THE OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY KEY TECHNICAL ISSUE AGREEMENT RESPONSES RELATED TO TSPAI.2.01, 2.02, 2.03, 2.04 AND 2.07 FOR A POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) issue resolution goal during this interim prelicensing period is to assure that the U.S. Department of Energy (DOE) has assembled enough information on a given issue for NRC to accept a license application for review. Resolution by the NRC during prelicensing does not prevent anyone from raising any issue for NRC consideration during the licensing proceedings. It is equally important to note that resolution of an issue by the NRC during the prelicensing period does not prejudge the NRC evaluation of the issue during the licensing review. Issues are resolved by the NRC during prelicensing when the staff have no further questions or comments about how DOE is addressing an issue. Pertinent new information could raise new questions or comments on a previously resolved issue.

By letter dated August 18, 2004, DOE submitted a report, "Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07)" (Bechtel SAIC Company, LLC, 2004a), to satisfy the informational needs of the referred agreements pertaining to scenario analysis. The information was requested by NRC during previous technical exchanges in May and August 2001.

This review addresses Total System Performance Assessment and Integration (TSPAI) Agreement TSPAI.2.02 comments that DOE has indicated are associated with agreements that the NRC staff has identified as being of high-risk significance. Specific Agreement TSPAI.2.02 Comments addressed in this review include: 34, 35, 37, 39, 42, 48, 54, 55, 56, 57, 60, 62, 78, 79, and J–1. The NRC staff will provide a response for the remaining of Agreement TSPAI.2.02 Comments (3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 36, 38, 43, 44, 49, 51, 59, 61, 63, 64, 65, 66, 68, 69, 70, J–2, J–3, J–4, J–7, J–8, J–9, J–10, J–11, J–12, J–13, J–14, J–15, J–17, J–20, J–21, J–22, J–23, J–24, J–25, J–26, and J–27), and Agreements TSPAI.2.01, 2.03, 2.04, and 2.07 under separate cover.

2.0 AGREEMENTS

Agreement language for TSPAI.2.02 is identified below:

Agreement TSPAI.2.02

"Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J–1, J–2, J–3, J–4, J–7, J–8, J–9, J–10, J–11, J–12, J–13, J–14, J–15, J–17, J–20, J–21, J–22, J–23, J–24, J–25, J–26, and J–27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted features, events, and processes (FEPs). The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03."

3.0 RELEVANCE TO OVERALL PERFORMANCE

The goal of scenario analysis is to ensure no significant aspect of the potential high-level waste repository is overlooked in the evaluation of its safety. The scenario analysis process provides the basis for initial development and identification of aspects relevant to waste isolation. Scenario analysis identifies features, events, and processes that could influence, directly or indirectly, dose risk to a reasonably maximally exposed individual from the potential high-level waste repository. Documentation of the compendium of features, events, and processes facilitates identification of aspects analyzed in the evaluation of repository safety and serves as a road map to the location of analyses and their conclusions. Screening arguments provide rationale for further consideration (or not) of features, events, and processes into the total system performance abstraction. A well-implemented process for identifying these features, events, and processes helps to ensure relevant aspects of the potential high-level waste repository and associated implications to the dose risk are studied.

4.0 RESULTS OF THE NRC REVIEW

Agreement TSPAI.2.02 is included in the TSPAI subissue for scenario analysis and event probability. This agreement resulted from a NRC staff review of the DOE documentation that is consistent with Review Methods 1 and 2 in Section 2.2.1.2 of the Yucca Mountain Review Plan (NRC, 2003). The NRC staff review of the DOE response for these agreements was conducted in accordance with the aforementioned review methods. These review methods include evaluating the identification of features, events, and processes and screening this list.

Agreement TSPAI.2.02 requested further technical basis for screening arguments on numerous features, events, and processes. The NRC staff categorized TSPAI.2.02 as having high-risk significance, based on the scope and content of the comments contained in this agreement. However, the individual comments within TSPAI.2.02 have not been separately categorized within the significance framework.

