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OVERNIGHT MAIL

JUL 05 2002

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TRANSMITTAL OF INFORMATION ADDRESSING KEY TECHNICAL ISSUE (KTI) AGREEMENT ITEMS CONTAINER LIFE AND SOURCE TERM (CLST) 1.05, 1.06, 1.07, AND 2.07

Reference: Ltr, Reamer to Brocoum, dtd 12/21/01

This letter transmits the report entitled, *Agreements CLST 1.05, 1.06, 1.07, and 2.07* which addresses the subject KTI agreements.

Agreement Items CLST 1.05, 1.06, and 1.07 seek information concerning the sensitivities and resolution of measurements of silica deposits on waste packages, the effects of silica deposits on corrosion rates, and alternative methods to measure corrosion rates of the container materials, respectively. Agreement Item CLST 2.07 concerns the waste package manufacturing steps and control of the process. Resolution of these agreement items was originally planned to be documented in future revisions of relevant Analysis and Model Reports prior to submittal of a license application. However, the information necessary to address these agreement items is available now and is being submitted early to facilitate the U.S. Nuclear Regulatory Commission (NRC) staff review, as agreed during the NRC/U.S. Department of Energy (DOE) Technical Exchange and Management Meeting on KTIs held April 15-16, 2002.

Details of the DOE approach and bases for closure of Agreement Items CLST 1.05, 1.06, 1.07, and 2.07 are provided in the enclosure. Alternative testing methods (i.e., high sensitivity probes, silica-free environment, and alternative methods for corrosion rates) covered under these agreement items are no longer part of the Yucca Mountain Site Characterization Project test plans. DOE believes that the information and testing plans discussed in the enclosure satisfy the underlying concerns of Agreement Items CLST 1.05, 1.06, and 1.07 and that they should be considered complete. The information provided in the enclosure also partially addresses agreement items CLST 1.03 and 1.04 concerning confirmation of linear polarization measurements with corrosion rate measurements using other techniques and the use of high sensitivity probes as an alternative method, respectively. However, complete information to support addressing both CLST 1.03 and 1.04 will not be available until completion of planned activities in Fiscal Year (FY) 2003 and FY 2004.

The referenced letter identified additional information required by NRC to complete Agreement Item CLST 2.07. Subsequent discussions with your staff, including those at the April 2002 NRC/DOE Technical Exchange and Management Meeting on KTIs, identified that the additional information is already covered by the work included under Agreement Item CLST 2.04, due for completion in FY 2003. DOE suggests that Agreement Item CLST 2.07 should be closed, and the remaining information be tracked as part of CLST 2.04.

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Several Total System Performance Agreement and Integration (TSPAI) agreement items are also partially related to Agreement Items CLST 1.05, 1.06, and 1.07 as discussed the enclosure. These are Agreement Items TSPAI 3.01, 3.04, and 3.05, mainly concerning sources of uncertainty and bases for representativeness of uncertainty/variability in corrosion rates and waste package and drip shield performance. The results from the examination of 5-year exposed samples, when available, are expected to provide the bases for addressing these TSPAI agreement items. Also, parts of Agreement Item TSPAI 2.02 (Comment #35) concerning the juvenile and early failure of waste containers are related to Agreement Item CLST 2.07. Resolution of all related TSPAI agreement items noted above will be documented in future submittals, as the supporting information becomes available.

This letter contains no new regulatory commitments. Please direct any questions concerning this letter and its enclosure to Paige R. Z. Russell at (702) 794-1315 or Timothy C. Gunter at (702) 794-1343.

Joseph D. Ziegler, Acting Assistant Manager
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OL&RC:TCG-1379

Enclosure:
Agreements CLST 1.05, 1.06, 1.07, and 2.07

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AGREEMENTS CLST 1.05, 1.06, 1.07, AND 2.07

June 2002

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ACRONYMS AND ABBREVIATIONS

AFM	Atomic Force Microscopy
AMR	Analysis and Model Report
CLST	Container Life and Source Term
CNWRA	Center for Nuclear Regulatory Waste Analysis
DI	de-ionized
DOE	U.S. Department of Energy
EBS	Engineered Barrier System
EDS	Energy Dispersive Spectroscopy
FY	Fiscal Year
KTI	Key Technical Issue
LTCTF	Long-Term Corrosion Test Facility
NRC	U.S. Nuclear Regulatory Commission
SEM	Scanning Electron Microscopy
TSPA	Total System Performance Assessment
TSPAI	Total System Performance Assessment Integrated

KTI Letter Report

AGREEMENTS CLST 1.05, 1.06, 1.07, AND 2.07

This letter report provides information to address several Key Technical Issue (KTI) agreements related to the Container Life and Source Term (CLST) KTI and specifically the waste package performance. Each KTI agreement addresses phenomena or considerations related to the performance of the waste package materials in a repository environment and the U.S. Department of Energy's (DOE's) ability to model these phenomena accurately and adequately.

The information in this letter report is provided in four parts. Part 1 provides the background and summarizes the technical issues of interest to the U.S. Nuclear Regulatory Commission (NRC) and DOE that preceded the KTI agreements. Part 2 provides the wording of the agreements and the status of their various component information needs. Part 3 provides the information called for by the KTI agreement, including the technical bases for any assertions and assumptions. Part 4 lists references.

