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DOE/WIPP 93-012

WIPP Supplementary Roof Support System

Room 1, Panel 1

Geotechnical Field Data Analysis Report

March 1993

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 .

DOE CONTRACT NUMBER: DE-ACO4-86AL31950

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WIPP SUPPLEMENTARY ROOF SUPPORT SYSTEM

ROOM 1, PANEL 1

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March 1993

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MASTER

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WIPP SUPPLEMENTARY ROOF SUPPORT SYSTEM

DOE/WIPP 93-012

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WIPP SUPPLEMENTARY ROOF SUPPORT SYSTEM

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List of Acronyms

SRSAG - Supplementary Roof Support Advisory Group
SPDV - Site and Preliminary Design Validation
PCG - Project Control Group

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1.0 EXECUTIVE SUMMARY

The design of the Room 1, Panel 1, supplementary roof support system was finalized in September 1991, and the system successfully installed in the test bin area between the bulkheads by December 1991.

Simultaneously with the support system installation, existing monitoring system was upgraded to meet the needs of the installed roof support. This included extensometers, closure stations, rockbolt load cells as well as survey measurements of roof sag and floor lift.

A Project Control Group (PCG) was established in order to monitor room and support system performance. Weekly meetings of the PCG were held to review all monitored data against criteria set in the initial design, and to modify these where necessary.

Records of these meetings have been kept, with copies of all data summaries and action notes. These data records are maintained in the Engineering data files.

After more than ten months of monitoring and reviewing experience, several modifications have been made both to the way data has been reported as well as to the load adjustment criteria.

The support system has performed as expected in the design, with no signs of instability developing considering the rates of roof deformation, the rock bolt loads and the observed fracture behavior in the roof. This is particularly true of the horizon in which the rockbolt anchors are located, the most critical part of the design.

The distribution of load build-up, throughout the 286 rockbolt load cells installed, in the Room 1 has been found satisfactory, and the load increases as evaluated by the PCG on a weekly basis have been within the acceptable range.

The minimum life of the installed support system is estimated at 15 years based on the highest roof expansion rate experienced to date. This report provides analysis of geotechnical field data collected up to December 1992.

2.0 BACKGROUND AND HISTORY

2.1 Introduction

The general layout of the underground facility is shown in Figure 2-1 including the specific location of Room 1, Panel 1.

An isometric diagram showing a conceptual view of the roof support system is given in Figure 2-2, with a more detailed drawing of one of the channel sections in Figure 2-3.

Figure 2-4 shows the instrumentation installed in Room 1, Panel 1.

2.2 The Project Control Group (PCG)

The PCG has been assembled to ensure proper performance of the installed Supplementary Roof Support System in Room 1, Panel 1. The functions of the PCG are as follows:

- Evaluate all monitored data on a regular basis against established monitoring criteria.
- Maintain appropriate records.
- Recommend remedial actions on an as needed basis.
- Update the program and modify the monitoring criteria as required.
- Institute additional analysis of monitored data.
- Provide feedback information to cognizant management.
- Produce reports for SRSAG.

FIGURE 2-1. Layout of the WIPP Underground

FIGURE 2-2. Supplementary Roof Support System Underground Storage Area
Panel 1, Room 1

FIGURE 2-3. Supplementary Roof Support System Room 1 Panel 1 Steel Set

FIGURE 2-4. Panel 1, Room 1, Instrumentation

3.0 PERFORMANCE TO DATE

The monitoring system has two basic functions. The first is to monitor the performance of the support system in order to confirm that the system is performing as designed.

In addition, it also monitors the performance of the room itself in order to assess roof stability and to determine possible need for withdrawal in the unlikely event that this becomes necessary.

3.1 Room Performance

3.1.1 Convergence Measurements

The convergence measurements for the eight radial convergence sets located in Room 1, are given in Figures 3-2 to 3-9, with the corresponding closure rates in Figure 3-1 for the periods June-December 1991, January-June 1992 and July-December 1992.

These results show that the closure rate has decreased throughout the room with time, thus indicating a current a state of stability.

