Model Administrative Change Notice

QA:QA

Complete only applicable items.

1. Document Number:	ANL-EBS-MD-000004	2. Revision:	02/AD 01	3. ACN:	02
4. Title:	General Corrosion and Localized Corrosion of the Drip Shield				
5. No. of Pages Attached:	14				

6. Approvals:		
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7. Affected Pages	8. Description of Change:
1-3	Clarified TSPA implementation independent of local seepage conditions. Defined that "coupon," "sample," and "specimen" all refer to the same type of tested material and are used interchangeably
6-4	Clarified modeling approach paragraph and discussion of implementation.
6-6	Rewrote the reasoning for exclusion of zero and negative corrosion rate data.
6-7, 6-8, & 6-14	Made zero and negative corrosion rate exclusion consistent with changes on p. 6-6.
6-13 & 6-19	Revised text and a table/figure caption to clarify the uncertainty discussion.

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6-20	Reworded to avoid connotation that aggressive model is applied only where seepage occurs.
6-23	Deleted parenthetical statement, and revised to avoid connotation similar to that fixed on page 6-20.
6-25	Corrected wording from “model” to “models.” Added explanation to the relative importance of p-value indicator.
6-30	Clarified that modeling of the drip shield general corrosion uses two corrosion rates.
9-2, 9-3	References updated with approved title and accession numbers.

As described in Sections 1.4 and 6.5 of the parent report, the general corrosion degradation of the drip shields is evaluated by modeling general corrosion of the underside and topside surface of the drip shield separately. The revised titanium general corrosion model presented in this addendum is based upon corrosion rates for Titanium Grade 7 determined by weight-loss measurement after 2.5 years of controlled exposure (Section 6.1[a]). Section 6.5 of the parent report was based upon corrosion rates for Titanium Grade 16 determined from weight-loss measurements after one year of exposure that have since been considered to have unreasonably high uncertainties and deemed unrepresentative of the corrosion of the alloy for the testing conditions. The measurement uncertainties were most likely the result of: (1) incomplete removal of corrosion products and other solid phases from the sample coupons by applying too mild cleaning procedures, which could have resulted in under-estimated corrosion rates for the alloy, and (2) the relatively short-term nature of the testing. The selected 2.5-year corrosion rate data supports two environmentally distinct corrosion rates, one for a relatively aggressive aqueous environment, the other corresponding to a rather benign environment. The TSPA implementation of drip shield general corrosion of the Titanium Grade 7 plate material (SNL 2007 [DIRS 179354], Table 4-2, Parameter 07-04A) is to apply the aggressive environment general corrosion rate to its topside surface and the benign environment general corrosion rate to the underside surface.

The aggressive and benign condition general corrosion rate models are based on the probability distribution functions that were fit to measured general corrosion rates of coupons exposed to those environments (Section 6.1[a]). The corrosion models are validated by using the five-year exposure test data for Titanium Grade 16 from the Long Term Corrosion Testing Facility (LTCTF) and literature information (Section 7.2[a]).

Titanium Grade 29 is a recently included drip shield material for use as the structural support members of the drip shield (SNL 2007 [DIRS 179354], Table 4-2, Parameter 07-04B). This material now requires a new analysis to determine a corrosion rate factor for the relative corrosion rate of Titanium Grade 29 based on Titanium Grade 7 corrosion rates (Section 6.2[a]). The corrosion rate factor is used in conjunction with the titanium corrosion model by application of the aggressive environmental condition, regardless of the spatial location of the structural support members.

In the descriptions of the titanium testing results discussed in this addendum, the terms "coupon," "sample," and "specimen" all refer to the same type of tested material and are used interchangeably.

Dust will settle and accumulate on the topside surfaces of the drip shields in the repository. For drip shields that are not subject to drips, hygroscopic salts in the dust could result in brines from the deliquescence of those salts at low relative humidity values. However, the amount of brines that could form from dust deliquescence will be extremely small and will not be able to support and maintain aggressive conditions (i.e., elevated fluoride concentrations) (SNL 2007 [DIRS 181267], Section 6.4.1.3). Therefore, the topside surface of the drip shields that is not subject to seepage will not be exposed to aggressive conditions that could result in increased general corrosion rates of the drip shields in the repository.

Geochemical interactions of some groundwater compositions relevant to the repository environment may evolve to concentrated solutions with elevated fluoride concentrations like the SCW used in long-term corrosion testing at the LTCTF (Section 6.2). The SCW contains a nominal dissolved fluoride concentration of about 1400 mg/L (DTN: LL040803112251.117 [DIRS 171362], file: *LL040803112251.117 Table 1.pdf*). The topside surfaces of the drip shields that are subject to seepage may be exposed to a more aggressive chemical environment and conditions (with elevated fluoride concentrations) than those not subject to seepage. Seepage on the topside surfaces of the drip shields may lead to conditions with elevated fluoride concentrations that could cause increased passive dissolution rates for titanium alloys (Brossia and Cragnolino 2001 [DIRS 162420], Figure 10; Brossia and Cragnolino 2004 [DIRS 180832], Figures 8 to 10).

The underside surfaces of the drip shields, which seepage cannot physically contact and where dust cannot settle and accumulate, are not expected to be exposed to aggressive conditions for general corrosion, and therefore general corrosion will proceed under benign conditions.