Agreement TSPAI.2.02

Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07) (Bechtel SAIC Company, LLC, 2004a), addresses Agreement TSPAI.2.02 by responding to each of the comments raised during technical exchanges in May and August of 2001.

Staff reviewed information provided in Key Technical Issue Letter Report (Bechtel SAIC Company, LLC, 2004a) to address Agreement TSPAI.2.02 Comments: 34, 35, 37, 39, 42, 48, 54, 55, 56, 57, 60, 62, 78, 79, and J–1. In the following sections the language associated with each of the individual comments is provided and the NRC staff's review of DOE's responses to each comment is provided.

4.1 Agreement TSPAI.2.02 Comment 34

Stress corrosion cracking of Waste Containers (2.1.03.02.00). Screened as included for waste package but as excluded for drip shield on the basis of low consequence *(CRWMS M&O, 2001a)*. The screening argument states that "...Source of stress for cracks is due to cold work stress and cracks caused by rockfall. However these cracks tend to be tight (i.e., small crack opening displacement) and fill with corrosion products and carbonate minerals. These corrosion products will limit water transport through the drip shield and thus not contribute significantly to overall radionuclide release rate from the underlying failed waste packages..." The screening argument for drip shield is weak. Simplified calculations by DOE indicate cracks will take considerable time to fill with corrosion products *(CRWMS M&O, 2000a)*. Cracks that develop in the DS may propagate and/or "open up" when subjected to subsequent loads caused by rockfall/drift collapse and/or seismic excitation allowing significant ground water infiltration through the drip shield.

Response to TSPAI.2.02 Comment 34

DOE responded to comment 34 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC,2004a).* This response indicates that the issue of stress corrosion cracking of the drip shield is addressed by the Container Life and Source Term (CLST) Agreement CLST.2.08. DOE submitted *Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion, Revision 1 (Bechtel SAIC Company, LLC, 2003a)*, in response to several CLST Agreements, including 1.12, 1.13, 1.14, 1.15, 2.08, and 6.01.

Based on NRC staff review of TBD6 (*NRC, 2004a*) and appendices, it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for stress corrosion cracking of the drip shield. Therefore, NRC staff believes that DOE has adequately addressed the issue of stress corrosion cracking of the drip shield as identified in TSPAI.2.02 Comment 34, which is generally described in the NRC staff's evaluation of DOE's response to CLST.2.08.

4.2 Agreement TSPAI.2.02 Comment 35

Juvenile and early failure of waste containers (2.1.03.08.00). Item screened as included for manufacturing and welding defects in waste container degradation analysis, and as excluded for manufacturing defects in drip shield degradation analysis, early failure of waste package and drip shield from improper quality control during the emplacement *(CRWMS M&O, 2001a)*. The screening argument states that the "Major effect of pre-existing manufacturing defects is to provide sites for crack growth by stress corrosion cracking. Tensile stress is required to have stress corrosion cracking. Because all fabrication welds of the drip shields are fully annealed prior to emplacement, drip shields are not subject to stress corrosion cracking, and are insignificant to cause stress corrosion cracking (stresses are temporary in nature). Manufacturing defects in the drip shield and early failures of the waste package and drip shield from improper quality control during emplacement can be excluded based on negligible consequence to dose." The basis for this assessment is that slap-down analysis of a 21-PWR waste package resulted in stresses in the waste package material that were less than 90 percent of the ultimate tensile strength. The impact energy associated with emplacement error is substantially less than that expected in a vertical tip over, emplacement errors are "not

expected to result in any damage." The results of the slap-down analysis are cited as the screening analyses of several features, events, and processes. The damage reported in the slap-down analyses causes concerns. While the impact energy of emplacement errors may be substantially less than those experienced in the slap-down analyses, a proper assessment of the extent of waste package damage as a result of emplacement errors should be performed.