This contrasts with the situation that occurred in the Site and Preliminary Design Validation (SPDV) Test Room 1, where the closure rates had begun to increase at the same stage in the room's life of approximately six years as shown in DOE/WIPP 92-010, Geotechnical Field Data and Analysis Report.

3.1.2 Extensometer Measurements

Figures 3-10 to 3-12 show the roof extensions reduced to bay strain rates against time for the period over which they have been installed. Bay strain is defined as the extension divided by the initial distance between the two anchors being considered. Bay strain rates are the bay strains divided by the time period over which the measurements are carried out.

This method of depicting the results allows for direct comparison of extensometer observations between bay lengths of different lengths, so the assessment of possible separation occurring at different Anhydrite levels can be made.

Based on an initial survey of extensometer data from locations throughout the underground where fracturing was known to have taken place, a 0.5% per year strain rate has been assumed as a reference value at which fracturing occurs. Further work is being done to improve this criterion.

The assessment of data collected from extensometers located in the room show the following results:

- The anchoring horizon (Bay B-C) at all three locations is stable, in that the strain rates are very low and not increasing.
- Anhydrite 'a' (Bay C-D) is showing no signs of increasing strain rate.

FIGURE 3-1. Panel 1 - Room 1 Convergence Rates

FIGURE 3-2. Convergence Points E520 Drift S-1639

FIGURE 3-3. Convergence Points E520 Drift-S1681

FIGURE 3-4. Convergence Points E520 Drift-S1717

FIGURE 3-5. Convergence Points E520 Drift-S1758

FIGURE 3-6. Convergence Points E520 Drift-S1802

NOTES:
1. EXCAVATION DATE: MAY 15, 1986.

CONVERGENCE POINTS
E520 DRIFT-S1841 PANEL 1/ROOM 1
ALL CHORDS

FIGURE 3-7. Convergence Points E520 Drift-S1841

FIGURE 3-8. Convergence Points E520 Drift-S1853

FIGURE 3-9. Convergence Points E520 Drift-S1884

Panel 1 Room 1-South/Roof Extensometer

FIGURE 3-10. Extensometer 51X GE-01017 - South

FIGURE 3-11. Extensometer 51X GE-01018 - Center

FIGURE 3-12. Extensometer 51X GE-01019 - North

- The zone across Anhydrite 'b' (Bay A-B) is showing relatively greater strain rates in the room center, followed by the north end. These rates are not increasing, however, and it is concluded that although separation is probably occurring, the situation is stable, and is being addressed by the support system, as designed.
- The highest roof expansion rate experienced from the anchoring horizon to the roof surface over the supported zone is 0.56 inches per year. This translates into a minimum support system life of approximately 15 years based on remaining length of roofbolt available for adjustment.

3.1.3 Load Cell Measurements

The performance of roofbolts installed in Room 1 is monitored by 286 load cells divided into twenty six rows with eleven load cells in each row, with the Row One at the south end of the room.

Several different ways of plotting and depicting the load cell data have been tried to date. Figures 3-13 to 3-22 are examples of these data plots, which show changes in loads with time across and along the room, and before and after detensioning. Figures 3-18 to 3-21 are particularly descriptive, as they show all 286 load changes simultaneously.

The general pattern for virtually all bolts is an initial relatively low weekly load increase that gradually steepens up, and then flattens out.

This can probably be attributed to an initial bedding-in of the system, followed by a more constant load rate as the roof expansion and rockbolt steel modulus control the rate of loading.

The rockbolts on either end of each channel section show relatively little load increase, with the inner ones exhibiting a somewhat arched pattern of load distribution. This is due to the downward bowing of the immediate roof across the room. The somewhat independent action of the three steel channel sections can be seen in most of the 26 channel sets.

The most significant finding made during load cell data assessment was that the rate of load increase on the load cells is due overwhelmingly to the downward bowing of the roof surface as indicated by convergence, extensometer and surveying data. It was therefore, necessary to modify the bolt adjustment criteria based on that movement rather than on theoretical weight distribution assumed initially. To reflect that situation a new load adjustment criterion have been developed. Details of this criteria are provided in Appendix B.

3.1.4 Observation Boreholes

Table 3-1 gives the details of the 15 observation boreholes installed in three sections in Room 1, as shown in Figure 2-4.

