV AND TUBING TO 52-L-001-W5

DRAFT

ECO 3-26-55
15 OF 29
443
M2
4/4/61

ECO 5565
16 OF 29 JRS
6-24
H3
MR
6/24/91

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING) **DRAFT**

Orig Drawing: 105-F-013-W ECO Number: 5565

ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Description of Change:

1 ADD THE INSTRUMENT AND VALVE NUMBER TAGS
T TO THIS DRAWING AS SHOWN ON THE ATTACHED
P PAGE

Drawing Cog. Engineer Approval: J.R. Stoble Date: 6-22-91

Cover Sheet Block (CC&D Use Only)

Received from EFR: _____ Initials / Date	Drafting Started: _____ Initials / Date
Date Assigned: _____ Initials / Date	Drafting Completed: _____ Initials / Date
Assigned to: _____ (Same as data base entry)	Return to EFR: _____ Initials / Date

REAR VIEW
ENCLOSURE SHOWN IN PHANTOM
FOR CLARITY ONLY.

ECO 550-
29
17 OF 29
H3

D-
MW
8/24/01

DRAFT

FRONT VIEW

ECO 5545

18 OF 29 6-24

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

mk
6/24/91

1. Drawing: 105-H-005-W

ECO Number: 5545

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. EXCHANGE "CRI" & "CRZ" DESIGNATIONS
2. CORRECT THE PRIORITY ALARM DESIGNATIONS
3. ADD HALFSHELL NUMBER IN LPU
4. ADD SYSTEM DESIGNATIONS
5. ADD RESISTOR TO 105-H-001-05 LOOP,
PLC TERMINALS 11 & 13
6. ADD SCT-02 TO 105-H-001-01 LOOP ($\pm 10V$ OUT)
7. CHANGE TERMINAL BLOCK DESIGNATIONS
IN 105-H-001-02 LOOP
8. "PRIORITY 1" TO "HIGH PRIORITY" & "PRIORITY 2" TO "LOW PRIORITY"

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J.R. Stroh Date: 6-22-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
Initials / DateDate Assigned: _____
Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

20 OF 29 1/2
29 6/24
113
MR
6/24/91

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 105-L-002-W2 ECO Number: 5545

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. ADD WIRING FOR THE SIGNAL CONDITIONING TRANSMITTER (SCT) AS SHOWN ON THE ATTACHED PAGES.

2. EXCHANGE "CR1" & "CR2" DESIGNATIONS

3. ADD A 15A CIRCUIT BREAKER IN-LINE BEFORE THE LINE PROTECTOR

4. ADD SYSTEM DESIGNATOR ON BLOCK DIAGRAM

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J. R. Stubble Date: 6-22-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
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Initials / Date

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Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

DESTINATION

TBA - H17
TBA - H22
TBA - H27
TBA - H32
TBA - H37
PLC POWER SUPPLY RACK
CURRENT TRANSMITTER IIRWH
DIGITAL INDICATOR DYS - 8
POWER STRIP
PRESSURE TRANSMITTER

TBC - 904

FAN

LIGHT (PANEL LEFT)

LIGHT (PANEL RIGHT)

SIGNAL CENTER BOARD

105-H-003-W

TBB-M01

TBB-M02

TBB-M07

TBB-M12

TBB-M17

TB0-N22
 PLC POWER SUPPLY RAC
 CURRENT TRANSMITTER TERMINAL
 DIGITAL INDICATOR DVS
 POWER STRIP
 PRESSURE TRANSMITTER
 10SP073C-CE26-C1-
 FAN
 LIGHT (PANEL LEFT)
 LIGHT (PANEL RIGHT)
 SIGNAL CONDITIONER
 105-H-005-W

PLC POWER SUPPLY
CURRENT TRANSMITTER
DIGITAL INDICATOR DIS
POWER STRIP
PRESSURE TRANSMITTER
FAN
LIGHT (PANEL LEFT)
LIGHT (PANEL RIGHT)
10SP023C-CE26-C1
10SP023C-CE26-C1
10SP023C-CE12-C2-1
10SP023C-CE12-C2-1

THE FOLLOWING EQUIPMENT MAY
WILL BE PLUGGED DIRECTLY INTO
120VAC POWER STRIP IN THE
HONEYWELL CHART RECORDER O
MKS INSTRUMENTS 246 DIGITAL
MKS INSTRUMENTS PDR C-2C.

SAMPLE BOTTLE #1 STATUS LIGHT	L13-404-02
SAMPLE BOTTLE #4 STATUS LIGHT	L14-408-02
TBC-901	CR3-412-02
10SP023C-CE26-C1-E	VC534PG013-416-02
10SP023C-CE26-C1-J	VC534PG020-420-02
10SP023C-CE26-C1-G	VC534PG021-504-02
10SP023C-CE26-C1-I	VC534PG022-508-02
10SP023C-CE26-C1-V	VC534PG023-512-02
LOCAL ALARM LIGHT	L16-516-02
TBC-913	CR1-520-02

HELIUM SUPPLY VALVE OPENED	L15-604-02
HELIUM SUPPLY VALVE CLOSED	L16-608-02
AUDIT SAMPLE ROUTINE STARTED	L17-612-02
TBC-909	CR2-616-02

CHANGE TO "P" 42

SPARE BLOCKS FOR MODULE #7 TERMINALS #1-#20

PLC MODULE #2 TERMINAL #19	534PLC00101-N01-01
10SP023C-CE12-C2-D11	W534TW011-N02-01
10SP023C-CE26-C1-D	VC534PG011-N03-01
10SP023C-CE26-C1-W	VC534PG019-N04-01
SAMPLE BOTTLE #1 STATUS LIGHT	L11-N05-01
SAMPLE BOTTLE #2 STATUS LIGHT	L12-N06-01
SAMPLE BOTTLE #3 STATUS LIGHT	L13-N07-01
SAMPLE BOTTLE #4 STATUS LIGHT	L14-N08-01
TBC-902	CR3-N09-01
10SP023C-CE26-C1-F	VC534PG013-N10-01
10SP023C-CE26-C1-K	VC534PG020-N11-01
10SP023C-CE26-C1-H	VC534PG021-N12-01
10SP023C-CE26-C1-U	VC534PG022-N13-01
10SP023C-CE26-C1-W	VC534PG023-N14-01
LOCAL ALARM LIGHT	L16-N15-01
TBC-914	CR1-N16-01
HELIUM SUPPLY VALVE OPENED	L15-N17-01
HELIUM SUPPLY VALVE CLOSED	L16-N18-01
AUDIT SAMPLE ROUTINE STARTED	L17-N19-01
TBC-910	CR2-N20-01
10SP023C-CE26-C1-B	105G001-N21-01

105-P-072	105P022-L1
MCG	105P022-L2
ELECTRONICS INC	105P022-CHD
LINE PROTECTOR	

WIRE NUMBER	
534PLC00101-N00-01	105P023C-CE26-C1
534PLC00101-N00-02	105P023C-CE26-C1
534PLC00101-N00-03	105P023C-CE26-C1

POWER DISTRIBUTION BLOCK

534PLC00101-404-01	PLC MODULE #4 TERMINAL #4
534PLC00101-408-01	PLC MODULE #4 TERMINAL #8
534PLC00101-412-01	PLC MODULE #4 TERMINAL #12
534PLC00101-416-01	PLC MODULE #4 TERMINAL #16
534PLC00101-420-01	PLC MODULE #4 TERMINAL #20
534PLC00101-504-01	PLC MODULE #5 TERMINAL #4
534PLC00101-508-01	PLC MODULE #5 TERMINAL #8
534PLC00101-512-01	PLC MODULE #5 TERMINAL #12
534PLC00101-516-01	PLC MODULE #5 TERMINAL #16
534PLC00101-520-01	PLC MODULE #5 TERMINAL #20
534PLC00101-604-01	PLC MODULE #6 TERMINAL #4
534PLC00101-608-01	PLC MODULE #6 TERMINAL #8
534PLC00101-612-01	PLC MODULE #6 TERMINAL #12
534PLC00101-616-01	PLC MODULE #6 TERMINAL #16
534PLC00101-620-01	PLC MODULE #6 TERMINAL #20
534PLC00101-704-01	PLC MODULE #7 TERMINAL #4
534PLC00101-708-01	PLC MODULE #7 TERMINAL #8
534PLC00101-712-01	PLC MODULE #7 TERMINAL #12
534PLC00101-716-01	PLC MODULE #7 TERMINAL #16
534PLC00101-720-01	PLC MODULE #7 TERMINAL #20

534PLC00101-N00-01	POWER DISTRIBUTION BLOCK
534PLC00101-N00-02	POWER DISTRIBUTION BLOCK

534PLC00101-N00-03	POWER DISTRIBUTION BLOCK
534PLC00101-N00-04	POWER DISTRIBUTION BLOCK

534PLC00101-N00-05	POWER DISTRIBUTION BLOCK
534PLC00101-N00-06	POWER DISTRIBUTION BLOCK

534PLC00101-N00-07	POWER DISTRIBUTION BLOCK
534PLC00101-N00-08	POWER DISTRIBUTION BLOCK

534PLC00101-N00-09	POWER DISTRIBUTION BLOCK
534PLC00101-N00-10	POWER DISTRIBUTION BLOCK

534PLC00101-N00-11	POWER DISTRIBUTION BLOCK
534PLC00101-N00-12	POWER DISTRIBUTION BLOCK

534PLC00101-N00-13	POWER DISTRIBUTION BLOCK
534PLC00101-N00-14	POWER DISTRIBUTION BLOCK

534PLC00101-N00-15	POWER DISTRIBUTION BLOCK
534PLC00101-N00-16	POWER DISTRIBUTION BLOCK

534PLC00101-N00-17	POWER DISTRIBUTION BLOCK
534PLC00101-N00-18	POWER DISTRIBUTION BLOCK

534PLC00101-N00-19	POWER DISTRIBUTION BLOCK
534PLC00101-N00-20	POWER DISTRIBUTION BLOCK

534PLC00101-N00-21	POWER DISTRIBUTION BLOCK
534PLC00101-N00-22	POWER DISTRIBUTION BLOCK

534PLC00101-N00-23	POWER DISTRIBUTION BLOCK
534PLC00101-N00-24	POWER DISTRIBUTION BLOCK

534PLC00101-N00-25	POWER DISTRIBUTION BLOCK
534PLC00101-N00-26	POWER DISTRIBUTION BLOCK

534PLC00101-N00-27	POWER DISTRIBUTION BLOCK
534PLC00101-N00-28	POWER DISTRIBUTION BLOCK

534PLC00101-N00-29	POWER DISTRIBUTION BLOCK
534PLC00101-N00-30	POWER DISTRIBUTION BLOCK

534PLC00101-N00-31	POWER DISTRIBUTION BLOCK
534PLC00101-N00-32	POWER DISTRIBUTION BLOCK

534PLC00101-N00-33	POWER DISTRIBUTION BLOCK
534PLC00101-N00-34	POWER DISTRIBUTION BLOCK

534PLC00101-N00-35	POWER DISTRIBUTION BLOCK
534PLC00101-N00-36	POWER DISTRIBUTION BLOCK

534PLC00101-N00-37	POWER DISTRIBUTION BLOCK
534PLC00101-N00-38	POWER DISTRIBUTION BLOCK

534PLC00101-N00-39	POWER DISTRIBUTION BLOCK
534PLC00101-N00-40	POWER DISTRIBUTION BLOCK

ADD AS SHOWN

SEE DETAIL 1

SPARES TO BE WIRED TO POWER DISTRIBUTION BLOCK AS NEEDED

25 OF 29
#3
MR. [signature]

9a

DRAWING CHANGE SHEET DRAFT
(1 SHEET PER DRAWING)

1. Drawing: 105-1-022-W ECO Number: 5545

2. ECO Search List:

3. Description of Change:

- 1. EXCHANGE "CR1" & "CR2" DESIGNATIONS
- 2. CHANGE "1" & "2" PRIORITY TO "HIGH" & "LOW".

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J.R. Stroh Date: 6-22-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR:	Initials / Date	Drafting Started:	Initials / Date
Date Assigned:	Initials / Date	Drafting Completed:	Initials / Date
Assigned to:	(Same as data base entry)	Return to EFR:	Initials / Date

DRAFT

ECO 55
26 OF 29
10/10/02
MR. J. H. 6-2

CHANGE AS SHOWN

29 JK
27 OF 29 6-2
H3
JMK
6/2/91

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING) **DRAFT**

1. Drawing: 105-)-030-W ECO Number: 5565

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. MOVE THE WIRES FROM "M" & "N" TO "P" & "R" ON THE INPUT CONNECTOR.
2. ADD THE DIODE & CAPACITOR CIRCUIT FOR S4.

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J. R. Strobe Date: 6-22-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
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Drafting Started: _____
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Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

CHIEF

A	105P023C	CL26	C1	TBC	908
B	105P023C	CL26	C1	TBC	N0012
C	VC534PG011	508	02		
D	VC534PG011	N03	01		
E	VC534PG013	416	02		
F	VC534PG013	N10	01		
G	VC534PG021	504	02		
H	VC534PG021	N12	01		
I	VC534PG020	420	02		
J	VC534PG020	N11	01		
K	VC534PG019	312	02		
L	VC534PG019	N04	01		
M	TBAC	GRD			
N					
O					
P					
Q					
R					
S					
T	VC534PG022	508	02		
U	VC534PG022	N13	01		
V	VC534PG023	512	02		
W	VC534PG023	N14	01		
X					
Y	TBAC	GRD			
Z					
a					
b					
c					
d					

113A
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122

S9P9
INLET SOLENOID VALVE
VC-534-PG-011

S8P8
SAMPLE BOTTLE 2 SOLENOID VALVE
VC-534-PG-021

S5P5
SAMPLE/PURGE FLOW SOLENOID
VC-534-PG-019

VC534PG022-508-02A
VC534PG022-N13-01B
VC534PG023-512-02C
VC534PG023-N14-01D

TBAC-GND-F

A B C D E F

PRIMARY SAMPLER

5

105-J-030-W

DRAFT

ECO 5565
PAGE 29 OF 29
#3
JRS
6-24-91

SUPERSEDED

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

1. Addendum Sheet to ECO Number: 5565 Drawing Number: 52-L-002-W2

2. Description of change:

REPLACE PAGE 8 OF THE ECO WITH THE
ONE ATTACHED. A 3-WAY VALVE WAS LEFT OFF
OF THIS PAGE BY MISTAKE. ITS SHOWN ON
PAGE 5 OF THE ECO IN PYID DRAWING 52-L-001-W.
THE VALVE IS 534-TW-010.

3. Approvals

Cognizant Engineer:

J.R. Stroble Aug Mendel

Signature

7-10-91

Date

CC&D Mgr. /Desig. Rep.:

B. Allen

Signature

7/10/91

Date

Other Approval:

A. Krause

Signature

7/10/91

Date

Other Approval::

Signature

Date

DRAFT

32 L 007 02

ADD AS SHOWN

ALL TUBING FROM THE MAIN CARBON BED OUTLET TO THE SAMPLER UNIT IS WRAPPED WITH HEAT TAPE (3/25 WATTS PER SQUARE INCH) THERE ARE OUTLETS FOR THIS TAPE ON THE SAMPLER RACK.

CHANGE AS SHOWN FOR THIS ADDENDUM

ADD AS SHOWN

CHANGE AS SHOWN

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

1. Addendum Sheet to ECO Number: 5565 Drawing Number: 52-L-002-W 3

2. Description of change:

REPLACE PAGE 10 OF THE ECO WITH THE ONE ATTACHED. A 3-WAY VALVE WAS LEFT OFF OF THIS PAGE BY MISTAKE. ITS SHOWN ON PAGE 5 OF THE ECO IN P&ID DRAWING 52-L-001-W. THE VALVE IS 534-TW-010.

3. Approvals

Cognizant Engineer:

J.R. Stroh per [signature]

Signature

7-10-91

Date

CC&D Mgr. /Desig. Rep.:

B. Allen

Signature

7/10/91

Date

Other Approval:

Signature

Date

Other Approval::

Signature

Date

ECO 5565
ADDENDUM
7-10-91

DRAFT

5.2 1-002 W3

CHARGE AS SHOWN

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

1. Addendum Sheet to ECO Number: 5565 Drawing Number: 52-L-001-W

2. Description of change: SEE ATTACHED PAGES

1. DELETE THE "A" NOTE MARKER. THE NOTE HAS BEEN DELETED, BUT THE MARKER STILL APPEARS ON THE DRAWING.
2. ADD A BOUNDARY BETWEEN THE WH06 MANIFOLD AND SANDIA NATIONAL LAB'S OXYGEN GETTERING SYSTEM.
3. VALVE HE-534-BL-004 SHOULD BE SHOWN AS NORMALLY OPEN.

Approvals

Authorized Engineer:

Dr. Mendiratta
Signature

7/12/91
Date

&D Mgr. /Desig. Rep.:

B. Allen
Signature

7/12/91
Date

Other Approval:

Signature

Date

Other Approval:

Signature

Date

SHOW THIS VALVE
NORMALLY OPEN
NORMALLY OPEN

WH06

EM05

WH06 EM05

MAKE-UP
GAS SYSTEM

EM05

WH06

6 IA 534 IW 011

IAS -A

1/2" SS

HE-534-BL-004

HE-534-BL-003

HE-534-BL-002

19 HE-534-RV-001

40-1260
SCCM

3 534-11-001-04

NOTES

- 1 95
- 2 80
- 3 80
- 4 80
- 5 80
- 6 80
- 7 80
- 8 80
- 9 80

APPENDUM 7-12-9

EC05565

1(1)

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

PAGE 1 OF 2
9-12-91

DRAFT

1d Addendum Sheet to ECO Number: 5565 Drawing Number: 52-L-002-W1

2p Description of change:

CHANGE THE DESCRIPTION AND PART NO.
FOR ITEM 70 FROM "UNION, ELBOW 1/2" SS-810-9"
TO "UNION, TEE 1/2" SS-810-3." THE ITEM 70
IS SHOWN ON 52-L-002-W4 & IS CORRECT, BUT THE
DESCRIPTION AND PART NO. ARE INCORRECT ON THIS
DRAWING.

3. Approvals

Cognizant Engineer:	<u>Don Hendriks</u>	<u>J.R. Stubble</u>	<u>9-12-91</u>
	Signature		Date
CC&DeMgrr./Desig. Rep.:	<u>B. Allen</u>		<u>9/12/91</u>
	Signature		Date
Other Approval:	<u>S. Hansen</u>		<u>9-12-91</u>
	Signature		Date
Other Approval:			
	Signature		Date

DRAFT

ECO 5565
 PAGE 2 OF 2
 ADDENDUM 9-12-9

52-L-002-W1

LIST OF MATERIAL

QTY REQ			ITEM NO.	ORDERING INFORMATION	NOTE	DRAWING NO. OR PART NO.	MATERIAL SPECIFICATION				
GR3	GR2	GR1					MATL	STD	NUMBER	COMP	FORM
			AR 56	STRAP, VELCRO BACK-TO-BACK 2" WIDE	L	3955T16					
			1 57	TRANSDUCER, PRESSURE DIFFERENTIAL 100mm HG		52-L-001-H08					
			AR 58	TUBE ADAPTER, MALE 1/4" X 3/8"	K	SS-4-TA-1-6	SST		316		
			AR 59	TUBING, 1/4" X 0.049" WALL	L	8955K11	SOFT COPPER				
			AR 60	TUBING, 1/4" X 0.028" WALL			SST	ASTM	A269		
			AR 61	TUBING, 1/2" X 0.049" WALL			SST	ASTM	A269		
			AR 62	TUBING, 1" X 0.083" WALL			SST	ASTM	A269		
			AR 63	TUBING, 2" X 0.188" WALL			SST	ASTM	A269		
			AR 64	UNION, 1/4"	C	SS-400-6	SST		316		
			AR 65	UNION, 1/2"	C	SS-810-6	SST		316		
			AR 66	UNION, 1"	C	SS-1610-6	SST		316		
			AR 67	UNION, 2"	D	SS-3200-6	SST		316		
			1 68	UNION, ULTRA-TORR 1/2" X 1/2"	J	SS-8-UT-6-810	SST		316		
			AR 69	UNION, ELBOW 1/2"	C	SS-400-9	SST		316		
			AR 70	UNION, ELBOW 1/2"	C	SS-810-9	SST		316		
			AR 71	UNION, ELBOW 1"	C	SS-1610-9	SST		316		
			AR 72	UNION, ELBOW 2"	D	SS-3200-9	SST		316		
			AR 73	UNION, REDUCING 1/2" X 1/4"	C	SS-810-6-4	SST		316		
			AR 74	UNION, REDUCING 1" X 1/2"	C	SS-1610-6-8	SST		316		
			AR 75	UNION, REDUCING 2" X 1"		SS-1610-R-32	SST		316		
			AR 76	UNION, TEE 1/4"	C	SS-400-3	SST		316		
			AR 77	UNION, TEE 1/2"	C	SS-810-9	SST		316		
			AR 78	UNION, TEE 1"	C	SS-1610-3	SST		316		
			AR 79	UNION, TEE 2"	D	SS-3200-3	SST		316		
			4 80	VALVE, BALL 3-WAY MANUALLY OPERATED 1"		52-L-001-H09					
			3 81	VALVE, BALL 2-WAY MANUALLY OPERATED 1/2"		52-L-001-H04					
			1 82	VALVE, BALL 2-WAY AIR-OPERATED 1/2" NC		52-L-001-H05					
			83								
			1 84	VALVE, CHECK IN-LINE 1/4"		52-L-001-H16					
			85								
			1 86	VALVE, RELIEF IN-LINE, 0.8 PSIG 1/4"		52-L-001-H19					
			3 87	VALVE, SOLENOID 3-WAY NC 1/4"		52-L-001-H06					
			1 88	VENT, EMERGENCY RELIEF, WEIGHT LOADED 0.8 PSIG, 2"		52-L-001-H14					
			3 89	VOST TUBE		52-L-001-H11					
			1 90	WORK STATION, W/DRAWER AND INSTRUMENT SHELF	L	SB-3672					
			AR 91	QUICK-CONNECT, STEM 1/4"	F	SS-QT2-D-400					
			92								
			AR 93	UNION CROSS 1/2"	C	SS-810-4	SST		316		
			AR 94	HOSE, FLEXIBLE TUBING 1/4" OD 36" L	M	J21-8-X-36B2	SST		316		
			AR 95	CONNECTOR, PORT 1/4"	C	SS-401-PC	SST		316		
			4 96	VALVE, BALL 2-WAY MANUALLY OPERATED 1/4"	N	SS-62TS4					
			AR 97	PLUG 1/4"							

CHANGED
 UNION, 1/2"
 SS-810

DRAFT

ECO 5625

11908.0005

13. Justification

THIS CHANGE IS REQUIRED TO ALLOW OPERATIONS
EASIER REPLACEMENT OF THE CARBON BED.

DRAFT

14. Administrative Tracking

YES N/A

- ☐ ☒ 1. FSAR
☐ ☒ 2. Calibration Procedures
☐ ☒ 3. Maintenance Procedures
☐ ☒ 4. Computer Software
☐ ☒ 5. Operations Procedures

YES N/A

- ☒ ☒ 6. ~~Startup~~/Acceptance Test
☐ ☒ 7. Test Requirement & Spec.
☐ ☐ 8. _____
☐ ☐ 9. _____
☐ ☐ 10. _____

15. Signature Requirements

KEY
 A=APPR.
 R=REVIEW
 S=SIGN NEW

DRAWING 7/19/91

- ☒ Cog. Engineer J.R. Stroh 7-19-91
☒ Cog. Eng. Mgr Jayne Harris 7/19/91
☒ Startup Michael R. B. 7/19/91
☒ QA CS Maty 7/23/91
☐ DOE _____
☐ Safety _____
☐ Dept. Manager _____
☐ Operations _____
☐ Security _____
☐ SNL _____
☒ RWHE WHO'S COG. Sen. Newirth 7/19/91
☒ RWHE COG. ENGR. Michael R. B. 7/19/91

16. Distribute as Marked

- ☐ Maintenance (MANDATORY) _____
☐ Ops. Support (MANDATORY) _____
☐ Startup _____
☐ Facility Operations _____
☐ U/G Operations _____
☐ Orig./Design Engr. _____
☐ Cog. Engineer _____
☒ Others TERRY CAMP
☐ _____
☐ _____
☐ _____
☐ _____

DRAFT

09-107 2007

ENGINEERING CHANGE ORDER

DOE ORDER 6430.1A DESIGN CRITERIA

CHECKLIST

PAGE 3 OF 5
1. ECO # 5625
2. DATE 7-18-91

The design requirements in DOE Order 6430.1A checked below have been applied to this Design.

3.	DIVISION	SUBDIVISION
☐ 1	General Requirements	☐ 0101 ☐ 0105 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☒ 2	Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0235 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0260 ☐ 0252 ☐ 0265 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0275 ☐ 0276 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☒ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☐ 3	Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☐ 4	Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☒ 5	Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☒ 0532
☐ 6	Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☒ 7	Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☒ 0721 ☐ 0722 ☐ 0724 ☐ 0727 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☒ 8	Doors and Windows	☐ 0800 ☒ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0836 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0870 ☐ 0880
☐ 9	Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0980 ☐ 0990 ☐ 0995
☐ 10	Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1055 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☐ 11	Equipment	☐ 1100 ☐ 1161
☐ 12	Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1250 ☐ 1270
☐ 13	Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☐ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☐ 1325 ☐ 1328
☐ 14	Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1460
☐ 15	Mechanical	☐ 1525 ☐ 1530 ☐ 1540 ☐ 1550 ☐ 1555 ☐ 1565 ☐ 1574 ☐ 1589 ☐ 1595
☒ 16	Electrical	☐ 1600 ☒ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1655 ☐ 1660 ☐ 1670 ☐ 1671 ☐ 1685 ☐ 1694
☐ 17	NOT APPLICABLE	No portion of DOE Order 6430.1A is applicable to this Design.
☐ 18	AS-BUILT	ECO is for as-built field verified changes only.

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

7/19/91

COMMENTS:

9a

DRAWING CHANGE SHEET

(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W5 ECO Number: 5625

2. ECO Search List:

3. Description of Change:

WITH ECO 5565 SH 13 OF 29 ADD FLEXIBLE STAINLESS STEEL TUBING (SWAGELOK P.N. SS-1240-G-S12) AND (2) 3/4" X 1" CONNECTIONS AT EACH END. ADD AS SHOWN BELOW.

4. Drawing Cog. Engineer Approval: *[Signature]* Date: 7/22/91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____	Drafting Started: _____
Initials / Date	Initials / Date
Date Assigned: _____	Drafting Completed: _____
Initials / Date	Initials / Date
Assigned to: _____	Return to EFR: _____
(Same as data base entry)	Initials / Date

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

n. Drawing: 52-L-002-W1 ECO Number: 5625

3. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3b Description of Change:

1. ADD FLEXIBLE STAINLESS STEEL TUBING, SWAGELOK
1. P.N. SS-12HC-6-S12 TO BILL OF MATL.

4. Drawing Cog. Engineer Approval: *M. W. J.* Date: 7/22/91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____	Drafting Started: _____
Initials / Date	Initials / Date
Date Assigned: _____	Drafting Completed: _____
Initials / Date	Initials / Date
Assigned to: _____	Return to EFR: _____
(Same as data base entry)	Initials / Date

DRAFT

ECO 5723

Page 1 of 6

Page 1 of 6

1. ECO No.: <u>5723</u> 5. KCC&D Review: <u>RP</u>	Initials Posted	2. Impact Level 1 ☐ 2 ☒ 3 ☐ 4 ☐ 3. System: <u>WH06.14</u> Equipment No.: <u>NA</u> Building: <u>U/B</u> 4. Associated Documents: PWR <u>13062 M</u> ECP <u>NA</u> P.O. <u>50652</u> Others <u>NA</u>	5. Document Type: Drawing <u>52-L-002-W1</u> ☒ Specification <u>52-L-002-W10</u> ☐ Vendor Data ☐ SDD ☐ Others _____ 6. Title of Change: <u>Revise VOC-10 Manifold Hangers</u>
7. Originator: (print) <u>M. W. KING</u>	Ext. No.: <u>8586</u>	Department: <u>RUHE</u>	Date: <u>8-21-91</u> 8. Cognizant Engineer: (print) <u>O. P. LIENDIRATH</u>
9. Description of Change: <div style="text-align: right; margin-right: 50px;"> Yes ☐ No ☒ Component indices change required (if yes, attach sheets) </div> <div style="font-size: 1.2em; margin-top: 20px;"> Change hanger details and Bill of Material on drawings 52-L-002-W10 and 52-L-002-W1. </div> <div style="margin-top: 20px;"> <div style="display: flex; justify-content: space-between;"> <div> ☒ 9a Drawing Change Sheet attached ☐ 9b Design Documentation Sheet attached </div> <div> ☐ 9c Vendor Data Change Sheet attached </div> </div> </div>			
10. <div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 60%;"> Yes ☒ No ☐ MODIFICATION IN PROGRESS Modification complete: <u>M. W. King</u> <u>10/7/91</u> <div style="display: flex; justify-content: space-between; font-size: 0.8em;"> Signature Date </div> ☐ Change drawing per as-built markup dated: _____ ☐ Change drawing per ECO-provided data ☐ Temporary modification </div> <div style="width: 35%; border-left: 1px solid black; padding-left: 10px;"> ECO will be incorporated after M.I.P. signed complete </div> </div>			
11. Design Verification Requirements: (per WP 09-018) EDT No.: _____ <div style="margin-top: 10px;"> <div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <u>JS</u> ✓ _____ _____ _____ _____ <u>JS</u> ✓ _____ </div> <div style="width: 70%;"> 1. Requirements satisfied by review/approval of design document 2. Independent review 3. Alternate calculations 4. Development testing 5. Design review 6. Other: <u>Final Drawing Review & Approval</u> </div> </div> </div>			
12. Addendum Sheet added: _____ <div style="display: flex; justify-content: space-between; font-size: 0.8em;"> Signature Date </div>			

13.153. Justification

These changes are required to
 to allow
 to lower the VOC-10 manifold and installation
 back support in Room 1,
 system

DRAFT

8/21/91

4. Administrative Tracking

YES NO N/A

- ☒ ☒ 1. FSAR
☒ ☒ 2. Calibration Procedures
☒ ☒ 3. Maintenance Procedures
☒ ☒ 4. Computer Software
☒ ☒ 5. Operations Procedures

YES N/A

- ☐ ☒ 6. Startup/Acceptance Test
☐ ☒ 7. Test Requirement & Spec.
☐ ☐ 8. _____
☐ ☐ 9. _____
☐ ☐ 10. _____

5. Signature Requirements

KEY
 A=APPR.
 R=REVIEW
 S=SIGN NEW
 DRAWING

authenticity 8/24/91
☒ Cog. Engineer *M.W. King 8/20/91*
☒ Cog. Eng. Mgr. *M.W. King 8/20/91*
☒ Startup *8/21/91*
☒ QA *8/22/91*
☐ DOE
☒ Safety *8/23/91*
☐ Dept. Manager
☒ Operations *8-23-91*
☐ Security
☐ SNL
J.R. Stroble 8-20-91

16. Distribute as Marked

☒ Maintenance (MANDATORY)
☒ Ops. Support (MANDATORY)
☒ Startup
☐ Facility Operations
☒ U/G Operations
☒ Orig./Design Engr. *M. King*
☐ Cog. Engineer
☐ Others
☒ *Bob Roland*
☒ *J.R. Stroble*
☒ *Jaime Gonzalez*

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W1 ECO Number: 5723

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

Revise the Bill of Material
as follows

Change item 36 to $\frac{1}{4}$ " MONKEY CLIP
w/ $\frac{5}{8}$ " DIA HOLE 52 EA

Add $\frac{9}{32}$ " GALVANIZED ALLOY CHAIN
GRADE 80 OR EQUAL
250 FT

4. Drawing Cog. Engineer Approval: *[Signature]* Date: 8-20-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____ Initials / Date	Drafting Started: _____ Initials / Date
Date Assigned: _____ Initials / Date	Drafting Completed: _____ Initials / Date
Assigned to: _____ (Same as data base entry)	Return to EFR: _____ Initials / Date

9a

DRAWING CHANGE SHEET

(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W10 ECO Number: 5723

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

Revise Detail 1 per the attached marked print.

4. Drawing Cog. Engineer Approval: *[Signature]* Date: 8-20-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

DRAFT

DETAIL 1
PIPE HANGER
(SEE NOTE 1)

DETAIL 2
RIB MOUNTED TUBING SUPPORT
(SEE NOTE 2)

52-L-002-W10

PAGE 9 OF 6
1. ECO # 57-23
2. DATE

DRAFT

DRAFT

3. DIVISION		SUBDIVISION									
☐ 1	General Requirements	☐ 0101	☐ 0105	☐ 0109	☐ 0110	☐ 0111	☐ 0140	☐ 0150	☐ 0170		
☐ 2	Site and Civil Engineering	☐ 0200	☐ 0201	☐ 0202	☐ 0203	☐ 0205	☐ 0210	☐ 0214	☐ 0215	☐ 0220	☐ 0221
		☐ 0245	☐ 0250	☐ 0256	☐ 0260	☐ 0262	☐ 0265	☐ 0267	☐ 0270	☐ 0273	☐ 0275
		☐ 0276	☐ 0278	☐ 0279	☐ 0280	☐ 0281	☐ 0283	☐ 0285	☐ 0290	☐ 0291	
☐ 3	Concrete	☐ 0300	☐ 0301	☐ 0310	☐ 0320	☐ 0330	☐ 0340	☐ 0350	☐ 0370	☐ 0380	
☐ 4	Masonry	☐ 0400	☐ 0401	☐ 0410	☐ 0420	☐ 0455					
☐ 5	Metals	☐ 0500	☐ 0512	☐ 0514	☐ 0521	☐ 0531	☐ 0532				
☐ 6	Wood and Plastics	☐ 0600	☐ 0610	☐ 0650							
☐ 7	Thermal and Moisture Protection	☐ 0710	☐ 0711	☐ 0714	☐ 0715	☐ 0719	☐ 0720	☐ 0721	☐ 0722	☐ 0724	☐ 0725
		☐ 0730	☐ 0750	☐ 0751	☐ 0753	☐ 0760	☐ 0790				
☐ 8	Doors and Windows	☐ 0800	☐ 0810	☐ 0820	☐ 0830	☐ 0833	☐ 0836	☐ 0839	☐ 0850	☐ 0860	☐ 0870
		☐ 0880									
☐ 9	Finishes	☐ 0900	☐ 0910	☐ 0920	☐ 0925	☐ 0930	☐ 0950	☐ 0965	☐ 0968	☐ 0970	☐ 0980
		☐ 0990	☐ 0995								
☐ 10	Specialties	☐ 1015	☐ 1020	☐ 1024	☐ 1027	☐ 1030	☐ 1040	☐ 1050	☐ 1052	☐ 1053	☐ 1055
		☐ 1060	☐ 1065	☐ 1070	☐ 1075	☐ 1080					
☐ 11	Equipment	☐ 1100	☐ 1161								
☐ 12	Furnishings	☐ 1201	☐ 1230	☐ 1250	☐ 1260	☐ 1270					
☐ 13	Special Facilities	☐ 1300	☐ 1304	☐ 1305	☐ 1306	☐ 1307	☐ 1318	☐ 1319	☐ 1320	☐ 1321	☐ 1322
		☐ 1323	☐ 1324	☐ 1325	☐ 1326	☐ 1328					
☐ 14	Conveying Systems	☐ 1401	☐ 1420	☐ 1440	☐ 1460						
☐ 15	Mechanical	☐ 1525	☐ 1530	☐ 1540	☐ 1550	☐ 1555	☐ 1565	☐ 1574	☐ 1589	☐ 1595	
☐ 16	Electrical	☐ 1600	☐ 1605	☐ 1620	☐ 1630	☐ 1639	☐ 1640	☐ 1650	☐ 1655	☐ 1660	☐ 1670
		☐ 1671	☐ 1685	☐ 1694							
4. ☒	NOT APPLICABLE	No portion of DOE Order 6430.1A is applicable to this Design.									
5. ☐	AS-BUILT	ECO is for as-built field verified changes only.									

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

TIME: 72:

DRAFT

ECO 5960

ENGINEERING CHANGE ORDER

USE BLACK INK

Page 1 of 5

1. ECO No.: <u>596D</u> CC&D Review: <u>2J</u>		2. Impact Level 1 ☐ 2 ☐ 3 ☒ 4 ☐	
Initials Posted	3. System: <u>EM05</u> Equipment No.: <u>105-P-023</u> Building: <u>V/E-R.M.1</u>		
	4. Associated Documents: PWR _____ ECP _____ P.O. _____ Others <u>ORR ACTION WH06.14</u> <u>4.3.1.3</u>		5. Document Type: Drawing <u>52-L-002-W2</u> ☒ Specification ☐ Vendor Data ☐ SDD ☐ Others _____
6. Title of Change: <u>VOC-10 EQUIPMENT DEBRIS PROTECTION</u>			
7. Originator: (print) <u>J.R. STROBLE</u>		Ext. No.: <u>8374</u> Department: <u>ELEC. ENG.</u> Date: <u>01-13-92</u>	8. Cognizant Engineer: (print) <u>J.R. STROBLE</u>
9. Description of Change: <div style="text-align: right;">Yes ☐ No ☒ Component indices change required (if yes, attach sheets)</div> <p style="text-align: center;">ADD THE VOC-10 EQUIPMENT PROTECTION STRUCTURE TO DRAWING 52-L-002-W2</p> <div style="display: flex; justify-content: space-between;"><div>☒ 9a Drawing Change Sheet attached ☐ 9b Design Documentation Sheet attached</div><div>☐ 9c Vendor Data Change Sheet attached</div></div>			
10. Yes ☐ No ☒ MODIFICATION IN PROGRESS Modification complete: _____ <div style="display: flex; justify-content: space-between;"><div>Signature</div><div>Date</div></div> <div style="display: flex; align-items: center;"><div style="margin-right: 10px;">} ECO will be incorporated after M.I.P. signed complete</div><div>☐ Change drawing per as-built markup dated: _____ ☐ Change drawing per ECO-provided data ☐ Temporary modification</div></div>			
11. Design Verification Requirements: (per WP 09-018) EDT No.: _____ <div style="display: flex;"><div style="flex: 1;"><u>J.R.</u> _____ _____ _____ _____ _____</div><div style="flex: 2;"><ol style="list-style-type: none">1. Requirements satisfied by review/approval of design document2. Independent review3. Alternate calculations4. Development testing5. Design review6. Other: _____</div></div>			
12. Addendum Sheet added: _____ <div style="display: flex; justify-content: space-between;"><div>Signature</div><div>Date</div></div>			

It 13. Justification

DRAFT

THIS STRUCTURE WAS ORIGINALLY INSTALLED DURING THE INSTALLATION OF THE ROOM 1 ROOF SUPPORT SYSTEM TO PROTECT THE VOC-10 EQUIPMENT AND TO ALLOW MINING OPERATIONS TO WORK OVER THIS EQUIPMENT.

THIS ECO IS BEING SUBMITTED TO ALLOW FOR THIS STRUCTURE TO STAY IN PLACE AS A PERMANENT PROTECTION STRUCTURE FOR VOC-10.

14. Administrative Tracking

YES N/A

- ☐ ☒ 1. FSAR
☐ ☒ 2. Calibration Procedures
☐ ☒ 3. Maintenance Procedures
☐ ☒ 4. Computer Software
☐ ☒ 5. Operations Procedures

YES N/A

- ☐ ☒ 6. Startup/Acceptance Test
☐ ☒ 7. Test Requirement & Spec.
☐ ☐ 8. _____
☐ ☐ 9. _____
☐ ☐ 10. _____

15. Signature Requirements

KEY

A=APPR.
R=REVIEW
S=SIGN NEW
DRAWING

to ☐ A Cog. Engineer J.R. Stroble 01-14-92
to ☐ A Cog. Eng. Mgr James A. Davis 1/14/92
to ☐ R Startup 1/14/92
to ☐ A QA 1/11/92
C ☐ DOE
a ☐ A Safety 1/21/92
e ☐ Dept. Manager
p ☐ Operations
e ☐ Security
N ☐ SNL

16. Distribute as Marked

☒ Maintenance (MANDATORY)
☐ Ops. Support (MANDATORY)
☐ Startup
☐ Facility Operations
☐ U/G Operations
☐ Orig./Design Engr.
☐ Cog. Engineer
☐ Others
☒ MINING OPS. TOM BROCKMAN

DRAFT

ENGINEERING CHANGE ORDER

DOE ORDER 6430.1A DESIGN CRITERIA

CHECKLIST

PAGE 3 OF 5
 1. ECO # 596C
 2. DATE 01-13-92

The design requirements in DOE Order 6430.1A checked below
 have been applied to this Design.

NO	DIVISION	SUBDIVISION
☒ 1	General Requirements	☐ 0101 ☐ 0105 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☒ 2	Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0221 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0260 ☐ 0262 ☐ 0265 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0274 ☐ 0275 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☐ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☒ 3	Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☒ 4	Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☒ 5	Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☐ 0532
☒ 6	Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☒ 7	Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☐ 0721 ☐ 0722 ☐ 0724 ☐ 0725 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☒ 8	Doors and Windows	☐ 0800 ☐ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0835 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0870 ☐ 0880
☒ 9	Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0980 ☐ 0990 ☐ 0995
☒ 10	Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1055 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☒ 11	Equipment	☐ 1100 ☐ 1161
☒ 12	Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1260 ☐ 1270
☒ 13	Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☐ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☐ 1326 ☐ 1328
☒ 14	Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1460
☒ 15	Mechanical	☐ 1525 ☐ 1530 ☐ 1540 ☐ 1550 ☐ 1555 ☐ 1565 ☐ 1574 ☐ 1589 ☐ 1595
☒ 16	Electrical	☐ 1600 ☐ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1655 ☐ 1660 ☐ 1670 ☐ 1671 ☐ 1685 ☐ 1694
4. ☐ NOT APPLICABLE	No portion of DOE Order 6430.1A is applicable to this Design.	
5. ☒ AS-BUILT	ECO is for as-built field verified changes only.	

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

COMMENTS:

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 4 of 5

1. Drawing: 52-1-002-WZ

ECO Number: 5960

2. ECO Search List: 5821

3. Description of Change:

ADD THE VOC-10 EQUIPMENT PROTECTION
STRUCTURE AS SHOWN ON THE ATTACHED
PAGE.

4. Drawing Cog. Engineer Approval: J.R. Stubble

Date: 01-14-92

DRAFT

ECO 5966
PAGE 5 OF 5

U.S. DEPARTMENT OF ENERGY
BUREAU OF ENERGY EFFICIENCY
AND BUILDING TECHNOLOGY
BUREAU OF ENERGY EFFICIENCY
AND BUILDING TECHNOLOGY
BUREAU OF ENERGY EFFICIENCY
AND BUILDING TECHNOLOGY

NOTES
1. THE DRAWING SHOWS THE PROPOSED LOCATION OF THE BUILDING
AND THE PROPOSED LOCATION OF THE BUILDING
AND THE PROPOSED LOCATION OF THE BUILDING
AND THE PROPOSED LOCATION OF THE BUILDING

DRAFT

ECO 5821

ENGINEERING CHANGE ORDER

DRAFT

USE BLACK INK

Page 1 of 37

1. ECO No.: <u>522</u> CC&D Review: <u>[Signature]</u>	Initials Posted	2. Impact Level 1 ☐ 2 ☐ 3 ☒ 4 ☐ 3. System: <u>EM05</u> Equipment No.: <u>105-P-023</u> Building: <u>U/G Rm-1</u> 4. Associated Documents: PWR <u>12080M, 12085M</u> ECP <u>2-EM91-185</u> P.O. <u>48460, 48470, 51057</u> Others _____ 5. Document Type: <u>412-M-225-W</u> Drawing <u>52-L-002-W1 to W10</u> ☒ Specification <u>105-J-022-W</u> ☐ Vendor Data <u>105-L-002-W1, W2</u> ☐ SDD <u>105-J-030-W</u> ☐ Others <u>105-J-013-W</u> ☐ <u>53-J-053-W2</u> 6. Title of Change: <u>VOC-10 Modification to Carbon Bed Ass'y</u>
7. Originator: (print) <u>J. R. Stroble</u>	Ext. No.: <u>8374</u> Department: <u>Elec. Eng.</u> Date: <u>10/4/91</u>	8. Cognizant Engineer: (print) <u>J. R. Stroble</u>
9. Description of Change: <div style="text-align: right; margin-right: 100px;"> Yes No ☒ ☐ </div> <div style="text-align: right; margin-right: 50px;"> Component indices change required (if yes, attach sheets) </div> <p>Change VOC-10 as follows:</p> <ol style="list-style-type: none"> 1. Place the carbon bed upright on a rack 2. Place valves, tubing, and instruments associated with the carbon bed on the same rack 3. Add a flow meter/indicator just upstream of the pressure relief valve (PRV) 4. Move the PRV closer to the exit (top) of the carbon bed 5. Remove valves VC-534-TW-010, 025, 026, 027, and 008 6. change all valves and tubing from manifold to PRV to 1" 7. change all valves and tubing from PRV to sampler to 1/4" 8. Delete drawings 52-L-002-W6, W8, and W10 9. Change system designator on above drawings all to EM05 <div style="margin-top: 20px;"> ☒ 9a Drawing Change Sheet attached ☐ 9c Vendor Data Change Sheet attached ☐ 9b Design Documentation Sheet attached </div>		
<div style="display: flex; justify-content: space-between;"> <div> Yes No ☒ ☐ MODIFICATION IN PROGRESS ☒ Modification complete: <u>J.R. Stroble</u> <u>1-5-93</u> Signature Date </div> <div style="border-left: 1px solid black; padding-left: 10px; width: 200px;"> ECO will be incorporated after M.I.P. signed complete </div> </div> <div style="margin-top: 10px;"> ☒ Change drawing per as-built markup dated: <u>1-5-93</u> ☐ Change drawing per ECO-provided data ☐ Temporary modification </div>		
Design Verification Requirements: (per WP 09-018) EDT No.: <u>E91-319, E91-283</u>		
<div style="display: flex;"> <div style="width: 20%; border-right: 1px solid black; padding-right: 5px;"> <u>EDT's E-91-319, E91-283</u> </div> <div style="width: 80%; padding-left: 5px;"> <ol style="list-style-type: none"> 1. Requirements satisfied by review/approval of design document 2. Independent review 3. Alternate calculations 4. Development testing 5. Design review 6. Other: _____ </div> </div>		
Addendum Sheet added: <u>Charles D. Haigner</u> <u>11/5/93</u> Signature Date		

13. Justification

1. Inverting the carbon bed will prevent the possibility of gases bypassing the carbon due to settling.
2. Associated components will need to be close to the carbon bed.
3. If the PRV opens, the amount of gas released will be unknown.
4. A 1" flow path was chosen to remain consistent with the existing system upstream of the carbon bed. This also reduces the number of pressure gradients in the system.
5. These valves are no longer necessary (See EDT E91-319).
6. Same as number 4 above.
7. 1/4" valves and line will increase the efficiency of the cleaning process.
8. This information was needed for construction, but is not needed for configuration control.

14. Administrative Tracking

YES N/A

- ☒ ☐ 1. FSAR
- ☒ ☐ 2. Calibration Procedures
- ☐ ☒ 3. Maintenance Procedures
- ☐ ☒ 4. Computer Software
- ☒ ☐ 5. Operations Procedures (D&AT)

YES N/A

- ☒ ☐ 6. Startup/Acceptance Test
- ☒ ☐ 7. Test Requirement & Spec.
- ☐ ☐ 8. _____
- ☐ ☐ 9. _____
- ☐ ☐ 10. _____

15. Signature Requirements

KEY
A=APPR.
R=REVIEW
S=SIGN NEW
DRAWING

☒ A	Cog. Engineer	<i>Kenneth E. Allen</i> 10/24/91
☒ A	Cog. Eng. Mgr	<i>James J. Allen</i> 10/24/91
☒ R	Startup	<i>W. J. Brack</i> 10/24/91
☒ S	QA	<i>C. E. Martin</i> 10/24/91
☐	DOE	
☒ S	Safety	<i>E. E. Buchanan</i> 10/24/91
☐	Dept. Manager	
☐	Operations	
☐	Security	
☐	SNL	
☒ A	D & AT	<i>R. J. Brack</i> 10/24/91
☒ S	EMHE MGR	<i>J. J. Brack</i> 10/24/91
☐		

16. Distribute as Marked

☒	Maintenance (MANDATORY)	_____
☐	Ops. Support (MANDATORY)	_____
☐	Startup	_____
☐	Facility Operations	_____
☐	U/G Operations	_____
☐	Orig./Design Engr.	_____
☐	Cog. Engineer	_____
☐	Others	_____
☐		_____
☐		_____
☐		_____
☐		_____

DRAFT

ENGINEERING CHANGE ORDER

DOE ORDER 6430.1A DESIGN CRITERIA

CHECKLIST

PAGE 3 OF 57

1. ECO # 5821

2. DATE 9-30-91

The design requirements in DOE Order 6430.1A checked below
have been applied to this Design.

3. DIVISION	SUBDIVISION
☐ 1 General Requirements	☐ 0101 ☐ 0106 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☐ 2 Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0225 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0250 ☐ 0262 ☐ 0265 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0275 ☐ 0276 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☐ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☐ 3 Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☐ 4 Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☐ 5 Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☐ 0532
☐ 6 Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☐ 7 Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☐ 0721 ☐ 0722 ☐ 0724 ☐ 0725 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☐ 8 Doors and Windows	☐ 0800 ☐ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0836 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0870 ☐ 0880
☐ 9 Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0980 ☐ 0990 ☐ 0995
☐ 10 Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1060 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☐ 11 Equipment	☐ 1100 ☐ 1161
☐ 12 Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1260 ☐ 1270
☐ 13 Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☒ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☒ 1326 ☐ 1328
☐ 14 Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1460
☐ 15 Mechanical	☐ 1525 ☐ 1530 ☒ 1540 ☒ 1550 ☒ 1555 ☐ 1565 ☒ 1574 ☐ 1589 ☐ 1595
☐ 16 Electrical	☐ 1600 ☐ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1655 ☐ 1660 ☐ 1670 ☐ 1671 ☐ 1685 ☐ 1694
☐ NOT APPLICABLE	(No portion of DOE Order 6430.1A is applicable to this Design.)
☐ AS-BUILT	(ECO is for as-built field verified changes only.)

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

COMMENTS: _____

9a

DRAWING CHANGE SHEET (1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-001-W ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. CHANGE THE PIPING SIZE AND ARRANGEMENT FROM THE CARBON BED + VOST TUBES TO THE SAMPLER.
 2. DELETE VALVES VC-534-TW-010, 025, 026 + 027, + 008
 3. ADD A FLOW METER AND THREE Z-WAY VALVES.
 4. DELETE SYSTEM BOUNDARIES BETWEEN EMOS & WH06.
(THE WHOLE SYSTEM & DRAWINGS ARE NOW EMOS)
 5. CHANGE BILL OF MATERIALS.
 6. ADD DRAWING REFERENCES.
 7. CHANGE SYSTEM DESIGNATOR TO JUST EMOS
- SEE ATTACHED PAGES.

4. Drawing Cog. Engineer Approval: J. R. Stroh Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
Initials / DateDate Assigned: _____
Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

DRAFT

DESIGNATION: 1111
A-100 7 25 1111

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	REMARKS
1	...	...	...	...
2	...	...	...	...
3	...	...	...	...
4	...	...	...	...
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55	...	...	...	...
56	...	...	...	...
57	...	...	...	...

CHANGE (SEE ATTACHED PAGE(S))

CHANGE (SEE ATTACHED PAGE(S))

CHANGE (SEE ATTACHED PAGE(S))

- NOTES
- 1. ...
 - 2. ...
 - 3. ...
 - 4. ...
 - 5. ...
 - 6. ...
 - 7. ...
 - 8. ...
 - 9. ...
 - 10. ...

SEE ATTACHED PAGE(S)

ADD TO

UNITS AND WIRING INFORMATION SYSTEM

DRAFT

ECO 5821
PAGE 6 OF 57

ELECTRICAL ENCLOSURE 105-P-023

QTY	PART NAME/DESCRIPTION	REF NO OR REF DESI	NATL./SPEC
1	CYLINDER, SIZE K, HELIUM	11-18-580	SCOTT SPECIALTY GASES
1	REGULATOR, HELIUM TWO STAGE 1-5 PSIG	11-18-580	SCOTT
1	FLOW METER, VARIABLE AREA 4.48 TO 44.8 SCMH 1/2" NPT	11-18-580	SCOTT
1	VALVE, BALL 1/2" 2-WAY MANUALLY OPERATED	11-18-580	WHITE
1	VALVE, BALL 1/2" 2-WAY AIR-OPERATED MC	11-18-580	WHITE
1	VALVE, SOLENOID 3-WAY MC	11-18-580	WHITE
1	CONTROLLER, PROGRAMMABLE LOGIC "PLC"	11-18-580	WHITE
1	TRANSDUCER, PRESSURE DIFFERENTIAL, 100MM HG	11-18-580	WHITE
1	VALVE, BALL 1" 3-WAY MANUALLY OPERATED	11-18-580	WHITE
1	BED, CARBON SORPTION	11-18-580	WHITE
1	VOST TUBES	11-18-580	WHITE
1	METER, MASS FLOW, 0-500 SCMH	11-18-580	WHITE
1	VALVE, BALL 1/2" 2-WAY AIR OPERATED NO	11-18-580	WHITE
1	VENT, EMERGENCY RELIEF 2" WEIGHT LOADED 0.875 PSI	11-18-580	WHITE
1	VALVE, CHECK 1/2" NPT	11-18-580	WHITE
1	VALVE, CHECK 1/2" NPT	11-18-580	WHITE
1	HOUSING, FILTER 27MM	11-18-580	WHITE
1	VALVE, BALL 1/2" 2-WAY MANUAL	11-18-580	WHITE
1	VALVE, 1/2" NPT, 0.2 PSIG	11-18-580	WHITE
1	INDICATOR/AMPLIFIER, FLOW	11-18-580	WHITE
1	INDICATOR/AMPLIFIER, PRESSURE	11-18-580	WHITE
1	CHART RECORDER, BCH DIGITAL SIGNAL	11-18-580	WHITE
1	CURRENT TRANSMITTER	11-18-580	WHITE
1	CURRENT INDICATOR	11-18-580	WHITE
1	VALVE, SOLENOID 1/2" NPT, 115VAC	11-18-580	WHITE
1	VALVE, SOLENOID 1/2" NPT, 115VAC	11-18-580	WHITE
1	PUMP, DIAPHRAGM	11-18-580	WHITE
1	HOUSING, FILTER (NO FILTER)	11-18-580	WHITE
1	INDICATOR, SAMPLE PRESSURE	11-18-580	WHITE
1	INDICATOR, PUMP PRESSURE	11-18-580	WHITE
1	METER, MASS FLOW 0-5000 SCMH	11-18-580	WHITE
1	CONTROLLER, FLOW	11-18-580	WHITE
1	VALVE, BALL 1"	11-18-580	WHITE
1	VALVE, CHECK 1"	11-18-580	WHITE
1	METER, MASS FLOW 0-10000 SCMH	11-18-580	WHITE

REFERENCE DRAWINGS

BIN SCALE TESTS, ROOM 1 LAYOUT	52-W-001-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM PIPING AND INSTRUMENT DIAGRAM (P&ID)	52-L-001-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM LAYOUT, FLOW SCHEME, AND DETAILS	52-L-002-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM SAMPLER ASSEMBLY 105-S-008	105-F-013-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM INSTRUMENT LOOPS AND ALARMS WIRING	105-N-005-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM PLC WIRING 534-PLC-001-01	105-L-022-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM SAMPLER WIRING 105-S-008	105-V-030-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM ELECTRICAL ENCLOSURE 105-P-023	105-L-002-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM PLAN ARRANGEMENT	105-L-003-W
BIN SCALE TESTS, VOC(10) MONITORING SYSTEM CARBON SORPTION BED	412-W-003-W

NOTES.

- 99.99999 PURE, TOTAL IMPURITIES <1 PPM, TMC <0.2 PPM, HE <1 PPM.
- ROTAMETER, SCOTT MODEL 52-31-S-4-1 WITH 150MM TUBE, 4.5-44.5 SCMH HELIUM, (CALIBRATION REQUIRED WITH UNITS), INLET PRESSURE SET AT 10 PSIG.
- HELIUM SERVICE, 0 TO 20 PSIG, STANDARD HANDLE.
- 50 PSIG (MIN) AIR MOUNTING KIT MS-MB-83.
- HELIUM LEAK TEST, LIGHT SWITCH KIT MS-SA-A1-133.
- SIX INCH O.D. STAINLESS STEEL PIPE WITH 0.25" WALL THICKNESS, LENGTH 8.15 FEET PACKED WITH 28.4 LBS. OF ACTIVATED CARBON. ORDERING INFORMATION PROVIDED ACCESSORY ITEMS.
- VOST TUBES PROVIDED BY ANALYTICAL LABORATORY.
- REMOVED
- REMOVED
- REMOVED
- WOORE IND P/N ACT/D-5A/4-70MM/117MM/EN/PM

BIN SCALE TESTS, VOC(10) MONITORING SYSTEM PIPING AND INSTRUMENT DIAGRAM (P&ID)

ENDS 52-L-001-W
FILE: 52-L-001-WB.S&D

ECO 5821
PAGE 7 OF 57

9a

DRAWING CHANGE SHEET

(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W1 ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. CHANGE THE SYSTEM DESIGNATOR TO EM05

2. CHANGE THE TITLE TO:

BINSCALE TESTS, VOC(10) MONITORING SYSTEM
 PANEL-1, ROOM-1 LAYOUT

3. CHANGE THE MATERIALS LIST ^{JAS 10-4-91} ~~ON~~ AS SHOWN ON ATTACHED PAGES

4. CHANGE THE "TABLE" TO A "RACK

1. Drawing Cog. Engineer Approval: J.R. Struble Date: 10-7-91

2. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
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Initials / Date

DRAFT

PLAN VIEW ROOM 1 AT PANEL 1
ASSEMBLY
BY: ARCHITECTURE SYSTEMS

DRAFT

DRAFT

ECO 5421
PAGE 11 OF 57

LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION	ORDERING INFORMATION	NOTE	DRAWING NO. OR PART NO.	MATERIAL SPECIFICATION	
					MATL	STD NUMBER (CCMP/FORM)
AR 1	ADHESIVE CAPSULE		A	10068038		
AR 2	AIR-SAMPLER, PRIMARY 2-CANISTER			105-F-013-W1		
AR 3	AIR-SAMPLER, SECONDARY 2-CANISTER			105-F-013-W1		
AR 4	ANCHOR, EXPANSION 1/8" x 5"		A			
AR 5	BED, CARBON SORPTION			52-L-001-H101		
AR 6	BLIND, 50# 2"					
AR 7	CANISTER AIR-SAMPLE 6-LITER		B	1650-M		
AR 8	CAF 1/2"		C	SS-810-0	SST	316
AR 9	CHANNEL, GALVANIZED FRAMING		H	922SH	PRE-GALV	
AR 10	CLAMP, TUBING 1/4" O.D.		H	92023	GALV	
AR 11	CLAMP, TUBING 1/2" O.D.		H	92026	GALV	
AR 12	CLAMP, TUBING 1" O.D.		H	92029	GALV	
AR 13	CONNECTOR, MALE 1/4" x 1/8"		C	SS-400-1-2	SST	316
AR 14	CONNECTOR, MALE 1/4" x 1/4"		C	SS-400-1-4	SST	316
AR 15	CONNECTOR, MALE 1/4" x 3/8"		C	SS-400-1-6	SST	316
AR 16	CONNECTOR, MALE 1/2" x 1/4"		C	SS-810-1-4	SST	316
AR 17	CONNECTOR, MALE 1/2" x 3/8"		C	SS-810-1-6	SST	316
AR 18	CONNECTOR, MALE 1/2" x 1/2"		C	SS-810-1-8	SST	316
AR 19	CONNECTOR, MALE 1" x 1"		C	SS-1610-1-161	SST	316
AR 20	CONNECTOR, MALE 2" PIPE WELD		C	SS-3220-1-32W	SST	316
AR 21	CONNECTOR, PORT 1/2"		C	SS-811-PC	SST	316
AR 22	CONNECTOR, PORT 1" x 1"		C	SS-1611-PC	SST	316
AR 23	CONNECTOR, PORT REDUCING 1/2" x 1/4"		C	SS-811-PC-4	SST	316
AR 24	CYLINDER, HELIUM SIZE 1"			52-L-001-H011		
AR 25	CYLINDER HOLDER, 2 CYLINDERS			52-L-003-H011		
AR 26	WIK COLT, 5/8" 11 UNC-2A 500 LG		H			
AR 27	FERRULE, FRONT 1"		C	SS-1613-1	SST	316
AR 28	THREE-HOLE CORNER PLATE		H	3140		
AR 29	FERRULE PACK, 1/4"		C	SS-400-SETS-100	SST	316
AR 30	FERRULE PACK, 1/2"		C	SS-810-SETS-100	SST	316
AR 31	FILTER DRIER, COMPRESSED AIR		L	9994K24		
AR 32	FITTING, ULTRA-HIGH 1/4"		L	SS-4-UT-6-400	SST	316
AR 33	FLANGE, SLP-ON FLAT FACE 2" 50#					
AR 34	FLOW METER, MASS 0 - 5000 SCCM			52-L-001-H121		
AR 35	FLOW METER, VARIABLE AREA 446 - 446 SCCM			52-L-001-H031		
AR 36	HANGER, PIPE 1"		H	93174-2	PRE-GALV	
AR 37	HOSE, FLEX 1/2"		E	940-6-18		
AR 38	HOSE, FLEX 1"		E	940-6-316		
AR 39	HOUSING FILTER 47mm			9220	SST	316
AR 40	HT FLANGE GASKET AND BOLT 1"					
AR 41	MANIFOLD BLOCK					
AR 42	NUT SPRING 1/4-20UNC-2B		H	9024-1/4	PRE-GALV	
AR 43	PLUG, 1/2"		C	SS-810-P	SST	316
AR 44	PLUG, 1"		C	SS-3220-P	SST	316
AR 45	QUICK-CONNECT BODY 1/4"		F	SS-104-B-400	SST	316
AR 46	QUICK-CONNECT STEM 1/4"		F	SS-104-S-400	SST	316
AR 47	QUICK-CONNECT BODY 1"		F	SS-178-B-1610	SST	316
AR 48	REDUCER 1/2" x 1/4"		L	SS-810-R-4	SST	316
AR 49	REDUCER 1" x 1/2"		C	SS-810-R-16	SST	316
AR 50	REGULATOR AIR PRESSURE 0-15 PSIG		L	1028K12		
AR 51	REGULATOR HELIUM TWO-STAGE 0-15 PSIG			52-L-001-H021		
AR 52	ROD ALL-THREAD 3/8-16UNC-2A		E	95790-AR31	INC	
AR 53	RACK, SAMPLER CARBON BED			52-L-003-H011		
AR 54	STRAP ONE-HOLE PIPE 1/4"		H	9-0084	PRE-GALV	
AR 55	STRAP ONE-HOLE PIPE 1/2"		H	9-0087	PRE-GALV	

52-L-002-w1

LIST OF MATERIAL

QTY	REQ	ITEM	ORDERING INFORMATION	NOTE	DRAWING NO. OR PART NO.	MATERIAL	STD	NUMBER	COMPLIFORM
1	57	TRANSDUCER, PRESSURE DIFFERENTIAL 100mm H ₂ O			52-L-001--081				
1	AR 58	TUBE ADAPTER, MALE 1/4" X 3/8"			SS-4-12-1-61	SST		316	
1	AR 59	TUBING, 1/4" X 0.049" WALL			8955K11	SOFT COPPER			
1	AR 60	TUBING, 1/4" X 0.028" WALL				SST	ASTM	A269	
1	AR 61	TUBING, 1/2" X 0.049" WALL				SST	ASTM	A269	
1	AR 62	TUBING, 1" X 0.083" WALL				SST	ASTM	A269	
1	AR 63	TUBING, 2" X 0.188" WALL				SST	ASTM	A269	
1	AR 64	UNION, 1/4"			SS-400-6	SST		316	
1	AR 65	UNION, 1/2"			SS-810-6	SST		316	
1	AR 66	UNION, 1"			SS-1610-6	SST		316	
1	AR 67	UNION, 2"			SS-3200-6	SST		316	
1	58	UNION, ULTRA-TORR 1/2" X 1/2"			SS-8-UT-6-810	SST		316	
1	AR 70	UNION, ELBOW 1/4"			SS-810-9	SST		316	
1	AR 71	UNION, ELBOW 1"			SS-1610-9	SST		316	
1	AR 72	UNION, ELBOW 2"			SS-3200-9	SST		316	
1	AR 73	UNION, REDUCING 1/2" X 1/4"			SS-810-6-4	SST		316	
1	AR 74	UNION, REDUCING 1" X 1/2"			SS-1610-6-81	SST		316	
1	AR 75	UNION, REDUCING 2" X 1"			SS-1610-6-321	SST		316	
1	AR 76	UNION, TEE 1/4"			SS-400-3	SST		316	
1	AR 77	UNION, TEE 1/2"			SS-810-3	SST		316	
1	AR 78	UNION, TEE 1"			SS-1610-3	SST		316	
1	AR 79	UNION, TEE 2"			SS-3200-3	SST		316	
1	80	VALVE, BALL 3-WAY MANUALLY OPERATED 1"			52-L-001--081	SST		316	
1	81	VALVE, BALL 3-WAY MANUALLY OPERATED 1/2"			52-L-001--041	SST		316	
1	82	VALVE, BALL 3-WAY AIR-OPERATED 1/2" NC			52-L-001--051	SST		316	
1	83	FOUR HOLE PLATE			B504				
1	84	VALVE, CHECK 1/4" N-LINE 1/4"			52-L-001--161				
1	85	UNIVERSAL SHELF BRACKET			BR44W				
1	86	VALVE, RELIEF 1/4" N-LINE, 0.8 PSIG 1/4"			52-L-001--191				
1	87	VALVE, SOLENOID 3-WAY NC 1/4"			52-L-001--061				
1	88	VENT, EMERGENCY RELIEF, WEIGHT LOADED 0.8 PSIG, 2"			52-L-001--141				
1	89	LOST TUBE			52-L-001--111				
1	90	WORK STATION, W/DRAWER AND INSTRUMENT SHELF			SB-3670				
1	AR 91	QUICK-CONNECT STEM 1/4"			SS-072-0-407				
1	AR 92	VALVE, BALL 1/2"			SS-63788				
1	AR 93	UNION CROSS 1/2"			SS-810-4	SST		316	
1	AR 94	HOSE, FLEXIBLE TUBING 1/2" OD 36" L			321-8-A-1882	SST		316	
1	AR 95	CONNECTOR, PORT 1/4"			SS-401-P1	SST		316	
1	86	VALVE, BALL 3-WAY MANUALLY OPERATED 1/4"			SS-62784				
1	AR 97	PLUG 1/4"			SS-400-P	SST		316	
1	AR 98	UNION CROSS 1/4"			SS-400-4	SST		316	
1	AR 99	REDUCER 1/4" X 1/2"			SS-400-P-81	SST		316	
1	100	VALVE, PLUG 1/4"			SS-4P47	SST		316	
1	AR 101	CONNECTOR, MALE 1/2" X 1/2"			SS-1610-1-8	SST		316	
1	AR 102	TEE, PIPE 1"			SS-1610-1	CS	ASTM	A108	
1	AR 103	NUT, SWAGelok 1/4"			SS-402-	SST		316	
1	104	HOLDER, CANISTER							
1	AR 105	NUT, SPRING 1/2-13UNC-28			N225	ZINC	ASTM	B633SC11	
1	AR 106	WASHER, FLAT 1/2-13UNC-28 5/16" D			W4CS 1/2"	ZINC	ASTM	B633SC11	
1	AR 107	NUT, HEX 3/8-16UNC-28			N4 3/8"	ZINC			
1	AR 108	WASHER, FLAT 1/2-16" D			30108A035	ZINC			
1	AR 109	SHEET, 10GA 13641				PRE-GALV	ASTM	A525	
1	AR 110	CLAMP, PIPE 2"			B2037	ZINC	ASTM	A570	
1	AR 111	POST, BASE			B279	ZINC			
1	112	FLOW METER, MASS 0-500 SCOM			52-L-001--1				

DRAFT

DRAFT

ECO 5821
PAGE 13 OF 57

LIST OF MATERIAL

QTY REQ	ITEM	ORDERING INFORMATION	NOTE	DRAWING NO. OR PART NO.	MATERIAL SPECIFICATION		
GR2	GR1	NO.			MATL	STD	NUMBER
2	113	SINGLE CHANNEL ADJUSTABLE BRACE	H	2634			
2	114	CLAMP, TUBING, 6"	H	92069			
3	115	HOSE, FLEXIBLE TUBING, 1"	M	SS-321-16-X-21	SST	316	
2	116	HOSE, FLEXIBLE TUBING, 1/4"	M	SS-321-4-X-21	SST	316	
4	117	VALVE, 2-WAY, 1"	C	SS--85TS16-JLI	SST	316	
1	118	VALVE, CHECK, 1"	C	SS-16C-1/3	SST	316	
1	119	UNION, CROSS, 1"	C	SS-1610-4	SST	316	
1	120	METER, MASS FLOW, 10000 SCOM	B	0358C-1000SVI			
1	121	VALVE, 3-WAY, 1/4"	C	SS-42XS4	SST	316	
AR	122	TUBING, CHROMATOGRAPHIC GRADE NICKEL, 1/4"					

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-1W2 ECO Number: 5821

2. ECO Search List: 5565

3. Description of Change:

1. CHANGE THE SYSTEM DESIGNATOR TO EM05
2. CHANGE THE TITLE TO:
BIN SCALE TESTS, ^{JH-4-11} ~~B~~ VOC (10) MONITORING SYSTEM
LAYOUT AND FLOW ~~ARRANGEMENT~~ SCHEME
3. USING THE SAME CONFIGURATION AS ON THIS
DRAWING (SYMBOLS FOR VALVES, FLOW, & STRUCTURES),
REPLACE THE CARBON BED ARRANGEMENT
ON THE TABLE TO AN ARRANGEMENT
WITH THE ATTACHED PAGE.

