WPO 31355

Repository Closure

Reasoned Argument for FEP Issue DR12

Geoff A. Freeze
INTERA Inc.
9 February 1996

Geoff Freeze

Recommended Screening Decision

Repository closure (due to salt creep and salt dilation) should be approximated in performance assessment calculations by a "porosity surface" that relates repository porosity, repository pressure, and time from repository excavation. Changing repository porosity (representative of closure) as a function of time and repository pressure (which is controlled by brine and gas flow) is to be included in future system-level PA calculations within the current PA modeling system through existing parameter values. The porosity-time-pressure relationship is determined from SANCHO simulations of disposal room closure as a function of gas-generation rate. The approximation is valid as long as the rate of room pressurization in performance assessment calculations is similar to the room pressurization history in the SANCHO-simulations. Even with a significantly different room pressurization history, the approximation is valid if the room pressures remain low enough that there is little or no room expansion.

Screening Issue

Long-term salt creep is driven by deviatoric stresses that develop within the intact salt surrounding an excavation. Prior to repository excavation, an undisturbed stress state existed in the Salado Formation in response to lithostatic loading. The presence of the repository excavations produces high deviatoric stresses in the Salado Formation near the disposal rooms, decreasing towards the undisturbed state with distance away from the repository. Following excavation, hydrologic and geochemical processes in the repository and the surrounding Salado Formation work to re-establish an equilibrium. This equilibrium state is achieved through the concurrent processes of salt creep and fluid (brine and gas) flow and the complex interactions between the two processes. The complex process of repository closure (salt creep) and its interaction with fluid flow is too computationally intensive to be efficiently incorporated into performance assessment calculations. Instead, an approximate relationship is required.

Basis for Recommended Screening Decision

Disposal room closure and consolidation is driven by the inward forces resulting from the excavation-related stress redistribution in the Salado Formation surrounding the room. Resistance to room closure is developed by the outward forces (backstress on the room walls) resulting from the stress distribution in the waste and backfill and from the pore pressure of the gas and brine in the room. A model used to evaluate repository performance must couple geomechanical closure with the hydrologic and chemical processes that control the room pore pressure.

The hydrologic process of brine inflow to the room increases the quantity of brine that occupies some of the available void volume in the room, thereby increasing room pressure. Gas generation, driven by chemical processes, increases the quantity of gas in a room, also increasing room pressure. The geomechanical process of room closure reduces the void volume available to store gas, additionally increasing pressure. Room pressurization may be mitigated by brine outflow, gas expulsion (outflow), or room expansion. In summary, the coupling between repository closure and fluid (brine and gas) flow is through room pressure.

Extensive in-situ and laboratory testing has been performed to determine the constitutive models and parameter values for creep deformation in halite (Krieg, 1984; Munson et al., 1989) and for consolidation of waste and backfill (Sjaardema and Krieg, 1987; Butcher, 1989; Butcher et al., 1991a; Butcher et al., 1991b). These models and parameters were used to perform simulations of room closure using a finite element creep closure code, SANCHO (Stone et al., 1985). Stone (1992) used SANCHO to simulate the closure of a perfectly sealed disposal room under five different gas-generation rate histories, covering the range of expected WIPP rates. In addition to constitutive models describing salt creep, waste consolidation, and backfill consolidation, the resistance to closure provided by the pressure of waste-generated gas, calculated from the ideal gas law, was simulated. These SANCHO results predicted room porosity as a function of time from excavation and of room pressure.

If the coupling between repository closure and fluid flow is to be represented by a porosity-time-pressure relationship, two assumptions must be made: (1) repository closure is approximated by repository porosity; and (2) the time-dependency of repository closure can be approximated by the time from excavation. Simulations were performed using TOUGH2 to test the coupling relationship and the associated assumptions (Freeze et al., 1995a; 1995b). Simulation results showed that the porosity-time-pressure relationship and the assumptions were valid for performance assessment calculations as long as simulated TOUGH2 room pressurization was similar to the room pressurization history in the SANCHO simulations. Even with a significantly different room pressurization history, the approximation is valid if the room pressures remain low enough that there is little or no room expansion.

References

Butcher, B.M. 1989. *Waste Isolation Pilot Plant Simulated Waste Compositions and Mechanical Properties*. SAND89-0372. Albuquerque, NM: Sandia National Laboratories.

Butcher, B.M., C.F. Novak, and M. Jercinovic. 1991a. *The Advantages of a Salt/Bentonite Backfill for Waste Isolation Pilot Plant Disposal Rooms*. SAND90-3074. Albuquerque, NM: Sandia National Laboratories.