1. BACKGROUND FOR AGREEMENTS CLST 1.05, 1.06, 1.07, AND 2.07

The primary focus of the KTI related to CLST is the adequacy of the technical basis for the models describing the degradation of the engineered barrier system (EBS) design in order to provide reasonable expectation that the models capture the range of expected processes and process interactions. The CLST KTI is focused on evaluating the adequacy of the methodology, testing, and modeling used by the DOE in the investigations related to container and waste form and the potential for criticality inside the waste package.

The CLST KTI covers six related subissues, two of which are directly related to the agreement items addressed in this letter report. The technical bases for the subissues and the rationale behind each subissue are explained in NRC's Issue Resolution Status Report, Key Technical Issue: Container Life and Source Term, Revision 3, January 2001(Reference 1). Agreement items CLST 1.05, 1.06, and 1.07 are related to Subissue 1, the effects of corrosion processes on the lifetime of the containers, while agreement item 2.07 is related to Subissue 2, the effects of phase instability and initial defects on the mechanical failure and lifetime of the containers.

These agreement items were reached during Technical Exchange and Management Meetings on the CLST KTI between the U. S. Nuclear Regulatory Commission (NRC) and the U. S. Department of Energy (DOE) on September 12-13, 2000. Agreement items CLST 1.05, 1.06, and 1.07 seek information concerning the sensitivities and resolution of measurements, the effects of silica deposits on corrosion rates, and alternative methods to measure corrosion rates of the container materials, respectively. Underlying concerns of these three agreement items are the uncertainties in the measured corrosion rates and confidence in the measurements by the use of alternative approaches. Agreement item CLST 2.07 is concerned with the waste package manufacturing steps and control of the process.

2. APPLICABLE NUCLEAR SAFETY STANDARDS/REQUIREMENTS/GUIDANCE

10 CFR 63, *Disposal of High-level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada*, Subpart B, Licenses, provides the requirements for pre-application review. These pre-application reviews include informal conferences between a prospective applicant and the NRC staff, as described in 10 CFR Part 2, *Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders*, paragraph 2.101 (a)(1). Consistent with these requirements and in accord with the memorandum of understanding between the two federal entities, Agreement between DOE/OCRWM and NRC/NMSS Regarding Prelicensing Interactions (Slater et al. 1998), a series of interactions was undertaken to identify information needed for a prospective License Application. At these meetings, agreements for the DOE to provide the NRC with information were recorded as KTI agreements.

2.1 APPLICABLE REQUIREMENTS

The Yucca Mountain disposal regulations include requirements to describe the capability and provide technical basis for the waste package to isolate waste, taking into account uncertainties in characterizing and modeling the behavior of the waste package to provide the technical basis for models used in the performance assessment (10 CFR63.115(b) and (c) and 10 CFR 63.114(b). Agreement items 1.05, 1.06, 1.07, and 2.07 are related to estimated corrosion rates and the associated uncertainties as input in waste package degradation models and waste package performance evaluations. Also, the quality assurance criteria under Subpart G, 10 CFR 63.142, dealing with control and processes related to the purchase, manufacturing, and testing of waste package materials are applicable.

2.2 KTI AGREEMENTS

Quoted below are the four CLST KTI agreements that are the subject of this Letter Report. The purpose of these agreements is to assure that sufficient information is available on a given KTI to enable the NRC to docket a License Application. Wording of CLST KTI agreements are based on summary highlights of the DOE and NRC Technical Exchange and Management Meeting held on September 12-13, 2000 (Reference 2):

> <u>CLST 1.05</u>
>
> "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."
>
> <u>CLST 1.06</u>
>
> "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."

CLST 1.07

"Provide documentation for the alternative methods to measure corrosion rates of the waste package materials (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."

CLST 2.07

"Provide documentation for the fabrication process, control, 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 Closure Weld Technical Guidelines Document) will be available to the NRC in January 2001."

2.3 STATUS OF AGREEMENTS

Prior to the NRC/DOE Technical Exchange and Management meeting on CLST KTI in September of 2000, the subissues 1, 2, 3, 4, and 6 were considered open. At the conclusion of the meeting, these subissues were designated as "closed pending" with DOE providing additional information on various technical issues. While these subissues remain "closed pending" at this time, NRC staff and DOE staff have discussed in recent months the work covered under these agreement items and the proposed approach by the DOE to satisfy the intent of the agreements. The DOE has also reprioritized the work related to the KTI agreement items using a risk-informed approach. This approach was presented to the NRC during the Technical Exchange meeting on April 14 and 15, 2002. At this meeting the DOE proposed closing a number of agreement items in Fiscal Year (FY) 02, including the four agreement items in this report. The technical bases for closing the agreements were to be documented in letter reports sent to NRC for review and acceptance. This letter report documents the basis for closure of CLST agreement items 1.05, 1.06, 1.07, and 2.07.

3. INFORMATION TO SATISFY KTI AGREEMENTS

3.1 CLST AGREEMENT ITEMS 1.05, 1.06 AND 1.07

As mentioned earlier, the underlying concern of the three agreement items CLST 1.05, 1.06, and 1.07 is the measurement uncertainties associated with the Alloy 22 corrosion rates obtained by weight loss methods. The work proposed in the agreement items, namely the use of high sensitivity probes, silica free environment tests, and the use of alternative methods, was intended to provide a better understanding of the uncertainties in the measurements and improve confidence in using the measured corrosion rates. At the time this work was proposed, the determination of the corrosion rates was complicated by uncertainties in the measurements, protective effects of deposits, and incomplete descaling. These alternative methods were considered to provide a measure of true (intrinsic) corrosion rates of Alloy 22 i.e. with very low measurement uncertainties. While the DOE agrees that it is desirable to establish the intrinsic corrosion rates, for risk-based performance assessment calculations consistent with 10 CFR 63, it is more important to establish corrosion rates in relevant environments and understand the range of uncertainties in these rates. This is particularly true for materials such as Alloy 22, which exhibits very low corrosion rates. The following proposed approach for addressing the underlying concerns is the same for all of the three agreement items. Therefore, it is appropriate that these three agreement items are treated together and apply the following discussion as the basis to consider these agreement items complete.

