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AN ANALYSIS OF THE MONITORING OF ROOMS AND PANELS AT WIPP

April 2006

PECOS MANAGEMENT SERVICES, INC.

ISO-2 Project
Carlsbad, NM

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ACRONYMS

ASER	Annual Site Environment Reports
CAMs	Continuous Air Monitors
CCA	Compliance Certification Application
CEMRC	Carlsbad Environmental Monitoring & Research Center
CFR	Code of Federal Regulations
CH	Contact Handled
CPRs	Cellulosics, plastics, and rubbers
CRA	Compliance Recertification Application
DOE	Department of Energy
DRZ	Disturbed Rock Zone
EPA	Environmental Protection Agency
HEPA	High Efficiency Particulate Air
HSGA	Head Space Gas Analyses
HWTF	Hazardous Waste Treatment Facility
NM	New Mexico
NMED	New Mexico Environment Department
NRC	National Research Council
PA	Performance Assessment
PL	Public Law
RH	Remote Handled
TRU	Transuranic
VOC	Volatile Organic Compounds
WIPP	Waste Isolation Pilot Project
WRES	Washington Regulatory and Environmental Services

AN ANALYSIS OF THE MONITORING OF ROOMS AND PANELS AT WIPP — *April 2006*

I. SCOPE AND PURPOSE

This report focuses on current and proposed monitoring plans for active and closed rooms and panels at the Waste Isolation Pilot Project (WIPP). The purpose of the report is to determine—from the environmental, safety, and health perspective—whether there are benefits to monitoring inside active and closed rooms in active panels and inside closed panels. Two monitoring applications are considered herein:

1. *Worker Safety* – while working in a panel after rooms are closed and while working in the repository after panels are closed; and
2. *Short- and Long-Term Repository Performance* – verify or revise assumptions and improvements to modeling and forecasting future conditions. Though generally more applicable to expansions to the WIPP or to the development of new repositories, this could include improved worker and public safety and risk reduction as well as more cost-effective operational efficiencies.

Data in this report are derived from the evaluation of information and documentation available in the public domain as well as from interviews with selected WIPP personnel.

II. BACKGROUND

Presently, there is no other operational repository for defense-related TRU waste within the United States. The generation of TRU waste is expected to continue after the WIPP reaches its limit; therefore, it is likely there will be a future need to either expand the WIPP repository, establish a new repository, or both. Operating requirements for the WIPP repository were developed following extensive experimental studies at several national laboratories and other institutions during which various models were tested. Though the performance assessed to 10,000 years, the initial operating requirements, including requirements to monitor pre-closure conditions within the repository, were not based on data from a functioning repository and were limited to monitoring active areas of the repository. Continued monitoring in closed rooms and panels would therefore provide an opportunity to obtain data from a functioning repository, an invaluable advantage in planning exercises for a new repository or for an expansion of the WIPP repository.

The background for this report, with respect to the issue of monitoring in closed rooms and panels, is presented in three sections: II.A. *Worker Safety*, II.B. *Short- and Long-Term Repository Performance*, and II.C. *Recent Inputs from DOE*.

II.A. Worker Safety

The purpose of worker safety monitoring programs associated with waste disposal activities in active rooms and panels is to detect any existing or developing conditions that could or would cause harm to the workers. Worker safety monitoring in the repository portion of the WIPP currently consists of three programs:

- Volatile Organic Compounds (VOC) Monitoring,
- Radiological Dose and Constituent Monitoring, and
- Geomechanical monitoring of the mined openings.

The VOC monitoring program requirements are specified in the Hazardous Waste Treatment Facility (HWTF) Permit for the Waste Isolation Pilot Project issued by the New Mexico Environment Department (NMED) in 1999 as modified through 2005 (NMED1999). The CH TRU Waste Documented Safety Analysis (DOE/WIPP 95-2065) details the requirements for the radiological dose and constituent monitoring in the repository, and repository geomechanical monitoring requirements are specified in the Compliance Certification Application (CCA1996) as updated in the Compliance Recertification Application (CRA2004) approved by the US Environmental Protection Agency (EPA) and the HWTF Permit (NMED1999).

