SOFTWARE VALIDATION PLAN AND REPORT FOR CLIMSIM FOR WINDOWS VERSION 1.0

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1.0 SCOPE OF THE VALIDATION

CLIMSIM is used in regulatory review to predict the variation in psychometric and thermodynamic properties of emplacement drifts for the repository. CLIMSIM is capable of linking individual branches together to construct an entire network; however, its intended application will be for a single emplacement drift. Consequently, the data used in this validation exercise is a 20-m airway with the expected perimeter and cross-sectional area of an emplacement drift. Although emplacement drifts at the repository are expected to be much greater in length, a length of 20-m was selected for this exercise because CLIMSIM divides the airway length into finite elements of 20 m or less. Hence, this validation exercise will validate CLIMSIM at its maximum finite element division length. A line load is applied for the entire 20 m as the only heat source in the model. CLIMSIM was validated by inputting data and comparing the results to an EXCEL spreadsheet that implores the equations used in CLIMSIM with the same input parameters. CLIMSIM solves the psychometric equations given in McPherson (1993) to study the effects of moisture in air. CLIMSIM is validated if the CLIMSIM calculations and the EXCEL calculations are equal.

2.0 REFERENCES

Mine Ventilation Services, Inc. "CLIMSIM for Windows Version 1.0 User's Manual and General Theory." Fresno, California.

McPherson, M.J. "Subsurface Ventilation and Environmental Engineering." Chapman & Hall. London, Great Britain. 1993.

3.0 ENVIRONMENT

3.1 Software

- CLIMSIM for Windows Version 1.0
- EXCEL 2002

3.2 Hardware

The following hardware platform is currently supported:

- Pentium-based PC or compatible running Windows WIN NT 4.0, WIN 2000/XP.

4.0 PREREQUISITES

No prerequisites are required to perform testing activities.

5.0 ASSUMPTIONS AND CONSTRAINTS

No assumptions or constraints are required to implement this software validation test plan.

6.0 TEST CASE FOR VALIDATION

The objective of this test case is to verify that the data input into CLIMSIM produces the same results when input into EXCEL applying the same equations.

6.1 Test Case Input

Table 6-1 contains the Input Parameters used in this exercise.

Table 6-1. Validation Input Parameters	
Branch Characteristic	**Value**
Dry Bulb (°C)	25.00
Wet Bulb (°C)	23.00
Pressure (kPa)	40.00
Quantity (m^3/s)	15.00
Length (m)	20.00
Depth In (m)	0.00
Depth Out (m)	0.00
Area (m^2)	19.50
Perimeter (m)	17.23
Friction (kg/m^3)	0.010
Wetness	0.010
Age In (days)	1.00
Age Out (days)	1.00
Virgin Rock Temperature (VRT) In (°C)	22.00
Geothermal Step (m/°C)	30.00
Conductivity (W/m °C)	1.40
Diffusivity ($m^2/s * 10^{-6}$)	2.00
Interval (m)	20.00
Linear Heat Source (kW) Sensible Heat	1.45
Length of Heat Source (m)	20

6.2 Test Case Procedure

The test was conducted using the following procedure:

1. Input the CLIMSIM General Theory equations into an EXCEL spreadsheet. These equations and their corresponding theory can be found in Section 7.0 of CLIMSIM for Windows Version 1.0 User's Manual. The EXCEL worksheet was constructed in the following methodology:

   (a) Input Psychrometric Constants
   (b) Input Psychrometric Equations
   (c) Input Heat Transfer Coefficient Equations
   (d) Input Equations from Gibson's Algorithm
   (e) Input Heat Output Calculations
   (f) Input Outlet Psychrometric Conditions
   (g) Input Output only Equations

2. Input the parameters contained in Table 6-1 into CLIMSIM and the EXCEL spreadsheet.

3. Verify that the results from CLIMSIM are identical to those produced in EXCEL.

The equations used in the EXCEL worksheet are lengthy and complex and are not included in the text of this report. The CLIMSIM Manual, however, is included as an attachment, and the procedure listed above may be viewed in more detail in the manual.

6.3 Test Case Results

Table 6-2 illustrates that the results from CLIMSIM are identical to the results from EXCEL. The Inlet column in Table 6-2 represents the data produced at the entrance of the emplacement drift, (at 0 m) while the Outlet column corresponds to the data at the exit of the drift at 20 m. The Dry Wall, Virgin Rock Temperature (VRT), Mean Skin Temperature (MST), and HTC outputs are not included in the EXCEL worksheet results because their derivations were not clearly represented in the CLIMSIM manual.

6.4 Validation Test Results Conclusion

The results from this validation indicate that the calculations performed in EXCEL are identical to those in CLIMSIM. The results produced in CLIMSIM for this validation exercise, therefore, have been validated.

Table 6-2. Inlet and Outlet Calculations from the Emplacement Drift				
Branch Parameters	**Inlet**		**Outlet**	
	CLIMSIM	**EXCEL**	**CLIMSIM**	**EXCEL**
Distance (m)	0.00*	0.00*	20.00*	20.00*
Dry Bulb (°C)	25.00*	25.00*	24.92	24.92
Wet Bulb (°C)	23.00*	23.00*	22.99	22.99
Pressure (kPa)	40.00*	40.00*	40.00	40.00
Moisture (g/kg)	46.02	46.02	46.03	46.03
Density (kg/m^3)	0.455	0.455	0.455	0.455
Humidity (%)	87.02	87.02	87.43	87.43
Enthalpy (kJ/kg)	142.37	142.37	142.30	142.30
Sigma Heat (kJ/kg)	137.94	137.94	137.87	137.87
Effective Temperature (°C)	20.69	20.69	20.64	20.64
Wet Bulb Globe Temperature (°C)	23.60	23.60	23.57	23.57
Strata QL (Latent Heat Load) (kW)	0.00	0.00	0.056	0.056
Strata QS (Sensible Heat Load) (kW)	0.00	0.00	-2.00	-2.00
*Indicates user input				

7.0 NOTES

The files associated with the CLIMSIM validation are located on the attached CD. The files are identified as follows:

CLIMSIM_Validation_Worksheet.xls	Contains the results produced from the equations taken from the CLIMSIM for Windows User's Manual.
CLIMSIM_Validation.CSW	Contains the CLIMSIM model used in this validation exercise.