Because of these environmental condition differences for exposure of the drip shield in the repository, general corrosion of the topside and underside surfaces of the drip shields is modeled separately using different sets of corrosion rates. A corrosion model developed for aggressive environmental conditions is applied to the topside surface of the drip shields that are subject to seepage (Section 6.1.6[a]). Another corrosion model developed for benign environmental conditions is applied to the topside surface of the drip shield that is not subject to seepage and the underside surface of all drip shields (regardless of whether the drip shields are being dripped on or not) (Section 6.1.7[a]).

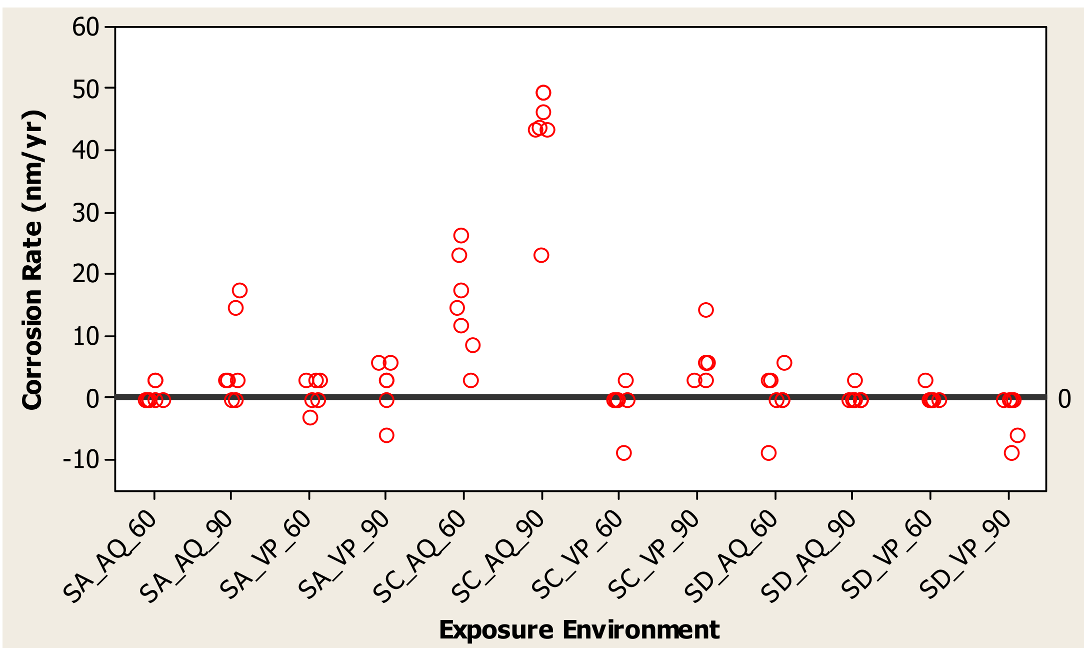
A reasonable alternate modeling approach is to apply the general corrosion rate distribution for aggressive conditions to all drip shield topside surfaces. The general corrosion rate distribution for benign conditions would then apply only to the drip shield underside surfaces. As this approach will apply the higher aggressive condition corrosion rates to more of the drip shields, it can be viewed as a conservative alternative (i.e., it results in an earlier failure of the portions of the drip shields that do not experience seepage). This is the conceptual model that is recommended for implementation in the TSPA (Section 8.1[a]).

6.1.3[a] Weight-Loss Data Analysis for Weight-Loss and Crevice Coupons

All general corrosion rates for Titanium Grade 7 are calculated by using weight-loss data obtained at the LTCTF (DTN: LL030410012251.056 [DIRS 169583]). The long-term corrosion tests performed at the LTCTF employed two types of specimen geometry (i.e., weight-loss

Year Coupon Corrosion Rates Sup12 SN241.xls) used in the model analysis were the weight-loss measurements and characteristics of the sample and exposure conditions.

Figure 6-2[a] shows comparison of the general corrosion rates of all Titanium Grade 7 weight-loss samples for different exposure conditions after a 2.5-year exposure in the LTCTF (i.e., aqueous and vapor phase for the SAW, SCW, and SDW solutions at 60°C and 90°C). The general corrosion rates of the weight-loss samples tested for the waterline condition for each of the exposure environments are included in the aqueous condition subset of their respective exposure condition. The general corrosion rates for the SCW aqueous condition at 60°C and 90°C are much higher than the rates for all other exposure conditions. With the exception of the sample set exposed to SCW aqueous conditions, the populations from each environment contained a number of specimens which exhibited zero or negative calculated corrosion rates. These results (which imply creation of additional metal) do not make physical sense for the process being measured, and are likely the result of one or more experimental limitations. One explanation is that the mass of material lost due to metal oxidation was below the resolution of the procedures and equipment used to quantify it. Another plausible explanation is that the chemical de-scaling procedure utilized to remove the corrosion product was unable to completely remove the tenacious oxide films (predominantly titanium oxides, TiO_2) from the surface of the sample coupons during the post-test sample-cleaning operations.