At the time the CLST agreement items were finalized (Reference 2), the use of high sensitivity probes in corrosion tests was considered as a potential alternative testing method. However, based on further evaluations other short-term electrochemical methods were deemed more appropriate alternatives than the use of high sensitivity probes. Accordingly, the current DOE plans have no provisions for corrosion testing using high sensitivity probes. The use of high sensitivity probes is also identified in one of the elements under CLST agreement item 1.04, "Install high sensitivity probes of Alloy 22 in some of the LTCTF." The DOE plans to address the underlying concern on uncertainties by detailed characterization of Alloy 22 samples exposed for 5 years in the Long-Term Corrosion Test Facility (LTCTF). Details of the examination plans and the types of data expected are presented later in this Section. These plans describe the number of samples to be analyzed, types of samples, and details regarding specimen surface analyses and weight measurements.

It is expected that the corrosion data from the 5-year exposed samples will improve the confidence in the currently available measured corrosion rates. The 5-year samples are expected to show lower corrosion rates than the 2–year samples with a smaller range of uncertainties. This expectation is based on the corrosion rate data obtained so far. Figure 1 shows the measured corrosion rates as a function of exposure times in the LTCTF at the Lawrence Livermore National Laboratory (LLNL). Also shown for corroborative purposes, are the 60 – 90 °C short-term (4-week and 8-week exposure) data obtained at the McDermott Laboratory facility (Reference 3). The data shows that after an initial sharp reduction in corrosion rate (within the first 6-months), the rates decrease with exposure time. This suggests that there is limited metal loss due to corrosion after the initial period or that the metal loss is too low to be discernible. The decrease is likely due to the fact that the passive film formed during the initial period is highly protective and essentially no further corrosion occurs in the LTCTF environments. Data from the 5-year samples are expected to follow this trend with the resulting corrosion rates lower than the 2-year sample data, which were used for the Total System Performance Assessment (TSPA)-Site Recommendation. It can also be seen in Figure 1 that the range of uncertainty/variability shows a systematic reduction as the exposure times increase.

Agreement item CLST 1.05 also relates to the measurement of uncertainties in titanium drip shield material. The DOE will also analyze the 5-year titanium samples during FY02 to obtain corrosion rate data. The 5-year titanium samples are Ti Grade 16 (UNS # R52402), which is titanium with an addition of 0.04 to 0.08 percent palladium (Pd). The present candidate material for the drip shield is Ti Grade 7 (UNS # R53400), which is titanium with an addition of 0.12 to 0.25 percent palladium. The Ti Grade 7 has been in test at the LTCTF for only 2 years. At the present time, it is expected that more useful information can be obtained from the 5-year exposed Ti Grade 16 samples concerning the corrosion rate, passive film and silica deposition. In terms of corrosion rate, Ti Grade 7 is expected to have better corrosion resistance than Ti Grade 16 due to its higher palladium content, hence an upper limit to the corrosion rates from the 5-year data. The 5-year Ti Grade 16 data should be statistically more significant than the results from 2-year exposed Ti Grade 7 samples.

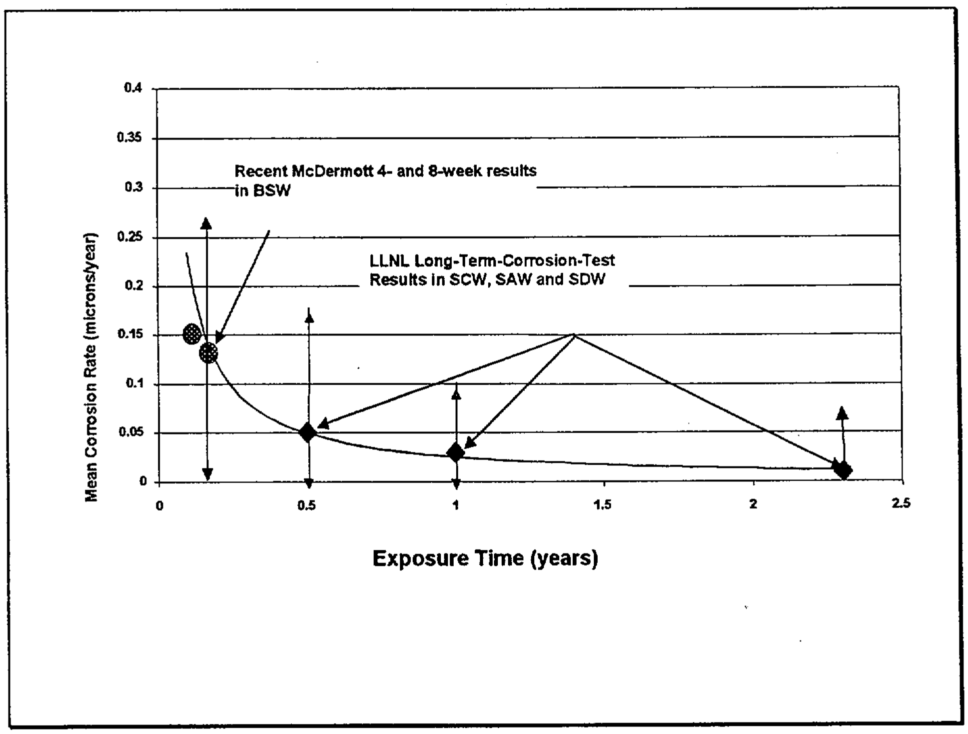

Figure 1. Alloy 22 Mean Corrosion Rate and Data Spread versus Exposure Time

Legend:

BSW	=	Basic Saturated Water, pH 11-13
LLNL	=	Lawrence Livermore National Laboratory
SCW	=	Simulated Concentrated Water, near-neutral pH
SAW	=	Simulated Acidic Water, pH ~2.7
SDW	=	Simulated Dilute Water, near-neutral pH.

(Reference: Long-term corrosion facility data [from more than 400 samples] are from Reference 4 and include results, and short-term data [4- and 8-week data] are data excerpted from Reference 3. The arrows indicate the range of values determined from the test results while the circles and diamonds indicate the mean of the distribution.)

Testing in the Absence of Silica:

Agreement item CLST 1.06 relates to corrosion testing in the absence of silica. The weight loss data obtained previously from the LTCTF showed that some of the samples exhibited negative values for weight loss even after descaling as documented in Process Model Report TDR-WIS-MD-000002, REV 00, ICN 02 (Reference 4). The Analysis/Model Report (AMR) documented that this weight gain could be due to the presence of silica bearing deposits, which were not completely removed by the descaling operations prior to weight loss measurements. This was subsequently verified by surface characterizations using the Atomic Force Microscope (AFM) and analyses of the deposits themselves. It was found that the deposits were predominantly silicates, with small amounts of sodium chloride in some cases, precipitated from the test solutions. To compensate for this, an additive correction term for the corrosion rate based on the measured thickness of the deposits was proposed. This correction term conservatively accounts for the potential error introduced in the weight loss measurements but does not address the question of possible reduced corrosion rates due to protection afforded by the silica deposits.

To resolve this question, tests in silica free environments were proposed as a possible approach. The DOE expects that any aqueous film contacting the waste package will most likely contain silica either from the mineral precipitates or from the dust deposits on the waste package surface. Thus, the data from the LTCTF are considered representative of realistic environments in the repository. Therefore, the current DOE plans do not include provisions to conduct long-term corrosion testing in silica-free environments. While the DOE agrees that it is desirable to establish the intrinsic corrosion rates, for risk-based performance assessment calculations consistent with 10 CFR 63 it is more important to establish corrosion rates in relevant environments and understand the range of uncertainties in the measurements. This is particularly true for materials such as Alloy 22, which exhibit very low corrosion rates.

While no long-term testing in silica-free environments is planned, limited short-term potentiostatic tests in the absence of silica have been conducted. The results show that there is no discernible difference in the estimated corrosion rates (based on measured passive current densities) in comparison to the data from the LTCTF. Figure 2 shows an example of corrosion data obtained in a dilute pure chloride solution subjected to potentiostatic testing. These data show that, with an applied potential of 100 mV more positive than the corrosion potential (of about –200mV), for 250 hours in a 1000 ppm Cl- solution at 95°C the corrosion rate was approximately 0.05 microns/year. The corrosion rate was calculated from the measured current densities using Faraday's Law per ASTM G 102. This is within the range of the rates obtained from the LTCTF weight loss measurements. Therefore, the postulated protective effects of silica deposits, if any, are not very significant. This will be further verified when the 5-year exposed samples are examined and characterized in detail. A detailed discussion can be found later in this Section describing how the 5-year samples will be analyzed for deposits including their effect on corrosion rates.

