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Page: 1 of 46

2. SDD Title
Emplacement Drift System Description Document

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1. SDD Title
Emplacement Drift System Description Document

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3. Revision	4. Description of Revision
00	Initial Issue. This document was previously issued using document identifier BCA000000-01717-1705-00019, and system name "Ex-Container System." This document supersedes the previous issuance. This document is a complete rewrite of the superseded document, driven largely by the use of an alternate source of regulatory requirements, the implementation of the License Application Design Selection effort, and the use of a new document development procedure.

DISCLAIMER

CONTENTS

Page

TABLES

Page

SUMMARY

The Emplacement Drift System is part of the Engineered Barrier System and provides the interface between the various waste package (WP) systems and the Ground Control System. In conjunction with the various WPs, the Emplacement Drift System limits the release and transport of radionuclides from the WP to the Natural Barrier following waste emplacement. Collectively, the Emplacement Drift System consists of the structural support hardware (emplacement drift invert and WP emplacement pallet) and any performance enhancing barriers (backfill, drip shields, and invert ballast) installed or placed in the emplacement drifts. The Emplacement Drift System is entirely located within the emplacement drifts in the subsurface portion of the Monitored Geologic Repository (MGR); specifically, it is physically bounded by the Subsurface Facility System, the Ground Support System, and the Natural Barrier. The Emplacement Drift System supports the key MGR functions of limiting radionuclide release to the Natural Barrier, minimizing the likelihood of a criticality external to the WPs, limiting natural and induced environmental effects, and providing WP support. The Emplacement Drift System limits radionuclide release to the Natural Barrier by controlling the movement of radionuclides within the emplacement drift and to the Natural Barrier, and by limiting water contact with the WPs. The Emplacement Drift System provides physical support and barriers for emplaced WPs that reduce water contact.

The Emplacement Drift WP spacing supports the thermal loading performance by complimenting drift layout and orientation as described in the system description document for the Subsurface Facility System. The Emplacement Drift System supports the WP and also provides an environment that aids in enhancing WP confinement performance.

As part of the Engineered Barrier System, the Emplacement Drift System interfaces with the WP systems. The Emplacement Drift System also interfaces with the Natural Barrier, Subsurface Facility System, and Ground Control System for the space and location of emplaced WPs, for the controlled release of radionuclides, and for controlling the heat, chemical, and physical effects that interact between these systems. The Emplacement Drift System interfaces with the Subsurface Ventilation System for preclosure heat removal from WPs. The Emplacement Drift System interfaces with the Waste Emplacement/Retrieval System and the Performance Confirmation Emplacement Drift Monitoring System for equipment clearance for the emplacement, retrieval, and monitoring of waste. The Emplacement Drift Systems' drip shields and backfill material interface with the WPs in the emplacement drift and with the Backfill Emplacement System for drip shield and backfill placement within the drift.

QUALITY ASSURANCE

The quality assurance (QA) program applies to the development of this document. The "SDD Development/Maintenance (Q SDDs) (WP# 16012126M5)" activity evaluation has determined the development of this document to be subject to "Quality Assurance Requirements and Description" requirements. This document was developed in accordance with AP-3.11Q, "Technical Reports."

1. FUNCTIONS AND DESIGN CRITERIA

The functions and design criteria for the system are identified in the following sections. Throughout this document the term "system" shall be used to indicate the Emplacement Drift System. The system architecture and classification are provided in Appendix B.

1.1 SYSTEM FUNCTIONS

1.1.1 The system contributes to the isolation of high-level waste from the Natural Barrier.

1.1.2 The system limits the likelihood of a self-sustainable fission reaction (external criticality) in both the near field and the far field.

1.1.3 The system limits the effect of rockfall on the WP.

1.1.4 The system provides a physical WP support for WPs within emplacement drifts.

1.1.5 The system influences the environment within emplacement drifts to protect WPs and the Natural Barrier.

1.1.6 The system limits the movement of radionuclides to the Natural Barrier upon WP breach.

1.1.7 The system limits microbial activity.

1.1.8 The system allows periodic inspection, testing, and maintenance of structures, systems, and components (SSCs) prior to permanent closure.

1.2 SYSTEM DESIGN CRITERIA

This section presents the design criteria for the system. Each criterion in this section has a corresponding Criterion Basis Statement in Appendix A of Volume I that describes the need for the criterion as well as a basis for the performance parameters imposed by the criterion. Each criterion in this section also contains bracketed traces indicating traceability, as applicable, to the functions (F) in Section 1.1, the "Monitored Geologic Repository Requirements Document" (MGR RD) (as modified by input transmittal "Preliminary Draft Requirements from the Monitored Geologic Repository Requirements Document" [TBV-3855]), and "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada." In anticipation of the interim guidance being promulgated as a Code of Federal Regulations, it will be referred to as "10 CFR 63" in this system description document. For the applicable version of the codes, standards, and regulatory documents imposed on the design of this system, refer to Appendix E.

1.2.1 System Performance Criteria

1.2.1.1 The system shall be designed such that when collectively assessed with the waste packages (WPs) and the natural barrier the expected annual dose to the average member of the critical group[1] shall not exceed 0.25 mSv (25 mrem) total effective dose equivalent at any time during the first 10,000 years after permanent closure, as a result of radioactive materials released from the geologic repository.

[F 1.1.1][MGR RD 3.1.C, 3.2.P][10 CFR 63.113(b)]

1.2.1.2 The system shall be designed to be capable of accommodating the following inventory of nuclear materials: 86,700 metric tons initial heavy metal of commercial spent nuclear fuel (SNF), 2,502 metric tons heavy metal of U. S. Department of Energy owned SNF (which includes 65 metric tons heavy metal naval SNF), 19,333 defense high-level radioactive waste canisters (which includes approximately 17 metric tons of immobilized plutonium waste forms), and 302 commercial high-level radioactive waste canisters.

[F 1.1.1][MGR RD 3.1.C, 3.2.A, 3.2.B, 3.2.P][10 CFR 63.113(b)]

1.2.1.3 The system shall limit the emplacement drift wall temperature to 96 degrees C or less during the preclosure period.

[F 1.1.3, 1.1.5][MGR RD 3.1.C, 3.2.H, 3.2.M][10 CFR 63.111(e)(1)]

1.2.1.4 If the MGR is closed between 50 and 125 years after emplacement of the initial waste package, the system shall limit the temperature of 50 percent of the pillar width to 96 degrees C or less during the postclosure period.

[F 1.1.5][MGR RD 3.1.C, 3.2.H, 3.2.N, 3.2.P][10 CFR 63.113(b)]

1.2.1.5 If the MGR is closed at 125 years after emplacement of the initial waste package or later, the system shall limit the temperature of the emplacement drift walls to 96 degrees C or less during the postclosure period.

[F 1.1.5][MGR RD 3.1.C, 3.2.H, 3.2.N, 3.2.P][10 CFR 63.113(b)]

1.2.1.6 The system shall be designed for line loading of WPs within individual emplacement drifts defined as TBD-3882 kW/m of emplacement drift averaged over TBD-3882 m of emplacement drift.

