UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF
AIR AND RADIATION

Mr. Dana Bryson, Acting Manager
Carlsbad Field Office
U.S. Department of Energy
P.O. Box 3090
Carlsbad, New Mexico 88221-3090

Dear Mr. Bryson:

The U.S. Environmental Protection Agency is continuing with its completeness review of the U.S. Department of Energy's (DOE) 2014 Compliance Recertification Application (CRA-2014) for the Waste Isolation Pilot Plant. This letter transmits the fourth set of Agency completeness comments and questions (see Enclosure). If you have any questions concerning this request, please have your staff contact Kathleen Economy at (202) 343-9844 or economy.kathleen@epa.gov.

Sincerely,

for Jonathan D. Edwards
Director
Radiation Protection Division

Enclosure: Fourth Set of CRA 2014 Completeness Questions

cc: Electronic Distribution
George Basabilvazo, DOE/CBFO
Russ Patterson, DOE/CBFO
Frank Marcinowski, DOE/HQ
Doug Tonkay, DOE/HQ
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Nick Stone, EPA Region 6
EPA WIPP Team
EPA WIPP Docket

ENCLOSURE

FOURTH SET OF EPA COMPLETENESS COMMENTS FOR CRA 2014

4-C-1. Waste Incompatibilities and Gas Generation. The WIPP Technical Assessment Team investigated the mechanisms and chemical reactions that resulted in the breach of at least one waste drum and release of waste material in the WIPP on February 14, 2014 (SRNL 2015). This report identified the presence of chemically incompatible contents in LANL Drum 68660 from waste stream LA-MIN02-V.001 as the cause of the release; the drum contents included nitrate salt residues, organic sorbent (SWheat Scoop® kitty litter), and neutralizing agent (triethanolamine or TEA), which represents a mixture of fuels and oxidizers. This mixture and the configuration of materials in the drum supported chemical reaction, thermal runaway, gas build-up and eventual venting of radioactive materials and hot matter (SRNL 2015).

The WIPP performance assessment currently includes only microbial gas generation via degradation of CPR and anoxic corrosion of steel as significant gas generation mechanisms. Screening of chemical gas generation FEPs (CRA-2014 Appendix SCR Section SCR-6.5.1) did not consider gas generation caused by chemical incompatibility such as occurred in Drum 68660. Please provide a detailed assessment of whether the contents of other drums from the LA-MIN02-V.001 waste stream could have similar chemical incompatibilities that may cause gas generation sufficient to affect performance assessment. Also, if the SWheat Scoop® kitty litter was used in any other waste streams that have been emplaced in the WIPP, the DOE should discuss the potential effects on performance assessment of possible gas generation from these waste streams in its response to the Agency.

SRNL (Savannah River National Laboratory). 2015. Waste Isolation Pilot Plant Technical Assessment Team Report. SRNL-RP-2014-01198, Revision 0.

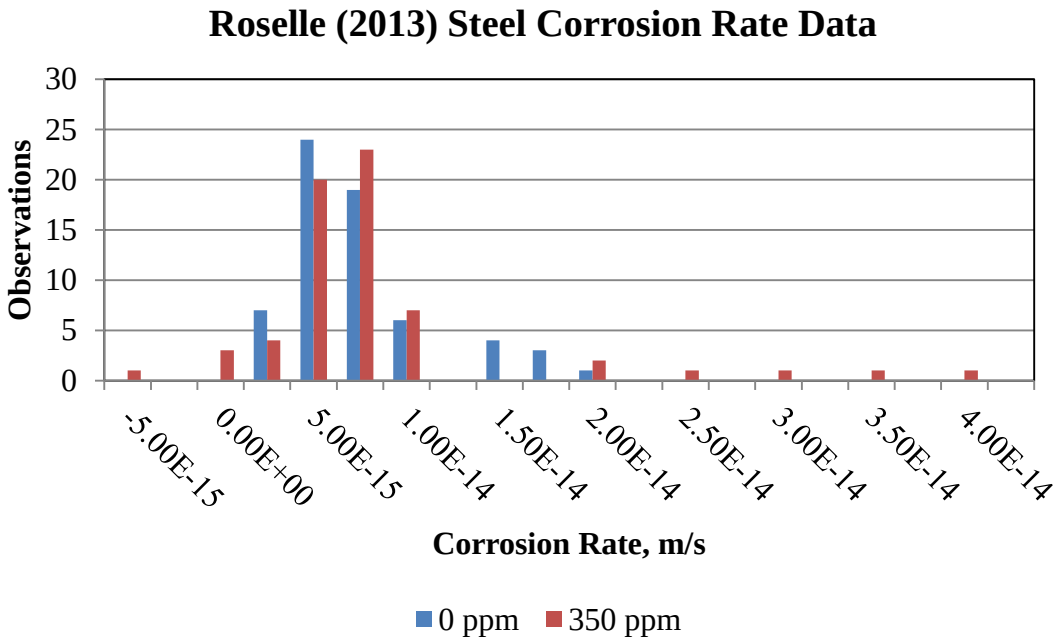
Wallace, T.C. 2014. Understanding the "What" and the "Why" of February 14, 2014. Los Alamos National Laboratory, LA-UR-14-2701.