4. Drawing Cog. Engineer Approval: J. R. Struble Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____	Drafting Started: _____
Initials / Date	Initials / Date
Date Assigned: _____	Drafting Completed: _____
Initials / Date	Initials / Date
Assigned to: _____	Return to EFR: _____
(Same as data base entry)	Initials / Date

DRAFT

NOTES

1. This drawing is a preliminary sketch and is not to be used for construction purposes.

DATE	100 34 401 71315
BY	100 34 401 71315
CHECKED	100 34 401 71315
APPROVED	100 34 401 71315
DESIGNED	100 34 401 71315
ENGINEER	100 34 401 71315
CONTRACTOR	100 34 401 71315
CLIENT	100 34 401 71315
PROJECT	100 34 401 71315
LOCATION	100 34 401 71315
DESCRIPTION	100 34 401 71315
REVISIONS	100 34 401 71315
REVISION 1	100 34 401 71315
REVISION 2	100 34 401 71315
REVISION 3	100 34 401 71315
REVISION 4	100 34 401 71315
REVISION 5	100 34 401 71315
REVISION 6	100 34 401 71315
REVISION 7	100 34 401 71315
REVISION 8	100 34 401 71315
REVISION 9	100 34 401 71315
REVISION 10	100 34 401 71315

REPLACE THIS WITH SIMILAR SYMBOLS
USING THE LAYOUT ON THE ATTACHED PAGE

40

DRAFT

9a

DRAWING CHANGE SHEET

(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W3 ECO Number: 5821

2. ECO Search List: 5565 _____

3. Description of Change:

1. CHANGE THE SYSTEM DESIGNATOR TO EM05

2. CHANGE THE TITLE TO:

BIN SCALE TESTS, VOC(10) MONITORING SYSTEM
LAYOUT AND FLOW SCHEME

3. USING THE SAME CONFIGURATION AS ON THIS
DRAWING (SYMBOLS FOR VALVES, FLOW, & STRUCTURES),
REPLACE THE CARBON BED ARRANGEMENT ON THE
TABLE TO AN ARRANGEMENT WITH THE ATTACHED PAGE.
NOTE: PUT THE APPROPRIATE ITEM NUMBER ON THE PARTS.

4. Drawing Cog. Engineer Approval: J.R. Strubbe Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____	Drafting Started: _____
Initials / Date	Initials / Date
Date Assigned: _____	Drafting Completed: _____
Initials / Date	Initials / Date
Assigned to: _____	Return to EFR: _____
(Same as data base entry)	Initials / Date

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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	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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REPLACE THIS WITH SIMILAR SYMBOLS
USING THE LAYOUT ON THE ATTACHED PAGE

DRAFT

9a

DRAWING CHANGE SHEET

(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W4 ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. DELETE DETAILS ON 2" TUBING.

2. ADD INFORMATION ON 52-L-002-W8 TO THIS DRAWING.

3. CHANGE SYSTEM TO EMOS & TITLE TO:

BINSCALE TESTS, VOC(10) MONITORING SYSTEM
~~HELIUM SYSTEM DETAILS~~

SEE ATTACHED PAGE(S)

4. CHANGE "TEE'S" FROM ITEM "70" TO "77"

4 Drawing Cog. Engineer Approval: J. R. Struble Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
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Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

U.S. DEPARTMENT OF ENERGY	
Washington Field Station (Main)	
Radio Isolation Plot Point	
10/23/57	
BRI SCALE TESTS	
VAN (10) MOVING SYSTEM	
MILITARY GRADE-10 (4) TANKS	
10/23/57	100 W-1

D P A E

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)**DRAFT**1. Drawing: 52-L-002-W5 ECO Number: 58212. ECO Search List: 5565

3. Description of Change:

1. EXCHANGE THE DETAILED PIPING INFORMATION ON
THIS DRAWING WITH THE ATTACHED PAGE .

2. CHANGE THE SYSTEM DESIGNATOR TO EM05

3. CHANGE THE TITLE TO:

BIN SCALE TESTS, VOC(10) MONITORING SYSTEM
CARBON BED RACK ARRANGEMENT4. Drawing Cog. Engineer Approval: J.R. Stroh Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
Initials / DateDate Assigned: _____
Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

DEAF

PAGE 26 OF 57

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

1. Drawing: 52-L-002-W6 ECO Number: 5821

2. ECO Search List: 5565

3. Description of Change:

DELETE THIS DRAWING. PUT THIS
INFORMATION ON 52-L-002-W7.

4. Drawing Cog. Engineer Approval: J. R. Stroh Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____ Initials / Date	Drafting Started: _____ Initials / Date
Date Assigned: _____ Initials / Date	Drafting Completed: _____ Initials / Date
Assigned to: _____ (Same as data base entry)	Return to EFR: _____ Initials / Date

9a

DRAWING CHANGE SHEET (1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W7 ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. ADD THE INFORMATION ON 52-L-002-W6 TO THIS DRAWING. SEE ATTACHED PAGE(S).
2. CHANGE THE SYSTEM DESIGNATOR TO EM05
3. CHANGE THE TITLE TO :
BIN SCALE TESTS, VOC (G) MONITORING SYSTEM
SAMPLER RACK DETAILS
4. CHANGE 1/4" FLEXIBLE TUBING TO 1/4" CHROMATOGRAPHIC
GRADE NICKEL TUBING

4. Drawing Cog. Engineer Approval: J.R. Stroh Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
Initials / DateDate Assigned: _____
Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

DRAFT

CHANGE
(SEE ATTACHED PAGE)

ADD INFO. FROM WG

ENCLOSURE (SEE ATTACHED PAGE)

01 JAN 8 1985
FBI - BOSTON

12 MAY 01 00 11Z
COLUMBIA 000

DRAFT

PROJECT NO.	5821
DATE	7-25-51
BY	W. J. ...
CHECKED BY	...
APPROVED BY	...
U.S. DEPARTMENT OF ENERGY Washington, D.C. 20545

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 52-L-002-W8 ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

DELETE THIS DRAWING. PUT THIS INFORMATION
ON 52-L-002-W4.

4. Drawing Cog. Engineer Approval: J.R. Stoble Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

Page 3 of 57

1a	1. Drawing: <u>52-L-002-W9</u> ECO Number: <u>5821</u>
2c	2. ECO Search List: _____ _____ _____ _____
3s	3. Description of Change: 1. CHANGE THE SYSTEM DESIGNATOR TO EMOS 2. CHANGE THE TITLE TO : BIN SCALE TESTS , VCC (IO) MONITORING SYSTEM BIN CONNECTION & RISER DETAILS JH 10-4-91 SEE ATTACHED PAGE
4.	Drawing Cog. Engineer Approval: <u>A. R. Stroh</u> Date: <u>10-7-91</u>

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 22 of 57

1. Drawing: 52-1-002-W10 ECO Number: 5821

2. ECO Search List: _____

3. Description of Change:

DELETE THIS DRAWING

4. Drawing Cog. Engineer Approval: J. R. Stroh Date: 10-7-91

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 33 of 57

1. Drawing: 53-J-053-W2 ECO Number: 5821

2. ECO Search List:

3. Description of Change:

1. CHANGE THE TABLE FOR VOC (10) TO A RACK.

4. Drawing Cog. Engineer Approval: *Edw. P. Allen* Date: 10/16/91

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 34 of 57

1. Drawing: 105-F-013-W ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. CHANGE THE DRAWING TITLE TO:

BIN SCALE TESTS, VOC (10) MONITORING SYSTEM
SAMPLER ASSEMBLY 105-S-008

4g Drawing Cog. Engineer Approval: J.R. Stroh Date: 10-7-91

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

D R A F T

1. Drawing: 105-H-205-W ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. ADD FLOW LOOP 105-H-001-06 AS SHOWN.
2. ADD TO REFERENCE DRAWING.

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: D. R. Stroh Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

DRAFT

OF THE FOLLOWING LOOPS:
 SAMPLER FLOW
 SAMPLER MOTOR CURRENT
 MONITORING PUMP MOTOR DIFFERENTIAL
 POWER LOSS

534 PLC-Q01 01

REFERENCE DRAWINGS

BIN SCALE TESTS, VOC(10) MONITORING SYSTEM	52-W 001-W
PURGE AND BURNING MONITORING SYSTEM	52-I 001-W
BIOL SCALE TESTS, VOC(10) MONITORING SYSTEM	52-I 002-W
FAULT, FLOW SCHEME, AND DETAILS	105-I 013-W
BIOL SCALE TESTS, VOC(10) MONITORING SYSTEM	105-H 005-W
SAMPLER ASSEMBLY	105-I 012-W
BIOL SCALE TESTS, VOC(10) MONITORING SYSTEM	105-J 030-W
INSTRUMENT LOOPS AND ALARMS WIRING	105-I 002-W
BIOL SCALE TESTS, VOC(10) MONITORING SYSTEM	105-I 003-W
PIED ARRANGEMENT	412-M 003-W

NOTES

1. FIELD WIRING IS LABELED USING THE LAST TWO DESIGNATORS ONLY
 EXAMPL: WIRE NUMBER 53410102 R22 IS LABELED R22-03
 IN THE FIELD

REV	DESCRIPTION	DATE	BY	CHK	DATE	BY	CHK
1	REVISED PER ECO	9/17/91	GC	MS	9/23/91	BA	5237
2	REVISED PER ECO	7/2/91	TRA	MS	7/8/91	BA	5565
3	ISSUE DESCRIPTION	7/2/91	CON	COC	7/10/91	RTIC MCH	M41816
DESIGNING ORIGINATOR BY ENGINEERING CHANGE ORDER (ECO)		DATE	DATE	DATE	DATE	DATE	DATE
DATE: 10/24/91		DATE: 1/20/91	DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91
BY: A. L. S. WARD		BY: J. R. SIMONE	BY: M. R. JAMES	BY: D. DAVIS	BY: W. ALLEN	BY: W. ALLEN	BY: W. ALLEN
COC: MGR JAMES		COC: MGR JAMES	COC: MGR JAMES	COC: MGR JAMES	COC: MGR JAMES	COC: MGR JAMES	COC: MGR JAMES
QA: H. ELOS		QA: H. ELOS	QA: H. ELOS	QA: H. ELOS	QA: H. ELOS	QA: H. ELOS	QA: H. ELOS
SAFETY: BECKMAN		SAFETY: BECKMAN	SAFETY: BECKMAN	SAFETY: BECKMAN	SAFETY: BECKMAN	SAFETY: BECKMAN	SAFETY: BECKMAN
APPRO: D. DAVIS		APPRO: D. DAVIS	APPRO: D. DAVIS	APPRO: D. DAVIS	APPRO: D. DAVIS	APPRO: D. DAVIS	APPRO: D. DAVIS
DATE: 4/8/91		DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91	DATE: 4/8/91
BY: W. A. WALKER		BY: W. A. WALKER	BY: W. A. WALKER	BY: W. A. WALKER	BY: W. A. WALKER	BY: W. A. WALKER	BY: W. A. WALKER
SCALE: 1/4" = 1'-0"		SCALE: 1/4" = 1'-0"	SCALE: 1/4" = 1'-0"	SCALE: 1/4" = 1'-0"	SCALE: 1/4" = 1'-0"	SCALE: 1/4" = 1'-0"	SCALE: 1/4" = 1'-0"

U.S. DEPARTMENT OF ENERGY
 Westinghouse Waste Isolation Division
 Waste Isolation Pilot Plant
 BIN SCALE TESTS
 VOC (10) MONITORING SYSTEM
 INSTRUMENT LOOP & ALARMS

ECO NO	105-11-005-W
REV	1 OF 1

9a

DRAWING CHANGE SHEET (1 SHEET PER DRAWING)

DRAFT

1. Drawing: 105-J-022-W ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. CHANGE REFERENCE DRAWINGS.

2. CHANGE TITLE TO:

BIN SCALE TESTS, VOC (10) MONITORING SYSTEM
PLC WIRING 534-PLC-001-01

4. Drawing Cog. Engineer Approval: J. R. Stroth Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
Initials / DateDate Assigned: _____
Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 4 of 57

1. Drawing: 105-J-022-W ECO Number: _____

2. ECO Search List: _____

3. Description of Change:

1. CHANGE THE TITLE TO:

BIN SCALE TESTS, VOC (10) MONITORING SYSTEM
PLC WIRING 534-PLC-001-01

4. Drawing Cog. Engineer Approval: J. R. Stroh Date: 10-7-91

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 42 of 57

1. Drawing: 105-J-030-W ECO Number: 5821

2. ECO Search List:

3. Description of Change:

1. CHANGE THE TITLE TO:

BIN SCALE TESTS, VOC(10) MONITORING SYSTEM
SAMPLER WIRING.

in. Drawing Cog. Engineer Approval: J. R. Stroh Date: _____

9a

DRAWING CHANGE SHEET (1 SHEET PER DRAWING)

DRAFT

1. Drawing: 105-L-002-W1 ECO Number: 5821

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

1. MOVE LIGHTS AND BUTTONS SHOWN INSIDE CABINET ON LEFT TO THE RIGHT SIDE, AND ADD ANOTHER DISPLAY (7) IN THEIR PLACE.
2. ADD REFERENCE DRAWINGS.
3. ADD ONE BUTTON⁴ LIGHT, AND REMOVE THE 4 BOTTOM LIGHTS ON THE FRONT DOORS
4. CHANGE PART NO. AND DESCRIPTION OF PILOT LIGHTS TO PUSH-TO-TEST LIGHTS - PART NO. ALLEN-BRADLEY 800T-PT16

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J.R. Stubb Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / DateDrafting Started: _____
Initials / DateDate Assigned: _____
Initials / DateDrafting Completed: _____
Initials / DateAssigned to: _____
(Same as data base entry)Return to EFR: _____
Initials / Date

DRAFT

NO.	DESCRIPTION	QTY	UNIT	PRICE	TOTAL
1	...	...	...	...	...
2	...	...	...	...	...
3	...	...	...	...	...
4	...	...	...	...	...
5	...	...	...	...	...
6	...	...	...	...	...
7	...	...	...	...	...
8	...	...	...	...	...
9	...	...	...	...	...
10	...	...	...	...	...

Supplies at 10%
1. ...
2. ...
3. ...
4. ...
5. ...
6. ...
7. ...
8. ...
9. ...
10. ...

NO.	DESCRIPTION	QTY	UNIT	PRICE	TOTAL
1	...	...	...	...	...
2	...	...	...	...	...
3	...	...	...	...	...
4	...	...	...	...	...
5	...	...	...	...	...
6	...	...	...	...	...
7	...	...	...	...	...
8	...	...	...	...	...
9	...	...	...	...	...
10	...	...	...	...	...

REFERENCE COMMENTS
1. ...
2. ...
3. ...
4. ...
5. ...
6. ...
7. ...
8. ...
9. ...
10. ...

NOTE:
1. ...
2. ...
3. ...
4. ...
5. ...
6. ...
7. ...
8. ...
9. ...
10. ...

NO.	DESCRIPTION	QTY	UNIT	PRICE	TOTAL
1	...	...	...	...	...
2	...	...	...	...	...
3	...	...	...	...	...
4	...	...	...	...	...
5	...	...	...	...	...
6	...	...	...	...	...
7	...	...	...	...	...
8	...	...	...	...	...
9	...	...	...	...	...
10	...	...	...	...	...

CHARGE
AS SHOWN

FRONT VIEW
AS SHOWN

CHARGE
(SEE ATTACHED PAGE)

9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

1. Drawing: 105-L-002-W2 ECO Number: 5821

2. ECO Search List: _____

3. Description of Change:

1. DELETE REFERENCE DRAWINGS

2. CHANGE THE TITLE TO:

BIN SCALE TESTS, VOC (10) MONITORING SYSTEM
 ELECTRICAL ENCLOSURE WIRING 105-P-023

3. ADD WIRES TO TBC AS SHOWN.

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J.R. Stille Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____	Drafting Started: _____
Initials / Date	Initials / Date
Date Assigned: _____	Drafting Completed: _____
Initials / Date	Initials / Date
Assigned to: _____	Return to EFR: _____
(Same as data base entry)	Initials / Date

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ECO 5821
PAGE 47 OF 57

CHANGE

DRAFT

ECO 5821
PAGE 48 OF 57

U.S. DEPARTMENT OF ENERGY
OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY
WASHINGTON, D.C. 20585
TELEPHONE (202) 546-5000
FACSIMILE (202) 546-5000
MAIL ROOM (202) 546-5000
HOURS: 9:00 AM - 5:00 PM, MONDAY - FRIDAY

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DRAFT

ECO 5821

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70	8	90
A	-	B
INC	2	INC
AND	5	AND
RELAY BASE CR1, CR2, CR3		

SEE DRAWING 105-H-005-W

CONSOLE BOARD POWER (POWER)

SEE DRAWING 105-H-005-W

SEE DRAWING 105-H-005-W

• WIRE IDENTIFICATION FOR WIRE NUMBER
IN COLUMN WITH ANTERIOR

534-H-001-05

1 (H) CT RED
(H) CT BROWN (CT)

SEE DRAWING 105-H-005-W

105-L-002-W2

SHIELD	817	SHIELD	PLC MODULE #8 TERMINAL #17 & #19
534UR00105-825-01	818	534UR00105-825-02	DIGITAL CURRENT INDICATOR (1)
SHIELD	825	SHIELD	JUMPER TO TIE 817
534UR00101-827-02	826	534UR00105-827-01	DIGITAL CURRENT INDICATOR (1)
534UR00102-828-02	827	534UR00101-828-01	
534UR00102-829-02	828	534UR00101-829-01	
SHIELD	829	SHIELD	
	830		
SPARES FOR FUTURE USE		SPARES FOR FUTURE USE	
CR3-412-02	901	534CR3001A	RELAY BASE CR3
CR3-N09-01	902	534CR3001B	RELAY BASE CR3
CT-IX-1	903	534CR3001A	RELAY BASE CR3
CR3-100-12	904	534CR30017	RELAY BASE CR3
	905		
	906		
CT-IX-2	907		
105P023C-CE26-CT-A	908		
CR2-616-02	909	534CR2001A	RELAY BASE CR1
CR2-N20-01	910	534CR2001B	RELAY BASE CR1
105P023C-CT7-CT1-A13	911	534CR20014	RELAY BASE CR1
105P023C-CE7-CT1-B13	912	534CR20017	RELAY BASE CR1
CR1-520-02	913	534CR1001A	RELAY BASE CR2
CR1-N16-01	914	534CR1001B	RELAY BASE CR2
105P023C-CT7-CT1-A12	915	534CR10014	RELAY BASE CR2
105P023C-CE7-CT1-B12	916	534CR10017	RELAY BASE CR2
534UR00106-918-03	917	534UR00101-917-01	
534UR00106-918-03	918	534UR00101-918-01	
SHIELD	919	SHIELD	
SPARES FOR FUTURE USE		SPARES FOR FUTURE USE	

DRAFT

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9a

DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

1. Drawing: 105-L-003-W ECO Number: 5821

2. ECO Search List: _____

3. Description of Change:

1. CHANGE THE "BENCH" TO A RACK SIMILAR TO THE "SOLENOID RACK".
2. ^{CHANGE} THE DESCRIPTION "SOLENOID RACK" TO "SAMPLER RACK".
3. MOVE THE "ELECTRICAL ENCLOSURE TO THE EAST.

SEE ATTACHED PAGES

4. Drawing Cog. Engineer Approval: J.R. Strobe Date: 10-7-91

5. Cover Sheet Block (CC&D Use Only)

Received from EFR: _____
Initials / Date

Drafting Started: _____
Initials / Date

Date Assigned: _____
Initials / Date

Drafting Completed: _____
Initials / Date

Assigned to: _____
(Same as data base entry)

Return to EFR: _____
Initials / Date

SLIPPERIES

A QUESTION OF ATTITUDE

CHANGE (SEE ATTACHED PAGES)

MOV

REFINING CHANNELS

ONE SCALE TESTS RUON LAYOUT	52 W 001
ONE SCALE TESTS	
MIC MECHANISM 377110	52 W 001
P & I DIAGRAMS	
ONE SCALE TESTS	
MIC MECHANISM, AND	52 W 001
RELATION SHIPS, DE 106	
MECHANISM 120000	
MIC MECHANISM 120000	51 W 001
RELATION SHIPS, DE 106	51 W 001

LEGEND

- 55 - REPLYING (7) CUBA HAS
REMOVED SIDE ON SIDE

NOTES

1 ONE BONDCLUCK SHIRT BE USED FOR GREENING. IT SHALL BE
LAFED GREEN AT BOTH ENDS

2 ALL EXPOSED WING PANELS OF ELECTRIC AND LUNAR SHIRT
BE GREENED.

[illegible]

DRAFT
ECO 5821
PAGE 51 OF 57

ECO 5821
PAGE 52 OF 57

SM 11.4.11.15

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED

REFERENCE DRAWINGS	
See Ref. 1110 below 1 (cont)	1110 1000 1
See Ref. 1111 below 1 (cont)	1111 1000 1
See Ref. 1112 below 1 (cont)	1112 1000 1
See Ref. 1113 below 1 (cont)	1113 1000 1
See Ref. 1114 below 1 (cont)	1114 1000 1
See Ref. 1115 below 1 (cont)	1115 1000 1
See Ref. 1116 below 1 (cont)	1116 1000 1
See Ref. 1117 below 1 (cont)	1117 1000 1
See Ref. 1118 below 1 (cont)	1118 1000 1
See Ref. 1119 below 1 (cont)	1119 1000 1
See Ref. 1120 below 1 (cont)	1120 1000 1
See Ref. 1121 below 1 (cont)	1121 1000 1
See Ref. 1122 below 1 (cont)	1122 1000 1
See Ref. 1123 below 1 (cont)	1123 1000 1
See Ref. 1124 below 1 (cont)	1124 1000 1
See Ref. 1125 below 1 (cont)	1125 1000 1
See Ref. 1126 below 1 (cont)	1126 1000 1
See Ref. 1127 below 1 (cont)	1127 1000 1
See Ref. 1128 below 1 (cont)	1128 1000 1
See Ref. 1129 below 1 (cont)	1129 1000 1
See Ref. 1130 below 1 (cont)	1130 1000 1
See Ref. 1131 below 1 (cont)	1131 1000 1
See Ref. 1132 below 1 (cont)	1132 1000 1
See Ref. 1133 below 1 (cont)	1133 1000 1
See Ref. 1134 below 1 (cont)	1134 1000 1
See Ref. 1135 below 1 (cont)	1135 1000 1
See Ref. 1136 below 1 (cont)	1136 1000 1
See Ref. 1137 below 1 (cont)	1137 1000 1
See Ref. 1138 below 1 (cont)	1138 1000 1
See Ref. 1139 below 1 (cont)	1139 1000 1
See Ref. 1140 below 1 (cont)	1140 1000 1
See Ref. 1141 below 1 (cont)	1141 1000 1
See Ref. 1142 below 1 (cont)	1142 1000 1
See Ref. 1143 below 1 (cont)	1143 1000 1
See Ref. 1144 below 1 (cont)	1144 1000 1
See Ref. 1145 below 1 (cont)	1145 1000 1
See Ref. 1146 below 1 (cont)	1146 1000 1
See Ref. 1147 below 1 (cont)	1147 1000 1
See Ref. 1148 below 1 (cont)	1148 1000 1
See Ref. 1149 below 1 (cont)	1149 1000 1
See Ref. 1150 below 1 (cont)	1150 1000 1
See Ref. 1151 below 1 (cont)	1151 1000 1
See Ref. 1152 below 1 (cont)	1152 1000 1
See Ref. 1153 below 1 (cont)	1153 1000 1
See Ref. 1154 below 1 (cont)	1154 1000 1
See Ref. 1155 below 1 (cont)	1155 1000 1
See Ref. 1156 below 1 (cont)	1156 1000 1
See Ref. 1157 below 1 (cont)	1157 1000 1
See Ref. 1158 below 1 (cont)	1158 1000 1
See Ref. 1159 below 1 (cont)	1159 1000 1
See Ref. 1160 below 1 (cont)	1160 1000 1
See Ref. 1161 below 1 (cont)	1161 1000 1
See Ref. 1162 below 1 (cont)	1162 1000 1
See Ref. 1163 below 1 (cont)	1163 1000 1
See Ref. 1164 below 1 (cont)	1164 1000 1
See Ref. 1165 below 1 (cont)	1165 1000 1
See Ref. 1166 below 1 (cont)	1166 1000 1
See Ref. 1167 below 1 (cont)	1167 1000 1
See Ref. 1168 below 1 (cont)	1168 1000 1
See Ref. 1169 below 1 (cont)	1169 1000 1
See Ref. 1170 below 1 (cont)	1170 1000 1
See Ref. 1171 below 1 (cont)	1171 1000 1
See Ref. 1172 below 1 (cont)	1172 1000 1
See Ref. 1173 below 1 (cont)	1173 1000 1
See Ref. 1174 below 1 (cont)	1174 1000 1
See Ref. 1175 below 1 (cont)	1175 1000 1
See Ref. 1176 below 1 (cont)	1176 1000 1
See Ref. 1177 below 1 (cont)	1177 1000 1
See Ref. 1178 below 1 (cont)	1178 1000 1
See Ref. 1179 below 1 (cont)	1179 1000 1
See Ref. 1180 below 1 (cont)	1180 1000 1
See Ref. 1181 below 1 (cont)	1181 1000 1
See Ref. 1182 below 1 (cont)	1182 1000 1
See Ref. 1183 below 1 (cont)	1183 1000 1
See Ref. 1184 below 1 (cont)	1184 1000 1
See Ref. 1185 below 1 (cont)	1185 1000 1
See Ref. 1186 below 1 (cont)	1186 1000 1
See Ref. 1187 below 1 (cont)	1187 1000 1
See Ref. 1188 below 1 (cont)	1188 1000 1
See Ref. 1189 below 1 (cont)	1189 1000 1
See Ref. 1190 below 1 (cont)	1190 1000 1
See Ref. 1191 below 1 (cont)	1191 1000 1
See Ref. 1192 below 1 (cont)	1192 1000 1
See Ref. 1193 below 1 (cont)	1193 1000 1
See Ref. 1194 below 1 (cont)	1194 1000 1
See Ref. 1195 below 1 (cont)	1195 1000 1
See Ref. 1196 below 1 (cont)	1196 1000 1
See Ref. 1197 below 1 (cont)	1197 1000 1
See Ref. 1198 below 1 (cont)	1198 1000 1
See Ref. 1199 below 1 (cont)	1199 1000 1
See Ref. 1200 below 1 (cont)	1200 1000 1

UNJJI

--- 25 --- INFORMATION (2) CONTAINS
INFORMATION NOT IN 1970

Table 5.

- 1 LOW CIRCULATION SPENT OR USED FOR CIRCULARS IN SMALL OR
LARGE CITIES AT BUREAU HEADS.
- 2 ALL REMOVED FROM PARTS OF ELECTRICITY EXCHANGING BUREAU
IN 1900-1901.

[illegible]

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 53 of 57

1. Drawing: 412-M-003-W ECO Number: 5821

2. ECO Search List:

3. Description of Change:

1. CHANGE TITLE TO :

BIN SCALE TESTS, VOC (10) MONITORING SYSTEM
CARBON SORPTION BED

2. CHANGE SYSTEM DESIGNATOR TO EM05

4. Drawing Cog. Engineer Approval: J.R. Stroh Date: 10-7-91

DRAFT

ECO 5821
PAGE 54 OF 57

VALVE IDENTIFICATION SHEET

NEW VALVE ☐REVISED DATA ☐VALVE REMOVED ☒

1. Valve Number: VC-534-TW-010 2. System: EM05
3. Building/Location: V/G, PANEL-1, RM-1 4. Size: 1/4"
5. Pressure: 100 PSI 6. Valve Type: BALL 3-WAY
7. Valve Operator: MANUAL 8. Valve Bonnet: N/A
9. Manufacturer: SWAGE LOK (WHITEY) 10. Catalog No.: SS-43X54
11. Body: SS-316 12. Trim: SS-316 13. Ends: SS-316
14. Piping Code: NA 15. Seis. Class: N/A
16. Working Pressure: ATM (0 PSIG) 17. Working Temperature: 85°F
18. Normal Valve Position/Full Open: X ^(CARBON BED TO SAMPLER) Full Closed: _____ % Throttled: _____
19. Spec. Number: D-0077 20. P.O. Number: N/A
21. Design Class: III A
22. P&ID: 52-L-001-W Sht.: _____ Zone: _____
23. Plan Drawing Number: 52-L-002-W Sht.: _____ Zone: _____
24. Isometric Drawing Number: 52-L-002-W
25. Piping Line Number: N/A
26. Document Providing Information
030 M41816 ECO 5348/5565 EWP _____
27. Service Remarks: _____

J.R. Stroble
Information by10-1-91
DateTAG NUMBER
EXAMPLESYSTEM
RWBUILDING
457INDICATES
VALVE
VNUMBER
001

DRAFT

ECO 58-21
PAGE 55 OF 57

VALVE IDENTIFICATION SHEET

NEW VALVE ☐REVISED DATA ☐VALVE REMOVED ☒

1. Valve Number: VC-534-TW-025 2. System: EM05
3. Building/Location: V/G, PANEL-1, RM-1 4. Size: 1"
5. Pressure: 100 PSI 6. Valve Type: BALL 3-WAY
7. Valve Operator: MANUAL 8. Valve Bonnet: N/A
9. Manufacturer: SWAGelok (WHITEY) 10. Catalog No.: SS-65XT616-F16
11. Body: SS-316 12. Trim: SS-316 13. Ends: SS-316
14. Piping Code: N/A 15. Seis. Class: N/A
16. Working Pressure: ATM (0 PSIG) 17. Working Temperature: 85°F
(VOST TUBES TO SAMPLER)
18. Normal Valve Position/Full Open: X Full Closed: _____ % Throttled: _____
19. Spec. Number: D-0077 20. P.O. Number: N/A
21. Design Class: III A
22. P&ID: 52-L-001-W Sht.: _____ Zone: _____
23. Plan Drawing Number: 52-L-002-W Sht.: _____ Zone: _____
24. Isometric Drawing Number: 52-L-002-W
25. Piping Line Number: N/A
26. Document Providing Information
030 M41816 ECO 5346/5565 EWP _____
27. Service Remarks: _____

J.R. Strubbe
Information by10-1-91
DateTAG NUMBER
EXAMPLESYSTEM
RWBUILDING
457INDICATES
VALVE
VNUMBER
001

DRAFT

ECO 5821
PAGE 56 OF 57

VALVE IDENTIFICATION SHEET

NEW VALVE ☐REVISED DATA ☐VALVE REMOVED ☒

1. Valve Number: VC-534-TW-026 2. System: EM05
3. Building/Location: V/G, PANEL-1, RM-1 4. Size: 1"
5. Pressure: 100 PSI 6. Valve Type: BALL 3-WAY
7. Valve Operator: MANUAL 8. Valve Bonnet: N/A
9. Manufacturer: SWAGelok (WHITEY) 10. Catalog No.: SS-65XT616-F16
11. Body: SS-316 12. Trim: SS-316 13. Ends: SS-316
14. Piping Code: N/A 15. Seis. Class: N/A
16. Working Pressure: ATM (0 PSIG) 17. Working Temperature: 85°F
(CARBON BED OR VAST TUBES TO PAV)
18. Normal Valve Position/Full Open: X Full Closed: _____ % Throttled: _____
19. Spec. Number: D-0077 20. P.O. Number: N/A
21. Design Class: III A
22. P&ID: 52-L-001-W Sht.: _____ Zone: _____
23. Plan Drawing Number: 52-L-001-W Sht.: _____ Zone: _____
24. Isometric Drawing Number: 52-L-002-W
25. Piping Line Number: N/A
26. Document Providing Information
030 M41316 ECO 5346/5565 EWP _____
27. Service Remarks: _____

J.R. Strick
Information by10-1-91
DateTAG NUMBER
EXAMPLESYSTEM
SWBUILDING
157INDICATES
VALVE
VNUMBER
001

DRAFT

ECO 5421
PAGE 57 OF 57

VALVE IDENTIFICATION SHEET

NEW VALVE ☐ REVISED DATA ☐ VALVE REMOVED ☒

1a Valve Number: VC-534-TW-027 2. System: EM05
3a Building/Location: V/G, PANEL-1, RM-1 4. Size: 1"
5a Pressure: 100 PSI 6. Valve Type: BALL 3-WAY
7a Valve Operator: MANUAL 8. Valve Bonnet: N/A
9a Manufacturer: SWAGelok (WHITEY) 10. Catalog No.: SS-65XT816-F16
11. Body: SS-316 12. Trim: SS-316 13. Ends: SS-316
14. Piping Code: N/A 15. Seis. Class: N/A
16a Working Pressure: ATM (0 PSIG) 17. Working Temperature: 95°F
(PRV OR BYPASS)
18a Normal Valve Position/Full Open: X Full Closed: _____ % Throttled: _____
19a Spec. Number: D-0077 20. P.O. Number: N/A
21a Design Class: TIE A
22. P&ID: 52-L-001-W Sht.: _____ Zone: _____
23a Plan Drawing Number: 52-L-002-W Sht.: _____ Zone: _____
24a Isometric Drawing Number: 52-L-002-W
25a Piping Line Number: N/A
26a Document Providing Information
030 M41816 ECO 5346/5565 EWP
27a Service Remarks: _____

Information by

Date

TAG NUMBER SYSTEM BUILDING INDICATES VALVE NUMBER
EXAMPLE 001

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

Page 1 of 2

1. Addendum A to ECO Number: 5821 Drawing Number: 52-L-001-W

2. Description of change:

REPLACE PAGES 7 AND ⁶~~8~~ OF ECO 5821 WITH
THE ATTACHED AS-BUILT FOR THIS MODIFICATION.
1-5-92

FILE: EC05821C.DWG (AVAILABLE FROM J.R. STROBLE)

Approvals

Authorizing Engineer:

J.R. Stroble

Signature

1-5-93

Date

C&D Mgr. / Desig. Rep.:

A. Hunt

Signature

1-5-93

Date

Other Approval:

Angela D. Naveira

Signature

1/5/93

Date

Other Approval:

Signature

Date

DRAFT

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

Page 1 of 2

1. Addendum 5 ^{add 1/5/93} ~~1368~~ to ECO Number: 5821 Drawing Number: 52-L-002-W3

2. Description of change:

REPLACE PAGES 19, 20, AND 21 OF ECO 5821
WITH THE ATTACHED AS-BUILT FOR THIS MODIFICATION
FILE: EC05821.DWG (AVAILABLE FROM J.R. STUBBLE)

3. Approvals

Cognizant Engineer:

J.R. Stubble

Signature

1-5-93

Date

CC&D Mgr./Desig. Rep.:

P. Hunt

Signature

1-5-93

Date

Other Approval:

Angela S. Najera

Signature

1/5/93

Date

Other Approval::

Signature

Date

DRAFT

ENGINEERING CHANGE ORDER **DRAFT**
ADDENDUM SHEET

Page 1 of 2

1. Addendum D4 ^{add 1/5/93} to ECO Number: 5821 Drawing Number: 105-J-022-W
JAS 1-5-93

2. Description of change:

ADD THE ATTACHED PAGE TO PAGE 41
OF THIS ECO (AS-BUILT AFTER MODIFICATION)

FILE: EC05821J.DWG

3. Approvals

Cognizant Engineer:

J.R. Strubbe
Signature

1-5-93
Date

CC&D Mgr. /Desig. Rep.:

G. Strubbe
Signature

1-5-93
Date

Other Approval:

Angela K. Nijssen
Signature

1/5/93
Date

Other Approval::

Signature

Date

ECO 5821
ADDENDUM 9
PAGE 2 OF 2

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

Page 1 of 2

1. Addendum E 5 ^{an} ₁₋₅₋₉₃ to ECO Number: 5821 Drawing Number: 52-L-002-W5

2. Description of change:

REPLACE PAGE 25 OF ECO 5821 WITH THE
ATTACHED AS-BUILT OF THE MODIFICATION

FILE: ECO 5821 B.DWG (AVAILABLE FROM J.R. STROBLE)

3. Approvals

Cognizant Engineer:

J.R. Stroble

Signature

1-5-93

Date

CC&D Mgr. /Desig. Rep.:

A. Stuart

Signature

1-5-93

Date

Other Approval:

Anaella D. Rajera

Signature

1/5/93

Date

Other Approval:

Signature

Date

DRAFT

U.S. DEPARTMENT OF ENERGY	
BROOKHAVEN NATIONAL LABORATORY	
SCALE TESTS, VC (100)	
AND SAMPLE TRACK ADJUSTMENT	
FIGURE 5821-002-01	REV. 10/18/80

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

Page 1 of 2

1. Addendum BF ^{REV 1/5/93} to ECO Number: 5821 Drawing Number: 105-H-005-W

2. Description of change:

REPLACE PAGES 36 AND 37 OF ECO 5821 WITH
THE ATTACHED AS-BUILT OF THE MODIFICATION.

FILE: ECO5821F.DWG (AVAILABLE FROM J.A. STROBLE)

DRAFT

3. Approvals

Cognizant Engineer:

J.R. Stroble
Signature

1-5-93
Date

CC&D Mgr. /Desig. Rep.:

P. Hunt
Signature

1-5-93
Date

Other Approval:

Angela D. Najera
Signature

1/5/93
Date

Other Approval::

Signature

Date

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

Page 1 of 2

1. Addendum G add 1/5/93 to ECO Number: 5821 Drawing Number: 105-L-002-W1

2. Description of change:

REPLACE PAGE 45 OF ECO 5821 WITH ATTACHED
AS-BUILT ADDENDUM TO THE MODIFICATION.

FILE: ECO 5821 G.DWG (AVAILABLE FROM J.R. STROBLE)

3. Approvals

Cognizant Engineer:

J.R. Stroble

Signature

1-5-93

Date

CC&D Mgr. /Desig. Rep.:

R. Strait

Signature

1-5-93

Date

Other Approval:

Angela D. Najera

Signature

1/5/93

Date

Other Approval:

Signature

Date

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

Page 1 of 2

1. Addendum ZB ^{add 1/5/93} to ECO Number: 5821 Drawing Number: 52-L-002-W2

2. Description of change:

REPLACE PAGES 15, 16, AND 17 WITH THE ATTACHED
AS-BUILT FOR THIS MODIFICATION.

FILE: ECO 5821A.DWG (AVAILABLE FROM J.R. STROBLE)

3. Approvals

Cognizant Engineer:

J.R. Stroble

Signature

1-5-93

Date

CC&D Mgr. / Desig. Rep.:

A. Hunt

Signature

1-5-93

Date

Other Approval:

Angela D. Najera

Signature

1/5/93

Date

Other Approval:

Signature

Date

ENGINEERING CHANGE ORDER
ADDENDUM SHEET

DRAFT

Page 1 of 2

1. Addendum H ^{can 1/5/93} 8 to ECO Number: 5821 Drawing Number: 52-L-002-W1

2. Description of change:

REPLACE PAGES 10, 11, 12, AND 13 OF THIS ECO
WITH THE ATTACHED AS-BUILTS FOR THE MODIFICATION

FILE: ECO5821H.DWG

3. Approvals

Cognizant Engineer:

J.R. Strobb

Signature

1-5-93

Date

CC&D Mgr. /Desig. Rep.:

A. Hest

Signature

1-5-93

Date

Other Approval:

Angela D. Najera

Signature

1/5/93

Date

Other Approval:

Signature

Date

DRAFT

NO.	REVISION	DATE	BY	CHKD.	APP'D.
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ATTACHMENT IV-4
BIN SCALE TEST ROOM VENTILATION DRAWINGS

DRAFT

Engineering change order

5071

DRAFT

PAGE 1 OF 2

ENGINEERING CHANGE ORDER (USE BLACK INK)		(1) CC&D REVIEW <u>SK</u> ECO- <u>507/</u>	
(2) IMPACT LEVEL ☐ LEVEL-1 ☒ LEVEL-3 ☐ LEVEL-2 (SEE SIDE 2 FOR APPROVALS)		(3) SYS/EQUIP NO./BLDG <u>74-B-344</u> 74-B-343 <u>74-B-343</u> <u>VU03</u>	
(5) DOCUMENT NO. DRAWING ☒ SPEC ☐ O&M MANUAL ☐ SDD ☐ <u>74F-024W</u> <u>54W-012-W</u>		(6) SHEET <u>1</u>	
(7) REVISION ADVANCED FROM <u>B</u> TO <u>C</u> FROM <u>---</u> TO <u>---</u>		(4) ASSOCIATED DOCUMENTS 030 <u>02265M</u> RELATED ECO <u>---</u> EDT <u>---</u> P.O. <u>---</u>	
(8) DOCUMENT TITLE <u>V16 Mine Plan Bulkhead - Locations</u> <u>V16 Equip Exp Shop Area - Room #1 Area #1</u>			
(9) DESCRIPTION OF CHANGE Y/N ☐ ELECTRICAL LOAD LIST (25-X-001-W) ☒ PANEL SCHEDULE (INCLUDE MARK-UP) - Revise ^{- 901-W} <u>54W-012W</u> TO SHOW LOCATION OF (EXCEPT <u>54W-003</u>) <u>BULKHEADS 74B-343, 74B-344 INSTALLATION.</u> - Revise <u>74-F-024W</u> TO SHOW MODIFICATIONS MADE IN FIELD INSTALLATION OF BULKHEAD - All MODS & LOCATION TO BE SHOWN ON ASBUILT OF <u>74-F-024W</u> WHEN JOB IS COMPLETE. AND MOD IS SIGNED OFF. <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto;">☒ YES ☐ NO **** MODIFICATION IN PROGRESS (ECO NOT TO BE INCORPORATED) ☐ MODIFICATION COMPLETE (ECO RELEASED FOR INCORPORATION)</div>			
(10) JUSTIFICATION - Installation of preplanned bulkheads - Asbuilt to keep ventilation drawings current			
(11) ORIGINATOR (PRINT) <u>R.C. SUPKA</u>	(12) PHONE <u>8189</u>	(13) ORGANIZATION <u>MINE ENGINEERING</u>	(14) DATE <u>11/16/90</u>
(15) COG. ENGINEER (PRINT) <u>R.C. SUPKA</u>	(12) PHONE <u>8189</u>	(16) DRAFTING REQUIRED DATE <u>2/8/91</u>	

- (17) RELATED CHANGES: INDICATE THE DOCUMENTS, INSTRUCTIONS OR PROCEDURES (OTHER THAN THE DRAWINGS OR DOCUMENTS IDENTIFIED IN EITHER 5 OR 9) THAT WILL BE AFFECTED BY THE CHANGE DESCRIBED IN BLOCK 9. ENTER THE DOCUMENT NUMBER(S) IN BLOCK 18.

YES NO N/A

- ☐ ☐ ☒ 1. CONCEPTUAL DESIGN REPORT
☐ ☐ ☒ 2. VENDOR DATA (WP 09-025)
☐ ☐ ☒ 3. FSAR
☐ ☐ ☒ 4. SEISMIC/STRESS ANALYSIS
☐ ☐ ☒ 5. DESIGN REPORT
☐ ☐ ☒ 6. INTERFACE CONTROL DWGS.
☐ ☐ ☒ 7. CALIBRATION PROCEDURES
☐ ☐ ☒ 8. INSTALLATION PROCEDURES
☐ ☐ ☒ 9. MAINTAINANCE PROCEDURES

YES NO N/A

- ☐ ☐ ☒ 10. TRAINING MANUAL
☐ ☐ ☒ 11. OPERATING PROCEDURES
☐ ☐ ☒ 12. SPARES/MULTIPLE UNIT LISTINGS
☐ ☐ ☒ 13. DO SPARES NEED MODIFIED
☐ ☐ ☒ 14. TEST PROCEDURES/SPECS.
☐ ☐ ☒ 15. COMPONENT INDICES
☐ ☐ ☒ 16. ASME CODED ITEMS
☐ ☐ ☒ 17. HUMAN FACTOR CONSIDERATIONS
☐ ☐ ☒ 18. COMPUTER SOFTWARE

- (18) RELATED DOCUMENT NO.; INSTRUCTION NO.; IDENTIFIED IN BLOCK 17. (CHANGES TO DOCUMENTS LISTED IN BLOCK 18 WILL NOT BE INCORPORATED BY THIS ECO).

DOCUMENT NO./REVISION

- (19) DISTRIBUTION

NAME	REQ.
R.C. SUPHA	MINE ENC
XXXXXXXXXX	

- (20) SIGNATURE REQUIREMENTS

KEY	ECO #
A=APPR. R=REVIEW	5071
A	COG. ENGINEER <i>Richard L. Lee</i>
A	COG. ENGR. MGR. <i>Lee</i> 11/16/90
R	Q.A. <i>MA</i> 11-6-90
	DCE
	SAFETY
	DEPT. MGR.
	OPERATIONS
	SECURITY
R	Start Up <i>ABrown</i> 11-16-90

- (21) DESIGN VERIFICATION REQUIREMENTS (PER WP 09-018)

☒	1. REQUIREMENTS SATISFIED BY REVIEW/APPROVAL OF DESIGN DOCUMENT
☐	2. INDEPENDENT REVIEW
☐	3. ALTERNATE CALCULATIONS
☐	4. DEVELOPMENT TESTING
☐	5. DESIGN REVIEW
☐	6. OTHER

EDT#

DRAFT

ECO 5147

TEMPORARY

DRAFT

PAGE 1 OF 15

ENGINEERING CHANGE ORDER
(USE BLACK INK)

(1) CC&O REVIEW JB
ECO- 5147

(2) IMPACT LEVEL
☐ LEVEL-1 ☒ LEVEL-3
☐ LEVEL-2
(SEE SIDE 2 FOR APPROVALS)

(3) SYS/EQUIP NO./BLDG
WO0/VARIOUS/SURFACE
U/G

(4) ASSOCIATED DOCUMENTS
030 07104T
RELATED ECO _____
EDT _____
P.O. 35-WPT-41130-ME

(5) DOCUMENT NO.
DRAWING ☐
SPEC ☐
O&M MANUAL ☐
SDD ☐
54-W-004-W
1632-S

(6) SHEET 1
(7) REVISION ADVANCED
FROM _____ TO _____
FROM _____ TO _____

(8) DOCUMENT TITLE
UNDERGROUND MINE VENTILATION SYSTEM

(9) DESCRIPTION OF CHANGE

Y/N
☐ ☒ ELECTRICAL LOAD LIST (25-X-001-W)
☐ ☒ PANEL SCHEDULE (INCLUDE MARK-UP)

LOCATE TEMPORARY, SELF POWERED,

A) UNDERGROUND ATMOSPHERIC MONITORING STATIONS AT THE FOLLOWING LOCATIONS:

- 1) AIR INTAKE SHAFT STATION
- 2) SALT HANDLING SHAFT COLLAR
- 3) SALT HANDLING SHAFT STATION
- 4) EXHAUST SHAFT STATION
- 5) WASTE SHAFT COLLAR
- 6) WASTE SHAFT STATION
- 7) STATION A BUILDING
- PROBES TO ATMOSPHERE
- PROBES IN EXHAUST DUCT

INSTALLATION DETAILS
ATTACHED

B) ASSIGN SKETCH NUMBER TO 1632-S
SHEET 12; SKETCH TO BE REMOVED
UPON REMOVAL OF DEFECTED PLATFORM

☒ YES ☐ NO

**** MODIFICATION IN PROGRESS
(ECO NOT TO BE INCORPORATED)

☐ MODIFICATION COMPLETE _____
(ECO RELEASED FOR INCORPORATION)

(10) JUSTIFICATION

UNITS ARE REQUIRED TO COLLECT CONTINUOUS MINE
ENVIRONMENT DATA FOR COMPLETION OF "UNDERGROUND
VENTILATION WINTER MONITORING PLAN".

(11) ORIGINATOR (PRINT)

(12) PHONE

(13) ORGANIZATION

(14) DATE

IAN LOOMIS

-8179

MINE ENGINEERING

2 JAN 91

(15) COO. ENGINEER (PRINT)

(16) PHONE

(17) DRAFTING REQUIRED DATE

IAN LOOMIS

-8179

TEMP

(17) RELATED CHANGES: INDICATE THE DOCUMENTS, INSTRUCTIONS OR PROCEDURES (OTHER THAN THE DRAWINGS OR DOCUMENTS IDENTIFIED IN EITHER 5 OR 9) THAT WILL BE AFFECTED BY THE CHANGE DESCRIBED IN BLOCK 9. ENTER THE DOCUMENT NUMBER(S) IN BLOCK 18.

YES NO N/A

- ☐ ☐ ☒ 1. CONCEPTUAL DESIGN REPORT
- ☒ ☐ ☐ 2. VENDOR DATA (WP 09-025)
- ☐ ☒ ☐ 3. FSAR
- ☐ ☐ ☒ 4. SEISMIC/STRESS ANALYSIS
- ☐ ☒ ☐ 5. DESIGN REPORT
- ☐ ☒ ☐ 6. INTERFACE CONTROL DWGS.
- ☒ ☐ ☐ 7. CALIBRATION PROCEDURES
- ☒ ☐ ☐ 8. INSTALLATION PROCEDURES
- ☒ ☐ ☐ 9. MAINTAINANCE PROCEDURES

YES NO N/A

- ☒ ☒ ☐ 10. TRAINING MANUAL
- ☒ ☐ ☐ 11. OPERATING PROCEDURES
- ☐ ☒ ☐ 12. SPARES/MULTIPLE UNIT LISTINGS
- ☐ ☒ ☐ 13. DO SPARES NEED MODIFIED
- ☒ ☐ ☐ 14. TEST PROCEDURES/SPECS.
- ☐ ☒ ☐ 15. COMPONENT INDICES
- ☐ ☒ ☐ 16. ASME CODED ITEMS
- ☐ ☒ ☐ 17. HUMAN FACTOR CONSIDERATIONS
- ☒ ☐ ☐ 18. COMPUTER SOFTWARE

(18) RELATED DOCUMENT NO.; INSTRUCTION NO.; IDENTIFIED IN BLOCK 17. (CHANGES TO DOCUMENTS LISTED IN BLOCK 18 WILL NOT BE INCORPORATED BY THIS ECO).

FROM ABOVE

DOCUMENT NO./REVISION

1) SUPPLIED W/ UNITS

(18) COMP. SOFTWARE SUPPLIED

2) " " "

W/ UNITS BY VENDOR FOR PC

3) PER PWR

4) PER PWR AS REQUIRED

AS APPROPRIATE - INFORMATION WILL

5) BY VENDOR & OJT

BE SUBMITTED VIA EDT.

6) SUPPLIED W/ UNITS

7) PER TEST PLAN

(19) DISTRIBUTION

NAME	ORG.
T. RAY	U/G FACILITIES
W. WILLIAMS	U/G FACILITIES

(20) SIGNATURE REQUIREMENTS

KEY	ECO #
A=APPR.	5147
R=REVIEW	
COG. ENGINEER	3 JAN 91
COG. ENGR. MGR.	11-8-91
CIA	
DCE	
SAFETY	
DEPT. MGR.	
OPERATIONS	
SECURITY	
FAC OPS	
START-UP	

(21) DESIGN VERIFICATION REQUIREMENTS PER WP 09-018

- 1. REQUIREMENTS SATISFIED BY REVIEW APPROVAL OF DESIGN DOCUMENT
- 2. INDEPENDENT REVIEW
- 3. ALTERNATE CALCULATIONS
- 4. DEVELOPMENT TESTING
- 5. DESIGN REVIEW
- 6. OTHER

EDT#

DRAFT

TITLE STATION DESCRIPTION		PAGE 1 OF 1	
PROJECT WINTER MONITOR	AUTHOR J. LOOMES	DATE 2 JAN 91	CHK'D. BY DATE
S.O.	CALC. NO.	FILE NO. VU00	GROUP MENG ENGINEERING

STATIONS 1 THROUGH 6 TO CONSIST
OF THE FOLLOWING EQUIPMENT:

Catalog No. Description

CR10	CR10 MODULE W/CR10WP/64K RAM
OS10.01	SOFTWARE OPTION
PS12	12V PWR SPLY W REGULATOR
PS12-ALK	ALKALINE BATTERIES
ENC 12/14	12" X 14" FIBERGLASS ENCLOSURE
SM192	SOLID STATE STORAGE MODULE
5234	SM192/716 BRACKET KIT
HMP35C	VAISALA TEMP AND RH PROBE
PTA427	PRESSURE SENSOR VAISALA
6234	SM192/716 BRACKET KIT
41002-2	12 PLATE RADIATION SHIELD - As REQ'D At 1, 2, 3, & 4

STATION 7 WILL COLLECT BOTH ATMOSPHERE
AND U/G EXHAUST DUCT INFORMATION AND
WILL CONSIST OF THE FOLLOWING EQUIPMENT:

CR10	CR10 MODULE W/CR10WP/64K RAM	
OS10-0.1	SOFTWARE OPTION	
PS12	12V PWR SPLY W/REGULATOR	
PS12-ALK	ALKALINE BATTERIES	
ENC 12/14	12" X 14" FIBERGLASS ENCLOSURE	
SM192	SOLID STATE STORAGE MODULE	
6234	SM192/716 BRACKET KIT	
HMP35C	VAISALA TEMP AND RH PROBE	- 2 EACH
PTA427	PRESSURE SENSOR VAISALA	- 2 EACH
*CR10KD	CR10 KEYBOARD & DISPLAY	
**41002-2	12 PLATE RAD SHEILD FOR HMP35C	- 2 EACH
5883 ENC	BAROMETER ENCLOSURE	
	VAISALA MOUNTING	
	55 FT. CABLE	

REV NO	REV DATE	AUTHOR	DATE	CHK'D BY	DATE	CHK'D BY	DATE
-----------	-------------	--------	------	----------	------	----------	------

**MINE
VENTILATION
SERVICES, INC.**

DRAFT

ECO # 5147
SHEET 4 OF 15

CALCULATION SHEET

Page.....1..... of.....8.....
Calculation No. 560
Made by. KW
Date 2 Jan 91
Checked by.....
Date.....

Project Title WATER MONITOR
Contract No. 560
Subject WEATHER STATION CONTROL PANEL
Ref Dwg.

SKETCH 1

SPACING REQUIREMENTS TO MOUNT WEATHER STATION CONTROL PANEL.

PLAN VIEWS

SIDE VIEW:

FRONT

DIMENSIONS GIVEN ARE TO CENTER OF BOLT HOLES

HOLES ARE SIZED FOR $\frac{7}{16}$ " ϕ BOLT

SKETCH 2

Page

2 of 3

MODEL 41004-5
GILL MULTI-PLATE RADIATION SHIELD

DRAFT

MODEL 41004-5	DWG A	PRD 03-87
GILL MULTI-PLATE RADIATION SHIELD FOR	DWG KL	DWG 06-88
CAMPBELL 2207/PHYS CHEM PROBE	CSW	PA1752

**MINE
VENTILATION
SERVICES, INC.**

DRAFT

ECO 5147
SHEET 6 of 15

CALCULATION SHEET

Page... 3 ... of ... 8
Calculation No. 560
Made by... KW
Date... 2 Jan 91
Checked by
Date

Project Title... WATER MONITOR
Contract No. ... 560
Subject... Weather Station - Rig Mounted
Ref. Dwg.

SHEET 3

RIG MOUNTED MINE WEATHER STATIONS (3 STATIONS -
AIR BASE, NATE SHAFT BASE AND EXHAUST SHAFT BASE)

NOTES

- ① UNISTEUT IS SECURED TO SALT.
- ② WEIGHT OF CONTROL PANEL IS APPROXIMATELY 50 POUNDS.

PIPE WELDED OR
BOLTED TO UNISTEUT

DRAFT

**MINE
VENTILATION
SERVICES, INC.**

CALCULATION SHEET

Page 4 of 6
 Calculation No. 500
 Made by KW
 Date 7 Jan 91
 Checked by _____
 Date _____

Project Title WATER MONITOR
 Contract No. 560
 Subject WATER STATION - SH. SECTION
 Ref. Dwgs. _____

SKETCH 4

STANDING SHAFT STATION - LOOKING NORTH (E.O. TOWARDS EXPERIMENTAL

SEA)

THE CONTROL PANEL CAN BE POSITIONED ANYWHERE ON EXISTING FRAME ON WEST SIDE OF MAN-DOOR. POSITION SHOULD ALLOW FOR EASY ACCESS FOR DATA COLLECTION AND SENSOR CANNOT BE POSITIONED MORE THAN 3 FT FROM CONTROL PANEL. PANEL

ECO 5147

SHEET 8 of 15

**MINE
VENTILATION
SERVICES, INC.**

DRAFT

CALCULATION SHEET

Page 5 of 8
Calculation No. 560
Made by KW
Date 2 Jan 91
Checked by
Date

Project Title WINDY MOUNT
Contract No. 560
Subject WINDY MOUNT - SILENT EXHAUST
Ref. Dwgs. SHED

SKETCH 5

EXHAUST SHAFT CONTROL PANEL MOUNTED ON SHED "A" RAILING

EXTEND UNISTRUT AT LEAST 3 INCHES
FOR SENSOR MOUNT

NOTE: IF UNISTRUT IS BOLTED TO RAILING, STAKERS
MAY BE NECESSARY TO BOLT CONTROL
PANEL TO UNISTRUT (SEE SIDE VIEW
SKETCH OF CONTROL PANEL).

MINE VENTILATION SERVICES, INC.

DRAFT

ECO# 5147 SHEET 9 OF 15

CALCULATION SHEET

Page 6 of 8
 Calculation No. 560
 Made by KW
 Date 2 Jan 91
 Checked by _____
 Date _____

Project Title WATER MONITOR
 Contract No. 560
 Subject Weather Station Exhaust Shaft
 Ref. Dwg. _____

418/H15

**MINE
VENTILATION
SERVICES, INC.**

DRAFT

ECO# 5147
SHEET 10

CALCULATION SHEET

Page.....7.....
Calculation N
Made by...K.W.
Date...4/2/91
Checked by...
Date.....

Project Title WATER MONITOR
Contract No. 5140
Subject WATER STATION - WATER SHUT COLLAR
Ref. Dwgs.

SKETCH 7:

WASTE SHUT COLLAR

**MINE
VENTILATION
SERVICES, INC.**

DRAFT

ECO# 5147
SHEET 11 OF 15

CALCULATION SHEET

Project Title Winter Monitor
Contract No. 50
Subject Weather Station - SH shaft collar
Ref. Dwgs.

Page 8 of 8
Calculation No. 300
Made by KW
Date 2 Jan 91
Checked by _____
Date _____

SKETCH 8:

SH SHAFT COLLAR

CONTROL PANEL CAN BE MOUNTED ON HEADFRAME. IT SHOULD BE POSITIONED SUCH THAT IT WILL NOT BE POSSIBLE TO BE HIT BY FALLING DEBRIS. PANEL CAN ALSO BE MOUNTED AWAY FROM SHAFT IF AN APPROPRIATE LOCATION CAN BE FOUND. GOVERNING CRITERIA IS TO NOT INTERFERE WITH SHAFT OPERATIONS OR MAINTENANCE.

WESTINGHOUSE WASTE ISOLATION DIVISION

ECO # 5147
SHEET 13 OF 15

DRAFT

TITLE INSTRUMENT PLATFORM - EXHAUST SHAFT				PAGE 2 OF 3	
PROJECT WINTER MONITOR	AUTHOR I. LOOMES	DATE 2 JAN 91	CHK'D. BY	DATE	CHK'D. BY
S.O.	CALC. NO.	FILE NO. VU00	GROUP MECH ENGINEERING		

ITEM	DESCRIPTION	QTY	WT	
1	CBX 13.75 X 40"	1	46 #	ALTERNATIVES TO BE APPROVED BY COG. ENG. ON PWR.
2	1/2 NOM Ø SCH 40 X 14'4"	1	3'4 #	
3	BOLT EYES FOR 1" CABLE	2	NEG	
4	AUX RECOVERY EYE	1	NEG	

WEIGHT OF INST. MOUNT APPROX - 49'4 #

A	R/T PROBE W/ SROUD	1	5 #
B	BAROMETER W/ CASE	1	8 #

TOTAL ESTIMATED WEIGHT 62'4 #

$$\text{LOAD} = \frac{62.25 \#}{8" \times 40"} = 0.19 \text{ PSI}$$

REV NO	REV DATE	AUTHOR	DATE	CHK'D BY	DATE	CHK'D BY	DATE
-----------	-------------	--------	------	----------	------	----------	------

WESTINGHOUSE WASTE ISOLATION DIVISION

DRAFT

ECO# 5147

SHEET 14 OF 15

TITLE		PAGE	
INSTRUMENT PLATFORM - EXHAUST SHAFT		3 OF 3	
PROJECT	AUTHOR	DATE CHK'D BY	DATE
MINUTE MONITOR	I. LOOMIS 25 JAN 91		
S.O.	CALC. NO.	FILE NO.	GROUP
		V000	PLANE ENGINEERING

REV NO	REV DATE	AUTHOR	DATE CHK'D BY	DATE

VELOCITY Pressure

$$V = 4137 \text{ ft/min}$$

$$\rho = 0.075 \text{ lb/ft}^3$$

$$P_v = \frac{\rho (V/10.43)^2}{2}$$

$$P_v = 0.075 (4137/10.43)^2$$

$$= 1.0617 \text{ in. w.g.}$$

$$= 1.0617 * 0.036 \text{ psi/in. w.g.}$$

$$= \underline{0.0383 \text{ psi}}$$

LOAD = 0.19 PSI

$$CF = \frac{0.19}{0.04} = 4.75$$

NORMAL TO AIRFLOW - FACTOR WILL BE HIGHER, UNIT IS OUT OF MAIN CIRCULATION

$V_t = 197 \text{ ft/min}$
 $V_{\text{max}} = (197 \text{ ft/min})(21 \text{ ft})$
 $= 4137 \text{ ft/min}$
 $\bar{V}_t = 2760 \text{ ft/min}$
 $\bar{V}_r = \frac{2760 \text{ ft/min}}{14 \text{ ft}}$
 $= 197 \text{ ft/min}$
 $\bar{V} = \frac{4137 \text{ ft/min}}{1.4} = 2955 \text{ ft/min}$

DEAF

ECO 6232

ENGINEERING CHANGE ORDER

DRAFT

Page 1 of 5

USE BLACK INK

1. ECO No.: <u>6232</u>		2. Impact Level 1 ☐ 2 ☐ 3 ☒ 4 ☐	
CC&D Review: <u>KA</u>		3. System: <u>VU01</u> Equipment No.: <u>N/A</u> Building: <u>413</u>	
4. Associated Documents: PWR <u>N/A</u> ECP <u>J</u> P.O. <u>J</u> Others <u>J</u>		5. Document Type: Drawing <u>41-F-026-019</u> ☒ <u>41-A-001-W</u> ☐ Specification ☐ Vendor Data ☐ SDD ☐ Others ☐	
6. Title of Change: <u>Supersede dng. 41-F-026-019</u>			
7. Originator: (print) <u>K. EALDEN</u>		8. Cognizant Engineer: (print) <u>K. EALDEN.</u>	
Ext. No.: <u>8174</u>		Department: <u>M.E.C.E.</u>	
Date: <u>2 June '92</u>			
9. Description of Change: <div style="text-align: right;">Yes ☐ No ☒</div> <div style="text-align: right;">Component indices change required (if yes, attach sheets)</div> <p><u>41-F-026-019, Underground Exhaust System Flow Diagram is to be superseded. Ref. to this dng. on dng. 41-A-001-W is to be revised accordingly.</u></p> <div style="display: flex; justify-content: space-between;"><div>☒ 9a Drawing Change Sheet attached ☐ 9b Design Documentation Sheet attached</div><div>☐ 9c Vendor Data Change Sheet attached</div></div>			
10. Yes ☐ No ☒ MODIFICATION IN PROGRESS Modification complete: _____ Signature _____ Date _____ ECO will be incorporated after M.I.P. signed complete ☐ Change drawing per addendum dated: _____ ☐ Change drawing per ECO-provided data ☐ Temporary modification			
11. Design Verification Requirements: (per WP 09-018) EDT No.: <u>N/A</u> <u>JWP</u> 1. Requirements satisfied by review/approval of design document 2. Independent review 3. Alternate calculations 4. Development testing 5. Design review 6. Other: _____			
12. Addendum Sheet added: _____ Signature _____ Date _____			

3. Justification

Dwgs. 54-A-001-WA thru. W9 have been produced to more fully detail the underground exhaust system flows for the various modes for which the system can be configured.

4. Administrative Tracking

N/A

- ☒ 1. FSAR
☒ 2. Calibration Procedures
☐ 3. Maintenance Procedures
☒ 4. Computer Software
☐ 5. Operations Procedures

YES N/A

- ☒ ☐ 6. Startup/Acceptance Test
☐ ☒ 7. Test Requirement & Spec.
☒ ☐ 8. SDD
☐ ☐ 9. _____
☐ ☐ 10. _____

5. Signature Requirements

KEY
 A=APPR.
 R=REVIEW
 S=SIGN NEW
 DRAWING

- ☒ A Cog. Engineer *Palde 2 June 92*
☒ A Cog. Manager *Wahl 6/2/92*
☐ R Startup *Q. Strait 6/4/92*
☒ R QA *6/4/92*
☐ Cog. Ops. Mgr. _____
☐ DOE _____
☐ Safety _____
☐ Maintenance _____
☐ Dept. Manager _____
☐ Asst. Gen. Mgr. _____
☐ Operations _____
☐ SNL _____
☐ _____
☐ _____
☐ _____

16. Distribute as Marked

- ☒ Maintenance (MANDATORY) _____
☒ Ops. Support _____
☒ Startup _____
☒ Facility Operations _____
☐ U/G Operations _____
☐ Orig./Design Engr. _____
☒ Cog. Engineer _____
☐ Others _____
☒ *Van Loomis* _____
☐ _____
☐ _____
☐ _____
☐ _____
☐ _____
☐ _____

ENGINEERING CHANGE ORDER

DOE ORDER 6430.1A DESIGN CRITERIA

CHECKLIST

PAGE 3 OF 5
 1. ECO # 6232
 2. DATE: 2 June '92

DRAFT

The design requirements in DOE Order 6430.1A checked below
 have been applied to this Design.

3.	DIVISION	SUBDIVISION
☐	General Requirements	☐ 0101 ☐ 0106 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☐	Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0235 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0260 ☐ 0262 ☐ 0266 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0275 ☐ 0276 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☐ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☐	Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☐	Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☐	Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☐ 0532
☐	Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☐	Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☐ 0721 ☐ 0722 ☐ 0724 ☐ 0727 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☐	Doors and Windows	☐ 0800 ☐ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0836 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0870 ☐ 0880
☐	Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0980 ☐ 0990 ☐ 0995
☐	Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1055 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☐	Equipment	☐ 1100 ☐ 1161
☐	Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1260 ☐ 1270
☐	Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☐ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☐ 1326 ☐ 1328
☐	Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1460
☐	Mechanical	☐ 1525 ☐ 1530 ☐ 1540 ☐ 1550 ☐ 1555 ☐ 1565 ☐ 1574 ☐ 1589 ☐ 1595
☐	Electrical	☐ 1600 ☐ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1655 ☐ 1660 ☐ 1670 ☐ 1671 ☐ 1685 ☐ 1694
4. ☒	NOT APPLICABLE	No portion of DOE Order 6430.1A is applicable to this Design.
5. ☐	AS-BUILT	ECO is for as-built field verified changes only.

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

COMMENTS: _____

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 4 of 5

1. Drawing: 41-F-026-019 ECO Number: 6232

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

This drawing is superseded by dwgs.

54-A-001-W1 thru: W9. when approved.

4. Drawing Cog. Engineer Approval:

3 JUNE '92

Date:

2 June '92

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 5 of 5

1. Drawing: 41-A-001-W

ECO Number: 6232

2. ECO Search List:

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change:

4. Delete reference to dwg. 41-F-026-019,
1. Underground Exhaust System, Flow Diagram.

5. ~~Add reference to dwg. 54-A-001-W,~~
2. ~~Underground Ventilation System, Process &~~
3. ~~Instrumentation Diagram.~~

[Signature]
3 June '92

4. Drawing Cog. Engineer Approval: *[Signature]*

Date: 2 June '92

DRAFT

Eco 6457

ENGINEERING CHANGE ORDER

Page 1 of 17

[illegible]

13. Justification

Maintain Configuration Control of Ventilation & Breathing Drawings.

As lock is needed to place E300 (mechanics) shop in operation.

