OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY KEY TECHNICAL ISSUE AGREEMENT RESPONSE TO CLST.1.02, 1.03, 1.04, 1.10, AND 1.11 FOR A POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA

1.0   INTRODUCTION

By letters dated December 9, 2003, May 28, 2004, June 24, 2004, and June 30, 2004, the U.S. Department of Energy (DOE) submitted a report, Technical Basis Document No. 6 (TBD 6): Waste Package and Drip Shield Corrosion and Appendices I, O, R, and V (Bechtel SAIC Company, LLC, 2003a, 2004a,b,c), to satisfy the informational needs of numerous key technical issue agreement items pertaining to the environmental degradation of the waste package and drip shield materials and to respond to issues raised by the U.S. Nuclear Regulatory Commission (NRC) related to corrosion processes and design of the waste package and drip shield at the potential repository at Yucca Mountain, Nevada. The information was requested by NRC during previous technical exchanges in September 2000, February 2001, July 2001, August 2001, and September 2001. Specific agreements addressed in this NRC review of the information provided by DOE in the technical basis document include CLST.1.02, 1.03, 1.04, 1.10, and 1.11 (Schleuter, 2000).

2.0   AGREEMENTS

Wordings of the five agreements are provided next.

CLST.1.02

"Provide the documentation for the path forward items listed on slide 12 [the subject of microbially influenced corrosion effects on Alloy 22 (i.e., surface elemental analysis of alloy test specimens for determination of selective dissolution, surface analysis of welded specimens for evidence of dealloying, and continued testing including simulated saturated repository environment to confirm the corrosion enhancement factor)]. DOE will provide the documentation in a revision to AMR 'General and Localized Corrosion of Waste Package Outer Barrier' by LA."

CLST.1.03

"Provide the documentation that confirms the linear polarization resistance measurements with corrosion rate measurements using other techniques. DOE will document the results of testing in the general corrosion rate measurements in the revision of Alloy 22 AMR "General and Localized Corrosion of Waste Package Outer Barrier by LA."

CLST.1.04

"Provide the documentation of Alloy 22 and titanium for the path forward items listed on slide 14 [continue testing in the LTCTF; add new bounding water test environments to LTCTF (simulated saturated water and basic saturated water); install thinner coupons in LTCTF with

larger surface area/volume ratios; install high sensitivity probes of Alloy 22 in some of the LTCTF vessels; materials testing continues during performance confirmation]. DOE will provide the documentation in a revision to 'AMR ANL–EBS–MD–000003 and ANL–EBS–MD–000004' by LA."

CLST.1.10

"Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 21 and 22 [measure corrosion potentials in the LTCTF to determine any shift of potential with time toward the critical potentials for localized corrosion; determine critical potentials on welded and welded and aged coupons of Alloy 22 versus those for base metal—particularly important if precipitation or severe segregation of alloying elements occurs in the welds; separate effects of ionic mix of species in YM waters on critical potentials—damaging species from potentially beneficial species; determine critical potentials in environments containing heavy metal concentrations]. DOE will provide the documentation in a revision to AMRs (ANL–EBS–MD–000003 and ANL–EBS–MD–000004) prior to LA."

CLST.1.11

"Provide the technical basis for the selection of the critical potentials as bounding parameters for localized corrosion, taking into account MIC. DOE will provide the documentation in a revision to AMRs (ANL–EBS–MD–000003 and ANL–EBS–MD–000004) prior to LA."

3.0   RELEVANCE TO OVERALL PERFORMANCE

Agreement CLST.1.02 is related to microbially influenced corrosion of the proposed waste package outer containers. Agreements CLST.1.03 and1.04 are related to the uniform corrosion rates of the waste package outer containers and the titanium alloy drip shield. Agreements CLST.1.10 and 1.11 are related to the localized corrosion of the proposed waste package outer containers and the titanium alloy drip shield. Agreement CLST.1.11 emphasizes consideration of microbial environment in determining critical potential.

