October 4, 2000

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Office of Licensing and Regulatory Compliance
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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION/U.S. DEPARTMENT OF ENERGY TECHNICAL EXCHANGE AND MANAGEMENT MEETING ON CONTAINER LIFE AND SOURCE TERM (SEPTEMBER 12-13, 2000)

Dear Mr. Brocoum:

Enclosed are the meeting summary highlights agreed upon during the September 12-13, 2000, Technical Exchange and Management meeting between the staff of the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. The main purpose of the meeting was to discuss one of the Key Technical Issues, Container Life and Source Term (CLST). The meeting was held in Las Vegas, Nevada.

If you have any questions regarding this letter, please contact the technical lead for CLST, Mr. Tae Ahn or the Senior Project Manager for issue closure, Mr. James Andersen. Mr. Ahn can be reached at (301) 415-5812 and Mr. Andersen at (301) 415-5717.

Sincerely,

/ra/

Janet Schlueter, Acting Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Container Life and Source Term

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Letter to S. Brocoum from J. Schlueter dated: October 4, 2000

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Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Container Life and Source Term

September 12-13, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Container Life and Source Term (CLST) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket the license application. Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review. Issue resolution at the staff level during prelicensing is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues are “closed’ if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of initial license application. Issues are “closed-pending’ if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues are “open’ if the NRC has identified questions regarding the DOE approach or information, and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in the license application.

The objective of this meeting is to discuss and review the progress on resolving the CLST KTI (see Attachment 1 for list of subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC’s ongoing review of DOE’s QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 through 4 and 6 were closed-pending. Subissue 5, “The effects of in-package criticality on waste package and engineered barrier subsystem performance” was not addressed at this meeting and will be addressed in a future meeting. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters’ slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the CLST subissues (see “Container Life and Source Term (CLST)” presentation given by Paige Russell). During the April 25-26, 2000, KTI Technical Exchange, the NRC listed Subissues 1 and 5 as open and Subissues 2, 3, 4, and 6 as closed-pending. During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC during the April 2000 Technical Exchange. DOE stated that it felt that the details provided during the meeting would be the basis for NRC to list Subissues 1, 2, 3, 4, and 6 as closed-pending.

2) Technical Discussions - Subissue #3, Rate at Which Radionuclides in Spent Nuclear Fuel are Released from the Engineered Barrier Subsystem Through the Oxidation and Dissolution of Spent Fuel and Subissue #4, Rate at Which Radionuclides in High-Level Waste Glass are Released from the Engineered Barrier Subsystem.

A summary of the current status of resolution was presented (see “Subissue 3 and 4: The Rate at Which Radionuclides in Spent fuel or High Level Waste Glass are Released from the Engineered Barrier System” presentation given by Christine Stockman). There are nine acceptance criteria, all of which are considered closed-pending by the DOE. There is substantial overlap in the topics relevant to both Subissues on Spent Nuclear Fuel and Glass Degradation. As a result of the overlap, DOE first discussed two topics common to both subissues. DOE addressed Total System Performance Assessment (TSPA) models and results to provide a risk-informed framework for subsequent discussions (Slides 4 - 19). TSPA information was provided on preliminary overall dose calculations, preliminary waste package results, and influences on waste form model results due to radionuclide inventory, in-package chemistry, high-level waste degradation, cladding perforation and unzipping, and Neptunium (Np) solubility. A staff question on the conclusion that there are no initial failures of the waste package for the first 10,000 years was addressed by stating the basis is addressed in detail in the slides for Subissue 2. The relative importance of dose contributions from commercial spent nuclear fuel versus the co-disposal packages was presented. Information provided indicated that the dose from spent nuclear fuel was much higher than that from high-level waste glass. Staff had questions on the degraded cladding analysis and sensitivity to dripping conditions. For the first topic, DOE indicated that the basis for their analysis is documented in later slides on cladding. For the second question, the DOE indicated that the quantity of water during intermittent dripping conditions was higher than under the always drip conditions, and therefore was more detrimental to cladding performance.