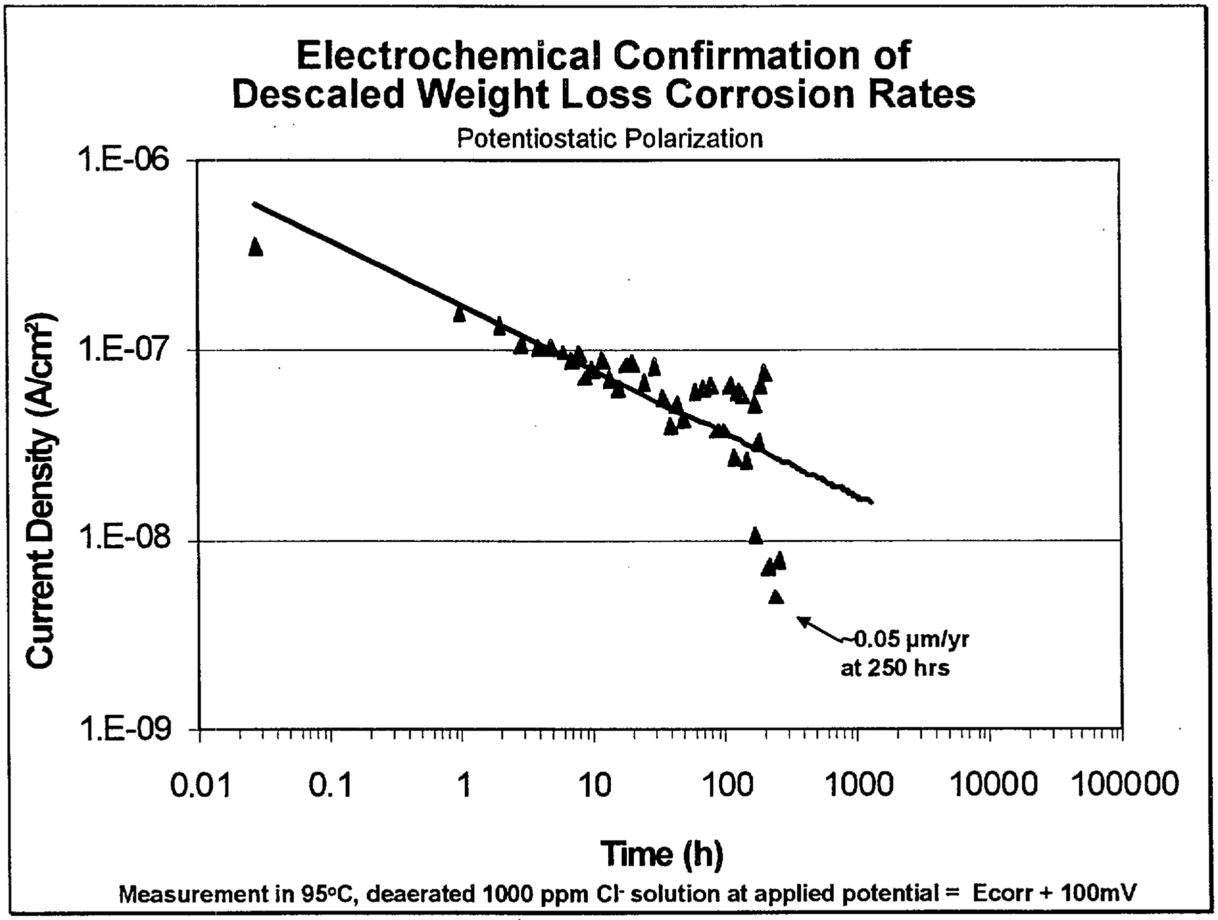

Figure 2. Electrochemically measured rates equivalent to two-year rates measured by descaled weight loss (Preliminary data from LLNL)

Alternative Methods of Corrosion Rate Measurements:

Agreement item CLST 1.07 requires the DOE to measure corrosion rates using alternative methods or justify the current approach of using the LTCTF data. This agreement item is also related to CLST 1.03, which calls for confirmation of linear polarization measurements with corrosion rate measurements using other techniques. The DOE is conducting corrosion rate measurements using alternative methods such as potentiostatic testing and linear polarization. However, results of this testing will be used only to corroborate the results of the LTCTF. The DOE plans to continue with the current approach of using the weight-loss data from the LTCTF including those from the 5-year exposed samples as the primary data for Alloy 22 general corrosion rates. This approach is justified in view of the fact that the corrosion rate decreases with exposure time so that data from the 5-year samples are more representative of the long-term steady state general corrosion rates than the short-term test conditions. Data shown in Figure 2 also support this view that corrosion rates from the short-term electrochemical tests can be used to validate the LTCTF weight loss data for corrosion rates.

Additional short-term electrochemical testing is underway. These include potentiostatic, linear polarization, and alternating current impedance measurements. Results from these tests will be available in FY 03.

Temperature Dependence:

The corrosion rates measured from the LTCTF do not show any discernible effects of temperature or environment as documented in TDR-WIS-MD-000002, REV 00, ICN 02, Waste Package Degradation Process Model Report (Reference 4). However, the temperature range of testing (60°C and 90°C) does not cover the entire range over which aqueous conditions may be present at the proposed Yucca Mountain Repository. For example, deliquescence of salt precipitates and dust particles may result in the formation of a thin aqueous film on waste package surfaces at temperatures of 120°C or higher. To account for corrosion rates at these higher temperatures, the DOE has reviewed the available short-term data (other than LTCTF data) and has developed correlations for temperature dependence. These data suggest weak temperature dependence for the range of interest with the activation energies in the range of about 25 kJ/mol (Reference 3). Such a weak dependence is expected for a highly corrosion resistant material such as Alloy 22.

Another concern associated with temperatures higher than the LTCTF test temperatures, is the possibility of localized corrosion causing a higher effective corrosion rate than occurs with general corrosion for which LTCTF data are representative. However, corrosion potential measurements carried out by the Center for Nuclear Waste Regulatory Analysis (CNWRA) suggest that corrosion potentials do not exceed repassivation potentials even at temperatures as high as 150°C (Reference 5). Figure 3 shows the variation in repassivation potential with temperature for an environment (silica-free, chloride only without the presence of other corrosion inhibiting anions) that is more aggressive than would be expected in the Yucca Mountain repository. Based on these data, it can be concluded that the corrosion rates measured in the LTCTF can be extrapolated to higher temperatures with reasonable confidence that localized corrosion will not occur.