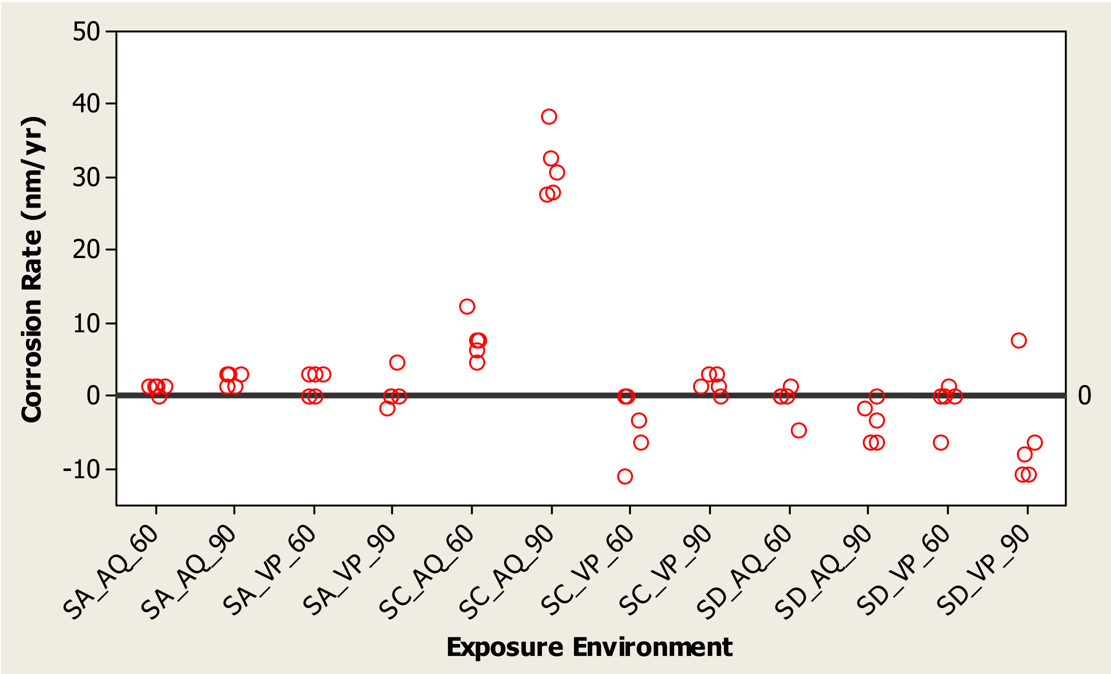
Source: Data DTN: LL030410012251.056 [DIRS 169583], file: *Ti-7 2 & one half Year Coupon Corrosion Rates Sup12 SN241.xls.*

Output DTN: SN0705DSGCANAL.001.

NOTES: SA = SAW (simulated acidic water), SC = SCW (simulated concentrated water), SD = SDW (simulated dilute water), AQ = aqueous phase, VP = vapor phase, 60 = 60°C, 90 = 90°C.

Figure 6-2[a]. Comparison of General Corrosion Rates of All Titanium Grade 7 Weight-Loss Samples for Different Exposure Conditions after 2.5-Year Exposure in the LTCTF

Comparison of the general corrosion rates of all Titanium Grade 7 crevice samples for different exposure conditions is shown in Figure 6-3[a]. The general corrosion rates of the waterline samples are included in the aqueous condition subset of their respective exposure condition. As observed for the weight-loss samples, the general corrosion rates of the crevice samples tested in the SCW aqueous condition at 60°C and 90°C are much higher than the rates for all other exposure conditions. Again, except for the SCW aqueous conditions, all the exposure conditions have some samples with negative or zero corrosion rates. These zero and negative corrosion rates are not indicative of the corrosion process and were probably caused by incomplete removal of the tenacious oxide films (predominantly titanium oxides, TiO_2) on the surface of the sample coupons during the post-test sampling cleaning operations.



Source: Data DTN: LL030410012251.056 [DIRS 169583], file: *Ti-7 2 & one half Year Coupon Corrosion Rates Sup12 SN241.xls.*

Output DTN: SN0705DSGCANAL.001.

NOTES: SA = SAW (simulated acidic water), SC = SCW (simulated concentrated water), SD = SDW (simulated dilute water), AQ = aqueous phase, VP = vapor phase, 60 = 60°C, 90 = 90°C.

Figure 6-3[a]. Comparison of General Corrosion Rates of All Titanium Grade 7 Crevice Samples for Different Exposure Conditions after 2.5-Year Exposure in the LTCTF

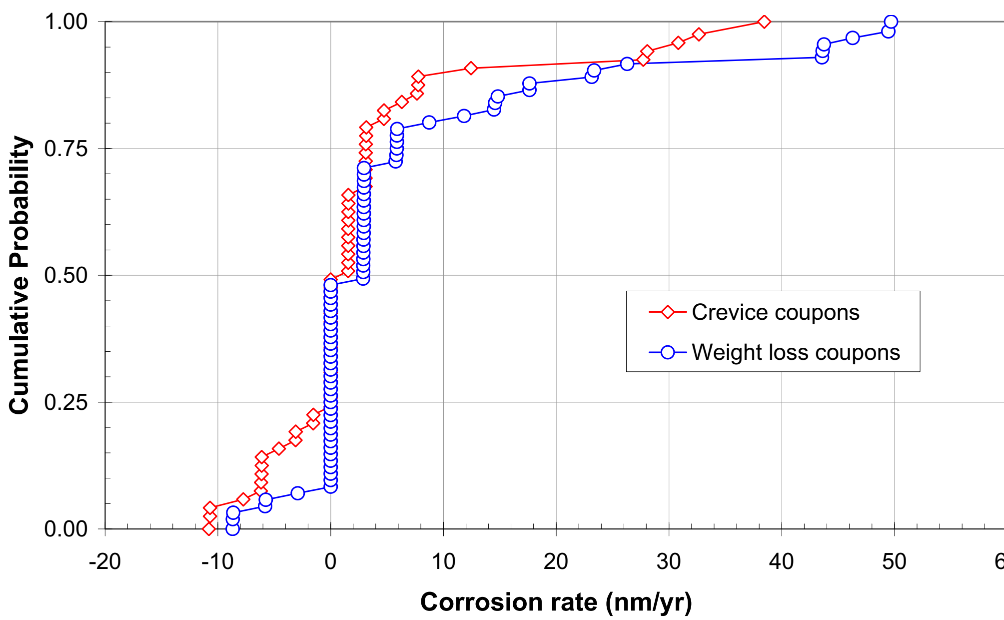
The post-test stereomicroscopic and scanning electron microscopic observations of weight-loss and crevice specimens indicated little or no signs of corrosion. The machining grooves remained uniform and sharp throughout each coupon. No crevice corrosion was observed on any of the tested coupons.