The next topic discussed that is common to both Subissue 3 and 4 is the in-package chemistry (Slides 20 - 22). This chemistry would affect radionuclide release from both spent nuclear fuel and the high-level waste glass. The effects of radiolysis on in-package chemistry were reviewed and DOE indicated that in the revised Summary of In-Package Chemistry for Waste Forms Analysis and Model Report (AMR) the discussion would be documented. Potentially mutually exclusive conditions were offered as a basis for neglecting the effects of radiolysis. The Center for Nuclear Waste Regulatory Analyses (CNWRA) staff had questions on the sufficiency of the technical basis for excluding radiolysis effects that will be provided in the revised AMR. Sensitivity of in-package pH to different parameters such as incoming fluid chemistry and drip rates was discussed. CNWRA staff questioned whether uncertainties associated with differing degradation rates for waste package components and different corrosion products had been considered. NRC staff questioned whether initial transient chemistry effects in the first water contacting the cladding was captured in the analysis. DOE indicated that the results for differing incoming water chemistry (Slide 22) and results from waste package breach due to localized corrosion would be documented in the revised AMR. NRC staff also questioned whether the time steps used in the in-package chemistry abstraction are sufficiently small to capture the expected behavior and processes such as evaporation that would be needed to be propagated in the case for initial failures. Three potential incoming water compositions have been used to assess effects on in-package pH (J-13, evaporated J-13, and post-thermal water). Questions on the assumption of high bicarbonate solutions by Mr. DiBella (NWTRB) were addressed by DOE. They indicated that reactions of waste glass, assuming fluids are in equilibrium with carbon dioxide in the gas phase at 4 times atmospheric concentrations, leads to high bicarbonate solutions. Several additional questions were posed by Mr. Morganstein (Nye County) on the impact of other engineered materials such as grouting and rock bolts on the incoming water chemistry. DOE stressed the importance of the waste package components dominating in-package chemistry. NRC staff inquired about any plans for confirmatory testing of the expected in-package chemistry. DOE responded that there is budget for limited work in that area.

Finally specific points pertinent to degradation of spent nuclear fuel cladding were addressed (Slides 23 -28). DOE's information to address concerns on hydride reorientation in cladding will be documented in two revised AMRs. Temperatures of less than about 200 ^{o}C were argued to be too low for significant hydride reorientation. NRC staff questioned whether the temperatures presented were mean temperatures and what was the distribution of temperatures for the cladding. Staff also questioned what was the distribution of stresses for the cladding. DOE indicated that hydride reorientation would be excluded in the feature, events, and processes (FEPs) analysis. NRC staff wanted to know whether the FEP will be screened out based on probability or consequence. The determination from the AMR was that the FEP was screened out based on probability. Stress corrosion cracking (SCC) was presented next by DOE and they indicated their approach will be documented in a revised AMR. A failure criterion of 180 MPa is currently used. CNWRA staff questioned whether the failure criterion is appropriate and relevant for the in-package chemical environment, in particular that associated with external surface of the cladding. DOE's approach for localized corrosion was presented next and is documented in three AMRs. DOE has concluded that for model predictions of in-package chemistry localized corrosion is not expected. CNWRA staff questioned how localized failure can be related to bulk in-package chemistry. NRC staff indicated a need for confirmatory testing for the model predicted environment to affirm that localized corrosion does not occur. DOE presented their approach for abstracting failure rates due to localized corrosion. Questions by CNWRA focused on the relationship between assumed failure rates and in-package chemistry and processes such as localized corrosion. Finally DOE indicated that they are evaluating failure modes for cladding including reactor operation, dry storage, and seismic events. CNWRA staff inquired about where analysis of seismic effects on cladding is documented.

As a result of additional discussions, NRC and DOE reached 10 agreements (see Attachment 1) for Subissues 3 and 4. In addition there was a separate agreement specific to Subissue #4. With these agreements, the NRC stated that Subissue 3 could be listed as closed-pending. DOE then discussed several issues specific to Subissue #4.

There are nine acceptance criteria; all of which are considered closed pending by the DOE. See above discussion of subissue 3 for description of TSPA models and results, and in-package chemistry pertinent to this subissue. Specific issues associated with high-level waste glass degradation were also presented (Slides 29 - 30). DOE addressed the pH range over which glass degradation is assessed and indicated that NRC has some concerns on the model in the acid pH region. They indicated that the concern would be addressed in the revised AMR on glass degradation. NRC staff questioned whether an analysis of the consequences on radionuclide release from assuming silicon bounds the release, rather than boron, had been completed. DOE indicated that this concern would also be documented in the revised AMR.

As a result of additional discussions, NRC and DOE reached 1 agreement (see Attachment 1). With this agreement, and the agreements listed above, the NRC stated that subissue 4 could be listed as closed-pending.

3) Technical Discussion on Subissue #2, Effects of phase instability and initial defects on the mechanical failure and lifetime of the containers

A discussion of acceptance criterion for Subissue #2 was presented by the DOE (see "Subissue 2: Effects of Phase Instability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers" presentation given by Joon Lee and Scott Bennett). DOE stated that it would address the effects of aging and phase instability of Alloy 22, the effects of initial defects in closure welds, and the effects of rockfall and seismic-induced ground motion.

Mr. von Tiesenhausen (Clark County) raised an issue regarding radiation-induced phase segregation at elevated temperatures under neutron and gamma flux. DOE stated that the radiation field is low enough (only 1000 R/hour at emplacement) to exclude this possibility in the FEP analysis.

Aging tests for base and welded Alloy 22 are ongoing and the results will be fed to mechanical failure and SCC analysis. Theoretical modeling will be employed to enhance confidence in the results. DOE stated that it would provide the revised AMR, taking into account the items listed on slides 5 and 6, including documentation of path forward items.

