RETRAN — A Program for One-Dimensional Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems

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NOTICE

ABSTRACT

RETRAN represents a new computer code approach for analyzing the thermal-hydraulic response of Nuclear Steam Supply Systems (NSSS) to hypothetical Loss of Coolant Accidents (LOCA) and Operational Transients. In contrast to the "conservative" approach, RETRAN provides "best estimate" solutions to hypothetical LOCAs and Operational Transients. RETRAN is a computer code package developed from the RELAP series of codes, from reference data, and from extensive analytical and experimental work previously conducted relative to the thermal-hydraulic behavior of light-water reactor systems subjected to postulated accidents and operational transient conditions. The RETRAN computer code is constructed in a semimodular and dynamic dimensioned form where additions to the code can be easily carried out as new and improved models are developed. This report (the third of a four volume computer code manual) describes the required input, the code output and shows a number of sample problems run with RETRAN. The three companion volumes describe the theory and numerical algorithms, the programming details, and the verification and qualification performed with RETRAN.

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1. INTRODUCTION

I. INTRODUCTION

The RETRAN Code Package is a semi-modular system of program modules used to analyze thermal-hydraulic transients. The package is actually a compendium of four program modules utilizing a common pool of data processing, I/O handling, resource allocation and computational subroutines.

The four program modules available in the RETRAN Code Package include: 1) RETRAN, the best estimate thermal-hydraulic transient analysis program; 2) RESTRT, the program used to continue (restart) RETRAN problems; 3) REEDIT, the program used to obtain printed edits of RETRAN problem solutions archived on data tapes; and 4) PLØTER, the program used to plot RETRAN problem solutions archived on RETRAN data tapes. Each of the four program modules features full dynamic dimensioning and resource allocation. Execution of a particular program module is facilitated by simply supplying the appropriate data deck.

The computer program RELAP4/003 version 85 released by the NRC as a portion of the Water Reactor Evaluation Model, WREM, package,[I-1] was used as the base for the general computational framework of program modules RETRAN and RESTRT. All reflood and evaluation model subroutines have been omitted and only the best estimate portion of the code was retained. Extensive modifications have been made to the best estimate portion of the code, correcting coding errors, and incorporating model changes to the flow and heat transfer solutions. Model improvements and additions have been made in the following areas:

(1) Conduction solution on different time step frequency than flow solution

(2) Volume state properties not updated every time step for quasi-static volumes

(3) Implicit two-surface heat transfer solution

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(4) Auxiliary minimum DNBR calculation

(5) Piping transport delay time model

(6) Non-equilibrium pressurizer model

(7) Extended trip logic featuring coincidence and indirect trip actions

(8) Generalized control system model

(9) Specified heat transfer coefficient option

(10) Improved junction property calculation

(11) Extended non-conducting heat exchanger model

(12) Fill model extended to account for time variant thermodynamic conditions

(13) Extended tabular power input capabilities

(14) Steady-state initialization

(15) Flow regime map

(16) Beattie two-phase friction multiplier

II. PROGRAM SUMMARY DESCRIPTION

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II. PROGRAM SUMMARY DESCRIPTION

A general overview of each of the four program modules available in the RETRAN Code Package, is given in the following section. The primary module, RETRAN, is used to perform thermal-hydraulic transient analyses. The program module, RESTRT, is used to continue previous RETRAN calculations and modules REEDIT and PLØTER are support software utilities used to aid in the interpretation of analytical results. All program modules, with the exception of PLØTER, will at the users option, provide printer plots of specified parameters at execution time. These printer plots are of great use in that they allow a cursory examination of the analysis immediately upon job completion.

1.0 RETRAN

The RETRAN program module is used to analyze thermal-hydraulic transients and requires numerical input data that completely describe the components and geometry of the system being analyzed. The input data include fluid volume sizes, initial flow, pump features, power generation, heat exchanger properties, and material compositions. A minimal amount of information is required to describe the initial pressure and temperature distribution within the system, provided the steady-state initialization option is used. This option allows the user to input the best known pressures and/or loss coefficients, and the code computes the remaining unknowns (provided the system is not underspecified), such that a steady-state condition may be maintained in the transient portion of the code. The steady-state option also computes volume enthalpies from a steady-state energy balance, with the restriction that generally only one enthalpy may be supplied per flow system, e.g., one enthalpy in the primary system and one in the secondary side of a steam generator. The option is also available to completely specify the system pressure and enthalpy distribution, which allows the system to be over specified, and which generally prevents a true steady-state condition from being maintained in the transient portion of the code. From the initial condition, transients can be initiated by the control actions input to the program that describes breaks in fluid piping, valve actions, pump changes, and power variations. The program computes for each time advancement fluid conditions such as flow, pressure, mass inventory, and steam-water fractions (quality); and fluid-solid interface conditions such as heat flux and surface temperature.

The degree of detail to which the system is described is completely specified by the program user. Nodalization of fluid flow paths within the piping and vessels is specified by the program user as is the temperature nodalization within solids such as reactor core fuel rods, pipe walls, and heat exchanger walls. Both reactor primary and secondary flow systems can be described. These systems are coupled by heat transfer through the walls of the heat exchangers. The system detail permitted is limited only by the computer core available. However, from a practical viewpoint, the detail is most generally limited by computer costs. Computer running time increases with increasing detail.

The definition of the thermal-hydraulic system is also completely specified by the user. A portion of a system such as a single reactor channel with a single fuel rod can be analyzed by supplying appropriate time-dependent boundary conditions, such as pressures and enthalpies in the lower and upper fluid plenums. These boundary conditions can be defined by the user, if known, or they can be obtained from a previous RETRAN analysis. For example, a rather gross analysis of a reactor blowdown transient may be performed using a RETRAN model that describes the entire primary flow loop, the upper and lower plenums, and a simple nodalization of the total reactor core. A second RETRAN calculation, using the previously calculated fluid condition in the upper and lower plenums, can be performed to analyze component effects such as a single core channel. The benefit derived by this approach is that the detailed core calculation can be separated from the overall system analysis. Although both calculations can be combined into a single RETRAN calculation, the separate approach is usually less expensive and more efficient for parameter studies.

2.0 RESTRT

The RESTRT program module is used to continue (restart) a RETRAN analysis from a minimal set of input data. This input data and the information obtained from the original problem input data archived on the RETRAN data tape are used to continue an analysis. All time-dependent information required to continue a problem, such as fluid thermodynamic conditions, conductor temperature distributions and power level are retrieved from the RETRAN data tape for the original solution time at which the problem is to be continued. Optional input data may be supplied to modify time-step selection features, edit frequencies, minor edit parameters and trip-control-system descriptions. Printer plots may also be requested at restart time.

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3.0 REEDIT

REEDIT is the program module used to obtain printed edits and/or printer plots of RETRAN problem solutions archived on magnetic data tapes. User input requirements are minimal and amount to specifying the RETRAN data tape description, major and minor edit frequencies, and an optional list of minor edit parameters. REEDIT allows all consecutive data records to be edited at any frequency and also permits editing to begin at any problem solution time specified.

4.0 PLØTER

The PLØTER program module processes RETRAN data tapes in conjunction with user specified card input parameters to produce Calcomp plots. Organization of plot sets and plot characteristics are defined by card input. PLØTER contains options for linear or logarithmic scales, axes lengths, scale range, axes labels, and options for combining parameters or performing operations such as differencing or scaling. Input data requirements are dependent on the complexity of the desired plots or plot sets.

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III. INPUT DATA REQUIREMENTS

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The input data requirements of the RETRAN Code Package consist of both computer-dependent job control cards and associated input data decks which are not computer dependent. Control cards required to execute a module of the RETRAN Code Package are discussed in the following sections and the input data deck organization and input data summaries for each module are discussed in subsequent sections.

1.0 CONTROL CARDS

Control card requirements for the RETRAN Code Package vary from one computer manufacturer to another and even within different computer operating systems designed for computers produced by a given manufacturer. The following sections discuss the control card requirements for the computer systems generally being used to execute large scientific programs such as RETRAN.

1.1 Control Data Corporation CYBER 70/170 and 6000 Series Computing Systems

The CDC control cards required to execute a program module in the RETRAN Code Package are presented as guidelines only, and are not intended to be taken verbatim. A detailed description of the control card usage can be obtained by referring to the SCOPE 3.4 reference manuals[III.1-1] or the NOS/BE 1 reference manual.[III.1-2]

Execution of a problem on any of the program modules in the RETRAN Code Package requires a common set of control cards. This set of control cards is a minimal set, since all files required to execute a problem are requested by the code through use of user-supplied input data. The following examples illustrate typical control card decks used to execute problems with the RETRAN Code Package.

```
RETRAN,T200,IØ500,P5,MT1.
ACCØUNT(MAJMIN,PASWD)
LABEL(TAPE,R,L=RETRANABS,VSN=606060,D=HY,NØRING)
COPYBF(TAPE,RETRAN)
UNLØAD(TAPE)
RFL(160000)
RETRAN.
7/8/9
   .
   .
   .
   .
RETRAN DATA DECK
   .
   .
   .
   .
6/7/8/9
```

In the sample problem illustrated above, the RETRAN loadmodule is copied from magnetic tape to a local disk file. The magnetic tape is then unloaded and the tape drive becomes available for later use if a data tape is to be generated or read. The RFL card is used to tell the operating system that the next step, or program execution, will require 160K octal words of central memory. This request for memory is the maximum core that the current job will require and will be reduced to the memory actually required, once the input data has been processed. Program execution is initiated by the control card RETRAN. Data for the program will then be read from the second record of file INPUT, the record immediately following the job control card record.

The following sample demonstrates the use of a loadmodule which resides on a permanent disk file and a card image data set also resident on a permanent disk file. Another option demonstrated, is the print line limit reset, where the system default line limit (generally not adequate for large RETRAN outputs) is extended to 55000 lines.

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```
RETRAN,T3000,IØ2000,P2,MT1.
ACCØUNT(MAJMIN,PASWD)
ATTACH(DATA,RETRANDTA,ID=YØU,CY=2)
ATTACH(RETRAN,RETRANABS,ID=ØWN,CY=1,PW=SECRET)
RFL(250000)
RETRAN(PL=55000,DATA)
6/7/8/9
```

Field length requirements for executing a problem using the RETRAN Code Package range from approximately 50,000 octal words for small REEDIT problems to the maximum available core for large RETRAN or RESTRT problems. It is required that the minimum user-supplied field length be at least as large as the field length required to load the RETRAN Code Package. Once execution has been initiated and all storage assignments made, the field length will be reduced automatically and the new field length edited. If the field length required to execute a problem is larger than that specified on an RFL control card, an informative message will be written and the job terminated. The field length specification for new problems can be estimated by requesting a large field length and then using the information edited after the field length is reduced, to estimate core requirements for subsequent runs. The RETRAN Code Package may require a slightly larger field length during initialization than during the actual problem solution, so the specified field should be several thousand octal words larger than the field length edited following the program field length reduction.

1.2 International Business Machine 360/370 Computing Systems

The IBM Job Control Language (JCL), required to execute a program module in the RETRAN Code Package will vary somewhat from system to system, but the guidelines illustrated in the following examples should be applicable to most systems with minor modifications. A detailed description of JCL requirements can be obtained from the IBM System/360 Operating System Job Control Language, OS/VS JCL and OS/VS2 MVS JCL reference manuals [III.1-3, III.1-4, III.1-5].

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A common set of JCL is used to execute any program module residing in the RETRAN Code Package. This set contains the minimal information generally required to specify the DD cards for the I/O operations performed by RETRAN. but may vary somewhat from system to system. The UNIT and DISP parameters are required on all DD cards. A SPACE parameter is also required for disk units with DISP=(NEW), while a dummy volume serial number is generally required for the tape and disk units with DISP(OLD). The remainder of the necessary information is supplied via user data contained in the input deck, thus minimizing JCL which the user must supply. The following sample illustrates the typical JCL used to execute problems with the RETRAN Code Package.

```
//JOBNAM JOB (------------------------)
//RETRAN  PROC XTIME=5,PAGES=100,XREG=1200K,FAST=1300.
//           RETRAN='RETRAN.RETRAN.DBLOPT2.NOVLY2',DISKS=DISKS,SER=E10001,
//           NTRK2=5,NTRK3=0,NTRK4=0,NTRK5=0,
//           VSN1=ANY,VSN11=ANY,VSN12=ANY,VSN13=ANY,
//           EXPDT11=98000,EXPDT12=98000,EXPDT13=98000,EXPDT14=98000,
//           FTBD1=15,FTBD2=2,FTBD3=0,FTBD4=0,FTBD5=0,
//           FTBB1=,FTBB2=,FTBB3=,FTBB4=,FTBB5=
//X          EXEC PGM=RETRAN,REGION=&XREG,TIME=&XTIME,PARM='8,&FAST'
//STEPLIB DD DSN=&RETRAN,UNIT=&DISKS,VOL=SER=&SER,DISP=SHR
//FT01F001  DD UNIT=(&DISKS,,DEFER),DISP=SHR,VOL=SER=&VSN1
//FT02F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK2)
//FT03F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK3)
//FT04F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK4)
//FT08F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK5)
//FT05F001  DD DDNAME=SYSIN
//FT06F001  DD SYSOUT=A,DCB=(RECFM=FBSA,LRECL=133,BLKSIZE=931),
//             SPACE=(TRK,(&PAGES,100))
//FT11F001  DD UNIT=(TAPE,,DEFER),DISP=(OLD,KEEP),VOL=SER=&VSN11,
//             LABEL=EXPDT=&EXPDT11
//FT12F001  DD UNIT=(TAPE,,DEFER),DISP=(OLD,KEEP),VOL=SER=&VSN12,
//             LABEL=EXPDT=&EXPDT12
//FT13F001  DD UNIT=(TAPE,,DEFER),DISP=(OLD,KEEP),VOL=SER=&VSN13,
//             LABEL=EXPDT=&EXPDT13
//FT14F001  DD UNIT=TAPE,DISP=(NEW,KEEP),LABEL=EXPDT=&EXPDT14
//FT50F001  DD SYSOUT=B
//FTB15F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD1),
```

```
//             DCB=BLKSIZE=&FTBB1
//FTB16F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD2),
//             DCB=BLKSIZE=&FTBB2
//FTB17F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD3),
//             DCB=BLKSIZE=&FTBB3
//FTB18F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD4),
//             DCB=BLKSIZE=&FTBB4
//FTB19F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD5),
//             DCB=BLKSIZE=&FTBB5
// PEND
//STPNAM  EXEC  RETRAN,XTIME=10,XREG=1250
//X.SYSIN  DD *
      .
      .
      .
      .
  RETRAN DATA DECK
      .
      .
      .
      .
/*EØF
```

In the example given above, the RETRAN load module is executed by use of the in-stream procedure named RETRAN. The execution time and region size are modified from their default values and the input data set is in card form and immediately follows the //X.SYSIN DD * control card. Any disk or tape data sets required by the job are requested by the code via user supplied input data.

The region size requested at execution time either by default or an explicit specification as illustrated above, is used throughout the job step since the region size cannot be modified during a given job step. Upon completion of the input processing, an edit is made which specifies the region size and the portion that is not used by the problem. The region specification used for future runs can be reduced by approximately the size of the unused block of memory. Since the input processing and initialization sequence may require slightly more memory than is required to execute the transient calculations, several thousand bytes of unused memory should be requested when making adjustments to the region size for subsequent runs.

The following sample demonstrates the use of a cataloged procedure and a card image input data set which resides on mass storage, where the cataloged procedure is identical to the in-stream procedure given in the first example,

```
//JOBNAM  JØB ()
//STPNAM  EXEC RETRAN
//X.SYSIN  DD DSN=RETRAN.TEST.DATA,UNIT=3330,VØL=SER=YURDSC,DISP=SHR
//*EØR
```

The use of a cataloged procedure can significantly reduce the number of control cards that the frequent RETRAN user must supply with a given job, once a procedure has been written for his system.

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2.0 DATA DECK ORGANIZATION

Input data decks for the RETRAN Code Package are processed by use of the INP data input processing package. Use of the INP package offers: free form input; card numbers to identify the cards; automatic removal of cards containing duplicate card numbers; arbitrary ordering of input cards except for duplicate cards; arbitrary use of comment cards and comments on data cards; ease of preparing cases in which only moderate changes are made from case to case; and a listing of the card data.

The data deck organization contains input for one or more problem sets and no relationship is assumed between problem sets. In fact, each problem set can be input data for a different executable program module, e.g., RETRAN, RESTRT, REEDIT or PLØTER. Each problem set consists of one or more cases in which the input data for cases other than the first consist of the data from the previous case plus modification cards entered for the present case.

A list containing a card sequence number and the card image of each card is printed at the beginning of printed output for each case. The card sequence numbers start at one for each case. The first line of the list contains, "LISTING OF INPUT DATA FOR CASE n", where n is the case number.

2.1 Title Card

A title card is designated by an equal sign (=) as the first non-blank character on a card. The remainder of the card can have any alphanumeric characters. The information on the title card and the current date are printed at the beginning of every edit following the input data processing. A title card must be entered for each case. If more than one title card is entered for a case, the contents of the last title card are used. If no title card is furnished, an error flag is set and the case is terminated upon completion of the input processing.

2.2 Comment Cards

An asterisk (*) or a dollar sign ($) appearing as the first non-blank character identifies the card as a comment card. Any information may be entered on the remainder of the card. Blank cards are treated as comment cards. There is no

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processing of comment cards other than listing them in the card list. Comment cards may be placed anywhere in the input deck.

2.3 Data Cards

All cards other than title cards, comment cards, slash cards, or period cards are considered data cards. The data cards contain a varying number of fields which may be decimal integer, decimal floating point or alphanumeric.

Blanks preceding and following fields are ignored. A decimal field is started by either a digit (0 through 9), a sign (+ or -), or a decimal point (.). A comma or a blank (with one exception noted below) terminates the decimal field. The decimal field has a number part, and optionally an exponent part. A decimal field without a decimal point or an exponent is a decimal integer field; a field with either a decimal point or an exponent or both is a decimal floating point field. A decimal floating point field without a decimal point is assumed to have a decimal point immediately in front of the first digit. The exponent denotes the power of ten to be applied to the number part of the field. The exponent part is a sign, an E or D, or an E or D and a sign followed by a number giving the power of ten. Rules for decimal floating point numbers are identical to those for entering data in Fortran E or F formatted fields except that no blanks (one exception) are allowed between characters. Floating point data punched by Fortran programs can be read; to permit this, a blank following an E or D denoting an exponent is treated as a plus sign. Acceptable ways of entering floating point numbers are illustrated by the following seven fields all containing the quantity 12.45,