4-C-2. Reassessment of Inundated Anoxic Steel Corrosion Rate Data.

a. **Experimental Data Used As Inputs For Parameter CORRMCO2** –The DOE needs to justify the values it has adopted for the parameter CORRMCO2 given the range of existing data. In the CRA-2014 PA the parameter CORRMCO2 has a range, distribution and median value that was modified from what was adopted in the CCA. The modification was based on experimental corrosion data under inundated conditions, at 1 atm and 0 ppm CO_2, as reported in Roselle (2013). Repository brines are predicted to be in equilibrium with CO_2 gas concentrations of 3.2 ppm CO_2 ($10^{-5.5}$ atm, Brush and Domski 2013) which is above 0 ppm CO_2. Additional corrosion experiments were performed by Roselle at CO_2 concentrations of 350 ppm, 1500 ppm and 3500 ppm, with

and without organic ligands, and for partially and fully immersed coupons. This range includes the predicted CO_2 gas concentrations of 3.2 ppm. The corrosion rates determined by Roselle (2013) for experiments at 0 and 350 ppm CO_2 concentrations are summarized in the figure below. The collective results from these experiments indicate corrosion does occur above 0 ppm and up to 350 ppm CO_2 and corroborate relevant data that indicates corrosion will occur at CO_2 concentrations above 0 ppm.

Please provide a justification for why the experimental corrosion data gathered from experiments above 0 ppm CO_2 concentrations were not included in the development of the parameter CORRMCO2.



b. Justify the Distribution of Parameter CORRMCO2 – In previous WIPP PAs, the lower limit of the steel corrosion rate was set equal to 0 m/sec, and, accordingly, the lower limit of the sampled range for CORRMCO2 should be 0 m/s. This lower limit is consistent with passivation of the steel surface by H_2S observed and reported in Telander and Westerman (1997). Telander and Westerman (1993, 1997) reported the results of anoxic corrosion experiments at H_2 and N_2 pressures up to 127 atm, which are applicable given the expected hydrostatic pressures anticipated in the WIPP repository. Based on an experiment with a N_2 pressure of 10 atm, Telander and Westerman (1997) recommended a corrosion rate of 2.25×10^{-14} m/s using results from the final 12 months of a 24-month experiment. EPA (1998) noted the effects of increased pressure on the steel corrosion rate in the experiments by Telander and Westerman (1993, 1997) and directed that the upper limit for CORRMCO2 used in the CCA PAVT should be increased to 3.17×10^{-14} m/s

(see Table Parameter CORRMCO2). Retaining this upper limit encompasses most, but not all, of the corrosion rate data measured by Roselle (2013) and includes consideration of the results reported by Telander and Westerman (1993, 1997).

The Roselle (2013) anoxic corrosion experiments with 0 ppm and 350 ppm CO_2 concentrations bracket anticipated CO_2 gas phase concentrations. It appears that the 350 ppm CO_2 corrosion data should have been included in the reassessment of the CORRMCO2 parameter because the experimental data indicate that steel corrosion rate will occur up to 350 ppm CO_2. However, the 350 ppm CO_2 corrosion data were not included in establishing the parameter valuation.

Please update the range, median and distribution for the CORRMCO2 parameter that reflects this experimental data.

Please provide justification as to why a uniform distribution for parameter CORRMCO2 was not adopted in the CRA-2014 PA.

