WPO 30793

DR-2: CAPILLARY ACTION (WICKING) WITHIN THE WASTE MATERIALS
Summary Memo of Record

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Subject: FEP Screening Issue DR-2

STATEMENT OF SCREENING DECISION

FEP Screening Issue DR-2 will be included in future system-level performance assessment calculations.

STATEMENT OF SCREENING ISSUE

This screening effort evaluates the need for including wicking in future system-level performance assessment calculations. Capillary action (wicking) is the ability of a material to carry a fluid by capillary forces above the level it would normally seek in response to gravity. Although the representation of wicking is implied by the use of two-phase Darcy flow, wicking in waste materials has been considered in the past to represent a level of detail that is beyond the available data for fundamentally defining the mechanism of wicking on gas generation. Nevertheless, the effect of wicking on gas generation and releases to the environment can be approximated and may be important and needs evaluation.

The present gas generation model estimates substantially different gas generation rates depending upon whether the waste is in direct contact with liquid or whether the waste is surrounded by water vapor in the gas phase. This behavior is consistent with experimental observations. Therefore, the physical extent of these regions of contact could be important. Present assumptions are that capillary action in cellulosics is not likely to be important because it applies to only a small portion of the total waste, which aside from its containers, is not likely to contain much metal. Similarly, capillarity in metal waste is also not likely because the sizes of the metal waste fragments are much larger than the 'pore' size needed to sustain capillarity. While 'pore' size of the sludges is probably small enough for capillary forces to be important, aside from the containers, the sludge is assumed to contain no free water because liquid sorbing materials such as dry portland cement are intentionally added to the sludge. Finally, while capillarity in the backfill is possible, it would be important only in regard to backfill that is in direct contact with metal (note there is no backfill in the current repository design).

The impact of wicking on direct releases to the surface during a drilling intrusion into the repository is also considered. Direct releases to the surface may occur during drilling due to cuttings and spallings in the drilling fluid and brine circulation from the repository to the surface in the wellbore. These releases are controlled by the prevailing pressure, permeability, and saturation conditions in the disposal room at the time of intrusion. The effect of wicking on these conditions may be important and needs to be evaluated.

APPROACH

The baseline gas generation model in BRAGFLO accounts for corrosion of iron and microbial degradation of cellulosics. The net reaction rate of these processes is directly dependent on brine saturation: an increase in brine saturation will increase the net reaction rate by weighting the inundated portion more heavily, while less weighting is applied to the slower humid portion. To simulate the effect of wicking on the net reaction rate, an effective brine saturation, which includes a wicking saturation contribution, is used to calculate reaction rates rather than the brine saturation. The wicking model is described in Appendix 2 of of the records package entitled "FEPs Screening Analysis for FEPs DR2, DR3, DR6, DR7, and S6".

A series of BRAGFLO simulations were performed to determine if wicking has the potential to enhance contaminant migration to the accessible environment. Effects of all other FEP issues were disabled in the simulations. Two basic scenarios were considered in the screening analysis, undisturbed performance and disturbed performance. Both scenarios included a 1.0 degree formation dip downward to the south. Intrusion event E1 is considered in the disturbed scenario and consists of a borehole that penetrates the repository and pressurized brine in the underlying Castile Formation. Two variations of intrusion event E1 are examined, E1 Up-Dip and E1 Down-Dip. In the E1 Up-Dip event the intruded panel region is located on the up-dip (north) end of the repository, whereas in the E1 Down-Dip event the intruded panel region is located on the down-dip (south) end of the repository. These two E1 events permit evaluation of the possiblity of increased brine flow into the panel region due to higher brine saturations down-dip of the borehole and the potential for subsequent impacts on contaminant migration. To incorporate the effects of uncertainty in each case (E1 Up-Dip, E1 Down-Dip, and undisturbed), a Latin hypercube sample size of 20 was used resulting in a total of sixty simulations. To assess the sensitivity of system performance on wicking in the waste materials, conditional complementary cumulative distribution functions (CCDFs) of normalized contaminated brine releases to the Culebra via human intrusion and shaft system, as well as releases to the subsurface boundary of the accessible environment, were constructed and compared to the corresponding baseline model CCDFs. In the baseline model calculations, the effects of all FEP issues are disabled. These comparisons provide direct information about how the inclusion of wicking may influence repository performance. In addition, performance measures are examined for direct releases during drilling due to cuttings and spallings and brine circulation from the repository to the surface. Potential releases to the surface during drilling are strongly influenced by three drivers: brine pressures, brine saturations, and permeability in the waste disposal area. Spallings, cuttings, and brine releases tend to increase with an increase in each of these drivers. The exception to this trend is that at high brine saturations (or low gas saturations) brine releases tend to decrease because gas volumes become to small to maintain an appreciable gas drive (gas expansion).

RESULTS AND DISCUSSION

CCDFs for releases to the Culebra and lateral land withdrawal boundary for E1 Up-Dip, E1 Down-Dip, and undisturbed cases are provided in Figure 4 of Appendix 1. Each figure compares CCDFs of normalized releases predicted by the baseline model and normalized releases predicted with capillary action. Note that releases to the Culebra via the shaft and intrusion borehole are shown on the left side of the figure whereas releases to the subsurface boundary of the accessible environment are presented on the right side of the figure. In all three cases (E1 Up-Dip, E1 Down-Dip, and undisturbed), the capillary action curves for releases to the Culebra are very close to the baseline curves for most of their lengths, with capillary action releases having only slightly higher values in the disturbed scenarios. In the E1 Up-Dip and E1 Down-Dip cases, CCDFs for releases to the subsurface boundary show higher probabilities for only small and insignificant releases. Undisturbed releases to the subsurface boundary of the accessible environment via the marker beds are consistently higher for the baseline model, with the baseline CCDF above and to the right of the capillary action CCDF. In summary, the differences in releases between the baseline and wicking results are minor and occuring primarily in the low release regions of the CCDFs.

Performance measures for direct release during drilling, which include maximum, mean, medium, and minimum values of volume averaged brine pressures, brine saturations, porosity, and permeability in the waste region for undisturbed conditions at 100, 1000, and 10000 years, are given in Table 3 of Appendix 1. Comparison of these table values with the baseline values given in Table 2 indicate that wicking produces slightly higher maximum, minimum, and median pressures at 100 years only and a higher median pressure at 1000 years. Note that these pressures are relatively low (hydrostatic pressure is approximately 7.8 MPa). In addition, all brine saturations, with the exception of the maximum value at 1000 years, are not significantly different than the corresponding baseline model values. Therefore, in all cases with the exception of the 1000 year intrusion time, direct releases during drilling will not be significantly different than those predicted by the baseline model.

The maximum brine saturation at 1000 years is approximately 7 per cent higher than the corresponding baseline value and this may result in releases greater than those predicted by the baseline model. A separate screening analysis of direct releases due to brine circulation from the repository to the surface is currently underway. The screening recommendation for wicking may be revisited in light of this analysis.

BASIS FOR RECOMMENDED SCREENING DECISION

Results indicate that wicking does not significantly impact releases to the accessible environment via the Culebra and Marker Beds. However, the impact of capillary action on potential releases due to a drilling untrusion may not be insignificant for intrusion times near 1000 years. Therefore, capillary action will be included in all future PA system-level modeling. This screening decision will be reevaluated once the separate and currently ongoing screening analysis of brine circulation to the surface is completed and the impact of wicking on this phenomena is further quantified.