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1. PURPOSE

The criticality consequence analysis for pressurized water reactor (PWR) waste packages (WP) (Civilian Radioactive Waste Management System [CRWMS] Management and Operating Contractor [M&O] 1997) focused on results obtained by maximizing postulated rates of reactivity insertion to assure no synergistic reactions could occur among waste packages from hypothetical criticality events. Other variables potentially influencing the criticality consequences were held constant during the above referenced analysis. One of those variables that may affect results is the exit area of the leakage paths from the WP. If the leakage area through the WP wall is sufficiently small, inflow rates will be restricted; lengthening the time required for flooding the WP and thus delaying potential criticality events, which require flooded conditions. However, if a criticality event does occur, a limited leakage area will reduce the exit flow volume. The immediate effect on the system from a limited leakage area is to reduce the negative reactivity effect of voiding the WP because the water/vapor escape rate may be lowered. This, in turn, leads to higher heat output, higher internal pressure, and higher temperatures. The higher pressure and density of the water vapor will increase the mass flow out of the waste package, so that eventually the negative reactivity from voiding the system becomes dominant, and the criticality event shuts down.

The purpose of this calculation is to determine the relation between reduction in the leakage area and possible increases in peak pressures and temperatures for such hypothetical criticality events. This calculation was performed under the AP3.12Q Revision 0, ICN 0 Procedure and will support WP design and analysis activities.

2. METHOD

The method for analyzing criticality consequences involving intact PWR spent nuclear fuel (SNF) in a degraded WP has been documented previously (CRWMS M&O 1997). The same methodology was followed for calculations to determine the sensitivity to variations in the rate of reactivity addition and to variations in the leakage area of the WP to the external drift of WP parameters important for assessing criticality consequences. The analysis deck from the initial consequence analysis was used as the basis for this calculation with parameters varied to determine their effect. The light water reactor (LWR) transient analysis code, RELAP5/MOD3.2 (NRC 1995a) was used to calculate the time evolution of the power level and other characteristics of a criticality event involving PWR SNF. The calculation was performed for time scales corresponding to a rapid reactivity insertion rate of 0.158 \$/s and a much slower rate of 0.0004 \$/s. The maximum insertion rate was derived from the time required (\cong 90 seconds) for a spherical particle of Fe_2O_3 to fall one meter in water at a Reynolds number of \cong 1.0 (CRWMS M&O 1997, Attachment III, Spreadsheet RLP5GEOM-1.xls, Sheet "Non-Fuel Vol"). This time provides an upper bound on the rate that reactivity in the WP can be increased through absorber redistribution. The low reactivity insertion rate approximates a more likely gradual shift in conditions conducive to criticality. The simulated criticality event is driven, in each case, by a linear rate of reactivity insertion up to a maximum of 14.18 \$ (CRWMS M&O 1997, Section 7) and held constant thereafter. Consequences of a transient criticality event are

evaluated in terms of the capacity of the WP to remain in a safe condition after such a hypothetical event.

ASSUMPTIONS

No additional assumptions beyond those given in the referenced consequence analysis (CRWMS M&O 1997, Section 4.3) were necessary for this calculation.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE APPROVED FOR QUALITY ASSURANCE (QA) WORK

4.1.1 RELAP5/MOD3.2

Title: RELAP5/MOD3.2

Version/Revision Number: V1.0

The transient simulation of criticality events is performed using the transient thermal-hydraulic code RELAP5/MOD3.2 (U.S. Nuclear Regulatory Commission (NRC) 1995a, NRC 1995b, CRWMS M&O 1999b, CRWMS M&O 1999c, CRWMS M&O 1999d, CRWMS M&O 1999e, CRWMS M&O 1999f, CRWMS M&O 1999g). RELAP5/MOD3.2 was developed for the U.S. Nuclear Regulatory Commission for simulations of operational transients in PWR systems such as loss of coolant. The transient criticality events involving PWR SNF within a waste package are similar to the situations for which RELAP5/MOD3.2 was developed to analyze. The software specifications are as follow:

- Software name: RELAP5/MOD3.2
- Software version/revision number: Version V1.0
- Software activity number: LV-1999-047
- Software tracking number: 10091-1.0-00
- Software media number: 10091-MED-1.0-00
- Computer type: Hewlett Packard (HP) 9000 Series Workstations
- Computer processing unit number: Software is installed on the (CRWMS M&O) workstation Bloom.

The RELAP5/MOD3.2 software used is: (a) appropriate for the application of WP transient criticality consequence calculations, (b) used within the range of the software validation, (c) and obtained from the Software Configuration Secretariat in accordance with appropriate procedures.

4.2 SOFTWARE ROUTINES

4.2.1 Excel

Title: Excel

Version/Revision Number: Microsoft Excel 97

The Excel spreadsheet program was used to generate graphical representations of various parameters calculated by RELAP5/MOD3.2 and to identify maximum values. No additional calculations were performed on the data files.

4.2.2 Strip

Title: Strip

Version/Revision Number: V00

The RELAP5/MOD3.2 program writes two files as output:

- (1) A formatted print file containing "major edits" at specified times.
- (2) A binary "restart" file to enable a case to resume.

The RELAP5/MOD3.2 code also has an option to collect minor edits (a history of particular variables) at each time point from the restart file and put them into a formatted strip file. The FORTRAN-90 program, "Strip", reads a RELAP5/MOD3.2 strip file and writes the information in a series of more compact files for use in later analysis. The output of the code can be readily checked against the strip files by visual inspection. The source code with sample input and output files are included in Attachment II. The source and executable code are included as part of the electronic data on a compact disk (CD) (CRWMS M&O 1999a).

4.3 MODELS

There were no models used in this calculation.

5. CALCULATION

As stated in Section 1, the purpose of this calculation is to determine the relation between reduction in the WP leakage area and increase in peak pressure and temperature for hypothetical criticality events. The calculation was performed for hypothetical criticality events where a reactivity insertion rate of 0.158 \$/s was used to approximate the maximum rate of change in the available reactivity due to absorber redistribution within the WP and a much slower insertion rate of 0.0004 \$/s to approximate a gradual shift in the system reactivity.

The basic RELAP5/MOD3.2 analysis input file from the initial consequence analysis (CRWMS M&O 1997, Attachment IV, CD file c103cbas.dk) was used for this calculation and is listed in Attachment III of this document. The area of the junction component (RELAP5 nomenclature) exiting the WP (Junction Label: J250) was varied for this calculation. Transport options set for this junction were homogeneous flow without momentum flux as recommended (NRC 1995b, p. 2-11).

The RELAP5/MOD3.2 reactivity consequence input data contained two void reactivity descriptions, one based on the change in the criticality factor, k_{eff} , with total WP density variations and the second based on MCNP calculations of k_{eff} versus decreasing water level in the WP. The k_{eff} versus water level data was used for the original analysis since this method of calculating void reactivity feedback conservatively did not activate until there was sufficient vapor generation in the WP to cause pressurization and subsequent voiding of the WP. Expected results from decreasing the exit junction area were an increase in pressure, delaying or possibly suppressing the void formation (and the subsequent WP inventory loss) necessary to terminate the criticality event. Thus, the k_{eff} versus water level method of calculating feedback reactivity was considered overly conservative for this calculation and the WP density reactivity data were used instead. To identify differences between calculations using the two reactivity feedback representations, results from this calculation are compared with the original consequence case (Cases: r5wp2d.c103c and c103x1hbv.test; Excel file: c103xmdl.xls, Sheet: "Conseq-vs-Sens.pr", "c103x1hbv.dat", and "c103c.dat"). The pressures calculated from these two cases are shown in Figure 5-1. Maximum values from the two cases are of the same order although the shapes differ. The fission energy generated using the density reactivity feedback data was slightly greater than that generated using the water level reactivity data (5.05E+07 J versus 4.95E+07 J at 20 seconds).

Unqualified data were used in the development of the results presented in this section.

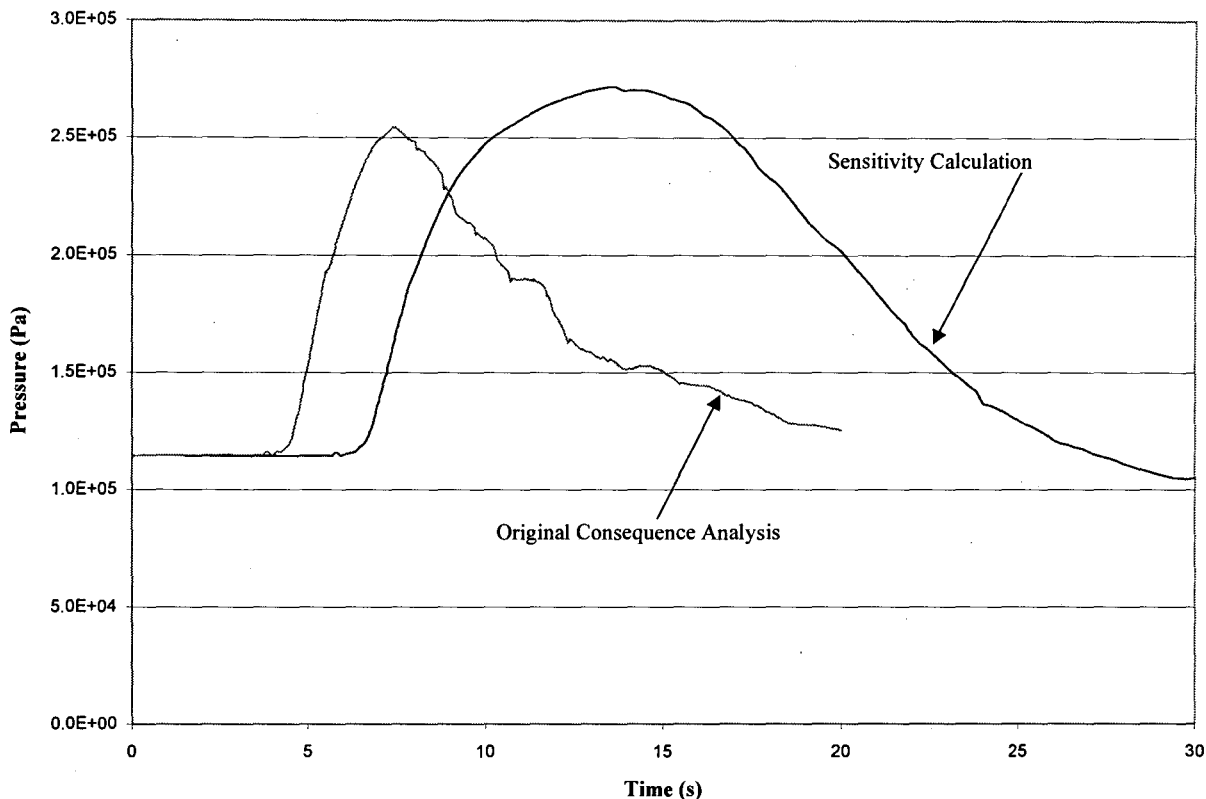


Figure 5-1. Pressure Response from Reactivity Consequence Analysis and Sensitivity Calculation for 100-cm² Junction Area

Frictional effects are important in the hydraulic calculations to maintain computational stability. These effects were simulated in the basis RELAP5/MOD3.2 representation of WP volumes containing SNF by applying loss coefficients in the connecting junctions. Frictional effects in other volumes were simulated allowing choked flow in their connecting junctions since relatively high pressures and mass flow rates were expected. Much lower pressures and mass flow rates were expected to occur during this sensitivity study with correspondingly minimal choking effects expected, especially for the cases with the low reactivity insertion rate. Thus, frictional effects in these junctions were simulated with loss coefficients, also. A value of 20 was used for these loss coefficients, based primarily on maintaining computational stability, but results from these calculations were not expected to be sensitive to the exact value. Doubling the value of the loss coefficients and comparing results checked the sensitivity of results to the value of the loss coefficient (Cases: r5wp2d.c230d and r5wp2d.c230d1; Excel File: c230junx.xls, Sheet "c230d.dat"). As shown in Figure 5-2 for volume pressure and in Figure 5-3 for the WP moderator inventory, results were insensitive to the loss coefficient value.

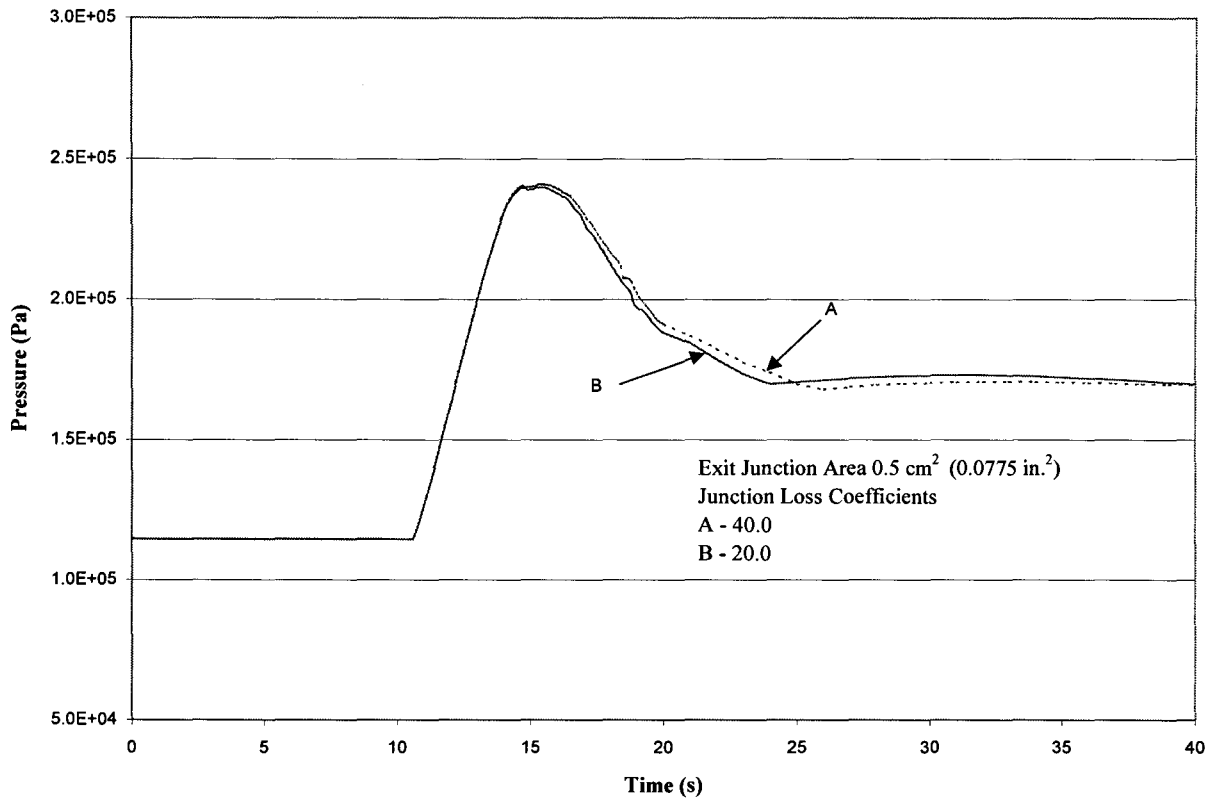


Figure 5-2. Sensitivity of WP Pressure to Loss Coefficient Value in Moderator Volumes

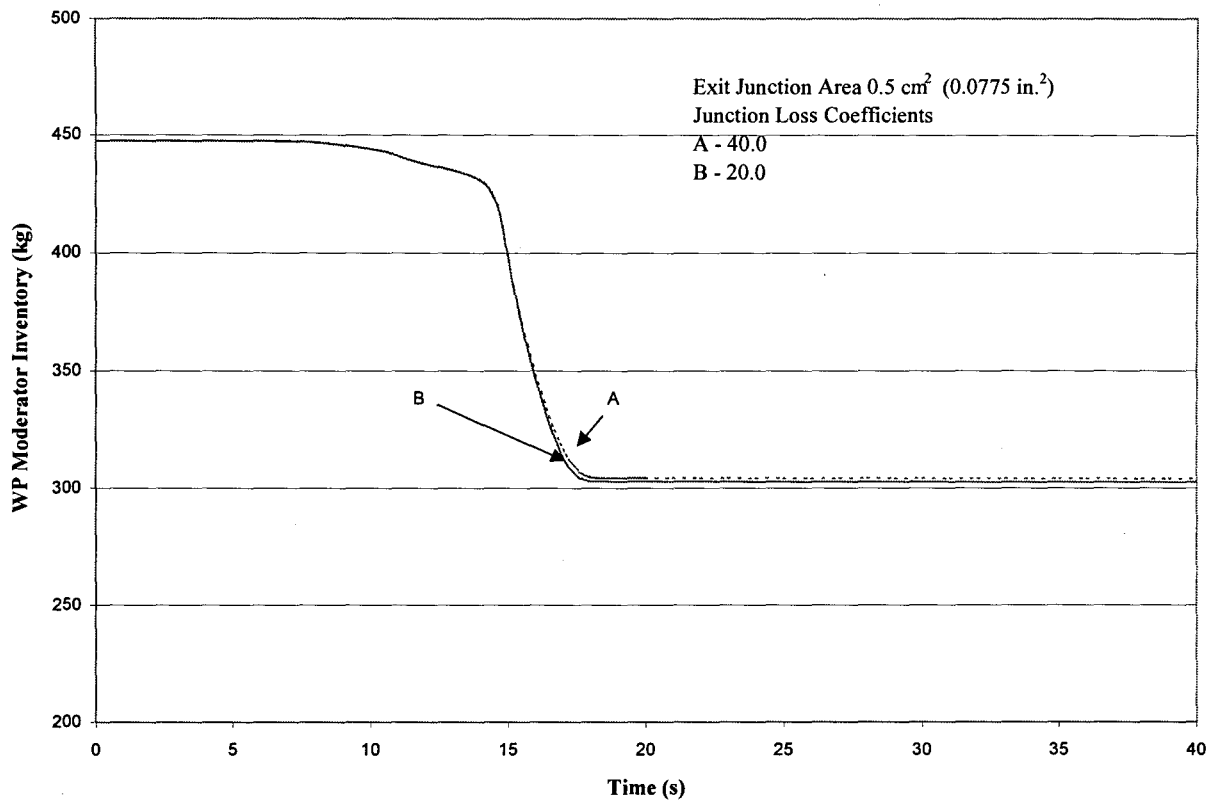


Figure 5-3. Sensitivity of WP Moderator Inventory to Loss Coefficient Value in Moderator Volumes

RELAP5/MOD3.2 input data parameters in this calculation modified from the basis calculation are listed in Table 5-1.

