

ATTACHMENT O
WIPP MINE VENTILATION RATE MONITORING PLAN

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O-1 Definitions

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

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

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

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

A reasonably conservative conversion factor, therefore, is 1.2. Using this factor, 35,000 scfm is very nearly $35,000 \times 1.2$ or 42,000 acfm.

Restricted Access: If the required ventilation rate in an active disposal room when waste disposal is taking place cannot be achieved or cannot be supported due to operational needs, access is restricted by the use of barriers, signs and postings, or individuals stationed at the entrance to the active disposal room when ventilation rates are below 35,000 scfm unless measures as described in Section O-3b(1) are implemented. Note: As provided in Section O-3b(2) entry to restricted access active rooms for the purpose of establishing normal ventilation is allowed.

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

Worker: Anyone who has unescorted access to the WIPP underground.

O-2 Objective

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

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

- 1 • If an active room ventilation rate of 35,000 scfm cannot be met, actions as described in
2 Section O-3b(1) shall be taken during waste disposal operations when workers are
3 present.

4 O-3 Design and Procedures

5 This section describes the three basic processes that make up the mine ventilation rate
6 monitoring plan:

- 7 • Test and Balance, a periodic re-verification of the satisfactory performance of the entire
8 underground ventilation system and associated components
- 9 • Monitoring of active disposal room(s) to ensure a minimum flow of 35,000 scfm
10 whenever waste disposal is taking place and workers are present in the room
- 11 • If an active disposal room ventilation rate of 35,000 scfm cannot be met, actions as
12 described in Section O-3b(1) shall be taken during waste disposal operations when
13 workers are present.

14 O-3a Test and Balance

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

16 The WIPP underground ventilation system and the underground ventilation modes of operation
17 are described in Permit Attachment A2, Section A2-2a(3). The Permittees shall verify
18 underground ventilation system performance by conducting a periodic Test and Balance. The
19 Test and Balance is a comprehensive series of measurements and adjustments designed to
20 ensure that the system is operating within acceptable design parameters. The Test and Balance
21 is an appropriate method of verifying system flow because it provides consistent results based
22 on good engineering practices. The testing of underground ventilation systems is described in
23 McPherson, 2009. Once completed, the Test and Balance data become the baseline for
24 underground ventilation system operation until the next Test and Balance is performed.

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

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

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

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

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

$$8 \quad P = R \times Q^2$$

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

11 The "Balance" portion of the process shall involve adjusting the settings of the system fans and
12 regulators to achieve the desired airflow distribution in all parts of the facility for each mode of
13 operation. The system baseline settings for the current Balance shall be established from the
14 previous Test and Balance. Adjustments shall then be made to account for changes in system
15 resistance due to excavation, convergence due to salt creep, approved system modifications, or
16 operational changes.

17 The Permittees shall use an appropriate ventilation simulator to process Test and Balance field
18 data. The simulator uses the Hardy-Cross Iteration Method (McPherson, 2009) to reduce field
19 data into a balanced ventilation network, including the appropriate regulator settings necessary
20 to achieve proper airflow distribution for the various operating modes. Once balanced, the same
21 simulator shall be used to evaluate changes such as future repository development and
22 potential system modification before they are implemented.

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

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

35 The Test and Balance is generally conducted on a 12- to 18-month interval, but in no case shall
36 the interval between consecutive Test and Balance performances exceed 18 months. This
37 interval is sufficient to account for changes in the mine configuration since over this period the
38 ventilated volume changes very little. Maintenance of ventilation control structures (e.g.,
39 bulkheads) occurs periodically to ensure the ventilation structure performs as expected. Historic

1 test and balance results confirm that changes between test and balances fall within anticipated
2 values.

