Chavez, Art V. - RES

Subject: Response to EPA Questions on Two-Phase Flow and ROM Permeability
Attachments: Review of Data Sets for ROM Permeability_06-14-12_Clean.docx; BRAGFLO Two-Phase Final.pdf; Summary of Capillary Pressure Model Rev00.docx

From: Patterson, Russ - DOE
Sent: Friday, June 15, 2012 8:30 AM
To: Tom Peake; Jonathan Walsh; Kathleen Economy; Shankar Ghose
Cc: Gross, Mike - RES; Kouba, Steve - WRES; Trone, Janis - SNL; Camphouse, Chris - SNL; Shoemaker, Paul - SNL; Thompson, Bill; Klein, Thomas - RES
Subject: Response to EPA Questions on Two-Phase Flow and ROM Permeability

Tom;

As we discussed during our teleconference on May 30, 2012 and as we have discussed since, the Department of Energy (DOE) is prepared to proceed with computational calculations for the performance assessment (PA) for the Waste Isolation Pilot Plant (WIPP) Panel Closure System (PCS) as described in the planned change request (PCR) submittal dated September 28, 2011. Before DOE can proceed with this PA, EPA requested information on the capillary pressure models in BRAGFLO. EPA also sent a comment via E-Mail on June 7, 2012, requesting information on DOE's basis for including or excluding data sets defining the permeability of crushed salt during the T2 and T3 time periods. This E-Mail responds to both of these requests.

DOE's recommendations on the parameters to be used in the PCS-2012 PA are defined in the "PCS-2012 Parameter Memo" sent to you via e-mail on May 4, 2012. In response to the EPA's comment of June 7, 2012, DOE has reviewed the PCS-2012 PA parameters for the time periods T1, T2, and T3, and the data sets used to define these parameters. Based on this review, DOE determined that the original parameters in the "PCS-2012 Parameter Memo" for the T2 and T3 time periods are appropriate and reasonably justified. The DOE's review is documented in the attached DOE internal memo, "Review of Data Sets for ROM Permeability_06-14-12.docx", which provides further explanation of the data sets reviewed and considered, and the rationale for the recommended parameter values during the T1, T2, and T3 time periods. The DOE also determined that the lower limit on permeability during the T1 time period should be reduced from 10^{-19} m^2 to 10^{-21} m^2. The recommended value for the upper limit on permeability during the T1 time period is unchanged at 10^{-12} m^2. The rationale for the upper and lower limits on permeability during the T1 time period is also documented in "Review of Data Sets for ROM Permeability_06-14-12.docx".

With regard to information on the capillary pressure models, the attached memo from Sandia National Laboratories ("BRAGFLO Two Phase Final.pdf") answers your recent questions regarding two-phase flow and capillary pressure usage in the BRAGFLO code at an in-depth level of detail. For clarity/simplicity I have included a summary description and table at the bottom of this memo (see below) and as an attachment titled " Summary of Capillary Pressure Model " in case the table does not format properly in your "Outlook" page.

As I stated above DOE is prepared to proceed with the computational phase of PCS-2012 PA. If EPA agrees with DOE, that the PCS-PA model parameters, as have been outlined and discussed in this memo, plus attachments, and previous documentation, will provide a reasonable representation of PCS long-term performance such that a comparison with past PCS performance can be evaluated, DOE would appreciate your concurrence to proceed.

Thanks

Russ

Capillary Pressure Models

Capillary pressure is a measure of the pressure difference between the non-wetting phase (gas in this case) and the wetting phase (brine), which varies with the saturations of the two phases. The capillary pressure model in BRAGFLO, Version 6.0, may be turned "on" or "off" for various materials in a BRAGFLO grid. The status of the key parameters for the BRAGFLO capillary pressure model in the "on" or "off" condition is summarized in the following table:

Table 1. Key parameters for BRAGFLO capillary pressure model

Capillary Pressure Model is Turned Off	The threshold capillary pressure[1], P_t, is 0, with PCT_A = 0, defined by input, and PCT_EXP = 0, defined by input CAP_MOD = 1, defined by input. PC_MAX is defined by input[2] but not used, and P0_MIN is defined by input[2] but not used.
Capillary Pressure Model is Turned On	The threshold capillary pressure, P_t, is nonzero; PCT_A and PCT_EXP are nonzero values, defined by input. A nonzero value for P_t results in a positive capillary pressure[3], P_c, which is a function of the time-dependent brine saturation. CAP_MOD = 2, defined by input. PC_MAX is defined by input[2] and is an upper bound on the capillary pressure; P0_MIN is defined by input[2] but not used.

Footnotes:

[1] The threshold capillary pressure, P_t, is defined by $P_t = (\text{PCT_A})k^{\text{PCT_EXP}}$, where k is permeability and PCT_A and PCT_EXP are input parameters for each material. The values of PCT_A and PCT_EXP for the PA for the Compliance Recertification Application of 2009 (CRA-2009) and for the PABC-2009 (Clayton et al., 2010) are documented in Table PA-3 of Appendix PA of CRA-2009 (DOE, 2009).

[2] PC_MAX is equal to 10^8 Pascals for all materials but is only used when CAP_MOD = 2. P0_MIN is equal to 1.01325×10^5 Pascals for all materials but has never been used in a performance assessment.

[3] The equation for capillary pressure, P_c, depends on the model for relative permeability for a given material. The models and equations for relative permeability and capillary pressure are documented in Section PA-4.2.1 of Appendix PA of CRA-2009 (DOE, 2009). The relative permeability model is defined by the BRAGFLO input parameter RELP_MOD, whose values are documented in Table PA-4 of Appendix PA of CRA-2009 (DOE, 2009).

References

Clayton, D.J., Camphouse, R.C., Garner, J.W., Ismail, A.E., Kirchner, T.B., Kuhlman, K.L., and M.B. Nemer. 2010. Summary Report of the CRA-2009 Performance Assessment Baseline Calculation. Sandia National Laboratories, Carlsbad, New Mexico. ERMS 553039.

DOE (U.S. Department of Energy), 2009. Title 40 CFR 191 Parts B and C Compliance Recertification Application. DOE/WIPP-09-3424. Carlsbad Field Office, Carlsbad, New Mexico.