Table Parameter CORRMCO2 (m/s)				
WIPP PA	**Distribution**	**Minimum**	**Maximum**	**Median**
CCA PA	Uniform	0.0	1.59×10^{-14}	7.94×10^{-15}
CCA PAVT CRA-2004 PA and PABC CRA-2009 PA and PABC	Uniform	0.0	3.17×10^{-14}	1.58×10^{-14}
CRA-2014 PA	Student-t	3.29×10^{-16}	1.84×10^{-14}	6.06×10^{-15}

Brush, L.H., and P.S. Domski. 2013. *Prediction of Baseline Actinide Solubilities for the WIPP CRA-2014 PA.* Sandia National Laboratories, ERMS 559138.

EPA. 1998. *Technical Support Document for Section 194.23: Parameter Justification Report.* Docket No. A-93-02 V-B-14.

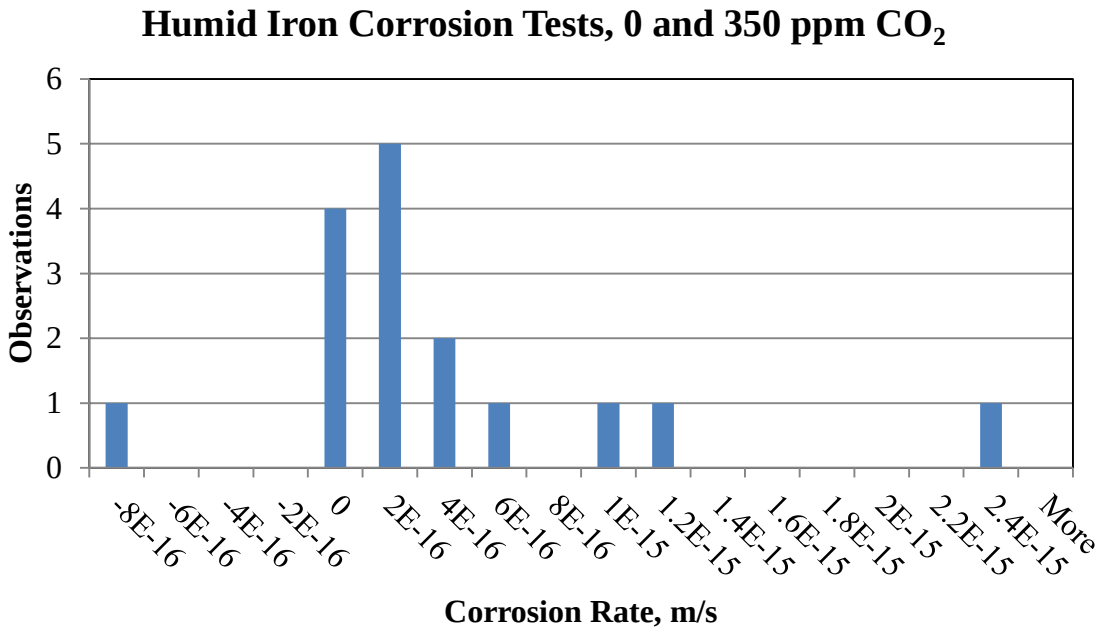
Roselle, G.T. 2013. *Determination of Corrosion Rates from Iron/Lead Corrosion Experiments to be Used for Gas Generation Calculations.* Sandia National Laboratories, ERMS 559077.

Telander, M.R., and R.E. Westerman. 1993. *Hydrogen Generation by Metal Corrosion in Simulated Waste Isolation Pilot Plant Environments: Progress Report for the Period November 1989 Through December 1992.* Prepared by Pacific Northwest National Laboratory for Sandia National Laboratory, SAND92-7347.

Telander, M.R., and R.E. Westerman. 1997. *Hydrogen Generation by Metal Corrosion in Simulated Waste Isolation Pilot Plant Environments.* Prepared by Pacific Northwest National Laboratory for Sandia National Laboratory, SAND96-2538.