14. Administrative Tracking

YES N/A

- ☒ ☐ 1. FSAR
☐ ☒ 2. Calibration Procedures
☒ ☐ 3. Maintenance Procedures
☐ ☒ 4. Computer Software
☒ ☐ 5. Operations Procedures

YES N/A

- ☐ ☒ 6. Startup/Acceptance Test
☐ ☒ 7. Test Requirement & Spec.
☐ ☒ 8. SDD
☐ ☐ 9. _____
☐ ☐ 10. _____

15. Signature Requirements

Impact Level

KEY
A=APPR.
R=REVIEW
S=SIGN NEW
DRAWING

1	A	Cog. Engineer	P.C. Shaker 10/14/92
1	A	Cog. Manager	H.F. Webb 10/14/92
2	R	Startup	10-23-92
3	S	QA	10-26-92
		Cog. Ops. Mgr.	
		DOE	
2		Safety	
		Maintenance	
		Dept. Manager	
		Asst. Gen. Mgr.	
		Operations	
		SNL	

16. Distribute as Marked

☐	Maintenance (MANDATORY)	
☐	Ops. Support	
☐	Startup	
☒	Facility Operations	Cont. Draw File
☒	U/G Operations	Cont. Draw File
☐	Orig./Design Engr.	
☒	Cog. Engineer	
☐	Others	
☒	WH OPS Cont Draw File	
☐		
☐		
☐		
☐		
☐		
☐		

ENGINEERING CHANGE ORDER

DOE ORDER 6430.1A DESIGN CRITERIA CHECKLIST

DRAFT

PAGE 3 OF 17
 1. ECO # 16457
 2. DATE: 10/19/91

The design requirements in DOE Order 6430.1A checked below have been applied to this Design.

3. DIVISION	SUBDIVISION
☐ 1 General Requirements	☐ 0101 ☐ 0106 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☐ 2 Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0235 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0260 ☐ 0262 ☐ 0266 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0275 ☐ 0276 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☐ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☐ 3 Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☐ 4 Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☐ 5 Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☐ 0532
☐ 6 Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☐ 7 Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☐ 0721 ☐ 0722 ☐ 0724 ☐ 0727 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☐ 8 Doors and Windows	☐ 0800 ☐ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0836 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0870 ☐ 0880
☐ 9 Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0980 ☐ 0990 ☐ 0995
☐ 10 Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1055 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☐ 11 Equipment	☐ 1100 ☐ 1151
☐ 12 Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1260 ☐ 1270
☐ 13 Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☐ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☐ 1326 ☐ 1328
☐ 14 Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1450
☐ 15 Mechanical	☐ 1525 ☐ 1530 ☐ 1540 ☐ 1550 ☐ 1555 ☐ 1565 ☐ 1574 ☐ 1589 ☐ 1595
☐ 16 Electrical	☐ 1600 ☐ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1655 ☐ 1660 ☐ 1670 ☐ 1671 ☐ 1685 ☐ 1694
4. ☐ NOT APPLICABLE	(No portion of DOE Order 6430.1A is applicable to this Design.)
5. ☒ AS-BUILT	(ECO is for as-built field verified changes only.)

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

COMMENTS: _____

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 4 of 17

1. Drawing: 54-W-001-W ECO Number: 6457

2. ECO Search List: 5071 _____
5147 _____

3. Description of Change:

Show Location of Bulkheads 74-B-520 (N250-E140)
74-B-521 (E300-S50), (Drive Thru - Air Lock)

4. Drawing Cog. Engineer Approval: Robert T. Lee Date: 10/19/07

9a
DRAWING CHANGE SHEET **DRAFT**
(1 SHEET PER DRAWING)

Page 5 of 17

1. Drawing: 54-W-002-W

ECO Number: 6457

2. ECO Search List: 5071

3. Description of Change:

Show Location of Bulkheads 74-B-520 (N250-E140)
74-B-521 (E300-550) (Rise Then - Airlock).

4. Drawing Cog. Engineer Approval: [Signature]

Date: 10/19/03

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 6 of 17

1. Drawing: 54-W-004-W

ECO Number: 6457

2. ECO Search List: 5071

3. Description of Change:

Show location of bulkheads 74-B-520 (N250-E140),
74-B-521 (E300-S50), Drive thru Airlock.

4. Drawing Cog. Engineer Approval: [Signature]

Date: 16/14/10

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 7 of 17

1. Drawing: 54-22-2457-2 ECO Number: 6457

2. ECO Search List: 5071

3. Description of Change:

Show location of bulkheads 74-B-520 (N250-514),
74-B-521 (E300-550), plus their A/L's.

4. Drawing Cog. Engineer Approval: R.C. Lusk Date: 10/19/97

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 8 of 17

1. Drawing: 54-W-506-W

ECO Number: 6457

2. ECO Search List: SC71

3. Description of Change:

Show Location of Bulkheads 74-B-520 (N250-E14)
74-B-521 (E300-S50), Drive Then A-100K.

4. Drawing Cog. Engineer Approval: R. C. [Signature]

Date: 10/15/02

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 9 of 17

1. Drawing: 54-W-007-W

ECO Number: 6457

2. ECO Search List: 5071

3. Description of Change:

Show location of Bulkheads 74-B-520 (N250-E140)
74-B-521 (E300-550), Drive thru A-frame.

4. Drawing Cog. Engineer Approval: [Signature]

Date: 10/10/02

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 1 of 17

1g Drawing: 54-W-012-W

ECO Number: 6457

2e ECO Search List: 5071

3t Description of Change:

1. Show location of bulkheads 74-B-520 (N250-014)
74-B-521 (E300-550), Prime then Airlock.

4. Drawing Cog. Engineer Approval: R.C. Smith

Date: 10/14/07

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 11 of 17

1. Drawing: 74-13-079-6 ECO Number: 6457

2. ECO Search List: 6060

3. Description of Change:

(By Index)

Show Location of Bulkheads 74-13-520 (N250-614)

74-13-521 (E300-550)

4. Drawing Cog. Engineer Approval: R.C. Smith Date: 10/16/02

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Page 12 of 17

1. Drawing: 74-11-088-W ECO Number: 6457

2. ECO Search List: NA

3. Description of Change: BUCKHEAD 74-11-5-20 (N250 - E190)

Create Drawing From Sheets 13/17 & 14/17

And Asbuilt Information Supplied At Completion
of Project.

4. Drawing Cog. Engineer Approval: R.C. Lumb Date: 10/19/97

201305 PM 5:14:31 PM 311B

FCC 6457

13/17

DRAFT

BULKHEAD 74-B-520 (N250-E:90)
SHEET #2

DRAWN BY: R.C. SUPKA
DATE: 8/10/92

SOUTH DOOR

NORTH DOOR

WINDOW

FRAMEWORK AND DOORS ARE TO BE SKINNED ON BOTH SIDES WITH
31 GAGE SHEETMETAL AND INSULATED WITH 3" OF ROCKWOOL INSULATION

40'

1.457

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

Page 15 of 17

1. Drawing: 74-A-089-W ECO Number: 6457

2. ECO Search List: NA

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3. Description of Change: BULKHEAD 74-B-521 (E300-550)

*Create Drawing From Sheets 16/17 & 17/17
And Asbuilt Information Supplied At Completion
of Project.*

4. Drawing Cog. Engineer Approval: *H.C. Smith* Date: 10/14/42

DESIGNED BY: [Redacted]
 DATE: 10/24/20
 SHEET: 1

DESIGNED BY: [Redacted]
 DATE: 10/24/20
 SHEET: 1

- (1) 1" x 1/2" x 1/4" TUB STEEL
- (2) 2" x 2" x 1/4" TUB STEEL (ASIM A200 (A200 B))
- (3) 1/2" x 1/2" x 1/4" STEEL PLATE (ASIM A200 (A200 B))
- (4) 2" x 4" x 1/4" TUB STEEL (ASIM A200 (A200 B))
- (5) 3" x 11/2" x 1/4" STEEL STRIP (ASIM A200 (A200 B))

DRAFT

10457

BULKHEAD 74-B-521 (E300-050)
SHEET #2

DRAWN BY R.C. SUPKAL
DATE: 8/10/92

42" DOOR

42" DOOR

MAN DOOR

FRAMING AND DOORS ARE TO BE SKINNED ON BOTH SIDES WITH
21 GAUGE SHEETMETAL AND INSULATED WITH 2\"/>

DRAFT

ECO 6493

ENGINEERING CHANGE ORDER

DRAFT

Page 4 of 77

USE BLACK INK

1. ECO No.: <u>6493</u> CC&D Review: <u>AS</u>		2. Impact Level 1 ☐ 2 ☐ 3 ☒ 4 ☐ <i>Rec'd Adm 11/11/92</i>	
3. System: <u>VU03</u> Equipment No.: <u>74-F-051</u> Building: <u>V/6</u>		5. Document Type: 54-W-001, 002, 004, 005, 006 Drawing 007, 012 ☒ Specification ☐ Vendor Data ☐ SDD ☐ Others _____	
4. Associated Documents: PWR <u>10367-M</u> ECP <u>10366-M</u> P.O. <u>NA</u> Others <u>NA</u>		6. Title of Change: <u>Asbuilt of Secondary Ventilation V/6</u>	
7. Originator: (print) <u>RICHARD C. SUPKA</u> Ext. No.: <u>8189</u> Department: <u>MINING ENGINEERING</u> Date: <u>11/11/92</u>		8. Cognizant Engineer: (print) <u>RICHARD C. SUPKA</u>	
9. Description of Change: <div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 60%;"> <p>Add Description of Fans (10HP SPDRVA) ☐ Yes ☒ No</p> <p>To Drawings 54-W-001-W 54-W-005-W 54-W-012-W 54-W-002-W 54-W-006-W 54-W-004-W 54-W-007-W</p> <p>Location & Configuration Supplied On Asbuilt of <u>Drawing 54-W-001-W</u> P. 11/11 of this ECO <i>AS 11/17/92</i></p> <p>Show New Drift Dimensions As Shown</p> <p>Show All Regulation Changes</p> </div> <div style="width: 35%;"> <p>Component indices change required (if yes, attach sheets)</p> <p style="text-align: right;"><i>RES 11/17/92</i></p> </div> </div> <div style="display: flex; justify-content: space-between; margin-top: 20px;"> <div> ☒ 9a Drawing Change Sheet attached ☐ 9b Design Documentation Sheet attached </div> <div> ☐ 9c Vendor Data Change Sheet attached </div> </div>			
10. Yes ☐ No ☒ MODIFICATION IN PROGRESS <div style="display: flex; justify-content: space-between; align-items: flex-start; margin-top: 10px;"> <div style="width: 70%;"> <p>Modification complete: _____ Signature _____ Date _____</p> <p>☐ Change drawing per addendum dated: _____</p> <p>☐ Change drawing per ECO-provided data</p> <p>☐ Temporary modification</p> </div> <div style="width: 25%; border-left: 1px solid black; padding-left: 10px;"> <p>ECO will be incorporated after M.I.P. signed complete</p> </div> </div>			
11. Design Verification Requirements: (per WP 09-018) EDT No.: _____ <div style="display: flex; margin-top: 10px;"> <div style="width: 30%;"> <p><u>AS</u></p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> </div> <div style="width: 70%;"> <p>1. Requirements satisfied by review/approval of design document</p> <p>2. Independent review</p> <p>3. Alternate calculations</p> <p>4. Development testing</p> <p>5. Design review</p> <p>6. Other: _____</p> </div> </div>			
12. Addendum Sheet added: _____ <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div>Signature _____</div> <div>Date _____</div> </div>			

11/17/92
2/11

13. 13. Justification

- Installation of Permanent (Long Term) Secondary Ventilation To Alcoves N780, E0 & N460, E0.
- Changes In Excavation of the V/G
- Removal / Addition of Regulators

14. 14. Administrative Tracking

YES N/A

- ☒ ☒ ☒ 1. FSAR
- ☒ ☒ ☒ 2. Calibration Procedures
- ☒ ☒ ☒ 3. Maintenance Procedures
- ☒ ☒ ☒ 4. Computer Software
- ☒ ☒ ☒ 5. Operations Procedures

YES N/A

- ☐ ☒ 6. Startup/Acceptance Test
- ☐ ☒ 7. Test Requirement & Spec.
- ☐ ☒ 8. SDD
- ☐ ☐ 9. _____
- ☐ ☐ 10. _____

15. 15. Signature Requirements

Project
OwnerProject
Mgr

A

Cog. Engineer *Richard C. Smith* 11/11/92

A

Cog. Manager *Smith* 11/11/92

R

Startup *Smith* 11-17-92

R

QA *Smith* 11/21/92

Cog. Ops. Mgr. _____

DOE _____

Safety _____

Maintenance _____

Dept. Manager _____

Asst. Gen. Mgr. _____

Operations _____

SNL _____

KEY
A=APPR.
R=REVIEW
S=SIGN NEW
DRAWING

16. Distribute as Marked

- ☒ Maintenance (MANDATORY) *HARRY ALLEN*
- ☐ Ops. Support _____
- ☐ Startup _____
- ☒ Facility Operations *CONTROL DWA FIRE*
- ☒ U/G Operations *CONTROL DWA FIRE*
- ☐ Orig./Design Engr. _____
- ☒ Cog. Engineer *R.C. SUPHAN*
- ☐ Others _____
- ☒ WH OPS - *HARRY PORTER*
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

D R A F T

ENGINEERING CHANGE ORDER

DOE ORDER 6430.1A DESIGN CRITERIA

CHECKLIST

3/14 11/17
3/11

PAGE 3 OF 4

1. ECO # 6492

2. DATE: 11/11/91

The design requirements in DOE Order 6430.1A checked below
have been applied to this Design.

3. DIVISION	SUBDIVISION
☐ 1 General Requirements	☐ 0101 ☐ 0106 ☐ 0109 ☐ 0110 ☐ 0111 ☐ 0140 ☐ 0150 ☐ 0170
☐ 2 Site and Civil Engineering	☐ 0200 ☐ 0201 ☐ 0202 ☐ 0203 ☐ 0205 ☐ 0210 ☐ 0214 ☐ 0215 ☐ 0220 ☐ 0221 ☐ 0245 ☐ 0250 ☐ 0256 ☐ 0260 ☐ 0262 ☐ 0266 ☐ 0267 ☐ 0270 ☐ 0273 ☐ 0274 ☐ 0276 ☐ 0278 ☐ 0279 ☐ 0280 ☐ 0281 ☐ 0283 ☐ 0285 ☐ 0290 ☐ 0291
☐ 3 Concrete	☐ 0300 ☐ 0301 ☐ 0310 ☐ 0320 ☐ 0330 ☐ 0340 ☐ 0350 ☐ 0370 ☐ 0380
☐ 4 Masonry	☐ 0400 ☐ 0401 ☐ 0410 ☐ 0420 ☐ 0455
☐ 5 Metals	☐ 0500 ☐ 0512 ☐ 0514 ☐ 0521 ☐ 0531 ☐ 0532
☐ 6 Wood and Plastics	☐ 0600 ☐ 0610 ☐ 0650
☐ 7 Thermal and Moisture Protection	☐ 0710 ☐ 0711 ☐ 0714 ☐ 0715 ☐ 0719 ☐ 0720 ☐ 0721 ☐ 0722 ☐ 0724 ☐ 0725 ☐ 0730 ☐ 0750 ☐ 0751 ☐ 0753 ☐ 0760 ☐ 0790
☐ 8 Doors and Windows	☐ 0800 ☐ 0810 ☐ 0820 ☐ 0830 ☐ 0833 ☐ 0836 ☐ 0839 ☐ 0850 ☐ 0860 ☐ 0861 ☐ 0880
☐ 9 Finishes	☐ 0900 ☐ 0910 ☐ 0920 ☐ 0925 ☐ 0930 ☐ 0950 ☐ 0965 ☐ 0968 ☐ 0970 ☐ 0971 ☐ 0990 ☐ 0995
☐ 10 Specialties	☐ 1015 ☐ 1020 ☐ 1024 ☐ 1027 ☐ 1030 ☐ 1040 ☐ 1050 ☐ 1052 ☐ 1053 ☐ 1054 ☐ 1060 ☐ 1065 ☐ 1070 ☐ 1075 ☐ 1080
☐ 11 Equipment	☐ 1100 ☐ 1161
☐ 12 Furnishings	☐ 1201 ☐ 1230 ☐ 1250 ☐ 1260 ☐ 1270
☐ 13 Special Facilities	☐ 1300 ☐ 1304 ☐ 1305 ☐ 1306 ☐ 1307 ☐ 1318 ☐ 1319 ☐ 1320 ☐ 1321 ☐ 1322 ☐ 1323 ☐ 1324 ☐ 1325 ☐ 1326 ☐ 1328
☐ 14 Conveying Systems	☐ 1401 ☐ 1420 ☐ 1440 ☐ 1460
☐ 15 Mechanical	☐ 1525 ☐ 1530 ☐ 1540 ☐ 1550 ☐ 1555 ☐ 1565 ☐ 1574 ☐ 1589 ☐ 1595
☐ 16 Electrical	☐ 1600 ☐ 1605 ☐ 1620 ☐ 1630 ☐ 1639 ☐ 1640 ☐ 1650 ☐ 1655 ☐ 1660 ☐ 1661 ☐ 1671 ☐ 1685 ☐ 1694
4. ☐ NOT APPLICABLE	No portion of DOE Order 6430.1A is applicable to this Design.
5. ☒ AS-BUILT	ECO is for as-built field verified changes only.

NOTE: A check placed in the Division column signifies that the entire Division shall be applicable to the Design, unless modified by checks indicated for specific Subdivisions.

COMMENTS: _____

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT 4/11
Page 4 of 19/1

1. Drawing: 54-W-001-W ECO Number: 6493

2. ECO Search List: 5071 _____
5147 _____
6457 _____

3. Description of Change:

Include Description of 10HP FAN IN ABOVE

N 460, E 0 & N 780, E 0,

Actual Length of Duct (Configuration ETC.) To Be
Included In Mark-Up of 54-W-001-W when
Asb. It Is Complete,

- Drift Have Been Enlarged As Shown,

4. Drawing Cog. Engineer Approval: Richard J. Lee Date: 12/20/2011

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT
REV. 4/11
11/11/92
Page 5 of 4

1. Drawing: 54-W-002-W ECO Number: 6493

2. ECO Search List: 5071 _____
6457 _____

3. Description of Change:

Include Description of 10HP FAN IN ALLOVE
N 460, E 0 & N 780, E 0,

Actual Length of Duct (Configuration ETC.) To Be
Included In Mark-Up of 54-W-001-W when
Asbuilt Is Complete,

- Duct Have Been Enlarged As Shown.

4. Drawing Cog. Engineer Approval: Richard L. Smith Date: 12/20/91
Richard L. Smith 11/16/92

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT
Rev 6/11
11/11/97
Page 5 of 5

1. Drawing: 54-W-004-W ECO Number: 6493

2. ECO Search List: 5071
6457

3. Description of Change:

Include Description of 10HP FAN IN ALCOVE
N 460, E 0 & N 780, E 0.

Actual Length of Duct (Configuration ETC.) To Be
Included In Mark-Up of 54-W-001-W when
Asbuilt Is Complete.

- Duct Have Been Enlarged As Shown

4. Drawing Cog. Engineer Approval: Richard T. Smith Date: 12/25/97
Richard T. Smith 11/16/97

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

DRAFT

Rev. 7/11
14/7/11
Page 7 of 1

1. Drawing: 54-W-005-W ECO Number: 6493

2. ECO Search List: 5071 _____
6457 _____

3. Description of Change:

Include Description of 10HP FAN IN ALCOVE
N 460, E 0 & N 780, E 0,

Actual Length of Duct (Configuration ETC.) To Be
Included In Mark-Up of 54-W-001-W when
Asbuilt Is Complete.

- Duct Have Been Enlarged As Shown

4. Drawing Cog. Engineer Approval: Richard L. Lee Date: 12/20/01
Richard L. Lee 9/16/97

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

Page 8 of 1

1. Drawing: 54-W-006-W ECO Number: 6493

2. ECO Search List: 5071 _____
6457 _____

3. Description of Change:

Include Description of 10HP FAN IN ALCOVE
N 460, E 0 & N 780, E 0.

Actual Length of Duct (Configuration ETC.) To Be
Included In Mark-Up of 54-W-001-W When
Asbuilt Is Complete.

- Drift Have Been Enlarged As Shown

4. Drawing Cog. Engineer Approval: Richard L. Sand Date: 12/20/91
Richard L. Sand 11/16/92

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

11/17/92
KCS 9/11

Page 6 of 6

1. Drawing: 54-W-007-W ECO Number: 6493

2. ECO Search List: 5071
6457

3. Description of Change:

Include Description of 10HP FAN IN ALCOVE
N 460, E 0 & N 780, E 0.

Actual Length of Duct (Configuration ETC.) To Be
Included In Make-Up of 54-W-001-W when
Asbuilt Is Complete.

- Duct Have Been Enlarged As Shown

4. Drawing Cog. Engineer Approval: Res. L. H. Lee Date: 12/20/91
Res. L. H. Lee 11/18/92

9a
DRAWING CHANGE SHEET
(1 SHEET PER DRAWING)

ACS
11/16/92
Page 10 of 11

1. Drawing: 54-W-012-W ECO Number: 6493

2. ECO Search List: 5071 _____
6457 _____
6467 _____

3. Description of Change:

Drifts To Be Enlarged As Shown,
See Page 11 of 11 of This ECO For Details,

4. Drawing Cog. Engineer Approval: R. J. Lark Date: 11/16/92

DRAFT

ATTACHMENT IV-5

**WIPP SUPPLEMENTARY ROOF SUPPORT SYSTEM,
UNDERGROUND STORAGE AREA, ROOM 1,
PANEL 1, DOE/WIPP 91-057**

DOE/WIPP 91-057
Revision 0

DRAFT

**Waste Isolation Pilot Plant
Supplementary Roof Support System
Underground Storage Area
Panel 1, Room 1**

October 1991

Waste Isolation Pilot Plant

DRAFT

DISCLAIMER

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Springfield, VA 22161

WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM
UNDERGROUND STORAGE AREA
PANEL 1, ROOM 1

D R A F T

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WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM
UNDERGROUND STORAGE AREA
PANEL 1, ROOM 1

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WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM
UNDERGROUND STORAGE AREA
PANEL 1, ROOM 1

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B	Destructive Tests
C	Support System Design
D	Geomechanical Monitoring Program

WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM
UNDERGROUND STORAGE AREA
PANEL 1, ROOM 1

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WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM
UNDERGROUND STORAGE AREA
PANEL 1, ROOM 1

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D	54-D-003-W2	Supplementary Roof Support Room 1, Panel 1, Steel Set Locations and Details
D	54-D-003-W3	Supplementary Roof Support Room 1, Panel 1, Steel Set Fabrication
D	54-D-003-W4	Supplementary Roof Support Room 1, Panel 1, Room 1 Cross-section
D	54-D-003-W5	Supplementary Roof Support Room 1, Panel 1, Wire Mesh and Lacing Detail

1.0 EXECUTIVE SUMMARY

D R A F T

WIPP is designed to provide a full-scale facility to demonstrate the technical and operational principles for permanent isolation of defense-generated transuranic waste. It is also designed to provide a facility in which studies and experiments can be conducted.

Dry Bin-Scale Tests are being planned as a portion of the WIPP Test Phase Performance Assessment Program described in the WIPP Test Phase Plan: Performance Assessment (DOE 1990 b). These Tests are anticipated to be conducted for a period of up to seven years. Room 1 of Panel 1 of the Underground Storage Area is to be used as the location of the Bin Scale Tests to investigate the generation of gas from the waste that is proposed to be stored at the WIPP in the near future.

The original design for the waste storage rooms in Panel 1 provided for a limited period of time during which to mine the openings and to emplace waste. Room 1 was scheduled to be filled in fewer than five years before being sealed. Initially mined to rough dimensions in 1986, Room 1 was later mined to finished dimensions in 1988. Information obtained from the Site and Preliminary Design Validation (SPDV) program indicates that the rooms in Panel 1 should remain stable without ground support and that creep closure would not adversely affect equipment clearances during at least five years following excavation.

The demonstration phase was later deferred and an experimental program including Bin Scale Tests was added for Panel 1. Delays in the test schedule have revised the date for first waste receipt. Therefore, based on the timing and scope of the test phase, an additional seven years of useful life may be required to complete the tests in Room 1, Panel 1.

To assess the long term stability of Panel 1, a panel of geotechnical experts was convened in April, 1991. The final report of the panel was issued on June 5, 1991. The panel agreed that the WIPP geotechnical monitoring program as used in the SPDV Test Rooms is adequate to provide early warning of deteriorating conditions in Panel 1. The panel reviewed the design and stability of the rooms in Panel 1 and concluded that these rooms could be expected to provide a useful life of at least seven years from the time of excavation (up to 11 years with a decreasing level of confidence) with routine maintenance (DOE, 1991). However, the panel also agreed that ground support measures could be used that would allow the Bin Scale Tests to be carried to completion. The test period as currently defined is up to seven years, thus requiring a room life of up to 12 years from when the room was mined. The following options or their combinations recommended by the Expert Panel have been evaluated to extend the life of Room 1 of Panel 1 and to provide added confidence in its ability to support the test program:

- Relying on the currently installed rock bolt system and upgrading, if necessary, based on the results of the geomechanical monitoring program.
- A ground support system using resin anchored rock bolts.
- Interlaced grout anchored wire cables and wire mesh to control rock falls.
- Cutting slots in the back and/or floor to relieve the lateral stresses.

Chainlink wire mesh pinned to the ribs (sidewalls), is provided to contain any minor spalling down to approximately 2.13m (7 feet) above the floor.

A conservative approach has been used throughout the design process. Areas where this has been done include the following:

- A minimum .76m (3 foot) grouted bolt length has been used where tests have shown 18 inches to be sufficient.
- The manufacturer's minimum yield load has been used for bolt design - tests give results 22-28% higher.
- The support effect of the existing 3.04m (10 feet) mechanically anchored rockbolts and the meshing and lacing has been disregarded.
- The wedge-shaped salt beam has inherent strength which has been disregarded.

As designed, the supplementary roof support system incorporates the four acceptance criteria stated above as well as five out of the seven Expert Panel recommendations. The support system can also be installed concurrently with bin operations. Figure 1-1 provides an isometric view of the support system for Room 1, Panel 1.

The geomechanical monitoring system represents an integral part of the roof support system design. The monitoring system is designed to monitor loads on each rock bolt, measure continuing creep and deformation in and around the room, identify stress loads on the rock and deflections of the steel channel supports.

The monitoring system allows for adjustment of loads in the rock bolts to accommodate room creep and to provide early indication of any unusual closure activity.

The test bins, within the standard waste boxes, are stacked two high along the ribs of the test room. The spacing is sufficient to allow personnel access between the bins for ground support installation, inspection, and routine ground control maintenance tasks.

In addition to the monitoring program, a testing program was implemented to confirm the validity of rock anchor calculations and installation procedures.

The testing program included destructive testing of rock anchors and a mock-up installation of a portion of the entire system.

The WIPP is committed to safely providing long term roof support.

SUPPLEMENTARY ROOF SUPPORT SYSTEM
UNDERGROUND STORAGE AREA
PANEL 1, ROOM 1

DRAFT

FIGURE 1-1. Isometric View Room 1, Panel 1, Supplementary Roof Support System

2.0 INTRODUCTION

WIPP is designed to provide a full-scale facility to demonstrate the technical and operational principles for permanent isolation of defense-generated transuranic waste. It is also designed to provide a facility in which studies and experiments can be conducted.

Bin Scale Tests are being planned as part of the WIPP Test Phase Performance Assessment Program described in the WIPP Test Phase Plan: Performance Assessment (DOE 1990 b). These Tests are anticipated to be conducted over a period of up to seven years.

Room 1 of Panel 1 of the Underground Storage Area is to be used as the location of the Bin-Scale Tests to investigate the generation of gas from the waste that is proposed to be stored at the WIPP in the near future.

The original design for the waste storage rooms in Panel 1 provided for a limited period of time during which to mine the openings and to emplace waste. Room 1 was initially mined to rough dimensions in 1986. Information obtained from the Site and Preliminary Design Validation (SPDV) program showed that the rooms would remain stable without ground support and that creep closure would not adversely affect equipment clearances during at least five years following excavation.

The demonstration phase was later deferred and an experimental program including Bin Scale Tests was added for Panel 1. Delays in the test schedule have revised the date for first waste receipt. Therefore, based on the timing and scope of the test phase, up to seven years of useful life are required to complete the tests in Room 1, Panel 1. This document presents the design for a supplementary roof support system for Room 1 of Panel 1 of the Underground Storage Area. System design and its implementation process is presented in Figure 2-1.

DRAFT

ROOF SUPPORT SYSTEM DESIGN AND IMPLEMENTATION

FIGURE 2-1. Roof Support System Design and Implementation
Room 1, Panel 1

3.0 DESIGN REQUIREMENTS

3.1 DESIGN CRITERIA/CONSIDERATIONS

The support system must be designed to accommodate the following criteria:

- 1) Provide a suitable supplementary roof support system to ensure that the Bin Scale Tests conducted in Room 1, Panel 1, of the Underground Storage Area will not be interrupted during the seven year period starting July 1991.
- 2) The basic design parameters are determined by geotechnical considerations such as the age of Room 1, existing and future ground deformations in and around Room 1, and the prevailing stratigraphy and stress conditions.
- 3) The support system takes cognizance of the recommendations of the Geotechnical Expert Panel.
- 4) The support system takes cognizance of Design Spec. No. D-0087.

3.2 DESIGN SPECIFICATIONS

Design specifications are contained in Document entitled "Design Spec., No. D-0087, Supplementary Roof Support for Room 1 of Panel 1."

3.3 DESIGN BASES

The Supplementary Roof Support System for Panel 1, Room 1, is a yieldable type support that consists of evenly spaced sets of 15 x 40 inverted steel channel sections supported by eleven rock anchors.

The design for the Supplementary Roof Support System for Room 1, Panel 1, is based on the following:

3.3.1 General

- The support system is able to be installed concurrently with bin operations.
- Safe access is provided for a minimum of seven years from July 1991.
- A minimum access height of 3.45m (11 feet, 4 inches), is provided after seven years.
- Support installation procedures take into account working within RMA boundaries.
- Corrosion is a non-impactive factor for the duration of the system installation, based on experience gained at the WIPP and in the potash basin mines.
- Because of accessibility limitations and RMA requirements during the testing program, only the center portion of Room 1 located between the ventilation bulkheads has been considered in this supplementary roof

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support design. Roof control for the remainder of the room will be addressed elsewhere at a later date.

3.3.2 Rock Mechanics

- The zone of rock between Anhydrite "b" and Anhydrite "a" is sufficiently stable to provide a good anchoring base for the support system rock anchors.
- Horizontal and vertical virgin stresses are equal at the repository horizon of 655m (2,150 feet).
- The geology and stratigraphy at Room 1, Panel 1, are similar to those in the SPDV Test Room area.
- Observations and measurements from the SPDV Test Rooms will be used as the bases for describing the deformation mechanisms occurring in Room 1, Panel 1.
- Creep deformations arise from differential stresses created as a result of excavating an opening of the given shape.
- Low-angle shear fractures will occur in the immediate roof rock, and once these have formed, roof movements into the excavation are increasingly associated with gravity rather than salt creep.
- The supplementary support system accommodates past and future room deformations.
- The roof failure mode is expected to be that of a detaching wedge, triangular in section, 10m (33 feet) wide and 2.13m (7 feet) high at the center. However, the design will accommodate, as a worst-case scenario, a rectangular section 33 feet wide and 7 feet high.
- The density of the immediate roof rock above Room 1, Panel 1, is 2,160 kg/m³ (135 pound per foot³) for all calculations.
- The rock anchor holes have a 7.6mm (3 inch) reamed-out section below the grouted portion that will be sufficient to prevent shearing of the tendons that may arise from differential lateral deformations that might take place in the roof rock.
- The roof expansion between the anchor horizon and hole collar is assumed to be 38mm (1.5 inch) per year.
- The maximum lateral differential deformation below Anhydrite "b" is assumed to be 12mm (0.5 inch).

3.3.3 System Design

- The system of rock anchors consist of resin grouted rock anchors, grade 60 steel, anchored above Anhydrite "b" horizon.
- Minimum resin bond length between anchor and salt is 0.91m (3 feet).
- The steel channel set assembly would act as a surface plate system that:

- Is capable of accommodating the design load
 - Is capable of accommodating monitoring devices that would allow continuous monitoring of bolt load
 - Allows detensioning of anchor loads as and when required
 - Assists in distributing the load between bolts
 - Is capable of supporting the lacing and meshing.
- Each rock bolt anchor extends downwards through the channel section plate for a distance of 18 inches to provide for a downward adjustment life of seven years. This accommodates the expected 38mm (1.5 inches) per year of roof expansion as well as the bearing plates and load cell assembly. If required, couplings will provide for additional adjustment.
 - Rock spalling in between sets is controlled by a system of wire mesh and lacing.
 - Floor maintenance will be carried out as and when required.
 - The transverse 16 mm (5/8 inch) diameter wire lacing ropes will be adjustable.
 - Rib spalling that may occur is contained by a wire mesh system that extends down to a height of approximately 2.1m (7 feet) above the floor.
 - No stability problems are expected from fracturing of the ribs, based on experience gained at the WIPP since the opening of the project.

3.3.4 Installation and Maintenance

- The bolt loads are readjusted when the load on a bolt reaches 1.1 times the design load.
- Existing 3.04m (10 foot) rockbolts may be removed in order to facilitate installation of the supplemental rockbolt supports.
- Existing instrumentation fixtures, installed cables, and piping will be relocated to the sides of the room to avoid damage during system installation and maintenance.
- Rock anchor holes will be drilled vertically with a tolerance of ± 2 degrees measured in such a way that the ends of the holes will not be closer than 0.5m (20 inches).
- Drilling tolerance for the depth of the hole is ± 25 mm (1 inch).

3.3.5 Testing and Monitoring

- A complete full-scale mock-up test will be carried out in Room 2. This will have at least five channel sets.

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- Quality control and creep tests will be carried out on each bolt. The test load will be taken to 1.33 times the maximum design load.
- The monitored data from Room 1 will be evaluated on an ongoing basis.
- The design loads for the rockbolts and associated anchoring system have been confirmed by the destructive tests that have been conducted.
- The geomechanical monitoring system is designed as an integral part of the support system and will:
 - Monitor the load on every rockbolt
 - Measure ongoing creep and deformation
 - Allow an assessment of the length of room life that might be obtained beyond seven years.

4.0 SYSTEM DESIGN

4.1. GEOLOGY AND ROCK MECHANICS

4.1.1 Rock Mechanics

Much of the understanding regarding the performance of excavations in salt at the WIPP has been gained from observations taken in the Site and Preliminary Design Validation (SPDV) Test Rooms. The case study presented by the roof fall in SPDV Test Room 1, together with numerical modelling results, provides the information for defining the size and shape of the rock wedge that must be supported by roof support system. This is assumed to have a triangular cross-section as shown in Figure 4-1.

The virgin in-situ stresses are one of the basic determining factors governing the rate of deformation in and around the mined opening.

The initial stress state at the repository horizon is established from Heims Rule for weak rocks (Hoek and Brown, 1980). This rule establishes the vertical stress as dependent on the depth of overburden and its average density, and the horizontal stresses to be equal to the vertical stress. Taking the average density for the overburden at the WIPP site as 2160 kg/m^3 (135 pound/foot³), the initial stresses at the repository horizon are about 2000 psi.

When a room is excavated in salt, the local virgin in-situ stress field is disturbed. The immediate initial response of the rock is to set up stress as if it were in an elastic rock, the so-called "time zero" response. Differential stresses are created around the excavation and it is these stress differences that drive the subsequent creep deformations that result in closure of the room.

With time, the stresses close to the excavation are relieved by creep of the salt into the excavation. Shear stresses develop at the strata interfaces due to the differences in the mechanical properties of the different rock types and lead to slippage at these contacts and eventually to bed separation. The presence of these strata interfaces further leads to the concentration of lateral stresses in the roof and floor beams leading ultimately to the development of low angle shear fractures. Once the shear fractures have developed, roof movements in an excavation are increasingly associated more with gravity effects than with salt creep. At this stage there are two processes at work in the strata above the excavation. These are:

- Creep of the salt - Salt creep is still occurring in the competent salt above the rock wedge and above the ribs.
- Kinematic movement of the immediate rock due to gravity - The rock wedge, if it is unsupported, will move down under its own weight. Figure 4-1.

Inclinometer measurements, in vertical and horizontal boreholes, give the horizontal and vertical deflections of these boreholes in the rooms roof and ribs respectively. The effect of the 2.13m (7 foot) clay seam can clearly be seen as a large relative horizontal difference in the movement of the salt immediately below the clay seam.

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FIGURE 4-1. Kinematic Movement of the Rock Wedge

Extensometers located in the roof, ribs and floor measure the extensions at different distances along the lengths of their boreholes. Closure meters measure the closure of the rooms, either between roof and floor or rib to rib. A composite picture of how the rock is deforming and moving into the excavated room is obtained when inclinometer, extensometer, and closure measurements are put together. The Expert Panel unanimously agreed that the mechanism of deformation at Room 1, Panel 1 would be very similar to that experienced at the SPDV Test Rooms. For further detailed discussion and information on Geology and Rock Mechanics at WIPP, refer to Appendix A.

4.1.2 Stratigraphy

The proposed underground storage facility is located 655m (2,150 feet) below the surface in bedded salt of the Permian Salado Formation. This formation consists primarily of halite, argillaceous halite, minor anhydrite, and minor polyhalitic units. Over 365m (1,200 feet) of impermeable evaporitic deposits separate the facility horizon from the first overlying sedimentary rocks and 620m (2,034 feet) of evaporites lie below the facility horizon and provide a barrier to Permian limestones and sandstones. Figure 4-2.

The facility horizon lies within a 12m (39.4 feet) thick unit consisting of halite, argillaceous halite, and polyhalitic halite (Figure 4-3). A thin, 0.3m (.98 feet) to 0.5m (1.64 feet) thick layer consisting of anhydrite and polyhalite, and identified as Marker Bed 139 lies about 1.5m (4.92 feet) below the floor level. Anhydrite beds (less than 10mm [.03 feet] thick), called anhydrite "a" and "b" occur about 4m (13.12 feet) and 2m (6.56 feet) above the roof. Thin clay seams called Clay G and Clay H are associated with the bottom of these beds. In addition, an intermittent thin clay layer identified as Clay F is found in the immediate roof of excavations.

The anhydrite and clay layers have a significant impact on the mechanical performance of excavations. The clay layers provide interfaces along which slip can occur whereas the thick layers can provide a stiff anhydrite band within the strata sequence that does not deform plastically with time. For further detailed discussion and information on Geology at the WIPP, refer to Appendix A.

4.1.3 Vertical Movements

The vertical movement that the roof support must accommodate are a combination of salt creep, dilation of the salt due to fracture development, and gravity effects once fractures have formed.

The total roof expansion that has to be accommodated has been taken as 38mm (1.5 inches) per year at midspan.

4.1.4 Lateral Movements

Lateral displacements occur at strata interfaces and within the immediate roof beam where discrete fractures have formed. These lateral differential displacements have been observed up to 15m (50 feet) into the roof at strata changes particularly the clay/salt contacts. The largest shifts are found at the clay/salt contact below the Anhydrite "b" layer. Lateral shifts can also be expected within the immediate roof beam where fractures form. The support system has been designed to accommodate a lateral shift of 12mm (.5 inch) per year and bed separation of 25mm (1 inch) per year at the clay/salt contact below the Anhydrite "b" layer once the bond at the interface is disrupted.

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FIGURE 4-2. Generalized Site Stratigraphy

FIGURE 4-3. Stratigraphy of the WIPP Repository Horizon

4.1.5 Anchor Horizon

The zone in which rock anchors were to be installed had to satisfy three main criteria:

- It had to be relatively stable, in that the creep deformations occurring in it should be low.
- The effect of installing anchors in it should not induce loading conditions that would increase the creep deformations significantly or reduce the overall strata stability at that horizon.
- Penetration of roof stratigraphy should be kept to a minimum.

The reasons for going into the zone above Anhydrite "b" can be summarized as follows:

- Rock mechanics data from extensometers, inclinometers and borehole surveys have shown that the zone above Anhydrite "b" is relatively stable. This was in part due to the fact that the well-defined clay seam associated with Anhydrite "b" served to concentrate differential stresses in the immediate roof rock below Anhydrite "b". The reason for this phenomenon arose from the inability of the clay seam to sustain shear stress.
- Large numbers of 3.04 m (10 feet) mechanically anchored rock bolts had been installed at a fairly precisely defined horizon, some .91m (3 feet) above Anhydrite "b". After more than two years of installation, during which time the rock bolts were known to have developed load, there was no evidence from rock mechanics measurements of roof strata deformations that this concentration of anchoring load was causing any separation to occur.
- Sandia National Laboratory has a requirement that Anhydrite "a" should not be penetrated if this can be avoided.
- No separation has been observed to date across the Anhydrite "a" layer.
- The difficulties involved in drilling, reaming, and installing the grout anchored rockbolts increase rapidly with depth. In order to meet the required design requirements with a high degree of confidence the anchor horizon chosen is that above Anhydrite "b".

4.2 CONCEPTUAL DESIGN

Room 1 of Panel 1 is currently five years old and must remain accessible for an additional seven years in order to support the Bin Scale Testing program without interruption. In order to extend the life of Room 1, a supplementary roof support system has been developed to minimize the possibility of any roof fall during testing.

On February 4, 1991, a substantial section of roof fell in Room 1 of the SPDV area. Geotechnical instrumentation had indicated accelerated room closure rates for some time, and the roof fall had been anticipated for several months. At that time, the room had been open for almost eight years. The four SPDV rooms had been mined to exactly the same dimensions as the waste storage (and disposal)

rooms 91.4m (300 feet) long, 10.05m (33 feet) wide, 3.96m (13 feet) high in Panel 1, in order to simulate, monitor, and study their behavior in response to lithostatic (overburden) pressure over time. No ground support, such as rock bolts, had been installed.

In response to the roof fall in SPDV Room 1 and to assess the long-term stability of Panel 1, Westinghouse convened a panel of geotechnical experts in April 1991. The final report of this panel was released on June 5, 1991. The expert panel agreed that the WIPP geotechnical monitoring program as used in the SPDV Test Rooms is an adequate tool for giving early warning of deteriorating conditions in Panel 1. Based on collected geotechnical monitoring data, panel members concluded that the rooms in the panel are likely to have a total life of seven to eleven years from the time of excavation using the currently installed roof support system, consisting of 3.04m (10 feet) long mechanically anchored rock bolts. Mining of Room 1, Panel 1, began during the second half of 1986. Therefore, as of July 1991, the remaining life of Room 1 is anticipated to be between two and six years. However, the panel agreed that measures could be taken in Panel 1 that would give a reasonable assurance that the Bin Scale Tests could be carried out to completion. In order to carry out the Bin Scale Tests, a solution to the support problem had to be found to extend the required life of Panel 1 for up to seven years. The expert panel suggested alternative actions which included use of the following:

- The use of full column resin or resin anchor bolts;
- Grout anchored cable with lacing and wire mesh;
- Slotting and/or relief entries;
- Yielding support;
- Rely on currently installed support and upgrade when necessary;
- Roof trusses;
- Mining new rooms.

They also indicated that the measures should be augmented by a monitoring program that would regularly assess the geomechanical conditions and that maintenance should be carried out as a routine activity in the rooms as they aged.

The WIPP project has evaluated the support systems suggested by the Geotechnical Expert Panel.

The initial evaluations looked at support systems (wooden cribs, wooden cribs with steel beams) that could be installed within the room and would provide a passive support as the rock deforms into the room. These systems were eventually abandoned because they interfered with the functional use of the room largely as a result of the physical size of the supports. They limited the number of bins that could be placed in the rooms and more importantly, the support could not be placed where it was most needed (i.e., midspan where the largest loads are developing) without eliminating equipment access to the bin locations.

Another form, a yielding support system, was then considered. This eliminated any need for bin removal and provided a more uniform support of the roof strata. The yielding system consisted of deep grout anchored rock bolts supporting a

steel cross beam with supplemental support being provided by yielding steel columns. The beam anchor bolts were designed so that their loads could be continually monitored and adjusted to accommodate room deformation by lowering the beam. As the design process became more detailed, it became clear that the major share of the load was carried by the beam support bolts; the yielding columns were in fact unnecessary and were therefore eliminated from the design. The beam itself was also modified from an initial I-beam to a more structurally convenient inverted channel section. This eliminated complex attachment plate structures needed for the I-beam suspension system. Any roof rock spalling between the steel sets is contained by a network of steel wire rope lacing underneath a mat of steel meshing and expanded metal.

As designed, roof support for Room 1, Panel 1, is providing the following:

- Progressive support of the detaching triangular wedge of roof rock as it develops.
- Containment of the detaching wedge of roof rock and safe control of the rate at which the detaching section moves downward based on the creep rate produced by the roof strata above.
- Accommodation of lateral movements in the roof strata above.

Throughout the design process, a conservative approach was used. The design is largely based on the room deformations and subsequent roof fall that took place in SPDV Test Room 1, which is seen as a worst case scenario. Previous resin grout anchor tests have shown that an eighteen inch bond length of grout would be sufficient, whereas a minimum .91m (3 feet) bond length is used in this design. The rock bolt design is based on the manufacturer's minimum yield strength of 209,000N (47.4 kips), whereas the destructive tests carried out in Room 2, Panel 2 gave actual minimum yield strengths 22% to 26% higher. A continuous channel section beam is used where individual plates would have been sufficient. Very little support capability has been assigned to the meshing and lacing, whereas it is certain that this will be capable of a considerable load carrying capacity. No strength has been assigned to the wedge-shaped rock salt beam formed as a result of roof fracture formation. It will have an inherent strength, this effect being enhanced by the existing 3.04m (10 foot) mechanically anchored rockbolts as well as the steel meshing and lacing. The existing system of 3.04m (10 foot) mechanically anchored rockbolts, installed on a 1.2m (4 foot) by 1.5m (5 foot) spacing have considerable load bearing capability which has been disregarded in the design.

The net effect of all the above factors when added together means that the design is very conservative, thus reducing the risk of potential failures.

4.3 DESIGN DESCRIPTION

The yielding roof support system for Room 1 of Panel 1 is designed to contain and support the detaching load while allowing it to be lowered. The system is not designed in any way to prevent the creep of rock into the room. The roof support consists of 27 steel channel support sets installed laterally across the room on 2.37m (7.8 feet) to 3.04m (10 foot) centers. The actual location of the channel sets will be determined in the field during their installation based on the location of the existing roof bolts which are installed on a 1.2m (4 foot) by 1.5m (5 foot) pattern. This is to minimize interference with the existing roof bolts.

Each support set is secured by 11 Dwyidag steel tendons (anchor bolts) that are 4.0m (13 feet) long. The resin grouted anchor bolts are anchored in between the Anhydrite "a" and the Anhydrite "b" horizons. The channel support anchor bolts are designed so the load of each bolt can be monitored and adjusted to accommodate continuous roof deformation. System adjustment is accomplished by keeping the tension on each anchor bolt within the design limits which are calculated to support the detaching load. Once the tension in the anchor bolt reaches the design limits, the bolt load is then relieved. Each anchor bolt extends .46m (18 inches) below the roof to accommodate downward movement of the roof due to creep. Roof strata extension measurements have shown that the anchor bolts will have to accommodate approximately 38mm (1.5 inches) of movement per year. To allow for differences in lateral deformations, each tendon is located in an oversized .08m (3 inch) diameter hole extending from the hole collar to the Anhydrite "b" clay horizon.

In order to cater for the possibility of shear and bending at Anhydrite "b" exceeding these limits, a set of five test anchors and four observation holes will be installed in Room 2 as a part of a mock-up. Periodic proof testing of the test anchors would be conducted when observations indicate that shearing and bending of the anchors are occurring.

The roof area between the channel sets is covered by a network of steel wire lacing cables underneath a mat of steel wire mesh and expanded metal. This mat is held in place by the channel support sets. Its function is to contain any rock spalling in between the channel support sets.

4.3.1 Steel Channels

Each roof support set consists of a structural steel channel placed with the web flat against the roof, running across the room (rib to rib) and 11 rock anchor bolts. The set is designed to accommodate the triangularly distributed wedge load. Eleven rock anchor bolts are required to support the channel. In the unlikely event that the roof detaches as a rectangular shaped section, the anchor capacities are sufficient to cater for this extra load.

The support channel is a 15 x 40 channel section 8.2m (27 feet) long. Each channel set consists of three 2.7m (9 foot) long sections connected together with four .19m (7.5 inch) by .08m (3 inch) splice plates. Two of these splice plates are welded to each end of the section center. The other channel is then connected by a .02m (.625 inch) bolt passing through the un-welded end of the plate and through the flange. The plates are placed on the outside of each flange and have a .04m (1.5 inch) long slot in which the bolt passes through; this allows for a small horizontal movement in each of the sections without affecting its performance. The channel has been divided in to three equal sections for ease of transport and installation.

The rock anchors are fastened through the centerline of each channel. The anchors are spaced every .61m (2 feet) in the middle of the room and every .76m (2.5 feet) or .91m (3 feet) near the ribs. Each rock anchor passes through a .04m (1.5 inch) diameter hole in the channel which allows for a .006m (.25 inch) tolerance in placing the anchors in the salt.

Each rockbolt will be tested to ensure its quality of installation. These tests are described in section 6.1.2.

Detailed channel support calculations are given in Appendix "C".

4.3.2 Rockbolts

The rock anchors that support the roof load are the most critical element of the design. The rockbolts are 4.0m (13 feet) long threaded No. 8 Dywidag rods with a 209,000N (47,400 pound) minimum yield strength. The rock anchors are inserted 3.5m (11.5 feet) into the roof and anchored between Anhydrite "a" and Anhydrite "b" horizons. The rock anchors are anchored by resin which bonds at least .91m (3 feet) of the bolt to the salt using one .84m (33 inch) long resin cartridge. Each rockbolt extends .46m (18 inches) below the roof to allow the back to expand downwards while supporting the load.

Since the assumed pattern of the detaching load is uneven, the design tension in each rockbolt is different. However, the suspension capacity of the rockbolts is such that all bolts can handle the maximum load which would be the case if the detached wedge was rectangular in section. Each anchor is to be monitored to ensure that the nuts are relieved before the tension rises above the designed limit. Further details regarding the design of the rockbolts are provided in Appendix "C".

4.3.3 Wire Mesh and Lacing

A mat of wire mesh and lacing is installed between the channel sets. The primary function of the mesh and lacing is to keep small pieces of salt from falling down from the roof. The lacing is made of .02m (.625 inch) diameter wire ropes placed not more than .91m (3 feet) apart in both the longitudinal and transverse directions. Above this, a layer of .10 x .10m (4 inch x 4 inch) welded wire mesh is placed. And lastly, a 10 gauge small aperture expanded metal is placed against the salt.

The transverse wire lacing ropes are approximately 9.1m (30 feet) long and extend from rib to rib. Each rope is anchored in place by 2.4m (8 feet) resin anchored rockbolt. For ease of channel installation, the wire mesh and expanded metal are temporarily attached to the existing 3.0m (10 foot) roof bolts and/or Hilti bolts.

4.3.4 Rib Support

The fracturing which is occurring in the ribs along potential failure planes, is similar to those in the roof. However, based on experience elsewhere at the WIPP, this fracturing is not expected to result in any serious stability problems over the anticipated working life of Room 1. Small scale flaking and peeling off of small pieces of rock will take place, these being expected to have a nuisance value as well as posing something of a threat to installed piping and cabling.

Wire mesh is therefore extended from the end of the channels in the roof, around the corners, and down the rib to a height of approximately 2.13m (7 feet) above floor level. This extra wire meshing is pinned to the wall with 1.2m (4 feet) mechanical rock bolts. The mesh and bolts do not prevent the flaking from occurring but contain it and allow subsequent removal and maintenance. This is standard practice in the WIPP underground to accommodate rib spalling.

4.4 DESIGN CALCULATIONS

Detailed design calculation for the Room 1 of Panel 1 roof support system are included in Appendix "C".

5.0 DESIGN IMPLEMENTATION

5.1 SURVEYING AND MARKING

The locations of currently installed rock bolts, and instrumentation equipment that may interfere with support installation has been accurately surveyed and is shown on a map of Room 1 (Drawing No. 54-D-003-W1 and 54-D-003-W2). These drawings will be used to locate the positions of the channel support sets and their associated rock anchors. Roof profiles will be determined at each channel support set location. Once the channel set locations have been plotted on the room map, they will be transferred underground and marked on the roof and ribs of the room. Individual rock anchor holes will then be accurately marked to determine precise locations of the anchor bolts. Experience has shown that a minimum accuracy of $\pm .063\text{m}$ (.25 inch) will be achieved while marking the positions of the boreholes.

5.2 RELOCATION OF INSTRUMENTATION, CABLES AND PIPING

Any damage to the existing instrumentation installations consisting of electric cables, gas piping, distribution boxes and lighting fixtures must be avoided during installation of the support system. For that reason, the suspended cabling will be moved to the side of the room and attached to the rib, and the piping will be lowered. Relocation of these fixtures will not affect the testing and monitoring program. Conveyor belting suspended from the rib will also be used to provide additional protection to the existing equipment.

5.3 SYSTEM INSTALLATION

5.3.1 Rock Drilling

5.3.1.1 Steel Channel Anchor Bolts

Each channel set has been designed for 11 bolt anchor holes which are to be installed vertically. It is required that all bolt anchor holes are drilled to a specified depth of 3.55m (11.5 feet), measured from the hole collar. An allowable vertical alignment tolerance of 2 degrees and a depth tolerance of .025m (1 inch) are expected. Deviations of anchor bolt holes are to be addressed on a hole-by-hole basis so that the distance apart at hole ends will not be less than 20 inches. In order to achieve the specified vertical tolerance, collaring alignment holes are required. The holes shall be drilled as accurately as possible to vertical and to a minimum depth of .076m (3 inches). After completing the collar alignment drilling, a .035m (1.375 inch) diameter pilot holes of the correct length will be drilled. These will then be reamed to .076m (3 inch) diameter to a depth of approximately 2.13m (7 feet). To ensure that there is an acceptable annulus in the anchorage zone, all .035m (1.375 inch) ± 0.030 diameter finishing bits will be properly gauged. Drawing No. 54-D-003-W2 provides details of the drilled hole.

5.3.1.2 Cable Lacing Anchors

The support system requires that lacing across the room width and length be terminated with resin grouted rock anchors and be provided with means for tensioning the cables. Lacing cable termination anchors will consist of a truss plate fastened to the roof by a .016m (5/8 inch) diameter and 2.4m (8 feet) long resin grouted bar. An adjustable eyebolt will pass through a truss plate and the

lacing cable will be terminated through this eyebolt as shown on Drawing No. 54-5-003-W5. The termination anchor holes will be drilled at 45° angle to a depth of 2.4m (8 feet) with drilling accuracy of ± 0.025 m (1 inch). Drilling detail for lacing holes anchors are shown on Drawing No. 54-5-0003-W4.

5.3.1.3 Rib Support Anchors

The rib anchors are installed to hold the chainlink wire mesh against the rib from the top corner down to approximately 2.13m (7 feet) above the floor. The chainlink meshing is installed to support small pieces of loose or broken salt. Chainlink meshing is currently used at the WIPP as a standard practice for rib maintenance underground. The rib anchors are standard 1.22m (4 feet) long mechanical anchors. Rib support anchor holes are drilled on approximately 1.52m (5 foot) pattern and are 1.22m (4 feet) deep to accommodate the anchors.

5.3.1.4 Recovery Operations

In the event that drilling tolerances or anchorage capacities are not met, the hole depth will be extended an additional .91m (3 feet). The anchor will be reinstalled at this depth.

5.3.2 Installation Sequence

5.3.2.1 Steel Anchor Bolts

Installation of the roof support system in Room 1, Panel 1, will commence with drilling of the steel channel anchor holes and installation of Dywidag anchor bolts.

Correct installation of the Dywidag anchors is critical to the whole support system. The minimum bond length of .91m (3 feet) is required in order to maintain design load capacity of the support system. This has been confirmed by the destructive tests described in Appendix B of this report. A minimum of .457m (18 inches) of the anchor bolt measured from the hole collar will protrude from the mouth of the drill hole. Both the Dywidag tendons and the resin will be installed according to the manufacturers specifications. Following anchor installation, each bolt will be quality checked to confirm its anchorage capacity. Details regarding quality control testing are included in Section 6.1.2.

5.3.2.2 Wire Mesh and Lacing

The wire mesh and lacing will be installed after testing of the anchor bolts is completed and advanced enough to provide adequate working space for wire mesh hanging operations. This would allow for simultaneous installation of wire mesh, cable lacing, and drilling of anchor holes. The wire mesh system consists of two layers, a layer of .10m x .10m (4 inch x 4 inch) welded wire mesh and another layer of expanded metal which is installed directly against the salt and above the welded wire mesh layer.

Both layers are attached to the existing 3.04m (10 foot) rock bolt plates in order to provide temporary suspension until the lacing and channel supports are finally installed. Drawing No. 54-D-003-W5 shows the installation detail of the meshing and lacing. The wire lacing rope will be doubled back through one of the eyebolts attached to the anchor plate, and the free end clamped with three crosby clamps. The loose end will then be passed through the opposite eyebolt and snug

ensioned by means of a come-along and clamped with three crosby clamps. The transverse lacing will be installed before the longitudinal ropes.

.3.2.3 Steel Channel Sets

The .381m (15 inch) by 177.92N (40 pound) channel steel set will be installed in three 2.74m (9 foot) long sections with the flanges down. Each section will be joined in place by the splice plates located along the flanges. An .356m (14 inch) wide by 2.743m (9 foot) long by .0191m (.75 inch) thick treated plywood gasket will be placed on top of the channel with .038m (1.5 inch) holes drilled to coincide with the hole pattern of the channel. The plywood gasket will first be fitted over the anchor bolt ends, thus forcing them to be correctly aligned before installation of the steel channel is attempted. The steel channel sections will be installed next, by passing the protruding Dywidag anchor ends through the .0381m (1.5 inch) pre-drilled holes. The final step will be the installation of the fastening nut assemblies, together with their associated plates and load cells. Drawing No. 54-D-003-W3 shows the channel support details. A setting load of 4448.22N (1000 pound) will be applied to the anchors. Steel spacers will be used to ensure contact at the rock anchor positions.

.3.2.4 Rib Support

Installation of the rib support system will commence with drilling of the rib anchor holes followed by hanging of the chainlink mesh together with anchor installation. Approved current WIPP installation procedures for rib bolting will be followed.

Since the rib support system is intended for protection against small scale flaking and peeling of small rock which are of nuisance value, its installation sequence will depend more on convenience than on a rigid schedule.

6.0 TESTING AND MONITORING

The most important component of the roof support system described herein is the rock anchor system. After each Dywidag rock anchor is grouted, both in the mock-up test as well as during actual Room 1 installations, the rock anchors will be subjected to performance tests. The testing will be carried out using as a guideline the specifications laid down in "Recommendations For Prestressed Rock And Soil Anchors", 1989, produced by the Post-Tensioning Institute of Phoenix, Arizona.

Monitoring of the loads on the rock anchors will be done during the test phase as well as prior to the actual installations. The information will be used to determine when and by how much the loads should be adjusted in order to keep pace with the deformation of the salt rock into the room. In addition to monitoring rock anchor loads, deformations in and around the room as well as deflections of the supporting channels will also be monitored. These measurements will enable a clear picture of the room stability to be obtained.

Three inch diameter, 12 foot long observation holes will be installed to monitor the development of shear offsets within the immediate roof, particularly in relation to the potential impact of such shearing on rock bolt performance. Any instrumentation that is destroyed or becomes defective during the operation of Room 1 will be replaced.

6.1 TESTING

6.1.1 Mock-up Test

A mock-up test will be performed in Room 2 of Panel 1 and will include installation of five complete channel sets. The objectives of the mock-up tests are as follows:

- Provide information necessary to evaluate existing equipment;
- Establish practical and safe installation procedures;
- Install and test monitoring equipment;
- Check the performance of the overall system as well as individual components;
- Establish procedures for rock anchor performance tests, and ensure that personnel are proficient in the use of these tests.

6.1.2 Quality Control Testing

The purpose of Quality Control testing is to ensure that every rock anchor installed is capable of handling at least 1.1 times the maximum design load. Because of the large number of bolts (approximately 300) to be installed, these tests have to be done as quickly as possible.

After a rock anchor has been installed for a minimum of 8 hours, it will be loaded to 26 kips (1.1 times the design load). The loading arrangement is shown in Drawing No. 54-D-003-W2. The load will be measured by the load cell and conveniently displayed during loading. After reaching 26 kips, the nut will be

tightened and the loading ram removed. The load will be continually monitored for a minimum of 1 hour to check whether there is any loss of load due to creep. If there is a load loss, the load will be reapplied and monitored. This will be repeated until all "slack" in the system has been removed, or the rock anchor installation is deemed to be unsatisfactory. Recovery operations as detailed in Section 5.3.1.4 may then be instituted. The above procedure may be modified based on field experience.

6.1.3 Destructive Tests

The main component of the support system described in this design document is the rock anchor system.

The primary emphasis of the anchorage system testing program is to guard against the most probable modes of movement that may lead to its failure. The importance of field validation tests of the anchorage system has been recognized as essential to the success of the whole support system.

The rock anchor system was tested by loading correctly installed bolts to destruction. These destructive tests determined that the anchorage capacity of the No. 8 Dywidag rockbolts tested in Room 2 of Panel 1, are equal or greater than guaranteed manufacturers specification of (47.4 KIPS) yield load or (71.1 KIPS) of ultimate load used for support system design. Details of the tests and the results obtained are given in Appendix B.

6.2 MONITORING

Since the support system will be adjusted during its operational life, it is essential to ensure that the loads on the anchors do not exceed the working loads specified by the design. The two main parts of the monitoring program will be observations of room performance and of support performance.

Room stability will be determined from data that will establish the rock mechanics performance of the excavations in terms of room closure, rock deformations in and around rooms, the development of fractures and bed separation at strata interfaces.

The support system performance will be determined from tests that will provide input data from field tests for the design, from tests to prove quality during installation, and from a program that will monitor loads that develop in the rock anchors and on the lacing during the working life of the support. The evaluation of the rock mechanics data characterizing room performance and of the support performance data will establish the effectiveness of the support system. A description of the Geomechanical Monitoring Program including specifications for the instruments is given in Appendix "D".

6.2.1 Geotechnical Monitoring

Geomechanical instrumentation can adequately establish the performance of excavations at the WIPP and provide adequate warning of deteriorating conditions. This has been demonstrated by the early warnings provided in SPDV Test Room 1 prior to its roof fall, and was confirmed by the views expressed by the Geotechnical Expert Panel convened to establish an estimate of the life of Panel 1 (US DOE, 1991 91-023). The geomechanical instrumentation for Room 1, Panel 1, has been upgraded based on a monitoring program presented to the

Geotechnical Expert Panel (US DOE, 1991 91-023). The basis of the revised monitoring program is:

- The measurement of deformations across the Anhydrite "a" and "b" layers in the roof in order to assess the development of bed separations at these strata interfaces.
- The measurement of room closure in order to assess the development of closure rates that exceed bounding levels and to establish the development of asymmetric room closure that may be an indication of fracture development along one rib and rotation of the roof slab. These measurements will be made by convergence measurements of roof/floor and wall/wall closure.
- The observation of conditions in the roof in observation boreholes in order to establish the extent of fracturing and bed separation.
- The measurement of lateral deformations within the pillars to establish the competency of the pillars. These measurements will be made by means of borehole extensometers.

6.2.2 Support System Monitoring

Monitoring of the support system under working conditions in the field is an integral element to ensure its successful performance. The monitoring program consists of measurement of:

- The load that develops in each rock anchor. This provides the basis for adjusting the tension on the anchor so that the load build-up does not exceed the design limits of 1.1 times the design load while accommodating the continued movements of the salt. The load will be measured by means of load cells located at the anchor nut.
- The load that develops on the lacing and mesh. This will be evaluated over selected lengths of the room. The load will be measured by means of hydraulic flat jacks located at cross-over points of the lacing.
- The extension of the cables due to the development of the load due to the detaching wedge. The cable deformation will be measured by means of a calibrated standard length and dial indicator.
- The deflection of the channel support arising from the action of the rock anchor supports and the load transferred by the lacing and meshing. The deflection will be measured by precise surveying techniques.

The purpose of the monitoring of lacing and meshing loads and extensions is to gather information for later analysis. Initially, the monitoring will be carried out daily but this frequency will be adjusted as data becomes available on the load changes with time. The measurement frequency will be based on observing load changes equivalent to 2 percent of maximum working load. The measurements of the loads will be compared with the criteria presented in Appendix "D" to establish when loads in the rock anchors must be adjusted, and the extent of that adjustment:

It should be noted that these criteria are preliminary. Field tests and analytical computations will be performed in order to more effectively define these criteria and the method of load adjustment that will be based on them.

The criteria and the adjustment to the loads will be reviewed as data becomes available and may be changed to be more effective. The process by which these factors become adjusted will require approval by the manager of Engineering for the Managing and Operating Contractor with concurrence from the managers of Operations and Safety.

6.2.3 Instrumentation

Geomechanical Instrumentation installed in Room 1 of Panel 1 will include:

- Beam support rock bolt load cells - Rock bolt load cells will be used to monitor the axial loading on the rock bolts. Loads on the cells are measured by means of resistance strain gages bonded to the cell in a full bridge configuration. The load cells are capable of monitoring loads of up to 444,800N (50 tons) with an approximate instrument sensitivity of 88.9N (20 pounds). In order to maximize the adjustment range of the support system, a low profile type cell will be used.
- Pressure cells or flat jacks - will be used to monitor loading on the cable lacing and mesh as a result of creep displacement. Pressure cells will be constructed of stainless steel and be capable of monitoring the range from 0 to 70 MPa (0 to 10,000 psi) with sensitivity of 0.4 per cent.
- Extensometers - Five borehole extensometers are installed in Panel 1, Room 1, to monitor rock mass deformation adjacent to the excavation. Three extensometers are installed in the roof to monitor possible bed separation within the roof beam. These extensometers are installed along the centerline in the middle at approximately 1/4 length locations of the room. Horizontal extensometers are installed in each wall at the center of the room.
- Convergence points - Convergence measurements will be taken from installed convergence points throughout the room. These measurements are used to determine the amount and rate of closure at selected points. Monitoring of horizontal and vertical convergence will allow for a comparison of the performance of the support system in response to the actual room closure.
- Level survey - Changes in elevation will be monitored at selected locations along the support beams and the rock surface. The elevation surveys will identify areas of differential movement which, in addition to the results from installed geomechanical instrumentation, will establish the response of the system to creep closure.

Due to the large number of instruments, a data acquisition system will be installed. This system will be capable of monitoring up to 330 resistance strain gaged rock bolt load cells. The data loggers will be incorporated into the Geomechanical Instrumentation System which will allow for timely monitoring and reporting.

7.0 ADDITIONAL REQUIREMENTS

Quality of installation and monitoring is of key importance to the successful performance of the support system.

- In order to provide continuity to all the activities and assure future system performance a Project Control Group shall be assembled to oversee all installation and monitoring activities. This group shall include representatives from Mine Engineering, Geotechnical Engineering, Mine Operations, Quality Control, Safety and an outside project consultant.
- Collected monitoring data shall be routinely reviewed and results compared with design parameters.
- Periodic progress reviews shall be conducted to evaluate system performance and to define possible changes to the system not foreseen during design stage.
- Possible further testing might be required to define performance of individual components.
- Further steps shall be taken to develop and validate a mathematical or numerical model which would more easily describe the behavior of the support system.

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DRAFT

WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM

DRAWINGS

Westinghouse Electric Corporation
Waste Isolation Division
Carlsbad, New Mexico
October 1991

DRAFT

DRAFT

SECTION C-C
SPANNED WITH OVERLAP
U.S.
SEE NOTE 4

SECTION D-D
SPANNED WITH OVERLAP
U.S.
SEE NOTE 4

SECTION E-E
ONE SIDE OVERLAP
U.S.
SEE NOTE 4

SECTION F-F
ONE SIDE OVERLAP
U.S.
SEE NOTE 4

NOTES:

1. PLACEMENT OF SPANNED STEEL TO BE DETERMINED IN FIELD.
2. LOCATION OF ONE SIDE OVERLAP TO BE DETERMINED IN FIELD.
3. LOCATION OF STEEL LACING TO BE DETERMINED IN FIELD.
4. SPANNED STEEL AND ONE SIDE OVERLAPPING SPANNED STEEL, FIELD OVERLAPPING AND STEEL.