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

[1] The critical group is defined in 10 CFR 63.115

1.2.1.7 The system shall maintain a 15-m standoff distance between emplaced WPs and Type I faults, and a 5-m standoff distance between emplaced WPs and splays associated with Type I faults.

[F 1.1.5][MGR RD 3.1.C, 3.2.P][10 CFR 63.113(b)]

1.2.1.8 For 10,000 years, the system shall allow free-liquid-phase water, from events identified in Table I-1, to drain out of emplacement drifts, via the emplacement drift floor.

Table I-1. Emplacement Drift Drainage Flow

Event Characteristic	Event Value
Water Volume	2 cubic meters per meter of emplacement drift (TBV-284)
Event Duration	1 week (TBV-284)
Event Frequency	1 event per year (TBV-284)

[F 1.1.5][MGR RD 3.1.C, 3.2.P][10 CFR 63.113(b)]

1.2.1.9 The invert structural members shall be composed of carbon steel.

[F 1.1.4, 1.1.5][MGR RD 3.1.C, 3.2.P][10 CFR 63.113(b)]

1.2.1.10 The invert ballast shall maintain the pH of water within the ballast to between 6.7 (TBV-3881) and 10.2 (TBV-3881) for 10,000 years.

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.11 The invert ballast material shall be granular.

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.12 The drip shield shall have an operating life of 10,000 years.

[F 1.1.1, 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.13 The drip shield shall divert water dripping into the emplacement drift around the WP and to the drift floor.

[F 1.1.1, 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.14 The drip shield and backfill (as a collective unit) shall be designed to withstand a 13 MT (28,665 lb) (TBV-245) rock (spherical geometry assumed) falling onto the top of the backfill without rupturing the drip shield or parting between the individual drip shield units.

[F 1.1.1, 1.1.3, 1.1.5][MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P, 3.3.I][10 CFR 63.113(a), 63.113(b)]

1.2.1.15 The drip shield and backfill (as a collective unit) shall be designed to withstand a 13 MT (28,665 lb) (TBV-245) rock (spherical geometry assumed) falling onto the top of the backfill without the drip shield contacting a WP.

[F 1.1.1, 1.1.3, 1.1.5][MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P, 3.3.I][10 CFR 63.113(a), 63.113(b)]

1.2.1.16 The drip shield shall be designed to withstand a Category 2 (TBV-1246) design basis earthquake without rupturing or parting between individual drip shield units.

[F 1.1.1, 1.1.5][MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.17 The drip shield shall be designed to withstand a Category 2 (TBV-1246) design basis earthquake without contacting waste packages.

[F 1.1.1, 1.1.5][MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.18 The drip shield materials shall be Grade 7 Titanium, a minimum of 15-mm thick at the time of emplacement.

[F 1.1.1, 1.1.3, 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.1.19 The backfill shall maintain the pH of water within the backfill to between 6.7 (TBV-3881) and 10.2 (TBV-3881) for 10,000 years.

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P, 3.3.I][10 CFR 63.113(a), 63.113(b)]

1.2.1.20 The invert and WP emplacement pallet shall maintain the WPs' nominal emplacement position for a minimum of 300 years.

[F 1.1.4][MGR RD 3.1.C, 3.1.G, 3.2.H][10 CFR 63.111(e)(1)]

1.2.1.21 The invert and WP emplacement pallet shall maintain the WPs' nominal horizontal emplacement position for 10,000 years after closure.

[F 1.1.4][MGR RD 3.1.C, 3.2.P][10 CFR 63.113(b)]

1.2.1.22 The invert and WP emplacement pallet shall provide structural support for the SSCs as identified in Table I-2.

Table I-2. SSCs Supported by Invert and Pallet

SSC
Waste Packages
Drip Shields (invert only)
Backfill (invert only)
Waste Emplacement/Retrieval System mobile equipment (SSCs entering emplacement drifts, invert only)
Backfill Emplacement System mobile equipment (SSCs entering emplacement drifts, invert only)
Performance Confirmation Emplacement Drift Monitoring System mobile equipment (SSCs entering emplacement drifts invert only)
Subsurface Emplacement Transportation System (SSCs within emplacement drifts invert only)
Subsurface Excavation System (SSCs placing inverts, as necessary, invert only)

[F 1.1.4][MGR RD 3.1.C, 3.1.G, 3.2.C][10 CFR 63.111(e)(1)]

1.2.2 Safety Criteria

1.2.2.1 Nuclear Safety Criteria

1.2.2.1.1 The system shall permit all emplacement operations to be conducted such that WPs are lifted no higher than 2.4 m (TBV-245) above the invert.

[F 1.1.4]

1.2.2.1.2 For 10,000 years after permanent closure, criticality events due to fissionable material released from a breached WP shall not increase the total radionuclide inventory of the MGR by more than 1 percent. The percentage radionuclide inventory increase for the MGR shall be measured by the sum of the products of probability of criticality occurrence, multiplied by the radionuclide inventory increment (measured in curies) due to that criticality, divided by the radionuclide inventory of the MGR, with the sum taken over time and any other parameters that characterize the occurrence of criticality. Both the radionuclide inventory and the increment due to criticality shall be evaluated at the instant 1,000 years following the criticality shutdown. (TBV-096)

[F 1.1.2][MGR RD 3.1.C, 3.2.P][10 CFR 63.113(b)]

1.2.2.2 Non-nuclear Safety Criteria

1.2.2.2.1 The selection of invert ballast and backfill materials shall consider the known health and safety hazards of the materials.

[F 1.1.4][MGR RD 3.3.A]

1.2.3 System Environment Criteria

1.2.3.1 The system shall limit the emplacement drift wall temperature to less than 200 degrees C (TBV-287) during the postclosure period.

[F 1.1.3, 1.1.5][MGR RD 3.1.C, 3.2.C, 3.2.P][10 CFR 63.113(b)]

1.2.3.2 The system shall limit the temperature of zeolite layers located 170 m (TBV-286) or further beneath the emplacement area horizon to less than 90 degrees C (TBV-286).

[F 1.1.5][MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.3.3 The system shall limit the change in temperature, at 45 cm below the soil surface, to 2 degrees C above what the established naturally occurring pre-emplacement average annual ground surface temperature is in the area directly above the emplaced WPs and extending 500 m beyond the edge of the emplaced WPs. (TBV-617)

[F 1.1.5][MGR RD 3.1.C, 3.2.F, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.3.4 The system shall limit the temperature of the PTn geologic unit to less than 96 degrees C (TBV-322).

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.3.5 The system shall be designed such that the differential uplift measured between the top of the TSw1 thermomechanical unit above the repository and the TSw1 thermomechanical unit at the preclosure controlled area boundary is less than 1 m (TBV-618).

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.3.6 The system shall be designed such that the differential uplift measured between the ground surface above the repository and the ground surface at the preclosure controlled area boundary is less than 0.5 cm/year (TBV-618).