VOC Monitoring. The VOC monitoring programs for the WIPP currently contain two elements. The first is head space gas analyses (HSGA) of TRU waste containers, which identifies and quantifies concentrations of selected VOC constituents. The second element is the monitoring of nine VOCs in the repository at a permanent station located downstream of all operations as well as at a moveable station, which is always located upstream of the closed and active panels to ensure concentrations of those VOCs do not exceed the limits established in Section IV and Appendix N of the HWTF Permit (NM1999). The nine target VOCs for this sampling plan are: carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethylene, 1,2-dichloroethane, methylene chloride, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane. These target VOCs were selected because together, they represent approximately 99 percent of risk due to air emissions.

The Department of Energy (DOE) has proposed a modification to the VOC monitoring program that would replace the HSGA requirement with a system to directly measure (sampling, analysis, and quantification) the concentration of the nine VOCs identified above in the atmosphere of each room of active disposal panels in which TRU mixed waste has been emplaced (DOE2005). This VOC monitoring will commence when the room is activated for waste disposal and will continue until the active panel is closed. This modification is in response to specific language in PL 108-137 and PL 108-447, and the NMED has incorporated this proposed VOC monitoring approach into the proposed HWTF permit modifications presented in the 311-RH Draft Permit (NMED2005).

Radiological Dose and Constituent Monitoring. The current radiological monitoring program for active disposal rooms and panels includes two alpha continuous air monitors (CAMs) and a beta CAM at the exit of the active room. The CAMs are typically in operation in the underground except when removed for maintenance or outage activities. The CAMs continually collect and measure airborne particulates by pulling air through a filter in proximity to an integral beta-gamma and/or alpha spectrometer. These underground CAMs provide a local and remote readout and alarm in the Central Monitoring Room. Each CAM is set to alarm within the limits in 10 CFR Part 835.1. Alpha CAMs are sensitive to an energy range of 1 MeV to 10 MeV. The Beta CAM has an energy range from 80 KeV to 2.5 MeV. The CAMs located in the exhaust of the active disposal room divert the underground ventilation exhaust through HEPA filters prior to release to the environment. In addition to the CAMS, the unfiltered repository ventilation air is sampled and analyzed for radionuclides (DOE/WIPP 95-2065) prior to release. There are no current or proposed radiological monitoring systems in either closed rooms or panels.

Geomechanical Monitoring. The current geomechanical monitoring program is specified in Attachment M2 of the HWTF Permit (NMED2003). It provides in situ data to support continuous assessment of the design for underground facilities, including:

- Early detection of conditions that could affect operational safety,
- Evaluation of disposal room closure that ensures adequate access,
- Guidance for design modifications and remedial actions, and
- Comparison of the behavior of underground openings with established design criteria.

This monitoring program consists of geomechanical instrumentation installed in the shafts and along the drifts of the WIPP facility as well as at numerous points in the panels and rooms to determine the physical measurement of salt creep both horizontally and vertically; it also allows frequent inspections of ceilings, walls, and floors of the active excavated areas for indications of loosening salt pieces. There are currently no provisions for geomechanical monitoring in closed rooms or panels nor are there plans for such monitoring.

II.B. Short- and Long-Term Repository Performance

With respect to the acquisition of operational data that would reduce uncertainties associated with the modeling and forecasting of future conditions, a National Research Council (NRC) committee on the WIPP produced a 2001 report entitled "Improving Operations and Long-Term Safety of the Waste Isolation Pilot Plant: Final Report" (NRC2001), which states in its Executive Summary (page one, fourth paragraph):

> "*The **overarching finding and recommendation** of this report is that the activity that would best enhance confidence in the safe and long-term performance of the repository is to monitor critical performance parameters during the long pre-closure phase of repository operations (35 to possibly 100 years). Indeed, in the first 50 to 100 years the rates of important processes such as salt creep, brine inflow (if any), and microbial activity are predicted to be the highest and will be less significant later. The committee recommends that the results of the on-site monitoring program be used to improve the performance assessment for recertification purposes.*"

The only monitoring program within the repository associated with collection of data related to the short- and long-term repository performance and the update/upgrade of the Performance Assessment (PA) or other modeling for the WIPP is the geomechanical portion of the monitoring program specified in the 1996 Compliance Certification Application (CCA) in Chapter 7.2.3.1, Appendix MON.4.1, and Appendix GTMP (CCA1996).