```
 12.45
+12.45
 1245+2
 1.245+1
 1.245E1
 1.245E+1
 1.245E 1
```

When entering a decimal zero for either an integer or floating point quantity, the zero can be written in either form. Thus, a floating point zero can be entered simply as 0 without a decimal point. A field starting with a non-blank character other than a digit, sign, comma, period or decimal point, asterisk, dollar sign, slash, or apostrophe is considered a default alphanumeric field. The field is terminated by a comma or the end of the card; all characters except commas are allowed and imbedded blanks are considered part of the alphanumeric field and do not terminate the field. An alphanumeric field can also be specified by enclosing the field within delimiters, either apostrophes (') or quotes ("). A blank or comma must follow the terminating apostrophe. The apostrophe field can be used to specify an alphanumeric field beginning with one of the special characters, e.g., a RETRAN data tape label request 'RETRAN8VØLSAMPLE'.

Data on a card may be continued on a continuation card by entering a plus sign as the first non-blank character on the continuation card. A field starting on a card must be completed on that card and may not continue to the next card. The plus sign indicating the continuation card is not considered part of the first data field on the continuation card and may be placed alone or adjacent to the first data field. Continuation cards themselves may be continued. In subsequent processing, data on continuation cards are treated as if the data were all entered on one card.

Comment information may follow the data fields on any data card including cards that are continued, by preceding the comments with an asterisk or dollar sign. A default alphanumeric field preceding a comment must be terminated by a comma or the comment information is considered part of the alphanumeric field.

When card format errors are detected, lines containing a dollar sign ($) located under the character causing the error, and a comment giving the card column containing the error are printed. A field containing an error is converted as an alphanumeric field of $$$$$$$$. An error flag is set and input processing continues, but the job will be aborted at the end of input processing. Usually another error is produced by a routine attempting to process the erroneous data.

The first field on a data card is treated as a card number which must be a positive decimal integer number. If the first field has an error or is not a positive decimal integer, the card number is replaced by the current card sequence number, an error statement is printed, and the error flag is set. Data on any card containing an error is not used and will be identified by the card sequence number in the list of unused data cards edited once all required cards have been read. Continuation cards do not have card numbers since they are considered an extension of the first card. After each card number and the accompanying data are converted, the card number is compared to previously entered card numbers. If a matching card number is found, the data entered on the previous card is replaced by the data of the current card. If the card being processed contains only a card number, the card number and the data entered on the previous card are deleted. If a card causes replacement or deletion of data, a statement is printed indicating that the card is a replacement card.

2.4 Terminator Cards

Each problem set and any stacked cases within problem sets are separated with terminator cards. Input data for cases are separated by slash cards; the final case is terminated by a period card instead of a slash card. The period card also serves as the separator between problem sets. A slash card has a (/) as the first non-blank character on a card; a period card has a (.) as the first non-blank character. Comments may follow the slash and period on slash and period cards.

When a slash card is used as a terminator, the list of card numbers and associated data used in the case are passed to the next case. Cards entered for the next case are added to the passed list or act as replacement cards depending on the card number. The resulting input is the same as if all previous slash cards were removed from the input to the problem set. The input data for a case is not passed to the case where a period card is encountered.

All of the executable modules in the RETRAN Code Package may be executed using the multiple case option. As noted previously, multiple problem sets may provide input data for any or all of the executable modules available in the RETRAN Code Package.

2.5 Card Number Utilization

Card numbers, in addition to being used to identify a card and to replace or to remove cards, can be used to indicate the use of a data card. The following example of such a RETRAN data card serves as an illustration. Volume Data Cards

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have card numbers 05XXXY where 05 indicates the card is Volume Data Card, XXX is an arbitrary volume number assigned by the user ranging from 001 to 999, and Y is a card sequence number. The volume number XXX is referenced by other data cards such as the Junction Data Cards and Pump Description Data Cards when additional features of volume XXX are described, e.g., flow paths, pumps, etc.

IV. RETRAN INPUT DATA SUMMARY

IV. RETRAN INPUT DATA SUMMARY

In the following description of the RETRAN input data cards, the card number is given along with a descriptive title of the data contained on the card. Next is given an explanation of any variable data such as the volume or junction number, which is included in the card number. Then, the order of the data (W1, W2, ...), the format (I, R or A), the variable name, and the input data requirements are given where applicable. The format of the data field, integer, real floating point, or alphanumeric is indicated by I, R, or A, respectively.

1.0 TITLE CARD

The title card entered for each case begins with an = sign in column 1 and must have at least one nonblank character in columns 2-72.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARDS 01000Y

The RETRAN problem control and description data are used to define the problem dimensions and data tape generation control. The data tape control variable, LDMP, determines whether or not RETRAN problem solution data is to be archived on magnetic tape. Data archived on magnetic tape may be used in subsequent RETRAN problems to provide hydrodynamic boundary conditions and/or power histories. Archived data may be used by RESTRT to continue RETRAN problems and by REEDIT and PLØTER to obtain printed edits and plots of RETRAN solutions, respectively. The remainder of the problem control and description data specify the basic problem dimensions and program options to be used. The only upper limit on the problem dimensions is that imposed by the available core storage.

Y is a sequence number ranging from 1 to 4 and need not be consecutive.

W1-I LDMP = Problem control flag.
0 = No data tape will be generated.
-1 = A data tape will be generated.

W2-I NEDI = Number of minor edit variables requested.
= 0, No minor edits will be generated
> 0, Minor edits will be generated
< 0, Both minor edits and printer plots will be generated. A printer plot of parameter versus time will be generated for each minor edit parameter.

W3-I NTC = Number of time step sets supplied.
(NTC $\geq$ 1)

W4-I NTRP = Number of trip control cards supplied.
(NTRP $\geq$ 1)

W5-I NVØL = Number of control volumes described.
(NVØL $\geq$ 1)

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W6-I	NBUB	=	Number of bubble parameter sets supplied. (NBUB $\geq$ 0)
W7-I	NTDV	=	Number of time-dependent volume boundary conditions specified on cards. (NTDV $\geq$ 0)
W8-I	NJUN	=	Number of flow paths or junctions described. (NJUN $\geq$ 1)
W9-I	NPMPC	=	Number of pump descriptions supplied. (NPMPC $\geq$ 0)
W10-I	NCKV	=	Number of valves described. A given valve description may be used for any number of junctions. (NCKV $\geq$ 0)
W11-I	NLK	=	Number of normalized area versus time curves supplied. A given curve may be used any number of times. (NLK $\geq$ 0)
W12-I	NFLL	=	Number of fill system curves supplied. A given curve may be used any number of times. (NFLL $\geq$ 0)
W13-I	NSLB	=	Number of heat conductors described. (NSLB $\geq$ 0)
W14-I	NGØM	=	Number of heat conductor geometries described. (for NSLB = 0, NGØM = 0) (for NSLB > 0, NGØM $\geq$ 1)

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W15-I NMAT = Number of heat conductor materials described.
(for NSLB = 0, NMAT = 0)
(for NSLB > 0, NMAT $\geq$ 1)

W16-I NCØR = Number of powered heat conductors or core sections described.
(for NSLB = 0, NCØR = 0)
(for NSLB > 0, NCØR $\geq$ 0)

W17-I NHTX = Number of non-conduction heat exchangers described.
(NHTX $\geq$ 0)

NOTE: Words 18 through 29 will default to 0 if not input.

W18-I NTMM = Two-stream momentum mixing option.
=0, Option not used
>0, Option will be used

W19-I NØDEL = Power calculation flag. NØDEL must equal 0 if NCØR is 0.

-1 = Retrieve normalized power from RETRAN data tape(s) specified on Card 01002Y.

0 = Retrieve normalized power from power versus time table supplied (See Scram Table Data Cards, Section IV.26.0.)

<u>Point Reactor Kinetics</u>

1 = One prompt neutron group plus six delayed neutron groups

2 = One prompt neutron group, six delayed neutron groups and eleven delayed gamma emitters

3 = One prompt neutron group, six delayed neutron groups, eleven delayed gamma emitters, plus U-239 and NP-239

W20-I	MWREAC	=	Metal water reaction calculation flag. MWREAC must equal 0 if NCØR is 0. =0, Option not used >0, Option will be used
W21-I	NLVC	=	Number of conglomerate volumes to be summed in equivalent liquid level calculation. (NLVC $\geq$ 0)
W22-I	MTDV	=	Number of time-dependent volume boundary conditions to be retrieved from a RETRAN data tape. (MTDV $\geq$ 0)
W23-I	ISFLAG	=	Option flag. This word is reserved for future use. Input value must be 0.
W24-I	NCHT	=	Number of specified heat transfer coefficient descriptions supplied on cards. (NCHT $\geq$ 0)
W25-I	JSST	=	Steady-state initialization flag. = 0, Use steady-state initialization option. May require 230000 and/or 230XXY cards. = 1, Do not use steady-state initialization option. (All volume pressures, enthalpies and junction form loss coefficients must be specified.) Do not use 230000 or 230XXY cards.
W26-I	IPRZR	=	Non-equilibrium pressurizer option flag. =0, No non-equilibrium pressurizer >0, Non-equilibrium option will be used
W27-I	ITRNS	=	Temperature transport delay option flag. =0, No temperature transport delay volumes >0, Transport delay option will be used

W28-I	IDNBC	=	Auxiliary DNB option flag. =0, No auxiliary DNB calculations >0, Auxiliary DNB calculations will be used
W29-I	ICF	=	Control system option flag. 0 = No controls 1 = Controls used

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3.0 PROBLEM CONTROL AND CONSTANTS DATA CARD 010005

The problem control and constants data required by RETRAN are applicable to the entire problem solution. The initial power, PØWER, is supplied in megawatts and corresponds to the initial thermal power generated in powered conductors and the associated power which may, at the user's option, be generated directly in a fluid volume associated with a powered conductor.

ØMEGA is a multiplicative constant used in the numerical solution of the conservation equations and determines the degree of implicitness. A value of one corresponds to a fully implicit solution; a value of zero corresponds to a fully explicit solution; and a value of 0.5 corresponds to a Crank-Nicolson solution of the linearized equations. The fully implicit integration scheme is recommended for general use. An ØMEGA equal to one does not imply that the overall RETRAN solution scheme is implicit, but only that the numerical integration technique used to solve the conservation equations is implicit.

W1-R	PØWER	=	Initial power (megawatts)
W2-R	ØMEGA	=	1.0 Implicit
			0.0 Explicit
			0.5 Crank-Nicolson

4.0 BOUNDARY CONDITION TAPE REQUEST DATA CARDS 01002Y

A boundary condition data tape request is used to request mounting of an archived RETRAN data tape to be used to supply time-dependent thermodynamic boundary conditions for the hydrodynamic solution and/or to provide a power history for the current problem solution. Boundary condition options are generally used to analyze component effects rather than system effects. A hot channel analysis is an example of such a component analysis, whereby core inlet and outlet thermodynamic boundary conditions and core power level computed for a blowdown analysis are used as boundary conditions for an analysis of a more detailed core model than the core model employed in the actual blowdown calculation.

A Boundary Condition Tape Request Data Card is required only if MTDV is greater than 1 or NØDEL (on Card 01000Y) is -1. Y is a sequence number ranging from 0 to 9. Y need not start at 0 and need not be consecutive.

W1-A W2-A W3-A	LABL(1) . LABL(2)	=	A string of 17 characters (blanks included), specifying the label of the RETRAN data set from which boundary conditions are to be retrieved. Note that the 17 characters including blanks usually require the use of Hollerith delimiters ('). The RETRAN data set may consist of a single reel of magnetic tape, or several reels.
W4-A	LABL(3)	=	VSN of first RETRAN data tape volume required.
W5-A	LABL(4)	=	Julian creation date.
. . .			
W(N)-A		=	VSN of last RETRAN data tape volume required.
W(N+1)-A		=	Julian creation date.

5.0 DATA TAPE LABEL DATA CARD 010040

A data tape label is required when a RETRAN problem is to generate a data tape. The supplied label is used throughout the analysis and if multiple volumes of magnetic tape are generated, each volume will be written with the same label field.

A Data Tape Label Data Card is required if LDMP (on Card 01000Y) is -1. If LDMP is 0, a Data Tape Label Data Card should not be supplied.

W1-A W2-A W3-A	LABL(1) · LABL(2)	= A string of 17 characters (blanks included) specifying the label to be assigned all RETRAN data tape volumes generated.

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6.0 WATER PROPERTY TABLE INPUT REQUEST DATA CARD 010050

A Water Property Table Input Request Data Card is required for all problems executed on the RETRAN program modules. The data contained on the 010050 card describes the labeled magnetic tape or permanent disk file containing the water property table. There is no restriction on the table size; however, it must be in the STH2ØG Module Table Format.[IV.6-1] The following input description covers input requirements for requesting tabular data from a labeled magnetic tape and a permanent mass storage file.

W1-A, W2-A, W3-A	LABL(1) . LABL(2)	=	A string of 17 characters (blanks included), specifying the magnetic tape or permanent file name. Note that the 17 characters including blanks usually require Hollerith delimiters.
W4-I	VSN	=	Magnetic tape visual serial number if read from tape. If read from disk, specify "DISK" for CDC or the disk serial number for IBM.
W5-A	DATE	=	Julian creation date if to be read from tape. VSN≠0
	or,ID	=	Permanent file ID for CDC disk file and blank field (' ') for IBM disk file.
W6-I	DEN	=	Magnetic tape density flag if read from tape. Density requests are 0 = 800 bpi, 1 = 556 bpi and 2 = 800 bpi for CDC and 2 = 1600 bpi for IBM. Must have 1600 bpi for IBM.
		=	0 for IBM disk file.
	or, CY	=	Permanent file cycle number for CDC disk file.
W7-I	FILE	=	Optional parameter if VSN≠'DISK', specifying file number containing tabular data. Default value is for file 1.
			Not used if VSN='DISK' (need not supply a value)

7.0 MINOR EDIT VARIABLE DATA CARDS 02000Y

RETRAN allows both major and minor edits of printed output during problem execution. The edit frequency for major and minor edits is specified by use of NMAJ and NMIN, respectively (on cards 03XXX0). The major edit is a fixed format while the minor edit allows the user to select a frequent edit of NEDI (on Card 01000Y) variables from a large pool of calculated parameters. Minor edits consist of up to eight (nine including elapsed time which is automatically edited) minor edit variables across a page and values for fifty time steps down a page. If more than eight minor edit variables are edited, the first eight will be edited on one page, the next eight (or fewer), on the next page and so on until all NEDI parameters have been edited. The variables for which minor edits can be obtained are listed in Tables IV.7-1 through IV.7-14.

Minor Edit Variable Data Card(s) are required if the absolute value of NEDI (on card 01000Y) is greater than 0. These data cards specify the variables to be edited in minor edits, as well as the parameters to be included on printer plots if requested. |NEDI| specifications must be entered. Y is a sequence number ranging from 0 to 9. Y need not start at 0 and need not be consecutive.

Format for the card is as follows:

W1-A = Variable Symbol

W2-I = Region Number

.

.

.

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W(K)-A = Variable Symbol

W(K+1)-I = Region Number

where K= |NEDI|

TABLE IV.7-1

VOLUME PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number is the desired volume number.

Symbol	Variable
PRES	Average Pressure
TEMP	Average Temperature
MIXL	Mixture Level
SATP	Saturation Pressure
SATT	Saturation Temperature
STVF	Saturated Liquid Specific Volume
STVG	Saturated Gas Specific Volume
STUF	Saturated Liquid Specific Energy
STUG	Saturated Gas Specific Energy
STHF	Saturated Liquid Specific Enthalpy
STHG	Saturated Gas Specific Enthalpy
VL**	Liquid Specific Volume
VS**	Gas Specific Volume
UW**	Internal Specific Energy
HW**	Specific Enthalpy
GASH	Gas Specific Enthalpy
LIQH	Liquid Specific Enthalpy
LIQL	Liquid Level
AVEX	Average Quality
GASM	Gas Mass
FMAS	Total Fluid Mass
ARMS	Air Mass
BUBM	Bubble Mass
LIQM	Liquid Mass
MIXV	Mixture Volume
GASV	Gas Volume
LIQV	Liquid Volume

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TABLE IV.7-1 (cont'd)

AVED	Average Density
UTØT	Total Energy
MIXQ	Mixture Quality
WVBR	Volume Average Flow
WQ**	Power Into Coolant
VØIV	Void Fraction

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TABLE IV.7-2

JUNCTION PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number is the desired junction number.

Symbol	Variable
WP**	Mass Flow Rate
ICHK	Choking Mode
DELA	Pressure Differential Due To Acceleration
DELE	Pressure Differential Due To Elevation
DELF	Pressure Differential Due To Friction
XP**	Quality
HP**	Enthalpy
AVDJ	Junction Density
PMPP	Pressure Differential Due To Pump
FMFR	Mass Fraction of Liquid In Junction Flow
DELP	Pressure Differential Due To Thermodynamic and Dynamic Heads
SPVJ	Specific Volume
AJNT	Time-Dependent Area

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TABLE IV.7-3

SYSTEM PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number must be 0.

Symbol	Variable
AE**	Energy Added
AMAS	Mass Added
BMSW	Mass Water
BMSA	Mass Air
EB**	Energy Balance
FE**	Fuel Energy
HE**	Energy Removed
PNRM	Normalized Power
QLØS	Heat Removal Rate
UFIL	Fill Energy
PØWR	Total Power
PTHR	Total Thermal Power
ULØS	Energy Loss

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TABLE IV.7-4

PUMP PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number is the desired pump number.

Symbol	Variable
SPED	Speed
TØRQ	Normalized Pump Torque
PMTQ	Normalized Motor Torque
PFTQ	Normalized Frictional Torque
PMPW	Pump Power (Irrecoverable Loss)

All torque values are normalized to rated conditions.

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TABLE IV.7-5

CONDUCTOR PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number is the desired conductor number.

Symbol	Variable
SE**	Stored Energy
FCHL	Left Surface Critical Heat Flux
FCHR	Right Surface Critical Heat Flux
HTCL	Left Surface Heat Transfer Coefficient
HTCR	Right Surface Heat Transfer Coefficient
PHIL	Left Surface Heat Flux
PHIR	Right Surface Heat Flux
WQCL	Left Surface Power To Coolant
WQCR	Right Surface Power To Coolant
IHTL	Left Surface Heat Transfer Mode
IHTR	Right Surface Heat Transfer Mode
TL**	Left Surface Sink Temperature
TR**	Right Surface Sink Temperature
GL**	Left Surface Mass Flux
GR**	Right Surface Mass Flux
TXXX	Conductor Node Temperature where XXX is the desired Conductor Node Number

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TABLE IV.7-6

CORE CONDUCTOR PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number is the desired core section number.

Symbol	Variable
NUCQ	Conductor Heating Rate
TAVG	Average Metal Temperature
TSUR	Surface Temperature
CTR*	Depth of Metal-Water Reaction (Outside)
QMWR	Heat Generation Rate From Metal-Water Reaction
CTRI	Depth of Metal-Water Reaction (Inside)
MØDQ	Direct Moderator Heating Rate

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TABLE IV.7-7

REACTOR KINETICS PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number must be 0.

Symbol	Variable
PERD	Reactor Period
REAC	Reactivity
W1**	Instantaneous Reactor Period From Previous Time Step
CN01	Current Concentration for Emitter 1
CN02	Current Concentration for Emitter 2
.	.
.	.
.	.
CN21	Current Concentration for Emitter 21
RKDT	RKEN Time Step Size
RC**	Control Reactivity
RW**	Coolant Reactivity
RV**	Void Reactivity
RF**	Fuel Reactivity
RD**	Doppler Reactivity
RTØT	Total Reactivity at t=0
RWIN	Coolant Reactivity at t=0
RVIN	Void Reactivity at t=0
RFIN	Fuel Reactivity at t=0
RDIN	Doppler Reactivity at t=0

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TABLE IV.7-8

EQUIVALENT LIQUID LEVEL PARAMETERS FOR MINOR EDITS

Region Number is the reference volume number for the equivalent liquid level calculation.

Symbol	Variable
ZLVC	Equivalent Liquid Level

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TABLE IV.7-9

TIME-STEP PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number must be 0.

Symbol	Variable
NSTP	Current Time Step Number
NTTS	Actual Time Step Number
DTØL	Old Time Step Size

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TABLE IV.7-10

HEAT EXCHANGER PARAMETERS AVAILABLE FOR MINOR EDITS

Region Number is the desired non-conducting heat exchanger number.

Symbol	Variable
THQ*	Primary Side Temperature
HTQ*	Heat Removal Rate
TSEC	Secondary Side Temperature
HTXC	Overall Heat Transfer Coefficient

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TABLE IV.7-11

NON-EQUILIBRIUM VOLUME PARAMETERS AVAILABLE FOR MINOR EDITS

The region number is the desired non-equilibrium volume number. Non-equilibrium volumes are numbered sequentially (beginning at 1) as they are encountered while processing the control volume input data.

Symbol	Variable
NELM	Non-Equilibrium Liquid Mass
NELH	Non-Equilibrium Liquid Enthalpy
NLVØ	Non-Equilibrium Liquid Volume
NELT	Non-Equilibrium Liquid Temperature
NEVM	Non-Equilibrium Vapor Mass
NEVH	Non-Equilibrium Vapor Enthalpy
NVVØ	Non-Equilibrium Vapor Volume
NEVT	Non-Equilibrium Vapor Temperature

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TABLE IV.7-12

TRANSPORT VOLUME PARAMETERS AVAILABLE FOR MINOR EDITS

Region number is the desired transport volume number. Transport volumes are numbered sequentially (beginning at 1) as they are encountered while processing the control volume input data.

Symbol	Variable
HXXX	Mesh Point Enthalpy where XXX is the Mesh Point Number

TABLE IV.7-13

CONTROL SYSTEM AND TRIP QUANTITIES AVAILABLE FOR MINOR EDITS

Region number is control block ID.

Symbol	Variable
CØUT	Control Block Output

Region number is the trip ID.

Symbol	Variable
TRPT	Trip Point Time
TRIP	Trip Activation Flag

TABLE IV.7-14

DNB PARAMETERS AVAILABLE FOR MINOR EDITS

Region number must be 0.

Symbol	Variable
HGRC	Average Linear Heat Generation Rate in Core
DNBC	Average DNBR in Core
HGRM	Linear Heat Generation Rate at Minimum Height
DNBM	DNBR at Minimum Height
HGRH	Linear Heat Generation Rate at the Hot Spot
DNBH	DNBR at the Hot Spot
ZDNB	Elevation where Minimum DNBR occurs
HGRZ	Linear Heat Generation Rate at Minimum DNBR location
DNBZ	Minimum DNBR in Core

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8.0 TIME-STEP DATA CARDS 03XXX0

RETRAN allows the user the option of time-step control. The time-step card count, NTC (on Card 01000Y), allows the user to specify multiple sets of time-step data. Integer constant NCHK controls the use of four time-step control options. If time-step control is not requested, the program will use the time step, DELTM, requested by the user. When time-step control is selected, the time step used is the maximum of DTMIN and the time step computed by the time-step control scheme.

All selected edit frequencies are based upon the maximum time-step size DELTM. NMIN specifies the number of DELTM time steps per minor edit (and data record if a data tape is to be generated), while NMAJ is the number of minor edits to be written per major edit. In other words, minor edits are written every NMIN*DELTM seconds and major edits are written every NMIN*NMAJ*DELTM seconds. NDMP is used to specify the frequency at which timing edits are performed. For example, timing edits are written every NMIN*NMAJ*NDMP*DELTM seconds.

NTC (on Card 01000Y) cards must be entered with XXX = 001, 002, ..., NTC. Words eight through eleven are optional.

W1-I	NMIN	=	Number of time steps per minor edit and number of time steps per data tape record. (0 is interpreted as 1)
W2-I	NMAJ	=	Number of minor edits per major edit. (0 is interpreted as 50)
W3-I	NDMP	=	Number of major edits per timing edit. (0 is interpreted as 1)
W4-I	NCHK	=	Option for time-step control. -1 = time-step control on nonlinear

conditions only

0	=	time-step control on linear and nonlinear conditions
1	=	no time-step control
2	=	explicit time-step and accuracy control

W5-R	DELTM	=	Maximum time-step size (sec). (0 < DELTM)
W6-R	DTMIN	=	Minimum sub-time-step size when under time-step control (sec). (0 < DTMIN $\leq$ DELTM). If NCHK = 1, DTMIN must be 0.0
W7-R	TLAST	=	End of current time-step data (sec).

If left blank, words eight through eleven will default to the appropriate values which will yield the standard RETRAN time-step controls and solution techniques.

W8-R	EPSMAX	=	Maximum error tolerance in explicit flow solution (0.0 is interpreted as 1.0E + 10) (Enter 0.0 if NCHK ≠ 2)
W9-R	EPSMIN	=	Minimum error tolerance in explicit flow solution (0.0 is interpreted as 0.0) (Enter 0.0 if NCHK ≠ 2)
W10-R	EPST	=	Error tolerance in heat transfer solution (0.0 is interpreted as 0.0)
W11-R	EPSCHG	=	Causal volume error limit (0.0 is interpreted as 0.0)

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8.1 Linear Time-Step Selection

The linear time-step selection algorithms and default coefficients used to predict time-step sizes based upon control volume thermodynamic and flow conditions are as follows (NCHK=0);

Pressure Change Ratio

$$DT_1 = C_1 \frac{P}{\frac{DP}{DU}\frac{DU}{DT} + \frac{DP}{DMF}\frac{DMF}{DT}} \qquad \text{(IV.8-1)}$$

where:

C_1 = constant (default value of 0.01)

P = thermodynamic pressure

$\frac{DP}{DU}$ = pressure change with respect to internal energy change

$\frac{DU}{DT}$ = internal energy rate of change

$\frac{DP}{DMF}$ = pressure change with respect to fluid mass change

$\frac{DMF}{DT}$ = fluid mass rate of change

Pressure Change with Respect to Mass Change

$$DT_2 = \frac{C_2}{\frac{DP}{DMF}\frac{DMF}{DT}} \qquad \text{(IV.8-2)}$$

$$DT_3 = \frac{C_2}{\frac{DP}{DMA}\frac{DMA}{DT}} \qquad \text{(IV.8-3)}$$

where

C_2 = constant (default value of 50.0)

MA = air mass

All other parameters are as previously defined.

<u>Pressure Change with Respect to Internal Energy Change</u>

$$DT_4 = \frac{C_3}{\frac{DP}{DU}\,\frac{DU}{DT}} \qquad \text{(IV.8-4)}$$

where

C_3 = constant (default value of 50.0)

All other parameters are as previously defined.

<u>Mass to Volume Mass Flow Ratio</u>

$$DT_5 = \frac{(MF + MA)}{\bar{W}} C_4 \qquad \text{(IV.8-5)}$$

where

C_4 = constant (default value of 1000.0)

MF = fluid mass

MA = air mass

$\bar{W}$ = volume average mass flow rate

Each of the five time steps described above is evaluated for all volumes and the minimum value is selected.

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8.2 Non-Linear Time-Step Control

Three additional time-step selection algorithms are also used by RETRAN. These additional algorithms are used in an attempt to predict non-linearities in the program solution caused by flow reversal and saturation line crossings and to subsequently minimize the time-step size and the resulting non-linear changes. The algorithms used by RETRAN to predict non-linear changes are described below (NCHK = -1 or 0).

Zero Flow Crossing

$$DT_6 = C_5 K \frac{W}{\frac{DW}{DT}} \qquad \text{(IV.8-6)}$$

where

C_5 = constant (default value of 1.0)

K = constant

= ∞ for $\Delta h < 50$ Btu/lbm

= 1.0 for 50 Btu/lbm $\leq \Delta h \leq$ 200 Btu/lbm

= 0.8 for $\Delta h > 200$ Btu/lbm

Δh = enthalpy change that occurs during a flow reversal

W = junction mass flow rate

$\frac{DW}{DT}$ = rate of change of junction mass flow rate

DELTM= maximum time-step size

The value of DT_6 is the minimum calculated for all junctions satisfying the condition

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$$\left(\frac{dW}{dT}\,DELTM + W\right)W < 0.0$$

Liquid to Two-Phase Saturation Line Crossing

$$DT_7 = \frac{P_S - P}{C_6 \frac{DP}{DMF} \frac{DMF}{DT}} \qquad \text{(IV.8-7)}$$

where

C_6 = constant (default value of 0.75)

P_S = saturation pressure

All other parameters are previously defined.

The value of DT_7 is the minimum calculated for all volumes satisfying the conditions

$$\frac{DMF}{DT} > 0.0$$

and

$$P_S < P.$$

Two-Phase to Liquid Saturation Line Crossing

$$DT_8 = C_7\, x\, \rho(v_g - v_f) \frac{MF}{\frac{DMF}{DT}} \qquad \text{(IV.8-8)}$$

where

C_7 = constant (default value of 0.75)

x = mixture quality

ρ = mixture density

v_g = saturated gas specific volume

v_f = saturated liquid specific volume

The value of DT_8 is the minimum calculated for all volumes satisfying the conditions

$$\frac{DMF}{DT} < 0.0$$

and

$$X < 0.1$$

The actual time step used by RETRAN is chosen as the minimum of time step increments DT_1 through DT_8, provided that the minimum lies between the user supplied maximum and minimum time step sizes. If the selected time step is out of the user supplied range, the nearest user supplied limit is selected. The time step selection process has a further restriction in that time steps are allowed to increase by no more than a factor of five from a given time step to the next. Time steps smaller than the user supplied minimum may be chosen so as to provide edits at even time boundaries.

8.3 Explicit Time-Step Selection

The explicit iterative method allows the time step to be increased or decreased depending upon the behavior of the flow solution. If nonlinear behavior is detected, the time step size is decreased until the solution has converged within EPSMIN and EPSMAX. However, if the flow solution behaves in a linear manner, the time step size is increased until the solution falls within EPSMIN and EPSMAX.

8.4 Causal Volume Criteria

The causal concept is based on the idea that the frequency with which fluid volumes or heat conductors need to be treated is inversely proportional to the time constants for which physical changes occur. Volumes or conductors that undergo large changes cause subsequent changes in other volumes and conductors. Thus, only those causal elements need to be treated at each time step.

A control volume is designated causal if its change in pressure, ΔP_i, due to change in mass and energy is greater than the user-defined limit, EPSCHG. That is, if

$$\left| \frac{\Delta P_i}{P_i} \right| > \text{EPSCHG} ,$$

Then the ith volume is causal. The causal volume is treated by making an equation of state call during the time step.

A noncausal volume is not treated during the current time step, but its behavior is monitored by assigning a credit equal to the cumulative change in mass and energy. This credit is added to each noncausal volume before checking to see if it is causal at a new time step. Noncausal volume pressures are updated using state derivatives, but other state properties are not updated.

8.5 Causal Heat Conductor Criteria

The causal conductor concept is based on the observation that, in many problems, the time constant for heat transfer is greater than the time constant for associated hydrodynamic changes. Thus, it is possible for heat transfer calculations to be performed less frequently than every hydrodynamic time step without significantly affecting the results.

A heat conductor is designated causal (i.e., sent through the heat conduction solution during the current time step) by meeting any of the following conditions:

(1) An adjacent fluid volume average flow or bulk temperature goes through a fractional change greater than EPST

(2) The total power fractional change is more than EPST

(3) A transition in heat transfer regimes is detected

(4) A conductor approaches CHF

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(5) An adjacent fluid volume bulk temperature crosses the conductor wall temperature

(6) If the conductor has been noncausal for more than one second.

8.6 Time-Step Algorithm Constants Data Card 030001 (This Card is Optional)

The time step algorithm constants override card allows the user to override the default values for constants given in equations (IV.8-1) through (IV.8-6). Any override values are preserved at restart.

W1-R	FC3	Constant C_1 in Equation IV.8-1 (default = 0.01)
W2-R	FC4	Constant C_5 in Equation IV.8-6 (default = 1.0)
W3-R	FC5	Constant C_2 in Equations IV.8-2 and -3 (default = 50.0)
W4-R	FC6	Constant C_3 in Equation IV.8-4 (default = 50.0)
W5-R	FC7	Constant C_4 in Equation IV.8-5 (default = 1000.0)

A value of 0.0 for any of the above fields leaves the default value unchanged.

8.7 Detailed Edit Card 030002. (This card is optional).

W1-I	IEVERY(1)	0, no effect on the printed output for the time-step set indicated by the subscript of IEVERY(J), where "J" refers back to XXX on cards 03XXX0
W2-I	IEVERY(2)	1, a major edit will be obtained for every actual time step for the time-step card indicated by the subscript of IEVERY(J).
.	.	2, a minor edit will be obtained for every actual time step for the time-step card indicated by the subscript of IEVERY(J). This has no effect on data record frequency.
.	.	3, both major and minor edits will be obtained for every actual time step for the time-step card indicated by the sub-script of IEVERY(J).
W(NTC)-I	IEVERY(NTC)	

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Caution: The use of this option may result in up to DELTM/DTMIN times as much printed output as requesting a major edit every standard time step.

9.0 TRIP CONTROLS

The control functions normally needed to simulate a reactor system may be described through the trip-control data. An arbitrary number of these control cards may be specified. Trips can be controlled by such parameters as elapsed time, reactor power or period, and volume pressure, temperature, mixture or liquid levels. These controlling variables can be used to perform a number of actions such as reactor scram, valve actions, fill water injections, pump shut off, and simplified heat exchanger control. At least one problem termination condition must be specified as a trip. Trip control parameters are compared to specified set points and if the set point condition is satisfied, the trip action can be delayed by a specified time that represents an instrumentation or mechanical delay.

Trips based on the elapsed time parameter are interrogated by steady state initialization and those which are activated at zero time are considered in the initialzation process. Thus fills, valves, etc. which are tripped at zero time will refer to the values from the appropriate tables such that a proper steady state initialization is calculated. Note that only trips activated on elapsed time, not those activated on other system parameters, are considered.

A trip is identified by the value of IDTRP assigned to it on the trip data cards. By using the same value of IDTRP on several cards, the user can model a trip which is actuated when any one of several conditions is met making the "ØR" logic function available. In addition, a single trip may initiate several actions, all beginning at the same time.

Coincidence trips allow modeling of trips which are activated when all of several conditions are met. Coincidence trips make the "AND" logic function available. With coincidence trips, it is possible to model "majority logic" where a trip is actuated only when at least two out of three conditions are met.

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Indirect trips are trips actuated by another trip but with an additional delay. Indirect trips allow a trip condition to initiate several actions at different times. With indirect trips, it is possible to model a sequence of events occurring at different times, all triggered by the same trip.

Reset trips allow previously activated trips to be reset. A reset trip used this way is sometimes called a "reverse" trip or an "off" trip. Reset trips, also reverse trips whose setpoint threshold has been crossed, but whose delay time has not yet expired. An indirect trip used this way is sometimes called a "blocking" trip.

9.1 <u>Coincidence Trip</u>

The coincidence trips, also called "AND" trip, refers to a trip which occurs only after both of two conditions have been satisfied. For example, a PWR may trip a safety injection system when there is low pressure and low level in the pressurizer. Consider the following example.

	IDTRP	IDSIG	IX1	IX2	SETPT	DELAY	
040020	2	4	10	0	2000.	0.0	*Hi Pressure Trip
040030	3	-6	10	0	10.	0.0	*Lo Water Level Trip
040040	4	13	2	3	0.0	0.0	*Coincidence Trip

Trip 2 is actuated when the pressure in volume 10 exceeds 2000.0 psia. Trip 3 is actuated when the water level in volume 10 drops below 10.0 feet. Trip 4 represents the safety injection system trip. Consider card 040040. IDSIG = 13 denotes that a coincidence trip is being used. IX1 = 2 denotes that trip 2 is one operand trip. IX2 = 3 denotes that trip 3 is the other operand trip. SETPT is not used and is arbitrarily set to 0. DELAY was set to 0 for this example. The card 040040 represents the logic that the safety relief system is activated with zero delay after both trip 2 and trip 3 have been actuated.

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In preparing trip data using coincidence trip the user must define operand trips before a coincidence trip can refer to them. In this example trip 2 and trip 3 are defined before the coincidence trip is defined.

9.2 Indirect Trip

An indirect trip is defined to be a trip which is actuated by another trip. The indirect trip simplifies modeling of trip logic which would be very cumbersome to model with the "ØR" logic function. Consider a system which trips the turbine whenever the reactor is scrammed. The reactor scram could be tripped by a number of different signals, say, six signals. The reactor scram logic could be modeled using six cards. To model the turbine trip with the "ØR" logic function, the user would have to duplicate those six cards with a different value of IDTRP and a larger value for the delays. If an indirect trip is used, only one additional trip card would be required. See example below.

	IDTRP	IDSIG	IX1	IX2	SETPT	DELAY	
040020	2	2	0	0	1.2	.5	*Scram on Hi Power
040030	2	4	10	0	1070.	1.0	*Scram on Hi Pressure
040040	2	-6	5	0	1.0	1.0	*Scram on Lo Level
040050	3	12	2	0	0	1.0	*Indirect Turbine Trip
							*1.0 Sec Delay

The value of IDTRP corresponding to reactor scram is 2. The reactor is scrammed if reactor power is high or if vessel pressure is high or if liquid level is low. The value of IDTRP corresponding to turbine trip is 3. The turbine is to be tripped one second after the reactor is scrammed.

Card 040050 represents the logic that the turbine is to be tripped one second after the reactor is scrammed. IDSIG = 12 denotes that an indirect trip will be used. IX1 = 2 denotes that the trip with IDTRP = 2 will be the initiating trip. IX2 is not used and must be set to 0. SETPT is not used and is arbitrarily set to 0. DELAY is set to 1.0 second.

IX2 is not used in the above example, so it is set to 0. IX2 may denote another initiating trip. When IX1 and IX2 are used to denote different initiating trips, the interpretation is that the indirect trip is actuated when either trip IX1 or IX2 is actuated.

In preparing trip data which uses indirect trips the user must observe the following rule. Initiating trips must be defined before an indirect trip can refer to them. In the example above, the scram trip is defined before the indirect trip.

9.3 Reset Trips

Consider the following example, where the trip logic for a relief valve is modeled. The valve is opened when the pressure in volume 10 exceeds 2400 psia and is closed when the pressure in volume 10 drops below 2300 psia.

	IDTRP	IDSIG	IX1	IX2	SETPT	DELAY	
040020	2	4	10	0	2400.	0.0	*Hi Pressure Normal Trip
040030	-2	-4	10	0	2300.	0.0	*Lo Pressure Reset Trip

The data on the reset trip card is analogous to the data on a normal trip card. The only difference is that the sign of IDTRP on all reset trip cards is negative. The absolute value of IDTRP on a reset trip card is equal to the value of IDTRP of the normal trip which is to be reset. In this example IDTRP = -2 for the reset trip and IDTRP = 2 for the corresponding normal trip. All other parameters on a reset trip card may have different values from the normal trip which is to be reset. The reset trip may monitor a different signal, have a different setpoint or have a different delay time from the normal trip.

Other points which the user should be aware of are:

- Any number of reset trip cards may be specified for a particular value of IDTRP. If the condition on any one reset card is met, then the trip is reset.

- If a normal trip and a corresponding reset trip are actuated at the same time, the reset trip dominates, and the normal trip is not actuated.

- Consider the following situation. The setpoint of a normal trip has been reached, but has not been actuated because of the delay time specified. If a reset trip is actuated during that delay time, the normal trip is reset and will not remember that the setpoint had been reached.

- Just as it is possible to build an oscillator in practice, it is possible to set up an oscillation which is contained entirely within the trip logic. If the delays specified on reset trips are all smaller than every delay specified on corresponding normal trips, then oscillations within the trip logic are avoided.

- Operand trips must be ordered in input before they are used in indirect, reset, etc. trips.

9.4 Trip Control Data Cards 04XXX0

NTRP (on card 01000Y) cards must be entered with XXX equal to the trip number. NTRP sets of 04XXX0 cards must be supplied but XXX need not start at 001 and need not be consecutive.

W1-I IDTRP = Action to be taken (IDTRP $\geq$ 1),
1 = End of problem.
IDTRP = IDSIG = 1 must be the first trip card.
IDTRP corresponds to entry on pertinent card elsewhere in input where trip action is desired. IDTRP's do not have to be in order on a set of trip control Data Cards.
IDTRP can be any arbitrary integer less than 999 with the exception noted above.

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W2-I IDSIG = Signal being compared. $(1 \le |IDSIG| \le 14)$

Signal being compared	Trip Limit
1 = Elapsed time	NOT APPLICABLE
2 = Normalized reactor power	+=HIGH,-=LOW
3 = Reactor period	+=HIGH,-=LOW
4 = Pressure (Vol IX1)	+=HIGH,-=LOW
Differential pressure If $IX2 \neq 0$ (Vol IX1, IX2)	+HIGH,-=LOW
5 = Mixture level (Vol IX1)	+=HIGH,-=LOW
6 = Liquid level (Vol IX1)	+=HIGH,-=LOW
7 = Water temperature (Vol IX1)	+=HIGH,-=LOW
Differential temperature If $IX2 \neq 0$ (Vol IX1, IX2)	+=HIGH,-=LOW
8 = Metal temperature (Core Section IX1)	+=HIGH,-=LOW
9 = Flow (Junction IX1)	+=HIGH,-=LOW
10 = Conductor temperature (Conductor number IX1) (Temperature node number IX2)	+=HIGH,-=LOW
11 = Not used	
12 = Indirect trip (Trip IX1 <u>OR</u> IX2)	NOT APPLICABLE
13 = Coincidence trip (Trip IX1 <u>AND</u> IX2)	NOT APPLICABLE
14 = Control block output (Control block IDC)	+=HIGH,-=LOW

W3-I IX1 = Volume, junction, core, conductor or control block numbers
(IX1 = 0 for IDSIG = 1,2,3)
(IX1 = Volume number for IDSIG = 4,5,6 or 7)
(IX1 = Core section number for IDSIG = 8)
(IX1 = Junction number for IDSIG = 9)
(IX1 = Conductor number for IDSIG = 10)
(IX1 = Control block IDC for IDSIG = 14)
(IX1 = IDTRP of a previously defined trip for IDSIG = 12 or 13)

W4-I IX2 = Volume, conductor node number or trip index.
(IX2 = Optional volume number for IDSIG = ± 4 or ± 7 for differential pressure or differential temperature trip)
(IX2 = Conductor node number for IDSIG = 10)
(IX2 = 0 or IDTRP of a previously defined trip for IDSIG = 12 or 13)
(Otherwise IX2 = 0)

W5-R SETPT = Signal setpoint.

W6-R DELAY = Delay time for initiation of action after reaching setpoint (sec).

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10.0 RETRAN CONTROL VOLUMES

Each RETRAN volume is defined by a set of Volume Data Cards consisting of up to nine cards per set. The data required to describe a volume include geometric information such as dimensions and elevation, initial conditions of the material in the volume, and option-control information.

Initial conditions within the volume can be completely specified by describing the state of the fluid and indicating the presence or absence of an air head. The input variables consist of enthalpy or temperature, pressure, relative humidity, or quality.

When using the steady-state initialization option, the volume pressure can be specified and the form loss coefficients(s) of the junctions(s) entering and/or leaving the volume will be calculated; or the pressure will be calculated if input is 0.0 and the form loss coefficient(s) of the junction(s) entering the volume are specified. Only one enthalpy per flow system should be supplied when the steady-state initialization option is used. The code will compute all other enthalpies from steady-state boundary conditions and the energy equation (a P-X or T-X entry specifies the enthalpy and T or P, respectively). The particular state in a volume is one of several possible states, many of which are completely specified by a subset of the four input variables. The remaining input variables, if any (which if used to convey thermodynamic information would overspecify the state), pass control information to the program defining the particular subset of input variables to be used.

Volumes in which a vapor-mixture interface exists may optionally contain air as well as steam in the gas region. If air is present, the mixture region is liquid only. The air option does not allow air to leave a volume and should be used only if the air will not attempt to flow from the volume.

10.1 Control Volume Boundary Conditions

The option of using special boundary volumes with explicit time-dependent fluid boundary conditions is intended primarily for performing detailed calculations on part of a reactor system using results of previous RETRAN calculations as boundary conditions. For a detailed core calculation, the special boundary

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volumes would be the upper and lower volumes which connect to the core regions. Any volume may be chosen independently to have fluid conditions described as an explicit function of time. The fluid conditions in such boundary volumes are unaffected by the course of the detailed transient being calculated. The necessary fluid boundary data may be provided either as tabular data on input cards or by automatic retrieval from a data tape created during a previous RETRAN calculation. Performing detailed calculations on part of a system by using special boundary volumes saves computer time as compared to modeling the complete system. A detailed calculation can be performed on any portion of the reactor system, such as a pump, by using special boundary volumes.

The geometric detail of a time-dependent volume is required, just as for a normal volume. Fluid conditions are required as a function of time and include pressure, temperature, quality and mixture level. The geometric detail plus these four time-dependent functions provide sufficient information to define completely the fluid conditions in a volume. For each time step, the data supplied on either cards or tape is interpolated to obtain current fluid conditions. To perform calculations for a single core channel, a RETRAN problem would be set up with the upper and lower volumes defined as time-dependent volumes. The data would be retrieved from the volumes representing the upper and lower plenums in a RETRAN calculation of the entire primary system.

10.2 Non-Equilibrium Pressurizer Model

The simulation of PWR plant transients, such as the loss of reactor coolant flow, uncontrolled rod withdrawal, loss of feedwater flow, and the like, require a model of the pressurizer that considers the physical processes taking place during these types of transients. A standard RETRAN control volume state solution for the pressurizer would assume that all of the contents are in thermal equilibrium. However, rather than behaving in an equilibrium manner, the pressurizer has two somewhat distinct regions such that a state solution of the whole volume is not a proper physical representation of the processes occurring. Non-equilibrium between pressurizer regions is particularly appropriate when the transient involves a surge of subcooled liquid into the pressurizer.

The RETRAN pressurizer model defines two separate thermodynamic regions which are not required to be in thermal equilibrium. The two regions are termed "liquid" and "vapor" regions, although each region may contain both liquid and vapor. Each region thermodynamic state solution is determined from a distinct mass and energy balance on that region. Hence, the thermodynamic state for each region is determined without restrictions as to the other. In other words the vapor region can be superheated and the liquid region subcooled, both saturated, vapor region saturated and liquid region subcooled, and so on. However, should the pressure rise above the critical point, all further calculations are performed using a single region equilibrium approach.

The mass and energy balance provides the total mass and energy in each region as a function of time through the transient. The solution of the thermodynamic state in each region then involves the determination of each region volume (constrained that the sum equals the total volume) such that the calculated pressure is equal in each region.

Included at the interface between the liquid and vapor regions is a flashing model which describes the movement of vapor from the liquid to the vapor region and a rainout model which describes the movement of liquid from the vapor region to the liquid region. Heat transfer between the regions is omitted as it is not considered significant relative to the other phenomena. The present RETRAN pressurizer model does not allow heat conductors to be specified in the pressurizer as their contribution is typically a second order effect in most transients. The pressurizer is initialized at equilibrium which precludes the use of an initial spray flow and heater power addition, when using the steady-state option.

10.? Temperature Transport Delay Time Model

The timing of temperature changes in the primary system can be very important in the simulation of plant transients for both BWR and PWR(s) because of the effects reactivity feedback and/or steam generator heat removal have on the system transient response. Temperature changes move through some regions (such as piping) essentially as a front, that is, the incoming fluid does not mix with the fluid within the particular region but only displaces it. The standard RETRAN method for determining the junction enthalpy is to homogeneously mix incoming fluid with the contents of a particular region; thus the outlet enthalpy begins to respond immediately to changes in the inlet. This is the type of response that best represents a plenum. Other options available in RETRAN to affect the determination of junction enthalpy (out of a volume), include a vapor-liquid separation model and an enthalpy transport model to more appropriately model heated sections. Taking the number of RETRAN control volumes to a theoretical infinite number would account for the transport phenomena. Unfortunately, there are realistic limitations on problem run time and size such that an approximate submodel is sometimes necessary to keep track of the enthalpy movement within a region. The temperature transport delay time model in RETRAN is intended to serve this purpose and is not designed to solve the transport problem in the most general sense.

10.4 Volume Data Cards 05XXXY

NVØL (on Card 01000Y) sets of cards must be entered, with XXX equal to the Control Volume Number. NVØL sets of 05XXXY cards must be supplied but XXX need not start at 001 and need not be consecutive. Y is a card sequence number ranging from 1 to 9 for each set, starting at 1, and must be consecutive. The following items may be entered on up to nine cards.

W1-I	IBUB	=	Bubble data index (06XXX1 Cards). $(0 \leq IBUB \leq NBUB)$ =0, volume is treated as homogeneous.
W2-I	IREAD	=	Volume data retrieval index. = 0, no retrieval < 0, use the data pertaining to volume $\lvert IREAD \rvert$ stored on the data tape generated during a previous run > 0, use set IREAD of the time-dependent volume conditions or Cards 07XXXY where IREAD = XXX.

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W3-R	P	=	Pressure ($0.0 \leq P \leq 3625.94$) (psia) For P = 0.0, pressure will be calculated
W4-R	TEMP or, HW	= =	Temperature ($32.018 < TEMP < 1472$) (°F) Thermodynamic Enthalpy (Btu/lb_m) For TEMP or HW = 0.0, Enthalpy will be calculated.
W5-R	X or, HUM	= =	Quality Humidity Dimensionless

NOTE: The user should refer to TABLE IV.10-1 when preparing the volume thermodynamic input to ensure that a proper combination of variables has been specified.

W6-R	V	=	Volume (ft^3) ($V>0.$)
W7-R	ZVØL	=	Volume height, bottom to top (ft) (ZVØL > 0.)
W8-R	ZM	=	Mixture level (from bottom) (ft) ($0. \leq ZM \leq ZVØL$)
W9-I	JTPMV	=	Two-phase friction index = 0, use Baroczy two-phase friction multiplier with Fanning friction losses = 1, homogeneous two-phase multiplier in Fanning friction losses (based on a density correction). = 2, Beattie two-phase friction multiplier with Fanning friction losses
W10-R	FLØWA	=	Flow area of volume (ft^2)

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TABLE IV.10-1

INITIAL CONDITIONS PRESENT FOR VARIOUS MIXTURE LEVELS

Mixture Level	Relative Humidity or Quality	Conditions Present		Thermodynamic Variables Used
Volume filled with water only (ZM = ZVOL)	X = 0.0 (flag)	Superheated Vapor	No Air Present	P-H
	X = 1.0	Saturated Vapor	No Air Present	P-X or T-X
	X = -1.0 (flag)	Saturated Liquid	No Air Present	P-X or T-X
	X = 0.0	Subcooled Liquid	No Air Present	P-H
	1.0 > X > 0.0	Two-Phase Mixture	No Air Present	P-X or T-X
	X = 0.0 (flag)	Two-Phase Mixture	No Air Present	P-H
Volume containing mixture (0 < ZM < ZVOL)	X=-1.0 (Flag) for P-H Entry P=0.0 if T>0.0, T=0.0 if P>0.0 and $0.0 \leq X_m < 1.0$	Two-Phase Mixture or Liquid	No Air Present	P-H, $T-X_m$, $P-X_m$
	X = 1.0 (flag)	Liquid	Air Present	P-T
Volume filled with air or steam-Air mixture (ZM = 0)	$h_m = 0.0$	Air Only Present		P-H
	$h_m > 0.0$	Superheated Vapor or Supercritical Vapor	Air Present	P-H

W11-R DIAMV = Equivalent diameter of flow area (ft)
If entered as 0., DIAMV will be reset
to

$$2\sqrt{FLØWA/\pi}$$

(For Fanning friction calculation only.)

W12-R ELEV = Elevation at the bottom of the volume (ft)

NOTE: If the remainder of this card is left blank it will default to the standard RETRAN calculations. If non-equilibrium pressurizer calculation is used, sprays cannot be on at time = 0, when steady-state initialization is employed.

W13-I INEQ = Flag indicating that the volume is to be handled in a non-equilibrium manner
=0 or blank, standard calculation
=1, non-equilibrium pressurizer calculation

W14-R VR = Rainout velocity for liquid droplet in the vapor region of the pressurizer (ft/sec)

W15-I IPTN = Flag indicating that the volume is to be handled as a temperature transport delay volume
= 0 or blank, standard calculation
= 1, temperature transport delay calculation

W16-I MESH = Number of intervals by which the volume is divided for the temperature transport delay model.
(MESH = 0 for IPTN = 0)
(MESH $\geq$ 1 for IPTN = 1)

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10.5 Equivalent Liquid Level Volume Calculation Card 060000

A conglomerate volume combining N RETRAN volumes, which must be stacked, may be specified for the purpose of obtaining an equivalent liquid level. The order of the volumes used to describe the conglomerate volumes is arbitrary except that the first volume becomes the reference volume. The total liquid mass in the conglomerate volume is obtained by summing the liquid mass in each of the volumes. A total liquid volume is obtained by dividing the total liquid mass by the density of saturated liquid in the reference volume. The level that the total liquid volume would reach in the conglomerate volume is then calculated. Finally, the liquid level in the conglomerate volume is compared to the elevation of the bottom of the reference volume and the result printed for each major edit. This option is useful in determining the beginning of core reflooding. This card is required only if NLVC (on Card 01000Y) is greater than 0.

W1-I	ILVC(1)	=	Indices for the volumes over which liquid
W2-I	ILVC(2)		masses are to be summed to determine the
o	o		equivalent liquid level. The bottom of the
o	o		first volume is used as the reference
o	o		elevation for the equivalent liquid level.
WN-I	ILVC(N)		N is equal to NLVC on Card 01000Y

11.0 BUBBLE DATA CARDS 06XXX1

The bubble rise model used in RETRAN is a semi-empirical fit to data for which the void distribution within the two-phase mixture is assumed to be linear with elevation. The purpose of this model is to estimate the junction enthalpy as a function of vertical elevation within the flow-source volume modified for either horizontal or vertical flow areas.

The input constant, ALPH, which must be limited to values of zero through unity, determines the maximum vertical bubble gradient at any instant. If ALPH is chosen as zero, the mixture is homogeneous; if chosen as unity, the bubble gradient is always the maximum within the permissible physical constraints. Values outside this range give negative values for the partial bubble density and so are not allowed. Each volume can have an individual ALPH chosen by the user.

The separation velocity of steam bubbles relative to the mixture interface, VBUB, is another input quantity which can be different for each volume. If the velocity is zero, no separation occurs although a bubble-density gradient may still exist. Large values of VBUB, say 10^6, provide for essentially complete separation.

If the steady-state initialization option is employed and bubble rise models are used in one or more volumes in which the enthalpy is supplied (P-X also specifies the enthalpy), these volumes should be assigned unique bubble rise models. This is required since the RETRAN code will adjust those bubble rise models to ensure a steady-state solution (duplicate models may be entered using two or more 06XXX1 cards). Steady-state initialization is thoroughly discussed in Volume 1: Equations and Numerics.

NBUB (on Card 01000Y) cards must be entered with XXX = 001, 002, ..., NBUB.

W1-R	ALPH	=	Bubble-gradient parameter ($0. \leq ALPH \leq 1.0$)
W2-R	VBUB	=	Bubble velocity (ft/sec) ($VBUB \geq 0.$)

Set Number 0 (ALPH = 0., VBUB = 0.) is built-in (homogeneous).

12.0 TIME-DEPENDENT VOLUME DATA CARDS 07XXYY

NTDV (from Card 010001) sets of cards must be entered with the set number XX = 01, 02, ..., NTDV. Data points may be entered on cards ordered by YY ranging from 00 to 99. YY need not start at 00 and need not be consecutive. The first entry for a set is the number of data points (IRIN) contained in the set. A data point consists of time, pressure, temperature, mixture quality, and mixture level. The first data point must begin at t = 0.0. At t = 0.0 the thermodynamic state of the time-dependent volume is obtained from the tabular data and information supplied on the volume card (05XXXY) is ignored. A set of Time-Dependent Volume Data cards is required for each time-dependent volume.

The thermodynamic variables used to obtain state properties are shown in Table IV.12-1. All five quantities are not always used to obtain state properties. However, all five quantities must be present for consistent interpolation between data points if the fluid changes phases and another set of thermodynamic variables is used to obtain the state properties.

Quality in all cases of time-dependent volumes is defined as average volume quality.

$$x = (\bar{h} - h_f)/h_{fg}$$

where

$\bar{h}$ = average volume specific enthalpy

h_f = saturated liquid specific enthalpy

h_{fg} = specific heat of vaporization

Quality of subcooled liquid is negative, and is greater than 1.0 for superheated vapor. This definition of quality is necessary to provide consistent definitions for interpolation.

Only two of the three thermodynamic quantities, - pressure, temperature, and quality - are required input to define each data point for the following conditions: If the volume contains saturated liquid, saturated vapor or two-phase mixture,

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TABLE IV.12-1

INPUT REQUIREMENTS FOR TIME-DEPENDENT VOLUMES

Mixture Level	Conditions Present		Thermodynamic Variables Used
Volume filled with water only (ZM = ZVOL)	Superheated Vapor	No Air Present	P,T
	Saturated Vapor	No Air Present	T,X
	Saturated Liquid	No Air Present	T,X
	Subcooled Liquid	No Air Present	P,T
	Two-Phase Mixture	No Air Present	T,X
Volume containing mixture (0 < ZM < ZVOL)	Two-Phase Mixture	No Air Present	T,X
	Liquid	Air Present	P,T,X
Volume filled with vapor-air or air only (ZM = 0)	Air Only Present		P,T
	Superheated or Supercritical Vapor	Air Present	P,T,X

temperature and quality may be supplied and pressure will be computed, or pressure and quality may be supplied and temperature will be computed. For subcooled liquid or superheated vapor, pressure and temperature must be supplied and quality will be calculated. Thermodynamic quantities not supplied should be entered as 0.0. The missing quantities will be calculated and stored in the appropriate table locations.

W1-I	IRIN	=	Number of data points in the set (IRIN > 0)
W2-R	TIMTBL(1)	=	Time (sec)
W3-R	PTABL(1)	=	Pressure (psia)
W4-R	TTABL(1)	=	Temperature (°F)
W5-R	XTABL(1)	=	Quality of mixture
W6-R	ZTABL(1)	=	Mixture level (from bottom of volume) (ft)

W7-R,... TIMTBL(2), PTABL(2), TTABL(2), XTABL(2), ZTABL(2).
W11-R,... ...

NOTE: Entry (1) must be data set for time = 0.0

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13.0 RETRAN JUNCTIONS

Junction cards are used to describe a flow path between RETRAN volumes. A junction is connected from one volume, IW1, and to another volume, IW2. This "from" and "to" description defines the positive flow direction and if the flow, WP, originates in volume IW1, the flow sign is positive. This "from" and "to" scheme also defines a reference for the momentum sense. The full open flow area is defined by AJUN and the junction elevation, ZJUN, is referenced to the same base as the volume elevation, ELEV.

Three types of junctions are permitted in RETRAN problems. The first of these junctions is a "normal" junction connecting two control volumes. The second junction type, a "fill" junction, is effectively a specified flow boundary condition. Fill junctions are described by setting IW1 to zero and selecting the set of tabular data describing the junction flow history. Selection of fill data is facilitated by setting IPUMP equal to the desired fill curve XX, described on cards 13XXYY. Fill junctions can be either positive or negative (flow is negative). In order for the correct volume flow to be calculated, the user must set MVMIX = -2 for negative fill junctions.

The third type of junction is a "spray" junction, used only with a non-equilibrium control volume to model a PWR pressurizer. Modeling the pressurizer spray system as a "normal" junction into the vapor region de-superheats the vapor region. The special "spray" option, called for by specifying an ISP equal to 1 involves the removal of mass and energy from the vapor region but does not de-superheat the region. The spray in falling through the atmosphere condenses vapor from that region. The spray plus condensed mass, is deposited directly in the liquid region without a time delay.

Form loss coefficients for all junctions are required. If the steady-state initialization option is not used, all junction form loss coefficients are required input. If the steady-state initialization option is used, any or all of the normal junction form loss coefficients may be calculated depending on the number of control volume pressures that are input. (i.e. if all control volume pressures are input, then all of the junction form loss coefficients can be calculated by the RETRAN Code).

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Three basic forms of the flow equation are provided in RETRAN. Each form contains a particular set of assumptions. The user chooses the form most appropriate for a particular junction. This choice is controlled by the index MVMIX.

Specifically the three basic forms are:

(1) Compressible single-stream flow with momentum flux

(2) Compressible two-stream flow with one-dimensional momentum mixing

(3) Incompressible single-stream flow without momentum flux.

The choice of the flow equation form depends upon the purpose and detail of the desired calculation. The forms for compressible single-stream flow with momentum flux and for compressible two-stream flow with one-dimensional momentum mixing both include a one-dimensional momentum flux term and are applicable when the control volumes represent a one-dimensional stream tube. The form for compressible two-stream flow with momentum mixing should be used only when two streams can combine and exchange momenta on a one-dimensional basis. The basic momentum mixing equation has four forms that represent four different flow patterns of the streams. The incompressible single stream flow form without the momentum flux term provides an alternate to the compressible flow equation with the momentum flux term for modeling multidimensional geometries.

General two- or three-dimensional flow problems are modeled using a one-dimensional approximation of the momentum flux term. The user must recognize this approximation when geometries containing predominately multidimensional flows are modeled.

13.1 Junction Data Cards 08XXXY

NJUN (on Card 01000Y) sets of cards must be entered with XXX equal to the Junction Number. NJUN sets of 08XXXY cards must be supplied but XXX need not start at 001 and need not be consecutive. Y is a card sequence number for each set, starting at 1, and must be consecutive. Normal junctions and fill junctions may be intermixed at will. The items listed below may be entered on up to nine cards.

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W1-I IW1 = Volume index at junction inlet (IW1 $\geq$ 0)

W2-I IW2 = Volume index at junction outlet (IW2 > 0)

W3-I IPUMP = (a) Pump index if IW1 > 0 and IW2 > 0. For junctions connecting to a pump volume, the suction side junction should have a negative pump number and the discharge junction should have a positive pump number. Flow in these junctions must be positive initially. IPUMP should correspond to the appropriate pump data (Cards 090XXY) were IPUMP is equal to XX. (IPUMP $\geq$ 1 and each IPUMP is unique)

(b) Fill index if IW1 = 0 and IW2 > 0. For fill junctions, IPUMP should correspond to the appropriate Fill Table Data Set (Cards 13XXYY) where IPUMP is equal to XX.

(c) Normal junction if IW1 > 0 and IW2 > 0 and junction is not connected to a pump volume. IPUMP = 0.

W4-I IVALVE = Valve index

(a) IVALVE = 0, no valve

(b) 1 $\leq$ IVALVE $\leq$ NCKV, IVALVE points to the desired valve description (on Cards 11XXX0) where IVALVE = XXX.

W5-R WP = Flow (lb/sec) (sign based on from-to convention)

W6-R AJUN = Junction flow area in square feet and must be greater than zero. For a time-dependent area junction (specified through use of a valve and normalized area versus time curve)

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AJUN is the full open area.

W7-R ZJUN = Junction elevation (ft)

(a) IW1 > 0, IW2 > 0 the ZJUN must lie between the bottom and top of both volumes IW1 and IW2.

(b) IW1 = 0, IW2 > 0 the ZJUN must lie between the bottom and top of volume IW2.

W8-R INERTA = Junction effective L/A (ft^{-1})

(a) IW1 > 0, IW2 > 0
INERTA $\geq$ 0.0

INERTA is calculated by the program if JCALCI = 2 or 3 and any input value is ignored. The calculated value is one-half of the length of each adjacent volume divided by the volume flow area where volume length is V/FLOWA.

(b) IW1 = 0
INERTA $\geq$ 0.0 (INERTA is not used for a fill flow solution.)

W9-R FJUNF = Forward flow "form loss coefficient". This is either a dimensionless positive number dependent on geometric changes occurring within the flow control volume or zero. It is the standard energy loss coefficient, as normally used in text books. The energy loss is

$$K \frac{V^2}{2}$$

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where FJUNF is K, and the velocity, V, is based on the junction area. When using the steady-state self initialization, the junction loss coefficient will be calculated if FJUNF = -1.0 (or FJUNR = -1.0 for negative flows) and the pressures on both sides of the junction are either defined through volume input or can be determined from other specified input.

W10-R FJUNR = Reverse flow "form-loss-coefficient". If FJUNR is entered as 0., FJUNR is set equal to FJUNF, provided FJUNF > 0.

W11-I JVERTL = Vertical junction index

= 0, junction flow area is not distributed vertically and junction enthalpy is "smoothed" when the two-phase mixture interface is near the junction elevation

= 1, junction flow area is assumed to be a circular area centered and distributed vertically about ZJUN

= 2, junction flow area not distributed vertically and junction enthalpy is "not smoothed." The junction flow is redistributed assuming a constant volumetric flow. The first time step occurs when the donor volume mixture level drops below the junction. (Typically used in jet pump suction junction.)

W12-I JCHØKE = Junction choking index, also see ICHØKE

0 = Table choking or sonic choking

-1 = No choking

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1 = Table choking only (if MVMIX is ≠ 3, this flow solution corresponds to incompressible flow with Bernoulli effects)

2 = Sonic choking only

W13-I JCALCI = Initial condition calculation index

= 0, use input for inertia and form loss coefficients as given by user

= 1, RETRAN calculates form loss coefficients FJUNF and FJUNR for sharp-edge area changes. (Equivalent to specifying loss coefficients as far as steady-state initialization is concerned).

= 2, RETRAN calculates inertias

= 3, RETRAN calculates both form loss coefficients and inertias

= -4, Fanning and momentum losses are omitted

NOTE: a) Options to calculate inertias and/or loss coefficients will override any corresponding values input.

b) When using the steady-state self initialization, a value of JCALCI equal to 1 or 3 has the same effect as supplying a value of FJUNF (or FJUNR) $\geq$ 0.

W14-I MVMIX = Flow equation type

= 0, compressible flow, single stream

= 1, mixed two-stream compressible flow in the volume "from" side

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= 2, mixed two-stream compressible flow in the volume "to" side

= 3, no momentum flux (incompressible flow, no Bernoulli effects)

= -2, special case of a fill with negative flow used to represent the outlet junction

W15-R DIAMJ = Junction diameter

If DIAMJ $\leq$ 0.0, the program will calculate DIAMJ as $2\sqrt{AJUN/\pi}$, (used for junction quality calculations)

W16-R CØNCØ = Contraction coefficient for critical flow correlations (0. is interpreted as 1.)

W17-I ICHØKE = Junction choking index to control table choking (used only if JCHOKE = 0 or 1, otherwise ICHOKE = 0)

0 = Table type choking will not be used in the subcooled (liquid phase) region, i.e., Moody or Henry data will not be used.

±1 = Use Moody table choking in the saturated region.

±2 = Use Henry table choking in the saturated region.

±3 = Use maximum value of Moody or Henry choking in the saturated region.

±4 = Use minimum value of Moody or Henry choking in the saturated region.

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NOTES: In all cases above:

(a) If ICHOKE > 0, the flow in the subcooled region will be the minimum of the specified table choking and the momentum solution. For 1 < ICHOKE ≤ 4 Moody or Henry choking will be used in the subcooled region. These models are designed for use in the saturated region, see note (c) for use of extended Henry tables (subcooled region).

(b) If ICHOKE < 0, table choking will be used in the saturated region only.

(c) By adding 10 to the absolute value of each of the options above, the flow in the subcooled region will be the minimum flow as determined using either the Henry extended tables or a momentum solution. Also, sonic choking will not be allowed. Choking in the saturated region will be controlled by |ICHOKE| - 10.

If |ICHOKE| ≥ 10, the negative option has no meaning and should not be used.

(d) JCHOKE = 0 and ICHOKE = 11 forces the momentum equation to a compressible energy balance form which is equivalent to the MVMIX = 0 form without the sonic velocity terms. This option also uses extended Henry table choking in the subcooled region and Moody in the saturated region.

W18-I IHQCØR = Enthalpy transport index

= 0, both sides off

= 1, inlet side on, outlet side off
volume "from" heated)

= 2, outlet side on, inlet side off
(volume "to" heated)

= 3, both sides on (both volumes heated).

W19-I ISP = Flag indicating that this is a pressurizer spray junction

=0 or blank, the junction is handled in the normal manner

=1, the junction flow is treated as a pressurizer spray junction

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14.0 PUMP DESCRIPTION DATA CARDS 090XXY

Pump descriptions are required for each centrifugal pump modeled in a RETRAN problem. The RETRAN pump model describes the interaction of a centrifugal pump and the fluid within a volume using information from the pump characteristic curves. An option is available to simulate the effect of two-phase flow on pump performance.

NPMPC (on Card 01000Y) sets of cards with XX equal to a pump number IPUMP (on Cards 08XXXY) must be entered. The values of XX need not start at 01 and need not be consecutive. Y is a card sequence number for each set and can range from 1 to 9.

W1-I	IPC	=	Pump curve set sequence number J on Card 100000
W2-I	ITPUMP	=	Trip number to shut off pump (ITPUMP $\geq$ 2)
		=	1000 when pump motor torque is controlled by control system
		=	-1000 when pump speed is controlled by control system
W3-I	IRP	=	Pump reversal indicator = 0, no reverse allowed = 1, reverse allowed
W4-I	IPM	=	Two-phase option index = 0, no two-phase option > 0, sequence index J on Card 100000 of the desired two-phase difference curve set.
W5-I	IMT	=	Pump motor torque curve or pump speed versus time curve set index or control block ID.

If |ITPUMP| ≠ 1000, IMT represents a curve set index. See Motor Torque Curve Data Cards 097XXY.

IMT<0, time dependent pump speed curve number where |IMT| is the curve number.

IMT=0, no motor torque curve

IMT>0, motor torque curve number

If ITPUMP = 1000,

IMT = ID of control block controlling pump motor torque

If ITPUMP = -1000

IMT = ID of control block controlling pump speed.

W6-R	PØMGAR	=	Rated pump speed (RPM)
W7-R	PSRAT	=	Pump speed ratio of initial speed-to-rated speed
W8-R	PFLØWR	=	Rated flow (gal/min)
W9-R	PHEADR	=	Rated head (ft)
W10-R	PTØRKR	=	Rated torque (lb_f-ft)
W11-R	PINRTA	=	Moment of inertia (lb_m-ft^2)
W12-R	VRHØI	=	Rated density (lb_m/ft^3) if VRHØI = 0.0, initial density is used
W13-R	TØRKMR	=	Rated pump motor torque (lb_f-ft) If TØRKMR = 0.0, it is set to the sum of

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			the frictional torque (TØRKF) and the hydraulic torque at time t = 0.
W14-R	TØRKF1	=	Coefficients for a third order polynomial frictional torque TØRKF. All four coefficients are optional and default to 0.0. The pump frictional torque is computed as
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.	.		
.	.		
W17-R	TØRKF4		TØRKF = TØRKF1 + TØRKF2*S + TØRKF3*S**2 + TØRKF4*S**3 where S is the absolute value of the ratio of the pump speed to rated speed.

15.0 PUMP HEAD MULTIPLIER DATA CARDS 091XXY

At least one set of Pump Head Multiplier Data Cards must be supplied if any value of IPM (on Cards 090XXY) is non-zero. For any non-zero values of IPM, XX corresponds to IPM. A single Pump Head Multiplier Curve can be used by more than one set of Pump Description Data Cards (090XXY). A Pump Head Multiplier Curve must be supplied for each unique non-zero value of IPM specified on Cards 090XXY. Y is a card sequence number ranging from 0 to 9. The sets are ordered by Y, but Y need not start at 0 and need not be consecutive to facilitate additions or deletions from the table.

W1-I	NPHM	=	Number of points on curve. ($\|NPHM\| \geq 1$) Positive value indicates no extrapolation, negative value permits extrapolation.
W2-R	PHDM(1)	=	Void fraction
W3-R	PHDM(2)	=	Head multiplier for difference curves in Set IPM
W4-R,	PHDM(3),		
W5-R,	PHDM(4),		
...	...		until NPHM points are entered. Void fraction must be in ascending sequence. Normally, both void fraction and multiplier will range from 0.0 to 1.0.

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16.0 PUMP TORQUE MULTIPLIER DATA CARDS 092XXY

The usage and general requirements for the Pump Torque Multiplier Data Cards are identical to those noted for the Pump Head Multiplier Data Cards (091XXY).

W1-I	NPTM	=	Number of points on curve ($\lvert NPTM \rvert \geq 1$) A negative value indicates that extrapolation is permitted
W2-R	PTKM(1)	=	Void fraction
W3-R	PTKM(2)	=	Torque multiplier for difference curves in Set IPM
W4-R,	PTKM(3),		
W5-R,	PTKM(4),		
...	...		until NPTM points are entered. Void fraction must be in ascending sequence.

17.0 PUMP STOP DATA CARDS 095XX1

This card must be present for each pump to which this option applies, where XX is the Pump Description Number XX on Cards 090XXY. Once any of the conditions below are met, the pump speed is set to 0.

W1-R	CAVCØN	=	Elapsed time (sec)
			$\leq$ 0.0, option not used
			> 0.0, option used
W2-R	FPUMP	=	Maximum forward speed (RPM)
			= 0.0, option not used
			$\neq$ 0.0, option used
W3-R	SPUMP	=	Maximum reverse speed (RPM)
			= 0.0, option not used
			$\neq$ 0.0, option used
			(Note: Normally this number is negative.)

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18.0 PUMP MOTOR TORQUE DATA CARDS 097XXY

Pump Motor Torque Data Cards are read if, on any 90XXY cards (Pump Description Data Cards), $|ITPUMP| \neq 1000$ and $IMT \neq 0$. If $|ITPUMP| \neq 1000$, positive values of IMT specify that Pump Motor Torque Data Cards with XX equal to IMT must be present, while negative values of IMT specify that Pump Motor Torque Data Card (actually Pump Speed Versus Time Data Cards) must be present and XX must equal $|IMT|$. Any given Motor Torque (or Pump Speed) curve may be used by more than one set of Pump Description Data Cards (090XXY). A Pump Motor Torque (Pump Speed) Curve must be supplied for each unique non-zero value of $|IMT|$. Y is a sequence number ranging from 0 to 9. The sets are ordered by Y, but Y need not start at 0 and need not be consecutive to facilitate additions or deletions from the table.

W1-I	NTMØ	=	Number of points in curve ($|NTMØ| \geq 1$) A negative value indicates that extrapolation is permitted	
W2-R	PTMØ(1)	=	Pump speed (RPM) Time (sec)	(IMT > 0) (IMT < 0)
W3-R	PTMØ(2)	=	Motor torque, normalized pump speed (RPM)	(IMT > 0) (IMT < 0)
W4-R,	PTMØ(3),			
W5-R,	PTMØ(4),			
...	...		until NTMØ points are entered. The independent variable (speed or time) must be in ascending sequence.	

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19.0 PUMP CURVE SET INPUT DATA CARD 100000

Pump curve set input flags are used to control the input of pump curve sets describing the performance characteristics of centrifugal pumps. Several options are available for selecting or specifying pump curve sets. Built-in curve sets may be used or modified by the user or a curve set supplied by the user. User supplied curve sets need not describe pump performance characteristics of all quadrants, but merely those describing the pump characteristics in the quadrant(s) necessary to define pump performance during the modeled transient. However, if all quadrants are not described, and characteristics are needed for a quadrant not described, the problem will be terminated. Any number of single-phase and/or single-phase minus two-phase curve sets may be supplied by the user.

This card is entered if NPMPC (on Card 01000Y) is greater than 0. At least one pair of data are required, where each pair has a unique sequence number J. The sequence number J ranges from 1 to the number of unique pump curve sets (set of head and torque curves) requested.

W1-I	NPC(J)	=	Built-in curve set use Flag.
			= 0, user will supply a pump curve set.
			= 1, Bingham Pump NS=4200 pump curve set will be used.
			= 2, Westinghouse Pump NS=5200 pump curve set will be used.
			= 3, Semi-scale two-phase head difference curve set will be used. The two-phase torque difference curve must be input by the user.
W2-I	NC(J)	=	Number of curves to be supplied for curve set NPC(J).

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< 0, |NC(J)| curves will be supplied and overlayed on built-in curve set NPC(J). ($1 \leq$ NPC(J) ≤ 3),

= 0, built-in curve set NPC(J) will be used without modification,

> 0, number of user supplied curves to be used in creating a pump curve set (NPC(J) = 0),

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. .
. .

until all desired pump curve set input flags have been set.

20.0 PUMP HEAD AND TORQUE DATA CARDS 10XYYZ

Pump Head and/or Torque Data Cards must be supplied for each unique value of the curve set sequence index J, if NC(J) on Card 100000 is non-zero, where X corresponds to the sequence number J. If NPC(J) is 0, Head and Torque Data Cards must be supplied for the quadrants describing the pump characteristics in the region of interest (characteristics in all quadrants need not be described). Any built-in curve set can be modified without having to supply the complete curve set if $1 \leq$ NCP(J) ≤ 3 and NC(J) < 0. Head curves one through eight are input by setting YY to the desired curve number, i.e., 01, 02,...or 08. Torque curves one through eight are specified by setting YY to the desired torque curve number plus eight, i.e., 09, 10,...or 16. Z is a sequence number for each curve ranging from 1 to 9. The individual curves are ordered by Z, but Z need not start at 1 and need not be consecutive.

W1-I	N	=	Number of data points ($\lvert N \rvert \geq 1$) Positive values indicate no extrapolation while negative values permit extrapolation. Extrapolation is generally not recommended.
W2-R	PHEAD(1)	=	Independent variable ($1 \leq YY \leq 8$) (v/α for YY odd; α/v for YY even)
or	PTØRK(1)	=	Independent variable ($9 \leq YY \leq 16$) (v/α for YY odd; α/v for YY even)
W3-R	PHEAD(2)	=	Dependent variable ($1 \leq YY \leq 8$) (h/α^2 for YY odd; h/v^2 for YY even)
or	PTØRK(2)	=	Dependent variable ($9 \leq YY \leq 16$) (β/α^2 for YY odd; β/v^2 for YY even)

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W(2N+1)-R PHEAD(2N) = Pairs of independent and dependent
or PTØRK(2N) = variables until |N| pairs have been entered.

NOTE: v, h, α and β are ratios of performance parameters to rated parameters, where v = flow ratio, h = head ratio, α = speed ratio and β = torque ratio

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21.0 VALVE DATA CARDS 11XXX0

A valve may be placed in any RETRAN junction by using a positive valve index, IVALVE, on Card 08XXXY, to refer to a Valve Data Card. The type of valve selected is determined by ITCV on the Valve Data Card. A choice of ITCV in the range of ITCV$\leq$-2 results in a valve which is closed until the trip conditions are satisfied and is then opened for the remainder of the transient, unless closed via reset trip action. A choice of ITCV in the range of ITCV$\geq$2 results in a valve which is open until the trip conditions are satisfied and is then closed for the remainder of the transient, unless opened via reset trip action. Either of these two types of valves is controlled by generalized trip data for which the action to be taken (IDTRP on Card 04XXX0), matches $|ITCV|$.

Either of two types of check valves may be chosen: Type 0 without a hysteresis loop in the characteristic flow-versus-pressure curve; and Type 1 with the hysteresis loop. The characteristic curves for these two types are shown in Figure IV.21-1.

Both types of check valves are controlled by flow-dependent pressure losses of the form $(CVi)W|W|/\rho$. Three regions of operation are defined for each check valve:

(1) CV1 is used for positive flow with the valve open

(2) CV2 is used for negative flow with the valve open

(3) CV3 is used for negative flow with valve almost closed.

For positive flow, the valve remains open and sustains a pressure loss proportional to CV1. For negative flow, the valve remains open if the pressure loss, which is proportional to CV2, is less than the back pressure, P_{cv}, required to close the valve.

After the valve closes, the pressure loss is proportional to CV3 for small leakage flows. Type 0 check valves open in exactly the reverse sequence of the closing sequence. A Type 0 valve opens when negative flow has decreased to a value such that the pressure loss for the open phase is less than the loss

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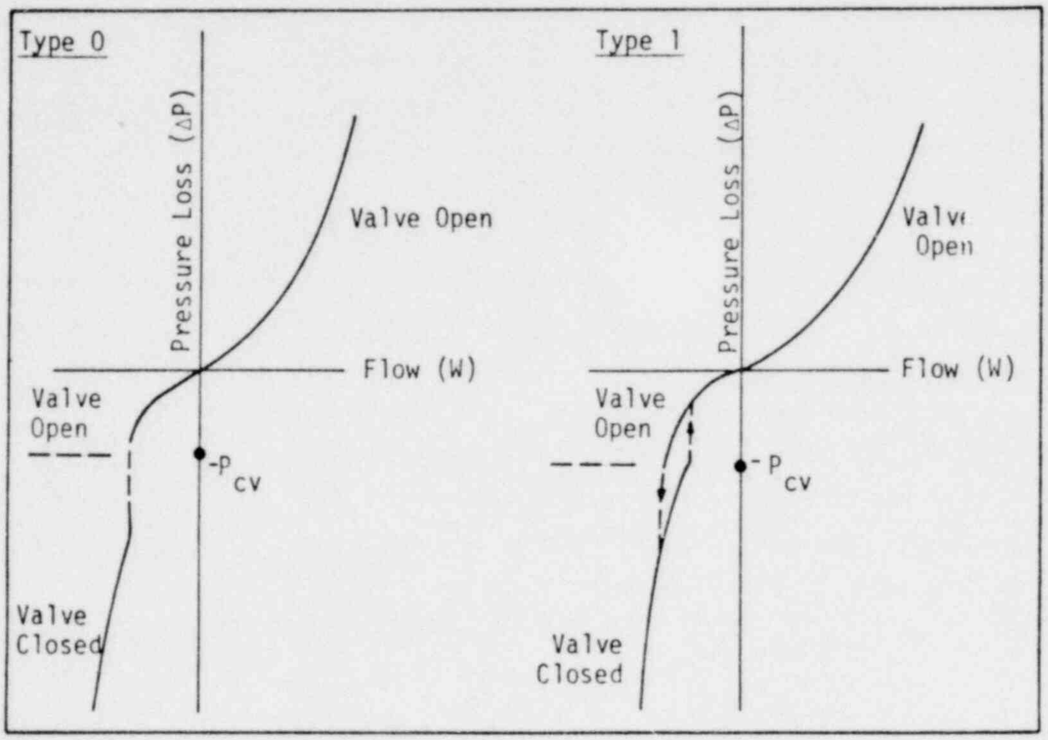

Figure IV.21-1 Check Valve Characteristic Curves required to keep the valve closed. A Type 1 valve reopens only when the pressure loss developed across the valve in the closed position is less than the required back pressure.

A time-dependent area may be associated with a valve defined by $|ITCV| \geq 2$. The normalized junction area for any time step is interpolated from an input table of area-versus-time (Cards 12XXYY). The junction area used during the time step is then given by the product of the interpolated normalized area and AJUN on Cards 08XXXY. A valve whose area is modulated by a feedback control system may be modeled by setting ITCV=1000 and IACV equal to the IDC of the control block described on cards 702XXX and 703XXX.

Valves having inertial properties differ from check valves in that the valve gates have a significant inertia which controls the rate of opening for a given differential pressure across the valve. The valve gates are assumed to be hinged on each side and open from the center. The differential pressure across the valve acts as a torque on the gates, and gate angle at any time is found by integrating the equation of motion. A viscous damping coefficient may optionally be supplied for the equation of motion. Once the gates reach a rotation of 90° they are latched and remain fully open.

Inertial valves are defined by setting ITCV=-1 in the valve data. Each valve must also be associated with a table of normalized area versus angle by setting the variable IACV to the appropriate table number. These tables are combined with the area versus time tables and may be intermixed but not used for both functions.

NCKV (on Card 01000Y) cards must be entered with XXX = 001, 002, ... NCKV. The data on the card are interpreted according to the type of valve being described.

W1-I	ITCV	=	Type of valve
			-1, inertial valve
			0, Type 0 check valve
			1, Type 1 check valve
			ITCV $\leq$ -2, a closed valve to open under control of trip ID = $|ITCV|$.

$|ITCV| \geq 2$, an open valve to close under control of trip ID = ITCV.
1000, time dependent area defined by control system

W2-I IACV = Number of the General Data Table containing area-versus-angle data if ITCV = -1
= Number of the General Data Table containing area-versus-time data ITCV $\geq$ 2 and ITCV $\neq$ 1000
= Control system IDC for area-versus-time from control system if ITCV=1000.
= 0 otherwise

W3-R PCV = Back pressure for closure (psia)
= 0. if $|ITCV| \geq 2$

W4-R CV1 = Forward flow friction coefficient if ITCV = 0 or 1 (dimensionless)
= Area*moment arm if ITCV = -1 (ft^3)
= 0. if $|ITCV| \geq 2$

W5-R CV2 = Reverse flow friction coefficient (valve open) if ITCV= 0 or 1 (dimensionless)
= Moment of Inertia if ITCV = -1 (lb_m*ft^2)
= 0. if $|ITVC| \geq 2$

W6-R CV3 = Reverse flow friction coefficient (valve closed) if ITCV = 0 or 1 (dimensionless)
= Damping constant if ITCV = -1.
= 0. if $|ITCV| \geq 2$

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22.0 GENERAL DATA TABLE CARDS 12XXYY

General Data Tables are used to provide input data for several models. Tabular normalized area versus time or normalized area versus angle data is used in conjunction with valve descriptions to describe transient area changes in RETRAN flow paths, XX corresponding to IACV on the valve data cards. The transient flow path area is assumed to be constant over a time step and is computed as the product of the interpolated normalized area (given the independent variables time since trip or angle), and the full open junction area AJUN (described on Cards 08XXXY).

Tabular data, used in conjunction with the control system function generator, is also input on General Data Table Cards. The tabular function generator data should be entered on General Data Table XX, where XX is the table number referenced by INC2 on card 703XXX. NLK (on Card 01000Y) sets of cards must be entered with XX = 01, 02, ..., NLK. YY is a card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NAREA	=	Number of data points ($\lvert NAREA \rvert \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation
W2-R	TAREA(1)	=	Time (sec) Angle (degrees) Control System Independent variable
W3-R	TAREA(2)	=	Area normalized to full open area AJUN Control System Dependent variable
W4-R, W5-R, ...	TAREA(3), TAREA(4), ...		Until NAREA points are entered, where the independent values are in ascending order.

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23.0 FILL TABLE DATA CARDS 13XXYY

Tabular fill data is used in conjunction with a "fill" junction to specify a flow boundary condition for a RETRAN problem. Water may be injected into any volume through one or more "fill" junctions, and flow through any of these junctions may be initiated by use of a trip signal. Fill curves are represented by tabular input of flow per unit area versus time or pressure. Several junctions can use a single fill curve.

The thermodynamic fluid properties for positive fills (positive flow) are determined from information supplied with the fill table. Negative fill thermodynamic properties are determined by the fluid conditions within the RETRAN volume supplying the fluid being removed from the system. In general, a negative fill is not a proper boundary condition and should be used with caution.

NFLL (on Card 01000Y) sets of cards must be entered with XX = 01, 02, ..., NFLL. YY is a card sequence number for each set ranging from 00 to 99, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card. At least one table pair must be entered.

W1-I	NFILL	=	Number of data points ($\|NFILL\| \geq 1$)
		=	0, when fill enthalpy and fill pressure are to be controlled by control system Positive value indicates no extrapolation; negative value permits extrapolation.
W2-I	ITFILL	=	Trip signal to start ($ITFILL \geq 2$) =1000 for fill controlled by control system If NFILL=0, then ITFILL must equal 1000
W3-I	JX	=	Independent variable flag or control block ID. If ITFILL=1000,

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JX=ID of control block controlling fill flux

If ITFILL≠1000, JX is a flag specifying independent variable used in fill table

JX = 0, time (sec)

JX > 0, pressure (P_{vol} + P_{grav}) (psia)

JX < 0, differential pressure (P_{vol} + P_{grav} - P_{fill}) (psia)

W4-I	JY	=	Flow type JY $\leq$ 0, flux in $lb_m/sec\text{-}ft^2$ JY > C, flux in gpm/ft^2
W5-R	FILTBL(1)	=	Time or pressure if ITFILL≠1000 and NFILL≠0 (sec or psia)
		=	Dummy value if ITFILL=1000 and NFILL≠0
		=	ID of control block controlling fill enthalpy, if NFILL=0 Note: ID has to be entered as a floating point number.
W6-R	FILTBL(2)	=	Flux ($lb_m/sec\text{-}ft^2$ or gpm/ft^2) if NFILL≠0 This flux is multiplied by the time-dependent junction area to obtain the junction mass flow rate.
		=	ID of control block controlling fill pressure if NFILL=0 Note: ID has to be entered as a floating point number.

NOTE: If ITFILL = 1000 and NFILL ≠ 0, W6-R is the control block output (independent variable and W7-R and W8-R are dependent variables. If NFILL=0, The following words are omitted.

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W7-R	FILENT(1)	=	Enthalpy of fill fluid Btu/lb_m. The enthalpy is not used when flow is negative, but a value must be supplied (0. is adquate).
W8-R	FILPRS(1)	=	Fill system pressure (psia). The pressure is not used when flow is negative and JX $\geq$ 0, but a value must be supplied (0. is adequate).
.	.		And so on for NFILL data points where a data point consists of FILTBL(1), FILTBL(2), FILENT(1) and FILPRS(1).
.	.		
.	.		

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24.0 KINETICS CONSTANTS DATA CARD 140000

The normalized thermal power generation may be computed by use of the point reactor kinetics equation with reactivity feedback if the power calculation indicater, NØDEL (on Card 01000Y), is set to 1, 2 or 3. A value of NØDEL equal to 1 specifies six groups of delayed neutrons will be used in the power calculation; a value equal to 2 specifies six groups of delayed neutrons and an optional eleven group fission product decay will be included in the power calculation; and a value of 3 indicates that the six delayed neutron groups, eleven fission product decay groups, and a two-group actinide decay will be treated in the power calculation.

The driving function for the point reactor kinetics equations is the reactivity. Contributions to the reactivity include a time-dependent control(scram) reactivity and reactivities due to feedback effects in each core region. Feedback effects include water density, Doppler, fuel temperature, and water temperature.

The total power in a core conductor is the sum of the direct fission power and the radioactive decay power. The inclusion of the decay heat terms gives a more realistic shutdown power calculation. All power need not be generated in the fuel elements. Direct gamma heating of the coolant may be considered in user defined core models.

Kinetics constants are required if NCOR (on Card 01000Y) is greater than 0 and NØDEL (on Card 01000Y) is greater than 0, but less than or equal to 3.

W1-R	KMUL	=	Multiplying factor for decay energy = 0., use ANS decay energy release rates > 0., multiply ANS rates by KMUL.
W2-R	BØVL	=	β/Λ, the effective delayed neutron fraction over prompt generation time (sec^{-1})
W3-R	RHØIN	=	Initial reactivity ($)

W4-R	UDUF	=	U-238 atoms consumed per U-235 atoms fissioned. The default value is 1.0. The yield fractions for U-239 and Np-239 are multiplied by UDUF.
W5-R	PRØMPT	=	Fraction of total power released at time of fission (default = 1.0 if no delay gamma emitters and 0.93001 for delay gamma if PRØMPT is omitted).
W6-R	LAMBDA	=	Fraction of surface heat flux utilized in producing subcooled vapor bubbles (default = 0.0).
W7-R	TAU	=	Vapor bubble lifetime (sec) (default = 0.0).

24.1 Delayed Neutron Data Override Cards 14000Y

Built-in values for delayed neutron decay constants and yield fractions may be overridden. If only six values are supplied, they will be interpreted as decay constant replacements and the yield fractions will default to built-in values. If the yield fractions (words 7 to 12) are supplied, the condition:

$$\sum_{i=1}^{6} \frac{\beta_i}{\beta} = 1.0$$

must be met or further input processing will be terminated. Y is a card sequence number ranging from 1 to 9.

W1-R	DLAMDA(1)	=	Decay constants for six delayed neutron groups.
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.	.		

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.	.	
W6-R	DLAMDA(6)	
W7-R,	AJOVRJ(1)	Yield fractions $\frac{\beta_i}{\beta}$ for six delayed groups.
.	.	
.	.	
.	.	
.	.	
W12-R.	AJOVRJ(6)	

25.0 REACTIVITY COEFFICIENT DATA CARDS 140XX0

NCØR (on Card 01000Y) sets of cards are required if NØDEL (on Card 01000Y) is in the range 1 to 3, where XX = 01, 02, ..., NCØR. A discussion of the reactivity coefficient data as used by the RETRAN code is found in Volume I; Equations and Numbers.

W1-R	DENWT	=	Density weighting factor. The sum of all DENWT should equal 1.0.
W2-R	FTWT	=	Fuel temperature weighting factor. The sum of all FTWT should equal 1.0.
W3-R	ALPHTM	=	Fuel temperature coefficient ($/°F)
W4-R	ALPHTW	=	Water temperature coefficient ($/°F).
W5-R	QPMØD	=	Fraction of QFRAC (16XXX0 cards) in moderator as prompt heat (default = 0.).
W6-R	QDMØD	=	Fraction of QFRAC in moderator as delayed heat (default = 0.).

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26.0 SCRAM TABLE DATA CARDS 141XYY

Scram Table Data Cards are required if NCØR (on Card 01000Y) is greater than 0 and NØDEL (on Card 01000Y) is greater than or equal to 0, but less than or equal to 0. If NØDEL is equal to 0, the Scram Table is used as a table of normalized power versus time and X may range from 0 to 9. The net normalized power is computed by summing the normalized power from all curves. When NØDEL is greater than 0, the Scram Table is a reactivity versus time table. A maximum of ten reactivity tables ($0 \leq X \leq 9$), may be input specifying the control reactivity as a function of time. Each table is activated by a trip signal. The total control reactivity is summed over all tables which have been tripped. The trip controls are such that once tripped, the trip stays on. Also, at any given entry, the time variable is the elapsed time since the trip, not problem time. YY is the card sequence number for the set and ranges from 00 to 99. YY need not start at 00 and need not be consecutive.

W1-I	NSCR	=	Number of data points ($\lvert NSCR \rvert \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation NSCR = IDC of control block if ITSCRM=1000
W2-I	ITSCRM	=	Trip number for scram ($ITSCRM \geq 2$)
		=	1000 for reactivity or normalized core power controlled by control system
W3-R	TSCR(1)	=	Time (sec)
W4-R	TSCR(2)	=	Reactivity in dollars ($1 \leq NØDEL \leq 3$) Normalized core power (NØDEL = 0)
W5-R, W6-R,	TSCR(3), TSCR(4),		until NSCR points are entered, where time values are in ascending order.

NOTE: If ITSCRM=1000, zero points are to be entered.

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27.0 DENSITY REACTIVITY TABLE DATA CARDS 1420XX

This set of cards is required if NCOR (on Card 01000Y) is greater than 0 and NØDEL (on Card 01000Y) is in the range of 1 to 3. XX is the card sequence number for the sets ranging from 00 to 99. The cards are ordered by XX, but XX need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NDEN	=	Number of data points Positive value indicates no extrapolation; negative value permits extrapolation NDEN = 1, reactivity is a constant value NDEN = 0, reactivity is always zero
W2-R	VØIDRØ(1)	=	Density (lbm/ft^3)
W3-R	VØIDRØ(2)	=	Reactivity ($)
W4-R, W5-R ...	VØIDRØ(3), VØIDRØ(4), ...		until NDEN points are entered, density values are in ascending order.

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28.0 DOPPLER TABLE DATA CARDS 1430XX

This set of cards is required if NCOR (on Card 01000Y) is greater than 0 and NØDEL (on Card 01000Y) is in the range 1 to 3. XX is the card sequence number for the set and ranges from 00 to 99. The cards are ordered by XX, but XX need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NDØP	=	Number of data points Positive value indicates no extrapolation; negative value permits extrapolation NDØP = 1, reactivity is a constant value NDØP = 0, reactivity is always zero
W2-R	DØPRØ(1)	=	Temperature (°F)
W3-R	DØPRØ(2)	=	Reactivity ($)
W4-R W5-R ...	DØPRØ(3), DØPRØ(4) ...		until NDØP points are entered, where temperature values are in ascending order.

29.0 DIRECT MODERATOR HEATING MULTIPLIER DATA CARDS 1440XX

This set of cards is optional and may be supplied only if NCØR (on card 01000Y) is greater than 0, NØDEL (on card 01000Y) is in the range 1 to 3, and QPMØD or QDMØD (on card 140XX0) is greater than 0.0. If the direct moderator heating option is used and the 1440XX cards are not supplied, the ratio of initial fluid specific volume to time t fluid specific volume in the given core volume is used as the multiplier (default option). XX is the card sequence number ranging from 00 to 99. XX need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NMØDHT	=	Number of data points in the table Positive value indicates no extrapolation Negative value permits extrapolation
W2-R	WEIGHT(1)	=	Fluid density (lb/ft^3)
W3-R	WEIGHT(2)	=	Moderator heating rate multiplier (dimensionless)
W4-R, W5-R	WEIGHT(3) WEIGHT(4)	=	Until NMODHT points are entered, where fluid density values are in ascending order.
...	...		

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30.0 SPECIFIED HEAT TRANSFER COEFFICIENT DATA CARDS 15000X

Included as a specified heat transfer coefficient option is the following condensing heat transfer coefficient correlation. Use of this correlation allows the user to model a PWR containment, for reflood backpressure calculations. The general form of the correlation [IV.30.1] is given by:

(1) Prior to blowdown, HTC = HMIN

(2) During blowdown, HTC = HMIN + (TAGMUL*HTAB - HMIN)/BLØTIM)ΔT_B

where

HTAG = 72.5*(QØVRV/BLØTIM)**0.62

ΔT_B = Elapsed time since blowdown initiation

(3) Post blowdown transition and long term

HTC = UCHMUL*HUCHID + (HMAX - UCHMUL*HUCHID)*EXP(-TRNCØN*ΔT_T)

where

HUCHID = Heat transfer coefficient from standard Uchida correlation

HMAX = Maximum value of HTC reached during the blowdown phase

ΔT_T = Elapsed time since end of blowdown

All parameters not specifically defined above are input parameters which are defined below. Three different specified heat transfer coefficient types are available, two of which are degenerate forms of the correlation defined above. NCHT (on Card 01000Y) 15000X cards must be supplied with X ranging from 1 to NCHT. Note that X must correspond to |IMCL| on the heat conductor (15XXXY) cards.

W1-I	MØDE	=	Specified heat transfer coefficient option. ($1 \leq$ MØDE ≤ 3)

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If MØDE-1

W2-R	BLØTIM	=	Estimated length of blowdown phase (sec)
W3-I	IBLØ	=	Trip ID used to initiate blowdown
W4-R	QØVRV	=	Ratio of primary coolant energy to net free containment volume (Btu/ft^3)
W5-R	TAGMUL	=	Tagami correlation multiplier (input is optional, default = 4.0)
W6-R	HMIN	=	Minimum pre-blowdown heat transfer coefficient (input is optional, default = 8.0, $Btu/hr\text{-}ft^2\text{-}^{\circ}F$)
W7-R	UCHMUL	=	Uchida correlation multiplier (input is optional, default = 1.2)
W8-R	TRNCØN	=	Transition decay constant (input is optional, default = 0.025 1/sec)

The default parameters noted above were taken from Reference IV.30-1.

If MØDE=2

W2-R	UCHMUL	=	Multiplier to be used with the Uchida correlation

If MØDE=3

W2-R	HCØNST	=	Constant heat transfer coefficient ($Btu/hr\text{-}ft^2\text{-}^{\circ}F$)

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31.0 HEAT CONDUCTOR DATA CARDS 15XXXY

A heat conductor can be described to represent one or more materials which conduct heat into the fluid of a volume, or between the fluids in two different volumes. In the former case, the conductor may represent core fuel rods, or a material insulated on one side and with no internal heat generation. The latter case may represent piping or a flat plate separating two volumes. When a conductor connects two volumes, it may be thought of as being analogous to a junction, where heat rather than fluid is flowing from one volume to the other. Powered conductors or core sections are described in a manner similar to passive conductors, with the exception that powered conductors require an extended description supplied on the Core Section Data Cards (16XXX0).

NSLB (on Card 01000Y) cards must be entered with XXX equal to the heat conductor number. XXX need not start at 001 and need not be consecutive. Y is a sequence number of 1 or 2.

W1-I	IVSL	=	Index number of volume at left conductor surface ($-1 \leq$ IVSL $\leq$ NVØL)
W2-I	IVSR	=	Index number of volume at right conductor surface ($-1 \leq$ IVSR $\leq$ NVØL)

A 0 value for either IVSL or IVSR means that the conductor surface does not conduct heat across the boundary. A -1 value for either IVSL or IVSR means that the conductor is used with a constant sink temperature and a heat transfer coefficient on the -1 side. For this case, the additional input quantities are needed: a constant heat transfer coefficient and a removal fraction of the total power initially generated in the core sections. The user can also model a heat conductor with fluid volumes on both sides. For steam generator conductors with fluid volumes on both sides, the left volume must be connected to the

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primary side of the system and the right volume to the secondary side of the system. At least one of the quantities IVSL or IVSR must be greater than 0. IVSL must be 0 for solid cylindrical heat conductors.

W3-I	IGØM	=	Geometry index (Refers to XX on the 17XXYY cards) (1 ≤ IGØM ≤ NGØM)
W4-I	ISB	=	Stack indicator 0 means that this conductor is at the bottom of a stack. 1 means that this conductor is stacked on top of the conductor described by the previous card.
W5-I	IMCL	=	Indicator for heat transfer correlations at left surface. <0 - use specified heat transfer coefficient |IMCL| defined on card 15000X, where |IMCL| = X 0 - use Groeneveld 5.9 1 - use Groeneveld 5.7 2 - use Dougall Rohsenow 1X - use G. E. CHF Correlation (ten's place digit = 1)
W6-I	IMCR	=	Indicator for heat transfer correlations at right surface. Same as IMCL above.
W7-R	ASUL	=	Heat transfer area at left surface (ft^2) ASUL = 0.0 if IVSL = 0 ASUL > 0.0 if IVSL ≠ 0

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W8-R ASUR = Heat transfer area at right surface (ft^2)
ASUR = 0.0 if IVSR = 0
ASUR > 0.0 if IVSR $\neq$ 0

W9-R VØLS = Total volume of conductor (ft^3)
VØLS > 0.0

W10-R HDML = Left side hydraulic diameter (ft)
HDML $\geq$ 0. If HDML = 0.0 and IVSL > 0, HDML will be set equal to DIAMV (on Card 05XXXY) for volume IVSL

W11-R HDMR = Right side hydraulic diameter (ft)
HDMR $\geq$ 0. If HDMR = 0.0 and IVSR > 0, HDMR will be set equal to DIAMV (on Card 05XXXY) for volume IVSR

W12-R DHEL = Left side heated equivalent diameter (ft)
DHEL $\geq$ 0. If DHEL = 0.0 and IVSL > 0, DHEL will be set equal to HDML

W13-R DHER = Right side heated equivalent diameter (ft)
DHER $\geq$ 0. If DHER = 0.0 and IVSR > 0, DHER will be set equal to HDMR

W14-R CHNL = Channel length on left side (ft)
If CHNL = 0.0 and IVSL > 0, CHNL will be set equal to ZVØL (on Card 05XXXY) for volume IVSR.

W15-R CHNR = Channel length on right side (ft)
If CHNR = 0.0 and IVSR > 0, CHNR will be set equal to ZVØL (on Card 05XXXY) for volume IVSR.

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W16-I IHXQF = IHXQF > 0 if the heat conductor is used to model a steam generator. Additionally, IVSR and IVSL must be > 0 and IVSL must be the primary side volume. IHXQF is an arbitrary positive integer representtative of the steam generator defined on Cards 230XXY. The overall heat transfer coefficient of the heat conductor is adjusted to achieve a steady state energy balance.

IHXQF = 0 if the heat conductor is not used to model a steam generator (default=0)

The following two quantities are required only if IVSL or IVSR is -1:

W17-R PFR = Fraction of total power generated in the core which is removed by this conductor ($0.0 \leq PFR \leq 1.0$)

W18-R HTC = Constant heat transfer coefficient (Btu/ft^2-hr-°F).

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32.0 CORE SECTION DATA CARDS 16XXX0

Any heat conductor may have internal heat generation. If a conductor does have internal heat generation, it is considered to be a core conductor and must be defined using a Core Section Data Card.

NCØR (on Card 01000Y) cards must be entered with XXX = 001, 002, ..., NCØR.

W1-I	ISLB	=	Conductor number
W2-R	CLTI	=	Initial cladding thickness (ft) If CLTI > 0.0, then metal-water reaction is calculated for this core section, provided MWREAC (on Card 01000Y) is greater than zero. If CLTI = 0.0, then no metal-water reaction is calculated for this core section.
W3-R	QFRAC	=	Fraction of power generated in core section $0.0 \leq \text{QFRAC} \leq 1.0$ and $\sum_{i=1}^{NCØR} \text{QFRAC}_i$ should = 1.0 for all values of NØDEL (on Card 01000Y).

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33.0 CONDUCTOR GEOMETRY DATA CARDS 17XXYY

The description of a heat conductor geometry proceeds from left to right, so that node one is at the left surface for rectangular geometry and at the center of the conductor for cylindrical geometry. A geometry description, provided by one set of Conductor Geometry Data Cards, includes the region width, node spacing, and material index for each region in the conductor. If the conductor is a core section, a ratio, PF, of the region power to total core section power must be specified for each region in the core section.

A simple gap-expansion model is available for cylindrical geometries. The expansion model is also appropriate for rectangular geometries for which the left boundary of the conductor is fixed and cannot move due to expansion. The model does not provide for any changes in volume or surface areas, but only calculates a modified conductivity in a gap due to expansion in adjacent regions. Linear coefficients of expansion with respect to temperature for the materials on either side of the gap are used to form a ratio of cold gap width to hot gap width. This ratio is then used as a multiplier in calculating gap conductivity. A gap is considered like any other region in the conductor; that is, its width, nodal spacing, and thermal properties are described in the problem input. NGØM (on Card 01000Y) sets of cards must be entered with XX = 01, 02, ..., NGØM. One card is required for each region and YY is the region number.

For YY = 01,

W1-I	IG	=	Geometry type 1 = Rectangular 2 = Cylindrical
W2-I	NR	=	Number of regions (NR $\geq$ 1)
W3-I	IM	=	Material index (1 $\leq$ IM $\leq$ NMAT)
W4-I	NDX	=	Number of space steps (NDX $\geq$ 1)

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W5-R	XØ	=	Radial distance to left surface (ft) XØ = 0.0 for a solid rod
W6-R	XR	=	Region width (ft)
W7-R	PF	=	Fraction of conductor power generated in region.

For YY = 02, 03, ..., NR,

W1-I	IGP =	Gap indicator 0 = No gap 1 = Gap expansion model desired Two successive region cards cannot have IGP = 1, nor can the last card in the set.

W2-I	IM	=	As for the first region card
W3-I	NDX		
W4-R	XR		
W5-R	PF		

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34.0 THERMAL CONDUCTIVITY DATA CARDS 18XXYY

NMAT (on Card 01000Y) sets of data must be entered with XX indicating the material number, XX 01, 02, ..., NMAT. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card. At least one table pair must be entered.

W1-I	NKP	=	Number of points in thermal conductivity table ($\|NKP\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation. NKP = 1, a constant value
W2-R	TPK(1)	=	Temperature (°F)
3-R	TPK(2)	=	Thermal conductivity (Btu/ft-hr-°F)
W4-R, W5-R, ...	TPK(3) TPK(4), ...		Until $\|NKP\|$ points are entered, temperature values are in ascending order.

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35.0 VOLUMETRIC HEAT CAPACITY DATA CARDS 19XXYY

NMAT (on Card 01000Y) sets of data must be entered with XX indicating the material number, XX = 01, 02, ..., NMAT. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items can be entered on each card. At least one table pair must be entered.

W1-I	NCP	=	Number of points in heat capacity table ($\lvert NCP \rvert \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation NCP = 1, a constant value
W2-R	TPC(1)	=	Temperature (°F)
W3-R	TPC(2)	=	Volumetric heat capacity (Btu/°F-ft^3)
W4-R, W5-R, ...	TPC(3), TPC(4), ...		until $\lvert NCP \rvert$ points are entered, where temperature values are in ascending order.

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36.0 LINEAR EXPANSION COEFFICIENT DATA CARDS 20XXYY

These cards are required for each material if and only if any heat conductor specifies the gap expansion model; that is, if IGP on any Card 17XXYY is 1, NMAT (on Card 010001) sets are entered with XX indicating the material number, XX = 01, 02, ..., NMAT. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NXP	=	Number of points in linear expansion coefficient table ($\|NXP\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation NXP = 1, a constant value
W2-R	TPX(1)	=	Temperature (°F)
W3-R	TPX(2)	=	Linear expansion coefficient, $°F^{-1}$
W4-R, W5-R, ...	TPX(3), TPX(4), ...		until $\|NXP\|$ points are entered, where temperature values are in ascending order.

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37.0 HEAT EXCHANGER DATA CARDS 21XXYY

Heat may be transferred by means of a volume-associated heat exchanger model which does not consider conduction. This option provides seven models which may be used to add or remove heat from the fluid of a volume. The enthalpy transport model may be used in conjunction with a heat exchanger if a continuous enthalpy profile through the volume is desired.

NHTX (on Card 01000Y) sets of data must be entered with XX = 01, 02, ..., NHTX. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card, and if a table is entered at least one table pair must be entered.

W1-I	IHTX	=	Number of data points for IHTYPE =2,3, or 4. Positive value indicates no extrapolation; negative value permits extrapolation.
		=	IHTX = 1, indicates a constant value.
		=	0 for $\|IHTYPE\| = 1$ or 5.
		=	ID of control block specifying rate of heat removal, for ITHTXQ=1000.
W2-I	ITHTXQ	=	ID of trip activating heat exchanger (ITHTXQ $\geq$ 2, ITHTXQ $\neq$ 1000)
		=	1000 if heat exchanger is to be controlled by a control block.
W3-I	JVØL	=	Control volume number
W4-I	IHTYPE	=	Type of heat exchanger option desired
		=	1, flow and temperature dependent heat exchanger with constant secondary sink temperature. Volume mass flow must be nonzero.

= -1, temperature dependent heat exchanger with constant secondary sink temperature.

= 2, flow and temperature dependent heat exchanger with time dependent secondary sink temperature. A time versus temperature table is supplied by the user.

= 3, time dependent heat exchanger. This option requires a table of time versus normalized power. The normalized power represents the fraction of total thermal power generated at any given time to be removed by the heat exchanger.

= 4, time dependent heat exchanger. This option requires a table of time versus power. Power represents the heat removal rate of the heat exchanger in megawatts and is not based on the fraction of power generated.

= 5, pressurizer heater model.

= 6, control system heat exchanger. Output of control block specified by IHTX determines the heat removal rate in units of normalized total thermal power.

= 7, control system heat exchanger. Output of control block specified by IHTX determines the heat removal rate in units of megawatts.

If IHTYPE = 1 or -1

W5-R HTQ = Fraction of power removed by heat exchanger

W6-R TSEC = Secondary side temperature (°F)

W7-R HTXCØ= Heat exchanger coefficient
(Btu-sec/hr-°F-lb_m) for IHTYPE = 1
(Btu/hr-°F) for IHTYPE = -1.

If HTXCØ is entered as zero, then the program calculates the steady-state value as HTXCØ = heat removal rate/(initial flow multiplied by the temperature difference between the primary fluid and secondary fluid).

If the heat exchanger is not tripped on at time zero, HTXCO must be nonzero.

If initial flow is zero, for IHTYPE = 1, the user must put in a non-zero value for HTXCØ.

The program will always use the input value of HTXCO if it is non-zero.

If IHTYPE = 2,3 or 4,

W5-R HTXTBL(1) = Time (sec)

W6-R HTXTBL(2) = Normalized power, secondary temperature (°F), or power (MW)

W7-R HTXTBL(3), until IHTX points are entered, where
W8-R, HTXTBL(4), time values are in ascending order.
... ...

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If IHTYPE = 5

W5-R	QHTR	=	Pressurizer heat capability (Kw)
W6-R	QTAU	=	Pressurizer heater time constant (sec)

If IHTYPE = 6 or 7

W5-R			Not used.
W6-R			Not used.

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38.0 STEADY-STATE INITIALIZATION CONVERGENCE CRITERIA DATA CARD 230000

The steady-state initialization convergence criteria card is optional. If this card is not supplied, default values are employed if the steady-state option is active. The criteria used for the steady-state initialization are edited, as are all parameters computed for the steady-state condition. Any zero value supplied by a user is considered to be a flag specifying the default value is to be used. This card should not be input when steady state is not being used.

W1-I	LCØUNT	=	Maximum number of steady-state iterations. If negative number is specified, the run will continue even if the convergence criteria for acceleration, pressure and enthalpy are not met (default = 25).
W2-R	ACEPSI	=	Maximum junction acceleration pressure (psi) (default = 1.E-5).
W3-R	HEPSI	=	Maximum enthalpy error Btu/lbm (default = 5.E-8).
W4-R	EPSIM	=	Maximum mass imbalance (fraction) (default = 5.E-13).

A value of 0 for any of the above fields leaves the default parameters unchanged.

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39.0 STEADY-STATE POWER REMOVAL SYSTEM DATA CARDS 230XXY

These cards are optional when using steady-state initialization but should not be supplied if steady-state initialization is not used. The energy balance capabilities for steady-state have been expanded and generalized to allow mutliple PWR steam generators or BWR feedwater systems. This card allows the user to describe how the power generated in the system is to be removed and which junction enthalpy to bias to make power generation and removal rates equal. Also, IHXQF on the heat conductor cards (150XXY series) is to be set equal to the steam generator number it is used to model (Word 1 on Cards 230XXY). Y is a sequence number varying from 1 to 9. XX is the power removal system number ranging from 01 to 99.

W1-I	ISGNUM	=	A unique arbitary number assigned to the steam generator (also equal to IHXQF on the appropriate heat conductor cards 150XXY). For a feedwater system, this variable should be set to 0.
W2-I	JBIAS	=	Junction number for which the enthalpy is to be biased. This junction must be a positive fill junction.
W3-I	JBAL	=	Outlet junction number for the power removal system (junction through which the power is removed).
W4-R	PØWF	=	Fraction of the total thermal power removed by this steam generator or feedwater system. Sum of all PØWF's on Cards 230XXY must be equal to 1.0.

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40.0 CONTROL SYSTEM MODELS

The response of various plant systems may have a large effect on the overall system response depending on the particular transient being analyzed. For example, in a BWR loss of feedwater heater transient, an accurate simulation of the feedwater flow response is necessary because of its large effect on the reactivity feedback. RETRAN provides the capability to model a variety of such reactor control systems. The RETRAN control system model truly models the dynamics of linear control systems. In addition, non-linear characteristics of control elements, such as clipping, saturation, and recovery time after saturation can be modeled. These additional capabilities allow easy representation of the various controllers in common use, such as a proportional-integral-derivative (PID) controller, or any arbitrary transfer function desired by the user.

Control elements available to the user include all of the more common analog computer elements plus a few that an analog computer can model only with difficulty. The types of elements available include integrators, differentiators, weighted summers, multipliers, dividers, delays, and function generators. The choice of components and their interconnections are specified via input data and may be completely arbitrary.

40.1 Model Description

Table IV.40-1 defines the nomenclature that is used to describe the control system model. The letter "x" refers to signals related to the input of a control block. The letter "y" refers to signals related to the output of a control block. The letter "h" refers to time step intervals. A scale factor "G" is used by all control blocks.

Table IV.40-2 presents the mathematical definition for each control block. The output is expressed either explicitly, as a function of the input, or implicitly, as the solution of a differential equation where the input is a given function of time. In addition, Table IV.40-2 briefly describes the numerical approximations used by the RETRAN coding to represent the control block.

The object of a control system model is to determine the ouput of a system given the input and information characterizing the system. The input is a given

TABLE IV.40-1

CONTROL SYSTEM MODEL NOMENCLATURE

$F_m[\ ]$	=	functional relation defined by the user via pairs of values of the independent and dependent variables in General Data Table m (12XXYY Cards).
g_1, g_2	=	user specified gains which apply to input 1 and input 2 respectively; these gains are used by SUM block only
G	=	user specified value for the overall gain of a control block
h_i	=	$t_i - t_{i-1}$, the i^{th} time interval
i	=	subscript used to denote values evaluated at i^{th} value of time
IDC	=	control block identification number
m	=	General Data Table index; only the FNG block uses m
n	=	user specified integer value denoting the number of samples taken and saved per delay interval; only the DLY block uses n
s	=	complex frequency in radians per second
t	=	time in seconds
t'	=	dummy variable representing time
t_i	=	i^{th} value of time
t_{i-1}	=	$(i-1)^{th}$ value of time
T	=	Delay time interval; T is used by DLY block only
v_{down}	=	user specified maximum negative rate of change for control block output, maximum "downward slew rate"; only the VLM block uses v_{down}
v_{up}	=	user specified maximum positive rate of change for control block output, maximum "upward slew rate"; only the VLM block uses v_{up}
x_i	=	value of x_1 (t) when $t=t_i$
x_0	=	value of $x_1(t)$ when t=0
$x_1(t)$	=	input 1 of control block represented as a function of time
$x_2(t)$	=	input 2 of control block represented as a function of time

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TABLE IV.40-1 (Cont'd.)

$y(t)$	=	output of control block represented as a function of time
y_i	=	value of $y(t)$ when $t=t_i$
y_{i-1}	=	value of $y(t)$ when $t=t_{i-1}$
y_{max}	=	user specified maximum value of $y(t)$
y_{min}	=	user specified minimum value of $y(t)$
y_0	=	value of $y(t)$ when $t=0$
t_1	=	lead time constant
t_2	=	lag time constant

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TABLE IV.40-2

MODELS FOR CONTROL BLOCKS

Symbol	Descriptive name	Mathematical definition	Numerical approximation used by RETRAN
DER	Differentiator	$y(t) = G \cdot \frac{dx(t)}{dt}$	$y_i = G \cdot \frac{x_i - x_{i-1}}{h_i}$
DIV	Divider	$y(t) = G \cdot \frac{x_1(t)}{x_2(t)}$	$y_i = G \cdot \frac{x_1(t_i)}{x_2(t_i)}$
DLY	Time delay	$y(t) = y_0$ for $0 \leq t \leq T$ $= G \cdot (t-T)$ for $t > T$	Numerical approximation used is described in Section IV.40.1 in text.
FNG	Function generator	$y(t) = G \cdot F_m[x(t)]$	$y_i = G \cdot F_m[x_i]$ where $F_m [\cdot]$ represents linear interpolation over a table of ordered pairs of independent and dependent variables.
INT	Integrator	$y(t) = y_0 + G \cdot \int_0^t x(t')\, dt'$	$y_i = y_{i+1} + G \cdot x_i \cdot h_i$ with y_0 given.
[illegible]	Lag compensation	$y(t) + \tau_2 \cdot \frac{dy(t)}{dt} = G \cdot x(t)$ with $y(0)=y_0$	$y_i = \frac{G \cdot x_i = \frac{\tau_2 \cdot y_{i-1}}{h_i}}{1 + \frac{\tau_2}{h_i}}$

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TABLE IV.40-2 (Cont'd)

MODELS FOR CONTROL BLOCKS

Symbol	Descriptive Name	Mathematical Definition	Numerical Approximation Used by RETRAN
LLG	Lead-lag	$y(t) + \tau_2 \cdot \frac{dy(t)}{dt} = G\left(x_1(t) + \tau_1 \cdot \frac{dx_1(t)}{dt}\right)$ with $y(0) = y_0$	$\dfrac{G \cdot (x_i + \frac{\tau_1 \cdot (x_i - x_{i-1})}{h_i}) + \frac{\tau_2 \cdot y_{i-1}}{h_i}}{(1 + \frac{\tau_2}{h_i})}$ with y_0 given
MUL	Multiplier	$y(t) = x_1(t) \cdot x_2(t)$	$y_i = x_1(t_i) \cdot x_2(t_i)$
LN	Natural logarithm	$y(t) = \ln [x(t)]$	$y_i = \ln [x_i]$
MAX	Maximum	$y(t) = \max [x_1(t), x_2(t)]$	$y_i = \max [x_1(t_i), x_2(t_i)]$
MIN	Minimum	$y(t) = \min [x_1(t), x_2(t)]$	$y_i = \min [x_1(t_i), x_2(t_i)]$
SUM	Weighted summer	$y(t) = G \cdot [g_1 \cdot x_1(t) + g_2 \cdot x_2(t)]$	$y_i = G \cdot [g_1 \cdot x_1(t_i) + g_2 \cdot x_2(t_i)]$
VLM	Velocity limiter	$y_i = y_{down}$ if $G \cdot x_i < y_{down}$ $= y_{up}$ if $G \cdot x_i > y_{up}$ $= G \cdot x_i$ otherwise	Same as mathematical definition

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TABLE IV.40-2 (Cont'd)

MODELS FOR CONTROL BLOCKS

Symbol	Descriptive Name	Mathematical Definition	Numerical Approximation Used by RETRAN
		where $y_{down} = y_{i-1} - h_i \cdot v_{down}$	
		$y_{up} = y_{i-1} + h_i \cdot v_{up}$	
XPØ	Exponentiation	$y_i = [x_1(t)]^{x_2(t)}$	$y_i = [x_1(t_i)]^{x_2(t_i)}$

function of time. The output is a function of time to be determined. When the input and output time functions can be related by a linear differential equation, the system is said to be linear. If information concerning the state of the system in terms of the initial output is known, the differential equation can be solved for the output given an arbitrary input. The DER, INT, LAG and LLG control blocks represent systems which are linear. RETRAN solves the differential equation characterizing these blocks by using a backward difference approximation to the first derivative. Solving the resulting difference equation for y_i in terms of x_i, x_{i-1}, y_{i-1}, and h_i represents an explicit formula for calculating the output of each block for each time step. This formula applies as long as the linear difference equation is a good approximation to the differential equation and the differential equation accurately represents the actual hardware.

In reality the input-output relation of the hardware can be represented by a linear system over only a finite range. To model this non-linear characteristic, RETRAN assumes that a control block is linear whenever its output is greater than y_{min} and less than y_{max}. If the linear model predicts an output greater than y_{max}, then the output is assumed to be equal to y_{max}. If the linear model predicts an output less than y_{min}, then the output is y_{min}. The user specifies the parameters y_{min} and y_{max}. In addition, RETRAN provides non-linear control blocks such as the FNG and VLM blocks to allow the user to model other types of non-linear behavior which may be in the hardware.

The numerical approximations used for the control blocks are straight-forward. The DER, INT, LAG, and LLG blocks were discussed above. The DIV, MUL, and SUM blocks simply take the inputs at time t_i and perform the operations indicated by their names to calculate the output. The FNG block takes the input at time t_i and linearly interpolates over the user supplied table to calculated the output. The VLM block calculates the maximum and minimum values the output may have without exceeding the user-specified rate limitations and calculates the output according to the conditions described in Table IV.40-2.

The method used to model the DLY block is conceptually simple, but difficult to describe symbolically. The details are described here to explain the significance of the n parameter required by the DLY block. The DLY block stores the values of the input for the past T seconds. The output of the DLY block at time t_i is the input that it had at time (t_i -T) multiplied by the scale factor G. The manner in which the DLY BLOCK block stores the input values is to make a stepwise continuous function out of the input, sample the input at fixed time intervals equal to (t/n), and save each sample for T seconds. Thus, n is equal to the number of samples of the input the DLY block has stored over the past T seconds. A larger value of n results in a more accurate representation of the past input at the cost of more storage. The user should strive to choose the smallest value of n consistent with acceptable accuracy.

40.2 Limitations, Precautions and Instructions

The OUT block does not represent an actual control element. Its function is to provide the user with a convenient means to monitor the output of any control block output or control input for the purposes of debugging. Use of the OUT block will result in the printing of the output of the specified control block or control input signal at every time step.

The order in which the output of each block is calculated affects the numerical results calculated by the control system for interconnected blocks. The order of computation is determined by the order of the control block description cards, which contain the interconnection information. Therefore, when control blocks are cascaded, the burden is upon the user to order computations sequentially from the beginning of the cascade to the end by ordering the control block description cards sequentially.

From Table IV.40-2 it can be seen that the control blocks which have to be initialized are only the DLY, INT, LAG, LLG, and VLM blocks. They are the only blocks which require past values of the output to calculate the new value of the output y_i. However, it is recommended that all control blocks and all control inputs be assigned an initial value of output by the user on the input data cards. This is recommended so that the control system model interfaces properly with the trip logic model in RETRAN. Only trips which monitor signals controlled by the control system are affected. These trips are affected only at time zero by the initial values. The values used for initialization for blocks other than those listed above need not be exact and need only be on the same side of the setpoints as the exact value for all trips monitoring those control signals. In other words, if the correct initial values would cause a trip to be actuated,

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any initial value which would cause the trip to be actuated may be input. It is recommended that the user initialize all values as accurate as practical. If the user wishes to cut corners, he may choose the initial value such that no trip monitoring that control signal will be activated by the initial value input. The only consequence of the short cut is to delay by one time step the actuation of a trip which might have occurred at time zero.

By the nature of digital computation, calculations are performed sequentially. If a loop is constructed using only those control blocks whose outputs are algebraic functions of their inputs (DIV, FNG, LN, MAX, MIN, MUL, SUM, and XPØ), the resulting outputs will not be correct and will not converge. Oscillations will occur in this case because the input for one element in the loop must be taken from calculations during the previous time step to start off the calculations around the loop. Unless that initial value happens to equal the new value calculated for that signal after going around the loop, oscillations will occur. These control blocks are idealized and do not exist alone in practice, just as an amplifier with infinite bandwidth does not exist in practice. Thus, the inability to model algebraic loops does not restrict the user from modeling practical systems with their practical limitations.

40.3 Control System Problem Dimensions Data Card 701000

The Control System Problem Dimensions Data Card (701000) specifies the number of inputs (NCI) and the number of control blocks (NCB) needed to model the reactor control system. This card is required only if control systems are to be modeled.

W1-I	NCI	=	Number of control input definition cards (NCI $\geq$ 0)
W2-I	NCB	=	Number of control block description cards (NCB $\geq$ 0)

40.4 Control Input Definition Data Cards 702XXX

The Control Input Definition Data Cards specify the input variables which the control system is to monitor and assign a unique identification number (IDC) to each variable. IDC may have any integer value greater than or equal to 1. If an

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identical value of IDC is used on more than one card, the last such card will replace all earlier definitions. NCI (on Card 701000) cards must be entered with XXX=001, 002,..., NCI.

W1-I	IDC	=	Control input ID (IDC $\geq$ 1)
W2-A		=	Variable symbol. See Tables IV.7-1 to IV.7-14. All variables in these tables plus CONS can be used.
W3-I		=	Region number. See Tables IV.7-1 to IV.7-14.
W4-R	GAIN	=	Input gain (gain is value of constant if CØNS block type is specified)
W5-R	CIC	=	Input block initial conditions.

40.5 Control Block Description Data Cards 703XXX

The Control Block Description Cards select the types of control blocks the user needs, assign a unique identification number (IDC) to each block, specify the values of parameters for each block, and describe the interconnections between all blocks and all input variables. The types of control blocks the user may select are listed in Table IV.40-3. The number of control parameters needed to describe each block depends on the block type. These parameters are outlined in Table IV.40-3. Each block has only one output; therefore the output of a block may be referenced by the IDC of the block. This allows the interconnections of the blocks to be specified by associating each input of a block with the IDC of the block whose output provides the input.

NCB (on card 701000) cards must be entered with XXX=001, 002, ..., NCB.

W1-I	IDC	=	Control Block ID (-NCB $\leq$ IDC $\leq$ -1)
W2-A	ITYPE	=	Control Block type

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TABLE IV.40-3

CONTROL BLOCK PARAMETERS

Symbol	Description	INC1	INC2	CGAIN	CP1	CP2	CIC	CMIN	CMAX
DER	Differentiator	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
DIV	Divider	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}
DLY	Time delay	IDC for $x_1(t)$	n	G	T	0.0	y_0	y_{min}	y_{max}
FNG	Function generator	IDC for $x_1(t)$	m	G	0.0	0.0	y_0	y_{min}	y_{max}
INT	Integrator	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
LAG	Lag compensation	IDC for $x_1(t)$	0	G	τ_2	0.0	y_0	y_{min}	y_{max}
LLG	Lead-lag compensation	IDC for $x_1(t)$	0	G	τ_1	τ_2	y_0	y_{min}	y_{max}
LN	Natural logarithm	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
MAX	Maximum	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.C	y_0	y_{min}	y_{max}
MIN	Minimum	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}

TABLE IV.40-3 (Cont'd)

CONTROL BLOCK PARAMETERS

Symbol	Description	INC1	INC2	CGAIN	CP1	CP2	CIC	CMIN	CMAX
MUL	Multiplier	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}
ØUT	Output	IDC for $x_1(t)$	IDC for $x_2(t)$	-	-	-	-	-	-
SUM	Weighted summer	IDC for $x_1(t)$	IDC for $x_2(t)$	G	g_1	g_2	y_0	y_{min}	y_{max}
VLM	Velocity limiter	IDC for $x_1(t)$	0	G	v_{up}	v_{down}	y_0	y_{min}	y_{max}
XPØ	Exponentation	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}

= DER for differentiator, s

= DIV for divider, (INC1)/(INC2)

= DLY for delays, e^{-Ts}

= FNG for function generator with no dynamic response

= INT for integrator, 1/s

= LAG for lag network, $(1/1+\tau_2 s)$

= LLG for lead-lag network, $(1+\tau_1 s)/1+\tau_2 s)$

= LN for natural logarithm, ln((INC1))

= MAX for Max((INC1),(INC2))

= MIN for Min((INC1),(INC2))

= MUL for multiplier, (INC1)(INC2)

= ØUT for listed output of control blocks and input signals at each time step

= SUM for sum of two inputs, g_1(INC1) + g_2(INC2)

= VLM for rate limited output,
$-|DOWNLIM| < (dy/dt) < |UPLIM|$

= XPØ for exponentiation, (INC1)**(INC2)

Note: (INC1) and (INC2) denote the output of control blocks with ID equal to INC1 and INC2, respectively.

W3-I INC1 = Input ID
(INC1$\geq$1) for input signals
(INC1$\leq$-1) for control blocks

W4-I INC2 = Input ID for second input if ITYPE=SUM, [illegible], or OUT
= General Data Table index if ITYPE=FNG (XX on 12XXYY Card)
= Number of samples in delay interval if ITYPE=DLY
= Input ID for divisor if ITYPE=DIV
= Input ID for exponent if ITYPE=XPO
= 0 otherwise

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Note: If ITYPE=ØUT, the following parameters may be omitted.

W5-R	CGAIN	=	Gain at output
		=	0.0 if ITYPE=ØUT
W6-R	CP1	=	Control parameter 1
		=	T time delay (sec) if ITYPE=DLY and CP2 = 0.0
		=	τ_2 lag time constant (sec) if ITYPE=LAG
		=	τ_1 lead time constant (sec) if ITYPE=LLG
		=	g_2, gain on input INC1 if ITYPE=SUM
			UPLIM per sec if ITYPE=VLM
		=	0.0 otherwise
		=	Control block ID when time delay is to be controlled by another control block if ITYPE=DLY
W7-R	CP2	=	Control parameter 2
		=	τ_2 lag time constant (sec) if ITYPE=LLG
			g_2, gain in input INC2 if ITYPE=SUM
		=	DOWNLIM per sec if ITYPE=VLM
		=	0.0 otherwise
W8-R	CIC	=	Output initial conditions
		=	0.0 if ITYPE=ØUT

Note: The following parameters may be omitted, in which case, they will assume their default values.

W9-R	CMIN	=	Output minimum limit. Default = -10^{+75}
W10-R	CMAX	=	Output maximum limit. Default = $+10^{+75}$

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41.0 PWR AUXILIARY DNB CALCULATION

The majority of the transients to be analyzed will not exceed the critical heat flux (CHF) for hot rod conditions. Indeed, acceptable margin above the Minimum Departure from Nucleate Boiling Ratio (MDNBR) is a design requirement for the less severe PWR plant transients. For such transients a detailed core-wide DNB analysis is not required. These transients will be analyzed via a subchannel model available in RETRAN. This model performs separative hydraulic analysis on a single hot subchannel using RETRAN boundary conditions during the transient. The DNB option is applicable only to a model with three or more conductor core nodes. Input of the DNB routine consists of modeling options, miscellaneous input, and standard heat flux and hot channel factors commonly used in DNB analyses for PWR's. Model options available include common CHF correlations, axial correction factor for CHF, grid space flow mixing correlation, and approximation for turbulent cross flow mixing, and a "cold wall" CHF correction factor. A summary of the model is presented in Table IV.41-1.

41.1 Auxiliary DNB Problem Dimension Data Cards 8001XX

The problem dimension data cards must be entered only if IDNBC (on Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

W1-I	LWR	=	Reactor type
		=	0, Auxiliary DNB routine not used
		=	1, PWR
		=	2, BWR
W2-I	ICW	=	Flag for cold wall
		=	0, no correction, recommended choice
		=	1, Westinghouse Correlation
W3-I	NUH	=	Flag for heat flux profile correction, F factor
		=	0, Uniform profile
		=	1, Westinghouse correlation
		=	2, B & W correlation

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TABLE IV.41-1

PWR AUXILIARY DNB MODELING

Model	Formation
Subchannel Array	Single channel, normalized to multiple subchannel array
Turbulent cross flow mixing	Rogers and Rosehart correlation
Heat flux factors and flow redistribution factors	Input from design assumptions or detailed hydraulic analysis
Engineering enthalpy rise factor	Output at initialization of RETRAN
CHF correlations	B&W-2, W-3 or MacBeth correlations available
Non-Uniform Axial Power Shape Correction	B&W or Westinghouse available, values vary with time and position
Grid Spacer Mixing and Cold Wall Effects on CHF	Westinghouse correlations available
DNB Calculation	Calculated at every 3 inch interval between input axial limits
Subchannel Mass Velocity	Varies with time and position as interpolated from RETRAN

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W4-I	ICHF	=	Flag for CHF correlation
		=	0, Flag not used
		=	1, W-3 correlation
		=	2, B & W-2 correlation
		=	3, MacBeth correlation
		=	4, Barnett correlation
		=	5, Bowring correlation
		=	6, Janssen and Levy correlation
W5-I	ISPCR	=	Flag for spacer grid
		=	0, Non mixing vane grid correlation
		=	1, Westinghouse R-Grid mixing vane correlation
		=	2, Westinghouse L-Grid mixing vane correlation
W6-I	NØA	=	Number of axial profile data sets
W7-I	N1	=	Number of volumes used for the DNB calculation

41.2 DNB Peaking Function Data Card 8002XX

The data cards must be entered only if IDNBC (on Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

W1-R	FQENG	=	Engineering heat flux factor, F_Q^E
W2-R	FRN	=	Total nuclear radial heat flux factor, either for the hot rod (PWR), $F_R^N \times F_L^N$, or for the average hot bundle (BWR), F_R^N.
W3-R	FQUNC	=	Heat flux uncertainty factor, F_Q^{UN}
W4-R	FDHCØR	=	Adjustment factor on hot bundle mass flux.
W5-R	FDELH	=	Channel enthalpy adjustment factor to account for the effects of turbulent cross flow enthalpy mixing.
W6-R	ZMIN	=	Minimum height of channel for CHF calculation (ft)

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W7-R ZMAX = Maximum height of channel for CHF calculation (ft)

41.3 DNB Geometry Data Cards 8003XX

The geometry data cards must be entered only if IDNBC (on Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

W1-R PITCH = Rod to rod pitch (ft)

W2-R RØDIA = Fuel rod diameter (ft)

W3-R EQDIA = Equivalent diameter based on wetted perimeter per assembly (ft)

W4-R TDC = Thermal diffusivity parameter, 0.0 is recommended

W5-R FRPOW = Fraction of power generated in fuel rod

W6-R RGRID = Factor dependent on axial grid spacing. (If ISPGR ≠ 0, this must be input. Otherwise this is optional.)

W7-R HEATL = Heat length (ft) (If ISPGR ≠ 0, this must be input. Otherwise this is optional.)

41.4 DNB Axial Power Profile Data Cards 8004XX

The axial power profile data cards must be entered only if IDNBC (on Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

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W1-R Y(1) = Position (Z/L)

W2-R AXIAL(1) = Axial power profile, normalized to unity

W3-R Y(2)

= Until NOA data points are filled

W4-R AXIAL(2)

41.5 DNB Volume Data Cards 8005XX

The volume numbers for which the DNB calculation will be done should be entered sequentially (bottom of core to top of core) on the 8005XX cards. The total number of entries should be equal to N1 on the 8001XX cards. XX is a sequence number which may range from 00 to 99.

W1-I NVLDNB(1) = Index number of first core volume used for DNB calculation (bottom of core)

W2-I NVLDNB(2) = Index number of second core volume used for DNB calculation

W3-I NVLDNB(3) = Index number of third core volume used for DNB calculation

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WN1-I NVLDNB(N1) = Index number of last core volume used for DNB calculation (top of core)

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V. RESTRT INPUT
DATA SUMMARY

V. RESTRT INPUT DATA SUMMARY

In the following description of the RESTRT input data cards, the card number is given along with a descriptive title of the data contained on the card. Next is given the order of the data (W1, W2...), the data format (I, R or A), the variable name, and the input data requirements where applicable. The format of the data field, integer, real floating point, or alphanumeric is indicated by I, R or A, respectively.

1.0 TITLE CARD

The first 16 columns of the RESTRT problem title must be identical to those of the original problem title.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARD 010001

W1-I LDMP = The data record on the original problem data tape at which restart is to be initiated (LDMP $\geq$ 1)

W2-I NEDI = Number of minor edit variables requested. If NEDI is omitted or 0, the minor edit variables specified on the original problem will be edited. If a negative value of NEDI is supplied, printer plots will generated for each of the minor edit variables requested.

W3-I NTC = Number of time step sets supplied. If NTC is omitted or 0, the time step sets supplied with the original problem will be used provided the original time step set covers the desired time frame. If a value of NTC is specified it must be greater than or equal to 0.

W4-I NTRP = Number of trip control cards supplied. If NTRP is omitted, the trip control cards supplied with the original problem will be used. If a value of NTRP is supplied it must be less than or equal to the number of trip control cards supplied with the original problem.

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3.0 DATA TAPE LABEL REQUEST DATA CARD 01003Y

A Data Tape Label Request Data Card is used to request a RETRAN data tape to be mounted for use in continuing a previous problem. Y is a sequence number which may range from 0 to 9.

W1-A W2-A W3-A	LABL(1) LABL(2)	=	The string of 17 characters (blanks included) assigned as the data tape label for the original RETRAN problem.
W3-A	LABL(3)	=	The VSN of the original problem data tape containing data record LDMP (on Card 010001).
W4-A	LABL(4)	=	The Julian creation date of the tape volume specified above.

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4.0 MINOR EDIT VARIABLE DATA CARDS 02000Y

Minor Edit Variable Data Card(s) are required only if |NEDI| (on Card 010001) is greater than 0. The same requirements apply for minor edit variable requests as for the original problem. See Section IV.7.0. The quantities edited on a RESTRT problem need not have any relation to those edited on the original problem.

5.0 TIME-STEP DATA CARDS 03XXX0

NTC (on Card 010001) cards must be entered with XXX = 001, 002, ..., NTC. The same rules apply as for the original RETRAN problem. See Section IV.8.0. The time-step sequence on the new run need not have any relation to that of the old run. No cards referring to problem times previous to the point of restart will be used, but they may be supplied.

6.0 <u>TRIP CONTROL DATA CARDS 04XXX0</u>

If a value of NTRP is supplied on Card 010001, NTRP must be less than or equal to the number of trip control cards specified in the original problem. Additionally, if NTRP is omitted or input as 0, the trips specified with the original problem input will be used. Any or all of the trip signals (IDSIG) specified with the original problem can be reset at restart time provided the trip (IDTRP) has not been actuated (See Section IV.9.0). If trip replacement data is supplied for a signal or trip already actuated, the conflicting replacement data will be edited and the problem terminated. The only exception to this rule is the problem end trip (IDTRP=1), which can always be reset. Trip control cards supplied at restart time must have the same card numbers as those being modified in the original problem. Additionally, the first four data items on each replacement card must match that from the original problem.

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VI. REEDIT INPUT
DATA SUMMARY

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VI. REEDIT INPUT DATA SUMMARY

In the following description of the REEDIT input data cards, the card number is given along with a descriptive title of the data contained on the card. Next is given the order of the data (W1, W2,...), the data format (I, R or A), the variable name, and the input data requirements where applicable. The format of the data field, integer, real floating point, or alphanumeric is indicated by I, R or A, respectively.

1.0 TITLE CARD

The first 16 columns of the REEDIT problem title must be identical to those of the original problem title.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARD 010001

W1-I	LDMP	=	-2
W2-I	NEDI	=	Number of minor edit variables requested. If NEDI is omitted or 0, no minor edits will be generated. If a negative value of NEDI is supplied, printer plots will be generated for each of the minor edit requests.
W3-I	NEDF	=	Number of edit frequency control cards supplied (NFDF $\geq$ 1).
W4-I	NPLØT	=	Data record number at which editing is to begin. If omitted, 1 is assumed and a consecutive set of RETRAN data must be specified beginning with the tape volume containing data record 1. If editing is to be initiated at a data record on a magnetic tape volume other than the first of a set, a continuous set of data is required only after data record NPLØT, and the first unused volume(s) need not be specified on the Data Tape Label Request Data Cards.

3.0 DATA TAPE LABEL REQUEST DATA CARDS 01003Y

A Data Tape Label Request Card is used to request an archived RETRAN data tape to be mounted and subsequently edited. Y is a sequence number ranging from 0 to 9. The Data Tape Label Request Data Cards are sequenced according to Y, but Y need not start at 0 and need not be consecutive.

W1-A, W2-A, W3-A	LABL(1), LABL(2)	=	The string of 17 characters (blanks included), assigned as the data tape label for the original problem.
W4-A	LABL(3)	=	The VSN of the first tape volume containing data to be edited. For example, if data in volume three of a five volume RETRAN data file is to be edited, the VSN for the third volume would be specified for LABL(3).
W5-A	LABL(4)	=	The Julian creation date for the tape volume specified above.
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.			
W(N)-A		=	The VSN of the last tape volume required for a consecutive set of RETRAN data.
W(N+1)-A		=	The Julian creation date for the tape volume specified above.

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4.0 MINOR EDIT VARIABLE DATA CARDS 02000Y

Minor Edit Variable Data Card(s) are required only if |NEDI| (on Card 010001) is greater than 0. The same requirements apply for the minor edit variable requests as for the original problem. The quantities being edited on a REEDIT problem need not have any relation to those of the original problem. (See Section IV.7.0).

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5.0 EDIT FREQUENCY CONTROL DATA CARDS 03XXX0

The Edit Frequency Control Data Cards specify the frequency at which the data records on a RETRAN data tape are to be read and minor and/or major edits produced. NEDF (on Card 010001) cards must be entered with XXX = 001, 002, ..., NEDF.

W1-I	NMIN	=	Number of data records per minor edit. (0 is interpreted as 1)
W2-I	NMAJ	=	Number of minor edits per major edit. (0 is interpreted as 50)
W3-R	TLAST	=	End of current edit frequency control data ($TLAST_{i-1} < TLAST_i$, (sec))

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VII. PLOTTER INPUT DATA SUMMARY

POOR ORIGINAL

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VII. PLØTER INPUT DATA SUMMARY

PLØTER requires input data in the form of data cards and problem solution data archived on magnetic tape. There are five forms of archived data tapes, which may be plotted using the PLØTER program module. The five acceptable data tape forms are:

(1) RETRAN
(2) RELAP4/003
(3) RELAP4/002
(4) RELAP3
(5) RETRAN STRANGER TAPES

The input requirements for PLØTER are essentially identical for all of the five tape types listed above. The record structure and format required for RETRAN STRANGER TAPES is given in Section VII.9.0.

In the following description of the PLØTER input data cards, the card number is given along with a descriptive title of the data contained on the card. Next is given the order of the data (W_1, W_2...), the data format (I, R, or A), the variable name and the input data requirements where applicable. The format of the data field (integer real, floating point, or alphanumeric) is indicated by I, R or A, respectively.

1.0 TITLE CARD

The PLØTER title is used for identification of the printed and plotted output from the plot jobs. The title does not need to match an original problem title since data from several problems may be plotted with one plot job. The PLØTER title will be printed just above each frame produced by the plot job.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARD 010001

W1-I	LDMP	=	-3
W2-I	NDSET	=	Number of tape data sets from which data is to be plotted (NDSET$\geq$1)
W3-I	NFRAME	=	Number of frames requested (NFRAME $\geq$ 1)
W4-I	NPLØTC	=	Number of plot curve requests. (NPLØTC $\geq$ 1)
W5-I	NPLØTD	=	Number of combination plot curve requests. (NPLØTD $\geq$ 0)
W6-I	NPEDIT	=	Option flag used to obtain tabular edits of curve data. Default value is zero or no edits. Tabular edits of each curve plotted will be produced if a non-zero value of NPEDIT is supplied.

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3.0 DATA TAPE REQUEST DATA CARDS 010XXY

XX is a data set number used to specify the data set on the Plot Curve Request Data Card (4XXYZS) from which the desired curve will be extracted and plotted. Y is a sequence number ranging from 0 to 9 for each data set. Hollerith delimiters may be required.

W1-A, W2-A, W3-A	LABL(1), LABL(2)	=	The string of 17 characters (blanks included) assigned as the data tape label for the original problem.
W4-A	LABL(3)	=	The VSN of the first tape volume of the data set containing data to be plotted. For example, if data in volume three of a five volume RETRAN data tape set is to be plotted, the VSN for the third volume would be specified for LABL(3).
W5-A	LABL(4)	=	The Julian creation date for the tape volume specified by W(4).
.			
.			
.			
W(N)-A			The VSN of the last tape volume of RETRAN data tape set to be plotted from.
W(N+1)-A			The Julian creation date for the data tape specified by W(N).

NON-RETRAN Data Tapes

For data tapes in acceptable format, other than RETRAN data tapes, only the first VSN and creation date must be supplied for multi-reel data sets, since automatic end-of-volume processing is used. However, if the data set recording density is other than 7-track 800 bpi, the following additional input is required,

W6-A	DENS	=	Data set recording density	7-track
			LØ = 200 bpi	
			HI = 556 bpi	
			HY = 800 bpi (default)	
			ND = 800 bpi	9-track
			PE = 1600 bpi	
			GE = 6250 bpi	

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4.0 INDEPENDENT AXIS SPECIFICATION DATA CARDS 02XX0Y

XX is the frame number used for identification of the base figures consisting of the axis grids and labels. Y is a sequence number ranging from 0 to 9. The default parameters noted below may be modified by use of an 02XX0Y card with XX equal to 00. The default re-set card must contain all ten data fields. The use of any 02XX0Y cards is optional. Note that scale increments are restricted to 1, 2, 2.5, 4, 5 or 8 times a power of ten.

W1-A	XVAR	=	Independent variable specification. Minor edit request symbols are used (default parameter is TIMX). See Section IV.7.0 for a discussion and list of available parameters and region numbers.
W2-I	XREG	=	Independent variable region number (default = 0).
W3-A	XLINØG		Request flag for a linear or logarithmic scale for the independent axis (default is linear). Input is either LIN or LØG.
W4-R	XLENG	=	Length of the independent axis (default is 8.0 inches).
W5-R	XMIN	=	Minimum value of the independent axis (default value = 0.0 or automatic scaling). Default scaling is performed for the first curve plotted on a frame. Any additional curves that are plotted on the frame are plotted using the scale factor, minimum value, maximum value (below), and axis annotation for the first curve.
W6-R	XMAX	=	Maximum value of the independent axis (default value = 0.0 or automatic scaling).

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W7-A	XLABL1	=	Independent axis label (default is minor edit label corresponding to the request symbol and region number for the first curve plotted).
W8-A	XLABL2		
W9-A	XLABL3		
W10-A	XLABL4		

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5.0 DEPENDENT AXIS SPECIFICATION DATA CARDS 03XXYZ

XX is the frame number for which the dependent axis specification applies. Y may range from 1 to 9 and is the Y axis number for frame XX. Z is a sequence number which may range from 0 to 9. Note that scale increments are restricted to 1, 2, 2.5, 4, 5 or 8 times a power of ten. The use of any 03XXYZ cards is optional.

W1-A	YLINØG	=	Request flag for linear or logarithmic scale for the dependent axis (default is linear). Input is either LIN or LOG.
W2-R	YLENG	=	Length of the dependent axis (default is 5.0 inches).
W3-R	YMIN	=	Minimum value of the dependent axis (default value = 0.0 or automatic scaling). Default scaling is performed for the first curve plotted using dependent axis Y. Any additional curves plotted with axis Y are plotted using the scale factor, minimum value, maximum value (below), and axis annotation for the first curve.
W4-R	YMAX	=	Maximum value of the dependent axis (default value = 0.0 or automatic scaling).
W5-A W6-A W7-A W8-A	YLABL1 YLABL2 YLABL3 YLABL4	=	Dependent axis label, default is the minor edit label corresponding to the request symbol and region number for the first curve plotted with axis Y scaling).

6.0 PLOT CURVE REQUEST DATA CARDS 4XXYZS

A Plot Curve Request Data Card is required for each curve to be plotted or each curve used as an operand in a combination curve plot. XX is the frame number the curve is to be plotted on. Y is the dependent axis number to be used on the frame. S is the sequence number of the curve to be plotted on frame XX; e.g., if one curve is to be plotted on frame XX, with dependent axis Y, S must be 1; if three curves are to be plotted on frame XX using dependent axis Y, S must range from 1 to 3. All frames are plotted sequentially from 1 through NFRAME (Card 010001) as are all dependent axes for a given frame. The curves for any dependent axis are plotted sequentially according to S. Z is a flag used to control the disposition of the curve as follows. For frames where multiple curves (maximum of 9) are plotted using a common dependent axis number Y, centered curve distinctions are added to the curves at 1.0 inch intervals. The centered symbols and the order in which they are used is illustrated by Figure VII.6-1.

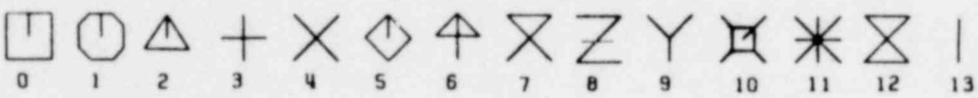

Figure VII.6-1 Centered Symbols

	Z	=	0, Curve to be plotted separately
	Z	=	1, Curve to be plotted separately and used with combination plot
	Z	=	2, Curve to be used as an operand with a combination plot only
W1-A	YVARC	=	Dependent variable specification. Minor edit request symbols are used. See Section IV.7.0 for a discussion and list of available parameters and region numbers.
W2-I	IYREGC	=	Dependent variable region number.

W3-I IDSETC = Data set number (XX on Card 010XXY), from which the variable is to be retrieved.

W4-R YSCTRN = Scale factor for dependent variable translation (default = 0.0).

W5-R YSCMAG = Scale factor for dependent variable magnification (default = 1.0).

NOTE: (The order of scaling operations = (Y+YSCTRN) *YSCMAG.

W6-R XSCTRN = Scale factor for independent variable translation (default = 0.0).

W7-A XSCMAG = Scale factor for independent variable magnification (default = 1.0).

NOTE: The order of scaling operations = (X+XSCTRN) *XSCMAG.

7.0 COMBINATION PLOT CURVE REQUEST DATA CARDS 06XXYZ

XX is the frame number the combination curve is to be plotted on, while Y is the dependent axis to be used on the frame. For example, XXY on an 06XXYZ card must correspond to XXY on an 03XXYZ card. Z is a sequence number ranging from 0 to 9. Combination curves are plotted on frame XX using dependent axis Y sequentially by increasing values of Z upon completion of plotting all separate curves on frame XX using dependent axis Y. A limitation of the combination curve plotting option is that all curve requests (word one, three and so on), must be from the same data set.

The arithmetic operations requested on a combination plot request data card are performed from left to right, with any operand scaling operations performed first. Any attempt to divide by zero yields a resultant equal to 1.0 E75.

W1-I	IDXCRV(1)	=	Card number of first curve (4XXYZS) or operand
W2-A	IØP(1)	=	Operator (+, -, * or/)
W3-I	IDXCRV(2)	=	Card number of second curve or operand
W(2*NØP)-A	IØP(NØP)	=	Operator
W(2*NØP+1)-I	IDXCRV(NØP+1)	=	Card number of last curve or operand used

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8.0 RELAP3, RELAP4/002 AND RELAP4/003 PLOT REQUEST SYMBOLS

PLØTER curve request parameters for RELAP3, RELAP4/002, and RELAP4/003 consist of two-word requests similar to that used for RETRAN, as shown below. The RELAP request parameters are given in TABLES VII.8-1 through VII.8-4.

W1-A Variable Symbol

W2-I Region Number

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TABLE VII.8-1

RELAP VOLUME PARAMETERS AVAILABLE FOR PLOTTING

Region number is the desired volume number.

RELAP4/003 Symbol	RELAP3 RELAP4/002 Symbol	Variable
PRES	PRES	Average pressure
FMAS	FMAS	Total mass
UTØT	UTØT	Total energy
TEMP	TEMP	Average temperature
AVED	AVED	Average density
HW**	HW**	Average enthalpy
AVEX	AVEX	Average quality
BUBM	BUBM	Bubble mass
MIXL	MIXL	Mixture level
STVF	STVF	Specific volume of saturated liquid
STVG	STVG	Specific volume of saturated gas
STHF	STHF	Specific enthalpy of saturated liquid
STHG	STHG	Specific enthalpy of saturated gas
SATT	SATT	Saturation temperature
SATP	SATP	Saturation pressure
LIQM	LIQM	Liquid mass
WQ**	WQ**	Power into coolant
SPED		Pump speed
TØRQ		Normalized hydraulic pump torque
WVBR		Volume average flow

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TABLE VII.8-2

RELAP JUNCTION PARAMETERS AVAILABLE FOR PLOTTING

Region number is the desired junction number.

RELAP4/003 Symbol	RELAP3 RELAP4/002 Symbol	Variable
WP**	WP**	Junction flow
HP**	HP**	Junction enthalpy
XP**	XP**	Junction quality
DELP	DELP	Total pressure differential
DELF	DELF	Pressure differential due to friction
DELE	DELE	Pressure differential due to elevation
PMPP	PMPP	Pressure differential due to pump
DELA	DELA	Pressure differential due to acceleration
SPVJ		Junction specific volume
ICHK		Choking index
	LF**	Leak force

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TABLE VII.8-3

RELAP CONDUCTOR PARAMETERS AVAILABLE FOR PLOTTING

Region number is the desired conductor number for RELAP/003 and the desired core section number for RELAP3 and RELAP4/002.

RELAP4/003 Symbol	RELAP3 RELAP4/002 Symbol	Variable
TL**	TL**	Left surface temperature
TR**	TR**	Right surface temperature
HTCL		Left heat transfer coefficient
HTCR	HTCR	Right heat transfer coefficient
PHIL		Left heat flux
PHIR		Right heat flux
PHIR	PHIR	Right heat flux
WQCL		Left heat transfer rate to coolant
WQCR		Right heat transfer rate to coolant
IHTL		Left heat transfer mode
IHTR		Right heat transfer mode
FCHL		Left critical heat flux
FCHR	FCHR	Right critical heat flux
TAVG	TAVG	Average conductor temperature
NUCQ	NUCQ	Conductor power
CTRI		Depth of metal water reaction
MØDQ		Direct moderator heating rate
SE**		Stored energy

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TABLE VII.8-4

RELAP SYSTEM PARAMETERS AVAILABLE FOR PLOTTING

Region number must be 0.

RELAP4/003 Symbol	RELAP3 RELAP4/002 Symbol	Variable
PNRM	PNRM	Normalized power
AE**	AE**	Total energy added during transient
FE**	FE**	Energy stored in fuel
LE**	LE**	Total energy leaked
HE**	HE**	Energy removed by heat exchanger
EB**	EB**	Energy balance term
LM**	LM**	Total mass leaked
BMSW	BMSW	Mass balance
REAC	REAC	Total reactivity
RV**	RV**	Reactivity due to coolant voids
RW**	RW**	Reactivity due to temperature changes in coolant
RF**	RF**	Reactivity due to temperature changes in fuel
RC**	RC**	Reactivity due to control rod changes
RD**	RD**	Reactivity due to Doppler effect (fuel temperature)
PØWR	PØWR	Power
QLØS	QLØS	Total heat removed
PERD	PERD	Reactor period

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9.0 RETRAN STRANGER DATA TAPE FORMAT AND STRUCTURE

RETRAN Stranger data tapes are binary data tapes generated by any program, subject to the format specifications given below. The data tape may be written using any FØRTRAN BUFFER IØ program compatible with the BUFØUT program discussed in Reference IV.6-1.

RECØRD 1: Must be 8-16 (A8) HØLLERITH WØRDS in length

First three words must be

