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date: December 20th, 2021

to: WIPP Records Center

from: Seth King *Signature on File*

subject: Repository volume, DRZ volume, and minimum brine volume for a direct brine release for a repository with new panels

Summary

This memo is to adjust the repository volume parameter (REFCON:VREPOS), define the DRZ volume used in actinide solubility calculations, and specify the minimum brine volume for a direct brine release (GLOBAL:DBRMINBV) for a WIPP repository with replacement and additional panels. The volume of the repository with the new panels is 853,284.89 m^3, the volume of all 19 waste panels modeled (including Panel 9). The DRZ volume is 3,076,379 m^3, calculated from the area of the repository (REFCON:AREA_CH) (216,952 m^2). The minimum brine volume for a direct brine release is calculated from the updated repository volume parameter and has a new value of 33,804 m^3.

Volume of the Repository

Brunell (2020) calculated the excavated storage volume of the repository excluding the volume of Panel 9 as no waste is emplaced in Panel 9. The exclusion of the Panel 9 volume was argued to be conservative as it increases inventory density modeled in the repository. However, this is inconsistent with the Salado Flow model and with the calculation of the fraction of the repository volume occupied by contact handled waste (GLOBAL:FVW), both of which include the Panel 9 volume. Panel 9 is modeled as containing waste; therefore, the volume of Panel 9 should be included in the excavated storage volume of the repository. Brunell (2020) calculated the 19-panel volume as 853,284.89 m^3 (including Panel 9), and this value should be used when Panel 9 is modeled as containing waste.

Volume of the DRZ

The volume of the DRZ[1] is used in the calculation of actinide solubilities. With the new panels added to the repository, the area of the repository and therefore volume of the DRZ have increased. The vertical extent of the DRZ is assumed to remain the same, 11.95 m above the repository and 2.23 m below the repository. The footprint of the repository is equal to the area available for contact handled (CH) waste disposal (REFCON:AREA_CH). The value for REFCON:AREA_CH for a 19-panel repository was calculated to

[1] Note that the volume of the DRZ is not a parameter in the PAPDB, but an input into the thermodynamic model.

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be 216,952 m^2; an increase from the 10-panel repository value of 111,500 m^2. The new footprint gives a total volume of the DRZ of 3,076,379 m^3 (sum of depths multiplied by the area).

Minimum Brine Volume for a DBR

Actinide solubility calculations for the Waste Isolation Pilot Plant (WIPP) Performance Assessment (PA) rely on the concentration of various constituents in brine. The concentration of these constituents is based on the volume of brine into which the constituents dissolve. A range of brine volumes is used in the solubility calculations; this range is defined as integer multiples of the minimum brine volume. The minimum brine volume is defined as the least amount of brine in the repository required for a direct brine release (DBR) to occur.

For a DBR to occur, two criteria must be met (Stoelzel and O'Brien 1996):

1. Volume averaged pressure in the vicinity of the repository encountered by drilling must exceed drilling fluid hydrostatic pressure (assumed to be 8 MPa).
2. Brine saturation in the repository must exceed the residual saturation of the waste material (sampled from a uniform distribution ranging from 0.0 to 0.552).

These criteria apply to local conditions at the site of the borehole intrusion, but because the inventory is assumed to be evenly distributed throughout the repository waste regions, the minimum brine volume is reported as the volume of brine required to saturate all waste regions to the minimum saturation. The minimum brine volume is then defined as:

Minimum Brine Volume = Minimum Brine Saturation × Volume of the Compressed Repository

The minimum brine volume for WIPP PA was originally calculated by Larsen in 1996 as 29,800 m^3. The value was then updated by Stein in 2005 to 10,000 m^3, by Clayton in 2006 to 13,700 m^3, and again by Clayton in 2008 to 17,400 m^3.

Consolidated Void Volume

Following the procedure used by Clayton (2008) and proposed by Stein (2005), the results from SANTOS were used to determine the consolidated void volume of a room that is associated with the 8 MPa minimum pressure needed for a DBR to occur. Table 1 (reproduced from Clayton 2008) shows the SANTOS results at 10,000 years for the pressure (P_i, i=1 to 4) and consolidated void volume (V_i, i=1 to 4) versus f-Factor (SNL, 1996).