U.S. DEPARTMENT OF ENERGY	
Supplementary Roof Support	
Room 1, Panel 1	
WIRE MESH & LACING DETAILS	
DATE: 10/2/54	BY: 54-D-003-W5

DRAFT

① SUPPLEMENTARY SUPPORT ASSEMBLY
PLAN VIEW - ROOM 1 AT PANEL 1
UNIT OF 100' SQUARE

LOW DEFORMATION ZONE
PLAN VIEW - ROOM 1 AT PANEL 1
UNIT OF 100' SQUARE

DRAFT

1. NUMBER OF DAYS THE FIRM IS TO BE EXTENDED IS FIVE.
2. SMALL BUSINESS FIRM HAS BEEN EXTENDING COMPLAINT

U.S. DEPARTMENT OF ENERGY
Washington State Institute of
Steel Reinforcement Plant
Steel Reinforcement Plant
Steel Reinforcement Plant

SUPPLEMENTARY ROOF SUPPORT
ROOM 1, PANEL 1
STEEL SET LOCATIONS & DETAILS

AJ06 54-D-003-W2

Washington State Indian Council
State Indian Fair Fund
1974-75

**SUPPLEMENTARY ROOF SUPPORT
ROOM 1, PANEL 1
STEEL SET LOCATIONS & DETAILS**

LAU06 54-D-003-W2

DRAFT

DRAFT

SECTION A-A
 1/4" = 1' AT PANEL 1
 TO LINDSAY BUILDING
 STEEL SUPPORT

U.S. DEPARTMENT OF ENERGY	
Nuclear Energy Research and Development Administration	
SUPPLEMENTARY ROOF SUPPORT	
ROOM 1, PANEL 1	
ROOM 1 CROSS SECTION	
AUG 54-D-003-W4	

DRAFT

[illegible]

1. USE HOLES 3 AND 9 AS A TEMPLATE TO DRILL HOLES IN HOLES 6.
2. FINISH TAPPING HOLES 6 AND 7 UPON INSTALLATION.

[illegible]

DRAFT

WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM

APPENDIX A
Geology and Rock Mechanics

Westinghouse Electric Corporation
Waste Isolation Division
Carlsbad, New Mexico
October 1991

DRAFT

WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM

APPENDIX A
Geology and Rock Mechanics

Westinghouse Electric Corporation
Waste Isolation Division
Carlsbad, New Mexico
October 1991

DRAFT

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3.0	Properties of Rocks at Repository Horizon
4.0	In Situ Stress Regime
5.0	Structural Response of Excavated Room
5.1	Roof Deformation
5.2	Rock Deformations About Room
5.3	Stresses Around Room
6.0	Performance Requirements for Support System
6.1	Performance
6.2	Geotechnical Design Basis for the Roof Support System for Room 1, Panel 1
6.2.1	Rockload To Be Supported
6.2.2	Vertical Movements
6.2.3	Lateral Movements

GEOTECHNICAL DESIGN SUMMARY REPORT

DRAFT

1.0 INTRODUCTION

The purpose of this report is to provide the geotechnical basis for the design of a system to support the rock in the roof of Room 1, Panel 1. The system must ensure that the room meets the functional requirements necessary to support its use as an underground laboratory for the study of gas generation from CH TRU radioactive waste (Molecke, 1990). This research program, called the Bin Scale Testing Program, is under development at the present time and the experiments are expected to start in the second half of 1991. Room 1 of Panel 1 is currently 5 years old and must remain accessible for a further 7 years in order to support the bin scale testing program.

The Geotechnical Design Summary Report interprets the geologic and rock mechanics data presented in the annual Geotechnical Field Data and Analysis Reports (US DOE, 1991a; US DOE, 1990) and other occasional reports (US DOE, 1991b) and presents the geotechnical assumptions that have been made for the design. The geotechnical investigations at the WIPP are comprehensive and provide detailed information on the site conditions that is not typically available for an engineering design. This has enabled a phenomenological model to be established that explains the performance of openings. This model establishes the mechanisms that must be addressed by the design of the support system in order to control the roof conditions in Room 1, Panel 1.

Following the collapse on February 4th, 1991 of the roof in the Site and Preliminary Design Validation (SPDV) Test Room 1 that confirmed the concerns raised by the Geotechnical Engineering Section concerning the capability to maintain the Panel 1 room for the period of the bin scale tests, a panel of Geotechnical experts was formed to evaluate the life expectancy of the underground room in which the tests will take place. The panel concluded that if no additional remedial measures were taken, the rooms in Panel 1 are likely to have a total life of seven to eleven years from the time of excavation using the currently installed roof support system, consisting of rockbolts. Mining of Room 1, Panel 1 began during the second half of 1986. Therefore the remaining life of this room is anticipated to be between two and six years (US DOE, 1991b). The most current geotechnical field data from this room does not indicate that its geomechanical performance differs significantly from that observed in SPDV Test Room 1. On this basis, the remaining life for Room 1 as currently supported is about two to three years.

The panel members agreed that measures could be taken that would provide reasonable assurance that the bin scale tests could be carried out to completion in Panel 1. They suggested a number of alternative actions that could be taken and recommended that the WIPP project evaluate the alternatives and select one, or a combination, of measures that would assure continued use of the rooms over the period of the tests. They also indicated that the measures should be augmented by a monitoring program that would regularly assess the geomechanical conditions and that maintenance should be carried out as a routine activity in the rooms as they aged.

The proposed underground storage facility is located 655m (2150 feet) below the surface in bedded salt of the Permian Salado Formation. A generalized stratigraphy showing the facility level is given in Figure 2.1. Over 300m (1000 feet) of impermeable evaporitic deposits separate the facility horizon from the overlying sedimentary rocks and 620m (2000 feet) of evaporites lie below the facility horizon and provide a barrier to Permian limestones and sandstones.

Halite is the most abundant mineral in the Salado and occurs in thick beds intercalated with thinner beds of polyhalite and anhydrite. Salado halite is rarely pure and usually contains trace and minor amounts of foreign material including clay, anhydrite and polyhalite. Halite crystal size and morphology vary considerably, and various large and small scale sedimentary features are abundant throughout out all of the Salado Salt. A detailed discussion of the Geology of the Salado formation can be found in the Geologic Mapping of the Air Intake Shaft at the Waste Isolation Pilot Plant (U. S. DOE, 1991c).

The facility horizon lies within a 12m (40 feet) thick unit consisting of halite, argillaceous halite, and polyhalitic halite. Figure 2.2 identifies the typical geology within this unit. Observations indicate that these geologic conditions are consistent across the site at the repository horizon. Figure 2.3 a, b, and c provide the stratigraphy exposed in Room 1, Panel 1.

A 0.5m (20 inches) to 0.8m (32 inches) thick persistent bed of sulfate (anhydrite and polyhalite), identified as Marker Bed 139 lies about 1.5m (5 feet) below the floor level. Considerable lateral variability in composition and thickness exists within this sulfate bed at both the regional and repository scale. The variability in thickness is associated with the top of the deposit and undulations up to 150mm (6 inches) have been observed in 100mm (4 inch) diameter bore (Holt, 1991). The bottom of the Marker Bed is sub horizontal and is underlain by Clay "E".

Anhydrite beds, called Anhydrites "a" and "b" occur about 4m (13 feet) and 2m (6.5 feet) above the roof. Thin clay seams called Clay G and Clay H are associated with the bottom of these beds. In addition, a thin clay layer identified as Clay F is found intermittently in the immediate roof of excavations.

The Marker Bed 139 and the clay layers can have a significant impact on the mechanical performance of excavations. The clay layers provide surfaces along which slip can occur whereas the Marker Bed acts as a unit that does not deform plastically with time. In addition, the undulating nature of the top of the Marker bed will resist shear movements along the interface with the overlying salt.

3.0

PROPERTIES OF ROCKS AT REPOSITORY HORIZON

The reference material properties for the repository horizon rocks are provided in Table 3.1. These properties are based on laboratory tests carried out during the site characterization phase of the WIPP Project (Kreig, 1983). The tests have demonstrated the range of mechanical properties associated with the WIPP strata, and in particular have defined the time dependent behavior of the salt.

Salt is a material that flows when subject to high confining pressures and deviatoric stress conditions. This behavior has long been recognized in the mining industry (Baar, 1977; Dreyer, 1981) and considerable efforts have been made to characterize this response from laboratory creep tests. However, extensive experience within the mining industry has demonstrated the difficulties involved in establishing in situ performance based on the laboratory characterization of salt creep (Baar, 1977).

TABLE 3.1
ROCK PROPERTIES OF THE REPOSITORY HORIZON

	<u>DIMENSIONS</u>	<u>SALT</u>	<u>ANHYDRITE</u>	<u>POLYHALITE</u>
<u>THERMAL PROPERTIES</u>				
Thermal Conductivity	W/(m.K)	5.0	4.7	1.4
Specific Heat	J/(kg.K)	860	860	860
Coefficient of Linear Expansion	K ⁻¹	45.0E-6	20-E6	24E-6
<u>MECHANICAL PROPERTIES</u>				
Young's Modulus	Pa	3.1E+10	7.5E+10	5.5E+10
Poisson's Ratio	dimensionless	0.25	0.35	0.36
Bulk Modulus	Pa	2.1E+10	8.3E+10	6.6E+10
Shear Modulus	Pa	1.2E+10	2.8E+10	2.0E+10
Density	Mg/m ³	2.3	2.3	2.3

D R A F T

PROPERTIES FOR SECONDARY CREEP FOR SALT

$$\dot{\epsilon} = D \bar{\sigma}^n e^{-Q/RT}$$

Where: $\dot{\epsilon}$ = effective creep strain rate

$\bar{\sigma}$ = effective stress

T = temperature in degrees Kelvin

D, n are empirical constants

$$D = 5.79E-36 \text{ Pa}^{-4.9}/\text{sec}$$

$$n = 4.9$$

$$Q/R = 6060 \text{ K}$$

Where: Q = the effective activation energy for salt,
(cal/mole)

R = the universal gas constant, (cal/mole.K)

Further explanation of the definitions for effective creep strain rate and effective stress are provided in DOE-WIPP-86-010, the Design Validation Final Report, Appendix C.

Reference parameter values are based on:

Branstetter, L.J., "Second Reference Calculation for the WIPP" SAND83-2461, Sandia National Laboratories, Albuquerque, New Mexico.

Krieg, R. D., Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant (WIPP) Project SAND83-1908, Sandia National Laboratories, Albuquerque, New Mexico.

The mechanical response of the salt at the WIPP has been characterized by a steady state creep law that was developed in the early 1980's by laboratory creep tests on the Salado salt (Hansen, 1979; Hansen and Mellegard, 1979; Hermann et al, 1980). This constitutive law relates creep strains to stress and temperature. The relationship ignores transient creep effects that will influence early time deformations and does not include dilation of the salt that will occur when the rock is subject to deviatoric stresses and low confining pressures. The steady state creep law has been used in the model studies to establish predictions of the structural performance of the openings.

Field observations at the WIPP (Cook and Roggenthen, 1991) and in the Carlsbad Potash Basin (Greenwald and Howarth, 1938) have shown that the brittle behavior of salt under deviatoric stresses with low confinement can be a significant factor contributing to the mechanical performance close to excavations. This brittle behavior of salt is generally not characterized by laboratory studies, and therefore, the constitutive law developed to define the creep behavior of salt at the WIPP does not include fracture development or rock dilation. The evaluation of performance must take into consideration the limitations of the constitutive law applied to the salt. Provided that these limitations are understood, and the structural responses of other stratigraphic zones are properly modeled, it will be possible to establish useful models with which to predict the structural performance of excavations at the WIPP.

4.0 IN SITU STRESS REGIME

The initial stress state at the repository horizon is established from Helms Rule for weak rocks (Hoek and Brown, 1980). This rule establishes the vertical stress as dependent on the depth of overburden and its average density, and the horizontal stresses to be equal to the vertical stress. Taking the average density for the overburden at the WIPP site as 2130 kg/m^3 (135 lb/ft^3), the initial stresses at the repository horizon are about 14 MPa (2000 psi).

Measurements of virgin in situ stress in salt are difficult to achieve since the measuring techniques assume that rock behaves in an elastic manner (Hoek and Brown, 1980) whereas salt deforms plastically. However, hydraulic fracturing tests have been carried out in boreholes in salt at the WIPP in order to estimate the stresses (Wawersik and Stone, 1986). Although data interpretation was difficult, it was concluded that the virgin in situ stress state at the WIPP is approximately uniform in all directions and that the stress magnitudes correspond to the weight of the overburden. This conclusion confirms the assumptions used for design purposes at the WIPP Project (US DOE, 1986).

5.0 STRUCTURAL RESPONSE OF EXCAVATED ROOM

Field observations form the basis for a phenomenological model of the structural performance of the underground excavations. This performance is best characterized by data from the SPDV Test Room Panel. These test rooms are among the oldest excavations underground, having been constructed in March and April, 1983. The rooms have the same size and shape as those in the proposed waste storage panels and are located at the same geologic horizon. They are relatively large excavations with each room having a nominal height of 3.95m, (13 feet) width of 10m (33 feet), and a length of 91m (300 feet). The rooms are separated by 30m (100 feet) wide pillars. This configuration results in an extraction ratio in the Test Room panel of about 25 percent. The rooms were excavated in order to confirm the geology, validate design assumptions for the underground, and provide data, where necessary for revision of the design.

TABLE 5.1

CLOSURE RATES BY TIME SINCE EXCAVATION
VERTICAL CONVERGENCE DATA

ROOM	DATE OF EXCAVATION AT INSTRUMENT	EXCAVATION COMPLETED TO FINAL DIMENSIONS	YEAR							
			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
PANEL 1:										
ROOM 1	JUNE 1986	AUGUST 1986	4.13	4.26	4.60	3.24	(3.57)			
ROOM 2	MARCH 1987	MARCH 1988	3.02	6.71	3.33	2.26				
ROOM 3	FEBRUARY 1987	MARCH 1988	1.60	9.85	3.34	2.71				
ROOM 4	FEBRUARY 1988	MARCH 1988	8.33	3.14	2.56					
ROOM 5	FEBRUARY 1988	MARCH 1988	9.19	2.76	2.28					
ROOM 6	FEBRUARY 1988	MAY 1988	8.36	3.41	2.76					
ROOM 7	MARCH 1988	MARCH 1988	9.26	3.22	2.70					
SPDV:										
ROOM 1	APRIL 1983	APRIL 1983	6.79	3.75	2.93	2.88	2.85	3.36	4.70	12.77
ROOM 2	MARCH 1983	MARCH 1983	7.69	3.16	2.39	2.19	2.14	2.33	2.74	2.87
ROOM 3	MARCH 1983	MARCH 1983	7.59	3.65	2.64					
ROOM 4	APRIL 1983	APRIL 1983	5.70	3.18	2.65	2.33	2.13	2.33	2.42	2.31

Notes: Closure rates in inches/year.
 Year is determined from date of excavation at instrument.
 () Estimated based on less than one full year of data.

Observations of the performance of these rooms have been routinely made over the past eight years. They have established room performance in terms of roof closure, rock movements and the development of fractures in the immediate vicinity of openings (US DOE, 1989; US DOE, 1990; Cook and Roggenbom, 1991). SPDV Test Room 1 has provided the most complete picture of the structural performance of an excavation. Measurements were taken in this room over a period of almost eight years, from immediately following its excavation until a major roof fall occurred. Different stages in the performance of the room can be related to its roof/floor closure history (see Figure 5.1). Other rooms are showing the same general behavior but none others (outside of the SNL experimental area where different conditions exist) have yet failed. SPDV Test Room 1 provides the most detailed example of the performance that can be expected from other rooms having similar geometries.

In addition, numerical analyses have been carried out to evaluate the structural performance in terms of stress and strain redistribution taking place about excavations with time. The analyses have used the near repository horizon stratigraphy described in Section 2.0 and the mechanical properties of the rock types provided in Section 3.0. Of particular significance to the interpretation of the model, are:

- o the time dependent relationship governing the mechanical response of the salt
- o the properties that control bed separations at the strata interfaces

The field observations and the numerical analyses have been used to develop a model of the mechanisms that occur in the roof of an excavation with time. The model is primarily based on the performance monitored in SPDV Test Room 1. Its various stages are shown in Figure 5.2. The field and analytical data supporting this phenomenological model are given in the following sections of the report.

It is expected that rooms having a geometry similar to the SPDV Test Rooms and the waste storage rooms will eventually pass through all the stages identified in Figure 5.2 unless remedial actions are taken to control roof deterioration and roof movements. The roof support system for Room 1, Panel 1 is based on the control of the conditions identified by the model.

5.1 ROOM DEFORMATION

Rooms with similar geometries have shown relatively consistent deformation characteristics. Although actual magnitudes of the room closures show a range of values. The variability in the closure rates is demonstrated in Table 5.1 which lists rates of closure at mid room, mid span for the SPDV Test Rooms and the rooms in Panel 1 all of which have similar geometries. The highest closure rates appear to be related to the rooms closest to the barrier pillars and are lower in the middle of panels and at the solid abutments. At present, no correlation has been established between closure rate and variables such as excavation sequence and variations in stratigraphy that might explain these differences.

The changes in roof profile have been correlated with time, based on data from SPDV Test Room 1. The room deformation is initially symmetrical about the room center but after about five years, the roof/floor closure, become asymmetric with one side closing faster than the other side. This behavior identified from SPDV Test Room 1 has been measured in other locations within the facility, and may be considered typical of the performance in the wider spanned excavations at the WIPP.

FIELD DATA

Deformation measurements show that the rock mass deforms with time and that rock movements generally reduce with distance from an excavation surface although this behavior is modified at strata interfaces. Movements occur both normal and parallel to excavation surfaces. In particular, the Anhydrite 'b' in the roof and the Marker Bed 139 in the floor are associated with relatively large vertical and lateral deformations. Typical inclinometer data from a room cross section are shown in Figure 5.3 covering the period from 1983 to 1987. Figure 5.4 provides the data for roof extensometers.

Bed separation has been identified at the Anhydrite 'b' in the roof after approximately three years. Vertical separation at the clay/salt interface beneath the anhydrite 'b' appears to increase at a rate of about 25mm per year once the bond across the interface is broken.

The geotechnical data show that the roof and floor of an excavation act as a series of flexing beams separated by zones or planes across which lateral differential movement occurs. This is largest at the Anhydrite 'b' but does occur at other horizons above and below the excavations in association with strata interfaces, generally clay/salt interfaces. Lateral shifts in the roof indicate that beam flexure was still occurring at a depth of 15m. In the floor, deflections were not as pronounced, and have largely disappeared at a depth of 15m. Differential lateral movements of about 12 mm per year have been measured in the immediate roof beam, five years after excavation. These rates of movement have been confirmed by the monitoring of lateral displacements in old excavations (U.S. DOE, 1991a). Rock deformations about a room also is governed by fracture development. The typical fracture development observed in the wide excavations is shown in Figure 5.5. The most significant fractures are low angled shear fractures develop at the rib/roof interface of excavations. In SPDV Test Room 1, these fractures became sufficiently persistent and continuous that a detached wedge formed in the roof of SPDV Test Room 1. This wedge fell eight years after the excavation of the room. Precise surveys of the roof in SPDV Test Room 1 following the rock fall are shown in Figure 5.6 and indicate the geometry of the roof cross-sections to be arch shaped. The condition of the roof in Room 1, Panel 1 is shown in Figure 5.7 as of the summer 1991.

MODEL DATA

Roof/floor closure for the model is compared with the field data in Figure 5.8. Roof/floor closure rate is 0.1 m per year (4 inches per year) and does not vary significantly with time. This is probably due to the limitations of the steady state of the creep law used for the calculations. A more sophisticated constitutive law that includes transient creep effects has been developed by SNL and would provide a more accurate simulation of the early time performance of the excavations.

Bed separation provided by the model at the Anhydrite 'b' level indicate that the separation is at a maximum above the mid span of the excavation and increases at about 12mm per year. The model is compared with the field data in Figure 5.8b. The model also shows that bed separation is occurring at the clay beneath the Anhydrite 'a' layer. This is not consistent with the field observations which do not indicate bed separation at this level. Further investigations of the performance at this layer are required.

D R A F T

The shear strains are shown in Figure 5.9. They build up with time as creep occurs under relatively constant compressive stress in the immediate roof beam and the contours of effective strains indicate potential failure planes. These planes are consistent with the fracture development that occurs in the roof of excavations with time.

6.3 STRESSES AROUND ROOM

Prior to excavation, the strata at the repository horizon are subject to an in situ stress field that is uniform in all directions and has a value of about 14MPa (2000 psi) which is equivalent to the overburden loading. Immediately the excavation is made, the stresses adjust to an elastic distribution. Of particular importance are the high shear stress concentrations that develop in the corners of the excavation (Mier, 1991). These may provide incipient fracturing that later develop into discrete fracture planes. With time, the stresses in the immediate vicinity of the excavation reduce due to stress relief as the salt moves into the opening. The excavation disturbs the stresses and the redistribution continues over time dependent properties of the salt. The principal maximum and minimum stresses induced at 0, 3 and 5 years following excavation are shown in Figures 5.10 and 5.11. These plots indicate the changes in stress that take place with time.

The influence of the stratigraphy on the stress distributions is evident immediately that the excavation is formed. The Marker Bed 139 modifies the structural performance of the floor and the anhydrite 'b' effects the stress distribution in the roof.

In the floor, the Marker Bed 139 acts as a stiff unit which does not exhibit time dependent behavior. The variable elevation in the upper boundary of the Marker Bed indicates that a high resistance to shear movements at this boundary develops. These immediate effects were also observed in numerical analyses presented by McKinnon (U.S. DOE 1991b) at the Geotechnical Expert Panel Meeting. The salt above and below the Marker Bed will deform with time and depending on the slippage between the salt and the anhydrite will maintain high compressive stress into the Marker Bed. These high stresses may cause brittle fracture of the Marker Bed 139 and its failure which would result in floor heave.

The clay beneath the anhydrite 'b' introduces a plane of low frictional resistance into the strata sequence. The plane will not support shear stresses, and this isolates the immediate roof beam. The plastic flow of the clay ensures that high shear stresses cannot develop at the interface and the low bond strength between the clay and the salt leads to separation at the interface. Once the immediate roof beam becomes isolated, the lateral movements of the pillars maintain the lateral stresses in the beam. With time, the shear strains build up in the beam and eventually result in the development of failure along particular surfaces. This failure initially occurs at room mid length. The localized failure relieves the lateral stresses in the beam. However, due to the continued lateral creep of the salt, the roof beam continues to be subject to compressive stress. The failures propagate in the longitudinal direction, gravity effects take over, and the weight of the unsupported section of the roof spanning increases. At some critical length, the strength of the beam cross section is exceeded and the roof falls as a unit.

A geotechnical design basis has been developed from the discussions presented in Section 5. The design provides a system support of the roof in Room 1, Panel 1 to meet the functional requirements described in Section 6.1. The geotechnical design basis is as follows:

- o The support system shall support the weight of the detached rock wedge that forms in the roof as a result of the development of low angled fractures from the ribs.
- o The support system shall accommodate vertical movements of the roof that include both differential and total displacements.
- o The support system shall accommodate lateral shifts

These requirements are discussed in the following sections in terms of the bounding values that encompass the conditions expected to be encountered in the field.

ROCKLOAD TO BE SUPPORTED

The weight of the detached rock wedge that forms in the roof depends on the orientation of the fractures that develop. The estimate is based on the observations of the rock fall geometry seen in SPDV Test Room 1 and the interpretation contours of shear strain in the roof (Miller, 1991). The wedge geometry consists of an arched or triangular shape that forms from low angled fractures starting at the ribs whose propagation is bounded and controlled by the bed separation occurring at the Anhydrite 'b'.

VERTICAL MOVEMENTS

The vertical movements that the roof must accommodate are a combination of salt creep, dilation of the salt due to fracture development, and gravity effects once fractures have formed.

The total displacement has been taken as 38mm per year (1.5 inches per year) vertical lowering of the roof at midspan. The differential movement is taken as the difference between displacement of the roof at mid span and that close to the ribs. The differential movement to be accommodated by the design has been taken as a maximum of 25mm per year (1 inch per year). Roof displacements are not always a maximum at mid span. Once fracturing becomes visible in the roof along one rib, then the field data shows that the roof deforms asymmetrical with one side lowering more rapidly than mid span or the other side.

LATERAL MOVEMENTS

The lateral displacements occur at strata interfaces and within the immediate roof beam where discrete fractures have formed. These lateral shifts may be associated with the widening of fracture apertures and bed separation. The lateral differential displacements have been observed up to 15m (50 feet) into the roof at strata changes particularly the clay/salt contacts. The largest shifts are found at the clay/salt contact below the Anhydrite 'b' layer. Lateral shifts can also be expected within the immediate roof beam where fractures form. The support system should be designed to accommodate a lateral shift of 12mm per year (0.5 inches per year) and bed separation of 25mm per year (1 inch per year) at the clay/salt contact below the Anhydrite 'b' layer once the bond at the interface is disrupted.

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CLEAR TO GRAYISH ORANGE - PINK HALITE, TRACE OF DISPERSED
POLYHALITE AND INTERCRYSTALLINE CLAY

GRAY CLAY SEAM WITH ANHYDRITE

CLEAR TO GRAYISH ORANGE - PINK HALITE, TRACE OF POLYHALITE
AND DISCONTINUOUS CLAY STRINGERS

CLEAR TO MODERATE REDDISH BROWN HALITE, TRACE OF SOME
POLYHALITE, AND TRACE OF CLAY

CLEAR TO MODERATE REDDISH BROWN HALITE, TRACE OF SOME
POLYHALITE, ANHYDRITE STRINGERS NEAR BOTTOM OF UNIT

ANHYDRITE UNDERLAIN BY CLAY SEAM (ANHYDRITE "a")

CLEAR TO MODERATE REDDISH-BROWN HALITE, TO SOME
POLYHALITE AND DISCONTINUOUS CLAY STRINGERS

CLEAR TO GRAYISH ORANGE - PINK HALITE

ANHYDRITE UNDERLAIN BY CLAY SEAM (ANHYDRITE "b")

CLEAR TO MODERATE REDDISH BROWN TO MEDIUM GRAY HALITE,
TRACE POLYHALITE AND SOME CLAY STRINGERS

CLEAR TO REDDISH-ORANGE HALITE, TRACE POLYHALITE

CLEAR HALITE, TRACE ARGILLACEOUS MATERIAL

CLEAR TO REDDISH-BROWN ARGILLACEOUS HALITE WITH
DISCONTINUOUS CLAY PARTINGS IN UPPER HALF

CLEAR TO REDDISH-ORANGE HALITE, TRACE POLYHALITE

REDDISH-BROWN TO BLuish-GRAY ARGILLACEOUS HALITE

REDDISH-ORANGE HALITE, TRACE POLYHALITE

TOP OF ORANGE BAND

CLEAR TO REDDISH-ORANGE AND REDDISH-BROWN HALITE,
ARGILLACEOUS IN UPPER PART TRACE POLYHALITE

CLEAR TO REDDISH-ORANGE POLYHALITIC HALITE, LOCALLY GRADING
DOWNWARDS TO POLYHALITE

ANHYDRITE UNDERLAIN BY CLAY SEAM, MARKER BED MB 139

CLEAR TO GRAY REDDISH-ORANGE HALITE, TRACE POLYHALITE AND
ARGILLACEOUS MATERIAL

TYPICAL 4.3 m HIGH
TEST ROOM

FIGURE 2.3b GEOLOGIC CROSS-SECTION OF PANEL 1, ROOM 1
View West

FIGURE 2.3C GEOLOGIC CROSS-SECTION OF PANEL 1, ROOM 1
View West

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SPDV Test Room 1 Convergence Date Combination of Instr. 8001 and 14001

SECRET

FIGURE 5.2 PHENOMENOLOGICAL MODEL OF ROOF FALL DEVELOPMENT

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c. EAST ROOF
EXTENSOMETER
51X GE-00

b. MID ROOF
EXTENSOMETER
51X GE-00

a. WEST ROOF
EXTENSOMETER
51X GE-00

129081

Figure 5.4

Extensometer Data from SPDV Test Rooms

6918-0626

Figure 6.5 Patterns of Fracturing (Idealized excavation effects modified from Borns & Stormont, 1987)

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SPDV TEST ROOM 1 BACK CAVITY

CROSS-SECTIONED VIEW

Full Scale 02/04/01
(Drawing Not To Scale)

8918-0621

Figure 5.7

Back Fractures, Panel 1, Room 1 mapped on 2/12/91

FIELD MEASUREMENTS

MODEL RESULTS

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FIGURE 5.9

CONTOURS OF EFFECTIVE STRAIN FOR MODEL

OF 33 FEET WIDE B 3 FEET HIGH ROOM.

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FIGURE 5.10
CONTOURS OF MAXIMUM PRINCIPAL STRESS FOR MODEL
OF 33 FEET WIDE BY 13 FEET HIGH ROOM.

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FIGURE 5.11 CONTOURS OF MINIMUM PRINCIPAL STRESS FOR MODEL

OF 33 FEET 1 BY 13 FEET HIGH ROOM.

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WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM

APPENDIX B
Destructive Tests

Westinghouse Electric Corporation
Waste Isolation Division
Carlsbad, New Mexico
October 1991

DRAFT

INTERNATIONAL MINING SERVICES INC.
RETYPE FAX RECEIVED FROM HAMISH MILLER

CONCLUSIONS FROM DESTRUCTIVE ROCKBOLT TESTS

The curves of load vs. extension were plotted for the 10 rockbolts that were tested to "failure". The points beyond which non-linear behavior occurred, were noted and these values are given in Table 1 below.

TABLE 1

TEST NO.	"YIELD" LOAD X 1,000 LB	BOLT STRESS AT "YIELD" PSI X 1,000
1	58.045	73.475
2	58.045	73.475
3	56.81	71.911
4	56.81	71.911
5	60.52	76.608
6	58.045	73.475
7	58.045	73.475
8	58.045	73.475
9	58.045	73.475
10	58.045	73.475

NOTE: "Yield" represents the point on the LOAD-EXTENSION curves where the curve departed from linearity. (see attached test results). The manufacturers of the Dywidag bolts give the "Yield Load" as 47.4 KIPS, which with a cross-sectional area of 0.79 sq. ins., gives a yield stress of 60,000 psi.

The results thus indicate that the mode of failure is that of bolt yield and not failure of the resin anchor bond.

There are slight indications of non-linearity in some of the test results, but it is felt that these are due to deformations of the plate and the "bedding-in" of the plate on the salt.

The test "yield" stresses are between 22% and 28% higher than the ASTM yield stress of 60,000 psi.

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BOLT TENSION VERSUS EXTENSION

ROOM 2 PANEL 1

(X 10000)

2 AND 3 DAYS CURE

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BOLT TENSION VERSUS EXTENSION

ROOM 2 PANEL 1

(X) 100000

BOLT TENSION VERSUS EXTENSION

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K 10000)

ROOM 2 PANEL 1

DRAFT Test 10

ROCK BOLT CERTIFICATION TEST DATA SHEET

Page 1 of 2

Mine WIPP Rock HALITE Rock Bolt No. PT081391-7
 Hole Length - 11'-7" Dia. - @ Anchor Gauged / @ midpoint N/A / @ collar N/A
 Orientation - VERT. (5° TOLERANCE) SMOOTH
 Bolt Grade - GR60 Length - 13'-0" Diameter - #9
 Shell Manufacturer - N/A Model - N/A Diameter - N/A
 Length - N/A
 Resin Manufacturer - C&G Model - H20-0204 Diameter - 1 1/4"
 Length - 12' No. Cartridges - 5
 Installation Date - 08/13/91 Time - 11:16 AM Torque - N/A ft/lb
 Test Date - 08/16/91 Time - 1:05 PM Torque - N/A ft/lb
 Test Jack - PC-60-CH9.5A Test Pump - PC-60-CH9.5 SN 23886
 Dial Indicator - AMES CD-0040 Calibrated - DATE 10-4-91
 Pressure Gauge - U.S. GAUGE DSI # 001 Calibrated - 02/06/91

Polymer Pump Pressure	Bolt Tension	Extensometer Reading	Displacement	Remarks
1	2470	0.020		
2	4940	0.015		
3	7410	0.035		
4	9880	0.055		
5	12350	0.085		
6	14820	0.112		
7	17290	0.138		
8	19760	0.159		7290 lbs
9	22230	0.179		
10	24700	0.199		
11	27170	0.223		
12	29640	0.250		
13	32110	0.278		
14	34580	0.301		
15	37050	0.322		
16	39520	0.341		
17	41990	0.359		
18	44460	0.370		
19	46930	0.380		
20	49400	0.391		
21	51870	0.401		
22	54340	0.412		
23	56810	0.421		
24	59280	0.431		
25	61750	0.443		
26	64220	0.454		
27	66690	0.470		
28	69160	0.485		
29	71630	0.497		
30	74100	0.511		
31	76570	0.526		
32	79040	0.536		
33	81510	0.542		
34	83980	0.553		
35	86450	0.562		
36	88920	0.571		
37	91390	0.583		
38	93860	0.593		
39	96330	0.603		
40	98800	0.614		
41	101270	0.624		
42	103740	0.634		
43	106210	0.644		
44	108680	0.654		
45	111150	0.664		
46	113620	0.674		
47	116090	0.684		
48	118560	0.694		
49	121030	0.704		
50	123500	0.714		

Test Results - ACCEPTED Maximum Pull Force - 101,600
 Displacement at Maximum Pull Force - APPROX. 2.65 in.
 Nature of Failure/Yield - BOLT YIELD @ 1100 PSI
 Other Remarks - 13.5 HOURS AFTER INSTALLATION
 Tested By - A. Bellman Approved By - P.R. [Signature]

Test 10.

מכאן נראה שיש להבחין בין שני סוגי תגובה:

Page 2 of 2

[illegible]

Test Results _____ Maximum Pull Force - _____
Displacement at Maximum Pull Force - _____
Nature of Failure/Yield - _____
Other Remarks _____
Tested By - D. Hollenave Approved By - SEB

DRAFT

ATTACHMENT
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/91

Room/Drift: Room 2 - Panel 1

Purpose of Hole: Pull Test: Destructive (PWR 12017T)
P4081391-7

Location: N. END 4' W Road 45.50 FT. FROM N. BULKHEAD

Depth at Completion: 11'-7"

Diameter: 1 7/8" d

Approximate Collar Coordinates

Vertical Angle: VERT. (5° TOLERANCE)

Direction/Azimuth:

Remarks: RESIN/ROCK ANCHOR TEST AT 1:05 PM (
AND COMPLETED AT 2:00 PM FOR
CERTIFICATION.

Signature/Department: D. Gallman 8/16/91

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Page 1 of 2

ROCK BOLT CERTIFICATION TEST DATA SHEET

Mine WIPP Rock HALITE Rock Bolt No. PT0B1391-6
Hole Location PANEL 1 - Room 2
Hole Length - 11'-7" Dia. - @ Anchor Gauge / @ midpoint N/A / @ collar N/A
Orientation - VERT. (5° TOLERANCE)
Bolt Grade - GR60 Length - 12'-11 7/8" Diameter - 1/2"
Shell Manufacturer - N/A Model - N/A Diameter - N/A
Resin Manufacturer - CELTITE Model - 100-0204 Diameter - 1/4"
Length - 12" No. Cartridges - 3
Installation Date - 08/12/91 Time - 11:04 AM Torque - N/A ft/lb
Test Date - 8/15/91 Time - 12:50 PM Torque - N/A ft/lb
Test Jack - PC-60-CH 9.5A Test Pump - PC-60-CH 9.5 SN 28896
Dial Indicator - AMES CD - 0040 Calibrated - PLUS 10.4-91
Pressure Gauge - U.S. GAUGE PSI # 001 Calibrated - 08/06/91

PSI X 100 Pump Pressure	Bolt Tension	Extensio- meter Reading	Displace- ment	Remarks
2	2470	0.020		
4	2940	0.012		
6	3410	0.032		
8	3880	0.050		
10	4350	0.070		
12	4820	0.088		
14	5290	0.105		
16	5760	0.121		
18	6230	0.136		
20	6700	0.152		
22	7170	0.172		
24	7640	0.190		
26	8110	0.207		
28	8580	0.224		
30	9050	0.244		
32	9520	0.263		
34	9990	0.283		
36	10460	0.303		
38	10930	0.323		
40	11400	0.343		
42	11870	0.363		
44	12340	0.383		
46	12810	0.403		
48	13280	0.423		
50	13750	0.443		
52	14220	0.463		
54	14690	0.483		
56	15160	0.503		
58	15630	0.523		
60	16100	0.543		
62	16570	0.563		
64	17040	0.583		
66	17510	0.603		
68	17980	0.623		
70	18450	0.643		
72	18920	0.663		
74	19390	0.683		
76	19860	0.703		
78	20330	0.723		
80	20800	0.743		
82	21270	0.763		
84	21740	0.783		
86	22210	0.803		
88	22680	0.823		
90	23150	0.843		
92	23620	0.863		
94	24090	0.883		
96	24560	0.903		
98	25030	0.923		
100	25500	0.943		
102	25970	0.963		
104	26440	0.983		
106	26910	1.003		
108	27380	1.023		
110	27850	1.043		
112	28320	1.063		
114	28790	1.083		
116	29260	1.103		
118	29730	1.123		
120	30200	1.143		
122	30670	1.163		
124	31140	1.183		
126	31610	1.203		
128	32080	1.223		
130	32550	1.243		
132	33020	1.263		
134	33490	1.283		
136	33960	1.303		
138	34430	1.323		
140	34900	1.343		
142	35370	1.363		
144	35840	1.383		
146	36310	1.403		
148	36780	1.423		
150	37250	1.443		
152	37720	1.463		
154	38190	1.483		
156	38660	1.503		
158	39130	1.523		
160	39600	1.543		
162	40070	1.563		
164	40540	1.583		
166	41010	1.603		
168	41480	1.623		
170	41950	1.643		
172	42420	1.663		
174	42890	1.683		
176	43360	1.703		
178	43830	1.723		
180	44300	1.743		
182	44770	1.763		
184	45240	1.783		
186	45710	1.803		
188	46180	1.823		
190	46650	1.843		
192	47120	1.863		
194	47590	1.883		
196	48060	1.903		
198	48530	1.923		
200	49000	1.943		
202	49470	1.963		
204	49940	1.983		
206	50410	2.003		
208	50880	2.023		
210	51350	2.043		
212	51820	2.063		
214	52290	2.083		
216	52760	2.103		
218	53230	2.123		
220	53700	2.143		
222	54170	2.163		
224	54640	2.183		
226	55110	2.203		
228	55580	2.223		
230	56050	2.243		
232	56520	2.263		
234	56990	2.283		
236	57460	2.303		
238	57930	2.323		
240	58400	2.343		
242	58870	2.363		
244	59340	2.383		
246	59810	2.403		
248	60280	2.423		
250	60750	2.443		
252	61220	2.463		
254	61690	2.483		
256	62160	2.503		
258	62630	2.523		
260	63100	2.543		
262	63570	2.563		
264	64040	2.583		
266	64510	2.603		
268	64980	2.623		
270	65450	2.643		
272	65920	2.663		
274	66390	2.683		
276	66860	2.703		
278	67330	2.723		
280	67800	2.743		
282	68270	2.763		
284	68740	2.783		
286	69210	2.803		
288	69680	2.823		
290	70150	2.843		
292	70620	2.863		
294	71090	2.883		
296	71560	2.903		
298	72030	2.923		
300	72500	2.943		
302	72970	2.963		
304	73440	2.983		
306	73910	3.003		
308	74380	3.023		
310	74850	3.043		
312	75320	3.063		
314	75790	3.083		
316	76260	3.103		
318	76730	3.123		
320	77200	3.143		
322	77670	3.163		
324	78140	3.183		
326	78610	3.203		
328	79080	3.223		
330	79550	3.243		
332	80020	3.263		
334	80490	3.283		
336	80960	3.303		
338	81430	3.323		
340	81900	3.343		
342	82370	3.363		
344	82840	3.383		
346	83310	3.403		
348	83780	3.423		
350	84250	3.443		
352	84720	3.463		
354	85190	3.483		
356	85660	3.503		
358	86130	3.523		
360	86600	3.543		
362	87070	3.563		
364	87540	3.583		
366	88010	3.603		
368	88480	3.623		
370	88950	3.643		
372	89420	3.663		
374	89890	3.683		
376	90360	3.703		
378	90830	3.723		
380	91300	3.743		
382	91770	3.763		
384	92240	3.783		
386	92710	3.803		
388	93180	3.823		
390	93650	3.843		
392	94120	3.863		
394	94590	3.883		
396	95060	3.903		
398	95530	3.923		
400	96000	3.943		
402	96470	3.963		
404	96940	3.983		
406	97410	4.003		
408	97880	4.023		
410	98350	4.043		
412	98820	4.063		
414	99290	4.083		
416	99760	4.103		
418	100230	4.123		
420	100700	4.143		
422	101170	4.163		
424	101640	4.183		
426	102110	4.203		
428	102580	4.223		
430	103050	4.243		
432	103520	4.263		
434	103990	4.283		
436	104460	4.303		
438	104930	4.323		
440	105400	4.343		
442	105870	4.363		
444	106340	4.383		
446	106810	4.403		
448	107280	4.423		
450	107750	4.443		
452	108220	4.463		
454	108690	4.483		
456	109160	4.503		
458	109630	4.523		
460	110100	4.543		
462	110570	4.563		
464	111040	4.583		
466	111510	4.603		
468	111980	4.623		
470	112450	4.643		
472	112920	4.663		
474	113390	4.683		
476	113860	4.703		
478	114330	4.723		
480	114800	4.743		
482	115270	4.763		
484	115740	4.783		
486	116210	4.803		
488	116680	4.823		
490	117150	4.843		
492	117620	4.863		
494	118090	4.883		
496	118560	4.903		
498	119030	4.923		
500	119500	4.943		
502	119970	4.963		
504	120440	4.983		
506	120910	5.003		
508	121380	5.023		
510	121850	5.043		
512	122320	5.063		
514	122790	5.083		
516	123260	5.103		
518	123730	5.123		
520	124200	5.143		
522	124670	5.163		
524	125140	5.183		
526	125610	5.203		
528	126080	5.223		
530	126550	5.243		
532	127020	5.263		
534	127490	5.283		
536	127960	5.303		
538	128430	5.323		
540	128900	5.343		
542	129370	5.363		
544	129840	5.383		
546	130310	5.403		
548	130780	5.423		
550	131250	5.443		
552	131720	5.463		
554	132190	5.483		
556	132660	5.503		
558	133130	5.523		
560	133600	5.543		
562	134070	5.563		
564	134540	5.583		
566	135010	5.603		
568	135480	5.623		
570	135950	5.643		
572	136420	5.663		
574	136890	5.683		

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ROCK BOLT CERTIFICATION TEST DATA SHEET

Mine _____ Rock _____ Rock Bolt No. PT081391-6
 Hole Location _____
 Hole Length - _____ Dia. - @ Anchor _____ / @ midpoint _____ / @ collar _____
 Orientation - _____
 Bolt Grade - _____ Length - _____ Diameter - _____
 Shell Manufacturer - _____ Model - _____ Diameter - _____
 Length - _____
 Resin Manufacturer - _____ Model - _____ Diameter - _____
 Length - _____ No. Cartridges - _____
 Installation Date - _____ Time - _____ Torque - _____ ft/lb
 Test Date - _____ Time - _____ Torque - _____ ft/lb
 Test Jack _____ Test Pump - _____
 Dial Indicator - _____ Calibrated - _____
 Pressure Gauge - _____ Calibrated - _____

Pump Pressure	Bolt Tension	Extensometer Reading	Displacement	Remarks
54				Comments -
53			AT 4900	11:30 PM
52				Holding AT 4900 PSI 1 1/2" RAM
51			AT 5000	9:20 PM
				Holding AT 4700 PSI 1 1/2" RAM
			AT 5100	6:15 PM 1:40 PM
				Holding AT 5000 PSI 1 1/2" RAM
			AT 5200	6:15 PM 1:15 PM
				Holding AT 5000 PSI 1 1/2" RAM
			AT 5300	6:15 PM 1:00 PM
				Holding AT 5100 PSI 1 1/2" RAM
			AT 5400	6:40 PM 1:07 PM
				Holding AT 5200 PSI 2" RAM
			AT 5500	6:40 PM 1:15 PM
				Holding AT 5100 PSI 2 1/4" RAM
			AT 5600	6:45 PM 1:25 PM
				Holding AT 5100 PSI 2 1/4" RAM
			AT 5700	6:45 PM 1:33 PM
				Holding AT 5200 PSI 2 3/4" RAM
			AT 5800	6:45 PM 1:40 PM
				Holding AT 5200 PSI 2 1/2" RAM
			AT 5900	6:45 PM 1:45 PM
				Holding AT 5200 PSI 2 1/2" RAM
			08/16/91	RED TO 5200 PSI 12:40 PM
				MAX FULL FORCE

Test Results - _____ Maximum Pull Force - _____
 Displacement at Maximum Pull Force - _____
 Nature of Failure/Yield - _____
 Other Remarks - _____
 Tested By - D. Faltmaier Approved By - P. B. [Signature]

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ATTACHMENT 1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/91

Room/Drift: PANEL 1 - ROOM 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PWR1201TT)

DT081391-6

Location: N END 4' W ROOM 2 36-40 FT. FROM N. BULKHEAD

Depth at Completion: 11'-7"

Diameter: 1 3/8" d COMPLETION

Approximate Collar Coordinates

Vertical Angle:

Direction/Azimuth: VERT. (5° TOLERANCE)

Remarks: RESIN / ROCK ANCHOR TEST AT 12:50 PM

AND COMPLETED AT 2:45 PM FOR

CERTIFICATION.

Signature/Department: D. Galbraith 8/15/91

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ROCK BOLT CERTIFICATION TEST DATA SHEET

Mine WIPP Rock HALITE Rock Bolt No. PT081391-1
Hole Location PANEL - ROOM 2
Hole Length - 11.50' Dia. - @ Anchor Gauged / @ midpoint N/A / @ collar N/A
Orientation - Vertical (5° TOLERANCE) Smooth
Bolt Grade - GR60 Length - 13'-0" Diameter - #8
Shell Manufacturer - N/A Model - N/A Diameter - N/A
Length - N/A
Resin Manufacturer - CELTITE Model - W20-0204 Diameter - 1 1/4"
Length - 12" No. Cartridges - 3
Installation Date - 08/13/01 Time - 10:16^{AM} Torque - N/A ft/lb
Test Date - 8/14/01 Time - 11:30^{AM} Torque - N/A ft/lb
Test Jack - EC-60-CH 5FA Test Pump - EC-60-D95 SN 23586
Dial Indicator - AMES 487 CD-0040 Calibrated - JUL 10-14-01
Pressure Gauge - USA466 PSI #001 Calibrated - 08-06-01

PSI Pump Pressure	LB Bolt Tension	Extensio- meter Reading	Displace- ment	Remarks
200	2470	0.000		
400	4940	0.062		
600	7410	0.082		
800	9880	0.102		
1000	12350	0.120		
1200	14820	0.138		
1400	17290	0.157		
1600	19760	0.174		
1800	22230	0.194		
2000	24700	0.210		
2200	27170	0.229		
2400	29640	0.248		
2600	32110	0.266		
2800	34580	0.282		
3000	37050	0.300		
3200	39520	0.319		
3400	41990	0.328		
3600	44460	0.338		
3800	46930	0.347		
4000	49400	0.356		
4200	51870	0.363		
4400	54340	0.372		
4600	56810	0.385		
4800	59280	0.399		
5000	61750	0.404		
5200	64220	0.409		
5400	66690	0.418		
5600	69160	0.425		
5800	71630	0.435		
6000	74100	0.451		
6200	76570	0.474		
6400	79040	0.534		
6600				
6800				
7000				
7200				
7400				
7600				
7800				
8000				
8200				
8400				
8600				
8800				
9000				
9200				
9400				
9600				
9800				
10000				

Test Results - ACCEPTED Maximum Pull Force - 59280 #
Displacement at Maximum Pull Force - .589 in.
Nature of Failure/Yield - Bolt YIELD 4600 PSI to 4700 PSI
Other Remarks - # 25.5 HRS AFTER INSTALLATION
Tested By - A. Bellum Approved By - R.E. Anderson

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/91

Room/Drift: PANEL 1 - ROOM 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PWR 120177)
PTOB1391-1

Location: N. END APPROX 4' ^W ROOM 2 APPROX. 4-6 FT FROM BULKHEAD
8/13/91

Depth at Completion: 11'-7"

Diameter: 1-3/8" ϕ COMPLETION

Approximate Collar Coordinates

Vertical Angle: VERT. (50 TOLERANCE)

Direction/Azimuth:

Remarks: RESIN/ROCK ANCHOR TESTED AT 11:30^{am} COMPLETED AT 12:05 PM
FOR CERTIFICATION.

Signature/Department: D. Ballmaier 8/14/91

ROCK BOLT CERTIFICATION TEST **DATA SHEET**

Mine WIPP Rock HALITE Rock Bolt No. P70B1391-2
Hole Location Panel 1 - Down 2
Hole Length - 11.50' Dia. - @ Anchor / @ midpoint N/A / @ collar N/A
Orientation - VERTICAL / DISPLACEMENT
Bolt Grade - GR60 Length - 13'-0" Diameter - "B
Shell Manufacturer - N/A Model - N/A Diameter - N/A
Length - N/A
Resin Manufacturer - CEMTITE Model - H20-0204 Diameter - 1 1/4"
Length - 12" No. Cartridges - 5
Installation Date - 08/15/91 Time - 10:31^{AM} Torque - N/A ft/lb
Test Date - 8/14/91 Time - 1:31^{PM} Torque - N/A ft/lb
Test Jack - PC-60-CH 9.5A Test Pump - PC-60-CH 9.5 342000 PSI
Dial Indicator - AMES 4822 CB-0040 Calibrated - 08-10-91
Pressure Gauge - USG 4.5 PSI Calibrated - 08-06-91

PSI x 100 Pump Pressure	LB Bolt Tension	Extensometer Reading	Displacement	Remarks
2	2470	0.000		
4	2440	0.023		
6	2410	0.049		
8	2380	0.073		
10	2350	0.098		
12	2320	0.121		
14	2290	0.149		
16	2260	0.174		
18	2230	0.204		
20	2200	0.231		
22	2170	0.260		
24	2140	0.295		
26	2110	0.328		
28	2080	0.358		
30	2050	0.388		
32	2020	0.418		
34	1990	0.447		
36	1960	0.478		
38	1930	0.508		
40	1900	0.538		
42	1870	0.568		
44	1840	0.598		
46	1810	0.628		
48	1780	0.658		
50	1750	0.688		
52	1720	0.718		
54	1690	0.748		
56	1660	0.778		
58	1630	0.808		
60	1600	0.838		
62	1570	0.868		
64	1540	0.898		
66	1510	0.928		
68	1480	0.958		
70	1450	0.988		
72	1420	1.018		
74	1390	1.048		
76	1360	1.078		
78	1330	1.108		
80	1300	1.138		
82	1270	1.168		
84	1240	1.198		
86	1210	1.228		
88	1180	1.258		
90	1150	1.288		
92	1120	1.318		
94	1090	1.348		
96	1060	1.378		
98	1030	1.408		
100	1000	1.438		
102	970	1.468		
104	940	1.498		
106	910	1.528		
108	880	1.558		
110	850	1.588		
112	820	1.618		
114	790	1.648		
116	760	1.678		
118	730	1.708		
120	700	1.738		
122	670	1.768		
124	640	1.798		
126	610	1.828		
128	580	1.858		
130	550	1.888		
132	520	1.918		
134	490	1.948		
136	460	1.978		
138	430	2.008		
140	400	2.038		
142	370	2.068		
144	340	2.098		
146	310	2.128		
148	280	2.158		
150	250	2.188		
152	220	2.218		
154	190	2.248		
156	160	2.278		
158	130	2.308		
160	100	2.338		
162	70	2.368		
164	40	2.398		
166	10	2.428		
168		2.458		
170		2.488		
172		2.518		
174		2.548		
176		2.578		
178		2.608		
180		2.638		
182		2.668		
184		2.698		
186		2.728		
188		2.758		
190		2.788		
192		2.818		
194		2.848		
196		2.878		
198		2.908		
200		2.938		

Test Results - ACCEPTED Maximum Pull Force - 59200 lb
Displacement at Maximum Pull Force - 0.996 in.
Nature of Failure/Yield - Bolt YIELD AT 3400 PSI
Other Remarks - 224 27.1 HRS AFTER INSTALLATION
Tested By - A. Dalkmann Approved By - P. K. ...

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/91

Room/Drift: DANIEL 1 - ROOM 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PWR 120177)
PT081391-2

Location: N. END APPROX 4' W OF ROOM 2 APPROX 12 FEET FROM N. BULKHEAD

Depth at Completion: 11'-7"

Diameter: 1 3/8" ϕ COMPLETION

Approximate Collar Coordinates

Vertical Angle: VERT. (5° TOLERANCE)

Direction/Azimuth:

Remarks: RESIN/ROCK ANCHOR TESTED AT 1:37 PM
AND COMPLETED AT 1:55 PM FOR
CERTIFICATION

Signature/Department: D J Gallivan 8/14/91

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ROCK BOLT CERTIFICATION TEST DATA SHEET

Mine WIPP Rock HALITE Rock Bolt No. P1081391-3
Hole Location Panel 1 - Room 2

Hole Length - 11'7" Dia. - @ Anchor 60450 @ midpoint N/A @ collar 4/A
Orientation - VERTICAL (3" TOLERANCE) SMOOTH

Bolt Grade - GR 60 Length - 13'-0" Diameter - 2.9

Shell Manufacturer - N/A Model - N/A Diameter - N/A
Length - N/A

Resin Manufacturer - CEATITE Model - H20-0204 Diameter - 1 1/4"
Length - 12" No. Cartridges - 5

Installation Date - 08/13/91 Time - 10:41 Torque - N/A ft/lb

Test Date - 08/13/91 Time - 2:00 PM Torque - N/A ft/lb

Test Jack - EC-60-CH 9.5A Test Pump - EC-6-CH 9.5 SN 70006 131%
Dial Indicator - AMES CD-0040 Calibrated - DIF 10-4-91
Pressure Gauge - US GAGE D31 2001 Calibrated - 05-06-91

PSI x 100 Pump Pressure	LBS Bolt Tension	Extensio- meter Reading	Displace- ment	Remarks
2	2470	0.000		
4	4940	0.011		
6	7410	0.028		
8	9880	0.050		
10	12350	0.069		
12	14820	0.088		
14	17290	0.106		
16	19760	0.127		
18	22230	0.151		
20	24700	0.179		
22	27170	0.199		
24	29640	0.228		
26	32110	0.244		
28	34580	0.268		
30	37050	0.292		
32	39520	0.313		
34	41990	0.339		
36	44460	0.360		
38	46930	0.382		
40	49400	0.405		
42	51870	0.429		
44	54340	0.456		
46	56810	0.489		
48	59280	0.519		
50	61750	0.549		
52	64220	0.579		
54	66690	0.609		
56	69160	0.639		
58	71630	0.669		
60	74100	0.699		
62	76570	0.729		
64	79040	0.759		
66	81510	0.789		
68	83980	0.819		
70	86450	0.849		
72	88920	0.879		
74	91390	0.909		
76	93860	0.939		
78	96330	0.969		
80	98800	0.999		
82	101270	1.029		
84	103740	1.059		
86	106210	1.089		
88	108680	1.119		
90	111150	1.149		
92	113620	1.179		
94	116090	1.209		
96	118560	1.239		
98	121030	1.269		
100	123500	1.299		
102	125970	1.329		
104	128440	1.359		
106	130910	1.389		
108	133380	1.419		
110	135850	1.449		
112	138320	1.479		
114	140790	1.509		
116	143260	1.539		
118	145730	1.569		
120	148200	1.599		
122	150670	1.629		
124	153140	1.659		
126	155610	1.689		
128	158080	1.719		
130	160550	1.749		
132	163020	1.779		
134	165490	1.809		
136	167960	1.839		
138	170430	1.869		
140	172900	1.899		
142	175370	1.929		
144	177840	1.959		
146	180310	1.989		
148	182780	2.019		
150	185250	2.049		
152	187720	2.079		
154	190190	2.109		
156	192660	2.139		
158	195130	2.169		
160	197600	2.199		
162	200070	2.229		
164	202540	2.259		
166	205010	2.289		
168	207480	2.319		
170	209950	2.349		
172	212420	2.379		
174	214890	2.409		
176	217360	2.439		
178	219830	2.469		
180	222300	2.499		
182	224770	2.529		
184	227240	2.559		
186	229710	2.589		
188	232180	2.619		
190	234650	2.649		
192	237120	2.679		
194	239590	2.709		
196	242060	2.739		
198	244530	2.769		
200	247000	2.799		
202	249470	2.829		
204	251940	2.859		
206	254410	2.889		
208	256880	2.919		
210	259350	2.949		
212	261820	2.979		
214	264290	3.009		
216	266760	3.039		
218	269230	3.069		
220	271700	3.099		
222	274170	3.129		
224	276640	3.159		
226	279110	3.189		
228	281580	3.219		
230	284050	3.249		
232	286520	3.279		
234	288990	3.309		
236	291460	3.339		
238	293930	3.369		
240	296400	3.399		
242	298870	3.429		
244	301340	3.459		
246	303810	3.489		
248	306280	3.519		
250	308750	3.549		
252	311220	3.579		
254	313690	3.609		
256	316160	3.639		
258	318630	3.669		
260	321100	3.699		
262	323570	3.729		
264	326040	3.759		
266	328510	3.789		
268	330980	3.819		
270	333450	3.849		
272	335920	3.879		
274	338390	3.909		
276	340860	3.939		
278	343330	3.969		
280	345800	3.999		
282	348270	4.029		
284	350740	4.059		
286	353210	4.089		
288	355680	4.119		
290	358150	4.149		
292	360620	4.179		
294	363090	4.209		
296	365560	4.239		
298	368030	4.269		
300	370500	4.299		
302	372970	4.329		
304	375440	4.359		
306	377910	4.389		
308	380380	4.419		
310	382850	4.449		
312	385320	4.479		
314	387790	4.509		
316	390260	4.539		
318	392730	4.569		
320	395200	4.599		
322	397670	4.629		
324	400140	4.659		
326	402610	4.689		
328	405080	4.719		
330	407550	4.749		
332	410020	4.779		
334	412490	4.809		
336	414960	4.839		
338	417430	4.869		
340	419900	4.899		
342	422370	4.929		
344	424840	4.959		
346	427310	4.989		
348	429780	5.019		
350	432250	5.049		
352	434720	5.079		
354	437190	5.109		
356	439660	5.139		
358	442130	5.169		
360	444600	5.199		
362	447070	5.229		
364	449540	5.259		
366	452010	5.289		
368	454480	5.319		
370	456950	5.349		
372	459420	5.379		
374	461890	5.409		
376	464360	5.439		
378	466830	5.469		
380	469300	5.499		
382	471770	5.529		
384	474240	5.559		
386	476710	5.589		
388	479180	5.619		
390	481650	5.649		
392	484120	5.679		
394	486590	5.709		
396	489060	5.739		
398	491530	5.769		
400	494000	5.799		
402	496470	5.829		
404	498940	5.859		
406	501410	5.889		
408	503880	5.919		
410	506350	5.949		
412	508820	5.979		
414	511290	6.009		
416	513760	6.039		
418	516230	6.069		
420	518700	6.099		
422	521170	6.129		
424	523640	6.159		
426	526110	6.189		
428	528580	6.219		
430	531050	6.249		
432	533520	6.279		
434	535990	6.309		
436	538460	6.339		
438	540930	6.369		
440	543400	6.399		
442	545870	6.429		
444	548340	6.459		
446	550810	6.489		
448	553280	6.519		
450	555750	6.549		
452	558220	6.579		
454	560690	6.609		
456	563160	6.639		
458	565630	6.669		
460	568100	6.699		
462	570570	6.729		
464	573040	6.759		
466	575510	6.789		
468	577980	6.819		
470	580450	6.849		
472	582920	6.879		
474	585390	6.909		
476	587860	6.939		
478	590330	6.969		
480	592800	6.999		
482	595270	7.029		
484	597740	7.059		
486	600210	7.089		
488	602680	7.119		
490	605150	7.149		
492	607620	7.179		
494	610090	7.209		
496	612560	7.239		
498	615030	7.269		
500	617500	7.299		
502	620000	7.329		
504	622500	7.359		
506	625000	7.389		
508	627500	7.419		
510	630000	7.449		
512	632500	7.479		
514	635000	7.509		
516	637500	7.539		
518	640000	7.569		
520	642500	7.599		
522	645000	7.629		
524	647500	7.659		
526	650000	7.689		
528	652500	7.719		
530	655000	7.749		
532	657500	7.779		
534	660000	7.809		
536	662500	7.839		
538	665000	7.869		
540	667500	7.899		
542	670000	7.929		
544	672500	7.959		
546	675000	7.989		
548	677500	8.019		
550	680000	8.049		
552	682500	8.079		
554	685000	8.109		
556	687500	8.139		
558	690000	8.169		
560	692500	8.199		
562	695000	8.229		
564	697500	8.259		

DRAFT

ATTACHMENT 1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/91

Room/Drift: PANEL 1 - ROOM 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PWR 120177)

PT081391-S

Location: N. END APPROX 4' W ROOM & APPROX. 15 FT FROM BULKHEAD

Depth at Completion: 11' - 7"

Diameter: 1-3/8" & COMPLETION

Approximate Collar Coordinates

Vertical Angle: VERT. (5° TOLERANCE)

Direction/Azimuth:

Remarks: RESIN/ROCK ANCHOR TEST AT 2:00^{pm} AND COMPLETED AT 2:1
FOR CERTIFICATION

Signature/Department: D. Bellman 8/14/91

DRAFT

ROCK BOLT CORROSION TEST

DATA SHEET

Mine W/P _____ Rock HALITE _____
Rock Bolt No. PT01391-4 _____
Hole Location _____

Hole Length - 11.7" Dia. - 6 Anchor (4x6) 8 midpoint N/A / 8 collar N/A
Orientation - YES. (5 Tensile) 3/4" 3/4"

Bolt Grade - G85 Length - 13'-0" Diameter - 5/8"

Shell Manufacturer - N/A Model - N/A Diameter - N/A
Length - N/A

Resin Manufacturer - CEI Model - H90-02M Diameter - 1 1/4"
Length - _____ No. Cartridges - _____

Installation Date - 08/12/91 Time - 10:51am Torque - N/A ft/lb

Test Date - 08/14/91 Time - 2:15 PM Torque - N/A ft/lb

Test Jack - RC-40-CH-15A
Dial Indicator - AWR-CP-0040
Pressure Gauge - W-GAGE 24" 5" 100

Calibrated - 08/08/91 BY: J. J. 10-8-91

Extensometer Reading Displacement Remarks

24.0	0.000	
44.0	0.007	
46.0	0.015	
48.0	0.025	
50.0	0.037	
52.0	0.050	
54.0	0.065	
56.0	0.080	
58.0	0.095	
60.0	0.110	
62.0	0.125	
64.0	0.140	
66.0	0.155	
68.0	0.170	
70.0	0.185	
72.0	0.200	
74.0	0.215	
76.0	0.230	
78.0	0.245	
80.0	0.260	
82.0	0.275	
84.0	0.290	
86.0	0.305	
88.0	0.320	
90.0	0.335	
92.0	0.350	
94.0	0.365	
96.0	0.380	
98.0	0.395	
100.0	0.410	
102.0	0.425	
104.0	0.440	
106.0	0.455	
108.0	0.470	
110.0	0.485	
112.0	0.500	
114.0	0.515	
116.0	0.530	
118.0	0.545	
120.0	0.560	
122.0	0.575	
124.0	0.590	
126.0	0.605	
128.0	0.620	
130.0	0.635	
132.0	0.650	
134.0	0.665	
136.0	0.680	
138.0	0.695	
140.0	0.710	
142.0	0.725	
144.0	0.740	
146.0	0.755	
148.0	0.770	
150.0	0.785	
152.0	0.800	
154.0	0.815	
156.0	0.830	
158.0	0.845	
160.0	0.860	
162.0	0.875	
164.0	0.890	
166.0	0.905	
168.0	0.920	
170.0	0.935	
172.0	0.950	
174.0	0.965	
176.0	0.980	
178.0	0.995	
180.0	1.010	
182.0	1.025	
184.0	1.040	
186.0	1.055	
188.0	1.070	
190.0	1.085	
192.0	1.100	
194.0	1.115	
196.0	1.130	
198.0	1.145	
200.0	1.160	
202.0	1.175	
204.0	1.190	
206.0	1.205	
208.0	1.220	
210.0	1.235	
212.0	1.250	
214.0	1.265	
216.0	1.280	
218.0	1.295	
220.0	1.310	
222.0	1.325	
224.0	1.340	
226.0	1.355	
228.0	1.370	
230.0	1.385	
232.0	1.400	
234.0	1.415	
236.0	1.430	
238.0	1.445	
240.0	1.460	
242.0	1.475	
244.0	1.490	
246.0	1.505	
248.0	1.520	
250.0	1.535	
252.0	1.550	
254.0	1.565	
256.0	1.580	
258.0	1.595	
260.0	1.610	
262.0	1.625	
264.0	1.640	
266.0	1.655	
268.0	1.670	
270.0	1.685	
272.0	1.700	
274.0	1.715	
276.0	1.730	
278.0	1.745	
280.0	1.760	
282.0	1.775	
284.0	1.790	
286.0	1.805	
288.0	1.820	
290.0	1.835	
292.0	1.850	
294.0	1.865	
296.0	1.880	
298.0	1.895	
300.0	1.910	
302.0	1.925	
304.0	1.940	
306.0	1.955	
308.0	1.970	
310.0	1.985	
312.0	1.999	
314.0	2.014	
316.0	2.029	
318.0	2.044	
320.0	2.059	
322.0	2.074	
324.0	2.089	
326.0	2.104	
328.0	2.119	
330.0	2.134	
332.0	2.149	
334.0	2.164	
336.0	2.179	
338.0	2.194	
340.0	2.209	
342.0	2.224	
344.0	2.239	
346.0	2.254	
348.0	2.269	
350.0	2.284	
352.0	2.299	
354.0	2.314	
356.0	2.329	
358.0	2.344	
360.0	2.359	
362.0	2.374	
364.0	2.389	
366.0	2.404	
368.0	2.419	
370.0	2.434	
372.0	2.449	
374.0	2.464	
376.0	2.479	
378.0	2.494	
380.0	2.509	
382.0	2.524	
384.0	2.539	
386.0	2.554	
388.0	2.569	
390.0	2.584	
392.0	2.599	
394.0	2.614	
396.0	2.629	
398.0	2.644	
400.0	2.659	
402.0	2.674	
404.0	2.689	
406.0	2.704	
408.0	2.719	
410.0	2.734	
412.0	2.749	
414.0	2.764	
416.0	2.779	
418.0	2.794	
420.0	2.809	
422.0	2.824	
424.0	2.839	
426.0	2.854	
428.0	2.869	
430.0	2.884	
432.0	2.899	
434.0	2.914	
436.0	2.929	
438.0	2.944	
440.0	2.959	
442.0	2.974	
444.0	2.989	
446.0	3.004	
448.0	3.019	
450.0	3.034	
452.0	3.049	
454.0	3.064	
456.0	3.079	
458.0	3.094	
460.0	3.109	
462.0	3.124	
464.0	3.139	
466.0	3.154	
468.0	3.169	
470.0	3.184	
472.0	3.199	
474.0	3.214	
476.0	3.229	
478.0	3.244	
480.0	3.259	
482.0	3.274	
484.0	3.289	
486.0	3.304	
488.0	3.319	
490.0	3.334	
492.0	3.349	
494.0	3.364	
496.0	3.379	
498.0	3.394	
500.0	3.409	
502.0	3.424	
504.0	3.439	
506.0	3.454	
508.0	3.469	
510.0	3.484	
512.0	3.499	
514.0	3.514	
516.0	3.529	
518.0	3.544	
520.0	3.559	
522.0	3.574	
524.0	3.589	
526.0	3.604	
528.0	3.619	
530.0	3.634	
532.0	3.649	
534.0	3.664	
536.0	3.679	
538.0	3.694	
540.0	3.709	
542.0	3.724	
544.0	3.739	
546.0	3.754	
548.0	3.769	
550.0	3.784	
552.0	3.799	
554.0	3.814	
556.0	3.829	
558.0	3.844	
560.0	3.859	
562.0	3.874	
564.0	3.889	
566.0	3.904	
568.0	3.919	
570.0	3.934	
572.0	3.949	
574.0	3.964	
576.0	3.979	
578.0	3.994	
580.0	4.009	
582.0	4.024	
584.0	4.039	
586.0	4.054	
588.0	4.069	
590.0	4.084	
592.0	4.099	
594.0	4.114	
596.0	4.129	
598.0	4.144	
600.0	4.159	
602.0	4.174	
604.0	4.189	
606.0	4.204	
608.0	4.219	
610.0	4.234	
612.0	4.249	
614.0	4.264	
616.0	4.279	
618.0	4.294	
620.0	4.309	
622.0	4.324	
624.0	4.339	
626.0	4.354	
628.0	4.369	
630.0	4.384	
632.0	4.399	
634.0	4.414	
636.0	4.429	
638.0	4.444	
640.0	4.459	
642.0	4.474	
644.0	4.489	
646.0	4.504	
648.0	4.519	
650.0	4.534	
652.0	4.549	
654.0	4.564	
656.0	4.579	
658.0	4.594	
660.0	4.609	
662.0	4.624	
664.0	4.639	
666.0	4.654	
668.0	4.669	
670.0	4.684	
672.0	4.699	
674.0	4.714	
676.0	4.729	
678.0	4.744	
680.0	4.759	
682.0	4.774	
684.0	4.789	
686.0	4.804	
688.0	4.819	
690.0	4.834	
692.0	4.849	
694.0	4.864	
696.0	4.879	
698.0	4.894	
700.0	4.909	
702.0	4.924	
704.0	4.939	
706.0	4.954	
708.0	4.969	
710.0	4.984	
712.0	4.999	
714.0	5.014	
716.0	5.029	
718.0	5.044	
720.0	5.059	
722.0	5.074	
724.0	5.089	
726.0	5.104	
728.0	5.119	
730.0	5.134	
732.0	5.149	
734.0	5.164	
736.0	5.179	
738.0	5.194	
740.0	5.209	
742.0	5.224	
744.0	5.239	
746.0	5.254	
748.0	5.269	
750.0	5.284	
752.0	5.299	
754.0	5.314	
756.0	5.329	
758.0	5.344	
760.0	5.359	
762.0	5.374	
764.0	5.389	
766.0	5.404	
768.0	5.419	
770.0	5.434	
772.0	5.449	
774.0	5.464	
776.0	5.479	
778.0	5.494	
780.0	5.509	
782.0	5.524	
784.0	5.539	
786.0	5.554	
788.0	5.569	
790.0	5.584	
792.0	5.599	
794.0	5.614	
796.0	5.629	
798.0	5.644	
800.0	5.659	
802.0	5.674	
804.0	5.689	
806.0	5.704	
808.0	5.719	
810.0	5.734	
812.0	5.749	
814.0	5.764	
816.0	5.779	
818.0	5.794	
820.0	5.809	
822.0	5.824	
824.0	5.839	
826.0	5.854	
828.0	5.869	
830.0	5.884	
832.0	5.899	
834.0	5.914	
836.0	5.929	
838.0	5.944	
840.0	5.959	
842.0	5.974	
844.0	5.989	
846.0	6.004	
848.0	6.019	
850.0	6.034	
852.0	6.049	
854.0	6.064	
856.0	6.079	
858.0	6.094	
860.0	6.109	
862.0	6.124	
864.0	6.139	
866.0	6.154	
868.0	6.169	
870.0	6.184	
872.0	6.199	
874.0	6.214	
876.0	6.229	
878.0	6.244	
880.0	6.259	
882.0		

DRAFT

ATTACHMENT 1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/91

Room/Drift: PANEL 1 - ROOM 2

Purpose of Hole: PULL TEST : DESTRUCTIVE (PWR 120/T)
PT 081391-4

Location: N. END 4' W ROAD APPROX. 28-30 FT FROM W. BULKHEAD

Depth at Completion: 11'-7"

Diameter: 1 3/8" ϕ COMPLETION

Approximate Collar Coordinates

Vertical Angle: VERT. (5° TOLERANCE)

Direction/Azimuth:

Remarks: RESIN/ROCK ANCHOR TEST AT 2:25 PM
AND COMPLETED AT 2:35 PM FOR CERTIFICATION.