```
WØRD(1)  =  8HRETRANbS
WØRD(2)  =  8HTRANGERb          b = blank
WØRD(3)  =  8HDATAbTAP
WØRD(4)  =  8H ⎫
   .          ⎪
   .          ⎬ Available for tape documentation
   .          ⎪
WØRD(8)  =  8H ⎭
WØRD(9)  =  8H ⎫
   .          ⎪
   .          ⎪
   .          ⎬ Optionally available for tape documentation
   .          ⎪
WØRD(16) =  8H ⎭
```

RECØRD 2:

```
WØRD(1)  =  NØFILS, Number of data files per plot record
WØRD(2)  =  Set size of file number 1
WØRD(3)  =  Number of sets in file number 1
   .
   .
   .
   .
WØRD(N*NØFILS) = Set size of file number NØFILS
WØRD(2*NØFILS+1) = number of sets in file number
                   NØFILS
```

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Example of a File:

M(1) V(1) P(1) T(1) X(1) . . . . Set 1
M(2) V(2) P(2) T(2) X(2)
M(3) V(3) P(3) T(3) X(3)
M(4) V(4) P(4) T(4) X(4) . . . . Set 4

Set size = 5

A file may consist of 1 set of n parameters

RECØRD 3: Data file heading (A8)
(First word of axis label)

WØRD(1) = 8HXXXXXXXX Heading for file Number 1
or 4HXXXX
(see below)

.
.
.
.
.

WØRD (NØFILS) = 8HXXXXXXXXX Heading for file Number NØFILS
(or 4HXXXX)

The data file heading is a single Hollerith word generally describing the data file. A file of one set should have an 8-character heading, while multiple set files should use a 4-character heading. The remaining 4 characters will be added to the heading word automatically. For example, consider the previous example, where the file contains control volume data. A heading word of bVØL will be expanded to bVØLbbb4 for plot requests for volume 4 (set 4).

RECØRD 4: WØRD(1) = 4HXXXX Plot request flag
WØRD(2) = PØSITIØN in set minus 1

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WØRD(3) = 8HXXXXXXXX 1st word of description

WØRD(4) = 4HXXXX 2nd word of description

WØRD(5) = 8HXXXXXXXX parameter units

.

.

.

.

and so on for $5 \cdot \sum_{I}^{NØFILS}$ (set size of file number I)

NOTE: The plot request flag must be set to 4HTIMX for the problem time.

RECØRDS 5 AND UP:

WØRD(1) = 4HPLØT

WØRD(2) = File 1 set 1

. .

. .

. .

. set N

WØRD(NSETS(1)*SETSIZ(1) + 1) = File 2 set 1

. .

. .

. .

. .

. set N

for all files in record

9.1 RETRAN Stranger Tape Use

Plot request consists of a 4-character alphanumeric flag defined at the time the stranger data tape is generated and an integer region number. If a file is comprised of a single set, the region number must be zero. For files with multiple sets, the region number corresponds to the set from which the data is to be retrieved.

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The remaining requirements are identical to those required for PLØTER.

Example Requests

Request: MASS 1 (Mass in volume 1 will be plotted)

Label: VØL 1 MASS INVENTØRY (LB)

Request: SPVL 4 (Specific volume of volume 4 will be plotted)

Label: VØL 4 SPEC. VØL (FT3/LB)

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VIII. ERROR MESSAGES DUE TO INPUT

VIII. ERROR MESSAGES DUE TO INPUT

RETRAN Code Package input data is carefully scrutinized by the input processing package and the problem specific input and initialization subroutines in an attempt to insure consistency and correctness of user supplied data. Any input or consistency errors detected during the input and initialization steps of a problem result in an error flag being set. The error flag is tested following the input and initialization steps, and if set, the problem is terminated so as to prevent execution of costly problems containing blatant input errors. Often, a given input error will propagate additional errors as input data is checked.

All detected input errors are flagged with an informative message and input processing continued, unless the error is significant enough to encumber further input processing, in which case the problem is terminated. Input errors are detected for three basic types of input errors discussed in the following sections.

1.0 DATA PROCESSOR ERRORS

The free form input data processing package checks user supplied data decks to insure that all data is in the appropriate format. Any errors detected are accompanied by one of the following error messages. All error comments are preceded by eight asterisks to facilitate recognition of error comments in the midst of regular program output. The lower case letters represent call parameters or symbols used in the subroutine descriptions, and actual values are substituted in the output.

1. INSUFFICIENT STORAGE ALLOCATION FOR PREVIOUS DATA, PROCESSING TERMINATED.

2. INSUFFICIENT STORAGE FOR DATA, PROCESSING TERMINATED.

3. $ (placed under column in error) $ POINTS TO CARD ERROR AT COL. i

4. END OF FILE ENCOUNTERED BEFORE END(.) CARD.

5. CONTINUATION CARD INDICATED, BUT NO PREVIOUS DATA CARD. TREATED AS NEW DATA CARD.

6. UNRECOGNIZABLE CARD NUMBER

7. WORD n5 ON CARD ic SHOULD BE IN ALPHANUMERIC FORMAT

8. CARD c+a+1 MISSING IN SEQUENCE

9. TOO FEW NUMBERS ON CARDS ic1 THROUGH ic2

10. TOO MANY NUMBERS ON CARDS ic1 THROUGH ic2

11. WORD n5 ON CARD ic SHOULD BE IN INTEGER FORMAT

12. WORD n5 ON CARD ic SHOULD BE IN FLOATING POINT FORMAT

13. CARDS ic1 THROUGH ic2 MISSING

14. ILLEGAL FORMAT ON CARD ic

15. m NUMBERS ON CARDS ic1 THROUGH ic2 ARE NOT A MULTIPLE OF n1

16. ITEM m ON CARD ic IS LESS THAN MINIMUM ALLOWED OF nmin

17. ITEM m ON CARD ic EXCEEDS MAXIMUM ALLOWED FOR nmax

18. ERROR IN LIMITS OF THE SET BEGINNING AT ITEM m ON CARD ic

19. LOWER LIMIT OF nmin NOT INCLUDED ON CARDS ic1 THROUGH ic2

20. UPPER LIMIT OF nmax NOT INCLUDED ON CARDS ic1 THROUGH ic2

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21. THE FOLLOWING CARDS WERE NOT USED

22. ITEM item ON CARD card IN ERROR

2.0 DATA CONSISTENCY ERRORS

Data consistency checks are performed by the problem specific input processing and initialization subroutines within the RETRAN Code Package. Consistency errors detected are noted by comments giving a description of the error. A complete listing of all consistency error messages is not provided since such a list would be prohibitively large. However, several error messages have been provided as illustration of consistency errors.

******** ILLEGAL POWER LEVEL (xxxxxx) ENCOUNTERED

******** ERROR, NODE iii IS NOT A VALID HEAT CONDUCTOR NUMBER

******** ERROR, FIRST TRIP CARD MUST BE A TIME LIMIT. EXECUTION DELETED.

******** NO TRIP CORRESPONDS TO FILL TRIP NUMBER iii INDEX = jjj

3.0 DYNAMIC STORAGE ALLOCATION

The dynamic storage allocation features of the RETRAN Code Package are provided by use of the FTB subcode. On each call to an FTB subroutine, appropriate data is checked to insure consistency and completeness. Further checking is also performed to guarantee that requested system resources are available. Should any errors, inconsistencies or requested resources which are unavailable be detected, one of the following errors will be edited and execution terminated.

The following messages can be issued during FTB initialization:

******** NOT SUFFICIENT FAST CORE SPACE FOR FTB ROUTINES.
******** ARGUMENT ERROR TO FTB INITIALIZATION.

All other FTB error messages are given by

******** ERROR NUMBER xx FROM FTB PACKAGE.

followed by a list of the information in the links and then an abnormal termination. The error number given in the error message refers to the following error comments:

1 Another file is already open on disk unit.

2 Subroutine INITAL not the first FTB routine called.

4 Reserve file cannot be closed or truncated.

5 Files in read-write or random modes cannot be truncated.

6 File ID wrong on block just read, probably disk or drum seek error or program error destroyed buffer.

7 Block number wrong on block just read, probably disk or drum seek error or program error destroyed buffer.

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8 File is a reserve file and shouldn't be.

9 File is already open.

11 File is not described.

12 File is not open.

13 File has not been written and has no storage assigned.

14 File already described.

15 Files in copy request on same disk or drum unit.

16 File size is less than or equal to zero or is too large.

17 Incorrect format for DMPFIL.

19 File ID is zero.

20 File ID's for copy not unique.

22 Subroutine parameter for setting preferred end of fast core is incorrect.

23 Processing mode is random and unit is disk or drum or PROC has been called.

24 Incorrect processing mode specified in subroutine argument.

25 Processing is not random and should be.

27 No space available for buffers in fast core.

29 No space available for file in disk or drum data sets.

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30 No space available for file in fast core.

31 Number of sets less than or equal to zero.

32 Not all sets processed on call to CLOSE.

34 Not enough space in fast core for links.

36 Set number out of range in call to GET or PUT.

37 Set size greater than that allowed by blocksize of disk or drum data set.

38 Set size less than or equal to zero.

39 The number of sets in the files specified for a copy are different.

40 The set sizes for files specified for a copy are different.

41 Calls to PROC exceeds number of sets in file.

42 Unit number not between 1 and 7.

43 File is not a reserve file and should be.

47 Enough space is available in fast core, bulk core, disk or drum, but it is not contiguous space.

48 File size cannot be increased without moving file.

Most of the FTB errors noted above are the result of coding errors and should be encountered rarely. However, previously detected input errors on occasion will propagate an FTB error. Two of the most commonly encountered errors are

```
******** NOT SUFFICIENT FAST CORE SPACE FOR FTB ROUTINES
```

and error number 16. Although error 16 is often propagated by input errors, both errors also appear when the user supplied memory field length is insufficient for the problem being executed (refer to Section III).

IX. RETRAN SAMPLE PROBLEMS

IX. RETRAN SAMPLE PROBLEMS

RETRAN sample problems are presented to illustrate the use of various program features, options and capabilities. To provide a means for checking the adaptation of the RETRAN Code Package to different computer systems, both CDC and IBM sample problems are presented: Standard Problem One, Standard Problem Five, and the Uncontrolled Rod Withdrawal are given as IBM examples, with the Eight Volume Sample Problem, Standard Problem Four, and the Turbine Trip Without Bypass given as CDC examples. The individual sample problems are discussed in the following sections.

In order to better demonstrate the use of RETRAN, both RETRAN output and RETRAN input have been provided for each of the sample problems. The input data was well defined in Section IV of this volume. The definitions of most RETRAN output parameters are given in Appendix A.

1.0 STANDARD PROBLEM ONE - EDWARDS' PIPE TEST

The Standard Problem One sample problem is a nine volume model of a straight pipe depressurization experiment performed by Edwards and O'Brien [IX.1-1]. This experiment is referred to as Standard Problem One from the NRC's Comparative Analysis of Standard Problems (CASP) series.

The Edwards' experiments consisted of fluid depressurization studies in a straight pipe 13.44 feet long with an inside diameter of 2.88 inches. The pipe was filled with water and brought to initial conditions ranging from 500 psig and 467°F to 2500 psig and 650°F. The particular experiment used for the sample problem was performed at nominal initial conditions of 1000 psig and 448°F.

The reported initial conditions for the nominal 1000 psig tests were 1014.7 psia and 465°F. However, the temperature measurements indicate that the temperature distribution across the pipe may have varied as much as 15°F. In addition, a non-uniform temperature distribution along the length of the pipe is indicated by the pressure versus time curves for each detector location. The slightly different saturation pressures measured at each detector indicated a slightly different initial temperature in the regions of the detectors. The initial conditions used for the sample problem were prescribed by assuming the nominal pressure of 1000 psig and a constant temperature based upon the mean energy content of the fluid in the test section.

A glass disc at one end of the pipe was designed to be broken with a single shot from a pellet gun to initiate depressurization to atmospheric conditions. The break opening time was estimated to be 1 msec. A small amount of glass was observed to remain at the circumference of the opening so that the break flow area was reduced by approximately 13% from the pipe cross sectional area.

The RETRAN noding is illustrated in Figure IX.1-1 where the eight pipe nodes are equal volume regions and the containment volume (volume 50), is effectively an infinite volume employed to provide a constant sink pressure. The system conditions are described in Table IX.1-1.

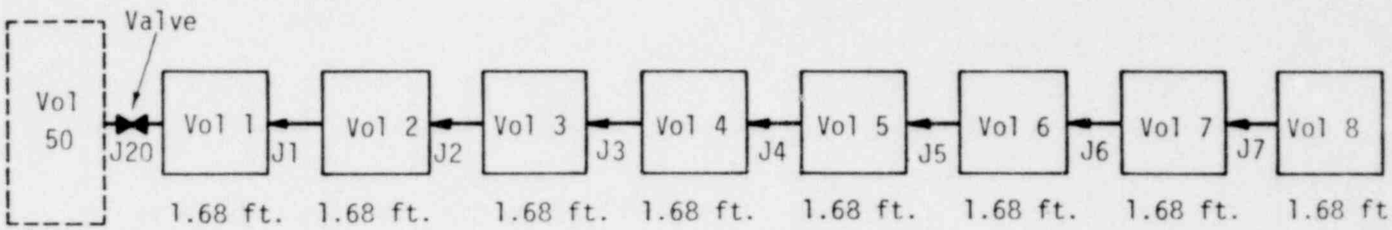

Figure IX.1-1 Schematic Diagram for Standard Problem One

TABLE IX.1-1

SYSTEM CONDITIONS USED FOR RETRAN STANDARD PROBLEM ONE SAMPLE PROBLEM

Initial Conditions

1. Pressure = 1014.7 psia
2. Temperature = 448°F
3. Mass Flow Rate = zero

Leak Description

1. Break initiated at time zero (i.e., no delay time to break)
2. Break opening time = 0.001 seconds
3. Break area at end of opening time = 87% of pipe flow area
   $= 0.03936\ ft^2$

   (The leak area is less than the full flow area because a small amount of the glass rupture disk remained in the opening).
4. Leak Elevation - Use horizontal volume centerline as zero reference. Therefore, leak elevation equals zero.

Transient Initiation and Termination

1. Transient initiation at time zero
2. Transient termination when pressure at closed end of pipe reaches containment pressure (atmospheric =14.7 psia).
3. Termination on elapsed time at 0.465 msec.

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The input listing for the Standard Problem One sample problem and output from the RETRAN program module at times 0.0 and 0.465 sec are given below. The problem was run using RETRAN on the IBM computing system. The job control language used corresponds to a small problem without restart-plot tape generation and without minor edits.