The geomechanical monitoring required for the active excavated areas of the repository is designed to determine:

- Creep closure and stresses,
- Initiation of brittle deformation,
- Extent of brittle deformation, and
- Displacement of deformation features.

For reasons detailed in the following section, no monitoring is being conducted nor is any monitoring planned for the closed rooms and/or panels with respect to verification or correction of the assumptions used in the PA, particularly with respect to the postulated gas generation and consequent potential effects.

II.C. Recent Inputs from DOE

After an initial evaluation of the documentation regarding the monitoring of closed rooms and panels, an information exchange meeting was held between PECOS and WIPP staff on February 14, 2006, during which the history, current operations, and plans for the monitoring of closed rooms and panels were reviewed. Discussion included possible parameters in addition to the nine VOCs that could be measured by the proposed closed room monitoring system. These parameters and their purpose are shown below:

- *Methane* – monitor for worker health and safety, explosion potential, and information on waste degradation;
- *H2* – monitor for worker health and safety and information on corrosion;
- *O2* – monitor for verification of early onset of anoxic conditions;
- *N2, CO2, H2S* – monitor for indications of microbial degradation;
- *Partial Pressure of Water Vapor* – information on brine inflow;
- *Room Gas Pressure* – monitor for gas generation rates; and
- *Radioactive material releases* – monitor for loss of containment within the panel.

The proceedings of that meeting are summarized in a report dated March 3, 2006 (PECOS2006).

III. SUMMARY OF FINDINGS

The analysis of the rooms and panels monitoring programs was accomplished by dividing the analysis into two major subtopics: Worker Safety and Short- and Long-Term Repository Performance. The available information and documentation on appropriate issues for each subtopic were evaluated, and the findings are presented in the following sections.

III.A. Worker Safety

The issues evaluated from the worker safety perspective include:

- VOC production from wastes stored in the WIPP,
- Radiation dose and material releases, and
- Production of other gases from wastes stored in the WIPP.

VOC Production. The primary source for the production of VOCs from the waste was projected to be the evaporation of any VOCs contained in the waste drums. Due to high VOC concentrations measured in unvented drums, the possibility of worker exposure to VOCs was a major concern during the initial WIPP permitting and certification process. However, results of the HSGA performed on over 70,000 drums of TRU Waste, some of which are summarized in the report entitled "Monitoring of Airborne Volatile Organic Compounds in Disposal Rooms at the Waste Isolation Pilot Plant, Carlsbad, New Mexico" (WRES2005), indicate that the highest VOC concentration measured by HSGA was five orders of magnitude below the associated action level established by HWTF permit (NMED1999). The potential production of VOCs is also limited by the requirement that the waste containers contain less than 1% by volume of liquids (DOE/WIPP-02-3122). Given the basic volatility of the VOCs and the results of HSGA conducted to date, it is a reasonable conclusion that any liquids remaining in the waste container after disposal in WIPP do not contain significant quantities of VOCs. More likely, the liquids will be water, oils, or a mixture thereof.

Another worker safety concern is the possibility for dispersion of VOCs from the waste containers into the air in active rooms or from active or closed rooms into active panels, which would thereby expose workers. First, the ventilation airflow maintained in the active rooms and panels would dilute any VOCs generated from the stored wastes, further reducing the risk of VOC concentrations exceeding the actions levels by a factor of more than five orders of magnitude. Secondly, when a room is filled, it is closed with a flexible membrane but is not hermetically sealed; therefore, any VOC releases in closed rooms could diffuse into the active panel, where they would immediately be further diluted by the ventilation air in the panel, posing no risk to the workers.

It was also postulated that a ceiling fall in either an active or closed room could result in a "puff" of higher concentration VOCs. This possibility was examined in the "Technical Evaluation Report for WIPP Room-Based VOC Monitoring" (WRES2003), which indicated that the proposed disposal room VOC monitors would provide ample warning of such occurrences. However, there are several other factors that reduce the possibility that a "puff" of higher concentration VOCs will occur.
First, as indicated above, there are essentially no VOCs expected to be present in the wastes. The highest concentrations of VOCs found by HSGA were still five orders of magnitude less than the allowable concentration limits (WRES2005). Thus, even if all the VOCs were released as a "puff," the VOC concentration of the "puff" would still be less than .001% of the allowable concentration limits prior to dilution by room/panel atmosphere.