Signature/Department: D. Balhaur 8/14/91

DRAFT

ROCK BOLT CERTIFICATION TEST DATA SHEET			
Mine <u>WIPP</u>	Rock <u>NALITE</u>	Rock Bolt No. <u>PT011391-5</u> Hole Location <u>PANEL 1-ROOM 2</u>	
Hole Length - <u>11'7"</u> Dia. - <u>Ø Anchor GAUGED</u> / Ø midpoint <u>N/A</u> / Ø collar <u>N/A</u> Orientation - <u>VERT. (5° PLUMBANCE)</u> <u>SMOOTH</u>			
Bolt Grade - <u>GR60</u>	Length - <u>13'0"</u>	Diameter - <u>4.8</u>	
Shell Manufacturer - <u>N/A</u>	Model - <u>N/A</u>	Diameter - <u>N/A</u> Length - <u>N/A</u>	
Resin Manufacturer - <u>CELTITE</u>	Model - <u>H20-0224</u>	Diameter - <u>1 1/4"</u> Length - <u>12"</u> No. Cartridges - <u>3</u>	
Installation Date - <u>09/13/91</u>		Time - <u>10:54 AM</u>	Torque - <u>N/A</u> ft/lb
Test Date - <u>08/14/91</u>		Time - <u>2:30 PM</u>	Torque - <u>N/A</u> ft/lb
Test Jack - <u>PC-40-CH 9.5A</u>		Test Pump - <u>PC-40-CH 9.5</u> SN <u>23886</u>	
Dial Indicator - <u>AMES</u> CS-0040		Calibrated - <u>5/88</u> 10-4-91	
Pressure Gauge - <u>UG-0405</u> CS1 4.001		Calibrated - <u>02/06/91</u>	

PST x 100 Pump Pressure	UBS Bolt Tension	Extensometer Reading	Displacement	Remarks
2	1470	0.009		
4	1940	0.012		
6	2410	0.038		
8	2880	0.050		
10	3350	0.074		
12	3820	0.111		
14	4290	0.145		
16	4760	0.177		
18	5230	0.206		
20	5700	0.231		
22	6170	0.251		
24	6640	0.274		
26	7110	0.295		
28	7580	0.316		
30	8050	0.340		
32	8520	0.360		
34	8990	0.373		
36	9460	0.380		
38	9930	0.391		
40	10400	0.400		
42	10870	0.411		
44	11340	0.421		
46	11810	0.432		
48	12280	0.443		
50	12750	0.453		
52	13220	0.463		
54	13690	0.473		
56	14160	0.483		
58	14630	0.492		
60	15100	0.502		
62	15570	0.512		
64	16040	0.522		
66	16510	0.532		
68	16980	0.542		
70	17450	0.552		
72	17920	0.562		
74	18390	0.572		
76	18860	0.582		
78	19330	0.592		
80	19800	0.602		
82	20270	0.612		
84	20740	0.622		
86	21210	0.632		
88	21680	0.642		
90	22150	0.652		
92	22620	0.662		
94	23090	0.672		
96	23560	0.682		
98	24030	0.692		
100	24500	0.702		
102	24970	0.712		
104	25440	0.722		
106	25910	0.732		
108	26380	0.742		
110	26850	0.752		
112	27320	0.762		
114	27790	0.772		
116	28260	0.782		
118	28730	0.792		
120	29200	0.802		
122	29670	0.812		
124	30140	0.822		
126	30610	0.832		
128	31080	0.842		
130	31550	0.852		
132	32020	0.862		
134	32490	0.872		
136	32960	0.882		
138	33430	0.892		
140	33900	0.902		
142	34370	0.912		
144	34840	0.922		
146	35310	0.932		
148	35780	0.942		
150	36250	0.952		
152	36720	0.962		
154	37190	0.972		
156	37660	0.982		
158	38130	0.992		
160	38600	1.002		
162	39070	1.012		
164	39540	1.022		
166	40010	1.032		
168	40480	1.042		
170	40950	1.052		
172	41420	1.062		
174	41890	1.072		
176	42360	1.082		
178	42830	1.092		
180	43300	1.102		
182	43770	1.112		
184	44240	1.122		
186	44710	1.132		
188	45180	1.142		
190	45650	1.152		
192	46120	1.162		
194	46590	1.172		
196	47060	1.182		
198	47530	1.192		
200	48000	1.202		
202	48470	1.212		
204	48940	1.222		
206	49410	1.232		
208	49880	1.242		
210	50350	1.252		
212	50820	1.262		
214	51290	1.272		
216	51760	1.282		
218	52230	1.292		
220	52700	1.302		
222	53170	1.312		
224	53640	1.322		
226	54110	1.332		
228	54580	1.342		
230	55050	1.352		
232	55520	1.362		
234	55990	1.372		
236	56460	1.382		
238	56930	1.392		
240	57400	1.402		
242	57870	1.412		
244	58340	1.422		
246	58810	1.432		
248	59280	1.442		
250	59750	1.452		
252	60220	1.462		
254	60690	1.472		
256	61160	1.482		
258	61630	1.492		
260	62100	1.502		
262	62570	1.512		
264	63040	1.522		
266	63510	1.532		
268	63980	1.542		
270	64450	1.552		
272	64920	1.562		
274	65390	1.572		
276	65860	1.582		
278	66330	1.592		
280	66800	1.602		
282	67270	1.612		
284	67740	1.622		
286	68210	1.632		
288	68680	1.642		
290	69150	1.652		
292	69620	1.662		
294	70090	1.672		
296	70560	1.682		
298	71030	1.692		
300	71500	1.702		
302	71970	1.712		
304	72440	1.722		
306	72910	1.732		
308	73380	1.742		
310	73850	1.752		
312	74320	1.762		
314	74790	1.772		
316	75260	1.782		
318	75730	1.792		
320	76200	1.802		
322	76670	1.812		
324	77140	1.822		
326	77610	1.832		
328	78080	1.842		
330	78550	1.852		
332	79020	1.862		
334	79490	1.872		
336	79960	1.882		
338	80430	1.892		
340	80900	1.902		
342	81370	1.912		
344	81840	1.922		
346	82310	1.932		
348	82780	1.942		
350	83250	1.952		
352	83720	1.962		
354	84190	1.972		
356	84660	1.982		
358	85130	1.992		
360	85600	2.002		
362	86070	2.012		
364	86540	2.022		
366	87010	2.032		
368	87480	2.042		
370	87950	2.052		
372	88420	2.062		
374	88890	2.072		
376	89360	2.082		
378	89830	2.092		
380	90300	2.102		
382	90770	2.112		
384	91240	2.122		
386	91710	2.132		
388	92180	2.142		
390	92650	2.152		
392	93120	2.162		
394	93590	2.172		
396	94060	2.182		
398	94530	2.192		
400	95000	2.202		
402	95470	2.212		
404	95940	2.222		
406	96410	2.232		
408	96880	2.242		
410	97350	2.252		
412	97820	2.262		
414	98290	2.272		
416	98760	2.282		
418	99230	2.292		
420	99700	2.302		
422	100170	2.312		
424	100640	2.322		
426	101110	2.332		
428	101580	2.342		
430	102050	2.352		
432	102520	2.362		
434	102990	2.372		
436	103460	2.382		
438	103930	2.392		
440	104400	2.402		
442	104870	2.412		
444	105340	2.422		
446	105810	2.432		
448	106280	2.442		
450	106750	2.452		
452	107220	2.462		
454	107690	2.472		
456	108160	2.482		
458	108630	2.492		
460	109100	2.502		
462	109570	2.512		
464	110040	2.522		
466	110510	2.532		
468	110980	2.542		
470	111450	2.552		
472	111920	2.562		
474	112390	2.572		
476	112860	2.582		
478	113330	2.592		
480	113800	2.602		
482	114270	2.612		
484	114740	2.622		
486	115210	2.632		
488	115680	2.642		
490	116150	2.652		
492	116620	2.662		
494	117090	2.672		
496	117560	2.682		
498	118030	2.692		
500	118500	2.702		
502	118970	2.712		
504	119440	2.722		
506	119910	2.732		
508	120380	2.742		
510	120850	2.752		
512	121320	2.762		
514	121790	2.772		
516	122260	2.782		
518	122730	2.792		
520	123200	2.802		
522	123670	2.812		
524	124140	2.822		
526	124610	2.832		
528	125080	2.842		
530	125550	2.852		
532	126020	2.862		
534	126490	2.872		
536	126960	2.882		
538	127430	2.892		
540	127900	2.902		
542	128370	2.912		
544	128840	2.922		
546	129310	2.932		
548	129780	2.942		
550	130250	2.952		
552	130720	2.962		
554	131190	2.972		
556	131660	2.982		
558	132130	2.992		
560	132600	3.002		
562	133070	3.012		
564	133540	3.022		
566	134010	3.032		
568	134480	3.042		
570	134950	3.052		
572	135420	3.062		
574	135890	3.072		
576	136360	3.082		
578	136830	3.092		
580	137300	3.102		
582	137770	3.112		
584	138240	3.122		
586	138710	3.132</		

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ATTACHMENT 1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 8/13/01

Room/Drift: PAUEL 1 - ROOM 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PWR 12017T)
PT081391-5

Location: N. END 4' W ROOM & 30-35 FT. FROM U. BULKHEAD

Depth at Completion: 11'-7"

Diameter: 1 3/8" @ COMPLETION

Approximate Collar Coordinates

Vertical Angle: VERT. (5° TOLERANCE)

Direction/Azimuth:

Remarks: RESIN/ROCK ANCHOR TEST AT 2:38 PM
AND COMPLETED AT 2:55 PM FOR
CERTIFICATION.

Signature/Department: D. Bellman 8/14/01

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ROCK BOLT CERTIFICATION TEST DATA SHEET

Page 1 of 2

Mine WIPP Rock MALITE Rock Bolt No. PT00001-1
 Hole Location Panel 1 - Room 2
 Hole Length - 11.50 Dia. - @ Anchor Gauged @ midpoint N/A @ collar N/A
 Orientation - Vertical (5° tolerance) smooth
 Bolt Grade - GR60 Length - 13'-0 1/4" Diameter - "0
 Shell Manufacturer - N/A Model - N/A Diameter - N/A
 Length - N/A
 Resin Manufacturer - Celuxite Model - H-20-0204 Diameter - 1 1/4" (32mm)
 Length - 12" No. Cartridges - 3
 Installation Date - 08/08/01 Time - 12:46 pm Torque - N/A ft/lb
 Test Date - 08/09/01 Time - 1:45 pm Torque - N/A ft/lb
 Test Jack - EC-60-CH2.5A Test Pump - EC-60-CH2.5A 23006
 Dial Indicator - Ames A112 CP-0060 Calibrated - 10-4-91 DUE
 Pressure Gauge - 42 GAGE PSIG 001 Calibrated - 8-6-91

Pump Psi Pressure	LBS Bolt Tension	Extensometer Reading	Displacement	Remarks
200	3410	0.000	0.000	
400	4940	0.017	0.017	
600	7410	0.144		
800	9880	0.165		
1000	12350	0.184		
1200	14820	0.205		
1400	17290	0.225		
1600	19760	0.246		
1800	22230	0.272		
2000	24700	0.293		
2200	27170	0.322	0.322	BLEED TO APPROX. 2100
2400	29640	0.354	0.354	HE IG - 16
2600	32110	0.371		
2800	34580	0.394		
3000	37050	0.414		
3200	39520	0.441		BLEED BACK TO 3100 AFTER 2 MIN.
3400	41990	0.464		* MINOR READING AT 3300 PSI.
3600	44460			
3800	46930			
4000	49400			
4200	51870			
4400	54340			
4600	56810			
4800	59280			
5000	61750			
5200	64220			
5400	66690			
5600	69160			
5800	71630			
6000	74100			
6200	76570			
6400	79040			
6600	81510			
6800	83980			
7000	86450			
7200	88920			
7400	91390			
7600	93860			
7800	96330			
8000	98800			
8200	101270			
8400	103740			
8600	106210			
8800	108680			
9000	111150			
9200	113620			
9400	116090			
9600	118560			
9800	121030			
10000	123500			

Test Results - ACCEPTED Maximum Pull Force 59280#
 Displacement at Maximum Pull Force - 0.765 in. 0.842 in.
 Nature of Failure/Yield - Bolt YIELD
 Other Remarks - Continued pull on 8/12/01 to 6700 psi with approx. 1" elongation
 Tested By - D. Hallman Approved By - R.F. Rasmussen

D R A F T

[illegible]

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ATTACHMENT 1-
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 08/08/01

Room/Drift: PANEL 1 - ROOM 2

Purpose of Hole: PULL TEST : DESTROYING (PWR 12017T)
PT080801-1

Location: NORTH END: APPROX. 4' E OF ROOM 2 APPROX. 10' FROM

Depth at Completion: 11'-6.5" (+1" - 0) 11'-6.5" NORTH BULKHEAD

Diameter: 1 7/8" COMPLETION

Approximate Collar Coordinates _____

Vertical Angle: VERTICAL (5" TOLERANCE)

Direction/Azimuth: _____

Remarks: BAT ROLL/RESIN ANCHORS TESTED ON 8-9-01 AT 1:45
TEST COMPLETED 2:30 PM FOR CERTIFICATION.

Signature/Department: D. Gallant / Mine Engineering

DRAFT

ROCK BOLT CERTIFICATION TEST DATA SHEET

Mine WIPP Rock WALITE Rock Bolt No. PROB0991-2
 Hole Location PAVEL 1 - Room 2
 Hole Length - 11.5' Dia. - @ Anchor GAUGED @ midpoint N/A @ collar N/A
 Orientation - VERTICAL (5° TOLERANCE) SMOOTH
 Bolt Grade - GR60 Length - 13'-0 1/4" Diameter - #8
 Shell Manufacturer - N/A Model - N/A Diameter - N/A
 Length - N/A
 Resin Manufacturer - CELTITE Model - 490-0204 Diameter - 1 1/4" (32mm)
 Length - 12" No. Cartridges - 3
 Installation Date - 08/08/91 Time - 1:13 pm Torque - N/A ft/lb
 Test Date - 08/09/91 Time - 2:55 pm Torque - N/A ft/lb
 Test Jack - RC-60-CH-25 Test Pump - RC-60-CH-9.5 25884
 Dial Indicator - MKS 432 LB - 0.001 Calibrated - 10-4-91 RID
 Pressure Gauge - U.S. GAGE 2512001 Calibrated - 8-6-91

Pump Pressure	Ext. Rod Bolt Tension	Ext. Rod Reading	Displacement (in)	Tension (lb)	Remarks
200	0.100	0.100	0.11	2470	
400	0.118	0.100	0.11	4940	
600	0.151	0.100	0.11	7410	
800	0.174	0.100	0.11	9880	
1000	0.191	0.100	0.11	12350	
1200	0.211			14820	
1400	0.229			17290	
1600	0.245			19760	
1800	0.262			22230	
2000	0.279			24700	
2200	0.297			27170	
2400	0.317			29640	
2600	0.336			32110	
2800	0.354			34580	
3000	0.372			37050	
3200	0.388			39520	HELD FOR 2 MIN. - 3000 PSI
3400	0.396			41990	HELD AT 3400
3600	0.408			44460	HELD FOR 2 MIN.
3800	0.415			46930	HELD FOR 2 MIN.
4000	0.425	0.324		49400	ADJUST TO 0.324 0.326
4200		0.357		51870	GAUGE CAME OFF BOLT
4400		0.347		49340	PLATE AT BACK DEFORMED
4600		0.354		51810	
4800		0.362		54280	HELD FOR 2 MIN. RID TO 3900
5000		0.373		56750	
5200		0.381		59220	
5400		0.387		61690	
5600		0.400		64160	
5800		0.417		66630	
6000		0.434		69100	
6200		0.455		71570	
6400		0.530	0.91	74040	BOLT YIELD - PUMP NEEDS TO 4700 BACK 4600
					0.571 AT 4600 PSI
					TEST TERMINATED 2:05 PM

39,520

*

Test Results - ACCEPTED Maximum Pull Force - 56750 / 58045
 Displacement at Maximum Pull Force - 0.530 in
 Nature of Failure/Yield - BOLT YIELD (APPARENT) 09/14/91 4700 PSI
 Other Remarks 2 1/2 HOURS AFTER INSTALLATION
 Tested By - A. T. Hallman Approved By - P. E. Hallman

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ATTACHMENT 1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 08/08/91

Room/Drift: PANEL 1 - Room 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PNE 12017T)
PT080891-2

Location: NORTH END: APPROX. 4' E OF ROOM 2 APPROX. 15' FROM
NORTH BULKHEAD

Depth at Completion: 11'-6" (+1" - 0") 11'-7"

Diameter: 1-3/8" COMPLETED

Approximate Collar Coordinates

Vertical Angle: VERTICAL (5° TOLERANCE)

Direction/Azimuth:

Remarks: ROCK/RESIN ANCHOR TESTED ON 8.9.91 AT 2:55 pm.
COMPLETED AT ≈ 3:05 pm FOR CERTIFICATION.

Signature/Department:

D. Ballmaier / Mine Engineering

DRAFT

ROCK BOLT CERTIFICATION TEST

DATA SHEET

Mine WIPP Rock HALITE Rock Bolt No. PROB0091-3
 Hole Location Russell - Room 2
 Hole Length - 11.5' Dia. - @ Anchor Gauged / @ midpoint N/A / @ collar N/A
 Orientation - VERTICAL (5° TOLERANCE) Smooth
 Bolt Grade - GR60 Length - 13'-0 1/4" Diameter - #8
 Shell Manufacturer - N/A Model - N/A Diameter - N/A
 Length - N/A
 Resin Manufacturer - CELTITE Model - H90-0204 Diameter - 1 1/4" (32mm)
 Length - 12" No. Cartridges - 3
 Installation Date - 08/08/91 Time - 1:46 pm Torque - N/A ft/lb
 Test Date - 08/09/91 Time - 3:30 pm Torque - N/A ft/lb
 Test Jack - RC-60-CH95A Test Pump - RC-60-H95 25986
 Dial Indicator - AMES 482 CP-0040 Calibrated - 10-4-91 OK
 Pressure Gauge - US6005 DS1E001 Calibrated - 9-6-91

PSI Pump Pressure	LBs Bolt Tension	Extensio- meter Reading	Displace- ment	Remarks
200	2470	0.100		
400	4940	0.113		
600	7410	0.135		
800	9880	0.157		
1000	12350	0.180		
1200	14820	0.202		
1400	17290	0.222		
1600	19760	0.238		
1800	22230	0.247		
2000	24700	0.263		
2200	27170	0.281		
2400	29640	0.296		
2600	32110	0.314		
2800	34580	0.334		
3000	37050	0.356		
3200	39520	0.376		HELD FOR 2 MIN. 3000
3300	40755	0.393		HOLDING
3400	41990	0.405		
3500	43225	0.413		HOLDING AFTER 1 MIN
3600	44460	0.425		HOLDING
3700	45695	0.436		HOLDING AFTER 1 MIN.
3800	46930	0.447		
3900	48165	0.460		
4000	49400	0.473		
4100	50635	0.485		
4200	51870	0.497		HOLDING AFTER 1 MIN
4300	53105	0.511		
4400	54340	0.524		HOLDING AFTER 1 MIN.
4500	55575	0.536		HOLDING
4600	56810	0.555		HELD FOR 2 MIN. RISE TO 4500 &
4700	58045	0.585		HELD 1 MIN. BA 4600 X PLATE DEF. 1/16"
4800	59280	0.686		POST YIELD - FAILURE APPARENT
4900	60515			CONTINUE LOADING PUMPING
4900	60515			DEF. .686 AT 4600 GAUG
4900	60515			.702 AT 4600 READING
4900	60515			TEST TERMINATED @ 3.45 PM

Test Results - ACCEPTED Maximum Pull Force - 58045 lb
 Displacement at Maximum Pull Force - 0.686 in 0.702 in
 Nature of Failure/Yield - BOLT YIELD @ 4700 psi (58045 lbs) APPARENT
 Other Remarks 2 1/2 HOURS AFTER INSTALLATION
 Tested By - D. DALLMAN Approved By - P.F. B...

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ATTACHMENT-1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: 08/08/91

Room/Drift: PANEL 1 - ROOM 2

Purpose of Hole: PULL TEST: DESTRUCTIVE (PWE 120 FT)

PT080891-3

Location: NORTH END: APPROX. 4' E OF ROOM 2 APPROX. 20-25 FT
FROM NORTH BULKHEAD

Depth at Completion: 11'-6" (4 1/4" - 0) 11'-7"

Diameter: 1-3/8" COMPLETION

Approximate Collar Coordinates

Vertical Angle: VERTICAL (5° TOLERANCE)

Direction/Azimuth:

Remarks: REIN/REIN ANCHOR TESTED ON 8.9.91 AT 3:30 pm
COMPLETED AT 3:45 pm FOR CERTIFICATION

Signature/Department: L. Ballmaier / Mine Engineering

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WORK CHANGE NOTICE

1. WCN No.: <u>1</u>		2. Critical System Yes ☐ No ☒	
3. Work Request: <u>12017-2</u>		4. Originated By / Phone No.: <u>T.E. Brockmeyer 8304</u> Date: <u>8/7/91</u>	5. Incorporated By / Phone No.: <u>T.E. Brockmeyer 8304</u> Date: <u>8/7/91</u>
6. DESCRIPTION OF CHANGE (Print or Type Proposed Change)			
Page	Step or Paragraph	Instructions: Rewrite Paragraph Changes, Draw Illustration Changes	
Attachment	6	CHANGE LARGE REAMED HOLE FROM 3" TO 3-4" ²	
5	7.2.4b	CHANGE HEAD FROM 1,000 [#] TO 200 P.S.I.	
5	7.2.6 ^{REF}	CHANGE ALL REFERENCE OF 1,000 [#] TO READ 200 P.S.I.	
5	7.2.7b	CHANGE 40,000 [#] TO READ 3,200 P.S.I.	
5	7.2.7	CHANGE 500 [#] TO READ APPROXIMATELY 100 P.S.I.	
7. Reason for Change: TO ACCOMMODATE FOR AVAILABLE EQUIPMENT. CHANGE DOES NOT AFFECT SCOPE NOR INTENT OR DESIGN		8. DESIGN CLASSIFICATION ☒ Class II or IIIA ☒ Class IIIB or Non-Facility	
		9. Required Approval	
		Signature	Date
		PIC All Classes <u>M. Campbell</u>	8/8/91
		Originator All Classes <u>T.E. Brockmeyer</u>	8/7/91
		Safety As Required <u>[Signature]</u>	8/8/91
		Quality Assurance II or IIIA <u>[Signature]</u>	8/8/91
		Cognizant Engineer II or IIIA <u>T.A. Gonzalez</u>	8/7/91
		Cognizant Operations Manager All Classes <u>T.E. Brockmeyer</u>	8/7/91
		Other	
Other			

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DESTRUCTIVE TESTING OF RESIN ANCHORS

Page 1 of 7

1.0 SCOPE

A representative sample of resin anchored Dywidag tendons will be pull tested to destruction. This will be achieved by installing the rock anchors in Room 2, Panel 1 in conditions as similar to those in Room 1 as possible. The results will be used as basic input data in the design of the supplemental support system proposed for Room 1, Panel 1.

2.0 OBJECTIVES

The objectives of the destructive testing are expected to yield results that:

- o provide data on both the mode and load at failure of the halite/resin/tendon bond.
- o establish the allowable design load for the rock anchor system.

In addition, other in situ tests are expected to provide results that:

- o check for interaction effects between rock anchors.
- o provide short term creep response of the rock anchor system.

3.0 SAFETY REQUIREMENTS

- 3.1 Personnel Safety - All personnel participating in or observing destructive testing shall be properly equipped.
- 3.2 For the safety of observers, personnel not actively participating in the destructive testing are requested to stay outside the designated work area. The boundary for a designated work area is to be established at least fifty (50) feet away.
- 3.3 During the performance of the destructive tests, safety chain or cables shall be attached to each item of test equipment weighing more than 10 lbs. that may be violently released or fall as a result of testing.

DESTRUCTIVE TESTING OF RESIN ANCHORS

Page 2 of 7

4.0 TEST MATERIALS

- 4.1 Resin: Celitite Lockset Polyester Resin Cartridge
High Viscosity, Code (H)
Gel Time, Two-to-Four Minutes Code (90)
Cartridge, 3212

0204 ^{Dg} 8.7.91QA Verification: KA Long

For additional information refer to Attachments 1, 2, and 3 for Material Safety Data Sheets, installation instructions, and product information.

- 4.2 Tendons: Dywidag Post-Tensioning System
#8 THREADBAR (LHT), ASTM A615 GR 60
FULL LOAD ANCHOR NUTS FOR GRADE 60 THREADBAR

QA Verification: KA Long

For additional information refer to Attachments 4 and 5.

5.0 TEST EQUIPMENT AND TEST REQUIREMENTS

- 5.1 A minimum of ten (10) rock anchors shall be installed, and loaded to failure. Initially, only one set (of five) rock anchor installations shall be tested in any given twenty-four (24) hours. The load will be recorded all the way to failure.

5.1.1 The failure mode is to be determined by pulling tendons completely of the hole.

5.1.2 For the purpose of destructive testing, failure is defined as an increasing or continuous deformation with no increase of the applied load.

- 5.2 There is to be a waiting period of at least twenty-four (24) hours between resin/anchor activation and the commencement of destructive testing. The waiting period assures that the resin has cured and is approaching ultimate strength. Fully cured resin develops compressive strength of 14,000 psi and tensile strength of 5,000 psi or more.

QA Verification: Mike Rosen

- 5.3 The testing equipment includes a hydraulic ram with a 60 ton capacity, a pressure gauge readable in 200 psi increments, and a dial indicator gauge for measuring deformation in increments of 0.001 inch. Rock/resin anchor deformation will be measured by means of the dial indicator.

QA Verification: Mike Rosen

DESTRUCTIVE TESTING OF RESIN ANCHORS

DRAFT

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- 5.4 Installation of properly calibrated Geotechnical instrumentation may be used where required.
- 5.5 All instruments and devices used for measuring or recording loads or deformation during the test shall have been properly calibrated with tags affixed indicating calibration due date.

QA Verification:

Mila Lopez

6.0 DRILLING AND ANCHOR/RESIN INSTALLATION INSTRUCTIONS

- 6.1 Drill each test hole as per Attachment 6 in accordance with applicable sections as prescribed in WP 04-220 and provided by factory representative's instructions.
- 6.1.1 Test hole locations shall have not less than four (4) feet spacings.
- 6.1.2 The 1-3/8 inch diameter bits shall be gauged prior to drilling above Anhydrite "b". Gauging assures the annular tolerance needed for a minimum bond length of three (3) feet.
- 6.1.3 Holes shall be drilled to a depth of 11 feet 6 inches with 1 inch tolerance, for test purposes only.
- 6.1.4 The perpendicular hole tolerance shall be 5 degrees as shown on Attachment 6.
- 6.2 Initially, only one set (of five) rock anchor installations shall be tested in any given twenty-four (24) hours. This may be changed subject to improved installation performance gained by experience and signed by cognizant engineer or his designee.
- 6.3 Resin and threadbar will be installed in accordance with the manufacturers' recommendations. A manufacturer's representative will be present during resin/anchor installation and destructive testing.
- 6.4 Insert required number of resin cartridges (3 minimum) through plastic or steel pipe and fed into the end of the hole. The resin is then followed by the threadbar with spin adapter.
- Care must be taken to avoid rupturing the resin cartridges.
- 6.5 Start rotation at about 50 rpm or more and gradually insert the threadbar bolt into the resin cartridge to rupture the cartridge.
- 6.5.1 Advance threadbar bolt at an approximate rate of 2 to 4 inches per second or as recommended by the factory representative.

X Due To AVAILABLE EQUIPMENT AND PERCAUTIONS
THE BAR IS TO BE INSERTED TO FULL DEPTH THE

- 6.5.2 Hold bolt in the hole and hold until the resin sets, approximately for two (2) to four (4) minutes.
- 6.5.3 Threadbar should have approximately eighteen (18) inches of thread protruding from the hole in its final position.
- 6.5.4 Thorough mixing of the resin ingredients is essential.
- 6.6 There is to be a waiting period of at least twenty-four (24) hours between resin/anchor activation and destructive testing.

A waiting period assures that the resin has cured and is approaching its ultimate strength. When fully cured, the resin develops a compressive strength of 14,000 psi and tensile strength of 5,000 psi or more.

QA Verification: *Mike Rogers*

7.0 FULL TEST INSTRUCTIONS

7.1 Preparation for tests

- 7.1.1 All instruments and devices used for measuring or recording loads or deformation during the testing shall have been properly calibrated with tags affixed indicating calibration due date.
- 7.1.2 Prepare data sheets. Applicable information and test data shall be recorded on data sheets, Attachment 7. See Section 8 for QA verification.
 - 7.1.2.1 Record at least the following: rock bolt number (i. e., PTmddy-#); mine; rock type; hole location; orientation; hole length and diameter; bolt grade, length, and diameter; installation date and time; test date and time; resin type, manufacturer, number of resin cartridges; and, identify test equipment by serial number and indicate calibration due date.
 - 7.1.2.2 Measure the hole length and record.
 - 7.1.2.3 When testing is complete, submit the data sheet to Mine Engineering.
 - 7.1.2.4 When testing is complete, submit WP Form 2014 to Mine Engineering, Attachment 8.

DESTRUCTIVE TESTING OF RESIN ANCHORS

Page 5 of 7

7.1.2.5 Mark the final depth of the threadbar at 11 feet 6 inches with 1 inch tolerance from the anchor end and record.

7.1.2.6 Estimate hole orientation and roughness (i.e., vertical and smooth) and record.

7.2 PULL TEST

7.2.1 Install a bearing plate against the rock followed by placing the ram over the threadbar followed by another bearing plate and load cell and bearing plate, and finally torque the anchor nut.

The anchor nut shall be tightened to the manufacturer's recommended torque values (150 ft-lbs to 300 ft-lbs).

7.2.1.1 Fasten safety chain or cable to all equipment weighing more than 10 lbs and anchor to adjacent rock bolt plates.

7.2.2 The ram alignment should be near parallel to the axis of the tested bolt and within the limits allowed by the installation.

7.2.3 Make hose connections from the hydraulic pump to the ram.

7.2.4 q Make load cell and other instrumentation connections to data logger.

7.2.4 b Apply 1,000 lb load on the ram to eliminate apparatus slack.

7.2.5 Attach a magnet mounted dial indicator gauge on the ram with the point set in place on the bolt or to a fixed reference point in the salt. Adjust the dial indicator gauge to zero.

7.2.6 Test loading shall continue to be applied starting with 1,000 lbs and increased by 1,000 lb increments up to 40,000 lbs. Loads are to be held for approximately one (1) minute before recording the load and deformation data. Record the test data, Attachment 7.

7.2.7 From 40,000 lbs, the load shall be applied in 500 lb increments. While approaching failure, data readings may be taken more often.

7.2.8 Testing the resin/rock anchor to failure is the acceptance criteria. The test is accepted as complete at failure.

DESTRUCTIVE TESTING OF RESIN ANCHORS

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7.2.8.1 For the purpose of destructive testing, failure is defined as an increasing or continuous deformation with no increase of the applied load.

7.2.9 Terminate testing.

7.2.10 Remove equipment and pull bolt from hole, if possible

7.2.11 Continue testing of the next installation.

8.0 TEST DATA, ILLUSTRATIONS AND REPORTS

8.1 The data sheet form (Attachment 7) shall be filled out for each test bolt installation. The data sheet shall be keyed to match the rock anchor pull test number (PT#ddy-#).

QA Verification: *Mike Rosen*

8.2 Each test shall be identified by rock anchor number and plotted on an appropriate scale. Each data point shall be plotted with the horizontal (x) axis showing displacement while the vertical (y) axis indicates load.

8.3 Photographs of a typical rock anchor installation shall be referenced to the rock anchor test number.

8.4 A report shall be prepared by Mine Engineering summarizing the test results and certifying the installation procedures and resin/rock anchors that have been tested and approved for installation at the WIPP.

8.5 The results will be used as basic input data in the design of the supplemental support system proposed for Room 1, Panel 1.

DRAFT

DESTRUCTIVE TESTING OF RESIN ANCHORS

Page 7 of 7

CONCURRENCE BY:

D. Galbraith

D. Galbraith, Senior Engineer
Mine Engineering

Chris Chene / J. A. Gonzalez

J. A. Gonzalez, Cognizant Engineer
Mine Engineering

8/7/91

P. F. Brading 8/7/91

S. C. Sethi

S. C. Sethi, Manager
Mine Engineering

MATERIAL SAFETY DATA SHEET

SECTION 1 - PRODUCT IDENTIFICATION AND USE

MANUFACTURER: CELTITE TECHNIK USA CANADIAN CONTACT: FOSECO CANADA INC.
150 CARLEY COURT GUELPH, ONTARIO
GEORGETOWN, KY 40324
(502) 863 - 6800

DRAFT

MANUFACTURERS IDENTIFICATION CODE:
20,35,37,40,45,50,70,90,0204,0510,1530
PRODUCT NAME: LOKSET POLYESTER RESIN CARTRIDGE
CHEMICAL FAMILY: Polyester Resin & Catalyst
PRODUCT USE: Anchoring Compound
WHMIS CLASSIFICATION: Class D, Division 2A; Class B, Division 3

SECTION 2 - HAZARDOUS INGREDIENTS

INGREDIENT	%	ACGIH/OSHA TLV			NTP CARC	IARC CARC
		TWA	STEL	CARC		
Polyester resin CAS# N.R.	10-30	N.E.	N.E.	NO	NO	NO
Styrene monomer CAS# 100-42-5	5-10	50P	100P	NO	NO	2B
Benzoyl Peroxide CAS# 94-36-0	.5-1.5	5M	N.E.	NO	NO	NO
Calcium Carbonate CAS# 471-34-1	60-100	N.A.	N.E.	NO	NO	NO
Propylene Glycol CAS# 57-55-6	.5-1.5	N.E.	N.E.	NO	NO	NO

units - P suffix denotes PPM and M suffix denotes mg/m3
m suffix denotes mppcf and c suffix denotes ceiling value
N.A.- Not Applicable N.E.- Not Established N.D.- Not Determined
CARC- Carcinogen N.D.F.- No Data Found N.R.- Not Reported
NOTE: See SUPPLEMENT for SARA Section 313 reporting information.

This document is prepared pursuant to the OSHA Hazard Communication Standard (29 CFR 1910.1200) and the Canadian Workplace Hazardous Materials System (WHMIS). In addition, other ingredients not 'Hazardous' per these standards may be listed.

SECTION 3 - PHYSICAL DATA

APPEARANCE: Tan or black resin mortar and white paste catalyst in plastic package.
ODOR: N.A. ODOR THRESHOLD: 0.1 ppm as Styrene
PERCENT VOLATILE: 11 SOLUBILITY IN WATER: N.A.
VAPOR PRESSURE(mmHg): 4.5 @ 20C(Styrene) SPECIFIC GRAVITY: 1.75-1.85
VAPOR DENSITY: 3.6 as Styrene EVAPORATION RATE: N.D.
BOILING POINT: 293F FREEZING POINT: N.D.
pH: Acidic COEF. OF WATER/OIL DISTRIBUTION: N.
PHYSICAL HAZARDS: Organic peroxide; Combustible Liquid

SPECIAL PROTECTION INFORMATION:

RESPIRATORY: Use MSHA (NIOSH) approved respirator if application produces vapors, mists, or fumes above the TLV.
VENTILATION: Adequate to prevent vapor build-up above the TLV.
PROTECTIVE GLOVES: Chemical resistant polyethylene or equivalent.
EYE PROTECTION: Safety glasses or goggles as required to prevent eye contamination.
OTHER: Use protective clothing to minimize contact with skin. Wash contaminated clothing before reuse.

SPILL OR LEAK PROCEDURES:

SPILL: Ventilate area. Remove all sources of ignition. Absorb with inert material and collect.
WASTE DISPOSAL METHOD: Dispose of in accordance with Federal, State, and local regulations.
STORAGE: For maximum shelf-life avoid storage in direct sunlight, elevated temperatures or near sources of heat such as steam pipes and radiators. Store in a cool, dry well-ventilated area.
OTHER: Since the product is a sealed cartridge, handling hazards are minimal unless product is damaged or misused.
SHIPPING INFORMATION: Not Applicable

SECTION 8 - FIRST AID MEASURES

EYES - Flush with water for at least 15 min. Consult a physician.
SKIN - Wash thoroughly with soap and water.
INGESTION - Consult a physician immediately.
INHALATION - Remove to fresh air if effects occur. Call a physician if effects persist.

SECTION 9 - PREPARATION DATE OF MSDS

Revision date: 12/11/89
Previous revision date: 01/01/89
For further information contact: Leo Hickam
Phone number: (502) 863 - 6800

SUPPLEMENT:**HAZARDOUS INGREDIENTS Continued...**

The following chemicals are subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) and 40 CFR Part 372.

<u>Chemical Name</u>	<u>CAS#</u>	<u>Maximum % by Weight</u>
Benzoyl Peroxide	94-36-0	1.5%
Styrene	100-42-5	10.0%

DRAFT

Dy/G. Sealy : G. Greenfield CelTite
GEORGETOWN, KY : 150 CARLEY CT. 40324
502/863-6800
PRINCETON, WV: Rogers St & Caperton Ave. 24740 304-425-7501
GRAND JUNCTION, CO 1440 Winters Ave. 81501 303-245-4007

INSTALLATION INSTRUCTIONS FOR CELTITE RESIN CARTRIDGES

- 1 Measure and mark drill steel 1" longer than bolt length. Note The bore hole should be shortened accordingly when headers or thick plates are used.
- 2 Insert required number of cartridges and place bolt into the base of the hole behind the resin.
- 3 With the head of the bolt placed firmly in the chuck of the boiler or in a spin-in wrench, push the bolt into the hole. Slow rotation is recommended but not required for adequate mixing.
- 4 When the bolt reaches just below the roof, stop upward movement and spin the bolt rapidly for five to ten seconds (See note for stopper.)
- 5 Stop rotation and push the bolt upward with the full thrust from the machine and hold until the resin sets.
- 6 If the bolt tends to drop out of the hole after the chuck or adapter is removed, simply push it back up into the hole and hold until the resin sets.
- 7 NEVER re-rotate the bolt after the final spin, as damage to the partially-set resin may occur.
- 8 Always wear safety glasses or eye shields when installing resin bolts.
- 9 To achieve maximum performance, selection of bolt diameter, cartridge type and related hole diameter are very important. CelTite® technical representatives are available to assist in the selection of the correct combination of components, based on specific applications.
- 10 Note for stopper: Contact CelTite® technical representative.
- 11 For applications other than fully grouted bolts, CelTite® technical representatives will instruct mine personnel in correct installation procedure.
- 12 Cartridges should be stored in a cool, well-ventilated and dry area away from direct sunlight. High temperature conditions can reduce shelf life of cartridges. Stock rotation is recommended so that oldest stock is used first.

CAUTION: Do not open or puncture cartridges. Contents of cartridges may cause mild irritation and should be avoided. Eye protection should always be used when bolting. If resin contacts the eyes, flush immediately with water for at least 15 minutes. Call a physician.

We believe that the information contained herein (which supersedes all previous information on this subject) is true and reliable. We cannot be held responsible for any loss, injury, or damage resulting from its use, as, of necessity, the information given is of a general nature, so that users are advised to consult us about their specific problems.

CelTite® warrants that its products, at the time of shipment, conform to the applicable descriptions herein and are free from defects in materials and workmanship. NO OTHER WARRANTY, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, SHALL EXIST IN CONNECTION WITH THE SALE OR USE OF ANY CELTITE® PRODUCT, AND ALL SUCH WARRANTIES ARE HEREBY EXPRESSLY EXCLUDED.

IN NO EVENT SHALL CELTITE® BE LIABLE FOR INJURY TO PERSON OR PROPERTY, LOSS OF BUSINESS OR PROFIT ON ANY OTHER DIRECT, INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES.

U.S. Patent Nos. 3731791, 3915297 Canada No. 872075 Other World Patents

05-00-03
04-22-88

The Lokset[®] Polyester **DRAFT** Resin Cartridge Anchor System

This system's simplicity of application enables bolts of various lengths to be anchored and grouted in one easy operation, with no need for injection equipment.

The Celtite Technik system consists of an easily handled "cartridge," containing a highly reinforced polyester resin component, together with its catalyst, in accurately measured quantities. The components are isolated from each other by a physical-chemical barrier which prevents reaction between the components until required. The cartridges are sausage-shaped and designed for rapid insertion into a range of bore hole sizes, where they may be readily pushed to the extremity at any angle above or below the horizon. Therefore, optimum bolt anchorage in a wide range of rock or concrete strengths is easily achieved simply by adjusting the length of the resin anchor zone.

No reaction takes place until the roof or rockbolt is rotated through the cartridge, mixing the components and initiating the curing action. The chemical nature (thixotropy) of the Lokset[®] cartridge allows the contents to be easily mixed yet minimizes resin displacement after mixing is complete.

The mixed resin totally fills the area (annulus) around the bolt, which for standard "point" anchorages will be firmly bonded to the substrate and bolt within minutes.

Celtite Technik's Lokset[®] Polyester Resin Cartridge.

The setting time of the resin components can be controlled. A combination of fast and slow-setting cartridges makes possible the simultaneous operation of anchoring, grouting and tensioning a rockbolt. The simplicity of this method of anchoring grouting eliminates the need for cumbersome injection equipment.

APPLICATIONS

- Rock bolting in mines and tunnels.
- Permanent rock reinforcement on highway rock cuts, dams and underground rock structures (power-houses and machinery galleries).
- Integral ties between reinforced concrete and rock faces above or below water.
- Vibration resistant anchorages for attachment of "critical" equipment to concrete or rock.
- Anchorage for electrical transmission towers.
- Uplift anchorages for near surface structures.
- Immediate post-tensioning of steel reinforcements in rock or concrete structures.

ADVANTAGES

Accuracy. All Anchorages can now be accurately designed with Celtite Technik resins having reproducible strength characteristics.

Speed. The fast-gelling Lokset[®] resins enable rapid installation to be carried out, a significant advantage in the area of tunnel bolting and rock slope stabilization. Application of load can be completed within minutes.

Permanence. The resins protect the embedded bolt from corrosion due to acid-bearing water, sea or ground water. Atmosphere is precluded from the bore hole, preventing further deterioration of the strata.

Safety. Millions of Lokset[®] resin anchors are used every year for critical jobs such as roof support or permanent rock reinforcement in mines, tunnels and foundations.

Vibration. Celtite Technik anchors are not affected by vibration and require no retensioning even after close proximity blasting.

Stress-free. No internal stresses are set up in the rock or concrete by resin anchors.

TECHNICAL SERVICE

Celtite Technik is available to discuss with you both installation techniques and the selection of proper Lokset[®] cartridges for your project. Our field representatives are ready to review your applications and help you to develop successful, economical anchoring systems.

Anchoring

DRAFT

INTRODUCTION

Installation of *Celtite Technik* polyester resin cartridges in rock and concrete have ranged from application of short 3/4-inch rebar "starter bars" into concrete to 1 3/8" diameter bolts for rock reinforcement, measuring 55' in length, weighing over 300 pounds and fully embedded in resin!

ANCHORAGE STRENGTHS

To achieve maximum anchorage strength between bolt and concrete or rock, the difference in diameter between hole and bolt should be kept to a minimum. This also insures better mixing of both catalyst and resin.

Standard Rebar or Threadbar bolts (conforming to ASTM A-615 specifications) are used without further refinement. Deformations on the bar serve to effectively mix the cartridge components during the "spin-in" or insertion cycle. (SEE BOLT SELECTION ON PAGE 6).

Spin adaptors are available from several manufacturers. Consult *CELTITE[®] TECHNIK* for source information.

UNDERWATER ANCHORAGES

Lokset[®] cartridges can be applied in underwater anchorage applications over 24 inches in length, in both concrete and rock. Consult *CELTITE[®] TECHNIK* for your specific job requirements.

APPLICATION EQUIPMENT

The hole-drilling equipment mentioned in this brochure is generally suitable for spinning in bolts. This equipment should be rotary percussive and have provision for independent rotation to maintain 100 rpm under load. Under no circumstances should the bolt be simply pushed through the resin cartridges as improper mixing can result, providing for possible anchorage failure.

RESIN ANCHORAGE CHARTS

Typical anchorage loadings* in rock for point anchored rockbolts used in accordance with the manufacturer's recommendations. Intended as a guide for site trials, which will establish the working specifications in the actual ground conditions. *Shown in Kips (1000 lbs. = 1 Kip).

Rock strengths are in uniaxial compression terms. Information based on work conducted by Imperial College, London (1970), J. A. Franklin, B.Sc., M.Sc., Ph.D., D.I.C.

Packaging.

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Order Code (1)	Cartridge Diameter (inches)	Pieces Per Carton	Weight Per Carton
2312	1 5/16	50	27.5 lbs.
2812	1 1/8	35	29.5 lbs.
3212	1 1/4	25	26.5 lbs.
3512	1 3/8	20	26.0 lbs.
4012	1 9/16	16	27.0 lbs.
4512	1 3/4	12	25.0 lbs.

Minimum shipment; single full cartons.

A full pallet contains 75 cartons of standard 12-inch cartridges.

(1) Do not forget to specify gel time (see description section on page 5).

STORAGE PROCEDURES

Lokset® cartridges should be stored in a cool, well-ventilated and dry area away from direct sunlight. High temperature conditions can reduce shelf life. Cartridges stored in extreme temperatures should be "normalised" at 50-70°F for at least two days prior to use to provide the expected gel time.

Pallets should not be stacked. Stock rotation is recommended so that the oldest stock is used first.

SAFE HANDLING PROCEDURES

REFER TO THE MATERIAL SAFETY DATA SHEET. Do not open or puncture cartridges prior to insertion. Contents of cartridges may cause mild irritation and contact should be avoided. Use in adequately ventilated area. Avoid prolonged inhalation of vapor. Eye protection should always be used when bolting. If resin contacts the eyes, flush immediately with water for at least 15 minutes. Seek medical attention.

Typical Lokset® resin anchor applications

Roof bolts in diversion tunnel.
Painville Lake Dam, Kentucky.
Army Corps of Engineers, Huntington District.

Stilling Basin Rock Anchors.
Smithland Dam, Ohio River.
Army Corps of Engineers, Nashville District.

The illustrations on page 3 and the engineering drawings above are reprinted courtesy of Denslag Systems International, Lemont, Illinois.

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LEFT HAND THREAD

PHYSICAL PROPERTIES

EFFECTIVE AREA: 0.79 SQ. IN.
ULTIMATE STRENGTH: 90 KSI
ULTIMATE LOAD: 71.1 KIPS
YIELD LOAD: 47.4 KIPS
WEIGHT: 2.67 LBS./FT.
MAX. BAR $\emptyset$ INCL. RIBS: 1.12 IN.
AVERAGE CORE $\emptyset$: 0.95 IN.
PITCH: 0.492 IN.

ATTACHMENT 4

DYWIDAG POST-TENSIONING SYSTEMS		DIMENSIONS: IN./MM FOR REFERENCE ONLY		REV.	DATE	NAME	DRAWING BOB JOE
TOLERANCES: ± .02 UNLESS NOTED					
		MATERIAL: ASTM A615, GR 60		SCALE N/A			
DATE: 08-23-90		DRAWN: S. MALPURI		APPROVED:

DYWIDAG SYSTEMS INTERNATIONAL U.S.A., INC.

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TABLE: COMPARISON OF BAR MECHANICAL PROPERTIES

Bar Size/Grade ASTM	#7/GR 60 A 615			#7/GR 75 F 432			#8/GR 60 A615		
	Yield (kips)	Tensile (kips)	Elong. (%)	Yield (kips)	Tensile (kips)	Elong. (%)	Yield (kips)	Tensile (kips)	Elong. (%)
Guaranteed per ASTM	36	54	8	45	60	8	47.4	71.1	8
Avg. actual per mill cert.	42	65	12	47	72	9	55	83	13

6/24/91

SENT BY DYWIDAG SYSTEMS LEHONT

7-30-90 02:02 PM

DRAFT

7887 65174

383 434 4478 0 0

Mat # 2-42393

NORTH STAR STEEL MINNESOTA

P.O. Box 64180

1878 Red Rock Road

Saint Paul, Minnesota 55164

CERTIFIED TEST REPORT

Size 10 Th.

Grade 7432-33

Date Rolled 5/3/90

P.O.

M.O. #

CHEMICAL ANALYSIS

C	MN	P	S	BI	CU	NI	CR	MO	CS	V
.43	.98	.043	.035	.22	.017	.42	.13	.16	.032	.019

AL

--	--	--	--	--

JOHNNY END-QUENCH HARDENABILITY RESULTS (HR.)

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12

J13	J14	J15	J16	J17	J18	J19	J20	J21	J22	J23	J24

PHYSICAL TEST REPORT

SPECIMEN AREA (sq in)	YIELD (KPS)	TENSILE (KPS)	TENSILE (KPS)	TENSILE (KPS)	GUAGE LENGTH (in)	% ELONG	RED	% R.A.	Heat Treatment
.79	34.9	69.3	88.6	112.2	8.0	13.7	OK		7432-33
.79	34.8	69.4	89.6	105.0	8.0	13.7	OK		7406

Grain Size: _____ Cleanliness: _____

Macro Etch: Specification: _____ Results: _____

Impact Test	Temp (F)	ft-lb.	% Shear*	% L.E.*

* By specification or request only

This material has been produced and tested in accordance with the requirements of applicable specifications unless otherwise stated below. We hereby certify that the above test results are representative of those obtained in the records of the company.

Any restriction to the certification as provided by North Star Steel Minnesota without the approval of the company of North Star Steel Minnesota negates the validity of this test report.

North Star Steel Minnesota is not responsible for the quality of the material's heat treatment.

SIGNED

5/3/90

SWORN AND SUBSCRIBED TO BEFORE ME

THIS _____ DAY _____

MY COMMISSION EXPIRES _____

THIS CERTIFICATE IS NOTORIZED ONLY WHEN REQUESTED.

DRAFT

								PRELIMINARY
NOMINAL SIZE	#6	20mm	#7	#8	#9	#10	#11	
PART NUMBER	B06U28810	B20U28810	B07U28810	B08U28810	B09U28810	B10U28810	B11U28810	
L (IN./mm)	1.375/34.9	1.625/41.3	1.625/41.3	1.750/44.5	2.125/54.0	2.250/57.2	2.625/66.7	
HEX 1 (IN./mm)								
HEX 2 (IN./mm)	1.250/31.8	1.375/34.9	1.375/34.9	1.500/38.1	1.688/42.9	1.813/46.0	2.063/52.4	
R (IN./mm)	0.885/22.0	1.000/25.4	1.000/25.4	1.120/28.4	1.250/31.8	1.419/36.0	1.530/38.9	
D (IN./mm)	1.063/27.0	1.188/30.2	1.188/30.2	1.313/33.4	1.438/36.5	1.641/41.7	1.821/46.3	
Ø DEG.	14	14	14	14	14	14	14	
THREADFORM: 8341/	743	785	744	745	746	747	724	
MINOR Ø	MIN. (IN./mm)	0.730/18.5	.782/19.9	0.858/21.7	0.974/24.7	1.096/27.8	1.238/31.4	1.406/35.7
	MAX. (IN./mm)	0.742/18.8	.794/20.2	0.868/22.0	0.986/25.0	1.108/28.1	1.252/31.8	1.420/36.1
WEIGHT LBS		0.27	0.54	0.5	0.72	0.89	1.20	1.77

→ L FOR #11, AND WEIGHTS FOR #9, #10 & #11 CHANGED.

MATERIAL:

AUSTEMPERED DUCTILE IRON
OR CAST STEEL
MIN. YIELD: 100 KSI
MIN. TENS: 120 KSI
MIN. EL. IN 2": 8%

TOLERANCES:

FOR HEX1, HEX2, R, D:
+0/-0.040"
FOR L: +0.125/-0"
FOR Ø: ±.01"

NOTES:

1. THREADFORM AS SPECIFIED WITH EXCEPTION OF MINOR DIAMETER (MINOR Ø) WHICH IS SPECIFIED IN TABLE.
2. AT BOTH ENDS OF NUT THREADFORM IS MODIFIED OVER LAST 1/2 TURN AS FOLLOWS: MINOR Ø OPENS UP TO MAJOR Ø AT CONSTANT RADIUS.

ATTACHMENT 5

DYWIDAG POST-TENSIONING SYSTEMS

DIMENSIONS: IN./mm
mm FOR REFERENCE ONLY

REV.	DATE	NAME
1	02-20-90	E.L.
2	08-01-90	E.L.
3	09-28-90	E.L.
4	01-29-91	E.L.

DRAWING: B00L21

FULL LOAD ANCHOR NUTS
FOR GRADE 60 THREADBAR

MATERIAL:

SCALE
1:1

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X CHANGE MADE DUE TO AVAILABLE EQUIPMENT
CRB
8/6/81

ROOFBOLT DETAIL
VERTICAL ALIGNMENT (TOL. 5°)

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ROCK BOLT CHARACTERIZATION TEST

Mine _____	Rock _____	Rock Bolt No. _____	Hole Location _____
Hole Length - _____	Dia. - @ Anchor _____ / @ midpoint _____ / @ collar _____	Orientation - _____	
Bolt Grade - _____	Length - _____	Diameter - _____	
Shell Manufacturer - _____	Model - _____	Diameter - _____	
Length - _____			
Resin Manufacturer - _____	Model - _____	Diameter - _____	
Length - _____	No. Cartridges - _____		
Installation Date - _____	Time - _____	Torque - _____	ft/lb _____
Test Date - _____	Time - _____	Torque - _____	ft/lb _____
Test Jack - _____	Test Pump - _____		
Dial Indicator - _____	Calibrated - _____		
Pressure Gauge - _____	Calibrated - _____		

[illegible]

Test Results - _____ Maximum Pull Force - _____
 Displacement at Maximum Pull Force - _____
 Nature of Failure/Yield - _____
 Other Remarks - _____
 Tested By - _____ Approved By - _____

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ATTACHMENT 1
WP 09-009
Page 1 of 2

UNDERGROUND DRILLING HOLE FIELD DATA SHEET

Date: _____

Room/Drift: _____

Purpose of Hole: _____

Location: _____

Depth at Completion: _____

Diameter: _____

Approximate Collar Coordinates _____

Vertical Angle: _____

Direction/Azimuth: _____

Remarks: _____

Signature/Department: _____

10/15/90

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WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM

APPENDIX C
Support System Design

Westinghouse Electric Corporation
Waste Isolation Division
Carlsbad, New Mexico
October 1991

WESTINGHOUSE WASTE ISOLATION DIVISION

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Check print
2

TITLE BOLT WORKING LOAD FOR 10' x 2' SPACING		PAGE 1 OF 3	
PROJECT	AUTHOR C. FRANCKE	DATE 9/5/91	DATE 9/6/91
SCALE NO.	FILE NO.	REVISIONS	

PROBLEM: DETERMINE THE MAXIMUM WORKING LOAD ON A BOLT IN A 2' x 10' SPACING.

ASSUMPTIONS:

- 1) DENSITY OF WIPP SALT = $135 \text{ lb/ft}^3 = 2.17 \text{ gm/cm}^3$
(DOC# ~~D-W-01~~ D-SI-W-01, REV 6)
- 2) THE ROCK REQUIRING SUPPORT IS DELINEATED BY AN ISOCLE'S TRIANGLE WITH ITS APOX AT CLAY G AND ITS BASE AT THE ROOF. THE HEIGHT OF THE TRIANGLE IS 7' (DISTANCE FROM ROOF TO CLAY G). THE BASE OF THE TRIANGLE IS 33' (WIDTH OF THE ROOM).
- 3) THE ROCKBOLT PATTERN SPACING WILL BE 2' ACROSS THE WIDTH OF THE ROOM AND 10' ALONG THE LENGTH OF THE ROOM.

METHOD: THE MAXIMUM VOLUME OF ROCK SUPPORTED BY EACH BOLT WILL BE CALCULATED AND MULTIPLIED BY THE DENSITY OF THE ROCK TO DETERMINE THE LOAD ON THE BOLT.

CALCULATIONS:

THE FOLLOWING DIAGRAM ILLUSTRATES THE DIMENSIONS OF THE ROCK REQUIRING SUPPORT.

CROSS-SECTION
VIEW

REV NO	REV DATE	AUTHOR	DATE CHK'D BY	DATE CHK'D BY	NO

WESTINGHOUSE WASTE ISOLATION DIVISION

DRAFT

TITLE BOLT WORKING LOAD FOR 10' X 2' SPACING		PAUSE 2 of 3	
PROJECT	DESIGNED BY C. FRANKS	DATE 9/8/91	UTIL CHECKED BY JRT/bwh
NO.	CALC NO.	SHEET NO.	GROUP

CALCULATIONS (CONT'D)VOLUME OF ROCK

THE VOLUME OF ROCK SUPPORTED BY A BOLT IS DETERMINED BY THE FOLLOWING EQUATION:

$$V = S_L S_W t$$

WHERE V = VOLUME OF ROCK TO BE SUPPORTED
 S_L = SPACING OF BOLTS IN THE LONG DIMENSION
 S_W = SPACING OF BOLTS IN THE SHORT DIMENSION
 t = THICKNESS OF ROCK TO BE SUPPORTED

THE VALUE OF " t " FOR A PARTICULAR BOLT IS THE AVERAGE THICKNESS OF THE ROCK ALONG A LINE " S_W " LONG CENTERED ON THE BOLT. THE MAXIMUM WORKING LOAD WILL BE AT THE CENTER OF THE SPAN WHERE $t = 7'$.

$$V = (10' \times 2') (7')$$

$$V = 140 \text{ ft}^3$$

REV NO.	REV DATE	AUTHOR	DATE CHECKED BY	UTIL CHECKED BY
------------	-------------	--------	-----------------	-----------------

WESTINGHOUSE WASTE ISOLATION DIVISION

DRAFT

TITLE BOLT WORKING LOAD FOR 10' x 2' SPACING		PAGE 3 OF 3	
PROJECT	AUTHOR C. FRANCKE	DATE CHECKED BY 9/8/91	DATE LIAISON BY
DESIGN NO.	SCALE NO.	FILE NO.	GROUP

CALCULATIONS: (CONT'D)WORKING LOAD

THE WEIGHT OF THE ROCK SUPPORTED BY A BOLT IS DETERMINED BY THE FOLLOWING EQUATION:

$$W = \rho V$$

WHERE: W = WEIGHT OF ROCK (WORKING LOAD)

ρ = DENSITY OF ROCK

V = VOLUME OF ROCK

Checker Notes:

Safe density changed
to that used in the
"Design Basis" report
for consistency

$$W = (135 \text{ lb/ft}^3)(140 \text{ ft}^3)$$

$$W = 18.9 \text{ kip} = 84.1 \text{ kN}$$

DISCUSSION:

THE MAXIMUM LOAD ON A BOLT IN THE PROPOSED 2' x 10' LAYOUT WILL BE 18.9 kip.

REV NO	REV DATE	AUTHOR	DATE CHECKED BY	DATE LIAISON BY
-----------	-------------	--------	-----------------	-----------------

- 3.1.9 Excavation shall permit early installation and start up of experiments in one or more rooms while excavation continues in the remainder of the experimental areas. The design shall permit access to, and utilization of, both waste and nonwaste experimental areas.

3.2 Configuration and Essential Features

DRAFT

3.2.1 General Location Underground

All depths assume ERDA No. 9 drill hole surface elevation as datum. This is 3409 ft above mean sea level.

The storage area floor is approx. 2,150 ft below the ground surface. The final level of the excavations shall be as determined by the contracting officer. All excavations shall be parallel to the existing bedding planes within allowable tolerances. To the extent practical, a marker bed in the excavation rib will be defined as the reference plane from which the excavation shall be continued. In addition, holes shall be drilled into the floor and roof of the excavation for determination of the location of Marker Bed - 139 and the clay seams above the roof. Coring of these holes shall begin before the continuous miner advances more than 250 feet from the location.

Based on the existing, the average dip of the sedimentary beds in the underground areas will be approximately 2 percent to the south east.

3.2.2 Salt Composition and Density

The halite is relatively free of impurities with the exception of occasional thin but separate layers of lightly interspersed argillaceous materials (up to 4%) and of polyhalite (less than 1%). Halite is also widely interbedded with layers of anhydrite ranging from a few inches to several feet in thickness. The overall moisture content is 0.4%.

For purposes of excavation calculations, the salt in place is assumed to have a density of 135 lb /cu ft (1.8225 tons/cu yd).

3.2.3 Creep Allowance

Excavation dimensions shall include an allowance for salt creep of 1 ft in the vertical dimension and nine inches in the required width of all rooms.

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PROJECT	AUTHOR C. FRANCKE	DATE CHECKED BY 9/5/91 JR T. W. L.	DATE CHECKED BY 9/6/91
CO	CALL NO	FILE NO	GROUP

PROBLEM: DETERMINE THE FACTOR OF SAFETY (FOS) OF ROCK BOLTS AGAINST TENDON FAILURE.

ASSUMPTIONS:

- 1) THE TENDON IS EXPECTED TO BE GRADE 60 STEEL WHICH MEETS ASTM STANDARD A615 (REF. 2).
- 2) THE MAXIMUM WORKING LOAD ON THE TENDON IS 18.9 kip (84.1 kN).
- 3) THE MINIMUM (GUARANTEED) ULTIMATE TENSILE STRENGTH OF THE TENDON IS 90,000 psi (REF. 2).
- 4) THE TENDON IS 1" DIAMETER. Value not verified

REFERENCES:

- 1) PTI (Post-Tensioning Institute), 1986, Recommendations for Prestressing Rock and Soil Anchors.
- 2) ASTM Standard A615.

METHOD:

THE WORKING LOAD ON THE TENDON IS CALCULATED.

CALCULATIONS:

THE MAXIMUM LOAD THAT THE TENDON CAN SUPPORT IS DETERMINED BY MULTIPLYING THE ULTIMATE TENSILE STRENGTH OF THE TENDON BY THE CROSS SECTIONAL AREA OF THE TENDON.

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PROJECT	DESIGNED BY C. FRANKS	DATE 9/19/91	DESIGNED BY J. H. B. R. K.
REV	DATE	DESIGNED BY	DATE

CALCULATIONS (CONT'D)

$$P_t = T_t \pi d_t^2 / 4$$

WHERE: P_t = MAXIMUM ALLOWED WORKING LOAD
 T_t = ULTIMATE TENSILE STRENGTH OF TENDON
 d_t = DIAMETER OF TENDON

$$P_t = (90 \text{ kip/in}^2) \pi (1 \text{ in})^2 / 4$$

$$P_t = 70.7 \text{ kip}$$

FACTOR OF SAFETY

$$F_{ofS} = \frac{\text{MAXIMUM ALLOWED TENSILE STRESS}}{\text{ACTUAL WORKING LOAD}}$$

$$F_{ofS} = 70.7 \text{ kip} / 18.9 \text{ kip}$$

$$F_{ofS} = 3.7$$

DISCUSSION:

ACCORDING TO THE PT I RECOMMENDATIONS (REF 1):
 "The tendon size is determined such that the design load for the anchor does not exceed 60% of the guaranteed ultimate strength of the tendon." THIS WOULD BE EQUIVALENT TO A F_{ofS} OF 1.7 (I.E. 1/0.6 = 1.7).
 NORMALLY, IN OTHER WORDS, THE WORKING LOAD SHOULD NOT EXCEED 0.6 * P_t = 42.4 kip, WHICH IT DOES NOT. NORMALLY, ONE DETERMINES A DESIRED SAFETY FACTOR, SUCH AS 1.7, AND DETERMINES THE REQUIRED BOLT DIAMETER. IN THIS CALCULATION THE SAFETY FACTOR WAS NOT CALCULATED UNTIL THE END SINCE BOLT DIAMETER AND LOAD WERE KN

Checker Note:
 Agree, however when evaluating the F_{ofS} we should use 60% of U_t, or Max Allowed Tensile Stress 42.4/18.9 or 2.2 which is still greater than 1.7
 I.E. recommended

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Designation: A 615 - 90

THIS STANDARD IS UNDER THE JURISDICTION OF THE COMMITTEE ON STEEL REINFORCEMENT AND RELATED PRODUCTS, WHICH IS RESPONSIBLE FOR THE REVISIONS OF THIS STANDARD. THE NEXT REVISION OF THIS STANDARD IS ANTICIPATED FOR 1995. THE COMMITTEE ON STEEL REINFORCEMENT AND RELATED PRODUCTS MEETS ANNUALLY TO REVIEW THE STANDARD AND TO MAKE REVISIONS AS NECESSARY.

AMERICAN ASSOCIATION OF STEEL CONSTRUCTORS
1015 LEXINGTON AVENUE
NEW YORK, N.Y. 10017-4299

Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement¹

This standard is issued under the designation A 615. 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 approval of a subsequent revision or indicates an editorial change since the last revision or approval.

This specification was developed for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards, or the specific form of this standard when adopted by the Department of Defense.

1. Scope

1.1 This specification covers deformed and plain billet-steel concrete-reinforcement bars in cut lengths or coils. A deformed bar is defined as a bar that is intended for use as reinforcement in reinforced concrete construction. The surface of the bar is provided with lugs or protrusions (hereinafter called *deformations*) which inhibit longitudinal movement of the bar relative to the concrete which surrounds the bar in such construction and conform to the provisions of this specification. The standard sizes and dimensions of deformed bars and their number designations shall be those listed in Table 1.

Note 1:—For coils of deformed bars, the capacity of industrial equipment limits the maximum bar size that can be straightened.

1.2 Bars are of three minimum yield levels; namely, 40 000, 40 000, and 75 000 psi, designated as Grade 40, Grade 60, and Grade 75, respectively.

1.3 Hot-rolled plain rounds, in sizes up to and including 2 in. in diameter in coils or cut lengths, when specified for dowels, spirals and structural ties or supports shall be furnished under this specification in Grade 40, Grade 60, and Grade 75 (Note 2). For bending properties, test provisions of the nearest nominal diameter deformed bar size shall apply. These requirements providing for deformations and marking shall not be applicable.

1.4 The weldability of the steel is not part of this specification.

Note 2:—The weight for plain rounds smaller than 2 in. in diameter shall be computed on the basis of the size in Specification A 500.

Note 3:—A complete metric companion to Specification A 615 has been developed—A 615M; therefore, no metric equivalents are presented in this specification.

2. Referenced Documents

2.1 ASTM Standards:

- A 370 Methods and Definitions for Mechanical Testing of Steel Products²
- A 510 Specification for General Requirements for Wire Rods and Coarse Round Wire Carbon Steels³

This specification is under the jurisdiction of ASTM Committee A6 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A6.02 on Steel Reinforcement.

Technical revision approved for 1990. This specification is under the jurisdiction of ASTM Committee A6 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A6.02 on Steel Reinforcement.

- A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment⁴
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵

2.2 U.S. Military Standards:

- MIL-STD-129 Marking for Shipment and Storage⁶
- MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage⁶

2.3 U.S. Federal Standard:

- Fed. Std. No. 123 Marking for Shipment (Civil Agencies)⁷

3. Ordering Information

3.1 Orders for material under this specification should include the following information:

- 3.1.1 Quantity (weight).
- 3.1.2 Name of material (deformed and plain billet-steel bars for concrete reinforcement).
- 3.1.3 Size.
- 3.1.4 Cut lengths or coils.
- 3.1.5 Deformed or plain.
- 3.1.6 Grade.
- 3.1.7 Packaging (see Section 19).
- 3.1.8 ASTM designation and year of issue, and
- 3.1.9 Certified mill test reports (if desired).

Note 4:—A typical ordering description is as follows: 10 tons deformed and plain billet-steel bars for concrete reinforcement, No. 3 40 000 psi, long, deformed, Grade 40, in secured coils to ASTM A 615. — Certified mill test reports are required.

4. Material and Manufacture

4.1 The bars shall be rolled from properly identified heats of mold cast or strand cast steel using the open-hearth, basic-oxygen, or electric-furnace process.

