CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

1. QA: L

Page: 1 Of: 22

2. Calculation Title			
RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation			
3. Document Identifier (including Revision Number) B00000000-01717-0210-00045 REV 00			4. Total Pages 22
5. Total Attachments N/A.	6. Attachment Numbers - Number of pages in each		
	Print Name	Signature	Date
7. Originator	Kevin G. Mon	Kevin Mon	JUN 2 2 1999
8. Checker	Haywood S. Anderson	Keith Ward FOR H.S. ANDERSON	JUNE 22 1999
9. Lead Design Engineer	Joon H. Lee	Joon Lee	June 23, 1999

10. Remarks
Uses TBV-568.

Supporting Electronic Media = ACC: MOL.19981209.0318, DTN: MO9904MWDWAP45.000.

For LA Design Selection.

Revision History

11. Revision No.	12. Date Approved	13. Description of Revision
00	6-23-99	Initial Issue.

Title: RIP Input Tables From WAPDEG For LA Design Selection Continuous Pre-Closure Ventilation

Document Identifier: B00000000-01717-0210-00045 REV 00

Originator: Kevin G. Mon

Checker: Haywood S. Anderson

Lead Discipline Engineer: Joon H. Lee

Department Manager: Robert L. Howard

Draft Date: June 22, 1999

CONTENTS

Page

1.0 Purpose 4

2.0 Method 4

3.0 Assumptions 5

4.0 Use of Computer Software 5

4.1. Software Approved for QA Work 5

4.2. Software Routines 6

5.0 Calculation Inputs 7

5.1. Description 7

5.1.1. Mkhistory Input Files and Parameters Used 9

5.1.2. WAPDEG Input Files and Parameters Used 9

5.2. Procedure 12

6.0 Results 13

7.0 References 21

8.0 Attachments 22

1.0 Purpose

The purpose of this calculation is to document the creation of tables for input into Integrated Probabilistic Simulator for Environmental Systems (RIP) version 5.19.01 (Golder Associates 1998) from Waste Package Degradation (WAPDEG) version 3.09 (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*) simulations. This calculation details the creation of the RIP input tables (representing waste package corrosion degradation over time) for the License Application Design Selection (LADS) analysis of the effects of continuous pre-closure ventilation. Ventilation during the operational phase of the repository could remove considerable water from the system, as well as reduce temperatures. Pre-closure ventilation is LADS Design Feature 7.

2.0 Method

Thermal hydrologic time, temperature, and relative humidity (RH) "histories" are pre-processed into a form suitable for use as input to the WAPDEG stochastic simulation code through the use of the pre-processor Mkhistory.

Based on user-supplied input, the stochastic simulation code WAPDEG is used to generate waste package failure profiles. WAPDEG's inputs include time-varying histories of the temperature and relative humidity at the waste package surface, various temperature and relative humidity thresholds for corrosion initiation, corrosion models, and corrosion model parameter distributions. A waste package may fail either through localized corrosion processes (pitting or crevice corrosion), leading to small pinhole perforations, or through general corrosion processes leading to much larger "patch" perforations. More detailed discussions of the WAPDEG conceptual model are given elsewhere (CRWMS M&O 1998a. *Total System Performance Assessment-Viability Assessment (TSPA-VA) Analyses Technical Basis Document - Chapter 5, Waste Package Degradation Modeling And Abstraction*. pp. 5-27 to 5-29). The waste package failure profiles consist of time-varying measures of the number of pit and patch penetrations on each waste package. The WAPDEG post-processor, Post308, abstracts this information, to produce one RIP input table (Golder Associates 1998. pp. 7-22 through 7-25) per WAPDEG simulation. The RIP input table contains:

1) The fraction of waste packages failed versus time curve for the simulation,
2) The average number of pit penetrations per failed waste package versus time curve, and
3) The average number of patch penetrations per failed waste package versus time curve.

Post308 has two main objectives:

a) It reformats the WAPDEG output to conform to the RIP input format and,
b) It decreases the number of points in each of the three curves discussed above to approximately 83 (or less depending on the data being processed), through a process of time averaging.

More detailed discussions of the WAPDEG version 3.09 and Post308 codes appear elsewhere (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*. Appendix D).

3.0 Assumptions

No assumptions are made in executing Mkhistory. The limitations on the Mkhistory software routine and on the validity of the resulting output are discussed in detail in Mkhistory's Software Routine Report (CRWMS M&O 1998c. *Software Routine Report for Mkhistory (Version 1.00)*).

For the calculations involved in attaining a post processed table for input into RIP there are two steps to consider: 1) WAPDEG input and output and; 2) Post processing of WAPDEG output for creation of tables for input to RIP. There are several assumptions necessary to consider for the WAPDEG input and output. The assumptions used to model waste package degradation in this calculation are identical to those used in the TSPA-VA REV 01 base case calculation (CRWMS M&O 1998d. *Creating Input Tables from WAPDEG for RIP*).

4.0 Use of Computer Software

4.1. Software Approved for QA Work

Mkhistory version 1.00 (CRWMS M&O 1998c. *Software Routine Report for Mkhistory (Version 1.00)*) was used to pre-process the thermal hydrologic time, temperature, relative humidity "histories" into a format usable by the WAPDEG code. The following has been obtained from the Software Configuration Secretary (SCS) relative to this software:

Software Name:	Mkhistory
Software Version:	1.00
CSCI Identifier:	30080 V1.00
Document Identifier:	30080–2999, REV 00
Media Identifier:	30080–M04–001, REV 00
Software Change Request:	LSBR 194

This software routine was obtained in accordance with appropriate procedures. Mkhistory was executed on a DELL PowerEdge 2200 Workstation equipped with Dual (2) Pentium II 266 MHz processors (CRWMS M&O tag 112371) in the Windows NT 4.0 operating system. Mkhistory version 1.00 has gone through the complete verification and validation process required by QAP-SI-0 REV 04 for a software routine and is thus a fully qualified software routine approved for use in quality affecting work. Mkhistory was used within the range of values tested and documented within its Software Routine Report (CRWMS M&O 1998c. *Software Routine Report for Mkhistory (Version 1.00)*).