4-C-3. Humid Steel Corrosion Rates. Roselle (2013) states that steel coupons hung in a humid environment exhibited essentially no corrosion regardless of CO_2 concentration. This statement contradicts the experimental data (reported in Roselle, 2013) conducted under humid experimental conditions, where samples were tested at 0 and 350 ppm CO_2. These experiments indicate corrosion does occur under humid conditions, with a mean corrosion rate of 3.0×10^{-16} m/s and median rate or 1.1×10^{-16} m/s, both positive values. The provided histogram of the corrosion rate data, obtained with gas phase CO_2 concentrations of 0 ppm and 350 ppm—which bracket anticipated repository conditions—demonstrates that the humid corrosion rate could be greater than zero.

Please justify why the DOE does not use the available and WIPP-relevant data in the derivation of corrosion rates that indicate corrosion will occur under humid conditions.



Roselle, G.T. 2013. *Determination of Corrosion Rates from Iron/Lead Corrosion Experiments to be Used for Gas Generation Calculations.* Sandia National Laboratories, ERMS 559077.

4-C-4. Steel Surface Area per Unit Volume in the Repository. The anoxic steel gas generation rate due to corrosion is proportional to the steel surface area per unit volume, D_s, (Appendix PA Equation PA.67) in the repository. The parameter D_s is defined by the following equation and inputs:

$D_s = A_d n_d / V_R$ (Appendix PA equation PA.75),

Where,

A_d - is the surface area of steel associated with a waste disposal drum (REFCON:ASDRUM, m^2/drum),
V_R - is the initial volume of a single room in the repository (REFCON:VROOM, m^3), and
$n_{d,}$ - is the ideal number of waste drums that can be close-packed into a single room (REFCON:DRROOM).

The input value for A_d used in the above equation (equation PA.75) has not changed since the CCA PAVT (Kicker and Herrick 2013), even though acceptance of significant quantities of AMWTP compressed waste since 2004 is likely to have increased the value for D_s. In addition the input n_d has not changed since the CCA, when it was based on calculations performed before waste placement began (Kicker and Herrick 2013). Steel surface area per unit repository volume is important to both gas generation through anoxic corrosion and the repository water balance.

Therefore, please update the calculation to account for the increased steel surface area that is representative of current and projected repository conditions. This calculation should include a reevaluation of the input A_d based on currently available data and include the amounts of compressed waste in the repository.

Please provide evidence that the calculation includes an update to the input value for n_d that is consistent with actual waste placement practices.

Kicker, D.C, and C.G. Herrick. 2013. *Parameter Summary Report for the Compliance Recertification Application, Rev. 0.* Sandia National Laboratories, ERMS 560298.

4-C-5. Steel Sulfidation Rate. The rate of gas production by sulfidation of iron in steel is determined by the rate of H_2S production through microbial degradation of cellulose and the stoichiometric coefficient for gas generation by sulfidation of steel (Appendix PA, equation PA.68). This formulation includes the assumption that all H_2S produced by microbial degradation of cellulose will instantaneously react to produce iron sulfide. Please provide the basis for this assumption, particularly in light of the Telander and Westerman (1997) experimental data that shows H_2S formed a passivating layer on steel and essentially halted steel corrosion.

4-C-6. Effects of Green Rust Formation on Gas Generation Stoichiometry. The stoichiometric coefficient used in PA for gas generation due to steel corrosion (STOIFX) has been maintained at its historical value of 1. This parameter value of "1" assumes no green rust will form on steel. The assumption is contradicted in Appendix SOTERM Section 2.3.4 of the CRA-2014, which includes the following statement:

> *Roselle (Roselle 2013) states that green rust is the most likely corrosion product in experiments with low atmospheric CO_2 concentrations (< 350 ppm).*

Roselle (2013 Section 4.3) then contradicts the above statement stating current experiments indicate no evidence that corrosion products will occur on steel under WIPP-relevant conditions. He further claims results from recent experiments are similar to what was observed in the earlier Telander and Westerman (1993) corrosion investigations [$Fe(OH)_2$]. However, corrosion products have been reported by Roselle (2013) in WIPP related experiments and contradicts Roselle's own assumption reported in Roselle, 2013 Section 4.3. Archeological evidence indicates corrosion products will occur under harsh anaerobic conditions. Réguer et al. (2007) and Rémazeilles et al. (2009) indicate long term corrosion products have formed on iron artifacts under anaerobic conditions and saline conditions. This is further corroboration that corrosion products, such as green rust, could form on WIPP steel. Production of corrosion products could result in a higher value of STOIFX, as demonstrated in the following equation:

$$6Fe + CO_2 + 15H_2O = Fe_6(OH)_{12}CO_3 \bullet 2H_2O + 7\ H_2$$

Given the contradictions, the DOE should discuss why a value of "1" should be used for the parameter STOIFX. In this discussion, the DOE needs to address all available data, including the solids characterization results from the iron corrosion experiments performed by Roselle (Roselle 2009, 2010, 2011a, 2011b) and analogue data that indicate corrosion occurs in anaerobic and saline high chloride media (e.g., Réguer et al. 2007, Rémazeilles et al. 2009) in the development of the parameter STOIFX.

