Department of Energy
Carlsbad Field Office
P. O. Box 3090
Carlsbad, New Mexico 88221

FEB 1 4 2012

Mr. Alan Perrin
U.S. Environmental Protection Agency
Office of Air and Radiation
401 M Street, S.W.
Washington, DC 20460

Subject: Planned Change Notice for Placement of Magnesium Oxide Supersacks

Dear Mr. Perrin:

Consistent with your approval letter of February 11, 2008, the Waste Isolation Pilot Plant (WIPP) is maintaining a minimum of 1.2 excess factor in each disposal room and a 94 percent or greater reactivity of magnesium oxide (MgO), verified annually. Our experience has shown, when placing an MgO supersack on each waste column, the excess factor has ranged from 1.22 to 2.85.

Based on historical data, the Department of Energy is placing an amount of MgO in the repository that exceeds the requirements established in your February 11, 2008 letter. We are informing you that we are instituting a process that allows us to emplace the MgO on every other waste row and to adjust the frequency to accommodate high cellulose, plastic and rubber (CPR) waste streams. Enclosed is the distribution analysis supporting the change. We believe this change will allow us to manage the placement of MgO more efficiently.

Our new process will:

- Continue to calculate the excess factor at the end of each shift when waste emplacement data are uploaded to the WIPP Waste Data System.
- Continue to allow personnel designated by procedure to direct additional MgO be emplaced during the next shift of waste disposal activities.
- Result in a more efficient distribution of MgO based upon the CPR content of the waste containers being emplaced.

If you have any questions, please contact Mr. Russell Patterson at (575) 234-7457.

Sincerely,

Jose R Franco

Jose R. Franco, Manager
Carlsbad Field Office

Enclosure

CBFO:OESH:RLP:ANC:12-0707:UFC 5486.00

cc: w/enclosure

T. Peake, EPA	*ED
K. Economy, EPA	ED
J. Walsh, EPA	ED
S. Ghose, EPA	ED
R. Lee, EPA	ED
F. Marcinowski, DOE-EM	ED
C. Gelles, DOE-EM	ED
CBFO M&RC	

cc: w/o enclosure

E. Ziemianski, CBFO	*ED
R. Nelson, CBFO	ED
G. Basabilvazo, CBFO	ED
S. McCauslin, CBFO	ED
F. Sharif, WTS	ED
A. Chavez, RES	ED

*ED denotes electronic distribution

ANALYSIS OF AN ALTERNATE EMPLACEMENT SCHEME FOR MgO SUPERSACKS

This report documents analyses in support of an alternate emplacement scheme for magnesium oxide (MgO) supersacks in the Waste Isolation Pilot Plant "WIPP" repository. The goals of this alternate emplacement scheme are to reduce the excess mass of MgO in each room, to provide WIPP Operations with flexibility in emplacing MgO supersacks, and to assure maintenance of an excess factor for MgO of 1.2 or greater in each room. The analysis uses a 3,000-pound supersack of MgO as the base case; a similar analysis for 4,200-pound supersacks of MgO is described in Appendix A.

Estimates of the Effective Diffusion Penetration Length for CO_2

Scientists at Sandia National Laboratories (SNL) have performed several analyses to estimate the effective length for (molecular) diffusion of carbon dioxide (CO_2) in brine in the WIPP repository environment. These analyses were focused on vertical diffusion of CO_2 because of the assumption that a single supersack of MgO was placed on top of each waste stack. However, the process of molecular diffusion is independent of direction (horizontal or vertical) in the repository, provided chemical gradients are approximately equal in either direction. In this situation, the effective diffusion length is similar in the vertical or horizontal directions, so the SNL analyses provide an estimate of the effectiveness of diffusion in the horizontal direction if MgO supersacks are not emplaced on every waste stack. The effective diffusion length is useful for evaluating transport (i.e., for bringing CO_2 into close proximity with MgO), but is not an indicator of the mass of MgO needed to react with all the CO_2 generated by microbial degradation of cellulosic, plastic, and rubber (CPR) materials. The inventory analysis in the next section determines the amount of MgO needed to react with the CO_2 generated by microbial degradation.