[F 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.3.7 The portions of the system designed to withstand a Frequency Category 2 design basis earthquake shall be designed using the input parameters defined in Tables I-3 through I-6. (TBV-273)

Table I-3. Parameters for the Vibratory Ground Motion Design Basis Earthquake–Subsurface Environment–Repository Interface (Underground) Design Spectral Accelerations for Design Earthquake Scaled to 5–10 Hz Frequency Range

Response Frequency (Hz)	Horizontal Motion (g)	Vertical Motion (g)
	Frequency Category 2 (10,000 Year Recurrence)	Frequency Category 2 (10,000 Year Recurrence)
0.3	0.0720 (TBV)	0.0378 (TBV)
0.5	0.125 (TBV)	0.0688 (TBV)
1	0.206 (TBV)	0.130 (TBV)
2	0.458 (TBV)	0.180 (TBV)
5	0.717 (TBV)	0.435 (TBV)
10	0.765 (TBV)	0.620 (TBV)
20	0.681 (TBV)	0.613 (TBV)
100	0.391 (TBV)	0.288 (TBV)

Table I-4. Parameters for the Vibratory Ground Motion Design Basis Earthquake–Subsurface Environment–Repository Interface (Underground) Design Spectral Accelerations for Design Earthquake Scaled to 1–2 Hz Frequency Range

Response Frequency (Hz)	Horizontal Motion (g)	Vertical Motion (g)
	Frequency Category 2 (10,000 Year Recurrence)	Frequency Category 2 (10,000 Year Recurrence)
0.3	0.186 (TBV)	0.101 (TBV)
0.5	0.252 (TBV)	0.149 (TBV)
1	0.286 (TBV)	0.206 (TBV)
2	0.465 (TBV)	0.212 (TBV)
5	0.471 (TBV)	0.309 (TBV)
10	0.374 (TBV)	0.295 (TBV)
20	0.302 (TBV)	0.244 (TBV)
100	0.231 (TBV)	0.156 (TBV)

Table I-5. Parameters for the Vibratory Ground Motion Design Basis Earthquake–Subsurface Environment–Repository Interface (Underground) Design Peak Velocity for Design Earthquake Scaled to 5–10 Hz and 1–2 Hz Frequency Ranges

Design Earthquake Frequency (Hz)	Horizontal Motion (cm/sec)	Vertical Motion (cm/sec)
	Frequency Category 2 (10,000 Year Recurrence)	Frequency Category 2 (10,000 Year Recurrence)
5 – 10	33.63 (TBV)	17.10 (TBV)
1 – 2	41.84 (TBV)	22.38 (TBV)

Table I-6. Parameters for the Ground Displacement Design Basis Earthquake–Surface and Subsurface Environment

Ground Displacement Design Basis Earthquake	Fault Displacement	Comment
Frequency Category 2 (100,000 Year Recurrence)	Less than 1 cm (TBV)	Considered insignificant with respect to repository design except for block-bounding fault displacements: Bow Ridge 12 cm (TBV) Solitario Canyon 30 cm (TBV)

[F 1.1.3, 1.1.5][MGR RD 3.1.C, 3.3.A][10 CFR 63.112(e)(8)]

1.2.3.8 Values representing the initial condition of the Natural Barrier shall be obtained from the Technical Data Management System.

[F 1.1.5][MGR RD 3.3.A]

1.2.4 System Interfacing Criteria

1.2.4.1 The system shall be designed in accordance with the interface agreements defined in "Interface Control Document for Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems for Mechanical and Envelope Interfaces."

[F 1.1.4][MGR RD 3.3.A]

1.2.4.2 The system shall provide physical supports for a maximum of 11,000 WPs.

[F 1.1.4][MGR RD 3.3.A]

1.2.4.3 The system shall accommodate a WP maximum surface dose rate of TBD-3764 for an intact WP at the time of emplacement.

[F 1.1.5][MGR RD 3.3.A]

1.2.4.4 The system shall accommodate a maximum WP thermal output of 11.8 kW at the time of emplacement.

[F 1.1.5][MGR RD 3.3.A]

1.2.4.5 The system shall accommodate removal of 70 percent of the heat generated by WPs by the Subsurface Ventilation System during the preclosure period.

[F 1.1.5][MGR RD 3.3.A]

1.2.4.6 The system shall provide for horizontal in-drift emplacement of WP Emplacement Pallets holding WPs within emplacement drifts by the Waste Emplacement/Retrieval System.

[F 1.1.4][MGR RD 3.3.A]

1.2.4.7 The system shall accommodate a minimum spacing of 10 cm between WPs within individual emplacement drifts.

[F 1.1.1, 1.1.4, 1.1.5][MGR RD 3.3.A]

1.2.4.8 The system shall accommodate a nominal spacing of 81 m between individual emplacement drifts.

[F 1.1.1, 1.1.5, 1.1.6][MGR RD 3.3.A]

1.2.4.9 The system shall accommodate a nominal emplacement drift excavated diameter of 5.5 m.

[F 1.1.1, 1.1.5][MGR RD 3.3.A]

1.2.4.10 The system emplacement area shall be entirely within the characterized area, as provided by the Subsurface Facility System.

[F 1.1.1][MGR RD 3.3.A]

1.2.4.11 The system shall accommodate the mobile equipment operating and coupon placement envelopes identified in "Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift."

[F 1.1.8][MGR RD 3.3.A]

1.2.4.12 The materials that contact the surface of the WPs, as emplaced during the preclosure period, shall be the same material as the WP outer surface.

[F 1.1.4, 1.1.5][MGR RD 3.3.A]

1.2.4.13 The system shall accommodate an emplacement drift ground support system composed primarily of carbon steel (steel sets and/or rock bolts and mesh).

[F 1.1.5][MGR RD 3.3.A]

1.2.4.14 The system shall affect the emplacement drift environment such that WP near field environments of Table I-7 are maintained.

Table I-7. WP Near Field Environment

Environment	Range/Value
Temperature	(TBD-234)
Humidity	(TBD-234)
Microbial	10^{14} microbes/year/m of emplacement drift (TBV-3881)
Colloidal	8×10^{-5} (TBV-3881) to 6×10^{-5} mg/ml (TBV-3881)
Water pH	6.7 (TBV-3881) to 10.2 (TBV-3881)
(TBD-234)	(TBD-234)

[F 1.1.5, 1.1.7][MGR RD 3.1.C, 3.2.O, 3.2.P, 3.3.A][10 CFR 63.113(a), 63.113(b)]

1.2.4.15 The system shall accommodate placement of the invert by the Subsurface Excavation System.

[F 1.1.4][MGR RD 3.3.A]

1.2.4.16 The system and all WPs emplaced within the system shall be located at least 200 m below the directly overlying ground surface. (TBV-619)

[MGR RD 3.1.C, 3.2.O, 3.2.P, 3.3.C][10 CFR 63.113(a), 63.113(b)]

1.2.5 Operational Criteria

1.2.5.1 The drip shield shall be designed to achieve a reliability of (TBD-3883) percent during the first 10,000 years after emplacement in an emplacement drift.