Borehole inspections reveal an active zone associated with Clay 'G', (Anhydrite 'b'), with a fractured zone of limited extent evident at several locations, some in excess of an inch.

There is also some evidence of activity at the Clay 'H' horizon, which is assumed to be due to drilling induced fracturing, rising from the process of drilling the

LOAD PROFILE HISTORY FOR ROW 13

NOTES:

Initial readings taken 02/27/92

FIGURE 3-13. Load Profile History

FIGURE 3-14. Load History for Row 1

FIGURE 3-15. Load Rate at Load Cell (13,6)

LOAD RATE AT 183 DAYS
ROOM 1 PANEL 1

FIGURE 3-16. Load Rate at 183 Days

LOAD RATE - 1ST LONGITUDINAL LINE
ROOM 1 PANEL 1

FIGURE 3-17. Load Rate - 1st Longitudinal Line Room 1, Panel 1

ROOM 1 LOAD GRID BEFORE DETENSIONING

FIGURE 3-18. Room 1 Load Grid Before Detensioning 07-30-92

ROOM 1 LOAD GRID AFTER DETENSIONING

FIGURE 3-19. Room 1 Load Grid After Detensioning 08-07-92

ROOM 1 LOAD GRID
BEFORE DETENSIONING

FIGURE 3-20. Room 1 Load Grid Before Detensioning 10-15-92

ROOM 1 LOAD GRID AFTER DETENSIONING

FIGURE 3-21. Room 1 Load Grid After Detensioning 10-29-92

FIGURE 3-22. Frequency of Load Rate Room 1, Panel 1

TABLE 3-1		
OBSERVATION DRILL HOLES: Room 1, Panel 1		
Inspected : 10-22-92 to 10-26-92 with borehole camera		
LOCATION	DEPTH TO FEATURE	DESCRIPTION
OH83	15' 11" 13' 1" 6' 9"	End of hole* Clay H Clay G, fracture zone, max. separations, 1/16"
OH84	15' 10" 13' 2" 6' 9" 4' 11"	End of hole* fracture, tight Clay G clay lens
OH80	15' 9" 5' 7-1/2" 5' 6"	End of hole* Anhydrite "b" frac., sep. < 1/16"
OH85	15' 7" 13' 4-1/2" 6' 10-1/2"	End of hole* fracture, tight frac. zone @ 1" wide, max. seps. 1/16"
OH86	15' 8" 13' 3-1/2" 6' 10"	End of hole* Clay H, fracture, tight Clay G, sep. < 1/4"?
OH87	15' 10" 13' 9" 7' 2-1/2"	End of hole* Clay H, fracture, tight Clay G, frac. zone 1" wide, seps < 1/16"
OH88	15' 9-1/2" 13' 8" 7' 3" 6' 9" 0" to 3"	End of hole* Clay H frac. zone, no seps. recorded clay lens Spalling halite
OH81	15' 10-1/2" 13' 4-1/2" 7' 0" 5' 10" - 6" 0"	End of hole* Clay H, undulates from 13' 2" to 13' 4-1/2" Separation frac. zone, seps. < 1/8" along clay drapes
OH89	15' 9-1/2" 13' 6" 7' 3" 1' 0" to 1/8"	End of hole* Clay H frac. zone @ 1-1/2" wide, seps. < 1/16" frac. zone, max. seps. 1/4"
OH90	15' 10" 13' 7-1/2" 7' 3"	End of hole* Clay H frac. zone at Clay G, < 1/2" wide, max. seps. 1/16"

TABLE 3-1 (Continued)		
OBSERVATION DRILLHOLES: Room 1, Panel 1		
Inspected: 10-22-92 to 10-26-92 with borehole camera		
LOCATION	DEPTH TO FEATURE	DESCRIPTION
OH91	15' 9-1/2" 13' 1" 7' 0" 6' 10"	End of hole* Clay H top of anhydrite "b" Clay G
OH92	15' 9" 13' 8" 13' 6-1/2" 13' 2" 6' 7-1/2" 5' 2-1/2"	End of hole* clay lens fracture, tight Clay H Clay G clay lens
OH82	15' 9" 5' 10" to 6' 2" 5' 0" 4' 11"	End of hole* frac. zone, seps. < 1/16" clay lens frac., sep < 1/16"
OH93	15' 6" 13' 4" 6' 7" 6' 6" to 6' 7"	End of hole* Clay H Clay G frac. zone, seps. < 1/16"
OH94	15' 7" 13' 0" 4' 5"	End of hole* Clay H clay lens