Response to TSPAI.2.02 Comment 35

DOE responded to comment 35 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of juvenile and early failure of waste containers is addressed, in part, by Agreement CLST.2.08. Although not explicitly addressed in the CLST 2.08 response, DOE responded to various issues of juvenile and early failure in their response to Agreement GEN.1.01 Comment 8 and in the *Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion, Revision 1 (Bechtel SAIC Company, LLC, 2003a).* In addition, DOE has examined the effect of fabrication processes and weld defects which may contribute to initial defects and juvenile failures in Agreements PRE.7.04 and 7.05.

Based on NRC staff review of TBD6 (*NRC, 2004a*) and Agreement GEN.1.01 *(NRC, 2005a)*, it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for dripshield degradation of which juvenile and early failure of waste containers is a component. Therefore, NRC staff believes that DOE has adequately addressed the issue of juvenile and early failure of waste containers as identified in TSPAI.2.02 Comment 35, which is generally described in the NRC staff's evaluation of DOE's response to CLST.2.08 and GEN.1.01 Comment 8.

4.3 Agreement TSPAI.2.02 Comment 37

Creeping of metallic materials in the engineered barrier subsystem (2.1.07.05.00) has been excluded from consideration in the total system performance assessment code *(CRWMS M&O, 2001a, 2001b)*. Although DOE correctly points out in the screening argument *(CRWMS M&O, 2001a)* that ". . .the deformation of many titanium alloys loaded to yield point does not increase with time," *(American Society for Metals International, 1990)*, it still does not specifically address the potential for creeping of titanium grades 7 and 24. For example, some titanium alloys have been shown to creep at room temperatures *(Ankem, S., et al., 1994)*. Creeping of the titanium drip shield subjected to dead loads caused by fallen rock blocks and/or drift collapse could significantly reduce the clearance between the drip shield and waste package over time. As a result, the drip shield may cause substantial damage to the waste package during its dynamic response to subsequent seismic loads. In addition, creeping could potentially cause separation of the individual drip shield units.

Response to TSPAI.2.02 Comment 37

DOE responded to comment 37 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of creep of metallic materials in the drip shield is addressed by Agreement CLST.2.08. DOE submitted *Technical Basis Document No. 6: Waste Package and*

Drip Shield Corrosion, Revision 1 (Bechtel SAIC Company, LLC, 2003a), in response to several CLST Agreements including 2.08.

NRC determined that although TBD6 addressed the mechanical degradation mode of high-temperature creep, DOE failed to address the potential mechanical degradation mode of low-temperature creep for the drip shield. The NRC Staff analysis by Neuberger et al (2002) indicates that titanium and some of its alloys may creep at temperatures as low as 50 EC [122 EF] when subjected to stress levels as low as 60-percent of the material's yield strength. Therefore, the technical basis for excluding low-temperature creep as a potential mechanical degradation mode for the titanium drip shield is not adequate and DOE should consider submitting more information in any potential LA.

4.4 Agreement TSPAI.2.02 Comment 39

Effects and Degradation of Drip Shield (2.1.06.06.00) was excluded on the basis of low consequence *(CRWMS M&O, 2001a)*. The drip shield is an important component of the engineered barrier subsystem and its function and degradation is explicitly considered in the total system performance assessment. The degradation of the drip shield due to corrosion processes is considered directly in the model abstraction for waste package degradation, whereas remaining aspects of drip shield behavior are considered as part of the engineered barrier subsystem analysis. For the secondary feature-event-process 2.1.06.06.01 (Oxygen embrittlement of Ti drip shield), DOE argues that it is explicitly considered in the screening argument, but no discussion is presented. It is noted that this issue is most relevant to mechanical failure of the drip shield, which is discussed under 2.1.07.01.00 (rockfall) and 2.1.07.02.00 (mechanical degradation or drift collapse). Although physical and chemical degradation processes have been included into the Total System Performance Assessment, their effects on the ability of the drip shield to withstand dead loads (caused by drift collapse and/or fallen rock blocks), rock block impacts, and seismic excitation is not accounted for in the screening arguments *(CRWMS M&O, 2001a, 2001b)*. In *CRWMS M&O, 2000b* it is stated that the impact of rockfall on the degraded drip shield has been screened as excluded until more detailed structural response calculations for the drip shield under various rock loads are available. No references are provided in this document as to when and where these analyses will be available.

