

**ATTACHMENT O**  
**WIPP MINE VENTILATION RATE MONITORING PLAN**

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**ATTACHMENT O**

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8 **ATTACHMENT O**

9 **WIPP MINE VENTILATION RATE MONITORING PLAN**

10 O-1 Definitions

11 Compliance with the mine ventilation requirements set forth in Permit Part 4 and Permit  
12 Attachment A2 requires the use and definition of the following terms:

13 Actual cubic feet per minute (**acfm**): The volume of air passing a fixed point in an excavation,  
14 normally determined as the product of the cross section of the excavation and the mean velocity  
15 of the air.

16 Standard cubic feet per minute (**scfm**): The actual cubic feet per minute passing a fixed point  
17 adjusted to standard conditions. In the Imperial measurement system, the standard condition for  
18 pressure is 14.7 pounds per square inch (**psi**) (sea level) and the standard condition for  
19 temperature is 492 degrees Rankine (freezing point of water or 32 degrees Fahrenheit). The  
20 greatest difference between acfm and scfm occurs in the summer when the pressure at the  
21 repository horizon is about 14.2 psi and the temperature is about 560 degrees Rankine (100  
22 degrees Fahrenheit). Then

23 
$$1 \text{ scfm} \times (560/492) \times (14.7/14.2) = 1.2 \text{ acfm}$$

24 A reasonably conservative conversion factor, therefore, is 1.2. Using this factor, 35,000 scfm is  
25 very nearly 35,000 x 1.2 or 42,000 acfm.

26 Restricted Access: If the required ventilation rate in an active room when waste disposal is  
27 taking place cannot be achieved or cannot be supported due to operational needs, access is  
28 restricted by the use of barriers, signs and postings, or individuals stationed at the entrance to  
29 the active disposal room when ventilation rates are below 35,000 scfm. Note: As provided in O-  
30 3c(2) entry to restricted access active rooms for the purpose of establishing normal ventilation is  
31 allowed.

32 Shift: Those work shifts when there is normal access to the Waste Isolation Pilot Plant (**WIPP**)  
33 underground.

34 Worker: Anyone who has normal access to the WIPP underground.

1 O-2 Objective

2 The objective of this plan is to describe how the ventilation requirements in the Permit will be  
3 met. This plan achieves this objective and documents the process by which the Permittees  
4 demonstrate compliance with the ventilation requirements by:

- 5 • Maintaining a minimum of 35,000 scfm of air through the active rooms when waste  
6 disposal is taking place and when workers are present in the rooms

7 This plan contains the following elements: Objective; Design and Procedures; Equipment  
8 Calibration and Maintenance; Reporting and Record Keeping; Quality Assurance.

9 O-3 Design and Procedures

10 This section describes the four basic processes that make up the mine ventilation rate  
11 monitoring plan:

- 12 • Test and Balance, a periodic re-verification of the satisfactory performance of the entire  
13 underground ventilation system and associated components
- 14 • Monitoring of active room(s) to ensure a minimum flow of 35,000 scfm whenever waste  
15 disposal is taking place and workers are present in the room
- 16 • Quarterly verification of the total mine airflow

17 O-3a Test and Balance

18 O-3a(1) Test and Balance Process

19 The WIPP ventilation system and the underground ventilation modes of operation are described  
20 in Permit Application A2-2a(3). The Permittees shall verify underground ventilation system  
21 performance by conducting a periodic Test and Balance. The Test and Balance is a  
22 comprehensive series of measurements and adjustments designed to ensure that the system is  
23 operating within acceptable design parameters. The Test and Balance is an appropriate method  
24 of verifying system flow because it provides consistent results based on good engineering  
25 practices. The testing of underground ventilation systems is described in McPherson, 1993.  
26 Once completed, the Test and Balance data become the baseline for underground ventilation  
27 system operation until the next Test and Balance is performed.

28 The "Test" portion of the process shall involve measuring the pressure drop and air quantity of  
29 every underground entry excluding alcoves or other dead end drifts. In addition, the tests shall  
30 verify resistance curves for each of the main regulators, measure shaft resistance, and measure  
31 main fan pressure and quantity. This is done at the highest achievable airflow to facilitate  
32 accurate measurements. From these measurements the frictional resistance of the system is  
33 determined.

34 Pressure shall be measured using the gage and tube method, which measures the pressure  
35 drop between two points using a calibrated pressure recording device and pitot tubes. Pressure  
36 drops across the shafts shall be measured by either calibrated barometers at the top and  
37 bottom of shafts or the gage and tube method. Airflow shall be measured using a calibrated  
38 vane anemometer to take a full entry traverse between system junctions. Fan pressure shall be

1 measured using a calibrated pressure recording device and pitot tube to determine both static  
2 and velocity pressure components.

3 Multiple measurements shall be taken at each field location to ensure accurate results.  
4 Consecutive field values must fall within  $\pm 5\%$  to be acceptable. These data shall be verified  
5 during the testing process by checking that:

- 6 • the sum of airflows entering and leaving a junction is equal to zero; and,
- 7 • the sum of pressure drops around any closed loop is equal to zero.