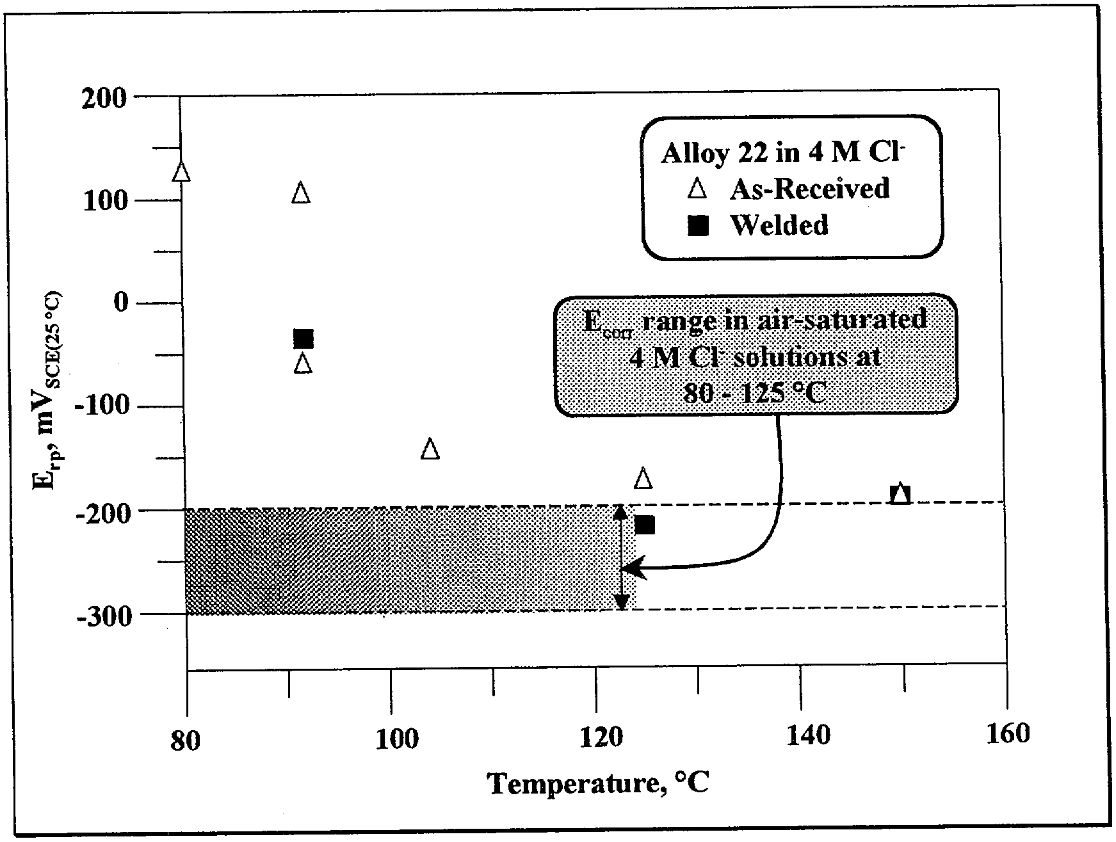

Figure 3. Effect of temperature on repassivation potential (Erp) for welded and base metal of Alloy 22 compared to corrosion potential Ecorr (Note: Data excerpted from CNWRA presentation by N. Sridhar to NWTRB, May 9, 2001, [Reference 5]).

Plans for the Examination of 5-Year Exposed Samples:

Alloy 22 samples exposed in the LTCTF environmental conditions for more than 5 years in the LTCTF will be removed for examination. The samples available for corrosion rate measurement are shown in the Table 1. The examination plan is provided in detail to underscore DOE's expectation that the results from the 5-year samples will provide the needed additional confidence in the measured corrosion rates.

The examination of the weight-loss and crevice samples will have the following objectives:

a) To characterize the deposits on the surface in each condition to compare the effects of temperature, solution composition, and pH

b) To determine corrosion rate by mass (weight) loss before and after descaling

c) To determine corrosion mode or corrosion characteristics on the surface of the specimens, both in the boldly exposed surface and in the creviced area.

Table 1: Samples of Alloy 22 to be removed for examination after 5-year exposure in LTCTF

	SAW, 90°C	SAW, 60°C	SCW, 90°C	SCW, 60°C	SDW, 90°C	SDW, 60°C
VESSEL-RACK	26 – 4	25 – 4	28 – 4	27 – 4	30 – 4	29 – 4
WEIGHT-LOSS	3BL, 3BV, 3WL, 3WV, 1BI, 1WI	3BL, 3BV, 3WL, 3WV, 1BI, 1WI	3BL, 3BV, 3WL, 3WV, 1BI, 1WI	3BL, 3BV, 3WL, 3WV, 1BI, 1WI	1BL, 1WL, 1WV, 1BI, 1WI	1BL, 1BV, 1WL, 1WV, 1BI, 1WI
TOTAL	14	14	14	14	5	6
CREVICE (CR)	3BL, 3BV, 3WL, 3WV	3BL, 3BV, 3WL, 3WV	3BL, 3BV, 3WL, 3WV	3BL, 3BV, 3WL, 3WV	3BL, 3BV, 3WL, 3WV	3BL, 3BV, 3WL, 3WV
TOTAL CR	12	12	12	12	12	12
TOTAL	26	26	26	26	17	18

Legend for abbreviations used in Table 1:

SAW = Simulated Acidic Water, pH ~2.7
SCW = Simulated Concentrated Water, near-neutral pH
SDW = Simulated Dilute Water, near-neutral pH
CR = Creviced sample
BL, BI, BV = Base Metal samples: fully immersed, at water-vapor interface, and vapor phase locations, respectively in the tanks
WL, WI, WV = Weld metal samples: fully immersed, at water-vapor interface, and vapor phase locations, respectively in the tanks

[Note: Additional details of the test procedures and the plans are contained in the LLNL Scientific Notebook used for this work]

Detailed Tasks Prior to Descaling:

- The racks containing weight-loss and crevice specimens will be lifted out of the tank. The racks will be kept wet by a fog of de-ionized (DI) water or immediately immersed in DI water as required by internal procedures.