Figure 6-4[a] shows the empirical cumulative distribution functions (ECDFs) of the calculated general corrosion rates of the weight-loss and crevice coupons. In constructing the ECDFs, the cumulative probability values of the general corrosion rate (except the upper and lower bounds) were calculated by the positions given by Equation 3[a] (Stedinger et al. 1993 [DIRS 105941], Section 18.3.2):

$$q_i = \frac{i - 0.5}{n} \qquad \text{(Eq. 3[a])}$$

where q_i is the cumulative probability of the *i*th smallest event (e.g., general corrosion rate) and n is the total number of events. The formula in Equation 3[a] is a traditional choice for probability plotting (Stedinger et al. 1993 [DIRS 105941], Section 18.3.2).

For each of the weight-loss and crevice coupon data sets, the ECDF combines all the data subsets for the different exposure conditions (aqueous phase, waterline, and vapor phase for the SAW, SCW, and SDW solutions at 60°C and 90°C) and sample conditions (mill-annealed and as-welded). The ECDFs present the data trends and comparative analysis of the weight-loss and crevice coupon data sets. About half of both the weight-loss and crevice coupon data sets have either zero or negative corrosion rates: 38 out of 78 data points for weight-loss samples, and 30 out of 60 data points for crevice samples.



Source: Data DTN: LL030410012251.056 [DIRS 169583], file: *Ti-7 2 & one half Year Coupon Corrosion Rates Sup12 SN241.xls*.

Output DTN: SN0704PADSGCMT.001, file: *Ti-7_2.5yr_Crevice Coupon Data Analysis.xls*.

Figure 6-4[a]. Empirical Cumulative Distribution Functions for General Corrosion Rate of All Titanium Grade 7 Weight-Loss and Crevice Samples after 2.5-Year Exposure in the LTCTF

Because they are spurious, the negative or zero corrosion rates measured for Titanium Grade 7 are excluded from further data and model analysis. For the weight-loss samples the average general corrosion rate for all the samples is 6.36 nm/yr, and the average rate for the samples with positive corrosion rates (i.e., excluding those with negative or zero values) is 13.42 nm/yr. For the crevice samples, the average general corrosion rate for all the samples is 2.75 nm/yr, and the

Table 6-2[a]. Measurement Uncertainty Analysis for Corrosion Rates Based upon Weight-Loss Measurements for Titanium Grade 7 after 2.5-Year Exposure in the LTCTF (Continued)

Parameters	Units	Crevice Coupons	Weight-Loss Coupons
$(\partial y/\partial w)^2 \Delta w^2$	—	5.198×10^{-23}	1.886×10^{-22}
$(\partial y/\partial \rho)^2 \Delta \rho^2$	—	3.800×10^{-24}	1.379×10^{-23}
$(\partial y/\partial t)^2 \Delta t^2$	—	9.283×10^{-27}	3.369×10^{-26}
$(\partial y/\partial a)^2 \Delta a^2$	—	1.745×10^{-27}	6.414×10^{-27}
$(\partial y/\partial b)^2 \Delta b^2$	—	1.745×10^{-27}	2.298×10^{-26}
$(\partial y/\partial c)^2 \Delta c^2$	—	6.211×10^{-27}	4.602×10^{-26}
$(\partial y/\partial d)^2 \Delta d^2$	—	3.531×10^{-29}	4.651×10^{-28}
Δy	cm/hr	7.470×10^{-12}	1.423×10^{-11}
Δy	μm/yr	6.543×10^{-04}	1.247×10^{-03}
Δy	nm/yr	0.654	1.247

Output DTN: SN0704PADSGCMT.001, file: *Ti-7_2.5 yr_Measurement_Uncertainty Analysis.xls*.

As shown in the last row of Table 6-2[a], the combined standard uncertainty corresponding to one standard deviation (1σ) in the measurement is estimated to be approximately 0.654 nm/yr for the crevice samples and 1.247 nm/yr for the weight-loss samples. As summarized in Table 6-3[a], for the crevice coupons approximately 6% of the standard deviation in the measured general corrosion rate is due to the measurement uncertainty (calculated by dividing the measurement uncertainty (0.654 nm/yr) by the standard deviation in the crevice coupon corrosion rates (10.976 nm/yr)). The remaining 94% is from the variations of the corrosion rate among the specimens. For the weight-loss coupons, approximately 8% of the standard deviation in the measured general corrosion rate is due to the measurement uncertainty, and 92% is from variability in the corrosion rate among the specimens.

