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Complete only applicable items.

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6. Approvals:

Preparer: Wendy Jaros Wendy Jaros — Print name and sign — 11-18-05 Date

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Responsible Manager: Ernest Hardin — Print name and sign — 11/21/05 Date

7. Affected Pages	8. Description of Change:
4-2	Delete citation: Delete from Table 4.1.1-2: ; Product Output of BSC 2004 [DIRS 169854], Table 7-10 This is part of CR 5600.
4-5	Delete citation: Delete from Table 4.1.2-2: is product output of BSC 2004 [DIRS 169854], Table 7-10 This is part of CR 5600.
8-21 & 8-24	Delete citation: Delete: , *Thermal Conductivity of the Potential Repository Horizon* (BSC 2004 [DIRS 169854]), This is part of CR 5600.

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9-4	Delete citation: BSC 2004. *Thermal Conductivity of the Potential Repository Horizon.* MDL-NBS-GS-000005 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040928.0006. 169854 This is part of CR 5600. Note: On page 9-4, there is a deletion of the reference DIRS#169861. This is a tracked chnage from ACN 01.
9-4	Delete citation: BSC 2004. *Multiscale Thermohydrologic Model.* ANL-EBS-MD-000049 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041014.0008. 169565 Note: During checking it was noticed that the citation of DIRS# 169854 , that was added to page 9-4 in ACN 01 was duplicate of a citation page 9-3.

Table 4.1.1-2. Thermal Properties of Materials Used for the Base Case of the Two-Dimensional In-Drift Convection Simulations

Parameter Name	Parameter Source	Parameter Value	Units
Invert Thermal Conductivity	DTN: GS000483351030.003 [DIRS 152932]	0.14-0.17[a]	W/m-K
Invert Emissivity	Incropera and DeWitt 1990 [DIRS 156693], Table A.11 (“Rock”)	0.9 (0.88-0.95)	-
Drip Shield Thermal Conductivity	ASME 1995 [DIRS 108417], Section II-D, Table TCD, p. 611	20.708[b]	W/m-K
Drip Shield Emissivity	Lide 1995 [DIRS 101876], p. 10-298	0.63	-
Waste Package Thermal Conductivity	BSC 2004 [DIRS 169990], Table 20	1.5	W/m-K
Waste Package Emissivity	DTN: MO0003RIB00071.000 [DIRS 148850]	0.87	-
Host Rock Thermal Conductivity (Tptpll)	DTN: SN0404T0503102.011 [DIRS 169129]	1.8895	W/m-K
Host Rock Emissivity	Incropera and DeWitt 1990 [DIRS 156693], Table A.11 (“Rock”)	0.9 (0.88-0.95)	-
Gravitational Constant	Incropera and DeWitt 1990 [DIRS 156693], Inside Back Cover	9.81	m/s^2

[a] Range of thermal conductivity of invert material (4-10 crushed tuff) of the 11 samples listed in DTN: GS000483351030.003 [DIRS 152932].

[b] Thermal Conductivity at 212°F (100 °C). The value was found by linear interpolation between values at 200°F (12.00 BTU/hr-ft-° F) and 250°F (11.85 BTU-hr-ft-°F), as given in ASME 1995 [DIRS 108417], Section II-D, Table TCD, p. 611. Conversion is 1 BTU/hr-ft-°F = 1.7307 W/m-°C (Bird et al. 1960 [DIRS 103524], pg. 753).

Table 4.1.1-3. Approximate In-Drift Geometries with Drip Shield

Case	Inner Cylinder Diameter *Di* (m)	Outer Cylinder Diameter D_o (m)	Invert Height (mm)	Outside Width of Drip Shield (mm)	Height of Drip Shield (mm)
24-BWR waste package diameter (smallest)	1.318	5.5	806	2512	2521
DHLW waste package diameter (largest)	2.110	5.5	806	2512	2521

NOTES: Inner cylinder diameters are given in BSC 2003 [DIRS 164053].

Outer cylinder diameters are given in BSC 2003 [DIRS 164069].

Invert height is given in BSC 2004 [DIRS 164101].

Outside width of drip shield is given in BSC 2003 [DIRS 171024].

The height of the drip shield is given in BSC 2003 [DIRS 171024] as the distance from the invert to the top of the drip shield.

