RAI Volume 3, Chapter 2.2.1.2.1, Third Set, Number 1, Supplemental:

Provide a technical basis for exclusion of FEP 1.1.03.01.0A, Error in Waste Emplacement, that is consistent with a screening decision of low consequence. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

Basis: In SAR Table 2.2-5 the FEP 1.1.03.01.0A is classified as excluded based on low consequence. Table 2.2-5 refers to SNL (2008) for further discussion of the technical bases for screening decision. The document SNL (2008, p. 6-39) states that FEP 1.1.03.01.0A is excluded by regulation. The version ERD 01 of the SNL (2008) corrects the screening decision as excluded on the basis of low consequence (in consistency with SAR Table 2.2-5). However, the screening argument was not updated to address consequence of errors in waste emplacement.

1. RESPONSE

The exclusion justification for FEP 1.1.03.01.0A, Error in Waste Emplacement, states the possible types of waste emplacement errors as: (1) emplacement of waste packages closer to each other than in the design specification and (2) emplacement of a waste package so that it straddles a known Quaternary fault with the potential for significant displacement (SNL 2008). In general, waste package emplacement errors can be defined as departures from specified requirements. Examples could include: not emplacing waste packages in conformance with the emplacement drift loading plan, emplacing waste packages too far apart, emplacing a waste package outside the waste package end points in a drift, and emplacing waste packages on faults encountered during excavation. Specifically with respect to postclosure repository performance, the relevant requirements for waste emplacement are summarized by the parameters that require controls to ensure the postclosure performance assessment analytical bases are established and maintained during design, construction, procurement, operations, and closure. Those postclosure control parameters relevant to waste package emplacement are identified and described in Table 1, which is adapted from SAR Tables 1.3.3-8 and 1.3.4-5, and Table 2, which is adapted from SAR Table 1.3.4-5. Each control parameter has either a control parameter value or range of values or a constraint relevant to the as-emplaced design configuration or emplacement operations. Some of the controls are related to controlled interface parameters. These represent parameters that are controlled through the configuration management system presented in SAR Chapter 5. Some control parameters are related to procedural safety controls, which apply when there are specific and unique operator, inspector, or verification activities required by the control parameter that are not addressed by standard administrative controls such as those management systems identified in SAR Chapter 5. Both the procedural safety controls and design configuration are controlled by management systems identified in SAR Chapter 5.

Effective implementation of these management systems will ensure that potentially significant waste package emplacement errors will be detected, evaluated, and mitigated as necessary during the operational period. Therefore, it is the potential consequences of undetected and unmitigated waste emplacement errors that must be considered further. Errors resulting in damage to waste packages, errors in emplacement spacing, and possible emplacement on faults are discussed below.

The potential that a waste package is subjected to handling damage during emplacement without the damage being detected is considered as part of included FEP 2.1.03.08.0A (Early Failure of Waste Packages). Handling damage is defined as any visible gouging or denting of the waste package surface that may jeopardize the performance of the Alloy 22 outer corrosion barrier. As described in SAR Section 2.3.6.6.3.2, the analysis considered possible damage between receipt and final inspection at the time of emplacement, including but not limited to possible damage associated with tilting to upright position, downending, and placement on the pallet. The mean and median probabilities of improper waste package handling causing damage and not being detected are 9.71×10^{-7} and 2.86×10^{-7} per waste package, respectively (SNL 2007b, Table 6-8). This probability distribution was considered along with probability distributions for improper base material selection, improper heat treatment of the outer shell and lid, improper weld filler material, and improper low-plasticity burnishing, to develop an overall distribution for the probability of early waste package failure per waste package, which is characterized by a lognormal distribution with a mean of 1.13×10^{-4} and an error factor of 8.17 (SNL 2007a, Section 6.5.1). For the repository inventory of approximately 11,600 waste packages, the mean number of early-failed waste packages is slightly more than one. While the damage mechanisms leading to early failure are expected to result in enhanced probability of stress corrosion cracking, the waste packages are treated as completely failed at the time of repository closure.

The potential that waste package emplacement errors could result in a violation of thermal line loading requirements per the approved emplacement drift loading plan (SAR Section 1.3.1.2.5) is also relevant to this FEP. Thermal management of the waste packages is required to maintain the integrity of engineered barrier components and to ensure that natural or altered conditions of the host rock conform to conditions analyzed for long-term repository performance (see SAR Section 2.3.5.4.3). The emplacement of waste packages is controlled through a loading plan that determines waste package loading sequences and interfaces with the repository operations to maintain temperatures within prescribed limits during the preclosure period. In the preclosure period, these operations establish the initial conditions for closure so that, upon termination of ventilation at closure, the thermal loading in the repository results in temperature transients during the thermal pulse that are consistent with the conditions analyzed in the repository performance assessment.