To assess initial defects in closure welds, DOE reviewed literature, identified the types of defects and the subset of defect types relevant to the waste package, and determined probability of occurrence per waste package for each type of defect. Questions were raised whether assessments based on data from generic engineering practices for other materials are relevant to Alloy 22 fabrication and welding. For this validation, DOE is conducting mock-up tests. Alloy 22 is considered as inspectable as other metals, as documented in the mock-up reports. Currently a maximum of 40 defects and average of 20 flaws are expected per container; no initial thru-wall failures are expected.

NRC staff raised the question about inspection technique to detect flaw size in the final waste package closure weld since DOE has based their flaw size distribution on techniques not directly applicable to the waste package. These techniques are liquid dye penetrant and radiographic inspections of stainless steel welds which are impossible to perform on a loaded waste package. DOE indicated the waste package closure weld will be inspected using the alternative technology of ultrasonic testing (UT) technique.

DOE is studying induction annealing and laser peening of outer and inner closure welds respectively.   DOE plans to follow the fabrication processes at vendor shops and the quality of each heat is screened for acceptable corrosion response using cyclic polarization. DOE will provide information on effect of entire fabrication sequence on phase instability of Alloy 22 including, the effects of welding, multiple passes, thick sections, and the proposed induction annealing process. DOE will also provide documentation on fabrication processes and controls.

DOE stated that rockfall calculations include temperature dependent material properties; rock impact on closure weld; effect of seismic ground motion; and integrity of emplacement pallet. The design of the waste package and drip shield prelude contact between waste package and drip shield during rock impact. The boundary conditions include drip shield fixed at base and free standing to allow drip shield to move horizontally. In the analysis, the rock size is given because the design basis rockfall size is still an open question being discussed in the Repository Design Thermal-Mechanical Effect KTI. The technical basis for the criteria to be applied to assess mechanical failure was provided. The Tresca failure criterion was argued to be reasonable.

However, DOE needs to either provide technical justification for not using solid element formulations in the finite element analysis or provide documentation using solid element formulations for drip shield rock fall analysis; NRC wants documentation of the point loading of rock fall analysis; DOE needs to demonstrate that the Tresca failure criterion bounds a fracture mechanics approach to calculating mechanical failure; and DOE needs to demonstrate drip shield and waste package mechanical analysis addressing seismic excitation is consistent with the design basis earthquake covered by Structural Deformation and Seismicity (SDS) KTI.

In addition to the above subjects discussed, the path forward presented covers other NRC general concerns in phase stability/aging, initial defects, welding, and rockfall. These path forward plans need to be implemented.

As a result of additional discussions, NRC and DOE reached 9 agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #2 could be listed as closed-pending.

4) Technical Discussion on Subissue #6, Effects of alternate engineered barrier subsystem design features on container lifetime and radionuclide release from the engineered barrier subsystem

A discussion of acceptance criterion for Subissue #6 was presented by the DOE (see “Subissue #6: Alternate EBS Design Features - Effect on Container Lifetime” presentation given by Gerald Gordon). DOE stated that it would specifically address the effects of design changes and titanium drip shield corrosion.

Regarding the current design, DOE stated that the current waste package and drip shield degradation models do not include the effects of backfill and that ceramic coatings are not part of the current design. DOE then stated that this subissue now focuses on drip shield performance. The failure modes of drip shields, such as corrosion, were then discussed. DOE stated that the detailed analysis of corrosion will be discussed in presentation for Subissue 1. DOE then presented the path forward activities which covered most of the NRC concerns. As a result of additional discussions, NRC and DOE reached 4 agreements (see Attachment 1). With these agreements and the path forward presented, the NRC stated that Subissue #6 could be listed as closed-pending.

5) Technical Discussion on Subissue #1, Effects of corrosion processes on the lifetime of the containers

A summary of the current status of resolution was presented (see attachment on "Subissue 1: The Effects of Corrosion Processes on the Lifetime of Containers" by Gerald Gordon). There are seven acceptance criteria; the subissue was considered closed-pending by the DOE. There were seven topics addressed by the DOE: environment around waste package and drip shield; microbial influenced corrosion (MIC) of Alloy 22 welds; general corrosion rates of alloy 22 and Ti-7 over long periods of time; long-term passive film stability of alloy 22 and Ti-7 ; localized corrosion of alloy 22 and Ti-7; stress corrosion cracking (SCC) testing of alloy 22 and Ti-7; and fabrication and welding of Alloy 22.

First, DOE addressed the environment around the waste package and drip shield (Slides 5 - 9). They indicated that solutions used for laboratory corrosion testing include bounding cases. DOE indicated that they will establish credible range for brine chemistry; evaluate the effect of introduced materials on water chemistry; determine likely concentrations and chemical form of minor constituents; types of brine which would evolve; and evaluate periodic water drip evaporation. CNWRA staff indicated that the adequacy of the treatment of environments on drip shield and waste package will also be addressed in the technical exchange and management meeting on the Evolution of the Near-Field Environment (ENFE). The importance of refluxing water was stressed by Mr. Shettel (Nye County). DOE responded that data from thermal tests would be considered and some tests would be conducted using crushed tuff.