8 Once the measurements are taken, data shall be used to calculate the resistance of every  
9 underground drift, as well as shafts and regulators using Atkinson's Square Law

10 
$$P=R \times Q^2$$

11 where the pressure drop of an entry (P) is equal to a resistance (R) times the square of the  
12 quantity of air flowing (Q) through the circuit.

13 The "Balance" portion of the process shall involve adjusting the settings of the system fans and  
14 regulators to achieve the desired airflow distribution in all parts of the facility for each mode of  
15 operation. Particular emphasis shall be given to the active disposal room(s) in the Waste  
16 Disposal Circuit to ensure that a minimum airflow of 35,000 scfm is achieved. The system  
17 baseline settings for the current Balance shall be established from the previous Test and  
18 Balance. Adjustments shall then be made to account for changes in system resistance due to  
19 excavation convergence due to salt creep, approved system modifications, or operational  
20 changes.

21 The Permittees shall use a commercially available ventilation simulator to process Test and  
22 Balance field data. The simulator uses the Hardy-Cross Iteration Method (McPherson, 1993) to  
23 reduce field data into a balanced ventilation network, including the appropriate regulator settings  
24 necessary to achieve proper airflow distribution for the various operating modes. Once  
25 balanced, the same simulator shall be used to evaluate changes such as future repository  
26 development and potential system modification before they are implemented.

27 The Test and Balance process culminates in a final report which is retained on site. Following  
28 receipt of the Test and Balance Report, the Permittees shall revise the WIPP surface and  
29 underground ventilation system procedures to incorporate any required changes to the  
30 ventilation system configuration. The Test and Balance data shall be used to adjust the  
31 operating range of fan controls, waste tower pressure, auxiliary air intake tunnel regulator  
32 settings, underground regulator settings, and door configurations. The model data and  
33 procedure changes shall be used to establish normal configuration settings to achieve the  
34 desired airflow in the underground. These settings shall then be modified by operations  
35 personnel throughout the year to compensate for system fluctuations caused by seasonal  
36 changes in psychrometric properties, and to meet specific operations needs. This ensures that  
37 the facility is operated at the design airflow rate for each ventilation mode.

38 O-3a(2) Test and Balance Schedule

39 The Test and Balance is generally conducted on a 12- to 18-month interval, but in no case shall  
40 the interval between consecutive Test and Balance performances exceed 18 months. This

1 interval is sufficient to account for changes in the mine configuration since over this period the  
2 ventilated volume changes very little. The quality and maintenance of ventilation control  
3 structures (e.g., bulkheads) is excellent, so leakage is small and relatively constant. Historic test  
4 and balance results confirm that changes between test and balances fall within anticipated  
5 values.

6 O-3b Total Mine Airflow

7 O-3b(1) Monitoring Total Mine Airflow

8 The Permittees shall use the Central Monitoring Room Operator's (**CMRO**) Log to monitor total  
9 mine airflow. Run-times for the various modes of operation shall be entered into the CMRO Log.  
10 For example, if the CMRO Log indicates that the ventilation system was configured for Alternate  
11 Mode (one main fan) at 8:00 am, and that this configuration was maintained until 11:30 am, a  
12 total of 3.5 hours of run-time in Alternate Mode would be recorded. Run times are recorded to  
13 the nearest quarter hour. The CMRO shall record each time when the ventilation system  
14 configuration is changed, including periods when there is no ventilation.

15  
16 O-3c Active Room Minimum Airflow

17 O-3c(1) Verification of Active Room Minimum Airflow

18 Whenever workers are present, the Permittees shall verify the minimum airflow through active  
19 room(s) when waste disposal is taking place of 35,000 scfm at the start of each shift, any time  
20 there is an operational mode change, or if there is a change in the ventilation system  
21 configuration.

22 O-3c(2) Measurement and Calculation of the Active Room Airflow

23 The Permittees shall measure the airflow rate and use the room cross-sectional area to  
24 calculate the volume of air flowing through a disposal room. The measurement of airflow shall  
25 use a calibrated anemometer and a moving traverse (McPherson, 1993). Airflow measurements  
26 shall be collected at an appropriate location, chosen by the operator to minimize airflow  
27 disturbances, near the entrance of each active room. The excavation dimensions at the  
28 measurement location are taken and the cross-sectional area is calculated. The flow rate is the  
29 product of the air velocity and the cross-section area. The value shall be entered on a log sheet  
30 (see Table O-3) and compared to the required minimum. The format and content of the log  
31 sheet may vary, but will always contain the data and information shown on Table O-3. Working  
32 values are in acfm and the conversion to scfm is described in section O-1 above.  
33 Measurements shall be collected, recorded, and verified by qualified operators.