Properties of the host rock are given in Table 4.1.2-2 below.

Table 4.1.2-2. Bulk Thermal Properties of Stratigraphic Unit Tsw35 (Tptpll)

Property	Value	Source
Wet bulk thermal conductivity [W/m °K] (Tptpll)	1.8895 [a]	DTN: SN0404T0503102.011 [DIRS 169129]
Drift wall emissivity	0.9 (0.88 - 0.95)	Incropera and DeWitt 1990 [DIRS 156693], Table A.11 values for "Rocks"

[a] Mean value for wet bulk thermal conductivity.

The fluid properties used in the three-dimensional natural convection simulations are listed in Table 4.1.2-3. FLUENT interpolates linearly between the data points. The fluid properties of the emplacement drift air are used to simulate the in-drift thermal response.

Table 4.1.2-3. Fluid Properties for Three-Dimensional In-Drift Convection Simulations

Data Name	Parameter Value	Units	Distribution
Air Heat Capacity at 280 K and 1 bar	1.006	kJ/kg-K	None
Air Heat Capacity at 300 K and 1 bar	1.007	kJ/kg-K	None
Air Heat Capacity at 350 K and 1 bar	1.009	kJ/kg-K	None
Air Heat Capacity at 400 K and 1 bar	1.014	kJ/kg-K	None
Air Heat Capacity at 450 K and 1 bar	1.021	kJ/kg-K	None
Air Dynamic Viscosity at 280 K and 1 bar	0.175×10^{-4}	Pa-s	None
Air Dynamic Viscosity at 300 K and 1 bar	0.185×10^{-4}	Pa-s	None
Air Dynamic Viscosity at 350 K and 1 bar	0.208×10^{-4}	Pa-s	None
Air Dynamic Viscosity at 400K and 1 bar	0.230×10^{-4}	Pa-s	None
Air Dynamic Viscosity at 450 K and 1 bar	0.251×10^{-4}	Pa-s	None
Air Thermal Conductivity at 280 K and 1 bar	0.0247	W/m-K	None
Air Thermal Conductivity at 300 K and 1 bar	0.0263	W/m-K	None
Air Thermal Conductivity at 350 K and 1 bar	0.0301	W/m-K	None
Air Thermal Conductivity at 400 K and 1 bar	0.0336	W/m-K	None
Air Thermal Conductivity at 450 K and 1 bar	0.0371	W/m-K	None

Source: Perry et al. 1984 [DIRS 125806], pp. 3-162 and 3-163.

The power inputs into the individual waste packages are found in *D&E / PA/C IED Typical Waste Package Components Assembly* (BSC 2004 [DIRS 167754], Table 12), as listed in Table 4.1.2-4. The three-dimensional natural convection simulations are conducted at 300, 1,000, 3,000, and 10,000 years. The powers listed for the two half packages are the heat generated by only half of a full package and not for a whole package. The order of the six full and two half-packages that are in a "seven-package segment" is listed in *D&E / PA/C IED Typical Waste Package Components Assembly* (BSC 2004 [DIRS 167754], Table 12). The segment consists of a half 21-PWR package, a 5-HLW long package, a 21-PWR, two 44-BWR packages, a 5-HLW short package, a 21-PWR package, and a half 44-BWR package. In order to investigate the dispersion coefficient, it is desirable to have a longer segment so that the edge effects can be minimized. Consequently, the simulations were extended by reflecting the segment at the half 44-BWR package. This resulted in simulations that had a half 21-PWR package at each end.

8.5.1 Acceptance Criterion 1: *System Description and Model Integration Are Adequate.*

1) *Total system performance assessment adequately incorporates important design features, physical phenomena, and couplings, and uses consistent and appropriate assumptions throughout the quantity and chemistry of water contacting engineered barriers and waste forms abstraction process.*

   Section 4.1 lists the sources of input for design features and physical features. Most of the design features that are inputs to the natural convection and condensation analyses are in accordance with Interface Exchange Design Drawings (IEDs). Appendix K discusses the effects of small changes to the IEDs subsequent to the calculations documented in this report. Supplementary properties of the planned components are inputs from ASME standards and other justified sources. These design features and couplings are adequately and appropriately incorporated into the natural convection and condensation models documented in this report. Simplifying assumptions about material properties are stated, justified, and appropriate. The ventilation efficiency as a function of drift location and time is input from *Ventilation Model and Analysis Report* (BSC 2004 [DIRS 169862]).