Table 6-3[a]. Comparison of Measurement Uncertainty (Δy) to the Sample Corrosion Rates Based upon Weight-Loss Measurements for Titanium Grade 7 after 2.5-Year Exposure in the LTCTF

Sample Configuration	Δy (nm/yr)	Mean Corrosion Rate (nm/yr)	Standard Deviation (nm/yr)
Weight-Loss Coupons	1.247	13.421	15.347
Crevice Coupons	0.654	8.324	10.976

Output DTN: SN0704PADSGCMT.001, file: *Ti-7_2.5 yr_Measurement_Uncertainty Analysis.xls*.

If the entire data set were taken for model analysis, only a small amount (approximately 6% to 8%) of the total variation in the measured general corrosion rate of the Titanium Grade 7 samples is due to the measurement uncertainty. Therefore, all (100%) of the measured variation could be considered due to the variability in the general corrosion processes for modeling purposes. As is discussed in Section 6.1.5[a], the weight-loss coupon data are divided into three groups with distinctively different rate distributions, and the measurement uncertainty is analyzed for each data group following the same method (Table 6-5[a]).

6.1.5[a] General Corrosion Data Selection and Analysis

All general corrosion rates for Titanium Grade 7 are calculated by using weight-loss data obtained at the LTCTF (output DTN: SN0704PADSGCMT.001). The long-term corrosion tests performed at the LTCTF employed two types of specimen geometry (i.e., weight-loss specimens and crevice specimens). Both types of specimens were exposed to repository-relevant environments for 2.5 years.

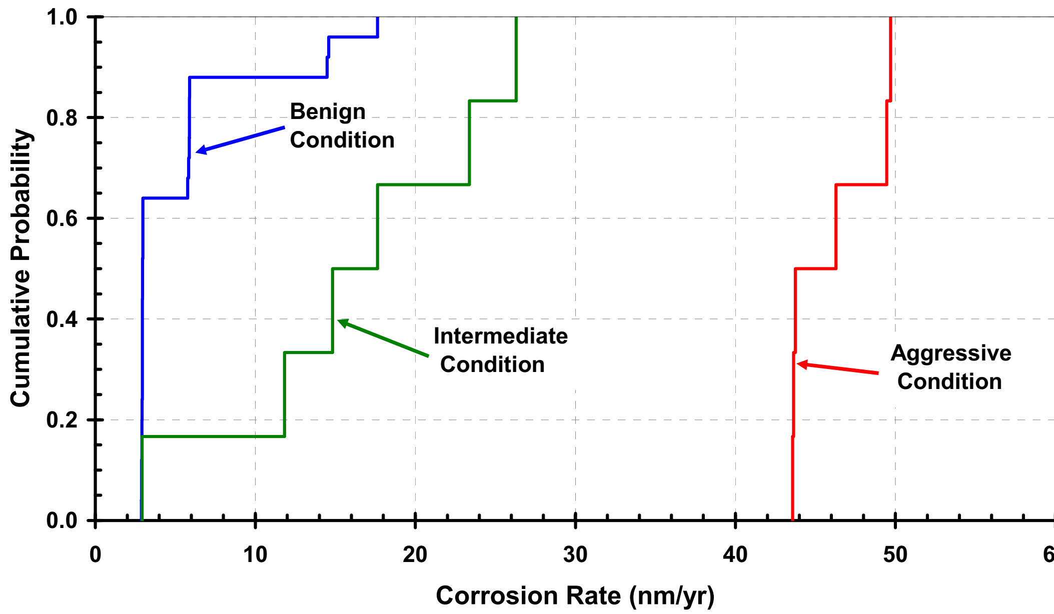
As was discussed in Section 6.1.3[a], negative or zero general corrosion rates were measured for some weight-loss and crevice samples (except those tested in the SCW aqueous conditions). These zero or negative corrosion rates (indicating no weight change or weight gains that imply the creation of metal) are not indicative of the process of corrosion. Metals are not thermodynamically stable in typical engineering and geologic application environments and corrode at rates that are determined by the exposure condition and characteristics of the passive films formed on the metal under that exposure condition. These negative or zero values are indicative of experimental limitations and were probably caused by incomplete removal of the oxide films (predominantly titanium oxides, TiO_2) on the surface of the sample coupons during the post-test sampling cleaning operations. Therefore, those negative or zero corrosion rates measured for Titanium Grade 7 are excluded from further data and model analysis.

Exclusion of the negative and zero corrosion rates is further justified because of the unrealistic aspect of general corrosion damages of the drip shields that would be predicted by a general corrosion model that incorporated such negative and zero rates. The probabilistic general corrosion model for the drip shields, as will be implemented in TSPA, assumes that the general corrosion rate is constant (i.e., time-independent), and the same general corrosion rates sampled from the probabilistic model are used for the entire simulation period in TSPA. This means that sampling of zero or negative general corrosion rates in TSPA will result in no general corrosion damage or thickness gains of drip shields to be evaluated in TSPA.