34 The operator shall compare the recorded acfm value with the minimum acfm value provided at  
35 the top of the log sheet. The airflow shall be re-checked and recorded whenever there is an  
36 operational mode change or a change in ventilation system configuration. Once the ventilation  
37 rate has been recorded and verified to be at least the required minimum, personnel access to  
38 the room is unrestricted in accordance with normal underground operating procedures. If the  
39 required ventilation rate cannot be achieved, or cannot be supported due to operational needs,  
40 access to the room shall be restricted. Those periods when active disposal room access is  
41 restricted shall be documented on the log sheet for that active disposal room. Entry to restricted

1 access active rooms for the purpose of establishing normal ventilation is allowed. Such entry  
2 shall be documented on the log sheet including a reference to the SOP used for reentry,

3 O-3d Quarterly Verification of Total Mine Airflow

4 The Permittees shall perform a quarterly verification of the total mine airflow to ensure that rates  
5 established by the Test and Balance for various operational modes are reasonably maintained.  
6 These checks are identified in Permit Attachment E, Table E-1, and are performed as indicated  
7 in Table E-1.

8 O-4 Equipment Calibration and Maintenance

9 Equipment used for the periodic Test and Balance, quarterly flow verification checks, and daily  
10 verification of active disposal room flow rate shall be calibrated in accordance with appropriate  
11 WIPP calibration and data collection procedures. Work performed by subcontractors shall also  
12 be calibrated to an equivalent standard. Equipment shall be inspected before each use to  
13 ensure that it is functioning properly and that the equipment calibration is current. Maintenance  
14 of equipment shall be completed by qualified individuals or by qualified off-site service vendors.

15 Equipment used to conduct the Test and Balance, Quarterly Verification of Total Mine Airflow,  
16 and to determine the airflow through the active disposal room(s) are provided in Table O-2.

17 O-5 Reporting and Recordkeeping

18 O-5a Reporting

19 The Permittees shall submit an annual report to NMED presenting the results of the data and  
20 analysis of the Mine Ventilation Rate Monitoring Plan. In the years that the Test and Balance is  
21 performed, the Permittees will provide a summary of the results in the annual report.

22 The Permittees shall evaluate compliance with the minimum ventilation rate for an active room  
23 specified in Permit Section 4.5.3.2 on a monthly basis. The Permittees shall report to the  
24 Secretary in the annual report specified in Permit Section 4.6.4.2 whenever the evaluation of the  
25 mine ventilation monitoring program data identifies that the ventilation rate specified in Permit  
26 Section 4.5.3.2 has not been achieved..

27 O-5b Recordkeeping

28 The Permittees shall retain the following information in the Operating Record:

- 29
- The CMRO Log documenting the ventilation system operating mode.
  - 30 • Active disposal room ventilation flow rate readings as documented on the Active  
31 Disposal Room Ventilation Rate Log Sheet (Table O-3).
  - 32 • The quarterly flow verification check and associated documentation.

33 These records will be maintained in the facility Operating Record until closure of the WIPP  
34 facility.

1 O-6 Quality Assurance

2 Quality assurance associated with the Mine Ventilation Rate Monitoring Plan shall comply with  
3 the requirements of the WIPP Quality Assurance Program Description (**QAPD**). The Permittees  
4 shall verify the qualification of personnel conducting ventilation flow measurements. The  
5 instrumentation used for monitoring active disposal rooms shall be calibrated in accordance with  
6 the applicable provisions of the WIPP procedures. The ventilation simulation software programs  
7 shall be controlled in accordance with the WIPP QAPD and WIPP computer software quality  
8 assurance plans.

9 Data generated by this plan, as well as records, and procedures to support this plan shall be  
10 maintained and managed in accordance with the WIPP QAPD. Nonconformance or conditions  
11 adverse to quality as identified in performance of this plan will be addressed and corrected as  
12 necessary in accordance with applicable WIPP Quality Assurance Procedures.

13

## REFERENCES

1

2 McPherson, M. J., 1993. *Subsurface Ventilation and Environmental Engineering*, Chapman &  
3 Hall, London, First Edition.

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## **TABLES**

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**TABLE O-1  
 Ventilation Operating Modes and Associated Flow Rates**

<b>Mode of Operation</b>	<b>Flow Rate (scfm) Nominal Design Values</b>
Normal (two main fans)	425,000
Alternate (one main fan)	260,000
Maintenance Bypass [parallel operation of main fan(s) and filtration Fan(s)]	260,000 to 425,000
Reduced (two filtration fans)	120,000
Minimum (one filtration fan)	60,000
Filtration (one filtration fan)	60,000

**TABLE O-2  
 Mine Ventilation Rate Testing Equipment**

<b>Equipment Used to Conduct Test</b>	<b>Ventilation Test Performed</b>		
	Test and Balance	Active Disposal Room(s)	Quarterly Flow Verification Check
Calibrated Anemometer	X	X	
Calibrated Differential Pressure Sensor	X		
Pitot Tubes	X		X
Tubing	X		X
Temperature Sensing Device	X		X
Relative Humidity Sensor	X		X
Calibrated Barometers	X		X
Electronic Manometer	X		X