Response to TSPAI.2.02 Comment 39

DOE responded to comment 39 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of drip shield degradation is addressed by Agreement CLST 2.08. DOE submitted *Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion, Revision 1 (Bechtel SAIC Company, LLC, 2003a)*, in response to several CLST Agreements, including 2.08.

Based on the NRC staff of review of TBD6 (*NRC, 2004a*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for drip shield degradation. Therefore, NRC staff believes that DOE has adequately addressed the issue of dripshield degradation as identified in TSPAI.2.02 Comment 39, which is generally described in the NRC staff's evaluation of DOE's response to CLST.2.08.

4.5 Agreement TSPAI.2.02 Comment 42

Pathways for unsaturated flow and transport in the waste and engineered barrier system (2.1.08.07.00) evaluates unsaturated flow and radionuclide transport that may occur along preferential pathways in the waste and engineered barrier subsystem *(CRWMS M&O, 2000c)*. The DOE indicates that preferential pathways are already "included" via "a series of linked one dimensional flowpaths and mixing cells through the engineered barrier subsystem, drip shield, waste package and into the invert *(CRWMS M&O, 2000c)*." Staff are concerned that preferred pathways in the engineered barrier subsystem are not being evaluated at the appropriate scale. Water has been observed to drip preferentially along grouted rock bolts in the enhanced characterization of repository block, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Interactions with engineered materials, such as cementitious and metallic components, can have a significant effect on evolved water and gas compositions. Because the description of 2.1.08.07.00 states that "Physical and chemical properties of the engineered barrier subsystem and waste form, in both intact and degraded states, should be considered in evaluating [preferential] pathways", staff expect the screening arguments to be based on an evaluation of these topics *(NRC, 2000)*.

Response to TSPAI.2.02 Comment 42

DOE responded to comment 42 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that DOE has screened as included FEP 2.1.08.07.0A, Unsaturated Flow in the Engineered Barrier System, in the performance assessment.

The NRC staff found DOE's response to Comment 42 acceptable, and the staff has no further questions at this time.

4.6 Agreement TSPAI.2.02 Comment 48

Spatial Heterogeneity of Emplaced Waste (2.1.01.04.00) is screened as excluded on the basis of low consequence *(CRWMS M&O, 2000c)*. Waste placed in Yucca Mountain will have physical, chemical, and radiological properties that will vary. The effect of spatial heterogeneity of the waste on repository-scale response is excluded based on low consequence but the heterogeneity within a waste package is implicitly included in the evaluation of in-package temperature used to determine perforation of the commercial spent nuclear fuel cladding. However, spatial variability that may affect degradation of engineering barrier, such as conditions leading to crevice corrosion vs passive corrosion of outer container, is not considered in this feature-event-process.

Response to TSPAI.2.02 Comment 48

DOE responded to comment 48 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that DOE split the FEP Spatial Heterogeneity of Emplaced Waste (2.1.01.04.00) and screened as included the following two FEPs in the performance assessment: 2.1.01.03.0A, Heterogeneity of Waste Inventory and 2.1.01.04.0A, Repository-Scale Heterogeneity of Waste Inventory.

The NRC staff found DOE's response to TSPAI.2.02 Comment 48 acceptable, and the staff has no further questions at this time.

4.7 TSPAI.2.02 Agreement Comment 54

Interaction with corrosion products (2.1.09.02.00) was excluded in the engineered barrier subsystem (except for colloid-related effects) on the basis of low consequence *(CRWMS M&O, 2001b)*. As noted in the NRC and U.S. Department of Energy technical exchange on Evolution of the Near-Field Environment, changes in seepage water chemistry resulting from interactions with engineered materials and their corrosion products were not adequately addressed in *(CRWMS M&O, 2000d)*. Water has been observed to drip preferentially along grouted rock bolts in the enhanced characterization of repository block, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Seepage waters that have interacted with engineered materials and their corrosion products, can have a significant effect on evolved water and gas compositions.