The ECDFs of the resulting corrosion rates for the weight-loss and crevice samples (excluding negative and zero rates) are shown in Figure 6-5[a]. The corrosion rates for the crevice coupons are systematically lower than those for the weight-loss coupons (output DTN: SN0704PADSGCMT.001]), and cannot be satisfactorily explained at this time. The crevice geometry coupons were used to evaluate crevice corrosion susceptibility of the titanium alloy in the LTCTF test media and are not ideal for a quantitative assessment of the general corrosion behavior. It is pointed out here that no localized crevice corrosion attack was noted on any specimens. The corrosion rate measurements from the crevice geometry coupons were not used for the model development. Furthermore, the inclusion of the crevice coupon data will result in lower modeled general corrosion rates, and using the weight-loss coupon data only is both conservative and appropriate. Accordingly, only the corrosion rates determined from the weight-loss geometry coupons were used for the model development. For the weight-loss samples (excluding those with negative or zero values), the general corrosion rates range from 2.88 nm/yr to 49.7 nm/yr, with an average rate of 13.42 nm/yr.

The above ECDF for the weight-loss samples includes data from three waterline weight-loss samples (2.93 nm/yr for SAW at 60°C, 8.74 nm/yr for SCW at 60°C, and 23.15 nm/yr for SCW at 90°C). These data were excluded from further data and model analysis because of potential

As summarized in the last column of Table 6-5[a], for the benign condition group samples, approximately 29% of the total variation in the measured general corrosion rate is due to the measurement uncertainty, and 71% of it is from the variations of the corrosion rate among the specimens. For the aggressive condition and intermediate condition group samples, the contribution of the measurement uncertainty to the total variation in the general corrosion rates is 55% and 15% respectively, and the rest of the total variation is due to the variability in the general corrosion processes.



Source: DTN: LL030410012251.056 [DIRS 169583], file: *Ti-7 2 & one half Year Coupon Corrosion Rates Sup12 SN241.xls*.

Output DTN: SN0704PADSGCMT.001.

Figure 6-8[a]. ECDFs for General Corrosion Rates of Titanium Grade 7 Weight-Loss Samples for Different Exposure Conditions

Table 6-5[a]. Comparison of Measurement Uncertainty (Δy) to the Weight-Loss Coupon Corrosion Rates for the Three Groups for Different Environmental Conditions

Sample Group	Sample Population	Combined Measurement Uncertainty Δy (nm/yr)	Sample Group Mean Corrosion Rate (nm/yr)	Sample Group Standard Deviation (nm/yr)	Contribution of Measurement Uncertainty to Total Variation (%)
Benign Condition	25	1.210	5.149	4.155	29.12
Intermediate Condition	6	1.247	16.148	8.400	14.85
Aggressive Condition	6	1.594	46.067	2.909	54.80

Output DTN: SN0704PADSGCMT.001, file: *Ti-7_2.5 yr_Measurement_Uncertainty Analysis.xls*.

Though there is this acknowledged variability in the general corrosion processes it does not need to be considered within TSPA. That is because the primary mechanism of drip shield failure is overall structural response. The structural response is based upon discrete set of drip shield thicknesses (e.g., 15, 10, and 5 mm cases) in *Seismic Consequence Abstraction* (SNL 2007 [DIRS 176828], Section 6.10). A variability treatment is developed in Sections 6.1.6[a] and 6.1.7[a] for possible sensitivity analysis.

6.1.6[a] Drip Shield General Corrosion Model for Aggressive Environmental Conditions

Geochemical interactions of some groundwater compositions relevant to the repository environment may evolve to concentrated solutions with elevated fluoride concentrations like the SCW used in long-term corrosion testing at the LTCTF (Section 6.2 of the parent report).

6.1.6.1[a] General Corrosion Rate Variability for Aggressive Environmental Conditions

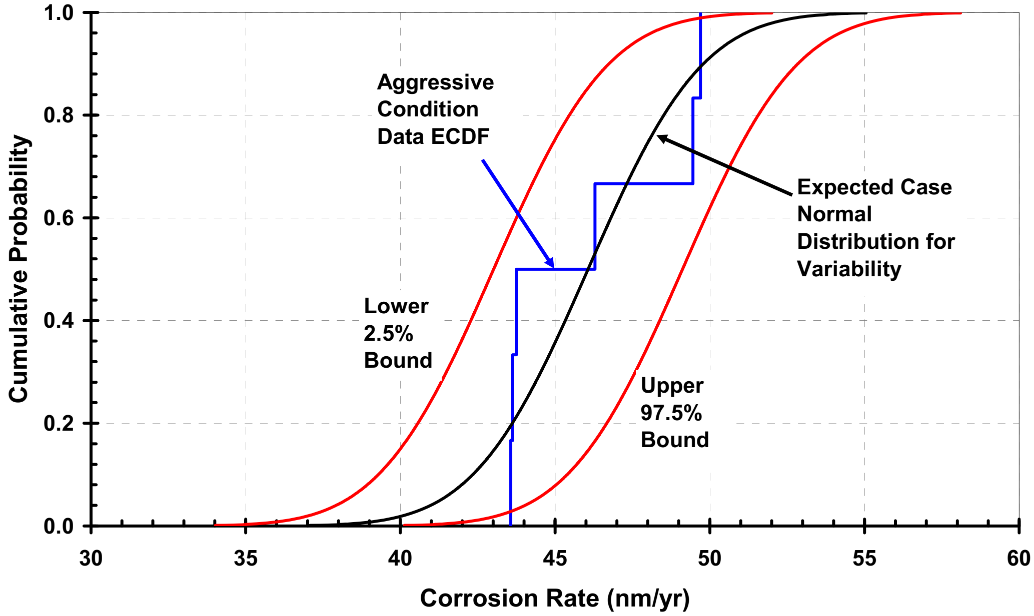
As was discussed in Section 6.1.2[a], the topside surface of the drip shield that is subject to seepage in the repository may become exposed to relatively aggressive environmental conditions with elevated dissolved fluoride concentration such as in the SCW environment. The six data points given for the aggressive condition in Table 6-4[a] were used to develop a probabilistic general corrosion model for the aggressive condition. This model best represents the topside surface of the drip shield that is subject to seepage. An alternate (and conservative) use by TSPA is to implement this aggressive general corrosion model on all topside surfaces (Section 8.1[a]).