Kanney and Vugrin (2006) calculate the effective diffusion length for CO_2 based on conditions in an intruded panel for the Performance Assessment Baseline Calculation (PABC)-2004 and for the Advanced Mixed Waste Treatment Plant (AMWTP) analysis. For the PABC-2004, the effective diffusion penetration length for CO_2 is estimated to be 1.0 meters (m) to 1.58 m (Kanney and Vugrin 2006, Table 6). The variability in diffusion length is due to the variability in the porosity of the waste filling a partly closed room. For the AMWTP analysis, which is more representative of the current inventory (because the current inventory includes supercompacted waste from the AMWTP), the effective diffusion penetration length for CO_2 ranges from 0.94 m to 1.90 m for waste in 55-gallon drums (without supercompacted waste) and is greater than 3.37 m when 55-gallon drums are combined with varying fractions of supercompacted waste or pipe overpacks (Kanney and Vugrin 2006, Table 11). The effective diffusion penetration lengths are for molecular diffusion (only) and are conservative because advective flow of brine or gaseous diffusion of CO_2 will greatly enhance the transport of CO_2 throughout a room.

The typical lateral dimensions of a waste stack are between 1.4 and 1.9 m. For example, the width of a seven pack of 55-gallon drums varies between 1.65 m and 1.91 m, the outside diameter of a ten-drum overpack (TDOP) is 1.8 m, and the outside dimensions of a standard waste box (SWB) are 1.38 m by 1.80 m. Given the conservative estimate for the diffusion length for CO_2, it is reasonable to assume that diffusion and advection of CO_2 will be effective transport mechanisms across an adjacent waste stack. In other words, the CO_2 generated by microbial degradation of CPR materials in a waste stack can react with MgO that is emplaced on an adjacent waste stack. This conclusion suggests that placing a supersack of

MgO on every other waste stack, or placing supersacks on all the waste stacks in every other row, are reasonable emplacement schemes for MgO.

Projected Number of MgO Supersacks to Maintain an MgO Excess Factor of 1.2

The Comprehensive Inventory Database (CID) contains information on the stored and projected waste streams that are expected to be transported from the generator sites and emplaced underground at the WIPP facility. The CID does not include information on waste that has already been emplaced at WIPP; this information is maintained in a separate database, WIPP's Waste Data System (WDS). The information in the CID is the logical focus for this analysis because it represents waste streams that will be shipped to WIPP in the future.

The data in the CID include final form container volume, container type(s), container count(s), and the total mass of CPR materials, including packaging, for contact-handled transuranic (CH TRU) and remote-handled transuranic (RH TRU) waste streams. The source data version of the CID is D.10.01, with an inventory date of December 31, 2010. The query for this analysis was performed on December 5, 2011, and the resulting data are Quality Level One, as defined by the American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance Standard (NQA)-1. The CPR waste materials and container materials in RH TRU waste streams are not included in this data set because the CPR materials in RH TRU waste streams, which are emplaced in the walls of each room, are accounted for in the room-based calculation of the MgO excess factor at the end of each waste emplacement shift (Washington TRU Solutions (WTS) 2011). This is appropriate because MgO supersacks are not emplaced directly on RH TRU waste containers.

The data for CH TRU waste streams in the CID have been used to estimate the CPR in a waste stack in the underground and to determine the number of supersacks of MgO needed per waste stack to maintain an MgO excess factor of 1.2. This analysis made the following assumptions:

- The MgO excess factor is 1.2.
- Each waste stack contains a single waste stream.
- A waste stack holds either: (i) 21 55-gallon drums, (ii) nine 100-gallon drums, (iii) three SWBs, (iv) one TDOP, or (v) one Standard Large Box 2 (SLB2).
- Each supersack holds 3,000 pounds of MgO.
- The mass of MgO needed to maintain an excess factor of 1.2, MgO_g [g], is estimated using the data in the CID for the masses of cellulose (C_{kg}), plastic (P_{kg}), and rubber (R_{kg}) materials in each waste stream by container type. The data from the CID include the CPR in waste materials and packing materials. The formula for MgO_g is based on the 2005 Safety Factor Calculation (Triay 2005), with appropriate changes for an excess factor of 1.2 and for the mass of materials in kilograms:

$$MgO_g = (1.2)(40.3\,g\,MgO/Mol)\left(\frac{(6000)(C_{kg} + 1.7P_{kg} + R_{kg})}{162\,g\,Cellulose/Mol}\right).$$