Response to TSPAI.2.02 Comment 54

DOE responded to comment 54 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that DOE has screened as included FEP 2.1.09.02.0A, Chemical Interaction with Corrosion Products, in the performance assessment.

The NRC staff found DOE's response to TSPAI.2.02 Comment 54 acceptable, and the staff has no further questions at this time.

4.8 Agreement TSPAI.2.02 Comment 55

Reaction Kinetics in Waste and Engineered Barrier Subsystem (2.1.09.07.00). [Engineered Barrier Subsystem]: Item screened as excluded on the basis of low consequence *(CRWMS M&O, 2001b)*. Consideration of chemical reactions, such as radionuclide dissolution and precipitation reactions and reactions controlling the reduction-oxidation state is included by considering reaction kinetics in the in-package equilibrium model but excluded based on low consequence for the engineered barrier subsystem. However, these processes may affect the composition of the near field environment, particularly for trace elements, and the effect on corrosion of container materials could be indirect and should be considered.

[Waste Form Misc]: Item screened as excluded on the basis of low consequence *(CRWMS M&O, 2000c)*. Adequate technical bases have not been provided to demonstrate that the combination of transport processes and reaction kinetics in the engineered barrier subsystem will not adversely impact performance by altering the composition of water contacting the drip shield and waste package.

Response to TSPAI.2.02 Comment 55

DOE responded to comment 55 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response

indicates that DOE split FEP 2.1.09.07.00, Reaction Kinetics in Waste and Engineered Barrier Subsystem, into the following two FEPS and screened both as included in the performance assessment: Reaction Kinetics in the Waste Package (2.1.09.07.0A) and Reaction Kinetics in Drifts.

The NRC staff found DOE's response to TSPAI.2.02 Comment 55 acceptable, and the staff has no further questions at this time.

4.9 Agreement TSPAI.2.02 Comment 56

Floor Buckling (2.1.07.06.00) has been screened as excluded in *(CRWMS M&O, 2001b)* and EBS Radionuclide Transport Abstraction *(CRWMS M&O, 2000e)* based on analyses documented in Repository Ground Support Analysis for Viability Assessment *(CRWMS M&O, 1998a)*, which indicate that floor heave from thermal-mechanical effects would not exceed about 10 mm. However, to address concerns raised by U.S. Nuclear Regulatory Commission staff about the appropriateness of the thermal-mechanical properties used in DOE calculations (such as the analyses cited above), the DOE has agreed to revise its assessment of floor buckling [Agreement RDTME.3.09 (DOE and U.S. Nuclear Regulatory Commission Technical Exchange on repository design and thermal-mechanical effects, February 6-8, 2001, Las Vegas, Nevada)]. Note that the screening argument relies on analyses that DOE has agreed to revise to address outstanding NRC concerns in repository design and thermal-mechanical effects Agreements 3.2-3.13 (repository design and thermal-mechanical effects Technical Exchange, February 6-8, 2001, Las Vegas, Nevada).

Response to TSPAI.2.02 Comment 56

DOE responded to comment 56 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of floor buckling is addressed by Agreements RDTME.3.02 through 3.13. DOE submitted *Technical Basis Document No. 4: Mechanical Degradation and Seismic Effects, Revision 1 (Bechtel SAIC Company, LLC, 2004b)*, as a combined response to these and other RDTME agreements.

Based on NRC staff review of TBD4 (*NRC, 2005b*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for the broader issue of drift degradation, of which floor buckling is a component. Therefore, NRC staff believes that DOE has adequately addressed the issue of floor buckling identified in TSPAI.2.02 Comment 56.

4.10 Agreement TSPAI.2.02 Comment 57

Undesirable materials left (1.1.02.03.00) is screened out on the basis of low consequences *(CRWMS M&O, 2001b)*. Although a report cited by the DOE *(CRWMS M&O, 1995a)* provides an analysis of acceptable upper bounds on materials introduced into the repository, no analysis has been conducted to determine if the current design will meet these limits. An assumption that the limits will be adhered to during the preclosure period is considered inadequate to exclude 1.1.02.03.00. DOE should provide adequate technical basis for the effect of introduced materials on water chemistry.