[F 1.1.1, 1.1.5][MGR RD 3.1.C, 3.2.O, 3.2.P][10 CFR 63.113(a), 63.113(b)]

1.2.6 Codes and Standards Criteria

1.2.6.1 Design of steel SSCs shall be in accordance with "Manual of Steel Construction Allowable Stress Design" or "Manual of Steel Construction Load and Resistance Factor Design."

[MGR RD 3.1.G]

1.2.6.2 The system shall comply with the applicable assumptions contained in the "Monitored Geologic Repository Project Description Document."

1.3 SUBSYSTEM DESIGN CRITERIA

There are no subsystem design criteria for this system.

1.4 CONFORMANCE VERIFICATION

This Section outlines the methods to be used to verify the conformance of the system with its design criteria.

1.4.1 The methods of conformance verification to be used are:

Analysis. Analysis is the process of accumulating results and conclusions intended to verify that a requirement has been satisfied. Analytical verification of compliance may include compilation and interpretation of results of tests, demonstrations, and examinations of lower-level components of the system. Analysis may also include logical arguments, modeling, calculations, tradeoff studies, reports (design and/or tradeoff), and other relevant information to verify compliance with a requirement, when physical testing of a system is impracticable.

Examination. Examination is the process of conducting careful observation and inspection, without use of special laboratory appliances and procedures, to verify compliance with specified requirements. Examination is a relatively direct method, involving, at most, simple physical manipulation or measurement. It is generally non-destructive and does not necessarily involve operation of the system being evaluated.

Demonstration. Demonstration is the qualitative process of displaying or operating a system or item in or near its operational environment to verify compliance with requirements. It differs from testing in that it is generally a qualitative and direct determination of the performance of a function and is performed without special instrumentation or other special equipment.

Test. Test is the quantitative process whereby data are collected, under controlled conditions, to document the performance of a product with respect to a standard. Manipulation and analysis of data derived from testing is an integral part of the method. Special instrumentation and scientific procedures are commonly employed. A test may be conducted in a laboratory or in the field (in situ).

1.4.2 Table I-8 correlates the criteria with the method to be used to verify compliance with the criteria. In the following table, items marked "N/A" (not applicable) have no verification required. These items are titles or contain explanatory materials. The other columns "Analysis," "Demo," "Exam," and "Test" refer to the verification methods identified in Section 1.4.1.

Table I-8. Conformance Verification

Criterion		Verification Method Code				
Number	Title	N/A	Analysis	Exam	Demo	Test
1.2	SYSTEM DESIGN CRITERIA	X				
1.2.1	System Performance Criteria	X				
1.2.1.1			X			
1.2.1.2			X			
1.2.1.3			X	X		
1.2.1.4			X			
1.2.1.5			X			
1.2.1.6			X	X		
1.2.1.7			X	X		
1.2.1.8			X			X
1.2.1.9			X	X		
1.2.1.10			X			X
1.2.1.11			X	X		
1.2.1.12			X			
1.2.1.13			X			X
1.2.1.14			X			X
1.2.1.15			X			X
1.2.1.16			X			X
1.2.1.17			X			X
1.2.1.18			X	X		
1.2.1.19			X			X
1.2.1.20			X			

Table I-8. Conformance Verification (Continued)

Criterion		Verification Method Code				
Number	Title	N/A	Analysis	Exam	Demo	Test
1.2.1.21			X			
1.2.1.22			X			
1.2.2	Safety Criteria	X				
1.2.2.1	Nuclear Safety Criteria	X				
1.2.2.1.1			X			
1.2.2.1.2			X			
1.2.2.2	Non-nuclear Safety Criteria	X				
1.2.2.2.1			X			
1.2.3	System Environment Criteria	X				
1.2.3.1			X			
1.2.3.2			X			
1.2.3.3			X			
1.2.3.4			X			
1.2.3.5			X			
1.2.3.6			X			
1.2.3.7			X			
1.2.3.8			X			
1.2.4	System Interfacing Criteria	X				
1.2.4.1			X			
1.2.4.2			X			
1.2.4.3			X			
1.2.4.4			X			
1.2.4.5			X			
1.2.4.6			X			
1.2.4.7			X			
1.2.4.8			X			
1.2.4.9			X			
1.2.4.10			X			
1.2.4.11			X			
1.2.4.12				X		
1.2.4.13			X			
1.2.4.14			X			
1.2.4.15			X			
1.2.4.16			X			X
1.2.5	Operational Criteria	X				
1.2.5.1			X			
1.2.6	Codes and Standards Criteria	X				
1.2.6.1			X			
1.2.6.2			X			
1.3	SUBSYSTEM DESIGN CRITERIA	X				

APPENDIX A CRITERION BASIS STATEMENTS

This section presents the criterion basis statements for criteria in Section 1.2 of Volume I. Descriptions of the traces to "Monitored Geologic Repository Requirements Document" (MGR RD) (as modified by input transmittal "Preliminary Draft Requirements from the Monitored Geologic Repository Requirements Document" [TBV-3855]) and "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada" are shown as applicable. In anticipation of the interim guidance being promulgated as a Code of Federal Regulations, it will be referred to as "10 CFR 63" in this system description document.

1.2.1.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the overall level of performance of the repository that this system will be contributing to. This criterion supports MGR RD 3.1.C and 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The performance parameters are taken from 10 CFR 63.113(b) and MGR RD 3.2.P.

1.2.1.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion set the design capacity for the MGR and flows directly from MGR RD 3.2.B. This criterion also envelops the operational cap provided in MGR RD 3.2.A. It should be noted that this design capacity, along with the required drift spacing, WP spacing, and WP capacity, effectively fixes the areal mass loading of the repository. Since the areal mass loading plays a significant role in the overall performance of the repository, this criterion also supports MGR RD 3.1.C and 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The MGR waste design capacity is taken from MGR RD 3.2.B.

1.2.1.3 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to limit the amount of thermal energy placed in the host rock during the preclosure period. Attainment of the WP and Emplacement Drift System thermal goals in the postclosure period depend on a relatively cool host rock at the time of closure.

In addition, this criterion is needed to preserve the option of retrieval. Excessive near field temperatures (temperatures far in excess of the limit specified in this criterion) could result in local rock failure which could have the potential to make retrieval difficult. These same temperatures can also create significant differential stresses between the drift wall rock and the drift wall ground support. This concern is described in detail in "Thermal Loading Study for FY 1996," Section 3.3.

This criterion supports MGR RD 3.1.C, 3.2.H, and 3.2.M; and 10 CFR 63.111(e)(1).

II. Criterion Performance Parameter Basis

The thermal limit value is taken from MGR RD 3.2.M.

1.2.1.4 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to enhance the ability of the repository to shed thermally mobilized water from the repository horizon. A section of host rock between emplacement drifts that is below the water boiling temperature is believed to allow drainage of thermally mobilized water above the repository horizon toward the water table, whereas a host rock entirely above the water boiling temperature would inhibit that flow of water.

This criterion supports MGR RD 3.1.C, 3.2.H, 3.2.N, and 3.2.P; and 10 CFR 63.113(b)

II. Criterion Performance Parameter Basis

The temperature and rock mass limitations are taken from MGR RD 3.2.N. The 50- to 125-year time span is derived from MGR RD 3.2.H.