- The samples will be cleaned by running DI water (with no mechanical soft brushing) to remove loose debris or deposits and set to dry in ambient air for at least 48 hours. Each sample will be photographed on both sides.

- Each sample will be examined under a stereomicroscope at X10, X40 and X80 magnifications. Characteristics (color, appearance, and type of deposits if any) will be documented.

- Prior to descaling, each sample will be weighed at least 3 times to determine mass change in time until the measured values are self-consistent. Weight-loss (or gain) will be recorded in each instance.

- Surface of selected samples (at least one sample for each exposure condition shown in Table 1]) will be analyzed using non-destructive methods. The characteristics of the surface scale or deposits will be studied mainly using Scanning Electron Microscopy (SEM). Energy Dispersive Spectroscopy (EDS) will be used to determine the composition of any surface scale present.

- In creviced specimens, the creviced area will be compared with the boldly exposed area both for the base metal and the weld seam (including the heat-affected zone). On the smooth surface of the creviced samples some AFM studies may also be conducted to determine the depth and topography of the scales.

Descaling and subsequent examinations:

- To determine the mass loss in a sample accurately, the sample has to be free from corrosion products and deposits that may have precipitated from the electrolyte or formed as a consequence of a reaction between the sample and the environment. ASTM G 1 provides methodologies and suggests several cleaning agents for nickel alloys (generally acid mixtures). A good cleaning agent must remove the surface scale without attacking the underlying substrate. Several trial cleaning methods are being studied to determine the type of solution and the cleaning process. These trials include: using Alloy 22 foil material, intentionally depositing silica on the foil surface by evaporating a solution containing dissolved metal-silicate, and chemical cleaning applied to another Ni-Cr-Mo alloy such as alloy C-4 from the LTCTF for cleaning process evaluation.

- Once the cleaning agent and cleaning process are selected, the weight-loss and crevice samples of Alloy 22 will be cleaned. After descaling, each flat sample will be photographed on both sides.

- Each sample will be weighed at least 3 times to determine mass change in time until the measured values are self-consistent. Mass-loss will be recorded in each instance.

- The descaled samples will be examined again. The characteristics of the cleaned surface will be studied mainly using SEM. EDS will be used to determine whether deposited materials were removed from the Alloy 22 surface.

- The creviced area of the crevice specimens will be compared with the boldly exposed area both for the base metal and the weld seam (including heat affected zone).

- On the smooth surface of the creviced samples some AFM studies may also be conducted to determine the depth and topography of the surface.

- The Alloy 22 U-bend samples will be may also be used to determine the composition and thickness of the scale on the surface using x-ray photoelectron spectroscopy and/or Auger techniques.

- Characteristics and the chemical analyses of electrolyte solutions from each tank will be recorded. These characteristics include: color; turbidity; pH; and concentration of cations such as Ni, Cr, Mo, Fe, Mo, and W and anions such as chloride, nitrate, silicate, and sulfate. The concentration of the cations will be determined in the parts per billion range.

Corrosion Rate Measurements for Titanium:

Ti Grade 16 samples exposed for 5 years in the LTCTF will be examined in order to obtain information on corrosion rate. Samples exposed to various environments similar to Alloy 22 samples will be examined.

Work described above is covered under one of the elements of the KTI agreement item CLST 1.04 which calls for continued testing in the long-term corrosion testing facility.

Results obtained from the work described above will be documented in the next revision of the two AMRs on general and localized corrosion of Alloy 22 (ANL-EBS-MD-000003) and drip shield (ANL-EBS-MD-000004). These documents are expected to be available during the third quarter of FY 03

3.2 CLST AGREEMENT ITEM 2.07

This agreement item requires the DOE to provide documentation for the fabrication process, control and implementation of the phases that affect TSPA model assumptions for waste package performance. In accordance with the agreement items two documents (References 6 and 7) were provided to the NRC by transmittal dated February 2, 2001 (Reference 8). After reviewing these documents, NRC requested that additional information on the effects of fabrication steps and variation in material compositions on Alloy 22 phase stability be addressed under this agreement item. The NRC comments and Request for Additional Information were documented in a letter to DOE dated December 21, 2001 (Reference 9). Subsequently, the fabrication reports have been updated, modified and reissued (References 10 and 11). DOE has since informed NRC at the April 2002 Technical Exchange meeting in Las Vegas, NV, that the requested information is covered under the work to be performed under CLST agreement item 2.04. Work to be performed under this item includes studies on samples obtained from mockups subjected to solution and induction annealing. In addition, samples from laser peened weld plates of prototypic thickness will also be studied to determine the effects of stress mitigation processes on performance. Induction annealing of plate mockups has been completed and the annealing of the full-diameter, one-quarter-length cylindrical mockup is expected to be completed in FY 02. Studies of the samples from this mockup will not be completed until FY 04. This is not expected to affect TSPA modeling efforts as the DOE believes that the results of this work are more important for the development and refinement of fabrication specifications than for TSPA.