```
//RETRAN    JOB
//RETRAN    PROC XTIME=5,PAGES=100,XREG=1200K,FAST=1300,
//               RETRAN='RETRAN00.MOD000',DISKS=DISKS,
//               SER=EI0001,NTRK2=5,NTRK3=0,NTRK4=0,NTRK5=0,
//               VSN1=ANY,VSN11=ANY1,VSN12=ANY2,VSN13=ANY3,
//               EXPDT11=98000,EXPDT12=98000,EXPDT13=98000,
//               EXPDT14=98000,FTBD1=15,FTBD2=2,FTBD3=0,FTBD4=0,FTBD5=0,
//               FTBB1=,FTBB2=,FTBB3=,FTBB4=,FTBB5=
//X         EXEC PGM=RETRAN,REGION=&XREG,TIME=&XTIME,PARM='8,&FAST'
//STEPLIB  DD DSN=&RETRAN,UNIT=&DISKS,VOL=SER=&SER,DISP=SHR
//FT01F001  DD UNIT=(&DISKS,,DEFER),DISP=SHR,VOL=SER=&VSN1
//FT02F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK2)
//FT03F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK3)
//FT04F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK4)
//FT08F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&NTRK5)
//FT05F001  DD DDNAME=SYSIN
//FT06F001  DD SYSOUT=A,DCB=(RECFM=FBSA,LRECL=133,BLKSIZE=931),
//             SPACE=(TRK,(&PAGES,100))
//FT11F001  DD UNIT=(TAPE,,DEFER),DISP=(OLD,KEEP),VOL=SER=&VSN11,
//             LABEL=EXPDT=&EXPDT11
//FT12F001  DD UNIT=(TAPE,,DEFER),DISP=(OLD,KEEP),VOL=SER=&VSN12,
//             LABEL=EXPDT=&EXPDT12
//FT13F001  DD UNIT=(TAPE,,DEFER),DISP=(OLD,KEEP),VOL=SER=&VSN13,
//             LABEL=EXPDT=&EXPDT13
//FT14F001  DD UNIT=(TAPE,,DEFER),DISP=(NEW,KEEP),
//             LABEL=EXPDT=&EXPDT14
//FT50F001  DD SYSOUT=B
//FTB15F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD1),
//             DCB=BLKSIZE=&FTBB1
//FTB16F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD2),
//             DCB=BLKSIZE=&FTBB2
//FTB17F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD3),
//             DCB=BLKSIZE=&FTBB3
//FTB18F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD4),
//             DCB=BLKSIZE=&FTBB4
//FTB19F01  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,&FTBD5),
//             DCB=BLKSIZE=&FTBB5
// PEND
//GO        EXEC RETRAN,XTIME=20
//X.SYSIN    DD *
```

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (S.P-1 / EDWARD'S PIPE TEST)
*
*10001 TAP EDT STP TRP VOL BUB TDV JUN PMP CKV NLK FLL SLB GOB MAT COR HTX
*
010001  0   0   8   3   9   1   0   8   7   1   1   0   0   0   0   0   0
*10002 NTMM NODEL MWK  NLV MTD  ISF CHT  SS  PRZ  TRN  IDNB  ICF
*
010002  0    0     0    0   0    0   0   1
*
*010002   POWER   OMEGA
010005     0.0     1.0
010050   '@1152.WATRPROP   '  'EI0001',  '  ',   0
*30000 NMIN NMAJ NUMP NCHK DELTM DTMIN    TLST      **TIME STEP
 30010   1   10   1    0    1.E-5 5.E-7  0.0005    **STEEP PART OF DEPRESSURIZN *
 30020  1    25   1    0   2.E-5 1.E-6   0.002     **STEEP PART OF DEPRESSURIIN *
 30030  1    10   1    0   5.E-5 1.E-6   0.0035    **STEEP PART OF DEPRESSURIZN *
 30040  1     5   1    0   1.E-4 1.E-6   0.004     **STEEP PART OF DEPRESSURIZN *
 30050  1     5   1    0   2.E-4 1.E-6   0.006     **STEEP PART OF DEPRESSERUZN *
 30060  1     8   1    0   5.E-4 5.E-6   0.01      **STEEP PART OF DEPRESSURIZN*
 30070  5    10   1    0   .001  .00001  0.1
 30080  5    10   1    0   .001  .0001   10.0
*40000 IDTRP  IDSIG  IXI  IX2  SETPT  DELAY        **TRIP CONTROL DATA **
 40010   1     1      0    0    0.465  0.0         **END OF BLOWDOWN **
 40020   1    -4      1    0   14.7    1E-3        **LIMITING PRESSURE END PRBLM*
 40030   2     1      0    0    0.0    0.0         **BROKEN END VALVE DATA   **
*50001 B IRD   PRESSURE      TEMPERATURE  QLTY  VOLUME      **VOLUME DATA CARD 1 *
 50091 1  0      14.7           0.0        0.4    1E+9      **SINK VOLUME DATA **
 50011 0  0    1014.7         427.1        0.0    0.07600   **BREAK END VOLUME **
 50021 0  0    1014.7         427.1        0.0    0.07600
 50031 0  0    1014.7         427.1        0.0    0.07600
 50041 0  0    1014.7         427.1        0.0    0.07600
 50051 0  0    1014.7         427.1        0.0    0.07600
 50061 0  0    1014.7         427.1        0.0    0.07600
 50071 0  0    1014.7         427.1        0.0    0.07600
 50081 0  0    1014.7         427.1        0.0    0.07600  **CLOSED  END VOLUME**
*50002  HEIGHT    MIXTLVL  2PH  FLOWAREA  HYDIAM    VOLELEV  **VOLUME DAT CARD 2 *
 50092   1E+4       0.01    0     1E+4      1.00   -506.00   **SINK VOLUME DATA **
 50012    0.24      0.24    0     0.04524   0.24     -0.12   **BREAK END VOLUME **
 50022    0.24      0.24    0     0.04524   0.24     -0.12
 50032    0.24      0.24    0     0.04524   0.24     -0.12
 50042    0.24      0.24    0     0.04524   0.24     -0.12
 500 2                                                  12

 50052    0.24      0.24    0     0.04524   0.24     -0.12
 50062    0.24      0.24    0     0.04524   0.24     -0.12
 50072    0.24      0.24    0     0.C4524   0.24     -0.12
 50082    0.24      0.24    0     0.04524   0.24     -0.12   **CLOSED END VOLUME**
*060001   ALPH     VBUB
060011    0.8      1E+3
*80001 FM   TO   PMP VLV  FLOWRATE       JUNAREA  JUNELEV   INERT  **JUN DAT CAD 1 *
 80081 1    9    0    1      0.0         0.03936   0.0     18.56806 *BRKN END VALV*
 80011 2    1    0    0      0.0          .04524   0.0     37.13615
 80021 3    2    0    0      0.0          .04524   0.0     37.13615
 80031 4    3    0    0      0.0          .04524   0.0     37.13615
 80041 5    4    0    0      0.0          .04524   0.0     37.13615
 80051 6    5    0    0      0.0          .04524   0.0     37.13615
 80061 7    6    0    0      0.0          .04524   0.0     37.13615
 80071 8    7    0    0      0.0          .04524   0.0     37.13615  **CLSD END JN*
*80002 FLOSC   RLOSC   JVT   JCK   JCL  MVMX   HYDIAM   CNC   ICK   HQ  **JUN DAT CD 2 *
 80082 1.02     0.56   0     1     0     0     0.22386  .6    0     0   **BRKN END JNTN*
 80012 0.0      0.0    0     1     0     0     0.24     1.    0     0
```

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```
 80022 0.0      0.0  0    1    0    0    0.24    1.   0    0
 80032 0.0      0.0  0    1    0    0    0.24    1.   0    0
 80042 0.0      0.0  0    1    0    0    0.24    1.   0    0
 80052 0.0      0.0  0    1    0    0    0.24    1.   0    0
 80062 0.0      0.0  0    1    0    0    0.24    1.   0    0
 80072 0.0      0.0  0    1    0    0    0.24    1.   0    0  **CL D END-1 JN*
*110000  ITCV   PCV  CVI  CV2  CV3
110010   -2   1  0    0    0    0        **B
*120100 NAREA  ITLK  SINK  TAR1 TAR2 TAR3 TAR4 TAR5 TAR6  ** TIME TO OPEN VALV *
120101   -3                0.0  0.0 1.E-3 1.0 10.0 1.0
.END TERMINATOR
```

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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/22/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (S.P-1 / EDWARD'S PIPE TEST)
CPU TIME = 2.288

* *

STANDARD TIME STEP NUMBER = 0 ACTUAL TIME STEP NUMBER = 0 TIME = 0.0 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
0.0	0.0	0.0	0.0	4.022150D+09	3.732577D+06	0.0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
2	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
3	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
4	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
5	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
6	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
7	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
8	1.01470D+03	3.94203D+00	4.27100D+02	5.18689D+01	4.46864D+02	0.0	0.0	2.40000D-01	3.94203D+00
9	1.47000D+01	3.73255D+06	1.15046D+03	3.73255D-02	2.12014D+02	9.99985D-01	3.72905D+01	1.00001D-02	5.59348D+01

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	2 TO 1		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
2	3 TO 2		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
3	4 TO 3		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
4	5 TO 4		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
5	6 TO 5		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
6	7 TO 6		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
7	8 TO 7		0.0	4.27100D+02	1.92794D-02	0.0	0.0	0.0	0.0	0.0
8	1 TO 9		0.0	4.27100D+02	1.92794D-02	1.00000D+03	0.0	0.0	0.0	0.0

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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/22/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (S.P-1 / EDWARD'S PIPE TEST)
CPU TIME = 105.102

* *

STANDARD TIME STEP NUMBER = 633 ACTUAL TIME STEP NUMBER = 1178 TIME = 4.654082D-01 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
0.0	0.0	0.0	0.0	4.022150D+09	3.732577D+06	0.0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.499320+01	1.340360-02	3.897470+02	1.763630-01	2.130110+02	2.150870-01	2.882940-03	2.400000-01	1.052060-02
2	1.592810+01	1.433240-02	3.902380+02	1.885840-01	2.160880+02	2.128270-01	3.050320-03	2.400000-01	1.128210-02
3	1.684850+01	1.524050-02	3.909040+02	2.005330-01	2.189740+02	2.109100-01	3.214380-03	2.400000-01	1.202620-02
4	1.757320+01	1.595990-02	3.914190+02	2.099990-01	2.211560+02	2.094670-01	3.343070-03	2.400000-01	1.261690-02
5	1.812270+01	1.650770-02	3.918050+02	2.172070-01	2.227620+02	2.084110-01	3.440380-03	2.400000-01	1.306730-02
6	1.851620+01	1.690080-02	3.926850+02	2.223790-01	2.238870+02	2.076780-01	3.509920-03	2.400000-01	1.339090-02
7	1.876660+01	1.715100-02	3.922570+02	2.256720-01	2.245930+02	2.072260-01	3.554130-03	2.400000-01	1.359690-02
8	1.888610+01	1.727010-02	3.923600+02	2.272380-01	2.249270+02	2.070180-01	3.575220-03	2.400000-01	1.369490-02
9	1.470000+01	3.732580+06	1.150460+03	3.732580-02	2.120140+02	9.999780-01	0.0	1.379500-05	8.251300+01

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	PRESSURE DIFFERENTIALS STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	2 TO 1		2.904280+00	3.902370+02	5.286890+00	-3.565260-01	0.0	-2.227710-01	-5.792970-01	0.0
2	3 TO 2		2.57[illegible]90+00	3.909100+02	4.958800+00	-3.720110-01	0.0	-1.751110-01	-5.471220-01	0.0
3	4 TO 3		2.192730+00	3.914380+02	4.726330+00	-3.403830-01	0.0	-1.287890-01	-4.691730-01	0.0
4	5 TO 4		1.785550+00	3.918440+02	4.563090+00	-2.951200-01	0.0	-8.820820-02	-3.833290-01	0.0
5	6 TO 5		1.356550+00	3.921470+02	4.452450+00	-2.368040-01	0.0	-5.419450-02	-2.909990-01	0.0
6	7 TO 6		9.120760-01	3.923580+02	4.384660+00	-1.689050-01	0.0	-2.749670-02	-1.964010-01	0.0
7	8 TO 7		4.581970-01	3.924850+02	4.353210+00	-8.996700-02	0.0	-9.259200-03	-9.922620-02	0.0
8	1 TO 9		3.055640+00	3.898130+02	5.698190+00	3.357840+00	0.0	-4.034540+00	-6.766970-01	0.0

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2.0 EIGHT VOLUME SAMPLE PROBLEM

The Eight Volume Sample Problem is a simplified representation of a 50-MW pressurized water reactor. The model has one steam generator secondary side volume, a large containment or sink volume, and three core volumes. The upper and lower plenum volumes are connected by a pump volume. A schematic diagram of this model is given in Figure IX.2-1.

At time 0.05 second, a leak is initiated from the upper plenum to the sink volume. The leak opens to a maximum of 8 ft^2 in 0.05 second. Power to the pump is cut off at 1.05 second and a reactor scram is initiated 0.1 second after the pressure in the upper plenum drops to 1000 psia.

A listing of the eight volume sample problem input including representative CDC job control language and the output from the RETRAN program module at times 0.0 and 0.4 second, is given below. Minor edit variables were used for this problem, but a restart-plot tape was not generated.

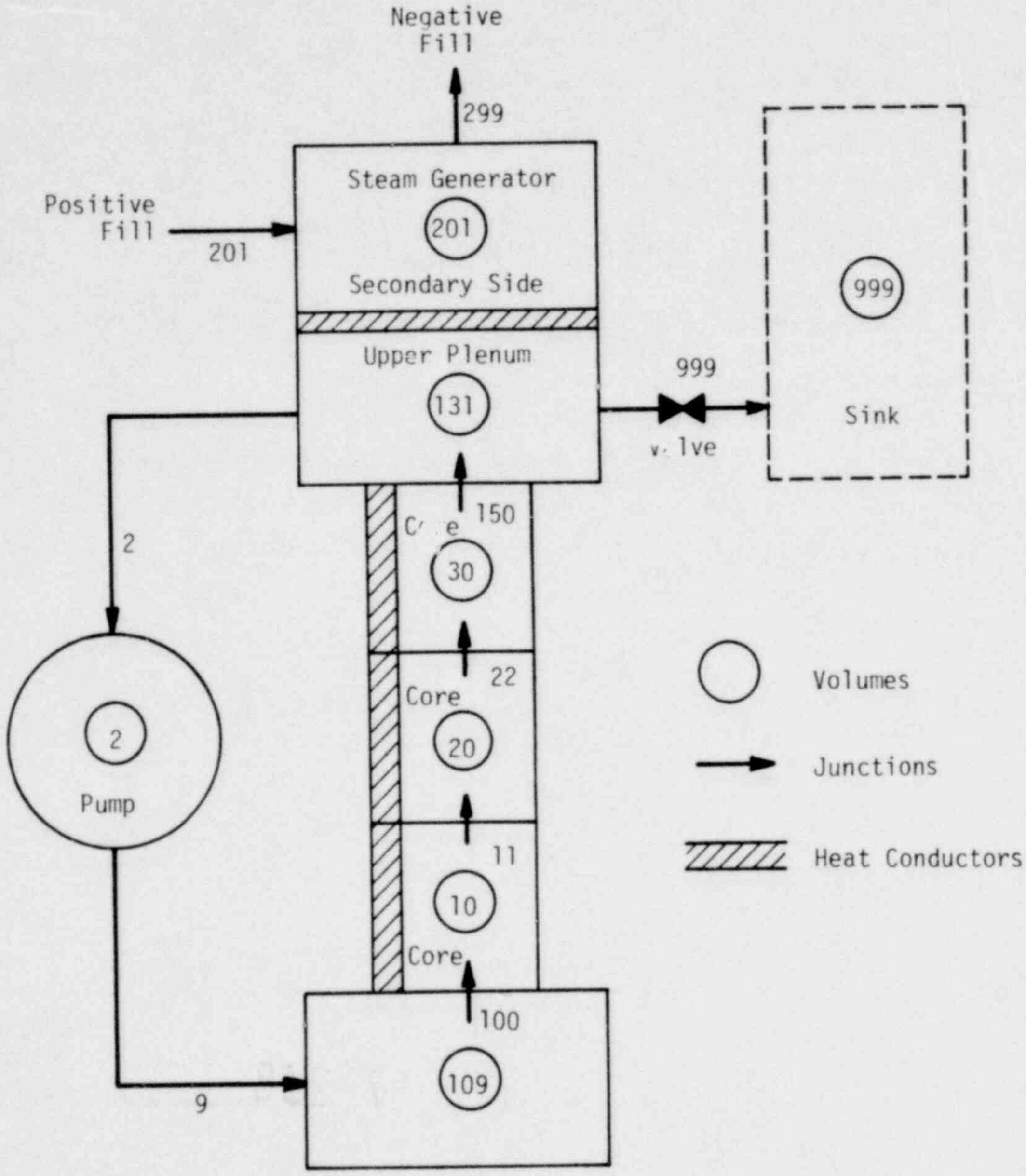

Figure IX.2-1 Eight-Volume Test Problem

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```
JOB.
ACCOUNT.
ATTACH(RETRAN,RETRAN01MOD000,ID=RETRAN,MR=1)
RFL(250000)
RETRAN(PL=77777)
```

LISTING OF INPUT DATA FOR CASE 1

```
 1     =RETRAN 8 VOLUME SAMPLE PROBLEM
 2     *
 3     *         PROBLEM DIMENSIONS
 4     *
 5     *
 6     *10001 TAP EDT STP TRP VOL BUB TDV JUN PMP CKV NLK FLL SLB GOB MAT COR HTX
 7     *
 8     010001  0   3   3   6   8   1   0   9   1   1   1   2   4   2   3   3   0
 9     *
10     *10002 NTMM NODEL MWR  NLV MTD  ISF CHT  SS  PRZ  TRN  IDNB  ICF
11     *
12     010002  0    2     1    0   0    0   0   1
13     *
14     *         PROBLEM CONSTANTS
15     *
16     010005  50.0  1.0
17     *
18     *
19     *
20     010050   "STEAMTABLE        "   "DISK"  "EIUCC"   1
21     *
22     *  QUOTED VARIABLES ARE USED FOR AN "IBM COMPUTER" USAGE.*****
23     *
24     020001  "T003" 20   "TEMP"  201  "GR**"  10  "HP**"  201
25     *
26     *
27     *         EDIT VARIABLES
28     *
29     020001  "PRES" 201  "TEMP"  201  "GR**"  10  "HP**"  201
       CARD ABOVE IS REPLACEMENT CARD.
30     020001  "T003" 20   "TEMP"  201  "GR**"  10  "HP**"  201
       CARD ABOVE IS REPLACEMENT CARD.
31     020001              "TEMP"  20`  "GR**"  10  "HP**"  201
       CARD ABOVE IS REPLACEMENT CARD
32     *
33     *         TIME STEPS
34     *
35     030010  1  1  50  0  0.010  0.001       0.05
36     030020  1  10  2  0  0.001  0.000001   0.4
37     030030 5   50  2  0  0.002  0.00002   20.0
38     *
39     *         TRIP CONTROLS
40     *
41     040010   1  1  0  0    0.1     0.0        * END PROBLEM ON ELAPSED TIME
42     040010   1  1  0  0    0.4     0.0        * END PROBLEM ON ELAPSED TIME
       CARD ABOVE IS REPLACEMENT CARD.
43     040020   1 -4 131 0   50.0     0.0        * END PROBLEM ON LOW PRESSURE IN VOL 131
44     040030   2  1  0  0    0.05    0.0        * ACTION 2 ON ELAP. TIME         (BREAK)
45     040040   3  1  0  0    1.05    0.01       * ACTION 3 ON ELAP. TIME          (PUMP)
46     040050   4 -4 131 0 1000.0     0.1        * ACTION 4 ON LOW PRESS IN VOL131(SCRAM)
47     040060  5  1  0  0  0.  0.  * STEAM GENERATOR SECONDARY SIDE FLOW
48     *
49     *         VOLUME DATA
50     *
51     052011  1 0  900. 539.698 -1. 1000.   20.   15.  * HEAT EXCHANGER 2ND. SIDE
52     052012  0       50.   .5     12.
53     051311  0  0  2254.00  579.182  0.0  100.0   10.0   10.0    * UPPER PLENUM
54     051312  0       10.0         0.0 11.0
55     050021  0  0  2258.0    541.0    0.0   15.0   14.0   14.0    * PUMP
56     050022  0        1.0         0.0  2.0
57     051091  0  0  2262.0   540.995  0.0   60.0    5.0    5.0    * LOWER PLENUM
58     051092  0       12.0         0.0  0.0
59     050101  0  0  2260.0   552.204  0.0    5.0    2.0    2.0    * CORE BOTTOM
```


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```
050102  0         1.8        0.0  5.0
050201  0  0  2258.0    580.486  0.0    5.0    2.0    2.0    * CORE MIDDLE
050202  0         1.8        0.0  7.0
050301  0  0  2256.0    607.681  0.0    5.0    2.0    2.0    * CORE TOP
050302  0         1.8        0.0  9.0
059991  0  0    14.7    1150.48  0.0   10E6   10.0   10.0    * C^NST PRESS SINK
059992  0        10E7        0.0 11.0
*
*          BUBBLE DATA
*
060011  0.8  100.0
*
*          JUNCTION DATA
*
082011  0 201 -1 0   64.76  1.  12.5  0.  ^.  0.
082012  0  1  3  0  0.   1.  0  0    * * FILL
082993  0 201  2  0  -64.76   1.  32.  0.  0.  0.
082994  0  1  3  -2  0.   1.  0  0   * NEG. FILL
080021 131  2 -10 0  600.0   1.0  15.0    0.0  0.0  0.0     * JUNCTION 1
080022   0  1  3  3    0.0   0.0        0  1
080091   2 109 10 0  600.0   1.0   2.0    0.0  0.0  0.0     * JUNCTION 2
080092   0  1  3  3    0.0   0.0        0  0
081001 109 10  0  0  600.0   2.0   5.0    0.0  0.0  0.0     * JUNCTION 3
081002   0  1  3  3    0.0   0.0        0  2
080111 10 20   0  0  600.0   2.0   7.0    0.0  0.0  0.0     * JUNCTION 4
080112   0  1  3  3    0.0   0.0        0  3
080221  20  30 0 0   600.0   2.0   9.0    0.0  0.0  0.0     * JUNCTION 5
080222  0  1  3  3     0.0   0.0        0  3
081501  30 131 0 0   600.0   2.0  11.0    0.0  0.0  0.0     * JUNCTION 6
081502  0  1  3  3     0.0   0.0        0  3
089991 131 999 0 1     0.0   8.0  15.0    0.0  0.0  0.0     * JUNCTION 7
089992  0  1  3  0     0.0   1.0        0  0
*
*          PUMP DESCRIPTION
*
090101  1  3  1  0 0   1185.0  1.0  6430.0   20.0  1500.0  7500.0
090102   0.0   0.0   0.0
*          PUMP CURVE INPUT INDICATORS
*
100000  1  0
*
*          VALVE DATA
*
110010 -2 1 0. 0. 0.  0.
*
*          AREA VERSUS TIME TABLE
*
120100  3   0.0  0.0    0.05  1.0    100.0  1.0
*
*
* FILL TABLE
130101  -4  5  0 0 0. 64.76  464.48  950.  1.05 64.76 464.48  950.
130102  4.05  0.  0.  0.     500.  0.  0.  0.
130201  -4  5  0  0  0. -64.76  1196.4  900. 1.05 -64.76 1196.4  900.
130202  4.05  0. 0. 0.     500.  0. 0. 0.
*
*          REACTOR KINETICS CONSTANTS
*
140000      0  400.0  0.0   1.0
*
*          REACTIVITY COEFFICIENT DATA
*
140010     0.25   0.3   0.0   0.0
140020     0.50   0.4   0.0   0.0
140030     0.25   0.3   0.0   0.0
```


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*
*          SCRAM TABLE
*
141000   3  4    0.0  0.0    0.5 -1.0     100.0 -20.0
*
*          DENSITY REACTIVITY TABLE
*
142000  -2  0.0  -2.0  46.0  0.0
*
*          DOPPLER TABLE
*
143000   3  100.0  2.0    700.0  1.0    5000.0 -4.0
*
*
*          HEAT CONDUCTOR DATA
*
150101   0 10   1   0 0 0  0.0    300.0   2.625 0.0  0.046  0. .048 0. 6.
150201   0  20  1   1 0 0  0.0    300.0   2.625 0.0  0.046  0. .048 0. 6.
150301   0 30   1   1 0 0  0.0    300.0   2.625 0.0  0.046  0. .048 0. 6.
152001 131 201  2 0 0 0 12000.0  12000.0  240.0  0.04  0.0    0. 0. 0. 0.
150102 0
150202 0
150302 0
152002 1
*
*          CORE SECTION DATA
*
160010   10                0.0025            0.3
160020   20                0.0025            0.4
160030   30                0.0025            0.3
*
*          CONDUCTOR GEOMETRY
*
170101   2  2  1  3   0.0   0.0150  1.0
170102   0     2  5         0.0025  0.0
170201   1  1  3  4   0.0   0.02    0.0
*
*                THERMAL CONDUCTIVITY TABLES
*
180100  20                                                * U02
180101   100.  5.00256    300.  3.996      500.  3.3282
180102   700.  2.85408    900.  2.50128   1100.  2.22948
180103  1300.  2.01528   1500.  1.84356   1700.  1.7046
180104  1900.  1.5516    2100.  1.4652    2300.  1.386
180105  2500.  1.3356    3000.  1.2708    3500.  1.2384
180106  3700.  1.2384    4000.  1.26      4300.  1.314
180107  4700.  1.404     5100.  1.5048
180200   15                                               * ZIRCALLOY
180201   100.  7.9092     300.  8.2224     500.  8.676
180202   700.  9.27       900. 10.0       1100. 10.872
180203  1300. 11.8872    1500. 13.0356    1700. 14.328
180204  1800. 14.652     2000. 16.02      2200. 17.892
180205  2500. 21.132     2900. 26.28      3300. 32.22
180301  -3     0.0 9.0   200.0 9.0   1600.0 15.0          * STNLESS STEEL 347
*                VOLUMETRIC HEAT CAPACITY TABLES
*
190100  20                                                * U02
190101   100.  57.79      300.  65.4       500.  69.14
190102   700.  71.43      900.  73.06     1100.  74.35
190103  1300.  75.43     1500.  76.39     1700.  77.28
190104  2500.  79.72     2700.  81.0      3000.  85.0
190105  3200.  89.7      3500.  99.0      3800. 111.6
190106  4100. 126.5      4400. 140.3      4600. 147.4
190107  4800. 153.0      5100. 156.2
190200  11
```


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190201    100.  40.248     300.  43.908     500.  46.158      * ZIRCALLOY
190202    700.  47.886     900.  49.368    1100.  50.73
190203   1300.  52.014    1500.  53.256    1700.  54.468
190204   1800.  52.2      3300.  52.2
190301    -2    200.0  60.0    2200.0  80.0                   * STNLESS STEEL 347
*      END TERMINATOR
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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN 8 VOLUME SAMPLE PROBLEM
CPU TIME = 3.009

* *

STANDARD TIME STEP NUMBER = 0 ACTUAL TIME STEP NUMBER = 0 TIME = 0. SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
1.000000E+00	5.000000E+01	1.714919E+08	0.	3.436109E+07	4.523448E+04	0.

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
2	2.25[illegible]00E+03	7.07981E+02	5.41000E+02	4.71988E+01	5.45000E+02	0.	0.	1.40000E+01	7.0798[illegible]E+02
10	2.[illegible]000E+03	2.33158E+02	5.52204E+02	4.66315E+01	5.54000E+02	0.	0.	2.00000E+00	2.33158E+02
20	[illegible].25800E+03	2.25563E+02	5.80486E+02	4.51126E+01	5.76000E+02	0.	0.	2.00000E+00	2.25563E+02
30	2.25600E+03	2.17749E+02	6.07681E+02	4.35497E+01	5.96000E+02	0.	0.	2.00000E+00	2.17749E+02
109	2.26200E+03	2.83208E+03	5.40995E+02	4.72014E+01	5.45000E+02	0.	0.	5.00000E+00	2.83208E+03
131	2.25400E+03	4.51828E+03	5.79182E+02	4.51828E+01	5.75000E+02	0.	0.	1.00000E+01	4.51828E+03
201	9.00000E+02	3.27672E+04	5.39698E+02	3.27672E+01	5.31955E+02	1.93704E-02	1.35569E+02	1.50000E+01	3.21325E+04
999	1.47000E+01	3.73247E+03	1.15048E+03	3.73247E-02	2.12016E+02	1.00000E+00	0.	0.	0.

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
2	131 TO 2		6.00000E+02	5.44282E+02	2.12682E-02	-4.00000E+00	2.28038E+00	-3.78858E-01	1.36384E+00	3.46231E+00
9	2 TO 109		6.00000E+02	5.41009E+02	2.11866E-02	-4.00000E+00	2.13049E+00	-7.35785E-01	8.57019E-01	3.46231E+00
11	10 TO 20		6.00000E+02	5.64053E+02	2.17421E-02	2.00000E+00	-6.37112E-01	-1.84345E-02	1.34445E+00	0.
22	20 TO 30		6.00000E+02	5.96286E+02	2.26196E-02	2.00000E+00	-6.15710E-01	-1.91220E-02	1.36517E+00	0.
100	109 TO 10		6.00000E+02	5.40992E+02	2.11860E-02	2.00000E+00	-1.14330E+00	-9.06555E-02	7.66046E-01	0.
150	30 TO 131		6.00000E+02	6.19530E+02	2.3[illegible]543E-02	2.00000E+00	-1.87128E+00	-1.50220E-01	-2.14957E-02	0.
999	131 TO 999		0.	5.79183E+02	2.21323E-02	2.23930E+03	3.13510E-01	0.	0.	0.
299	0 TO 201		-6.47600E+01	1.19634E+03	5.01730E-01	0.	1.48758E+00	0.	0.	0.
201	0 TO 201		6.47600E+01	4.64480E+02	1.99224E-02	0.	-2.90306E+00	0.	0.	0.

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H20 (BTU/HR)
10	2	1.18500E+03	9.77469E-01	0.	1.00000E+00	8.41907E+05

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)
10	RIGHT	10	1	1.70650E+05	7.08324E+05	3.13178E+03	6.08490E+02	1.20000E+06	1.33974E+05	5.11950E+07
20	RIGHT	20	1	2.27533E+05	7.09039E+05	3.18394E+03	6.47463E+02	1.20000E+06	1.60130E+05	6.82600E+07
30	RIGHT	30	1	1.70650E+05	7.09754E+05	3.25211E+03	6.48473E+02	1.20000E+06	1.41973E+05	5.11950E+07
200	LEFT	131	1	-1.25646E+04	4.82758E+05	8.29812E+02	5.59859E+02	2.16000E+05		-1.50775E+08
	RIGHT	201	2	1.25646E+04	9.16571E+04	3.18018E+03	5.35906E+02	4.66272E+03	7.54034E+06	1.50775E+08

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H20 (FT)	DEPTH REAC. INT. ZR-H20 (FT)	HEAT GEN. ZR-H20 (BTU/HR)	COND. HEATING RATE (BTU/HR)	DIR. MODERATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	10	0.	0.	0.	5.11950E+07	0.	9.22374E+02	1.26724E+03
2	20	0.	0.	0.	6.82600E+07	0.	1.09450E+03	1.60863E+03
3	30	0.	0.	0.	5.11950E+07	0.	9.69657E+02	1.32454E+03

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
0.	9.30010E-01	6.99900E-02	0.	0.	0.	0.	0.	0.

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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN 8 VOLUME SAMPLE PROBLEM
CPU TIME = 107.731

* *

STANDARD TIME STEP NUMBER = 355 ACTUAL TIME STEP NUMBER = 1036 TIME = 4.000000E-01 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
3.514921E-01	1.757460E+01	7.841033E+07	0.	3.435983E+07	4.523448E+04	0.

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
2	2.86687E+02	4.88529E+01	5.36463E+02	3.25686E+00	4.13207E+02	1.80813E-01	8.83324E+00	1.40000E+01	4.00197E+01
10	3.51888E+02	2.38730E+01	5.26648E+02	4.77460E+00	4.32239E+02	1.46474E-01	3.49678E+00	2.00000E+00	2.03762E+01
20	3.61427E+02	2.32904E+01	5.35482E+02	4.65807E+00	4.34789E+02	1.54568E-01	3.59995E+00	2.00000E+00	1.96904E+01
30	3.69470E+02	2.28071E+01	5.43095E+02	4.56143E+00	4.36899E+02	1.61684E-01	3.68756E+00	2.00000E+00	1.91196E+01
109	3.82782E+02	3.25696E+02	5.27866E+02	5.42827E+00	4.40314E+02	1.38191E-01	4.50083E+01	5.00000E+00	2.80688E+02
131	2.18645E+02	1.04868E+02	7.39340E+02	1.04868E+00	3.89347E+02	4.49506E-01	4.71386E+01	1.00000E+01	5.77290E+01
201	8.99595E+02	3.27672E+04	5.39628E+02	3.27672E+01	5.31901E+02	1.93632E-02	5.59694E+00	1.36973E+01	3.21327E+04
999	3.06128E+01	1.19179E+04	8.07287E+02	1.19179E-01	2.51495E+02	6.21732E-01	7.40974E+03	1.00000E+01	4.50816E+03

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
2	131 TO 2		-2.64524E+02	5.37151E+02	3.11481E-01	-6.67166E+01	1.42303E-01	2.32081E+00	-1.25082E-01	6.41284E+01
9	2 TO 109		-1.19925E+03	5.27916E+02	1.83347E-01	-9.83256E+01	1.38555E-01	1.24292E+01	-2.16295E+01	6.41284E+01
11	10 TO 20		4.86811E+03	5.31449E+02	2.16721E-01	-9.45328E+00	-6.57915E-02	-1.02848E+01	-1.98039E+01	0.
22	20 TO 30		5.22740E+03	5.40103E+02	2.21606E-01	-7.91204E+00	-6.42781E-02	-1.20152E+01	-1.99915E+01	0.
100	109 TO 10		4.47047E+03	5.27827E+02	1.83311E-01	3.10292E+01	-1.27996E-01	-4.32553E+01	-1.23541E+01	0.
150	30 TO 131	MOODY	5.53791E+03	5.46805E+02	2.24729E-01	1.51378E+02	-6.83386E-02	1.88979E+02	-3.84403E+01	0.
999	131 TO 999	MOODY	7.19598E+03	7.37036E+02	9.48218E-01	2.23786E+02	6.48138E-03	3.57955E+02	-2.78347E+01	0.
299	0 TO 201		-6.47600E+01	1.19635E+03	5.01862E-01	0.	1.48758E+00	0.	0.	0.
201	0 TO 201		6.47600E+01	4.64480E+02	1.99224E-02	0.	-2.90306E+00	0.	0.	0.

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H20 (BTU/HR)
10	2	1.18500E+03	2.13955E+01	0.	1.00000E+00	1.84282E+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)
10	RIGHT	10	3	6.17607E+05	1.60691E+06	4.36744E+04	4.46656E+02	9.66627E+06	1.25730E+05	1.85282E+08
20	RIGHT	20	3	6.83748E+05	1.64412E+06	4.76582E+04	4.49383E+02	1.04177E+07	1.48713E+05	2.05125E+08
30	RIGHT	30	3	6.13294E+05	1.67514E+06	5.12525E+04	4.49074E+02	1.10837E+07	1.30941E+05	1.83988E+08
200	LEFT	131	3	4.42020E+05	7.00013E+05	3.38349E+04	4.02510E+02	2.37622E+06		5.30424E+09
	RIGHT	201	2	1.20201E+04	9.16605E+04	3.10951E+03	5.35767E+02	4.66272E+03	7.07337E+06	1.44241E+08

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H20 (FT)	DEPTH REAC. INT. ZR-H20 (FT)	HEAT GEN. ZR-H20 (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	10	1.93438E-11	0.	0.	1.79946E+07	0.	8.85684E+02	1.25094E+03
2	20	2.57728E-11	0.	0.	2.39929E+07	0.	1.04352E+03	1.58735E+03
3	30	2.53666E-11	0.	0.	1.79946E+07	0.	9.21245E+02	1.30830E+03

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-4.74249E-01	8.05737E-01	1.94263E-01	-2.08219E+00	-3.78172E-01	0.	-1.75735E+00	0.	5.33342E-02

RETRAN-01-MOD003 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN 8 VOLUME SAMPLE PROBLEM
CPU TIME = 43.720
* *

SYSTEM ELAPSED TIME (SEC)	VOL 201 AVG. TEMP. (DEG. F)	COND 10 RIGHT M FLUX LBM/S-F2	JUN 201 ENTHALPY (BTU/LB)
0.	5.31955E+02	1.20000E+06	4.64480E+02
1.00000E-02	5.31953E+02	1.22158E+06	4.64480E+02
2.00000E-02	5.31952E+02	1.22794E+06	4.64480E+02
3.00000E-02	5.31951E+02	1.24780E+06	4.64480E+02
4.00000E-02	5.31949E+02	1.27129E+06	4.64480E+02
5.00000E-02	5.31948E+02	1.29530E+06	4.64480E+02
5.10000E-02	5.31948E+02	1.31835E+06	4.64480E+02
5.20000E-02	5.31948E+02	1.51641E+06	4.64480E+02
5.30000E-02	5.31948E+02	2.73359E+06	4.64480E+02
5.40000E-02	5.31948E+02	3.88636E+06	4.64480E+02
5.50000E-02	5.31948E+02	5.20737E+06	4.64480E+02
5.60000E-02	5.31948E+02	6.55329E+06	4.64480E+02
5.70000E-02	5.31947E+02	7.73104E+06	4.64480E+02
5.80000E-02	5.31947E+02	8.38251E+06	4.64480E+02
5.90000E-02	5.31947E+02	8.61532E+06	4.64480E+02
6.00000E-02	5.31947E+02	8.44484E+06	4.64480E+02
6.10000E-02	5.31947E+02	7.94791E+06	4.64480E+02
6.20000E-02	5.31947E+02	7.25718E+06	4.64480E+02
6.30000E-02	5.31947E+02	6.32918E+06	4.64480E+02
6.40000E-02	5.31946E+02	5.35511E+06	4.64480E+02
6.50000E-02	5.31946E+02	4.47046E+06	4.64480E+02
6.60000E-02	5.31946E+02	3.40435E+06	4.64480E+02
6.70000E-02	5.31946E+02	2.55082E+06	4.64480E+02
6.80000E-02	5.31946E+02	1.65345E+06	4.64480E+02
6.90000E-02	5.31946E+02	8.10512E+05	4.64480E+02
7.00000E-02	5.31946E+02	1.53333E+05	4.64480E+02
7.10000E-02	5.31945E+02	1.10503E+06	4.64480E+02
7.20000E-02	5.31945E+02	2.05587E+06	4.64480E+02
7.30000E-02	5.31945E+02	3.01673E+06	4.64480E+02
7.40000E-02	5.31945E+02	3.96094E+06	4.64480E+02
7.50000E-02	5.31945E+02	4.70029E+06	4.64480E+02
7.60000E-02	5.31945E+02	5.69560E+06	4.64480E+02
7.70000E-02	5.31945E+02	6.45384E+06	4.64480E+02
7.80000E-02	5.31945E+02	7.14151E+06	4.64480E+02
7.90000E-02	5.31945E+02	7.30446E+06	4.64480E+02
8.00000E-02	5.31945E+02	6.93267E+06	4.64480E+02
8.10000E-02	5.31944E+02	5.98298E+06	4.64480E+02
8.20000E-02	5.31944E+02	4.46664E+06	4.64480E+02
8.30000E-02	5.31944E+02	2.54974E+06	4.64480E+02
8.40000E-02	5.31944E+02	6.55028E+05	4.64480E+02
8.50000E-02	5.31944E+02	1.57598E+06	4.64480E+02
8.60000E-02	5.31944E+02	3.53232E+06	4.64480E+02
8.70000E-02	5.31944E+02	5.03981E+06	4.64480E+02
8.80000E-02	5.31943E+02	6.31583E+06	4.64480E+02
8.90000E-02	5.31943E+02	7.13527E+06	4.64480E+02
9.00000E-02	5.31943E+02	7.50473E+06	4.64480E+02
9.10000E-02	5.31943E+02	7.50031E+06	4.64480E+02
9.20000E-02	5.31943E+02	7.45371E+06	4.64480E+02
9.30000E-02	5.31943E+02	7.37115E+06	4.64480E+02
9.40000E-02	5.31942E+02	7.24667E+06	4.64480E+02

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3.0 STANDARD PROBLEM FIVE

Standard Problem Five from the NRC's CASP series was the prediction of test S-02-8 in the Semiscale Mod-1 experimental program. This system was a scale model PWR with an electrically heated core of 40 rods. Test S-02-8 was a 200% double-ended break with the heated core at full power (1.6 MW). Nominal initial conditions prior to the break were 2200 psia, 600°F, and a flow of 17 lbm/sec through the operating loop. There was no ECC injection.

The Standard Problem Five sample problem is a ten volume model. This model was obtained by adding a secondary side to the steam generator of a nine volume model originally developed to check out RELAP/SLIP [IV.3-1]. This model of Standard Problem Five gave reasonable agreement with results from a 45 volume model [IX.3-2] at a savings in computer time of about 60%. The schematic diagram of the model is given in Figure IX.3-1.

The input listing and output from the Standard Problem Five run at times 0.0 and 5.0 seconds is given below.

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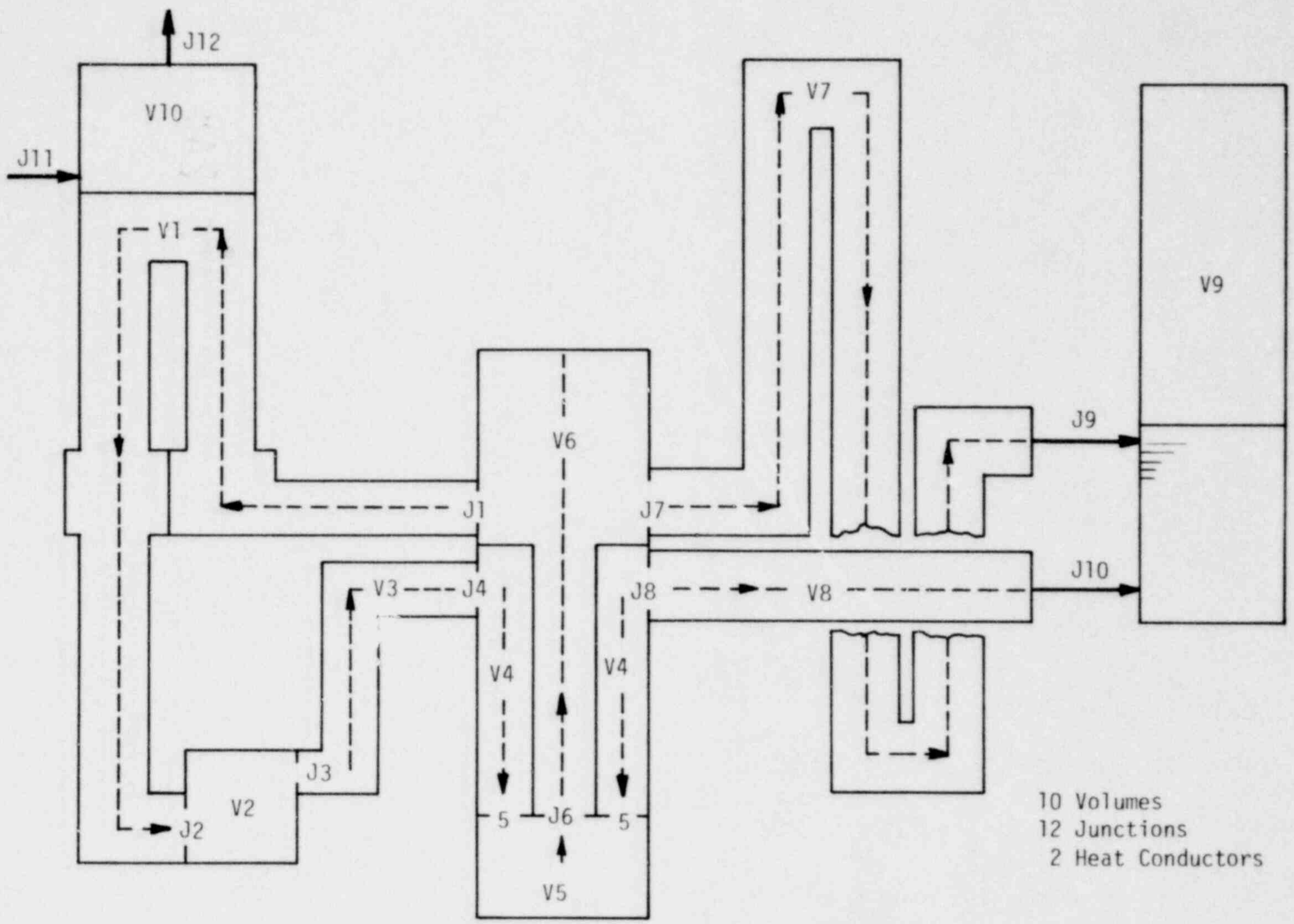

Figure IX.3-1 Simplified Model for Standard Problem Five

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (SIMPLIFIED S.P-5 / S-02-8 TEST)
*
* PROBLEM DIMENSIONS DATA
*
*10001 TAP EUI TSP TRP VOL BUB TDV JUN PMP CKV NLK FIL SLR GOM MAT COR HTX
*
010001   0  0   4   5  10   1   0  12   1   2   1   2   2   2   4   1   0 0
*10005    INITIAL POWER       OMEGA
*
010005         1.5747          1.0              * FULL POWER
*
*   CHANGES FOR  IBM  MACHINE  RUNS  *
*
*  QUOTED VARIABLES ARE USED FOR AN "IBM COMPUTER" USAGE.****
*
010050  '01152.WATRPROP   '  'EI0001',  '  ',   0
.
*
*     TIME  STEP  DATA
*
*3XXX0  NMIN  NMAJ NDMP NCHK  DELTM  DTMIN    TLAST
*
030010   1     2   10    0    .001   .00001    0.01   *  TIME STEP 1
030020   4     2   10    0    .002    .00005   0.1    *  TIME STEP 2
030030  10     1   10    0    .01    .0001     1.0    *  TIME STEP 3
030040  10    10   10    0    .02    .0002    25.0    *  TIME STEP 4
*
*     TRIP  CONTROL  DATA
*
*4XXX0    ID  SIG  V/J  IPT  SETPOINT  DELAY
*
040010   1    1    0    0       0.1        0.  *  END TRIP, TRANSIENT
040010   1    1    0    0       5.0        0.  *  END TRIP, TRANSIENT
CARD ABOVE IS REPLACEMENT CARD.
040020   2    1    0    0       0.00005    0.  *  BREAK OPENING PUMP SIDE BREAK
040030   3    1    0    0       0.0        0.  *  POWER TRIP
040040   4   -4    8    0    1000.0        0.  *  VESSEL SIDE BREAK VALVE
040050   5    1    0    0     500.0        0.  *  PUMP TRIP (NO TRIP)
*
*  VOLUME DATA
*
*5XXX1 BB IR PRESSURE TEMPER QLY VOLUME HEIGHT MIXLVL F FLOWARA EQDIAM ELEVATON
050011 0  0  2255.    583.788  0. 2.262  15.281 15.281 0 .05116  .25522 -3.50764
050021 0  0  2263.877     0.   0. .1603  1.1616 1.1616 0 .037611 .21883 -3.50764
050031 0  0  2281.4      0.0   0. .53953 3.7925 3.7925 0 .037611 .22245 -3.08607
050041 0  0  2280.618    0.0   0. .9047  13.886 13.886 0 .058738 .07352 -13.6063
050051 1  0  0.0        0.     0. .59184 2.3885 2.3885 0 .56275  .33396 -15.9948
050061 0  0  2275.3      0.0   0. 1.0165 18.013 18.013 0 .052986 .0358  -13.6063
050071 0  0 0.0         0.0    0. .87619 13.869 13.869 0 .0376   .1824  -4.0885
050081 0  0 0.0         0.0    0. .18365 .21883 .21883 0 .03.611 .1927  -.10942
050091 1  0  39.856     70.    1. 90.    11.5   2.     0 8.727   2.9435 -.10942
050101 1  0  872.     529.06 -1. 6.8717 12.12  9.6667 0  .567   .0316  3.45
*
* BUBBLE DATA
060011   .8   3.
*                                                            PAGE 10 OF 13.
*  JUNCTION DATA
*
*8XXX1 VI VO PP VV FLOWRT AREA  ELEVTIN INERT FLOSS RLOSS V C CL M HOI CON IC HG
```

```
080011 6  1  0  0  16.402 .01969 .70833 318.3    0.  9.997 0 0 0  0 0.  1.  0  1
080021 1  2  -1 0 16.402 .03761 -3.4741 404.     0.  34.42 0 0 0  0 0.  1.  0  0
080031 2  3  1  0 16.402 .03761 -2.9432 444.     0.  8.536 0 0 0  0 0.  1.  0  0
080041 3  4  0  0 16.402 .01969  0.     160.8  0.   1.998 0 0 0  0 0.  1.  0  0
080051 4  5  0  0 16.402 .05874 -13.6063 150. 1.843 1.34 0 -1 0  0 0.  1.  0  0
080061 5  6  0  3 16.402 .04912 -13.6063 266.  -1.0 13.25 0 0 0  0 0.  1.  0  2
080071 6  7  0  0  0.     .03761  .70833  777. 417.5 417.5 0 0 0  0 0.  1.  0  1
080081 4  8  0  0  0.     .03761  0.       254. 3.929 3.213 0 0 0  0 0.  1.  0  0
080091 7  9  0  2  0.     .00262  .70833 1300. 6.463 6.563 0 0 0  0 0.  .6 11  0
080101 8  9  0  1  0.     .00262  0.      506.6 2.19  2.19  0 0 0  0 0.  1. 11  0
080111 0  10 1  0  2.22  .02321 12.3025  0.   1.     .45   1 0 2  0 0.  1.  0  0
080121 0  10 2  0 -2.22  .02321 15.56    0.   0.45  1.    1 0 2 -2 0.  1.  0  0
* PUMP DATA *******************************************************************
*
*90XXY PC TR RV 2F MTC RPM IRATIO FLOW  HEAD PTORQUE  INERTIA RDENS FRIC MTORQ
090011 1  3  0  2  0  3560. .8605  180.  192. 34.80  38.3     62.30  0.      0.
090012     6.7    0.     0.                 * COEFFIENTS FOR FRICTIONAL TORQUE
*
*910XXY  REF  ANC .RS RES RPT  MAR 74  PG17
*910XXY PTS   VF MULTI     VF MULTI                           HEAD MULTIPLIER
091021   -11   0. 0.   .1 0.   .15 .05   .24 .8   .3 .96   .4 .98
091022          .6 .97   .8 .9   .9 .8   .96 .5   1. 0.
*
*9200X  TORQUE MULTIPLIER.  REF. STND PROB 5 SLPPL INFO. SR6-4-75
092021   9   0.  -.17     .0001    -.17    .006  0.     .1  0.  .15   .05
092022          .24 .56     .86        .56    .96     .45 1.   0.
*
*10XYYZ NC1 NC2 NC3 NC4   PUMP CURVE INDIC
100000   0  16   3  -8
*
* SEMISCALE MOD-1 PUMP CURVE.SINGLE PHASE.   REF. ANCR-1165. PP.12 - 13
*      H/T TYP PTS      X     Y     /     X     Y     /     X     Y     /     X     Y
101011           10      0.   1.22         .1  1.2          .2   1.15        .3  1.18
101012                   .4   1.16         .5  1.15         .6  1.13         .7  1.1
101013                   .9   1.04        1.   1.
101021            7      0.   -.37         .1  -.32         .2  -.275        .3  -.2
101022                  .50   0.           .8      .545
101023                                    1.   1.
101031            9     -1.     1.5       -.96 1.5         -.86 1.33        -.81 1.28
101032                  -.75  1.32        -.57 1.37        -.37 1.37        -.2  1.3
101033                   0.    1.22
101041            9     -1.     1.5       -.87 1.36        -.75  1.1        -.6   .96
101042                  -.46   .87        -.3   .8         -.2    .76       -.1   .74
101043                   0.    .73
101051            9      0.    .96        .06 1.            .2  1.1          .3  1.18
101052                   .5   1.35         .6  1.4.6        .9  1.81        .96 1.9
101053                  1.    1.95
101061           10      0.    .73                                           .1   .725
101062                  .26    .75        .34  .78          .4   .8          .5   .9
101063                 .56  1.       .6  1.06        .83  1.5        1.   1.95
101071           10     -1.   .17     -.92   .29     -.74   .48     -.6   .59
101072                  -.5   .67     -.41   .76     -.31   .81     -.2   .87
101073                  -.08   .92    0.    .96
101081           10      -1.    .17                        -.8  -.1         -.69 -.2
101082                   -.58  -.28       -.5  -.34        -.39 -.4         -.3  -.42
101083                   -.2   -.42       -.1  -.41        0.   -.37
*
101091           10      0.     .71        .1   .75         .2   .81         .3   .86
101092                   .53  1.03         .6  1.05         .7  1.07         .8  1.08
101093                   .9   1.07        1.   1.02
101101             8     0.    -.08      0.07  0.      .16    .1      .3   .23
```

```
101102              .51   .45     .68   .64     .81   .78     1.   1.02
101111         10   -1.    1.13    -.8   .92     -.7   .983    -.6   .76
101112               -.5   .71     -.4   .68     -.3   .66     -.2   .665
101113               -.1   .68     0.    .71
101121         10   -1.    1.13                  -.91  .87     -.84  .74
101122               -.8   .69     -.7   .59     -.6    .54    -.5   .5
101123               -.35  .48     -.2   .43     0.    .32
101131          4    0.   -.74    .16   -.65    .4    -.55    1.   -.29
101141          9    0.    .32     .18  .2       .3   .14      .4   .1
101142                .6   .06     .7   .01      .76 -.03      .93 -.2
101143               1.   -.29
101151          7   -1.   -1.69    -.94  -1.6    -.7   -1.34
101152              -.5   -1.13    -.3   -.96    -.17  -.66    0.   -.74
101161          7   -1.   -1.69    -.88 -1.4     -.74 -1.17    -.57 -.9
101162               -.2   -.33    -.1  -.2      0.   -.08
*
102091         10    0.    .71     .1   .75      .2   .81      .3   .86
102092                .53  1.03    .6  1.05      .7  1.07      .8  1.08
102093                .9   1.07   1.   1.02
102101          8    0.   -.06   0.07  0.     .16   .1      .3   .23
102102              .51   .45     .68   .64     .81   .78     1.   1.02
102111         10   -1.    1.13    -.8   .92     -.7   .983    -.6   .76
102112               -.5   .71     -.4   .68     -.3   .66     -.2   .665
102113               -.1   .68     0.    .71
102121         10   -1.    1.13                  -.91  .87     -.84  .74
102122               -.8   .69     -.7   .59     -.6    .54    -.5   .5
102123               -.35  .48     -.2   .43     0.    .32
102131          4    0.   -.74    .16   -.65    .4    -.55    1.   -.29
102141          9    0.    .32     .18  .2       .3   .14      .4   .1
102142                .6   .06     .7   .01      .76 -.03      .93 -.2
102143               1.   -.29
102151          7   -1.   -1.69    -.94  -1.6    -.7   -1.34
102152              -.5   -1.13    -.3   -.96    -.17  -.86    0.   -.74
102161          7   -1.   -1.69    -.88 -1.4     -.74 -1.17    -.57 -.9
102162               -.2   -.33    -.1  -.2      0.   -.08
*
*
*
* VALVE DATA ***************************************************************
*
*11XX0 ID AV BKPRES CV1 CV2 CV3
110010 -2  1   0.    0.  0.  0.        * RUPTURE DISC - 1. BD COLD LEG
110020 -2  0   0.    0.  0.  0.        * RUPTURE DISC - 2. BD HOT LEG
*
*
* LEAK TABLE DATA *******************************************
*
*12XYY PTS TRP SINK    T   A        T   A       T   A
120101  4   0.  1.   4.45   1.   4.55  .6   60.  .6      * VESSEL SIDE BREAK LEA
*
*      FILL DATA
*
130101 4 3 0 0 0.  95.64 419. 381.54 1.  95.64 419. 381.54
130102 1.75 0. 419. 381.54 500. 0. 419. 381.54
130201 4 3 0 0 0. -95.64
130202                     1199.4 798.55 1. -95.64 1199.4 798.55
130203 1.75 0. 1199.4 798.55 500. 0. 1199.4 798.55
*
*
* POWER GENERATION DATA ****************************************************
*
```

IX-25

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```
*
* SCRAM TABLE DATA (POWER CURVE) *************
* SCRAM TABLE DATA (POWER CURVE) TEST S-02-8.
* POWER CURVE REF. FROM LETTER OF TRANSMITTAL OF INITIAL CONDITIONS. SEPT 26.
141001  -7    3    * MOD-1, 100% INITIAL POWER
141002     0.  1.   .63 .7  1.9 .67  8.1 .254  20. .051  30. .051  30.1 0.
*
150011  0 6  1  0 2 2  0.  23.698   .208344  0.   .0358  0.  .04453  0.  5.5 0
150021 1 10 2 0 2 2 104.313 129.717 .43888 0. .03158 0. .06178 0. 0. 1
160010  1                0.    1.
*
* SLAB GEOMETRY DATA ***************
*17X0Y GOM REG MAT STP  RADIST  REGIONWIDTH POWRFRAC * MATERIAL AND GEOMETRY ***
170101  2   4   1   1    0.        .0029167     0.    * BN AT CENTER OF ROD
170102     0    2   2              .0071633     1.    * HEATER ELEMENT
170103     0    1   2              .00425       0.    * BN BETWN. HEATER AND TUBE
170104     0    3   3              .00325       0.    * 316L SST. CLADDING
170201 2 1 4 3 .01675 .004083 0.
* THERMAL CONDUCTIVITY DATA *****
180101   -2   500.  14.21   1500.  13.42   * BN
180201  -3         68.   13.    212.  12.8   392.  15.      * CONSTANTAN
180301   -2   500.  9.56  1500.  13.82  * SS
180401 -3 212. 10. 752. 11. 1632. 18.
* VOLUMETRIC HEAT CAPACITY DATA ****
190101   -10   400.  40.31  500.  43.63  625.  47.75              * BN
190102         756.  50.75  875.  53.  1000.  55.17               *BN
190103          1250.  58.25  1500.  60.89  1875. 63.6 2000. 64.344 * BN
190201  -7    212. 56.  572. 61.  932. 67.  1472. 73.  * CONSTANTIN-1
190202             2192.  78.  2552.  84.  3000.  90.  * CONSTANTIN-2
190301  -6   500.  61.25  1000.  66.11  1500.  70.79       * SS
190302          2000.  75.29  2375.  78.75  2500.  79.61     * SS
190401 1 68. 57.23
230000    -35
230011   1   11   12    1.
*  END TERMINATOR
```

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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE     EPRI                          11/22/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
 RETRAN SAMPLE PROBLEM (SIMPLIFIED S.P-5 / S-02-8 TEST)
CPU TIME =   18.108
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

STANDARD TIME STEP NUMBER =     0           ACTUAL TIME STEP NUMBER =     0           TIME = 0.0           SECONDS

 NORMALIZED     CORE           THERMAL         HEAT REMOV.   ENERGY          WATER MASS    AIR MASS
 CORE           POWER          POWER           RATE          BALANCE         BALANCE       BALANCE
 POWER          (MW)           (BTU/HR)        (BTU/HR)      (BTU)           (LBM)         (LBM)
 1.0000000D+00  1.5747000D+00  5.4087880D+06  0.0           3.3722050D+05  1.5301680D+03  1.4964050D+01

 VOLUME         AVG. PRES.    TOT. MASS     AVG. ENTH.    AVG. DEN.     AVG. TEMP.    AVG. QUAL.    BUBB. MASS    MIX. LEV.     LIQ. MASS
 NUMBER         (PSIA)        (LB)          (BTU/LB)      (LB/FT3)      (DEG. F)                    (LB)          (FT)          (LB)
    1           2.255000D+03  1.016110D+02  5.837880D+02  4.492090D+01  5.785000D+02  0.0           0.0           1.528100D+01  1.016110D+02
    2           2.263880D+03  7.196290D+00  5.843780D+02  4.489260D+01  5.789690D+02  0.0           0.0           1.161600D+00  7.196290D+00
    3           2.281400D+03  2.422760D+01  5.843750D+02  4.490510D+01  5.790100D+02  0.0           0.0           3.792500D+00  2.422760D+01
    4           2.280620D+03  4.062470D+01  5.843840D+02  4.490400D+01  5.790140D+02  0.0           0.0           1.388600D+01  4.062470D+01
    5           2.282720D+03  2.657650D+01  5.843950D+02  4.490480D+01  5.790280D+02  0.0           0.0           2.388500D+00  2.657650D+01
    6           2.275300D+03  4.292620D+01  6.298900D+02  4.222940D+01  6.113900D+02  0.0           0.0           1.801300D+01  4.292620D+01
    7           2.272570D+03  3.699940D+01  6.298810D+02  4.222760D+01  6.113720D+02  0.0           0.0           1.386900D+01  3.699940D+01
    8           2.278640D+03  1.273680D+01  5.843750D+02  4.490310D+01  5.790030D+02  0.0           0.0           2.188300D-01  1.273680D+01
    9           3.985600D+01  9.754120D+02  3.814200D+01  1.100420D+01  7.000000D+01  8.777930D-05  0.0           2.000000D+00  9.753260D+02
   10           8.720000D+02  2.618580D+02  5.290600D+02  3.810670D+01  5.282280D+02  1.028670D-02  1.043710D-02  9.666700D+00  2.591640D+02

 JUNCTION  CONNECTING  CHOKE  JUN. FLOW      JUN. ENTH.     JUN. SPVL.    P  R  E  S  S  U  R  E    D  I  F  F  E  R  E  N  T  I  A  L  S
 NUMBER     VOLUMES    COND.  (LB/SEC)       (BTU/LB)       (FT3/LB)      STAG. PSI     ELEV. PSI     FRIC. PSI     ACCL. PSI     PUMP PSI
    1       6 TO  1           1.640200D+01  6.753930D+02  2.556130D-02  2.031510D-01 -2.624940D+00 -1.769020D+01  0.0           0.0
    2       1 TO  2           1.640200D+01  5.837980D+02  2.226090D-02 -9.087540D+00  2.202390D+00 -1.482040D+01 -8.881780D-16  2.170550D+01
    3       2 TO  3           1.640200D+01  5.843780D+02  2.227540D-02 -1.752280D+01 -5.416750D-01 -3.641060D+00  2.220450D-16  2.170550D+01
    4       3 TO  4           1.640200D+01  5.843740D+02  2.226960D-02 -4.286600D-01  1.706810D+00 -1.278150D+00  1.804110D-16  0.0
    5       4 TO  5           1.640200D+01  5.843930D+02  2.226930D-02 -1.913980D+00  2.537470D+00 -6.234930D-01  1.593370D-06  0.0
    6       5 TO  6           1.640200D+01  5.843930D+02  2.226950D-02  7.159910D+00 -3.013660D+00 -4.146260D+00 -1.593370D-06  0.0
    7       6 TO  7           0.0           7.209040D+02  3.231020D-02  3.215960D+00 -2.183530D+00 -1.032430D+00  1.054990D-06  0.0
    8       4 TO  8           0.0           5.843760D+02  2.227030D-02  2.355930D+00 -2.077840D+00 -2.780890D-01  1.590830D-06  0.0
    9       7 TO  9           0.0           6.298840D+02  2.368100D-02  2.232720D+03  1.152460D-01  0.0           0.0           0.0
   10       8 TO  9           0.0           5.843750D+02  2.227020D-02  2.238780D+03 -8.181340D-01  0.0           0.0           0.0
   12       0 TO 10          -2.219800D+00  1.197220D+03  5.191480D-01  0.0           1.216570D+00  2.558120D+00  0.0           0.0
   11       0 TO 10           2.219800D+00  5.203840D+02  1.738130D-01  0.0           9.166530D-01 -8.564670D-01  0.0           0.0

 PUMP       VOLUME     PUMP SPEED     NORM. PUMP    NORM. FRIC.   NORM. MOT.    POWER TO H2O
 NUMBER     NUMBER     (RPM)          TORQUE        TORQUE        TORQUE        (BTU/HR)
    1          2       3.063380D+03  6.647120D-01  1.000000D+00  1.000000D+00  3.433720D+04

 HEAT COND.   VOL.  H.T.   SURF. FLUX     CRIT. FLUX     H.T. COEFF.    SURF. TEMP.   MASS FLUX      STORD ENRGY    POWR TO H2O
 NUMBER       NUM.  MODE   (BTU/HR-FT2)  (BTU/HR-FT2)  (BTU/H-F2-F)  (DEG. F)      (LBM/HR-FT2)  (BTU)          (BTU/HR)
   1  RIGHT    6     2     2.267470D+05  7.267500D+05  4.024250D+04  6.599560D+02  1.114390D+06  8.316940D+03  5.374450D+06
   2  LEFT     1     1    -5.353010D+04  9.000000D+04  2.195660D+03  5.541200D+02  1.154170D+06                -5.408790D+06
      RIGHT   10     2     4.303890D+04  9.369120D+04  5.756490D+03  5.357050D+02  1.409400D+04 -1.903890D+04  5.408790D+06