3 O-3b Active Room Minimum Airflow

4 O-3b(1) Verification of Active Room Minimum Airflow

5 Whenever workers are present, the Permittees shall verify the minimum airflow through active
6 room(s) when waste disposal is taking place of 35,000 scfm at the start of each shift, any time
7 there is an operational mode change, or if there is a change in the ventilation system
8 configuration. If an active room ventilation rate of 35,000 scfm cannot be met, measures such
9 as those described below shall be taken during waste disposal operations when workers are
10 present.

11 Measures to allow waste emplacement in an active room when, under abnormal conditions,
12 35,000 scfm cannot be achieved will be prescribed in standard operating procedure(s) (**SOPs**)
13 described in Section O-5c. These measures may include, but are not limited to, the following:
14 the adjustment of the volatile organic compound (**VOC**) immediately dangerous to life or health -
15 based action levels in Permit Part 4, Section 4.6.3.2 (these adjustments are directly proportional
16 to the actual flow rate that is less than 35,000 scfm); or the use of personal protective
17 equipment (**PPE**) as described in Occupational Safety and Health Administration (**OSHA**)
18 Standard 29 Code of Federal Regulations (**CFR**) 1910.134.

19 Implementing measures taken at the WIPP facility regarding the 35,000 scfm ventilation rate
20 and associated details (i.e., date, start time, end time, and reason) will be recorded in the
21 Central Monitoring Room Operator's (**CMRO**) Log and reported to the New Mexico Environment
22 Department (**NMED**) as required by Section O-5a.

23 O-3b(2) Measurement and Calculation of the Active Disposal Room Airflow

24 The Permittees shall measure the airflow rate and use the disposal room cross-sectional area to
25 calculate the volume of air flowing through a disposal room. The measurement of airflow shall
26 use a calibrated anemometer and a moving traverse (McPherson, 2009). Airflow measurements
27 shall be collected at an appropriate location, chosen by the operator to minimize airflow
28 disturbances, near the entrance of each active disposal room. The excavation dimensions at the
29 measurement location are taken and the cross-sectional area is calculated. The flow rate is the
30 product of the air velocity and the cross-section area. The value shall be entered on a log sheet
31 and compared to the required minimum. The format and content of the log sheet may vary, but
32 will always contain the following data and information as applicable:

- 33 • Date
- 34 • Time
- 35 • Ventilation flow rate reading
- 36 • If the required minimum ventilation rate was achieved
- 37 • If the room was restricted

- 1 • If Section O-3b(1) measures will be implemented (implementing procedure and revision
- 2 number, if applicable)
- 3 • The reason for waste emplacement under 35,000 scfm ventilation rate, if applicable
- 4 • Signature

5 Working values are in acfm and the conversion to scfm is described in Section O-1 above.
6 Measurements shall be collected, recorded, and verified by qualified operators.

7 The operator shall compare the recorded acfm value with the minimum acfm value provided at
8 the top of the log sheet. During waste disposal operations, the airflow shall be re-checked and
9 recorded whenever there is an operational mode change or a change in ventilation system
10 configuration. Once the ventilation rate has been recorded and verified to be at least the
11 required minimum, personnel access to the room is unrestricted in accordance with normal
12 underground operating procedures. If the required ventilation rate cannot be achieved, or
13 cannot be supported due to operational needs, access to the room shall be restricted. Those
14 periods when active disposal room access is restricted shall be documented on the log sheet for
15 that active disposal room. Entry to restricted access active rooms for the purpose of establishing
16 normal ventilation or for emplacing waste under the conditions identified in Section O-3b(1) is
17 allowed. Such entry shall be documented on the log sheet including a reference to the SOP
18 used.

19 O-4 Equipment Calibration and Maintenance

20 The list of equipment used to conduct the Test and Balance and to determine the airflow
21 through the active disposal room(s) is provided in Table O-1.

22 Equipment shall be calibrated, as appropriate, in accordance with WIPP facility calibration and
23 data collection procedures. Work performed by subcontractors shall also be calibrated to an
24 equivalent standard. Equipment shall be inspected before each use to ensure that it is
25 functioning properly and that the equipment calibration is current. Maintenance of equipment
26 shall be completed by qualified individuals or by qualified off-site service vendors.