Response to TSPAI.2.02 Comment 57

DOE responded to comment 57 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the impact of undesirable materials being left in the drift on groundwater chemistry is addressed by Agreement CLST.1.01. DOE submitted *Technical Basis Document No. 5: In-Drift Chemical Environment, Revision 1 (BSC2003b)*, in response to several CLST Agreements, including 2.08.

Based on NRC staff review of TBD5 (*NRC, 2004b*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for the impact of undesirable materials being left in the drift on groundwater chemistry. Therefore, NRC staff believes that DOE has adequately addressed the issue of impact of undesirable materials being left in the drift on groundwater chemistry as identified in TSPAI.2.02 Comment 57.

4.11 Agreement TSPAI.2.02 Comment 60

The exclusion of Gas generation (2.1.12.01.00) and Gas generation from concrete (2.1.12.05.00) in *(CRWMS M&O, 2001b, 2000c)* is unacceptable, because adequate technical bases have not been provided to justify the characterization of chemical environments in the engineered barrier subsystem in terms of bulk water and gas compositions. The possibility of existence of local heterogeneity in gas composition in the drift, altering the chemistry of dripshield and waste package environment and adversely impacting repository performance should be explored. Local variations in the efficiency of advection/diffusion processes, relative to reaction rates, should be evaluated.

Response to TSPAI.2.02 Comment 60

DOE responded to comment 60 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the impact of gas generation on chemical environment affecting the waste package and dripshield is addressed by Agreement ENFE.2.04 and 2.06. DOE submitted *Technical Basis Document No. 5: In-Drift Chemical Environment, Revision 1 (BSC2003b)*, in response to several ENFE Agreements, including 2.04 and 2.06.

Based on NRC staff review of TBD5 (*NRC, 2005c*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for gas generation, based upon the information provided in TBD5. Therefore, NRC staff believes that DOE has adequately addressed the issue of impact of gas generation as identified in TSPAI.2.02 Comment 60.

4.12 Agreement TSPAI.2.02 Comment 62

Thermal and other waste and engineered barrier subsystem-related changes in the adjacent host rock (2.2.01.02.00) is screened as excluded on the basis of low consequence (thermal-mechanical effects) and low probability (thermal-hydrological-chemical and backfill

effects) *(CRWMS M&O, 2001c)*. Changes in host rock properties result from thermal effects or other factors related to emplacement of the waste and engineered barrier subsystem, such as mechanical or chemical effects of backfill. Properties that may be affected include rock strength, fracture spacing and block size, and hydrologic properties such as permeability. The screening argument did not consider mechanical degradation of the rock mass, such as fracture-wall rock alteration owing to long-term exposure to heat, moisture, and atmospheric conditions. Such degradation would increase the severity of mechanical failure, *(Ofoegbu G.I., 2000)*. However, DOE is expected to reevaluate its assessment of long-term mechanical degradation to satisfy outstanding DOE and NRC Agreements RDTME.3.11 and 3.19. In the analyses, it is necessary to account for long-term mechanical degradation of the host rock mass in its assessment of drift degradation, rockfall, and changes in hydrological properties; and their effects on repository performance.

Response to TSPAI.2.02 Comment 62

DOE responded to comment 62 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of thermal and other waste and engineered barrier subsystem-related changes in the adjacent host rock is, in part, addressed by Agreements RDTME.3.11 and 3.19. DOE submitted *Technical Basis Document No. 4: Mechanical Degradation and Seismic Effects, Revision 1 (Bechtel SAIC Company, LLC, 2004b)*, as a combined response to these and other RDTME Agreements.

Based on NRC staff review of TBD4 (*NRC, 2005b*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for the broader issue of drift degradation of which thermal and other waste and engineered barrier subsystem-related changes in the adjacent host rock is a component. Therefore, NRC staff believes that DOE has adequately addressed the issue of thermal and other waste and engineered barrier subsystem-related changes in the adjacent host rock as identified in TSPAI.2.02 Comment 62.