In addition to the work covered under CLST 2.04, DOE has initiated studies to evaluate the effects of base metal and weld filler metal compositional variation on material behavior. It is planned to produce welded plates of prototypical thickness with the material compositions covering the range specified in the ASTM-B-575 for Alloy 22. Samples obtained from these plates will be included in future aging and phase stability studies. Results of this study are not expected until FY 04 and will be used for the development of the fabrication specification.

The December 21, 2001 NRC letter also requested that the DOE address the issue of manufacturing defects in the drip shield under CLST 2.07 per another agreement item

TSPA-Integrated (TSPAI) I 2.02 (#35). The DOE plans to address the manufacturing defects in the drip shield in the next revision of the AMR, Analysis of Mechanism of Early Waste Package Failures, ANL-EBS-MD-000023 (Reference 12). The DOE believes that this approach is appropriate as this document also addresses manufacturing defects in the waste package. This document is expected to be available in the third quarter of FY 03 (April-June, 2003).

Agreement item CLST 2.07 is, therefore, considered complete considering that the work needed to address this agreement item will be covered under agreement item 2.04.

3.3 SUMMARY

Details of the DOE approach and bases for closure of agreement items CLST 1.05, 1.06, 1.07, and 2.07 were provided above. The first three items relate to corrosion testing methods intended to increase confidence in the measured corrosion rates. The DOE plans to satisfy the underlying concern about uncertainties in the measured corrosion rates by detailed examination of 5-year exposed samples of Alloy 22 from the LTCTF. In addition, the DOE plans to use short-term electrochemical testing to obtain corroborative data on corrosion rates. Based on current data, the general corrosion rates measured by the weight-loss method is expected continue to show a decreasing trend with exposure times as well as smaller ranges of uncertainty. Detailed characterization of 5-year samples including analyses of surface characteristics will provide a better understanding of uncertainties and improve confidence in the measured corrosion rates.

Based on the information and testing plans discussed in previous sections, alternative testing methods (high sensitivity probes, silica-free environment and alternative methods for corrosion rates) covered under the three agreement items are not needed to satisfy the underlying concerns of the agreement items and should be closed.

As for CLST 2.07, the DOE believes that the agreement item has been satisfied by the submittal of the two fabrication process documents (References 6, and 7) and subsequent discussions with the NRC staff. The additional information requested by NRC is already covered by the work included under CLST 2.04. The issue of manufacturing defects in the drip shield requested by NRC is more appropriately included in the revision of the existing document on the mechanism for early failures of waste packages (reference 12).

3.4 RELATED TSPAI AGREEMENT ITEMS

TSPAI agreement items 3.01, 3.04, and 3.05 are related to the CLST agreement items 1.05, 1.06, 1.07 discussed in this report. TSPAI 3.01 requires that significant sources of uncertainty be propagated into projections of waste package and drip shield performance. TSPAI 3.04 requires DOE to provide the technical basis that the representation of variation of general corrosion rates does not result in risk dilution of projected dose responses. TSPAI 3.05 requires the technical basis for the representation of uncertainty/variability in the general corrosion rates. Results from the examination of 5-year exposed samples are expected to provide the basis for addressing these TSPAI agreement items.

TSPAI agreement item 2.02 (#35) is related to CLST item 2.07. This has been addressed above under the subsection on CLST item 2.07.

4. REFERENCES

4.1 DOCUMENTS CITED

1. NRC (U.S. Nuclear Regulatory Commission) 2001. *Issue Resolution Status Report Key Technical Issue: Container Life and Source Term. Rev. 3.* Washington, D.C.: U.S. Nuclear Regulatory Commission
2. Letter, J. Schlueter to S. J. Brocoum, dated October 4, 2000
3. Fred Hua, Jeff Sarver, John Jevee, and Gerald Gordon, *"General Corrosion Studies of Candidate Container Materials in Environments Relevant to Nuclear Waste Repository"*, Paper No. 02530, Corrosion 2002, Denver, Colorado
4. CRWMS M&O 2000. *Waste Package Degradation Process Model Report.* TDR-WIS-MD-000002 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001228.0229.
5. Corrosion-Related Studies at CNWRA, Presentation by Narasi Sridhar to NWTRB, May 9 2001, Washington DC
6. CRWMS M&O 2000. *Waste Package Operations Fabrication Process Report.* TDR-EBS-ND-000003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000927.0002.
7. CRWMS M&O 2000. *Waste Package Operations FY-00 Closure Weld Technical Guidelines Document.* Development Plan TDP-EBS-ND-000005 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000228.0492.
8. Letter, Brocoum to C.W. Reamer, February 02, 2001
9. NRC Letter, W. Reamer to S. J. Brocoum, December 21, 2001
10. Plinski, M.J. 2001. *Waste Package Operations Fabrication Process Report.* TDR-EBS-ND-000003 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20011003.0025.
11. Knapp, M.C. 2001. *Waste Package Project FY-01 Closure Methods Report.* TDR-EBS-ND-000006 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20011004.0134.
12. CRWMS M&O 2000. *Analysis of Mechanisms for Early Waste Package Failure.* ANL-EBS-MD-000023 REV 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001011.0196.

4.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR 2. Energy: Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders. Readily available.

10 CFR 63. Energy: Disposal of High-level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Readily available.

ASTM G 1-90, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens, American Society for Testing and Materials, West Conshohoken, Pa.* Reapproved in 1999.

ASTM G 102 – 89, *Standard Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements. American Society for Testing and Materials, West Conshohoken, Pa.* Reapproved in 1999.