The probability of waste package misplacement and the probability that such misplacement may result in violation of the thermal limits for the repository have been calculated. The probability associated with placing a waste package in the wrong location is 4.0×10^{-6} per demand. The probability of placing a waste package in the right location, but with the wrong thermal load is 2.6×10^{-5} per demand. The combined probability of either placing a waste package in the wrong location, or emplacing with the wrong thermal load, is:

$$4.0 \times 10^{-6} + 2.6 \times 10^{-5} = 3.0 \times 10^{-5}$$

For the repository inventory of approximately 11,600 waste packages, the mean number of misplaced waste packages is considerably less than one. A misplaced waste package does not affect the performance of adjacent waste packages. The possible consequences of errors in waste emplacement spacing are therefore bounded by the already low consequences of the waste package early failure modeling case included in the performance assessment (SAR Figure 2.4-18 and SAR Figure 2.4-35), which considers consequences of failures due to undetected manufacturing defects and handling damage that are assumed conservatively to fully compromise the flawed package.

Table 1. Summary of Conformance of Subsurface Facility Design to Postclosure Control Parameters Relevant to Waste Package Emplacement Spacing

Postclosure Control Parameter Number and Title	Postclosure Control Parameter Value, Range of Values or Constraints	Design Criteria/Configuration	Postclosure Procedural Safety Control
02-01, As-Emplaced Waste Configuration (Controlled Interface Parameter);	The configuration for the emplaced waste packages shall be controlled through the configuration management system (Section 5).	The process for emplacing the waste packages and maintaining the configuration of their emplacement are described in Section 1.3.4.8.2. This process includes the operational and monitoring controls related to the in-drift positioning of the waste packages. Design considerations for emplacement of sequences of waste packages in a drift for thermal management purposes are described in Section 1.3.1.2.5.	NA
03-21 Waste package handling	The waste package shall be handled in a controlled manner during fabrication, handling, transport, storage, emplacement, installation, operation, and closure activities to minimize damage; surface contamination; and exposure to adverse substances.	NA (Background information: Criteria and design considerations for safe handling of the waste package from the surface facilities to the emplacement areas underground are described in Section 1.3.3.5. The waste package, when being transported in the TEV, rests on its pallet, and the surfaces of the waste package do not contact any other surfaces other than the pallet supports. Speed of travel of the TEV is designed and controlled to a slow rate and the pallet is restrained inside the shielded compartment so that its load is prevented from moving and incurring).	The waste package emplacement procedures will include handling requirements to limit activities that could physically degrade, contaminate and limit exposure of adverse substances to the surface of the waste package. Inspection procedures will be developed to identify damage, surface contamination or exposure to adverse substances at the time of waste package emplacement. The TEV will have adequate means to inspect visible waste package surfaces. The operational and monitoring controls applicable to the TEV when handling the waste package on its pallet from the surface facilities to the underground turnouts are described in Section 1.3.3.5.2.3. Travel and movements of the TEV are controlled, and documented by remote operators from the CCCF.

Table 1. Summary of Conformance of Subsurface Facility Design to Postclosure Control Parameters Relevant to Waste Package Emplacement Spacing (continued)

Postclosure Control Parameter Number and Title	Postclosure Control Parameter Value, Range of Values or Constraints	Design Criteria/Configuration	Postclosure Procedural Safety Control
03-22 Waste package handling and emplacement	Waste package handling and emplacement activities shall be monitored through equipment with resolution capable of detecting waste package damage. An operator and an independent checker shall perform the operations.	NA (Background Information: In order to minimize damage, the pallet carrying the waste package is restrained inside the shielded compartment of the TEV and there is no movement or handling of the waste package inside the TEV when in transit. Handling of the pallet holding the waste package during emplacement is limited to lowering of the loaded pallet on to the emplacement).	The operational and monitoring controls on the waste package emplacement system are presented in Sections 1.3.4.8.2.3 and 1.3.4.8.2.4, respectively. Procedures will be used to control the inspection by an operator and independent checker of the handling of the loaded pallet during emplacement. This inspection will be conducted remotely from the CCCF, using high-resolution cameras and by monitoring and verification of operational steps. The TEV operational steps are described in Sections 1.3.3.5.2.1 and 1.3.4.8.2.2.
05-01, Waste Package Handling and Emplacement	Waste package handling and emplacement activities shall be monitored through appropriate equipment. An operator and an independent inspector shall verify proper waste package installation.	NA (Background information: The operational and monitoring controls on the waste package emplacement system are presented in Sections 1.3.4.8.2.3 and 1.3.4.8.2.4, respectively. Design of monitoring equipment, instrumentation, and sensors that are part of the transport and emplacement vehicle and that are needed to satisfy this requirement is described in Section 1.3.4.8.2.5.)	The waste package handling and emplacement procedures will be developed and include requirements for monitoring during handling. Verification of waste package handling will be done by an operator from the remote CCCF location with the use of high-resolution cameras and electronic sensors. An independent inspector will verify the adequacy of the emplacement.
05-02, Waste Package Spacing	Adjacent waste packages in a given emplacement drift shall be emplaced 0.1 m (nominal) apart, from the top surface of the upper sleeve of one waste package to the bottom surface of the lower sleeve of the adjacent waste package.	NA (Background information: The design of the TEV is to emplace a waste package at a nominal spacing of 10 cm from a previously emplaced waste package as presented in Section 1.3.4.8.2.1.)	The waste package emplacement procedures will be developed and include emplacement limitations to be met. Monitoring equipment, instrumentation, and sensors that are part of the TEV are used to control this operation. The controls and instrumentation needed to satisfy this requirement are described in Section 1.3.4.8.2.5.