4.13 Agreement TSPAI.2.02 Comment 78

Seismic Vibration Causes Container Failure (1.2.03.02.00). The Seismic Vibration Causes Container Failure features, events, and processes has been excluded from consideration in the total system performance assessment code *(CRWMS M&O, 2001a, 2001d)*. The screening argument cites preliminary seismic analyses of the drip shield and waste package as the basis for this screening decision *(CRWMS M&O, 2000f)*. Because these analyses were not available at the time of this review, it is not clear as to whether the appropriate combinations of dead loads (caused by drift collapse and/or fallen rock blocks), rock block impacts, and seismic excitation were considered. Moreover, the ability of these loads to initiate cracks and/or propagate preexisting cracks may not have been adequately addressed. In addition, DOE has not demonstrated that the drip shield, pallet, and/or waste package will respond in a purely elastic manner when subjected to the aforementioned loading conditions. The screening argument for 1.2.03.02.00 also states that "... it does not appear credible that the drip shield would be breached, because the drip shield has been designed to withstand up to a 6-MT rockfall." based on the rockfall on drip shield analyses performed by the DOE *(CRWMS M&O,*

2000g). DOE, however, has not adequately demonstrated that the drip shield has in fact been designed to withstand 6-MT rock blocks.

Response to TSPAI.2.02 Comment 78

DOE responded to comment 78 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of seismically induced container failure is addressed by Agreements RDTME.3.17 and 3.19 and Agreements CLST.2.02 and 2.08. DOE submitted *Technical Basis Document No. 4: Mechanical Degradation and Seismic Effects, Revision 1 (Bechtel SAIC Company, LLC, 2004b)*, in response to several RDTME Agreements, including: 3.17 and 3.19. DOE also submitted *Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion, Revision 1 (BSC2003a)*, in response to several CLST Agreements, including: 2.02 and 2.08.

Based on NRC staff reviews of TBD4 (*NRC, 2005b*) and TBD6 (*NRC, 2004a*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for drift degradation and seismically induced container failure. Therefore, NRC staff believes that DOE has adequately addressed the issue of seismically induced container failure as identified in TSPAI.2.02 Comment 78.

4.14 Agreement TSPAI.2.02 Comment 79

The effects of large block rockfall (2.1.07.01.00) on the drip shield and waste package has been screened as excluded *(CRWMS M&O, 2001a, 2001b, 2001d)*. The Drift Degradation Analysis *(CRWMS M&O, 2000i)* Analysis Model Report (analysis and model report) indicates that thermal loading, seismicity, and time-dependent mechanical degradation of the host rock would have minor effect on the integrity of the drifts through the entire period of regulatory concern. However, several deficiencies associated with this analysis were identified by the NRC staff at the NRC and DOE repository design and thermal-mechanical effects technical exchange [see the Comments on 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) for additional discussion pertaining to the DOE rockfall analyses]. As was pointed out at the container life and source term and repository design and thermal-mechanical effects technical exchanges, the rockfall on drip shield analyses *(CRWMS M&O, 2000j)* did not consider (i) the temperature effects on mechanical material behavior, (ii) seismic motion of the supporting invert, (iii) point load impacts, (iv) appropriate material failure criteria, (v) material degradation processes, (vi) multiple rock block impacts, and (vii) boundary conditions that account for the potential interactions between the drip shield and gantry rails. Consequently, U.S. Department of Energy has not adequately demonstrated that the drip shield has been designed to withstand 6, 10, or 13-MT rock block impacts. Because the framework for the invert is constructed from carbon steel, their potential degradation may affect the orientation of the waste packages over time. In other words, the invert floor cannot be expected to keep the waste packages in a horizontal position for the entire regulatory period. As a result, rock block impacts on the waste package may occur at angles that are not perpendicular to the waste package longitudinal axis. Angled rock block impacts near the closure lid welds may have significantly different results than non-angled impacts. This is a new scenario that has not been presented to DOE. [Cladding]: Mechanical failure of cladding due to rockfall is excluded based on low probability

because rockfall on intact waste package will not cause rod failure *(CRWMS M&O, 2000h)*. Main screening argument is based on intact waste package. However, the discussion is confusing because arguments based on the presence of backfill are also used in quantitative estimates. Although the conclusion can be acceptable due to presence of intact waste package, the screening arguments should be improved on the bases of appropriate calculations.