Table 5-1. RELAP5/MOD3.2 Parameters Modified for Sensitivity Calculation

Parameters	Options	Value Used
WPexit junction area (cm ²)	Variable	0.1 - 10.0, 100.0
Loss coefficients for interior junctions	Variable	40, 20
Transport equation in exit junction	Momentum flux (a) On (b) Off	Off
Choked flow calculation for exit junction	(a) Homogeneous (b) Non-equilibrium	Homogeneous
Void reactivity calculation	(a) k _{eff} versus liquid level (b) k _{eff} versus WP density	k _{eff} versus WP density

6. RESULTS

The criterion for determining where the exit junction area becomes influential in criticality consequences is where the exit mass flow becomes sufficiently restricted to limit the contribution of the void reactivity in terminating the event due to moderator mass loss. The initial power rise in criticality events with large reactivity insertion rates is halted by the Doppler reactivity feedback with significant void or density reactivity feedback (ultimately from voiding the WP) required to completely terminate the criticality (CRWMS M&O 1997, Section 7). As the exit junction area is decreased sufficiently, the exit mass flow rate becomes restricted, resulting in higher pressures and temperatures, which partially determine criticality consequences (CRWMS M&O 1997, Section 7). For sufficiently slow events, where the Doppler and moderator density reactivity feedback effects can terminate the criticality event without the necessity of a large void generation due to boiling (with subsequent moderator mass loss from internal pressurization), varying the exit junction area has little effect on the criticality consequences since internal pressures and exit flow rates remain low.

Unqualified data were used in the development of the results presented in this section.

6.1 RAPID REACTIVITY INSERTION RATE

A series of cases having a rapid reactivity insertion rate were run with decreasing exit junction area as a variable parameter. The reactivity insertion rate for these cases was 0.158 \$/s corresponding to the maximum reactivity of 14.18 \$ (CRWMS M&O 1997, p. 28) added in 90 seconds. As expected, peak values of the system pressure and fuel temperature were insensitive to the junction area until the exit flow area was decreased to sufficiently small values. The results for these variables are summarized in Table 6-1 (Excel File c230junx.xls: Sheet "Summary") with the pressure variation shown in Figure 6-1 and the temperature variation shown in Figure 6-2.

Table 6-1. Maximum Temperature and Pressure Values for a Reactivity Insertion Rate of 0.158 \$/s

Exit Junction Area (cm ²)	Temperature		Pressure	
	(K)	(°F)	(Pa)	(psi)
10.0	437.3	327.5	1.326E+05	19.2
5.0	437.3	327.5	1.326E+05	19.2
1.5	437.3	327.5	1.405E+05	20.4
0.5	437.4	327.7	2.399E+05	34.8
0.375	440.5	333.2	4.005E+05	58.1
0.25	505.9	451.0	1.951E+06	283.0

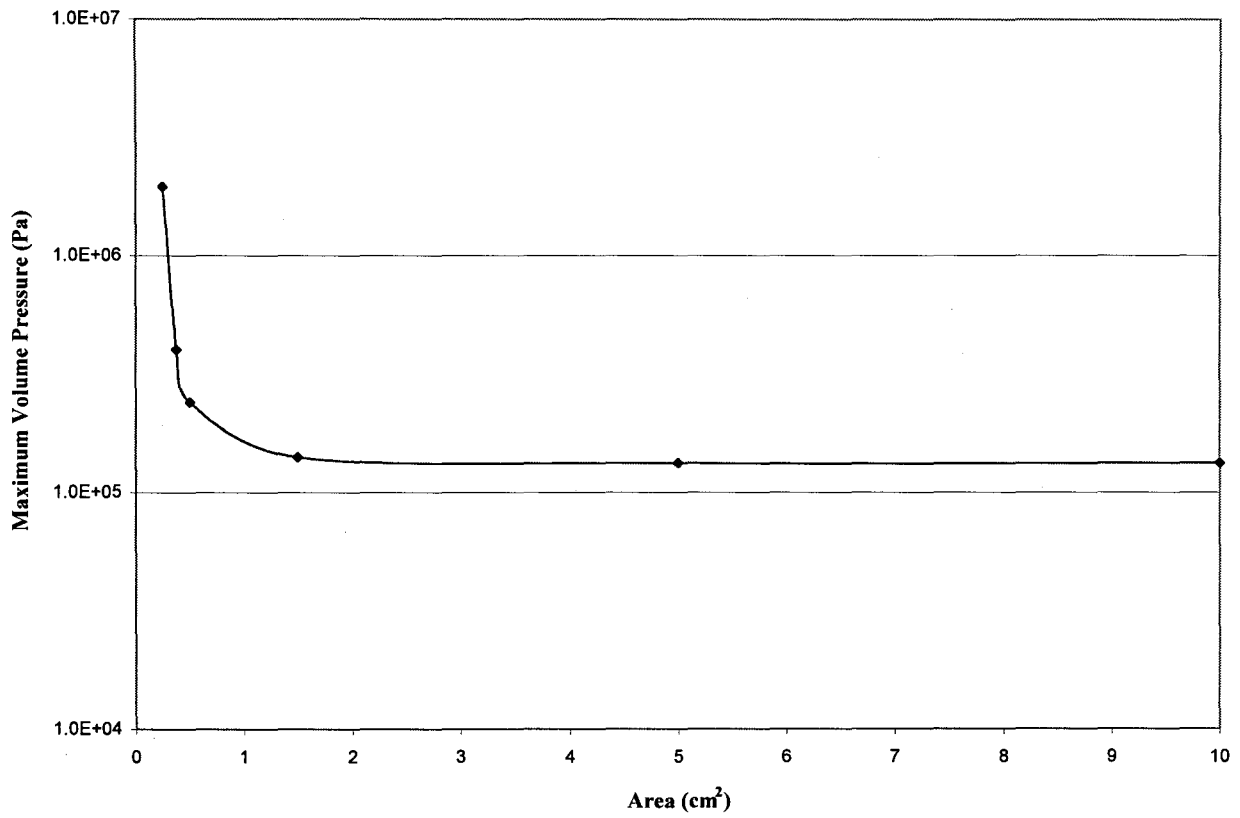


Figure 6-1. Peak WP Pressures versus WP Egress Junction Area for 0.158-\$/s Reactivity Insertion Rate

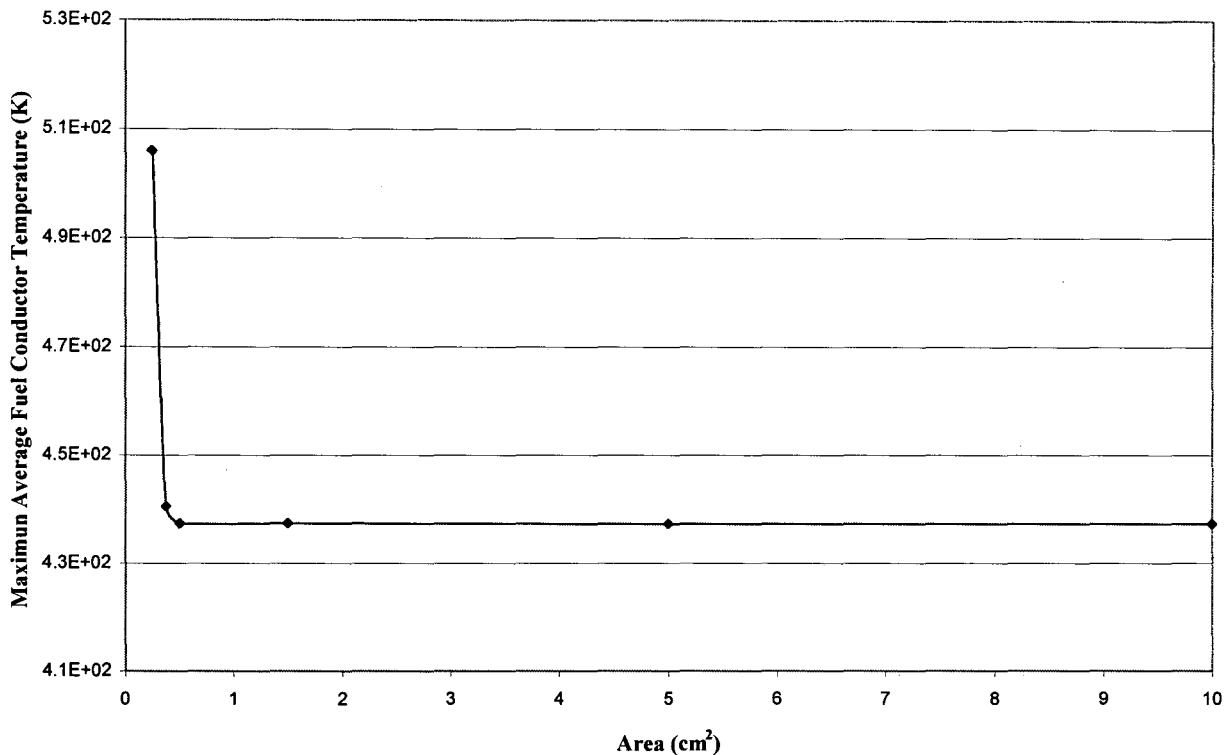


Figure 6-2. Peak Average Fuel Temperature for SNF versus WP Egress Junction Area for 0.158- $\$/s$ Reactivity Insertion Rate

Detailed histories for a number of parameters affecting the criticality consequences are shown in Figures 6-3 through 6-9 with the exit junction area as a parameter (Case IDs: r5wp2d.c230a, r5wp2d.c230b, r5wp2d.c230c, r5wp2d.c230d, r5wp2d.c230f, and r5wp2d.c230e, respectively). In each case, the pressures and temperatures reached maximum values prior to ending the calculation. Figure 6-3 (Excel file: c230junx.xls; Sheet "V150-pres") shows the pressure histories for a representative (since variation in parameter values among components was small) interior volume of the WP and Figure 6-4 (Excel file: c230junx.xls; Sheet "Cond080-Temp") shows the temperature histories for a representative SNF assembly. Figure 6-5 (Excel file: c230junx.xls; Sheet "Norm-Powr") shows the fission power for the various cases; Figure 6-6 (Excel file: c230junx.xls; Sheet "WP-Inventry") shows the WP moderator inventory; and Figure 6-9 (Excel file: c230junx.xls; Sheet "Jun250-W") shows the exit junction mass flow rates. Figure 6-7 (Excel file: c230junx.xls; "Sheet c230a- $\$/s$ -Cmp") and Figure 6-8 (Excel file: c230junx.xls; Sheet "c230f- $\$/s$ -Cmp") show reactivity components for exit junction areas of 10.0 cm² and 0.375 cm², respectively. The increase in magnitude of the void reactivity components correlates with the decrease in the respective WP fluid inventories.

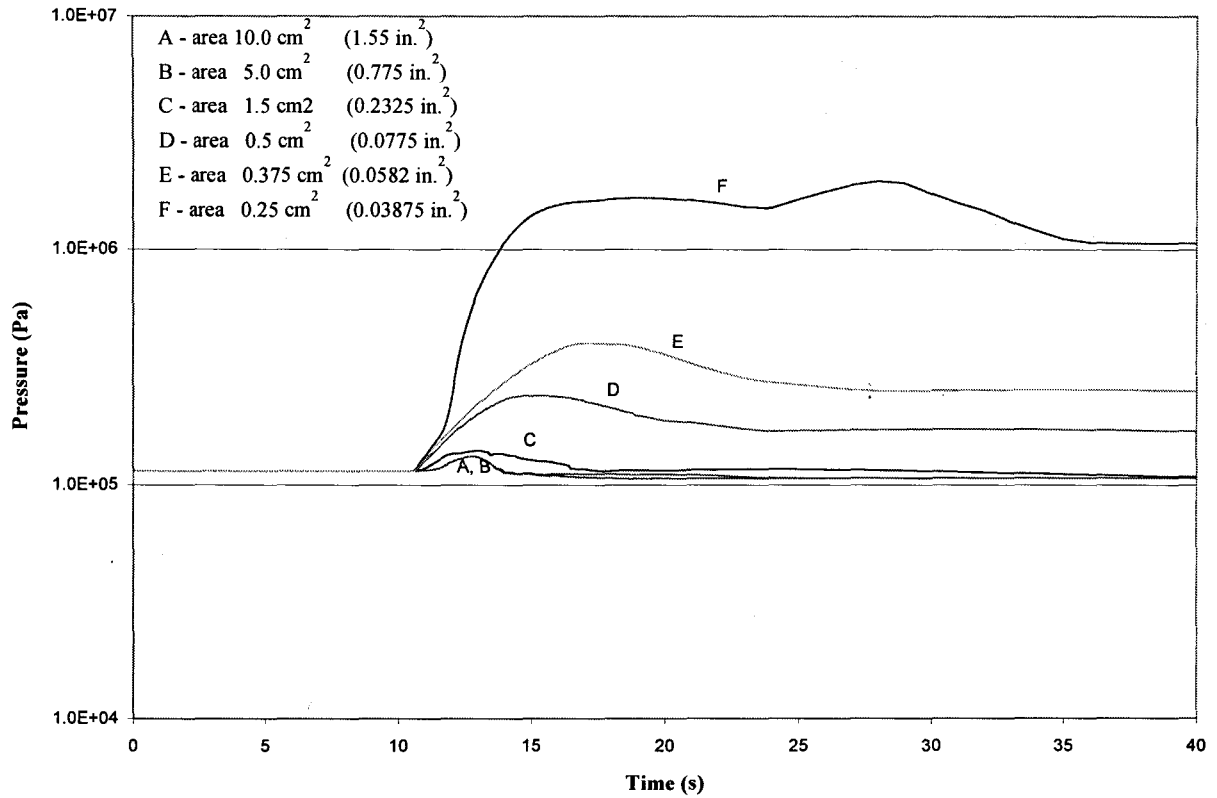


Figure 6-3. WP Pressure Histories for a Range of Egress Junction Areas for 0.158-\$/s Reactivity Insertion Rate

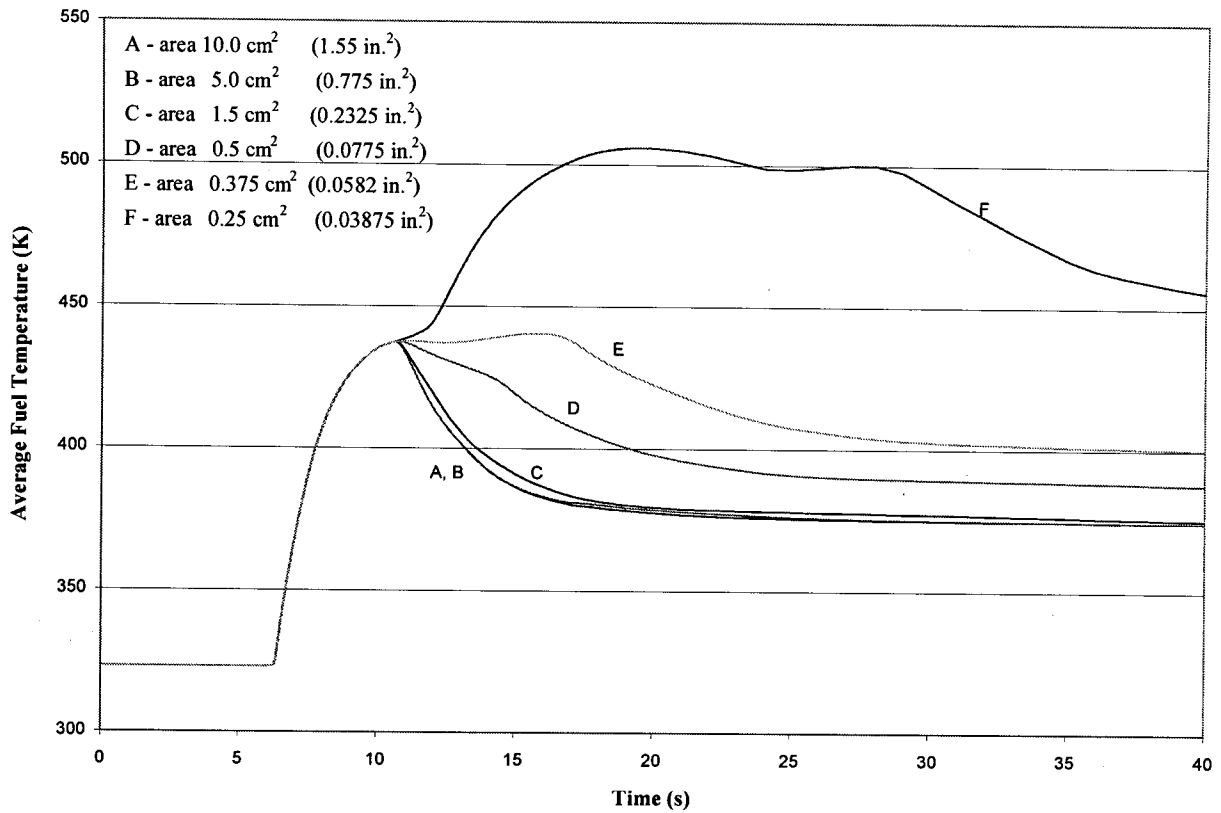


Figure 6-4. Fuel Temperature Histories for 0.158-\$/s Reactivity Insertion Rate Parameterized by Egress Junction Area