* Depth of the camera lens at the end of the borehole.

observation holes. The drilling induced fracturing noted at the Anhydrite 'a' horizon in the observation boreholes can be explained by reference to the response of stressed rock when a borehole is drilled through it. There are continuous layers of rock with different moduli and strength parameters throughout the succession above the rooms. These differences are particularly significant through the Anhydrite 'a' and 'b' zones. When a borehole is drilled through these zones, the rock relaxes into the hole, with a rate of deformation that depends on its mechanical and rheological properties, as well as the existing stress condition and the borehole diameter. The mechanical and rheological properties of salt, clay and anhydrite differ considerably, these differences giving rise to differential strains within and between the strata. Depending on their magnitudes, these strains can result in shear failure occurring which will manifest itself as a fracture zone around the periphery of the borehole. The failed material will tend to fall away. This is what has been observed in the borescope video, and has sometimes been incorrectly described as a separation. The extent of the failure zone is limited to the immediate vicinity of the borehole, and does not represent a general failure or separation along Anhydrite 'a'.

In four holes there is some evidence of slight fracturing occurring between the roof surface and Anhydrite 'b'.

It should be realized that the separations that were observed represent the total movement that has taken place over the life of Room 1. These are consistent and taken together with other measured data do not constitute a reason for concern.

3.1.5 Visual Observations

Weekly inspections were made by Mine Operations' personnel, and documented in shift activity reports. No cause for concern was ever reported regarding the state of the roof support system.

3.1.6 Elevation Surveys

Accurate surveys of the roof and floor elevations were carried out by the Site Surveyors. By referencing the measurements to the established benchmarks, it was possible to use the survey data to separate roof sag from floor lift.

Figure 3-23 compares floor lift and roof sag results as measured over a two month period September to October 1992.

From the figure it can be seen that except for one location, the floor lift is greater than the roof sag. In one place the floor contributes more than 60% of the total room closure. It appears that a higher rate of floor lift can be observed at the south end of the room. Further analyses are being conducted to establish whether the installation of the roof support system has stiffened the roof to the extent that a result has been to increase the rate of floor lift. It is felt that this is unlikely in view of the relatively low overall constraint offered by the roof support which is being continually detensioned.

3.1.7 Operating Height

The most important result of room closure is the effect it has on operating height.

FIGURE 3-23. Panel 1, Room 1 Roof/Floor Contribution

Because the ends of the roofbolts move downwards very little, the effective operating height that is measured between the ends of the protruding roofbolts and the floor below is predominately affected by the floor lift or heave.

If an average figure of three inches per year of total room closure is taking place, and a 50% contribution from floor lift is assumed (1.5 inches per year), then the room has a life of approximately 5.3 years.

An engineering study addressing floor maintenance is currently being finalized.

3.2 SUPPORT SYSTEM PERFORMANCE

3.2.1 Roofbolts

The performance of the Dywidag roofbolts can be summarized as follows:

- No bolts have failed or shown signs of loading problems, such as excessive bending.
- Sufficient free bolt length exists for approximately 15 years at current rates of roof expansion.
- There are no signs of any corrosion taking place.
- There are no signs of slippage of the anchors.
- No break-up of the roof between bolts has been observed.

It is therefore, concluded that the Dywidag roofbolts are performing as per design expectations.

No apparent failures of the previously installed 10 foot mechanically anchored roofbolts have been observed. It is concluded that the 10 foot roofbolts are still providing some additional support.

3.2.2 Channel Sections

The steel channel beams have deformed to follow the roof profile.

The compression lines caused by high loads applied during proof testing, remain unchanged since installation.

It is concluded that the channel beams are performing as expected in the design.

3.2.3 Meshing

There are no signs of large loose pieces of rock trapped in the meshing.

