STATUS OF PLANNED CHANGE REQUESTS FOR THE WASTE ISOLATION PILOT PLANT - 8139

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ABSTRACT

At the submittal of the initial abstract to the Waste Management Symposium, the U.S. Department of Energy (DOE) had submitted and contemplated submitting a total of four planned change requests (PCRs) for U.S. Environmental Protection Agency (EPA) action before March of 2009. That date is the regulatory deadline for submitting the second Compliance Recertification Application (CRA-2009) to the EPA. The Panel Closure PCR has subsequently been withdrawn in favor of postponing a final decision until after sufficient data has been obtained from the monitoring of hydrogen and methane in waste-filled rooms. A proposal to change a set of performance assessment (PA) parameters and a conceptual model has been removed from consideration due to schedule constraints. These parameters were the shear strength of the waste and the extent and evolution of the disturbed rock zone surrounding the rooms.

A PCR was submitted to the EPA in April 2006 to reduce the mass of magnesium oxide (MgO) that must be emplaced in the repository. The EPA is currently reviewing the information submitted by DOE.

A PCR was submitted to the EPA in November 2007 to allow emplacement of remote-handled transuranic (RH-TRU) waste in shielded containers on the floor of the repository.

INTRODUCTION

The regulations that govern the disposal of radioactive waste in the Waste Isolation Pilot Plant (WIPP), Title 40 Code of Federal Regulations (CFR) Part 194 [1], require the DOE to, “report any planned . . . changes in activities or conditions pertaining to the disposal system that differ significantly from the most recent compliance application." To this end, any changes that could be considered significant changes to operational procedures are formally submitted to the EPA with DOE's recommendation of significance (significant or not significant). This paper will discuss the three PCRs submitted to the EPA since approval of the first Compliance Recertification Application (CRA-2004) which was approved by EPA in March 2006.

PANEL CLOSURES

At the present time, the Option D panel closure is the approved design for permanent closure of waste-filled panels. The Option D design (Figure 1), which was one of four options described in the Compliance Certification Application (CCA) [2], and was specified by the EPA in its certification decision for the WIPP, and the New Mexico Environment Department (NMED) in the Hazardous Waste Facility Permit (HWFP). Subsequent to certification, testing of the specialized concrete proposed for the panel closures and the complexity involved in installing the massive structure indicated that it would be extremely difficult to install the Option D design in the underground facility. Installation of permanent closures in Panels 1 and 2 has therefore been delayed, pending approval of a revised design by EPA and NMED.

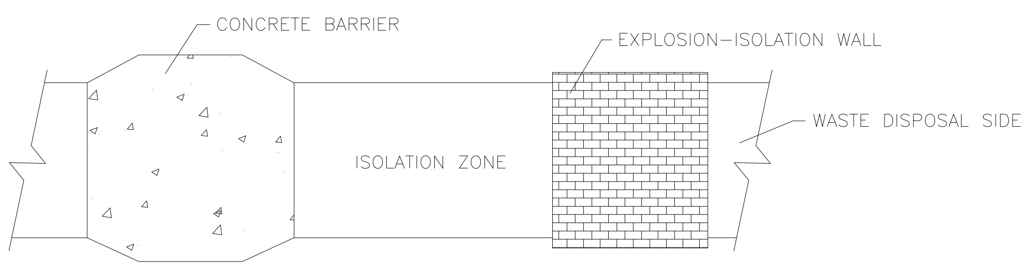

Fig. 1 Option D. Explosion Isolation Wall and Concrete Barrier with DRZ Removed

DOE submitted a revised panel closure design and draft monitoring plan to EPA (PCR) and NMED (permit modification request (PMR)) in October 2002. After numerous meetings with the EPA, NMED and stakeholders, it was agreed to withdraw both submittals. DOE withdrew the PCR in October 2007. In addition, DOE submitted a Class 2 permit modification request to the NMED in November 2007, with a copy to the EPA, for the NMED approval to perform long-term monitoring of gas concentrations in panels that are filled with waste. This will help DOE develop a permanent panel closure design that is simpler to construct without adverse impacts on the long-term performance of the repository. In light of these monitoring plans and numerous meetings with the EPA, NMED and stakeholders, it was agreed to withdraw both revised design submittals until enough monitoring data had been obtained to allow a more feasible but equally robust design to be submitted. DOE withdrew the PCR in October 2007.