Mkhistory version 1.00 is an appropriate application because it is able to read input data and produce output files that can be used as input into WAPDEG.

4.2. Software Routines

The software used was WAPDEG version 3.09 (TBV-568) and its post processor, Post308 (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*) (TBV-568). The following has been obtained from the Software Configuration Secretary (SCS) relative to this software:

Software Name:	WAPDEG
Software Version:	3.09
CSCI Identifier:	30048 V3.09
Document Identifier:	30048–2999, REV 02
Media Identifier:	30048–M04–001, REV 02
Software Change Request:	LSBR 177

This software was obtained in accordance with appropriate procedures. The WAPDEG simulations were executed on Hewlett-Packard HP-UX 20 workstations (CRWMS M&O tags 102877, 112515, 108319, 107436, 107437, 108335, 111031) or on a DELL PowerEdge 2200 Workstation equipped with Dual (2) Pentium II 266 MHz processors (CRWMS M&O tag 112371) in the Windows NT 4.0 operating system. The post processing was accomplished on a DELL PowerEdge 2200 Workstation equipped with Dual (2) Pentium II 266 MHz processors (CRWMS M&O tag 112371) in the Windows NT 4.0 operating system.

WAPDEG version 3.09 is an appropriate application because it is able to read input data and produce output files that can be post processed to create tables for input into RIP. Although there has been a software routine report (SRR) prepared for version 3.09 of the WAPDEG code (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*), WAPDEG has not gone through the complete verification and validation process required by QAP-SI-0 REV 04 so it is not to be considered qualified and is to be considered "to be verified" (TBV-568). WAPDEG version 3.09 was used within the range of values tested and documented in its Software Routine Report (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*).

Post308 is an appropriate application because it is able to read input data and post process it to make tables for input into RIP. Although all of the documentation necessary to fully qualify the Post308 code has been included in the WAPDEG version 3.09 SRR (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*, Appendix D), since WAPDEG version 3.09 has not gone through the complete verification and validation process required by QAP-SI-0 REV 04, Post308 is not to be considered qualified and is to be considered "to be verified" (TBV-568).

Post308 was used within the range of values tested and documented in its Software Routine Report (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*, Appendix D).

5.0 Calculation Inputs

5.1. Description

Files containing the thermal hydrologic time, temperature, and relative humidity (RH) "histories" at the surface of waste packages in the center, middle, and edge zone of the repository were obtained (Dunlap 1999) (DTN: MO9903MWDTHM56.000) as an Excel workbook, AEG-pre-ventLTA.xls. This workbook is included in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000). Each worksheet in the Excel workbook starts with 13 rows of cells that contain a unique header followed by columns of ASCII numerical data. Column 1 contains the time (years), Column 2 the waste package surface temperature (°C), Column 3 the relative humidity at the waste package surface (fraction), Column 4 the liquid saturation of the invert (fraction), and Columns 5, 6, and 7 are composed of zeros. These histories are "to be verified" (DTN: MO9903MWDTHM56.000). Cell "A1" of each worksheet contains a unique text string (i.e., CZ_22_cfX_vent, MZ_22_cfX_vent, or EZ_22_cfX_vent). The first two characters of the text string indicate whether the data in the worksheet correspond to the center ("CZ"), edge ("EZ") or middle ("MZ") zone of the potential repository; the next two characters (after the "_") ("22") indicate that the data correspond to the long-term average climactic state; the next two or four characters (after the "_") can be either "cf" (as above) for commercial spent nuclear fuel or "dhlw" for defense high-level waste; X can take on values from 1 to 6 for commercial spent nuclear fuel ("cf") or either one or two for defense high-level waste ("dhlw") (i.e., there are six types of commercial spent nuclear fuel waste packages and two types of defense high-level waste packages); the next four characters (after the "_") ("vent") represent the continuous pre-closure ventilation LADS analysis. Each worksheet in the Excel workbook was saved as an individual ASCII text file named consistently with the unique contents of the cell "A1" of each worksheet (i.e., CZ_22_cfX_vent, MZ_22_cfX_vent or EZ_22_cfX_vent).

These thermal hydrologic history files (i.e., CZ_22_cfX_vent, MZ_22_cfX_vent or EZ_22_cfX_vent) were pre-processed by the Mkhistory code. The bulk of Mkhistory's pre-processing is devoted to copying Columns 1, 2, and 3 (the columns containing the time, temperature, and RH at the waste package surface) from the thermal hydrologic history file named in Column 1 of the Mkhistory input file (f07CZventLTA.mk, f07EZventLTA.mk, or f07MZventLTA.mk) to the file named in Column 2 of the Mkhistory input file. The contents of f07CZventLTA.mk are:

```
8
CZ_22_cf1_vent                    CZ22cf1vent.hst
CZ_22_cf2_vent                    CZ22cf2vent.hst
CZ_22_cf3_vent                    CZ22cf3vent.hst
CZ_22_cf4_vent                    CZ22cf4vent.hst
CZ_22_cf5_vent                    CZ22cf5vent.hst
CZ_22_cf6_vent                    CZ22cf6vent.hst
CZ_22_dhlw1_vent                  CZ22dhlw1vent.hst
CZ_22_dhlw2_vent                  CZ22dhlw2vent.hst
```