1.2.1.5 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to reduce the uncertainty associated with the thermo, thermomechanical, and thermochemical changes that can occur to the host rock at temperatures above the boiling point of water.

This criterion supports MGR RD 3.1.C, 3.2.H, and 3.2.P; and 10 CFR 63.113(b)

II. Criterion Performance Parameter Basis

The temperature limitation is taken from MGR RD 3.2.N. The 125 year or later time span is taken from MGR RD 3.2.H.

1.2.1.6 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to produce a more uniform temperature distribution along the axis of an individual emplacement drift. This criterion also has the added benefit of reducing the cost of excavation (the space between WPs is reduced [compared to advanced conceptual and viability assessment designs]; therefore, less emplacement drift length is needed) and emplacement drift construction materials (materials used for ground support, drip shields, backfill, inverts, etc., are reduced proportionally with emplacement drift length reduction).

Line loading of emplacement drifts is driven by "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.8.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

1.2.1.7 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the bounding fault standoff distance (i.e., the distance from any WP to the nearest fault) that protects the WPs from faults and splays (a minor fault that branches off of a larger fault) that represent potential preferential pathways.

This criterion supports MGR RD 3.1.C and 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The minimum distances between WPs and Type I faults and splays are taken from "Subsurface Facility System Description Document," Volume II, Criterion Basis Statement 1.2.1.8.

1.2.1.8 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the system level of performance for draining free-liquid-phase water away from the emplacement drift to contribute to the long-term performance of WPs.

This criterion supports MGR RD 3.1.C and 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The water volume is taken from "Controlled Design Assumptions Document" assumption TDSS 026.

The 10,000-year timeframe is taken from 10 CFR 63.113(b).

1.2.1.9 Criterion Basis Statement

I. Criterion Need Basis

This criterion reduces the uncertainties associated with emplacement drift radionuclide transport, as compared to the other primary invert material candidate (concrete).

This criterion supports MGR RD 3.1.C and 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The invert material selection is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.6.

1.2.1.10 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish one function of the invert ballast, to control the pH of water transporting radionuclides.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The 10,000-year timeframe is taken from 10 CFR 63.113(b), and is corroborated by Table 4 of "Manager System Requirements/System Description Documents." The upper pH bound is obtained from Table 4 of "Manager System Requirements/System Description Documents" (Invert Barrier Requirements). The lower pH bound is obtained from "Groundwater Chemistry Along Flow Paths Between a Proposed Repository Site and the Accessible Environment."

1.2.1.11 Criterion Basis Statement

I. Criterion Need Basis

This criterion reduces the uncertainties associated with emplacement drift radionuclide transport, as compared to the other primary invert material candidate (concrete).

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The invert ballast material selection is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.6.

1.2.1.12 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the drip shield is designed with an operating life long enough to achieve the functions allocated to it.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The 10,000 year timeframe is taken from 10 CFR 63.113(b), and is corroborated by the drip shield operating life in Table 4 of "Manager System Requirements/System Description Documents" (Drip Shield Barrier Requirements). The preliminary results transmitted in the "Manager System Requirements/System Description Documents" input transmittal indicate that additional performance is necessary over and above the 5,000 year life assigned to the drip shield in "Enclosure 2 - Guidelines for Implementation of EDA II," Section 9.0, which was transmitted by "Direction to Transition to Enhanced Design Alternative II" and baselined in "Interim Direction for Enhanced Design Alternative (EDA) II" (ECR No. E1999-0046).

1.2.1.13 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to protect the WP from dripping water during its operating life.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

N/A

1.2.1.14 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish one of the required functions of the drip shield and backfill, to protect the WP from rock fall during its operating life.

This criterion supports MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P, and 3.3.I; and 10 CFR 63.113(a) and 63.113(b).

This criterion is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1 and 6.9g1.

II. Criterion Performance Parameter Basis

The rock fall parameter is taken from Section 8.1 of "TBV-245 Resolution Analysis: Design Basis Block Size Assessment."

1.2.1.15 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish one of the required functions of the drip shield and backfill, to protect the WP from rock fall during its operating life.

This criterion supports MGR RD 3.1.C, 3.1.G, 3.2.O, 3.2.P and 3.3.I; and 10 CFR 63.113(a) and 63.113(b).

This criterion is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1 and 6.9g1.

II. Criterion Performance Parameter Basis

The rock fall parameter is taken from Section 8.1 of "TBV-245 Resolution Analysis: Design Basis Block Size Assessment."

1.2.1.16 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to preserve the functionality of the drip shield after a design basis earthquake during its operating life.

This criterion supports MGR RD 3.1.C, 3.1.G, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

This criterion is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1 and 6.9g1.

II. Criterion Performance Parameter Basis

The specification of a Category 2 design basis earthquake for the drip shield is assumed until this parameter is substantiated. Design for a Category 1 design basis earthquake only (an earthquake of lesser magnitude and higher frequency of occurrence) would not ensure with sufficient confidence that the drip shield would operate properly during the entire operating life.

1.2.1.17 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to preserve the functionality of the drip shield after a design basis earthquake during its operating life.

This criterion supports MGR RD 3.1.C, 3.1.G, 3.2.O, and 3.2.P, and 10 CFR 63.113(a) and 63.113(b).

This criterion is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1 and 6.9g1.

II. Criterion Performance Parameter Basis

The specification of a Category 2 design basis earthquake for the drip shield is assumed until this parameter is substantiated. Design for a Category 1 design basis earthquake only (an earthquake of lesser magnitude and higher frequency of occurrence) would not ensure with sufficient confidence that the drip shield would operate properly during the entire operating life.

1.2.1.18 Criterion Basis Statement

I. Criterion Need Basis

This criterion is intended to ensure that the drip shield design will meet its other performance requirements.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The drip shield material and thickness is obtained from the "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.9.

1.2.1.19 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish one of the functions of backfill, to control the pH of water transporting radionuclides.

This criterion supports MGR RD 3.1.C, 3.2.O, 3.2.P, and 3.3.I; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The 10,000-year timeframe is taken from 10 CFR 63.113(b), and is corroborated by Table 4 of "Manager System Requirements/System Description Documents." The upper pH bound is obtained from Table 4 of "Manager System Requirements/System Description Documents." (Drip Shield Barrier Requirements). The lower pH bound is obtained from "Groundwater Chemistry Along Flow Paths Between a Proposed Repository Site and the Accessible Environment."

1.2.1.20 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the period of time that the system must physically support and maintain the WPs' as-emplaced position within an emplacement drift. The WP must be physically supported and maintained in the emplaced position to ensure that the emplacement, performance monitoring, possible retrieval, and closure activities can be performed with sufficient clearance around the emplaced WPs.

This criterion supports MGR RD 3.1.C, 3.1.G, and 3.2.H; and 10 CFR 63.111(e)(1).

This criterion is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1 and 6.9g1.