Table 1 SANTOS Results at 10,000 years for Pressure and Consolidated Void Volume versus f-Factor (SNL 1996).

f-Factor	Pressure (MPa)	Void Volume (m^3)
0.025	2.825	240.3
0.05	4.371	310.6
0.1	6.382	425.4
0.2	9.158	593.0

The void volume associated with the minimum pressure (8 MPa) is calculated with linear interpolation using the formula defined in Clayton (2008):

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$$V = V_3 + \frac{(P - P_3)(V_4 - V_3)}{(P_4 - P3)} = 425.4 + \frac{(8 - 6.382)(593.0 - 425.4)}{(9.158 - 6.382)} = 523.1 \frac{m^3}{room}$$

Minimum Brine Saturation

The DBR conceptual model (Stoelzel and O'Brien 1996) states in order for a DBR release to occur, the brine saturation in the repository must be above the sampled residual brine saturation for the waste area (WAS_AREA:SAT_RBRN). As recommended by Stein (2005) and used by Clayton (2008), a median value of 0.276 for WAS_AREA:SAT_RBRN is used as reasonable lower end estimate.

DBR volume as a function of brine saturation in the intruded waste panel for lower intrusions from CRA-2019 is plotted in Figure 1. This figure shows that all significant DBR volumes come from saturation values above 0.276.

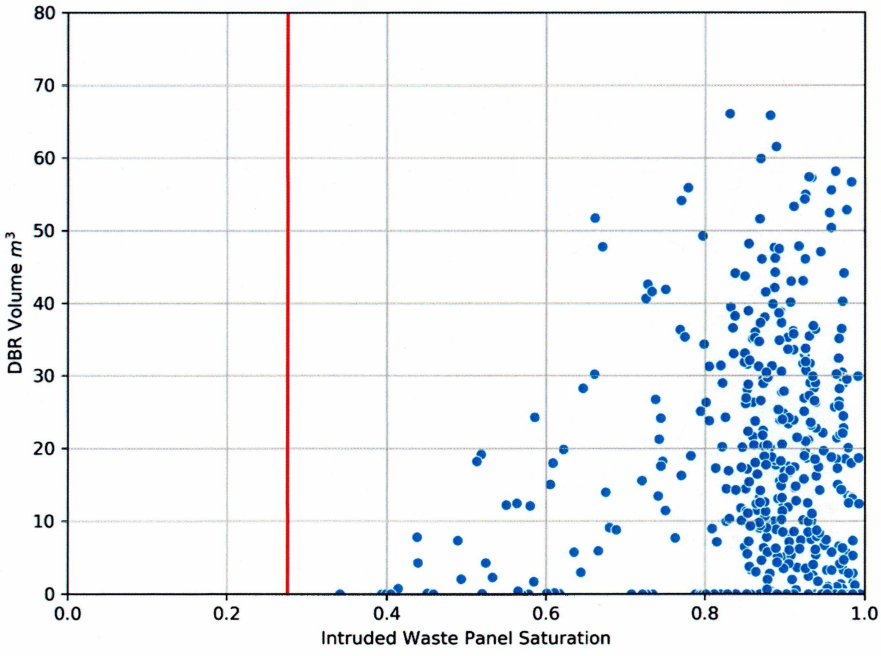


Figure 1 Scatter plot of DBR volume vs. brine saturation in the intruded waste panel from CRA-2019. The vertical line indicates the median value of the WAS_AREA:SAT_RBRN parameter.

Number of Equivalent Rooms

The number of equivalent rooms is used to convert the compressed room volume found above to the compressed repository volume so that the minimum brine volume parameter can be used for inventory-scale concentration calculations. Previous calculations by Schreiber (1991), Stein (2002), and Clayton (2008) used the REFCON:VREPOS value of 438,406.08 m^3. With the new panels, the volume of the repository has been updated. The REFCON:VREPOS value of 853,284.89 m^3 will be used here.

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The volume of a single room as derived by Schreiber (1991) is stored in the parameter database as REFCON:VROOM (3644.378 m^3). The number of equivalent rooms is then:

$$\frac{REFCON:VREPOS}{REFCON:VROOM} = \frac{853{,}284.89}{3{,}644.378} = 234.14\, rooms$$

Minimum Brine Volume

Using the values discussed above for the consolidated void volume, number of equivalent rooms, and minimum brine saturation, a reasonable minimum volume of brine in the repository required for a DBR is:

$$523.1\frac{m^3}{room} \times 234.14\, rooms \times 0.276 = 33{,}804\, m^3$$

This value is 1.94 times larger than the value calculated by Clayton (2008) since the volume of the repository has increased by the same factor.

Conclusion

Two parameter changes are listed in Table 2. The updated DRZ volume for solubility calculations is changed to 3,076,379 m^3, from an increased area of 216,952 m^2.

Table 2 – Updated Parameter Values

Material	Property	Description	Units	CRA-2019 Value	**RPPA Value**
REFCON	VREPOS	Excavated storage volume of repository.	m^3	438,406.08	853,284.89
GLOBAL	DBRMINBV	Minimum volume of brine in the repository required for a direct brine release.	m^3	17,400	33,804

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