i.e., eight thermal hydrologic history files are to be pre-processed by Mkhistory, and data from Columns 1, 2, and 3 of CZ_22_cf1_vent are to be copied to Columns 1, 2, and 3 of CZ22cf1vent.hst. The above are the contents of f07CZventLTA.mk before execution of Mkhistory (several data segments are appended to this file during Mkhistory program execution as discussed in CRWMS M&O 1998c. *Software Routine Report for Mkhistory (Version 1.00)*). The thermal hydrologic "history" files before and after pre-processing by Mkhistory and the f07CZventLTA.mk, f07EZventLTA.mk and f07MZventLTA.mk files after execution of Mkhistory (choosing the default 1,000,000 total number of waste packages in order to retain the maximum possible six digits of accuracy for the fraction of waste packages represented by each history) are included in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000).

WAPDEG version 3.09 (TBV-568) analyzes the inputs (*.inp, *.cdf, and *.hst files, see below) (DTN: MO9904MWDWAP45.000) and creates several output files (*.aux, *.bin, *.cam, *.crm, *.out, *.pat) (DTN: MO9904MWDWAP45.000). Post308 (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*, Appendix D) reads from the *.bin, *.pat, *.out files of the WAPDEG version 3.09 runs and creates several output files (*.asc, *.dat, *.rip) (DTN: MO9904MWDWAP45.000). The *.rip files are used as input to RIP and are described in Section 6.0.

The method of producing an output from WAPDEG for input into RIP entails the use of a number of files for the WAPDEG code to read. With the exception of the thermal hydrologic time, temperature, relative humidity "history" files discussed above, these files are identical to those discussed in the TSPA-VA REV 01 base case calculation (CRWMS M&O 1998d. *Creating Input Tables from WAPDEG for RIP*. Section 5.0) (DTN: MO9810SPA00013.000). The following are the files required for WAPDEG:

1) Files containing the relative humidity (RH) and temperature histories at the surface of waste packages (the *.hst files discussed above). These histories are "to be verified" (DTN: MO9904MWDWAP45.000).
2) Cumulative distribution function (cdf) for the temperature threshold for the onset of carbon steel corrosion. This threshold is used for the outer barrier or corrosion allowance material (CAM) (file: TThresh.cdf) (CRWMS M&O 1998e. *Cumulative Distribution Functions for the Temperature Threshold for the Onset of Carbon Steel Corrosion*) (DTN: MO9810SPA00013.000).
3) A cumulative distribution function (cdf) each for the RH threshold for the onset of humid-air corrosion (file: HARH.cdf) and the transition from humid-air corrosion to aqueous corrosion (file: AQRH.cdf) for the CAM outer barrier (CRWMS M&O 1998f. *Cumulative Distribution Functions for the Relative Humidity Thresholds for the Onset of Carbon Steel Corrosion*) (DTN: MO9810SPA00013.000).
4) Cumulative distribution functions for the inner barrier corrosion resistant material (CRM) general corrosion rates with no drips (CRWMS M&O 1998g. *Cumulative Distribution Functions for No*

Drip Corrosion Resistant Material General Corrosion Model) at 25, 50, and 100°C (files: gnd17550.cdf, gnd27550.cdf, gnd37550.cdf) (DTN: MO9810SPA00013.000).

5) Cumulative distribution functions for general corrosion rates under dripping for the CRM (CRWMS M&O 1998h. *Cumulative Distribution Functions for the Dripping Case of the Corrosion Resistant Material General Corrosion Model*) at 25, 50, and 100°C (files: g8415050.cdf, g8425050.cdf, g8435050.cdf) (DTN: MO9810SPA00013.000).

These file names and other model parameters are contained in the WAPDEG input file for the particular simulation being executed. With the exception of the thermal hydrologic time, temperature, and relative humidity "history" files discussed above, the other parameters in the WAPDEG input file are identical to those discussed in the TSPA-VA REV 01 base case calculation (CRWMS M&O 1998d. *Creating Input Tables from WAPDEG for RIP*. Section 5.0) (DTN: MO9810SPA00013.000). The WAPDEG input file (*.inp) is read by WAPDEG version 3.09 (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*) (TBV-568). The outputs resulting from the WAPDEG simulations are then read by the post processor, Post308 (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*, Appendix D) (TBV-568), which generates a table in a format appropriate for input into RIP (Golder Associates 1998. pp. 7-22 through 7-25). The RIP input table contains:

1) The fraction of waste packages failed versus time curve for the simulation,
2) The average number of pits per failed waste package versus time curve and,
3) The average number of patch penetrations per failed waste package versus time curve.

5.1.1. Mkhistory Input Files and Parameters Used

Three Mkhistory input files were used (f07CZventLTA.mk, f07EZventLTA.mk and f07MZventLTA.mk for the center, edge and middle repository zones, respectively). The contents of f07EZventLTA.mk (before Mkhistory execution) are:

```
8
EZ_22_cf1_vent                    EZ22cf1vent.hst
EZ_22_cf2_vent                    EZ22cf2vent.hst
EZ_22_cf3_vent                    EZ22cf3vent.hst
EZ_22_cf4_vent                    EZ22cf4vent.hst
EZ_22_cf5_vent                    EZ22cf5vent.hst
EZ_22_cf6_vent                    EZ22cf6vent.hst
EZ_22_dhlw1_vent                  EZ22dhlw1vent.hst
EZ_22_dhlw2_vent                  EZ22dhlw2vent.hst
```

The file names specified in the first column of f07EZventLTA.mk are read by Mkhistory, and the file names in the second column contain Mkhistory output. The user-supplied total number of waste packages used was the default 1,000,000.