Second, DOE addressed MIC of Alloy 22 welds (Slides 10 - 12). DOE indicated microbial activity can alter the chemical environment and enhance corrosion attack. The effects of MIC are accounted for in the general corrosion model by including an enhancement factor of 2.0 for the rate of corrosion. This enhancement factor was determined from linear polarization measurements using both inoculated and sterile conditions. CNWRA staff questioned the resolution and appropriateness of the technique and whether the sterile solution had nutrients that can enhance the corrosion rate. DOE stated that the technique sensitivity is sufficient based on values cited in literature, and that sterile solution did not contain aggressive nutrients. DOE also indicated that corroborative testing from batch tests would be used to support existing tests. DOE responded to a question by Mr. Shettel (Nye county) on the significance of potential of mutation of microbes by radiation, stating that they had investigated the possibility and documented the analysis. The potential for de-alloying from MIC was also presented by DOE. They indicated that surface elemental analysis of base metal and welded specimens will be conducted after testing to determine whether selective dissolution is operative. DOE also indicated that they would address the different enhancement factors derived using solution composition and linear polarization techniques. CNWRA staff also asked whether potential deleterious species formed in a biofilm would be considered. DOE indicated that their treatment of microbial effects would be documented in a revised AMR.

Third, DOE addressed general corrosion rates over long time periods (Slides 13 - 14). General corrosion is modeled for both the titanium drip shield and the Alloy 22 waste package. Container lifetime is predicted to be greater than 10,000 years. Examination of silica surface deposits has been conducted and evaluated by DOE using atomic force microscopy. A testing program to evaluate passive film stability has been established. DOE indicated that they would continue their testing in the long term corrosion test facility and would be adding two new "bounding water" compositions (basic saturated water and simulated saturated water). Additional actions DOE will take include using thinner specimens and larger surface area to volume samples, installation of high sensitivity probes in some test vessels, and continuing materials testing during performance confirmation period. DOE indicated that the testing program is not strictly subdivided between regulatory time periods such as performance confirmation, but is a program of continuous, long-term testing. Extrapolation of corrosion rate data collected at 60 and 90 ^{o}C to 120 ^{o}C was questioned by Mr. DiBella (NWTRB). DOE responded that there was no measurable effect due to temperature. CNWRA staff questioned the sensitivity and measurement technique used for the high sensitivity probes. CNWRA staff questioned whether other standard methods to measure the corrosion rates, such as ASTM standard G-102, have been used by DOE. Finally, NRC and CNWRA staff questioned the sensitivity of DOE's existing methods to capture the variability and uncertainty in the silica deposition correction and its impact on general corrosion rate measurements. The importance of minor elements in the water that may affect the measured general corrosion rates was raised (Mr. Morgenstein, Nye county). DOE replied that minor constituents would be added to J-13 type water and evaporated to prepare solutions for corrosion testing.

The fourth item addressed by DOE was long-term passive film stability (Slides 16 -17). To address NRC concerns on passive film stability, DOE indicated that they will calculate potential-pH diagrams for multi-component Alloy 22. DOE will grow oxide films at higher temperatures to accelerate film growth, allowing compositional and structural studies to be conducted. DOE will address the kinetics of film growth and determine whether the film becomes mechanically brittle. The investigation of passive film thickness will include chemical, structural, and mechanical properties. NRC questioned whether intergranular dry air oxidation would be investigated and DOE indicated that they would address this in the testing program. CNWRA asked if differing cation mobility leading to vacancy movement and void formation, would be addressed in the testing program. DOE stated this effect would also be studied in the testing program. Additional items DOE will complete include: (1) correlating changes in the corrosion potential with compositional changes in the passive film over time, (2) analyzing cold-worked materials to determine changes in film structural properties, (3) examination of films on samples of the natural analog mineral Josephinite that have been exposed in stream beds, and (4) comparing films on Alloy 22 to films on similar passive alloys from longer industrial experience. CNWRA staff indicated that besides the industrial database there is additional information from natural analogs, including geothermal systems, that should be considered by DOE. CNWRA staff also questioned the techniques and measurement used by DOE for investigating passive films, suggesting that meta-stable breakdown of the film may not be addressed using current techniques. Finally, CNWRA asked whether passive film composition in welded and thermally aged samples, including across grain boundaries, will be evaluated in DOE's testing program.