The waste package, composed of the containers and the waste forms, is the primary engineered barrier controlling the release of radionuclides from spent nuclear fuel and high-level waste glass. Corrosion processes, promoted by the presence of an aqueous environment contacting the surface of the containers, will be the primary causes of container failure under undisturbed conditions. The mode and rate of corrosion need to be evaluated to determine container lifetimes. Corrosion processes potentially important in the degradation of the engineered barriers include humid-air and uniform aqueous corrosion, localized (pitting, crevice, and intergranular) corrosion, microbially influenced corrosion, stress corrosion cracking, and hydrogen embrittlement. Fabrication processes, such as cold working, welding, and postweld heat treatments, may alter the corrosion resistance of the waste package materials.

Drip shield performance is important because the drip shields are incorporated into the design of the engineered barrier system to limit both the amount of water contacting the waste package as a result of dripping and damage to the waste package from rockfall. Initiation of aqueous corrosion of the waste packages depends on the deliquescence of dust or the contact with seepage water. The presence of drip shields will delay the contact of seepage water with

the waste package surface, resulting in a significantly longer container lifetime. In addition, once the containers are breached, the amount of water available for the dissolution of spent nuclear fuel and high-level waste glass and advective transport of the released radionuclides could be limited, even by the presence of a partially damaged drip shield.

The NRC risk insights analysis ranks the persistence of a passive film on the waste package outer container as high significance to waste isolation (NRC, 2004). Localized corrosion of the waste package and the integrity of the drip shields also have a medium significance to waste isolation (NRC, 2004). The persistence of a passive film on the waste package outer container surface is anticipated to result in low corrosion rates and long waste package lifetimes. High temperatures and aggressive water chemistry conditions can have a detrimental effect on stability of the passive film and may accelerate corrosion over extended surface areas or promote localized corrosion. Fabrication processes also may affect stability of the passive film. Microbial activity on or near the waste packages also may alter the local environment and influence the waste package corrosion, especially localized corrosion. While intact, the drip shield will also limit the quantity of water contacting the waste packages and waste forms and limit the formation of aggressive environments on the waste package surfaces. Penetration of the waste package by corrosion processes will allow water to contact the waste forms and allow the release of radionuclides, however, the transport of water and the release rate of the radionuclides may be restricted by the small apertures of the penetrations.

4.0   RESULTS OF THE NRC REVIEW

Agreements CLST.1.02, 1.03, 1.04, 1.10, and 1.11 are included in the integrated subissue titled degradation of engineered barriers. These agreements resulted from a staff review of the DOE documentation that is consistent with NRC (2003, Section 2.2.1.3.1.2, Review Method 2). The NRC review of the response for these agreements was also conducted in accordance with the aforementioned review method. This review method includes evaluation of the sufficiency of the experimental data used to support parameters in conceptual models and process-level models.

4.1   CLST.1.02

The focus of CLST.1.02 was the preferential dissolution as indicted by the results from the chemical analysis of the solution after a 5-month immersion test in 100X J–13 well water at room temperature for Alloy 22 and a higher uniform corrosion rate measured with the linear polarization method for Alloy 22 in microbe-containing environments (Lian, et al., 1999). Although no localized corrosion was visually observed on the Alloy 22 specimen, the post-test solution with microbes contained higher concentrations of chromium and nickel than did the post-test sterile solution. This result was an indication of microbially influenced corrosion for Alloy 22. Furthermore, the chromium content in the post-test solution containing microbes also was higher than the nickel content, even though the bulk phase of Alloy 22 contains more nickel than chromium. The higher content of chromium in solution suggests a higher preferential dissolution rate for chromium, which may lead to the breakdown of the passive oxide film formed on the Alloy 22 surface and could potentially lead to the suceptibility of Alloy 22 to localized corrosion in the microbial environments. The DOE response in Technical Basis Document No. 6, Appendix I (Bechtel SAIC Company, LLC, 2004a), presented the 5-year test results for Alloy 22 specimens exposed to a simulated Yucca Mountain water inoculated with