The gas monitoring program will measure methane and hydrogen gas concentrations, the two explosive gases of concern, behind a substantial barrier and steel bulkhead that isolates the waste inside filled panels. Monitoring of *in situ* conditions in filled panels was recommended by the National Academy of Sciences [3] and is supported by EPA, NMED, and stakeholders for WIPP. The monitoring activities will provide data to confirm assumptions in long-term performance predictions.

If gas production is low, as is expected, installation of final panel closures will be delayed until DOE begins to fill Panel 8 with waste, at which time the final closure of Panels 4 and 5 must be started (Figure 2). Under current projections this will occur in 2012 If the measured gas concentrations exceed defined fractions of the lower explosive limit (LEL) of hydrogen or methane, more frequent monitoring (at 10% of LEL) or installation of the explosion isolation wall (at 20% of LEL) would be required.

Fig. 2 Underground Disposal Area Showing Panels 1-10

No changes are required for CRA-2009 because the Option D panel closure design will remain the basis for CRA-2009, unchanged from CRA-2004. However, any long-term monitoring data for methane and hydrogen will be reported in yearly monitoring reports and will be summarized in CRA-2009 and in future CRAs.

MAGNESIUM OXIDE

The EPA required the WIPP disposal system to include both natural and engineered barriers in order to provide confidence that repository performance will exceed EPA's long-term containment requirements [4]. DOE selected MgO as an engineered barrier during the CCA [2]. The presence of adequate amounts of MgO ensures that favorable and consistent conditions are maintained in WIPP brines by reacting with any carbon dioxide (CO_2) produced by microbial consumption of organic carbon in the waste materials. If CO_2 is not removed by reaction with MgO, its presence could cause brine in the waste rooms to become more acidic, resulting in increased actinide solubilities. MgO also helps to reduce predicted releases by reacting with

CO_2, and thus reducing repository pressure. PA calculations assume there is enough MgO to react with all CO_2.

DOE is currently required to emplace a minimum of 1.67 moles of MgO for every mole of organic carbon in the emplaced cellulose, plastic, and rubber (CPR) materials, or a loading factor of 1.67. The value of 1.67 represents a 67% excess over the amount of MgO that is required to react with the maximum amount of CO_2 that could be generated by microbial processes under the most conservative assumptions.

The mass of MgO needed to obtain a specific loading factor is based on a deterministic equation. This equation [5] determines the amount of MgO to be emplaced on a per-room basis:

$$m_{required}^{MgO} = \left(1.67 \bullet (6) \bullet \left[\frac{m_C + m_R + 1.7 \bullet m_P}{162 g / mole}\right] + M_{brn}^{MgO}\right) \bullet \left(\frac{2.2046 \text{ lbs}}{\text{kg}}\right) \bullet \left(\frac{\text{kg}}{1000\text{g}}\right) \bullet \left(\frac{40.3\text{g}}{\text{mole}}\right) \qquad \text{(Eq. 1)}$$

where

$m_{required}^{MgO}$ = mass in pounds of MgO that must be emplaced to maintain a safety factor of 1.67

M_{brn}^{MgO} = moles MgO lost to brine outflows

and

m_C = mass of cellulose (g)

m_R = mass of rubber (g)

m_P = mass of plastic (g)

The factor of 6 in Equation (1) represents the fact that the chemical formula for cellulose material is taken as $C_6H_{10}O_5$ so there are 6 moles of organic carbon for each mole of cellulose material. The factor of 1.7 represents the ratio of the moles of organic carbon per unit mass of plastic material versus per unit mass of cellulose material

In April 2006, DOE submitted a PCR to EPA to reduce the MgO loading factor to 1.2. The proposed loading factor represents a balance between vehicle-related health risks to the public, the cost of emplaced MgO, and a degree of uncertainty in microbial processes. DOE's proposed value also acknowledges that the WIPP Waste Information System (WWIS) now tracks the emplaced mass of MgO and cellulose/plastic/rubber material (CPR) on a room-by-room basis. The loading factor of 1.2 assumes that the microbial degradation mechanism will be dominated by sulfate reduction, which produces 1 mole of CO_2 for each mole of organic carbon, and that methanogenesis, which produces 1 mole of CO_2 for every 2 moles of organic carbon, will not be a factor.