- The number of 3,000 pound supersacks per stack is then calculated as:

$$\#\,Supersacks\,per\,Stack = \frac{MgO_g}{(454g/lb)(3{,}000lb/sack)(\#stacks)}$$
$$= \frac{MgO_g}{(454g/lb)(3{,}000lb/sack)(container\,count/\#\,containers\,per\,stack)},$$

where the number of stacks (*# stacks*) in the above formula is based on data for the anticipated container count for each waste stream by container type from the CID and on the number of containers in a waste stack by container type, defined in the third bullet above.

Table 1 presents the numerical data for final form container volume as a function of the number of supersacks needed per waste stack. The data in Table 1 are calculated using the CPR content and the type of waste container(s) for each waste stream, and presented in discrete "bins" or intervals based on the number of MgO supersacks needed per waste stack. The first bin is for waste streams that need 0 to 0.125 supersacks per waste stack, which corresponds to one supersack for eight or more waste stacks. The second bin is for waste streams that need 0.125 to 0.143 supersacks per waste stack, which corresponds to one supersack for seven to eight waste stacks. The next bins increase the amount of MgO per waste stack by one or more supersacks. The highest bin needs more than four supersacks per waste stack to maintain an excess factor of 1.2. Table 1 also presents the number of (final) waste forms in each bin.

Table 1. Final Form Container Volumes as a Function of the Number of 3,000 Pound Supersacks of MgO Per Waste Stack Needed for an Excess Factor of 1.2

Number of MgO Supersacks per Waste Stack	**Final Form Container Volume (m^3)**	**Number of Final Form Containers**
0 to 0.125 (1 supersack for more than 8 waste stacks)	8578.5	39
0.125 to 0.143 (1 supersack for 7 to 8 waste stacks)	0.0	0
0.143 to 0.167 (1 supersack for 6 to 7 waste stacks)	354.6	3
0.167 to 0.2 (1 supersack for 5 to 6 waste stacks)	12389.7	9
0.2 to 0.25 (1 supersack for 4 to 5 waste stacks)	5394.9	27
0.25 to 0.33 (1 supersack for 3 to 4 waste stacks)	3978.9	27
0.33 to 0.5 (1 supersack for 2 to 3 waste stacks)	7382.4	67
0.5 to 1 (1 supersack for 1 to 2 waste stacks)	28412.4	103
1 to 2 supersacks for every waste stack	9489.0	54
2 to 4 supersacks for every waste stack	515.7	12
> 4 supersacks for every waste stack	65.1	7
Totals	76561.3	348

The values in Table 1 indicate that approximately 38,000 m^3, about 50% of the total volume of waste, would need less than 0.5 supersacks of MgO per waste stack to maintain an excess factor of 1.2. The mixing of various waste streams and final form containers in each room, the initial emplacement of a supersack of MgO on every other waste stack (or on every waste stack in every other row), and the use of the room-based calculation at end of shift to determine when additional supersacks are needed will be adequate to maintain an MgO excess factor of 1.2, thereby providing sufficient mass of MgO to react with the CO_2 generated by degradation of CPR materials without having to place a supersack on every waste stack.

The procedure for emplacement of MgO supersacks in the WIPP underground is WP 05-WH1025, CH Waste Downloading and Emplacement (WTS 2011). This procedure will be changed to initially emplace a 3,000 pound supersack of MgO on every other waste stack or on each waste stack in every other row, rather than placing a supersack on every waste stack. The requirement in section 3 of the procedure CH Waste Downloading and Emplacement, to calculate the MgO excess factor at the end of shift, when waste emplacement data are uploaded to WIPP's WDS, will remain unchanged. If the MgO excess factor for the room is less than 1.2, then additional MgO supersacks will be added as defined in the existing procedure.