Yucca Mountain rocks. The coupon exposed to the nonsterile solution showed uniformly distributed arrays of micropitting with sizes ranging from 0.2 to 0.7 Fm [7.8 × 10^{13} to 2.8 × 10^{12} mils], which cannot be characterized as typical pitting corrosion, but is significantly different from the corrosion observed under the sterile conditions. DOE indicated investigations are ongoing to study the effect of Yucca Mountain organisms on material corrosion and groundwater chemistry. Performance confirmation activities should include the long-term immersion tests using not only mill-annealed Alloy 22 specimens but also heat-treated and welded specimens. The long-term immersion tests will verify if the localized effects in the form of submicron-sized degradation will evolve into typical pitting corrosion that has the autocatalytic behavior and a high localized penetration rate.

A twofold enhancement factor of the uniform corrosion rate in solutions containing microbes, including sulfate-reducing bacteria, was obtained with linear polarization methods (Lian et al., 1999). Yang and Cragnolino (2004) and Yang, et al. (2004) reported the presence of sulfate-reducing bacteria may increase the anodic current for passive alloys such as stainless steels. Hence, the twofold enhancement factor used in the DOE model analyses (Bechtel SAIC Company, LLC, 2003a,b) is most likely a conservative value for microbially influenced uniform corrosion. Therefore, it is acceptable.

Although the staff considers this agreement closed, DOE should consider the following comments:

•	The comparative analysis of solutions in which Alloy 22 base metal had been incubated for 5 months in 100X J–13 well water at room temperature indicated a higher level of nickel and chromium in microbe-containing solutions than in the sterile solutions. If this is true, localized corrosion of Alloy 22 in the microbial environments may not be ruled out because microbially influenced corrosion is usually manifested in the form of localized corrosion rather than a uniform corrosion (Lewandowski, 2000; Little, et al., 2000). The surface analysis results provided in Technical Basis Document No. 6, Appendix I (Bechtel SAIC Company, LLC, 2004a), have not provided evidence supporting the argument that such dealloying was not occurring. The surface of the specimens was too rough, and no convincing conclusions could be drawn from the results presented. As a matter of fact, sputtering x-ray photoelectron spectroscopy of microbe-colonized Alloy 22 indicates the presence of alloying elements in the bio-film layer. It is noted that the DOE plans to continue with the long-term immersion tests during performance confirmation period. The long-term test will address the question on the susceptibility of Alloy 22 to microbially influenced corrosion.

•	The linear polarization resistance method should not be used to measure the corrosion rate of passive alloys in solutions containing a sulfate-reducing bacteria, and perhaps not other bacteria either, because it has been shown that the sulfate-reducing bacteria produces intermediate reducing species (Yang and Cragnolino, 2004). Use of the linear polarization method requires that other secondary reactions not directly corrosion-related but involving charge transfer are not significant (ASTM International, 2004; Oldham and Mansfeld, 1973).

•	The low corrosion rate results for the corrosion of welded Alloy 22 coupons in the Long-Term Corrosion Test Facility at 60 EC [140 EF] were provided. The Technical Basis Document No. 6, Appendix I (Bechtel SAIC Company, LLC, 2004a), stated that

characterization tests showed the presence of heat-tolerant, desiccation-tolerant, and radiation-tolerant bacteria in the simulated water at 60 EC [140 EF]. No quantitative bacteria cell counts, however, were presented during the test. A certain level of cell density is needed for the bacteria to cause any significant microbially influenced corrosion.

- It is not known if the rocks collected aseptically at Yucca Mountain and used to inoculate the simulated Yucca Mountain water in the immersion tests (Martin, et al., 2004) contain a range of possible types of bacteria that may thrive in Yucca Mountain conditions. Characterization of the bacteria grown from the same Yucca Mountain rocks (Horn, et al., 2003) did not seem to include the sulfate-reducing bacteria identified in the early literature (Lian, et al., 1999). In addition, other bacteria that may cause microbially influenced corrosion for Alloy 22 may be introduced by dust blown into the drift or by ventilation during the preclosure period. Bacteria that may be introduced by ventilation should be considered in the studies.