Secondly, the ceilings as well as the walls in the rooms and panels have been rockbolted to prevent the loss of structural integrity and subsequent fall of the salt. The effectiveness of this program is demonstrated by the fact that there have not been any ceiling falls of any appreciable size (greater than one or two square feet or greater than 100 pounds) since the initial mining of the drifts and support areas in the 1987-1988 time frame—a period of over 17 years. Because two panels have been filled in less than six years, it is not anticipated that any panel where there is active waste disposal will be open for more than three years. Therefore, the probability of a ceiling fall in a room or panel is very low.

Finally, the waste containers are generally stacked to within 3 to 4 feet of the ceiling of the room and topped with approximately 1½ feet of magnesium oxide, which is contained in woven polypropylene bags (CRA2004, Chapter 3, pages 3-17). Because the waste containers are primarily structurally sound metal containers, in the case of a significant ceiling fall, the salt would only drop about 1½ to 2½ feet onto the magnesium oxide bags and would therefore not build up significant momentum. If the salt were to fall on the bags, the bags would split, and the magnesium oxide would cascade out of the split packs down around the waste containers, an action that would absorb and dissipate much of any momentum associated with the fallen salt. Once the magnesium oxide is dispersed, the fallen salt would weigh directly upon the waste containers, which are generally able to withstand significant stresses and would not necessarily be crushed to the point of releasing the small amounts of VOCs that may still be within the containers. The sum of these factors indicates it is highly unlikely a ceiling fall in an active or closed room would generate VOC concentrations of concern for worker safety.

While it is possible that greater quantities of any residual VOCs (but still not enough to be of worker safety concern) might be released after the salt creep compacts the waste containers, it is not expected that this condition will occur for at least 20 years after room closure, as discussed in more detail below, which thus makes this possibility moot with respect to worker safety during the expected operating life of any individual panel within the WIPP.

Once the panels are closed, ventilation airflow ceases. So the only mechanism for significant transport of the VOCs into active parts of the WIPP is through a positive pressure differential between the closed panels and the drifts. Such a positive pressure differential would primarily occur as a result of either ceiling falls, which would cause an instantaneous, but transient, pressure rise; or salt creep, which would cause a low, but steady pressure differential over time. The other possible source of VOC transport from closed panels would be the result of a pressure increase associated with secondary gas generation, which requires brine intrusion into the room, either from seepage from the disturbed rock zone (DRZ) or as a result of drilling activities. Studies of the DRZ brine inflow for the WIPP point to the following deduction: *"The volume of Salado brine inflow during disposal operations is very small, and is insufficient to warrant any preventive measures"* (SAND2000). Brine inflow from drilling is not predicted to occur until 100 years or more post repository closure.

Additional substantiation of the minimal impact of the VOCs associated with the waste disposal operations in WIPP is provided in Section 5.4 of the Annual Site Environment Reports for 2004 and Section 5.3 of the Annual Site Environment Reports for 2003, and 2002 (ASER2002, 2003, 2004), which indicate that none of the nine VOCs have been detected at or above the method reporting limits.

Radiation Dose and Material Releases. There have been no reports that the CAMs or any other radiation monitoring devices deployed in the repository have detected any releases of radioactivity from any of the active disposal rooms in the seven years of operational history. No radionuclides have been found in the repository exhaust with the exception of one quarterly composite sample collected in 2003 that was determined by the Carlsbad Environmental Monitoring & Research Center to be an anomaly (CEMRC2004). The possibility of release of radioactive materials from a closed room or panel would require that the waste containers be breached; and the most likely mechanism for breaching of the waste containers during the remaining active life of the repository would be due to ceiling fall or salt creep. As discussed in the **VOC Production** section above, the possibility of a ceiling fall occurring and consequently causing breach of the waste containers is remote, as is the possibility a salt creep (discussed in more detail in a following section) will cause a container breach within the next 20 to 30 years.