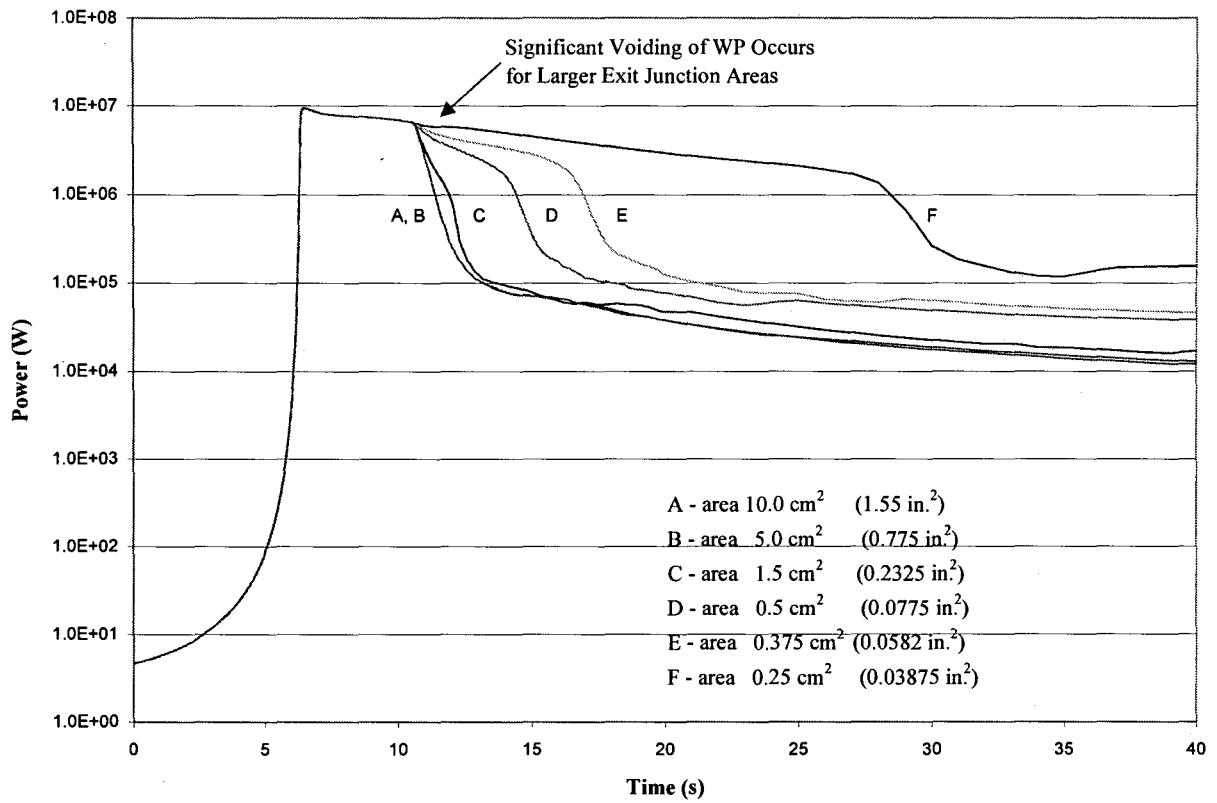


Figure 6-5. Fission Power Histories for 0.158- β /s Reactivity Insertion Rate Parameterized by Egress Junction Area

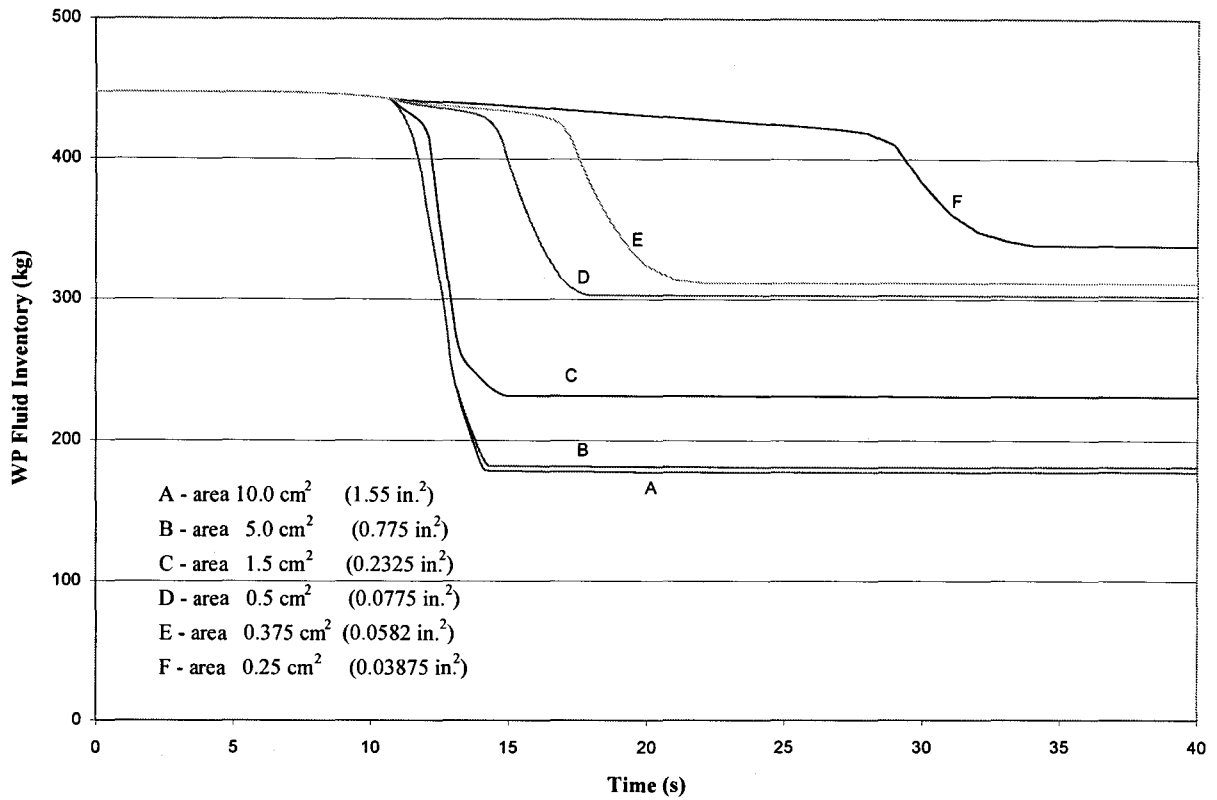


Figure 6-6. WP Moderator Inventory Histories for 0.158- $\$/s$ Reactivity Insertion Rate Parameterized by Egress Junction Area

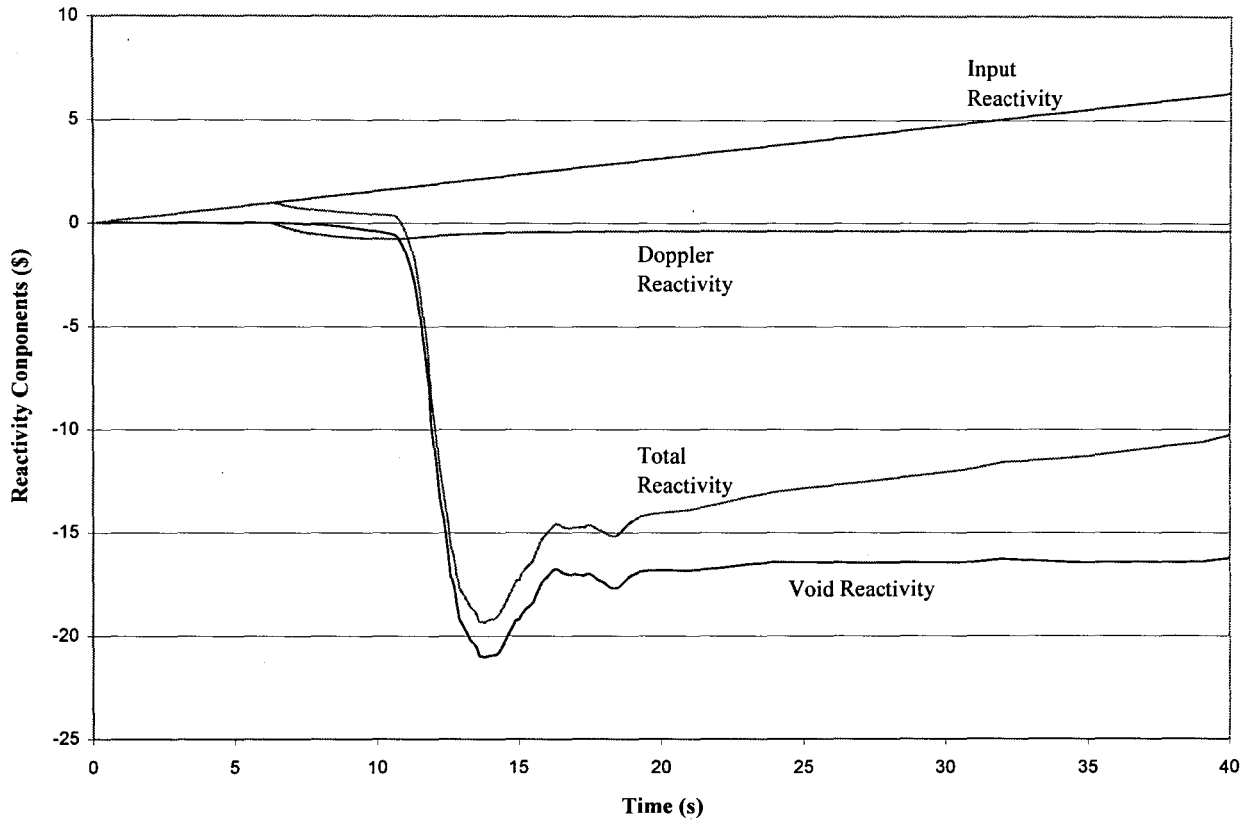


Figure 6-7. Reactivity Component Histories for 0.158-\$/s Reactivity Insertion Rate with 10.0-cm² Egress Junction Area

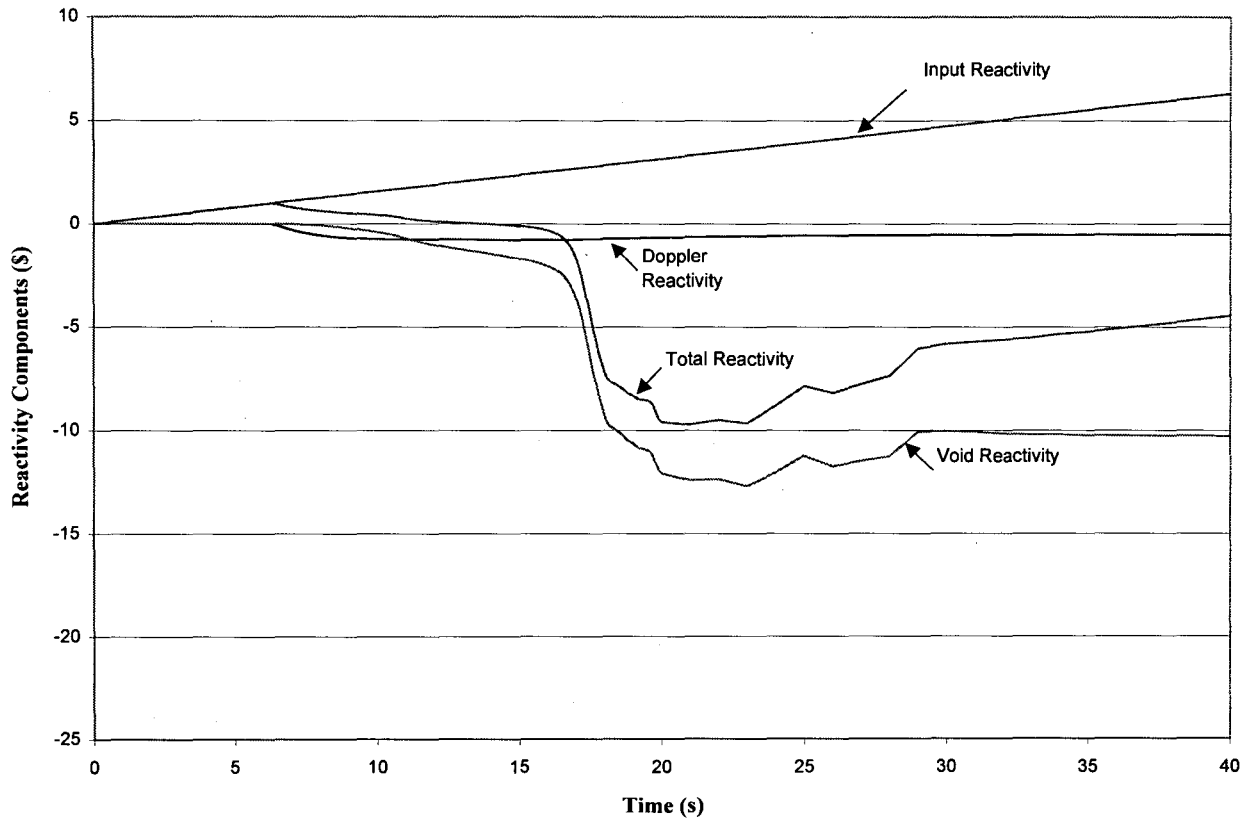


Figure 6-8. Reactivity Component Histories for 0.158-%/s Reactivity Insertion Rate with 0.375-cm² Egress Junction Area

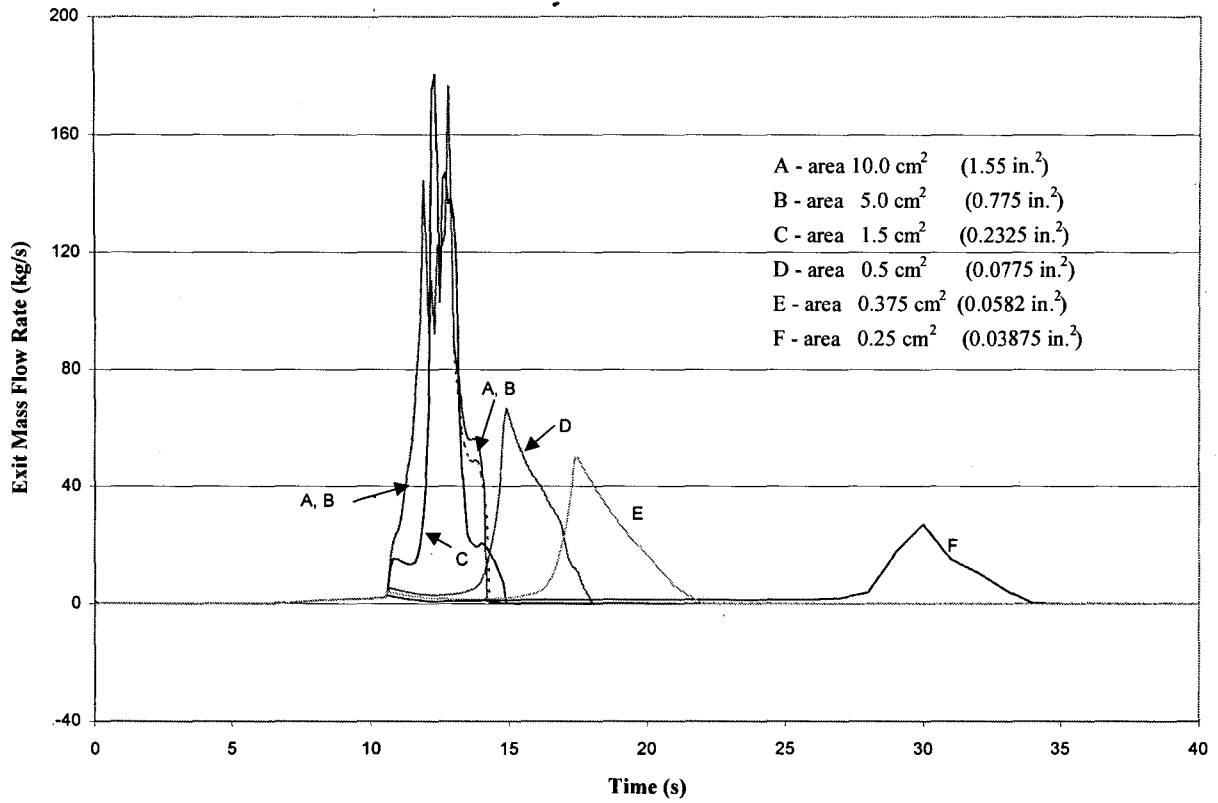


Figure 6-9. WP Egress Junction Mass Flow Rate Histories for 0.158- $\$/s$ Reactivity Insertion Rate Parameterized by Egress Junction Area

6.2 SLOW REACTIVITY INSERTION RATE

The slow criticality event evaluated for exit area sensitivity used the PWR SNF basis WP description (CRWMS M&O 1997) with a reactivity addition rate of 0.0004 $\$/s$. Junction areas for these cases ranged from 5.0 cm^2 to 0.1 cm^2 (Case IDs: r5wp2d.c221a, r5wp2d.c221a, r5wp2d.c221b, r5wp2d.c221c, r5wp2d.c221d, r5wp2d.c221e, and r5wp2d.c221f, respectively). No discernable differences are apparent in the results from these cases as shown in Figures 6-10 through 6-15. These figures include only the results from cases having the largest and smallest exit junction area (Excel file: c230junx.xls, Sheet "C221a.data" and "C221f.data") as results from the intermediate area cases were essentially identical. Thus, for this slow reactivity insertion rate, the exit junction area had no effect on the results. The negative reactivity from the change in fuel temperature and bulk density was sufficient to compensate the slow reactivity rate without vapor generation as shown in Figure 6-10 where the maximum SNF assembly fuel temperatures are below the vaporization level. Differential pressure histories associated with the corresponding temperature histories are shown in Figure 6-11. Differential values are shown since the change in pressure is small with respect to the absolute pressure. The normalized fission power history is given in Figure 6-12; the WP moderator inventory history in Figure 6-13; the reactivity components in Figure 6-14, and the exit junction mass flow rates in Figure 6-15. The total reactivity in these cases oscillates around zero (Figure 6-14) with the void reactivity gradually increasing as the moderator inventory decreases (Figure 6-13).