- Results reported by Dunn, et al. (2001) and Dunn and Brossia (2002) were obtained in microbe-free solutions. These results, however, may not be applicable to assess the dissolution of metals in the microbial environment.

Based on the NRC review of the DOE response to Agreement CLST.1.02 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.1.2, Review Method 2), NRC found the DOE response to the agreement to be satisfactory.

4.2   CLST.1.03

The focus of CLST.1.03 is the validation of the corrosion rate measurement using the linear polarization resistance method. The linear polarization resistance method is not a direct metal loss (or metal thinning) method. This measurement is based on the charge transfer at the metal-solution interface and the Faraday law to derive the corrosion rate. One important assumption is that all the anodic charge transfer reactions are the result of dissolution of the metal into solution. Therefore, results measured with linear polarization resistance method for Alloy 22 in Yucca Mountain waters need validations using other methods.

The DOE response in Technical Basis Document No. 6, Appendix V (Bechtel SAIC Company, LLC, 2004b), provides comparison between the Alloy 22 corrosion rate measured with the linear polarization method and the general corrosion rates obtained with the weight-loss method in the Long-Term Corrosion Test Facility in three solutions (simulated acidified water, simulated dilute water, and simulated concentrated water) at four time intervals (6, 12, 28, and 60 months). Although the weight-loss data are scattered in a large range, the general trend was that the corrosion rate decreased from 50 nm/yr [1.97×10^{-3} mils/yr] at a 6-month interval to 7 nm/yr [2.76×10^{-4} mils/yr] at a 60-month interval. The corrosion rates obtained with the linear polarization method are close to the rates measured with the weight-loss method.

Corrosion rates of the welded Alloy 22 specimen were also measured with the linear polarization resistance method at room temperatures in solutions with and without the presence of microorganisms. The measured corrosion rates with and without the presence of microorganisms were scattered from 5 to 30 nm/yr [1.97×10^{-4} to 1.18×10^{-3} mils/yr]. The data exhibit no decreasing trend during a 123-day period. On average, it appeared the corrosion

rates obtained in the presence of microorganisms were higher than those obtained without the presence of the microorganisms.

Corrosion rates obtained with the potentiostatic polarization method in concentrated saturated acidified water and other concentrated NaCl-containing solutions also were presented. The Alloy 22 specimens were polarized to constant anodic potentials (0.2 or 0.4 V versus Ag/AgCl electrode) in the passive range. The polarization current was measured near the end of the polarization period (1, 7, or 28 days) and was used to derive the passive dissolution rate. Such measured passive dissolution rates were from 0.22 to 1.25 μm/yr [8.66×10^{-3} to 4.92×10^{-2} mils/yr] at temperatures from 90 to 100 °C [194 to 212 °F]. The linear polarization resistance method also was used to measure the corrosion rate after the potentiostatic test. The rates were measured after the surface of the specimens was electrochemically modified at temperatures from 90 to 100 °C [194 to 212 °F]. These rates are in agreement with the data obtained from the weight-loss methods.

Although the staff considers this agreement closed, DOE should consider the following comment:

•   As discussed in Section 4.1, intermediate chemical species may be produced by microbial activity, and these intermediate chemical species may affect significantly accuracy of the linear polarization resistance method for application in the solution containing microbes.

Based on the NRC review of the DOE response to agreement CLST.1.03 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.1.2, Review Method 2), NRC found the DOE response to the agreement to be satisfactory.