5.1.2. WAPDEG Input Files and Parameters Used

Six WAPDEG input files were used to generate the RIP input tables for the LADS analysis of pre-closure ventilation: f07CZndLTA.inp, f07EZndLTA.inp, f07MZndLTA.inp, f07CZydLTA.inp,

f07EZydLTA.inp, and f07MZydLTA.inp. The first three input files representing the no-dripping case for the center, edge, and middle zones, respectively, and the last three input files representing the dripping case for the center, edge, and middle zones, respectively. These input files are included in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000).

The first three characters of the input file names ("f07") represent Design Feature 7 of the LADS analysis (continuous pre-closure ventilation). The next two characters ("CZ", "EZ", or "MZ") indicate the input file represents either the center ("CZ"), edge ("EZ"), or middle ("MZ") repository zone. The next two characters indicate that a no-drip case ("nd") is being simulated or that 100% of the waste package surface is subjected to dripping ("yd") throughout the simulation. The next three characters ("LTA") indicate that the long-term average climate is being used. Below is shown the input file f07EZydLTA.inp used in the WAPDEG simulation:

```
f07EZydLTA.inp
Edge Zone  Continuous Pre-closure Ventilation histories
always drip, 100%, feature 07  LADS 10/10/98 B Bullard
Uncertainty/Variability=50/50 drip, 50th Quantile

START OF PARAMETERS
3.09                          |Version number of code
 8                            |Number of alternate histories
EZ22cf1vent.hst               |History file 1
    71429, 0., 0.             |packs/history, T std, RH std
EZ22cf2vent.hst               |History file 2
   142857, 0., 0.             |packs/history, T std, RH std
EZ22cf3vent.hst               |History file 3
   142857, 0., 0.             |packs/history, T std, RH std
EZ22cf4vent.hst               |History file 4
   142857, 0., 0.             |packs/history, T std, RH std
EZ22cf5vent.hst               |History file 5
   142857, 0., 0.             |packs/history, T std, RH std
EZ22cf6vent.hst               |History file 6
   142857, 0., 0.             |packs/history, T std, RH std
EZ22dhlw1vent.hst             |History file 7
   142857, 0., 0.             |packs/history, T std, RH std
EZ22dhlw2vent.hst             |History file 8
    71429, 0., 0.             |packs/history, T std, RH std
10.0, 2.0                     |Thickness of outer, inner barriers (cm)
75., 0.35                     |% thick to fail CRM, frac variance to packs
400, 964, 3100, 3100          |Number of packs, patches/pack, pits/patch
1.0, 1.e6, 1200               |Bin start time & end time (y), and # of bins
1.e4, 5.e4, 1.e5, 1.e6        |Output times (y) for cumul. pit penetrations
304058394, F, F               |Random# seed, restart flag, ignore CAM variance
0.0, 0.0                      |Max temp, RH change over a time step (C, %RH)
180., 180.                    |Angle defining top/bottom (degrees)
Fixed                         |Distribution for fraction top seeing drips
1.                            |Distribution parameter(s)
Fixed                         |Distribution for fraction bottom seeing drips
1.                            |Distribution parameter(s)
Fixed                         |Distribution for dripping start time
0.                            |Distribution parameter(s)
Fixed                         |Distribution for dripping stop time
1000000.                      |Distribution parameter(s)
```

T, F	Neutral(T/F) water initially, new water (T/F)
Fixed	Distr for time range for ceramic protection
0.0	Distribution parameter(s)
1.0	Package variance share
[No Drip Model, CAM]	This segment always required
CAMGeneral+PitMultiples	CAM corrosion model for no drips
B-Normal	Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6	Mean, StDev, Min, Max
[No Drip Model, CRM]	This segment always required
CRMGeneralRateOnly	CRM corrosion model for drips
3, 1.e+6	Number of dists (temps), max CRM rate
25.	Temp appropriate for dist #1
File	Distribution type for #1
gnd17550.cdf	Distribution parameter (s)
50.	Temp appropriate for dist #1
File	Distribution type for #1
gnd27550.cdf	Distribution parameter (s)
100.	Temp appropriate for dist #2
File	Distribution type for #2
gnd37550.cdf	Distribution parameter (s)
[No Drip Features]	This segment always required
File	Distr for thermal protection temperature
TThresh.cdf	Distribution parameter(s)
File	Dist type for humid-air initiation
HARH.cdf	Distribution parameter(s)
File	Dist type for humid-air/aqueous transition
AQRH.cdf	Distribution parameter(s)
1.0	RH correlation factor
0.0, 0.0	Galvanic protect depth %, % patches protected
0.0	Spalling depth as a % of thickness
Fixed	Dist for multiple for CAM corrosion rate
1.0	Distribution parameter(s)
Fixed	Dist for multiple for CRM corrosion rate
1.0	Distribution parameter(s)
1.0	Pack variance share for multiples
[Neutral Drip Model, CAM]	Required if any non-neutral drips can be seen
CAMGeneral+PitMultiples	CAM corrosion model for no drips
B-Normal	Distribution for pit multiple
1.5, 0.25, 1.0, 1.0e6	Mean, StDev, Min, Max
[Neutral Drip Model, CRM]	Required if any non-neutral drips can be seen
CRMGenrate+ArrheniusPit	CRM corrosion model for drips
3, 1.e+6	Number of dists (temps), max CRM rate
25.	Temp appropriate for dist #1
File	Distribution type for #1
g8415050.cdf	Distribution parameter (s)
50.	Temp appropriate for dist #1
File	Distribution type for #1
g8425050.cdf	Distribution parameter (s)
100.	Temp appropriate for dist #2
File	Distribution type for #2
g8435050.cdf	Distribution parameter (s)
Normal	Distribution type for A (b0)
11.275, 2.4495	Distribution parameter(s)
Fixed	Distribution type for K (b1)
5.5494e+003	Distribution parameter(s)
Fixed	Distribution type for n
0.5	Distribution parameter(s)
[Neutral Drip Features]	Required if any non-neutral drips can be seen
File	Distr for thermal protection temperature
TThresh.cdf	Distribution parameter(s)

```
Uniform                    |Dist type for CRM LC T init
80., 100.                  |Distribution parameter
File                       |Dist type for humid-air initiation
HARH.cdf                   |Distribution parameter(s)
File                       |Dist type for humid-air/aqueous transition
AQRH.cdf                   |Distribution parameter(s)
1.0                        |RH correlation factor
0.0, 0.0                   |Galvanic protect depth %, % patches protected
0.0                        |Spalling depth as a % of thickness
Fixed                      |Dist for multiple for CAM corrosion rate
1.0                        |Distribution parameter(s)
Fixed                      |Dist for multiple for CRM corrosion rate
1.0                        |Distribution parameter(s)
1.0                        |Pack variance share for multiples
```