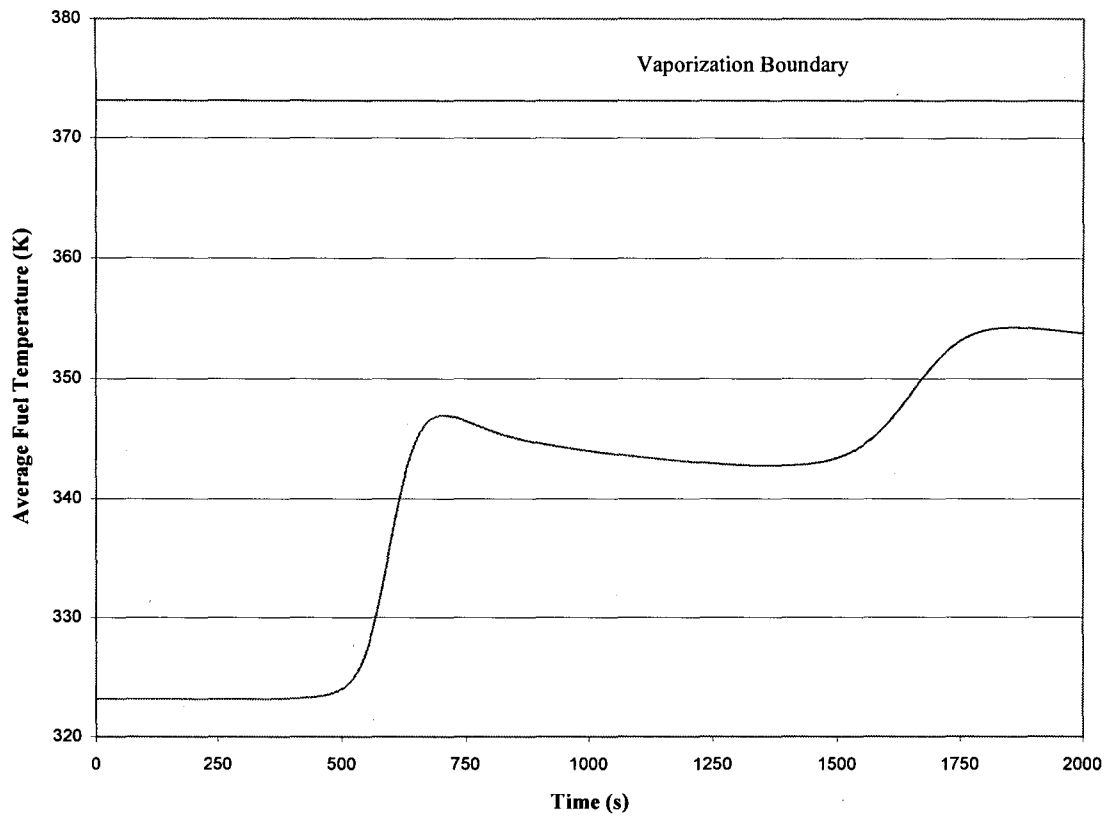


Figure 6-10. Fuel Temperature Histories for 0.1- and 5.0-cm² Egress Junction Areas and a 0.0004- β /s Reactivity Insertion Rate

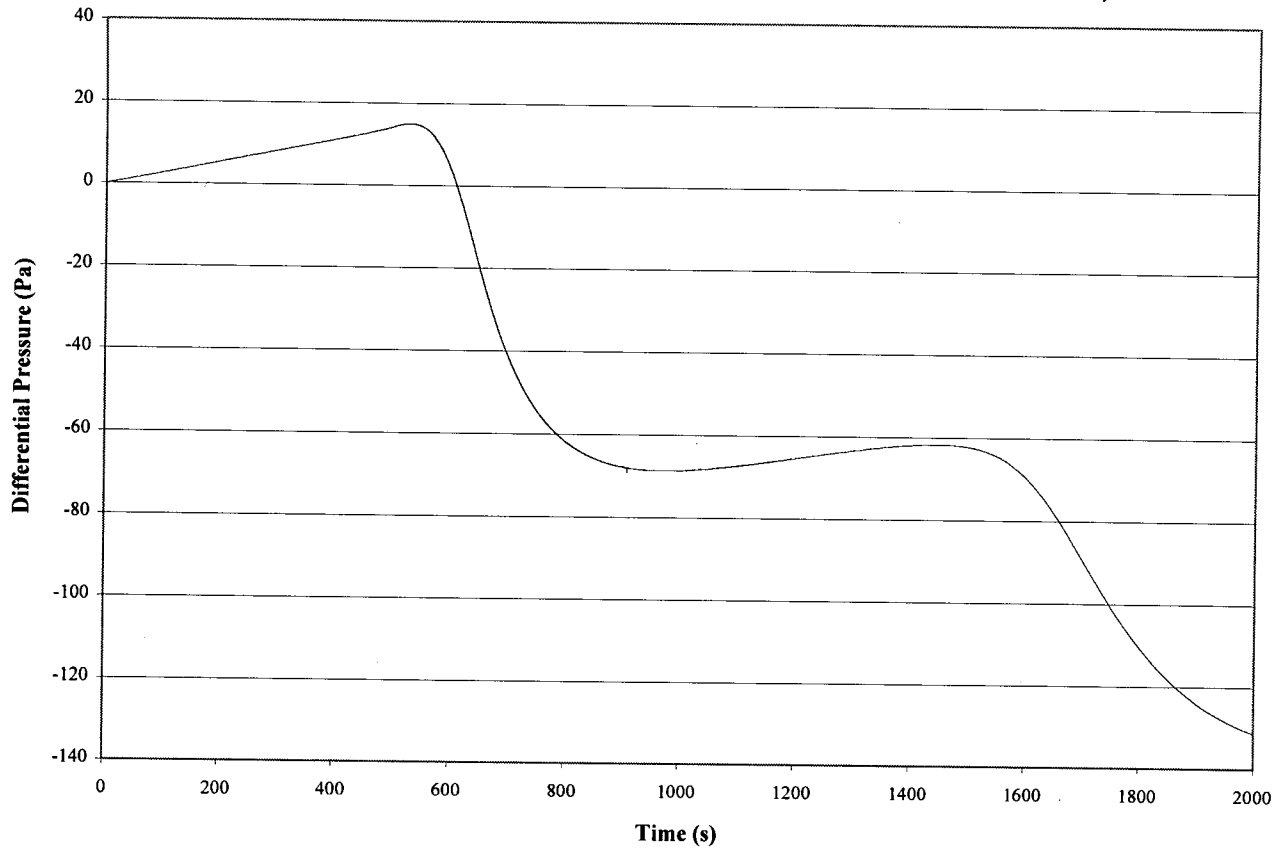


Figure 6-11. Pressure Histories for 0.1- and 5.0-cm² Egress Junction Areas and a 0.0004-\$/s Reactivity Insertion Rate

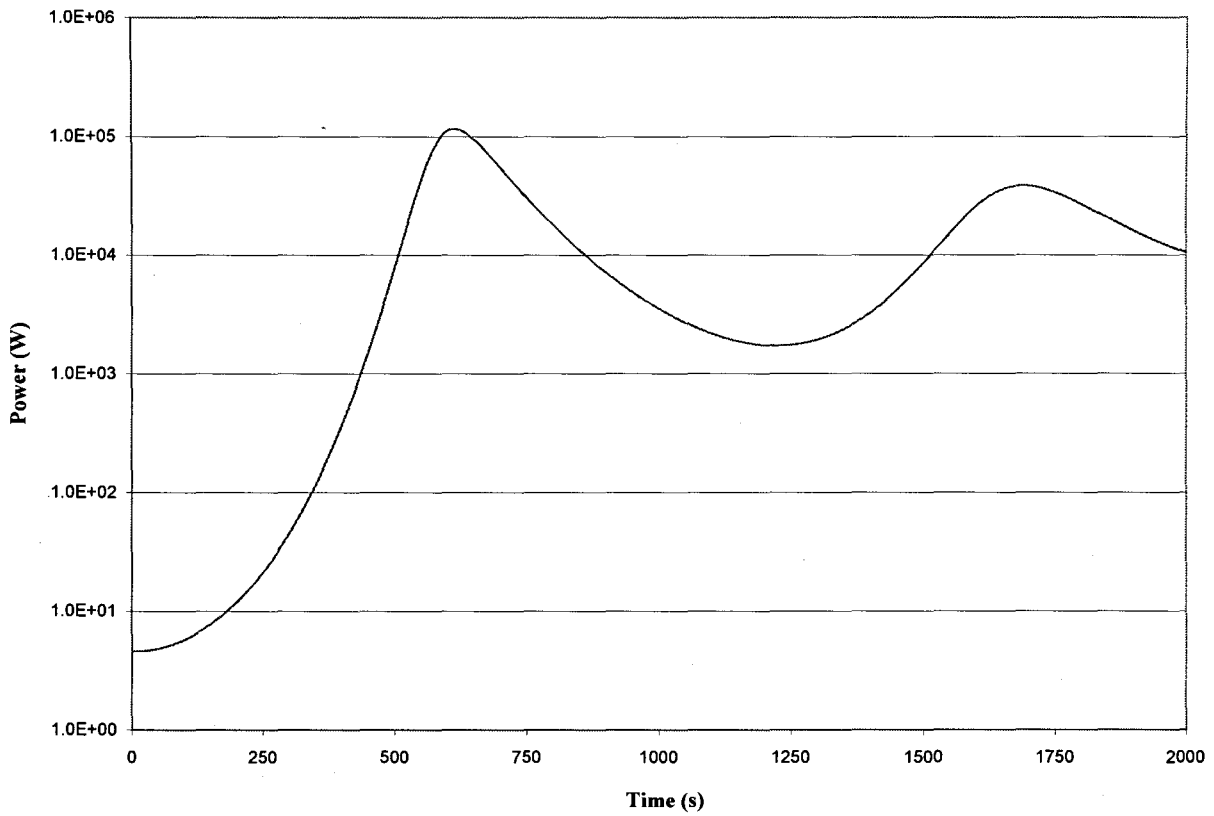


Figure 6-12. Fission Power Histories for 0.1- and 5.0-cm² Egress Junction Areas and a 0.0004- β /s Reactivity Insertion Rate

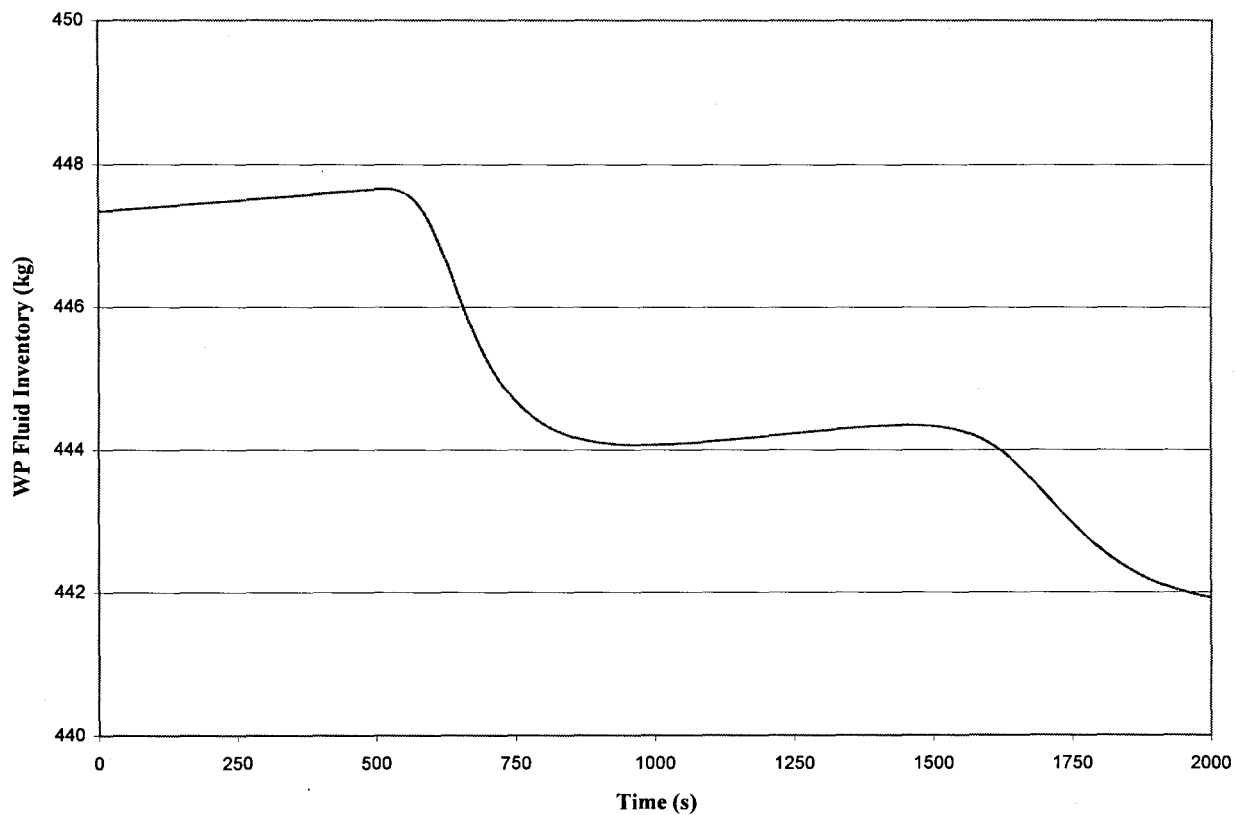


Figure 6-13. WP Moderator Inventory Histories for 0.1- and 5.0-cm² Egress Junction Areas and a 0.0004- β /s Reactivity Insertion Rate

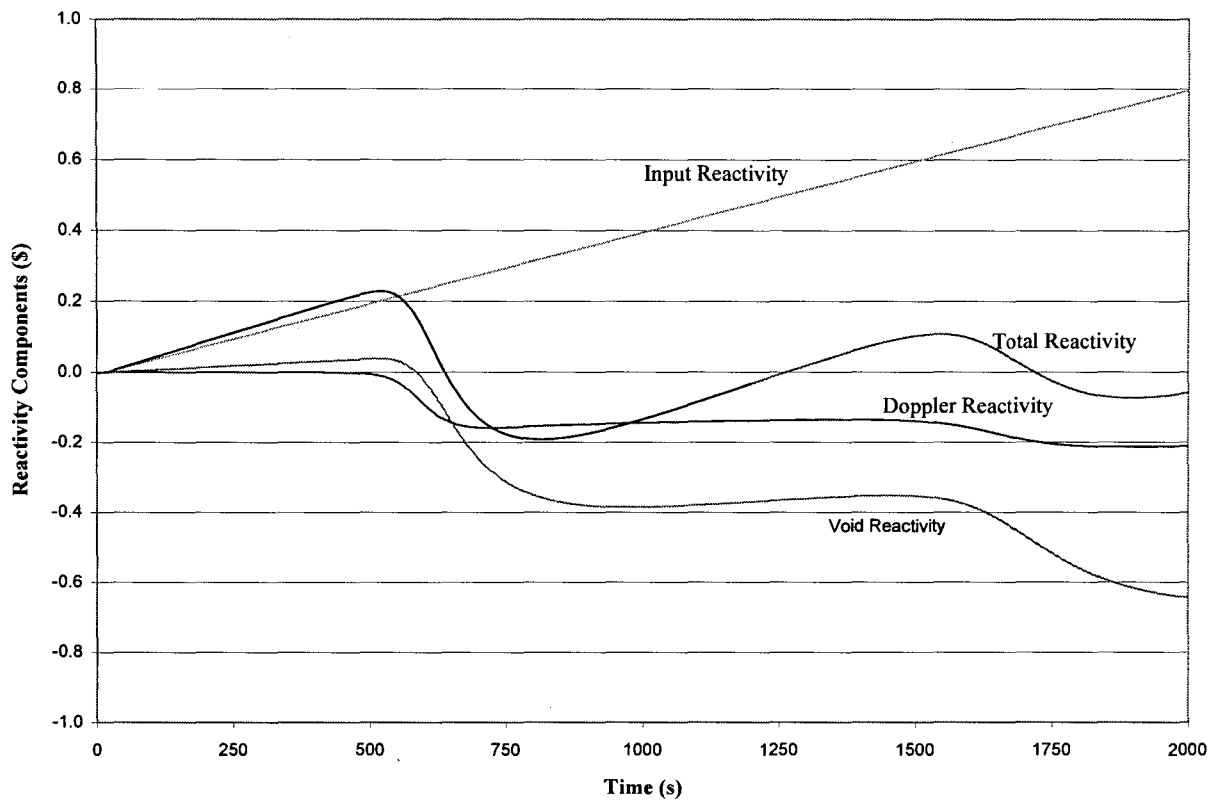


Figure 6-14. Reactivity Histories for 0.1- and 5.0-cm² Egress Junction Areas and a 0.0004-\$/s Reactivity Insertion Rate

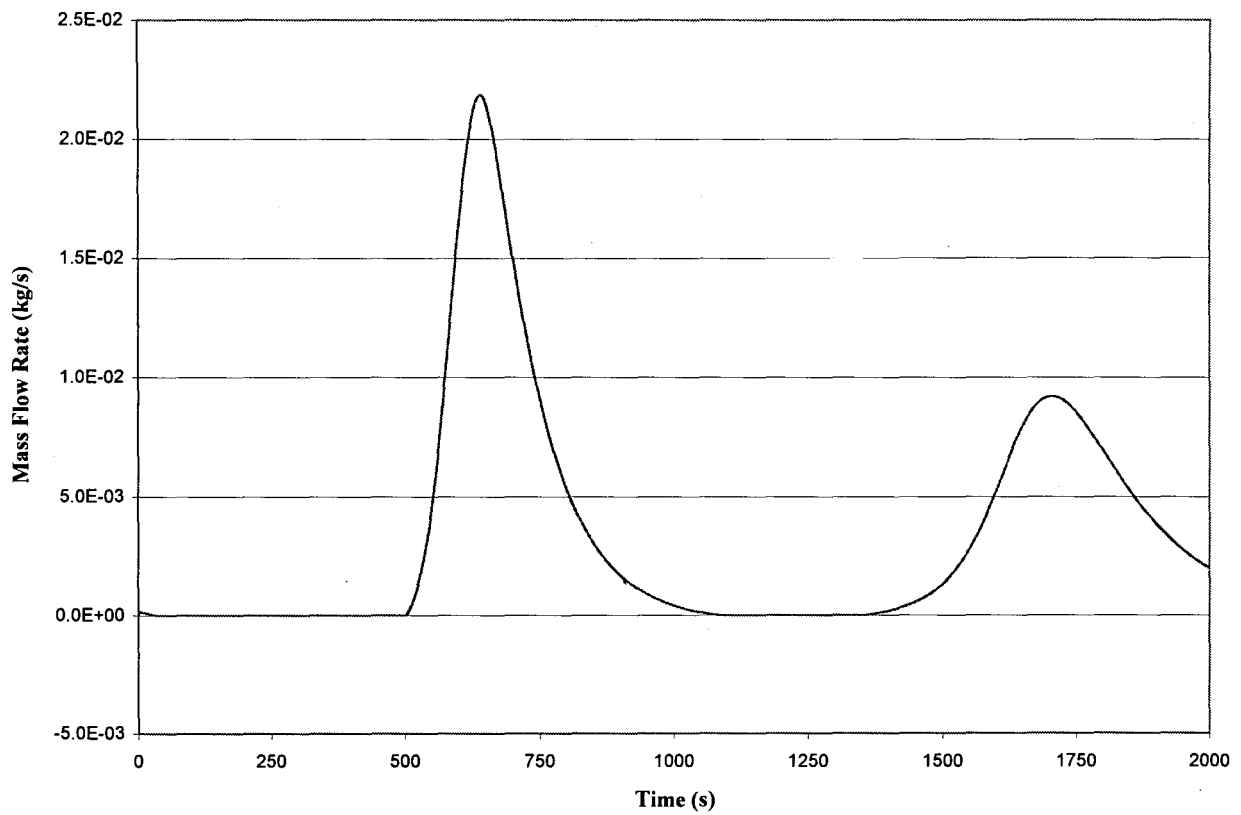


Figure 6.15. WP Egress Junction Mass Flow Rate Histories for 0.1- and 5.0-cm² Egress Junction Areas and a 0.0004- $\$/s$ Reactivity Insertion Rate

7. ATTACHMENTS

Hardcopy attachments are listed in Table 7-1. Electronic data files are provided on a CD (CRWMS M&O 1999a).