There is no visible bulging of the mesh downwards caused by loose salt. The meshing is performing satisfactorily.

3.2.4 Lacing Cables

The loads on the lateral cables are not visibly increasing.

The longitudinal cables are tight due to the load increasing.

The lacing cables are performing satisfactorily.

4.0 SUPPORT SYSTEM MAINTENANCE AND TESTING

June 1992

As a result of floor uplift, the floor developed a small cavity near the southwest corner of the room. To eliminate the hazard to traffic, the floor was repaired with salt fill and cement.

In order to assess the extent of the floor heave, forty eight, seven foot deep observation holes were drilled into the floor on a regular pattern, see Figure 4-1. These were probed and any fracturing was noted. This data was analyzed and compared with other selected geotechnical information.

It was concluded that the floor movement was due to a hinging action resulting in uplift mainly along the eastern side of the room, Figure 4-2. This was consistent with what was occurring in all the rooms in Panel 1. However, the situation appeared different at the south end of the room adjacent to the ventilation bulkhead, in that more uplift was taking place on the western side of the room. As a result of the floor study, a floor heave maintenance plan is being evaluated.

August 5, 1992

Sixty-two of the Dywidag bolt loads were adjusted, using the criterion of 20% deviation from the theoretical load distribution as described in the original design.

The load build up was faster in the bolts that had been previously the most highly loaded. After adjustment the pattern of load distribution was again similar to what it had been before adjustment took place. It was therefore, decided to review and modify the criterion for future load adjustment.

October 19, 1992

Using the new criterion for load adjustment, 176 bolts (16 sets) were adjusted, based on the projected rate of loading. The loads were all adjusted down to a uniform load of 5,000 lbs. The effect of unloading of these bolts can be seen in Figure 3-21.

No problems were encountered during the adjustment operation.

Bent Plate Testing

Observations made during bolt testing and detensioning operations suggested that the accuracy of the load cells can be affected by thickness of the steel plate, load cell/plate interface and off center load cell position.

Following these observations several designs and load cell/plate configurations have been tested. Based on test results it was determined that the accuracy of the load cell readings can be significantly improved by replacing existing 1/2" plates with 3/4" steel plates and a teflon buffer.

The plate/buffer design modification was accepted by the PCG. The "new" plate design is scheduled for implementation as soon as the required materials become available.

FIG. 1. PANEL 1 TYPICAL FLOOR FRACTURING SURVEY

FIGURE 4-1. Room 1, Panel 1 Typical Floor Fracturing Survey

MECHANISM OF DEFORMATION AROUND PANEL 1 ROOMS

FIGURE 4-2. Mechanism of Deformation around Panel 1 Rooms

Room 2, Mock-up Tests

Since the mock-up system installation several full scale performance tests have been conducted to aid in maintaining the roof support system in Room 1. Tests conducted in Room 2 included bolt load distribution tests and channel set load distribution tests. This testing was performed to gather the data required for development of procedures to detension the bolts and to disconnect individual channel sets. Testing involved duplicating the loads in Room 2 from three of the channel sets located in Room 1. To determine the load distribution between bolts, a decrease in load on one of the bolts and the reaction of the remaining bolt loads were investigated. The results indicated that no significant load redistribution between bolt and the channel has occurred during detensioning of individual bolts.

Testing of the support sets with disconnected channels indicated that separation of individual channels has no adverse affects on the performance of the entire set.

5.0 MODIFICATIONS**5.1 MONITORING SYSTEM**

No modifications were made to the monitoring system.

5.2 SUPPORT SYSTEM

No modifications were made to the support system during this period.

Instructions for replacement of the defective roofbolt has been developed to aid in proper bolt installation in the unlikely case of bolt failure. Details of the bolt replacement procedure are included in Appendix 'C'.

5.3 MONITORING CRITERIA

The updated load adjustment procedure is described in the report "Modified Load Adjustment Procedure", and a copy is given in Appendix B.

The load adjustment procedure is based on the following:

- The maximum design load for any bolt is 20,000 lbs.
- All bolts will be detensioned to a constant load value of 5,000 lbs.
- In order to reduce maintenance time, the load on any or all bolts in the set may be lowered when any single bolt reaches 20,000 lbs.
- Subsequent measured bolt loads should be correlated with roof deformations.