 CORE SECT.   HEAT COND.    DEPTH REAC.   DEPTH REAC.   HEAT GEN.     COND. HEAT-   DIR. MODER-   AVG. METAL    CENTERLINE
 NUMBER       NUMBER        EXT. ZR-H2O   INT. ZR-H2O   ZR-H2O        ING RATE      ATOR HT RT    TEMPERATURE   TEMPERATURE
                            (FT)          (FT)          (BTU/HR)      (BTU/HR)      (BTU/HR)      (DEG. F)      (DEG. F)
    1            1          0.0           0.0           0.0           5.374450D+06  0.0           9.127830D+02  9.127830D+02
```

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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/22/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (SIMPLIFIED S.P-5 / S-02-8 TEST)
CPU TIME = 172.430
* *

STANDARD TIME STEP NUMBER = 345 ACTUAL TIME STEP NUMBER = 602 TIME = 5.0000000D+00 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
4.6200000D-01	7.2751140D-01	2.4857040D+06	0.0	3.3737840D+05	1.5301680D+03	1.4964050D+01

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	9.069820+02	4.435200+01	5.696940+02	1.960740+01	5.328700+02	6.258240-02	2.775650+00	1.528100+01	4.157630+01
2	9.047870+02	3.100190+00	5.702440+02	1.933990+01	5.325830+02	6.390280-02	1.981110-01	1.161600+00	2.902080+00
3	9.035390+02	1.008180+01	5.725270+02	1.868630+01	5.324190+02	6.759790-02	6.815110-01	3.792500+00	9.400320+00
4	9.022420+02	1.604390+01	5.762830+02	1.773400+01	5.322490+02	7.350410-02	1.179290+00	1.388600+01	1.486460+01
5	9.034320+02	2.643420+01	5.289030+02	4.466440+01	5.324050+02	2.407740-03	1.204250-02	2.284630+00	2.637060+01
6	9.017540+02	2.052310+01	5.665890+02	2.018990+01	5.321850+02	5.912820-02	1.213490+00	1.801300+01	1.930960+01
7	7.597200+02	2.673720+00	8.716720+02	3.051530+00	5.123000+02	5.288380-01	1.413960+00	1.386900+01	1.259760+00
8	8.984370+02	4.938710+00	5.769470+02	1.741130+01	5.317490+02	7.534790-02	3.721210-01	2.188300-01	4.566590+00
9	5.148210+01	1.140160+03	1.209970+02	1.283470+01	1.523600+02	6.810130-04	0.0	2.381050+00	1.139390+03
10	9.006390+02	2.618580+02	5.338350+02	3.810670+01	5.320390+02	1.045870-02	0.0	9.702550+00	2.591190+02

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S: STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	6 TO 1		-6.552360+00	5.697160+02	5.074060-02	-4.757100+00	-1.210670+00	6.186300+00	2.185280-01	0.0
2	1 TO 2		5.138440+00	5.697220+02	5.059890-02	2.030170+00	9.673790-01	-3.316720+00	-2.129810-01	1.061870-01
3	2 TO 3		5.909120+00	5.702760+02	5.145360-02	1.084390+00	-2.263810-01	-1.189190+00	-2.249940-01	1.061870-01
4	3 TO 4		8.258210+00	5.725710+02	5.340760-02	2.954930-01	6.690320-01	-1.064930+00	-1.004080-01	0.0
5	4 TO 5		7.823590-01	5.763530+02	5.609000-02	-8.204870-01	1.209160+00	-4.287070-01	-4.003340-02	0.0
6	5 TO 6		6.546960-01	1.196150+03	4.978180-01	1.680560+00	-1.609260+00	-8.463080-02	-1.332970-02	0.0
7	6 TO 7		4.004860+00	8.811650+02	2.740890-01	1.416470+02	-7.873520-01	-1.409910+02	-1.314780-01	0.0
8	4 TO 8		1.094330+01	5.763330+02	5.636830-02	3.316980+00	-8.241490-01	-2.641870+00	-1.490370-01	0.0
9	7 TO 9	MOODY	4.396050+00	8.714780+02	3.270080-01	7.102480+02	-6.183160-01	7.164020+02	-6.456430+00	0.0
10	8 TO 9	MOODY	1.202700+01	5.769960+02	5.720860-02	8.494190+02	-9.645310-01	8.604410+02	-1.107900+01	0.0
12	0 TO 10		0.0	0.0	0.0	0.0	1.216570+00	2.558120+00	0.0	0.0
11	0 TO 10		0.0	0.0	0.0	0.0	9.166530-01	-8.564670-01	0.0	0.0

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	2	2.406050+03	6.674640-02	7.857820-01	1.000000+00	2.708090+03

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	6	6	3.572620+04	1.358880+05	1.176480+02	8.361060+02	6.733480+04	9.330260+03	8.467970+05
2	LEFT	1	2	3.439170+01	1.291120+05	1.675680+02	5.333330+02	5.092070+04		3.475000+03
	RIGHT	10	2	9.545260+02	9.000000+04	8.769730+02	5.331250+02	2.171850-36	-1.917720+04	1.199570+05

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.0	0.0	0.0	2.483000+06	0.0	9.104650+02	9.096090+02

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4.0 STANDARD PROBLEM FOUR

Standard Problem Four from the NRC's CASP series was the prediction of test number 4906 in the General Electric Boiling Water Reactor Blowdown Heat Transfer Program. The Two-Loop Test Apparatus (TLTA) is a scaled simulation of a two-loop Boiling Water Reactor with an electrically heated 7x7 core bundle. The test conditions for test number 4906 include a break size of 1.20 times the nominal area of the suction line of one of the recirculation loops, and nominal bundle power and flow conditions [IX.4-1].

The RETRAN model used to analyze Standard Problem Four is depicted schematically in Figure IX.4-1. Twenty-nine volumes are used in the model. This model is discussed in greater detail in EPRI NP-169 [IX.4-2]. The input listing and output at times 0.0 and 1.0 seconds are given below.

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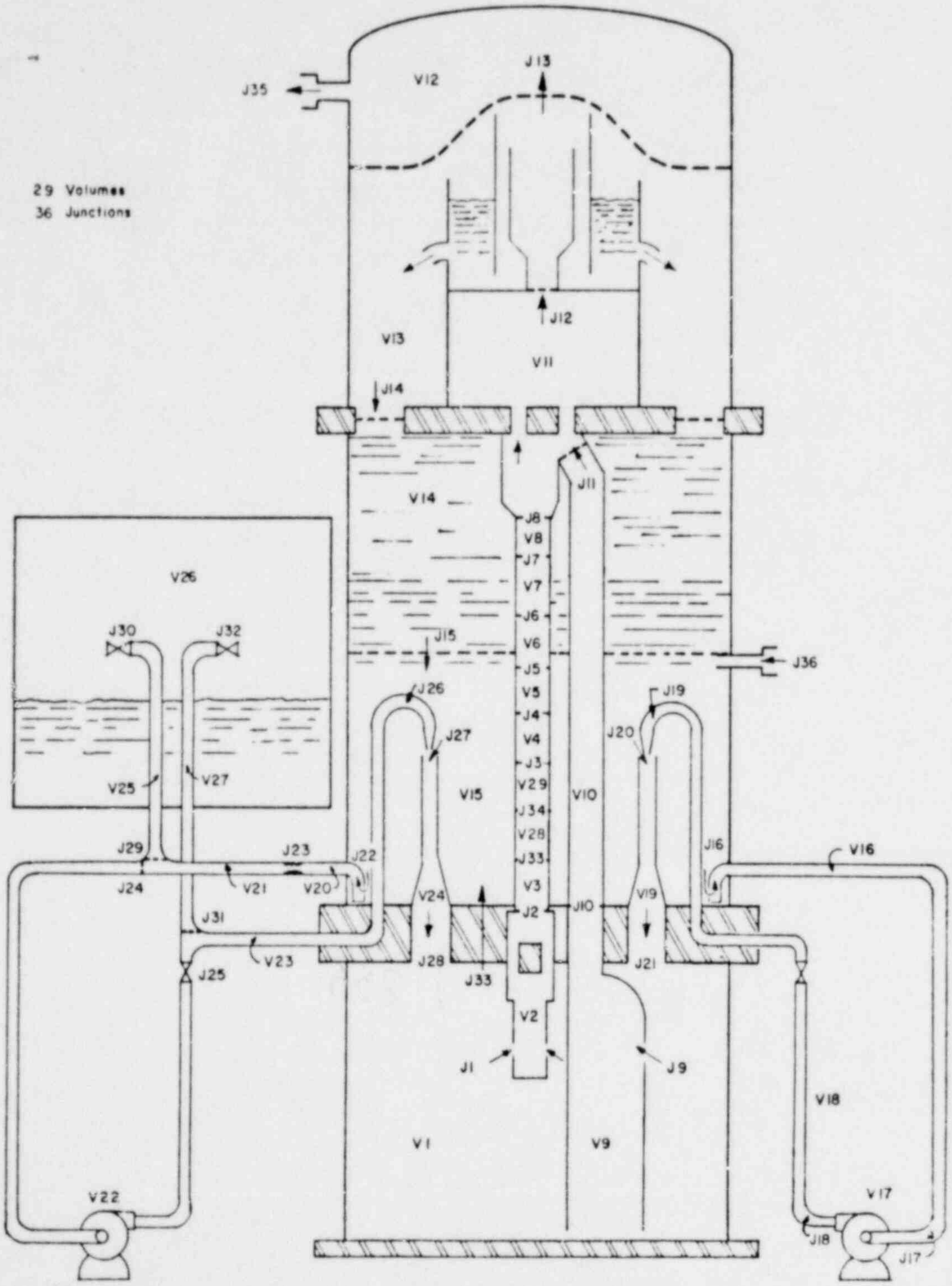

Figure IX.4-1 Model for Standard Problem Four

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LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM ( GE-BDHT-TLTA TEST-4906 )
*
*
* PROBLEM DIMENSIONS
*
*
*10001 TAP EDI NTS TRP VOL BUB TDV JUN PMP CKV NLK FLL SLB GEO MAT COR HX
*
010001  0   0   8  11  29   4   0  36  2   4   4   2   38  20  5   24  0
*
*10002 NTMM NODEL MWR  NLV  MTD  ISF NCHT  SS  PRZ  TRNS  IDNB  ICF
*
010002   1   0      0    0    0    0   0    1
010050   *STEAMTABLE        *   *DISK*  *EIUCC*   1
*
* PROBLEM CONTROL AND CONSTANTS
*10005 POWER  OMEGA
010005  4.56     1.
*
* MINOR EDITS
*
* TIME STEPS
*
*3XXX0 MIN MAJ DMP CHK DLMAX DLMIN TLAST
030010  2  10  1  0  .001  .000025 .1
030020  5  20  3  0  .004  .0005  1.
030030  4  20  2  0  .005  .0005 1.5
030040  2  25  2  0  .02  .001  20.
030050  4  50  1  0  .01  .001   25.
030060  4  50  1  0 .025  .0025  47.
030070  2  50  1  0 .05   .005   50.
030080  1  50  1  0 .1    .01    100.
*
* TRIPS
*
*
$4XXX0  IDTRP RIG IX1 IX2  SETPOINT  DELAY      TRIPS
*
040010    1    1   0   0   1.          0.     *PROBLEM END
040010    1    1   0   0   4.5         0.     *PROBLEM END
CARD ABOVE IS REPLACEMENT CARD.
040020    2    1   0   0   0.          0.     *TRIP 2 STEAM LINE
040030    3    1   0   0   0.          0.     *TRIP 3 FEEDWATER
040040    4    1   0   0   0.          0.     *TRIP 4 RECIRC. PUMP ISOLATION
040050    5    1   0   0   0.          0.     *TRIP 5 SUCTION BLOWDOWN VALVE
040060    6    1   0   0   0.          0.     *TRIP 6 DISCHARGE BLOWDOWN VALVE
040070    7    1   0   0   0.          0.     *TRIP 7 POWER
040080    8    1   0   0   0.001       0.     *TRIP 8 PUMP-UNBROKEN
040090    9    1   0   0   0.294       0.     *TRIP 9 PUMP-BROKEN LOOP
040100    1   -4  12   0   40.         0.     *TRIP 10 PROBLEM END UP.PL.P
040110   11    1   0   0   0.001       0.     *TRIP 11 COEF. J-23
*
*  VOLUME  DATA
*
*5XXX1 BB IR PRESSURE  TEMPERATURE  X  VOLUME   HEIGHT  MIXLVL
050011 2  0  1043.0       525.311  0.  2.495    3.513    3.513   *LOWER PLENUM
050021 0  0  1036.71      525.309  0.  0.2721   2.203    2.203   *FLOW TUBE
050031 0  0  1034.19      532.03   0.  0.2425   2.25001  2.25001 *1ST CORE VOL.
050041 0  0  1031.22      581.787  0.  0.1257   1.1668   1.1668  *2ND CORE VOL.
050051 0  0  1030.27      596.493  0.  0.1257   1.1668   1.1668  *3RD CORE VOL.
050061 0  0  1029.45      610.215  0.  0.1078   1.0001   1.0001  *4TH CORE VOL.
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050071 0  0  1028.05        625.401  0.  0.2515   2.3334   2.3334  *5TH CORE VOL.
050081 0  0  1026.62        638.062  0.  0.1078   1.0001   1.0001  *6TH CORE VOL.
050091 1  0  1031.0         525.401  0.  1.922    3.265    3.265   *GUIDE TUBES
050101 0  0  1028.0         525.582  0.  1.031   13.136   13.136   *BYPASS TUBES
050111 0  0  1024.8         631.284  0.  2.323    4.781    4.781   *UPPER PLENUM
050121 1  0  1020.0        1192.07   0.  3.440    3.354    3.354   *STEAM DOME
050131 1  0  1021.7         837.664  0.  5.49     7.376    0.47    *MIXING PLENUM
050141 1  0  1022.808       546.167  0.  7.724    8.73     8.73    *UPPER DOWNCOM.
050151 1  0  1024.46        526.602  0.  4.220    5.0      5.0     *LOWER DOWNCOM.
050161 0  0  1028.228       526.596  0.  1.9976  23.034   23.034   *RECIR.SCTN-UNB
050171 0  0  1152.6         527.046  0.  0.267    1.184    1.184   *RECIR.PUMP-UNB
050181 0  0  1156.689       527.04   0.  0.571   23.422   23.422   *RECIR.DSCH-UNB
050191 0  0  1043.121       526.576  0.  0.0536   3.275    3.275   *JET PUMP-UNB
050201 0  0  1024.601       526.601  0.  0.063    1.246    1.246   *RECIR.SCTN-BRK
050211 0  0  1023.458       526.603  0.  0.19385  0.242    0.242   *SUCTION BRKN T
050221 0  0  1148.04        526.422  0.  1.876   13.537   13.537   *RECIR.PUMP-BRK
050231 0  0  1139.969       526.435  0.  0.1194   3.057    3.057   *RECIR.DSCH-BRK
050241 0  0  1042.963       526.576  0.  0.0536   4.655    4.655   *JET PUMP-BRK
050251 0  0  1023.597788    526.603  0.  0.5841   4.044    4.044   *RECIR.BLDN-LN
050261 4  0    19.0          80.0    1.  2000.  100.0      5.0     *DISCHARGE TANK
050271 0  0  1177.828928    526.377  0.  0.2119   5.524    5.524   *RECIR.BLDN-LN
050281 0  0  1033.244       547.434  0.  0.1796   1.66667  1.66667
050291 0  0  1032.200       564.702  0.  0.1527   1.41667  1.41667
*
*5XXX2    2PH     FLOARA   HDIAMA      ELEV                              VOL
050012      0       .74      .194       .521                           * LOWER PLENUM
050022      0       .1104    .005      2.578                           * FLOW TUBE
050032      0       .1078    .0351     4.781                           - 1ST CORE VOLUME
050042      0       .1078    .0351    10.1143                          * 2ND CORE VOLUME
050052      0       .1078    .0351    11.2810                          * 3RD CORE VOLUME
050062      0       .1078    .0351    12.4477                          * 4TH CORE VOLUME
050072      0       .1078    .0351    13.4477                          * 5TH CORE VOLUME
050082      0       .1078    .0351    15.7810                          * 6TH CORE VOLUME
050092      0       .612     .441       .573                           * GUIDE TUBES
050102      0       .0985    .1771     3.812                           * BYPASS TUBES
050112      0       .592     .8683    16.781                           * UPPER PLENUM
050122      0      1.030     .160     22.234                           * STEAM DOME
050132      0       .788     .448     17.645                           * MIXING PLENUM
050142      0       .9603    .429      9.417                           * UPPER DOWNCOMER
050152      0       .9603    .429      4.721
050162      0       .04587   .242    -16.913                           * RECIRC SCTN-UNB.
050172      0       .04587   .242    -16.913                           * RECIRC PUMP-UNB.
050182      0       .0048    .456    -15.855                           * RECIRC DSCH-UNB.
050192      0       .0246    .02075    4.028                           * JET PUMP-UNB.
050202      0      .03322   .0288      4.875                           * RECIRC SCTN-BRK.
050212      0       .04587   .242      5.879                           * SUCTION BRKN T
050222      0       .04587   .242     -7.416                           * RECIRC PUMP-BRK.
050232      0       .0048    .1265     4.510                           * RECIRC DSCH-BRK.
050242      0       .0246    .02075    2.648                           * JET PUMP-BRK.
050252      0     10000.     .242      5.99                            * RECIRC BLDN LINE
050262      0    19.6       5.        0.                               * DISCHARGE TANK
050272      0     10000.     .1616     4.51                            * RECIRC BLDN LINE
050282      0       .1078    .0351     7.031
050292      0       .1078    .0351     8.69766
*
* BUBBLE SETS
*
*6XXX1 GRAD  VBUB
060011   .8     3.                            * BUBBLE - SEPARATION WITH GRADIENT
060021  1.      30.
060031  1.      0.                            * BUBBLE - MAX.GRADIENT/NO SEP.
060041  0.  1.E10                                                 * BUBBLE SEP.
*
* JUNCTION DATA
*
```

```
*8XXX1 IN OT PP V     FLOW    JUNARA     ELEV  INERTA       JUN
080011  1  2  0  0    37.7      .02793    2.857 17.06 *    LOWER PLN.-FLOW TUBE
080021  2  3  0  0    37.7      .0891     4.781 35.16 *    FLOW TUBE-CORE
080031 29  4  0  0    37.7      .0891    10.1143    0. *                      CORE
080041  4  5  0  0    37.7      .0891    11.2810    0. *    2ND JUNCTION IN CORE
080051  5  6  0  0    37.7      .1078    12.4477    0. *    3RD JUNCTION IN CORE
080061  6  7  0  0    37.7      .0891    13.4477    0. *    4TH JUNCTION IN CORE
080071  7  8  0  0    37.7      .0891    15.7810    0. *    5TH JUNCTION IN CORE
080081  8 11  0  0    37.7      .0891    16.781 12.92 *   CORE-UPPER PLENUM
080091  1  9  0  0     3.1      .00212    3.063  8.79 *    LOWER PLN.-GUIDE TUBE
080101  9 10  0  0     3.1      .02405    3.823 82.3  *    GUIDE TUBE-BYPASS
080111 10 11  0  0     3.1      .07977   16.948 84.6  *    BYPASS-UPPER PLENUM
080121 11 13  0  0    46.8      .07928   21.478 26.22 *    STANDPIPE-STEAM-SEP.
080131 13 12  0  0     5.11     .7H8     24.979 11.49 *   STEAM SEP.-STEAM DOME
080141 13 14  0  0    35.69     .5573    17.896 15.24 *    MIX.PLN.-UP.DOWNCOM.
080151 14 15  0  0    39.11     .9603     9.438    0. *   UP.DOWNC.-LOW DOWNC.
080161 15 16  0  0    10.       .[illegible]5     5.146    0. *    UNBROKEN DOWNC-RECIRC
080171 16 17 -1  0    10.       .04587  -16.792    0. *    UNBROKEN PUMP INLET
080181 17 18  1  0    10.       .0048   -15.792    0. *    UNBROKEN PUMP OUTLET
080191 18 19  0  0    10.       .001119   7.291 2445. *    UNBROKEN JET DRIVE
080201 1[illegible] 19  0  0    11.5      .00343    7.291 172.2 *    UNBROKEN JET SUCTION
080211 19  1  0  0    21.5      .0246     4.031 172.2 *    UNBROKEN JET DSCH.
080221 15 20  0  0     9.41     .03322    5.146  30.8 *    BROKEN DOWNC-RECIRC
080231 20 21  0  4     9.41    .008427    6.000  74.6 *    BL SCTN LINE
080241 21 22 -2  0     9.41     .04587    6.00      0. *    PUMP SUCTION-BLOWDOWN
080251 22 23  2  3     9.41     .0048     4.51      0. *    BRK PUMP 150. VALVE
080261 23 24  0  0     9.41     .001119   7.291 918.9 *    BROKEN  JET DRIVE
080271 15 24  0  0    10.49     .00343    7.291 172.2 *    BROKEN  JET SUCTION
080281 24  1  0  0    19.9      .0246     3.341 172.2 *    BROKEN  JET DSCH
080291 21 25  0  0     0.       .04587    6.0   197.9 *    SCTN BLOWDOWN VALVE
080301 25 26  0  1     0.       .037439   9.882 290.6 *    BD VALVE - SCTN
080311 27 23  0  0     0.       .0048     4.51  749.  *    DSCH BLOWNDOWN VALVE
080321 27 26  0  2     0.       .014314   9.882 482.2 *   BD VALVE - DSCHRG
080331  3 28  0  0    37.7      .0891     7.0310    0. *                      CORE
080341 28 29  0  0    37.7      .0891     8.69766   0. *                      CORE
080351  0 12  2  0    -5.11     .04587   24.906     0. *    STEAMLINE OUTLET
080361  0 15  1  0     1.69     .00545    9.437     0. *    FEEDWATER INLET
*
*8XXX2     FCOEF   RCOEF  VR JC JL MV     DIA   CON  IC HQ      JUN
080012     .9237  1.2751   1  0  0  0    0.418    .7 11 0   * LOWER PLN.-FLOW TUBE
080022        0.      0.   0  0  1  0    0.       .7 11 2   * FLOW TUBE-CORE
080032        0.      0.   0  0  3  0    0.       .7 11 3   * 1ST JUN. IN CORE
080042        0.      0.   0  0  3  0    0.       .7 11 3   * 2ND JUN. IN CORE
080052        0.      0.   0  0  3  0    0.       .7 11 3   * 3RD JUN. IN CORE
080062        0.      0.   0  0  3  0    0.       .7 11 3   * 4TH JUN. IN CORE
080072        0.      0.   0  0  3  0    0.     .7   11 3   * 5TH JUN. IN CORE
080082        0.      0.   0  0  1  0    0.       .7 11 1   * CORE-UPPER PLENUM
080092        0.      0.   1  0  1  0    0.03125  .7 11 0   * LOW.PLN.-GUIDE TUBE
080102        0.      0.   1  0  3  0    0.0208   .7 11 0   * GUIDE TUBE-BYPASS
080112        0.      0.   0  0  3  0    0.125    .7 11 0   * BYPASS-UP.PLN.
080122        0.      0.   1  0  3  0    0.166    .7 11 0   * STANDPIPE-STEAM SEP.
080132        0.      0.   1  0  3  0    .083     .7 11 0   * STEAM SEP.-STEAM DOME
080142        0.      0.   1  0  3  0     .5      .7 11 0   * MIX.PLN.-UP.DOWNCOM.
080152        0.      0.   1  0  3  0    0.0417   .7 11 0   * UP.DOWNC.-LOW.DOWNC.
080162     .71    1.2567   1  0  2  0    0.       .7 11 0   * UNBROKEN DOWNC.-RECIR
080172        0.      0.   0  0  3  0    0.       .7 11 0   * UNBROKEN PUMP INLET
080182        0.32  0.436  0  0  2  0    0.     1.02 11 0   * UNBROKEN PUMP OUTLET
080192      .01     1.17   1  0  0  2    0.0225 1.0 11 0    * UNBROKEN JET DRIVE
080202      .9      3.     2  0  0  2    0.0225   .7 11 0   * UNBROKEN JET SUCTION
080212      .926    .828   1  0  0  0     .005    .7 11 0   * UNBROKEN JET DSCH.
080222    .784    1.28     1  0  0  0    0.       .7 11 0   * BROKEN DOWNC-RECIRC
080232       .3      .3    0  0  0  0    0.0    1.0 11 0    * BL SCTN. LINE
080242       0.      0.    0  0  3  0    0.0208   .7 11 0   * PUMP SUCTION-BLOWDOWN
080252       .32    .436   0  0  2  0    0.     1.02 11   0 * BRK. PUMP DISCHARGE
080262      .01     1.17   1  0  0  2 0.0225   .7   11 0    * BROKEN JET DRIVE
080272      .9      1.0    2  0  0  2    0.0225   .7 11 0   * BROKEN JET SUCTION
080282      .926   32.0    1 -1  0  0   1.386   1.0 0  0    * BROKEN JET DSCH.
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080292       .4       .9  0  0  0  0    0.0208  1. 11 0   * SCTN BLOWDOWN VALVE
080302     .166   .166    0  0  0  0     0.      .7 11 0   * BD VALVE-SCTN
080312    .0612   .138    0  0  0  0    0.0208 2.56 11 0   * DSCH BLOWDOWN VALVE
080322     .277   .277    0  0  0  0     0.      .7 11 0   * BD VALVE-DSCHRG
080332       0.      0.  0  0  3  0    0.       .7 11 3   *               CORE
080342       0.      0.  0  0  3  0    0.       .7 11 3   *               CORE
080352       0.      0.  0  0  3  0    0.    .7   11 0   * STEAMLINE OUTLET
080362       0.      0.  0  0  1  0    0.0417  .7 11 0   * FEEDWATER INLET
*
* PUMP DATA
*
*90AXY IPC TRP REV 2PH MT RPM R/R FLOW HEAD TORQUE INERTIA DENST MTQRQ FRIC
090011  1   8   0   2  0 3550. 1. 145. 690.   70.     30.1  47.2   0.   3.
090021  1   9   0   2  0 3550. 1. 120. 710.  111.     3.23  47.2   0.   4.
*910YY                                     PUMP HEAD MULTIPLIER CARDS
*910YY NO.PTS VF   H    VF  H    VF  H     VF   H    VF   H    VF   H
091021  -11   0.  0.   .1  0.   .15 .05   .24  .8   .3  .96   .4  .98
091022        .6  .97  .8  .9   .9  .8    .96  .5   1.  0.
*920YY                                     PUMP TORQUE MULTIPLIER CARDS
*920YY NO.PTS VF   T    VF  T     VF  T     VF  T    VF  T      VF  T
092021  -6    0.  0.   .17 .08  .3  .56   .65 .62  .8  .62    1.  .5
*
* PUMP CURVE SET INPUT
100000  0  16  3   -8
* PUMP HEAD AND TORQUE DATA
101011     3       0.    1.12     .5      1.10     1.      1.    * PUMP HEAD 1
101021     3       0.    -.56     .79     0.       1.      1.    * PUMP HEAD 2
101031     3      -1.    1.58    -.5      1.19     0.      1.12  * PUMP HEAD 3
101041     3      -1.    1.58    -.5       .94     0.       .71  * PUMP HEAD 4
101051     3       0.     .65     .5       .73     1.      1.    * PUMP HEAD 5
101061     3       0.     .71     .5       .73     1.      1.    * PUMP HEAD 6
101071     3       -.94  -.39    -.51     0.       0.       .65  * PUMP HEAD 7
101081     3       -.94  -.39    -.5      -.54     0.      -.56  * PUMP HEAD 8
*
101091     3       0.     .56     .5       .83     1.      1.03  * PUMP TORQUE 1
101101     3       0.    -.42     .36     0.       1.      1.03  * PUMP TORQUE 2
101111     3      -1.     .98    -.5       .47     0.       .60  * PUMP TORQUE 3
101121     3      -1.     .98    -.5       .92     0.       .83  * PUMP TORQUE 4
101131     3       0.    -.62     .54     0.       1.       .5   * PUMP TORQUE 5
101141     3       0.     .83     .5       .67     1.       .5   * PUMP TORQUE 6
101151     3      -1.   -2.48    -.5     -1.84     0.      -.62  * PUMP TORQUE 7
101161     3      -1.   -2.48    -.5     -1.47     0.      -.42  * PUMP TORQUE 8
*
102091     3       0.     .56     .5       .83     1.      1.03  * PUMP TORQUE 1
102101     3       0.    -.42     .36     0.       1.      1.03  * PUMP TORQUE 2
102111     3      -1.     .98    -.5       .47     0.       .60  * PUMP TORQUE 3
102121     3      -1.     .98    -.5       .92     0.       .83  * PUMP TORQUE 4
102131     3       0.    -.62     .54     0.       1.       .5   * PUMP TORQUE 5
102141     3       0.     .83     .5       .67     1.       .5   * PUMP TORQUE 6
102151     3      -1.   -2.48    -.5     -1.84     0.      -.62  * PUMP TORQUE 7
102161     3      -1.   -2.48    -.5     -1.47     0.      -.42  * PUMP TORQUE 8
*
* VALVES
*
*11     TRP LEAK PCV CV1 CV2 CV3
110010  -5  1  0  0  0  0            * SUCTION BLOWDOWN VALVE
110020  -6  2  0  0  0   0           * DISCHARGE BLOWDOWN VALVE
110030   4  3  0  0  0  0            * RECIRC. PUMP ISOLATION VALVE
110040  11  4  0  0  0  0              * VALVE J23
*
* VALVE AREAS
*
120101  9         0.  0.  .033 0. .067 .052 .102 .479 .135 .468 * V2 BD VLVE J30
120102  .168 .688 .194 .935 .237 1. 1000. 1.
120201  8         0.  0.  .001 0. .035 .002 .069 .099 .103 .346 * V10 BD VLV J32
120202  .136 .823 .173 1. 1000. 1.
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120301 4       0. 1. .2 1. .75 0. 1000. 0.                 * ISOLATION VALVE AREA
120401  5           0. 1.  1.25 1.  3.75 .86 7.5 .86  9.7 .70  100. .70
*
* FILLS
*
130101 14  3  0  0
130102  0.0  310.0917431 47.0733 14.7 .095 306.4 47.0733 14.7
130103  .193 295.8 47.0733 14.7 .289 282.0 47.0733 14.7 .387 266.6 47.0733 14.7
130104 .485 235.8 47.0733 14.7 .624 165.7 47.0733 14.7 .711 107.3 47.0733 14.7
130105 .906 46.8 47.0733 14.7 1.101 47.9 47.0783 14.7 1.296 46.3 47.0733 14.7
130106 1.491 35.19 47.0733 14.7 19.104 0.0 47.0733 14.7 100. 0.0 47.0733 14.7
130201 19 2 0 0
130202 0.0 -111.4017877 1192.07 1022. .193 -109.8 1192.07 1022.
130203 .485 -106.9 1192.07 1022. .583 -97.5 1192.07 1022.
130204 .614 -93.1 1192.07 1022. .647 -88.6 1192.07 1022.
130205 .808 -74.0 1192.07 1022. 1.101 -67.7 1192.07 1022.
130206 1.491 -64.9 1192.07 1022.  1.881 -55.3 1192.07 1022.
130207 2.303 -49.1 1192.07 1022. 2.8888 -40.8 1192.07 1022.
130208 3.408 -35.4 1192.07 1022. 4.[illegible]86 -29.7 1192.07 1022.
130209 5.78 -15.0 1192.0[illegible] 1022. 6.7[illegible] -8.5 1192.07 1022.
130210 7.503 -4.6 1192.07 1022. 7.67 0.0 1192.07 1022.
130211  100.0  0.0  1192.07  1022.0
*
*    POWER
*
* SCRAM TABLE
*1410XX PTS TRP SEC REAC   SEC REAC
141001 18 7 0. 1. .136 1. .636 .982 1.136 .958 1.636 .898 2.136 .84  * POWER
141002 2.636 .796 3.386 .75 6.136 .6 9.136 .485 14.136 .337 19.136 .22
141003 25.136 .128 30.136 .082 35.136 .06 40.136 .05 45.136 .045 50.136 .04
*
* HEAT CONDUCTORS
*
*15     VL VR GM ST CL CR ASUL  ASUR     VOLUME
150011 0  3  1  0  12 12  0.  .331340 .00311590       *1ST CORE VOLUME M-25 ROD
150021 0 28  2  1  12 12  0.  .245437 .00230807       *2ND CORE VOLUME M-25 ROD
150031 0 29  3  1  12 12  0.  .208621 .00196186       *3RD CORE VOLUME M-25 ROD
150041 0  4  4  1  12 12  0.  .171806 .00161565       *4TH CORE VOLUME M-25 ROD
150051 0  5  3  1  12 12  0.  .171806 .00161565       *5TH CORE VOLUME M-25 ROD
150061 0  6  5  1  12 12  0.  .147262 .00138484       *6TH CORE VOLUME M-25 ROD
150071 0  7  6  1  12 12  0.  .343612 .00323130       *7TH CORE VOLUME M-25 ROD
150081 0  8  7  1  12 12  0.  .147262 .00138484       *8TH CORE VOLUME M-25 ROD
150091 0  3  8  0  12 12  0.  .331340 .00311590       *1ST CORE VOLUME M-14 ROD
150101 0 28  9  1  12 12  0.  .245437 .00230807       *2ND CORE VOLUME M-14 ROD
150111 0 29 10  1  12 12  0.  .208621 .00196186       *3RD CORE VOLUME M-14 ROD
150121 0  4 10  1  12 12  0.  .171806 .00161565       *4TH CORE VOLUME M-14 ROD
150131 0  5 10  1  12 12  0.  .171806 .00161565       *5TH CORE VOLUME M-14 ROD
150141 0  6 10  1  12 12  0.  .147262 .00138484       *6TH CORE VOLUME M-14 ROD
150151 0  7 11  1  12 12  0.  .343612 .00323130       *7TH CORE VOLUME M-14 ROD
150161 0  8 12  1  12 12  0.  .147262 .00138484       *8TH CORE VOLUME M-14 ROD
150171 0  3 13  0  12 12  0.  15.5730 .146447         *1ST CORE VOLUME MIX
150181 0 28 14  1  12 12  0.  11.5355 .108479         *2ND CORE VOLUME MIX
150191 0 29 15  1  12 12  0.   9.8052 .092208         *3RD CORE VOLUME MIX
150201 0  4 15  1  12 12  0.   8.0749 .075936         *4TH CORE VOLUME MIX
150211 0  5 15  1  12 12  0.   8.0749 .075936         *5TH CORE VOLUME MIX
150221 0  6 15  1  12 12  0.   6.9213 .065088         *6TH CORE VOLUME MIX
150231 0  7 19  1  12 12  0.  16.1497 .151871         *7TH CORE VOLUME MIX
150241 0  8 20  1  12 12  0.   6.9213 .0650885        *8TH CORE VOLUME MIX
150251 0  1 17  0   2  2  0.    17.93  1.936          *VESSEL - LOWER PLENUM
150261 0 15 17  0   2  2  0.    22.09  2.386          *VESSEL - LOWER ANNULUS
150271 0 14 17  0   2  2  0.    37.78  4.0802         *VESSEL - UPPER ANNULUS
150281 0 13 17  0   2  2  0.    19.73  2.1308         *VESSEL - MIXING PLENUM
150291 0 12 17  0   2  2  0.    14.55  1.5714         *VESSEL - STEAM DOME
150301 0 13 16  0   2  2  0.    13.0    .172          *INTERNALS IN MIX PLENUM
150311 0 16 18  0   2  2  0.    17.0    .408          *RECIRC. DISCHARGE OL
150321 0 18 18  0   2  2  0.    33.56  .8054          *RECIRC. SUCTION OL
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150331 0 20 18  0   2  2  0.     3.61  .086665        *BROKEN RECIRC.
150341 0 21 18  0   2  2  0.     3.61  .086665        *BROKEN RECIRC.
150351 0 22 18  0   2  2  0.    32.93  .7903          *DISCHARGE
150361 0 23 18  0   2  2  0.     3.28  .07872         *TEE TO VESL. NOZ.
150371 0 25 18  0   2  2  0.    19.83  .47592         *SUCTION BLOWDOWN
150381 0 27 18  0   2  2  0.    10.13  .2431          *DISCH. BLOWDOWN
*15     HDML  HDMR    DHEL  DHER  CHNL  CHNR
150012  0.    .0597    0.   .0597  0.   2.250     0  * S 1-2
150022  0.    .0597    0.   .0597  0.   1.667     0  * S 2-2
150032  0.    .0597    0.   .0597  0.   1.417     0  * S 3-2
150042  0.    .0597    0.   .0597  0.   1.167     0  * S 4-2
150052  0.    .0597    0.   .0597  0.   1.167     0  * S 5-2
150062  0.    .0597    0.   .0597  0.   1.        0  * S 6-2
150072  0.    .0597    0.   .0597  0.   2.333     0  * S 7-2
150082  0.    .0597    0.   .0597  0.   1.        0  * S 8-2
150092  0.    .0597    0.   .0597  0.   2.250     0  * S 9-2
150102  0.    .0597    0.   .0597  0.   1.667     0  * S10-2
150112  0.    .0597    0.   .0597  0.   1.417     0  * S11-2
150122  0.    .0597    0.   .0597  0.   1.167     0  * S12-2
150132  0.    .0597    0.   .0597  0.   1.167     0  *S13-2
150142  0.    .0597    0.   .0597  0.   1.        0  *S14-2
150152  0.    .0597    0.   .0597  0.   2.333     0  *S15-2
150162  0.    .0597    0.   .0597  0.   1.         0 *S16-2
150172  0.    .0597    0.   .0597  0.   2.250     0  *S17-2
150182  0.    .0597    0.   .0597  0.   1.667     0  *S18-2
150192  0.    .0597    0.   .0597  0.   1.417     0  *S19-2
150202  0.    .0597    0.   .0597  0.   1.167     0  *S20-2
150212  0.    .0597    0.   .0597  0.   1.167     0  *S21-2
150222  0.    .0597    0.   .0597  0.   1.        0  *S22-2
150232  0.    .0597    0.   .0597  0.   2.333     0  *S23-2
150242  0.    .0597    0.   .0597  0.   1.        0  *S24-2
150252  0.    .705     0.   0.     0.   0.        0  *S25-2
150262  0.    .910     0.   0.     0.   0.        0  *S26-2
150272  0.    .910     0.   0.     0.   0.        0  *S27-2
150282  0.    .747     0.   0.     0.   0.        0  *S28-2
150292  0.    .970     0.   0.     0.   0.        0  *S29-2
150302  0.    0.       0.   0.     0.   0.        0  *S30-2
150312  0.    0.       0.   0.     0.   0.         0 *S31-2
150322  0.    0.       0.   0.     0.   0.        0  *S32-2
150332  0.    0.       0.   0.     0.   0.        0  *S33-2
150342  0.    0.       0.   0.     0.   0.        0  *S34-2
150352  0.    0.       0.   0.     0.   0.         0 *S35-2
150362  0.    0.       0.   0.     0.   0.        0  *S36-2
150372  0.    0.       0.   0.     0.   0.        0  *S37-2
150382  0.    0.       0.   0.     0.   0.        0  *S38-2
* CORE DATA
*
* AXIAL PEAKING FACTOR IS 1.385
*16XXX0 ISLAB  THICK  QFRACTION   QPMOD QDMOD
160010   1     0.    .00295788               * 1ST CORE VOLUME M-25 HEATER
160020   2     0.    .00383132               * 2ND CORE VOLUME M-25 HEATER
160030   3     0.    .00392400               * 3RD CORE VOLUME M-25 HEATER
160040   4     0.    .00339714               * 4TH CORE VOLUME M-25 HEATER
160050   5     0.    .00329701               * 5TH CORE VOLUME M-25 HEATER
160060   6     0.    .00257407               * 6TH CORE VOLUME M-25 HEATER
160070   7     0.    .00437615               * 7TH CORE VOLUME M-25 HEATER
160080   8     0.    .00094855               * 8TH CORE VOLUME M-25 HEATER
160090   9     0.    .00166977               * 1ST CORE VOLUME M-14 HEATER
160100  10     0.    .00216284               * 2ND CORE VOLUME M-14 HEATER
160110  11     0.    .00221516               * 3RD CORE VOLUME M-14 HEATER
160120  12     0.    .00191774               * 4TH CORE VOLUME M-14 HEATER
160130  13     0.    .00186121               * 5TH CORE VOLUME M-14 HEATER
160140  14     0.    .00145311               * 6TH CORE VOLUME M-14 HEATER
160150  15     0.    .00247041               * 7TH CORE VOLUME M-14 HEATER
160160  16     0.    .00053547               * 8TH CORE VOLUME M-14 HEATER
160170  17     0.    .11225649               * 1ST CORE VOLUME MIX  HEATER
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160180   18     0.    .14540484                       * 2ND CORE VOLUME MIX  HEATER
160190   19     0.    .14892229                       * 3RD CORE VOLUME MIX  HEATER
160200   20     0.    .12892684                       * 4RD CORE VOLUME MIX  HEATER
160210   21     0.    .12512670                       * 5TH CORE VOLUME MIX  HEATER
160220   22     0.    .09769018                       * 6TH CORE VOLUME MIX  HEATER
160230   23     0.    .16608185                       * 7TH CORE VOLUME MIX  HEATER
160240   24     0.    .03599898                       * 8TH CORE VOLUME MIX  HEATER
*
* CONDUCTOR GEOMETRY
170101  2  2  2  2   .0104167 .0081633 0.            * HTR RODS VOL. 3 M-25 CERAMIC
170102   0     1  3           .0048575    1.          * HTR RODS VOL. 3 M-25 INCONEL
170201  2  2  2  2   .0104167 .0106342 0.            * HTR RODS VOL.30 M-25 CERAMIC
170202   0     1  3           .0023966     1.         * HTR RODS VOL.30 M-25 INCONEL
170301  2  2  2  2   .0104167 .0110945 0.            * HTR RODS VOL. 5 M-25 CERAMIC
170302   0     1  3           .0019236    1.          * HTR RODS VOL. 5 M-25 INCONEL
170401  2  2  2  2   .0104167 .0111742 0.            * HTR RODS VOL. 4 M-25 CERAMIC
170402   0     1  3           .0018466    1.          * HTR RODS VOL. 4 M-25 INCONEL
170501  2  2  2  2   .0104167 .0109125 0.            * HTR RODS VOL. 6 M-25 CERAMIC
170502   0     1  3           .0021083    1.          * HTR RODS VOL. 6 M-25 INCONEL
170601  2  2  2  2   .0104167 .0099666 0.            * HTR RODS VOL. 7 M-25 CERAMIC
170602   0     1  3           .0030542    1.          * HTR RODS VOL. 7 M-25 INCONEL
170701  2  2  2  2   .0104167 .0063750 0.            * HTR RODS VOL. 8 M-25 CERAMIC
170702   0     1  3           .0066458    1.          * HTR RODS VOL. 8 M-25 INCONEL
170801  2  2  2  2   .0104167 .0103742 0.            * HTR RODS VOL. 3 M-14 CERAMIC
170802   0     1  3           .0026466    1.          * HTR RODS VOL. 3 M-14 INCONEL
170901  2  2  2  2   .0104167 .0116866 0.            * HTR RODS VOL.30 M-14 CERAMIC
170902   0     1  3           .0013342    1.          * HTR RODS VOL.30 M-14 INCONEL
171001  2  2  2  2   .0104167 .0119202 0.            * HTR RODS VOL. 6 M-14 CERAMIC
171002   0     1  3           .0011006    1.          * HTR RODS VOL. 6 M-14 INCONEL
171101  2  2  2  2   .0104167 .0113233 0.            * HTR RODS VOL. 7 M-14 CERAMIC
171102   0     1  3           .0016975    1.          * HTR RODS VOL. 7 M-14 INCONEL
171201  2  2  2  2   .0104167 .0094842 0.            * HTR RODS VOL. 8 M-14 CERAMIC
171202   0     1  3           .0035366    1.          * HTR RODS VOL. 8 M-14 INCONEL
171301  2  2  2  2   .0104167 .0091668 0.            * HTR RODS VOL. 3 MIX  CERAMIC
171302   0     1  3           .0038540    1.          * HTR RODS VOL. 3 MIX  INCONEL
171401  2  2  2  2   .0104167 .0111088 0.            * HTR RODS VOL.30  MIX CERAMIC
171402   0     1  3           .0019120    1.          * HTR RODS VOL.30  MIX INCONEL
171501  2  2  2  2   .0104167 .0114498 0.            * HTR RODS VOL. 6 MIX  CERAMIC
171502   0     1  3           .0015710    1.          * HTR RODS VOL. 6 MIX  INCONEL
171601  1  1  4  1  0.        .01323      0.          *                        GEOM. 16
171701  1  1  5  1  0.        .108        0.          *                        GEOM. 17
171801  1  1  5  1  0.        .024        0.          *                        GEOM. 18
171901  2  2  2  2   .0104167 .0105775 0.            * HTR RODS VOL. 7 MIX  CERAMIC
171902   0     1  3           .0024433    1.          * HTR RODS VOL. 7 MIX  INCONEL
172001  2  2  2  2   .0104167 .0078008 0.            * HTR RODS VOL. 8 MIX  CERAMIC
172002   0     1  3           .0052200    1.          * HTR RODS VOL. 8 MIX  INCONEL
*
* THERMAL CONDUCTIVITY DATA
*
180101   2       70.    8.36  3000.    23.33              * THERMAL COND. INCONEL 1
180201   6  200.  3.05  400.  2.32  600.  1.83            * THERMAL COND. OXIDE   1
180202     1000.  1.27  1400.  1.1  4000.  1.             * THERMAL COND. OXIDE   2
180300   12                                                * THERMAL COND. ALUMINA 1
180301     70. 17.0       212. 17.0       300. 16.1        * THERMAL COND. ALUMINA 2
180302   400. 12.7        500. 10.9       600.  9.5        * THERMAL COND. ALUMINA 3
180303   700.  8.3        800.  7.35      900.  6.6        * THERMAL COND. ALUMINA 4
180304  1000.  6.        1500.  4.2      2000.  3.4        * THERMAL COND. ALUMINA 5
180401   3   0.  8.4  1000. 12.58  3000. 12.58            *THERMAL COND. SS 304   1
180501  6   32.  30.  212.  29.5   392.  28.3             * THERMAL COND. SA-302  1
180502      572.  26.6  752. 24.7 3000. 24.7              * THERMAL COND. SA-302  2
*
* VOLUMETRIC HEAT CAPACITY
*
190101   2       70.   56.43  3000.    98.18              * VOL. HT. CAP. INCONEL 1
190201   6  200.  34.0  400.  37.4  600. 40.8             * VOL. HT. CAP. OXIDE   1
190202     1000.  45.1  1400.  48.5  3000.  56.           * VOL. HT. CAP. OXIDE   2
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190300   12                                          * VOL. HT. CAP. ALUMINA 1
190301    70.  45.28   200.  52.99  300.  57.72      * VOL. HT. CAP. ALUMINA 2
190302   400.  60.96   500.  63.44  600.  65.43      * VOL. HT. CAP. ALUMINA 3
190303   700.  67.18   800.  68.17  900.  68.92      * VOL. HT. CAP. ALUMINA 4
190304  1000.  69.91  1500.  73.40 2000.  76.13      * VOL. HT. CAP. ALUMINA 5
190401  11  130. 45.09 280. 44.89 400. 45.09         * VOL. HT. CAP. SS-304  1
190402       600. 45.89 80P  47.34  1000. 49.35      * VOL. HT. CAP. SS-304  2
190403      1200. 55.55 1400. 53.86  1600. 55.91     * VOL. HT. CAP. SS-304  3
190404      1800. 57.36 2000. 58.12                  * VOL. HT. CAP. SS-304  4
190501  9 32. 56.9  130. 56.9  350. 60.8  450. 62.3  * VOL. HT. CAP. SA-302  1
190502       530. 65.2   620. 67.2    710. 70.2      * VOL. HT. CAP. SA-302  2
190503       800. 77.5  3000. 77.5                   * VOL. HT. CAP. SA-302  3
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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE   EPRI   21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (GE-BDHT-TLTA TEST-4906)
CPU TIME = 11.569

* *

STANDARD TIME STEP NUMBER = 0   ACTUAL TIME STEP NUMBER = 0   TIME = 0.   SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
1.000000E+00	4.560000E+00	1.584826E+07	0.	1.454559E+06	7.435437E+03	1.757527E+02

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.04300E+03	1.17933E+02	5.25311E+02	4.72677E+01	5.31000E+02	0.	0.	3.51300E+00	1.17933E+02
2	1.03671E+03	1.28605E+01	5.25309E+02	4.72638E+01	5.30992E+02	0.	0.	2.20300E+00	1.28605E+01
3	1.03419E+03	1.13801E+01	5.32030E+02	4.69281E+01	5.36297E+02	0.	0.	2.25001E+00	1.13801E+01
4	1.03122E+03	2.88367E+00	5.81787E+02	2.29409E+01	5.48324E+02	5.34881E-02	1.54242E-01	1.16680E+00	2.72943E+00
5	1.03027E+03	2.36992E+00	5.96493E+02	1.88538E+01	5.48212E+02	7.65072E-02	1.81316E-01	1.16680E+00	2.18860E+00
6	1.02945E+03	1.74257E+00	6.10215E+02	1.61648E+01	5.48114E+02	9.79614E-02	1.70704E-01	1.00010E+00	1.57186E+00
7	1.02805E+03	3.50729E+00	6.25401E+02	1.39455E+01	5.47948E+02	1.21790E-01	4.27153E-01	2.33340E+00	3.08013E+00
8	1.02662E+03	1.34798E+00	6.38062E+02	1.25044E+01	5.47778E+02	1.41693E-01	1.90999E-01	1.00010E+00	1.15698E+00
9	1.03100E+03	9.08258E+01	5.25401E+02	4.72559E+01	5.31059E+02	0.	0.	3.26500E+00	9.08258E+01
10	1.02800E+03	4.87100E+01	5.25582E+02	4.72454E+01	5.31198E+02	0.	0.	1.31360E+01	4.87100E+01
11	1.02480E+03	3.06047E+01	6.31284E+02	1.31746E+01	5.47562E+02	1.31545E-01	4.02588E+00	4.78100E+00	2.65788E+01
12	1.02000E+03	7.88789E+00	1.19207E+03	2.29299E+00	5.46989E+02	9.99884E-01	7.88697E+00	3.35400E+00	9.15068E-04
13	1.02170E+03	2.79520E+01	8.18843E+02	5.0914[illegible]	5.47192E+02	4.22399E-01	2.61934E-10	4.70000E-01	1.61451E+01
14	1.02281E+03	3.55243E+02	5.46167E+02	4.5992[illegible]	5.47324E+02	1.72260E-04	6.11940E-02	8.73000E+00	3.551[illegible]2E+02
15	1.02446E+03	1.99158E+02	5.26602E+02	4.71939E+01	5.32000E+02	0.	0.	5.00000E+00	1.99158E+02
16	1.02823E+03	9.42799E+01	5.26596E+02	4.71966E+01	5.32000E+02	0.	0.	2.30340E+01	9.42799E+01
17	1.15260E+03	1.26165E+01	5.27046E+02	4.72529E+01	5.32500E+02	0.	0.	1.18400E+00	1.26165E+01
18	1.15669E+03	2.69830E+01	5.27040E+02	4.72557E+01	5.32500E+02	0.	0.	2.34220E+01	2.69830E+01
19	1.04312E+03	2.53029E+00	5.26576E+02	4.72070E+01	5.32000E+02	0.	0.	3.27500E+00	2.53029E+00
20	1.02460E+03	2.97323E+00	5.26601E+02	4.71941E+01	5.32000E+02	0.	0.	1.24600E+00	2.97323E+00
21	1.02346E+03	9.14841E+00	5.26603E+02	4.71932E+01	5.32000E+02	0.	0.	2.42000E-01	9.14841E+00
22	1.14804E+03	8.86974E+01	5.26422E+02	4.72800E+01	5.32000E+02	0.	0.	1.35370E+01	8.86974E+01
23	1.13997E+03	5.64456E+00	5.26435E+02	4.72744E+01	5.32000E+02	0.	0.	3.05700E+00	5.64456E+00
24	1.04296E+03	2.53029E+00	5.26576E+02	4.72069E+01	5.32000E+02	0.	0.	4.65500E+00	2.53029E+00
25	1.02360E+03	2.75656E+01	5.26603E+02	4.71933E+01	5.32000E+02	0.	0.	4.04400E+00	2.75656E+01
26	1.90000E+01	6.22509E+03	4.85416E+01	3.20042E+00	8.00000E+01	4.81921E-04	0.	5.00000E+00	6.22209E+03
27	1.17783E+03	1.00230E+01	5.26377E+02	4.73006E+01	5.32000E+02	0.	0.	5.52400E+00	1.00230E+01
28	1.03324E+03	8.27417E+00	5.47434E+02	4.60700E+01	5.48418E+02	0.	0.	1.66667E+00	8.27417E+00
29	1.03220E+03	4.67800E+00	5.64702E+02	3.06353E+01	5.48440E+02	2.67539E-02	1.25155E-01	1.41667E+00	4.55285E+00

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		3.77000E+01	5.25310E+02	2.11562E-02	6.03187E+00	-4.60181E-01	-5.43788E+00	1.33815E-01	0.
2	2 TO 3		3.77000E+01	5.25308E+02	2.11583E-02	2.50301E+00	-7.28163E-01	-1.78553E+00	-1.06927E-02	0.
3	29 TO 4		3.77000E+01	5.7359[illegible]E+02	3.83153E-02	6.90986E-01	-2.43631E-01	-4.41092E-01	6.26280E-03	0.
4	4 TO 5		3.77000E+01	5.89482E+02	4.85087E-02	7.00548E-01	-1.69310E-01	-5.20615E-01	1.06228E-02	0.
5	5 TO 6		3.77000E+01	6.03361E+02	5.78225E-02	5.87090E-01	-1.32504E-01	-4.49822E-01	4.76331E-03	0.
6	6 TO 7		3.77000E+01	6.16045E+02	6.56062E-02	1.14010E+00	-1.69110E-01	-9.61187E-01	9.80724E-03	0.
7	7 TO 8		3.77000E+01	6.35312E+02	7.81183E-02	1.21185E+00	-1.56400E-01	-1.05198E+00	3.46575E-03	0.
8	8 TO 11		3.77000E+01	6.40210E+02	8.13884E-02	2.81467E+00	-2.62122E-01	-1.54672E+00	1.00582E+00	0.
9	1 TO 9		3.10000E+00	5.25310E+02	2.11562E-02	1.20140E+01	2.35638E-02	-7.03974[illegible]+00	4.99781E+00	0.
10	9 TO 10		3.10000E+00	5.25399E+02	2.11615E-02	2.99780E+00	-2.68211E+00	-3.93339E-02	2.76348E-01	0.
11	10 TO 11		3.10000E+00	5.25574E+02	2.11665E-02	3.12451E+00	-2.35834E+00	-5.94004E-03	7.60224E-01	0.
12	11 TO 13		4.08000E+01	6.31281E+02	7.59312E-02	3.04721E+00	-2.08710E-01	-2.61226E+00	2.26243E-01	0.
13	13 TO 12		5.11000E+00	1.19209E+03	4.35384E-01	1.01283E+00	-4.11525E-02	-9.17288E-03	1.76250E+00	0.
14	13 TO 14		3.56900E+01	5.46737E+02	2.21997E-02	-1.00308E+00	1.43386E+00	-1.25927E-02	4.18195E-01	0.
15	14 TO 15		3.91100E+01	5.46078E+02	2.16718E-02	-1.65326E+00	2.11583E+00	-8.20716E-04	4.61755E-01	0.
16	15 TO 16		1.00000E+01	5.26605E+02	2.11890E-02	-3.86854E+00	4.13524E+00	-2.66353E-01	3.41998E-04	0.
17	16 TO 17		1.00000E+01	5.26611E+02	2.11873E-02	-1.24372E+02	3.58053E+00	-1.35091E-01	9.35895E-02	1.21020E+02

18	17 TO 18	1.00000E+01	5.27045E+02	2.11628E-02	-1.38919E+01	-3.99605E+00	-1.35312E+01	8.96007E+01	1.21020E+02
19	18 TO 19	1.00000E+01	5.27025E+02	2.11651E-02	1.67703E+01	-3.21968E+00	-1.35243E+01	2.63649E-02	0.
20	15 TO 19	1.15000E+01	5.26602E+02	2.11892E-02	3.13[illegible]93E+01	5.09940E-01	-2.44921E+01	7.36715E+00	0.
21	19 TO 1	2.15000E+01	5.26578E+02	2.11836E-02	1.85506E+00	1.11141E+00	-2.97494E+00	-8.47162E-03	0.
22	15 TO 20	9.41000E+00	5.26605E+02	2.11890E-02	-3.16325E-01	5.64688E-01	-2.48446E-01	-8.35209E-05	0.
23	20 TO 21	9.41000E+00	5.26600E+02	2.11892E-02	1.23024E+00	-1.64524E-01	-9.70003E-01	9.57168E-02	0.
24	21 TO 22	9.41000E+00	5.26603E+02	2.11895E-02	-1.24582E+02	2.18260E+00	-1.10007E-01	7.56682E-03	1.22517E+02
25	22 TO 23	9.41000E+00	5.26415E+02	2.11509E-02	-6.07343E-01	-2.19518E+00	-1.10327E+01	1.08681E+02	1.22517E+02
26	23 TO 24	9.41000E+00	5.26433E+02	2.11554E-02	1.07862E+01	3.47891E-01	-1.09183E+01	2.15857E-01	0.
27	15 TO 24	1.04900E+01	5.26602E+02	2.11892E-02	2.65764E+01	7.36139E-01	-2.04279E+01	6.88465E+00	0.
28	24 TO 1	1.99000E+01	5.26578E+02	2.11836E-02	1.44656E+00	8.84922E-01	-2.56427E+00	-2.32789E-01	0.
29	21 TO 25	0.	5.26606E+02	2.11893E-02	5.26869E-02	-6.59396E-01	-1.03198E-02	-[illegible].17029E-01	0.
30	25 TO 26	0.	5.26601E+02	2.11896E-02	1.00460E+03	-6.13298E-01	0.	0.	0.
31	27 TO 23	0.	5.26381E+02	2.11412E-02	2.03129E+01	4.05454E-01	-8.12580E+00	1.25926E+01	0.
32	27 TO 26	0.	5.26374E+02	2.11415E-02	1.15883E+03	-8.57764E-01	0.	0.	0.
33	3 TO 28	3.77000E+01	5.38730E+02	2.14736E-02	9.35522E-01	-6.33233E-01	-2.95786E-01	6.50215E-03	0.
34	28 TO 29	3.77000E+01	5.56113E+02	2.71279E-02	7.55305E-01	-4.17301E-01	-3.33133E-01	4.87135E-03	0.
36	0 TO 15	1.69000E+00	4.70733E+01	1.60682E-02	0.	7.26262E-01	0.	0.	0.
35	0 TO 12	-5.11000E+00	1.19211E+03	4.36142E-01	0.	1.58435E-02	0.	0.	0.

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUF	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	17	3.55000E+03	8.93026E-01	0.	1.00000E+00	1.07533E+05
2	22	3.55000E+03	9.29338E-01	0.	1.00000E+00	1.77450E+05

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	3	2	1.38934E+05	8.00000E+05	1.17634E+04	5.60487E+02	1.25900E+06	8.12654E+01	4.60342E+04
2	RIGHT	28	2	2.43101E+05	8.00000E+05	1.55488E+04	5.64199E+02	1.25900E+06	5.36408E+01	5.96659E+04
3	RIGHT	29	2	2.92682E+05	7.73246E+05	1.70468E+04	5.65610E+02	1.25900E+06	4.44828E+01	6.10597E+04
4	RIGHT	4	2	3.07735E+05	7.46512E+05	1.74660E+04	5.55943E+02	1.25900E+06	3.65143E+01	5.28706E+04
5	RIGHT	5	2	2.98613E+05	7.23493E+05	1.71923E+04	5.65581E+02	1.25900E+06	3.66675E+01	5.13035E+04
6	RIGHT	6	2	2.72039E+05	7.02039E+05	1.63988E+04	5.64703E+02	1.25900E+06	3.16955E+01	4.00610E+04
7	RIGHT	7	2	1.98210E+05	6.78210E+05	1.39822E+04	5.62124E+02	1.25900E+06	7.75161E+01	6.81072E+04
8	RIGHT	8	2	1.00247E+05	6.58307E+05	9.93245E+03	5.57871E+02	1.25900E+06	3.83979E+01	1.47626E+04
9	RIGHT	3	2	7.84302E+04	8.00000E+05	8.83836E+03	5.57550E+02	1.25900E+06	7.00664E+01	2.59871E+04
10	RIGHT	28	2	1.37147E+05	8.00000E+05	1.16788E+04	5.60307E+02	1.25900E+06	4.83184E+01	3.36609E+04
11	RIGHT	29	2	1.65252E+05	7.73246E+05	1.28091E+04	5.61342E+02	1.25900E+06	4.05617E+01	3.44751E+04
12	RIGHT	4	2	1.73721E+05	7.46512E+05	1.31230E+04	5.61562E+02	1.25900E+06	3.34483E+01	2.98463E+04
13	RIGHT	5	2	1.68600E+05	7.23493E+05	1.29184E+04	5.61263E+02	1.25900E+06	3.34099E+01	2.89665E+04
14	RIGHT	6	2	1.53571E+05	7.02039E+05	1.23211E+04	5.60578E+02	1.25900E+06	2.85518E+01	2.26152E+04
15	RIGHT	7	2	1.11893E+05	6.78210E+05	1.05055E+04	5.58599E+02	1.25900E+06	6.89397E+01	3.84477E+04
16	RIGHT	8	2	5.65908E+04	6.58307E+05	7.46266E+03	5.55361E+02	1.25900E+06	3.24145E+01	8.33367E+03
17	RIGHT	3	2	1.12187E+05	8.00000E+05	1.05706E+04	5.59289E+02	1.25900E+06	3.57744E+03	1.74708E+06
18	RIGHT	28	2	1.96175E+05	8.00000E+05	1.39677E+04	5.62609E+02	1.25900E+06	2.40289E+03	2.26297E+06
19	RIGHT	29	2	2.36375E+05	7.73246E+05	1.53195E+04	5.63870E+02	1.25900E+06	2.00692E+03	2.31770E+06
20	RIGHT	4	2	2.48488E+05	7.46512E+05	1.56949E+04	5.64157E+02	1.25900E+06	1.65657E+03	2.00652E+06
21	RIGHT	5	2	2.41164E+05	7.23493E+05	1.54502E+04	5.63821E+02	1.25900E+06	1.65372E+03	1.94737E+06
22	RIGHT	6	2	2.19665E+05	7.02039E+05	1.47359E+04	5.63021E+02	1.25900E+06	1.41085E+03	1.52036E+06
23	RIGHT	7	2	1.60051E+05	6.78210E+05	1.25644E+04	5.60687E+02	1.25900E+06	3.45578E+03	2.58477E+06
24	RIGHT	8	2	8.09461E+04	6.58307E+05	8.92522E+03	5.56848E+02	1.25900E+06	1.67699E+03	5.60252E+05
25	RIGHT	1	1	-1.57487E-09	9.00000E+04	4.32897E+02	5.31000E+02	1.99946E+05	5.77769E+04	-2.82374E-08
26	RIGHT	15	1	-1.21614E-09	9.00000E+04	3.34290E+02	5.32000E+02	1.54077E+05	7.13621E+04	-2.68645E-08
27	RIGHT	14	2	1.99671E-06	9.00000E+04	4.41942E-02	5.47324E+02	1.40206E+05	1.26123E+05	7.54358E-05
28	RIGHT	13	1	-1.49102E-09	9.00000E+04	4.09849E+02	5.47192E+02	1.86396E+05	6.58468E+04	-2.94178E-08
29	RIGHT	12	8	-1.81899E-11	9.00000E+04	5.00000E+00	5.46989E+02	0.	4.85391E+04	-2.64663E-10
30	RIGHT	13	1	-1.65155E-09	1.02011E+05	4.53975E+02	5.47192E+02	1.86396E+05	3.99947E+03	-2.14702E-08
31	RIGHT	16	1	-5.82956E-09	1.39552E+05	1.60242E+03	5.32000E+02	7.84827E+05	1.22027E+04	-9.91025E-08
32	RIGHT	18	1	-3.12076E-08	2.21615E+05	8.57827E+03	5.32500E+02	7.50000E+06	2.41147E+04	-1.04733E-06
33	RIGHT	20	1	-1.10031E-08	5.64618E+05	3.02452E+03	5.32000E+02	1.01975E+06	2.59203E+03	-3.97213E-08
34	RIGHT	21	1	-5.55310E-09	1.86174E+05	1.52642E+03	5.32000E+02	7.38522E+05	2.59203E+03	-2.00467E-08
35	RIGHT	22	1	-5.54389E-09	1.69836E+05	1.52389E+03	5.32000E+02	7.38522E+05	2.36368E+04	-1.82560E-07
36	RIGHT	23	1	-3.84093E-08	3.87923E+05	1.05579E+04	5.32000E+02	7.05750E+06	2.35441E+03	-1.25982E-07
37	RIGHT	25	1	-1.81899E-11	9.00000E+04	5.00000E+00	5.32000E+02	0.	1.42341E+04	-3.60706E-10
38	RIGHT	27	1	-1.81899E-11	9.00000E+04	5.00000E+00	5.32000E+02	0.	7.27079E+03	-1.84264E-10

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.	0.	0.	4.60343E+04	0.	5.92422E+02	5.92422E+02
2	2	0.	0.	0.	5.96279E+04	0.	5.91269E+02	5.91269E+02
3	3	0.	0.	0.	6.10703E+04	0.	5.91668E+02	5.91668E+02
4	4	0.	0.	0.	5.28706E+04	0.	5.92224E+02	5.92224E+02
5	5	0.	0.	0.	5.13123E+04	0.	5.92164E+02	5.92164E+02
6	6	0.	0.	0.	4.00610E+04	0.	5.91293E+02	5.91293E+02
7	7	0.	0.	0.	6.81072E+04	0.	5.90407E+02	5.90407E+02
8	8	0.	0.	0.	1.47625E+04	0.	5.89824E+02	5.89824E+02
9	9	0.	0.	0.	2.59871E+04	0.	5.67282E+02	5.67282E+02
10	10	0.	0.	0.	3.36609E+04	0.	5.68795E+02	5.68795E+02
11	11	0.	0.	0.	3.44752E+04	0.	5.69760E+02	5.69760E+02
12	12	0.	0.	0.	2.98463E+04	0.	5.70410E+02	5.70410E+02
13	13	0.	0.	0.	2.89665E+04	0.	5.69852E+02	5.69852E+02
14	14	0.	0.	0.	2.26152E+04	0.	5.68405E+02	5.68405E+02
15	15	0.	0.	0.	3.84477E+04	0.	5.67440E+02	5.67440E+02
16	16	0.	0.	0.	8.33367E+03	0.	5.64816E+02	5.64816E+02
17	17	0.	0.	0.	1.74708E+06	0.	5.79670E+02	5.79670E+02
18	18	0.	0.	0.	2.26298E+06	0.	5.80027E+02	5.80027E+02
19	19	0.	0.	0.	2.31772E+06	0.	5.81062E+02	5.81062E+02
20	20	0.	0.	0.	2.00652E+06	0.	5.82224E+02	5.82224E+02
21	21	0.	0.	0.	1.94738E+06	0.	5.81360E+02	5.81360E+02
22	22	0.	0.	0.	1.52038E+06	0.	5.79009E+02	5.79009E+02
23	23	0.	0.	0.	2.58478E+06	0.	5.78930E+02	5.78930E+02
24	24	0.	0.	0.	5.60262E+05	0.	5.76983E+02	5.76983E+02

RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (GE-BDHT-TLTA TEST-4906)
CPU TIME = 222.494

* *

STANDARD TIME STEP NUMBER = 325 ACTUAL TIME STEP NUMBER = 471 TIME = 1.000000E+00 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
9.645280E-01	4.398248E+00	1.507862E+07	0.	1.454593E+06	7.435438E+03	1.757527E+02

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.00824E+03	1.17822E+02	5.25782E+02	4.72234E+01	5.31335E+02	0.	0.	3.51300E+00	1.17822E+02
2	1.00644E+03	1.28537E+01	5.25436E+02	4.72389E+01	5.31059E+02	0.	0.	2.20300E+00	1.28537E+01
3	1.00529E+03	1.12630E+01	5.40582E+02	4.64454E+01	5.43004E+02	0.	0.	2.25001E+00	1.12630E+01
4	1.00335E+03	1.64496E+00	6.27372E+02	1.30864E+01	5.44987E+02	1.29714E-01	2.13373E-01	1.16680E+00	1.43159E+00
5	1.00279E+03	1.37229E+00	6.50574E+02	1.09172E+01	5.44918E+02	1.65537E-01	2.27165E-01	1.16680E+00	1.14512E+00
6	1.00227E+03	1.03844E+00	6.69202E+02	9.63298E+00	5.44856E+02	1.94301E-01	2.01769E-01	1.00010E+00	8.36666E-01
7	1.00136E+03	2.16386E+00	6.88020E+02	8.60381E+00	5.44745E+02	2.23416E-01	4.83440E-01	2.33340E+00	1.68042E+00
8	1.00042E+03	8.69696E-01	6.99602E+02	8.06768E+00	5.44631E+02	2.41391E-01	2.09937E-01	1.00010E+00	6.59759E-01
9	1.00489E+03	9.08036E+01	5.25302E+02	4.72443E+01	5.30952E+02	0.	0.	3.26500E+00	9.08036E+01
10	1.00225E+03	4.86989E+01	5.25471E+02	4.72346E+01	5.31083E+02	0.	0.	1.31360E+01	4.86989E+01
11	9.99870E+02	2.61454E+01	6.45655E+02	1.12550E+01	5.44565E+02	1.58518E-01	4.14452E+00	4.78100E+00	2.20009E+01
12	9.97603E+02	7.72546E+00	1.19021E+03	2.24577E+00	5.44289E+02	9.95866E-01	0.	6.71885E-04	3.19379E-02
13	9.97522E+02	1.92936E+01	9.44363E+02	3.51432E+00	5.44280E+02	6.18029E-01	2.04106E-03	2.14860E-01	7.36961E+00
14	9.98726E+02	2.99213E+02	5.48885E+02	3.87381E+01	5.44426E+02	9.96355E-03	1.44825E+00	7.95641E+00	2.96232E+02
15	1.00069E+03	1.98038E+02	5.31591E+02	4.69283E+01	5.35913E+02	0.	0.	5.00000E+00	1.98038E+02
16	1.00466E+03	9.42313E+01	5.26790E+02	4.71722E+01	5.32127E+02	0.	0.	2.30340E+01	9.42313E+01
17	1.08807E+03	1.25948E+01	5.27889E+02	4.71716E+01	5.33084E+02	0.	0.	1.18400E+00	1.25948E+01
18	1.13997E+03	2.69755E+01	5.27098E+02	4.72425E+01	5.32525E+02	0.	0.	2.34220E+01	2.69755E+01
19	1.00875E+03	2.52152E+00	5.29441E+02	4.70433E+01	5.34225E+02	0.	0.	3.27500E+00	2.52152E+00
20	9.76848E+02	2.95687E+00	5.31163E+02	4.69344E+01	5.35547E+02	0.	0.	1.24600[illegible]00	2.95687E+00
21	5.40827E+02	1.91835E+00	5.31221E+02	9.89606E+00	4.75172E+02	9.70121E-02	1.86103E-01	2.4200[illegible]-01	1.73225E+00
22	7.97143E+02	5.23313E+01	5.28169E+02	2.78951E+01	5.17797E+02	2.72571E-02	1.42640E+00	1.35[illegible]0E+01	5.09049E+01
23	1.73165E+02	1.76096E-01	5.58695E+02	1.47484E+00	3.69918E+02	2.52935E-01	4.45409E-02	3.0[illegible]00E+00	1.[illegible]1555E-01
24	1.00142E+03	2.53129E+00	5.25650E+02	4.72255E+01	5.31223E+02	0.	0.	4.[illegible]500E+00	2.53129E+00
25	5.17100E+02	5.13703E+00	5.33956E+02	8.79478E+00	4.70488E+02	1.07107E-01	5.50211E-01	4.[illegible]4400E+00	4.58682E+00
26	1.96659E+01	6.88437E+03	6.05564E+01	3.28006E+00	9.18437E+01	6.70258E-04	0.	5.[illegible]3728E+00	6.38009E+03
27	1.32006E+02	1.95956E-01	5.93950E+02	9.24757E-01	3.48503E+02	3.14024E-01	6.15349E-02	[illegible].52400E+00	1.34421E-01
28	1.00450E+03	4.63348E+00	5.69688E+02	2.57989E+01	5.45126E+02	4.06574E-02	1.88386E-01	[illegible].66667E+00	4.44510E+00
29	1.00391E+03	2.59705E+00	6.00401E+02	1.70075E+01	5.45054E+02	8.80768E-02	2.28740E-01	1.41667E+00	2.36831E+00

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S — STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.79249E+01	5.25778E+02	2.11759E-02	1.74646E+00	-4.59862E-01	-1.30478E+00	-1.81854E-02	0.
2	2 TO 3		1.79333E+01	5.25433E+02	2.11691E-02	1.14041E+00	-7.24206E-01	-4.83207E-01	-6.69982E-02	0.
3	29 TO 4		1.98662E+01	6.14604E+02	6.80495E-02	3.88403E-01	-1.36872E-01	-2.70429E-01	-1.88972E-02	0.
4	4 TO 5		2.05431E+01	6.39002E+02	8.39976E-02	4.08769E-01	-9.74067E-02	-3.32855E-01	-2.14919E-02	0.
5	5 TO 6		2.11697E+01	6.61143E+02	9.84998E-02	3.67390E-01	-7.78236E-02	-3.14318E-01	-2.47519E-02	0.
6	6 TO 7		2.17098E+01	6.76498E+02	1.08582E-01	7.25417E-01	-1.03381E-01	-6.65599E-01	-4.35630E-02	0.
7	7 TO 8		2.29369E+01	6.98021E+02	1.22827E-01	7.82779E-01	-9.79424E-02	-7.35497E-01	-5.06595E-02	0.
8	8 TO 11		2.34485E+01	7.00656E+02	1.24672E-01	1.12094E+00	-2.15152E-01	-9.58162E-01	-5.23775E-02	0.
9	1 TO 9		2.14223E+00	5.25778E+02	2.11759E-02	3.29437E+00	2.37357E-02	-3.37576E+00	-5.76550E-02	0.
10	9 TO 10		2.16107E+00	5.25301E+02	2.11666E-02	2.76010E+00	-2.68149E+00	-1.91702E-02	5.94333E-02	0.
11	10 TO 11		2.16389E+00	5.25463E+02	2.11713E-02	2.28571E+00	-2.32843E+00	-3.29725E-03	-4.60205E-02	0.
12	11 TO 13		3.38492E+01	6.45495E+02	8.87637E-02	2.26057E+00	-1.78251E-01	-2.11077E+00	-2.84445E-02	0.
13	13 TO 12		3.10745E+00	1.19290E+03	4.47084E-01	4.70926E-02	-4.00447E-02	-8.64835E-03	-1.60041E-03	0.
14	13 TO 14		3.48225E+01	5.85001E+02	4.95404E-02	-1.11123E+00	1.07376E+00	-1.72078E-02	-5.46802E-02	0.
15	14 TO 15		9.96266E+01	5.43013E+02	2.18460E-02	-1.98321E+00	2.04214E+00	-3.73616E-03	5.51926E-02	0.
16	15 TO 16		1.10023E+01	5.31574E+02	2.13085E-02	-4.05911E+00	4.12965E+00	-3.24303E-01	-2.53764E-01	0.
17	16 TO 17		1.10694E+01	5.26802E+02	2.11981E-02	-8.35214E+01	3.57888E+00	-1.62979E-01	-3.37427E-01	7.97680E+01

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18	17 TO 18		1.10814E+01	5.27887E+02	2.11992E-02	-6.42051E+01	-3.99470E+00	-1.67463E+01	-5.17804E+00	7.97680E+01
19	18 TO 19		1.11065E+01	5.27083E+02	2.11716E-02	1.95764E+01	-3.22049E+00	-1.70999E+01	-7.43947E-01	0.
20	15 TO 19		1.57158E+01	5.31571E+02	2.13086E-02	4.48555E+01	5.08229E-01	-4.55332E+01	-1.69411E-01	0.
21	19 TO 1		2.68312E+01	5.29431E+02	2.12572E-02	3.23810E+00	1.10903E+00	-4.55692E+00	-2.09797E-01	0.
22	15 TO 20		7.34839E+01	5.31574E+02	2.13085E-02	1.26352E+01	5.61508E-01	-1.32256E+01	-2.88266E-02	0.
23	20 TO 21	EX.HEN.	7.35008E+01	5.31142E+02	2.13072E-02	3.95244E+02	-1.63622E-01	4.01110E+02	-1.31044E+00	0.
24	21 TO 22		-3.11603E+01	5.28125E+02	3.60374E-02	-1.99748E+02	1.29080E+00	-9.73519E-01	2.31265E+00	2.01744E+02
25	22 TO 23	MOODY	0.	5.28139E+02	3.58252E-02	6.24044E+02	-1.01707E+00	0.	0.	2.01744E+02
26	23 TO 24	EX.HEN.	-7.69583E+00	5.26264E+02	2.11891E-02	-4.64725E+02	7.46597E-01	-3.91969E+02	6.65944E-01	0.
27	15 TO 24		8.19596E-01	5.31571E+02	2.13086E-02	-7.53076E-01	7.36567E-01	5.84127E-02	4.19039E-02	0.
28	24 TO 1		-6.88423E+00	5.25778E+02	2.11759E-02	-6.76896E+00	8.84809E-01	5.91222E+00	2.80674E-02	0.
29	21 TO 25		1.06185E+02	5.30642E+02	1.00702E-01	2.25224E+01	-1.23242E-01	-2.49429E+01	-2.54382E+00	0.
30	25 TO 26	MOODY	1.09937E+02	5.33930E+02	1.13418E-01	4.98150E+02	-1.15171E-01	5.01390E+02	-3.35546E+00	0.
31	27 TO 23		-7.54266E+00	5.21862E+02	1.11298E+00	-1.13800E+02	2.10747E-03	1.13375E+02	-4.22680E-01	0.
32	27 TO 26	MOODY	7.46107E+00	5.95983E+02	1.08331E+00	1.12986E+02	-1.73610E-02	1.11888E+02	1.08065E+00	0.
33	3 TO 28		1.79627E+01	5.52326E+02	2.74312E-02	6.75387E-01	-5.12292E-01	-1.26370E-01	3.67254E-02	0.
34	28 TO 29		1.90131E+01	5.84430E+02	4.83606E-02	4.27157E-01	-2.33203E-01	-2.08266E-01	-1.43121E-02	0.
36	0 TO 15		2.57950E-01	4.70733E+01	1.60682E-02	0.	7.26262E-01	0.	0.	0.
35	0 TO 12		-3.20501E+00	1.19290E+03	4.47021E-01	0.	1.58435E-02	0.	0.	0.

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	17	2.94418E+03	6.74952E-01	1.00000E+00	1.00000E+00	6.74041E+04
2	22	0.	9.96783E-01	1.00000E+00	1.00000E+00	0.

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	3	2	1.38699E+05	8.00000E+05	1.14877E+04	5.57304E+02	5.99573E+05	8.09023E+01	4.59567E+04
2	RIGHT	28	2	2.38049E+05	7.59423E+05	1.50402E+04	5.60962E+02	6.18035E+05	5.34065E+01	5.84259E+04
3	RIGHT	29	2	2.85591E+05	7.12099E+05	1.64660E+04	5.62407E+02	6.50192E+05	4.42959E+01	5.95802E+04
4	RIGHT	4	2	3.00055E+05	6.70574E+05	1.68704E+04	5.62781E+02	6.75978E+05	3.63632E+01	5.15512E+04
5	RIGHT	5	2	2.88629E+05	6.34845E+05	1.62646E+04	5.62672E+02	6.98004E+05	3.65172E+01	4.95882E+04
6	RIGHT	6	2	2.54441E+05	6.06194E+05	1.27662E+04	5.64795E+02	7.17713E+05	3.16260E+01	3.74695E+04
7	RIGHT	7	2	1.82435E+05	5.77189E+05	9.68032E+03	5.63599E+02	7.47723E+05	7.74353E+01	6.26868E+04
8	RIGHT	8	2	9.47715E+04	5.59279E+05	7.40110E+03	5.57443E+02	7.76683E+05	3.83145E+01	1.39562E+04
9	RIGHT	3	2	7.87094E+04	8.00000E+05	8.65382E+03	5.54325E+02	5.99573E+05	6.97836E+01	2.60796E+04
10	RIGHT	28	2	1.34729E+05	7.59423E+05	1.13149E+04	5.57041E+02	6.18035E+05	4.81389E+01	3.30675E+04
11	RIGHT	29	2	1.61720E+05	7.12099E+05	1.23908E+04	5.58114E+02	6.50192E+05	4.04166E+01	3.37383E+04
12	RIGHT	4	2	1.69880E+05	6.70574E+05	1.26939E+04	5.58378E+02	6.75978E+05	3.33299E+01	2.91864E+04
13	RIGHT	5	2	1.63293E+05	6.34845E+05	1.22625E+04	5.58243E+02	6.98004E+05	3.32938E+01	2.80547E+04
14	RIGHT	6	2	1.44088E+05	6.06194E+05	9.91188E+03	5.59401E+02	7.17713E+05	2.84925E+01	2.12187E+04
15	RIGHT	7	2	1.04223E+05	5.77189E+05	7.81928E+03	5.58082E+02	7.47723E+05	6.88296E+01	3.58123E+04
16	RIGHT	8	2	5.53189E+04	5.59279E+05	6.27837E+03	5.53449E+02	7.76683E+05	3.23199E+01	8.14637E+03
17	RIGHT	3	2	1.12143E+05	8.00000E+05	1.03295E+04	5.56087E+02	5.99573E+05	3.56199E+03	1.74640E+06
18	RIGHT	28	2	1.92223E+05	7.59423E+05	1.35152E+04	5.59357E+02	6.18035E+05	2.39310E+03	2.21739E+06
19	RIGHT	29	2	2.30815E+05	7.12099E+05	1.48030E+04	5.60655E+02	6.50192E+05	1.99904E+03	2.26319E+06
20	RIGHT	4	2	2.42503E+05	6.70574E+05	1.51665E+04	5.60985E+02	6.75978E+05	1.65011E+03	1.95819E+06
21	RIGHT	5	2	2.33190E+05	6.34845E+05	1.46306E+04	5.60865E+02	6.98004E+05	1.64740E+03	1.882[illegible]8E+06
22	RIGHT	6	2	2.05371E+05	6.06194E+05	1.15723E+04	5.62611E+02	7.17713E+05	1.40803E+03	1.42144E+06
23	RIGHT	7	2	1.47696E+05	5.77189E+05	8.90576E+03	5.61337E+02	7.47723E+05	3.45162E+03	2.38525E+06
24	RIGHT	8	2	7.73185E+04	5.59279E+05	6.93322E+03	5.55790E+02	7.76683E+05	1.67280E+03	5.35144E+05
25	RIGHT	1	1	-8.03490E+01	9.00000E+04	2.43639E+02	5.31003E+02	9.73806E+04	5.77770E+04	-1.44066E+03
26	RIGHT	15	1	-2.60426E+03	9.00000E+04	6.8585[illegible]E+02	5.32100E+02	3.76734E+05	7.13699E+04	-5.75280E+04
27	RIGHT	14	2	6.71502E+03	9.00000E+04	2.51449E+0[illegible]	5.47103E+02	2.53744E+05	1.26094E+05	2.53694E+05
28	RIGHT	13	3	4.42654E+03	9.00000E+04	1.63739E+03	5.46989E+02	1.64518E+05	6.58326E+04	8.73356E+04
29	RIGHT	12	3	1.34647E+01	9.00000E+04	5.00074E+00	5.46988E+02	1.71330E+02	4.85391E+04	1.95912E+02
30	RIGHT	13	3	2.66368E+03	1.02374E+05	1.81368E+03	5.45755E+02	1.64518E+05	3.99247E+03	3.46278E+04
31	RIGHT	16	1	-1.96842E+02	1.34128E+05	1.73669E+03	5.32012E+02	8.67430E+05	1.22029E+04	-3.34632E+03
32	RIGHT	18	1	6.91790E+01	2.19107E+05	9.34859E+03	5.32532E+02	8.34859E+06	2.41160E+04	2.32165E+03
33	RIGHT	20	1	-1.32692E+04	8.01264E+05	1.57192E+04	5.34687E+02	7.96801E+06	2.60066E+03	-4.79018E+04
34	RIGHT	21	2	1.72844E+05	2.09560E+06	9.51351E+03	4.93487E+02	5.84034E+06	2.46952E+03	6.23968E+05
35	RIGHT	22	2	4.21234E+04	4.34719E+05	5.36822E+03	5.25704E+02	1.29326E+06	2.34584E+04	1.38712E+06
36	RIGHT	23	3	4.11798E+05	1.48519E+06	4.08056E+04	3.80174E+02	5.70735E+06	1.93937E+03	1.35070E+06
37	RIGHT	25	7	5.17082E+04	9.00735E+04	1.16240E+03	5.15115E+02	3.89696E+01	1.39300E+04	1.02537E+06
38	RIGHT	27	3	8.77835E+02	9.00000E+04	5.00000E+00	5.24443E+02	1.51613E-02	7.19609E+03	8.89247E+03

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.	0.	0.	4.44014E+04	0.	5.91059E+02	5.92208E+02
2	2	0.	0.	0.	5.75128E+04	0.	5.89723E+02	5.91115E+02
3	3	0.	0.	0.	5.89040E+04	0.	5.90115E+02	5.91523E+02
4	4	0.	0.	0.	5.09952E+04	0.	5.90681E+02	5.92083E+02
5	5	0.	0.	0.	4.94921E+04	0.	5.90640E+02	5.92023E+02
6	6	0.	0.	0.	3.86399E+04	0.	5.90363E+02	5.91153E+02
7	7	0.	0.	0.	6.56913E+04	0.	5.89812E+02	5.90264E+02
8	8	0.	0.	0.	1.42389E+04	0.	5.88964E+02	5.89580E+02
9	9	0.	0.	0.	2.50653E+04	0.	5.65946E+02	5.67129E+02
10	10	0.	0.	0.	3.24669E+04	0.	5.67386E+02	5.68662E+02
11	11	0.	0.	0.	3.32523E+04	0.	5.68359E+02	5.69632E+02
12	12	0.	0.	0.	2.87876E+04	0.	5.69022E+02	5.70284E+02
13	13	0.	0.	0.	2.79390E+04	0.	5.68489E+02	5.69727E+02
14	14	0.	0.	0.	2.18130E+04	0.	5.67550E+02	5.68285E+02
15	15	0.	0.	0.	3.70839E+04	0.	5.66788E+02	5.67321E+02
16	16	0.	0.	0.	8.03806E+03	0.	5.63868E+02	5.64674E+02
17	17	0.	0.	0.	1.68511E+06	0.	5.78323E+02	5.79490E+02
18	18	0.	0.	0.	2.18270E+06	0.	5.78550E+02	5.79883E+02
19	19	0.	0.	0.	2.23551E+06	0.	5.79585E+02	5.80925E+02
20	20	0.	0.	0.	1.93535E+06	0.	5.80754E+02	5.82089E+02
21	21	0.	0.	0.	1.87830E+06	0.	5.79916E+02	5.81227E+02
22	22	0.	0.	0.	1.46645E+06	0.	5.78175E+02	5.78880E+02
23	23	0.	0.	0.	2.49309E+06	0.	5.78360E+02	5.78800E+02
24	24	0.	0.	0.	5.40389E+05	0.	5.76119E+02	5.76801E+02

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5.0 TURBINE TRIP WITHOUT BYPASS

The BWR plant modeled for the Turbine Trip Without Bypass (TTWOB) Sample Problem was a General Electric BWR/4. Since not all these plants are the same, the results are not necessarily totally applicable to a specific plant. The initial conditions were assumed to be conservative, as in the SAR. The initial power level was 104% of normal, with normal core flow and 105% of normal steam flow assumed. End of core life conditions were used to develop the physics parameters including the scram curve worth.

The geometric nodalization used in the TTWOB transient analysis sample problem is shown in Figure IX.5-1. The model utilizes 20 control volumes and 26 junctions. The control system requiring modeling for the TTWOB problem included the turbine stop valve, the safety relief valves, and the feedwater control system. The model is discussed in greater detail in EPRI NP-45[illegible] [IX.5-1].

The TTWOB sample problem input is given below. It is noted that this example created a restart-plot tape, and had minor edits and printer plots. This sample problem was also used for examples of RESTRT, REEDIT, and PLOTER. These are discussed in Sections X, XI, and XII. TTWOB output at 0.0 second, the minor edits, and representative printer plots are given for the TTWOB sample problem.

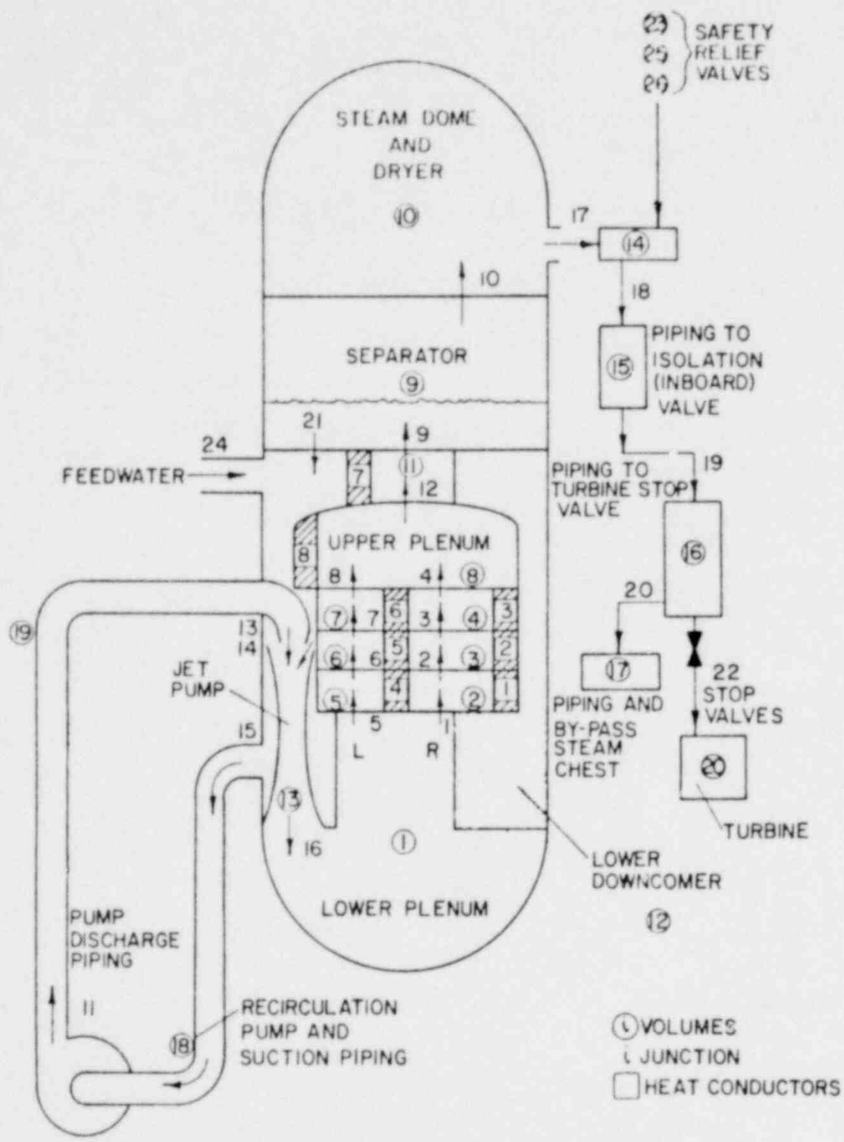

Figure IX.5-1 BWR TTWOB RETRAN Model

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LISTING OF INPUT DATA FOR CASE 1