4.3   CLST.1.04

The focus of CLST.1.04 was to ensure that long-term behavior of the uniform corrosion rates are properly assessed in the bounding chemistry expected for Yucca Mountain conditions. Because the corrosion rates of Alloy 22 and titanium in Yucca Mountain waters are near the detection limit of the weight-loss method using relatively large specimens, a more sensitive method should be considered in the measurement to gain confidence in the measured corrosion rates. The DOE response in Technical Basis Document No. 6, Appendix R (Bechtel SAIC Company, LLC, 2004c), provided data obtained from specimens of Alloy 22 and other engineering alloys tested in simulated acidified water, simulated concentrated water, and simulated dilute water in the Long-Term Corrosion Testing Facility (since 1997) at intervals of 6 months and 1, 2, and 5 years. DOE also provided data obtained with Alloy 22 foil samples in autoclaves for a temperature range 120–220 °C [248–428 °F] after exposure for 130 or 157 days. The solutions used for the Alloy 22 foil tests include near-saturated, high molar concentrations of sodium and potassium brines (chlorides and nitrates). The corrosion rates measured at these temperatures and concentrations would result in less than 2 mm [7.87×10^{-2} in] of general corrosion in 10,000 years. In addition, DOE also provided data from the short-term testing using electrochemical methods in highly aggressive and bounding solutions (e.g., calcium chloride, basic saturated water, and simulated saturated water). DOE stated that testing in the Long-Term Corrosion Testing Facility will be continued during the performance confirmation period with new ranges of predicted environments, including bounding environments, and new types of alloys to reflect current design specifications of the

waste package (Bechtel SAIC Company, LLC, 2004c). In the new tests, DOE plans to use specimens that have a 50 times larger surface-to-volume ratio than the specimens previously used. It is expected these high surface-to-volume specimens will increase the sensitivity of the measurements. Therefore, the use of high-sensitivity probes is no longer needed. This DOE response sufficiently addresses the issues associated with agreement CLST.1.04.

Although the staff considers this agreement closed, DOE should consider the following comment:

•   The data obtained with the thin foil Alloy 22 specimens at temperatures between 120 and 220 EC (248 and 428 EF) scattered significantly. Some of the results are significantly negative. The effect by oxide film should have a certain trend with temperature, solution chemistry, and immersion time. Therefore, this large scattering is probably more the result of formation of scale rather than oxide. A well-controlled cleaning procedure should be used to avoid the scale effect, especially for the thin foil specimens planned for future tests during the performance confirmation period.

Based on the NRC review of the DOE response to Agreement CLST.1.04 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.1.2, Review Method 2), NRC found the DOE response to the agreement to be satisfactory.

4.4   CLST.1.10

The focus of CLST.1.10 was to ensure that the assessment of localized corrosion as a potential degradation mode for the waste packages and the drip shield considered the evolution of corrosion potentials, the effects of fabrication processes, and the variations in chemistry of the solutions contacting the waste package and drip shield surfaces. The DOE response (Bechtel SAIC Company, LLC, 2004b, 2003a) includes repassivation potentials for mill-annealed Alloy 22 in concentrated NaCl, solutions of NaCl + KNO_3, $CaCl_2$, and $CaCl_2$ + $Ca(NO_3)_2$ at 60–160 EC [140–320 EF] obtained with cyclic potentiodynamic polarization measurements. Effects of the fabrication processes were evaluated by repassivation potential measurements of welded Alloy 22 in concentrated $CaCl_2$ solutions. The effects of nitrate as an inhibitor for localized corrosion in chloride-containing solutions were evaluated for a range of chloride concentrations, nitrate-to-chloride concentration ratios, and temperatures. Corrosion potential measurements were obtained for mill-annealed Alloy 22 in simulated dilute water, simulated concentrated water, simulated acidified water, and basic saturated water at 60–90 EC [140–194 EF] and in concentrated solutions of NaCl, $CaCl_2$, and $CaCl_2$ + $Ca(NO_3)_2$ at 90–120 EC [194–248 EF] after long-term exposures of hundreds of days.