II. Criterion Performance Parameter Basis

The time period is derived from MGR RD 3.2.H. The 300-year time period is chosen over the 100-year time period (both are given in the MGR RD) because modifications to the inverts and WP emplacement support hardware after emplacement will be difficult. It is chosen in this document to apply the additional cost in initial design and fabrication of a 300 year design life support rather than to incur a possibly much larger additional cost at some point in the future that could require removal and replacement of all the WPs and their supporting structures. Further, 10 CFR 63.111(e)(1) stipulates that the option of retrievability be preserved until the performance confirmation program is completed, and 10 CFR 63.131(b) requires that the performance confirmation program continue until permanent closure.

1.2.1.21 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to designate the invert and pallet's postclosure WP support performance. Degradation of the invert and WP may occur, but horizontal movement of the WP must be minimized to ensure that the WP does not contact the drip shield. Contact between the drip shield and the WP has the potential to cause adverse reactions between the SSCs. This criterion supports MGR RD 3.1.C, 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The 10,000-year timeframe is taken from 10 CFR 63.113(b).

1.2.1.22 Criterion Basis Statement

I. Criterion Need Basis

This criterion is necessary to ensure that the invert will be able to withstand its anticipated loading and still function to support WPs, performance enhancing barriers, and emplacement and retrieval operations.

This criterion supports MGR RD 3.1.C, 3.1.G, and 3.2.C; and 10 CFR 63.111(e)(1).

This criterion is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1 and 6.9g1.

II. Criterion Performance Parameter Basis

N/A

1.2.2.1.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to implement a portion of the safety strategy as described in "Decision Package Executive Summary, Strategy to Mitigate Preclosure Offsite Exposure," Description V of Options 1 and 2. The executive summary is an attachment to "Strategy to Mitigate Preclosure Offsite Exposure." A portion of that safety strategy is to not lift the WP above its design basis height. Lifts above the design basis drop height could result in a waste package breach and subsequent exposure if dropped. This criterion will ensure that the emplacement hardware, primarily the WP pedestal, is not designed such that emplacement equipment is forced to lift the WP higher than its design basis drop height.

II. Criterion Performance Parameter Basis

The lift height value is taken from "Waste Package Design Basis Events," Table 8-1. Implicit in the value identified is the concept that WPs will be emplaced in a horizontal position, which is consistent with the current design. In addition, the lift height value is identical to the horizontally-oriented drop height criterion baselined in the system description documents for the various disposal containers (DCs).

1.2.2.1.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the probability and consequences of postclosure criticality events do not cause the repository to exceed the postclosure performance requirement of MGR RD 3.1.C and 3.2.P, and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

Other than the 10,000-year criticality control period, the actual content and quantification of the postclosure criticality criterion has not been confirmed. As a result, this criterion will need to be verified, and the following parameters are assumed. The 1 percent inventory increase measured at 1,000 years was chosen as the standard to which the consequences of postclosure criticalities would be held below because the effect of the relatively small incremental increase in the inventory (of 1 percent due to criticality events) will be negligible compared to the effect of other total system performance related parameters, such as infiltration rate, which can vary by over 100 percent. Further analyses are expected to substantiate these effects as being negligible.

The timeframe used for the 10,000-year criticality control period is taken from 10 CFR 63.113(b).

1.2.2.2.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that health and safety issues related to placement of the invert ballast and backfill materials are considered in the design.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.3.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the maximum temperature of the drift wall to limit the thermomechanical response of the host rock. Excessive near field temperatures (temperatures in excess of the temperature limit for this criterion) could result in local rock failure which could have the potential to degrade the system's performance. High temperatures (above the temperature limit for this criterion) can also create significant differential stresses between the drift wall rock and the drift wall ground support. This concern is described in detail in "Thermal Loading Study for FY 1996," Section 3.3.

This criterion supports MGR RD 3.1.C, 3.2.C, and 3.2.P; and 10 CFR 63.113(b).

II. Criterion Performance Parameter Basis

The thermal limit value is taken from the recommendations given in "Thermal Loading Study for FY 1996" in Sections 3.3.3 and 7.

1.2.3.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to preserve the ability of the zeolite layer beneath the emplacement area to act as a natural barrier to radionuclide migration. Temperatures above 90 to 100 degrees C may potentially alter the zeolite (e.g. clinoptilolite) layer to analcime, which has much poorer sorption properties for radionuclides than does clinoptilolite, as discussed in "Thermal Loading Study for FY 1996," Section 3.2.4.

This criterion also supports MGR RD 3.1.C, 3.1.G, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The zeolite temperature limit is taken from "Thermal Loading Study for FY 1996," Section 7.

1.2.3.3 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the bounds for limiting the temperature of the soil surface above the emplaced WPs and just below the soil surface. Soil temperature limits are necessary to limit the environmental impacts at the surface and reduce the potential for adverse changes to the geologic structures which might increase water infiltration toward the repository emplacement structure.

This criterion supports MGR RD 3.1.C, 3.2.F, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The thermal bound on the soil temperature is provided by MGR RD 3.2.F.

1.2.3.4 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to bound the temperature limits of the PTn geologic unit to limit the thermal, thermomechanical, and thermochemical response of the host rock. The effects of temperature changes in the PTn geologic unit have not been fully studied, however, it is speculated in the "Site Characterization Plan Thermal Goals Reevaluation," pp. 18 and 19, that the PTn could limit the amount of infiltrating water that could readily percolate to the repository horizon, and could act as a barrier against the release of radioactive carbon gas emanating from a breached waste package.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

Although a PTn temperature limit is recommended in the "Site Characterization Plan Thermal Goals Reevaluation," p. 21 (recommendation 16), no quantitative limit is established as part of the recommendation. However, it is suggested on p.19 of the same document that an appropriate temperature limit for the PTn could be the boiling point of water. That suggestion forms the basis for establishing the 96 degrees C temperature limit in this criterion.

1.2.3.5 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to preserve the integrity of the natural barrier, as discussed in the 'Assessment of Goals' section (p. 10) of the "Site Characterization Plan Thermal Goals Reevaluation." The following discussion is paraphrased from that document. The potential repository will initially be surrounded by relatively undisturbed rock formations. After waste emplacement begins, the repository will locally heat up and expand. If this expansion is sufficient, this can result in large horizontal stresses developing in the far field and an uplift in the repository region. If this uplift is large enough, it could cause the rock above the repository, especially the non-welded PTn units, to extend, resulting in fracturing of the units. This would damage the principal natural barrier above the potential repository, and could result in the opening of preferential pathways for water infiltration, or pathways for gas migration.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The thermomechanical unit uplift value for the TSw1 is taken from recommendation 3 listed in the 'Summary and Recommendations' section (p. 20) of the "Site Characterization Plan Thermal Goals Reevaluation."