Butcher, B.M., T.W. Thompson, R.G. Van Buskirk, and N.C. Patti. 1991b. *Mechanical Compaction of WIPP Simulated Waste.* SAND90-1206. Albuquerque, NM: Sandia National Laboratories.

Freeze, G.A., Larson, K.W., and P.B. Davies. 1995a. *A Summary of Methods for approximating Salt Creep and Disposal Room Closure in Numerical Methods of Multiphase Flow.* SAND94-0251. Albuquerque, NM: Sandia National Laboratories.Freeze, G.A., Larson, K.W., and P.B. Davies. 1995b. *Coupled Multiphase Flow and Closure Analysis of Repository Response to Waste-Generated Gas at the Waste Isolation Pilot Plant (WIPP).* SAND93-1986. Albuquerque, NM: Sandia National Laboratories.Freeze

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Munson, D.E., A.F. Fossum, and P.E. Senseny. 1989. "Approach to First Principles Model Prediction of Measured WIPP In Situ Room Closure in Salt," *Proceedings of the 30th U.S. Rock Mechanics Symposia at the University of West Virginia, June 19-22, 1989.* Rotterdam, Netherlands: A.A. Balkeema.

Sjaardema, G.D., and R.D. Krieg. 1987. *A Constitutive Model for the Consolidation of WIPP Crushed Salt and Its Use in Analyses of Backfilled Shaft and Drift Configurations.* SAND87-1977. Albuquerque, NM: Sandia National Laboratories.

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Stone, C.M., R.D. Krieg, and Z.E. Beisinger. 1985. *SANCHO, A Finite Element Computer Program for the Quasistatic, Large Deformation, Inelastic Response of Two-Dimensional Solids.* SAND84-2618. Albuquerque, NM: Sandia National Laboratories.

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Repository Closure

Reasoned Argument for FEP Issue DR12

M. E. Fewell / for D. R. Anderson 2/7/96

Geoff A. Freeze
INTERA Inc.
7 February 1996

Geoff Freeze

Recommended Screening Decision

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References

Butcher, B.M. 1989. *Waste Isolation Pilot Plant Simulated Waste Compositions and Mechanical Properties.* SAND89-0372. Albuquerque, NM: Sandia National Laboratories.

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Appendix D.
Conceptual Model/Parameter Reconciliation Form

Part A.

FEP ID: DR12

FEP Description: Repository Closure = f (brine inflow and gas outflow)

(To be completed by FEP Screening Lead Staff)

The effects of the FEP Issue will be captured in parameters values. Candidate Parameters are: porosity-time-pressure relationships for repository

Print Name GEOFF FREEZE Signature Geoff Freeze Date 2-7-96

FEP Screening Lead Staff

Part B.

WIPP Project Office:

The effects of above FEP are included in CCA calculations as recommend above.

Print Name______ Signature______ Date______

WIPP Project Office

(After completion of Part B pass to **WIPP Parameter Task Leader**.)

Parts C, D,E - Instructions:

1. **WIPP Parameter Task Leader - Pass this form to the WIPP PI(s) or PA Analyst(s) responsible for parameter values relevant to the FEP Screening Issue.**
2. **WIPP PI(s) or PA Analyst(s) - Complete Part C then return to WIPP Parameter Task Leader.**
3. **WIPP Parameter Task Leader - After Step 2 is completed, complete Part D, make copies as noted in Part E and submit this completed form to SWCF Center.**

Part C. WIPP Staff responsible for parameter values relevant to the FEP Screening Issue.

The effects of the FEP Issue is *captured* in the following parameters:

Print Name______ Signature______ Date______

Staff Responsible for parameter value specific to FEP Screening Issue

(Additional staff as applicable)

Print Name______ Signature______ Date______

Staff Responsible for parameter value specific to FEP Screening Issue

Print Name______ Signature______ Date______

Staff Responsible for parameter value specific to FEP Screening Issue

Part D. WIPP Parameter Task Leader Notification - FEP Issue is captured in the following parameters (use attachment if necessary).

Parameter	**Database ID**

Print Name______ Signature______ Date______

Parameter Task Leader

Part E. Copies of this form sent to:

1. FEP Lead Staff ______(name)
2. Staff Responsible for parameter value specific to FEP Screening Issue______(name)
3. **SWCF**______(File ID #)

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KE 2/9/96

~~Appendix D.~~

Conceptual Model/Parameter Reconciliation Form

Part A.