Source: Adapted verbatim from SAR Tables 1.3.3-8 and 1.3.4-5.

The postclosure control parameter relevant to waste package emplacement on a Quaternary fault with potential for significant displacement is identified and described in Table 2, which is adapted from SAR Table 1.3.4-5.

Table 2. Summary of Conformance of Subsurface Facility Design to Postclosure Control Parameters Relevant to Waste Package Emplacement on a Fault

Postclosure Control Parameter Number and Title	Postclosure Control Parameter Value, Range of Values or Constraints	Design Criteria/ Configuration	Postclosure Procedural Safety Control
01-05 Repository Standoff from Quaternary Fault*	The emplacement drifts shall be located a minimum of 60 m from a Quaternary fault with potential for significant displacement*	The repository design has located the emplacement openings with a minimum standoff of 60 m from a Quaternary Fault with potential for significant displacement* (Section 1.3.2.2.1).	NA

Source: Adapted verbatim from SAR Table 1.3.4-5 (except for * note).

* There are two known Quaternary faults with potential for significant displacement in the immediate vicinity of the repository area: the Solitario Canyon Fault and the Bow Ridge Fault (SAR Section.3.4.2.2).

Quaternary faults other than the Solitario Canyon Fault and the Bow Ridge Fault exist within the general area of the repository block (as shown in SAR Figure 1.1-73). Some Quaternary faults are expected to be encountered during construction (e.g., SAR Figure 1.1-61), some of which may not be known at present. For postclosure, the potential for fault displacement (offset) along unknown faults/splays and its potential impact on waste packages are explicitly included in the TSPA as described in included FEP 1.2.02.03.0A (Fault Displacement Damages EBS Components). As discussed in SAR Section 2.3.4.5.5.1, postclosure fault displacement could impact key Engineered Barrier System (EBS) components by causing mechanical damage to the waste packages and drip shields. Potential faulting within the emplacement drifts generally results in small displacements along the faults. With the exception of the Solitario Canyon Fault and the Ghost Dance Fault, which are immediately outside the western and eastern boundaries of the emplacement drifts, a fault displacement of greater than 0.1 cm is associated with a mean annual exceedance frequency of less than 10^{-5} per year (SNL 2007a, Section 6.11). In addition, only the small number of waste packages located directly above faults is subject to damage from fault displacement. The small contribution to mean annual dose from emplacement of waste packages on faults is calculated in the seismic fault displacement modeling case in the performance assessment (SAR, Section 2.4.1.2.4), and need not be further considered in this FEP exclusion justification.

CONCLUSIONS

Proposed 10 CFR 63.114(e) provides that “Specific features, events, and processes must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.” Conversely, a FEP may be excluded from the TSPA if radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would not be significantly changed by its omission.

In addition to the operational requirements and safety controls to avoid waste emplacement errors described above, postclosure control parameters will be subject to quality assurance controls applied in accordance with 10 CFR 63.142, as discussed in the exclusion justification for FEP 1.1.08.00.0A, Inadequate Quality Control and Deviations from Design. Through the application of the controls, the analytical bases of the performance assessment will be established and maintained during the preclosure period. As discussed in SAR Section 1.9.2, the use of appropriate management systems will ensure that postclosure control parameters will be maintained during design, construction, procurement, operations, and closure. Effective implementation of these controls and management systems will ensure that potentially significant waste package emplacement errors will be detected, evaluated, and mitigated as necessary during the operational period. There are no reasonably foreseeable emplacement errors that might remain undetected and unmitigated at the time of closure that would result in fully compromising a waste package, and the consequences of undetected and unmitigated emplacement errors are therefore bounded by the already low consequences of the waste package early failure modeling case included in the performance assessment (SAR Figure 2.4-18 and SAR Figure 2.4-35), which considers consequences of failures due to undetected manufacturing defects that are assumed conservatively to fully compromise the flawed package. As a result, the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would not be significantly changed by the exclusion of FEP 1.1.03.01.0A.

2. COMMITTMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

SNL (Sandia National Laboratories) 2007a. *Seismic Consequence Abstraction.* MDL-WIS-PA-000003 REV 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070928.0011.

SNL 2007b. *Analysis of Mechanisms for Early Waste Package/Drip Shield Failure.* ANL-EBS-MD-000076 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070629.0002; DOC.20071003.0015; LLR.20080311.0094; DOC.20080918.0002; DOC.20090204.0003.

SNL 2008. *Features, Events, and Processes for the Total System Performance Assessment: Analyses*. ANL-WIS-MD-000027 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080307.0003; DOC.20080407.0009; LLR.20080522.0166.