1.2.3.6 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to preserve the integrity of the natural barrier, as discussed in the 'Assessment of Goals' section (p. 10) of the "Site Characterization Plan Thermal Goals Reevaluation." The following discussion is paraphrased from that document. The potential repository will initially be surrounded by relatively undisturbed rock formations. After waste emplacement begins, the repository will locally heat up and expand. If this expansion is sufficient, this can result in large horizontal stresses developing in the far field and an uplift in the repository region. If this uplift is large enough, it could cause the rock above the repository, especially the non-welded PTn units, to extend, resulting in fracturing of the units. This would damage the principal natural barrier above the potential repository, and could result in the opening of preferential pathways for water infiltration, or pathways for gas migration.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The ground surface uplift rate above the repository is taken from recommendation 4 listed in the 'Summary and Recommendations' section (p. 20) of the "Site Characterization Plan Thermal Goals Reevaluation."

1.2.3.7 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to define the seismic environment that the system must be designed to withstand.

This criterion supports MGR RD 3.1.C and 3.3.A, and 10 CFR 63.112(e)(8).

II. Criterion Performance Parameter Basis

The values contained in this criterion are obtained from "Seismic Criteria for Bin 2 and Bin 3 SDDs."

1.2.3.8 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to represent the environment that the system must operate in. This system substantially alters the subsurface environment to create it's own environment, which is part of the design solution of the system. Thus, the initial condition of the Natural Barrier is the environment that the system must operate within.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure mechanical interface consistency between the design of this system and the DC systems. This is done by specifying the design be done in accordance with the interface agreements defined in "Interface Control Document for Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems for Mechanical and Envelope Interfaces."

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.2 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the total number of WPs to be emplaced within the system.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

Type I Analysis: Number of DCs Emplaced

Purpose

The purpose of this analysis is to establish the maximum number of WPs to be emplaced by the system.

Assumptions

1. The option used for loading high-level waste (HLW) and defense SNF (DSNF) canisters into DCs will be the "co-disposal" option (used in section 3.1).

Rationale: The "Waste Quantity, Mix and Throughput Study Report," Paragraph 5.4.2, identifies two loading options, a "co-disposal" and a "separate" option. The co-disposal option denotes disposal of most of the DSNF in a "5-Pack" HLW DC (1 DSNF canister in each HLW DC). In this option, certain DSNF waste (such as naval spent nuclear fuel (SNF)) is disposed of separately. The separate option denotes separate disposal of HLW (4 canisters in one DC) and DSNF. The co-disposal option is used as the reference option in the "Waste Quantity, Mix and Throughput Study Report," as that option offers a reduction in the total number of DCs by approximately 2,000 containers.

2. A total of 10,305 DCs will need to be emplaced (used in section 3.1).

Rationale: The schedule shown in the "Waste Quantity, Mix and Throughput Study Report," Table 5-6, identifies 7,759 DCs required for canistered SNF. The same report (Table 5-9) also identifies a total of 2,546 DCs for HLW and DSNF. The total of 10,305 is determined by adding 7,759 and 2,546.

3. The disposal of plutonium mixed-oxide SNF will not affect the number of canistered SNF DCs. The disposal of immobilized plutonium will require approximately 200 DCs in addition to those required for HLW/DSNF (used in section 3.1).

Rationale: "Incorporate Plutonium Disposition Materials in the CRWMS Baseline" (Baseline Change Proposal BCP-00-98-0001) requires that the MGR store additional waste as noted above.

Criterion Analysis: This section investigates the total number of DCs to be transported and emplaced by the system.

The total number of DCs to be emplaced by the system is 10,305 per Assumption 2. Approximately 200 HLW DCs are required to accommodate the disposal of immobilized plutonium per Assumption 3. Adding 10,305 and 200 provides 10,505 as the maximum number of DCs. Rounding 10,505 up to the nearest 1,000 DCs provides a conservative margin in the number of DCs to be emplaced by the system. The maximum number to be emplaced by the system is therefore 11,000 DCs.

Conclusion

The system is required to transport and emplace a maximum of 11,000 DCs.

*The software models used to generate throughput data in "Waste Quantity, Mix and Throughput Study Report" were not qualified. However, it is stated that the report does provide input to repository design. The input used in this analysis was necessary to establish bounds for design with adequate conservative margins, and hence does not

disqualify the results of the analysis. Additionally, the bounding design criterion does not affect nuclear safety.

Note: Donald F. Smith and Ovadia Lev assisted with the preparation of the preceding Type I Analysis.

1.2.4.3 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to identify the maximum surface dose rate to be expected at the WP surface. Radiation fields have the potential to change the physical properties of materials and to alter physical processes over time.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.4 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface between this system and emplaced WPs. Maximum WP thermal output affects the thermal limitations placed on this system.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The WP maximum thermal output is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.11.

1.2.4.5 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface between this system and the Subsurface Ventilation System. Removal of WP decay heat by the ventilation system affects the thermal limitations placed on this system.
This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The WP heat removal percentage and timeframe is obtained from "Monitored Geologic Repository Project Description Document," Section 2.1.1.1.

1.2.4.6 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface with the Waste Emplacement/Retrieval System. Horizontal in-drift emplacement also affects the design of the Performance Confirmation Emplacement Drift Monitoring System and the Backfill Emplacement System.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.7 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface between this system and the Waste Emplacement/Retrieval System. This criterion is a quantification of the criterion to line load the WPs.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The WP spacing is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.8.

1.2.4.8 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface with the Subsurface Facility System. Drift spacing affects the thermal limitations placed on this system. This criterion is a quantification of the criterion to preclude the merging of the pore water boiling fronts between individual emplacement drifts. This spacing is also intended to reduce the influence of one emplacement drift on another (as compared to subsurface facility designs with more closely spaced emplacement drifts).

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The drift spacing is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.1.

1.2.4.9 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface with the Subsurface Facility System. The excavated drift diameter affects the thermal limitations placed on this system.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The drift spacing is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.3.

1.2.4.10 Criterion Basis Statement

I. Criterion Need Basis

This criterion identifies an interface between this system and the Subsurface Facility System. This criterion is necessary to ensure that the system is located entirely within the area at Yucca Mountain that has been characterized for disposal of HLW. The location of the repository is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.2.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.11 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to establish the requirements for bounding the physical envelope available to the system, as an interface with the emplaced WPs, Ground Control System, Waste Emplacement/Retrieval System, Backfill Emplacement System, and the Performance Confirmation Emplacement Drift Monitoring System.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.12 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the WP supports do not result in an adverse interaction between the WP outer barrier material and the support materials. In addition, it ensures that the SSCs that contact the waste package will withstand the maximum waste package external temperature.

The "License Application Design Selection Report" evaluated a number of design features and alternatives. The majority of the design alternatives, and the recommended design alternative, include a WP design with Alloy 22 as the outer barrier (Table 5-4 and Section 7.3, Recommendation 6). The single design alternative that did not include an Alloy 22 outer barrier, did include a carbon steel outer barrier (Table 5-4).