In response to a request from the EPA, DOE submitted an uncertainty analysis to further demonstrate the conservatism of the 1.2 loading factor. This uncertainty analysis [6] starts with a number of conservative assumptions: (i) microbes remain active through the lifetime of the repository, (ii) microbes will consume all of the organic carbon in the CPR materials that are emplaced in the repository, and (iii) other materials in the waste, such as lime and the corrosion products of iron-based materials, do not react with CO_2. The use of these assumptions maintains a conservative framework for determining the required amount of MgO in the repository. The DOE evaluated 15 uncertainties related to MgO effectiveness, which are grouped into three categories:

- Uncertainties in the quantities of CO_2 produced by microbial consumption of the organic carbon in the emplaced CPR materials
- Uncertainties in the amount of MgO that is available to react with CO_2
- Uncertainties in the moles of CO_2 sequestered per mole of MgO that is available to consume CO_2

Whenever possible, uncertainties were quantified and represented as random variables. The remaining uncertainties were reviewed qualitatively and are included via assumptions in the final estimation of MgO effectiveness. The results from the uncertainty analysis are dominated by the effective yield of CO_2 and the role of methanogenesis. These items are important because the yield of CO_2 per mole of organic carbon can be substantially less than previously assumed.

The resulting uncertainty analysis, which is based on a number of conservative assumptions, was submitted to EPA in November 2006. The uncertainty analysis predicts that an MgO loading factor of 1.2 will be more than sufficient to react with the maximum amount of CO_2. The MgO PCR has no impact on PA because the MgO loading factor of 1.2 still provides enough MgO to react with all CO_2. If EPA approves this PCR, then the CRA-2009 will be modified to explain the technical basis for reducing the MgO loading factor from 1.67 to 1.2. EPA is currently reviewing the DOE reports and letters related to the MgO PCR. As of January 18, 2008, EPA has not issued a final decision on the MgO PCR.

SHIELDED CONTAINERS

On January 24, 2007, the WIPP received its first shipment of RH-TRU waste. RH-TRU waste is currently packaged for disposal in RH-TRU canisters. The RH-TRU canisters are loaded into horizontal boreholes that are drilled perpendicular to the walls of the disposal rooms on approximately 8 foot centers [7].

For a variety of reasons the DOE is proposing to ship and emplace some of the RH-TRU waste in shielded containers which can be stored on the floor of the disposal rooms along with contact handled TRU CH-TRU waste. The shielded container is designed to hold a 30-gallon drum and has approximately the same exterior dimensions as a 55-gallon drum. The cylindrical sidewall of the shielded container has 1-inch-thick lead shielding sandwiched between a double-walled steel shell with an external wall thickness of 1/8 inch and an internal wall thickness of 3/16 inch. The lid and bottom of the container are made from 3.0 inch thick steel. The empty weight of the container is approximately 1,800 pounds. The shielded container and any inner 30-gallon drums will be vented [8].

The emplacement of RH-TRU waste in the walls of the disposal rooms is appropriate and necessary for higher activity waste streams; however, there are several reasons why an alternative disposal scheme is advantageous for lower activity RH-TRU waste steams. The drilling and emplacement operations for the RH-TRU canisters impede direct access to a room because the specialized equipment required to emplace the canisters into boreholes is very large and the operations are time consuming: it requires an eight-hour shift to emplace one RH-TRU canister. In addition, borehole drilling is limited to drilling one to two boreholes per shift. The borehole drilling equipment also restricts access to the room. DOE will also realize greater efficiencies by being able to ship up to nine shielded containers per shipment – three HalfPACTs, each containing three shielded containers. The DOE will be able to increase the efficiency of utilization of the WIPP facility by easing the restrictions on waste handling needed during emplacement of RH waste canisters in the walls of the rooms, and accounting for the loss of some RH TRU waste disposal locations due to the delayed start of the RH TRU mission.