Réguer, S., P. Dillman and F. Mirambet. 2007. Buried iron archaeological artefacts: corrosion mechanisms related to the presence of Cl-containing phases. Corrosion Science 49:2726-2744.

Rémazeilles, C., D. Neff, F. Kergourlay, E. Foy, E. Conforto, S. Réguer, P. Refait and P. Dillmann. 2009. Mechanisms of long-term anaerobic corrosion of iron archaeological artefacts in seawater. *Corrosion Science* 51:2932-2041.

Roselle, G.T. 2009. *Iron and Lead Corrosion in WIPP-Relevant Conditions: Six Month Results.* Milestone report, October 7, 2009, Sandia National Laboratories, ERMS 546084.

Roselle, G.T. 2010. *Iron and Lead Corrosion in WIPP-Relevant Conditions: 12 Month Results.* Milestone report, October 14, 2010, Sandia National Laboratories, ERMS 554383.

Roselle, G.T. 2011a. *Iron and Lead Corrosion in WIPP-Relevant Conditions: 18 Month Results.* Milestone report, May 3, 2011, Sandia National Laboratories, ERMS 555246.

Roselle, G.T. 2011b. *Iron and Lead Corrosion in WIPP-Relevant Conditions: 24 Month Results.* Milestone report, January 5, 2011, Sandia National Laboratories, ERMS 554715.

Roselle, G.T. 2013. *Determination of Corrosion Rates from Iron/Lead Corrosion Experiments to be Used for Gas Generation Calculations.* Sandia National Laboratories, ERMS 559077.

Telander, M.R., and R.E. Westerman. 1993. *Hydrogen Generation by Metal Corrosion in Simulated Waste Isolation Pilot Plant Environments: Progress Report for the Period November 1989 Through December 1992.* Prepared by Pacific Northwest National Laboratory for Sandia National Laboratory, SAND92-7347.

4-(14)15-1 Plan View of the Repository with Updated Dimensions. The repository layout has changed since the 2009 recertification. Please provide a plan view of the repository design. This should include the dimensions and locations of the repository and should provide the dimensions of the current and planned excavated areas and the run-of-mine salt panel closure system.

4-23-1 Volume of Repository Operations and Experimental Areas. Please clarify the planned excavated volume of the repository operations and experimental areas, accounting for past and current activities and excavations for planned experimental activities in the underground.

On August 11, 2011, the DOE submitted to the EPA a Planned Change Notice to initiate mining activities for a 'contingently funded' Salt Disposal Investigations (SDI) project in the WIPP underground. The planned SDI test required increasing the repository footprint in the experimental area by mining an additional 61,000 m^3. On June 20, 2012, the DOE notified the EPA that an *alternative* to the SDI had been developed entitled the Salt Defense Disposal Investigations (SDDI). The SDDI test plans to mine 31,000 m^3 in the experimental area, approximately half of the SDI design. Verbal communication between Department and Agency staff indicated the SDI test was cancelled due to funding issues.

The modeled experimental volume area in the CRA 2014 has been increased to reflect the "contingently funded" SDI volume of 61,000 m^3 and not 31,000 m^3 volume, reflective of the SDDI test. The volume of excavation that the DOE is actually planning for the testing is unclear.

U.S. Department of Energy (DOE), 2011. *Notification of Intent to Begin the Salt Disposal Investigations*. Letter from Edward Ziemianski to Jonathan Edwards dated August 11, 2011. Carlsbad, New Mexico.

U.S. Department of Energy (DOE), 2012. *Notification of Revisions to the Salt Disposal Investigations Testing Concepts*. Letter from Jose R. Franco to Jonathan Edwards dated June 20, 2012. Carlsbad, New Mexico.