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 x 1.2 or 42,000 acfm.

Restricted Access: If the required ventilation rate in an active disposal room 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.

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

Worker: Anyone who has normal 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 an annual running average of 260,000 scfm through the underground repository
- Maintaining a minimum of 35,000 scfm of air through the active disposal rooms when workers are present in the rooms

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

~~O-3 Implementation and Approval~~

~~The Permittees have implemented this plan and it will be maintained in the facility Operating Record until closure of the WIPP facility.~~

O-3 Design and Procedures

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

- Test and Balance, a periodic re-verification of the satisfactory performance of the entire underground ventilation system and associated components
- Monitoring and calculation of the Running Annual Average of the Total Mine Airflow to verify achievement of the 260,000 scfm minimum requirement
- Monitoring of active disposal room(s) to ~~assure~~ ensure a minimum flow of 35,000 scfm whenever workers are present in the room
- Quarterly verification of the total mine airflow

O-3a Test and Balance

O-3a(1) Test and Balance Process

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

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

Pressure ~~is~~ shall be measured using the gage and tube method, which measures the pressure drop between two points using a calibrated pressure recording device and pitot tubes. Pressure drops across the shafts ~~are~~ shall be measured by either calibrated barometers at the top and bottom of shafts or the gage and tube method. Airflow ~~is~~ shall be measured using a calibrated

vane anemometer to take a full entry traverse between system junctions. Fan pressure ~~is~~ shall be measured using a calibrated pressure recording device and pitot tube to determine both static and velocity pressure components.

Multiple measurements ~~are~~ shall be taken at each field location to ~~assure~~ ensure accurate results. Consecutive field values must fall within ±5% to be acceptable. These data ~~are~~ shall be verified during the testing process by checking that:

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

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

$$P=R \times Q2$$

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

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

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

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

O-3a(2) Test and Balance Schedule

The Test and Balance is generally conducted on a 12- to 18-month interval, but in no case shall the interval between consecutive Test and Balance performances exceed 18 months. ~~an~~ This interval is sufficient to account for changes in the mine configuration since over this period the ventilated volume changes very little. The quality and maintenance of ventilation control structures (e.g., bulkheads) is excellent, so leakage is small and relatively constant. Historic test and balance results confirm that changes between test and balances fall within anticipated values. ~~In no case will the interval between Test and Balance performance be greater than 18 months.~~

~~The Permittees select the specific time to conduct the Test and Balance based on the following operational considerations:~~

- ~~Available testing windows~~
- ~~Operational considerations~~
- ~~Ongoing or upcoming system modification considerations~~
- ~~Availability of testing personnel~~

O-3b Running Annual Average of the Total Mine Airflow

O-3b(1) Monitoring Total Mine Airflow

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

O-3b(2) Calculation of the Running Annual Average of Total Mine Airflow

The Permittees shall calculate the running average flow rate on a monthly basis. The Permittees shall use the logged runtime data for various modes of operation (as described in O-3b(1)) and the nominal design flow-rates for the various modes presented in Table O-1 to calculate the average monthly flow rate for the facility.

The average monthly mine flow rate is computed monthly using the following formula:

Monthly Average Flow Rate = {[Normal Mode Run-time (hrs.) x 425,000 scfm]
+ [Alternate Mode Run-time (hrs.) x 260,000 scfm]
+ [Maintenance Bypass Run-time (hrs.) x 260,000 scfm]
+ [Reduced Mode Run-time (hrs.) x 120,000 scfm]
+ [Minimum Mode Run Time (hrs.) x 60,000 scfm]
+ [Filtration Mode Run-time (hrs.) x 60,000 scfm]}
/ 730 Hours per month.

The running annual average of total mine airflow annual average flow rate ~~is~~ shall be calculated using the monthly averages and the following formula:

$$\text{Annual Average Flow Rate} = \frac{\sum \text{Monthly Average for Previous 12 Months}}{12}$$

The use of an average value of 730 hours per month in the monthly average calculation is reasonable, given that all the numbers involved are very large and that the final use of the monthly average flow is in an annual calculation. The Permittees will notify NMED within seven calendar days if either the minimum running annual average mine ventilation exhaust rate of 260,000 scfm ~~and~~ or a minimum active room ventilation rate of 35,000 scfm when workers are present in the room are not achieved.

O-3c Active Disposal Room Minimum Airflow

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

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

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

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

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

O-3d Quarterly Verification of Total Mine Airflow

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

O-4 Equipment Calibration and Maintenance

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

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

O-5 Reporting and Record Keeping

O-5a Reporting

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

The Permittees shall calculate the running annual average mine ventilation rate on a monthly basis and evaluate compliance with the minimum active room ventilation rate specified in O-3b(2) on a monthly basis. Whenever the evaluation of the mine ventilation monitoring program data identifies that the ventilation rates specified in O-3b(2) have not been achieved, the Permittees will notify the Secretary in writing within seven calendar days.

O-5b Record Keeping

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

- The CMRO Log documenting the ventilation system operating mode.
- The underground facility running annual average mine ventilation rate on a monthly basis.
- Active disposal room ventilation flow rate readings as documented on the Active Disposal Room Ventilation Rate Log Sheet (Table O-3).
- The quarterly flow verification check and associated documentation.

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

O-6 Quality Assurance

Quality assurance associated with the Mine Ventilation Rate Monitoring Plan shall comply~~ies~~ with the requirements of the WIPP Quality Assurance Program Description (**QAPD**). The Permittees shall verify the qualification of personnel conducting ventilation flow measurements. The instrumentation used for monitoring both underground and active disposal ~~is~~ shall be

calibrated in accordance with the applicable provisions of the WIPP procedures. The software used to calculate the monthly and annual running averages and the ventilation simulation software programs ~~are~~ shall be controlled in accordance with the WIPP QAPD and WIPP computer software quality assurance plans.

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

REFERENCES

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

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TABLES

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TABLE O-1
Ventilation Operating Modes and Associated Flow Rates

Mode of Operation	Flow Rate (scfm) Nominal Design Values
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

Equipment Used to Conduct Test	Ventilation Test Performed		
	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

TABLE O-3
Active Disposal Room Ventilation Rate Log Sheet (Example)

ROOM NUMBER _____

NOTE: When airflow reading is below 42,000 acfm, access will be restricted.

DATE	TIME	AIRFLOW READING	WAS 42,000 ACFM ACHIEVED?		ROOM ACCESS WAS RESTRICTED?		SIGNATURE	VERIFIED BY
			YES	NO	YES	NO		