27 O-5 Reporting and Recordkeeping

28 O-5a Reporting

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

32 The Permittees shall evaluate compliance with the minimum ventilation rate for an active room
33 specified in Permit Part 4, Section 4.5.3.2 on a monthly basis. The Permittees shall report to the
34 Secretary in the annual report specified in Permit Part 4, Section 4.6.4.2 whenever the
35 evaluation of the mine ventilation monitoring program data identifies that the ventilation rate
36 specified in Permit Part 4, Section 4.5.3.2 has not been achieved. The Permittees will identify
37 the implementing measures as described in Section O-3b(1) used to allow waste handling
38 activities to proceed when the 35,000 scfm ventilation rate is not achieved. These implementing

1 measures and associated details (i.e., date, start time, end time, and reason) will be reported to
2 NMED in the annual Mine Ventilation Rate Monitoring Report required by this section.

3 The Permittees shall also notify NMED by e-mail within 15 calendar days of commencement of
4 waste emplacement operations taking place below 35,000 scfm. The notification shall include
5 the date, start time, end time, reason and implementing measure taken, as applicable. If the
6 Permittees have not completed the waste emplacement activity by the time of this notification, a
7 follow-up e-mail shall be provided within 15 calendar days to notify NMED of the end of the
8 waste emplacement activity and other relevant information not previously provided.

9 O-5b Recordkeeping

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

- 11 • The CMRO Log documenting the ventilation system operating mode.
- 12 • Active disposal room log sheet documenting the ventilation flow rate readings and
13 applicable information listed in Section O-3b(2).

14 These records will be maintained in the facility Operating Record until closure of the WIPP
15 facility.

16 O-5c Standard Operating Procedure Applicable to Abnormal Operating Conditions for
17 Active Room Ventilation Flow Rate

18 The abnormal operating conditions procedure provides instructions necessary to evaluate VOC
19 concentrations in an adjacent filled room prior to commencing waste emplacement operations in
20 an active disposal room when workers are present at a reduced active room ventilation flow
21 rate. Abnormal conditions that may prevent 35,000 scfm from being met, may include, but are
22 not limited to, barometric pressure changes, maintenance activities, and equipment
23 malfunctions. VOC data in the adjacent filled room are collected and analyzed in accordance
24 with Permit Part 4, Section 4.6.3. Adjusted VOC action levels are prescribed at a maximum of
25 5,000 scfm increments (e.g., 30,000 scfm, 25,000 scfm, 20,000 scfm, 15,000 scfm, and 10,000
26 scfm) to provide a means of assessment. When the measured flow rates fall between the
27 increment values in the SOP, the lower flow rate is used for determining the adjusted VOC
28 action level. The validated VOC monitoring data are compared to the action levels prescribed in
29 the standard operating procedure and a decision flow path is provided to the Facility Shift
30 Manager, or designee, to determine applicable actions.

31 These actions include, but are not limited to, commencing waste emplacement operations at a
32 reduced active room ventilation flow rate based on the adjusted VOC action levels, commencing
33 waste emplacement operations at a reduced active room ventilation flow rate with the use of
34 PPE as described in OSHA standard 29 CFR 1910.134, or restricting access to the active
35 disposal room until the ventilation flow rate requirements of Permit Part 4, Section 4.5.3.2 are
36 met. As stated in the abnormal operating conditions procedure, implementing measures taken
37 at the WIPP facility are recorded in the CMRO Log and reported to NMED as required by
38 Section O-5a.

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 O-7 References

14 McPherson, Malcolm J. 2009. *Subsurface Ventilation Engineering*. 2nd. Fresno, California: Mine
15 Ventilation Services Inc.

1

TABLES

2

1
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**Table O-1
 Mine Ventilation Rate Testing Equipment**

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

3