One should note that the "number of packs" on the fourth input file line after the last history file name is 400 for all of the input files, and that the sum of the "packs/history" (the first value on each line after the history file name) is 1 million (as the sum of the fractions of waste packages represented by each of the input histories (i.e., MZ_22_cf5_vent) was one and the total number of waste packages entered into Mkhistory was 1 million). In the case where the "number of packs" disagrees with the sum of the "packs/history," WAPDEG normalizes the "packs/history" to the "number of packs" based on the fraction of the sum of the entered "packs/history" for all histories used (i.e., the "packs/history" are normalized so that they sum to 400 (the "number of packs")).

To gain a deeper understanding of the WAPDEG code, refer to the Software Routine Report for WAPDEG (CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09)*). These input files are included in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000).

5.2. Procedure

Mkhistory was compiled with the Microsoft Developer's Studio 97 FORTRAN compiler. The program prompts the user for a list-file name (i.e., f07EZventLTA.mk). The Mkhistory program then prompts the user for the total number of waste packages to be considered. The user enters "0" to cause the default value of 1 million waste packages to be used.

To run the WAPDEG simulations on the Hewlett-Packard HP-UX 20 workstations, it is necessary to create a directory containing all the necessary input files as well as the program itself (i.e., WAPDEG version 3.09). First it is necessary to compile the code in Fortran 77 in order to make it executable. This is done by typing, f77 +O2 wap309.f -o wap309 on the UNIX command line. After compiling the program and importing all the above mentioned inputs, run the code by typing the name of the executable (in this case, wap309) on the UNIX command line and entering the name of the input file i.e., f07EZydLTA.inp.

The "raw" output from WAPDEG consists of six files: a *.out file, *.pat file, *.bin file, *.crm file, *.cam file, and *.aux file (where "*" is the input file name prefix). The content and format of these files are discussed in the WAPDEG version 3.09 Software Routine Report (CRWMS M&O 1998b. Section 4.1). These files are also included in the electronic media supporting this calculation

(CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000). Only the *.out (waste package failure curves), *.pat (cumulative number of patch penetrations for each failed waste package), and *.bin (cumulative number of pit penetrations for each waste package) files are used to create the RIP input tables.

In order to create the tables for input to RIP, Post308 is executed in a Windows-DOS window within the same directory as the output files from WAPDEG (i.e., *.bin, *.pat, *.out). The program prompts the user for the particular filename prefix that is common to the WAPDEG simulation output files to be post processed. After the program post processes the WAPDEG output, it prompts the user to enter a file name for the RIP input table to be created. The output from the post processor consists of three files: *.asc, *.dat, and the user-supplied RIP input table file name. The content and format of these files are discussed in the WAPDEG version 3.09 Software Routine Report (CRWMS M&O 1998b. Appendix D). These files are also included in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000).

6.0 Results

Since unqualified inputs were used in the development of the results presented in this section, they should be considered TBV. This document will not directly support any construction, fabrication, or procurement activity, and therefore, the inputs and outputs are not required to be procedurally controlled as TBV. However, any use of the data from this analysis for inputs into documents supporting construction, fabrication, or procurement is required to be controlled as TBV in accordance with appropriate procedures. Furthermore, this calculation makes use of software routines (WAPDEG version 3.09 and Post 308) that are unqualified (TBV-568).

The primary outputs of Mkhistory are the *.hst files used as input to WAPDEG. For reference the contents of MZ22cf2vent.hst are:

0.5	56.98	0.064034
1.0	57.35	0.063001
2.0	56.76	0.062032
5.0	55.08	0.066557
10.0	52.59	0.074919
15.0	50.37	0.082927
20.0	48.43	0.091162
25.0	46.69	0.098997
30.0	45.16	0.106988
35.0	43.76	0.114936
40.0	42.52	0.122495
45.0	41.41	0.129861
50.0	40.41	0.136883
60.0	38.71	0.149912
75.0	36.73	0.166764
99.0	34.52	0.188138
100.0	37.11	0.842718
110.0	63.84	0.948139
125.0	76.07	0.971175
150.0	85.75	0.999995
175.0	91.47	0.999997
200.0	95.11	0.990592