FEP ID: DR12

FEP Description: Repository Closure = f (brine inflow and gas outflow)

(To be completed by FEP Screening Lead Staff)

The effects of the FEP Issue will be captured in parameters values. Candidate Parameters are: porosity-time-pressure relationships for repository

Print Name GEOFF FREEZE Signature Geoff Freeze Date 2-7-96
FEP Screening Lead Staff

Part B.

WIPP Project Office:

The effects of above FEP are included in CCA calculations as recommend above.

Print Name Margaret Chu Signature Date 2-16-96
WIPP Project Office

(After completion of Part B pass to **WIPP Parameter Task Leader**.)

Parts C, D,E - Instructions:

1. **WIPP Parameter Task Leader - Pass this form to the WIPP PI(s) or PA Analyst(s) responsible for parameter values relevant to the FEP Screening Issue.**
2. **WIPP PI(s) or PA Analyst(s) - Complete Part C then return to WIPP Parameter Task Leader.**
3. **WIPP Parameter Task Leader - After Step 2 is completed, complete Part D, make copies as noted in Part E and submit this completed form to SWCF Center.**

Part C. WIPP Staff responsible for parameter values relevant to the FEP Screening Issue.

The effects of the FEP Issue is *captured* in the following parameters: porosity - time - pressure relationships for repository

Print Name Palmer Vaughn Signature Palmer Vaughn Date 3/6/96
Staff Responsible for parameter value specific to FEP Screening Issue

(Additional staff as applicable)

Print Name Barry Butcher Signature B. Butcher Date 3/6/96
Staff Responsible for parameter value specific to FEP Screening Issue

Print Name James D. Schreiber Signature James D. Schreiber Date 3/8/96
Staff Responsible for parameter value specific to FEP Screening Issue

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Part D. WIPP Parameter Task Leader Notification - FEP Issue is captured in the following parameters (use attachment if necessary).

Parameter See Attachment **Database ID**

Print Name Martin Tierney Signature Martin Tierney Date 3/15/96
Parameter Task Leader

Part E. Copies of this form sent to:

1. FEP Lead Staff Geoff Freeze (name)
2. Staff Responsible for parameter value specific to FEP Screening Issue Butcher, Schreiber, Vaughn (name)
3. **SWCF**-A:1.2.07.3:PA:QA:TSK:DR12 (File ID #)

SWCF-A: 1.2.07.3: PA: QA: TSK: DR12

FEP DR12 — Attachment, Part D.

Part D. WIPP Parameter Task Leader Notification - FEP Issue is captured in the following parameters.

Parameter: Porosity - time - pressure relationships for repository.

These relationships, obtained from SANCHO calculations, are contained in data values within the BRAGFLO code, version 4.00, in the BLOCK DATA STARTUP subprogram. The porosity is computed as a function of pressure and time in subroutines CONSOL and CONSOL1, which call subroutines POR_SURF, TRI_INTERP, and LOCATE to interpolate among the porosity values set in BLOCK DATA STARTUP to obtain the repository porosity at the specified time and pressure.

Print Name James D. Schreiber Signature James D. Schreiber Date 3/8/96

Appendix D.
Conceptual Model/Parameter Reconciliation Form

Part A.

FEP ID: DR12

FEP Description: Repository Closure = f (brine inflow and gas outflow)

(To be completed by FEP Screening Lead Staff)

The effects of the FEP Issue will be captured in parameters values. Candidate Parameters are: porosity-time-pressure relationships for repository

Print Name GEOFF FREEZE Signature Geoff Freeze Date 2-7-96
FEP Screening Lead Staff

Part B.

WIPP Project Office:

The effects of above FEP are included in CCA calculations as recommend above.

Print Name__________ Signature__________ Date_____
WIPP Project Office

(After completion of Part B pass to **WIPP Parameter Task Leader**.)

Parts C, D,E - Instructions:

1. **WIPP Parameter Task Leader - Pass this form to the WIPP PI(s) or PA Analyst(s) responsible for parameter values relevant to the FEP Screening Issue.**
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Print Name__________ Signature__________ Date_____
Staff Responsible for parameter value specific to FEP Screening Issue

(Additional staff as applicable)

Print Name__________ Signature__________ Date_____
Staff Responsible for parameter value specific to FEP Screening Issue

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Parameter Task Leader

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1. FEP Lead Staff __________(name)
2. Staff Responsible for parameter value specific to FEP Screening Issue__________(name)
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