Fifth, DOE addressed localized corrosion (Slides 18 -22). Both pitting and crevice corrosion are considered in DOE's treatment of localized corrosion. Cyclic polarization studies have been performed in a range of environments and temperatures and indicate that localized corrosion is not expected. DOE indicated that this conclusion needs to be validated for welded material. Results from polarization studies and crevice studies for both Alloy 22 and stainless steel were presented. These results indicated that even though there is margin of 100 mV for stainless steel, no credit for stainless steel is assumed. CNWRA staff requested clarification regarding the use of the terms of corrosion current in some AMRs. DOE indicated that they would measure corrosion potentials in their testing program to determine any shift of potential with time toward the critical potential for localized corrosion. Critical potentials on welded and welded and aged coupons of Alloy 22 versus those for base metals will be evaluated by DOE. Separate effects of ionic mixtures of damaging species (chloride, fluoride, and possibly sulfate) and beneficial species in Yucca Mountain water on critical potentials will be investigated by DOE. DOE also indicated that critical potentials in environments containing heavy metal concentrations (e.g., Pb, As, and Hg) would also be conducted. NRC staff asked whether ionic ratios observed in the thermal testing will be addressed in the testing program. DOE replied these types of waters would be evaluated in the testing program. CNWRA staff questioned the existing confidence for the lower bound of the critical potential obtained in short-term tests, including microbial effects. DOE indicated that the uncertainty in the range of the parameter is being partially addressed by including four standard deviations of the parameter in the TSPA calculations and will be confirmed by additional testing.

Sixth, DOE addressed stress corrosion cracking (SCC) in Slides 23 - 37. DOE described their approach for SCC which focuses on initiation and subsequent propagation of the crack. DOE is using 300 series stainless steel data for the SCC initiation threshold. DOE is evaluating propagation by measuring crack growth rates of Alloy 22 under high stress intensities. High residual stresses associated with the final closure weld will require stress mitigation treatment. DOE has proposed using two post-weld stress mitigation treatments (laser peening and induction annealing). Constant load stress corrosion cracking test results in 20% basic saturated water, using stepped-up stresses, were described. These results indicate that Alloy 22 is resistant to SCC initiation up to 1.8 times the yield strength. Updated results of the cyclic loading tests for Alloy 22 on stress corrosion crack growth will be provided in a revised AMR. In addition results for 20% cold-worked Alloy 22 crack growth, Ti- grade 7 crack growth for cold-worked samples will also be provided in an updated AMR. NRC staff asked if value of stress intensity provided in the plots is K maximum, and DOE confirmed that it is the maximum value. CNWRA staff asked about some details concerning the tests (i.e., air over-pressure), and whether future testing included testing for range of potentials. DOE replied that there is a plan to test over a range of potentials. Next DOE addressed the stress mitigation with laser peening concept. They indicated that stress relief up to 3 mm may be possible. CNWRA staff asked several questions on the thickness of the compressive layer, its variability, and its uncertainty. Because the SCC initiation is the critical step in the potential degradation of the waste package within the first 10,000 years, the CNWRA staff indicated the critical importance of well characterizing this information on the compressive layer. In the discussion of the DOE approach to induction annealing, Mr. von Tiesenhausen (Clark County) asked whether residual stress will be measured across the weld. DOE indicated that this parameter would be mapped. CNWRA asked about the availability of details of the time and temperature of the annealing process. DOE indicated that information is available and will be provided in the fabrication report. Ms. Treichel (Nevada Nuclear Waste Task Force) requested details on the cooling procedures used in the annealing process and DOE replied both air or sprayed water could be used to cool the annealed areas. DOE indicated that they would qualify and optimize the mitigation process, generate SCC data for mitigated materials over a range of metallurgical conditions, and would continue slow strain rate testing in same environments previously described. CNWRA staff requested details on how DOE would reduce the uncertainty in the exponential parameter used in the SCC model. DOE indicated that additional testing would constrain the value. NRC staff asked whether testing would include low pH conditions and DOE agreed that they would include that environment. DOE also indicated that they would evaluate the SCC resistance of welded and laser peened material, the resistance of induction annealed material, and the resistance of full thickness material from the prototype cylinder of Alloy 22. NRC staff asked whether the effects of stresses arising from rockfall on SCC of the waste package and drip shield has been considered. DOE indicated that this analysis for the waste package would be addressed after the revised analysis of the drip shield was completed.

Finally, DOE addressed concerns on fabrication and welding of Alloy 22 (Slides 38 - 39). CNWRA staff asked whether the fabrication mock-up was only the Viability Assessment design or whether the mock-ups included the Site Recommendation design. DOE stated that the mock-ups included the new design. Thin welded specimens are included in the long term testing program. DOE stated that no defects were observed in the two full diameter mockups of Alloy 22 waste packages. Finally, DOE stated that one inch thick laser peened mockups samples have been fabricated and the residual stress gradients have been verified. DOE indicated that they would use samples from welds in the mockups in their SCC testing program, once a specimen geometry can be defined. In addition, representative weld test samples will be used for MIC work, thermal aging, and localized corrosion evaluations. NRC staff requested more information on the potential importance of compositional variation associated with the welding and its effect on corrosion. DOE was asked whether structural effects after annealing would be examined (Mr. von Tiesenhausen), and they replied affirmatively.