233.0	97.46	0.984834
266.0	97.56	0.982516
300.0	97.57	0.981543
450.0	97.33	0.984569
500.0	97.23	0.986186
550.0	97.13	0.987774
600.0	97.03	0.989756
700.0	96.88	0.992160
800.0	96.77	0.993909
900.0	96.70	0.995018
1000.0	96.64	0.996040
1100.0	96.60	0.996673
1200.0	96.56	0.997281
1300.0	96.52	0.997834
1600.0	96.43	0.999025
1800.0	96.40	0.999338
2000.0	96.38	0.999690
2500.0	96.31	1.000000
4000.0	83.46	0.999995
5000.0	76.85	0.999993
6000.0	71.56	0.999992
7000.0	67.23	0.999991
7990.0	63.58	0.999990
8990.0	60.55	0.999990
10000.0	58.03	0.999989
15000.0	47.98	0.999988
20000.0	42.03	0.999988
30000.0	34.43	0.999987
40000.0	30.46	0.999987
80000.0	24.63	0.999987
100000.0	23.55	1.000000

The other outputs of Mkhistory are appended to the *.mk files and consist of the history file input segment (i.e., all the text in the input file lines from "8 |Number of alternate histories" to "71429, 0., 0. |packs/history, T std, RH std"), documentation of the sum of the fraction and total number of waste packages represented by each history, and a text segment that could be used to graph all of the histories processed. These files are contained in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*).

The RIP input tables for the LADS analysis of the effects of pre-closure ventilation were created from WAPDEG version 3.09 and post processed by Post308 and are contained in the electronic media supporting this calculation (CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation"*) (DTN: MO9904MWDWAP45.000). The RIP input tables have the same prefix name as the corresponding input files with a *.rip extension. Their formatting as a multidimensional lookup-table is discussed in the RIP - Theory Manual and User's Guide (Golder Associates 1998. pp. 7-22 through 7-25).

For reference the RIP input table f07MZydLTA.rip (DTN: MO9904MWDWAP45.000) is shown below.

```
! From wapdeg file: f07MZydLTA
! From wapdeg version: 3.09
! Postprocessor: post308
```

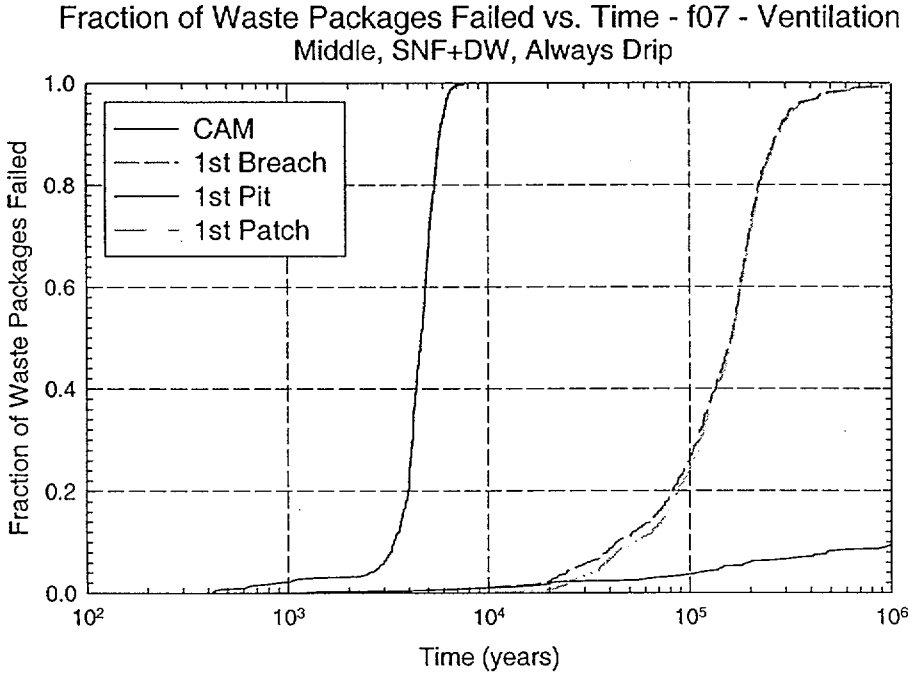
```
! f07MZydLTA.inp
! Middle Zone  Continuous Pre-closure Ventilation histories
! always drip, 100%, feature 07  LADS 10/10/98 B Bullard
! Uncertainty/Variability=50/50 drip, 50th Quantile
!
! START OF PARAMETERS
 2
 3  82
 1   2   3
          0.0000
       1243.5146
       4407.4554
      15135.3858
      22282.6896
      25570.3945
      29724.2873
      34901.4069
      38688.6829
      41697.9902
      47094.2203
      53413.5073
      58566.7462
      64217.1602
      69595.9464
      74140.8504
      78079.3119
      81286.6429
      85125.0859
      88614.9906
      91735.1926
      95503.4780
      99434.2442
     102921.7579
     105319.1137
     109027.4808
     112201.8454
     114158.2219
     117494.9465
     120226.4435
     122322.7386
     125898.1035
     129570.8165
     134133.1047
     138038.4265
     139636.8361
     142895.7091
     147064.2781
     150489.8452
     153995.2040
     157582.2131
     161252.7744
     165008.8340
     167880.4018
     169824.3652
     171790.8387
     173780.0829
     176810.1512
     179887.0915
     181970.0859
     184077.2001
```