The effects of heavy metals on the corrosion and critical potentials were not evaluated. The DOE response cited the results obtained by Andresen, et al. (2004) in stress corrosion cracking tests as evidence the presence of heavy metals would not alter the localized corrosion susceptibility of Alloy 22. In addition, DOE indicated that lead concentrations would be limited by solubility and that no evidence exists for mercury to enhance the localized corrosion susceptibility of nickel-chromium-molybdenum alloys.

Data for titanium alloys proposed for the drip shield (Grades 7 and 24) were not included in the DOE response. DOE indicated the performance of Titanium Grade 7 is included in Appendix P

of the technical basis document (Bechtel SAIC Company, LLC, 2004b, 2003a). The DOE response sufficiently addresses the issues associated with Agreement CLST.1.10.

Although the staff considers this agreement closed, DOE should consider the following comments:

- The DOE response contains incorrect information regarding active dissolution and passivation. For example, the statement on page O–12 (Bechtel SAIC Company, LLC, 2004b) reads, "In the pure chloride solutions, E_{corr} for mill-annealed Alloy 22 rods is negative, and it is assumed that the alloy remains active and free from passivation." Although the statement does not specifically identify the environment, the assumption is incorrect. The corrosion potential of passive chromium containing alloys is dependent on the passive corrosion rate and the rate at which oxidizing species are reduced at the alloy surface. Alloy 22 is designed to remain passive under a wide range of environmental conditions including chloride containing solutions. The low corrosion potential observed for the mill-annealed Alloy rods in pure chloride solutions may be a result of the low oxygen solubility in the chloride solution.

- The DOE response indicates that no effects of fabrication processes were observed. The absence of any measured difference in localized corrosion susceptibility may be an artifact of the aggressive solution, {5 mol/L [molar] $CaCl_2$}. In less aggressive solutions, the increased localized corrosion susceptibility of the welded material may be observed easily (Dunn, et al., 2003). No information is provided on the effects of postweld heat treatments. Appendix U shows decreased ductility and impact strength for some combinations of base alloy and filler metal heats. Decreased localized corrosion resistance is likely after solution annealing (Dunn, et al., 2003).

- The effect of carbonate as an inhibitor was not evaluated. Previous work has shown that bicarbonate and carbonate can act as inhibitors for Alloy 22 and stainless steels (Jallerat, et al., 1984; Dunn, et al., 2004).

- The cited reference (Andresen, et al., 2004) is not appropriate for evaluating the effects of heavy metals on localized corrosion. Andresen, et al. (2004) examines the effects of lead on stress corrosion cracking. These tests are of limited use for either stress corrosion cracking or localized corrosion because the solubility of lead in carbonate solutions is quite low. The conclusion is misleading that the addition of lead salts had no effect on localized corrosion susceptibility, based on results of the E_{corr} measurements. For open circuit conditions, the E_{corr} of chromium-containing passive alloys typically decreases when localized corrosion is initiated.

- The statement in Technical Basis Document No. 6, Appendix O (Bechtel SAIC Company, LLC, 2004b, page O–27) about mercury solubility seems to contradict a statement in Technical Basis Document No. 5 (Bechtel SAIC Company, LLC, 2003c, page A–19). In Technical Basis Document No. 6, Appendix O, page O–27, DOE states that the effect of mercury was not studied because of the absence of mercury in Yucca Mountain environments and because mercury salts are rather insoluble. In contrast, in Technical Basis Document No. 5, Appendix A, page A–19 (Bechtel SAIC Company, LLC, 2003c), DOE states that ambient mercury concentrations in Yucca Mountain groundwater are expected to be in the range 10^{-3} to 10^{-2} ppb. It is noted that mercury

has few solubility controls, however, the ability of mercury to concentrate is limited by in-brine water because mercury is volatile and transfers to the atmosphere (Bechtel SAIC Company, LLC, 2003c). The basis should be consistent for the disposition of agreements related to the effects of trace elements.