6.0 CONCLUSIONS AND RECOMMENDATIONS**6.1 SUPPORT SYSTEM PERFORMANCE**

Evaluation of all Room 1, Panel 1 geomechanical instrumentation data monitored shows that the values were found to be within the limits of the set criteria.

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.

6.2 SYSTEM ADJUSTMENTS AND/OR MODIFICATIONS

The following adjustments and/or modifications to the roof support system installed in Room 1 are recommended to maintain and/or improve future system performance:

- The connecting pins holding the channel beam segments together should be pulled, thus disconnecting the three sections in each set from one another.
- Teflon buffers should be installed between the load cells and the steel plates.
- Existing 1/2" steel plates should be replaced by 3/4" steel plates.
- A suitable method for monitoring the loads on the horizontal and longitudinal cables should be found and implemented.

7.0 REFERENCES

Additional information related to Room 1, Panel 1 supplementary roof support system design, room and support system performances can be found in the following publications:

- DOE/WIPP 91-057, WIPP Supplementary Roof 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, Vol. I and II, March 1992.
- DOE/WIPP 92-024, WIPP Supplementary Roof Support System Room 1, Panel 1, Geotechnical Field Data Analysis Biannual Report.

APPENDIX A

SRSAG MEETING MINUTES

November 12, 1992

MEETING MINUTES

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Attendees		Distribution	
Name	Organization	Attendees Plus	
F. G. Ashford	WID		
T. P. Burrington	WID		
R. C. Carrasco	WID		
C. M. Chmura	WID		
J. J. Magyar	WID		
L. M. Rencehausen	WID		
S. C. Sethi	WID		
R. C. Supka	WID		
J. E. Gilbert	WPSO		
H. D. Miller	Consul.		
		Prepared By	Date
		C. Chmura	11/30/92
Subject or Purpose of Meeting		Location	Date
MEETING MINUTES OF NOV. 12th SRSAG MEETING		Eng. Bldg.	11/12/92
Item Number	Discussions or Resolutions	Action By	Date
	<p>1. Mr. Subhash Sethi opened the meeting by reviewing the reasons for the existence of the Room 1, Panel 1 Supplementary Roof Support System Advisory Group (SRSAG).</p> <p>2. Mr. Chris Chmura provided an update of activities in Room 1, Panel 1.</p> <p>Including repairs performed on Room 1 floor.</p> <p>Mr. Chmura gave an update of the roof bolt adjustment program in Room 1. He provided a short description of the bolt detensioning process. Mr. Chmura stated that a majority of the roofbolts have been detensioned and that the adjustment program has been a success. Additionally he stated that, based on past experience, it is now the practice to detension all the roofbolts in the affected channel.</p> <p>3. Mr. Rey Carrasco provided observations and evaluations of room and support system performance based on data gathered from a variety of Rock Mechanics instrumentation installed in room.</p> <p>Mr. Carrasco described the consistent loading of the load cells monitoring the rockbolts in Room 1. He explained that plotting of the roof extensometer data gives a curve that is not perfectly smooth for low deformations observed because at the low deformation values being monitored, the system is operating at the limits of its resolution. A lower resolution would show a much smoother trending curve. He noted that only 3 observation boreholes were showing a slight (1/16") separation directly below the Anhydrite "b".</p>		