Summary

The emplacement of a 3,000 pound supersack of MgO on every other waste stack (or on each waste stack in every other row) and the use of a room-based calculation to identify the need for additional MgO needed to maintain an excess factor of 1.2 in the room are adequate to provide sufficient mass of MgO to react with the CO_2 generated by degradation of CPR materials in a room.

References

Kanney, J. and E. Vugrin, 2006. *Updated Analysis of Characteristic Time and Length Scales for Mixing Processes in the WIPP Repository to Reflect the CRA-2004 PABC Technical Baseline and the Impact of Supercompacted Mixed Waste and Heterogeneous Waste Emplacement*. Memorandum to David S. Kessel, dated August 31, 2006. Carlsbad, New Mexico: Sandia National Laboratories.

Triay, Ines R., 2005. *Plans for Emplacement of Additional MgO*. Letter from Inez R. Triay, Acting Manager, Carlsbad Field Office, U.S. Department of Energy, to Ms. Bonnie C. Gitlin, Acting Director, Radiation Protection Division, U.S. Environmental Protection Agency, dated March 5, 2005.

Washington TRU Solutions (WTS), 2011. *CH Waste Downloading and Emplacement*, Revision 7 (WP 05-WH1025). Effective Date: September 13, 2011.

APPENDIX A – CALCULATIONS FOR 4,200 POUND SUPERSACKS OF MgO

Waste stream data in the CID has also been analyzed to determine the number of 4,200 supersacks of MgO needed per stack of waste. This analysis made identical assumptions about the waste streams as for the analysis with 3,000 supersacks.

The data for CH TRU waste streams in the CID have been reanalyzed to determine the number of 4,200 pound supersacks of MgO needed per waste stack to maintain an MgO excess factor of 1.2. This analysis made identical assumptions to the analysis with 3,000 pound supersacks, except that the weight of the supersack is 4,200 pounds.

Table A-1 presents the numerical data for final form container volume as a function of the number of 4,200 pound supersacks per waste stack. The data in Table A-1 are presented in the same discrete "bins" or intervals as the bins in Table 1 for the analysis with 3,000 pound supersacks. The computational procedure is again based on each waste stream's CPR content and on the type of waste containers for each waste stream, and determines the number of MgO supersacks needed per waste stack. Table A-1 also presents the number of final form container types in each bin.

Table A-1. Final Form Container Volume as a Function of the Number of 4,200 Pound Supersacks of MgO Per Waste Stack Needed for an Excess Factor of 1.2

Number of MgO Supersacks per Waste Stack	**Final Form Container Volume (m^3)**	**Number of Final Form Containers**
0 to 0.125 (1 supersack for more than 8 waste stacks)	8933.1	42
0.125 to 0.143 (1 supersack for 7 to 8 waste stacks)	12389.7	9
0.143 to 0.167 (1 supersack for 6 to 7 waste stacks)	4600.3	20
0.167 to 0.2 (1 supersack for 5 to 6 waste stacks)	1794.4	20
0.2 to 0.25 (1 supersack for 4 to 5 waste stacks)	3034.0	16
0.25 to 0.33 (1 supersack for 3 to 4 waste stacks)	6869.0	52
0.33 to 0.5 (1 supersack for 2 to 3 waste stacks)	22297.1	68
0.5 to 1 (1 supersack for 1 to 2 waste stacks)	10428.3	83
1 to 2 supersacks for every waste stack	6139.7	28
2 to 4 supersacks for every waste stack	10.7	3
> 4 supersacks for every waste stack	65.1	7
Totals	76561.3	348

The values in Table A-1 indicate that 39,000 m^3, about 51% of the total volume of waste, needs less than 0.33 supersacks of MgO per waste stack, which is equivalent to one supersack of MgO for every three waste stacks. This could lead to a recommended emplacement scheme of one 4,200 pound supersack for every three waste stacks. This approach might appear to emplace less MgO than the recommended emplacement scheme for the 3,000 pound supersack, but the difference is not significant. With a 4,200 pound supersack, the recommendation is 0.333 supersacks per waste stack, equivalent to 1,400 pounds of MgO per waste stack. With a 3,000 pound supersack, the recommendation is 0.5 supersacks per waste stack, equivalent to 1,500 pounds of MgO per waste stack. The difference of 100 pounds between the two recommendations is not considered significant.