Production of Other Gases from Wastes. The worker safety concern with the possible production of other gases from the wastes in a closed room or panel relates to either a large pressure increase or the generation of an explosive or flammable mixture and the consequent failure of the isolation wall. The first standing Committee on WIPP, under the NRC, issued its final report in1996 titled “The Waste Isolation Pilot Plant: A Potential Solution for the Disposal of Transuranic Waste.” Included in the scope of the NRC1996 report was the issue of gas generation from three sources:

1) *Radiolysis*;
2) *Anoxic corrosion*, the chemical reaction of the carbon steel waste containers with any brine that might be present to produce mainly hydrogen gas; and
3) *“Microbial reactions”* with some of the organic waste constituents, e.g., cellulose.

Radiolysis. Laboratory experiments and model calculations have shown radiolysis to be insignificant. Thus, there will be no significant contribution to the gas pressure due to decomposition of cellulosics, plastics, and rubbers (CPRs) by particulate and electromagnetic radiation. Radioactive decay and exothermic reactions produce heat, which can increase gas pressure. The contribution of these two factors is expected to cause an increase in temperature within the repository of less than 10 degrees Centigrade. An increase in temperature of this magnitude is insignificant (CRA2004, Chapter 6).

Anoxic Corrosion. In the 1996 NRC report cited above, the following conclusions about anoxic corrosion were presented in Chapter 3, pages 39 & 40:

> *"Anoxic corrosion of steels . . . will produce significant quantities of H_2 and consume significant quantities of H_2O if*
> 1) *. . . sufficient brine enters the repository after filling and sealing;*
> 2) *Significant microbial activity . . . does not occur; and*
> 3) *Under humid conditions (gaseous, but not aqueous, H_2O present) anoxic corrosion of steels and other Fe-base alloys will not occur"*

At present, there is no evidence that there are any brine pockets moving within the repository. Therefore, corrosion of metal alloys to produce hydrogen gas will be limited by the amount of water present in the waste drums. As mentioned above, the WIPP Waste Acceptance Criteria require that the waste containers contain less than 1% by volume of liquids (DOE/WIPP-02-3122). Further, the references seem to suggest that the small amount of liquid in the waste containers is not only water, which further reduces the potential for hydrogen production. Thus, the amount of hydrogen produced in the atmosphere of closed rooms or panels is not expected to be enough to support deflagration during the pre-closure time period of the WIPP.

Microbial Reactions. The 1996 NRC report cited above concluded that with respect to gas generation by microbial action (from Chapter 3, page 41), "Biological gas generation will be no more than a brief transient because it will be limited by brine availability as well as by nutrient depletion."

For completeness in this background section, the following text concerning gas generation in the repository appears in the Executive Summary of the NRC 1996 report (page 5, item 9):

> "*Gas generation will be minimal in a dry or nearly dry repository such as WIPP because both chemical and biological gas-generating processes (e.g., metal corrosion and bacterial action on organic matter) require a liquid phase for mass transport of the reactants and products that are involved in gas formation*."

A review of the Compliance Recertification Application (CRA), Chapter 6 determined that the anaerobic microbial degradation of CPRs would generate carbon dioxide and methane gases. The generation process is reasonably expected to be slow, with cellulosics degrading the most rapidly and rubbers degrading the slowest. Microbial reactions require water but do not consume or produce water. Absence the inflow of brine to a closed room or panel, the only source of water available to sustain microbial degradation is, as is the case for anoxic corrosion, the water contained within the waste container. Because the amount of liquid is less than 1% by volume of each waste container and because the generation process is slow, no significant buildup of methane following room or panel closure is expected.

Finally, the room closure system is not impermeable. Any gas generation in a closed room would vent to the active panel, and the ventilation system would immediately dilute it. Similarly, the panel closure explosion wall and the DRZ around the explosion wall are not designed to be impermeable. Any gas generation in a closed panel would vent to the open repository and thus evade any pressure buildup.

III.B. Short- and Long-Term Repository Performance

The CCA and other early documentation presented during the development and licensing of the WIPP identified numerous issues that were considered to have the potential to cause releases of radioactive material during and after closure of the WIPP. In order to verify or improve the PA or other predictive tools for short- and long-term purposes, the 2001 NRC report cited above recommended expanded monitoring programs for the following:

- Gas generation,
- Brine intrusion and impacts, and
- Impact of geomechanical changes on closed rooms and panels.