5. Chemical Composition

5.1 An analysis of each heat of steel shall be made by the manufacturer from test samples taken preferably during the pouring of the heats. The percentages of carbon, manganese, phosphorus, and sulfur shall be determined. The phosphorus content thus determined shall not exceed 0.06 %.

5.2 The chemical composition thus determined shall be reported on request to the purchaser or his representative.

¹ Annual Book of ASTM Standards, Vol. 11.15.

² Annual Book of ASTM Standards, Vol. 11.15.

³ Available from Naval Publications and Forms Center, 1200 Reed Blvd., Philadelphia, PA 19105.

TABLE 1: Cold-chamber Bar Designation Numbers, Nominal Weights, Nominal Dimensions, and Cold-chamber Requirements

Bar Designation	Nominal Dimensions*				Sectional Properties		
	Nominal Weight lb/ft	Depth in	Gross Sec- tional Area in ²	Perimeter in	Moment of Inertia (in ⁴)	Section Modulus in ³	Plastic Section Modulus in ³
1	1.75	1.75	1.11	3.74	1.24	1.15	1.15
2	1.88	1.88	1.20	4.01	1.50	1.29	1.29
3	2.43	2.43	1.51	4.93	2.45	1.58	1.58
4	3.02	3.02	1.74	5.58	3.52	1.98	1.98
5	3.64	3.75	2.00	6.19	4.84	2.34	2.34
6	4.30	4.00	2.29	7.42	7.00	2.50	2.50
7	5.00	4.25	2.50	8.44	9.90	2.68	2.68
8	5.63	4.50	2.87	9.09	13.49	2.84	2.84
9	6.33	4.75	3.16	10.00	16.87	3.07	3.07
10	7.25	4.93	3.52	10.92	21.25	3.25	3.25
11	8.25	5.00	4.00	11.92	26.00	3.42	3.42

1. The number of cylinders of a selected car are numbered 1 to those of a standard car having the same weight per foot as the selected car. The numbers are based on the number of cylinders of an car located in the nearest diameter of the cars.

5.3 An analysis may be made by the purchaser from finished bars. The phosphorus content thus determined shall not exceed that specified in 5.1 by more than 25 %.

9. Requirements for Deformations

6. Deformations shall be spaced along the bar at substantially uniform distances. The deformations on opposite sides of the bar shall be similar in size and shape.

5.2 The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45°. Where the line of deformations forms an included angle with the axis of the bar of from 45 to 70° inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the line of deformation is over 70°, a reversal in direction is not required.

5.3 The average spacing or distance between deformations on each side of the bar shall not exceed seven tenths of the nominal diameter of the bar.

6.4 The overall length of deformations shall be such that the gap between the ends of the deformations on opposite sides of the bar shall not exceed $12\frac{1}{4}\%$ of the nominal perimeter of the bar. Where the ends terminate in a longitudinal rib, the width of the longitudinal rib shall be considered the gap. Where more than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25% of the nominal perimeter of the bar; furthermore, the summation of gaps shall not exceed 25% of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.14 times the nominal diameter.

6.5 The spacing, height, and gap of deformations shall conform to the requirements presented in Table 1.

7. Measurements of Deformations

7.1 The average spacing of deformations shall be determined by dividing a measured length of the bar specimen by the number of individual deformations and fractional parts of deformations on any one side of the bar specimen. A measured length of the bar specimen shall be considered the distance from a point on a deformation to a corresponding point on any other deformation on the same side of the bar. Spacing measurements shall not be made over a bar area containing bar marking symbols involving letters or numbers.

7.2 The average height of deformations shall be determined from measurements made on not less than two typical deformations. Determinations shall be based on three measurements per deformation, one at the center of the overall length and the other two at the quarter points of the overall length.

7.3 Insufficient height, insufficient circumferential coverage, or excessive spacing of deformations shall not constitute cause for rejection unless it has been clearly established by determinations on each lot (Note 5) tested that typical deformation height, gap, or spacing do not conform to the minimum requirements prescribed in Section 6. No rejection may be made on the basis of measurements if fewer than ten adjacent deformations on each side of the bar are measured.

NOTE 5—A lot is defined as all the bars of one bar number and pattern of deformation contained in an individual shipping release or shipping order.

A. Tensile Requirements

3.1 The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 2.

3.2 The yield point or yield strength shall be determined by one of the following methods:

3.1 The yield point shall be determined by drop of the beam or plate in the gauge of the testing machine.

3.2.2 Where the steel tested does not have a well defined yield point, the yield strength shall be determined at extension under load using an autographic diagram method or an

TABLE 2 Tensile Requirements

	SPACE 40	SPACE 50	SPACE 75
Tensile strength, min. psi	70 000	90 000	100 000
Initial strength, min. psi	40 000	50 000	75 000
Compression at 200,000 psi, min. %			
Bar no.			
1	1	3	
2 3 4	2	3	
5		1	
6		1	
7 8		1	
9 10 11		1	4

1. The first step is to identify the problem or question that needs to be answered.

 

TABLE 3 Bend Test Requirements

Bar Size (Nominal)	Grade 40	Grade 60	Grade 75
1 1/2	180°	180°	180°
2	180°	180°	180°
3	180°	180°	180°
4	180°	180°	180°
5	180°	180°	180°
6	180°	180°	180°
8	180°	180°	180°
10	180°	180°	180°
12	180°	180°	180°
14	180°	180°	180°
16	180°	180°	180°
18	180°	180°	180°
20	180°	180°	180°
22	180°	180°	180°
24	180°	180°	180°
26	180°	180°	180°
28	180°	180°	180°
30	180°	180°	180°
32	180°	180°	180°
34	180°	180°	180°
36	180°	180°	180°
38	180°	180°	180°
40	180°	180°	180°
42	180°	180°	180°
44	180°	180°	180°
46	180°	180°	180°
48	180°	180°	180°
50	180°	180°	180°
52	180°	180°	180°
54	180°	180°	180°
56	180°	180°	180°
58	180°	180°	180°
60	180°	180°	180°
62	180°	180°	180°
64	180°	180°	180°
66	180°	180°	180°
68	180°	180°	180°
70	180°	180°	180°
72	180°	180°	180°
74	180°	180°	180°
76	180°	180°	180°
78	180°	180°	180°
80	180°	180°	180°
82	180°	180°	180°
84	180°	180°	180°
86	180°	180°	180°
88	180°	180°	180°
90	180°	180°	180°
92	180°	180°	180°
94	180°	180°	180°
96	180°	180°	180°
98	180°	180°	180°
100	180°	180°	180°

180° = 180° bend
180° = 180° bend

extensometer as described in 13.1.2 and 13.1.3 of Methods and Definitions A 370. The extension under load shall be 0.005 in./in. of gage length (0.5 %) for Grade 40 and Grade 60 and shall be 0.0035 in./in. of gage length (0.35 %) for Grade 75. When material is furnished in coils, the test sample must be straightened prior to placing it in the jaws of the tensile machine (see Note 6).

9.3 The percentage of elongation shall be as presented in Table 2.

Note 6—Straightening should be done carefully to avoid the formation of local sharp bends and to minimize cold work. Insufficient straightening prior to attaching the extensometer can result in lower-than-actual yield strength readings.

9. Bending Requirements

9.1 The bend-test specimen shall withstand being bent around a pin without cracking on the outside of the bent portion. The requirements for degree of bending and sizes of pins are presented in Table 3.

9.2 The bend test shall be made on specimens of sufficient length to ensure free bending and with apparatus which provides:

9.2.1 Continuous and uniform application of force throughout the duration of the bending operation.

9.2.2 Unrestricted movement of the specimen at points of contact with the apparatus and bending around a pin free to rotate.

9.2.3 Close wrapping of the specimen around the pin during the bending operation.

9.3 Other acceptable more severe methods of bend testing, such as placing a specimen across two pins free to rotate and applying the bending force with a fixed pin, may be used. When failures occur under more severe methods, retests shall be permitted under the bend test method presented in 9.2.

10. Permissible Variation in Weight

10.1 The permissible variation shall not exceed 6 % under nominal weight, except for bars smaller than 1/4 in. plain round, the permissible variation in weight shall be computed upon the basis of the permissible variation in diameter in Specification A 510. Reinforcing bars are evaluated on the basis of nominal weights. In no case shall the overweight of any bar be the cause for rejection.

10.2 The specified limit of variation shall be evaluated in accordance with Practice E 29 (rounding method).

11. Finish

11.1 The bars shall be free of detrimental surface imperfections.

11.2 Rust, seams, surface irregularities, or mill scale shall not be cause for rejection, provided the original dimensions, cross-sectional area, and tensile properties of a bend and twisted test specimen are not less than the requirements of this specification.

11.3 Surface imperfections other than those specified in 11.1 shall be considered detrimental when specimens containing such imperfections fail to conform to other tensile or bending requirements.

12. Test Specimens

12.1 Tension test specimens shall be the full section of the bar as rolled. The unit stress determination shall be based on the nominal bar area.

12.2 The bend test specimens shall be the full section of the bar as rolled.

13. Number of Tests

13.1 For bar sizes No. 3 to 11, inclusive, one tension test and one bend test shall be made of the largest size rolled from each heat. If, however, material from one heat differs by three or more designation numbers, one tension and one bend test shall be made from both the highest and lowest designation number of the deformed bars rolled.

13.2 In the case of Nos. 14 and 18 bars, one tension test and one bend test shall be made of each size rolled from each heat.

14. Retests

14.1 If any tensile property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

14.2 If the results of an original tension specimen fail to meet the specified minimum requirements and are within 2000 psi of the required tensile strength, within 1000 psi of the required yield point, or within two percentage units of the required elongation, a retest shall be permitted on two random specimens for each original tension specimen failure from the lot. If all results of these retest specimens meet the specified requirements, the lot shall be accepted.

14.3 If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in 14.4 and 14.5, a retest shall be permitted on two random specimens from the same lot. If the results of both test specimens meet the specified requirements, the lot shall be accepted. The retest shall be performed on test specimens that are at a temperature but not less than 50°F.

14.4 If any test specimen fails because of mechanical reasons such as failure of testing equipment or improper specimen preparation, it may be discarded and another specimen taken.

14.5 If any test specimen develops flaws, it may be discarded and another specimen of the same size bar from the same heat substituted.

15. Inspection

15.1 The inspector representing the purchaser shall be free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacture

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er's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests (except product analysis) and inspection, shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

15.2 *For Government Procurement Only*—Except as otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements specified herein and may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification, where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

16. Rejection

16.1 Unless otherwise specified, any rejection based on tests made in accordance with 5.3, shall be reported to the manufacturer within 5 working days from the receipt of samples by the purchaser.

16.2 Material that shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

17. Rehearing

17.1 Samples tested in accordance with 5.3 that represent rejected material shall be preserved for 2 weeks from the date rejection is reported to the manufacturer. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

18. Marking

18.1 When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer's heat or test identification number.

18.2 Each producer shall identify the symbols of his marking system.

18.3 All bars produced to this specification, except plain round bars which shall be tagged for grade, shall be identified by a distinguishing set of marks legibly rolled onto the surface of one side of the bar to denote in the following order:

18.3.1 *Print of Origin*—Letter or symbol established as the producer's mill designation.

18.3.2 *Size Designation*—Arabic number corresponding to bar designation number of Table 1.

18.3.3 *Type of Steel*—Letter S indicating that the bar was produced to this specification.

18.3.4 *Minimum Yield Designation*—For Grade 60 bars, either the number 60 or a single continuous longitudinal line through at least 5 spaces offset from the center of the bar side. For Grade 75 bars, either the number 75 or two continuous longitudinal lines through at least 5 spaces offset each direction from the center of the bar. (No marking designation for Grade 40 bars.)

19. Packaging

19.1 When specified in the purchase order, packaging shall be in accordance with the procedures in Practices A 700.

19.2 *For Government Procurement Only*—When specified in the contract or order, and for direct procurement by or direct shipment to the U.S. government, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

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WESTINGHOUSE WASTE ISOLATION DIVISION

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TITLE FACTOR OF SAFETY - ANCHOR BOND		PAGE 1 OF 3	
PROJECT	APPROVAL A. FRANCKE 9/8/11	DATE CHECKED BY JRTyler 9/4/11	DATE
80	CALC NO	FILE NO	GROUP

PROBLEM: DETERMINE FACTOR OF SAFETY (FoS) FOR A RESIN ANCHOR BOND TO SALT VS. WORKING LOAD ON THE ANCHOR.

ASSUMPTIONS:

- 1) MAXIMUM WORKING LOAD ON THE ANCHOR IS 12.9 kip (84.1 kN).
- 2) FIXED ANCHOR LENGTH IS 3' (0.91 m).
- 3) AVERAGE HOLE (AND ANCHOR) DIAMETER IS 1 1/8" (0.035 m).
- 4) UNCONFINED COMPRESSIVE STRENGTH (UCS) OF WIPP SALT IS TAKEN AS 25 MPa. (SEE DISCUSSION).

See below

REFERENCES:

- 1) G.S. Littlejohn and D.A. Bruce, "Rock Anchors - State of the Art - Part 1: Design", Ground Engineering, May 1975.
- 2) PTI (Post-Tensioning Institute), Recommendations for Prestressed Rock and Soil Anchors, 1986.
- 3) BSI (British Standards Institute), BSI 8081, "British Standard Code of Practice for Ground Anchors", 1989.
- 4) SAND 78-1596, Geologic Characterization Report, Powers et al.

METHOD: THE ULTIMATE ANCHOR LOAD IS CALCULATED BASED ON THE SIZE OF THE ANCHOR AND THE ANCHOR BOND STRENGTH.

For most elastic rocks using the higher UCS value from lab testing may be appropriate, however, because the strength of salt is time dependent, I'm not certain this is a conservative approach. The original checker comment (using 1 N/mm²) was to use a lower value. This needs to be discussed. A reasonable field test to evaluate time dependent slippage might need be developed for confirmation.

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TITLE FACTOR OF SAFETY - ANCHOR BOND		PAGE 2 of 3	
PROJECT	AUTHOR C. FRANKS	DATE 4/8/1	DATE CHG'D BY JRT/bursh 4/4/1
SS	DATE NO	SITE NO	GROUP

CALCULATIONS:

ACCORDING TO REF 1., THE ULTIMATE ANCHOR LOAD IS CALCULATED AS FOLLOWS:

$$P_2 = \pi d_a L_a \tau$$

WHERE: P_2 = LOAD TO CAUSE BOND FAILURE
 d_a = EFFECTIVE ANCHOR DIAMETER
 L_a = FIXED ANCHOR LENGTH
 τ = WORKING BOND STRENGTH

REF. 1 FURTHER STATES THAT, IN THE ABSENCE OF FULL TEST DATA ON BOND STRENGTH, τ CAN BE ESTIMATED AS 1/10 OF THE UCS OF THE ROCK. THEREFORE:

$$\begin{aligned}\tau &= 0.1 (\text{UCS}) \\ &= 0.1 (25 \text{ MPa}) \\ \tau &= 2.5 \text{ MPa} = 2500 \text{ kN/m}^2\end{aligned}$$

This does not address the lack of relevant data, as suggested by Littlejohn & Bruce.

τ IS OFTEN REDUCED TO $1/3 \tau$ TO ADD A SAFETY FACTOR. THIS WILL NOT BE DONE HERE BECAUSE THE $1/3 \tau$ VALUE IS USED TO DETERMINE (DESIGN) ANCHOR LENGTH OR DIAMETER. SINCE ANCHOR LENGTH & DIAMETER ARE PRE-DETERMINED, THE FULL VALUE OF τ IS USED SO THAT THE REAL SAFETY FACTOR CAN BE DETERMINED.

THE LOAD TO CAUSE BOND FAILURE IS THEN:

$$\begin{aligned}P_2 &= \pi (0.05 \text{ m}) (0.9 \text{ m}) (2500 \text{ kN/m}^2) \\ P_2 &= 230 \text{ kN} = 56 \text{ kip}\end{aligned}$$

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TITLE FACTOR OF SAFETY - ANCHOR BOND		PAGE 3 OF 3	
SUBJECT	AUTHOR C. FRANKS	DATE 9/5/91	DATE CHECKED BY J. K. Tyburski
DATE 9/5/91	CALC. NO.	FILE NO.	GROUP

CALCULATIONS (CONT'D)FACTOR OF SAFETY - ANCHOR BOND

$$FOS = \frac{\text{LOAD CAUSING FAILURE}}{\text{WORKING LOAD}}$$

$$FOS = 56 \text{ kip} / 18.9 \text{ kip} = 3.0$$

DISCUSSION

RECOMMENDED SAFETY FACTORS FOR ANCHOR BOND RANGE FROM 1.5 TO 4, DEPENDING ON ROCK TYPE AND APPLICATION (REF. 1, 2, 3). SAFETY FACTOR IS NORMALLY INTRODUCED INTO THE CALCULATION BY REDUCING σ_c , WORKING BOND STRENGTH, TO 25% TO 30% OF THE ULTIMATE BOND STRENGTH (REF. 2). THIS WOULD BE EQUIVALENT TO A SAFETY FACTOR OF 2 TO 4. AS IS EXPLAINED ON PAGE 2 OF THIS CALC, σ_c WAS NOT REDUCED SO THAT THE TRUE FACTOR OF SAFETY COULD BE DETERMINED.

See
Connect
P 1 of 3

THE VALUE USED FOR UNCONFINED COMPRESSIVE STRENGTH (UCS) IS BASED ON LABORATORY TESTING (REF. 4) AND ENGINEERING JUDGMENT. BECAUSE UCS VALUES FROM LAB TESTING USUALLY UNDERESTIMATE THE IN SITU STRENGTH, THE HIGHEST VALUE FROM REF 4 WAS USED.

THE 3' FIXED ANCHOR LENGTH PROVIDES AN ACCEPTABLE FACTOR OF SAFETY AGAINST FAILURE OF THE ANCHOR BOND.

THE ABOVE ASSUMPTIONS WILL BE VERIFIED BY FIELD TESTING.

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Fig 3 Possible failure modes based on test results at Trinity Clear Creek (after Saliman and Schaefer, 1968)

posed by Littlejohn and Truman-Davies (1974) where 2000 lb anchors were spaced at 1m centres. Another method to dissipate load within the rock mass, is simply to install anchors at different inclinations as in the design by Soliman (1968) for the Zardes Dam, Algeria. In some other countries a minimum distance between anchors is stipulated. Broms (1968), reviewing Swedish practice, confirmed a minimum spacing of 2.5m, whilst the Czech Standard (1974) recommends 1.5m, one consideration being to reduce "inter-hole grouting", although this phenomenon is not necessarily a disadvantage in practice.

It is noteworthy that these guide rules or approaches are based on experience and engineering judgement, and not on an intimate knowledge of stress distribution around the anchor.

Remarks

With regard to uplift capacity no experimental or practical evidence and only very little theoretical data substantiate the methods currently used (Table 1) to calculate the ultimate resistance to pull-out of individual, or groups of anchors. Indeed, there would appear to be results (Saliman and Schaefer (1968) and Brown (1970)) which indicate that failure in a rock mass does not generally occur in the form of an inverted 90 deg cone or wedge. However, it is reassuring to know that most designs are likely to be conservative in adopting a cone method with no allowance for the shear strength of the rock mass.

Nevertheless, some standardisation on safety factors for temporary and permanent anchors is desirable together with agreement on what allowances should be made for surcharge due to unconsolidated overburden and the effect of upper layers of weathered rock.

In general, effort should now be expended, in the form of field testing in a

wide range of rock materials and masses which have been carefully classified, in order to study the shape and position of the rock zones mobilised at failure. Such programmes should accommodate single anchors and groups tested over a range of inclinations. Only in this way can anchor design in relation to overall stability be optimised both technically and economically.

BOND BETWEEN CEMENT GROUT AND ROCK

Introduction

Most designs to date concerning straight shaft fixed anchors have been successfully based on the assumption of uniform bond distribution over the fixed anchor surface area. In other words it has been generally accepted that the bond developed is merely a function of fixed anchor dimensions and applied load.

However, recent experimental and theoretical analyses have indicated that the character of the bond to the rock is more complex, and reflects additional parameters which often give rise to a markedly non-uniform stress distribution. Thus, in many cases the assumed mechanism of load transfer in the fixed anchor zone may be grossly inaccurate. For example, the situation could well arise where, for a high capacity anchor, the level of bond stress at the loaded (or proximal) end may be extremely high, possibly approaching failure, whereas the more distal parts of the fixed anchor may in effect be redundant. Clearly, such a situation will have a bearing on overall stability analyses, the interpretation of anchor extensions, and long-term creep behaviour.

Design criteria are reviewed relating to the magnitude and distribution of bond fixed anchor dimensions, and factors of safety. For comparison, the results of relevant theoretical and experimental investigations are presented.

The straight shaft anchor is assumed to fail, on the development of bond or shear in the region of the rock/grout interface, and as described by Littlejohn (1972) it is usual in Britain to assume an equivalent uniform distribution of bond stress along the fixed anchor. Thus the anchor load, P , is related to the fixed anchor design by the equation

$$P = \pi d L \tau \quad (1)$$

where L = fixed anchor length
 d = effective anchor diameter
 τ = working bond stress

This approach is used in many countries e.g. France (Farguet, 1972), Italy (Vasscardi, 1973), Canada (Coates, 1970) and USA (White, 1973).

The rule is based on the following simple assumptions:

- (i) Transfer of the load from the fixed anchor to the rock occurs by a uniformly distributed stress acting over the whole of the curved surface of the fixed anchor.
- (ii) The diameter of the borehole and the fixed anchor are identical.
- (iii) Failure takes place by sliding at the rock/grout interface (smooth borehole) or by shearing adjacent to the rock/grout interface in weaker medium (rough borehole).
- (iv) There are no discontinuities or inherent weakness planes along which failure can be induced, and
- (v) There is no local debonding at the grout/rock interface.

Where shear strength tests are carried out on representative samples of the rock mass, the maximum average working bond stress at the rock/grout interface should not exceed the minimum shear strength divided by the relevant safety factor (normally not less than 2). This approach applies primarily to soft rocks where the uniaxial compressive strength (UCS) is less than 7N/mm², and in which the holes have been drilled using a rotary percussive technique. In the absence of shear strength data or field pull-out tests, Littlejohn (1972) states that the ultimate bond stress is often taken as one-tenth of the uniaxial compressive strength of massive rock (100 per cent core recovery) up to a maximum value τ_u of 4.2N/mm², assuming that the crushing strength of the cement grout is equal to or greater than 42N/mm². Applying an apparent safety factor of 3 more, which is conservative bearing in mind the lack of relevant data, the wor-

Fig 4 Relationship between shear stress and uniaxial compressive strength

Fig 5 Effect of angle on ultimate UCS ratio

bond stress is therefore limited to 1.4 N/mm².

In this connection it is noteworthy that Codes (1970) allows a maximum working bond of 2.45 N/mm² but with a safety factor of 1.75 which indicates a value of τ_{ult} of 4.3 N/mm². In some rocks, particularly in highly weathered varieties with a relatively low τ_{ult} value the assumption that τ_{ult} equals 10 per cent rock UCS may lead to an artificially low estimate of shear strength (Figs 4 and 5). In such cases the assumption that τ_{ult} equals 20-35 per cent UCS may be justified.

As a guide to specialists, bond values, as recommended throughout the world for a wide range of igneous, metamorphic and sedimentary rocks, are presented in Table III. Where included, the factor of safety relates to the ultimate and working bond values calculated assuming uniform bond distribution. It is common to find that the magnitude of bond is simply assessed by experienced engineers: the value adopted for working bond stress often lies in the range 0.35 to 1.4 N/mm². Koch (1972) suggests bond stresses in this range for weak, medium and strong rock (Table III), and the Australian Code CA 35—1973 states that a value of 1.05 N/mm² has been used in a wide range of igneous and sedimentary rocks, but confirms that pile testing has permitted bond values of up to 2.1 N/mm² to be employed.

In this connection the draft Czech Standard (1974) concludes that since the estimation of bond magnitude and distribution is a complex problem, field anchor tests should always be conducted to confirm bond values in design, as there is no efficient or reliable alternative. Certainly, a common procedure amongst anchor designers is to arrive at estimates of permissible working bond values by factoring the value of the average ultimate bond calculated from test anchors, when available. Usually the recommended safety factor ranges from 2 to 3, but is frequently lower in very competent rocks, and higher in weaker, fissured, or weathered varieties.

The degree of weathering of the rock is

Fig. 5 Effect of weathering at Curcanti McWay Transmission Line (after Salomon and Schuster, 1968)

TABLE III—ROCK/GROUT BOND VALUES WHICH HAVE BEEN RECOMMENDED FOR DESIGN

Rock type	Working bond (N/mm ²)	Ultimate bond (N/mm ²)	Factor of safety	Source
Igneous				
Medium hard basalt		1.75		USA—Baker (1958)
Weathered granite		1.50-2.50	3-4	USA—Baker (1958)
Basalt	1.31-1.38	2.88	2.2-3.2	USA—Baker (1958)
Granite	1.38-1.66	4.83	2.8-3.5	USA—Baker (1958)
Serpentine	0.45-0.59	1.95	4.3-5.5	USA—Baker (1958)
Granite & basalt		1.72-2.10	1.5-2.5	USA—PCI (1974)
Metamorphic				
Metastatic schist		2.25		USA—White (1973)
Slate & hard shale		0.83-2.38	1.5-2.5	USA—PCI (1974)
Sedimentary				
Clayey sandstone		0.35		USA—Baker (1958)
Claystone		0.35		USA—Baker (1958)
Clay—Grades I-III		0.35		USA—PCI (1974)
Tested limestones				
Chalk limestones	0.83-0.97	2.78	3.3-4.0	USA—White (1973)
Crystalline limestones	0.88-1.00	2.78	3.3-4.0	USA—White (1973)
Stratified limestones		1.25-1.52	1.5-2.5	USA—PCI (1974)
Archeanous sediments				
Hard coarse-grained sandstone	2.48		1.75	Canada—Coch (1972)
Weathered sandstone		0.89-0.86	3.0	New Zealand—Coch (1972)
Weathered mudstone		0.89	3.0-2.5	New Zealand—Coch (1972)
Weathered sandstone	0.48		3.0	USA—Baker (1958)
Weathered sandstone	0.00		3.0	USA—Baker (1958)
Weathered sandstone	0.88-0.83	2.24	2.7-3.3	USA—Baker (1958)
Weathered sandstone		0.83-1.72	1.5-2.5	USA—PCI (1974)
Argillaceous sediments				
Keuper marl		0.17-0.25	3.0	USA—Baker (1958)
Weathered shale		0.36		Canada—Coch (1972)
Soft sandstone & shale	0.10-0.14	0.37	2.7-3.7	USA—Baker (1958)
Soft shale		0.21-0.83	1.5-2.5	USA—PCI (1974)
General				
Competent rock (where UCS > 20 N/mm ²)		Uniaxial compressive strength—20 up to a maximum value of 1.4 N/mm ²	3	USA—Baker (1958)
Weak rock		Uniaxial compressive strength—70 up to a maximum value of 1.4 N/mm ²	3	USA—Baker (1958)
Medium rock	0.35-0.70			Australia—Coch (1972)
Strong rock	0.70-1.05			Australia—Coch (1972)
Wide variety of igneous and metamorphic rocks	1.05		2	Australia—Coch (1972)
Wide variety of rocks	0.88			France—Baker (1958)
	0.80			Switzerland—Coch (1972)
	0.70			Switzerland—Coch (1972)
	0.70	1.25-2.80	2.2-3.0	Switzerland—Coch (1972)
	0.88			Italy—Baker (1958)
	1.4	2.78	3	Canada—Coch (1972)
		4.2	3	USA—White (1973)
		15-20 per cent of grout crushing strength	3	Australia—Coch (1972)
Concrete		3.8-2.70	1.5-2.5	USA—PCI (1974)

TABLE IV—ROCK/GROUT BOND VALUES WHICH HAVE BEEN EMPLOYED IN PRACTICE

Rock type	Working bond (N/mm ²)	Test bond (N/mm ²)	Ultimate bond (N/mm ²)	Factor of safety	Source
Igneous					
Basalt	1.83		6.37	3.3	USA—Baker (1958)
Basalt	1.10	3.80			USA—Baker (1958)
Tuff	0.80				France—Coch (1972)
Basalt	0.83	0.72			USA—Baker (1958)
Granite	1.36	1.72			USA—Baker (1958)
Dolerite	1.36	1.72			USA—Baker (1958)
Very fissured felsite	1.36	1.72			USA—Baker (1958)
Very hard dolerite	1.36	1.72			USA—Baker (1958)
Hard granite	1.36	1.72			USA—Baker (1958)
Basalt & tuff	1.36	1.72			USA—Baker (1958)
Granodiorite	1.08				USA—Baker (1958)
Shattered basalt		1.01			USA—Baker (1958)
Decomposed granite		1.24			USA—Baker (1958)
Flow breccia		0.83			USA—Baker (1958)
Hydrated porphyry	0.33-0.87				USA—Baker (1958)
Fractured diorite	0.85				USA—Baker (1958)
Granite	0.83	0.81			USA—Baker (1958)
Metamorphic					
Schist	0.31				USA—Baker (1958)
Alf types	1.20				USA—Baker (1958)
Weathered fractures	1.36	1.72			USA—Baker (1958)
Tuffite				1.1	USA—Baker (1958)
Elk schist	1.22	1.67			USA—Baker (1958)
Weak metam sediments	1.10	1.25			USA—Baker (1958)
Slate	0.43				USA—Baker (1958)
Metastatic greywacke	1.57	1.73			USA—Baker (1958)
Metastatic greywacke	0.33-0.59				USA—Baker (1958)
Metastatic greywacke	0.51				USA—Baker (1958)
Metastatic greywacke		0.25			USA—Baker (1958)
Metastatic greywacke	0.34				USA—Baker (1958)
Metastatic greywacke	0.93-1.20	1.02-1.72			USA—Baker (1958)
Metastatic greywacke	0.25				USA—Baker (1958)

Rock	Working bond (N/mm ²)	Test bond (N/mm ²)	Ultimate bond (N/mm ²)	$\sigma = \frac{P}{A}$ (N/mm ²)	$\tau = \frac{P}{A \cdot l}$ (N/mm ²)	Source
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Metamorphosed rocks						
Basaltic schist	0.08					Italy—Berardi (1972)
Quartzite schist	0.10					Italy—Berardi (1972)
Argillaceous & calcareous schist	0.03					Italy—Berardi (1972)
Slate	0.06	1.24	1.3			Switzerland—Moeschler & Wolf (1972)
Slightly metamorphosed	0.04	1.08	1.3			USA—Burr (1972)
Slate & gneiss	1.08	1.40	1.3			Germany—Angen (1972)
Various metamorphosed	0.53	0.80	1.5			Germany—Brahm & Poring (1972)
Metastatic gneiss	0.60	0.90	1.5	3.0		USA—Nicholson Anchorage Co. Ltd (1972)
Slate	0.60	0.90	1.50	1.5	3.0	Britain—Littlejohn & Truman (1974)
Sound Metastatic gneiss	1.74	2.16				USA—Feld & White (1974)
Metastatic gneiss	1.50			1.24		USA—Feld & White (1974)
Very strong gneiss & mud band	0.07					USA—Feld & White (1974)
Carbonate sediments						
Loamy limestone		0.63				Italy—Berardi (1960)
Flashed limestone & marls	1.08	1.19	1.1			Britain—Cementation Co. Ltd (1962)
Limestone	0.68					Switzerland—Muller (1966)
Peel limestone	0.32					France—Monnequin & Cambier (1966)
Massive limestone	0.20-0.70					France—Monnequin & Cambier (1966)
Karst limestone	0.54					France—Monnequin & Cambier (1966)
Tertiary limestone	1.00		2.53	2.8		Switzerland—Leisinger & Co. Ltd (1966)
Limestone	0.63-0.87 (average)		4.95-6.87			Switzerland—Ruttner (1966)
Marly limestone	0.21-0.35 (measured)					Italy—Berardi (1967)
Limestone	0.28		0.27			USA—Soliman & Schaefer (1968)
Delemin limestone	0.20-0.94		1.80			Italy—Berardi (1968)
Marly limestone	0.28					Canada—Brown (1970)
Limestone	0.46					Italy—Berardi (1972)
Limestone	1.18	1.42		1.2		Italy—Berardi (1972)
Chalk			0.70			France—Soliman Co. Ltd (1968)
Delemin siltstone	0.43	1.66				USA—Burr (1972)
Limestone & marly bands	0.37	0.96		1.5		Britain—Associated Tunneling Co. Ltd (1973)
Argillaceous sediments						
Sandstone	1.44	1.58	1.1			Canada—Golder Branner (1973)
Hard sandstone	1.42	1.56	1.1			Italy—Berardi (1968)
Bunter sandstone	0.96	0.96	1.03			Britain—Cementation Co. Ltd (1962)
Sandstone	0.76	0.84	1.1			Britain—Cementation Co. Ltd (1962)
Sandstone	0.74					Czechoslovakia—Nežst (1968)
Sandstone	0.31	0.40	1.73	1.29	5.6	USA—Dressel (1970)
Sandstone	0.80					USA—Thompson (1970)
Peel sandstone	0.47					Germany—Brunner (1970)
Good sandstone	1.14					Germany—Brunner (1970)
Sandstone & Breccia	0.28					France—Soliman (1968)
Sandstone		0.95				Australia—Williams et al (1972)
Bunter sandstone	0.60	1.20	2.0			Britain—Littlejohn (1973)
Sandstone	1.17					Australia—McLeod & Meadley (1974)
Argillaceous sediments						
Shale	0.62					Canada—Jurgens (1968)
Marl	0.10	0.28	2.8			Italy—Berardi (1967)
Shale	0.30		0.63	2.1		Canada—Manna & Seaton (1967)
Very weathered shale	0.13-0.24		0.20			USA—Soliman & Schaefer (1968)
Shale	0.62					USA—Korshin (1970)
Grey siltstone	0.14-0.24	0.21-0.38	1.5			Britain—Universal Anchorage Co. Ltd (1962)
Clay marl	0.62					Germany—Schwarz (1972)
Shale	0.62					Canada—McRae et al (1972)
Argillite	0.62					Canada—Golder Branner (1973)
Mudstone	0.63	0.88	1.4			Australia—McLeod & Meadley (1974)
Miscellaneous						
Bedded sandstone & shale	0.25-0.90					Italy—Bonomini (1961)
Porous sand	1.57	1.72	1.1			Britain—Cementation Co. Ltd (1962)
Shale & sandstone	0.07	0.10	1.5			USA—Rai (1964)
Salt rocks	0.75					Sweden—Nord (1968)
Sandstone & shale	1.82					Poland—Sulik et al (1967)
Siltstone & mudstone	1.65					Australia—Maddox et al (1967)
Fractured rock (75 per cent shale)			0.24			USA—Soliman & Schaefer (1968)
Peel			0.35			USA—Soliman & Schaefer (1968)
Average			0.75			USA—Soliman & Schaefer (1968)
Good						Italy—Berardi (1972)
Limestone & clay breccia	0.20-0.25					

a major factor which affects not only the ultimate bond but also the load-deflection characteristics. Fig. 6 shows the results produced by test anchors in rhyolite tuff, of both sound and weathered varieties. No data are provided on grout or rock strengths but it is significant that the equivalent uniform bond stress at maximum jack capacity is scarcely 0.1 N/mm². For design in soft or weathered rocks there are signs that the standard penetration test is being fur-

ther exploited. For example, Suzuki et al (1972) state that for weathered granite the magnitude of the bond can be determined from the equation

$$\tau_{\text{ult}} = 0.007N + 0.12 \text{ (N/mm}^2\text{)}$$

where N = number of blows per 0.3m

Similarly, Littlejohn (1970) illustrates a correlation between N and ultimate bond

for steel rods in concrete

$$\tau_{\text{ult}} = 0.01N \text{ (N/mm}^2\text{)}$$

In grades III, IV and I of chalk, he served a range of τ_{ult} of 0.21–1.07 N/mm², based on test anchors pulled to failure.

Although it would appear from evidence presented in subsequent sections that assumptions made in relation to uniform bond distribution are not strictly accurate it is noteworthy that few failures are countered at the rock/grout interface. New designs are often based on the successful completion of former projects that is, former working conditions are re-employed or slightly modified according to the judgement of the designer.

Table IV contains data abstracted from reports of rock anchor contracts throughout the world in addition to the work test, and ultimate bond values, the assumed and designed safety factors are provided where available. In certain cases fixed anchor diameter has been inferred to facilitate analysis of the data, as possible.

It will be noted that, even for one type, the magnitude of bond used in practice is extremely variable. There are many reasons for this, the most important of which are:

- Different designers use different bond values and safety factors, which may be related to type of anchor and extent of anchor testing programme.
- "Standard" values for a certain type have often been modified to reflect local peculiarities or irregularities of geology.
- Factors related to the construction techniques e.g. drilling method, flush procedure, and grout pressure may influence the results obtained. (The effect of these aspects will be discussed in Part II Construction.)

On the whole however, it would appear that the bond values employed are to a degree consistent with rock type and competency.

Fixed anchor dimensions

The recommendations made by various engineers with respect to length of anchor are presented in Table V. Under certain conditions it is recognised that shorter lengths would suffice, even the application of a generous factor of safety. However, for a very short anchor the effect of any sudden drop in quality along the anchorage zone, a constructional error or inefficiency could induce a serious decrease in anchor's capacity.

With regard to the choice of anchor meter several considerations may be taken into account:

- Type and size of tendon.
- The relation of diameter to per cent area of fixed anchor and hence anchor capacity, assuming uniform bond.
- Ratio of steel area to cross-sectional area of borehole for efficient bond distribution and corrosion protection.
- Drilling method and rig to be used.
- Nature of rock in the anchor zone, presence of unconsolidated material, etc.

The authors find from a survey of several hundred commercial anchors that no direct relationship may be observed between the diameter of types, but that most anchors conform to the trend indicated in Table VI.

RECOMMENDATIONS

3.2.3 Factors of Safety

The design load P for the anchor equals the maximum anticipated load applied to the anchor times the factor of safety used in the design of the anchored structure. The value of the factor of safety depends upon the type of application, the degree of uncertainty in the design of the structure, and the risk.

3.2.4 Anchor Tendon Design

The tendon size is determined such that the design load for the anchor does not exceed 60 percent of the guaranteed ultimate tensile strength (GUTS) of the tendon. The lock off load, which shall be determined by the design engineer, may be larger or smaller than the design load. The recommendations for corrosion protection given in Section 6.0 "Corrosion Protection" shall be considered.

3.2.5 Free Stressing Length

The free stressing length should not be less than 15 feet [4.572m].

3.2.6 Bond Length

The bond length can be estimated by the following equation:

$$L_b = \frac{P}{\pi \cdot d \cdot \tau_u}$$

Where

- L_b = bond length
- P = design load for the anchor
- π = 3.14
- d = diameter of the drill hole
- τ_u = working bond stress in the interface between rock and grout

The working bond stress used to determine the bond length is normally 25 to 50 percent of the ultimate bond stress.

The ultimate bond stress depends on the

1. Shear strength of the rock
2. Discontinuities in the rock mass

COMMENTARY

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The engineer should not compound various factors of safety when designing an anchored structure. The uncertainty and risk associated with the work should be fully considered in determining the design load. The design engineer applies a separate factor of safety to the applied loads, the design load on the anchor, and the anchor test load. The actual factor of safety for the anchor will have been compounded, resulting in an overly conservative design.

The load in an anchor tendon may either increase or decrease with time depending on the behavior of the structure.

The minimum stressing length recommended is to prevent significant reductions in transfer load due to stressing anchorage losses or movement.

The bond length normally is not less than 10 feet. For normal applications the bond between the tendon and anchor grout is not critical.

Pull-out tests may be used to determine the ultimate interface bond stress between the rock and the anchor grout. Pull-out tests usually require that the tendon capacity be increased or the bond length reduced in order to fail the anchor. Pull-out test should not be required if the anchors are tested as described in Section 3.7.

When selecting the working bond stress the engineer should consider the critical nature of the anchor application, variations in the rock properties, and the installation procedures.

"British Standard Code of practice for
Ground Anchorages" British Standards Institute, 1989

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Table 25. Rock-grout bond values which have been recommended for design after Littlejohn and Bruce 1977

Rock type	Working bond N/mm^2	Ultimate bond N/mm^2	Load factor of safety	Source
Igneous				
Medium hard basalt		5.73	3.6	India Rao (1964)
Weathered granite		1.50 to 2.50		Japan Suzuki et al (1972)
Basalt	1.21 to 1.39	3.88	2.8 to 3.2	Britain Wychalls-Jones (1974)
Granite	1.38 to 1.55	4.83	3.1 to 3.5	Britain Wychalls-Jones (1974)
Serpentine	0.45 to 0.59	1.55	2.6 to 3.5	Britain Wychalls-Jones (1974)
Granite and basalt		1.72 to 3.10	1.5 to 2.5	USA PCI (1974)
Metamorphic				
Manhattan schist	0.70	1.80	4.0	USA White (1973)
Slate and hard shale		2.83 to 1.38	1.5 to 2.5	USA PCI (1974)
Sedimentary				
Calcareous sediments				
Limestone	1.00	2.83	3.8	Switzerland Leisinger (1968)
Chalk - Grades I - III	0.01 N (N = SPT n blows/0.3 m)	0.22 to 1.07	1.5 to 2.0 (Temporary) 3.0 to 4.0 (Permanent)	Britain Littlejohn (1970)
Tertiary limestone	0.83 to 0.97	2.78	2.8 to 3.3	Britain Wychalls-Jones (1974)
Chalk limestone	0.86 to 1.00	2.78	2.8 to 3.2	Britain Wychalls-Jones (1974)
Soft limestone		1.03 to 1.52	1.5 to 2.5	USA PCI (1974)
Dolomitic limestone		1.38 to 2.07	1.5 to 2.5	USA PCI (1974)
Arenaceous sediments				
Hard coarse-grained sandstone	2.45		1.75	Canada Coates (1970)
Weathered sandstone		0.69 to 0.85	3.0	New Zealand Inman (1971)
Well-cemented mudstone		0.69	2.0 to 2.5	New Zealand Inman (1971)
Bunter sandstone	0.40		3.0	Britain Littlejohn (1973)
Bunter sandstone	0.60		3.0	Britain Littlejohn (1973)
Ultimate compressive stress > 20 N/mm^2				
Hard fine sandstone	0.69 to 0.83	2.24	2.7 to 3.3	Britain Wychalls-Jones (1974)
Sandstone		0.83 to 1.72	1.5 to 2.5	USA PCI (1974)
Argillaceous sediments				
Keuper marl		0.17 to 0.25	3.0	Britain Littlejohn (1973)
Weak shale		0.45 C _u		C _u = uncorrected cohesion
Soft sandstone and shale	0.10 to 0.11	0.37	1.5 to 3.7	Canada Coates-Brownner (1973)
Soft shale		0.21 to 0.83	1.5 to 2.5	Britain Wychalls-Jones (1974)
General				
Competent rock (where ultimate compressive stress > 20 N/mm^2)	Ultimate compressive strength - 30 to 100 maximum value of 10 N/mm^2	Ultimate compressive strength - 10 to 30 maximum value of 4.2 N/mm^2	3	Britain Littlejohn (1972)
Weak rock	0.35 to 0.70	-	-	Australia Kech (1972)
Medium rock	0.70 to 1.25			
Strong rock	1.25 to 4.0			
Wide variety of igneous and metamorphic rocks	1.25		2	Australia Standard CA35 (1973)

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Table 25. continued

Rock type	Working bond	Ultimate bond	Load factor of safety	Source
Wide variety of rocks	4 mm ²	4 mm ²		
	398			France: Serard (1972)
	350			Switzerland: Walther (1953)
	370			Switzerland: Camo (1945)
	100	120 to 250	2 to 2.5 (Temporary)	Switzerland: Camo (1971)
			3 (Permanent)	Italy: Mancini (1973)
	369	376	4	Canada: Golden Browner (1973)
	1.4	4.2	3	USA: White (1973)
		15% to 20% of grout crushing strength	3	Australia: Langworth (1971)
Concrete		120 to 276	1.5 to 2.5	USA: PCI (1974)

Figure 56. Distribution of bond along fixed anchor length (after Serard (1967))

For compact sandy gravel ($\phi = 40^\circ$) at Vauxhall Bridge, London and compact dune sand ($\phi = 35^\circ$) at Ardeer, Scotland, values of B equal to 101 and 31 have been measured in the field (Littlejohn 1970) which are in good agreement with respective values of 99 and 35 estimated from Figure 6.

The value of A depends to a large extent on construction technique and for the type B anchorage relevant to equation (3), values of 1.7 and 1.4 have been recorded in compact sandy gravel ($\phi = 40^\circ$) and compact dune sand ($\phi = 35^\circ$), respectively (Littlejohn 1970).

Littlejohn (1970) estimated for equation (3) that A lay in the range of 1 to 2 but that if the soil was not com-

acted or displaced during the casing installation and no residual grout pressure was left at the fixed anchor-grout-soil interface on completion of the injection stage, A might reduce to a value approximating to K_0 . In the light of experience, this reduction is now considered unduly pessimistic since even with tremie grouting the full hydrostatic head of the grout is applied at the anchor interface, which creates a contact pressure greater than $K_0 \sigma'_v$ in normally consolidated ground.

As a consequence, even for the tremie grouting method, it is difficult to envisage a value of A less than 1 for design purposes.

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TITLE FACTOR OF SAFETY - WEDGE PULLOUT		PAGE 1 of 4	
PROJECT	DESIGNER C. FRANKS	DATE CHECKED BY 9/5/91	DATE CHECKED BY 7/4/91
NO.	CALC NO.	FILE NO.	GROUP

PROBLEM: DETERMINE THE FACTOR OF SAFETY (FOS) AGAINST PULLOUT OF A ROCK WEDGE BY A ROCKBOLT.

ASSUMPTIONS:

- 1) THE GEOMETRY OF THE WEDGE IS AS SHOWN ON THE SKETCH ON PAGE 2.
- 2) COHESION OF SALT IS $C = 1000 \text{ psi} = 6.89 \text{ MPa}$ (REF 1)
- 3) DENSITY OF WIPP SALT, $\rho = 135 \text{ lb/ft}^3$ (REF 2)

REFERENCES:

- 1) SAND 78-1596, "Geological Characterization Report", POWERS, et al, 1978.
- 2) D-51-W-01, "Design Basis - Underground Excavations" Bechtel

METHOD: THE SHEAR RESISTANCE OF THE WEDGE ABOVE CLAY G AND THE WEIGHT OF THE WEDGE ARE COMPARED.

THE SHEAR STRENGTH OF SALT WILL BE TAKEN AS EQUAL TO THE COHESION. THIS IS A VERY CONSERVATIVE VALUE SINCE

$$T = C + \sigma \tan \phi \quad (\text{REF 1})$$

WHERE T IS THE SHEAR STRENGTH, σ IS NORMAL FORCE (I.E. UCS FOR MAXIMUM) AND ϕ IS THE FRICTION ANGLE.

General Comment: I don't know that this calculation is significant to a bolt in salt.

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WESTINGHOUSE WASTE ISOLATION DIVISION

TITLE FACTOR OF SAFETY - WEDGE PULL OUT				PAGE 3 of 4	
PROJECT	AUTHOR C. FRANKS	DATE 9/8/81	CHECKED BY J. T. [unclear]	DATE CHECKED BY 9/8/81	DATE
REV	CALC NO	PILE NO	GROUP		

CALCULATIONS:

WEIGHT OF WEDGE

$$W = \frac{1}{2} b h w \rho$$

WHERE W = WEIGHT OF WEDGE
 ρ = DENSITY OF SALT
 b, h, w ARE BY FIGURE 1.

$$W = \frac{1}{2} (21' \times 10.5' \times 35') (135 \text{ lb/ft}^3)$$

$$W = 491 \text{ kip} = 2.18 \text{ MN}$$

SHEAR RESISTANCE OF SMALL WEDGE

$$S = A T \cos \theta$$

$$= \left[\frac{1}{2} b' h' + 2 + 2 + \sqrt{2} h' w \right] T \cos \theta$$

WHERE: S = SHEAR RESISTANCE OF SMALL WEDGE
 T = SHEAR STRENGTH OF ROCK
 b', h', w ARE BY FIGURE 1
 θ = ANGLE OF WEDGE FRACTURE

THE DIAGRAM BELOW ILLUSTRATES THE FORCES INVOLVED:

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TITLE FACTOR OF SAFETY - WEDGE PULLOUT		PAGE 4 OF 4	
DESIGNER C. FRANKS	DATE 9/5/91	DATE CHECKED BY JR Tybirk	DATE 9/4/91
BU	CALL NO.	FILE NO.	GROUP

CALCULATIONS: (CONT'D)SHEAR RESISTANCE OF WEDGE (CONT'D)

$$S = \left[\frac{1}{2} (7' \times 3.5') (2) + (2 \times \frac{1}{2} \times 3.5' \times 33') \right] T \cos \theta$$

$$S = (351 \text{ ft}^2 \times \frac{144 \text{ in}^2}{\text{ft}^2} \times 1000 \text{ psi}) \cos \theta$$

$$S = (50,544 \text{ kip}) \cos \theta$$

$$\tan \theta = \frac{7'}{30.5'}$$

$$\theta = 23^\circ$$

$$S = (50,544 \text{ kip}) \cos 23^\circ$$

$$S = 46,530 \text{ kip}$$

FACTOR OF SAFETY

$$F \& S = \frac{46,530 \text{ kip}}{491 \text{ kip}} = 95$$

DISCUSSION:

THE CALCULATED F & S IS QUITE ADEQUATE

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stress space (σ, T) where σ and T denote normal and shear stresses, and an envelope is drawn tangent to the circles representing the ultimate shear stress of any value of confining pressure. SAND 78-1
1978

Peters,

When the data from Tables 9.2.4-1 and 9.2.4-2 are plotted, three Mohr's circles which are normal for SEM rock salt are obtained in Figure 9.2.4-2A in stress space (σ, T). The ultimate stresses can be approximated by a straight line (Coulomb) envelope of the form $T = C + \sigma \tan \phi$. In conventional engineering terminology, C is called the cohesion and ϕ , the angle of internal friction. In this case, at ambient temperatures, rock salt from the 2,700 foot level has an apparent cohesion of approximately 1,000 psi and an angle of internal friction of 33° . Similar data for other rocks are being used for mine pillar design. However, it should be recognized that the validity of these ultimate stress analyses rests on two assumptions: (1) failure is independent of the intermediate principal stress, and (2) failure is defined solely in terms of stresses and independent of strain, strain rate and time. Both of these assumptions are currently being evaluated for rock salt.

In contrast to other rocks, it is important to remember that rock salt undergoes large deformations long before the ultimate stress is reached. Since these deformations can exceed 15% even at ambient temperature, it is conceivable that a practical failure condition might incorporate a maximum deformation criterion. To illustrate this case, a Coulomb envelope was constructed (Figure 9.2.4-2B) which defines the stress magnitudes at an arbitrarily chosen constant value of strain ($\epsilon_1 = 2.5\%$). This value is the average strain at the ultimate stress of samples tested in uniaxial compression at ambient temperature and a loading rate of 30 psi/min. It can be seen that Figure 9.2.4-2B is different from the ultimate stress envelope in Figure 9.2.4-2A. Clearly, the shapes of the Mohr envelopes are highly dependent on failure criteria. The values obtained also depend on the manner in which the Mohr's envelope is drawn. In Figure 9.2.4-2A, a "best fit" straight line tangent to the circles was drawn; while in B, a parabola was drawn tangent to the circles.

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APPENDIX C - CHANNEL SUPPORT DESIGN

The final design of the steel beam support system was the result of an evolutionary process that started by considering an I beam. The original concept called for an I beam that would be held in place by eight rock anchors and four yieldable steel posts. This design had several difficulties with it:

- o Each I beam would weigh about 2,000 pounds, making the installation process difficult and potentially dangerous.
- o The supporting rock anchors could not be attached to the centerline of the I beam. Instead, the rock anchors would have to be attached by means of a separate plate to the flanges of the I beam. This would have generated excess moments in the beam as well as introducing torque forces, which would have been difficult to calculate.
- o The yieldable posts would have been difficult to test, and as they were not performing any function that the rock anchors could not provide, they were eliminated from the design.

The final design calls for a 15 x 40 channel with 11 rock anchors that are fastened through the centerline of the channel.

The channel will be made of three 9 foot sections bolted together with four 7.5 inch by 3 inch splice plates which allow for greater ease in the handling and placement of the channel.

The beam has been designed to accommodate the unequal distribution of the rock load, and the rock anchors will be tensioned to account for the fact that most of the detached load is in the middle of the room.

The support channel design calculations are given below.

WESTINGHOUSE WASTE ISOLATION DIVISION CALCULATION COVER SHEET

DRAFT

System: <i>AUOO</i>
PWR: <i>N/A</i>

Design Class: <i>III-A.</i>
Sheet No.: <i>1</i> of <i>9</i>
Ref. EDT: <i>N/A</i>

FSAR Checked: ☒ FSAR Change Required: *yes*

DOE Order 6430.1A Checked: ☒

Source of Data: 1. *Geotech. Expert Report - WIPP, June 1991*
 2. *---*
 3. *---*

Source of Formulas
and References:

AISC - Manual of steel Construction
Blodgett - Design of Weldments

Type of Calculation: Prelim.: _____ Final: ☒

References:

Washington
Drawings

P&ID/Dwg. No./Rev.:

54-D 003-W1
- W2
- W3
- W4
- W5

Entitled:

Supplementary Roof
Support, Room 11, Panel 1
General Arrangement,
Sections and Details

RECORD OF ISSUES

Rev.	Description	By	Date	Chk'd	Date	App'd	Date
<i>0</i>	<i>Issued for external review</i>	<i>JMK</i>	<i>9/1/91</i>	<i>HG</i>	<i>9/6/91</i>	<i>JMP</i>	<i>9/6/91</i>

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TITLE		U/G. Room 1 - Roof Supp. System		PAGE		2 of 9	
PROJECT	AUTHOR	DATE	CHK'D. BY	DATE	CHK'D. BY	DATE	
	JHK	8/29/91	HS	9/6/91			
S.O.	CALC. NO.	FILE NO.	GROUP				
	6-91-JHK		H.C.E.				

Data and assumptions for the below calculations:

- Density of salt material is 135 lb/ft³ as per Design Basis - U/G Excavations, D-51-W-01, page 6.
- The total load overburden is based on 10 ft spacing of the rows of Rock Bolts in the longitudinal direction of the room.
- Triangular distribution of the load is assumed across the width of the room (33'-0").
- Material of the Rock Bolts is as per ASTM A 615 - Grade 60. Yield stress $F_y = 60,000$ psi, allowable working

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PAGE 3 OF 9		TITLE: V/G. Room 1 - Roof Support System	
PROJECT: V/G. Room 1 - Roof Support System		PROJECT: V/G. Room 1 - Roof Support System	
AUTHOR: JHK		AUTHOR: JHK	
DATE: 12/29/91		DATE: 12/29/91	
FILE NO. 6-91-37K		FILE NO. 6-91-37K	
GROUP: H&C.E.		GROUP: H&C.E.	

stress in tension $f_t = 0.6 f_y = 36 \text{ ksi}$. (see PTI-1986)

5. Allowable load in the Rock bed is

$$P_w = 4 \times f_t = 0.79 \times 36.0 = 28.4 \text{ k}$$

Triangular load:

Weight of the overburden

$$w = \left(\frac{1}{2} \times 10.0 \times 33.0 \times 7.0 \right) \times 135 \text{ lb/ft}^3 = 156,000 \text{ lb}$$

Load per linear foot across the

$$w = \frac{2 \times 156,000}{33.0} = 9,455 \text{ k/ft}$$

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TITLE <u>U/G. Room 1 - Roof Support System</u>		PAGE <u>4</u> OF <u>9</u>	
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S.O.	CALC. NO. <u>G-91-JMK</u>	FILE NO.	GROUP <u>H. & C.E.</u>

Load on the critical Rock Bolt @ center of the room: (spacing @ 2'-0")

$$P_w^{max} = 2'0" \times 9.16 = 18.33 k < P_w$$

Adjacent Rock Bolt:

$$P_w' = 2'0" \times 8.30 = 16.6 k$$

In case the center R.B. fails

half of the load i.e. $\frac{1}{2} 18.33 k$

= 9.16 k will be taken by the

adjacent R.B.

$$2P_w = 16.6 + 9.16 = 25.76 k < P_w = 28.4 k - \text{see page 3}$$

$\Rightarrow$ no overloading occurs

Spacing of R.Bs. across the room

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	JHK	8/29/91	HS	9/6/91	
S.O.	CALC. NO.	FILE NO.	GROUP		
	6-91-JHK		H.P.C.E.		

Check of stress in the channel from bending. (L15x40; $S = 3.37 \text{ in}^3$).

Assume conservatively $M = 1/10 \text{ w l}^2$

$$M = \frac{1}{10} 8.9 \times 2.0^2 = 3.56 \text{ kft} \sim \text{@ center of the room}$$

$$\sigma = \frac{3560 \times 12}{3.37} = 12676 \text{ psi} < \text{Allow.}$$

Section modulus "S" of the L15x40 with a $\phi 1.5"$ hole.

Static moment M_x :

$$\begin{aligned} 11.8 \times 2.74 &= 32.33 \text{ in}^3 \\ - 0.75 \times 3.27 &= -2.45 \\ \hline M_x &= 29.88 \text{ in}^3 \end{aligned}$$

$$x_0 = \frac{M_x}{A_0} = \frac{29.88}{11.05} = 2.70 \text{ in}$$

$$\begin{aligned} I &= I_0 + A_1 x_1^2 - I_p - A_2 x_2^2 = 9.23 + 11.8 \times 0.043^2 - \\ &\quad - \frac{1}{12} \times 1.5 \times 0.5^3 - 0.75 \times 0.92^2 = 8.71 \text{ in}^4 \end{aligned}$$

$$S = \frac{I}{C} = \frac{8.71}{2.70} = 3.21 \text{ in}^3$$

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	JHK	01/30/91	HS	9/10/91			
S.O.	CALC. NO.	FILE NO.	GROUP				
	6-91-JHK		H. PCE.				

Check new stress in the [15 (see page 5)

$$H = 356 \text{ kft} \Rightarrow \sigma = \frac{356 \times 12}{3.21} = 13308 \text{ psi} < \sigma_{\text{all}}$$

Shear in the web:

$$F_w^{\text{max}} = 18'33''$$

$$A = \frac{18330}{14000} = 1.31 \text{ in}^2$$

$$r_{\text{req}} = \frac{1.31}{1.5 \times 2\pi} = 0.42 \text{ in} \Rightarrow r_{\text{used}} \sim 1.00 > 0.42.$$

Use $\phi 2''$ washer under

the rock bolt (see below)

Bending of the [15 perpendicular to the
length of the beam @ supp

$$q = \frac{2P_w}{15' \times 24'} = \frac{28400}{15 \times 24} =$$

$$= 78.9 \text{ psi}$$

$$M = \frac{1}{2} 78.9 \times 4.75^2 = 890 \text{ lb. in}$$

$$\sigma = \frac{890}{1.042} = 21192 \text{ psi} \approx \sigma_{\text{allow.}}$$

$$S = \frac{1}{6} 10 \times 0.5^3 = 0.0208$$

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TITLE U/G. Room 1 - Roof Supporting System		PROJECT U/G. Room 1 - Roof Supporting System		AUTHOR JHK - 10/30/91		DATE 9/16/91	
PAGE 9		GROUP H.C.E.		CALC. NO. 6-91-JHK		FILE NO.	

Shear (along the perimeter)
 $A = 4 \times 5.5 \times 0.5 = 11 \text{ in}^2$

$$\tau = \frac{28400.0}{11.0} = 2582 \text{ psi} = 2582 \text{ psi} = 2582 \text{ psi} = 2582 \text{ psi}$$

Combined stress: (bending + shear)

$$\left(\frac{f_b}{f_c}\right)^2 + \left(\frac{\tau}{\tau_c}\right)^2 \leq 1$$

$$\left(\frac{27.19}{23.76}\right)^2 + \left(\frac{2.54}{14.0}\right)^2 = 0.795 + 1.033 = 1.828 < 1.0$$

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	JMK	8/30/91	HS	9/6/91	
S.O.	CALC. NO.	FILE NO.	GROUP		
	6-91-JMK		M. & C.E.		

Design of splice: - assumed as a flexible pin, allowing ^{small} horizontal movement.

C.G. of the weld:

$$S_{M_x} = 2(3 \times 1.5) = 9 \text{ in}$$

$$L = 3 \times 3 = 9 \text{ in}$$

$$x_0 = \frac{9 \cdot 0}{9 \cdot 0} = 1 \text{ in}$$

Design of the weld:

See table XXIII, page 4-80
AISC

$$k = 1.0 \quad a = 1.5$$

$$h = 3 \quad P = 5.66k$$

$$C = 0.775$$

$$D = \frac{P}{CC_e} = \frac{5.66k}{0.775 \times 1.0 \times 3.0} = 2.43$$

Use 3/16 weld

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S.O.	CALC. NO. <u>6-91-JMK</u>	FILE NO.	GROUP <u>M. P.C.E.</u>		

Splice plate - stresses from bending and shear.

Assume $\frac{3}{8}$ " thick

Moment:

$$M = \frac{1}{2} \sqrt{5.66} \times 2.5 = 7075 \text{ in-lb}$$

$$\sigma = \frac{7075.0}{0.562} = 12589 \text{ psi} \Rightarrow \text{OK}$$

Shear:

$$\tau = \frac{\frac{1}{2} 5660}{3 \times 0.375} = 2515 \text{ psi} \approx 14000$$

Combined stress:

$$\left(\frac{12589}{23760} \right)^2 + \left(\frac{2515}{14000} \right)^2 = 0.28 + 0.03 = 0.31 < 1.0 \Rightarrow \text{OK}$$

Bolt at the sliding end.

$$\tau = \frac{\frac{1}{2} 5.66}{0.306} = 9.25 \text{ ksi}$$

Assume $\phi \frac{5}{8}$ "

$$A = 3.14 \times 0.31^2 =$$

$$\text{Use Bolts A 325 } (F_v = 17.5 \text{ ksi}) = 0.306 \text{ in}^2$$

Finger tight.

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WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM

APPENDIX D
Geomechanical Monitoring Program

Westinghouse Electric Corporation
Waste Isolation Division
Carlsbad, New Mexico
October 1991

DRAFT

GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL 1

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GEOTECHNICAL MONITORING PROGRAM FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL 1

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GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL 1

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A

Geomechanical Instrumentation System Specifications

GEOTECHNICAL MONITORING PROGRAM FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL 1

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GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL 1

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1.0 INTRODUCTION

A system to support the roof in Room 1, Panel 1 has been designed on the basis of the rock mechanics data that is given in Appendix A. The design itself, is presented in Chapter 4 Support System, Underground Storage Area, Panel 1, Room 1. The support system accommodates a controlled yield of the roof rock as the creep of the salt takes place. The success of the planned system relies heavily on a monitoring program that will determine not only the geomechanical performance of the room but will also assess the structural performance of the support system.

The support system is designed to carry the dead weight of a rock wedge that is forming in the roof of Room 1. The development of this wedge has been established from the rock fall that occurred in SPDV Test Room 1 and from observations of fracture development in other parts of the underground facility. The wedge is not yet fully formed but experience in would indicate that it will form within the next 7 years in Room 1, Panel 1 unless fracture development in the roof can be controlled. The support system in Room 1 has two purposes. It is designed to minimize the development and propagation of roof fractures thereby, ensuring that the rock remains self supporting for as long as possible, and secondly the system must have a capacity to carry the dead weight of the rock wedge once it forms in the roof while accommodating both vertical and lateral displacements due to far field creep effects.

The geotechnical monitoring program will establish the loads that are developing in the support and the deformations of the rock that are taking place around the room. The geotechnical data will be used to ensure that the support system is performing in a controlled manner and to establish the load adjustments required to the support system in order to accommodate the creep movements of the salt, and to confirm that room performance remains within satisfactory bounds. Geomechanical monitoring of a room can give indications of its deterioration. Monitoring of the performance of excavations at the WIPP has already provided early identification of such conditions. SPDV Test Room 1 showed evidence of worsening conditions at least 3 years prior to the roof failure in that room. In addition, the Geotechnical Expert Panel has expressed confidence that instrumentation in Panel 1 can give adequate notification of deteriorating conditions (US DOE, 1991).

This plan describes the geotechnical monitoring program that will be implemented to evaluate both the room performance and the performance of the support system. The plan describes the instrumentation that will be installed in the room, and it discusses the criteria that will be applied to ensure that the support system is adjusted in a controlled manner and that room performance remains satisfactory. It should be noted that as more data becomes available, especially on the interaction of the support with the room, then the criteria that are the basis for adjusting the loads on the support may require modification.

The plan has been developed and will be implemented in accordance with the general requirements for the control of test activities as described in the Geotechnical Engineering Program Plan (Westinghouse, 1991a). The Geotechnical Engineering Program Plan supports the Quality Assurance Program implemented at the site (Westinghouse, 1991b) and covers the eighteen criteria that are defined in the Quality Assurance Program for Nuclear Facilities (ANSI/ASME NQA-1-1989).

2.0 MONITORING OF ROOM PERFORMANCE

The program for monitoring room performance has already been developed and implemented in Room 1, Panel 1. The basis for the monitoring is that the measurements and observations are simple to make; that minimal maintenance of instrumentation is required; that instrumentation is easily replaced if it malfunctions; and that conditions throughout the room are known. The data should provide data on geomechanical performance features that have been identified elsewhere in the underground facility, especially in the SPDV Test Rooms as features that should be compared with other data collected at the site. Room performance is being characterized from the following:

- The development of bed separations and lateral shifts at the interfaces of the salt and the clays underlying the anhydrites "a" and "b".
- The establishment of the room closure rates and determination if they are accelerating with time or exceeding expected rates.
- The assessment of the behavior of the pillars.
- The assessment of fracture development in the roof and floor.

The instrumentation in Room 1, Panel 1 was upgraded during the summer of 1991 from the original monitoring program established for the panel in 1988. At that time, limitations were imposed on penetrations through the Anhydrite "b" in the roof. These limitations were in effect for waste storage considerations and no longer apply to the use of the room as the location for the bin scale tests. Roof conditions are now assessed from observation boreholes and from extensometer measurements. Measurements of room closure, rock displacements and observations of fracture development in the immediate roof beam can now be made and used to evaluate the performance of the room. The upgraded monitoring program was presented to the Geotechnical Expert Panel who considered that it was adequate to determine deterioration within the room and could provide early warning of deteriorating conditions in the room (US DOE, 1991).

The location of the instrumentation monitoring room performance is shown in Figure 2-1. The specifications for the instruments are given in Table 2.1. A summary of the installation requirements including tolerances, workmanship and national codes and standards that the instrumentation monitoring system must meet are given in Appendix A. Figures 2-2 and 2-3 provide the instrumentation cabling layout for the convergence meters and extensometers respectively.

2.1 Room Convergence Measurements

Vertical and horizontal convergence stations will be installed at seven cross sections throughout the room to monitor roof/floor and wall/wall room closure. The locations for the instruments are provided in Figure 2-1. At each cross section, roof/floor convergence will be measured at mid span and at room quarter points and wall/wall convergence will be measured at mid wall height. The convergence measurements will establish the rates of room closure for comparison with predicted rates and will be evaluated to determine asymmetric roof/floor closure of the room.

Each convergence station will consist of a mechanical anchor fixed about 150 mm below the rock surface. Details of a typical convergence anchor installation are given in Figure 2-4. An extensometer consisting of a wire or tape stretched under a constant tension and an accurate distance measuring device is attached between the anchors. Changes in length between the anchors will be monitored periodically to determine room closure. The convergence measurements can be made manually or remotely. For manual measurements the extensometer is put in place only for a reading and is subsequently removed. For the remote readings, the extensometer remains in position and the manual extensometer measuring device is replaced by a electronic device capable of measuring length changes. In Room 1, a potentiometer readout with a range of 36 inches will be used where remote readings can be obtained. Remote readings cannot be made at all locations because the permanent installation of wires across the room will interfere with access into the room.

2.2 Extensometer Measurements

Borehole extensometers will be installed in the roof and the walls of Room 1. Roof extensometers will monitor bed separations at anhydrites "a" and "b", and dilation and creep movements within the immediate roof beam of salt. Wall extensometers will monitor the lateral deformations within the pillars.

Within each borehole, five measuring points will be anchored to the rock to monitor rock movements towards the room. Details of a typical borehole extensometer installation are shown in Figure 2-5. In the roof holes, the anchors are nominally fixed at depths into the hole of 0, 2m (6.5 feet), 2.3m (7.5 feet), 4m (13 feet), and 4.3m (14 feet), for the purpose of monitoring bed separation across the anhydrites "a" and "b". In the wall holes, the anchors are fixed at depths of 0, 1.5m (5 feet), 3m (10 feet), 4.6m (15 feet), 7.6m (25 feet) and 15m (50 feet). The specifications for the drilling of boreholes, the installation of extensometers and for the instruments are given in Table 2.2.

Calibration of the measuring device for the multiple point extensometers will be carried out either by the manufacturer or by the Site Calibration Laboratory. Calibration will be traceable to National Institute of Standards and Testing (NIST).

Readings will either be taken manually with a readout device provided by the manufacturer or will be performed remotely through the automatic data acquisition system that is maintained in the underground. Measuring frequency, once the room is in use as a laboratory for the bin scale tests will be carried out every week. This frequency may be adjusted to meet any changes that develop.