Table 7-1. List of Attachments

Attachment Number	Description	Number of Pages
I	Document Input Reference Sheets (DIRS)	3
II	STRIP FORTRAN Source with Sample Input and Output Files	8
III	Base RELAP5/MOD3.2 Data File	21
IV	Directory List of Files on CD (CRWMS M&O 1999a)	3

8. REFERENCES

1. Civilian Radioactive Waste Management System (CRWMS) Management & Operating Contractor (M&O) 1997. *Criticality Consequence Analysis Involving Intact PWR SNF in a Degraded 21 PWR Assembly Waste Package*. BBA000000-01717-0200-00057 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980106.0331.
2. Nuclear Regulatory Commission (NRC) 1995a. *RELAP5/MOD3 Code Manual, Volume I: Code Structure, System Models, and Solution Methods*. NUREG/CR-5535. Washington, D.C.: NRC. TIC: 238741.
3. NRC 1995b. *RELAP5/MOD3 Code Manual, Vol. 2, Users's Guide and Input Requirements*. NUREG/CR-5535. Washington, D.C.: NRC. TIC: 243017.
4. CRWMS M&O 1999a. *Electronic Data for Sensitivity Study of Reactivity Consequences to Waste Package Egress Area, CAL-EBS-NU-000001 REV 00*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990923.0240.
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10. CRWMS M&O 1999g. *Validation Test Report (VTR) for RELAP5/MOD3.2 VI.0*. Las Vegas, Nevada: CRWMS M&O. SDN: 10091-VTR-1.0-00. ACC: MOL.19990929.0036.

ATTACHMENT I

**OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
DOCUMENT INPUT REFERENCE SHEET**

1. Document Identifier No./Rev.: CAL-EBS-NU-000001 REV 00		Change: N/A	Title: Sensitivity Study of Reactivity Consequences to Waste Package Egress Area						
Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To			
2. Technical Product Input Source Title and Identifier(s) with Version		3. Section				Unqual.	From Uncontrolled Source	Un-confirmed	
2a									
1	Civilian Radioactive Waste Management System (CRWMS) Management & Operating Contractor (M&O) 1997. <i>Criticality Consequence Analysis Involving Intact PWR SNF in a Degraded 21 PWR Assembly Waste Package.</i> BBA000000-01717-0200-00057 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980106.0331.	Sect. 4.3	TBV-3292	Sect. 3	List of Assumptions in Initial Reactivity Consequence Analysis Resolved by peer review	3	√	N/A	N/A
2	Nuclear Regulatory Commission (NRC) 1995a. <i>RELAP5/MOD3 Code Manual, Volume I: Code Structure, System Models, and Solution Methods.</i> NUREG/CR-5535. Washington, D.C.: NRC. TIC: 238741.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A
3	NRC 1995b. <i>RELAP5/MOD3 Code Manual, Vol. 2, Users's Guide and Input Requirements.</i> NUREG/CR-5535. Washington, D.C.: NRC. TIC: 243017.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A

Waste Package Operations

Calculation

Title: Sensitivity Study of Reactivity Consequences to Waste Package Egress Area

Document Identifier: CAL-EBS-NU-000001 REV 00

Page: I-2 of I-3

**OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
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1. Document Identifier No./Rev.: CAL-EBS-NU-000001 REV 00		Change: N/A	Title: Sensitivity Study of Reactivity Consequences to Waste Package Egress Area						
Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To			
2. Technical Product Input Source Title and Identifier(s) with Version		3. Section				Unqual.	From Uncontrolled Source	Un-confirmed	
4	CRWMS M&O 1999a. <i>Electronic Data for Sensitivity Study of Reactivity Consequences to Waste Package Egress Area, CAL-EBS-NU-000001 REV 00.</i> Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990923.0240.	N/A	TBV-3293	Sect. 5, 6	Data Files on Compact Disk (CD) Resolved by peer review	3	√	N/A	N/A
5	CRWMS M&O 1999b. <i>Installation Test Plan (ITP) for RELAP5/MOD3.2 V1.0.</i> Las Vegas, Nevada: CRWMS M&O. SDN: 10091-ITP-1.0-00 ACC: MOL.19990929.0035.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A
6	CRWMS M&O 1999c. <i>Validation Test Plan (VTP) for RELAP5/MOD3.2 V1.0.</i> Las Vegas, Nevada: CRWMS M&O. SDN: 10091-VTP-1.0-00. ACC: MOL.19990929.0034.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A
7	CRWMS M&O 1999d. <i>Software Activity Plan (SAP) for RELAP5/MOD3.2 V1.0.</i> Las Vegas, Nevada: CRWMS M&O. SDN: 10091-SAP-1.0-00. ACC: MOL.19990929.0031.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A
8	CRWMS M&O 1999e. <i>Software Requirements Document (RD) for RELAP5/MOD3.2 V1.0.</i> Las Vegas, Nevada: CRWMS M&O. SDN: 10091-RD-1.0-00. ACC: MOL.19990929.0032.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A

**OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
DOCUMENT INPUT REFERENCE SHEET**

1. Document Identifier No./Rev.: CAL-EBS-NU-000001 REV 00		Change: N/A	Title: Sensitivity Study of Reactivity Consequences to Waste Package Egress Area						
Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To			
2. Technical Product Input Source Title and Identifier(s) with Version		3. Section				Unqual.	From Uncontrolled Source	Un-confirmed	
9	CRWMS M&O 1999f. <i>Software Design Document (DD) for RELAP5/MOD3.2 V1.0</i> . Las Vegas, Nevada: CRWMS M&O. SDN: 10091-DD-1.0-00. ACC: MOL.19990929.0033.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A
10	CRWMS M&O 1999g. <i>Validation Test Report (VTR) for RELAP5/MOD3.2 V1.0</i> . Las Vegas, Nevada: CRWMS M&O. SDN: 10091-VTR-1.0-00. ACC: MOL.19990929.0036.	Entire	N/A	Sect. 5, 6	Software Documentation	N/A	N/A	N/A	N/A

ATTACHMENT II

STRIP Program

The RELAP5/MOD3.2 program writes two files as output:

- 1) a formatted print file containing "major edits" at specified times, a list periodically of the minor edit variables, and
- 2) a binary "restart" file to enable a case to resume.

The major edits form periodic snapshots of the problem variables. Minor edits form histories of particular problem variables and can thus be displayed graphically. The RELAP5/MOD3.2 code also has an option to collect all the minor edit variables at each time point from the restart file and put them into a formatted "strip" file. The FORTRAN-90 program, "Strip", reads a RELAP5/MOD3.2 strip file, pairs the time variable with each minor edit variable and writes the information in a series of more compact files for use in later analysis. The output of the code can be readily checked against the strip files by visual inspection.

1. STRIP Source

```

C      Last change:  T    25 Jun 99   10:45 am
C      program strip
c
c      implicit REAL*8  (a-h,o-z)
c
c      program to read RELAP strip files and align into columns for use
c      with Excel or Psiplot for plotting.
c
c
c      units
c      50      = data input
c      55      = spread sheet output
c      60      = print file
c
c      dimension          plotdat(75)
c      INTEGER*4          scrno, scrni, itall, isprd
c      LOGICAL*4          isfopn, isfdef, skipr
c      CHARACTER*10       headr1, headr2, headr3
c      CHARACTER*1        alf(27)
c      CHARACTER*1        num(10), noyes, yes
c      CHARACTER*120      iomsg
c      CHARACTER*80       card
c      CHARACTER*15       filenam, outfile, avar, tmpnam, dum1, dum2
c      CHARACTER*10       alfvar(75), numvar(75)
c      CHARACTER*13       cblnk
c      CHARACTER*7        chdir(2)
c
c      data cblnk /'          '/
c      data headr1 /'plotinf  '/, headr2 /'plotalf  '/,
*      headr3 /'plotrec  '/
c      data yes  /'y'/'

```

```
c
  data num /'0', '1', '2', '3', '4', '5', '6', '7', '8', '9'/
  data maxpts /1500/, maxvar /75/
  data deltt20 /2.0d0/
  DATA zero /0.0e0/

c
c   define files and open them
c
  scrni  = 5
  scrno  = 6
  itall  = 50
  iout   = 60
  WRITE (UNIT=scrno, FMT=2041)
2041  FORMAT (' input data file name = ':)
  read (UNIT=scrni, FMT=3001) filenam
  WRITE (UNIT=scrno, FMT=2042)
2042  FORMAT (' input final time = ':)
  read (scrni, '(e12.5)') fintim

c
3001  FORMAT (a15)
3002  FORMAT (a4)
  inquire (file=filenam, exist=isfdef, err=1001, iostat=ierr)
  if (.not.isfdef) then
    write (scrno, 2005) filenam
    GO TO 2000
  end if
2005  format (' data file ',a15,' does not exist/' exit called')
  open (unit=itall, file=filenam, status='old', form='formatted',
*      access='sequential', err=1005, iostat=ierr)

c
c   count records in filenam - mrec
  irec  = 1
  mrec  = 0
10     read (UNIT=itall, FMT=1107) card
  dum1  = ADJUSTL(card(1:10))
  if (dum1(1:7) .ne. headr3(1:7))go to 10
  mrec  = mrec + 1
  read (card(16:30), '(e15.6)') timdat
  if (timdat .lt. fintim) go to 10
  rewind (UNIT=itall)

c
  skipr = .false.
  write (UNIT=scrno, FMT=2044) mrec
2044  format (' Input file has ',i5, 'records'/
*      ' set skip flag to reduce number y or n' :)
  read (scrni, '(a1)') noyes
  if (noyes .eq. yes) then
    skipr = .true.
    write (UNIT=scrno, FMT=2046)
    read (scrni, '(i6)') numskp
  END if
2046  format (' number of records to skip = ':)
c
25     write (UNIT=scrno, FMT=2045)
2045  format (' Continue data procesing - y or n ':)
```

```
      READ (scrni, '(a1)') noyes
      if (noyes .ne. yes) go to 2000
c
c   read two records, skip first record - title records
      read (UNIT=ital1, FMT=1107) card
      read (UNIT=ital1, FMT=1107) card
1107 format (a80)
c   look for plot information record
30   read (UNIT=ital1, FMT=1107) card
      DO 40 i=1,80
      m = i
      IF (card(i:i) .ne. ' ') GO TO 45
40   continue
c   blank card - read next one
      go to 30
45   IF (card(m:m+6) .eq. headr1(1:7)) then
      read (card(11:20), '(i10)') numdat
      END if
      IF (numdat .GT. maxvar) then
      WRITE (UNIT=scrno, FMT=1023)
      GO TO 2000
      END if
1023 FORMAT (' number of minor edits exceeds max allowed'/
*      ' exit called')
      numdat = numdat - 1
c   read minor edit variable headings
      read (UNIT=ital1, FMT=1020) avar, (alfvar(k), k=1,numdat)
      read (UNIT=ital1, FMT=1020) avar, (numvar(k), k=1,numdat)
1020 format (8a10)
c
c   select the record to plot
c
      ivarl = irec + 1
      IF (ivarl .GT. numdat) then
      WRITE (UNIT=scrno, FMT=1022)
      GO TO 2000
      END if
1022 FORMAT (' list of minor edits exceeded')
      do 75 n=ivarl,numdat
      write (UNIT=scrno, FMT=2022) alfvar(n), numvar(n)
      READ (scrni, '(a1)') noyes
      irec = n
      IF (noyes .EQ. yes) GO TO 80
75   continue
c   check for more files
      go to 25
c
c   read the data records - terminate with EOF
c
2022 format (1x,a10,2x,a10,' ':)
c
80   continue
c
      dum1 = ADJUSTL(alfvar(irec))
      dum2 = ADJUSTL(numvar(irec))
```

```
DO 84 j=1,8
IF (dum1(j:j) .EQ. ' ') GO TO 84
jdx = j
84 continue
DO 86 j=1,8
IF (dum2(j:j) .EQ. ' ') GO TO 86
kdx = j
86 continue
jdx = min0(jdx,5)
kdx = 8-jdx
tmpnam = dum1(1:jdx)//dum2(1:kdx)
outfile = tmpnam(1:(jdx+kdx))//'.dat'
c
c CALL SYSTEM ('dir')
c pause
call SYSTEM ('cd temp')
c CALL SYSTEM ('dir')
c WRITE (UNIT=scrno, FMT=9031) outfile
9031 FORMAT (' file name = ',a12)
c pause
inquire (file=outfile, exist=isfdef, err=1001, iostat=ierr)
if (isfdef) then
  open (unit=iout, file=outfile, status='old',
* form='formatted', access='sequential', err=1010,
* iostat=ierr)
  close (UNIT=iout,STATUS='delete')
end if
c
  open (unit=iout, file=outfile, status='new',
* form='formatted', access='sequential', err=1010,
* iostat=ierr)
c
  WRITE (UNIT=iout, FMT=2020) filenam
2020 FORMAT (5x,'data from file - ',a15/)
  WRITE (UNIT=iout, FMT=2015) alfvar(1),
* alfvar(iirc), numvar(iirc)
2015 format (5x,a10,5x,a10/5x,' (sec) ',4x,a10/)
  IF (skipr) then
    nrec = numskp
  else
    nrec = 1
  end if
c WRITE (UNIT=scrno, FMT=9010) nrec
9010 FORMAT (' nrec to skip = ',i6)
kcnt = 0
ctim = zero
lrecno = 0
call system ('cd ..')
c CALL SYSTEM ('dir')
c pause
c continue
c read the first record of strip file
read (UNIT=ital1, FMT=2001, END=2090, ERR=1001) avar,
* (plotdat(k), k=1,numdat)
IF (.not. skipr) GO TO 96
```

```
IF (kcnt .EQ. 0) GO TO 96
if (plotdat(1) .le. 200.0d0) then
  lrecno = kcnt
  kcnt = kcnt + 1
  IF (plotdat(1).LT.(ctim+2.0)) then
    GO TO 90
  else
    ctim = plotdat(1)
    GO TO 96
  END if
else
c skip nrec-1 records
  nxtrec = lrecno + nrec -1
c WRITE (UNIT=scrno, FMT=9021) nxtrec
end if
9021 FORMAT (' nxtrec = ', i6)
95 kcnt = kcnt + 1
if (kcnt .lt. nxtrec) then
  GO TO 2090
end if
2001 format (a15, 4e15.6/(5e15.6))
2010 FORMAT (1p,2e15.6)
lrecno = kcnt
96 continue
call system ('cd temp')
WRITE (UNIT=iout, FMT=2010) plotdat(1), plotdat(irec)
if (kcnt .eq. 0) kcnt = 1
call system ('cd ..')
c call system ('cd juveni~1')
2090 continue
IF (plotdat(1) .lt. fintim) GO TO 90
rewind (UNIT=ital1)
CALL SYSTEM ('cd temp')
CLOSE (UNIT=iout, STATUS='keep')
call system ('cd ..')
c call system ('cd juveni~1')
go to 25
c
c error messages
c
1001 write (scrno, 1002) ierr, filenam
1002 format (' error = ',i8,' encountered attempting to access file ',
* a20)
go to 2000
c
1005 write (scrno, 1006) ierr, filenam
1006 format (' error = ',i8,' encountered attempting to open file ',
* a20)
go to 2000
c
1010 write (scrno, 1006) ierr, outfile
c
2000 continue
end
```

2. Sample Input Strip File

```

RELAP5/3.2          strip file          24-Jun-1999  12:54:10
relap5/mod2 waste package c103xlhbw.test.strp
plotinf          55          0
plotalf  time      p          p          p          p          p          p
p          p          hvmix    hvmix    sonicj    vapgen    vapgen
vapgen
vapgen  vapgen  vapgen  tmass  tmassv  tmassv  tmassv
tmassv
tmassv  tmassv  tmassv  tmassv  tmassv  tmassv  tmassv
mflowj
mflowj  mflowj  mflowj  mflowj  mflowj  mflowj  mflowj
mflowj
mflowj  mflowj  mflowj  htvat   rkfipow  rkgapow  rkreac
cntrlvar
cntrlvar  cntrlvar  cntrlvar  cntrlvar  cntrlvar  cntrlvar  cntrlvar
plotnum          0 150010000  60010000  70010000  80010000  90010000
100010000
250010000 240010000  90010000 250010000 250010000 150010000  60010000
70010000
80010000  90010000 100010000          0 260010000 150010000  60010000
70010000
80010000  90010000 100010000 220010000 230010000 240010000 250010000
80010000
80020000  70010000  70020000 240010000 230010000 230020000 250010000
220010000
220020000 20010000  20020000  3301008          0          0          0
81
      14          56          60          65          70          75          80
plotrec          .000000E+00  1.013254E+05  1.013254E+05  1.013254E+05  1.013254E+05
1.013254E+05  1.013254E+05  1.013254E+05  1.013254E+05  1.013254E+05
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  4.490972E+02
.000000E+00  6.368977E+00  1.967957E+01  1.967957E+01  1.967957E+01  1.967957E+01
1.967957E+01  1.967957E+01  2.415648E+01  2.415648E+01  2.415648E+01  1.376029E+01
3.502303E+01  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00
.000000E+00  .000000E+00  .000000E+00  .000000E+00  3.231511E+02  4.634700E+00
3.653000E-01  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00
plotrec          1.000000E-02  1.075159E+05  1.060990E+05  1.038763E+05
1.015874E+05  9.924545E+04  9.686730E+04  9.374152E+04  9.516440E+04
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  4.490874E+02
.000000E+00  6.368994E+00  1.967962E+01  1.967960E+01  1.967958E+01  1.967958E+01
1.967956E+01  1.967954E+01  2.415642E+01  2.415642E+01  2.415642E+01  1.376026E+01
3.501335E+01  3.410194E-02  2.372985E-03  2.627495E-02  3.793676E-03  3.793676E-03
6.202511E-02  5.451060E-02  -2.357969E-02  2.478254E+00  4.129710E-02  4.129710E-02
-1.562832E-02  1.348391E-02  1.050594E-03  3.231511E+02  4.651265E+00  4.651265E+00
3.653010E-01  3.553265E-03  .000000E+00  -1.459565E-10  -1.171647E-03  -1.171647E-03
4.726666E-03  3.555020E-03  5.008634E-02  .000000E+00  7.100000E-01  7.100000E-01
plotrec          2.000000E-02  1.046268E+05  1.032420E+05  1.011549E+05
9.907315E+04  9.699584E+04  9.492212E+04  9.210218E+04  9.337293E+04  9.337293E+04
.000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00  .000000E+00