As a result of additional discussions, NRC and DOE reached 17 agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #1 could be listed as closed-pending.

6) Update on Features, Events and Processes (FEP)

The DOE stated that it was revising all the FEPs AMR, incorporating NRC comments, and would have them completed by January 2001. The DOE further stated that it would revise the FEPs database after completion of the FEPs AMR revisions.

7) Public Comments

None

C. William Reamer	Dennis R. Williams
Deputy Director	Deputy Assistant Manager
Division of Waste Management	Office of Licensing & Regulatory Compliance
Nuclear Regulatory Commission	Department of Energy

Summary of the Resolution of the Key Technical Issue on Container Life and Source Term

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	The effects of corrosion processes on the lifetime of the containers	Closed-Pending	1) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 8. DOE will provide the documentation in a revision to AMR “Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier” by LA. 2) Provide the documentation for the path forward items listed on slide 12. DOE will provide the documentation in a revision to AMR “General and Localized Corrosion of Waste Package Outer Barrier” by LA. 3) Provide documentation that confirms the linear polarization resistance measurements with corrosion rate measurements using other techniques. DOE will provide the documentation in a revision to AMR “General and Localized Corrosion of Waste Package Outer Barrier” by LA. 4) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 14. DOE will provide the documentation in a revision to AMR “ANL-EBS-MD-000003 and ANL-EBS-MD-000004" by LA.

			5) Provide additional details on sensitivities, resolution of measurements, limitations, and deposition of silica for the high sensitivity probes. DOE will document the results of the sensitivity probes including limitation and resolution of measurements as affected by silica deposition in the Alloy 22 AMR and Ti Corrosion AMR (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 6) Provide the documentation on testing showing corrosion rates in the absence of silica deposition. DOE will document the results of testing in the absence of silica deposits in the revision of Alloy 22 AMR (ANL-EBS-MD-000003) prior to LA. 7) Provide the documentation for the alternative methods to measure the corrosion rate of the waste package material (e.g., ASTM G-102 testing) or provide justification for the current approach. DOE will document the alternative methods of corrosion measurement in the revision of Alloy 22 AMR (ANL-EBS-MD-000003), prior to LA. 8) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 16 and 17. DOE will provide the documentation in the revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 9) Provide the data that characterizes the passive film stability, including the welded and thermally aged specimens. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA.

			10) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 21 and 22. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 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. 12) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slides 34 and 35. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000005 and ANL-EBS-MD-000006) prior to LA. 13) Provide the data that characterizes the distribution of stresses due to laser peening and induction annealing of Alloy 22. DOE will provide the documentation in a revision to AMR (ANL-EBS-MD-000005) prior to LA.

			14) Provide the justification for not including the rockfall effect and deadload from drift collapse on SCC of the waste package and drip shield. DOE will provide the documentation for the rockfall and dead-weight effects in the next revision of the SCC AMR (ANL-EBS-MD-000005) prior to LA. 15) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 39. DOE will provide documentation for Alloy 22 and Ti path forward items on slide 39 in a revision to the SCC and general and localized corrosion AMRs (ANL-EBS-MD-000003, ANL-EBS-MD-000004, ANL-EBS-MD-000005) by LA. 16) Provide the documentation on the measured thermal profile of the waste package material due to induction annealing. DOE stated that the thermal profiles will be measured during induction annealing, and the results will be reported in the next SCC AMR (ANL-EBS-MD-000005) prior to LA. 17) Provide additional detail on quality assurance acceptance testing. DOE stated that it would provide guidance and criteria in the next revision of the Technical Guidance Document (TGD) for LA. The development of the LA sections and associated programs and process controls for the procurement and fabrication of waste package materials and components will be included. This will include consideration of the controls for compositional variations in Alloy 22. The TGD revision will be issued by June 2001, contingent upon NRC publication of the final 10 CFR 63 and the Yucca Mountain Review Plan.

2	The effects of phase instability and initial defects on the mechanical failure and lifetime of the containers	Closed-Pending	1) Either provide documentation using solid element formulation, or provide justification for not using it, for the drip shield - rockfall analysis. DOE stated that shell elements include normal stresses and transverse stresses in the calculations and provide more accurate results for thin plates and use far fewer elements. Therefore, shell elements will be used instead of solid elements. This justification will be documented in the next revision of AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, prior to LA. 2) Provide the documentation for the point loading rockfall analysis. DOE stated that point loading rock fall calculations will be documented in the next revisions of AMRs ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, and ANL-UDC-MD-000001, Design Analysis for UCF Waste Packages, both to be completed prior to LA. 3) Demonstrate how the Tresca failure criterion bounds a fracture mechanics approach to calculating the mechanical failure of the drip shield. DOE stated that it believes its current approach of using ASME Code is appropriate for this application. Additional justification for this conclusion will be included in the next revision of AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, to be completed prior to LA.