DOE is therefore proposing a change to the emplacement scheme for a portion of the RH-TRU waste. DOE proposes to package a subset of the RH-TRU waste streams in shielded containers and place those containers on the floor of the disposal rooms, in a similar manner to the emplacement scheme for CH-TRU waste containers. Candidate RH-TRU waste for disposal in shielded containers must result in a dose rate of less than 200 millirem/hour at the container surface, which is the surface dose rate limit for CH-TRU waste. These waste streams and containers will remain designated as RH-TRU waste in the WIPP WWIS. They will be counted against the limit of 5,100,000 curies for RH TRU waste defined by the WIPP Land Withdrawal Act and the limit of 250,000 cubic feet (7,080 cubic meters) for RH TRU waste defined by the Consultation and Cooperation Agreement between DOE and the state of New Mexico [9].

DOE has performed a number of analyses and tests concerning shielded containers, which include an analysis of the RH-TRU inventory [10] that could be placed in shielded containers, the impact to long-term repository performance (PA) [11], and testing of the container to meet Nuclear Regulatory Commission and Department of Transportation requirements. The first two items are discussed in this paper and the last one is discussed in another paper to be presented at Waste Management ’08.

A Shielded Container Performance Assessment (SCPA) [9] was conducted to evaluate the impact of emplacing RH TRU waste in shielded containers on the long-term performance of the repository. Given the uncertainty of the exact amount of RH TRU waste that can be emplaced in shielded containers, the SCPA used a bounding approach that considered several extreme cases, including a case with all the RH TRU waste in RH containers in the walls (the current baseline) and a case with all the RH TRU waste in shielded containers on the floor. The results from the SCPA indicate insignificant differences in repository releases for these two cases relative to the compliance limits. This result is expected because the volume and radioactivity of all RH TRU waste streams is only a few percent of the total volume and total radioactivity for the current baseline inventory. RH TRU waste has negligible effect on long-term performance in any emplacement configuration.

It follows that RH TRU and CH TRU wastes behave in a similar fashion over most of the 10,000 year regulatory period, and anticipated releases from RH TRU waste will be a very small contributor (a few percent) to total releases from the repository.

An analysis of RH-TRU waste streams was performed to determine which could be loaded in shielded containers and meet the 200 mrem/hour limit surface dose rate limit. This analysis started by calculating the number of 30-gallon drum equivalents expected to be generated using the WIPP capacity volume for RH-TRU waste (7080 m^3). Each 30-gallon drum will be inserted in a 55-gallon shielded container. Once the number of shielded containers is determined, the inventories of CPR, steel and lead used in packaging and emplacement were determined. As part of this analysis, the RH-TRU waste inventory was also screened using gamma factors and Microshield® evaluations to estimate the limiting gamma emitter activity per shielded container that would produce a surface dose rate of less than 200 mrem/h. Candidate waste streams were then selected from populations of drums that have a high probability to be adequately shielded (i.e. are less than 200 mrem/h) for handling based on these calculations. It has been estimated that RH-TRU waste containing less than 2 curies of Cesium-137 or 0.12 curies of Cobalt-60 per 30 gallon drum is a candidate for packaging in shielded containers because the 1-inch lead shielding is predicted to reduce the surface dose rate to less than 200 millirem/hour.

The Shielded Container PCR was submitted to the EPA in November 2007.

The Shielded Container PCR will not be reflected in the PA for CRA-2009. The impact on long-term releases is expected to be minor, as explained above. This and the use of the new containers will be discussed in the CRA-2009 if it is approved by the EPA.

CONCLUSION

The approval to emplace less MgO in the repository represents a decreased radiation exposure to waste handlers, the cost of MgO, and uncertainty in microbial processes. Specifying an MgO loading factor significantly greater than 1.0 increases health risks to today's population without benefit to future populations, increases the cost of repository operations, and does not provide additional assurance that the repository will perform as predicted.

The results of the SCPA indicate that the shielded containers will have a minimal impact on long-term repository performance and therefore on compliance with the 40 CFR Part 194 requirements. With regard to the waste inventory the DOE will not be adding or removing RH TRU waste streams and will be selecting those that will not exceed the surface dose rate limit of 200 mrem/hr for emplacement in shielded containers. The impact on the WIPP facility and operations will be limited to revision of certain aspects of the WWIS and to procedural changes to the process of transporting, handling and emplacement of the shielded containers. The addition of this payload container will allow DOE to realize greater efficiencies in transporting and emplacing RH TRU waste in a safe and compliant manner.

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