```

.000000E+00	.000000E+00	.000000E+00	.000000E+00	4.490737E+02
.000000E+00	6.368986E+00	1.967959E+01	1.967957E+01	1.967956E+01
1.967954E+01	1.967952E+01	2.415640E+01	2.415640E+01	1.376025E+01
3.500011E+01	1.121941E-03	-2.055325E-05	5.532075E-04	-2.973859E-05
6.016500E-03	5.328805E-03	-1.381403E-03	2.883632E+00	3.447919E-03
-4.805961E-04	2.801862E-04	-1.327511E-05	3.231511E+02	4.665872E+00
3.653039E-01	6.650467E-03	.000000E+00	-1.975029E-11	-2.797694E-03
9.453333E-03	6.655639E-03	1.003265E-01	.000000E+00	7.100000E-01
plotrec	3.000000E-02	1.030670E+05	1.016796E+05	9.958141E+04
9.748258E+04	9.538323E+04	9.328374E+04	9.043707E+04	9.172116E+04
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	4.490573E+02
.000000E+00	6.368982E+00	1.967958E+01	1.967956E+01	1.967954E+01
1.967953E+01	1.967951E+01	2.415638E+01	2.415638E+01	1.376024E+01
3.498396E+01	3.957219E-03	2.322828E-04	2.791887E-03	3.424082E-04
1.097558E-02	9.389635E-03	-3.279840E-03	3.393939E+00	6.364134E-03
-1.647311E-03	1.425709E-03	9.158744E-05	3.231511E+02	4.679066E+00
3.653085E-01	9.416994E-03	.000000E+00	2.848080E-10	-4.753726E-03
1.418000E-02	9.426274E-03	1.507059E-01	.000000E+00	7.100000E-01
plotrec	4.000000E-02	1.015588E+05	1.001717E+05	9.807489E+04
9.597816E+04	9.388151E+04	9.178519E+04	8.894152E+04	9.022409E+04
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	4.490383E+02
.000000E+00	6.368978E+00	1.967957E+01	1.967955E+01	1.967953E+01
1.967951E+01	1.967949E+01	2.415637E+01	2.415637E+01	1.376023E+01
3.496519E+01	3.526008E-03	2.458410E-04	2.495895E-03	3.359990E-04
1.018977E-02	8.453297E-03	-2.934241E-03	3.850954E+00	5.489125E-03
-1.321726E-03	1.270948E-03	9.147199E-05	3.231511E+02	4.690910E+00
3.653145E-01	1.187258E-02	.000000E+00	7.489204E-10	-7.020047E-03
1.890667E-02	1.188662E-02	2.012105E-01	.000000E+00	7.100000E-01
plotrec	5.000000E-02	1.001984E+05	9.881131E+04	9.671442E+04
9.461755E+04	9.252073E+04	9.042416E+04	8.758023E+04	8.886284E+04
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	4.490168E+02
.000000E+00	6.368974E+00	1.967955E+01	1.967954E+01	1.967952E+01
1.967950E+01	1.967948E+01	2.415635E+01	2.415635E+01	1.376022E+01
3.494398E+01	3.133709E-03	2.562385E-04	2.224622E-03	3.285738E-04
9.479837E-03	7.613232E-03	-2.623204E-03	4.272640E+00	4.721612E-03
-1.038623E-03	1.129399E-03	9.080387E-05	3.231511E+02	4.701482E+00
3.653218E-01	1.403956E-02	.000000E+00	1.356153E-09	-9.574360E-03
2.363333E-02	1.405897E-02	2.518272E-01	.000000E+00	7.100000E-01

3. STRIP Sample Output File

data from file - 103x1hbx.s02

time (sec)	tmass 0
0.000000E+00	4.490972E+02
1.000000E-02	4.490874E+02
2.000000E-02	4.490737E+02
3.000000E-02	4.490573E+02

4.000000E-02	4.490383E+02
5.000000E-02	4.490168E+02
6.000000E-02	4.489931E+02
7.000000E-02	4.489673E+02
8.000000E-02	4.489395E+02
9.000000E-02	4.489084E+02
1.000000E-01	4.488697E+02
2.000000E-01	4.435170E+02
3.000000E-01	4.425587E+02
4.000000E-01	4.425541E+02
5.000000E-01	4.425543E+02

ATTACHMENT III. Base RELAP5/MOD3.2 Data File

```

= relap5/mod2 waste package (b & w 15 by 15 21 fa)
*-----*
*
* { this is /kappa/jrw/lv/relap/r5wp2d.in
*
* the input is a transition from tmi-1 power uprate lbloca
* to waste package (near field) criticality excursion consequences
* with 4.90 wt.% u-235 , 34,000 mwd/mtu burnup and 25,000 year decay
*
* b & w heavy isotope actinide contribution }
*
*----- base description -----*
*
* fti document 32-1244460-00
* by: ks pacheco
*
* the base deck for the tmi-1 model was taken from 2772base1.in
* contained in 32-1234886-00. /kappa/ksp/tmipug/base/tmibase.in
*
* 21fa, 208-pins/fa, 16-guide tubes/fa, 1-instrument tube/fa
* one-fifth length model - Power into Assembly is 5 Watts
* for Full Length assemblies
*-----*
*
* deck obtained from tuck w. (lynchburg) 07/31/97
* 07/31/97 modification - jam (lv)
* delete most of the $$$ cards from deck
* convert to mod3 format
* junction control flag - change from 3xxxx to 0xxxx
* no horizontal stratification
* heat structure cards ...8xx and ...9xx - CHF Changes
* MOD2 - 5 wds, MOD3 - 9 wds
* add Time-Dependent Vol and Time-Dependent Junction to input
* InFlow Conditions
* Add Minor Edits
* Case 001 Using small time steps to make sure case runs ok
* Case 002 Match Tuck Worsham's data (Fax memo - 08/04/97)
* Case 003 Use short time steps through power peak
* Case 004 Add Doppler Weight Factors to activate Fuel Temp Feedback
* B&W Relap5 has been modified to compute Doppler Weights
* internally if none supplied.
* Add Avg Fuel Temp To Minor Edits
* Add variable Void Weight Factors porportional to Control
* Volume relative size
* Case 005 Rerun Case C003 with Doppler Weights
* Case 006 Add Reactivity Control Blocks to Edit Components to Case 004
* Case 101 Switch to Implicit Numerics
* Shorten time steps to avoid zero mass in control volumes

```

```

*         around 5.8 sec, turn on the choking model for junctions in
*         non-fuelled volumes.
* Case 111 Similar to Case 101: reduce reactivity ramp by 50%;
*         increase refill rate by 50%;
*         change minor edits;
*         adjust minor edit frequencirs to 0.05 sec
* Case 102 Try Case 101 with automatic T.S. control to cut down on
*         number of minor edit points
*         Redo case 102 to include fission and decay heat power,
*         add reactivity table vs mixture level
* Case 102a review short T.S. case again
*         102b check for T.S. convergence (more stable than case 102a)
*         102c check further for T.S. convergence
*         103a actually add mixture level calc - limit to top fuelled row
*         delete void reactivity table
*         103b 08/20/97 - revise case c103a and rerun
*         revise MCNP void reactivity table to use delta rho
*         and include all restart time steps, remove mixture level flgs
*         103c reinstate the mixture level model in vols 21001, 05001, 10001,
*         20001

```

```

*-----*

```

```

100 new transnt
101 run
* 101 inp-chk
102 british british
105 150. 160.
*
* noncondensable gas
110 "nitrogen"

```

```

*-----*

```

```

* time step control
*   end      min      max      time  minor  major  restart
*   time     delt     time     step  edit   edit   point
*   (sec)    (sec)    step    optn  freq   freq   freq
*
* Case 103a time steps
201  0.1      1.0-8    1.0-4    07    100    1000    1000
202  1.5      1.0-8    1.0-3    07    100    100     100
203  4.0      1.0-8    5.0-5    07    1000   10000   10000
204  20.0     1.0-8    5.0-5    07    10000  20000   20000
*
* Case c103a.rst01 time steps
205  30.0     1.0-8    5.0-5    07    10000  20000   20000
*
* Case c103a.rst02 time steps
206  40.0     1.0-8    1.0-4    07    1000   10000   10000
*
* Case c103a.rst03 time steps
207  80.0     1.0-8    1.0-4    07    1000   10000   10000

```

* Case c103a.rst04 time steps
 208 360.0 1.0-8 1.0-3 07 1000 10000 10000

* Case c103a.rst05 time steps
 209 1800.0 1.0-8 1.0-2 07 200 1000 1000

* general tables

* reactivity insertion

20200100 reac-t
 20200101 0.0 0.0 30.0 14.18 1.0+10 14.18
 * 20200101 0.0 0.0 30.0 7.09 1.0+10 7.09

* average fuel temperature vs. reactivity

20200200 reac-t
 *
 * fuel temp. K reactivity, dollars density lb/ft**3
 *
 20200201 273.16 +0.1719079
 20200202 300.01 +0.1719079
 20200203 323.16 0.0
 20200204 373.16 -0.3488604
 20200205 433.16 -0.7295469
 20200206 543.16 -1.3918144
 20200207 813.16 -2.8696928

* moderator density reactivity feedback

20200500 reac-t
 *
 * density kg/m**3 reactivity, dollars fuel temp. f
 *
 20200501 701.470834 -22.8341124 * 1004
 20200502 726.523364 -20.0375898 * 1004
 20200503 751.575895 -17.4413905 * 1004
 20200504 776.628425 -15.0255317 * 1004
 20200505 801.680954 -12.7766726 * 1004
 20200506 826.733484 -10.6782739 * 1004
 20200507 851.786013 -08.7187079 * 1004
 20200508 876.838543 -06.8856192 * 1004
 20200509 901.891072 -05.1688975 * 518
 20200510 921.933098 -03.9010990 * 518
 20200511 941.975121 -02.6972060 * 518
 20200512 960.112521 -01.6592902 * 518
 20200513 975.044461 -00.8234196 * 212

20200514	990.260409	00.00	*	122
20200515	1002.101192	+00.6225345	*	122
20200516	1043.387881	+00.6225345	*	80.33

*
 *
 * MCNP mixture level reactivity table (beta = 0.005)
 * Row 5 of fueled assemblies
 * Ref: W.D. reactor physics book + J. Massari Doc
 *

	Mixture level (ft)	Reactivity (\$)
--	--------------------	-----------------

20201000 reac-t

20201001	0.0	-30.902
20201002	0.04399	-30.902
20201003	0.18933	-16.660
20201004	0.23657	-14.959
20201005	0.28415	-12.911
20201006	0.71	0.0

*
 *
 * minor edits
 *

*
 *
 * pressure

301	"p"	150010000	* Vol Pressure
302	"p"	060010000	* Vol Pressure
303	"p"	070010000	* Vol Pressure
304	"p"	080010000	* Vol Pressure
305	"p"	090010000	* Vol Pressure
306	"p"	100010000	* Vol Pressure
307	"p"	250010000	* Vol Pressure

*
 *
 * enthalpy

315	"hvmix"	090010000	* Vol Enthalpy
317	"hvmix"	250010000	* Vol Enthalpy

*
 *
 * volume vapor generation/unit vol

321	"vapgen"	150010000	* Vol vapor gen rate
322	"vapgen"	060010000	* Vol vapor gen rate
323	"vapgen"	070010000	* Vol vapor gen rate
324	"vapgen"	080010000	* Vol vapor gen rate
325	"vapgen"	090010000	* Vol vapor gen rate
326	"vapgen"	100010000	* Vol vapor gen rate

*
 *

* Volume Mass

*
 329 "tmass" 0 * Fluid Inventory
 330 "tmassv" 260010000 * Vol Mass
 331 "tmassv" 150010000 * Vol Mass
 332 "tmassv" 060010000 * Vol Mass
 333 "tmassv" 070010000 * Vol Mass
 334 "tmassv" 080010000 * Vol Mass
 335 "tmassv" 090010000 * Vol Mass
 336 "tmassv" 100010000 * Vol Mass
 337 "tmassv" 220010000 * Vol Mass
 338 "tmassv" 230010000 * Vol Mass
 339 "tmassv" 240010000 * Vol Mass
 340 "tmassv" 250010000 * Vol Mass

* mass flow

*
 341 "mflowj" 080010000 * Jun Flow
 342 "mflowj" 080020000 * Jun Flow
 343 "mflowj" 070010000 * Jun Flow
 344 "mflowj" 070020000 * Jun Flow
 345 "mflowj" 240010000 * Jun Flow
 346 "mflowj" 230010000 * Jun Flow
 347 "mflowj" 230020000 * Jun Flow
 348 "mflowj" 250010000 * Jun Flow
 349 "mflowj" 220010000 * Jun Flow
 351 "mflowj" 220020000 * Jun Flow
 352 "mflowj" 020010000 * Jun Flow
 353 "mflowj" 020020000 * Jun Flow

* average fuel temperature

*
 361 "htvat" 3301008 * Avg Metal Temp

* control variables

* kinetics parameters

*
 389 "rkfipow" 0 * "fission" "power"
 390 "rkgapow" 0 * "decay heat" "power"
 391 "rkreac" 0 * "total" "reactivi"
 392 "cntrlvar" 081 * "MCNP void Reactivity"
 393 "cntrlvar" 014 * "doppler reac"
 394 "cntrlvar" 056 * "void reactivity"
 395 "cntrlvar" 060 * "ramp reactivity"
 396 "cntrlvar" 065 * "total calc reac"
 397 "cntrlvar" 070 * "assembly energy"
 398 "cntrlvar" 075 * "Sum (Heat slab vapor gen rate)

* waste package

*

*

* modeling begins with central planar region

*

*

*

* bottom of cylinder

*

1400000 "bot-watr" "branch"

* no. of jun jun cntrl

1400001 2 0

* aflow(norm) len vol angle(az) inclin elev change

1400101 0.00 .2293299 .2075716 0.0 -90.0 -.2293299

* wall rough hyd dia cntrl

1400102 4.1667-5 1.0+10 00

* vol cntrl press temp

1400200 003 14.696 122.00

* from vol to vol ajun k(f) k(r) jun cntrl

1401101 140000000 010010000 .2038375 72.0 72.0 01000

* liq vel vap vel interface vel

1401201 0.0 0.0 0.0

* from vol to jun ajun k(f) k(r) jun cntrl

1402101 140000000 150000000 .5419829 0.0 0.0 01003

* liq vel vap vel interface vel

1402201 0.0 0.0 0.0

*

* bottom side of cylinder

*

1500000 "bos-watr" "branch"

1500001 1 0

1500101 0.00 .2293299 .2276341 0.0 -90.0 -.2293299

* cntrl (therm-off, mix-off, pack-on,
vert strat-on, interphase fric-pipe,
wall-xdir, non-eq)

1500102 4.1667-5 1.0+10 0000000

1500200 003 14.696 122.00

1501101 150000000 060010000 .4076750 72.0 72.0 01000

1501201 0.0 0.0 0.0

*

* side of cylinder fuel level 1

*

1600000 "s1-watr" "branch"

1600001 1 0

1600101 0.00 .71 .7989270 0.0 -90.0 -.71

1600102 4.1667-5 1.0+10 00

1600200 003 14.696 122.00

1601101 160000000 110010000 .4076750 72.0 72.0 01000

1601201 0.0 0.0 0.0

*

* side of cylinder fuel level 2

*

1700000 "s2-watr" "branch"