Gas Generation. The issue of gas generation is presented in detail in the **Worker Safety** Section above. The consensus of the documentation on that topic is that gas generation is not expected to occur while the repository is active, primarily due to the absence of brine (discussed in more detail below) and to the slow transition of the atmosphere to anoxic conditions in closed rooms and panels. However, the assumptions used for gas generation in the PA were not based on any tests of measurements conducted in conditions that were comparable to closed rooms or panels.

Brine Intrusion and Impacts. As indicated above, the key factor in the production or lack of gases in closed rooms and panels is the presence of water or brine. The possibility of brine inflow has been examined extensively during the planning and development of WIPP, and several possible pathways have been postulated including:

- Drainage from the DRZ,
- Brine inflow from other layers in the Salado formation, and
- Brine inflow due to human intrusion (drilling).

Drainage from the DRZ. Testing of the Salado formation salt indicates that it contains less than 1% water by volume (CCA1996, Appendix GCR). Further, the change in permeability and pressures in the salt in the DRZ resulted in the release and movement of that water into the open spaces of the WIPP repository as shown by the infrequent salt nodes and small stalactites that have formed on the walls and ceilings of underground workings. However, the relative volume of the released brine is very small and evaporates almost immediately upon exposure to the atmosphere in the repository. It is recognized that no data regarding brine inflow has been collected in either closed rooms or panels in the WIPP to support the assumption in the PA that the DRZ drainage would flow into a closed room or panel in sufficient quantities to cause any significant gas generation in the short term. The required long-term (post-closure) monitoring program will not provide any new data about brine inflow from the DRZ.

Brine inflow from other layers in the Salado formation. A review of the two NRC reports cited above and the CRA (Chapter 6) indicates that this possibility was included in the evaluation of possible releases in the "Undisturbed Performance" scenario and was determined to be of no concern both during the active operational period of WIPP and for centuries thereafter. An earlier paper by Knowles and Economy that determined, "*Brine inflow is of significance only with respect to its influence on the long-term, post-closure behavior of the disposal system over the 10,000 year regulatory period*" (SAND2000) further substantiated this conclusion.

Brine inflow due to human intrusion (drilling). The CRA (Chapter 6, pages 6-7) indicates that the "Disturbed Performance" scenarios include possibilities of boreholes being drilled in and through the repository with the consequent release of brine into the repository; however, both the CCA and CRA require that active institutional controls of the WIPP property will be effective for at least 100 years post-closure (CCA1996, CRA2004).

In summary, it is not expected that there will be sufficient brine inflows to closed rooms or panels during the operational period of WIPP that would support any of the gas generation scenarios. Also, there is no current or planned data collection that will update the post-closure brine inflow assumptions used in the PA.

Impact of Geomechanical Changes. The primary geomechanical change of concern with respect to closed rooms and panels is salt creep. As summarized in the 1996 NRC report cited above, excavations at the WIPP will creep closed by movement inwards from the entire volume of salt. The report also states, "*. . . measurements at WIPP show that open rooms tend to close at a constant rate of about 1 percent per year*" (Chapter 4, page 48). Appendix B of The Design Report for a Revised Panel Closure System at the Waste Isolation Pilot Plant, Amended Closure Plan Permit Modification Request to the NMED in October 2002, presented data that indicated an estimated creep closure rate of about 2 percent per year for the panels (DOE2002). Using that rate and the assumptions stated in that same report that the void volume in a panel is approximately 90%, at the time of projected WIPP closure in 2035, the volume of Panel 1 would have been reduced by less than one-half and the other panels even less. Based upon this data, salt creep will not result in any significant increase in gas pressure through waste consolidation during the active life of WIPP. However, it appears that the assumptions about salt creep made for the PA were not based on actual construction and stabilization techniques in use in the WIPP.

IV. CONCLUSIONS

Based on the information reviewed as summarized above, the following conclusions are presented.

IV.A. Worker Safety

The history of measured VOC concentrations in over 70,000 drums has demonstrated that there are insufficient quantities of VOCs available in the wastes (the highest VOC concentration measured was five orders of magnitude less than the action level) to pose a threat to worker health or safety, even if all VOCs in all the waste containers in a room were emitted instantaneously. Therefore, the proposed active and closed room VOC monitoring system is not necessary, though it does provide a reasonable backup to the primary VOC monitoring system for the WIPP.