186208.7137		
188364.9089		
190546.0718		
192752.4913		
194984.4600		
197242.2736		
199526.2315		
201836.6364		
204173.7945		
206538.0156		
208929.6131		
211348.9040		
216281.4079		
221309.4710		
223872.1139		
227775.5980		
231739.4650		
235780.1260		
241272.1507		
249767.5290		
258527.7673		
264549.6526		
272282.1605		
281850.7456		
290072.9259		
302035.2022		
316241.7379		
337016.4474		
396694.8738		
530461.8226		
1000000.0000		
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0056	1.6272	0.0021
0.0166	1.7753	0.1982
0.0328	1.3920	0.4450
0.0467	1.1308	0.6358
0.0569	0.9272	0.8895
0.0690	0.8352	1.2350
0.0819	0.7437	1.3725
0.0934	0.6927	1.4864
0.1081	0.6429	1.5908
0.1218	0.5825	1.7919
0.1330	0.5546	1.9451
0.1424	0.5293	2.0770
0.1588	0.5041	2.1220
0.1719	0.4742	2.3690
0.1845	0.4609	2.6039
0.1945	0.4456	2.7844
0.2105	0.4158	2.9506
0.2246	0.3896	3.1272
0.2323	0.3874	3.2603
0.2478	0.3868	3.3730
0.2608	0.3836	3.7793
0.2734	0.3840	4.0685
0.2852	0.3900	4.2027
0.2947	0.4092	4.5143
0.3176	0.4172	4.5421
0.3218	0.4233	4.6914
0.3351	0.4301	4.9479

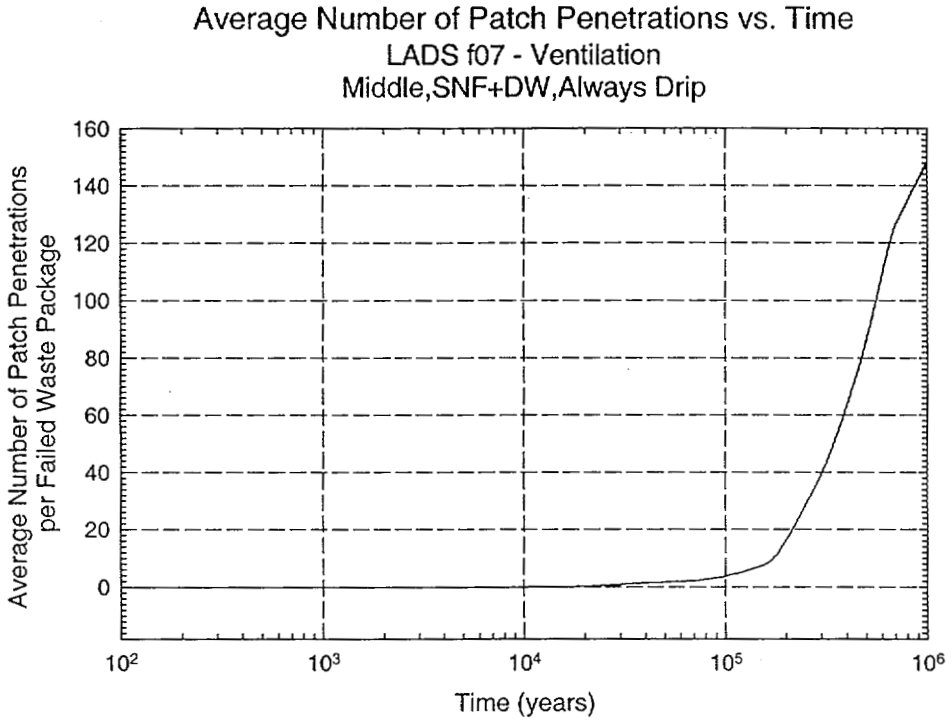
0.3511	0.4486	5.0986
0.3576	0.4961	5.2536
0.3703	2.2336	5.5611
0.3870	0.3488	5.8388
0.3985	0.3715	6.2082
0.4256	0.3935	6.3727
0.4291	0.4020	6.5604
0.4332	0.4577	6.8326
0.4477	0.6751	7.0910
0.4578	0.3959	7.3960
0.4746	0.4161	7.5934
0.4857	0.4607	7.9473
0.4964	0.5986	8.3636
0.5154	0.9791	8.8273
0.5274	0.5736	9.2158
0.5451	0.8898	9.4159
0.5575	0.4126	9.7224
0.5637	0.7051	10.1864
0.5829	0.2982	10.8006
0.6086	0.2917	11.2105
0.6180	0.2953	11.6795
0.6280	0.3026	12.2062
0.6324	0.3162	12.8713
0.6492	0.3235	13.3789
0.6577	0.3345	14.0193
0.6714	0.3500	14.5526
0.6843	0.3909	15.1074
0.6963	0.4811	15.6515
0.7100	5.7888	16.1482
0.7181	0.3934	16.6937
0.7264	0.4612	17.2913
0.7415	0.6440	17.7309
0.7482	0.8654	18.3638
0.7609	0.2661	18.9380
0.7741	0.2799	20.2844
0.8016	0.2932	21.3335
0.8047	0.3107	22.1081
0.8120	0.3294	23.2478
0.8278	0.3685	24.0977
0.8338	0.4691	25.0968
0.8457	0.7827	26.4434
0.8579	0.6617	28.5809
0.8728	0.3437	30.5305
0.8848	0.4841	31.7540
0.8971	0.5336	33.3897
0.9093	0.5009	35.5141
0.9220	0.7652	37.2830
0.9311	0.3260	40.0591
0.9450	0.3747	43.2330
0.9534	0.7961	48.1155
0.9660	0.8504	62.2716
0.9826	0.8673	93.2621
0.9975	0.5363	147.9148

The RIP input table consists of a column of times in years (the first single column of data) followed by three columns consisting of the fraction of waste packages failed, the number of pit penetrations per failed waste package, and the number of patch penetrations per failed waste package. These last three columns all share the same time grid (the first single column of data).