   Properties of the natural materials are taken from the Technical Data Management System (DTN numbers in Section 4.1) and other justified sources. These sources assure consistency in the calculation of the quantity of water contacting engineered barriers and waste forms in the abstraction process.

2) *The abstraction of the quantity and chemistry of water contacting engineered barriers and waste forms uses assumptions, technical bases, data, and models, that are appropriate and consistent with other related U.S. Department of Energy abstractions. For example, the assumptions used for the quantity and chemistry of water contacting engineered barriers and waste forms are consistent with the abstractions of "Degradation of Engineered Barriers" (Section 2.2.1.3.1); "Mechanical Disruption of Engineered Barriers (Section 2.2.1.3.2); "Radionuclide Release Rates and Solubility Limits" (Section 2.2.1.3.4); "Climate and Infiltration" (Section 2.2.1.3.5); and "Flow Paths in the Unsaturated Zone" (Section 2.2.1.3.6). The descriptions and technical bases provide transparent and traceable support for the abstraction of quantity and chemistry of water contacting engineered barriers and waste forms;*

   The technical bases provide transparent and traceable support for the abstraction of quantity of water contacting engineered barriers and waste forms. The abstractions of the condensation rates (Section 8.3, Appendices H and I) are based upon models that include direct inputs (Section 4.1) from established sources (see item 1 above). The abstraction is clearly documented in this report as well as in the output DTNs (Table 8.3.2-1). The ventilated drip shield assumption used to select the abstraction of condensation for TSPA-LA is consistent with a similar assumption made in *Multiscale Thermohydrologic Model* (BSC 2004 [DIRS 169565]).

The convection model has also been validated by comparison to experimental data from the 25% and 44% Yucca Mountain Natural Convection Tests conducted in Las Vegas (Section 7.4). The temperature data-simulation comparisons in this section show that the FLUENT predictions are generally high, though in good qualitative agreement with the observed temperature trends. The results are within the justified validation criteria thereby validating the use of FLUENT to predict component temperature differences.

Coupled processes that are not addressed in this report are considered, and their rationale for exclusion is presented in *Engineered Barrier System Features, Events, and Processes* (BSC 2004 [DIRS 169898]).

9) *Performance-affecting processes that have been observed in thermal-hydrologic tests and experiments are included into the performance assessment. For example, the U.S. Department of Energy either demonstrates that liquid water will not reflux into the underground facility or incorporates refluxing water into the performance assessment calculation, and bounds the potential adverse effects of alteration of the hydraulic pathway that result from refluxing water.*

The three-dimensional natural convection simulations are validated against a series of scaled tests designed to observe natural convection flow patterns (Section 7.4). The tests were conducted at two geometric scales (25% and 44% scales based on the repository design), with and without drip shields, and under both uniform and distributed heat loads. Both cross-sectional and axial flow velocities were measured in these tests. The gas flow patterns are found to be directly responsible for the redistribution of moisture within the drift. Evidence of moisture migration is also observed in the ECRB Cross Drift (BSC 2004 [DIRS 170004] Section 6.10.2.2) and in the Drift-Scale Test (Blair et al., 1998 [DIRS 133836], Section 8). Hence the argument for vapor migration by natural convection is well grounded in experimental observation.

12) *Guidance in NUREG-1297 and NUREG-1298 (Altman, et. al., 1988 [DIRS 103597 and 103750]), or other acceptable approaches, is followed.*

Inputs were selected and documented, and documents were checked and reviewed according to applicable BSC procedures, which comply with NUREG-1297 and 1298 (Section 2).

8.5.2 Acceptance Criterion 2: *Data Are Sufficient for Model Justification.*

1) *Geological, hydrological, and geochemical values used in the license application are adequately justified. Adequate description of how the data were used, interpreted, and appropriately synthesized into the parameters is provided;*

Properties of the natural materials are taken from the Technical Data Management System (DTN numbers in Section 4.1) and other appropriately justified sources. Descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided in those documents.

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