Based on the NRC review of the DOE response to Agreement CLST.1.10 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.1.2, Review Method 2), NRC found the DOE response to the agreement to be satisfactory.

4.5   CLST.1.11

The focus of CLST.1.11 was to ensure that critical potentials selected as input parameters for the analyses models bound the long-term behavior of corrosion potentials for Yucca Mountain conditions, particularly in the presence of microorganisms. The DOE response (Bechtel SAIC Company, LLC, 2004b, 2003a) provided the basis for the selection of critical potentials for localized corrosion. The repassivation potentials defined as ERCO (the potential at which the forward and reverse scans are intersected on a cyclic potentiodynamic polarization curve) or ER1 (the potential at which the reversed scan reaches a current density of 1 $\mu A/cm^2$ [9.29×10^{14} A/ft^2] on a cyclic poteniodynamic polarization curve) were used as the critical potentials. The general justification for use of critical potentials as bounding parameters for localized corrosion is adequate, except for microbially influenced corrosion.

For microbially influenced corrosion, a recent study at the Center for Nuclear Waste Regulatory Analyses (Yang, et al., 2004) indicated measurement of the true repassivation potential may be difficult using the potentiodynamic method in a solution containing sulfate-reducing bacteria because the aggressive intermediate products produced by microbial activities and adsorbed on the electrode surface may be removed during the anodic polarization. Therefore, it may not be realistic to use a critical potential such as the repassivation potential to predict the succeptibility of Alloy 22 to localized corrosion in microbial environments. Long-term testing should be conducted to assess the possibility of localized corrosion in the environments containing microbes. As discussed in Section 4.1, The DOE response in Technical Basis Document No. 6, Appendix I (Bechtel SAIC Company, LLC, 2004a), presented the 5-year test results for Alloy 22 specimens exposed in a simulated Yucca Mountain water inoculated with Yucca Mountain rocks. The specimen exposed to the nonsterile solution clearly showed uniformly distributed arrays of micropitting. This type of corrosion attack cannot be characterized as typical pitting corrosion, but it is significantly different from the corrosion observed in the microbial-free environments. Longer-term immersion tests should be conducted in the performance confirmation period to evaluate if the micropores observed in the 5-year test will continue to evolve into pitting corrosion. In addition, the longer-term immersion tests should include a range of possible microorganisms that may be introduced into the potential drift during the construction and emplacement of the waste packages in the drift. DOE response sufficiently addressed the issues associated with Agreement CLST 1.11 with respect to the license application.

Although the staff considers this agreement closed, DOE should consider the following comment:

- Longer time tests for creviced specimens exposed above and below the repassivation potential in $CaCl_2$ solutions at 120 EC [248 EF] would further support the assessment of the time effect.

Based on the NRC review of the DOE response to Agreement CLST.1.11 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.1.2, Review Method 2), NRC found the DOE response to the agreement to be satisfactory.

5.0   SUMMARY

NRC reviewed the DOE key technical issue agreement responses within TBD 6 and Appendices I, O, R and V to determine whether any important aspect of agreements CLST.1.02, 1.03, 1.04, 1.10, and 1.11 was excluded from the response. In addition, NRC performed an independent assessment to determine whether the information provided would support submission of a potential license application for a geologic repository. Notwithstanding new information that could raise new questions or comments concerning these agreements, the information provided satisfies the intent of the agreements. On the basis of this review, NRC agrees with DOE that the information assembled in response to agreements CLST.1.02, 1.03, 1.04, 1.10, and 1.11 are adequate to support the submission of a license application for the potential repository at Yucca Mountain.

6.0   STATUS OF THE AGREEMENTS

Based on the preceding review, NRC agrees with DOE that the information provided with respect to agreements CLST.1.02, 1.03, 1.04, 1.10, and 1.11 is adequate to support submission of the license application. Therefore, NRC considers agreements CLST.1.02, 1.03, 1.04, and 1.10, and 1.11 to be closed.

7.0   REFERENCES

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