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Item Number		Action By	Date
	<p>Mr. Carrasco also presented data related to the monitoring of the ribs in Room 1, Panel 1. He noted that the 3 foot diameter horizontal boreholes located in the East rib at the North end of Room 1 give an excellent insight into the condition of the rib. Evaluation of the presented data indicated stable rib conditions.</p> <p>Mr. Carrasco presented load cell monitoring data that indicated loads distribution to be within design limits and noted that, as predicted, the roof bolts near the center of the room are loading the quickest.</p>		
4.	<p>A general discussion on Project Control Group (PCG) activities took place. It was agreed that the power to make day to day ground control decisions be given to the PCG, with the stipulation that should the course of action be in doubt, a reconvening of the SRSAG will occur to make the ultimate decision.</p>	PCG	
5.	<p>The need to continue "mock-up activities" in Room 2, Panel 1 (on a as needed basis) was agreed upon as well as the need to document and review the activities on a case by case basis to reduce monitoring redundancy between Room 1 and Room 2.</p>		
6.	<p>Bent Plate Testing Program by Richard C. Supka.</p> <p>Mr. Supka presented an overview of the testing program including a description of the testing apparatus and materials tested. He concluded that by using a variety of different materials as buffers and varying plate thicknesses, the error in reading of the vertical load can be reduced to less than 0.1%. A combination of 1/16" Teflon buffers (1 on each side of the load cell) and 3/4" roofbolt plates replacing the original 1/2" plates proved to be the best combination. The SRSAG directed that the buffers and plates be installed in Room 1, Panel 1 as soon as the necessary material is procured.</p>	Mine and Geotech Eng. and Mine Ops.	
7.	<p>Room 1 evaluation by Hamish Miller</p> <p>Dr. Miller made a presentation addressing performance of the room and roof support system. Each component of the support system was evaluated and found to be performing as designed. Overall room performance was found to be satisfactory.</p>		

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Item Number		Action By	Date
	<p>As a result of experience in monitoring the loads on roofbolts in Room 1 the following recommendations to modify the roof bolt load adjustment procedure were made and adopted:</p> <ul style="list-style-type: none">- Limit maximum load to 20 kips per bolt, as per design requirements.- De-tension all roof bolts to a constant load of 5 kips.- Any or all bolts in a set may be de-tensioned when a single bolt reaches 20 kips.- An attempt should be made to correlate bolt load changes with roof expansion rates. <p>Performance evaluation of roof support system included:</p> <ul style="list-style-type: none">- <u>Roof Bolts:</u>- No failures of any of the resin roof bolts has been observed.- The remaining bolt length is considered sufficient to support the design life.- No corrosion of the roof bolts has been observed.- At this stage, the loads on the bolts occur as a result of bowing of the roof beam, and not by deadweight loading.- The 10 foot roof bolts continue to act as an additional support- <u>Channels:</u>- The channels have deformed to match the bowing of the back.- The joining plates between the channels are stressed and it is recommended that the plates be disconnected.	Mine Eng. Mine Ops.	

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Item Number		Action By	Date
	<ul style="list-style-type: none">- <u>Steel Mesh & Cables:</u>- No problems observed- Initial tensioning of the cables has been observed- Recommend de-stressing of the cables as required		
	<p>8. General Discussion:</p> <p>A general discussion took place among SRSAG members regarding the load distribution along the back and floor in Room 1 and how this affects floor heave. It was agreed to evaluate possible solutions for floor repair and maintenance. Slotting, backfilling, grouting and milling the floor were mentioned as possible solutions.</p> <p>The decision to detension the cables in the support system on as needed basis was approved at this time.</p> <p>The draft of the second biannual report is scheduled for completion in January 1993. The final report will be issued in March 1993.</p>	<p>Mine and Geotech. Eng. and Mine Ops.</p> <p>Mine Eng. Mine Ops.</p>	<p>Jan. 1993</p> <p>Mar 1993</p>

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APPENDIX B

MODIFIED ROOFBOLT LOAD CELL LOAD ADJUSTMENT CRITERIA

MODIFIED ROCKBOLT LOAD CELL LOAD ADJUSTMENT CRITERIA

The criteria for adjusting the loads on the roofbolt load cells currently used in Room 1, Panel 1, are given in Appendix B of the report "WIPP Supplementary Support System Room 1, Panel 1 Geotechnical Field Data Analysis Biannual Report", DOE/WIPP 92-024.

In view of the results obtained to date from the load cell monitoring program, as well as some new thinking on the subject, the following modifications to the load adjustment procedure have been developed.