```
 1   =RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
 2   * ASSUME CONSTANT RECIRC PUMP SPEED
 3   *
 4   *10001 TAP EDT STP TRP VOL BUB TDV JUN PMP CKV NLK FIL SLB GOM MAT COR HTX
 5   *
 6   010001  0  -8   4   9   20  3   0   26  1   4   5   4   8   4   5   6   0
 7   010001 -1  -8   4   9   20  3   0   26  1   4   5   4   8   4   5   6   0
     CARD ABOVE IS REPLACEMENT CARD.
 8   *
 9   *10002 NTMM NODEL MWR  NLV MID  ISF CHT  SS  PRZ  TRN  IDNB  ICF
10   *
11   010002  1     2    0    1   0    0   0    0    0    0     1    1
12   *
13   *   PROBLEM  CONSTANTS  *
14   *
15   *10005    POWER    IMP/EXP
16   *
17   010005    2533.4      1.0
18   *
19   **
20   *  CHANGES FOR  *IBM*  MACHINE*  RUNS  ***************************************
21   *
22   *
23   020000  *PNRM* 0  *RD**  0  *RV**  0  *PRES* 10
24   020001  *WP**  24  *WP**  17  *RF**  0  *MIXL* 9
25   *
26   702001      1     *LIQL*  9    8.00     39.78       * LIQUID  LEVEL  VOL 9
27   702002      2     *WP**  17    0.012    36.649      * STEAM  FLOW
28   702003      3     *WP**  24    0.012    36.649      *  FEEDWATER FLOW
29   702004      4    *CONS*   0    1.0       1.0        * SETPOINT CONSTANT
30   *703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1    CP2     CIC      CMIN     CMAX
31   703001    -1  *SUM*    1    -2     1.0    1.0    1.0   39.78
32   703002     -2 *SUM*    2     3     0.8   -1.0    1.0    0.0     -32.0     32.0
33   703003    -3  *SUM*   -1     4     1.0    1.0  -39.78   0.0
34   703004    -4  *LLG*   -3     0    -1.67   0.6     6.0   0.0
35   703005    -5  *INT*   -4     0     0.025  0.0    0.0    0.0     -15.6     24.4
36   703006    -6  *SUM*   -5    -4     1.0    1.0    1.0    0.0      -50.0    50.0
37   703007    -7  *SUM*   -6     4     1.0    1.0   44.747 44.747    0.0     50.0
38   703008    -8  *DLY*   -7    10     1.0    0.2    0.0    44.747    0.0     50.0
39   703009    -9  *FNG*   -8     5  3515.81   0.0    0.0    3054.1   292.98  3515.81
40   703010   -10  *VLM*   -9     0     1.0   732.5  732.5  3054.1   292.98  3515.81
41   *
42   *
43   *
44   010040    *RETRANBWRTTWOBSHO*
45   010050  *STEAMTABLE        *  *DISK*  *EIUCC*  1
46   *
47   *20000    EDIT VARIABLES
48   *
49   020000  *PNRM* 0  *RD**  0  *RV**  0  *PRES* 10
     CARD ABOVE IS REPLACEMENT CARD.
50   020001  *WP**  24  *WP**  17  *RF**  0  *MIXL* 9
     CARD ABOVE IS REPLACEMENT CARD.
51   *
52   *    TIME  STEPS   *
53   *
54   *3XXX0    MIN  MAJ  NDMP  CHK   DELTM   DTMIN    TLAST
55   *
56   080010    1    1    100    0    .001    .0005    .001
57   030020    1    1    100    0    .01     .0005    .101
58   030030    1    4    100    0    .01     .0005    .200
```

```
030040   1    10   100    0    .01      .0001     1000.
*
*     TIME  STEP  ALGORITHM  CONSTANTS   *
*
*30001   C1    C5     C4     C3     C4
*
030001  .5-2   1.     25.    25.    500.
*
*     TRIPS    *
*
*4XXX0    IDTRP IOSIG IX1   IX2  SETPOINT   DELAY
*
040010   1       1      0     0   2.          0.0       * END OF PROBLEM
040010   1       1      ,     0   1.0         0.0       * END OF PROBLEM
CARD ABOVE IS REPLACEMENT CARD.
040020   1      -2      0     0   1-9         0.0       * END OF PROBLEM - LOW POWER
040030   2       1      0     0   0.001       0.0       * TURBINE TRIP
040040   4       1      0     0   0.011       0.07      * SCRAM TABLE
040050   3       1      0     0   0.0         0.0       * FEEDWATER
040060   5       1      0     0   1+9         0.0       * PUMP
040070   6       4     14     0   1105.5      .4 *4 S/R VLV 1080PSIG +1% .4 SEC DELAY
040080   7       4     14     0   1115.6      .4 *4 S/R VLV 1090PSIG +1% .4 SEC DELAY
040090   8       4     14     0   1125.7      .4 *4 S/R VLV 1100PSIG +1% .4 SEC DELAY
*
*    VOLUME  DATA   *
*
*5XXX1  BB  RD  PRES   ENTHALPY    HUMID  VOLUME   HEIGHT   MIXLVL
*
050011  0   0     0.0      0.0        0.0  2672.62  17.38    17.38 *LOWER PLENUM
050021  0   0     0.0      0.0        0.0   239.48   4.0      4.0  *CORE - 1
050031  0   0     0.0      0.0        0.0   239.48   4.0      4.0  *CORE - 2
050041  0   0     0.0      0.0        0.0   239.48   4.0      4.0  *CORE - 3
050051  0   0     0.0      0.0        0.0   203.12   4.0      4.0  *BY-PASS - 1
050061  0   0     0.0      0.0        0.0   203.12   4.0      4.0  *BY-PASS - 2
050071  0   0     0.0      0.0        0.0   203.12   4.0      4.0  *BY-PASS - 3
050081  0   0     0.0      0.0        0.0   867.58   6.433    6.433*UPPER PLENUM
050091  2   0     0.0    649.538     -1.0  2897.55  24.12     5.13 *SEPARATOR
050101  0   0     0.0      0.0        0.0  3624.10  17.29    17.29 *STEAM DOME-DRY
050111  0   0     0.0      0.0        0.0   211.612  5.484    5.484*STAND PIPES
050121  0   0     0.0      0.0        0.0  3478.28  33.82    33.82 *LWR DOWNCOMER
050131  0   0  1057.5      0.0        0.0   195.36  16.4     16.4  *JET PUMPS
050141  0   0     0.0      0.0        0.0   648.30  48.544   48.544*STM LINE TO SR VV
050151  0   0     0.0      0.0        0.0   444.515 17.127   17.127*SR VV TO ISO VV
050161  0   0     0.0      0.0        0.0  2322.96  42.631   42.631*ISO TO TURB STM
050171  0   0     0.0      0.0        0.0   108.33   3.777    3.777*BYPASS STM CHEST
050181  0   0     0.0      0.0        0.0   541.48  42.175   42.175*RECIRC PMP + SUC
050191  0   0  1181.119    0.0        0.0   593.125 51.194   51.194*PUMP DISCHARGE
050201  0   0     0.0   1189.66       0.0  1+9      10.0     10.0  *TURBINE
*
*5XXX2    2PH    FLOWAREA   DIAMETER   ELEVATION
*
050012     0       1.0+9      0.69         0.0
050022     0      59.869      0.047612    17.38
050032     0      59.869      0.047612    21.38
050042     0      59.869      0.047612    25.38
050052     0      50.7801      .15208     17.38
050062     0      50.7801      .15208     21.38
050072     0      50.7801      .15208     25.38
050082     0       1.0+9     15.29        29.38
050092     0   10000.00       0.552       41.294
050102     0     265.18      18.36        52.02
050112     0      32.702      0.50542     35.81
050122     0      93.34       3.58         9.27
050132     0      31.52       0.1833       9.27
050142     0      10.1389     1.797        5.6815
050152     0      10.1389     1.797       -9.649
```

```
050162    0    10.1389    1.797     -37.232
050172    0     2.0       0.797       5.232
050182    0     7.1489    2.1333    -27.65
050192    0     7.2131    1.0943    -23.32
050202    0     1.9       1.9        -0.5
*
* LIQUID LEVEL
060000   9
*
*BUBBLE SEPARATION DATA
*
*6XXX1 GRADIENT  VBUB
060011      .8      3.
060021     .05       361.168
060031      .0      3.
*
*
*  JUNCTION DATA
*
*8XXX1 FM TO PP VV FLOWRATE  JUNAREA   ELEVATION INERTIA
080011  1  2  0  0 20011.45  38.8889   17.380      0.1433 *LWR PLNM TO CORE-V2
080021  2  3  0  0 20011.45  38.8889   21.380      0.0660 *CORE-V2 TO CORE-V3
080031  3  4  0  0 20011.45  38.8889   25.380      0.0660 *CORE-V3 TO CORE-V4
080041  4  8  0  0 20011.45  38.8889   29.380      0.0510 *CORE-V4 TO UPPER PLNM
080051  1  5  0  0   1377.44  14.967   17.380      0.1497 *LWR PLNM TO BYPASS-1
080061  5  6  0  0   1377.44  50.7801  21.380      0.0788 *BYPASS-1 TO BYPASS-2
080071  6  7  0  0   1377.44  50.7801  25.380      0.0788 *BYPASS-2 TO BYPASS-3
080081  7  8  0  0   1377.44  50.7801  29.380      0.0574 *BYPASS-3 TO UPPER PLNM
080091 11  9  0  0 21388.89  32.702    41.294      0.9190 *ST.PIPES TO SEPARATOR
080101  9 10  0  0   3054.1   99.75    53.000      0.1000 *SEPARATOR TO DRYER
080111 18 19  1  0   9500.0    7.1489 -22.250     10.0400 *RECRC.PUMP DISCHARGE
080121  8 11  0  0 21388.89  32.702    35.810      1.1170 *UP-PLNM TO ST.PIPES
080131 12 13  0  0 11888.89   3.9      25.670      1.5700 *LWR D.COMER TO J.PUMPS
080141 19 13  0  0   9500.0    1.26    25.670      6.7800 *RECRC. TO JET PUMPS
080151 12 18 -1  0   9500.0    7.1489  13.460      4.5400 *LWR D.COMER TO RECRC.
080161 13  1  0  0 21388.89  31.52      9.270      0.6003 *J.PUMPS TO LWR PLENUM4
080171 10 14  0  0   3054.1   10.139   53.330      3.1830 *STM DOME TO STM LINE
080181 14 15  0  0   3054.1   10.139    6.580      5.3150 *STM LINE SR TO ISO VV
080191 15 16  0  0   3054.1   10.139   -8.750     13.4610 *ISO VV TO TURB STOP VV
080201 16 17  0  0      0.0    2.0      5.399     22.5490 *STM LN TO BPASS STMCCH
080211  9 12  0  0 18334.79  93.0      41.300      0.8803 *SEPARA. TO LWR D.COMER
080221 16 20  0  4   3054.1   10.1389   4.500     11.25   *TURBINE STOP VLV LEAK
080231  0 14  4  3      0.0    0.414   10.390      0.0    *SAFETY REL.VLV NEGFILL
080241  0 12 -1  0   3054.1    1.0     40.290      0.0    *FEEDWATER FILL
080251  0 14  2  1      0.0    0.552   10.390      0.0    *SAFETY REL.VLV NEGFILL
080261  0 14  3  2      0.0    0.552   10.390      0.0    *SAFETY REL.VLV NEGFILL
*
*8XXX2 FLOSS  RLOSS  JV  JC  CL  MV  DIAMETER  CON  CH  HQ
080012 -1.0    0.0    1  -1  0   0   0.0       1.   0   2
080022  0.893  0.893  0  -1  0   0   0.0       1.   0   3
080032  1.326  1.326  0  -1  0   0   0.0       1.   0   3
080042  0.860  0.860  0  -1  0   0   0.0       1.   0   1
080052 -1.0    0.0    0  -1  0   0   0.0       1.   0   2
080062  6.492  6.492  0  -1  0   0   0.0       1.   0   3
080072  7.151  7.151  0  -1  0   0   0.0       1.   0   3
080082 96.090 95.568  0  -1  0   0   0.0       1.   0   1
080092  0.449  0.254  0  -1  0   0   0.50542   1.   0   0
080102  0.648  0.958  0  -1  0   0   2.43000   1.   0   0
080112 -1.0    0.0    1  -1  0   0   2.13330   1.   0   0
080122  0.364  0.664  0  -1  0   0   0.50542   1.   0   0
080132  0.272  1.067  0  -1  0   2   0.29000   1.   0   0
080142 -1.0    0.686  0  -1  0   2   0.28330   1.   0   0
080152  1.153  1.153  0  -1  0   0   2.13330   1.   0   0
080162  0.875  0.605  0  -1  0   0   1.42000   1.   0   0
080172  0.810  0.810  1  -1  0   0   1.79700   1.   0   0
080182  1.152  1.152  1  -1  0   0   1.79700   1.   0   0
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080192 10.251  9.991  1  -1  0   0   1.79700    1.   0  0
080202  2.300  2.300  0  -1  0   0   1.79700    1.   0  0
080212  1.813  1.413  0  -1  0   0   0.0        1.   0  0
080222  1.0    0.45   1  -1  1   0   0.0        1.   0  0
080232  0.0    0.0    1  -1  3  -2   0.0        1.   0  0
080242  0.0    0.0    1  -1  3   0   0.0        1.   0  0
080252  0.0    0.0    1  -1  3  -2   0.0        1.   0  0
080262  0.0    0.0    1  -1  3  -2   0.0        1.   0  0
*
* PUMP DATA
*
*90XXY IPC TRP REV ZPH MTQ  RPM  SRO   GPM    HEAD  TORQUE  INERTIA DENS TORKMR
*
090011  1   5   0   0   0  1665.  1. 90400.   530. 33200. 14059.8   47.2 0. 332.
*
*100000  PUMP CURVE INDICATOR
*
*100000  NPC(J)  NC(J)
*
100000     0    4
*
*10XYZ H/T IC NO           PUMP  HOMOLOGOUS CURVES
*10XYYZ  N  PHD(1) OR PTK(1)  PHD(2) OR PTK(2)
*
101011   6  0. 1.36  .265 1.31  .531 1.24  .796 1.13  .885 1.08  1. 1. *HEAD 1
101021   4  .752 .373  .870 .649  .943 .839  1. 1.                     *HEAD 2
101091   6  0. 0.  .265 .162  .531 .537 .796 .874  .885 .95  1. 1.   *TORQUE 1
101101   4  .752 .474  .870 .733  .943 .885  1. 1.                     *TORQUE 2
*
* VALVE DATA
*
*11XXX0 TRP IACV PCV CV1 CV2 CV3
*
110010  -6    2   0.  0.  0.  0.        * 4 S/R VALVES AT 1080 PSIG *1 PCT
110020  -7    3   0.  0.  0.  0.        * 4 S/R VALVES AT 1090 PSIG *1 PCT
110030  -8    4   0.  0.  0.  0.        * 3 S/R VALVES AT 1100 PSIG *1 PCT
110040   2  1   0. 0. 0. 0.     * MSTV
*
* LEAK - AREA VS TIME DATA
*
*12XXYY PTS TRP PRES    TIME  NORM AREA
*
* LEAK DATA   STEAM LINE  MTSV  AREA CLOSURE RATE
*
120101   3              0.  1.   .1  0.    1.+9  0.  *  TURB STOP VALVE
120201   3              0.  0.   .1 1.  1.+9 1.    * S/R VALVE STROKE TIME .1 SEC
120301   3              0.  0.   .1 1.  1.+9 1.    * S/R VALVE STROKE TIME .1 SEC
120401   3              0.  0.   .1 1.  1.+9 1.    * S/R VALVE STROKE TIME .1 SEC
120501    -6     0.0    .08333    10.0    .08333
120502   25.6  .500000  40.0 .750000    50.0 1.0       200.0  1.0
*
* FILL TABLE    S/R VALVE  CAPACITY     DIA=5.030 INCH  AREA=0.138  FT*2
*
*13XXYY PTS TRP JX JY FILTBL(1) FILTBL(2) FILENT(1) FILPRS(1)
*
130101   -2   1000   -10   0
130102  100.  100.  405.708  1200.  1000.  1000.  405.708  1200.
130201   2   6   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
130301   2   7   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
130401   2   8   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
*
* KINETICS CONSTANTS DATA
*
*14000        KMUL B/L  RHOIN  UDUF  PROMPT LAMBDA TAU
*
140000          0  121.826 0.     0.     0.       0.   0.  * EOC
```


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*
*  REACTIVITY  COEFFICIENT
*
*140X0  DENWT   FTWT   ATF  ATW  *********EOC-H*******
*
* WEIGHTING FACTOR   CORE BYPASS AREA WTNG
*
*140XX0  DENWT   FTWT   ALPHM  ALPHW  QPMOD  QDMOD
*
140010 .263849   .413294  0.  0.  .025438   .025438   *BTM CORE
140020 .273239   .428003  0.  0.  .025438   .025438   *MID CORE
140030  .101317   .158703  0.  0. .025438   .025438   *TOP CORE
140040  .149445     0.    0.  0.  .735      .735 * BTM B.P.
140050  .154764     0.    0.  0.  .732      .732 * MIB B.P.
140060  .057386     0.    0.  0.  .691      .691 * TOP B.P.
*
* SCRAM CURVE  EOC -$32.    EOC HALING $40. X 0.8
*
141001  13  4
141002  0. 0.  .2 0.  .564 - 372  .9 -.703  1.267 -1.10  1.633 -1.63  2.  -2.6
141003  2.75 -4.82  3.5 -10.9  4.25 -22.7  5. -31.  5.75 -32.  500. -32.
*
*  DENSITY R ACTIVITY  (-15.1 CENT/PERCENT OF VOID CHANGE)
*
* VOID TIMES 1.3
*
142001    -8
142002   19.816   -18.46  24.187  -14.04    28.558  -9.88
142003   32.928  -6.5    37.299  -3.64  41.670  -1.56
142004   46.041   0.0   50.0   0.0
*
*  DOPPLER TABLE
*
*143XX PTS   TEMP(F)   REAC($)   TEMP(F)   REAC($)   TEMP(F)   REAC($)
*
*        DOPPPER COEFFICIENT.... -0.00173 $/F.
*
143001  6
143002  500.  0.    1000.  -.865     1500.  -1.73     2000.  -2.60
143003  3000.   -4.33     5000.  -7.79
*
*
* HEAT SLAB DATA
*
*15XX1 SL  SR  GM  ST  CL  CR    ASUFL    ASUFR    VOLS
*
150011  0  2  1  0 10 10      0.  16177.86 189.7528
150021  0  3  1  1 10 10      0.  16177.86 189.7528
150031  0  4  1  1 10 10      0.  16177.86 189.7528
150041  2  5  2  0  2  2 4000.63 4000.63  26.6709
150051  3  6  2  1  2  2 4000.63 4000.63  26.6709
150061  4  7  2  1  2  2 4000.63 4000.63  26.6709
150071 11 12  3   0   2   2 1674.78 1822.52 40.925 * STAND PIPES
150081  8  12  4   0   2   2  377.1    398.2  188.87 * UPPER PLENUM
*
*15XX2  HDML     HDMR     DHEL     DHER     CHNL     CHNR  IHXGF  PFR  HTC
*
150012   0.     .047612   0.     .059211     0.        4.  0
150022   0.     .047612   0.     .059211     0.        4.  0
150032   0.     .047612   0.     .059211     0.        4.  0
150042 .047612 .189472 .243067 .200100     4.        4.  0
150052 .047612 .189472 .243067 .200100     4.        4.  0
150062 .047612 .189472 .243067 .200100     4.        4.  0
150072   0.     2.657   0.   3.2      0.     5.     0
150082   0.   .2367   0.     .5169   0.      0.    0
*
```

```
*
* CORE DATA
*
* N1 = 7  IS AT UO-2 PELLET SURFACE.
* N2 = 9  IS AT ZR-2 CLADDING INSIDE SURFACE.
* N3 = 11 IS AT A HALF DEPTH OF CLADDING.
* EOC  HALING  CORE DATA
*16XX0 SLB N1 N2 N3  CLDTHK  QFRAC   QPMOD   QDMOD  * LOCATION
*16XX0 SLB           CLDTHK  QFRAC   QPMOD   QDMOD  * LOCATION
*
160010  1          0.       .372157                        * CORE-1 (BOT)
160020  2          0.       .378722                        * CORE-2 (MID)
160030  3          0.       .230616                        * CORE-3 (TOP)
160040  4          .00      .007017                   * BYPASS-1 (BOT)
160050  5          .00      .007140                        * BYPASS-2 (MID)
160060  6          .00      .004348                  * BYPASS-3 (TOP)
*
*
*
* SLAB GEOMETRY
*
*1XYY IG NR GAP IM SP  RADDIST   REGWIDTH   PFRACT
*
170101  2  3       1  6    0.      .02029167     1.     * UO-2 PELLET
170102         1   3  2            5.0-4         0.     * HE GAP
170103         0   2  4            .00266667     0.     * ZIRCALOY-2 CLADDING
170201  1  1       2  3    0.      .00666667     1.     * FUEL CHANNEL WALL (ZRR4)
170301  2  1       4   1  .25271   .02229      0.    * STAND PIPES
170401  2  1       4  1  7.65      .16667        0.      * UPPER PLENUM
* NO HEAT GENERATION IN FUEL CHANNEL WALL. USE FOR MODERATOR(CORE BY-PASS)
*
* DIRECT AND CONDUCTION HEATING.
*
*18XXYY   THERMAL CONDUCTIVITY DATA
*
* THERM COND  U02  REF  GEMP-482 FIG-13  86 W/CM
*
180101  -11                                            * THERM COND  U02   1
180102   212.  4.28   392.  3.47   752.  2.66  1112.  2.20 * THERM COND  U02   2
180103  1472.  1.88  1832.  1.62  2192.  1.44  2912.  1.21 * THERM COND  U02   3
180104  3632.  1.16  5072.  1.16               5500.  1.16 * THERM COND  U02   4
*
* THERMAL COND  ZR-4  REF  BRASSFIELD%1968<GEMP-482 RECOM... LWR LOCA
*
180201  -8      0.   8.    1490. 12.32  2150. 17.5         * THERM COND ZR-6   1
180202  2372. 19.7   2552. 21.8   2732. 24.0   3292. 28.9  * THERM COND ZR-4   2
180203  3360. 33.1                                         * THERM COND ZR-4   3
*
* THERMAL COND HELIUM  REF  THETA1-B EQN
*
180301   -6                                                * THERM COND HELIUM 1
180302   100. .0937  1100. .163   2100. .212   3100. .253  * THERM COND HELIUM 2
180303  4100. .289   5100. .322                            * THERM COND HELIUM 3
*
* THERM CON  SS-304 9REF  NUC SYS MATLS HDBK  PROP CODE 3112 PG 1.0
*
180401   -2    100. 8.536   1500. 19.62                    * THERM COND  SS-304
*
*        SA-302   REF   TOULOUKIAN
*
180501 -5   32.  30.  212.  29.5   392.  28.3          * THERMAL COND. SA-3022 1
180502     572.  26.6  752. 24.7                       * THERMAL COND. SA-3022 2
*
* VOLUMETRIC HEAT CAPACITY
*
* SPEC HEAT  U02  REF  BRASSFIELD%1968<GEMP-482 RECOM...LWR LOCA
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*
* SPEC HEAT  U02  95 PCT  TH DEN AT 1000F  642 LB/FT3
*
* SPEC HEAT  U02  REF  BRASSFIELD%1968<GEMP-482 TOULOUKIAN SAME TO 3750 F
*
190101  -19                                              * VOL HT CAP U02    1
190102     77. 36.22        100. 37.12        200. 40.05   * VOL HT CAP U02    2
190103    300. 41.98        400. 43.88        600. 45.18   * VOL HT C:P U02    3
190104    800. 46.41       1000. 47.32                     * VOL HT CAP U02    4
190105                                       2400. 50.77   * VOL HT CAP L02    5
190106  2600. 51.43        2800. 52.61       3000. 54.57   * VOL HT CAP U02    6
190107  3200. 57.42        J400. 61.23       3600. 65.93   * VOL HT CAP U02    7
190108  4600. 95.15        4800. 99.31       5000. 101.57  * VOL HT CAP U02    8
190109  5074. 101.76                                       * VOL HT CAP U02    9
*
* SPEC HEAT  ZR-2   REF BMI-1803 ELDRIDGE ET AL (1967)              DEN 409.55
*
190201   15                                        * VOL HT CAP  ZR-2        1
190202    32.  28.75      932.  32.56   1112.  34.40  * VOL HT CAP  ZR-2        2
190203  1184.  35.22    1490.  35.22    1508.  49.14  * VOL HT CAP  ZR-2        3
190204  1544.  57.74    1580.  60.20    1616.  70.43  * VOL HT CAP  ZR-2        4
190205  1652.  79.85    1688.  75.35    1724.  59.38  * VOL HT CAP  ZR-2        5
190206  1760.  45.86    1787.  34.81    3300.  34.81  * VOL HT CAP  ZR-2        6
*
* SPEC HEAT  HELIUM  REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3
*
190301  -2      32. .0149       3400. .0149              * VOL HT CAP HELIUM 1
*
* SPEC HEAT  SS-304  REF  NUC SYS MATLS HDBK     DENSITY # 494 LB/FT3 AT 530F6
*
190401  -12                                              * VOL HT CAP SS-3UU 1
190402   100. 54.74    150. 56.51    200. 58.                * VOL HT CAP SS-3UU 2
190403   300. 54.43    400. 62.      600. 64.02              * VOL HT CAP SS-3U4 3
190404   800. 65.36   1000. 66.94   1200. 69.11              * VOL HT CAP SS-3UU 4
190405  1400. 71.63   1450. 72.27   1500. 72.87              * VOL HT CAP SS-3UU 5
*
190501 -7   130. 56.9   350. 60.8    450. 62.3         * VOL. HT. CAP. SA-302  1
190502      530. 65.2   620. 67.2    710. 70.2         * VOL. HT. CAP. SA-3022 2
190503      800. 77.5                                  * VOL. HT. CAP. SA-3022 3
*
* COEF OF LINEAR THERMAL EXPANSION
*
* THERM EXPAN COEF  U02  REF  GEMP-482
*
200101  -2   0. 3.72-6   4082. 11.0-6                    * EXPAN COEF  U02   1
*
* THERM EXPAN COEF  ZR-4  REF  GEMP-482 %1968<<
*
200201   -4                                              * THERM EXPAN ZR-4  1
200202     0.  3.10-6   1580.  4.64-6   1584.  5.4-6      * THERM EXPAN ZR-44 2
200203  3400.  5.40-6                                    * THERM EXPAN ZR-44 3
*
* THERM EXPAN COEF  HELIUM
*
200301  -2     0. 0.    1+9 0.                           * THER EXPAN  ZR-44
*
* THERM EXPAN COEF  SS-304
*
200401  -2     0. 0.   2650. 0.                          * THER EXPAN  SS-T04
*
200501 -2     0.  0.       10000.  0.                * THERMAL EXP. DUMMY CSSTEL
*
*
*
*
*
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* FEEDWATER  CONTROL  SYSTEM
*
*
701000    4    10
*
*702XXX    IDC    VAR    REG   GAIN    CIC
*
702001      1     "LIQL"  9    8.00    39.78      * LIQUID  LEVEL  VOL 9
CARD ABOVE IS REPLACEMENT CARD.
702002      2     "wP**" 17    0.012   36.649     * STEAM  FLOW
CARD ABOVE IS REPLACEMENT CARD.
702003      3     "wP**" 24    0.012   36.649     *  FEEDWATER FLOW
CARD ABOVE IS REPLACEMENT CARD.
702004      4     "CONS"  0    1.0      1.0       * SETPOINT CONSTANT
CARD ABOVE IS REPLACEMENT CARD.
*703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1    CP2    CIC     CMIN    CMAX
703001    -1  "SUM"   1    -2     1.0     1.0    1.0   39.78
CARD ABOVE IS REPLACEMENT CARD.
703002     -2 "SUM"   2     3     0.8    -1.0    1.0    0.0    -32.0    32.0
CARD ABOVE IS REPLACEMENT CARD.
703003    -3  "SUM"  -1     4     1.0     1.0  -39.78  0.0
CARD ABOVE IS REPLACEMENT CARD.
703004    -4  "LLG"  -3     0    -1.67    0.6    6.0   0.0
CARD ABOVE IS REPLACEMENT CARD.
703005    -5  "INT"  -4     0     0.025  0.0    0.0    0.0    -15.6    24.4
CARD ABOVE IS REPLACEMENT CARD.
703006    -6  "SUM"  -5    -4     1.0     1.0    1.0    0.0     -50.0   50.0
CARD ABOVE IS REPLACEMENT CARD.
703007    -7  "SUM"  -6     4     1.0     1.0    44.747 44.747   0.0    50.0
CARD ABOVE IS REPLACEMENT CARD.
703008    -8  "DLY"  -7    10     1.0     0.2    0.0    44.747   0.0    50.0
CARD ABOVE IS REPLACEMENT CARD.
703009    -9  "FNG"  -8     5  3515.81   0.0    0.0    3054.1   292.98  3515.81
CARD ABOVE IS REPLACEMENT CARD.
703010   -10  "VLM"  -9     0     1.0    732.5  732.5  3054.1   292.98  3515.81
CARD ABOVE IS REPLACEMENT CARD.
*
*    AUXILIARY  DNB  CALCULATION  *
*
*  (1)  AUX.  DNB  DIMENSION  DATA   *
*8001X    LWR  ICW  NUH  ICHF ITCROF  NOA
*
800100    2    0    0    4    0      13           3
*
*  (2)  PEAKING  FUNCTION  DATA  *
*8002X  FQENG  FRN  FQUNC  FDHCOR  FDRED  ZMIN  ZMAX
*
800200  1.03   1.40  1.0    1.0     1.0   5.0   11.0
*
*  (3)  GEOMETRY  DATA  *
*8003X  PITCH    RODIAM   EQUDIAM    TDC   FRCPOWER   NDELT
800300  0.0615   0.04692  0.047612   0.0   0.956057
*
*  (4)  AXIAL  POWER  PROFILE  *
*8004X     Y(1) - AXIAL(1) , Y(2) - AXIAL(2)........................
*
800400  0.0  0.0   0.08333  1.081904  0.16667  1.25934  0.25  1.267476
800401  0.3333 1.238666  0.41667 1.203747  0.5 1.166797  0.58333 1.113869
800402  0.6667  1.039859  0.75  0.934232  0.83333  0.76685
800403  0.91667  0.498281  1.0  0.0
800500   2   3   4
230000  -25
230011  0  24  22  1.0
*
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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE   EPRI   21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
CPU TIME =   31.916
* *

STANDARD TIME STEP NUMBER =   0   ACTUAL TIME STEP NUMBER =   0   TIME = 0.   SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
1.000000E+00	2.533400E+03	8.673285E+09	0.	2.387385E+11	2.157923E+08	0.

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.06032E+03	1.26224E+05	5.26356E+02	4.72284E+01	5.31845E+02	0.	0.	1.73800E+01	1.26224E+05
2	1.03640E+03	1.08419E+04	5.48683E+02	4.52725E+01	5.48937E+02	9.00759E-04	9.76590E+00	4.00000E+00	1.08321E+04
3	1.03321E+03	4.69804E+03	5.93788E+02	1.96177E+01	5.48561E+02	7.16818E-02	3.36764E+02	4.00000E+00	4.36128E+03
4	1.02852E+03	3.19976E+03	6.30426E+02	1.33613E+01	5.48004E+02	1.29489E-01	4.14336E+02	4.00000E+00	2.78543E+03
5	1.02963E+03	9.52808E+03	5.32347E+02	4.69086E+01	5.36542E+02	0.	0.	4.00000E+00	9.52808E+03
6	1.02833E+03	9.39882E+03	5.43902E+02	4.62722E+01	5.45645E+02	0.	0.	4.00000E+00	9.39882E+03
7	1.02712E+03	7.96230E+03	5.52702E+02	3.92000E+01	5.47838E+02	9.29701E-03	7.40255E+01	4.00000E+00	7.88827E+03
8	1.02609E+03	1.07907E+04	6.38617E+02	1.24376E+01	5.47715E+02	1.42655E-01	1.53935E+03	6.43300E+00	9.25131E+03
9	1.02013E+03	3.2830[illegible]E+04	6.49538E+02	1.13304E+01	5.47005E+02	1.60692E-01	4.44627E+01	5.13000E+00	2.75549E+04
10	1.01998E+03	8.309[illegible]E+03	1.19213E+03	2.29274E+00	5.46786E+02	9.99976E-01	8.30891E+03	1.72900E+01	1.98395E-01
11	1.02023E+03	2.60815E+03	6.38449E+02	1.23252E+01	5.47017E+02	1.43520E-01	3.74322E+02	5.48400E+00	2.23383E+03
12	1.02647E+03	1.64262E+05	5.25986E+02	4.72250E+01	5.31516E+02	0.	0.	3.38200E+01	1.64262E+05
13	1.05750E+03	9.22634E+03	5.26341E+02	4.72274E+01	5.31829E+02	0.	0.	1.64000E+01	9.22634E+03
14	1.01220E+03	1.47504E+03	1.19182E+03	2.27524E+00	5.46054E+02	9.99093E-01	1.47370E+03	4.85440E+01	1.33781E+00
15	1.00688E+03	1.00570E+03	1.19186E+03	2.26245E+00	5.45413E+02	9.98872E-01	1.00456E+03	1.71270E+01	1.13403E+00
16	9.60155E+02	4.99793E+03	1.19184E+03	2.15153E+00	5.39671E+02	9.96415E-01	4.98001E+03	4.26310E+01	1.79161E+01
17	9.67109E+02	2.34871E+02	1.19181E+03	2.16811E+00	5.40539E+02	9.96732E-01	2.34104E+02	3.77700E+00	7.67538E-01
18	1.11520E+03	2.55804E+04	5.26796E+02	4.72417E+01	5.32255E+02	0.	0.	4.21750E+01	2.55804E+04
19	1.18112E+03	2.80448E+04	5.26785E+02	4.72831E+01	5.32327E+02	0.	0.	5.11940E+01	2.80448E+04
20	9.58025E+02	2.15381E+08	1.18966E+03	2.15331E+00	5.39404E+02	9.92996E-01	2.13823E+08	1.00000E+01	1.50824E+06

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.00115E+04	5.26345E+02	2.11743E-02	2.36438E+01	-3.47889E+00	-2.01650E+01	-1.60807E-06	0.
2	2 TO 3		2.00115E+04	5.71020E+02	3.62925E-02	2.49047E+00	-9.01253E-01	-1.58922E+00	4.45823E-10	0.
3	3 TO 4		2.00115E+04	6.16555E+02	6.55041E-02	4.1217[illegible]E+00	-4.58041E-01	-3.66370E+00	7.97982E-10	0.
4	4 TO 8		2.00115E+04	6.44297E+02	8.37987E-02	3.21862E+00	-4.63391E-01	-2.75523E+00	2.25413E-10	0.
5	1 TO 5		1.37744E+03	5.26345E+02	2.11743E-02	3.06879E+01	-3.50161E+00	-2.71863E+01	8.43894E-08	0.
6	5 TO 6		1.37744E+03	5.38348E+02	2.14654E-02	1.30613E+00	-1.29418E+00	-1.19523E-02	-4.50663E-07	0.
7	6 TO 7		1.37744E+03	5.49456E+02	2.33900E-02	1.20149E+00	-1.18711E+00	-1.43768E-02	-1.24439E-06	0.
8	7 TO 8		1.37744E+03	5.55948E+02	2.76311E-02	1.03374E+00	-8.22261E-01	-2.11482E-01	-5.86168E-10	0.
9	11 TO 9		2.13889E+04	6.38446E+02	8.11983E-02	3.84336E+00	-1.94049E+00	-1.90286E+00	-1.33964E-09	0.
10	9 TO 10		3.05410E+03	1.19214E+03	4.36096E-01	1.45009E-01	-1.16403E-01	-2.86059E-02	-1.29144E-11	0.
11	18 TO 19		9.50000E+03	5.26816E+02	2.11669E-02	-6.58417E+01	-2.90701E+00	-1.82846E+01	-1.87525E-06	8.70333E+01
12	8 TO 11		2.13889E+04	6.38613E+02	8.04380E-02	2.08370E+00	-5.12250E-01	-1.57145E+00	1.00465E-09	0.
13	12 TO 13		1.18889E+04	5.25987E+02	2.11752E-02	3.11368E+00	2.85659E+00	-5.97027E+00	-1.84710E-06	0.
14	19 TO 13		9.50000E+03	5.26755E+02	2.11510E-02	5.29929E+01	-4.99187E+00	-4.80010E+01	4.97421E-08	0.
15	12 TO 18		9.50000E+03	5.26002E+02	2.11744E-02	-9.25429E+01	1.07403E+01	-5.23069E+00	-9.09060E-09	8.70333E+01
16	13 TO 1		2.13889E+04	5.26352E+02	2.11737E-02	-1.76993E+00	2.87956E+00	-1.10963E+00	1.70821E-06	0.
17	10 TO 14		3.05410E+03	1.19214E+03	4.36113E-01	3.44674E+00	4.86142E-01	-3.93288E+00	-2.53721E-10	0.
18	14 TO 15		3.05410E+03	1.19185E+03	4.39581E-01	5.26967E+00	4.89745E-01	-5.75941E+00	-6.62226E-12	0.
19	15 TO 16		3.05410E+03	1.19187E+03	4.42100E-01	4.62815E+01	2.27497E-01	-4.65090E+01	-2.17960E-09	0.
20	16 TO 17		0.	1.19181E+03	4.61220E-01	2.14866E+00	-3.44399E-01	-1.80427E+00	1.92792E-10	0.
21	9 TO 12		1.83348E+04	5.46278E+02	2.19037E-02	-6.49097E+00	6.66254E+00	-1.71570E-01	1.75108E-06	0.
22	16 TO 20		3.05410E+03	1.19181E+03	4.65847E-01	6.67106E+00	-3.05047E-01	-6.36601E+00	-1.53506E-10	0.
26	0 TO 14		0.	1.19220E+03	4.39832E-01	0.	-3.09109E-01	0.	0.	0.
25	0 TO 14		0.	1.19220E+03	4.39832E-01	0.	-3.09109E-01	0.	0.	0.
24	0 TO 12		3.05410E+03	4.03234E+02	1.88949E-02	0.	4.62740E+00	0.	0.	0.
23	0 TO 14		0.	1.19220E+03	4.39832E-01	0.	-3.09109E-01	0.	0.	0.

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EQUIVALENT LIQUID LEVEL IS 4.96859E+00 FEET ABOVE THE BOTTOM OF VOLUME 9

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00019E+00	0.	1.00000E+00	2.67910E+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	2	2	1.93845E+05	7.99099E+05	1.39194E+04	5.62864E+02	1.20331E+06	1.14071E+07	3.13600E+09
2	RIGHT	3	2	1.97265E+05	7.28318E+05	1.40061E+04	5.62645E+02	1.20331E+06	1.15282E+07	3.19132E+09
3	RIGHT	4	2	1.20121E+05	6.70511E+05	1.08889E+04	5.59035E+02	1.20331E+06	8.63345E+06	1.94330E+09
4	LEFT	2	2	2.81386E+02	1.24875E+06	5.30327E+02	5.49468E+02	1.20331E+06		1.12572E+06
	RIGHT	5	1	3.73754E+03	1.40612E+05	3.18784E+02	5.48267E+02	9.76521E+04	4.11580E+05	1.49525E+07
5	LEFT	3	2	1.65704E+03	1.06188E+06	1.28369E+03	5.49851E+02	1.20331E+06		6.62923E+06
	RIGHT	6	2	2.47861E+03	1.37947E+05	1.56392E+03	5.49566E+02	9.76521E+04	4.12279E+05	9.91601E+06
6	LEFT	4	2	1.34472E+03	1.06188E+06	1.15210E+03	5.49171E+02	1.20331E+06		5.37972E+06
	RIGHT	7	2	1.55903E+03	1.36082E+05	1.23915E+03	5.49096E+02	9.76521E+04	4.11753E+05	6.23712E+06
7	LEFT	11	1	-4.79973E+03	3.06876E+05	3.37047E+03	5.45592E+02	2.35460E+06		-8.03849E+06
	RIGHT	12	1	4.41069E+03	1.44025E+05	1.03234E+03	5.35788E+02	8.24941E+05	1.20907E+06	8.03849E+06
8	LEFT	8	1	-7.48551E+01	9.00000E+04	5.00000E+00	5.32744E+02	7.70000E-02		-2.82279E+04
	RIGHT	12	1	7.32590E+01	1.76675E+05	1.67441E+03	5.31559E+02	8.24941E+05	5.47891E+06	2.82279E+04

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.	0.	0.	3.13600E+09	8.18558E+07	1.69371E+03	2.42551E+03
2	2	0.	0.	0.	3.19132E+09	8.32997E+07	1.71104E+03	2.46116E+03
3	3	0.	0.	0.	1.94330E+09	5.07239E+07	1.29390E+03	1.66730E+03
4	4	0.	0.	0.	1.60782E+07	4.45943E+07	5.49074E+02	
5	5	0.	0.	0.	1.65452E+07	4.51907E+07	5.49922E+02	
6	6	0.	0.	0.	1.16168E+07	2.59781E+07	5.49283E+02	

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
7.70004E+00	4.29929E+00	1.27784E+01	1.68090E+00	1.34549E+01	0.	6.00000E+00	1.10390E+01	1.54115E+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
0.	9.30010E-01	6.99900E-02	0.	0.	0.	0.	0.	0.

DATA RECORD NUMBER 1 WAS WRITTEN ON TAPE VSN = 065865 ON 78325 AND WAS LABELED RANBWRTTWOBSHO

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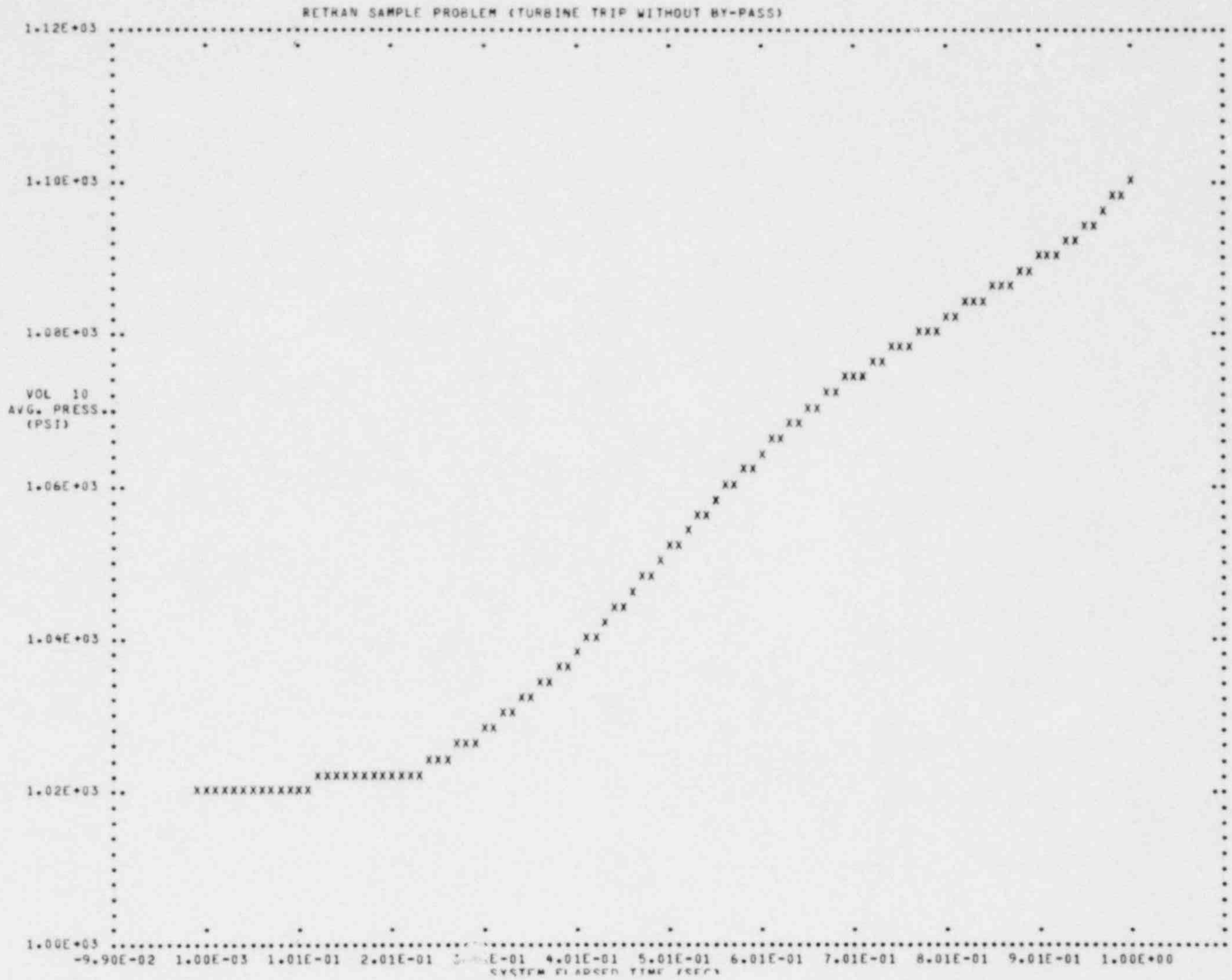
RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 21/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
CPU TIME = 60.699

SYSTEM ELAPSED TIME (SEC)	SYSTEM NORM. POWER	REACTOR DOPPLER REAC ($)	REACTOR VOID REAC. ($)	VOL 10 AVG. PRESS. (PSI)	JUN 24 MASS FLOW (LB/SEC)	JUN 17 MASS FLOW (LB/SEC)	REACTOR FUEL REAC. ($)	VOL 9 MIX. LEVEL (FEET)
0.	1.00000E+00	0.	0.	1.01998E+03	3.05410E+03	3.05410E+03	0.	5.13000E+00
1.00000E-03	1.00000E+00	7.18694E-10	-7.11164E-12	1.01998E+03	3.05410E+03	3.05410E+03	0.	5.13000E+00
1.10000E-02	1.00000E+00	9.26275E-09	2.42650E-12	1.01998E+03	3.05410E+03	3.05410E+03	0.	5.13000E+00
2.10000E-02	1.00000E+00	2.98680E-08	1.98435E-08	1.01998E+03	3.05410E+03	3.05410E+03	0.	5.13000E+00
3.10000E-02	1.00000E+00	5.60168E-08	1.58733E-07	1.01998E+03	3.05410E+03	3.05409E+03	0.	5.13000E+00
4.10000E-02	1.00000E+00	8.07488E-08	4.29815E-07	1.01998E+03	3.05410E+03	3.05408E+03	0.	5.13000E+00
5.10000E-02	1.00000E+00	1.03980E-07	8.11225E-07	1.01998E+03	3.05410E+03	3.05404E+03	0.	5.13000E+00
6.10000E-02	1.00000E+00	1.25611E-07	1.27290E-06	1.01998E+03	3.05410E+03	3.05391E+03	0.	5.13000E+00
7.10000E-02	1.00000E+00	1.45547E-07	1.78468E-06	1.01998E+03	3.05410E+03	3.05363E+03	0.	5.12999E+00
8.10000E-02	1.00000E+00	1.63734E-07	2.32217E-06	1.01998E+03	3.05410E+03	3.05307E+03	0.	5.12998E+00
9.10000E-02	1.00000E+00	1.80149E-07	2.86937E-06	1.01998E+03	3.05410E+03	3.05202E+03	0.	5.12997E+00
1.01000E-01	1.00000E+00	1.94803E-07	3.42156E-06	1.01998E+03	3.05410E+03	3.05015E+03	0.	5.12998E+00
1.11000E-01	1.00000E+00	2.07721E-07	4.00027E-06	1.01999E+03	3.05410E+03	3.04687E+03	0.	5.12993E+00
1.21000E-01	1.00000E+00	2.26579E-07	5.43179E-06	1.01999E+03	3.05410E+03	3.04205E+03	0.	5.12987E+00
1.31000E-01	1.00001E+00	2.33455E-07	6.53652E-06	1.02001E+03	3.05410E+03	3.03466E+03	0.	5.12979E+00
1.41000E-01	1.00001E+00	2.38541E-07	8.51666E-06	1.02003E+03	3.05410E+03	3.02325E+03	0.	5.12974E+00
1.51000E-01	1.00001E+00	2.39800E-07	1.20798E-05	1.02005E+03	3.05410E+03	3.00617E+03	0.	5.12956E+00
1.61000E-01	1.00001E+00	2.35835E-07	1.72691E-05	1.02010E+03	3.05410E+03	2.98159E+03	0.	5.12933E+00
1.71000E-01	1.00002E+00	2.24254E-07	2.54341E-05	1.02016E+03	3.05410E+03	2.94846E+03	0.	5.12899E+00
1.81000E-01	1.00003E+00	1.99747E-07	4.19891E-05	1.02025E+03	3.05410E+03	2.90329E+03	0.	5.12847E+00
1.91000E-01	1.00005E+00	1.50002E-07	7.55674E-05	1.02037E+03	3.05410E+03	2.84284E+03	0.	5.12774E+00
2.00000E-01	1.00008E+00	4.82001E-08	1.25931E-04	1.02052E+03	3.05410E+03	2.77311E+03	0.	5.12693E+00
2.10000E-01	1.00013E+00	-1.17877E-07	1.85671E-04	1.02073E+03	3.05410E+03	2.67878E+03	0.	5.12574E+00
2.20000E-01	1.00020E+00	-4.21721E-07	3.10280E-04	1.02100E+03	3.05411E+03	2.56902E+03	0.	5.12427E+00
2.30000E-01	1.00031E+00	-9.60683E-07	5.12470E-04	1.02134E+03	3.05412E+03	2.44619E+03	0.	5.12245E+00
2.40000E-01	1.00047E+00	-1.95521E-06	8.66572E-04	1.02175E+03	3.05413E+03	2.31305E+03	0.	5.12003E+00
2.50000E-01	1.00072E+00	-2.04974E-06	9.00163E-04	1.02224E+03	3.05413E+03	2.17544E+03	0.	5.11730E+00
2.60000E-01	1.00100E+00	-3.52103E-06	1.39885E-03	1.02279E+03	3.05414E+03	2.03854E+03	0.	5.11471E+00
2.70000E-01	1.00150E+00	-5.56655E-06	2.09650E-03	1.02341E+03	3.05414E+03	1.90443E+03	0.	5.11211E+00
2.80000E-01	1.00220E+00	-8.61660E-06	3.04539E-03	1.02409E+03	3.05413E+03	1.77434E+03	0.	5.10943E+00
2.90000E-01	9.99553E-01	-1.31111E-05	4.32842E-03	1.02483E+03	3.05408E+03	1.64875E+03	0.	5.10662E+00
3.00000E-01	9.93359E-01	-1.21278E-05	5.98901E-03	1.02564E+03	3.05402E+03	1.52766E+03	0.	5.10358E+00
3.10000E-01	9.86202E-01	1.62859E-06	8.12545E-03	1.02648E+03	3.05359E+03	1.41055E+03	0.	5.10030E+00
3.20000E-01	9.79155E-01	3.00982E-05	1.07822E-02	1.02738E+03	3.05315E+03	1.29669E+03	0.	5.09676E+00
3.30000E-01	9.72572E-01	7.30005E-05	1.40725E-02	1.02831E+03	3.05226E+03	1.18532E+03	0.	5.09289E+00
3.40000E-01	9.66588E-01	1.29323E-04	1.80462E-02	1.02929E+03	3.05138E+03	1.07571E+03	0.	5.08865E+00
3.50000E-01	9.61265E-01	1.97779E-04	2.27722E-02	1.03031E+03	3.04930E+03	9.67219E+02	0.	5.08396E+00
3.60000E-01	9.56646E-01	2.76964E-04	2.83210E-02	1.03137E+03	3.04722E+03	8.59291E+02	0.	5.07877E+00
3.70000E-01	9.52774E-01	3.65384E-04	3.47629E-02	1.03246E+03	3.04297E+03	7.51468E+02	0.	5.07297E+00
3.80000E-01	9.49689E-01	4.61466E-04	4.21649E-02	1.03357E+03	3.03873E+03	6.43204E+02	0.	5.06652E+00
3.90000E-01	9.47430E-01	5.63558E-04	5.05860E-02	1.03472E+03	3.03141E+03	5.34274E+02	0.	5.05941E+00
4.00000E-01	9.46035E-01	6.69935E-04	6.00842E-02	1.03589E+03	3.02408E+03	4.24791E+02	0.	5.05168E+00
4.10000E-01	9.45545E-01	7.78797E-04	7.07175E-02	1.03709E+03	3.01676E+03	3.15069E+02	0.	5.04330E+00
4.20000E-01	9.46007E-01	8.88267E-04	8.25423E-02	1.03831E+03	3.00943E+03	2.05601E+02	0.	5.03423E+00
4.30000E-01	9.56576E-01	1.09056E-03	1.18199E-01	1.03956E+03	3.00211E+03	9.68115E+01	0.	5.02611E+00
4.40000E-01	9.64545E-01	1.13379E-03	1.34071E-01	1.04084E+03	2.99478E+03	-1.12483E+01	0.	5.01591E+00
4.50000E-01	9.71450E-01	1.16516E-03	1.46532E-01	1.04215E+03	2.98746E+03	-1.16682E+02	0.	5.00365E+00
4.60000E-01	9.79670E-01	1.21938E-03	1.71807E-01	1.04348E+03	2.98013E+03	-2.18178E+02	0.	4.99156E+00
4.70000E-01	9.91585E-01	1.25636E-03	1.96796E-01	1.04482E+03	2.97281E+03	-3.14361E+02	0.	4.97902E+00
4.80000E-01	1.00534E+00	1.26852E-03	2.23181E-01	1.04617E+03	2.96548E+03	-4.03971E+02	0.	4.96606E+00


RETHAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
VOL 10
AVG. PRESS.
(PSI)
1.12E+03
1.10E+03
1.08E+03
1.06E+03
1.04E+03
1.02E+03
1.00E+03
-9.90E-02
1.00E-03
1.01E-01
2.01E-01
4.01E-01
5.01E-01
6.01E-01
7.01E-01
8.01E-01
9.01E-01
1.00E+00

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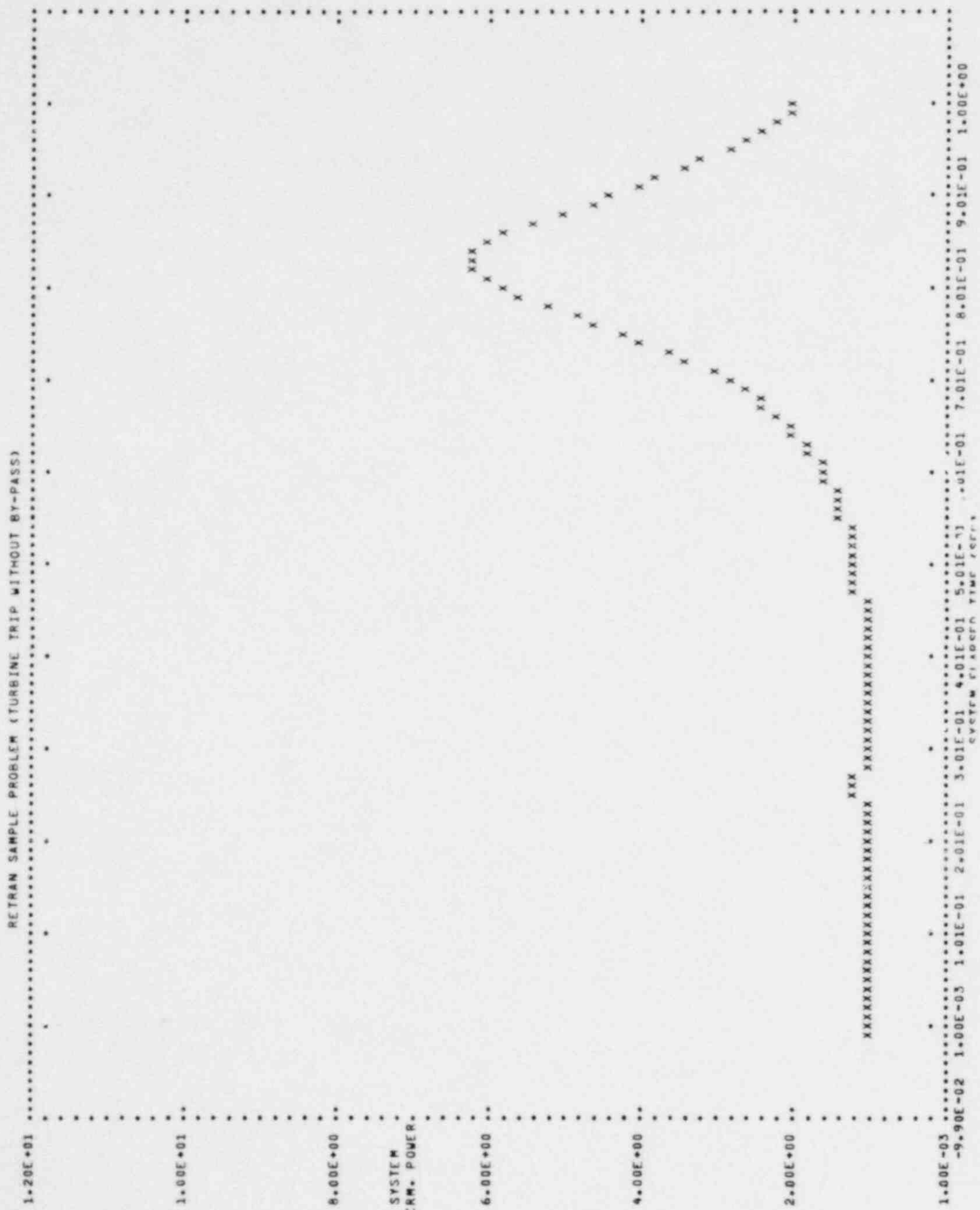
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
SYSTEM
NORM. POWER
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
1.00E-03
-9.90E-02
1.00E-03
1.01E-01
2.01E-01
3.01E-01
4.01E-01
5.01E-01
7.01E-01
8.01E-01
9.01E-01
1.00E+00

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6.0 UNCONTROLLED ROD WITHDRAWAL

A Westinghouse three-loop plant was used to develop the Uncontrolled Rod Withdrawal (UCRW) Sample Problem. However, the results are not necessarily totally applicable to a specific plant. Initial conditions assumed for this sample problem are given in Table IX.6-1. The UCRW transient consists of a linear time-dependent reactivity insertion which results in a core power rise and, hence, system pressure and temperature rise until scram occurs due to a high neutron flux (overpower) or an overpower or overtemperature trip.

Figure IX.6-1 gives a schematic of the PWR model nodalization. The basic model consists of 20 volumes, 31 junctions and 7 heat conductors. All pertinent control systems, and safety and relief valves are modeled in some detail. A more detailed discussion of the model is found in EPRI NP-454 [IX.5-1].

The input for the UCRW Sample Problem is given below. A restart-plot tape was created by this problem. Minor edits and printer plots were also obtained. This sample problem was used to obtain examples of RESTRT, REEDIT, and PLOTER runs. These will be discussed in Sections X, XI and XII. The UCRW output at 0.0 second, minor edits, and representative printer plots are given below.

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TABLE IX.6-1

PWR BASE CASE INITIAL CONDITIONS

Parameter	Units	Value
Thermal Power	MW	2244
Steam Flow	10^6 lb/hr	9.86
Core Flow	10^6 lb/hr	98.4
Core Bypass Flow	10^6 lb/hr	3.08
Pressurizer Pressure	psia	2220
Core Inlet Temperature	°F	550.2
Scram Curve	MWD/T	BOL
Scram Worth	$	-8.79
Moderator Coefficient	¢/%	0.0
Doppler Coefficient	¢/°F	-0.7(nom)

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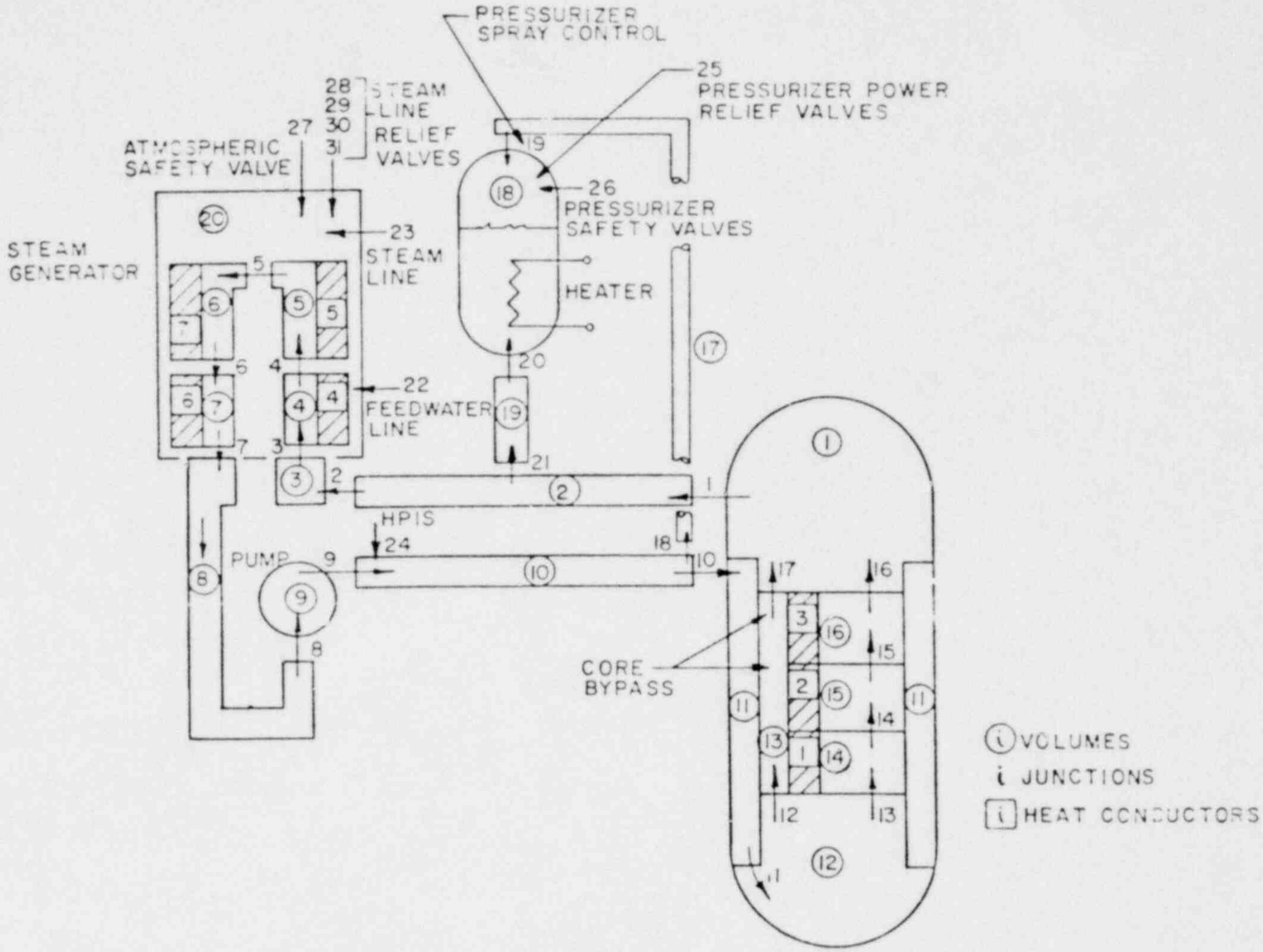

Figure IX.6-1 Typical PWR RETRAN Model for Uncontrolled Rod Withdrawal

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LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
*
***   ***   UNCONTROLLED RCCA WITHDRAWAL AT POWER   ***   ***
*      TAP EDT STP TRP VOL BUB TDV JUN PMP VLV LEK FIL SLB GEO MAT COR HX FM
010001 -1   8   3   42  20  2   0   31  1  10   8   7   7   2   4   3   3
*
*
*      NTMM  NODEL MWR  NLV  MTD  ISF NCHT  JSST IPRS ITRNS IDNB ICF
*
010002    0    2    0    1    0    0    0    1    1    1    1    1
*
010040    *UCRW              *
*
*     PROBLEM CONSTANTS
010005  2244.    1.
*
*   CHANGES FOR  IBM  MACHINE  RUNS  *
*
*
*  QUOTED VARIABLES ARE USED FOR AN "IBM COMPUTER" USAGE.******
*
*
020001  *PRES* 1  *PRES* 18  *TEMP* 2  *PRES* 20  *PNRM* 0  *WP***  21
020002  *RC*** 0  *RD*** 0
702001      1    *TEMP*   2     1.0    606.5      * HOT LEG TEMPERATURE
702002      2    *TEMP*   8     1.0    549.51     * COLD LEG TEMPERATURE
702003      3    *PRES*  18     1.0   2220.0      * PRESSURIZER  PRESS
702004      4   *CONS*    0     1.0      1.0      * CONSTANT BLOCK  1.0
702005      5   *CONS*    0   56.99    56.99      * CONSTANT BLOCK 56.99
703001    -1  *SUM*   1     2        1.0   1.0   -1.0   56.99
703002    -2  *SUM*   1     2        0.5   1.0    1.0  578.005
703003    -3  *SUM*  -2     4    -0.0107   1.0  -578.005  0.0
703004    -4  *SUM*   3     4   0.000453   1.0  -2220.    0.0
703005    -5  *SUM*  -4     4        1.0   1.0    0.0    0.0
703006    -6  *SUM*  -3    -5        1.0   1.0    1.0    0.0
703007    -7  *SUM*  -6     4        1.0   1.0   1.095   1.095
703008    -8  *MUL*   5    -7        1.0   0.0    0.0   62.404
703009    -9  *SUM*  -8    -1        1.0  -1.0    1.0   -5.414
703010   -10  *DER*  -2     0        0.2   0.0    0.0    0.0   0.0    1.+9
703011   -11  *SUM* -10     4        1.0  -1.0    0.0    0.0
703012   -12  *SUM*  -2     4    0.00068   1.0  -578.005  0.0   0.0    1.+9
703013   -13  *SUM* -12     4        1.0  -1.0    1.11   1.11
703014   -14  *SUM* -11   -13        1.0   1.0    1.0    1.11
703015   -15  *MUL* -14     5        1.0   0.0    0.0   63.255
703016   -16  *SUM* -15    -1        1.0  -1.0    1.0   -6.269
703017   -17  *SUM*   3     4        1.0   1.0  -2220.    0.0     0.0   1.+9
703018   -18  *FNG* -17     8        1.0   0.0    0.0     7.886-4
703019   -19  *LAG* -18     0        1.0   1.0    0.0     7.886-4
*
010050   "STEAMTABLE       "  "DISK"   "EIUCC"   1
010050  *@1152.WATRPRCP   *  *EI0001*,  *  *,   0
CARD ABOVE IS REPLACEMENT CARD.
*
*     EDIT VARIABLES
*
030001   .01   1.   25.   25.   500.
*     TIME STEPS
*
*3XXX0 MIN MAJ RST CHK DTMAX DTMIN TLAST
```