The emplacement of WPs on supports results in intimate contact between the WP outer barrier and the supports, and these areas of contact are potential crevice corrosion locations. As the relative humidity in the drift increases, galvanic reactions may take place in the crevice locations. When a corrosion resistant material (such as Alloy 22) is in contact with a less noble material (such as carbon steel), active corrosion of the carbon steel could occur generating hydrogen. This could potentially charge hydrogen into the nickel base alloys causing embrittlement of the WP outer barrier ("Metals Handbook: Volume 13 Corrosion," p. 652). It is therefore important that dissimilar metal contacts at the WP surface are avoided. The WP support surfaces contacting the WP outer barrier should be fabricated from the same material as the WP outer barrier.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.13 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed as an interface with the Ground Control System. The use of concrete as the primary ground support material can have significant affects on the pH of water entering an emplacement drift. Elimination of concrete as the primary ground support material relieves the system (some portions of which are tasked to control the pH of water within emplacement drifts) of the need to compensate for substantial amounts of concrete in the emplacement drifts.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

The ground support material is obtained from "Monitored Geologic Repository Project Description Document," Section 2.2.1.1.4.

1.2.4.14 Criterion Basis Statement

I. Criterion Need Basis

This criterion maintains the near field environment interface between the system and the emplaced WPs. The system design determines many of the emplacement drift environment variables that the DC will have to be designed for.

This criterion supports MGR RD 3.1.C, 3.2.O, 3.2.P, and 3.3.A; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

Environment parameters, with the exception of the lower pH bound, are obtained from Table 4 of "Manager System Requirements/System Description Documents."

The lower pH bound is obtained from "Groundwater Chemistry Along Flow Paths Between a Proposed Repository Site and the Accessible Environment."

1.2.4.15 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure that the design of the inverts includes consideration for the constructability of the inverts, such as loads placed on the inverts by the Subsurface Excavation System as the inverts are placed.

This criterion supports MGR RD 3.3.A.

II. Criterion Performance Parameter Basis

N/A

1.2.4.16 Criterion Basis Statement

I. Criterion Need Basis

This criterion responds directly to MGR RD 3.3.C, and supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b). This criterion is intended to be met in conjunction with a similar criterion levied upon the Subsurface Facility System.

II. Criterion Performance Parameter Basis

The overburden depth is taken from MGR RD 3.3.C.

1.2.5.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion is needed to ensure a minimum reliability is designed into the drip shields.

This criterion supports MGR RD 3.1.C, 3.2.O, and 3.2.P; and 10 CFR 63.113(a) and 63.113(b).

II. Criterion Performance Parameter Basis

The 10,000 year timeframe is taken from 10 CFR 63.113(b), and is corroborated by the drip shield operating life in Table 4 of "Manager System Requirements/System Description Documents" (Drip Shield Barrier Requirements).

1.2.6.1 Criterion Basis Statement

I. Criterion Need Basis

This criterion ensures that the design complies with "Manual of Steel Construction Allowable Stress Design" or "Manual of Steel Construction Load and Resistance Factor Design."

This criterion supports MGR RD 3.1.G, and is supported by guidance contained in the "Compliance Program Guidance Package for Ex-Container System," guidance statements 6.7g1, 6.9g1, 7.1g1, and 7.2g1.

II. Criterion Performance Parameter Basis

N/A

1.2.6.2 Criterion Basis Statement

I. Criterion Need Basis

The "Monitored Geologic Repository Project Description Document" allocates controlled project assumptions to systems. This criterion identifies the need to comply with the applicable assumptions identified in the subject document. The approved assumptions will provide a consistent basis for continuing the system design.

II. Criterion Performance Parameter Basis

N/A

APPENDIX B ARCHITECTURE AND CLASSIFICATION

The system architecture and QA classification are identified in Table I-9. The QA classifications are established in Table 1 of "Classification of the MGR Ex-Container System" (as modified by input transmittal "Classification of the Emplacement Drift System").

Table I-9. System Architecture and QA Classification

Emplacement Drift System	QL-1	QL-2	QL-3	CQ	TBV
Invert	X				460
Drip Shield	X				N/A
Backfill	X				N/A
WP Emplacement Pallet	X				460

APPENDIX C ACRONYMS, SYMBOLS, AND UNITS

C.1 ACRONYMS

This section provides a listing of acronyms used in Volume I.

CQ	conventional quality
DC	disposal container
DSNF	defense spent nuclear fuel
F	Function
HLW	high-level waste
MGR RD	Monitored Geologic Repository Requirements Document
MGR	Monitored Geologic Repository
N/A	not applicable
QA	quality assurance
QL	quality level
SNF	spent nuclear fuel
SSCs	structures, systems, and components
TBD	to be determined
TBV	to be verified
WP	waste package

C.2 SYMBOLS AND UNITS

This section provides a listing of symbols and units used in Volume I.

C	Celsius
cm	centimeters
hr	hour
k_{eff}	Effective neutron multiplication factor
kW	kilowatt
lb	pounds
m	meters
mrem	milli-Roentgen equivalent man
mSv	millisievert
pH	potential of hydrogen
PTn	Paintbrush tuff nonwelded
rem	roentgen equivalent man
TSw1	Topopah Spring welded unit 1-lithophysal rich

APPENDIX D FUTURE REVISION RECOMMENDATIONS AND ISSUES

This appendix identifies issues and actions that require further evaluation. The disposition of these issues and actions could alter the functions and design criteria that are allocated to this system in future revisions to this document. However, the issues and actions identified in this appendix do not require TBDs or TBVs beyond those already identified.

D.1 Issue 1-- Use of Design Solution Constraints as Design Criteria

Several design solution constraints have been implemented as design criteria in this version of the system description document for the Emplacement Drift System. Certain of these design solution constraints are appropriate to be deleted from Section 1 and moved to Section 2 when Section 2 of this document is written. Specifically, the design solution constraints from the following design criteria will be moved to Section 2: 1.2.1.9 (invert material), 1.2.1.18 (drip shield material and thickness), and 1.2.4.7 (minimum WP spacing).

APPENDIX E REFERENCES

This section provides a listing of references used in Volume I.

"Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift." CRWMS M&O. BCA000000-01717-5705-00007, Rev. 00. July 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991018.0232.

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"Controlled Design Assumptions Document." CRWMS M&O. B00000000-01717-4600-00032, Rev. 05. July 8, 1998. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980804.0481.

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"Interim Direction for Enhanced Design Alternative (EDA) II." CRWMS M&O. ECR E1999-0046. June 23, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990625.0069.

"License Application Design Selection Report." CRWMS M&O. B00000000-01717-4600-00123, Rev. 01. May 28, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990528.0303.

"Manager System Requirements/System Description Documents." CRWMS M&O. RSO-RSO-99311.T. October 15, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991019.0380.

"Manual of Steel Construction Allowable Stress Design." American Institute of Steel Construction, Inc. Ninth Edition. January 1997. Chicago, Illinois: American Institute of Steel Construction, Inc. TIC: 232994.

"Manual of Steel Construction Load and Resistance Factor Design." American Institute of Steel Construction, Inc. Second Edition. 1995. Chicago, Illinois: American Institute of Steel Construction, Inc. TIC: 236850.

"Metals Handbook: Volume 13 Corrosion." American Society for Metals. 1987. Materials Park, OH: American Society for Metals. TIC: 209807.

"Monitored Geologic Repository Project Description Document." CRWMS M&O. B00000000-01717-1705-00003, Rev. 00, DCN 01. October 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991117.0160.

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