1700001 1 0

1700101 0.00 .71 .5438773 0.0 -90.0 -.71

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```
1700102  4.1667-5  1.0602200  00
1700200  003          14.696      122.00
1701101  170000000  180000000  1.1080708  0.0  0.0  01000
1701201  0.0          0.0          0.0
*
* side of cylinder fuel level 3
*
1800000  "s3-watr"    "branch"
1800001  1            0
1800101  0.00        .71          .8980821    0.0  90.0  .71
1800102  4.1667-5    2.1134025   00
1800200  003         14.696      122.00
1801101  180010000  190000000  1.3339422  0.0  0.0  01000
1801201  0.0         0.0          0.0
*
* side of cylinder fuel level 4
*
1900000  "s4-watr"    "branch"
1900001  1            0
1900101  0.00        .71          .8738187    0.0  90.0  .71
1900102  4.1667-5    2.0432176   00
1900200  003         14.696      122.00
1901101  190010000  210000000  1.0380308  0.0  0.0  01000
1901201  0.0         0.0          0.0
*
* side of cylinder - fuel level 5
*
2100000  "s5-watr"    "branch"
2100001  1            0
2100101  0.00        .71          .7822260    0.0  90.0  .71
2100102  4.1667-5    1.6252320   0100000
2100200  003         14.696      122.00
* 2101101  210010000  240000000  1.0380308  0.0  0.0  01000
   2101101  210010000  240000000  1.0380308  0.0  0.0  00000
2101201  0.0         0.0          0.0
*
* 21 fuel assemblies
*
* half symmetry gives 13 planar fuel areas
*
* modeling begins with central fuel length,
*
* center fuel column, at the cylinder bottom
*
* hydraulic dia. based on flow around fuel-clad, guide tubes, inst. tube
*
*-----*
*
* column 1
*
0100000  "fuel-010"  "branch"
0100001  2            0
0100101  0.00        .71          .3516846    0.0  -90.0  -.71
0100102  3.133-6     .04168514   00
0100200  003         14.696      122.00
```


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0101101	010000000	020010000	.2038375	72.0	72.0	01000
0101201	0.0	0.0	0.0			
0102101	010000000	060000000	.4076750	72.0	72.0	01003
0102201	0.0	0.0	0.0			
*						
0200000	"fuel-020"	"branch"				
0200001	2	0				
0200101	0.00	.71	.3516846	0.0	-90.0	-.71
0200102	3.133-6	.04168514	00			
0200200	003	14.696	122.00			
0201101	020000000	030000000	.2038375	72.0	72.0	01000
0201201	0.0	0.0	0.0			
0202101	020000000	070000000	.4076750	72.0	72.0	01003
0202201	0.0	0.0	0.0			
*						
0300000	"fuel-030"	"branch"				
0300001	2	0				
0300101	0.00	.71	.3516846	0.0	90.0	.71
0300102	3.133-6	.04168514	00			
0300200	003	14.696	122.00			
0301101	030010000	040000000	.2038375	72.0	72.0	01000
0301201	0.0	0.0	0.0			
0302101	030000000	080000000	.4076750	72.0	72.0	01003
0302201	0.0	0.0	0.0			
*						
0400000	"fuel-040"	"branch"				
0400001	2	0				
0400101	0.00	.71	.3516846	0.0	90.0	.71
0400102	3.133-6	.04168514	00			
0400200	003	14.696	122.00			
0401101	040010000	050000000	.2038375	72.0	72.0	01000
0401201	0.0	0.0	0.0			
0402101	040000000	090000000	.4076750	72.0	72.0	01003
0402201	0.0	0.0	0.0			
*						
0500000	"fuel-050"	"branch"				
0500001	2	0				
0500101	0.00	.71	.3516846	0.0	90.0	.71
*						
*			cntrl	(therm-off, mix-on, pack-on,		
*			vert strat-on, interphase fric-pipe,			
*			wall-xdir, non-eq)			
0500102	3.133-6	.04168514	0100000			
0500200	003	14.696	122.00			
0501101	050010000	220000000	.2038375	72.0	72.0	01000
0501201	0.0	0.0	0.0			
0502101	050000000	100000000	.4076750	72.0	72.0	01003
0502201	0.0	0.0	0.0			
*						
*-----**-----**-----**-----**-----**-----**-----**-----**-----*						
*						
* column 2						
*						
0600000	"fuel-060"	"branch"				
0600001	2	0				
0600101	0.00	.71	.7033692	0.0	-90.0	-.71

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0600102	3.133-6	.04168514	00				
0600200	003	14.696	122.00				
0601101	060000000	070010000	.4076750	72.0	72.0	01000	
0601201	0.0	0.0	0.0				
0602101	060000000	160000000	.4076750	72.0	72.0	01003	
0602201	0.0	0.0	0.0				

*

0700000	"fuel-070"	"branch"					
0700001	2	0					
0700101	0.00	.71	.7033692	0.0	-90.0	-.71	
0700102	3.133-6	.04168514	00				
0700200	003	14.696	122.00				
0701101	070000000	080000000	.4076750	72.0	72.0	01000	
0701201	0.0	0.0	0.0				
0702101	070000000	110000000	.4076750	72.0	72.0	01003	
0702201	0.0	0.0	0.0				

*

0800000	"fuel-080"	"branch"					
0800001	2	0					
0800101	0.00	.71	.7033692	0.0	90.0	.71	
0800102	3.133-6	.04168514	00				
0800200	003	14.696	122.00				
0801101	080010000	090000000	.4076750	72.0	72.0	01000	
0801201	0.0	0.0	0.0				
0802101	080000000	120000000	.4076750	72.0	72.0	01003	
0802201	0.0	0.0	0.0				

*

0900000	"fuel-090"	"branch"					
0900001	2	0					
0900101	0.00	.71	.7033692	0.0	90.0	.71	
0900102	3.133-6	.04168514	00				
0900200	003	14.696	122.00				
0901101	090010000	100000000	.4076750	72.0	72.0	01000	
0901201	0.0	0.0	0.0				
0902101	090000000	130000000	.4076750	72.0	72.0	01003	
0902201	0.0	0.0	0.0				

*

1000000	"fuel-100"	"branch"					
1000001	2	0					
1000101	0.00	.71	.7033692	0.0	90.0	.71	
1000102	3.133-6	.04168514	0100000				
1000200	003	14.696	122.00				
1001101	100010000	230000000	.4076750	72.0	72.0	01000	
1001201	0.0	0.0	0.0				
1002101	100000000	200000000	.4076750	72.0	72.0	01003	
1002201	0.0	0.0	0.0				

*

*-----**-----**-----**-----**-----**-----**-----**-----**-----**-----*

*

* column 3

*

1100000	"fuel-110"	"branch"					
1100001	2	0					
1100101	0.00	.71	.7033692	0.0	-90.0	-.71	
1100102	3.133-6	.04168514	00				

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1100200	003	14.696	122.00			
1101101	110000000	120000000	.4076750	72.0	72.0	01000
1101201	0.0	0.0	0.0			
1102101	110000000	170000000	.4076750	72.0	72.0	01003
1102201	0.0	0.0	0.0			

*

1200000	"fuel-120"	"branch"				
1200001	2	0				
1200101	0.00	.71	.7033692	0.0	90.0	.71
1200102	3.133-6	.04168514	00			
1200200	003	14.696	122.00			
1201101	120010000	130000000	.4076750	72.0	72.0	01000
1201201	0.0	0.0	0.0			
1202101	120000000	180000000	.4076750	72.0	72.0	01003
1202201	0.0	0.0	0.0			

*

1300000	"fuel-130"	"branch"				
1300001	2	0				
1300101	0.00	.71	.7033692	0.0	90.0	.71
1300102	3.133-6	.04168514	00			
1300200	003	14.696	122.00			
1301101	130010000	200000000	.4076750	72.0	72.0	01000
1301201	0.0	0.0	0.0			
1302101	130000000	190000000	.4076750	72.0	72.0	01003
1302201	0.0	0.0	0.0			

*

* water - column 3

*

----------*-----*-----*-----*-----*-----*-----*-----*

*

2000000	"ts-watr"	"branch"				
2000001	2	0				
2000101	0.00	.71	.8633786	0.0	90.0	.71
2000102	4.1667-5	1.0+10	0100000			
2000200	003	14.696	122.00			
* 2001101	200010000	240000000	.7540857	0.0	0.0	01000
2001101	200010000	240000000	.7540857	0.0	0.0	00000
2001201	0.0	0.0	0.0			
* 2002101	200000000	210000000	1.7958536	0.0	0.0	01003
2002101	200000000	210000000	1.7958536	0.0	0.0	00003
2002201	0.0	0.0	0.0			

*

* top of cylinder

*

*

* three water columns

*

*

2200000	"cl-watr"	"branch"				
2200001	2	0				
2200101	0.00	.3484394	.8633786	0.0	90.0	.3484394
2200102	4.1667-5	1.0+10	00			
2200200	003	14.696	122.00			
* 2201101	220010000	250000000	.2038375	0.0	0.0	01000
2201101	220010000	250000000	.2038375	0.0	0.0	00000

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```

2201201  0.0      0.0      0.0
* 2202101  220000000 230000000  .8234784  0.0  0.0  01003
  2202101  220000000 230000000  .8234784  0.0  0.0  00003
2202201  0.0      0.0      0.0
*
2300000  "c2-watr"  "branch"
2300001  2          0
2300101  0.00     .3484394  .8633786  0.0  90.0  .3484394
2300102  4.1667-5 1.0+10    00
2300200  003      14.696   122.00
* 2301101  230010000 250000000  .4076750  0.0  0.0  01000
  2301101  230010000 250000000  .4076750  0.0  0.0  00000
2301201  0.0      0.0      0.0
* 2302101  230000000 240000000  .8234784  0.0  0.0  01003
  2302101  230000000 240000000  .8234784  0.0  0.0  00003
2302201  0.0      0.0      0.0
*
2400000  "c3-watr"  "branch"
2400001  1          0
2400101  0.00     .3484394  .4918077  0.0  90.0  .3484394
2400102  4.1667-5 1.6908844 00
2400200  003      14.696   122.00
* 2401101  240010000 250000000  .9732914  0.0  0.0  01000
  2401101  240010000 250000000  .9732914  0.0  0.0  00000
2401201  0.0      0.0      0.0
*
* top plenum
*
2500000  "tp-watr"  "branch"
2500001  1          0
2500101  0.00     .5249344  1.2517607  0.0  90.0  .5249344
2500102  4.1667-5 1.3256083 00
2500200  003      14.696   122.00
* 2501101  250010000 260000000  .1076391  0.0  0.0  01000
  2501101  250010000 260000000  .1076391  0.0  0.0  00000
2501201  0.0      0.0      0.0
*
* outside of waste package,
*
* drift at 14.696 psia
*
2600000  "drift"    "tmdpv01"
2600101  238.46  1.0  0.0  0.0  90.0  1.0  1.0e-6  0.0  0010
2600200  003
2600201  0.0      14.696   220.00
*
* drift inflow volume
*
3600000  "gnd-watr" "tmdpv01"
3600101  238.46  1.0  0.0  0.0  90.0  1.0  1.0e-6  0.0  0010
3600200  103
3600201  0.0      14.696   122.0
*
* Time-Dependent Junction for inflow
*

```

Waste Package Operations

Calculation

Title: Sensitivity Study of Reactivity Consequences to Waste Package Egress Area

Document Identifier: CAL-EBS-NU-000001 REV 00

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```

3700000      "in-flow"  "tmdpjun"
3700101      360010000  250000000  1.0
3700200      1          0
3700201      0.0        1.381e-3  0.0    0.0
* 3700201    0.0        2.762e-3  0.0    0.0

```


heat structure input

*

waste package wall

*

```

13121000    9  20  1  1  0.0
13121100    0  2
13121101   10.0  19
13121201    6  19
13121301    0.0 19
13121400    0
13121401   122. 20
13121501   140010000  10000000  1  1  1.73  9
13121601    0  0  0  0  1  1.73  9
13121701    0  0.0  0.0  0.0  9
* 13121801   0  0.0  0.0  0.0  9
* 13121901   0  0.0  0.0  0.0  9
  13121801   0.0 10.0 10.0  0.0  0.0  0.0  0.0  1.0  9
  13121901   0.0 10.0 10.0  0.0  0.0  0.0  0.0  1.0  9

```

*

*

fuel assembly clad, guide tubes, & inst-tube in fuel region

*

```

13481000    13  3  2  1  0.01570833
13481100    0  1
13481101    2  0.01791112
13481201    5  2
13481301    0.0 2
13481400    0
13481401   122. 3
*
*                225 *2.3633333 = 531.75 ft
*                112.5*2.3633333 = 265.875 ft
13481501    010010000  10000000  1  1  265.8750  5
13481502    060010000  10000000  1  1  531.7500  13
13481601    010010000  10000000  1  1  265.8750  5
13481602    060010000  10000000  1  1  531.7500  13
13481701    0  0.0  0.0  0.0  13
* 13481801   0  0.0  0.0  0.0  13
* 13481901   0  0.0  0.0  0.0  13
  13481801   0.0 10.0 10.0  0.0  0.0  0.0  0.0  1.0  13
  13481901   0.0 10.0 10.0  0.0  0.0  0.0  0.0  1.0  13
* 13481801   0  0.05360754  0.05360754  0.0  13

```

```

* 13481901  0  0.04701465  0.04701465  0.0  13
*
*-----*
*
*      fuel assembly pellets - water in gap region
*
13301000  13      10      2      1      0.0
13301100  0      1
* 13301101  6      0.01535833  1      0.01570833  2      0.01791667
13301101  9      0.01535833
* 13301201  3      6      -4      7      -5      9
13301201  3      9
* 13301301  1.0  6      0.0  7      0.0  9
13301301  1.0  9
13301400  -1
13301401  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301402  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301403  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301404  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301405  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301406  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301407  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301408  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301409  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301410  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301411  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301412  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301413  122. 122. 122. 122. 122. 122. 122. 122. 122. 122.
13301501  0  0  0  0  0.0  13
*
* length of fuel pin = #pins/ass'y * 141.8/(5 * 12)
*                      = 208 * 2.363 = 491.57333
*
13301601  010010000  10000000      1      1      245.78667  5
13301602  060010000  10000000      1      1      491.57333  13
13301701  1000      0.1      0.0      0.0  5
13301702  1000      0.2      0.0      0.0  13
* 13301801  0      0.0      0.0      0.0  13
* 13301901  0      0.05492351  0.05492351  0.0  13
13301801  0.0  10.0  10.0  0.0  0.0  0.0  0.0  1.0  13
13301901  0.0  10.0  10.0  0.0  0.0  0.0  0.0  1.0  13
*
*-----*
*
***
***
*** reactor vessel heat structures
***
***
*
*
* lower plenum of reactor vessel
*
*
*

```

```

*-----*
*
*
* heat structure composition type
*
*
*-----*
*
* fuel (uo2)
*
20100300 "tbl/fctn" 1 1
*-----*
*
* gap (hot channel)
*
20100400 "tbl/fctn" 3 1
*-----*
*
* clad (zr-4)
*
20100500 "tbl/fctn" 1 1
*-----*
*
* base metal (carbon steel)
*
20100600 "tbl/fctn" 1 1
*-----*
*
* cladding (stainless steel)
*
20100700 "tbl/fctn" 1 1
*-----*
*
*$$$ *$$$ *
*$$$ *$$$ * gap (avg channel)
*$$$ *$$$ *
*$$$ *$$$ 20100900 "tbl/fctn" 3 1
*$$$ *
*-----*
*
*
* heat structure thermal conductivities
*
*
*-----*
*
* fuel (uo2)
*
20100301 70.0 1.237e-3 200.0 1.237e-3
20100302 400.0 1.022e-3 800.0 0.745e-3
20100303 1200.0 0.592e-3 1600.0 0.492e-3
20100304 2000.0 0.430e-3 2400.0 0.395e-3
20100305 2800.0 0.383e-3 3200.0 0.367e-3
20100306 3600.0 0.370e-3 4000.0 0.380e-3
20100307 4400.0 0.405e-3 5000.0 0.470e-3

```

*

* gap (bol)

*

20100401	"helium"	0.989748
20100402	"nitrogen"	0.008098
20100403	"oxygen"	0.002153
20100404	"krypton"	0.000000
20100405	"xenon"	0.000002

*

* clad (zr-4)

*

20100501	70.0	2.333e-3	200.0	2.333e-3	400.0	2.458e-3
20100502	800.0	2.805e-3	1200.0	3.278e-3	1600.0	3.805e-3
20100503	1800.0	4.112e-3	2000.0	4.445e-3	2100.0	4.667e-3
20100504	2200.0	4.945e-3	2800.0	7.000e-3		

*

* thermal conductivity base metal (carbon steel)

*

20100601	0.0	.00728	2000.0	.00728
----------	-----	--------	--------	--------

*

* thermal conductivity cladding (stainless steel)

*

20100701	0.0	.00311	2000.0	.00311
----------	-----	--------	--------	--------

*

*

*

* heat structure volumetric heat capacities

*

*

*

* volumetric heat capacity fuel (uo2)

*

20100351	77.0	33.8	200.0	40.62	400.0	43.87
20100352	600.0	45.82	800.0	47.12	1000.0	48.10
20100353	1200.0	48.88	1600.0	49.92	2000.0	50.37
20100354	2400.0	51.35	2800.0	53.62	3200.0	58.17
20100355	3600.0	66.30	4000.0	78.97	4400.0	90.80
20100356	4800.0	99.12	5100.0	101.40		

*

* volumetric heat capacity gap (hot channel)

*

20100451	32.0	0.000075	5400.0	0.000075
----------	------	----------	--------	----------

*

* volumetric heat capacity clad

*

20100551	32.0	28.346	1062.0	33.232	1140.0	35.432
20100552	1480.0	35.432	1510.0	49.440	1530.0	56.440
20100553	1560.0	58.916	1590.0	61.800	1610.0	66.332
20100554	1620.0	76.220	1650.0	80.340	1680.0	78.28
20100555	1700.0	74.16	1780.0	35.432	3000.0	35.432

*

* volumetric heat capacity base metal (carbon steel)

*

20100651 0.0 64.4 2000.0 64.4

*

* volumetric heat capacity cladding (stainless steel)

*

20100751 0.0 64.4 2000.0 64.4

*

*

* general tables

*

*

* test power insertion

*

* 20200100 power

* 20200101 0.0 0.0 5.0 0.0 25.0 1.0-2

*

*

* control variables

*

*

* 20547400 "hcpwr" "constant" 3.15e6

* 20547400 "hcpwr" "function" 3.15e4 0.0 0

* 20547401 time 0 1

*

reactor kinetics

*

* power in watts per assembly

*

30000000 "point" "separabl"

30000001 "gamma-ac" 5.00000 .00000 .28637e+03 1.0 1.0

30000002 "ans73" 0.0 1.0

30000301 0.3230 0.000491 0.2910 0.00000341

*

*

* general table for waste package reactivity insertion ttt = 1

*

30000011 1

30000012 10081

*

*

Waste Package Operations

Calculation

Title: Sensitivity Study of Reactivity Consequences to Waste Package Egress Area

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* moderator density reactivity feedback

*

* beff = 0.005

*

	density lf/ft**3	reactivity, dollars	fuel temp. f
30000501	43.6995724	-22.8341124	* 1004
30000502	45.2602714	-20.0375898	* 1004
30000503	46.8209705	-17.4413905	* 1004
30000504	48.3816695	-15.0255317	* 1004
30000505	49.9423685	-12.7766726	* 1004
30000506	51.5030675	-10.6782739	* 1004
30000507	53.0637665	-08.7187079	* 1004
30000508	54.6244655	-06.8856192	* 1004
30000509	56.1851645	-05.1688975	* 518
30000510	57.4337238	-03.9010990	* 518
30000511	58.6822830	-02.6972060	* 518
30000512	59.8121897	-01.6592902	* 518
30000513	60.7424057	-00.8234196	* 212
30000514	61.6903146	00.00	* 122
30000515	62.4279606	+00.6225345	* 122
30000516	65.0000000	+00.6225345	* 80.33

*

* control volume weighting - modified from Original deck with uniform weights

*

30000701	010010000	0	.02191015	0.0
30000702	020010000	0	.02191015	0.0
30000703	030010000	0	.02191015	0.0
30000704	040010000	0	.02191015	0.0
30000705	050010000	0	.02191015	0.0
30000706	060010000	0	.04382030	0.0
30000707	070010000	0	.04382030	0.0
30000708	080010000	0	.04382030	0.0
30000709	090010000	0	.04382030	0.0
30000710	100010000	0	.04382030	0.0
30000711	110010000	0	.04382030	0.0
30000712	120010000	0	.04382030	0.0
30000713	130010000	0	.04382030	0.0
30000714	140010000	0	.01293183	0.0
30000715	150010000	0	.01418173	0.0
30000716	160010000	0	.04977361	0.0
30000717	170010000	0	.03388387	0.0
30000718	180010000	0	.05595103	0.0
30000719	190010000	0	.05443940	0.0
30000720	200010000	0	.05378898	0.0
30000721	210010000	0	.04873313	0.0
30000722	220010000	0	.05378898	0.0
30000723	230010000	0	.05378898	0.0
30000724	240010000	0	.03063990	0.0
30000725	250010000	0	.07798541	0.0

*

30000501
30000502
30000503

30000504
 30000505
 30000506
 30000507
 30000508
 30000509
 30000510
 30000511
 30000512
 30000513
 30000514
 30000515
 30000516
 30000701
 30000702
 30000703
 30000704
 30000705
 30000706
 30000707
 30000708
 30000709
 30000710
 30000711
 30000712
 30000713
 30000714
 30000715
 30000716
 30000717
 30000718
 30000719
 30000720
 30000721
 30000722
 30000723
 30000724
 30000725

*-----**-----**-----**-----**-----**-----**-----**-----**-----**-----*

*
* average fuel temperature vs. reactivity
*

	fuel temp. f	reactivity, dollars	density lb/ft**3
30000601	32.0	+0.1719079	* 62.4279606
30000602	80.33	+0.1719079	* 62.4279606
30000603	122.0	0.0	* 61.6903146
30000604	212.0	-0.3488604	* 61.6903146
30000605	320.0	-0.7295469	* 60.7424057
30000606	518.0	-1.3918144	* 60.7424057
30000607	1004.0	-2.8696928	* 56.1851645

*
*
*

* heat structure weighting - (added to deck - B&W code does weights internally)

30000801	3301001	0	.04762000	0.0
30000802	3301002	0	.04761900	0.0
30000803	3301003	0	.04761900	0.0
30000804	3301004	0	.04761900	0.0
30000805	3301005	0	.04761900	0.0
30000806	3301006	0	.09523800	0.0
30000807	3301007	0	.09523800	0.0
30000808	3301008	0	.09523800	0.0
30000809	3301009	0	.09523800	0.0
30000810	3301010	0	.09523800	0.0
30000811	3301011	0	.09523800	0.0
30000812	3301012	0	.09523800	0.0
30000813	3301013	0	.09523800	0.0

* Control Blocks

20500000	999								
20500100	cntrlvar	function	0.04762	0.0	0				
20500101	htvat	3301001	002						
20500200	cntrlvar	function	0.04761	0.0	0				
20500201	htvat	3301002	002						
20500300	cntrlvar	function	0.04761	0.0	0				
20500301	htvat	3301003	002						
20500400	cntrlvar	function	0.04761	0.0	0				
20500401	htvat	3301004	002						
20500500	cntrlvar	function	0.04761	0.0	0				
20500501	htvat	3301005	002						
20500600	cntrlvar	function	0.095238	0.0	0				
20500601	htvat	3301006	002						
20500700	cntrlvar	function	0.095238	0.0	0				
20500701	htvat	3301007	002						
20500800	cntrlvar	function	0.095238	0.0	0				
20500801	htvat	3301008	002						
20500900	cntrlvar	function	0.095238	0.0	0				
20500901	htvat	3301009	002						
20501000	cntrlvar	function	0.095238	0.0	0				
20501001	htvat	3301010	002						
20501100	cntrlvar	function	0.095238	0.0	0				
20501101	htvat	3301011	002						
20501200	cntrlvar	function	0.095238	0.0	0				
20501201	htvat	3301012	002						
20501300	cntrlvar	function	0.095238	0.0	0				
20501301	htvat	3301013	002						
20501400	cntrlvar	sum	1.0	0.0	0				
20501401	-6.63322e-5	1.0	cntrlvar 1	1.0	cntrlvar 2	1.0	cntrlvar 3		
20501402	1.0	cntrlvar 4	1.0	cntrlvar 5	1.0	cntrlvar 6			
20501403	1.0	cntrlvar 7	1.0	cntrlvar 8	1.0	cntrlvar 9			
20501404	1.0	cntrlvar 10	1.0	cntrlvar 11	1.0	cntrlvar 12			
20501405	1.0	cntrlvar 13							

20502000	cntrlvar	function	0.02191015	0.0	0				
----------	----------	----------	------------	-----	---	--	--	--	--

20502001	"rho"	010010000	005				
20502100	cntrlvar	function	0.02191015	0.0	0		
20502101	"rho"	020010000	005				
20502200	cntrlvar	function	0.02191015	0.0	0		
20502201	rho	030010000	005				
20502300	cntrlvar	function	0.02191015	0.0	0		
20502301	rho	040010000	005				
20502400	cntrlvar	function	0.02191015	0.0	0		
20502401	rho	050010000	005				
20502500	cntrlvar	function	0.0438203	0.0	0		
20502501	rho	060010000	005				
20502600	cntrlvar	function	0.0438203	0.0	0		
20502601	rho	070010000	005				
20502700	cntrlvar	function	0.0438203	0.0	0		
20502701	rho	080010000	005				
20502800	cntrlvar	function	0.0438203	0.0	0		
20502801	rho	090010000	005				
20502900	cntrlvar	function	0.0438203	0.0	0		
20502901	rho	100010000	005				
20503000	cntrlvar	function	0.0438203	0.0	0		
20503001	rho	110010000	005				
20503100	cntrlvar	function	0.0438203	0.0	0		
20503101	rho	120010000	005				
20503200	cntrlvar	function	0.0438203	0.0	0		
20503201	rho	130010000	005				
20503300	cntrlvar	function	0.01293183	0.0	0		
20503301	rho	140010000	005				
20503400	cntrlvar	function	0.01418173	0.0	0		
20503401	rho	150010000	005				
20503500	cntrlvar	function	0.04977361	0.0	0		
20503501	rho	160010000	005				
20503600	cntrlvar	function	0.03388387	0.0	0		
20503601	rho	170010000	005				
20503700	cntrlvar	function	0.05595103	0.0	0		
20503701	rho	180010000	005				
20503800	cntrlvar	function	0.05443940	0.0	0		
20503801	rho	190010000	005				
20503900	cntrlvar	function	0.05378898	0.0	0		
20503901	rho	200010000	005				
20504000	cntrlvar	function	0.04873313	0.0	0		
20504001	rho	210010000	005				
20504100	cntrlvar	function	0.05378898	0.0	0		
20504101	rho	220010000	005				
20504200	cntrlvar	function	0.05378898	0.0	0		
20504201	rho	230010000	005				
20504300	cntrlvar	function	0.03063990	0.0	0		
20504301	rho	240010000	005				
20504400	cntrlvar	function	0.07798541	0.0	0		
20504401	rho	250010000	005				
*							
20505000	cntrlvar	sum	1.0	0.0	0		
20505001	0.0	1.0	cntrlvar 20	1.0	cntrlvar 21	1.0	cntrlvar 22
20505002		1.0	cntrlvar 23	1.0	cntrlvar 24	1.0	cntrlvar 25
20505003		1.0	cntrlvar 26	1.0	cntrlvar 27	1.0	cntrlvar 28
20505004		1.0	cntrlvar 29	1.0	cntrlvar 30	1.0	cntrlvar 31