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```
030010  1   2   50  0   .01    1.-4    .1
030020  1    4    5   0    .05    .001    15.
030030  1   10    2   0    .5     .01     70.
*
*      TRIP CONTROLS                                                        *
*
* TRIP ACTION IDENTIFICATION
*  1 = END OF PROBLEM TIME TRIP
*  2 = LOW STEAM GENERATOR LEVEL
*  3 = FLOW MISMATCH
*  4 = TURBINE TRIP
*  5 = SAFETY INJECTION SYSTEM
*  6 = LOW PRESSURIZER PRESSURE
*  7 = LOW PRESSURIZER LEVEL
*  8 = HIGH STEAM FLOW
*  9 = LOW TAVG
* 10 = LOW STEAM PRESSURE
* 11 = FEEDWATER ISOLATION
* 12 = PRESSURIZER POWER RELIEF VALVES
* 13 = PRESSURIZER SAFTEY VALVES
* 14 = STEAM LINE SAFTEY VALVES
* 15 = STEAM LINE RELIEF VALVE 1
* 16 = REACTOR SCRAM
* 17 = STEA[illegible] RELIEF VALVE 2
* 18 = S[illegible] RELIEF VALVE 3
* 19 = S[illegible]NE RELIEF VALVE 4
* 20 = MISC GENL TIME  0.0  TRIP  START FILL TABLES ETC
* 21 = REACTOR COOLANT PUMP
* 22 = PRESSURIZER CONTROL HEATERS 1
* 23 = PRESSURIZER BACKUP  HEATERS 1
* 24 = PRESSURIZER CONTROL HEATERS 2
* 25 = UNCONTROLLED ROD WITHDRAWL
*
040010      1   1   0  0       5.03       0.0
040010      1   1   0  0       3.0        0.0
CARD ABOVE IS REPLACEMENT CARD.
040020      4      1      0    0     1.+9      0.0    * TURBINE TRIP MANUAL
040030      6     -4     18    0     1860.     0.0    * LOW PRESSURIZER PRESS
040040      7     -6    18     0     13.31     0.0    * LOW PRESSURIZER LEVEL
040050      5     13      6    7      0.0      1.0    * LOW PRESS AND LEVEL
040060      9    -14     -2    0     531.      0.0    * LOW TAVG
040070     16      6     18    0     42.45     1.0    * HIGH PRESSURIZER LEVEL
040080     16     12      6    0      0.0      1.0    * LOW PRESSURIZER PRESS
040090     16      4     18    0     2425.     1.0    * HIGH PRESSURIZER PRESS
040100     16      2      0    0      1.18     0.5    * NUCLEAR OVERPOWER
040110     16     14     -9    0      0.0      2.3    * OVER TEMPERATURE DELTA T
040120     16     14    -16    0      0.0      2.3    * OVER POWER DELTA T
040130     16     -9      9    0  24528.8       .6    * LOW COOLANT FLOW ALL PUMPS
040140     16     12      4    0      0.0      1.0    * SCRAM FROM TURBINE TRIP
040150     16     12      5    0      0.0      0.5    * SCRAM FROM SIS
040160      5     12     16    0      0.0      1.0    * TURBINE TRIP FROM SCRAM
040170     11     13      9   16      0.0      2.0    * FW ISOLATION SRAM AND TAVG
040180     11     12      5    0      0.0      0.5    * FW ISOLATION FROM SIS
040190     21      1      0     0  1+9         0.     * RECIRC PUMP TRIP          SS
***     ***     ***     STEADY STATE
040200     13      4     18     0  2500.       1.     * OPEN PRES SAFETY VALVE
040210    -13     -4     18     0  2400.       1.     * CLOSE PRES SAFETY VALVE
040220     12      4     18     0  2350.        .5    * OPEN  PRES RELIEF VALVE
040230    -12     -4     18     0  2250.        .5    * CLOSE PRES RELIEF VALVE
*
***     ***   S/R SET POINTS RAISED 70 PSI TO ALLOW FOR INITIALIZATION
```

```
040240     14      4     20     0  1050.        .5   * OPEN  S.L. SAFETY VALVES
040250    -14     -4     20     0   950.        .5   * CLOSE S.L. SAFETY VALVES
040260     15      4     20     0  1100.        .5   * OPEN  S.L. RELIEF VALVE  1
040270    -15     -4     20     0  1000.        .5   * CLOSE S.L. RELIEF VALVE  1
040280     17      4     20     0  1115.        .5   * OPEN  S.L. RELIEF VALVE  2
040290    -17     -4     20     0  1015.        .5   * CLOSE S.L. RELIEF VALVE  2
040300     18      4     20     0  1130.        .5   * OPEN  S.L. RELIEF VALVE  3
040310    -18      4     20     0  1030.        .5   * CLOSE S.L. RELIEF VALVE  3
040320     19      4     20     0  1145.        .5   * OPEN  S.L. RELIEF VALVE  4
040330    -19     -4     20     0  1045.        .5   * CLOSE S.L. RELIEF VALVE  4
*
040340     20      1      0     0     0.        0.      * GENL MISC TRIP AT TIME 0.
040350     22     -4     18     0   2235.       0.   * PRESSUR HEATERS  CONTROL  ON
040360    -22     +4     18     0   2235.       0.   * PRESSUR HEATERS  CONTROL OFF
040370     23     -4     18     0   2195.       0.   * PRESSUR HEATERS BACKUP    ON
040380    -23     +4     18     0   2195.       0.   * PRESSUR HEATERS  BACKUP  OFF
040390    24    -4    18    0   2213.        0.   * PRESSUR HEATERS  CONTROL  ON
040400    -24     +4    18    0   2227.        0.   * PRESSUR HEATERS CONTROL  OFF
***     ***      ***     STEADY STATE
040410     16      1     0     0    1+9   0      * SCRAM ON TIME LOSS PUMP POWER
040420     25    1     0     0     0.      0.            * URW REACTIVITY INSER
*
*      VOLUME DATA
*
*5XXXY R V PRESSURE ENTHLP QUAL VOLUM HEIGH MXLVL F FLOWA HYDIA ELEVAT
* UPPER PLENUM
050011 0 0 2240.64   672.887 0.0 984.3 11.58 11.58 0  1.+9     .5  -4.71 * UP PLEN
050021 0 0 2225.659 622.842 0.0 295.2  2.82  2.82 0 13.77  2.42  -1.21 * HOT LS7
050031 0 0 2225.58   622.869 0.0 405.9  5.05  5.05 0 113.6  6.      1.61 * S7 PLEN
050041 0 0 2218.3    607.966 0.0 607.5 14.87 14.87 0 40.84 .05      6.66 * SG T
050051 0 0 2208.72   582.600 0.0 607.5 14.87 14.87 0 40.84 .05     21.53 * SG TUB
050061 0 0 2203.59   564.798 0.0 607.5 14.87 14.87 0 40.84 .05     21.53 * SG TU 3
050071 0 0 2203.72   552.363 0.0 607.5 14.87 14.87 0 40.84 .05      6.66 * SG TUB4
050081 0 0 2194.2    547.317 0.0 801.6 16.46 16.46 0 15.72  2.58  -9.8  * PMP SUC
050091 0 0 2242.9    547.691 0.0 576.   5.19  5.19 0  1.+9  1.+9  -4.04 * PMPS
050101 0 0 2272.07   547.593 0.0 247.8  2.3   2.3  0 12.36  2.29  -1.15 * CL4 LSG
050111 0 0 2269.714 547.487 0.0 789.9 26.77 26.77 0 29.51  1.45 -19.9  * DN3MR
050121 0 0 2272.28   547.407 0.0 806.2  9.85  9.85 0  1.+9    .5 -26.55 * LW PLEN
050131 0 0 2255.34   547.474 0.0  42.7 12.   12.   0  3.52  .026 -16.7  * BYPASS
050141 0 0 2260.54   558.382 0.0 167.4  4.    4.   0 43.75 .0412 -16.7  *BTM CORE
050151 0 0 2255.44   586.327 0.0 167.4  4.    4.   0 43.75 .0412 -12.7  *MID CORS
050161 0 0 2250.34   614.273 0.0 167.4  4.    4.   0 43.75 .0412  -8.7  *TOP CORE
050171 0 0 2287.95   547.596 0.0 5.075 43.3  43.3  0 .1015 .359     1.15 * SPAY LN
050181 1 0 2220.     0.0     0.0  1300. 33.77 20.27  0 38.48  7.      8.78 * PRESSU
050182     1      4.    * PRESSURIZER INPUT FLAG RAINOUT VELOCITY
050191 0 0 2224.204 697.896 0.0   28.6 8.78  8.78 0 .7213  .9538  0.    * SURGE
050261 2 0  871.12 614.934 -1.0   8543. 63.    49.5  0  33.9  .112    6.66 * SG SC
*
*
*  PIPE TRANSPORT INPUT
*5XXXY  INEQ RAINVEL TRANSPT MESH
050022      0    0         1      20
150082      0    0         1      20
050102      0    0         1      20
050112      0    0         1      20
050132      0    0         1      20
050172      0    0         1      20
*
*
*  SEPARATION MODELS
060011   1.   3.       * PRESSURIZER
```