GENERAL OBSERVATIONS AND CONCEPTS

1. The original criteria of load adjustment were based on the theoretical worse case of a load distribution and roof expansion rate that was expected to develop across the channel set after the immediate roof has detached. Since this has not yet happened, the actual expansion of the rock at the rockbolt locations varies from the pattern assumed in the original design.
2. At the present, it is the actual rock movement that causes the build-up in loads on the load cells. This roof expansion cannot be suppressed by any practical means.
3. The general pattern of load build-up that is occurring in Room 1, can be seen from the load profile history diagrams compiled for each channel set. The load build-up is occurring more rapidly in the center of the room, developing virtually no load (from the original setting load of 1,000 lbs) at the outer edges of the room.
4. Load cells that were adjusted down remained most active gaining more weight per week than the remaining load cells in the set. Although; the magnitude of the loads may vary for each set, the pattern of load gain is the same for all the sets where the loads have been adjusted.
5. The pattern of load built-up on the bolts should follow the pattern of roof expansion from the roof surface to the anchoring horizon. This roof expansion in the center of Room 1, derived from extensometer measurements is currently about 0.5 inches per year.
6. From the measurements taken it can be seen that the roof in the center of the room is bulging downwards by about 0.01 inches per week. This would give a theoretical weekly increase in load of approximately 2200 lbs. per week, based on the elastic modules of the Dywidag tendon, and assumed free length of 9 feet.
7. As of yet, no bolts are loading at this weekly rate. The conclusion is therefore, that either the system is still bedding in, or that the rate of expansion of the roof is not as great as 0.01 inches per week.
8. The shape of the load vs time graphs for individual bolts show that the rates are increasing, as would be expected if bedding-in is still taking place, with the system becoming "stiffer" with time.

9. As the end of the bedding-in phase approaches, the rate of load increase should tend to a constant value representative of the roof expansion rate at that location.

Load Adjustment Criteria

1. The loads on all bolts will be adjusted down to a constant value of 5,000 lbs. The value of 5,000 lbs. is arbitrary, and future experience may dictate that this be modified to some other value.
2. The load on any individual bolt shall not exceed the maximum load of 20,000 lbs.
3. All bolts in a set can be adjusted down even though they have not reached the maximum load of 20,000 lbs.
4. The loads should be allowed to increase (matching the downward movement of the roof) at whatever rate happens to apply at that location.
5. Careful observation of the rates of load increases for different bolts will allow scheduling of adjustments to minimize the number of times that Room 1 will have to be entered to adjust bolt loads.
6. The rates of increase in bolt loads are a direct measure of the downward movement of the roof, and it should be possible to correlate these increases with extensometer readings. This will validate the method described above.

APPENDIX C
DEFECTIVE ROOFBOLT REPLACEMENT INSTRUCTIONS

DYWIDAG ROOFBOLT REPLACEMENT INSTRUCTIONS

Procedure for replacement of defective roofbolts in the supplementary roof support system in Room 1, Panel 1 has been developed to insure proper installation of the replacement roofbolts in any channel set.

It should be noted that the probability of a roofbolt failure after successful installation is extremely small and unlikely to occur.

The analysis of geomechanical data collected to date provide proof of successful operation of the installed roofbolts.

The evidence of a roofbolt failure would be observed as a drop in the load on the load cell for that bolt. To confirm rockbolt failure the suspected load cell will be tested for reading accuracy. The failure of these monitoring devices is a much more likely event than the failure of the bolt.

LOAD CELL TESTING AND BOLT REPLACEMENT INSTRUCTIONS

1. Install a roof jack between roof and floor within two feet on opposite sides of the suspect bolt.
2. Take manual readings of the load cell to corroborate the datalogger results.
3. If these readings do show a significant drop in load (to be determined by the Cognizant Engineer), slacken off the nut by using the Dywidag ram.
4. Take off the complete assembly below the channel beam.
5. Bench test the load cell to be sure that it is functioning correctly.
6. If bolt replacement is required (to be determined by the Cognizant Engineer) cut a 3.5 inch diameter circular hole in the channel beam, at a location not more than six inches from the center of the existing defective bolt hole.
7. Clear the material above the beam, so as to expose the salt back.
8. Install a new Dywidag rockbolt as per the installation procedure set out in PWR 13195, used for system installation.
9. Carry out the proof load testing as described in PWR 13195.
10. Install the load cell as in PWR 13195.
11. Preload the bolt to the desired load (as determined by the Cognizant Engineer), using manual readout of the load cell data.
12. Reconnect the load cell to the datalogger and test the system.

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