Available data and information indicate there is no worker safety issue with respect to gas generation because the prerequisite conditions (brine inflow, anoxic atmosphere) will not materialize in closed rooms or panels during the active life of the repository. However, the proposed active and closed room monitoring system could be adapted to provide DOE with additional scientific data regarding issues such as gas generation, brine inflow, and pressure buildup in closed rooms and panels, which would verify this conclusion.

Radiation measurements to identify loss of containment in a closed room or panel are not warranted with respect to worker safety due to the remote possibility of loss of containment occurring during the pre-closure period.

IV.B. Short- and Long-Term Repository Performance

Data obtained from a functioning repository regarding gases produced and the resulting pressure changes; geomechanical parameters; radiation migration; and temperature changes would be more difficult to refute than data obtained through laboratory experiments and computer modeling—regardless of how accurate the experiments and/or modeling might be.

Additionally, data obtained by monitoring in closed rooms and panels would be invaluable in determining the accuracy of the models used in the PA for the WIPP. Such data would enable future modeling to be more accurate, since it might reveal that certain events may or may not occur; or that events occur on a different timescale and/or on a different magnitude. These data would help insure workers and the general public are protected from unintended radioactive releases into the accessible environment.

Because certain events postulated to occur post-closure of rooms and panels do not seem likely, monitoring can dispel or prove such improbable situations. For example, there is a postulation that rapid generation of methane and a subsequent explosion initiated by, perhaps, static electricity produced by radioactive decay may occur. Monitoring for selected gases, including methane, would confirm or dismiss this possibility. In addition, it would be possible to determine whether the rate of production (if any) of carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethylene, 1,2-dichloroethane, methylene chloride, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane either occurs or does not occur. Gas pressure monitoring would provide information as to whether or not pressures within the repository exceed lithostatic. If pressures exceed lithostatic, fracturing of rock can occur and possibly create a pathway for the release of radioactivity to the accessible environment.

Geomechanical monitoring would measure the creep of the salt formation and the rate of brine inflow. This creep is expected to crush the waste drums and cause the release, within the repository, of radioactive material. The waste CPRs would be more accessible to any brine flow, which is necessary for microbial degradation to occur.

Radiation monitoring will provide data regarding the rate of actinide migration within the repository. Knowledge of the rate of migration of radioactive materials will be useful in the design of future repositories.

Although temperature changes within the repository are not expected to be significant, any change can have a profound effect on the performance of the repository. Elevated temperatures will cause an increase in gas pressure within the repository. In addition, temperature affects the rate of chemical reactions and the microbial degradation of CPRs. It is therefore desirable to monitor temperature within the repository.
Because one of the basic assumptions for the WIPP is that there will be active institutional controls in place for the first 100 years after closure, there could be extensive benefits to establishing and maintaining a monitoring program within the repository to assess the actual performance of the repository after completion of waste disposal. Collection of data for this 100-year time period would certainly confirm or refute most of the assumptions with respect to brine inflow, salt creep, and gas generation.

Two additional factors should be part of the decision to monitor in closed rooms and panels: technical feasibility and cost. Any monitoring design must include a mechanism to determine when sensors are not providing accurate data. Sensors do fail and there must be a reliable way to determine if a failure has occurred. Inaccurate data will compromise the design of enlarged or new repositories.

V. RECOMMENDATIONS

It will prove advantageous to the national radioactive waste management program to monitor for gases produced and resulting pressure changes; selected geomechanical parameters; radiation migration; and temperature changes in the closed rooms and panels of the WIPP. Therefore, it is recommended that:

1) The DOE expand the proposed room monitoring system to include the collection of samples for analysis for those parameters listed in Section II.C in order to establish background conditions in the open rooms and to determine if there is gas generation or if there are other changes in conditions once the room is closed.
2) The sampling tubes from the closed rooms be extended to beyond the panel closure system, and the sampling program recommended above be continued for the life of the repository in order to measure the effects of panel closure.
3) The DOE also consider any other parameters that would provide information for the design of new repositories that should be included in monitoring activities in closed rooms and panels.
4) The DOE investigate the possibility of monitoring after waste disposal has been completed and once the repository is closed. This will entail a mechanism to transmit data to the surface, a delay of shaft closures until the end of the active institutional control period, or another comparable approach.

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