			4) Provide information on the effect of the entire fabrication sequence on phase instability of Alloy 22, including the effect of welding thick sections using multiple weld passes and the proposed induction annealing process. DOE stated that the aging studies will be expanded to include solution annealed and induction annealed Alloy 22 weld and base metal samples from the mock-ups as well as laser peened thick, multi-pass welds. This information will be included in revisions of the AMR "Aging and Phase Stability of the Waste Package Outer Barrier," ANL-EBS-MD-000002, before LA. 5) Provide the "Aging and Phase Stability of Waste Package Outer Barrier," AMR, including the documentation of the path forward items listed in the "Subissue 2: Effects of Phase Instability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers" presentation, slides 5 & 6. DOE stated that the "Aging and Phase Stability of the Waste Package Outer Barrier" AMR, ANL-EBS-MD-000002, Rev. 00 was issued 3/20/00. This AMR will be revised to include the results of the path forward items before LA. 6) Provide the technical basis for the mechanical integrity of the inner overpack closure weld. DOE will provide the documentation in AMR, ANL-UDC-MD-000001, Rev. 00, Design Analysis for UFC Waste Packages in the next revision, prior to LA.

			7) Provide documentation for the fabrication process, controls, and implementation of the phases which affect the TSPA model assumptions for the waste package (e.g., filler metal, composition range). DOE stated that updates of the documentation on the fabrication processes and controls (TDR-EBS-ND-000003, Waste Package Operations Fabrication Process Report and TDP-EBS-ND-000005, Waste Package Operations FY-00 Closure Weld Technical Guidelines Document) will be available to the NRC in January 2001. 8) Provide documentation of the path forward items in the "Subissue 2: Effects of Phase Instability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers" presentation, slide 16. DOE stated that the rockfall calculations addressing potential embrittlement of the waste package closure weld and rock falls of multiple rock blocks will be included in the next revision of the AMR ANL-UDC-MD-000001, Design Analysis for UCF Waste Packages, to be completed prior to LA. Rock fall calculations addressing drip shield wall thinning due to corrosion, hydrogen embrittlement of titanium, and rock falls of multiple rock blocks will be included in the next revision of the AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, to be completed prior to LA. Seismic calculations addressing the load of fallen rock on the drip shield will be included in the next revision of the AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, to be completed prior to LA.

			9) Demonstrate the drip shield and waste package mechanical analysis addressing seismic excitation is consistent with the design basis earthquake covered in the SDS KTI. DOE stated that the same seismic evaluations of waste packages and drip shield (revision of AMRs ANL-UDC-MD-000001 and ANL-XCS-ME-000001) will support both the SDS KTI and the CLST KTI, therefore consistency is ensured. These revisions will be completed prior to LA.
3	The rate at which radionuclides in spent nuclear fuel are released from the engineered barrier subsystem through the oxidation and dissolution of spent nuclear fuel	Closed-Pending	The agreements below address both subissues 3 & 4 1) In the revision to the "Summary of In-Package Chemistry for Waste Forms," AMR, the NRC needs to know whether and how initial failures are included in the in-package chemistry modeling, taking into account the multiple barrier analysis. DOE stated that the Summary of In-Package Chemistry for Waste Forms ANL-EBS-MD-000050 deals with time since waste package breach, instead of time of waste package failures. The model is appropriate for the current implementation in the TSPA scenarios because breaches do not occur until after aqueous films may be sustained. Multiple barrier analyses are discussed in the TSPAI IRSR, and therefore will be discussed in the TSPA KTI Technical Exchange.

			2) In the revision to the "Summary of In-Package Chemistry for Waste Forms," AMR, address specific NRC questions regarding radiolysis, incoming water, localized corrosion, corrosion products, transient effects, and a sensitivity study on differing dissolution rates of components. DOE stated that these specific questions are currently being addressed in the revision of the Summary of In-Package Chemistry for Waste Forms AMR, ANL-EBS-MD-000050 and related AMRs and calculations. To be available in January 2001. 3) Provide a more detailed calculation on the in-package chemistry effects of radiolysis. DOE stated that the calculations recently performed as discussed at the 9/12/00 Technical Exchange and preceeding teleconferences are being documented. These calculations will be referenced and justified in the revision of the Summary of In-Package Chemistry for Waste Forms AMR, ANL-EBS-MD-000050 and will be available in January 2001. 4) Need consistency between abstractions for incoming water and sensitivity studies conducted for in-package calculations, in particular, taking into account the interaction of engineered materials on the chemistry of water used for input to in-package abstractions. DOE stated that the revision of the Summary of In-Package Chemistry for Waste Forms AMR, ANL-EBS-MD-000050 will discuss the applicability of abstractions for incoming water, taking into account the revised Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier AMR. The revision will be available in January 2001.