Response to TSPAI.2.02 Comment 79

DOE responded to comment 79 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicates that the issue of large block rockfall is addressed by Agreements RDTME.3.17 and 3.19 and Agreements CLST.2.02 and 2.08. DOE submitted *Technical Basis Document No. 4: Mechanical Degradation and Seismic Effects, Revision 1 (Bechtel SAIC Company, LLC, 2004b)*, in response to several RDTME Agreements, including: 3.17 and 3.19. DOE submitted *Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion, Revision 1 (Bechtel SAIC Company, LLC, 2003a)*, in response to several CLST Agreements, including: 2.02 and 2.08.

Based on NRC staff review of TBD4 (*NRC, 2005b*) and TBD6 (*NRC, 2004a*), it appears that DOE will be able to provide sufficient information for the staff to evaluate the technical basis of DOE's screening arguments for the broader issue of drift degradation of which large block rockfall is a component. Therefore, NRC staff beleives that DOE has adequately addressed the issue of large block rockfall as identified in TSPAI.2.02 Comment 79.

4.15 Agreement TSPAI.2.02 Comment J-1

Container form (2.1.03.11.00) has been excluded from consideration in the total system performance assessment code *(CRWMS M&O, 2001a)*. The varying clearance between the drip shield and different waste package designs and the concomitant effects that this may have on the consequences of rock block impacts and/or seismic excitation have not been addressed by DOE.

Response to TSPAI.2.02 Comment J-1

DOE responded to comment J-1 in *Key Technical Issue Letter Report (Response to TSPAI.2.01, 2.02, 2.03, 2.04, and 2.07), Revision 2 (Bechtel SAIC Company, LLC, 2004a).* This response indicated that DOE has screened as included FEP 2.1.03.11.0A, Container Form, for inclusion in the performance assessment.

The NRC staff found DOE's response to TSPAI.2.02 Comment J-1 acceptable, and the staff has no further questions at this time.

5.0 SUMMARY

NRC staff reviewed the information provided by DOE for a subset of the comments associated

with Agreement TSPAI.2.02. NRC staff also reviewed DOE responses for several other related agreements, as identified in section 4 (above). In addition, NRC staff performed an independent assessment to determine if the information provided by DOE is adequate to allow for a detailed review of those portions of any potential license application. NRC staff found that the information provided by DOE adequately addressed a majority of Agreement TSPAI.2.02 Comments evaluated by the staff (34, 35, 39, 42, 48, 54, 55, 56, 57, 60, 62, 78, 79, and J–1) and would allow for a detailed review of those portions of any potential license application, with the exception of TSPAI.2.02 Comment 37 (see Section 4.3). The NRC Staff has not completed reviews of the information provided to address all of the remaining comments associated with Agreement TSPAI.2.02. As such, Agreement TSPAI.2.02 will remain open until the NRC staff has completed the review of the information provided by DOE to address the remaining comments associated with Agreement TSPAI.2.02.

6.0 STATUS OF THE AGREEMENTS

Based on the preceding review, NRC staff agrees that the information provided by DOE adequately addresses a majority of the comments associated with Agreement TSPAI.2.02 evaluated by the staff, with the exception of Comment 37 (see Section 4.3). As such, Agreement TSPAI.2.02 will remain open until the NRC staff has completed its review of the information provided by DOE to address the remaining comments. Responses to the review of information provided by DOE to address the remaining Agreement TSPAI.2.02 comments will be transmitted to DOE, under separate cover.

7.0 REFERENCES

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