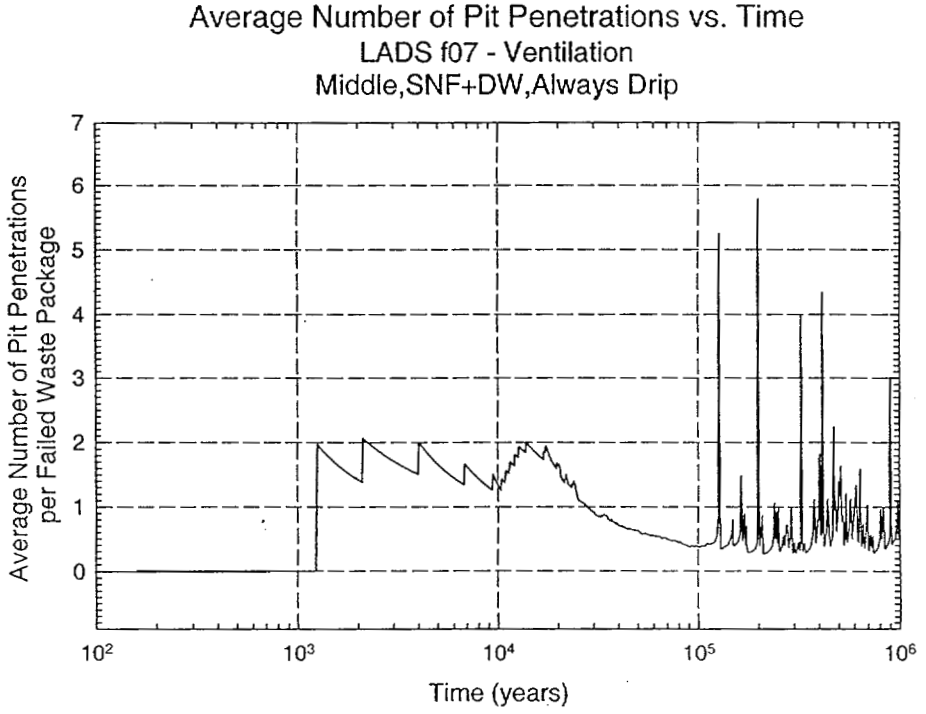
Below is a graph (derived from the f07MZydLTA.dat file) of the first breach (by either patch penetration or pit penetration) curves of both the CAM (outer carbon steel) and CRM (inner Alloy 22) layers, and the first patch penetration and first pit penetration curves of the CRM inner layer for the dripping (f07MZydLTA.inp) case:



Below is shown a graph of the average number of patch penetrations per failed waste package (derived from the f07MZydLTA.asc file):



Below is shown a graph of the average number of pit penetrations per failed waste package (also derived from the f07MZydLTA.asc file):



The first breach curve for the CRM and the average number of patch penetrations and average number of pit penetrations per failed waste package curves are also represented in the RIP input table, f07MZydLTA.rip.

7.0 References

CRWMS M&O 1998a. *Total System Performance Assessment-Viability Assessment (TSPA-VA) Analyses Technical Basis Document - Chapter 5, Waste Package Degradation Modeling And Abstraction.* B00000000-01717-4301-00005 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981008.0005. DTN: MO9807MWDWAPDG.000.

CRWMS M&O 1998b. *Software Routine Report for WAPDEG (Version 3.09).* CSCI: 30048 V3.09. DI: 30048-2999 REV 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981012.0224.

CRWMS M&O 1998c. *Software Routine Report for Mkhistory (Version 1.00).* CSCI: 30080 V1.00. DI: 30080-2999 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981202.0194.

CRWMS M&O 1998d. *Creating Input Tables from WAPDEG for RIP.* B00000000-01717-0210-00013 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981110.0431. DTN: MO9810SPA00013.000.

CRWMS M&O 1998e. *Cumulative Distribution Functions for the Temperature Threshold for the Onset of Carbon Steel Corrosion.* B00000000-01717-0210-00015 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980603.0253. DTN: MO9810SPA00013.000.

CRWMS M&O 1998f. *Cumulative Distribution Functions for the Relative Humidity Thresholds for the Onset of Carbon Steel Corrosion.* B00000000-01717-0210-00016 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980603.0257. DTN: MO9810SPA00013.000.

CRWMS M&O 1998g. *Cumulative Distribution Functions for No Drip Corrosion Resistant Material General Corrosion Model.* B00000000-01717-0210-00012 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980715.0174. DTN: MO9810SPA00013.000.

CRWMS M&O 1998h. *Cumulative Distribution Functions for the Dripping Case of the Corrosion Resistant Material General Corrosion Model.* B00000000-01717-0210-00014 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980831.0012. DTN: MO9810SPA00013.000.

CRWMS M&O 1998i. *Supporting Media for "RIP Input Tables From WAPDEG For LA Design Selection: Continuous Pre-Closure Ventilation".* PC-format CD-ROM. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981209.0318. DTN: MO9904MWDWAP45.000.

Dunlap, 1999. *Thermal-Hydrology Modeling of the Pre-Closure Ventilation Alternative Designs.* DTN: MO9903MWDTHM56.000. CRWMS M&O. Las Vegas, Nevada.

Golder Associates 1998. *RIP Integrated Probabilistic Simulator for Environmental Systems, Theory Manual and User's Guide.* Redmond, Washington: Golder Associates. TIC: 238560.

8.0 Attachments

N/A.