			5) Provide the plan for experiments demonstrating in-package chemistry, and take into account subsequent NRC comments, if any. DOE stated that the current planning provides for the analysis of additional in-package chemistry model support. This analysis will determine which parts of the model are amenable to additional support by testing, and which parts are more amenable to sensitivity analysis, or use of analogues. Based on these results, longer range testing will be considered. If testing is determined to be appropriate, test plans will be written in FY01 and made available to the NRC. 6) Provide additional technical basis for the failure rate and how the rate is affected by localized corrosion. DOE stated that the technical basis for local corrosion conditions will be added to by additional discussion of local chemistry in the Summary of In-package Chemistry for Waste Forms revision ANL-EBS-MD-000050 which will be available in January 2001. Current Clad Degradation Summary Abstraction AMR Section 6.3, ANL-WIS-MD-000007 and Clad Degradation - Local Corrosion of Zirconium and its Alloys Under Repository Conditions AMR, ANL-EBS-MD-000012 contain the overall technical basis. 7) Provide data to address chloride induced localized corrosion and SCC under the environment predicted by in-package chemistry modeling. DOE stated that the technical basis for the models used for localized corrosion and SCC will be expanded in future revisions of the Clad Degradation Summary Abstraction AMR, ANL-WIS-MD-000007, available by LA.

			8) Provide the documentation on the distribution for cladding temperature and stress used for hydride embrittlement. DOE stated that the stresses are documented in the Initial Cladding Conditions AMR, ANL-EBS-MD-000048. CAL-UDC-ME-000001 contains the waste package internal temperatures. Waste package surface temperatures were provided within the TSPA model (ANL-EBS-HS-000003, Rev 00, ICN 01 and ANL-EBS-MD-000049). The updated versions of these documents will be available in January 2001. 9) Provide a technical basis for critical stress that is relevant for the environment in which external SCC takes place. DOE stated that critical stress from SCC experiments under more aggressive conditions will be cited in the Revision of the Cladding Degradation Summary Abstraction AMR, ANL-WIS-MD-000007, which will be available in January 2001. 10) Provide analysis of the rockfall and vibratory loading effects on the mechanical failure of cladding, as appropriate. DOE stated that the vibratory effects are documented in Sanders et. al. 1992 SAND90-2406, A Method For Determining The Spent-Fuel Contribution To Transport Cask Containment Requirements. This will be discussed in the SDS KTI meeting. The analysis of the rockfall effects on the mechanical failure of cladding will be addressed if the agreed to updated rockfall analysis in Subissue #2, Item 8 and Subissue #1, Item 14 demonstrate that the rock will penetrate the drip shield and damage the waste package.

4	The rate at which radionuclides in high-level waste glass are released from the engineered barrier subsystem	Closed-Pending	See agreements above, in addition: 1) In the revision to the "Defense High Level Waste Glass Degradation," AMR, address specific NRC questions regarding (a) the inconsistency of the rates in acid leg for glasses, (b) the technical basis for use of boron versus silica in the radionuclide release from glass, and (c) clarification of the definition of long term rates of glass dissolution. DOE stated that these questions will be addressed in the Defense High Level Waste AMR revision and will be available in January 2001.
5	The effects of in-package criticality on waste package and engineered barrier subsystem performance	Open - See Note 1	TBD - See Note 1
6	The effects of alternate engineered barrier subsystem design features on container lifetime and radionuclide release from the engineered barrier subsystem	Closed-Pending	1) Provide documentation for the path forward items in the "Subissue 6: Alternate EBS Design Features - Effect on Container Lifetime" presentation, slides 7 & 8. DOE stated that the documentation of the path forward items will be completed and as results become available, they will documented in the revisions of AMRs (ANL-EBS-MD-000005, Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier and the Stainless Structural Material, and ANL-EBS-MD-000004, General Corrosion and Localized Corrosion of the Drip Shield), to be completed by LA.

			2) Provide additional justification for the use of a 400 ppm hydrogen criterion or perform a sensitivity analysis using a lower value. DOE stated that additional justification will be found in the report "Review of Expected Behaviour of Alpha Titanium Alloys under Yucca Mountain Condition" TDR-EBS-MD-000015, which is in preparation and will be available in January 2001. 3) Provide the technical basis for the assumed fraction of hydrogen absorbed into titanium as a result of corrosion. DOE stated that additional justification will be found in the report "Review of Expected Behaviour of Alpha Titanium Alloys under Yucca Mountain Condition" TDR-EBS-MD-000015, which is in preparation and will be available in January 2001. 4) Provide temperature distribution (CCDF) of the drip shield as a function of time under the current EBS design. DOE stated that the temperature distribution will be provided in the next revision of the AMR, ANL-EBS-MD-000049, Rev 00, ICN 01, which will be available in January 2001.

Note 1 - Subissue #5, "The effects of in-package criticality on waste package and engineered barrier subsystem performance" were not addressed at this meeting and will be addressed in a future meeting.