2.3 Survey Measurements

Survey measurements will be made in the room by the surveyors from Mine Engineering. These measurements will be used to separate roof and floor deformations. The measurements will be taken on a routine basis, probably at intervals of about 3 months.

2.4 Fracture Mapping of Observation Boreholes

Three observation boreholes have been drilled into the roof of Room 1, Panel 1. Additional boreholes will be installed at the existing locations to monitor the behavior of the roof cross-section. Observations of bed separation and lateral

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strata shifts will be made on a routine basis at intervals of about 3 months. The boreholes will be monitored using a scratch probe that has been used for the Excavation Effect Program (U.S. DOE, 1986). The holes can also be viewed with a borehole camera if the fractures require visual observation.

In addition, the boreholes for the rock anchors will be observed for fractures immediately following their drilling. This will be carried out using the scratch probe and the borehole camera.

2.5 Data Acquisition

The instrumentation monitoring room performance, is currently read manually. Conversion to remote reading of instrumentation is planned. This conversion will take place once the data acquisition system for the monitoring of the support system is installed in the room. It may not be practical to convert all the instrumentation to remote readings. The roof extensometers will be converted to remote reading. The ancillary equipment to allow remote reading of the quarter point convergence stations will be installed but a final decision on installation of the wires will depend on establishing that they will not be damaged by personnel maintaining or sampling the bins. The roof/floor convergence stations at midspan i.e. down the middle of the central access way and the wall/wall convergence stations will not be monitored remotely as they would interfere with access.

Remote instrumentation will be monitored from a data logger located in an alcove in S1950 of Panel 1 between Rooms 4 and 5. The data logger is part of the Geomechanical Instrumentation System installed in the underground. The system is controlled from a computer located on the surface. The data logger that will be used to remotely read the instrumentation monitoring room performance in Room 1 is already in place. The specifications to which the datalogger is manufactured are provided in Appendix A.

The results from the instrumentation in the room will be evaluated on a continuous basis. Documentation of the results will be provided annually in the Geotechnical Field Data and Analysis Reports.

3.0 MONITORING OF SUPPORT SYSTEM PERFORMANCE

The monitoring of the support system performance provides an assessment of the manner in which the support is controlling roof movements including the breakup of the immediate roof. The monitoring program in Room 1, Panel 1 will evaluate the following:

- The performance of the structural system that supports the roof.
- The load that develops in each rock anchor for the purpose of adjusting loads so that the build up is controlled in a consistent manner.

The basis for the instrumentation will be that the measurements are simple; that instrumentation is easily replaced if it malfunctions; and that the performance of each anchor can be continuously monitored and readily compared with performance of other anchors. The instrumentation layout for monitoring the

support system performance is provided in Figure 2-6. Cabling layouts are provided in Figures 2-7, 2-8, and 2-9.

The most important of these measurements are those that determine the anchor loads. These measurements will be used to adjust the anchors to ensure that they are not stressed beyond the allowable working stresses and that the roof is lowered in a controlled manner that accommodates the continued creep of the solid salt.

The measurements of cable elongation and pressures developing on the sheeting will be taken to determine how these components of the support system are performing. No adjustments are planned on the basis of these measurements. However, if they show load buildup, additional actions may be considered. It is not expected that breakup of the roof rock will be excessive, it appears more likely that the rock will remain primarily self supporting until the detached wedge in the roof fully forms. It is not expected that this will occur within the next two years based on the experience obtained from SPDV Test Room 1. Therefore, it is not believed that loads approaching the full weight of the detached wedge will develop on the expanded metal sheeting and the cables.

3.1 Rockbolt Load Cells

The rockbolt load cells will monitor the axial loading on the rock anchors. The measurements will be made on each anchor and will be the basis for adjusting the load on each anchor, should an adjustment become necessary.

Each load cell consists of a cylindrical body with a central annulus for the rock anchor. The load measuring element is a spool of high strength steel or aluminum on which electrical resistance strain gauges are bonded in a full bridge configuration that provides temperature stability and compensates for off center loading. A steel outer cover and O ring seals protect the strain gauges from mechanical damage and water penetration.

The load cells shall have sufficient capacity to measure up to 50 kips with a sensitivity of 0.02 kips. In order to maximize the vertical adjustment on the tendons, the height of the load cells shall not exceed 75 mm. The typical load cell installation is shown in Figure 2-10.

3.2 Pressure Cells

Pressure Cells will monitor the pressures that develop between the expanded metal sheeting and the salt roof. The measurements will be made in selected areas within the room that are expected to have the greatest roof movements and hence, be more susceptible to the development of loads due to the breakup of the immediate roof rock. Typical pressure cell installation is shown in Figure 2-11.

Each pressure cell is manufactured from two steel plates welded together. The space between the two plates is filled with de-aired antifreeze solution or hydraulic fluid and is connected via a high-pressure stainless steel tube to a pressure gage and/or pressure transducer. A pump is used to inflate the pressure cell and press the cell against the rock. A change in load on the cell will cause a deflection of the diaphragm which results in a change in the fluid pressure. The pressure cells, in Room 1, will be installed between the rock and the mesh to monitor the pressure distribution on the cable lacing and mesh.

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The pressure cells will be constructed from corrosion resistant materials such as stainless steel. The pressure cell can be modified for remote monitoring by replacing the pressure gage with or adding a pressure transducer.

The pressure cells will be placed between the rock surface and support mesh. An important factor to take into consideration when installing a pressure cell is to ensure good contact with the surrounding material and to avoid localized or point loading of the cell. To avoid point loading, each pressure cell will be encapsulated with a concrete based grout. After the grout has set up, the pressure cell will be placed between two steel plates in order to evenly distribute the load on it. The pressure cells will be pumped up so that the cell is completely filled with fluid.

Pressure in the cells will be monitored using pressure gages. Monitoring of the pressure cells can be changed from manually read to remotely read with the addition of a pressure transducer to the cell.

3.3 Cable Elongation

Crack meters will monitor the elongation of the cables that support the mesh and expanded metal sheeting. The measurements will be made at selected sections within the room that are expected to have the largest deformations and subsequently load the mesh and cables. Typical crack meter installation is shown in Figure 2-12.

3.4 Data Acquisition System

The data acquisition system shall provide for remote multiplexing of the load cells at locations within the room. The data acquisition system shall be capable of handling the required number of multiplexers. The data acquisition system shall be configured to monitor 33 rows of load cells, each row containing 11 loads cells.

The data logger will consist of a programmable controller, switching units, and a readout device. To prevent thermal deterioration, the switching units must multiplex all signal functions for each instrument. Continuous connection to a constant-voltage power bus is not allowed.

The data logger will include a Racal-Vadic Model VA1251G/K modem for data link connection to the surface data logging computer.

To facilitate compatibility with existing GIS equipment, existing communication parameters, protocol, and programming must be incorporated into the data logging components.

A Racal-Vadic Modem Model VA1251G/K will exchange ASCII character data over the datalink cable via the following parameters:

- Baud Rate - 300
- Parity - Even
- Stop Bits - One
- Word Length - Seven Bits

The two panel switches on the Racal-Vadic Modem are to be set as follows:

- Analog/Digital Loopback - OFF
- Transmit Reversal - OFF

The modem's RS-232 interface will connect with the supplier-provided control units to ensure proper data communications.

The surface datalogging computer has been programmed to communicate with all underground control units through an exchange of ASCII character data. The computer sends a two character address sequence down the datalink cable through the surface modem. Each control unit then demodulates the character sequence through its modem. Each control unit is uniquely programmed (via a PROM chip) to respond to its own address sequence. Upon receipt of its address sequence, each control unit will poll its instruments, perform any necessary data reduction, and send instrument readings through the modem as a string of ASCII characters.

4.0 ADJUSTMENT OF SUPPORT SYSTEM

The anchors will be set to a nominal load of 500 kg (1000 lb) after proof testing to 1.33 times their working load. The purpose of the preload is to ensure that the lacing and meshing under the channel is secured firmly in position. As the loads change they will be compared with an estimate of conditions. There are two cases to be considered. These are the control of load during the detachment of the wedge when the full loads have not developed and the case when the wedge has detached and the working loads have been reached and any continued build up would be dependent on the creep of the solid salt onto the wedge that creates a stress build up in the support system that must be relieved by the controlled yield of the support.

Initially, the roof will be self supporting as the fractures will not have developed sufficiently to define a detached wedge. It is likely that this condition will be maintained for a period of years, especially if the bolting systems are able to reduce the widening and propagation of the fractures that do develop. However, for worst case conditions, it will be assumed that fractures will propagate and that gradually the degree of self support of the roof will be lost. As this occurs, the rock anchors will provide increasing roof support and loads will build up in the anchors. Once the roof wedge becomes detached, then the rock anchors will be fully supporting the wedge and will have reached their working loads. Control of anchor loads must consider the adjustments needed during load build up when the wedge is not fully detached and load distributions may not be as expected, and those required once the wedge has detached and is subject to both vertical and lateral movements due to the creep of the solid salt.

In addition, the wedge shape must be taken into account when estimating the adjustments that must be made to the anchor loads. Two possible geometric shapes have been proposed to define the wedge that develops in the roof of excavations. A triangular distribution identified from visual observation of the roof fall in SPDV Test Room 1, and a parabolic distribution based on survey data of the roof of the room after the fall. For the purpose of assessing the adjustments to the anchors in Room 1, both distributions will be compared with the field data to determine which is more appropriate. The comparison will be carried out on a row by row basis and also over time since the geometry of the wedge may depend on

location within the room and load distribution within a row of anchors may change with time as fractures develop.

4.1 Criteria for Load Adjustment

The preliminary criteria for adjusting the loads in the anchors are as follows for the two cases that have been identified:

CASE 1: Load distribution below Maximum Working Load

This case will occur as the load develops from the nominally applied loads due to the increasing support provided to the wedge as the fractures develop. During this stage it is not obvious precisely how the loads will build up, but it is expected that they will develop slowly because the rock is still self supporting. Based on these assumptions, the following criteria will be applied to load adjustments for a row during the build up to maximum working loads:

- No adjustments will be considered necessary to a row of anchors until the load in one anchor exceeds 27.5 MPa (4 kips.)
- If the load distribution within a row of anchors is consistent with a triangular or a parabolic load distribution, then no adjustment is necessary. Consistent is taken to mean, variations from the load distribution of less than 20 percent for all anchors in the row.
- If the loading for a row of anchors is consistent with a triangular or a parabolic distribution but with a variation from 20 to 25 percent for an individual anchor, then no adjustment is necessary, but an analysis shall be made to establish the rate of load increase for all anchors within the row and to estimate whether the variation is increasing and the time that it will take to reach a value of 25 percent above the remainder of the distribution.
- If the load distribution for a row of anchors is consistent with a triangular or a parabolic load distribution but with a variation of 25 percent for an individual anchor, then an adjustment to that anchor will be carried out. The load on the anchor will be reduced by not more than 50 percent.
- If the load in one anchor exceeds 27.5 MPa (4 kips) and the load distribution within the row is not consistent with either a triangular or a parabolic distribution, then a study will be carried out to establish whether an alternative plausible load distribution can be established. If this is possible, then this distribution will be used to determine the adjustment to the anchor load.

For example, if the loads develop on one side of the room due to asymmetric room closure, then an asymmetric load distribution may be found to be a more appropriate basis for load redistribution.

CASE 2: Load Distribution at Maximum Working Loads

Load distribution at maximum working load is considered to have developed when controlled adjustment of a row of bolts cannot reduce the anchor loads below

is levels that are consistent with the weight of a detached rock wedge. Once this stage has been reached, then the following criteria will be used to adjust the anchors in each row:

- If the measured load in an anchor is 10 percent or more over the allowable working load for that anchor, an adjustment to the load will be made. The load on the anchor will be reduced by not more than 50% of its allowable working load.
- If the load distribution does not conform with a triangular or parabolic distribution, a study will be carried out to determine whether the measured distribution is reasonable and can be explained in terms of a geometric wedge shape that is appropriate.

These criteria are based on our expectation of the performance of the roof rock and of the support system and their interaction. A mock up demonstration is planned in another room in Panel 1. During the demonstration, loads in the anchors will be adjusted to establish the effects of changing loads by a controlled amount on the loads that develop on nearby bolts. Should the data from the demonstration indicate that the criteria do not provide adequate control for support system adjustments, then alternative criteria will be developed. The application of the modified criteria to the adjustment of the support system in Room 1 will require the approval of the Manager of Engineering for the Managing and Operating Contractor for the WIPP with concurrence from the Managers of Operations, Safety, and Quality Assurance.

AI 4.2 ANALYTICAL EVALUATION FOR LOAD ADJUSTMENTS

In parallel with the monitoring of actual loads in the rock anchors, a study will be carried out to determine the load transfer that can occur between anchors. The study will include field tests and analytical computations. The field tests will investigate how load changes in one bolt affect adjacent bolts. Computational analyses will look at load transfer effects between bolts. These studies will be completed before adjustments to anchor loads are required in Room 1, Panel 1.

Computer simulations will assess the effects of adjusting the loads within the tendons. This will be done on a row basis, since the available software codes are based on two dimensional modelling. This assumes that interaction effects between rows spaced nominally 10 feet apart will not be significant. The codes that will be used are VISCOT, a finite element code and FLAC, a finite difference code. Both codes were developed for the structural analysis of geologic media. The VISCOT code which is a version of a publicly available code originally developed by Owen and Hinton (1980) was modified for use in the Salt Repository Program for the disposal of high level radioactive wastes. The FLAC code (ITASCA, 1991) is a proprietary code developed by ITASCA, Inc. to simulate the behavior of geotechnical materials which may undergo plastic flow.

The codes will be used to determine interaction effects between bolts supporting the isolated rock wedge. They will establish if adjusting the load in one anchor within a row will change the loads in other bolts within the row and by how much. They will also assess whether asymmetric load distributions can develop due to lateral or differential vertical displacements of the salt and how these effects can be compensated for or minimized by adjusting the anchor loads.

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A preliminary assessment of load redistribution has been carried out using VISCOT. For the case of the fully detached wedge reduction in bolt loading of will be redistributed among the other bolts in a row without overloading of any bolt. The redistributions for a number of cases are shown in Figures 4-1. It should be noted that the study of bolt load adjustment will be an ongoing activity and that field data will be assessed to determine the effectiveness of the analytical evaluations for load adjustments.

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FIGURE 2-1. Room Performance Instrumentation

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FIGURE 2-2. Wire Convergence Meter Cabling

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FIGURE 2-3: EXTENSOMETER CABLING

- Main cable line
- Sub cable line
- Connector

FIGURE 2-3. Extensometer Cabling

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Note: • Floor installations may be recessed greater than 3 in. and protected with coverplate.
• Dimensions approximate

FIGURE 2-4. Typical Radial Convergence Point

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FIGURE 2-5. Typical Rod-Type Extensometer Installation

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FIGURE 2-6: SUPPORT SYSTEM PERFORMANCE INSTRUMENTATION

FIGURE 2-6. Support System Performance Instrumentation

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FIGURE 2-7: ROCKBOLT LOAD CELL CABLING

FIGURE 2-7. Rockbolt Load Cell Cabling

FIGURE 2-8. Pressure Cell Cabling

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FIGURE 2-9: WIRE ROPE STRAIN GAGE CABLING

- WIRE ROPE STRAIN GAGE
- - - - - WIRE ROPE
- STRAIN GAGE

FIGURE 2-9. Wire Rope Strain Gage Cabling

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FIGURE 2-10. Typical Load Cell Installation

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FIGURE 2-11. Typical Pressure Cell Installation

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FIGURE 2-12. Typical Crackmeter Installation

FIGURE 4-1. Rock Bolt Loading Redistribution

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Table 2-1

PANEL 1 ROOM 1
GEOMECHANICAL INSTRUMENTATION SPECIFICATIONS

TABLE 2.1
PANEL 1 ROOM 1
GEOMECHANICAL INSTRUMENTATION SPECIFICATIONS

Instrument Type	Measured	Range	Precision	Accuracy	Method
Borehole Extensometers	Cumulative Deformation	0-2 in.	± 0.001 in.	± 0.001 in.	Sonic Probe
Convergence Points	Cumulative Deformation	2-50 ft.	± 0.001 in.	± 0.005 in.	Inope Extensometer
Convergence Meters Wire	Cumulative Deformation	0-3 ft.	± 0.004 in.	± 0.032 in.	Rotary Potentiometer
Rockbolt Load Cells	Load	0-50 tons	± 40 lbs	± 40 lbs	Strain Gage
Earth Pressure Cells	Lithostatic Pressure	0-10 psi	± 0.05 psi	± 0.05 psi	Vibrating Wire
Crackmeters	Cumulative Strain	0-4 in.	± 0.0008 in.	± 0.004 in.	Vibrating Wire

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APPENDIX A

GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION	SPECIFICATION
CABINET DESIGN AND PERFORMANCE	<p>Specification No.E-P-309</p> <ol style="list-style-type: none">1. Cabinets shall be wall-mounted Maintenance to wall. Maintenance on wall-mounted cabinets shall be from the front.2. Cabinet enclosures shall be NEMA Type 4X enclosures.3. Interface cabinets shall be fitted with flame-resistant gaskets and tamperproof screws.4. All controls, instruments, and devices shall be shown on the contract drawings.5. Cabinets shall have their identification permanently marked on the cabinet or panel structure immediately adjacent to their location. Identification shall be clearly visible.
INSTRUMENTATION CABLES	<p>Specification No.E-Q-281</p> <ol style="list-style-type: none">1. Cable shall be suitable for use in dry and wet location, capable of continuous operation temperature of 90 degrees Celsius. It shall be UL-listed as Type TC cable in accordance with NFPA 70, Article 340.2. Cable shall be rated for 300V or 600V insulation, single- or multiple-twisted pairs.3. Each conductor shall be tinned, soft or annealed copper, Class B seven-strand concentric in accordance with ASTM B 33 and ASTM B 8, Size No. 18 AWG for single pairs and No. 20 AWG for multiple pairs.4. Cable shields for single-twisted pairs shall be made of aluminum tape wrapped around the conductor and the tinned stranded copper drain wire.5. Shielding for multiple shielded pairs shall consist of a group shield wrapped around each pair and drain wire and an overall cable shield wrapped around the whole cable assembly and drain wire.6. Conductor Identification shall be by color codes in accordance with NEMA WC 30.
INSTRUMENTATION CABLES	

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GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION	SPECIFICATION
	<p>7. Insulation and Jacket For U/G installations the following materials are approved for use for cable insulation and jacketing as designated below:</p> <p>1. Jacketing:</p> <p>CPE - Chlorinated Polyethylene</p> <p>CSP - Chlorosulphonated Polyethylene</p> <p>- Neoprene</p> <p>2. Insulation:</p> <p>EPR - Ethylene Propylene Rubber</p> <p>PPE - Polypropylene Ethylene</p> <p>XLPE - Crosslink Polyefin (Polyethylene)</p> <p>EPDM - Ethylene Propylene Diene Monomer</p> <p>8. All wires and cables shall be identified at junction boxes and cabinets with wire and cable marker indicating the instrument number of the wired device.</p>
INSTRUMENTATION CABLES	
TERMINAL BLOCKS & STRIPS	<p>Specification No.E-P-244</p> <p>1. Terminal blocks shall be surface-mounted, molded plastic screw-terminals, barrier type, capable of accepting No. 20 through No. 12 AWG wire terminated with solderless ring-tongue compression-type lugs. An 8-inch horizontal clear gap shall be provided between adjacent columns.</p>

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GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION

SPECIFICATION

2. Thirty percent unused spare terminals shall be provided for each group of terminal blocks.
3. Terminal blocks shall be grouped by circuit type and segregated according to circuit voltage and destination of field wiring.
4. Not more than wires shall be connected to any one terminal point.
5. Terminal strips for power connections shall be fitted with covers to minimize shock hazards.
6. Each terminal block marking strip shall be identified. Identification of terminal blocks and terminal points shall be alphanumeric, with each terminal block having unique identifying letters and each terminal point to identify instrument input.

GROUNDING

Specification No.E-P-247

1. Instrument cases, relays, and other switching devices shall be grounded to the cabinet or panel steel structure through their mounting screws. Additional grounding shall not be required.
2. For each instrument circuit with a definite ground at the cabinet or panel, a single wire shall be run independently to the applicable ground bus and fastened thereto with a drilled-and-tapped connection, or on a terminal board for wall-mounted cabinets. Each ground point shall be readily accessible for removal, testing, and replacements.
3. Signal cable shielding and grounding requirements shall be included in the wiring diagrams.
1. Control Unit: When the control unit is activated by the communication controller, either locally or remotely by the GIS Data Logger, it shall, in turn, activate the readout unit and switching module simultaneously to read

FUNCTIONS OF TYPICAL INTERFACE DEVICES

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GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION

SPECIFICATION

all the sensors and transmit the output of the readout unit to the GIS Data Logger. When the last connected sensor has been read, the unit shall deactivate itself.

2. Switching Module: Sequentially connects the readout unit to the sensors, enabling each one to be read.

3. Remote Readout/Polling Unit: When the readout unit connected to particular sensor, the readout unit shall energize the sensor, receive its measurement, display the reading, and the transmit the reading to the communication controller through the signal converter.

4. Signal Converter: If the output from the readout unit is not in conformance with EIA RS-232-C and ANSI X3.4, a signal converter shall be furnished to generate a serial ASCII signal. The signal converter shall be either an internal subsystem in the control unit or an external unit.

5. Communication Controller: Under the control of the GIS Data Logger, the Communication Controller shall activate the remote readout/polling unit to start the data transmission and deactivated the remote readout/polling unit when data transmission is complete.

FUNCTIONS OF TYPICAL INTERFACES DEVICES

When interrogated by the GIS Data Logger, the Communication Controller shall be able to handle the malfunction or failure of the interface devices. The Communication Controller shall modulate and demodulate the signal for the data link cable/

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WP 04-ED1341
Rev. 0

0 New procedure written from WP 04-110/WP 04-1NO042

TECHNICAL REVIEW ORGANIZATIONS (check as applicable)

Facility Operations	X	Mining Operations	N/A	Engineering	X	Radiological Engineering	N/A
Underground Operations	X	Hoisting Operations	N/A	Quality Assurance	N/A	Environmental	N/A
Waste Handling Operations	N/A	Safety	N/A	Regulatory Assurance	N/A	Sandia National Laboratories	N/A

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1.0 PURPOSE and SCOPE

- 1.1 The purpose of this procedure is to provide instructions for Facility Operations to operate the Site Back Up Power System during loss of (Utility Power) Public Service Power at the Waste Isolation Pilot Plant (WIPP).
- 1.2 The scope of this procedure includes safe operation of the following:
 - The Site Back Up Power System during loss of (Utility Power) Public Service Power
 - Alternatives for energizing the site with and without the Plant Sub buses

2.0 REFERENCES

2.1 BASELINE DOCUMENTS

25-J-020-W, (Sheets 1-9) WIPP Site Primary Power Distribution - One Line Diagram

2.2 REFERENCED DOCUMENTS

- WP 04-ED1021, Site Surface Electrical Distribution System
- WP 04-ED1221, Operation of Site Surface Electrical Distribution Breakers
- WP 04-ED1301, Operation of Diesel Generator No. 1
- WP 04-ED1321, Operation of Diesel Generator No. 2
- WP 04-ED1621, Normal Underground Electrical Distribution Lineups

3.0 DEFINITIONS

3.1 ACRONYMS

- CAM - Continuous Air Monitor
- CB - Circuit Breaker
- CMRO - Central Monitoring Room Operator
- DG - Diesel Generator
- LIS - Load Interrupter Switch

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- OPS - Operations
- PS - Plant Sub
- SUB - Substation
- U/G - Underground
- VIS - Vacuum Interrupter Switch

4.0 EQUIPMENT LIST

NONE

5.0 PRECAUTIONS AND LIMITATIONS

- 5.1 High Voltage is present in switches and breakers; use CAUTION when positioning these devices.
- 5.2 LIS(s) SHALL NOT be operated from CLOSED to OPEN position with a connected load.
- 5.3 Under NO circumstances SHALL an attempt be made to override or defeat KEY interlocks without Engineering concurrence.
- 5.4 Operation of Site CBs SHALL be performed in accordance with WP 04-ED1221.
- 5.5 U/G Switching and lineups SHALL be performed by Procedure WP 04-ED1621.
- 5.6 Breaker and system interlocks SHALL NOT be relied upon for safe operation of site Electrical Systems.
- 5.7 Utility Sub CB-1 SHALL NOT be CLOSED paralleling 1 or 2 diesel generators with Utility Power.
- 5.8 The sequence of CB operation OR substation energization will be at the FOSS's discretion.
- 5.9 Any CB or switch which is Danger Tagged or Locked Out SHALL NOT be operated.
- 5.10 When starting or energizing equipment identified in this procedure use the specific procedure for that equipment.
- 5.11 Inspect for missing or improperly installed panels, doors or hardware.
- 5.12 Inspect relays for flags and ground loss indications (95 relay light normally ON).
 - 5.12.1 DO NOT CLOSE a CB that has a flag.

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5.12.2 DO NOT energize equipment being served by the tripped CB with a flag.

5.12.3 Notify the FOSS of any relay flags found.

5.12.4 Reset relay flags after Maintenance and Engineering concur, with the exceptions of the following:

A) When a 27 (under voltage) relay flag and a 86 (lockout) relay flag are BOTH present due to a known power outage, AND NO other flags are present.

B) Make only one attempt to RESET 86 (lockout) relay.

C) When an 81 (Under Frequency) relay flag is present, due to a known power outage.

5.12.5 Plant Sub 13.8 Kv breakers feeding U/G will NOT CLOSE if the U/G 13.8 Kv switchgear panel is OPEN. This will cause the 95 (ground check) relay light on corresponding PS CB to be OFF.

5.13 The performance of this procedure requires coordinated activities between Surface Facility Operations and U/G Operations. The Central Monitoring Room Operator (CMRO) will be the contact point and coordinate these activities.

5.14 Perform Section(s) of procedure as directed by the FOSS.

6.0 INITIAL CONDITIONS

None

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7.0 PROCEDURE

7.1 ENERGIZING SITE WITH BACKUP POWER USING 13.8 Kv
CABLES (NOT using PS).

7.1.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO to align the U/G
for receiving power from the Exhaust Shaft
Feeder,
AND
Configure for one (1) 860 fan in filtration.

7.1.2 Verify Utility Sub CB-1 is OPEN.

NOTE: Attachment 1 **SHALL** be completed in
conjunction with Steps 7.1.3 through 7.1.19.

7.1.3 Reduce loads per Attachment 1.

7.1.4 Start Diesel Generator No.1
OR
No. 2.

7.1.5 Verify the following Plant Sub CBs are OPEN:

- CB-10
- CB-1
- CB-2
- CB-3
- CB-4
- CB-9
- CB-5
- CB-6
- CB-7
- CB-8

7.1.6 Verify SB Air Compressors 45-G-400A/B are OFF
at control panel.

7.1.7 Verify SB Air Compressors 45-G-403A/B are OFF
at control panel.

7.1.8 Verify Air Compressors 41-G-021A/B are OFF at
control panel(s).

7.1.9 Verify Chilled Water Pumps 41-B-891A/B are
OFF at control panel.

7.1.10 Line Up Sub 2 by verifying the following:

- A) OPEN Sub 2 LIS 25P-SW15/2A.
- B) CLOSE Sub 2 LIS 25P-SW15/2B.
- C) CLOSE Sub 2 CB-1 Main Breaker.

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- D) CLOSE Sub 2 CB-2.
Water Chiller, 41-B-890A.
- E) CLOSE Sub 2 CB-3.
Air Handling Unit CH Area,
41-B-812.
- F) CLOSE Sub 2 CB-4.
Air Handling Unit CH Area,
41-B-813.
- G) CLOSE Sub 2 CB-5.
WHB Overpack, 41P-MCC04/5.
- H) CLOSE Sub 2 CB-6.
Water Chiller, 41-B-890B.
- I) OPEN Sub 2 CB-7 (Spare).
- J) CLOSE Sub 2 CB-8.
Mech. Equip. Room WHB,
41P-DP04/3.
- 7.1.11 OPEN Sub 4 CB-1 Main Breaker.
- 7.1.12 Line Up Sub 6 by verifying the following:
 - A) OPEN Sub 6 LIS 25P-SW15/6A.
 - B) CLOSE Sub 6 LIS 25P-SW15/6B.
 - C) CLOSE Sub 6 CB-1 Main Breaker.
 - D) OPEN Sub 6 CB-2.
Switchrack 7, 24P-SWRO4/7.
 - E) CLOSE Sub 6 CB-3.
Hoist, 33P-HMO4/1.
 - F) OPEN Sub 6 CB-4 (Spare).
 - G) CLOSE Sub 6 CB-5.
Switchrack, 33P-SWRO4/1.
- 7.1.13 Line Up SB Sub by verifying the following:
 - A) OPEN SB Sub LIS 45P-SW15/1A.
 - B) CLOSE SB Sub LIS 45P-SW15/1B.
 - C) CLOSE SB Sub CB-1 Main Breaker.
 - D) CLOSE SB Sub CB-2.
Elect. Equip. Room SB,
45P-MCC04/4.

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- E) CLOSE SB Sub CB-3.
Mech. Equip. Room WHB,
41P-MCCO4/6.
- F) CLOSE SB Sub CB-4.
Hoist Control Room WHB,
31P-MCCO4/1.
- G) Verify SB Sub CB-5 is OPEN and LOCKED.
Tie to Sub 3 CB-1.

7.1.14 Line Up Sub 1 by verifying the following:

- A) CLOSE Sub 1 LIS 25P-SW15/1B2.
- B) CLOSE Sub 1 LIS 25P-SW15/1B1.
Tie To Sub 3 Top Side of the
LIS 25P-SW15/3B.
- C) CLOSE Sub 1 CB-1 Main Breaker.
- D) CLOSE Sub 1 CB-2.
SB, 45P-MCCO4/3.
- E) CLOSE Sub 1 CB-3.
RH Waste Area, 41P-MCCO4/1.
- F) CLOSE Sub 1 CB-4.
Operating Gallery,
41P-MCCO4/2.
- G) CLOSE Sub 1 CB-5.
Mech. Equip. Room WHB,
41P-MCCO4/3.
- H) CLOSE Sub 1 CB-6.
Air Handling Unit RH Area,
41-B-803.
- I) CLOSE Sub 1 CB-7.
Air Handling Unit RH Area,
41-B-804.
- J) Verify Sub 1 CB-8 is OPEN and LOCKED.
Tie to Sub 3 CB-18.
- K) CLOSE Sub 1 CB-9.
Bldgs 482, 41P-MPC03/3
and EOC 462, 45P-DP04/27.

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- 7.1.15 Verify CLOSED LIS 25P-SW15/11 Exhaust Shaft Feeder.
- 7.1.16 Line UP Sub 3 by verifying the following:
- A) CLOSE Sub 3 LIS 25P-SW15/3A.
 - B) CLOSE Sub 3 LIS 25P-SW15/3B.
 - C) OPEN SUB 3 CB-8 Main Breaker.
 - D) OPEN Sub 3 CB-10 Main Breaker.
 - E) OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.
 - F) OPEN Sub 3 CB-6.
Safety and Emergency Bldg.,
45P-DP04/25A and 45P-DP04/25B.
 - G) OPEN Sub 3 CB-12.
Engineering Bldg. 486
45P-DP04/50.
 - H) OPEN Sub 3 CB-13.
Switchrack 6, 25P-SWR04/6.
 - I) Verify Sub 3 CB-1 is OPEN and LOCKED.
Tie CB to SB Sub CB-5.
 - J) Verify Sub 3 CB-18 is OPEN and LOCKED.
Tie to Sub 1 CB-8.
 - K) CLOSE either Sub 3 CB-7 if DG 1 is
operating,
OR
CB-11 if DG 2 is operating.
 - L) CLOSE locally Sub 3 CB-9 tie breaker
between Sub 3 Buses A and B.
 - M) CLOSE Sub 3 CB-5.
EFB, 41P-MCC04/7.
- 7.1.17 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that Exhaust
Shaft Feeder can be energized.
- 7.1.18 CLOSE SUB 3 CB-8 Main Breaker, energizing
Exhaust Shaft Feeder.
- 7.1.19 Verify Attachment 1 is complete.

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- 7.1.20 CLOSE Sub 3 CB-10 Main Breaker energizing Subs 1, 2, 6 and SB.
- 7.1.21 Start Air Compressor 41-G-021A
OR
41-G-021B.
- 7.1.22 Start EFB Air Compressors 41-G-022A
AND
41-G-022B (as required).
- 7.1.23 Verify LPUs 835 and 836 are operational.
- 7.1.24 Verify UPSs 335 and 336 are operating with inverter supplying load.
- 7.1.25 Start the Underground Ventilation and Filtration System (UVFS) in accordance with WP 04-VU1001.
- 7.1.26 Start the following:
 - Start Vacuum Pump 41-G-040A
OR
41-G-040B
 - Start Vacuum Pump 41-G-040C
OR
41-G-040D
 - Start WHB Exhaust Fan(s) as directed by the FOSS
 - Start SB Zone 6 HVAC
- 7.1.27 ~~IF~~ <900 Kw on operating DG,
~~THEN~~ AIS Hoisting operation may begin as required.
- 7.1.28 Perform load reduction list Attachment 2 as required.
- 7.1.29 Perform the following:
 - Shut down EFB Air Compressors 41-G-022A
AND
41-G-022B
 - Verify Diesel Fire Pump Shut down MODE switch in AUTO/TEST position.

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7.1.30 At the completion of hoisting, pick up available perimeter lighting.

7.1.31 Experimental loads and additional equipment may be energized at the direction of the FOSS.

7.2 RETURNING SITE TO UTILITY POWER.

7.2.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that Exhaust Shaft Feeder is being de-energized.

7.2.2 Shut down filtration.

7.2.3 Shut down operating fan 41-B-860A
OR
41-B-860B
OR
41-B-860C.

7.2.4 Shut down the following:

- Shut down operating Air Compressor
41-G-021A
OR
41-G-021B
- Shut down operating Vacuum Pumps
- Shut down operating WHB Exh. Fan(s)
- Shut down Zone 6 SB HVAC

7.2.5 OPEN Sub 3 CB-8, Main Breaker de-energizing Exhaust Shaft Feeder.

7.2.6 OPEN Sub 3 CB-10 Main Breaker de-energizing Subs 1, 2, 6 and SB.

7.2.7 OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.

7.2.8 OPEN Sub 3 CB-9.
Tie Breaker.

7.2.9 OPEN either Sub 3 CB-7 if DG 1 is operating,
OR
CB-11 if DG 2 is operating.

7.2.10 Shut down operating DG No.1
OR
DG No. 2.

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7.2.11 Realign substation CBs and LISS in accordance with procedure WP 04-ED1021.

7.3 OPTION 1 ENERGIZING SITE WITH BACKUP POWER, USING PS.

7.3.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO to align the U/G for receiving power from the Exhaust Shaft Feeder,
AND
Configure for one (1) 860 fan in filtration.

7.3.2 Verify Utility Sub CB-1 is OPEN.

NOTE: Attachment 1 SHALL be completed in conjunction with Steps 7.3.3 through 7.3.22.

7.3.3 Reduce loads per Attachment 1.

7.3.4 Start Diesel Generator No.1
OR
No. 2.

7.3.5 Verify the following Plant Sub CBs are OPEN:

- CB-10
- CB-1
- CB-2
- CB-3
- CB-4
- CB-9
- CB-5
- CB-6
- CB-7
- CB-8

7.3.6 IF Sullair Air Compressors are NOT to be operated, skip Step 7.3.7 and proceed to Step 7.3.8.

7.3.7 Perform the following lineup:

- A) Verify Sullair Air Compressors 45-G-009
AND
45-G-010 are OFF at control panel(s).
- B) Verify Sullair Air Dryer 45-K-001 is OFF at control panel.
- C) CLOSE Sub 5 LIS 25P-SW15/5.
- D) CLOSE Sub 5 CB-1 Main Breaker.

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- E) OPEN Sub 5 CB-2.
Switchrack 1, 24P-SWR04/1.
 - F) OPEN Sub 5 CB-3.
Salt Handling Hoist House.
 - G) OPEN Sub 5 CB-4.
Switchrack 2, 24P-SWR04/2.
 - H) OPEN Sub 5 CB-5.
38P-DP04/1.
 - I) OPEN Sub 5 CB-6 (Spare).
 - J) OPEN Sub 5 CB-7 (Spare).
 - K) OPEN Sub 5 CB-8.
Switchrack 3, 24P-SWR04/3.
 - L) OPEN Sub 5 CB-9.
Bldg 485, 45P-MPC04/1.
 - M) OPEN Sub 5 CB-10.
Perimeter & Street Lights.
 - N) OPEN Sub 5 CB-11.
Switchrack 8, 24P-SWR04/8.
 - O) OPEN Sub 5 CB-13.
Switchrack 9, 24P-SWR04/9.
 - P) CLOSE Sub 5 CB-14.
Compressor, 45-G-010.
 - Q) CLOSE Sub 5 CB-15.
Compressor, 45-G-009.
-
- 7.3.8 Verify SB Air Compressors 45-G-400A/B are OFF at control panel.
 - 7.3.9 Verify SB Air Compressors 45-G-403A/B are OFF at control panel.
 - 7.3.10 Verify Air Compressors 41-G-021A/B are OFF at control panel(s).
 - 7.3.11 Verify Chilled Water Pumps 41-B-891A/B are OFF at control panel.
 - 7.3.12 OPEN Sub 4 CB-1 Main Breaker.
 - 7.3.13 Verify CLOSED LIS 31P-SW15/1 Waste Shaft Feeder.

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- 7.3.14 Verify CLOSED VIS 25P-VIS15/11 Exhaust Shaft Feeder.
- 7.3.15 Line UP Sub 3 by verifying the following:
- A) CLOSE Sub 3 LIS 25P-SW15/3A.
 - B) CLOSE Sub 3 LIS 25P-SW15/3B.
 - C) OPEN Sub 3 CB-8 Main Breaker.
 - D) OPEN Sub 3 CB-10 Main Breaker.
 - E) OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.
 - F) OPEN Sub 3 CB-6.
Safety and Emergency Bldg.
45P-DP04/25A and 45P-DP04/25B.
 - G) OPEN Sub 3 CB-12.
Engineering Bldg. 486
45P-DP04/50.
 - H) OPEN Sub 3 CB-13.
Switchrack 6, 25P-SWR04/6.
 - I) Verify Sub 3 CB-1 is OPEN and LOCKED.
Tie CB to SB Sub CB-5.
 - J) Verify Sub 3 CB-18 is OPEN and LOCKED.
Tie CB to Sub 1 CB-8.
 - K) CLOSE either Sub 3 CB-7 if DG 1 is
operating,
OR
CB-11 if DG 2 is operating.
 - L) CLOSE locally Sub 3 CB-9 tie breaker
between Sub 3 Buses A and B.
 - M) CLOSE Sub 3 CB-5.
EFB, 41P-MCC04/7.
- 7.3.16 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that U/G Feeders
can be energized.
- 7.3.17 CLOSE Sub 3 CB-8 Main Breaker Energizing
Exhaust Shaft Feeder.
- 7.3.18 Start EFB Air Compressors 41-G-022A
AND
41-G-022B (as required).

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- 7.3.19 Verify LPUs 835 and 836 are operational.
- 7.3.20 Verify UPSs 335 and 336 are operating with inverter supplying load.
- 7.3.21 Start the UVFS in accordance with WP 04-VU1001.
- 7.3.22 Verify Attachment 1 is complete.
- 7.3.23 CLOSE Sub 3 CB-10 Main Breaker energizing SB Sub and Waste Hoist Sub.
- 7.3.24 Verify OPEN PS CB-9.
Buses A & B tie breaker.
- 7.3.25 CLOSE PS CB-4.
Energizing PS Bus A.
- 7.3.26 CLOSE PS CB-3.
Energizing Subs 2 and 6.
- 7.3.27 CLOSE PS CB-2.
Salt Handling Shaft Feeder.
- 7.3.28 CLOSE PS CB-7.
Energizing PS Bus B.
- 7.3.29 CLOSE PS CB-6.
Energizing Sub 1.
- 7.3.30 CLOSE PS CB-5.
Waste Shaft Feeder.
- 7.3.31 CLOSE PS CB-8 IF Sullair Air Compressor is to be operated.

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7.3.32 Start the following:

- Start one Air Compressor 41-G-021A
OR
41-G-021B
OR
41-G-009
OR
41-G-010
- Start Vacuum Pump 41-G-040A
OR
41-G-040B
- Start Vacuum Pump 41-G-040C
OR
41-G-040D
- Start WHB Exhaust Fan(s) as directed by
the FOSS
- Start SB Zone 6 HVAC

7.3.33 IF <900 Kw on operating DG,
THEN AIS Hoisting operation may begin as
required.

7.3.34 Perform load reduction list Attachment 2 as
required.

7.3.35 Perform the following:

- Shut down EFB Air Compressors 41-G-022A
AND
41-G-022B
- Verify Diesel Fire Pump Shut down MODE
switch in AUTO/TEST position

7.3.36 At the completion of hoisting, pick up
perimeter lighting.

7.3.37 Experimental loads and additional equipment
may be energized at the direction of the
FOSS.

7.4 RETURNING SITE TO UTILITY POWER AFTER PERFORMING
OPTION 1.

7.4.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that U/G Feeders
are being de-energized.

7.4.2 Shut down filtration.

7.4.3 Shut down operating fan 41-B-860A
OR
41-B-860B
OR
41-B-860C.

7.4.4 Shut down the following:

- Shut down operating Air Compressor
41-G-021A
OR
41-G-021B
OR
41-G-009
OR
41-G-010
- Shut down operating Vacuum Pumps
- Shut down operating WHB Exhaust Fan(s)
- Shut down Zone 6 SB HVAC

7.4.5 OPEN the following PS CBs:

- CB-2
- CB-3
- CB-4
- CB-5
- CB-6
- CB-7
- CB-8 (If CB was closed)

7.4.6 OPEN Sub 3 CB-8 Main Breaker de-energizing
Exhaust Shaft Feeder.

7.4.7 OPEN Sub 3 CB-10 de-energizing SB and Waste
Hoist Sub.

7.4.8 OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.

7.4.9 OPEN Sub 3 CB-9.
Tie Breaker.

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- 7.4.10 OPEN either Sub 3 CB-7 if DG 1 is operating,
OR
CB-11 if DG 2 is operating.
- 7.4.11 Shut down operating DG No.1
OR
DG No. 2.
- 7.4.12 Realign substation CBs and LISS in accordance
with procedure WP 04-ED1021.

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7.5 OPTION 2 ENERGIZING SITE WITH BACKUP POWER, USING PS
BUS A.

- A) IF U/G is manned,
THEN notify U/G Ops VIA CMRO to align the
U/G for receiving power from the Exhaust
Shaft Feeder
AND
Salt Handling Shaft Feeder
AND
Configure for one (1) 860 fan in
filtration.

7.5.1 Verify Utility Sub CB-1 is OPEN.

NOTE: Attachment 1 SHALL be completed in
conjunction with Steps 7.5.2 through 7.5.19.

7.5.2 Reduce loads per Attachment 1.

7.5.3 Start Diesel Generator No.1
OR
No. 2.

7.5.4 Verify the following Plant Sub CBs are OPEN:

- CB-10
- CB-1
- CB-2
- CB-3
- CB-4
- CB-9
- CB-5
- CB-6
- CB-7
- CB-8

7.5.5 Verify SB Air Compressors 45-G-400A/B are OFF
at control panel.

7.5.6 Verify SB Air Compressors 45-G-403A/B are OFF
at control panel.

7.5.7 Verify Air Compressors 41-G-021A/B are OFF at
control panel(s).

7.5.8 Verify Chilled Water Pumps 41-B-891A/B are
OFF at control panel.

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7.5.9 Line Up Sub 2 by verifying the following:

- A) OPEN Sub 2 LIS 25P-SW15/2B.
- B) CLOSE Sub 2 LIS 25P-SW15/2A.
- C) CLOSE Sub 2 CB-1 Main Breaker.
- D) CLOSE Sub 2 CB-2.
Water Chiller, 41-B-890A.
- E) CLOSE Sub 2 CB-3.
Air Handling Unit CH Area,
41-B-812.
- F) CLOSE Sub 2 CB-4.
Air Handling Unit CH Area,
41-B-813.
- G) CLOSE Sub 2 CB-5.
WHB Overpack, 41P-MCC04/5.
- H) CLOSE Sub 2 CB-6.
Water Chiller, 41-B-890B.
- I) OPEN Sub 2 CB-7 (Spare).
- J) CLOSE Sub 2 CB-8.
Mech. Equip. Room WHB,
41P-DP04/3.

7.5.10 OPEN Sub 4 CB-1 Main Breaker.

7.5.11 Line Up Sub 6 by verifying the following:

- A) OPEN Sub 6 LIS 25P-SW15/6B.
- B) CLOSE Sub 6 LIS 25P-SW15/6A.
- C) CLOSE Sub 6 CB-1 Main Breaker.
- D) OPEN Sub 6 CB-2.
Switchrack 7, 24P-SWR04/7.
- E) CLOSE Sub 6 CB-3.
Hoist, 33P-HM04/1.
- F) OPEN Sub 6 CB-4 (Spare).
- G) CLOSE Sub 6 CB-5.
Switchrack, 33P-SWR04/1.

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7.5.12 Line Up SB Sub by verifying the following:

- A) OPEN SB Sub LIS 45P-SW15/1B.
- B) CLOSE SB Sub LIS 45P-SW15/1A.
- C) CLOSE SB Sub CB-1 Main Breaker.
- D) CLOSE SB Sub CB-2.
Elect. Equip. Room SB,
45P-MCC04/4.
- E) CLOSE SB Sub CB-3.
Mech. Equip. Room WHB,
41P-MCC04/6.
- F) CLOSE SB Sub CB-4.
Hoist Control Room WHB,
31P-MCC04/1.
- G) Verify SB Sub CB-5 is OPEN and LOCKED.
Tie CB to Sub 3 CB-1.

7.5.13 Line Up Sub 1 by verifying the following:

- A) Verify Sub 1 LIS 25P-SW15/1B1 is OPEN.
- B) OPEN Sub 1 LIS 25P-SW15/1B2.
- C) OPEN Sub 1 CB-1 Main Breaker.
- D) CLOSE Sub 1 CB-2.
SB, 45P-MCC04/3.
- E) CLOSE Sub 1 CB-3.
RH Waste Area, 41P-MCC04/1.
- F) CLOSE Sub 1 CB-4.
Operating Gallery, WHB
41P-MCC04/2.
- G) CLOSE Sub 1 CB-5.
Mech. Equip. Room WHB,
41P-MCC04/3.
- H) CLOSE Sub 1 CB-6.
Air Handling Unit RH Area,
41-B-803.
- I) CLOSE Sub 1 CB-7.
Air Handling Unit RH Area,
41-B-804.

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- J) UNLOCK and CLOSE Sub 1 CB-8.
Tie to Sub 3 CB-18.
- K) CLOSE Sub 1 CB-9.
Bldgs 482, 41P-MPC03/3
and EOC 462, 45P-DP04/27.
- 7.5.14 Verify CLOSED VIS 25P-VIS15/11 Exhaust Shaft Feeder.
- 7.5.15 Line Up Sub 3 by verifying the following:
- A) IF U/G is manned,
THEN notify U/G Ops VIA CMRO that U/G
Feeders can be energized.
- B) OPEN Sub 3 LIS 25P-SW15/3B.
- C) CLOSE Sub 3 LIS 25P-SW15/3A.
- D) OPEN Sub 3 CB-8 Main Breaker.
- E) OPEN Sub 3 CB-9.
Tie Breaker.
- F) OPEN Sub 3 CB-10 Main Breaker.
- G) OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.
- H) OPEN Sub 3 CB-6.
Safety and Emergency Bldg.
45P-DP04/25A and 45P-DP04/25B.
- I) OPEN Sub 3 CB-12.
Engineering Bldg. 486,
45P-DP04/50.
- J) OPEN Sub 3 CB-13.
Switchrack 6, 25P-SWR04/6.
- K) Verify Sub 3 CB-1 is OPEN and LOCKED.
Tie CB to SB Sub CB-5.
- L) UNLOCK and CLOSE Sub 3 CB-18.
Tie to Sub 1 CB-8.

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- M) CLOSE either Sub 3 CB-7 if DG 1 is operating,
OR
CB-11 if DG 2 is operating.
- N) CLOSE locally Sub 3 CB-9 tie breaker between Sub 3 Buses A and B.
- O) CLOSE Sub 3 CB-5.
EFB, 41P-MCC04/7.
- P) Start EFB Air Compressors 41-G-022A
AND
41-G-022B (as required).
- 7.5.16 Verify LPUs 835 and 836 are operational.
- 7.5.17 Verify UPSs 335 and 336 are operating with inverter supplying load.
- 7.5.18 Start the UVFS in accordance with WP 04-VU1001.
- 7.5.19 Verify Attachment 1 is complete.
- 7.5.20 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that U/G Exhaust Shaft and Salt Handling Shaft Feeders can be energized.
- 7.5.21 CLOSE Sub 3 CB-8 energizing SB Sub, Waste Hoist Sub and Exhaust Shaft Feeder.
- 7.5.22 CLOSE PS CB-4.
Energizing PS Bus A.
- 7.5.23 CLOSE PS CB-3 energizing Subs 2 and 6.
- 7.5.24 CLOSE PS CB-2 Salt Handling Shaft Feeder.

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7.5.25 Start the following:

- Start Air Compressor 41-G-021A
OR
41-G-021B
- Start Vacuum Pump 41-G-040A
OR
41-G-040B
- Start Vacuum Pump 41-G-040C
OR
41-G-040D
- Start WHB Exhaust Fan(s) as directed by
the FOSS
- Start SB Zone 6 HVAC

7.5.26 IF <900 Kw on operating DG,
THEN AIS Hoisting operation may begin as
required.

7.5.27 Perform load reduction list per Attachment 2,
as required.

7.5.28 Perform the following:

- Shut down EFB Air Compressors 41-G-022A
AND
41-G-022B (as required).
- Verify Diesel Fire Pump Shut down MODE
switch in AUTO/TEST position.

7.5.29 At the completion of hoisting, pick up
perimeter lighting.

7.5.30 Experimental loads and additional equipment
may be energized at the direction of the
FOSS.

7.6 RETURNING SITE TO UTILITY POWER AFTER PERFORMING
OPTION 2.

7.6.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that U/G Feeders
are being de-energized.

7.6.2 OPEN PS CB-2 Salt Shaft Feeder.

7.6.3 Shut down filtration.

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- 7.6.4 Shut down operating fan 41-B-860A
OR
41-B-860B
OR
41-B-860C.
- 7.6.5 Shut down Air Compressor 41-G-021A
OR
41-G-021B.
- 7.6.6 OPEN PS CB-3 de-energizing Subs 2 and 6.
- 7.6.7 Shut down the following:
 - Shut down operating Vacuum Pumps
 - Shut down operating WHB Exh. Fan(s)
 - Shut down Zone 6 SB HVAC
 - OPEN PS CB-4 de-energizing PS Bus A
- 7.6.8 OPEN Sub 3 CB-8 Main Breaker de-energizing SB
Sub, Waste Hoist Sub and Exhaust Shaft
Feeder.
- 7.6.9- OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.
- 7.6.10 OPEN Sub CB-9.
Tie Breaker.
- 7.6.11 OPEN either Sub 3 CB-7 if DG 1 is operating,
OR
CB-11 if DG 2 is operating.
- 7.6.12 Shut down operating DG No. 1
OR
DG No. 2.
- 7.6.13 Realign substation CBs and LISs in accordance
with procedure WP 04-ED1021.

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7.7 OPTION 3 ENERGIZING SITE WITH BACKUP POWER, USING PS BUS B.

7.7.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO to align the U/G for receiving power from the Waste Shaft Feeder,
AND
Configure for one (1) 860 fan in filtration.

7.7.2 Verify Utility Sub CB-1 is OPEN.

NOTE: Attachment 1 SHALL be completed in conjunction with Steps 7.7.3 through 7.7.20.

7.7.3 Reduce loads per Attachment 1.

7.7.4 Start Diesel Generator No.1
OR
No. 2.

7.7.5 Verify the following Plant Sub CBs are OPEN:

- CB-10
- CB-1
- CB-2
- CB-3
- CB-4
- CB-9
- CB-5
- CB-6
- CB-7
- CB-8

7.7.6 IF Sullair Air Compressors are NOT to be operated, skip Step 7.7.7 and proceed to Step 7.7.12.

7.7.7 Perform the following lineup:

- A) Verify Sullair Air Compressors 45-G-009
AND
45-G-010 are OFF at control panel(s).
- B) Verify Sullair Air Dryer 45-K-001 is OFF at control panel.
- C) CLOSE Sub 5 LIS 25P-SW15/5.
- D) CLOSE Sub 5 CB-1 Main Breaker.
- E) OPEN Sub 5 CB-2.
Switchrack 1, 24P-SWR04/1.

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- F) OPEN Sub 5 CB-3.
Salt Handling Hoist House.
 - G) OPEN Sub 5 CB-4.
Switchrack 2, 24P-SWR04/2.
 - H) OPEN Sub 5 CB-5.
38P-DP04/1.
 - I) OPEN Sub 5 CB-6 (Spare).
 - J) OPEN Sub 5 CB-7 (Spare).
 - K) OPEN Sub 5 CB-8.
Switchrack 3, 24P-SWR04/3.
 - L) OPEN Sub 5 CB-9.
Bldg 485, 45P-MPC04/1.
 - M) OPEN Sub 5 CB-10.
Perimeter & Street Lights.
 - N) OPEN Sub 5 CB-11.
Switchrack 8, 24P-SWR04/8.
 - O) OPEN Sub 5 CB-13.
Switchrack 9, 24P-SWR04/9.
 - P) CLOSE Sub 5 CB-14.
Compressor, 45-G-010.
 - Q) CLOSE Sub 5 CB-15.
Compressor, 45-G-009.
- 7.7.8 Verify SB Air Compressors 45-G-400A/B are OFF at control panel.
- 7.7.9 Verify SB Air Compressors 45-G-403A/B are OFF at control panel.
- 7.7.10 Verify Air Compressors 41-G-021A/B are OFF at control panel(s).
- 7.7.11 Verify Chilled Water Pumps 41-B-891A/B are OFF at control panel.
- 7.7.12 Line Up Sub 2 by verifying the following:
- A) OPEN Sub 2 LIS 25P-SW15/2A.
 - B) CLOSE Sub 2 LIS 25P-SW15/2B.
 - C) CLOSE Sub 2 CB-1 Main Breaker.

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- D) CLOSE Sub 2 CB-2.
Water Chiller 41-B-890A.
 - E) CLOSE Sub 2 CB-3.
Air Handling Unit CH Area,
41-B-812.
 - F) CLOSE Sub 2 CB-4.
Air Handling Unit CH Area,
41-B-813.
 - G) CLOSE Sub 2 CB-5.
WHB Overpack, 41P-MCC04/5.
 - H) CLOSE Sub 2 CB-6.
Water Chiller, 41-B-890B.
 - I) OPEN Sub 2 CB-7 (Spare).
 - J) CLOSE Sub 2 CB-8.
Mech. Equip. Room, 41P-DP04/3.
- 7.7.13 OPEN Sub 4 CB-1 Main Breaker.
- 7.7.14 Line Up Sub 6 by verifying the following:
- A) OPEN Sub 6 LIS 25P-SW15/6A.
 - B) CLOSE Sub 6 LIS 25P-SW15/6B.
 - C) CLOSE Sub 6 CB-1 Main Breaker.
 - D) OPEN Sub 6 CB-2.
Switchrack 7, 24P-SWRO4/7.
 - E) CLOSE Sub 6 CB-3.
Hoist, 33P-HM04/1.
 - F) OPEN Sub 6 CB-4 (Spare).
 - G) CLOSE Sub 6 CB-5.
Switchrack, 33P-SWR04/1.
- 7.7.15 Line Up SB Sub by verifying the following:
- A) OPEN SB Sub LIS 45P-SW15/1A.
 - B) CLOSE SB Sub LIS 45P-SW15/1B.
 - C) CLOSE SB Sub CB-1 Main Breaker.
 - D) CLOSE SB Sub CB-2.
Elect. Equip. Room SB,
45P-MCC04/4.

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- E) CLOSE SB Sub CB-3.
Mech. Equip. Room WHB,
41P-MCC04/6.
- F) CLOSE SB Sub CB-4.
Hoist Control Room WHB,
31P-MCC04/1.
- G) Verify SB Sub CB-5 is OPEN and LOCKED.
Tie CB to Sub 3 CB-1.

7.7.16 Verify CLOSED LIS 31P-SW15/1 Waste Shaft Feeder.

7.7.17 Line Up Sub 1 by verifying the following:

- A) Verify LIS 25P-SW15/1B1 is OPEN.
- B) CLOSE LIS 25P-SW15/1B2.
- C) CLOSE Sub 1 CB-1 Main Breaker.
- D) CLOSE Sub 1 CB-2.
SB, 45P-MCC04/3.
- E) CLOSE Sub 1 CB-3.
RH Waste Area, 41P-MCC04/1.
- F) CLOSE Sub 1 CB-4.
Operating Gallery, WHB.
41P-MCC04/2.
- G) CLOSE Sub 1 CB-5.
Mech. Equip. Room WHB,
41P-MCC04/3.
- H) CLOSE Sub 1 CB-6
Air Handling Unit RH Area,
41-B-803.
- I) CLOSE Sub 1 CB-7.
Air Handling Unit RH Area,
41-B-804.
- J) Verify Sub 1 CB-8 is OPEN and LOCKED.
Tie to Sub 3 CB-18.
- K) CLOSE Sub 1 CB-9.
Bldgs 482, 41P-MPC03/3
and EOC 462, 45P-DP04/27.

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7.7.18 Line Up Sub 3 by verifying the following:

- A) OPEN Sub 3 LIS 25P-SW15/3A.
- B) CLOSE Sub 3 LIS 25P-SW15/3B.
- C) OPEN Sub 3 CB-8 Main Breaker.
- D) OPEN Sub 3 CB-10 Main Breaker.
- E) OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.
- F) OPEN Sub 3 CB-6.
Safety and Emergency Bldg.
45P-DP04/25A and 45P-DP04/25B.
- G) OPEN Sub 3 CB-12.
Engineering Bldg. 486
45P-DPO4/50.
- H) OPEN Sub 3 CB-13.
Switchrack 6, 25P-SWR04/6.
- I) Verify Sub 3 CB-1 is OPEN and LOCKED.
Tie to SB Sub CB-5.
- J) Verify Sub 3 CB-18 is OPEN and LOCKED.
Tie CB to Sub 1 CB-8.
- K) CLOSE either Sub 3 CB-7 if DG 1 is
operating,
OR
CB-11 if DG 2 is operating.
- L) CLOSE locally Sub 3 CB-9 tie breaker
between Sub 3 Buses A and B.
- M) CLOSE Sub 3 CB-5.
EFB, 41P-MCC04/7.

7.7.19 Start EFB Air Compressors 41-G-022A
AND
41-G-022B (as required).

7.7.20 Verify Attachment 1 is complete.

7.7.21 CLOSE Sub 3 CB-10 Main Breaker energizing SB
Sub and Waste Hoist Sub.

7.7.22 CLOSE PS CB-7.
Energizing PS Bus B.

7.7.23 CLOSE PS CB-6 energizing Subs 1, 2 and 6.

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- 7.7.24 IF U/G is manned,
THEN notify U/G Ops VIA CMRO to align the U/G
for receiving power from the Waste Shaft
Feeder.
- 7.7.25 CLOSE PS CB-5 Waste Shaft Feeder.
- 7.7.26 Verify LPU's 835 and 836 are operational.
- 7.7.27 Verify UPS's 335 and 336 are operating with
inverter supplying load.
- 7.7.28 Start the UVFS in accordance with
WP 04-VU1001.
- 7.7.29 CLOSE PS CB-8 IF Sullair air compressors are
to be operated.
- 7.7.30 Start the following:
- Start Air Compressor 41-G-021A
OR
41-G-021B
OR
41-G-009
OR
41-G-010
 - Start Vacuum Pump 41-G-040A
OR
41-G-040B
 - Start Vacuum Pump 41-G-040C
OR
41-G-040D
 - Start WHB Exhaust Fan(s) as directed by
the FOSS.
 - Start SB Zone 6 HVAC
- 7.7.31 IF <900 Kw on operating DG,
THEN AIS Hoisting operation may begin as
required.
- 7.7.32 Perform load reduction list per Attachment 2,
as required.

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7.7.33 Perform the following:

- Shut down EFB Air Compressors 41-G-022A
AND
41-G-022B
- Verify Diesel Fire Pump Shut down MODE
switch in AUTO/TEST position

7.7.34 At the completion of hoisting, pick up
perimeter lighting.

7.7.35 Experimental loads and additional equipment
may be energized at the direction of the
FOSS.

7.8 RETURNING SITE TO UTILITY POWER AFTER PERFORMING
OPTION 3.

7.8.1 IF U/G is manned,
THEN notify U/G Ops VIA CMRO that Waste Shaft
Feeder is being de-energized.

7.8.2 Verify OPEN PS CB-5 Waste Shaft Feeder.

7.8.3 Shut down operating fan 41-B-860A
OR
41-B-860B
OR
41-B-860C.

7.8.4 Shut down filtration.

7.8.5 Shut down Air Compressor 41-G-021A
OR
41-G-021B.

7.8.6 Shut down the following:

- Shut down operating Vacuum Pumps
- Shut down operating WHB Exh. Fan(s)
- Shut down Zone 6 SB HVAC

7.8.7 OPEN PS CB-6 de-energizing Subs 1 and 6.

7.8.8 OPEN PS CB-7 de-energizing PS Bus B.

7.8.9 OPEN Sub 3 CB-10 Main Breaker de-energizing
Sub 2, 4, SB Sub and Waste Handling Sub.

7.8.10 OPEN Sub 3 CB-5.
EFB, 41P-MCC04/7.

- 7.8.11 OPEN Sub 3 CB-9.
Tie Breaker.
- 7.8.12 OPEN either Sub 3 CB-7 if DG 1 is operating,
OR
CB-11 if DG 2 is operating.
- 7.8.13 Shut down operating DG No.1
OR
DG No. 2.
- 7.8.14 Realign substation CBs in accordance with
procedure WP 04-ED1021.

7.9 OPTION 4 ENERGIZING PS BUSES USING PS TIE CB-9.

NOTE: This note applies to Option 4. Option 4 MAY
BE used with Options 2 or 3.

- 7.9.1 PS tie breaker CB-9 MAY BE used if the
following conditions exist.

- A) Both PS Buses are in a condition to be
energized.
- B) PS CB-9 can be CLOSED IF ONE or more of
the following CBs or LISs are open:

- 1) Sub 3 CB-10.
- 2) Sub 3 CB-9.
- 3) Sub 3 CB-8.
- 4) PS CB-7.
- 5) PS CB-4.
- 6) Sub 3 LIS 25P-SW15/3B.
- 7) Sub 3 LIS 25P-SW15/3A.

- 7.9.2 CLOSE PS CB-9.
Tie Breaker.

- 7.9.3 At the direction of the FOSS available PS CBs
MAY BE operated.

8.0 REVIEW

None

9.0 RECORDS

No Quality Assurance records are generated by this
procedure.

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ATTACHMENT 1

BACKUP POWER LOAD LIST

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NOTE: De-energize Attachment 1 in any order or concurrently if desired.

- 1.0 SB Elevator at 45P-DP04/2 (Room 226).
- 2.0 SB HVAC System at the Local Control Panels.
- 3.0 WHB HVAC System at the Local Control Panels.
- 4.0 Vacuum Pumps 41-G-040A, B, C & D at the Local Control Panel.
- 5.0 WHB Lighting Panels at 41P-MCC04/6.
- 6.0 Forklift Battery Recharging Station Dist.
Panel 41P-DP04/21 at 41P-MCC04/5.
- 7.0 Perimeter Lights in 45P-LP04/5 CB 8/10, 16/18, 22/24 and 21/23 (Overpack & Repair Room).
- 8.0 Trupact Maintenance Facility 41P-DP04/4 at 41P-MCC04/5.
- 9.0 Safety Building Chiller 45-E-646 at Local Control Panel.
- 10.0 Engineering Building Chiller 45-E-407 at Local Control Panel.

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ATTACHMENT IV-6

**WIPP SUPPLEMENTARY ROOF SUPPORT SYSTEM,
ROOM 1, PANEL 1, GEOTECHNICAL FIELD DATA
ANALYSIS BI-ANNUAL REPORT, DOE/WIPP 92-024**

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DOE/WIPP 92-024

**WIPP Supplementary Roof Support System
Room 1, Panel 1
Geotechnical Field Data Analysis
Bi-Annual Report**

Waste Isolation Pilot Plant

This document is issued by Westinghouse Electric Corporation, Waste Isolation Division, as the Managing and Operating Contractor for the Department of Energy, Waste Isolation Pilot Plant, Carlsbad, New Mexico, 88221.

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**WASTE ISOLATION PILOT PLANT
SUPPLEMENTARY ROOF SUPPORT SYSTEM
ROOM 1, PANEL 1
GEOTECHNICAL FIELD DATA ANALYSIS
BI-ANNUAL REPORT**

DOE/WIPP 92-024

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List of Acronyms

MOC - Management and Operating Contractor
PCG - Project Control Group
PWR - Plant Work Request
QA - Quality Assurance
SNL - Sandia National Laboratories
SPDV - Site and Preliminary Design Validation
VOC - Volatile Organic Compound
WID - Waste Isolation Division
WIPP - Waste Isolation Pilot Plant
WPSO - WIPP Project Site Office

1.0 EXECUTIVE SUMMARY

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In June 1991, WID initiated the design effort to develop a supplementary roof support system to extend the life of Room 1, Panel 1, to allow successful completion of the bin-scale test program. A number of potential options for ground control were considered leading to the finalization of the currently installed roof support system. This highly instrumented system is "state of the art" for mine ground control and will provide extensive geotechnical data. The system is an innovative blend of several standard techniques and incorporates five of the suggestions made by the Geotechnical Panel in its report of June 1991, on the effective life of Rooms in Panel 1. It extends the anticipated life of the room while providing additional room integrity over the short and mid-term.

The design was subjected to an exhaustive scrutiny by two formal Design Review Panels. The first review was conducted on August 27, 1991, by an Internal Design Review Panel consisting of qualified personnel from Engineering, Operations, QA and Safety representing WID, SNL and WPSO. The other Formal Design Review of the Room 1, Panel 1, Supplementary Roof Support System was performed in September 1991, by a group of rock mechanics experts not associated with the WIPP project. This External Design Review Panel consisted of representatives from industry, government (U.S. Bureau of Mines), research and safety (Mines Safety and Health Administration Technical Center), academia, and independent design firms. The Design Review Panels approved the design based on reviewed design documents, on-site observations at the WIPP underground facility, and detailed discussions with members of the design team.

The original requirement was to have only a section of the room completed in October in preparation for first waste receipt. This goal was met and the relatively complex installation in the entire room was completed in December 1991. The Support System, with all its instrumentation, is now fully operational and generating geotechnical data. The Geotechnical Monitoring Program that has been implemented in Room 1, Panel 1, follows the general requirements for the control of the activities as described in the Geotechnical Engineering Program Plan (Westinghouse, 1991).

Examination of extensometer, closure and load cell data indicate that Room support is performing within the design parameters. No flags have been raised based on the criteria outlined in Section 4.0 and the data collected to date.

All the anchors were initially loaded to approximately 445 kN (1000 lbs). The results of load cell monitoring indicates a steady increase of load on the rock bolts. The anchors installed near the room centerline have shown the greatest increase with the outermost anchors showing little or no load.

2.0 BACKGROUND AND HISTORY OF EVENTS

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2.1 SUPPORT DESCRIPTION

The yielding roof support system for Room 1, Panel 1, is designed to contain and support the weight of the detaching salt wedge of the immediate roof while allowing it to be lowered. The system is not designed in any way to prevent the creep of salt into the room. The roof support consists of 26 steel channel support sets installed laterally across the room on 2.37-m (7.8-ft) to 3.04-m (10-ft) centers. The actual location of the channel sets was determined in the field during their installation based on the location of the existing roof bolts that are installed on an engineered pattern. This was done to minimize interference with the existing roof bolts.

Each support set is secured by 11 Dwyidag steel tendons (anchor bolts) that are 4.0 m (13 ft) long. The resin grouted anchor bolts are anchored between the Anhydrite 'a' and the Anhydrite 'b' horizons. The channel support anchor bolts are designed so that the load on each bolt can be monitored and adjusted to accommodate continuous roof deformation. System adjustment is accomplished by keeping the tension on each anchor bolt within the design limits, which are calculated to support the detaching salt wedge. Once the tension in the anchor bolt reaches a predetermined limit, the bolt load is then relieved. Each anchor bolt extends .46 m (18 in.) below the roof to accommodate downward movement of the roof. Roof strata extension measurements have shown that the anchor bolts will have to accommodate approximately 13 mm (0.54 in.) of movement per year. To allow for differences in lateral deformations, each tendon is located in an oversized .08 m (3 in.) diameter hole extending from the hole collar to 0.16 m (6 in.) past the Anhydrite 'b' clay horizon. Lateral deformations will be checked by nine observation holes located throughout Room 1.

In order to monitor for the possibility of shear and bending at Anhydrite 'b' exceeding these limits, an additional set of five test anchors and four observation holes are being installed in Room 2 as a part of a mock-up test. Periodic proof testing of the test bolts would be conducted in the unlikely event that observations indicate that bending of the bolts is occurring.