Assuming that the underlying model for the corrosion rate variability is normal, a normal probability model was fit to the aggressive condition sample data. The sample mean ($\bar{x}$) and sample standard deviation (s) for the aggressive condition data are calculated by Equations 19[a] and 20[a] (Scheaffer and McClave 1990 [DIRS 154197], Section 5.1):

$$\bar{x} = \frac{\sum_{i=1}^{6} x_i}{6} = \frac{276.40}{6} = 46.067 \qquad \text{(Eq. 19[a])}$$

$$s = \sqrt{\frac{\sum_{i=1}^{6} (x_i - \bar{x})^2}{6-1}} = 2.909 \qquad \text{(Eq. 20[a])}$$

Note that about a half of the total variation in the aggressive condition data is due to the measurement uncertainty (Table 6-5[a]). For the modeling purpose, the entire variation in the data is assumed to be due to the variability in the corrosion process. The resulting normal probability model represents the *variability* in the drip shield general corrosion rates for the aggressive conditions. The variability in the general corrosion rate is likely due to the randomness of the corrosion process under the conditions in the exposure environment. Figure 6-9[a] shows the variability distribution of the model (labeled as "Normal Fit to the Data"). As discussed in Section 6.1.6.2[a], the uncertainty in the corrosion model (Equations 19[a] and 20[a]) is characterized by assuming that the mean of the corrosion model is uncertain. The distribution for the uncertain mean is also shown in Figure 6-9[a].



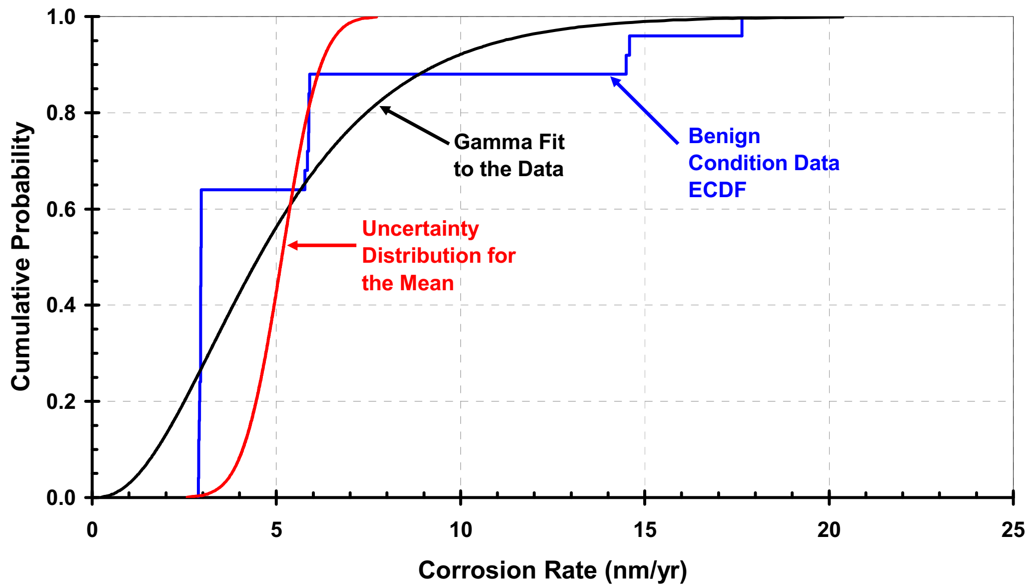
Source: Output DTN: SN0704PADSGCMT.001, file: *DS GC Model Analysis_aggressive condition_rev1.xls*.

Figure 6-11[a]. General Corrosion Rate Variability Distributions for the 2.5 Percentile and 97.5 Percentile Mean Values for Aggressive Environmental Condition

6.1.7[a] Drip Shield General Corrosion Model for Benign Environmental Conditions

As discussed in Section 6.1.2[a], the topside surface of the drip shield that is not subject to seepage and the underside surfaces of all drip shields (which seepage cannot physically contact and where dust cannot settle and accumulate) are likely subject to benign environmental conditions for all time in the repository. The 25 data points listed for the benign condition in Table 6-4[a] were used to develop a probabilistic general corrosion model for the drip shield under benign conditions. This model is applicable to the topside surface of drip shields that are not subject to seepage and the entire underside surface of all drip shields. An acceptable (and conservative) alternative approach recommended for TSPA implementation is to use this model on only the underside surface of drip shields (Section 8.1[a]).

Note that approximately 30% of the total variation in the benign condition data is due to the measurement uncertainty (Table 6-5[a]). For the modeling purpose, the entire variation in the data is assumed to be due to the variability in the corrosion process. The description of the general corrosion model for the benign condition is split into two parts. First is the characterization and quantification of the uncertainty in the general corrosion model for the benign environmental condition. Second is the description of the corrosion rate variability model that represents the data.



Source: Output DTN: SN0704PADSGCMT.001, file: *DS GC Model Analysis_benign condition.xls*.