```

*
20505500  cntrlvar  sum      1.0      0.0  0
20505501  0.0  1.0  cntrlvar 32  1.0  cntrlvar 33  1.0  cntrlvar 34
20505502      1.0  cntrlvar 35  1.0  cntrlvar 36  1.0  cntrlvar 37
20505503      1.0  cntrlvar 38  1.0  cntrlvar 39  1.0  cntrlvar 40
20505504      1.0  cntrlvar 41  1.0  cntrlvar 42  1.0  cntrlvar 43
20505505      1.0  cntrlvar 44
*
20505600  cntrlvar  sum      1.0      0.0  0
20505601  0.1185681  1.0  cntrlvar 50  1.0  cntrlvar 55
*
20506000  cntrlvar  function  1.0      0.0  0
20506001  time      0          001
20506500  cntrlvar  sum      1.0      0.0  0
20506501  0.0  1.0  cntrlvar 14  1.0  cntrlvar 56  1.0  cntrlvar 60
*
20507000  cntrlvar  integral  1.0      0.0  0
20507001  rktpow    0
*
20507500  cntrlvar  sum      6.22971e-2  0.0  0
20507501  0.0  1.0  htgamw 312100100  1.0  htgamw 312100200
20507502      1.0  htgamw 312100300  1.0  htgamw 312100400
20507503      1.0  htgamw 312100500  1.0  htgamw 312100600
20507504      1.0  htgamw 312100700  1.0  htgamw 312100700
20507505      1.0  htgamw 312100900
*
*          scale factor = 1/area sum
20508000  cntrlvar  sum      0.26289886  0.0  0
20508001  0.0  0.3516846 voidf 050010000  0.7033692 voidf 100010000
20508002      0.8633786 voidf 200010000  0.7822260 voidf 210010000
*
20508100  cntrlvar  function  1.0      0.0  0
20508101  cntrlvar  80          010
. * end of data

```

ATTACHMENT IV

The directory of files on the electronic media (CD) for this calculation is given in Table IV-1. Files from the HP-9000 workstation directory were copied first to a personal computer (PC), then to the CD. File names and sizes in bytes are listed as given on the originating hardware. The RELAP5/MOD3.2 program uses and creates a number of data files. Many of these files are intermediate in nature and thus are important but may not be directly referenced either as initial input data files or as resource files for tabular and/or graphical display of results from the calculation. File connections (traceability) for a particular dataset are listed in the appropriate spreadsheet giving the PC data files and RELAP5/MOD3.2 files.

Table IV-1. Directory of Files on Compact Disk

File Name	Date Created	File Size	File Type
c221a.s04	07-05-99 12:58p	3,504,018	PC-ASCII Data
c221b.s02	07-03-99 2:23p	1,839,186	PC-ASCII Data
c221c.s02	07-03-99 4:28p	1,839,186	PC-ASCII Data
c221d.s02	07-03-99 4:29p	1,839,186	PC-ASCII Data
c221e.s02	07-05-99 9:53a	1,839,186	PC-ASCII Data
c221f.s02	07-05-99 11:08a	1,839,186	PC-ASCII Data
c230a.s01	06-30-99 9:35a	616,978	PC-ASCII Data
c230b.s01	06-30-99 9:36a	616,978	PC-ASCII Data
c230c.s01	06-30-99 9:36a	616,978	PC-ASCII Data
c230d.s01	06-30-99 4:51p	616,978	PC-ASCII Data
c230d1.s02	07-02-99 8:17a	616,978	PC-ASCII Data
c230e.s01	07-01-99 2:21p	616,978	PC-ASCII Data
c230f.s01	07-02-99 8:54a	616,978	PC-ASCII Data
c230junx.xls	07-07-99 2:29p	6,398,464	PC-Binary Data
c103xmdl.xls	09-20-99 10:24a	5,004,288	PC-Binary Data
RLP5GEOM-1.xls	09-16-99 10:19a	63,488	PC-Binary Data
strip.for	06-25-99 10:45a	7,556	FORTTRAN-90 Source
strip.exe	06-25-99 10:47a	20,095	PC-Binary Program
c221a.r01	07/07/99 2:49 PM	4926	HP-ASCII Data
c221a.r01.lst	07/07/99 2:50 PM	4457263	HP-ASCII Data
c221a.r02	07/07/99 2:50 PM	5039	HP-ASCII Data
c221a.r02.lst	07/07/99 2:50 PM	7292526	HP-ASCII Data
c221a.strip	07/07/99 2:50 PM	6767	HP-ASCII Data
c230a.r01	07/07/99 3:07 PM	5155	HP-ASCII Data
c230a.r01.lst	07/07/99 3:07 PM	593883	HP-ASCII Data
c230a.strp	07/07/99 3:07 PM	7186	HP-ASCII Data
c230a.strp.lst	07/07/99 3:07 PM	25744	HP-ASCII Data
c230a.strp.set01	07/07/99 3:07 PM	608821	HP-ASCII Data
c230b.r01	07/07/99 3:07 PM	5207	HP-ASCII Data
c230b.r01.lst	07/07/99 3:07 PM	594097	HP-ASCII Data
c230b.strp	07/07/99 3:07 PM	7185	HP-ASCII Data
c230b.strp.lst	07/07/99 3:07 PM	25744	HP-ASCII Data
c230b.strp.set01	07/07/99 3:07 PM	608821	HP-ASCII Data
c230c.r01	07/07/99 3:07 PM	5262	HP-ASCII Data
c230c.r01.lst	07/07/99 3:07 PM	594204	HP-ASCII Data
c230c.strp	07/07/99 3:07 PM	7185	HP-ASCII Data
c230c.strp.lst	07/07/99 3:07 PM	25744	HP-ASCII Data
c230c.strp.set01	07/07/99 3:07 PM	608821	HP-ASCII Data

File Name	Date Created	File Size	File Type
c230d.r01	07/07/99 3:07 PM	5301	HP-ASCII Data
c230d.r01.lst	07/07/99 3:07 PM	594311	HP-ASCII Data
c230d.strp	07/07/99 3:07 PM	7239	HP-ASCII Data
c230d.strp.lst	07/07/99 3:07 PM	25851	HP-ASCII Data
c230d.strp.set01	07/07/99 3:07 PM	608821	HP-ASCII Data
c230d1.strp	07/07/99 3:07 PM	7302	HP-ASCII Data
c230d1.strp.lst	07/07/99 3:07 PM	25958	HP-ASCII Data
c230d1.strp.set02	07/07/99 3:07 PM	608821	HP-ASCII Data
c230e.r01	07/07/99 3:07 PM	5355	HP-ASCII Data
c230e.r01.lst	07/07/99 3:07 PM	594418	HP-ASCII Data
c230e.strp	07/07/99 3:07 PM	7293	HP-ASCII Data
c230e.strp.lst	07/07/99 3:07 PM	25958	HP-ASCII Data
c230e.strp.set01	07/07/99 3:07 PM	608821	HP-ASCII Data
c230f.r01	07/07/99 3:07 PM	5409	HP-ASCII Data
c230f.r01.lst	07/07/99 3:07 PM	594525	HP-ASCII Data
c230f.strp	07/07/99 3:07 PM	7354	HP-ASCII Data
c230f.strp.lst	07/07/99 3:07 PM	26065	HP-ASCII Data
c230f.strp.set01	07/07/99 3:07 PM	608821	HP-ASCII Data
r5wp2d.c221a	07/07/99 2:50 PM	44800	HP-ASCII Data
r5wp2d.c221a.lst	07/07/99 2:50 PM	8588538	HP-ASCII Data
r5wp2d.c221a.rst	07/07/99 14:51 PM	35238016	HP-Binary Data
r5wp2d.c221a.strip	07/07/99 2:51 PM	7389	HP-ASCII Data
r5wp2d.c221a.strip.lst	07/07/99 2:51 PM	26172	HP-ASCII Data
r5wp2d.c221a.strip.set04	07/07/99 2:51 PM	3457691	HP-ASCII Data
r5wp2d.c221b	07/07/99 2:51 PM	44868	HP-ASCII Data
r5wp2d.c221b.lst	07/07/99 2:52 PM	8588645	HP-ASCII Data
r5wp2d.c221b.rst	07/07/99 14:52 PM	16572368	HP-Binary Data
r5wp2d.c221b.strip	07/07/99 2:52 PM	7417	HP-ASCII Data
r5wp2d.c221b.strip.lst	07/07/99 2:52 PM	26279	HP-ASCII Data
r5wp2d.c221b.strip.set02	07/07/99 2:52 PM	1814870	HP-ASCII Data
r5wp2d.c221c	07/07/99 2:52 PM	44937	HP-ASCII Data
r5wp2d.c221c.lst	07/07/99 2:52 PM	8588752	HP-ASCII Data
r5wp2d.c221c.rst	07/07/99 14:52 PM	16572368	HP-Binary Data
r5wp2d.c221c.strip	07/07/99 2:52 PM	7445	HP-ASCII Data
r5wp2d.c221c.strip.lst	07/07/99 2:52 PM	26386	HP-ASCII Data
r5wp2d.c221c.strip.set02	07/07/99 2:52 PM	1814870	HP-ASCII Data
r5wp2d.c221d	07/07/99 2:52 PM	45137	HP-ASCII Data
r5wp2d.c221d.lst	07/07/99 2:52 PM	8589073	HP-ASCII Data
r5wp2d.c221d.rst	07/07/99 14:53 PM	16572368	HP-Binary Data
r5wp2d.c221d.strip	07/07/99 2:53 PM	7473	HP-ASCII Data
r5wp2d.c221d.strip.lst	07/07/99 2:53 PM	26493	HP-ASCII Data
r5wp2d.c221d.strip.set02	07/07/99 2:53 PM	1814870	HP-ASCII Data
r5wp2d.c221e	07/07/99 2:53 PM	45207	HP-ASCII Data
r5wp2d.c221e.lst	07/07/99 2:53 PM	8589180	HP-ASCII Data
r5wp2d.c221e.rst	07/07/99 14:53 PM	16572368	HP-Binary Data
r5wp2d.c221e.strip	07/07/99 2:53 PM	7501	HP-ASCII Data
r5wp2d.c221e.strip.lst	07/07/99 2:53 PM	26600	HP-ASCII Data
r5wp2d.c221e.strip.set01	07/07/99 2:53 PM	1814870	HP-ASCII Data
r5wp2d.c221f	07/07/99 2:53 PM	45404	HP-ASCII Data
r5wp2d.c221f.lst	07/07/99 2:53 PM	8589501	HP-ASCII Data
r5wp2d.c221f.rst	07/07/99 14:54 PM	16572368	HP-Binary Data
r5wp2d.c221f.strip	07/07/99 2:54 PM	7529	HP-ASCII Data
r5wp2d.c221f.strip.lst	07/07/99 2:54 PM	26707	HP-ASCII Data

File Name	Date Created	File Size	File Type
r5wp2d.c221f.strip.set02	07/07/99 2:54 PM	1814870	HP-ASCII Data
r5wp2d.c230a	07/07/99 3:07 PM	44428	HP-ASCII Data
r5wp2d.c230a.lst	07/07/99 3:07 PM	7564836	HP-ASCII Data
r5wp2d.c230a.rst	07/07/99 15:07 PM	21439144	HP-Binary Data
r5wp2d.c230b	07/07/99 3:07 PM	44620	HP-ASCII Data
r5wp2d.c230b.lst	07/07/99 3:08 PM	7565157	HP-ASCII Data
r5wp2d.c230b.rst	07/07/99 15:08 PM	21439144	HP-Binary Data
r5wp2d.c230c	07/07/99 3:08 PM	44806	HP-ASCII Data
r5wp2d.c230c.lst	07/07/99 3:08 PM	7565478	HP-ASCII Data
r5wp2d.c230c.rst	07/07/99 15:08 PM	21439144	HP-Binary Data
r5wp2d.c230d	07/07/99 3:08 PM	45000	HP-ASCII Data
r5wp2d.c230d.lst	07/07/99 3:09 PM	7565799	HP-ASCII Data
r5wp2d.c230d.rst	07/07/99 15:09 PM	21439144	HP-Binary Data
r5wp2d.c230d1	07/07/99 3:09 PM	45117	HP-ASCII Data
r5wp2d.c230d1.lst	07/07/99 3:09 PM	8177637	HP-ASCII Data
r5wp2d.c230d1.rst	07/07/99 15:10 PM	10567976	HP-Binary Data
r5wp2d.c230e	07/07/99 3:10 PM	45204	HP-ASCII Data
r5wp2d.c230e.lst	07/07/99 3:10 PM	7566120	HP-ASCII Data
r5wp2d.c230e.rst	07/07/99 15:10 PM	21439144	HP-Binary Data
r5wp2d.c230f	07/07/99 3:10 PM	45409	HP-ASCII Data
r5wp2d.c230f.lst	07/07/99 3:11 PM	7566441	HP-ASCII Data
r5wp2d.c230f.rst	07/07/99 15:11 PM	21439144	HP-Binary Data
runxrlp5	07/07/99 3:36 PM	2829	HP-ASCII Data
runxstrp	07/07/99 3:37 PM	524	HP-ASCII Data
c103cbas.dk	07/27/99 10:59 AM	45,042	HP-ASCII Data
c103x1hbv.test.lst	09/20/99 4:11 PM	6,429,401	HP-ASCII Data
c10cx1hbv.test	09/20/99 4:10 PM	49,137	HP-ASCII Data