The roof area between the channel sets is covered by a network of steel wire lacing cables underneath a mat of steel wire mesh and expanded metal. This mat is held in place by the channel support sets. Its function is to contain any rock spalling between the channel support sets.

Rib support installed in Room 1 consists of the chainlink mesh secured to the salt by 1.22 m (48 in.) long mechanically anchored bolts. This support system is intended for protection against small scale flaking and peeling of rock that might be of nuisance value.

2.2 SUPPORT SYSTEM INSTALLATION

Installation of the roof support system in Room 1, Panel 1, commenced in October 1991. Detailed instructions that guided the installation activities of the system and ensured quality and correctness of the installation were furnished by Mine Engineering and Mine Operations and are contained in the PWR #13195M "Installation Instructions for Supplementary Roof Support System in Room 1, Panel 1." Installation of the entire system was performed by the Westinghouse Underground Operations with technical assistance provided by Mine and Geotech-

nical Engineering. The original plan called for installation of the roof support over the first 30.5-m (100-ft) segment of the room in preparation for initial waste receipt. This goal was met and the remainder of the installation covering the entire room was completed in December 1991.

Installation of the roof support system in Room 1, Panel 1, commenced with installation of the rib support over the entire length of the room. Following already approved WIPP installation procedures, east and west ribs of the room were bolted with the chainlink wire mesh and 1.22 m (48 in.) long mechanical rockbolts.

Following installation of the rib support, all existing instrumentation consisting of electric cables, gas piping, distribution boxes was permanently moved to the side of the room and attached to the rib. VOC piping was lowered to allow for installation of the support system. To avoid damage to critical sections of the monitoring equipment, a temporary enclosure was erected to protect them from dust and debris generated during drilling and subsequent installation of the support system hardware.

Correct installation of the Dywidag anchors was critical to the whole support system. All channel set locations and individual anchor holes were surveyed in and marked to ensure correct location of each hole. In order to achieve the specified tolerances collaring, alignment holes of 35 mm (1 3/8 in.) diameter were used.

After completing the collar alignment drilling, each hole was drilled to its specified depth of 3.5 m (11 ft 6 in.) and reamed to a .08 m (3 in.) diameter.

WIRE MESH AND LACING

Wire mesh and lacing were installed after the drilling of the anchor bolt holes was completed and advanced enough to provide adequate working space for wire mesh hanging operations. This allowed for simultaneous installation of wire mesh, cable lacing, and drilling of anchor holes. The wire mesh system consists of two layers, a layer of .10 m x .10 m (4 in. x 4 in.) welded wire mesh and another layer of expanded metal that was installed directly against the salt and above the welded wire mesh layer.

Both layers were attached to the roof rock in order to provide temporary suspension until the lacing and channel supports were finally installed. The wire lacing rope was doubled back through one of the eyebolts attached to the anchor plate, and the free end clamped with three crosby clamps. The loose end was then passed through the opposite eyebolts and snug tensioned. The transverse lacing ropes were interweaved with the longitudinal ropes.

ANCHOR BOLTS

The Dywidag bolts and the resin were installed according to the manufacturer's specifications, which had been verified earlier by destructive testing in Room 2, Panel 1. The minimum bond length of .92 m (3 ft) was used to maintain design load capacity of the support system. A minimum of .457 m (18 in.) of the anchor bolt was left protruding from the mouth the drill hole. Following anchor installation, each bolt was quality checked by applying a torque of 150 ft-lbs to each bolt.

D R A F T

STEEL CHANNEL SETS

Steel channel sets with their associated hardware were installed in three 2.74 m (9 ft) long sections with the flanges down. Each section was joined in place by bolting the plates along the flanges.

TESTING

The final step after installing all the hardware and monitoring load cells was related to testing of the entire support system.

Quality of the installation was verified by proof testing of all installed bolts. Each Dwydags bolt was tensioned to 116 kN (26 kips) and monitored for a period of 5 minutes to determine its holding capacity. After being accepted, each bolt was reset to its initial load of approximately 445 kN (1000 lbs).

MONITORING INSTRUMENTATION

The support system instrumentation was installed concurrently with the steel channels and their associated hardware. Installation of the Data Acquisition System consisting of interface cabinets, cabling and datalogging equipment was completed by February 29, 1992.

2.3 MONITORING SYSTEM DESCRIPTION AND PURPOSE

Since the support system loads will be adjusted during its operational life, it is essential to ensure that the loads on the anchors do not exceed the working loads specified by the design. The two main parts of the monitoring program will include observations of room performance and support performance.

Room stability will be determined from data that will establish the rock mechanics performance of the excavations in terms of room closure, rock deformations in and around rooms including roof expansion rates, the development of fractures and bed separation at strata interfaces.

Support system performance will be determined from observations and field test data, from a program that will monitor loads that develop in the rock anchors during the working life of the support. The evaluation of the rock mechanics data characterizing room performance and of the support performance data will establish the effectiveness of the support system. A full description of the Geomechanical Monitoring Program including specifications for the instruments is given in Appendix D of the WIPP Supplementary Support System Underground Storage Area, Panel 1, Room 1, DOE/WIPP 91-057, October 1991.

2.3.1 Geotechnical Monitoring

The geomechanical instrumentation installed in Room 1, Panel 1, will allow the performance of the room to be assessed and will indicate when support system components and conditions begin to deteriorate. Examples of room closure, extensometer and load cell data are given in Figures 2-1 to 2-3. The previously used method of using room closure rates as a measure of roof stability was successfully used in predicting the roof fall in SPDV Room 1. Safe and timely withdrawal from the room was accomplished. Since then, the roof stability evaluation data base has been extended to include data from extensometers, load cells, borehole observations and elevation surveys.

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ROOM1, PANEL 1, CLOSURE RATE - CENTER ROOM

FIGURE 2-1 Room 1, Panel 1, Closure Rate, Center Room

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NOTES:

Initial readings taken 02/27/92

LOAD PROFILE HISTORY FOR ROW 7

FIGURE 2-2 Load Profile History for Row 7

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ROOM 1, PANEL 1, ROOF EXTENSOMETER - CENTER

FIGURE 2-3 Room 1, Panel 1, Roof Extensometer, Center

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The only situation requiring withdrawal from Room 1, Panel 1, would be if the integrity of the support system as a whole was compromised by some unforeseen event. This could be, for example, a failure of the ground at or above the anchoring horizon. Because of the nature of salt rock, this could not occur instantaneously, or even over a short period of time. In a sense, if it were to occur, the failure process would already be taking place. No such signs have yet been observed by the monitoring system, which is designed to detect this and other types of failures. It should also be strongly emphasized that compared with the successful predictive method of measuring roof to floor (room) closure rates, the full suite of monitoring measurements being made constitute a much more sensitive and precise method of determining support system and/or component failure.

The basis of the revised monitoring program is:

- The measurement of roof expansion rates from the anchoring horizon to the roof surface. This provides an extremely sensitive measurement of roof stability.
- The measurement of deformations across the Anhydrite 'a' and 'b' layers in the roof in order to assess the development of bed separations at these strata interfaces.
- The measurement of room closure in order to assess the development of closure rates that exceed bounding levels and to establish the development of asymmetric room closure that may be an indication of fracture development along one rib and rotation of the roof slab. These measurements will be made by convergence measurements of roof/floor and wall/wall closure.
- Roof sag and floor lift is determined separately.
- The observation of conditions in the roof in observation boreholes in order to establish the extent of fracturing and bed separation.
- The measurement of lateral deformations within the pillars to establish the competency of the pillars. These measurements will be made by means of borehole extensometers.
- Accurate surveys will also be carried to verify measurements of closure, roof sag and floor lift.

2.3.2 Support System Monitoring

Monitoring of the Room 1, Panel 1, support system under working conditions in the field is an integral element of the support system that ensures its successful performance. The monitoring program consists of measurement of:

- The load that develops in each rock anchor. This provides the basis for adjusting the tension on the anchor so that the load build-up does not exceed the design limits of 1.1 times the design load while accommodating the continuing movement of the salt. The load is measured by means of load cells located at the anchor nut.

- The deflection of the channel section arising from the action of the rock anchor supports. The deflection is measured by precise surveying techniques.

Initially, the monitoring will be carried out weekly, but this frequency will be adjusted as data becomes available or the load changes with time. The measurement frequency will be based on observing load changes equivalent to 20 percent of maximum working load. The measurements of the loads will be compared with the criteria presented in Appendix "B" to establish when loads in the rock anchors must be adjusted, and the extent of that adjustment:

It should be noted that these criteria are preliminary. Field tests including the Room 2, Panel 1, Mock-up set and analytical computations will be performed in order to more effectively define these criteria and the method of load adjustment that will be based on them.

The criteria and the adjustment to the loads will be reviewed as data becomes available and may be changed to be more effective. The process by which these factors become adjusted will require approval by the Manager of Engineering for the MOC with concurrence from the Managers of Operations and Safety.

2.3.3 Instrumentation

Geomechanical Instrumentation installed in Room 1 of Panel 1 includes:

- Beam support rock bolt load cells - Rock bolt load cells are used to monitor the axial loading on the rock bolts. Loads on the cells are measured by means of resistance strain gages bonded to the cell in a full bridge configuration. The load cells are capable of monitoring loads of up to 444.8 kN (50 tons) with an approximate instrument sensitivity of 88.9 N (20 lbs). In order to maximize the adjustment range of the support system, a low profile type cell was used.
- Extensometers - Five borehole extensometers are installed in Panel 1, Room 1, to monitor rock mass deformation adjacent to the excavation. Three extensometer sets are installed in the roof to monitor possible bed separation within the roof beam. These extensometer sets are installed along the centerline at approximately 1/4 length locations of the room. Horizontal extensometers are installed in each wall at the center of the room to monitor pillar deformation.
- Convergence points - Seven sets of 4 convergence measurements are made in the room. These measurements are used to determine the amount and rate of closure at selected points. Monitoring of horizontal and vertical convergence will allow for a comparison of the performance of the support system in response to the actual room closure.
- Roof sag and floor lift will be determined separately, so that the contribution of each to total room closure can be determined.
- Level survey - Changes in elevation are monitored at selected locations along the support beams and the rock surface. The elevation surveys will identify areas of differential movement that, in addition to the results from installed geomechanical instrumentation, will establish the response of the system to creep closure.

Due to the large number of instruments, a data acquisition system was installed. This system is capable of monitoring up to 330 resistance strain-gaged rock bolt load cells. The data logger is incorporated into the Geomechanical Instrumentation System, which allows for timely monitoring and reporting.

2.4 ROOM 2, PANEL 1. EXPERIMENTAL PROGRAM

Room 2, Panel 1, will be used to carry out the tests that may be required to develop experience that can be applied to the support system in Room 1. These will include:

- Plate bending tests
- Loading/unloading Dwyidag bolts in order to determine interactions
- Resin bond testing

The Geotechnical Monitoring Program presented in Appendix "B" provides additional detail regarding the experimental programs and performance testing planned for the Mock-up installed in Room 2, Panel 1.

3.0 MONITORING DATA

D R A F T

Geotechnical observations have been conducted in Room 1, Panel 1, as part of routine operational monitoring. Data collected from this monitoring is included in the annual Geotechnical Field Data and Analysis Report (DOE/WIPP 92-010). Convergence measurements have been conducted in this room since the initial excavation. Roof extensometers were installed in June 1991. Monitoring of rock bolt load cells began in February 1992. Examples of the data collected are given in Figures 2-1 through 2-3. The data presentation will be modified in the near future as additional data becomes available.

3.1 CONVERGENCE

One horizontal and three vertical convergence measurements are made at seven different locations in Room 1, Panel 1. The twenty one vertical closure rates vary from 1.24 in./yr to 3.50 in./yr, with an average of 2.37 in./yr. Only 3 of these 21 measured closure rates are higher than predicted, and are due to local conditions. The average closure rate of 2.37 in./yr is well below that of SPDV Room 1 at an equivalent age (3.36 in./yr). In addition, the closure rates are decreasing, indicative of an increasingly stable situation.

3.2 EXTENSOMETERS

Three roof and two wall extensometers have been monitored in Room 1, Panel 1, since June 1991. The roof expansion rates from above Anhydrite 'b' to the roof surface show a decreasing trend (Figure 3-1) and are much lower than those of SPDV Room 1 at a similar age. SPDV Room 1 roof expansion rates showed increases right from the time they were installed in 1983, soon after excavation, up to the time the room was closed to access in 1990. Furthermore, the expansion rate across Anhydrite 'a' in Room 1, Panel 1, is just about zero, showing that no opening up is occurring across Anhydrite 'a'.

3.3 BOLT LOADING

The installed load cells have been monitored on a weekly basis since completion of the data acquisition system checkout and verification. These load cells have monitored the increase in load on each bolt as a result of roof expansion since the initial setting load. The monitoring results indicate that loads are increasing at a lower rate away from the room center towards the ribs as illustrated in Figure 2-2.

3.4 BOREHOLE OBSERVATION

The results of borehole observation surveys indicate the development of a thin fractured zone immediately below Anhydrite 'b'. The fracture zone was observable in approximately half of the boreholes inspected during bolt installation. There was no indication of fracturing above Anhydrite 'b'.

3.5 VISUAL OBSERVATION

The results of weekly room inspections indicate no observable changes in the condition of the supplementary roof support or of the room.

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FIGURE 3-1 Room 1, Panel 1, Roof Expansion Rates Center Room

D R A F T

3.6 ELEVATION SURVEYS

An initial survey was conducted to determine X, Y, and Z coordinates of the individual roof bolts and geomechanical instrumentation. This survey will serve as the baseline to determine the displacement of the support system and instrumentation as a result of salt creep.

4.0 MONITORING CRITERIA

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Evaluation forms for assessment of data provided by geomechanical instrumentation are given in Appendix C.

4.1 CONVERGENCEOPERATING HEIGHT

Convergence readings will be transformed into measurements of operating height. When the actual height at any point approaches within 2 in. of the ends of the Dywidag, a flag will be set. Convergence will also be separated into roof sag and floor heave.

CONVERGENCE RATE (SEPARATED IN ROOF SAG AND FLOOR HEAVE)

Roof sag and floor heave rates will be annualized to inches per year. There will be three criteria that will trigger action flags.

- if 4 consecutive readings show an increase
- if the convergence rate is greater than 2.5 in./yr.
- if the difference between outer readings and the center one is greater than 0.5 in./yr.

Rib-to-rib convergence readings will be read and evaluated in terms of their effect on cross-sectional area change. At this stage, no criteria for setting action flags will be used for horizontal closure. Condition of the ribs is evaluated under wall extensometers.

4.2 EXTENSOMETERSROOF EXTENSOMETERS

The roof extensometers have anchors at horizons enclosing the following 'bays'.

- Bay 1 - roof to below 'b'
- Bay 2 - below 'b' to above 'b'
- Bay 3 - above 'b' to below 'a'
- Bay 4 - below 'a' to above 'a'
- Bay 5 - roof to above 'b'

Readings of Bay 5 (roof to above 'b', the anchoring horizon), will be used to compare with changes in rockbolt load cell readings.

The bay strain rates in Bays 1, 2, 3, and 4 will be flagged if:

- there are 4 consecutive readings of increases
- they exceed 0.5% strain/year

This critical strain rate is based on preliminary work that indicates that fracturing will occur when strain rates exceed about 0.6% per year. Work is continuing to refine and improve this criterion.

A flag will also be set if roof sag minus the sum of strains in bays 1, 2, 3, and 4 show increases over 4 consecutive readings. This could indicate an active fracture somewhere above the anchoring horizon.

Bays 4 and 5 readings will also be compared with changes in rockbolt loads when the bolt loads are adjusted by loosening the nut. The purpose of this is to assess the stability of the anchoring horizon.

WALL EXTENSOMETERS

Bay strain rates will set an action flag when they exceed 0.5% strain/ year.

4.3 ROCKBOLT LOAD CELLS

These will be evaluated as per the criteria set out in Appendix 'B'.

New ways of displaying the data such as plotting load surfaces representing load changes in three dimensions, plotting loads down and across the room, are being investigated.

4.4 BOREHOLE OBSERVATIONS

All vertical and lateral separations will be noted, as well as their progression.

4.5 VISUAL OBSERVATIONS

A weekly visit check sheet will be filled out for Room 1. These will be discussed at the weekly PCG meeting and a decision made as to whether action flags should be set.

4.6 ELEVATION SURVEYS

These will be normally carried out twice a year. The results will be used to:

- compare with closure/extensometers data
- draw surface elevation contours and compare with previous readings
- separate roof sag and floor lift and compare with rock mechanics measurements. These will be performed monthly with frequency adjusted if necessary.
- check mid-height baseline rib benchmarks to adjust roof sag and floor lift.

5.0 CONCLUSIONS AND RECOMMENDATIONS**D R A F T****5.1 SUPPORT SYSTEM PERFORMANCE**

Evaluation of monitoring data provided by the geomechanical instrumentation installed in room shows that all monitored values were found to be within monitoring criteria limits.

The level of performance of the Supplementary Roof Support System in Room 1, Panel 1, as well as the room itself were found to be within their respective design parameters.

5.2 SYSTEM ADJUSTMENT AND/OR MODIFICATIONS

No modifications or support system adjustments are needed or recommended at this time.

6.0 REFERENCES

D R A F T

DOE/WIPP 91-057, WIPP Supplementary Support System Underground Storage Area, Panel 1, Room 1, October 1991

DOE/WIPP 91-023, Report of the Geotechnical Panel on the Effective Life of Rooms in Panel 1, June 1991

DOE/WIPP 92-010, Geotechnical Field Data and Analysis Report

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APPENDIX A
SRSAG Meeting Minutes

MEETING MINUTES

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HA:92:4543

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Attendees		Distribution	
Name	Organization	Attendees Plus	
T. F. Brockman	WID	See Distribution List	
T. P. Burrington	WID		
R. C. Carrasco	WID		
D. Galbraith	WID		
H. D. Ripley	WID		
S. C. Sethi	WID		
J. E. Gilbert	WPSO		
J. R. Tillerson	SNL		
H. D. Miller	Consul.		
		Prepared By	Date
		C. Chmura	3/24/92
Subject or Purpose of Meeting		Location	Date
REVIEW OF SUPPLEMENTARY ROOF SUPPORT SYSTEM IN R1, P1 BY		Eng. Bldg.	3/19/92
Item Number SRSAG	Discussions or Resolutions	Action By	Date
	<p>1. Mr. Subhash Sethi opened the meeting by explaining the background and reasons for the existence of the Room 1, Panel 1 Supplementary Roof Support System Advisory Group (SRSAG).</p> <p>He referred to the letter of Oct. 16, 1991, from Dr. C.M. Cox, Deputy General Manager, in which the Appointment and Charter for the above group were set out (copy of letter attached).</p> <p>2. Mr. Chris Chmura made a presentation in which he outlined the history of the Room 1, Panel 1 support design project, leading up to the current status where data is being obtained from various monitoring stations in the room.</p> <p>Mr. Chmura described the problem that had been experienced with the discrepancy in readings of the rockbolt loads as indicated by load cells and the hydraulic ram and gauge. This was observed during testing of roofbolts in Room 1 and Room 2. Reason for load discrepancy has not been fully identified; however, bending of steel plates observed under high loads and possible 'off-center' loading of the load cells was suspected. Discussions on the subject have also been held with the load cell manufacturer.</p> <p>Mr. Jack Gilbert asked for further clarification and discussed the possibility of testing an installation on surface under controlled conditions.</p>

MEETING MINUTES

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Item Number		Action By	Date
	<p>Dr. Hamish Miller suggested that the results from the load cells installed in Room 1 appeared to indicate that they were operating satisfactorily. If this could be shown to be so, then it might not be necessary to replace all the plates as had been proposed.</p> <p>It was finally decided to evaluate all aspects of the problem and have a resolution in place within a month's time.</p> <p>3. Mr. Rey Carrasco made a presentation regarding the current status of the monitoring system. Among the information he displayed were copies of the initial sets of load cell readings. These showed that the system was performing satisfactorily as designed.</p> <p>There was a fair amount of discussion concerning the data and Mr. Joe Tillerson made a number of observations and suggestions regarding the way in which the data could be plotted and displayed.</p> <p>4. There was much discussion regarding the determination of criteria for assessing the performance of the support system as well as the stability of the room. This was extended into a discussion of the criteria on which a decision to retrieve bins and to abandon the room might be made.</p> <p>The point was made that the only situations that would require bin retrieval and abandoning the room would be:</p> <p>4.1 Failure of the support system as a whole arising from rock separation above the anchoring horizon. These were regarded as a remote possibility and it was felt that the monitoring system would give more than enough time (at least more than 6 months) to retrieve the bins and evacuate the room safely.</p> <p>The Project Control Group would more fully define the criteria to be used.</p>	<ul style="list-style-type: none">• Mine Eng.• Geotech Eng.• Geotech Eng.• Geotech Eng.• Mine Eng.• Mine Eng.• Mine Ops• Safety

MEETING MINUTES

DRAFT

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Item Number		Action By	Date
	<p>4.2 Failure of bolt/resin/salt bonding giving rise to individual bolts failing. It was agreed that this eventuality could be safely handled by replacement of individual defective bolts. Mr. Tillerson recommended that these procedures be formalized. This was agreed to.</p>	<ul style="list-style-type: none">• Mine Ops.• Mine Eng.	
	<p>5. Mr. Tillerson suggested that providing additional roof supports in the section of Room 1 outside the actual bin storage area, particularly where the data logging shed was located, should be evaluated. Mr. Sethi stated that this is currently being addressed.</p>		
	<p>Mr. Chmura reported that he and Dr. Miller had inspected the area the day before with Mr. Teddy Garcia of Operations. This had been done in order to see what practical drilling patterns were possible. Dr. Miller suggested that roof extensometer should be installed in the center of the drift to provide data to evaluate the roof stability before installation of additional roof support is initiated. Three months observations period will be required to complete the evaluation. A report will be issued with recommendations.</p>	<ul style="list-style-type: none">• Mine Eng.• Geotech Eng.	
	<p>6. The attendees reviewed the format for the semi-annual report, as sent to Mr. Arlen Hunt, letter no. AA:92:0875, dated March 24, 1992, Mr. Tillerson suggested the format for the criteria. The group approved the format with this change.</p>		
	<p>7. There were wide ranging discussions on the functions of the SRSAG and how to make its role more effective. It was felt desirable to include Mr. Jack Gilbert as a permanent member of the group to provide for WPSO representation.</p>		
	<p>It was also decided that the Project Control Group (PCG) would meet weekly to discuss and evaluate all the results from the monitoring stations.</p>	Mine Eng.	
	<p>The PCG should request a meeting of the SRSAG if they felt that the monitoring showed any results that needed to be flagged as unusual or alarming.</p>		
	<p>6. The SRSAG is normally scheduled to meet once every quarter. However, in view of the requirement to complete the initial report by April 30, 1992, it was decided that the Group meet in about four weeks.</p>	All Participants	

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From : General Manager's Office
WMN : 887-8202
Date : October 16, 1991
Subject: APPOINTMENT AND CHARTER, SUPPLEMENTARY ROOF SUPPORT SYSTEM
ADVISORY GROUP, PANEL 1

to : M. L. Bibby L. R. Fitch L. L. Reed
T. P. Burrington T. W. Halverson L. M. Rancehausen
W. H. Caplinger J. L. Lee ~~W. H. Caplinger~~

This letter appoints and charters an advisory group to be known as the Supplementary Roof Support System Advisory Group (SRSAG). The function of this group is to periodically evaluate the data obtained from the monitoring of the performance of the Supplementary Roof Support System in Room 1, Panel 1, and to recommend any actions necessary to maintain the safety of personnel and the integrity of the experiments. Recommendations will be made to the Assistant General Manager, Operations.

Permanent members of the group will be the managers of Environment, Safety, and Health; Geotechnical Engineering; Mine Engineering; and Underground Operations; and a representative from Sandia National Laboratories. The manager of Mine Engineering is appointed chairman of the group and is responsible for scheduling the meetings and for providing a secretary to record actions, track action items, and issue the minutes of the meetings. Other staff managers are responsible for providing support as required.

The group will meet at least quarterly during the life of the bin-scale experiments in Panel 1. During the meetings, the group will review geotechnical data, evaluate the performance of the roof support system in Panel 1, and generate recommendations as necessary.

The minutes of the meeting will be issued promptly after each meeting. Geotechnical data will be summarized annually in the Geotechnical Field Data Analysis Report.

Dr. C. H. Cox
Deputy General Manager

MRB:cl

AA:91:0585

DRAFT

DISTRIBUTION
HA:92:4543

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E. K. Hunter, WPSO
M. H. McFadden, WPSO

REVISION 1
April 26, 1992

D R A F T

GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL 1
APPENDIX B

**GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL
APPENDIX B**

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GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL
APPENDIX B

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FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL
APPENDIX B**

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**GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL
APPENDIX B**

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(Continued)

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2	Results of Anchorage Testing

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**GEOTECHNICAL MONITORING PROGRAM
FOR ROOF SUPPORT SYSTEM IN ROOM 1, PANEL
APPENDIX B**

List of Acronyms

DOE - Department of Energy
MOC - Management and Operating Contractor
NIST - National Institute of Standards and Testing
PWR - Plant Work Request
SPDV - Site and Preliminary Design Validation
WIPP - Waste Isolation Pilot Plant
WPIO - WIPP Project Integration Office

GEOTECHNICAL MONITORING PROGRAM

D R A F T

1.0 INTRODUCTION

A system to support the roof in Room 1, Panel 1, for a period of 7 years from July 1991, has been designed and installed. The design itself is presented in the Design Report for the Supplementary Roof Support System, Underground Storage Area, Panel 1, Room 1 (DOE/WIPP 91-057). The support system accommodates the creep of the salt that takes place by a controlled yield. The success of the planned system relies heavily on a monitoring program that will determine not only the geomechanical performance of the room but will also assess the structural performance of the support system. In order to assure that the room remains stable and the structural support system is performing satisfactory, criteria have been developed against which the conditions in the room will be evaluated. The criteria are based on information from the SPDV Test Rooms and from Panel 1. The criteria as currently defined are presented in Section 2. However, they will be changed as more field and analytical data becomes available.

This plan describes the geotechnical monitoring program that will be implemented to evaluate both the room performance and the performance of the support system. The plan describes the instrumentation that is installed in Room 1, and a mock up that is installed in Room 2, Panel 1, to establish the structural performance of different parts of the system. In addition, the plan discusses the criteria that will be applied to ensure that the support system is adjusted in a controlled manner and that room performance remains satisfactory.

The Geotechnical Monitoring Program has been developed and is being implemented in accordance with the general requirements for the control of test activities as described in the Geotechnical Engineering Program Plan (WP 07). These requirements cover the eighteen criteria that are defined in the Quality Assurance Program for Nuclear Facilities (ANSI/ASME, 1989). The Geotechnical Engineering Program Plan is controlled by the QA Program implemented at the site (WP 13-1).

The geomechanical monitoring of a room can give early indications of its deterioration. Monitoring of the performance of excavations at the WIPP has already provided early identification of such conditions. SPDV Test Room 1 showed evidence of worsening conditions at least 3 years prior to the roof failure in that room. In addition, the Geotechnical Expert Panel has expressed confidence that instrumentation in Panel 1 can give adequate notification of deteriorating conditions (DOE/WIPP 91-023).

1.1 PURPOSE OF GEOTECHNICAL MONITORING PROGRAM

The geotechnical monitoring program will establish the loads that are developing in the support and the deformations of the rock that are taking place around the room. The geotechnical data will be used to ensure that:

- The support system is performing in a controlled manner.
- To establish the load adjustments to the support system required in order to accommodate the creep movements of the salt.
- To confirm that room performance remains within satisfactory bounds.

1.2 DESCRIPTION OF SUPPORT SYSTEM

The support system is designed to carry the dead weight of a rock wedge that is forming in the roof of Room 1. The development of this wedge has been identified from the rock fall that occurred in the SPDV Test Room 1 and from observations of fracture development in other parts of the underground facility. The wedge is not yet fully formed but, experience in SPDV Test Room 1 indicates that it will form fully in Room 1, Panel 1, within the next 7 years and become detached from the intact rock. The support system is designed to contain and support the weight of the detaching wedge while allowing it to be lowered in a controlled manner. To achieve this objective, the system accommodates both vertical and lateral displacements of the rock due to far field creep effects.

The most important part of the support system performance involves the controlled yield of the roof. It is expected that the interaction between the support system and the roof will pass through several stages that will be identified from the field data and computational evaluations.

The anchors were set to a nominal load of 1000 lbs after proof testing to 1.3 times their working load. The purpose of the preload is to ensure that the lacing and meshing under the channel is secured firmly in position. As the loads change with time, they will be compared with an estimate of conditions. There are two cases to be considered. These are the control of load during the detachment of the wedge, when the full loads have not developed, and the case when the wedge has detached and the working loads have been reached. Any continued build up of the load would be dependent on the creep of the solid salt onto the wedge that creates a stress in the support system that must be relieved by the controlled adjustment of the support.

Initially, the roof will be self supporting as the separation of the wedge has not yet developed. It is likely that this condition will be maintained for a period of time, especially if the bolting system is able to reduce the widening and propagation of the fractures. As the wedge becomes detached, the roof support will be transferred from the roof beam to the anchors. As this occurs, the rock anchors will provide increasing roof support and loads will build up in the anchors. Once the roof wedge becomes detached, then the rock anchors will be fully supporting the wedge and will have reached their working loads. Control of anchor loads must consider the adjustments needed during load build up when the wedge is not fully detached and load distributions may not be as expected, and those required once the wedge has detached and is subject to both vertical and lateral movements due to the creep of the solid salt.

In addition, the wedge shape must be taken into account when estimating the adjustments that must be made to the anchor loads. For the purpose of initially assessing the adjustments to the anchors in Room 1, a triangular distribution will be compared with the field data. The comparison will be carried out on a row by row basis and also over time since the geometry of the wedge may depend on location within the room and load distribution within a row of anchors may change with time as fractures develop.

The theoretical loading distribution is shown in Figure 1-1 and provides the fraction of the total load that should typically be carried by each bolt within

TOTAL LOADS IN
A ROW OF BOLTS = W

FIGURE 1.1a

FIGURE 1.1b

12010-0785

FIGURE 1-1 Load Distribution Below Maximum Working Load

a row. Figure 1-1 indicates the comparison that will be made between the theoretical and measured data and the bounding limits for the theoretical loading distribution.

2.0 CRITERIA FOR EVALUATING ROOM AND SUPPORT SYSTEM PERFORMANCE

2.1 LOAD ADJUSTMENT CRITERIA

The criteria for adjusting the loads in the anchors for the two cases that have been identified are as follows:

CASE 1: Load distribution below Maximum Working Load

This case will occur as the load increases from the nominally applied loads due to the increasing support provided to the wedge as the fractures develop. During this stage it is not obvious exactly how the loads will build up, but it is expected that they will develop slowly because the rock is still self supporting. Based on these assumptions, the following criteria will be applied to load adjustments for a row during the build up to maximum working loads:

- The load on an anchor will not be adjusted until the load in one anchor is more than 17.8 kN (4 kips) greater than the load in any other anchor within the same channel set. This is based on results from anchor testing that indicate that changes in load below this value does not significantly affect loads in nearby anchors.
- If the load distribution within a row of anchors is consistent with an acceptable triangular distribution, then no adjustments are necessary. Consistent means that an increase in individual bolt loads do not deviate by more than 20 percent from an acceptable load distribution along the row of anchors. Acceptable means that the load for a row of anchors is distributed within the bounds shown in Figure 1-1.
- If the loading for a row of anchors is consistent with a triangular or a parabolic distribution but with a variation from 20 to 25 percent for an individual anchor, then no adjustment is necessary, but the rate of load increase for all anchors within the row will be established and an estimation made as to whether the variation is increasing.
- If the load distribution for a row of anchors is consistent with a triangular or a parabolic load distribution but with a variation greater than 25 percent for an individual anchor, then an adjustment to that anchor will be carried out. The load on the anchor will be reduced to conform within 20 percent of the distribution geometry.
- If the load distribution within a row is not consistent with either a triangular or a parabolic distribution, then a study will be carried out to establish whether an alternative plausible load distribution can be established. If this is possible, then this distribution will be used to determine the adjustment to the anchor load. For example, if the loads develop on one side of the room due to asymmetric room closure, then an asymmetric load distribution may be found to be a more appropriate basis for load redistribution.

CASE 2: Load Distribution at Maximum Working Loads

Load distribution at maximum working load is considered to have developed when controlled adjustment of a row of bolts cannot reduce the anchor loads below levels that are consistent with the weight of a detached rock wedge. Once this

stage has been reached, then the following criteria will be used to adjust the anchors in each row:

- If the measured load in an anchor is 22 Kips or 10 percent more than the design working load of that anchor, an adjustment to the load will be made. The load on the anchor will be reduced to a level of not more than 80 percent (16 Kips) of the working load for that bolt.
- If the load distribution does not conform with a triangular or parabolic distribution, a study will be carried out to determine whether the measured distribution is reasonable and can be explained in terms of a geometric wedge shape that is appropriate.

These criteria are based on our expectation of the performance of the roof rock and of the support system and their interaction. A mock up demonstration is in progress in another room in Panel 1. This demonstration will try to establish the effects of adjusting the loads on rock anchors. The mock up is described in Section 4 of this Program Plan. During the demonstration, loads in the anchors will be adjusted to establish the effects of changing loads by a controlled amount on the loads that develop on nearby bolts.

Should the data from the demonstration indicate that the criteria do not provide adequate control for support system adjustments, then alternative criteria will be developed.

2.2 MONITORING CRITERIA

Monitoring criteria has been identified to assess the performance of the support system and room. This criteria will be used as flags that will indicate that additional monitoring or action is required. Preliminary criteria that form the basis for monitoring Room 1, Panel 1, are as follows:

- a. Roof closure rate in excess of the equivalent of 63.5 mm (2.5 in.) per year at midspan of excavation, based on readings over a three month period using closure measurements in combination with precise surveys of roof and floor movements. An increase in four consecutive measurements. A roof closure rate difference greater than 0.5 in. per year between midspan and quarter span points of a cross-sectional area.
- b. Rock bolt load in excess of 98 kN (22 kips) for a single bolt and/or the nut is 1 in. or less from the end of the bolt.

The criterion is based on the bolts not exceeding their allowable design loads due to creep movements of the salt.
- c. The measured roof sag minus the sum of strains between extensometer anchors show an increase over four consecutive readings. This would indicate possible fracturing above the anchoring horizon.
- d. Expansion of the salt between roof extensometer anchors exceeds 0.5 microstrain/year. This would indicate possible fracturing between the extensometer anchors.
- e. Actual height at any point approaches within 6 in. of the minimum allowable operating height of 11 ft 4 in..

If any of these flags are set, then additional monitoring and evaluation of the data will be conducted. The process for evaluating the monitoring results and for retrieval of the bins is shown in Figure 2-1.

These criteria will be continuously reassessed as more data becomes available. For example, numerical approaches are being developed to study the effect of the rock bolts on the performance of Room 1, Panel 1. The results from these studies will be compared with in situ room performance to establish their usefulness. Should their usefulness become established, then their predictions may become a part of the performance assessment process for the room. However, field data will always be the underlying basis for making decisions on room behavior, including the need to vacate the room.

FIGURE 2-1 Panel 1, Room 1, Monitoring Process

3.0 MONITORING OF ROOM PERFORMANCE

Room performance is already being monitored in Room 1, Panel 1. The monitoring system is characterized by the fact that the measurements and observations are simple to make; minimal maintenance of instrumentation is required, instrumentation is easily replaced if it malfunctions; and conditions throughout the room are known. The monitoring program will provide data to compare the performance of Room 1, Panel 1, with that established elsewhere in the underground facility. Room performance is being characterized by the following:

- The development of bed separations and lateral shifts at the interfaces of the salt and the clays underlying the Anhydrites "a" and "b".
- Room closure. The closure due only to roof movement will be separated from the total closure.
- The behavior of the pillars.
- Fracture development in the roof and floor.
- Distribution of load on the support system.

The instrumentation in Room 1, Panel 1, was upgraded during the summer of 1991 from the original monitoring program established for the panel in 1988. At that time, limitations were imposed on penetrations through the Anhydrite "b" in the roof. These limitations were in effect for waste storage considerations and no longer apply because the room is now to be used as the location for the bin scale tests. Roof conditions are now assessed from observation boreholes and from extensometer measurements. Measurements of room closure, rock displacements, and observations of fracture development in the immediate roof beam can now be made and used to evaluate the performance of the room. A description of the monitoring program was presented to the members of the Geotechnical Expert Panel who decided that it was adequate to determine deterioration within the room and that it could provide early warning of deteriorating conditions in the room (DOE/WIPP 91-023). This monitoring program was upgraded to provide additional data for analysis of room performance.

The location of the instrumentation monitoring room performance is shown in Figure 3-1. The specifications for the instruments are given in Table 3-1. A summary of the installation requirements including tolerances, workmanship, and national codes and standards that the instrumentation must meet are given in Attachment 1. Figures 3-2 and 3-3 provide the instrumentation cabling layout for the convergence meters and extensometers respectively.

3.1 ROOM CONVERGENCE MEASUREMENTS

Vertical and horizontal convergence stations will be installed at seven cross sections throughout the room to monitor roof/floor and wall/wall room closure. At each cross section, roof/floor convergence will be measured at mid span and at room quarter points, and wall/wall convergence will be measured at mid room height. The convergence measurements will establish the rates of room closure for comparison with expected rates and whether the roof/floor closure of the room is asymmetric.

FIGURE 3-1 Room Performance Instrumentation

FIGURE 3-2 Wire Convergence Meter Cabling

FIGURE 3-3 Extensometer Cabling

ROOM 1, PANEL 1, GEOMECHANICAL INSTRUMENTATION SPECIFICATIONS

Table 3-1

Type	Measured	Range	Precision	Accuracy	Method	Reading Frequency
Borehole Extensometers	Cumulative Deformation	0-50 mm	± 0.03 mm	± 0.03 mm	Sonic Probe	weekly
Convergence Points	Cumulative Deformation	0.6-15 m	± 0.03 mm	± 0.13 mm	Tape Extensometer	weekly
Convergence Meters Wire	Cumulative Deformation	0-0.9 m	± 0.1 mm	± 0.8 mm	Rotary Potentiometer	weekly
Rockbolt Load Measuring System	Load	0-445 kN	± 0.1 kN	± 4.5 kN	Strain Gage	weekly
Pressure Cells	Pressure	0-70 kPa	± 0.3 kPa	± 0.3 kPa	Vibrating Wire	weekly
Jointmeters	Cumulative Strain	0-100 mm	± 0.02 mm	± 0.1 mm	Vibrating Wire	weekly
Observation Boreholes	Separation/Displacement	N/A	± 0.03 m	± 0.03 m	Neil Probe/Camera	monthly
Elevation Surveys	Floor/Back/Roofbolts	N/A	± 0.0001 deg	± 3.0 mm	Theodolite	semi-annually
Location Surveys	X,Y,Z Coordinates of roofbolts	N/A	± 0.0001 deg	± 3.0 mm	Theodolite	once or as required

NOTE: Reading frequencies will be adjusted as necessary.

Each convergence station will consist of a mechanical anchor fixed about 150 mm (6 in.) below the rock surface. Details of a typical convergence anchor installation are given in Figure 3-4. An extensometer consisting of a wire or tape stretched under a constant tension and with an accurate distance measuring device is attached between the anchors. Changes in distance between the anchors will be monitored periodically to determine room closure.

The convergence measurements can be made manually or remotely. For manual measurements, the extensometer is put in place only for a reading and is subsequently removed. For the remote readings, the extensometer remains in position, and the manual extensometer measuring device is replaced by an electronic length measuring device. In the application in Room 1, a potentiometer readout with a range of 0.9 m (36 in.) will be used for vertical measurements at room quarter points where remote readings can be obtained. The instrumentation for remote readings have not been installed because the permanent installation of wires across the room will interfere with access into the room. The locations that are monitored for convergence are shown in Figure 3-1. Convergence measuring is conducted on a weekly basis. This frequency may be adjusted to meet any changes that develop. Calibration of the read out units for measuring convergence will be carried out either by the manufacturer or by the Site Calibration Laboratory. Calibration will be traceable to NIST Standards.

3.2 EXTENSOMETER MEASUREMENTS

Borehole extensometers are installed in the roof and the walls of Room 1. Roof extensometers monitor bed separations at Anhydrites "a" and "b" and the expansion due to creep movements within the immediate roof beam of salt. Wall extensometers monitor the lateral deformations within the pillars.

Within each borehole, measuring rods are anchored to the rock to monitor rock movements towards the room. Details of a typical borehole extensometer installation are shown in Figure 3-5. In the roof holes, the anchors are nominally fixed at depths into the hole of 0, 2, 2.3, 4 and 4.27 m (0, 6.5, 7.5, 13, and 14 ft), for the purpose of monitoring bed separation across the anhydrites "a" and "b". In the wall holes, the anchors are fixed at depths of 0, 1.5, 3, 4.5, 7.6 and 15.2 m (0, 5, 10, 15, 25 and 50 ft). The specifications for the drilling of boreholes, the installation of extensometers, and for the instruments are given in Table 3-2.

Calibration of the measuring device for the multiple point extensometers are carried out either by the manufacturer or by the Site Calibration Laboratory. Calibrations are traceable to NIST Standards.

Readings are taken either manually with a readout device provided by the manufacturer or will be performed remotely through the automatic data acquisition system that is maintained by the MOC in the underground. Measurements are currently taken remotely on a weekly basis. The frequency may be adjusted to meet any changes.

3.3 SURVEY MEASUREMENTS

Elevation survey measurements are made in the room by the surveyors from the Mine Engineering group. The measurements and their frequency are described in Table 3-3. The survey data are used to aid in determining the ratio of roof to

- Note:
- Floor installations may be recessed greater than 75 mm and protected with coverplate.
 - Dimensions are approximate

FIGURE 3-4 Typical Radial Convergence Point

FIGURE 3-5 Typical Rod-type Extensometer Installation

Table B-2

SPECIFICATIONS FOR EXTENSOMETERS

Depth	Nominal length $+300-0$ mm
Diameter	76 mm to 79 mm
Straightness	Line of sight at total depth
Orientation (vertical)	1 degree above horizontal or horizontal holes. 0 degree from vertical, ± 1 degree for vertical holes.
Orientation (horizontal)	Normal to room centerline, ± 1 degree
Counterbore	150 mm ± 6 mm diameter by 292 mm (± 12 mm) deep

Table 3-2
**ROOM 1, PANEL 1
SURVEY REQUIREMENTS**

Task/Type of Survey	Frequency	Deliverable	Comments
1. Elevation of back at each rock bolt.	twice a year	Provide cross-sectional profile at each channel set location.	a. To confirm the initial location of anhydrite "b." b. To compare roof expansion data with extensometer data.
2. Elevation of the roof bolts.	twice a year	Provide a table of bolt elevations.	a. Determine bolt displacement due to creep. b. May confirm possible separation at anhydrite "a."
3. X, Y, Z, coordinates of the roof bolts.	one time at installation time. After as required.	Provide as installed bolt coordinates.	a. Provides data to determine roof deformation due to creep.
4. Floor centerline elevation.	twice a year	Provide a centerline elevation profile.	a. Provides data to determine ratio of roof/floor creep.
5. Roof sag/ Floor lift.	once a month	Provide separate measurements of roof/sag and floor lift.	a. Allows separate contributions of roof sag and floor lift of room closure to be determined.

floor deformations. Convergence points will be used to determine total closure and extensometers will be used to determine roof movement.

3.4 FRACTURE MAPPING OF OBSERVATION BOREHOLES

Fifteen observation boreholes have been drilled into the roof of Room 1, Panel 1. Observations of bed separation and lateral strata shifts will be made on a routine basis at intervals of about 3 months. The boreholes will be monitored using a scratch probe that has been used for the Excavation Effects Program (DOE/WIPP 91-012). The holes can also be viewed with a borehole camera if the fractures require visual observation.

In addition, the boreholes for the rock anchors will be observed for evidence of fractures immediately following their drilling.

3.5 INSPECTION SURVEYS

Inspection surveys are carried out routinely by a team consisting of Mining Operations personnel. These inspections are conducted weekly or more frequently should conditions warrant. Additional inspections may be conducted by Mining Engineering and Geotechnical Engineering personnel.

The inspections will take note of:

- conditions of roof, walls and floors, specifically related to fracture development.
- brine accumulations from roof holes.
- condition of support system including the twisting and deformation of channels.
- condition of bolts regarding possible corrosion.
- condition of expanded metal sheeting and mesh.
- evidence of load distribution on cables.
- any other unusual conditions that might impact room or support system performance.

The survey documentation is maintained in the operations and engineering files. To aid the documentation of conditions, an initial survey using camera and video equipment is carried out and changes from these conditions with time are recorded.

3.6 DATA ACQUISITION

A data logger is installed in Room 1, Panel 1, for remote reading of the rock bolt load cells. Some of the instrumentation for monitoring room performance is currently read manually. Full conversion to remotely read all the instrumentation is planned. It may not be practical to convert all the instrumentation to remote reading. The ancillary equipment to allow remote reading of the quarter point convergence stations will be installed, but a final decision on installation of the wires will depend on establishing that they will not be damaged by personnel maintaining or sampling the bins. The roof/floor conver-

gence stations at mid-span, i.e., down the middle of the central access way, and the wall/wall convergence stations will not be monitored remotely as that would interfere with access.

The instrumentation is monitored utilizing a data link cable located in the S1950 drift. The data link cable is part of the Geomechanical Instrumentation System installed in the underground. The system is controlled from a computer located on the surface. The specifications for the datalogger are provided in Attachment 1.

The results from the instrumentation in the room will be routinely evaluated. Documentation of the results will be provided annually in the Geotechnical Field Data and Analysis Reports that are prepared by the Geotechnical Engineering Section and made publicly available by the U.S. DOE, WPIO.

4.0 MONITORING OF SUPPORT SYSTEM PERFORMANCE

The monitoring of the support system performance provides an assessment of the manner in which the system is supporting the wedge as it detaches and breaks up, should this occur. The monitoring program in Room 1, Panel 1, will evaluate the following:

- the performance of the structural system that supports the roof.
- the load that develops in each rock anchor, for the purpose of adjusting loads so that the build up is controlled in a consistent manner.

The basis for the instrumentation must be that the measurements are simple, that instrumentation is easily replaced if it malfunctions, and that the performance of each anchor can be continuously monitored and readily compared with the performance of other anchors. The instrumentation layout for monitoring the support system performance is provided in Figure 4-1. Cabling layout is provided in Figure 4-2.

The most important of these measurements are those that determine the anchor loads. These measurements will be used to adjust the anchors to ensure that the anchors are not stressed more than 10% of the allowable working stress (22 Kips) and that the roof is lowered in a controlled manner, which accommodates the continued creep of the solid salt.

It is not expected that breakup of the roof rock will be excessive; it appears more likely that the rock will remain primarily self supporting until the detached wedge in the roof forms fully. It is not expected that this will occur within the next two years based on the experience obtained from SPDV Test Room 1. Therefore, it is not believed that loads approaching the full weight of the detached wedge will develop on the expanded metal sheeting and the cables.

4.1 ROCKBOLT LOAD CELLS

The rockbolt load cells monitor the axial loading on the rock anchors. The measurements will be made on each anchor and will be the basis for adjusting the load on each anchor, should an adjustment become necessary.

Each load cell consists of a cylindrical body with a central annulus for the rock anchor. The load measuring element is a spool of high strength steel or aluminum on which electrical resistance strain gauges are bonded in a full bridge configuration that provides temperature stability and some compensation for eccentric loading. An outer steel cover and O ring seals protect the strain gauges from mechanical damage and water penetration.

The load cells shall have sufficient capacity to measure up to 50 kips with a sensitivity of 0.02 kips. In order to maximize the vertical adjustment on the tendons, the height of the load cells shall not exceed 75 mm (3 in.). The typical load cell installation is shown in Figure 4-3.

4.2 DATA ACQUISITION SYSTEM

The data acquisition system is providing for remote multiplexing of the load cells at locations within the room. The data acquisition system is capable of handling the required number of multiplexers. The data acquisition system is

FIGURE 4-1 Support System Performance Instrumentation

FIGURE 4-2 Rockbolt Load Cell Cabling

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FIGURE 4-3 Typical Load Cell Installation

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CONV5.FRM

ROOM 1. PANEL 1. DATA EVALUATION SHEET

EXTENSOMETERS

BACK

DATE: / / 92

NAME: _____

LOCATION	BAY.ID.	EXTENSION inches	BAY STR.RATE %str/yr(4)	MO.CONS. 1-4	ACTION Y/N
SOUTH	1				
	2				
	3				
	4				
	5				
CENTER	1				
	2				
	3				
	4				
	5				
NORTH	1				
	2				
	3				
	4				
	5				

NOTE:RATE VALUES CALCULATED OVER THE LAST 4 READINGS.

- BAY 1 - ROOF TO BELOW "b"
- BAY 2 - BELOW "b" TO ABOVE "b"
- BAY 3 - ABOVE "b" TO BELOW "a"
- BAY 4 - BELOW "a" TO ABOVE "a"
- BAY 5 - ROOF TO ABOVE "b"

ACTION:

configured to monitor up to 33 rows of load cells, each row containing 11 load cells. The load cell data is compared with previous readings to determine the loading profile on the support system.

The data logger consists of a programmable controller, switching units, and a readout device. To prevent thermal deterioration, the switching units multiplex all signal functions for each instrument. Continuous connection to a constant-voltage power bus is not allowed. To facilitate compatibility with existing data acquisition system, existing communication parameters, protocol, and programming is incorporated into the data logging components.

The data logger includes a Racal-Vadic Model VA1251G/K modem for data link connection to the surface data logging computer. A Racal-Vadic Modem Model VA1251G/K exchanges ASCII character data over the datalink cable via the following parameters:

- Baud Rate
 - 300
- Parity
 - Even
- Stop Bits
 - One
- Word Length
 - Seven Bits

The two panel switches on the Racal Vadic Modem are to be set as follows:

- Analog/Digital Loopback
 - OFF
- Transmit Reversal
 - OFF

The modem's RS-232 interface is connected with the supplier-provided control units to ensure proper data communications.

The surface datalogging computer is programmed to communicate with all underground control units through an exchange of ASCII character data. The computer sends a two character address sequence down the datalink cable through the surface modem. Each control unit then demodulates the character sequence through its modem. Each control unit is uniquely programmed (via a PROM chip) to respond to its own address sequence. Upon receipt of its address sequence, each control unit will poll its instruments, perform any necessary data reduction, and send instrument readings through the modem as a string of ASCII characters.

5.0 MOCK UP TEST IN ROOM 2

This section describes the tests that will be carried out as part of the mock up of the support system installed in Room 2 of Panel 1. The mock up will provide data to validate the design of the support system. It will establish the performance of the different parts of the support system and determine longterm performance. Whenever possible, physical changes to the support system will be tried out in Room 2 where their effects can be evaluated before actions are taken in Room 1.

5.1 ANCHORAGE TESTING

Field testing was conducted to determine the anchorage capacity of the bolts. The tests were carried out with different lengths of bonded resin to establish the influence of bonded length on the performance of the anchorage and establish the minimum anchor bond length required to meet the design requirements.

The bolt installation was similar to those installed in Room 1, Panel 1. The bolts were anchored above the Anhydrite "b" at a depth of 3.5 m (11 ft 6 in.). Six bolts, with different bond lengths, were tested. Three bolts were installed with sufficient resin for a nominal 300 mm (12 in.) length anchor and three bolts installed with a nominally 600 mm (24 in.) anchor length. Failure of the bolt installation was identified by comparing bolt deformation, using a dial indicator attached to the end of the bolt, to the actual load on the bolt.

The results of anchorage testing are presented in Attachment 2. A detail description of this testing can be found in PWR 21401T. Field testing of the three ft resin anchor was conducted in Room 2, Panel 1, before installation of the Room 1, Panel 1, supplemental roof support. Testing of 10 bolts indicated that the failure mode was bolt yield and not failure of the resin anchor bond. The results of anchorage testing are presented in Attachment 2. A detail description of this testing can be found in PWR 12017T.

5.2 LOAD BUILD UP IN ANCHORS

The purpose of these tests is to establish the rate of load build up in the rock anchors with time and to investigate if the initial anchorage load affects the rate. Anchors will be tested at three initial load settings of 1,000, 8,000 and 16,000 lb (4.5, 35.7, and 71.5 kN). At each load setting, three anchors will be monitored in order to assess repeatability. The load changes will be monitored at a minimum weekly frequency. The loads will be allowed to build up to 97.8 kN (22 kips) before being reset to the initial load setting. The test will be continued for four loading cycles.

5.3 SYSTEM PERFORMANCE

5.3.1 Evaluation of Instrument Accuracy

An evaluation will be carried out to verify the accuracy of the instrumentation and of the data acquisition system monitoring the instrument outputs.

The accuracy and precision of the rock bolt load cells will be determined by testing a random sampling of the cells in a loading frame and monitoring the loads using a load traceable to NIST standards. The data collected will determine accuracy, precision, and any hysteresis effects due to cycling of

loads. As part of an ongoing evaluation of cell accuracy, two load cells will be selected at random every six months and recalibrated.

The overall accuracy of the measuring system including the instruments and data acquisition system will be evaluated during the check out of the system once the data acquisition system is installed.

5.3.2 Total System Performance

The following tests will be conducted using a full scale mock up of the support system:

- monitoring the influence of the channel on room performance, i.e., how the loaded channels affect creep of the salt.
- bedding effects will be examined by comparing the loading/unloading of the bolts on channels with and without plywood and steel. This will provide additional insight for interpreting the data obtained during the proof-testing in Room 1.
- load history will be recorded on complete channels to establish the load build up relative to time and location.

6.0 ANALYTICAL EVALUATION FOR LOAD ADJUSTMENTS

In parallel with the monitoring of actual loads in the rock anchors, a study will be carried out to determine the load transfer that can occur between anchors. The study will include field tests and analytical computations. The field tests will investigate how load changes in one bolt affect adjacent bolts. The loads on nearby bolts will be monitored while an adjustment is being made to a single bolt. The results of field monitoring and computational analyses will be used to determine the load transfer effects between bolts. These studies will be completed before adjustments to anchor loads are required in Room 1, Panel 1.

Computer simulations will assess the effects of adjusting the loads within the anchor bolts. This will be done on a row by row basis, since the available software codes are based on two dimensional modelling and it is assumed that interaction effects between rows spaced nominally 10 ft apart will not be significant. The codes that will be used are VISCOT, a finite element code, and FLAC, a finite difference code. Both codes were developed for the structural analysis of geologic media. The VISCOT code, which is a version of a publicly available code originally developed by Hinton and Owen (1982) was modified for use in the Salt Repository Program for the disposal of high level radioactive wastes. The FLAC code is a proprietary code that can be applied to repository projects. (Itasca, 1991)

The codes will be used to determine interaction effects between bolts supporting the isolated rock wedge. They will establish whether adjusting the load in one anchor within a row will change the loads in other bolts within the row and by how much. They will also assess whether asymmetric load distributions can develop due to lateral or differential vertical displacements of the salt, and how these effects can be compensated for or minimized by adjusting the anchor loads.

A preliminary assessment of load redistribution has been carried out using FLAC. The redistributions for a number of cases are shown in Figure 6-1. It should be noted that the study of bolt load adjustment will be an ongoing activity and that field data will be assessed to determine the effectiveness of the analytical evaluations for load adjustments.

JOB TITLE : THEORETICAL ROCKBOLT LOAD DISTRIBUTION (LOAD IN KIPE): NOMINAL LOADING

FLAC (Version 3.01)

LEGEND

3/01/1992 13:07
step 2000

$7.889E-01 < x < 3.222E+01$
 $-1.222E+01 < y < 1.922E+01$

Grid plot

0 5E 0

Reaction forces
Max Vector = $1.599E+01$

0 2E 1

GEOTECHNICAL ENGINEERING
WASTE ISOLATION PILOT PLANT

FIGURE 6-1 Theoretical Rockbolt Load Distribution

JOB TITLE : THEORETICAL ROCKBOLT LOADS (LOAD IN KIPE): INCREASED LOAD ON CENTER BOLT

FLAC (Version 3.01)

LEGEND

9/01/1992 13:57
step 2000

$1.883E-01 < x < 3.222E+01$
 $-1.222E+01 < y < 1.922E+01$

Grid plot

0 5E 0

Reaction forces

Max Vector = $1.990E+01$

0 2E 1

Applied forces

Max Vector = $1.999E+01$

0 5E 1

GEOTECHNICAL ENGINEERING
WASTE ISOLATION PILOT PLANT

.250 .750 1.250 1.750 2.250 2.750
($\times 10^{-1}$)

$\times 10^{-1}$
.500
.000
.500
.000
.500
.000
-1.000

FIGURE 6-1 Theoretical Rockbolt Load Distribution
(Continued)

JOB TITLE : THEORETICAL ROCKBOLT LOADS ROAD IN KIIPS: INCREASED LOAD ON 3RD BOLT FROM R2B

FLAC (Version 3.01)

LEGEND

3/01/1982 12:35
step 2000

$1.383E-01 < x < 3.222E+01$
 $-1.222E+01 < y < 1.922E+01$

Grid plot

Reaction forces

Max Vector = $1.508E+01$

Applied forces

Max Vector = $1.835E+01$

GEOTECHNICAL ENGINEERING
ASTE ISOLATION PILOT PLANT

0.250 0.750 1.250 1.750 2.250 2.750
(in 10" 1)

(in 10" 1)

GEOTECHNICAL MONITORING PROGRAM

U R A P U

APPENDIX A

FIGURE 6-1 Theoretical Rockbolt Load Distribution
(Continued)

JOB TITLE : THEORETICAL ROCKBOLT LOADS LOAD IN KIIPS: INCREASED LOAD ON 1ST BOLT FROM ASD

FLAC (Version 3.01)

LEGEND

3/01/1992 12:19
step 2000

$1.000E-01 < x < 3.200E+01$
 $-1.222E+01 < y < 1.922E+01$

Grid plot

Reaction forces
Max Vector = $1.000E+01$

Applied forces
Max Vector = $1.200E+01$

GEOTECHNICAL ENGINEERING
WASTE ISOLATION PILOT PLANT

.250 .750 1.250 1.750 2.250 2.750
($\times 10^{-1}$)

FIGURE 6-1 Theoretical Rockbolt Load Distribution
(Continued)

7.0 REFERENCES

- ANSI/ASME, 1989, "Quality Assurance Program for Nuclear Facilities," NQA-1-1989.
- DOE/WIPP 91-012, 1991, Geotechnical Field Data and Analysis Report.
- DOE/WIPP 91-023, June 1991, Report of the Geotechnical Panel on the Effective Life of Rooms in Panel 1.
- DOE/WIPP 91-057, 1991, Supplementary Roof Support System. Underground Storage Area. Panel 1. Room 1.
- ITASCA, Consulting Group, Inc., 1991, Fast Lagrangian Analysis of Continua (FLAC). Version 3.0. Minneapolis, Minnesota.
- Owen, D.R.J., and Hinton, E., 1980, Finite Elements in Plasticity: Theory and Practice, Pineridge Press Limited, U.K.
- WP 07, Geotechnical Engineering Program Plan, Waste Isolation Division.
- WP 13-1, WID Quality Assurance Program, Revision 13, Waste Isolation Division.

GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION

SPECIFICATION

CABINET DESIGN AND PERFORMANCE

Specification No.E-P-309

1. Cabinets shall be wall-mounted. Maintenance on wall-mounted cabinets shall be from the front.

2. Cabinet enclosures shall be NEMA Type 4X enclosures.

3. Interface cabinets shall be fitted with flame-resistant gaskets and tamperproof screws.

4. All controls, instruments, and devices shall be shown on the contract drawings.

5. Cabinets shall have their identification permanently marked on the cabinet or panel structure immediately adjacent to their location. Identification shall be clearly visible.

INSTRUMENTATION CABLES

Specification No.E-Q-281

1. Cable shall be suitable for use in dry and wet location, capable of continuous operation temperature of 90 degrees Celsius. It shall be UL-listed as Type TC cable in accordance with NFPA 70, Article 340.

2. Cable shall be rated for 300V or 600V insulation, single- or multiple-twisted pairs.

3. Each conductor shall be tinned, soft or annealed copper, Class B seven-strand concentric in accordance with ASTM B 33 and ASTM B 8, Size No. 16 AWG for single pairs and No. 20 AWG for multiple pairs.

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DOE/MIPP 92-024
APPENDIX B
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GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION

SPECIFICATION

INSTRUMENTATION CABLES

4. Cable shields for single-twisted pairs shall be made of aluminum tape wrapped around the conductor and the tinned stranded copper drain wire.

5. Shielding for multiple shielded pairs shall consist of a group shield wrapped around each pair and drain wire and an overall cable shield wrapped around the whole cable assembly and drain wire.

6. Conductor identification shall be by color codes in accordance with NEMA WC 30.

7. Insulation and Jacket

For U/G installations the following materials are approved for use for cable insulation and jacketing as designated below:

1. Jacketing:

CPE - Chlorinated Polyethylene

CSP - Chlorosulphonated Polyethylene

- Neoprene

2. Insulation:

EPR - Ethylene Propylene Rubber

PPE - Polypropylene Ethylene

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Page 2 of 5

GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

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INSTRUMENTATION CABLES

XLPE - Crosslink Polyolefin (Polyethylene)

EPDM - Ethylene Propylene Diene Monomer

8. All wires and cables shall be identified at junction boxes and cabinets with wire and cable marker indicating the instrument number of the wired device.

TERMINAL BLOCKS & STRIPS

Specification No.E-P-244

1. Terminal blocks shall be surface-mounted, molded plastic screw-terminals, barrier type, capable of accepting No. 20 through No. 12 AWG wire terminated with solderless ring-tongue compression-type lugs. An 8-inch horizontal clear gap shall be provided between adjacent columns.

2. Thirty percent unused spare terminals shall be provided for each group of terminal blocks.

3. Terminal blocks shall be grouped by circuit type and segregated according to circuit voltage and destination of field wiring.

4. Not more than two wires shall be connected to any one terminal point.

5. Terminal strips for power connections shall be fitted with covers to minimize shock hazards.

6. Each terminal block marking strip shall be identified. Identification of terminal blocks and terminal points shall be alphanumeric, with each terminal block having

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ATTACHMENT 1
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GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION

SPECIFICATION

unique identifying letters and each terminal point to identify instrument input.

GROUNDING

Specification No.E-P-247

1. Instrument cases, relays, and other switching devices shall be grounded to the cabinet or panel steel structure through their mounting screws. Additional grounding shall not be required.

2. For each instrument circuit with a definite ground at the cabinet or panel, a single wire shall be run independently to the applicable ground bus and fastened thereto with a drilled-and-tapped connection, or on a terminal board for wall-mounted cabinets. Each ground point shall be readily accessible for removal, testing, and replacements.

3. Signal cable shielding and grounding requirements shall be included in the wiring diagrams.

FUNCTIONS OF TYPICAL INTERFACE DEVICES

1. Control Unit: When the control unit is activated by the communication controller, either locally or remotely by the GIS Data Logger, it shall, in turn, activate the readout unit and switching module simultaneously to read all the sensors and transmit the output of the readout unit to the GIS Data Logger. When the last connected sensor has been read, the unit shall deactivate itself.

2. Switching Module: Sequentially connects the readout unit to the sensors, enabling each one to be read.

3. Remote Readout/Polling Unit: When the readout unit

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APPENDIX B
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GEOMECHANICAL INSTRUMENTATION SYSTEM SPECIFICATIONS

MATERIALS/INSTALLATION

SPECIFICATION

connected to particular sensor, the readout unit shall energize the sensor, receive its measurement, display the reading, and transmit the reading to the communication controller through the signal converter.

4. Signal Converter: If the output from the readout unit is not in conformance with EIA RS-232-C and ANSI X3.4, a signal converter shall be furnished to generate a serial ASCII signal. The signal converter shall be either an internal subsystem in the control unit or an external unit.

5. Communication Controller: Under the control of the GIS Data Logger, the Communication Controller shall activate the remote readout/polling unit to start the data transmission and deactivate the remote readout/polling unit when data transmission is complete.

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ATTACHMENT 1
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APPENDIX B
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DRAFT

ATTACHMENT 2
DOE/WIPP 92-024
APPENDIX B
Page 1 of 1

From Engineering
WM 887-8709
Date January 13, 1992
Subject ROOM 2, PANEL 1 PARTIAL RESIN QUANTITY TESTING

To S. C. Sethi

cc: T. H. Brockman T. P. Burrington K. M. Chandra
T. F. Kocialeki J. M. Kowalski

On December 30, 1991, destructive testing of six anchor bolts in Room 2, Panel 1 was completed. The purpose of these tests was to determine the anchoring capacity of variable quantities of resin, specifically, those contained in 24 inch and 12 inch cartridge lengths. The tests were conducted with assistance from the Mining Operations section using hydraulic equipment which they provided.

The results of the tests are attached for your inspection. The tests conducted on the 6 bolts have shown that both 24 inch and 12 inch cartridge lengths have very similar anchoring capacities. Failure of the three bolts anchored with 12 inch resin cartridges was observed to occur at 54.0 kips, 53.0 kips and 54.0 kips, with the average being 53.7 kips. For the bolts anchored with 24 inch cartridges, failure was observed to occur at 52.0 kips, 51.0 kips and 51.0 kips with the average being 51.3 kips.

The precise mode of failure for these bolts has not been identified. The manufacturer of the Dywidag bolts, however, specified a yield strength of 47.4 kips for the bolts. The results of these six tests, therefore, tend to suggest that failure is likely to have been caused by bolt yield.

These six tests demonstrate that there is no significant difference in anchoring capacity when using 24 inches of resin over 12 inches of resin. Determining the minimum quantity of resin which will cause it to fail before a bolt reaches yield cannot be accomplished within the scope of these tests. These latest tests served to identify that that quantity is less than 12 inches. Should it become necessary to address the question regarding a minimum quantity of resin beyond the range determined from these six recent tests, a series of additional tests will need to be devised and conducted.

Should you have any questions, please do not hesitate to call (ext. 8709).

J. Carlos Lopez

cc Carlos Lopez, Senior Engineer.
Advanced Repository Technology

tw/rem

Attachments

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APPENDIX C
Evaluation Forms

DRAFT

CONV2.FRM

ROOM 1. PANEL 1. DATA EVALUATION SHEET

CONVERGENCE RATE

CONVERGENCE

DATE: / / 92

NAME: _____

LOCATION	CHORD	CLOSURE	ACTUAL HEIGHT	ACT.-16".	ACCEPT Y/N
S1884	EAST				
	CENTER				
	WEST				
S1853	EAST				
	CENTER				
	WEST				
S1841	EAST				
	CENTER				
	WEST				
S1802	EAST				
	CENTER				
	WEST				
S1758	EAST				
	CENTER				
	WEST				
S1717	EAST				
	CENTER				
	WEST				
S1681	EAST				
	CENTER				
	WEST				
S1639	EAST				
	CENTER				
	WEST				

ACTION:

DRAFT

CONV4.FRM

ROOM 1, PANEL 1, DATA EVALUATION SHEET

CONVERGENCE RATE

FLOOR LIFT

DATE: / / 92

NAME: _____

LOCATION	CHORD	CLOSURE DIFF.	CL.RATE in/yr	MO.CONT. INCR.	ROOF SAG in/yr(4)	ACCEPT Y/N
	EAST					
S1884	CENTER					
	WEST					
S1853	CENTER					
	EAST					
S1841	CENTER					
	WEST					
	EAST					
S1802	CENTER					
	WEST					
	EAST					
S1758	CENTER					
	WEST					
	EAST					
S1717	CENTER					
	WEST					
	EAST					
S1681	CENTER					
	WEST					
	EAST					
S1639	CENTER					
	WEST					

NOTE: RATE VALUES CALCULATED OVER THE LAST 4 READINGS.
ACTION:

DRAFT

CONV3.FRM

ROOM , PANEL 1, DATA EVALUATION SHEET

CONVERGENCE RATE

ROOF SAG

DATE: / / 92

NAME: _____

LOCATION	CHORD	CLOSURE	CL. RATE in/yr	NO. CONT. INCR.	ROOF SAG in/yr(4)	ACCEPT Y/N
S1884	CENTER	WEST				
	EAST					
S1853	CENTER					
	EAST					
S1841	CENTER	WEST				
	EAST					
S1802	CENTER	WEST				
	EAST					
S1758	CENTER	WEST				
	EAST					
S1717	CENTER	WEST				
	EAST					
S1681	CENTER	WEST				
	EAST					
S1639	CENTER	WEST				
	EAST					

NOTES: RATE VALUES CALC. OVER THE LAST 4 READINGS.
ACTION:

CONV 6 . FRM

EXTENSOMETERS

WALL

DATE: / / 92

NAME: _____

[illegible]

NOTE:RATE VALUES CALCULATED OVER THE LAST 4 READINGS.

ACTION:

DRAFT

ROOM 1, PANEL 1 MONITORING DATA

PROJECT CONTROL GROUP

WEEKLY EVALUATION SUMMARY SHEET

DATE: _____

NAME: _____

MONITORING CRITERIA	EVALUATED Y/N	ACCEPTED Y/N	ACTION Y/N
Operating height			
Convergence Rate			
Roof Sag Rate			
Floor Lift Rate			
Roof Extensometers			
Rib Extensometers			
Load Cells			
Surveys			
Boreholes			

COMMENTS:

END

DATE
FILMED

12/22/93