Figure 6-12[a]. Drip Shield General Corrosion Model for Benign Environmental Conditions along with the ECDF for the Experimental Data Used for the Model Analysis

6.1.7.2[a] Corrosion Rate Variability for Benign Environmental Condition

The benign environmental condition data consist of 16 values between 2.88 and 2.96 nm/yr; six values between 5.77 and 5.90 nm/yr; two values of 14.49 and 14.59 nm/yr; and one value of 17.64 nm/yr. These data are very much "clustered," and, as such, no probability distribution will fit the entire data set. Figures 6-13[a] to 6-17[a] show Minitab fits to these data for normal, lognormal, gamma, Weibull, and exponential distributions, respectively.

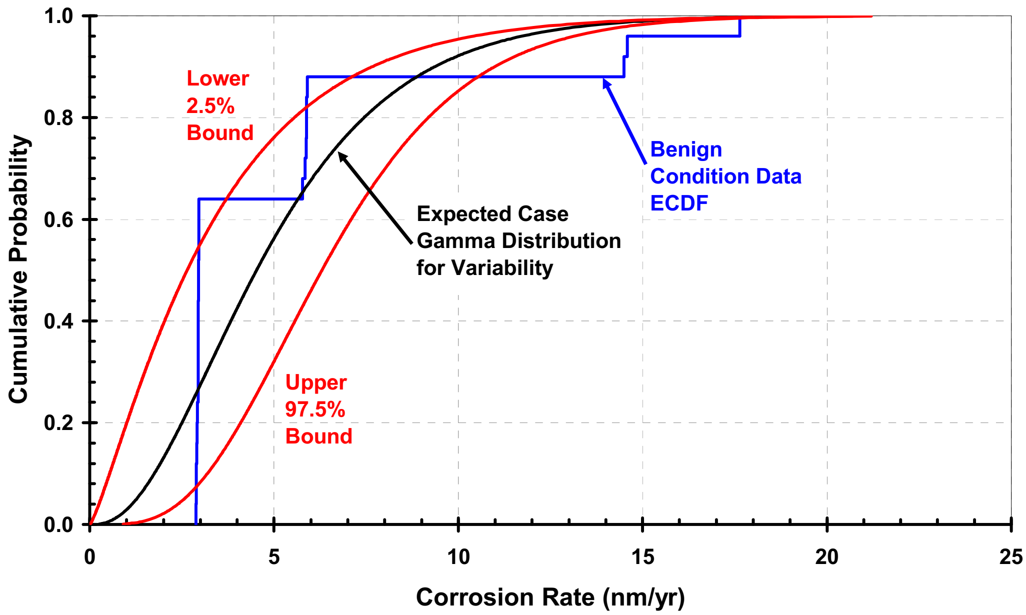
The legends in Figures 6-13[a] to 6-17[a] give the Anderson-Darling statistic and the p-value associated with the goodness-of-fit test for the respective probability models. These values are summarized in Table 6-6[a]. In general, a p-value of 0.05 or greater indicates a good fit of a model to the data.

Table 6-6[a]. Summary of Minitab Fitting Statistics for Benign Environmental Condition Data

Probability Model	Anderson-Darling Statistic	p-value
Normal	4.338	< 0.005
Lognormal	3.447	< 0.005
Gamma	3.744	< 0.005
Weibull	3.529	< 0.010
Exponential	3.987	< 0.003

Source: Output DTN SN0705DSGCANAL.001.

The small p-values presented in Table 6-6[a] indicate that, in the strictest sense, none of these models is entirely representative for these data. Figure 6-18[a] shows the ECDF for the benign condition corrosion data compared to the CDFs for gamma, Weibull, and lognormal distributions. While none of these three models fits this type of clustered data well, each provides a qualitatively similar level of approximation.



Source: Output DTN: SN0704PADSGCMT.001, file: *DS GC Model Analysis_benign condition.xls*.

Figure 6-19[a]. Drip Shield General Corrosion Model for Benign Environmental Conditions along with the ECDF for the Experimental Data Used for the Model Analysis

6.1.8[a] Use of Constant General Corrosion Rates over Repository Time

The titanium drip shield general corrosion model uses two constant (temperature-independent) corrosion rates based upon multi-year weight-loss measurements. The model implementation in TSPA uses those corrosion rates for the entire drip shield lifetime (tens of thousands of years). While perhaps counterintuitive, this is a conservative extrapolation without any detrimental increase in uncertainty with time for reasons to be discussed here.

The inherent nature of passive film growth kinetics is typically inversely proportional with time, following a log-linear decrease with time (Jones 1996 [DIRS 169906], Section 4.5.2). As this passive film increases in thickness, the passive corrosion rate, as measured by passive current density, also decreases with time (Jones 1996 [DIRS 169906], Figure 4.21). Eventually the (relatively constant) dissolution processes occurring on the passive film itself will equal the (decreasing) passive film formation rate, and steady state will be obtained. Decreasing corrosion rates of titanium in oxidizing environments are supported by both project data results (Figure 27 in the parent report) and literature results (Figure 7-1[a]).

Other than change of environmental conditions, there is no known way for this process to reverse, i.e., the passive corrosion rate cannot spontaneously increase at some future time. A rockfall event can and will physically scratch the drip shield, exposing fresh titanium metal that will immediately form a new oxide layer, returning to the model growth/corrosion rate within a couple of years at the most. The largest uncertainty lies in the lower limit of what the titanium passive film corrosion rate might truly be as the current model is extrapolated to long time frames.

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