```
060021   0.  14.07    * STEAM GENERATOR  SECONDARY
*
060000   20         *  LIQUID LEVEL OF S.G. SEC
*
*       JUNCTION DATA
*
*BOXXY FM TO PP VV FLOWRT JUNAR JNELE INERTIA KFOR KREV JV JC CL MV DI CN IC Q
* VESSEL EXIT
* SG ENTR
080011  1  2  0  0 28194.  13.77  0.     2.4   .4187  0.0 0  1  0  0 0. 1. -1 0
080021  2  3  0  0 28194.
080022                      13.77 1.61   1.19  .7534 0.0  0  1  0  0 0. 1. -1 0
* S7 TUBE ENTH
080031  3  4  0  0 28194.1045
080032                      32.04  6.66   .49 1.0645 0.0  0  1  0  0 0. 1. -1 2
* SG TUBE
080041  4  5  0  0 28194.1045
080042                      32.04 21.53   .75  .3984 0.0  0  1  0  0 0. 1. -1 3
* SG BEND
080051  5  6  0  0 28194.1045
080052                      32.04 36.3    .75  .5470 0.0  0  1  0  0 0. 1. -1 3
* SG TUBE
080061  6  7  0  0 28194.1045
080062                      32.04 21.5'   .75  .2983 0.0  0  1  0  0 0. 1. -1 3
* SG TUBE EXIT
080071  7  8  0  0 28194.1045
080072            '         15.72  6.66  `.8  .3463 0.0   0  1  0  0 0. 1. -1 1
* PUMP ENTR
080081  8  9 -1  0 28194.1045
080082                      12.36 -4.04  2.54  .0712 0.0  0  1  0  0 0. 1. -1 0
* PUMP EXIT
080091  9 10  1  0 28194.1045
080092                      12.36  0.    1.32  .0611 0.0  0  1  0  0 0. 1. -1 0
* VESSEL ENTR
080101 10 11  0  0 28194. 12.36  0.     1.67 1.1502 0.0  0  1  0  0 0. 1. -1 0
* LOWER PLENUM
080111 11 12  0  0 28194. 19.69 -19.9    .59  .9106 .88  0  1  0  0 0. 1. -1 0
* BY PASS IN
080121 12 13  0  0   856.  1.5  -16.7   1.8  16.938 0.0  0  1  0  0 0. 1. -1 0
* CORE ENTRY
080131 12 14  0  0 27338. 43.75 -16.7    .18 8.9129 0.0  0  1  0  0 0. 1. -1 2
* CORE
080141 14 15  0  0 27338. 43.75 -12.7    .09 2.8927 0.0  0  1  0  0 0. 1. -1 3
* CORE
080151 15 16  0  0 27338. 43.75  -8.7    .09   2.7894 0.0 0 1  0  0 0. 1. -1 3
* CORE EXIT
080161 16  1  0  0 27338. 43.75  -4.7    .05 7.7418 0.0  0  1  0  0 0. 1. -1 1
* BY PASS OUT
080171 13  1  0  0   856.  1.5  -4.7    1.8 13.8994 0.0  0  1  0  0 0. 1. -1 0
* PRESSURIZER SPRAY LINE JUNCTIONS
080181 10 17  0  0  .1045 .1015  1.15 247.5   1.    .5   0  1  0  0 0. 1. -1 0
080191 17 18 0 1 .1045 .253614  42.08 123.3 100. 100. 2  1  0  0  0.0 1. -1 0
080192   1        * PRESSURIZER SPRAY JUNCTION
* PRESS EXIT
080201 19 18  0  0 -.1045 .6013  8.78   0.     2.8  2.3   2  1  2  0 0. 1. -1 0
* FEEDWATER TO S.G.
080211  2 19  0  0 -.1045 .6013   .0    0.     2.3  2.8   0  1  2  3 0. 1. -1 0
080221  0 20  4  9  2739.785 3.  6.66   0.     0.   0.    0  1  0  0 0. 1.  1 0
* S.G. TO STEAM LINE
080231  0 20  5 10 -2739.785 3. 69.66   0.     0.   0.    0  1  0 -2 0. 1. -1 0
*     HPIS      4 PUMPS
```


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```
080241  0 10  6  0      0.  4.     .0     0.     0.    0.     0  1  0  0 0. 1. -1  0
*  PRESSURIZER POWER RELIEF VALVES   2 EACH
080251  0 18  1  2      0.  2.   41.7     0.     0.    0.     0  1  0  0 0. 1. -1  0
*  PRESSURIZER SAFTEY VALVES     3 EACH
080261  0 18  2  3      0.  3.   41.7     0.     0.    0.     0  1  0  0 0. 1. -1  0
*  STEAMLINE ATMOSPHERIC SAFTLY VALVES      3 EACH
080271  0 20  3  4      0.  3.   62.2     0.     0.    0.     0  1  0  0 0. 1. -1  0
*  STEAMLINE RELIEF VALVES
080281  0 20  7  5      0.  3.   62.2     0.     0.    0.     0  1  0  0 0. 1. -1  0
080291  0 20  7  6      0.  3.   62.2     0.     0.    0.     0  1  0  0 0. 1. -1  0
080301  0 20  7  7      0.  3.   62.2     0.     0.    0.     0  1  0  0 0. 1. -1  0
080311  0 20  7  8      0.  3.   62.2     0.     0.    0.     0  1  0  0 0. 1. -1  0
*
*
*      PUMP CURVE INPUT OPTION
100000     2     0
*      PUMP DESCRIPTION
*        TR P RV 2P MT RPM   IS  FLOW   HEAD TORQUE INERTIA D  FRIC  MT
*90  RATED CONDITIONS 1180. 1. 265500. 260. 77535. 210000. 47.66 3606. 0.
****      RATED TORQUE EFFICIENCY = 77 PER CENT   TIME CONST = 6.5 SEC
090011  1  21 0  1  0 1180. 1. 265500. 260. 59319. 210000. 47.66 3606. 0.
*      PUMP HEAD AND TORQUE MULTIPLIER
091011 11  0.0  0.0 0.1 0.0 0.15 0.05 0.24 0.80 0.30 0.96 0.40 0.98   *  HEAD
091012       0.60 0.97 0.80 0.90 0.90 0.80 0.96 0.50 1.00 0.0
092011  2   0.0  0.0   1.0  0.0       * TORQUE
*
*  VALVE DATA
*
110010  1000    -19  0  0  0  0          * PRESSURIZER SPRAY VALVE
110020  -12  1  0  0  0  0          * PRESS  POWER RELIEF VALVES   2 EACH
110030  -13  2  0  0  0  0          * PRESS SAFETY VALVE    3 EACH
110040  -14  3  0  0  0  0          * ATM. SAFETY VALVE
110050  -15  4  0  0  0  0          * STM LINE RELIEF VALVE 1
110060  -17  5  0  0  0  0          * STM LINE RELIEF VALVE 2
110070  -18  6  0  0  0  0          * STM LINE RELIEF VALVE 3
110080  -19  7  0  0  0  0          * STM LINE RELIEF VALVE 4
110090   11  0  0  0  0  0          * FEEDWATER FLOW VALVE
110100    4  0  0  0  0  0          * STEAM LINE ISOLATION VALVE
*
*
*    LEAK TABLES
120101  -3          0. 0.   .1 1.   1*9 1.   * PRESS POWER RELIEF VALVE
120201  -3          0. 0.   .1 1.   1*9 1.   * PRESS SAFETY VALVE
120301  -3          0. 0.   .1 1.   1*9 1.   * STM LINE ATM. SAFETY VALVE
120401  -3          0. 0.   .1 1.   1*9 1.   * STM LINE RELIEF VALVE 1
120501  -3          0. 0.   .1 1.   1*9 1.   * STM LINE RELIEF VALVE 2
120601  -3          0. 0.   .1 1.   1*9 1.   * STM LINE RELIEF VALVE 3
120701  -3          0. 0.   .1 1.   1*9 1.   * STM LINE RELIEF VALVE 4
*
*      FILL DATA
*
*  PRES POWER RELIEF VALVE          PSIA VS LMB/SEC
130101  -2  20  1  0  2250. -54.255 1100. 2250.  2350. -58.333 1100. 2350.
* PRESS SAFTEY VALVES               PRES(PSIA) VS  FLOW(LBM/SEC)  EACH VALVE
130201  -2  20  1  0  2400. -74.407 1100. 2400.  2500. -80. 1100. 2400.
* ATMOSPHERIC SAFTEY VALVES     PRES(PSIA) VS FLOW (LBM/SEC)  EACH VALVE
130301  -2  20  1  0  950. -25.0206 1100. 950.  1050. -27.972 1100. 1050.
*      SG FEEDWATER          102 PCT FLOW
130401  -2  20  0  -1  .0 913.262 415.503 853.4  1.+9 913.262 415.503 853.4
*      SG STEAM FLOW      102 PCT FLOW
130501  -2  20  0  -1  .0 -913.262 1100. 500.  1.+9 -913.262 1100. 500.
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*  HPIS                 PRESSURE (PSIA)  VS  FLOW (GPM)  EACH PUMP
130601  -2  4  1  1  100. 100. 100. 100.  101. 100. 100. 100.
* STEAMLINE RELIEF VALVES      PSIA VS LBM/SEC      4 EACH
130701  -2  20  1  0 1100. -227.173 1100. 100.  1145. -236.473 1100. 1145.
*
*
*       REACTOR DATA
*
*140000       B/L
140000   0   400.   0.0   .73   .93
*
*        REACTIVITY COEFFICIENTS
*
140010      0.22780  0.22780 .0  .0  .026   .026
140020      0.54450  0.54450 .0   .0    .026   .026
140030      0.22780  0.22780  .0   .0   .026   .026
*
*       SCRAM CURVE (-8.79 $ TOTAL WORTH)
*
141001   15   16   0. 0.   .2 -.0659   .4 -.176   .8 -.615   1. -1.05
141002   1.2 -1.71   1.4 -2.72   1.6 -4.34   1.7 -5.71   1.8 -7.74
141003   1.85 -8.35   1.9 -8.57   1.95 -8.66   2.3 -8.79   1+9 -8.79
*
*141101 PTS  TRP      RAPID ROD WITHDRAWL 5.625E-4 DK/SEC  EG  .078125 $/SEC
141101   3   25    0. 0.   19.73 1.542   1+9 1.542
*
*       DENSITY REACTIVITY CURVE -  MODERATOR COEFFICIENT = ZERO
*       RHO   $
142001      -2      0.0  0.0      1300.0  0.0
*
*       DOPPLER REACTIVITY CURVE
*           TEMP    $
143001   -8   550. 0.   700. -.01354   800. -.03646   1000. -.1059
143002   1200. -.1948   1400. -.3031   1700. -.5031   1950. -.6941
*
*
*     HEAT CONDUCTORS
*        V1 V2 GE ST CL CR AREALF AREART VOL  HOYL  HDYR HEDL  HEDR CHANL CHANR
*  CORE
150011  0 14  1  0  2  2      0. 14153. 124.43 0.  .04   0.  .047    0.  4.  0
150021  0 15  1  1  2  2      0. 14153. 124.43 0.  .04   0.  .047    0.  48.  0
150031  0 16  1  1  2  2      0. 14153. 124.43 0.  .04   0.  .047    0.  12.  0
*  STEAM GENERATOR
150041  4 20  2  0  2  2 29514. 33322. 131. .0646 .112 .0646 .112 14.87 14.87  0
150051  5 20  2  1  2  2 29514. 33322. 131. .0646 .112 .0646 .112 29.75 29.75  0
150061  7 20  2  0  2  2 29514. 33322. 131. .0646 .112 .0646 .112 59.5  29.75  0
150061  7 20  2  0  2  2 29514. 33322. 131. .0646 .112 .0646 .112 59.5  14.87  0
CARD ABOVE IS REPLACEMENT CARD.
150071  6 20  2  1  2  2 29514. 33322. 131. .0646 .112 .0646 .112 44.62 14.87  0
150071  6 20  2  1  2  2 29514. 33322. 131. .0646 .112 .0646 .112 44.62 29.75  0
CARD ABOVE IS REPLACEMENT CARD.
*
*       CORE DATA
*       SLAB PO NODES     CLAD     POWER
160010  1               0.       0.282
160020  2               0.       0.436
160030  3               0.       0.282
*
* GEOMETRY DATA
*       GEO REG MAT SS RADIUS  WIDTH  PFR
170101  2   3   1   4 .0        .01529  1.     *  FUEL PELLET
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170102    1     4   2          2.71-4  0.     *  GAP
170102    1     4   2          3.35-4  0.     *  GAP
CARD ABOVE IS REPLACEMENT CARD.
170103    0     2   3          .002025 0.     *  CLAD
170103    0     2   3          1.958-3 0.     *  CLAD
CARD ABOVE IS REPLACEMENT CARD.
170201  2   1   3   3 .0323    .00417  0.     *  S. G. TUBES
*
*18XXYY   THERMAL CONDUCTIVITY DATA
*
* THERM COND  UO2  REF GEAP-5591 LYONS ET AL (1968)   95 PCT TH DEN   93 W/CM
180101  -15                                        * THERM COND  UO2  1
180102    32. 5.49  212. 4.40   392. 3.67   752. 2.76      * THERM COND  UO2  2
180103  1112. 2.23  1472. 1.88  1832. 1.65  2192. 1.48     * THERM COND  UO2  3
180104  2500. 1.40  3000. 1.33  3500. 1.33  4000. 1.39     * THERM COND  UO2  4
180105  4500. 1.51  4800. 1.61  5100. 1.73                 * THERM COND  UO2  5
*
* THERMAL COND  ZR-4  REF  BRASSFIELD%1968<GEMP-482 RECOM... LWR LOCA
180201  -8      0.   8.     1490. 12.32  2150. 17.5        * THERM COND ZR-4   1
180202  2372. 19.7   2552. 21.8   2732. 24.0   3292. 28.9  * THERM COND ZR-4   2
180203  3360. 33.1                                         * THERM COND ZR-4   3
*
180301  -3       212.  10.     752.  11.   1832.  18.      * INCONEL-600
*
* GAP
180400   1           0.  .136
*
* VOLUMETRIC HEAT CAPACITY
*
* SPEC HEAT  UO2  REF  BRASSFIELD%1968<GEMP-482 RECOM...LWR LOCA
* SPEC HEAT  UO2  95 PCT  TH DEN AT 1000F  642 LB/FT3
* SPEC HEAT  UO2  REF  BRASSFIELD%1968<GEMP-482 TOULOUKIAN SAME TO 3750 F
190101  -19                                                  * VOL HT CAP UO2    1
190102    77. 36.22        100. 37.12        200. 40.05      * VOL HT CAP UO2    2
190103   300. 41.96        400. 43.88        600. 45.18      * VOL HT CAP UO2    3
190104   800. 46.41       1000. 47.32                        * VOL HT CAP UO2    4
190105                                      2400. 50.77      * VOL HT CAP UO2    5
190106  2600. 51.43       2800. 52.61       3000. 54.57      * VOL HT CAP UO2    6
190107  3200. 57.42       3400. 61.23       3600. 65.93      * VOL HT CAP UO2    7
190108  4600. 95.15       4800. 99.31       5000. 101.57     * VOL HT CAP UO2    8
190109  5074. 101.76                                         * VOL HT CAP UO2    9
*
* SPEC HEAT  ZR-2   REF HMI-1803 ELDRIDGE ET AL (1967)                DEN 409.5
190201   15                                       * VOL HT CAP  ZR-2        1
190202    32.  26.75      932.  32.56   1112.  34.40  * VOL HT CAP  ZR-2        2
190203  1184.  35.22     1490.  35.22   1508.  49.14  * VOL HT CAP  ZR-2        3
190204  1544.  57.74     1580.  60.20   1616.  70.43  * VOL HT CAP  ZR-2        4
190205  1652.  79.85     1688.  75.35   1724.  59.38  * VOL HT CAP  ZR-2        5
190206  1760.  45.86     1787.  34.81   3300.  34.81  * VOL HT CAP  ZR-2        6
*
* INCONEL-600, CP....REF. NUCLEAR SYSTEMS MATERIALS HANDBOOK, SEC. 3.
190301 -8  200. 57.2600   400. 60.1409   450. 60.6320   500. 61.1216*INCONEL-600
190302        550. 61.6716   600. 62.0564   800. 64.1549   1000. 67.2913*INCNL600
*
* GAP
* SPEC HEAT  HELIUM  REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3
190401  -2      32. .0149        5400. .0149                 * VOL HT CAP HELIUM 1
*
* COEF OF LINEAR THERMAL EXPANSION
*
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* THERM EXPAN COEF  U02  REF  GEMP-482
200101  -2  0. 3.72-6   4082. 11.0-6                        . EXPAN COEF  U02   1
*
* THERM EXPAN COEF  ZR-4  REF  GEMP-482 X1968<<
200201   -4                                                 * THERM EXPAN ZR-4  1
200202     0.  3.10-6  1580.  4.64-6  1584.  5.4-6          * THERM EXPAN ZR-4  2
200203  3400.  5.40-6                                       * THERM EXPAN ZR-4  3
*
200300  -2  0. 0.  2000. 0.               *  INCONEL 600
*
* GAP
200400  -2
200401     0.0    0.0    2000.  0.
*
*21XXYY   HEAT EXCHANGER DATA   FOR  PRESSURIZER HEATERS
*       IHTX TRIP VOL   KW  TC
210101   0   22   18  5 200. 1.-9       *  CONTROL HEATER
210201   0   23   18  5 900. 30.          * 2 BACKUP HEATERS  450 KW EACH
210301   0   24   18  5 200. 30.          *  CONTROL HEATER
*
*   CONTROL SYSTEMS
701000    5   19
* OVER TEMPERATURE DELTA-T TRIP CONTROL SYSTEM
*702XXX     IDC     VAR     REG   GAIN    CIC
* FUNCTION GENERATOR PRESSURIZER SPRAY CONTROL SYSTEM
120801  4   0.0 7.886-4  25. 7.886-4  40. 1.  1.+9 1.
*
*
*   DNB MODEL INPUT
*8001XX LWR ICW NUM ICHF ITCROF NOA
800100   1   0    1   1    0       11
*8001XX LWR ICW NUM ICHF ITCROF NOA      N1
800100   1   0    1   1    0       11      3
CARD ABOVE IS REPLACEMENT CARD.
*8002XX FQENG  FNR  FGUNC FDHCOR FDHENG ZMIN ZMAX
*8002XX    FEQ  FNR   FUNG   HCEN         ZMIN  ZMAX
800200   1.03  1.73   1.      .95    1.       5.   12.
*8003XX   PITCH            DIAM                    EQHEATDIA   TDC     PF     EDIT
*8003XX   PITCH            DIAM                    EQHEATDIA   TDC     PF
800300    0.04691666667  0.03516666667      0.04452          .0  0.974     5
800300    0.04691666667  0.03516666667      0.04452          .0  0.974
CARD ABOVE IS REPLACEMENT CARD.
*8004XX   Z/L  PROF
800400    0. .21   .1 .45   .2 .75   .3 1.1   .4 1.33   .5 1.62
800401   .6 1.41   .7 1.47   .8 1.05   .9 .64   1. .24
*8005XX   NVLDNB(1)     NVLDNB(2) .........NVLDNB(N1)
800500    14      15     16
230000   -25
230011   1  22  23  1.0
*
*
* THE FOLLOWING CARDS,IF INCLUDED, WILL RUN CASE IN SS(OTHERWISE IN TRANSIENT)
*
*
*   STEADY STATE PACKAGE   ******************************************
*
*
010002    0    2    0    1    0    0    0    0    1    1    1    1
CARD ABOVE IS REPLACEMENT CARD.
050011 0 0    0.0     0.0   0.0 984.3 11.58 11.58 0  1.+9     .5  -4.71 * UP PLEN
CARD ABOVE IS REPLACEMENT CARD.
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477   050021 0 0     0.0   622.842 0.0 295.2  2.82  2.82 0 13.77  2.42  -1.21 * HOT L57
      CARD ABOVE IS REPLACEMENT CARD.
478   050031 0 0     0.0     0.0   0.0 405.9  5.05  5.05 0 113.6  6.     1.61 * S7 PLEN
      CARD ABOVE IS REPLACEMENT CARD.
479   050041 0 0     0.0     0.0   0.0 607.5 14.87 14.87 0 40.84 .05     6.66 * SG T
      CARD ABOVE IS REPLACEMENT CARD.
480   050051 0 0     0.0     0.0   0.0 607.5 14.87 14.87 0 40.84 .05    21.53 * SG TUB
      CARD ABOVE IS REPLACEMENT CARD.
481   050061 0 0     0.0     0.0   0.0 607.5 14.87 14.87 0 40.84 .05    21.53 * SG TU 3
      CARD ABOVE IS REPLACEMENT CARD.
482   050071 0 0     0.0     0.0   0.0 607.5 14.87 14.87 0 40.84 .05     6.66 * SG TUB4
      CARD ABOVE IS REPLACEMENT CARD.
483   050081 0 0     0.0     0.0   0.0 801.6 16.46 16.46 0 15.72  2.58  -9.8  * PMP SUC
      CARD ABOVE IS REPLACEMENT CARD.
484   050091 0 0     0.0     0.0   0.0 576.   5.19  5.19 0  1.+9  1.+9  -4.04 * PMPS
      CARD ABOVE IS REPLACEMENT CARD.
485   050101 0 0     0.0     0.0   0.0 247.8  2.3   2.3  0 12.36  2.29  -1.15 * CL4 L5G
      CARD ABOVE IS REPLACEMENT CARD.
486   050111 0 0     0.0     0.0   0.0 789.9 26.77 26.77 0 29.51  1.45 -19.9  * DN3MR
      CARD ABOVE IS REPLACEMENT CARD.
487   050121 0 0     0.0     0.0   0.0 806.2  9.85  9.85 0  1.+9    .5 -26.55 * LW PLEN
      CARD ABOVE IS REPLACEMENT CARD.
488   050131 0 0     0.0     0.0   0.0  42.7 12.   12.   0  3.52  .026 -16.7  * BYPASS
      CARD ABOVE IS REPLACEMENT CARD.
489   050141 0 0     0.0     0.0   0.0 167.4  4.    4.   0 43.75 .0412 -16.7  *BTM CORE
      CARD ABOVE IS REPLACEMENT CARD.
490   050151 0 0     0.0     0.0   0.0 167.4  4.    4.   0 43.75 .0412 -12.7  *MID CORS
      CARD ABOVE IS REPLACEMENT CARD.
491   050161 0 0     0.0     0.0   0.0 167.4  4.    4.   0 43.75 .0412  -8.7  *TOP CORE
      CARD ABOVE IS REPLACEMENT CARD.
492   050171 0 0     0.0   547.596 0.0 5.075 43.3  43.3  0 .1015 .359    1.15 * SPAY LN
      CARD ABOVE IS REPLACEMENT CARD.
493   050191 0 0     0.0   657.896 0.0   28.6 8.78  8.78 0 .7213  .9538  0.   * SURGE
      CARD ABOVE IS REPLACEMENT CARD.
494   080011  1  2  0  0     0.0 13.77  0.    2.4 .4187    0.0 0  1  0  0 0. 1. -1 0
      CARD ABOVE IS REPLACEMENT CARD.
495   080031  3  4  0  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
496   080041  4  5  0  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
497   080051  5  6  0  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
498   080061  6  7  0  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
499   080071  7  8  0  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
500   080081  8  9 -1  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
501   080091  9 10  1  0     0.0
      CARD ABOVE IS REPLACEMENT CARD.
502   080092                    12.36  0.  1.32  -1.0     0.0  0  1  0  0 0. 1. -1 0
      CARD ABOVE IS REPLACEMENT CARD.
503   080101 10 11  0  0     0. 12.36  0.      1.67 1.1502 0.0  0  1  0  0 0. 1. -1 0
      CARD ABOVE IS REPLACEMENT CARD.
504   080111 11 12  0  0     0. 19.69 -19.9     .59  .9106 .88  0  1  0  0 0. 1. -1 0
      CARD ABOVE IS REPLACEMENT CARD.
505   080141 14 15  0  0     0. 43.75 -12.7     .09 2.8927 0.0  0  1  0  0 0. 1. -1 3
      CARD ABOVE IS REPLACEMENT CARD.
506   080151 15 16  0  0     0. 43.75  -8.7     .09   2.7894 0.0 0 1  0  0 0. 1. -1 3
      CARD ABOVE IS REPLACEMENT CARD.
507   080161 16  1  0  0     0. 43.75  -4.7     .05 7.7418 0.0  0  1  0  0 0. 1. -1 1
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        CARD ABOVE IS REPLACEMENT CARD.
508     080171 13  1  0  0      0.0 1.5  -4.7    1.8 -1.0    0.0  0  1  0  0 0. 1. -1 0
        CARD ABOVE IS REPLACEMENT CARD.
509     080181 10 17  0  8 0.0     .1015  1.15 247.5   1.     .5   0  1  0  0 0. 1. -1 0
        CARD ABOVE IS REPLACEMENT CARD.
510     080191 17 18 0 1 0.0 .253614  42.08 123.3 100. 100. 2  1  0  0  0.0 1. -1 0
        CARD ABOVE IS REPLACEMENT CARD.
511     080201 19 18  0  0   0.0  .6013  8.78   0.    2.8  2.3   2  1  2  0 0. 1. -1 0
        CARD ABOVE IS REPLACEMENT CARD.
512     080211  2 19  0  0  0.0   .6013   .0    0.    2.3  2.8   0  1  2  3 0. 1. -1 0
        CARD ABOVE IS REPLACEMENT CARD.
513     080221  0 20  4  9     0.0   3.  6.66   0.    0.   0.    0  1  0  0 0. 1.  1 0
        CARD ABOVE IS REPLACEMENT CARD.
514     080231  0 20  5 10     0.0   3. 69.66   0.    0.   0.    0  1  0 -2 0. 1. -1 0
        CARD ABOVE IS REPLACEMENT CARD.
515     150041  4 20  2  0  2  2 29514. 33322. 131. .0646 .112 .0646 .112 14.87 14.87  1
        CARD ABOVE IS REPLACEMENT CARD.
516     150051  5 20  2  1  2  2 29514. 33322. 131. .0646 .112 .0646 .112 29.75 29.75  1
        CARD ABOVE IS REPLACEMENT CARD.
517     150061  7 20  2  0  2  2 29514. 33322. 131. .0646 .112 .0646 .112 59.5  29.75  1
        CARD ABOVE IS REPLACEMENT CARD.
518     150071  6 20  2  1  2  2 29514. 33322. 131. .0646 .112 .0646 .112 44.62 14.87  1
        CARD ABOVE IS REPLACEMENT CARD.
519     *
520     *
521     *   END OF THE STEADY STATE PACKAGE   ******************************
522     *
523     *
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RETRAN-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/24/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
CPU TIME = 37.233
* *

STANDARD TIME STEP NUMBER = 0 ACTUAL TIME STEP NUMBER = 0 TIME = 0.0 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
1.000000D+00	2.244060D+03	7.691930D+09	0.0	3.172093D+08	4.861958D+05	0.0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	2.242150D+03	4.195270D+04	6.228870D+02	4.262190D+01	6.065600D+02	0.0	0.0	1.158000D+01	4.195270D+04
2	2.226970D+03	1.257870D+04	6.228420D+02	4.261090D+01	6.064680D+02	0.0	0.0	2.820000D+00	1.257870D+04
3	2.227890D+03	1.729520D+04	6.228820D+02	4.260940D+01	6.064990D+02	0.0	0.0	5.050000D+00	1.729520D+04
4	2.219550D+03	2.643400D+04	6.078160D+02	4.351270D+01	5.959710D+02	0.0	0.0	1.487000D+01	2.643400D+04
5	2.209840D+03	2.732410D+04	5.822560D+02	4.497790D+01	5.772270D+02	0.0	0.0	1.487000D+01	2.732410D+04
6	2.204570D+03	2.790480D+04	5.644740D+02	4.593390D+01	5.636240D+02	0.0	0.0	1.487000D+01	2.790480D+04
7	2.204520D+03	2.830940D+04	5.521430D+02	4.659990D+01	5.538700D+02	0.0	0.0	1.487000D+01	2.830940D+04
8	2.198010D+03	3.755130D+04	5.470770D+02	4.684550D+01	5.498500D+02	0.0	0.0	1.646000D+01	3.755130D+04
9	2.245380D+03	2.699010D+04	5.474330D+02	4.685790D+01	5.501960D+02	0.0	0.0	5.190000D+00	2.699010D+04
10	2.273690D+03	1.161630D+04	5.473840D+02	4.687770D+01	5.501930D+02	0.0	0.0	2.300000D+00	1.161630D+04
11	2.271330D+03	3.702580D+04	5.474310D+02	4.687400D+01	5.502280D+02	0.0	0.0	2.677000D+01	3.702580D+04
12	2.273900D+03	3.779000D+04	5.474590D+02	4.687420D+01	5.502530D+02	0.0	0.0	9.850000D+00	3.779000D+04
13	2.256930D+03	2.001110D+03	5.474450D+02	4.686450D+01	5.502200D+02	0.0	0.0	1.200000D+01	2.001110D+03
14	2.262140D+03	7.751890D+03	5.584190D+02	4.630760D+01	5.589320D+02	0.0	0.0	4.000000D+00	7.751890D+03
15	2.256970D+03	7.494610D+03	5.863510D+02	4.477070D+01	5.804500D+02	0.0	0.0	4.000000D+00	7.494610D+03
16	2.251790D+03	7.218540D+03	6.142830D+02	4.312150D+01	6.007270D+02	0.0	0.0	4.000000D+00	7.218540D+03
17	2.224830D+03	2.376990D+02	5.475960D+02	4.683730D+01	5.502970D+02	0.0	0.0	4.330000D+01	2.376990D+02
18	2.220000D+03	3.235870 04	7.401750D+02	2.489900D+01	6.507550D+02	1.001440D-01	0.0	2.027000D+01	2.912710D+04
19	2.225520D+03	1.067850D+03	6.978960D+02	3.733740D+01	6.508200D+02	0.0	0.0	8.780000D+00	1.067850D+03
20	8.711200D+02	9.528300D+04	6.149340D+02	1.115330D+01	5.281100D+02	1.376680D-01	9.589890D+03	4.950000D+01	8.216550D+04

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.819400D+04	6.228880D+02	2.346200D-02	4.560180D+00	2.604820D-01	-4.820670D+00	-9.515300D-09	0.0
2	2 TO 3		2.819400D+04	6.228400D+02	2.346850D-02	9.540410D+00	-1.164380D+00	-8.376040D+00	1.317910D-10	0.0
3	3 TO 4		2.819400D+04	6.228790D+02	2.346930D-02	7.341440D+00	-2.993790D+00	-4.347650D+00	1.031640D-07	0.0
4	4 TO 5		2.819400D+04	5.927570D+02	2.254310D-02	9.781910D+00	-4.568940D+00	-5.212970D+00	3.317050D-07	0.0
5	5 TO 6		2.819400D+04	5.717540D+02	2.195650D-02	5.326260D+00	4.869350D-02	-5.374960D+00	2.280870D-07	0.0
6	6 TO 7		2.819400D+04	5.571940D+02	2.158110D-02	7.373490D-02	4.777700D+00	-4.851430D+00	2.505590D-07	0.0
7	7 TO 8		2.819400D+04	5.470920D+02	2.134520D-02	2.135630D-01	5.083390D+00	-5.296960D+00	9.947000D-08	0.0
8	8 TO 9		2.819400D+04	5.470810D+02	2.134680D-02	-3.996000D+01	-4.088780D-02	-1.439330D+00	2.923110D-08	4.144030D+01
9	9 TO 10		2.819400D+04	5.474310D+02	2.134120D-02	-4.023240D+01	-4.702060D-01	-6.876280D-01	2.310290D-08	4.144030D+01
10	10 TO 11		2.819400D+04	5.473840D+02	2.133220D-02	1.223200D+01	2.120720D+00	-1.435270D+01	-3.050130D-09	0.0
11	11 TO 12		2.819400D+04	5.474490D+02	2.133300D-02	-4.649630D-01	4.918520D+00	-4.453550D+00	3.755920D-10	0.0
12	12 TO 13		8.560000D+02	5.474530D+02	2.133400D-02	1.682890D+01	-3.555850D+00	-1.327310D+01	-1.247300D-08	0.0
13	12 TO 14		2.733800D+04	5.474530D+02	2.133400D-02	1.083740D+01	-2.246320D+00	-8.591030D+00	-2.324270D-07	0.0
14	14 TO 15		2.733800D+04	5.693890D+02	2.188130D-02	5.105490D+00	-1.264980D+00	-3.840510D+00	-4.386670D-07	0.0
15	15 TO 16		2.733800D+04	6.033130D+02	2.282400D-02	5.112180D+00	-1.220720D+00	-3.891450D+00	-3.763000D-07	0.0
16	16 TO 1		2.733800D+04	6.252530D+02	2.353370D-02	1.060090D+01	-2.309700D+00	-8.291210D+00	-5.866450D-09	0.0
17	13 TO 1		8.560000D+02	5.474370D+02	2.133670D-02	1.491970D+01	-3.663480D+00	-1.125620D+01	-1.040790D-06	0.0
18	10 TO 17		0.0	5.474300D+02	2.133330D-02	4.885900D+01	-7.416230D+00	0.0	0.0	0.0
19	17 TO 18		0.0	5.475710D+02	2.135170D-02	4.829130D+00	-4.829130D+00	0.0	-2.170580D-06	0.0
20	19 TO 18		0.0	6.978900D+02	2.678410D-02	5.515210D+00	-5.515210D+00	0.0	-4.519820D-07	0.0
21	2 TO 19		0.0	6.228880D+02	2.346980D-02	1.455320D+00	-1.079090D+00	-3.762310D-01	-6.946420D-07	0.0
31	0 TO 20		0.0	1.197240D+03	5.188040D-01	0.0	1.789530D+00	0.0	0.0	0.0
30	0 TO 20		0.0	1.197240D+03	5.188040D-01	0.0	1.789530D+00	0.0	0.0	0.0

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29	0 TO 20	0.0	1.197240+03	5.188040-01	0.0	1.789530+00	0.0	0.0	0.0
28	0 TO 20	0.0	1.197240+03	5.188040-01	0.0	1.789530+00	0.0	0.0	0.0
27	0 TO 20	0.0	1.197240+03	5.188040-01	0.0	1.789530+00	0.0	0.0	0.0
26	0 TO 18	0.0	1.120250+03	1.604490-01	0.0	1.425400+00	0.0	0.0	0.0
25	0 TO 18	0.0	1.120250+03	1.604490-01	0.0	1.425400+00	0.0	0.0	0.0
24	0 TO 10	0.0	5.474310+02	2.133300-02	0.0	0.0	0.0	0.0	0.0
23	0 TO 20	-2.739790+03	1.197240+03	5.214150-01	0.0	1.889350+00	0.0	0.0	0.0
22	0 TO 20	2.739790+03	4.174950+02	1.915840-02	0.0	-2.990230+00	0.0	0.0	0.0

EQUIVALENT LIQUID LEVEL IS 1.279930+01 FEET ABOVE THE BOTTOM OF VOLUME 20

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	1.180000+03	9.775970-01	0.0	1.000000+00	3.315790+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	14	1	1.486300+05	8.525620+05	5.341280+03	5.867590+02	2.249530+06	5.420480+06	2.103620+09
2	RIGHT	15	1	2.297960+05	8.534610+05	5.433780+03	6.227400+02	2.249530+06	7.102850+06	3.252400+09
3	RIGHT	16	1	1.486300+05	8.543650+05	5.558060+03	6.274680+02	2.249530+06	5.447800+06	2.103620+09
4	LEFT	4	1	-1.031590+05	7.695450+05	5.445710+03	5.770280+02	2.485270+06		-3.054980+09
	RIGHT	20	2	9.136400+04	2.026010+05	8.381300+03	5.390110+02	2.909510+05	4.026640+06	3.054960+09
5	LEFT	5	1	-7.192070+04	7.707150+05	5.337080+03	5.637510+02	2.485270+06		-2.129870+09
	RIGHT	20	2	6.369730+04	1.111660+05	6.998160+03	5.372120+02	2.909510+05	3.967510+06	2.129870+09
6	LEFT	7	1	-3.468910+04	7.713570+05	5.242660+03	5.472530+02	2.485270+06		-1.027290+09
	RIGHT	20	2	3.072270+04	1.111660+05	4.860190+03	5.344310+02	2.909510+05	3.851870+06	1.027290+09
7	LEFT	6	1	-4.996910+04	7.713520+05	5.276560+03	5.541540+02	2.485270+06		-1.479790+09
	RIGHT	20	2	4.425560+04	2.026010+05	5.833210+03	5.356970+02	2.909510+05	3.923920+06	1.479790+09

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEATING RATE (BTU/HR)	DIR. MODERATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.0	0.0	0.0	2.103620+09	5.615410+07	1.225400+03	1.561490+03
2	2	0.0	0.0	0.0	3.252400+09	8.681980+07	1.587440+03	2.205090+03
3	3	0.0	0.0	0.0	2.103620+09	5.615410+07	1.268450+03	1.611460+03

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
5.840230+00	4.857910+00	1.397100+01	3.060910+00	1.775510+01	1.743990+00	6.500000+00	1.454540+01	1.587890+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
0.0	9.300000-01	7.000000-02	0.0	0.0	0.0	0.0	0.0	0.0

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	18	0.0
2	18	0.0
3	18	0.0

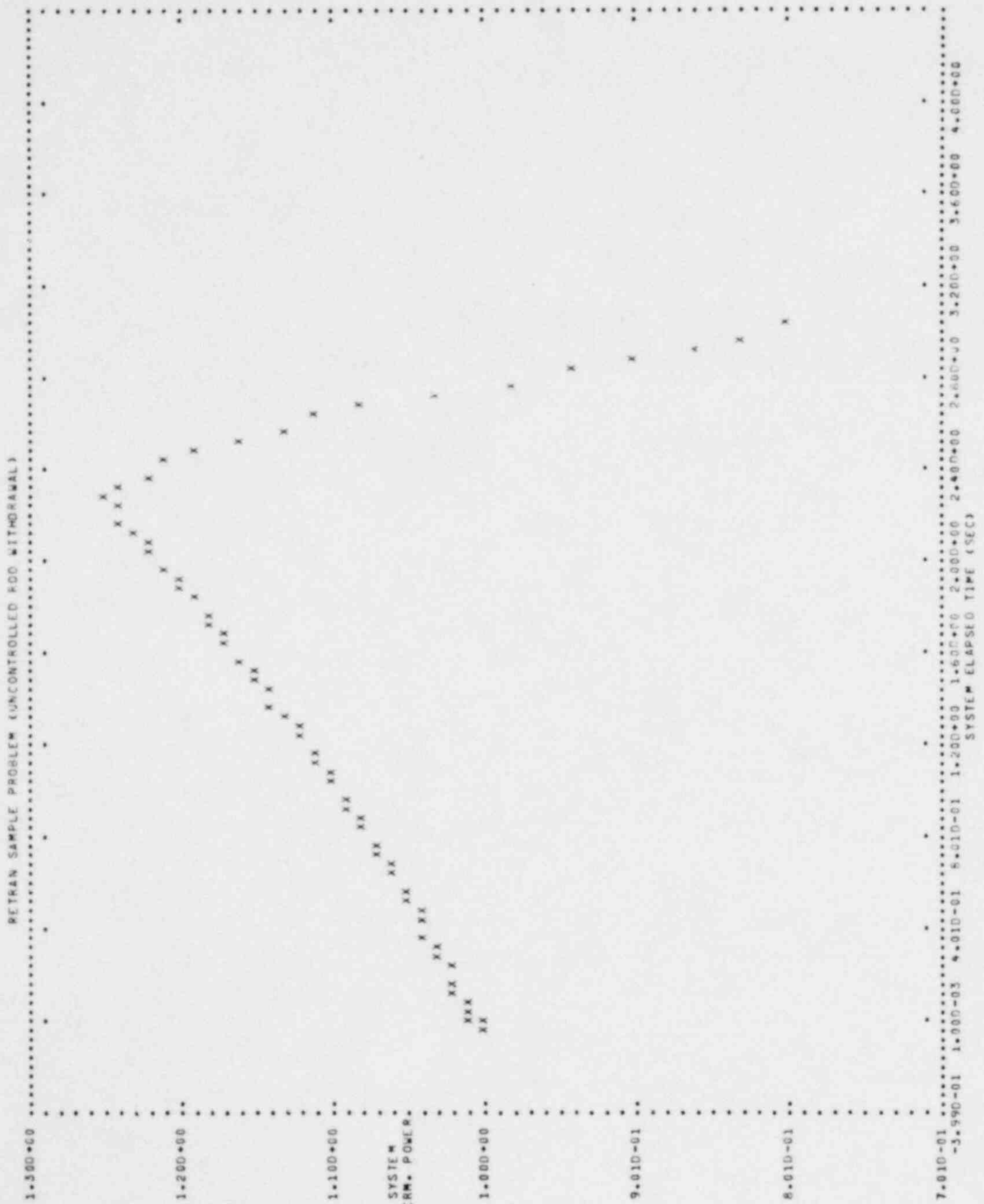
DATA RECORD NUMBER 1 WAS WRITTEN ON TAPE VSN = 081988 ON 78328 AND WAS LABELED UCRW

1757 301

RETRAN-01-MOD00[illegible] 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/24/78
*** EPRI RELEASE 0[illegible] -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE P[illegible]OBLEM (UNCONTROLLED ROD WITHDRAWAL)
CPU TIME = 128.64
* *

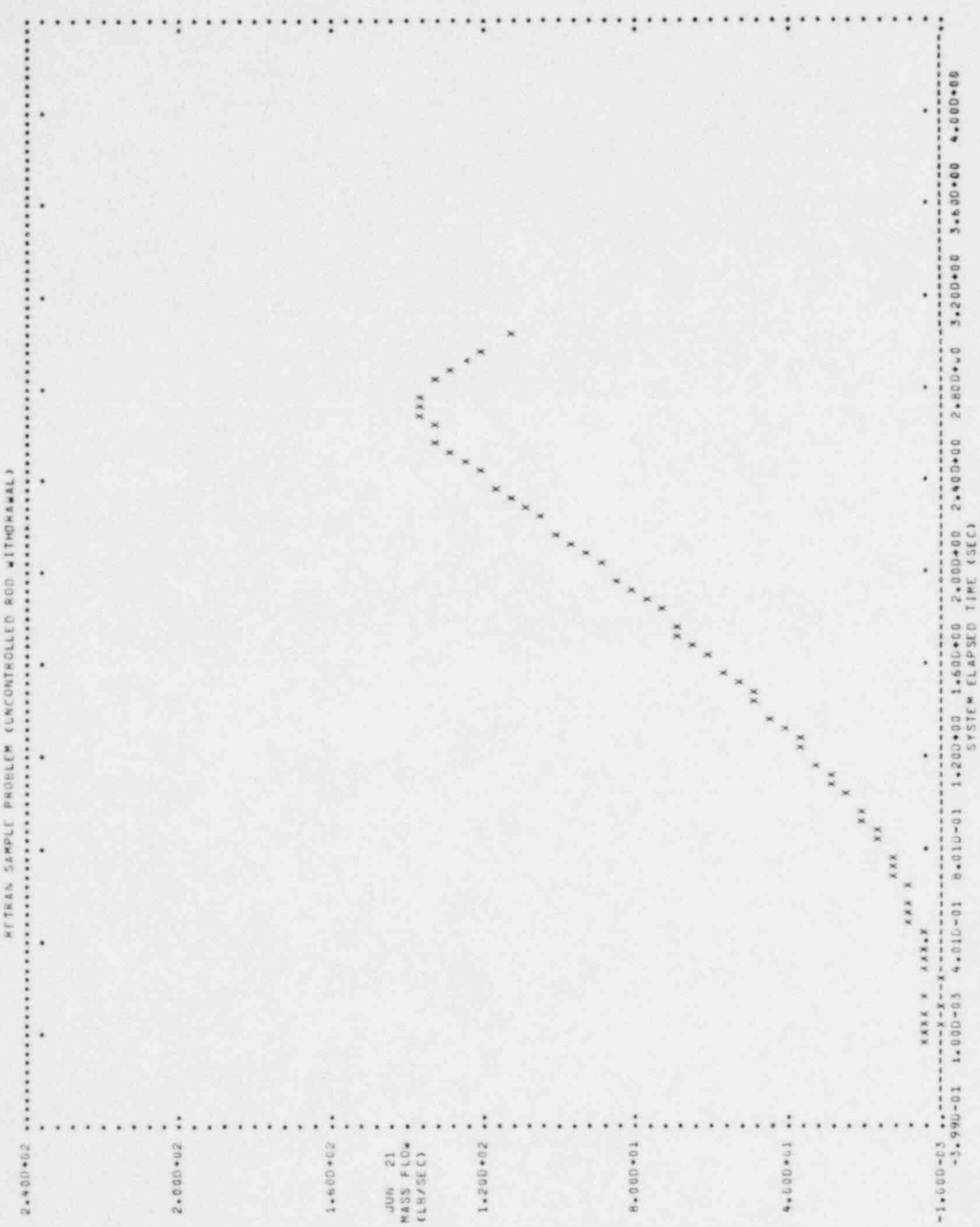
SYSTEM ELAPSED TIME (SEC)	VOL 1 AVG. PRESS. (PSI)	VOL 18 AVG. PRESS. (PSI)	VOL 2 AVG. TEMP. (DEG. F)	VOL 20 AVG. PRESS. (PSI)	SYSTEM NORM. POWER	JUN 21 MASS FLOW (LB/SEC)	KINETICS CONTROL REAC ($)	REACTOR DOPPLER REAC ($)
0.0	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00000D+00	0.0	0.0	0.0
1.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00055D+00	6.22479D-05	7.81551D-04	-2.51828D-08
2.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00128D+00	1.26934D-04	1.56310D-03	-4.16758D-07
3.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00201D+00	-9.01123D-04	2.34465D-03	-3.09704D-06
4.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00275D+00	1.88686D-04	3.12620D-03	-4.06838D-06
5.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00349D+00	5.16624D-04	3.90775D-03	-6.18190D-06
6.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00424D+00	-2.43719D-03	4.68931D-03	-1.18566D-05
7.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00499D+00	7.02018D-04	5.47086D-03	-1.37997D-05
8.00000D-02	2.24215D+03	2.22000D+03	6.06468D+02	8.71120D+02	1.00574D+00	1.62613D-03	6.25241D-03	-1.88754D-05
9.00000D-02	2.24217D+03	2.22000D+03	6.06469D+02	8.71120D+02	1.00649D+00	3.45456D-02	7.03396D-03	-2.74807D-05
1.00000D-01	2.24217D+03	2.22000D+03	6.06469D+02	8.71120D+02	1.00725D+00	3.79363D-02	7.81551D-03	-3.10312D-05
1.50000D-01	2.24216D+03	2.22002D+03	6.06470D+02	8.71120D+02	1.01111D+00	-2.06011D-02	1.17233D-02	-6.51236D-05
2.00000D-01	2.24218D+03	2.22006D+03	6.06471D+02	8.71120D+02	1.01504D+00	1.53861D-02	1.56310D-02	-1.38898D-04
2.50000D-01	2.24227D+03	2.22005D+03	6.06473D+02	8.71120D+02	1.01911D+00	-2.28238D-02	1.95388D-02	-1.55202D-04
3.00000D-01	2.24226D+03	2.22005D+03	6.06475D+02	8.71120D+02	1.02315D+00	1.30832D-01	2.34465D-02	-3.23992D-[illegible]
3.50000D-01	2.24235D+03	2.22005D+03	6.06479D+02	8.71120D+02	1[illegible]740D+00	5.49620D-01	2.73543D-02	-3.5683[illegible]-04
4.00000D-01	2.24242D+03	2.22002D+03	6.06482D+02	8.71120D+0[illegible]	[illegible]3167D+00	1.22477D+00	3.12620D-02	-4.[illegible]594D-04
4.50000D-01	2.24249D+03	2.22002D+03	6.06484D+02	8.71120D+0[illegible]	[illegible].03600D+00	[illegible].56282D+00	3.51698D-02	[illegible].41780D-04
5.00000D-01	2.24257D+03	2.22003D+03	6.06484D+02	8.71120D+02	1.04042D+00	4.31476D+00	3.90775D-[illegible]	-8.13253D-04
5.50000D-01	2.24265D+03	2.22014D+03	6.06486D+02	8.71120D+02	1.04491D+00	6.37563D+00	4.2985[illegible]-02	-1.00415D-03
6.00000D-01	2.24273D+03	2.22013D+03	6.06486D+02	8.71120D+02	1.04947D+00	7.01246D+00	4.[illegible]31D-02	-1.21459D-03
6.50000D-01	2.24285D+03	2.22012D+03	6.06489D+02	8.71120D+02	1.05410D+00	7.94774D+00	[illegible].08008D-02	-1.44468D-03
7.00000D-01	2.24297D+03	2.22022D+03	6.06491D+02	8.71120D+02	1.05881D+00	9.23589D+[illegible]	5.47086D-02	-1.69452D-03
7.50000D-01	2.24311D+03	2.22032D+03	6.06493D+02	8.71120D+02	1.06359D+00	1.0544[illegible]+01	5.86163D-02	-1.96422D-03
8.00000D-01	2.24327D+03	2.22042D+03	6.06496D+02	8.71120D+02	1.06845D+00	1.[illegible]43D+01	6.25241D-02	-2.25391D-03
6.50000D-01	2.24345D+03	2.220[illegible]D+03	6.06499D+02	8.71120D+02	1.07337D+00	[illegible].33553D+01	6.64318D-02	-2.56368D-03
9.00000D-01	2.24364D+03	2.22053D+03	6.06503D+02	8.71120D+02	1.07837D+[illegible]	1.53035D+01	7.03396D-02	-2.89364D-03
9.50000D-01	2.24384D+03	2.2206[illegible]D+03	6.06508D+02	8.71123D+02	1.0834[illegible]+00	1.73063D+01	7.42473D-02	-3.24391D-03
1.00000D+00	2.24406D+03	2.22073D+03	6.06513D+02	8.71123D+02	1.[illegible]58D+00	1.94428D+01	7.81551D-02	-3.61458D-03
1.05000D+00	2.24429D+03	2.22083D+03	6.06519D+02	8.71123D+02	[illegible].09379D+00	2.17856D+01	8.20628D-02	-4.00577D-03
1.10000D+00	2.24454D+03	2.22093D+03	6.06526D+02	8.71123D+[illegible]	1.09907D+00	2.42902D+01	8.59706D-02	-4.41758D-03
1.15000D+00	2.24473D+03	2.22104D+03	6.06533D+02	8.712[illegible]D+02	1.10443D+00	2.69697D+01	8.98784D-02	-4.85011D-03
1.20000D+00	2.24504D+03	2.22123D+03	6.06542D+02	[illegible]26D+02	1.10985D+00	2.98118D+01	9.37861D-02	-5.30346D-03
1.25000D+00	2.24533D+03	2.2214[illegible]D+03	6.06551D+02	[illegible].71126D+02	1.11535D+00	3.28006D+01	9.76939D-02	-5.77775D-03
1.30000D+00	2.24563D+03	2.22162D+03	6.06562D+0[illegible]	8.71130D+02	1.12092D+00	3.53341D+01	1.01602D-01	-6.27307D-03
1.35000D+00	2.24595D+03	2.22181D+03	6.0657[illegible]D+02	8.71130D+02	1.12655D+00	3.81424D+01	1.05509D-01	-6.78952D-03
1.40000D+00	2.24628D+03	2.22201D+03	6.0[illegible]6D+02	8.71132D+02	1.13226D+00	4.10457D+01	1.09417D-01	-7.32721D-03
1.45000D+00	2.24664D+03	2.222[illegible]0D+03	[illegible].06601D+02	8.71132D+02	1.13805D+00	4.40972D+01	1.13325D-01	-7.88623D-03
1.50000D+00	2.24701D+03	2.22240D+0[illegible]	6.06616D+02	8.71136D+02	1.14390D+00	4.73576D+01	1.17233D-01	-8.46670D-03
1.55000D+00	2.24740D+03	2.2227[illegible]D+03	6.06633D+02	8.71136D+02	1.14982D+00	5.08151D+01	1.21140D-01	-9.06871D-03
1.60000D+00	2.24782D+03	2.2[illegible]04D+03	6.06652D+02	8.71140D+02	1.15582D+00	5.40982D+01	1.25048D-01	-9.69237D-03
1.65000D+00	2.24826D+03	[illegible].22337D+03	6.06672D+02	8.71140D+02	1.16188D+00	5.73182D+01	1.28956D-01	-1.03376D-02
1.70000D+00	2.24873D+0[illegible]	2.22363D+03	6.06694D+02	8.71146D+02	1.16802D+00	6.05335D+01	1.32864D-01	-1.10050D-02
1.75000D+00	2.2492[illegible]D+03	2.22393D+03	6.06717D+02	8.71148D+02	1.17424D+00	6.40539D+01	1.36771D-01	-1.16942D-02
1.80000D+00	2.24[illegible]4D+03	2.22431D+03	6.06742D+02	8.71151D+02	1.18052D+00	6.78339D+01	1.40679D-01	-1.24054D-02
1.85000D+00	[illegible]25028D+03	2.22468D+03	6.06769D+02	8.71155D+02	1.18687D+00	7.16166D+01	1.44587D-01	-1.31388D-02
1.90000D+0[illegible]	2.25085D+03	2.22508D+03	6.06797D+02	8.71158D+02	1.19330D+00	7.54760D+01	1.48495D-01	-1.38944D-02
1.9500[illegible]	2.25144D+03	2.22547D+03	6.06827D+02	8.71162D+02	1.19980D+00	7.94309D+01	1.52402D-01	-1.46723D-02
2.00[illegible]D+00	2.25202D+03	2.22587D+03	6.06859D+02	8.71166D+02	1.20638D+00	8.33911D+01	1.56310D-01	-1.54727D-02
[illegible]50000D+00	2.25258D+03	2.22641D+03	6.06893D+02	8.71171D+02	1.21302D+00	8.72938D+01	1.60218D-01	-1.62956D-02

[illegible]7 302



RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
SYSTEM NORM. POWER
1.300+00
1.200+00
1.100+00
1.000+00
9.010-01
8.010-01
7.010-01
-3.990-01
1.000-03
4.010-01
8.010-01
1.200+00
1.600+00
2.000+00
2.400+00
2.800+00
3.200+00
3.600+00
4.000+00
SYSTEM ELAPSED TIME (SEC)

1757 303


RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
2.400D+02
2.000D+02
1.600D+02
JUN 21
MASS FLOW
(LB/SEC)
1.200D+02
8.000D+01
4.000D+01
-1.000D-03
-3.990D-01 1.000D-03 4.010D-01 8.010D-01 1.200D+00 1.600D+00 2.000D+00 2.400D+00 2.800D+00 3.200D+00 3.600D+00 4.000D+00
SYSTEM ELAPSED TIME (SEC)

1757 304

X. RESTRT SAMPLE PROBLEMS

X. RESTRT SAMPLE PROBLEMS

The use of the RESTRT program module and the flexibility allowed by this module are briefly outline in Section II.2.0. Two RESTRT sample problems are presented as examples which illustrate the use of RESTRT. These examples correspond to RETRAN sample problems, the Turbine Trip Without Bypass and the Uncontrolled Rod Withdrawal.

1.0 TURBINE TRIP WITHOUT BYPASS

The Turbine Trip Without Bypass RETRAN Sample Problem is discussed in Section IX.5.0. That run was terminated at 1.0 seconds and created a restart-plot tape.

The RESTRT example restarts the transient at 0.9 seconds and continues to 2.0 seconds. The input listing is given and output at times 0.9 and 2.0 sec are given. Representative printer plots from this RESTRT run are given. Note that the printer plot gives information calculated during the RESTRT run only, and does not give information calculated from the original RETRAN run. Also, the RESTRT program module has created a new restart-plot tape which could be used to start another RESTRT run or to obtain PLOTER output.

1757 306

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
010001    92   0   0   1
010030    "RETRANBWRTTWOBSHO"  "65865"  "78325"
040010    1   1   0   0   2.0   0.0
.
```

RESTRT-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 22/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
CPU TIME = 11.414

* *

STANDARD TIME STEP NUMBER = 91 ACTUAL TIME STEP NUMBER = 139 TIME = 9.000000E-01 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
4.570435E+00	1.157874E+04	3.954500E+10	0.	2.387386E+11	2.157923E+08	0.

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.14363E+03	1.26320E+05	5.26687E+02	4.72646E+01	5.32204E+02	0.	0.	1.73800E+01	1.26320E+05
2	1.12248E+03	1.10147E+04	5.49997E+02	4.59943E+01	5.50542E+02	0.	0.	4.00000E+00	1.10147E+04
3	1.12096E+03	5.58678E+03	5.95978E+02	2.33288E+01	5.58625E+02	5.63279E-02	3.14691E+02	4.00000E+00	5.27209E+03
4	1.11690E+03	3.66816E+03	6.33203E+02	1.53172E+01	5.58173E+02	1.16450E-01	4.27157E+02	4.00000E+00	3.24100E+03
5	1.11844E+03	9.52452E+03	5.33808E+02	4.68911E+01	5.37806E+02	0.	0.	4.00000E+00	9.52452E+03
6	1.11776E+03	9.39406E+03	5.45354E+02	4.62488E+01	5.46932E+02	0.	0.	4.00000E+00	9.39406E+03
7	1.11586E+03	9.24404E+03	5.58615E+02	4.55102E+01	5.57098E+02	0.	0.	4.00000E+00	9.24404E+03
8	1.11460E+03	1.20750E+04	6.43821E+02	1.39180E+01	5.57915E+02	1.33794E-01	1.61556E+03	6.43300E+00	1.04594E+04
9	1.08754E+03	2.96555E+04	6.80873E+02	1.02347E+01	5.54865E+02	1.97448E-01	2.71200E+01	4.43197E+00	2.38001E+04
10	1.08725E+03	8.74744E+03	1.19723E+03	2.41369E+00	5.61198E+02	1.00000E+00	0.	0.	0.
11	1.09831E+03	2.90651E+03	6.42028E+02	1.37351E+01	5.56086E+02	1.34085E-01	3.89719E+02	5.48400E+00	2.51679E+03
12	1.09743E+03	1.64272E+05	5.26850E+02	4.72279E+01	5.32275E+02	0.	0.	3.38200E+01	1.64272E+05
13	1.13792E+03	9.23203E+03	5.26781E+02	4.72565E+01	5.32272E+02	0.	0.	1.64000E+01	9.23203E+03
14	1.08297E+03	1.55702E+03	1.19760E+03	2.40170E+00	5.61208E+02	1.00000E+00	0.	0.	0.
15	1.07666E+03	1.06019E+03	1.19799E+03	2.38505E+00	5.61090E+02	1.00000E+00	0.	0.	0.
16	1.05931E+03	5.42180E+03	1.19999E+03	2.33379E+00	5.61487E+02	1.00000E+00	0.	0.	0.
17	1.05749E+03	2.52836E+02	1.19930E+03	2.33394E+00	5.60778E+02	1.00000E+00	0.	0.	0.
18	1.18623E+03	2.55962E+04	5.27130E+02	4.72708E+01	5.32609E+02	0.	0.	4.21750E+01	2.55962E+04
19	1.25824E+03	2.80641E+04	5.27090E+02	4.73156E+01	5.32658E+02	0.	0.	5.11940E+01	2.80641E+04
20	9.58025E+02	2.15331E+08	1.18966E+03	2.15331E+00	5.39404E+02	9.92994E-01	2.13823E+08	1.00000E+01	1.50852E+06

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.85755E+04	5.26670E+02	2.11583E-02	2.13573E+01	-3.49125E+00	-1.77920E+01	7.40447E-02	0.
2	2 TO 3		1.88983E+04	5.71394E+02	2.84605E-02	1.02509E+00	-9.63578E-01	-1.21842E+00	-1.15691E+00	0.
3	3 TO 4		1.98802E+04	6.19414E+02	5.69603E-02	3.28535E+00	-5.37240E-01	-3.15492E+00	-4.06804E-01	0.
4	4 TO 8		1.97431E+04	6.47844E+02	7.42423E-02	2.81974E+00	-5.23019E-01	-2.35499E+00	-5.82717E-02	0.
5	1 TO 5		1.23031E+03	5.26670E+02	2.11583E-02	2.53852E+01	-3.50354E+00	-2.18896E+01	-8.01027E-03	0.
6	5 TO 6		1.26773E+03	5.39482E+02	2.14668E-02	5.70826E-01	-1.29367E+00	-1.02096E-02	-7.33051E-01	0.
7	6 TO 7		1.31446E+03	5.50569E+02	2.17589E-02	1.96237E+00	-1.27439E+00	-1.20228E-02	6.75954E-01	0.
8	7 TO 8		1.20637E+03	6.42855E+02	7.13776E-02	1.20450E+00	-9.42373E-01	-4.17311E-01	-1.55185E-01	0.
9	11 TO 9		1.85581E+04	6.41937E+02	7.29453E-02	1.28261E+01	-1.76953E+00	-1.22581E+00	9.83077E+00	0.
10	9 TO 10		1.65617E+03	1.18960E+03	4.06137E-01	2.93686E-01	-1.22346E-01	-7.13106E-03	1.64209E-01	0.
11	18 TO 19		9.42979E+03	5.27145E+02	2.11540E-02	-6.97957E+01	-2.90933E+00	-1.80683E+01	-3.43633E+00	8.73370E+01
12	8 TO 11		1.89155E+04	6.43732E+02	7.20063E-02	1.36885E+01	-5.71288E-01	-1.04391E+00	1.20733E+01	0.
13	12 TO 13		1.05549E+04	5.26837E+02	2.11738E-02	-4.41091E+00	2.85824E+00	-4.89955E+00	-6.45222E+00	0.
14	19 TO 13		9.40658E+03	5.27056E+02	2.11366E-02	5.01380E+01	-4.99544E+00	-4.71721E+01	-2.02947E+00	0.
15	12 TO 18		9.44432E+03	5.26853E+02	2.11730E-02	-9.44955E+01	1.07446E+01	-5.18710E+00	-1.60110E+00	8.73370E+01
16	13 TO 1		1.99544E+04	5.26782E+02	2.11608E-02	-4.73135E+00	2.88135E+00	-9.87559E-01	-2.83757E+00	0.
17	10 TO 14		1.11322E+03	1.19719E+03	4.14524E-01	4.25834E+00	5.12467E-01	-4.39869E-01	4.33094E+00	0.
18	14 TO 15		9.98387E+02	1.19756E+03	4.16576E-01	6.79059E+00	5.16377E-01	-5.26836E-01	6.78013E+00	0.
19	15 TO 16		8.88014E+02	1.19790E+03	4.19688E-01	1.86088E+01	2.42779E-01	-3.21407E+00	1.56375E+01	0.
20	16 TO 17		4.03215E+01	1.19980E+03	4.29277E-01	1.91990E+00	-3.72775E-01	-5.27088E-02	1.49442E+00	0.
21	9 TO 12		1.72721E+04	5.56027E+02	2.20318E-02	-1.00805E+01	6.46539E+00	-1.56683E-01	-3.77183E+00	0.
22	16 TO 20		0.	1.19980E+03	4.29273E-01	9.92059E+01	-3.30371E-01	0.	0.	0.
26	0 TO 14		0.	0.	0.	0.	-3.09109E-01	0.	0.	0.
25	0 TO 14		0.	0.	0.	0.	-3.09109E-01	0.	0.	0.
24	0 TO 12		2.65783E+03	4.03234E+02	1.88949E-02	0.	4.62740E+00	0.	0.	0.

1757 308

23	0 TO 14	0.	3.	0.	0	-3.09109E-01	0.	0.	0.

EQUIVALENT LIQUID LEVEL IS 4.34036E+00 FEE ABOVE THE BOTTOM OF VOLUME 9

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	9.99005E-01	0.	1.00000E+00	2.67591E+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	2	2	2.26981E+05	8.00000E+05	1.61046E+04	5.72692E+02	1.14059E+06	1.21660E+07	3.67207E+09
2	RIGHT	5	2	2.30661E+05	7.43968E+05	1.62147E+04	5.72651E+02	1.18118E+06	1.22958E+07	3.73161E+09
3	RIGHT	4	2	1.30700E+05	6.83670E+05	1.21685E+04	5.68738E+02	1.19419E+06	9.11001E+06	2.11445E+09
4	LEFT	2	1	4.17546E+03	1.33736E+06	3.03085E+03	5.51708E+02	1.14059E+06		1.67044E+07
	RIGHT	5	1	4.13224E+03	1.38601E+05	2.95678E+02	5.51737E+02	8.89162E+04	4.14123E+05	1.65315E+07
5	LEFT	3	1	-7.77207E+02	1.06001E+06	3.14012E+03	5.58178E+02	1.18118E+06		-3.10932E+06
	RIGHT	6	1	2.96989E+03	1.37462E+05	3.05052E+02	5.56622E+02	9.16551E+04	4.18529E+05	1.18814E+07
6	LEFT	4	1	-5.02150E+03	1.06112E+06	3.16664E+03	5.56411E+02	1.19419E+06		-2.00892E+07
	RIGHT	7	1	-7.12841E+02	1.33964E+05	3.01476E+02	5.54787E+02	8.92876E+04	4.16716E+05	-2.85182E+06
7	LEFT	11	1	-2.50683E+04	3.07082E+05	2.96079E+03	5.47492E+02	1.98601E+06		-4.19838E+07
	RIGHT	12	1	3.56764E+03	1.47338E+05	9.86746E+02	5.35878E+02	7.80180E+05	1.21161E+06	6.50204E+06
8	LEFT	8	1	-1.25069E+02	9.00000E+04	5.00000E+00	5.32745E+02	7.06718E-02		-4.71637E+04
	RIGHT	12	1	-1.09726E+03	1.77606E+05	1.60078E+03	5.31578E+02	7.80180E+05	5.47902E+06	-4.22793E+05

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.	0.	0.	1.43268E+10	3.80193E+08	1.79969E+03	2.53137E+03
2	2	0.	0.	0.	1.45129E+10	4.535[illegible]2E+08	1.81812E+03	2.56803E+03
3	3	0.	0.	0.	8.84787E+09	2.65667E+08	1.36148E+03	1.73531E+03
4	4	0.	0.	0.	7.35525E+07	2.03747E+08	5.52155E+02	
5	5	0.	0.	0.	7.57[illegible]32E+07	2.06447E+08	5.57491E+02	
6	6	0.	0.	0.	3.39972E+07	1.37828E+08	5.55296E+02	

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
8.86149E+00	3.75329E+00	1.47059E+01	1.43934E+00	1.54844E+01	0.	8.00000E+00	1.27041E+01	1.25229E+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-1.35892E-01	9.82654E-01	1.73456E-02	6.60818E-01	-6.23205E-01	0.	1.45175E+00	0.	-1.67728E-01

DATA RECORD NUMBER 92 WAS WRITTEN ON TAPE VSN = 060776 ON 78326 AND WAS LABELED RETRANBWRTTWOBSHO

1757 309

RESTRT-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 22/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
CPU TIME = 52.858

* *

STANDARD TIME STEP NUMBER = 201 ACTUAL TIME STEP NUMBER = 249 TIME = 2.000000E+00 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
6.082724E-01	1.540997E+03	5.286235E+09	0.	2.387385E+11	2.157923E+08	0.

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.20362E+03	1.26377E+05	5.27012E+02	4.72860E+01	5.32534E+02	0.	0.	1.73800E+01	1.26377E+05
2	1.17866E+03	1.09964E+04	5.52158E+02	4.59177E+01	5.52301E+02	0.	0.	4.00000E+00	1.09964E+04
3	1.17568E+03	5.71528E+03	6.03265E+02	2.38654E+01	5.64600E+02	5.63893E-02	3.22281E+02	4.00000E+00	5.39300E+03
4	1.17144E+03	3.61457E+03	6.45539E+02	1.50934E+01	5.64144E+02	1.25671E-01	4.54248E+02	4.00000E+00	3.16033E+03
5	1.17316E+03	9.52830E+03	5.34112E+02	4.69097E+01	5.38126E+02	0.	0.	4.00000E+00	9.52830E+03
6	1.17180E+03	9.39492E+03	5.45890E+02	4.62530E+01	5.47454E+02	0.	0.	4.00000E+00	9.39492E+03
7	1.17101E+03	9.36595E+03	5.53468E+02	4.61104E+01	5.49457E+02	0.	0.	4.00000E+00	9.36595E+03
8	1.16925E+03	1.17661E+04	6.53289E+02	1.35619E+01	5.63908E+02	1.46703E-01	1.72611E+03	6.43300E+00	1.00400E+04
9	1.16981E+03	3.04600E+04	6.96087E+02	1.05123E+01	5.63969E+02	2.07715E-01	4.11503E+01	4.58873E+00	2.41330E+04
10	1.16969E+03	9.35152E+03	1.20007E+03	2.58037E+00	5.78052E+02	1.00000E+00	0.	0.	0.
11	1.16685E+03	2.89311E+03	6.56760E+02	1.36718E+01	5.63650E+02	1.44675E-01	4.18560E+02	5.48400E+00	2.47455E+03
12	1.17428E+03	1.63991E+05	5.29477E+02	4.71471E+01	5.34453E+02	0.	0.	3.38200E+01	1.63991E+05
13	1.20186E+03	9.22813E+03	5.28009E+02	4.72365E+01	5.33323E+02	0.	0.	1.64000E+01	9.22813E+03
14	1.16304E+03	1.65538E+03	1.20187E+03	2.55342E+00	5.78684E+02	1.00000E+00	0.	0.	0.
15	1.17152E+03	1.13514E+03	1.20468E+03	2.55366E+00	5.83200E+02	1.00000E+00	0.	0.	0.
16	1.17210E+03	5.88001E+03	1.20827E+03	2.53126E+00	5.87393E+02	1.00000E+00	0.	0.	0.
17	1.17175E+03	2.74304E+02	1.20802E+03	2.53212E+00	5.87024E+02	1.00000E+00	0.	0.	0.
18	1.26251E+03	2.55988E+04	5.27970E+02	4.72756E+01	5.33362E+02	0.	0.	4.21750E+01	2.55988E+04
19	1.32701E+03	2.80786E+04	5.27442E+02	4.73402E+01	5.33012E+02	0.	0.	5.11940E+01	2.80786E+04
20	9.58025E+02	2.15381E+08	1.18966E+03	2.15331E+00	5.39404E+02	9.92994E-01	2.13823E+08	1.00000E+01	1.50851E+06

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.04690E+04	5.26999E+02	2.11484E-02	2.45238E+01	-3.49129E+00	-2.08898E+01	1.42779E-01	0.
2	2 TO 3		2.03935E+04	5.77930E+02	2.73926E-02	2.49267E+00	-9.68914E-01	-1.30456E+00	2.10194E-01	0.
3	3 TO 4		1.99610E+04	6.29778E+02	3.69343E-02	3.69895E+00	-5.40703E-01	-3.15776E+00	4.84197E-04	0.
4	4 TO 8		1.97181E+04	6.62078E+02	7.56961E-02	2.89224E+00	-5.12580E-01	-2.40831E+00	-2.86405E-02	0.
5	1 TO 5		1.37255E+03	5.26999E+02	2.11404E-02	3.03160E+01	-3.50511E+00	-2.68162E+01	-5.24456E-03	0.
6	5 TO 6		1.36851E+03	5.39825E+02	2.14588E-02	1.36095E+00	-1.29392E+00	-1.17413E-02	5.52833E-02	0.
7	6 TO 7		1.36713E+03	5.51021E+02	2.17512E-02	7.98912E-01	-1.28276E+00	-1.29709E-02	-4.96823E-01	0.
8	7 TO 8		1.27799E+03	6.21090E+02	5.24765E-02	1.75398E+00	-9.43452E-01	-3.43773E-01	4.66753E-01	0.
9	11 TO 9		2.18304E+04	6.56682E+02	7.31401E-02	5.88365E-01	-1.79701E+00	-1.80134E+00	-3.00998E+00	0.
10	9 TO 10		3.19512E+03	1.18608E+03	3.73240E-01	1.15558E-01	-1.30753E-01	-2.71173E-02	-4.23127E-02	0.
11	18 TO 19		9.53079E+03	5.27982E+02	2.11516E-02	-6.44953E+01	-2.91301E+00	-1.83621E+01	1.32229E+00	8.70927E+01
12	8 TO 11		2.16156E+04	6.58265E+02	7.37296E-02	-1.03039E+00	-5.63334E-01	-1.48133E+00	-3.07506E+00	0.
13	12 TO 13		1.22557E+04	5.29454E+02	2.12096E-02	6.12432E+00	2.85688E+00	-6.26528E+00	2.71592E+00	0.
14	19 TO 13		9.53866E+03	5.27411E+02	2.11254E-02	5.43673E+01	-5.00060E+00	-4.82708E+01	1.09584E+00	0.
15	12 TO 18		9.50669E+03	5.29470E+02	2.12089E-02	-9.20854E+01	1.07383E+01	-5.23890E+00	5.06653E-01	8.70927E+01
16	13 TO 1		2.18084E+04	5.28006E+02	2.11693E-02	-6.42961E-01	2.88036E+00	-1.14342E+00	1.09398E+00	0.
17	10 TO 14		3.12025E+03	1.20013E+03	3.87538E-01	2.76512E+00	5.45877E-01	-3.79633E+00	-4.65332E-01	0.
18	14 TO 15		4.79641E+02	1.20221E+03	3.92065E-01	-4.34092E-01	5.50304E-01	-6.91678E-01	-5.75467E-01	0.
19	15 TO 16		4.53256E+02	1.20468E+03	3.91654E-01	3.38230E-01	2.61770E-01	-9.01927E-01	-3.01927E-01	0.
20	16 TO 17		2.15030E+01	1.20817E+03	3.95457E-01	4.73568E-01	-4.04660E-01	-2.34208E-02	4.54872E-02	0.
21	9 TO 12		1.87205E+04	5.68269E+02	2.24492E-02	-4.57342E+00	6.48521E+00	-1.81491E-01	1.73030E+00	0.
22	16 TO 20		0.	1.20817E+03	3.95452E-01	2.12999E+02	-3.58621E-01	0.	0.	0.
26	0 TO 14		-9.51045E+02	1.20218E+03	3.92063E-01	0.	-3.09109E-01	0.	0.	0.
25	0 TO 14		-9.51045E+02	1.20218E+03	3.92063E-01	0.	-3.09109E-01	0.	0.	0.
24	0 TO 12		2.61872E+03	4.03234E+02	1.88949E-02	0.	4.62740E+00	0.	0.	0.

1757 310

23	0 TO 14	-7.13284E+02	1.20220E+03	3.92075E-01	0.	-3.09109E-01	0.	0.	0.

EQUIVALENT LIQUID LEVEL IS 4.46087E+00 FEET ABOVE THE BOTTOM OF VOLUME 9

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00095E+00	0.	1.00000E+00	2.68112E+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	2	2	2.13675E+05	8.00000E+05	1.63640E+04	5.78003E+02	1.22377E+06	1.20635E+07	3.45681E+09
2	RIGHT	3	2	2.17314E+05	7.43507E+05	1.64639E+04	5.77627E+02	1.21055E+06	1.21870E+07	3.51568E+09
3	RIGHT	4	2	1.31189E+05	6.74172E+05	1.27489E+04	5.74461E+02	1.19415E+06	9.07360E+06	2.12235E+09
4	LEFT	2	1	6.09197E+02	1.42760E+06	3.20889E+03	5.52538E+02	1.22377E+06		2.43716E+06
	RIGHT	5	1	4.16428E+03	1.44655E+05	3.16607E+02	5.51284E+02	9.69183E+04	4.14122E+05	1.66597E+07
5	LEFT	3	1	-1.94417E+03	1.06247E+06	3.21859E+03	5.64023E+02	1.21055E+06		-7.77792E+06
	RIGHT	6	1	4.51797E+03	1.41747E+05	3.18410E+02	5.61646E+02	9.67607E+04	4.23049E+05	1.80747E+07
6	LEFT	4	1	-2.53677E+03	1.06112E+06	3.18249E+03	5.63374E+02	1.19415E+06		-1.01487E+07
	RIGHT	7	1	3.60296E+03	1.37678E+05	3.10558E+02	5.61126E+02	9.35788E+04	4.22500E+05	1.44141E+07
7	LEFT	11	1	-2.44646E+04	3.06845E+05	3.48005E+03	5.56631E+02	2.41150E+06		-4.09729E+07
	RIGHT	12	1	3.19387E+03	1.42697E+05	1.03478E+03	5.37521E+02	8.27090E+05	1.22540E+06	5.82083E+06
8	LEFT	8	1	-1.55922E+02	9.00000E+04	5.00000E+00	5.32749E+02	7.69897E-02		-5.87980E+04
	RIGHT	12	1	-4.52070E+03	1.76129E+05	1.67836E+03	5.31741E+02	8.27090E+05	5.48003E+06	-1.74190E+06

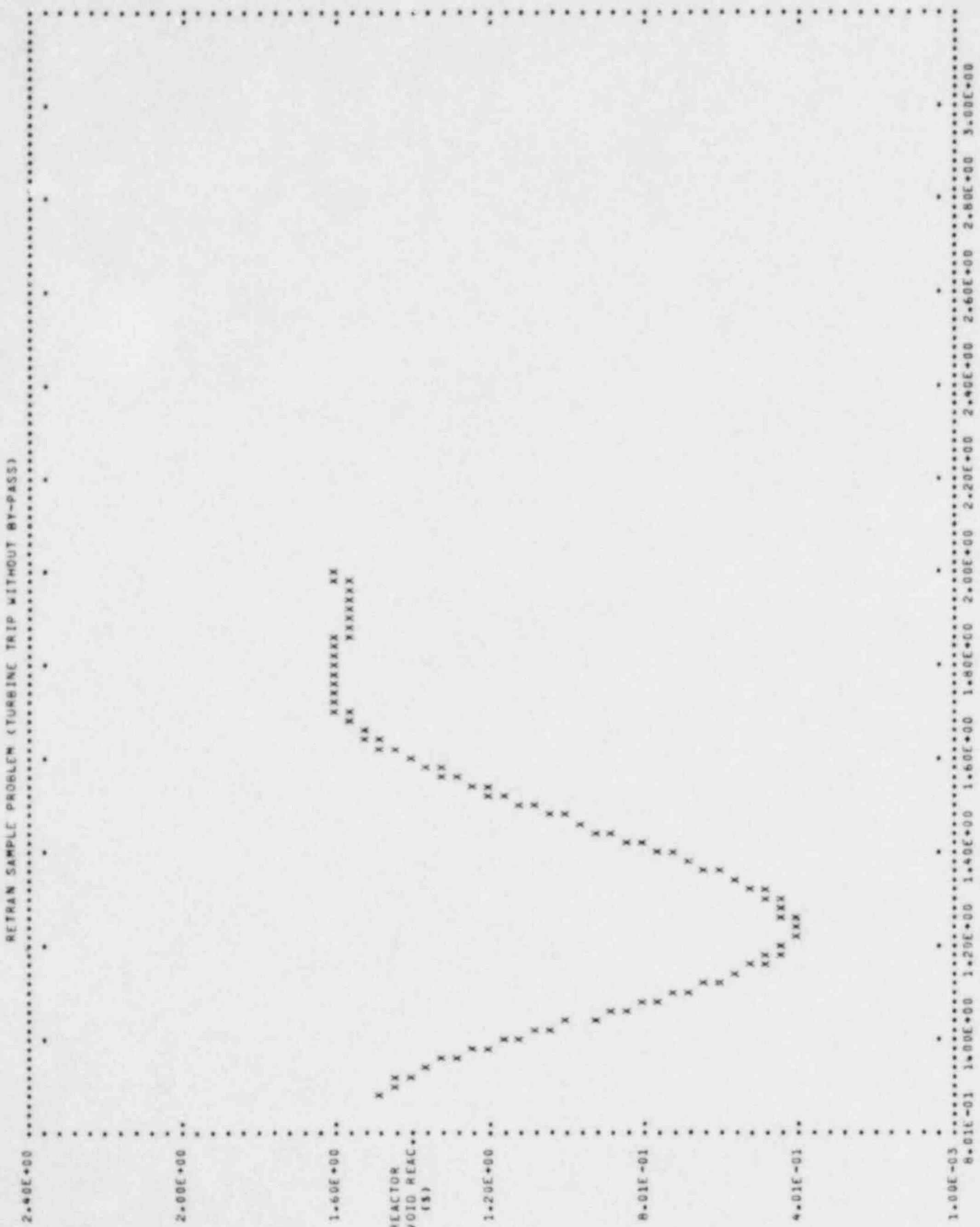
CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.	0.	0.	1.90683E+09	5.04967E+07	1.78456E+03	2.54557E+03
2	2	0.	0.	0.	1.93027E+09	6.15933E+07	1.80214E+03	2.58203E+03
3	3	0.	0.	0.	1.17608E+09	3.48303E+07	1.35520E+03	1.74404E+03
4	4	0.	0.	0.	9.77943E+06	2.71259E+07	5.52154E+02	
5	5	0.	0.	0.	1.00755E+07	2.74768E+07	5.62960E+02	
6	6	0.	0.	0.	4.28232E+06	1.85857E+07	5.62295E+02	

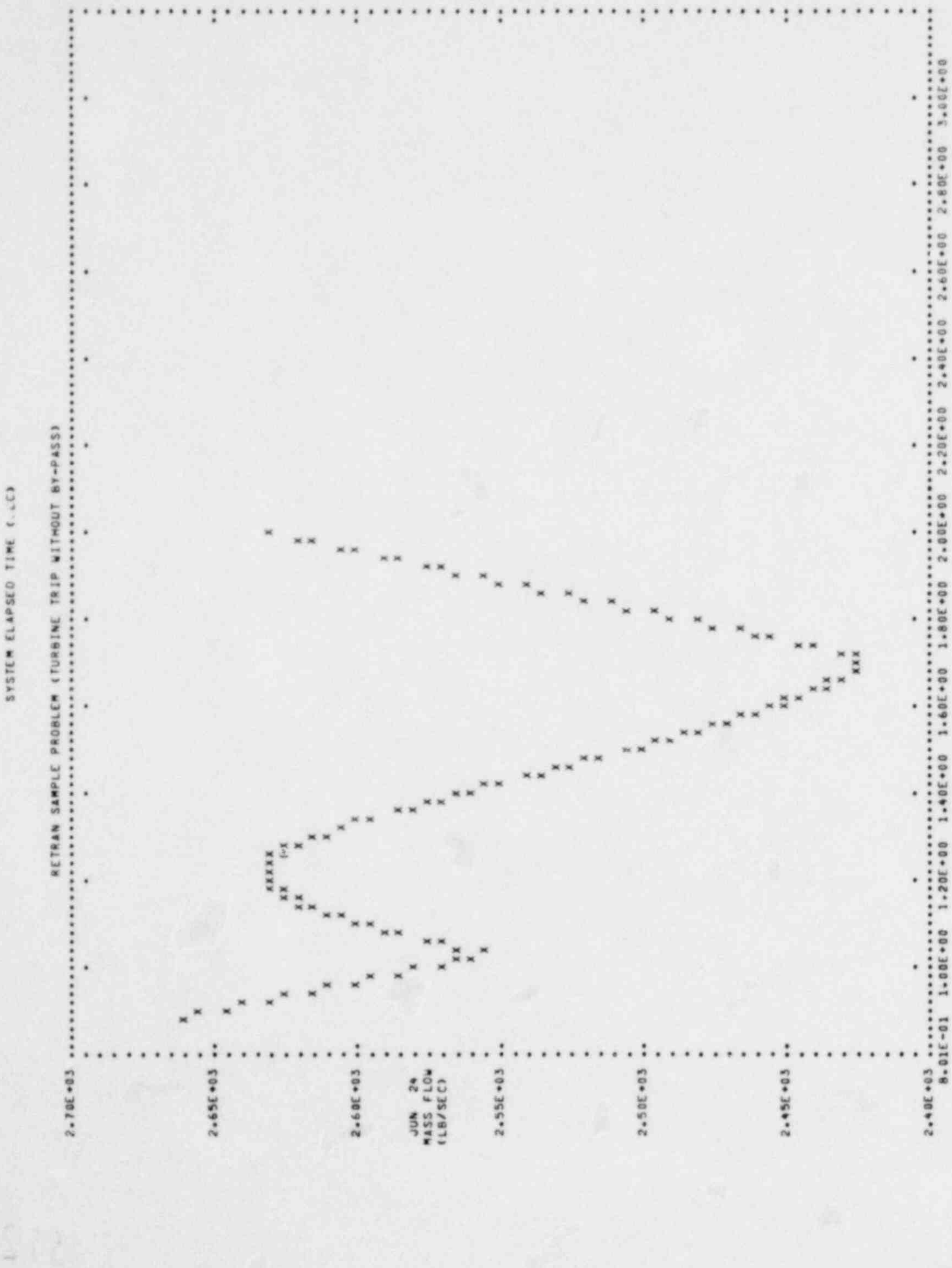
AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
8.46740E+00	3.94480E+00	1.40519E+01	1.60158E+00	1.47958E+01	0.	8.00000E+00	1.21391E+01	1.45391E+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-3.06305E-01	8.78982E-01	1.21018E-01	-9.74401E-01	-2.38591E+00	0.	1.56251E+00	0.	-1.50995E-01

DATA RECORD NUMBER 202 WAS WRITTEN ON TAPE VSN = 060776 ON 78326 AND WAS LABELED RETRANBWRTTWOBSHO

1757 311


SYSTEM ELAPSED TIME (SEC)
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
REACTOR
VOID REAC.
($)
2.40E+00
2.00E+00
1.60E+00
1.20E+00
8.01E-01
4.01E-01
1.00E-03
8.01E-01
1.00E+00
1.20E+00
1.40E+00
1.60E+00
1.80E+00
2.00E+00
2.20E+00
2.40E+00
2.60E+00
2.80E+00
3.00E+00


SYSTEM ELAPSED TIME (SEC)
RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
2.70E+03
2.65E+03
2.60E+03
JUN 24
MASS FLOW
(LB/SEC)
2.55E+03
2.50E+03
2.45E+03
2.40E+03
8.01E-01
1.00E+00
1.20E+00
1.40E+00
1.60E+00
1.80E+00
2.00E+00
2.20E+00
2.40E+00
2.60E+00
2.80E+00
3.00E+00

1357 313

2.0 UNCONTROLLED ROD WITHDRAWAL

The Uncontrolled Rod Withdrawal RETRAN Sample Problem is discussed in Section IX.6.0. That problem was terminated at 3.05 seconds and created a restart-plot tape labeled UCRW.

The RESTART example restarts the transient at 3.05 seconds and continues to 5.03 seconds. The input listing, and output from the example for the initial and final times are given below. Representative printer plots are also given.

7 314

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
010001    70    0    0    1
010030    *UCRW              *    *081988*   *78328*
040010    1    1    0    0    5.0    0.0
.
```

```
RESTRT-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE    EPRI                    11/24/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
 RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
CPU TIME =     6.342
* * * * * * * * * * * * * * * * * * * * * * * * * *   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

STANDARD TIME STEP NUMBER =     69          ACTUAL TIME STEP NUMBER =    109          TIME = 3.000000D+00 SECONDS
```

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
7.938620D-01	1.781426D+03	6.113169D+09	0.0	3.172351D+08	4.861958D+05	0.0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	2.263380D+03	4.183260D+04	6.253150D+02	4.249980D+01	6.082730D+02	0.0	0.0	1.158000D+01	4.183260D+04
2	2.248060D+03	1.254990D+04	6.248620D+02	4.251310D+01	6.079060D+02	0.0	0.0	2.820000D+00	1.254990D+04
3	2.249290D+03	1.728100D+04	6.238270D+02	4.257440D+01	6.072180D+02	0.0	0.0	5.050000D+00	1.728100D+04
4	2.241530D+03	2.642820D+04	6.082470D+02	4.350320D+01	5.963570D+02	0.0	0.0	1.487000D+01	2.642820D+04
5	2.231710D+03	2.732960D+04	5.823650D+02	4.498710D+01	5.773630D+02	0.0	0.0	1.487000D+01	2.732960D+04
6	2.226460D+03	2.791150D+04	5.645330D+02	4.594480D+01	5.637120D+02	0.0	0.0	1.487000D+01	2.791150D+04
7	2.226430D+03	2.831610D+04	5.521970D+02	4.661090D+01	5.539460D+02	0.0	0.0	1.487000D+01	2.831610D+04
8	2.219840D+03	3.756020D+04	5.471310D+02	4.685650D+01	5.499220D+02	0.0	0.0	1.646000D+01	3.756020D+04
9	2.267140D+03	2.699570D+04	5.475110D+02	4.686760D+01	5.502850D+02	0.0	0.0	5.190000D+00	2.699570D+04
10	2.295410D+03	1.161840D+04	5.474830D+02	4.688630D+01	5.503000D+02	0.0	0.0	2.300000D+00	1.161840D+04
11	2.293100D+03	3.703410D+04	5.474900D+02	4.688460D+01	5.503020D+02	0.0	0.0	2.677000D+01	3.703410D+04
12	2.295650D+03	3.779740D+04	5.475450D+02	4.688340D+01	5.503490D+02	0.0	0.0	9.850000D+00	3.779740D+04
13	2.278680D+03	2.001480D+03	5.475420D+02	4.687320D+01	5.503250D+02	0.0	0.0	1.200000D+01	2.001480D+03
14	2.283720D+03	7.748870D+03	5.590050D+02	4.628950D+01	5.594320D+02	0.0	0.0	4.000000D+00	7.748870D+03
15	2.277500D+03	7.474720D+03	5.885560D+02	4.465180D+01	5.821760D+02	0.0	0.0	4.000000D+00	7.474720D+03
16	2.275220D+03	7.180740D+03	6.184000D+02	4.289570D+01	6.036790D+02	0.0	0.0	4.000000D+00	7.180740D+03
17	2.262890D+03	2.377500D+02	5.478790D+02	4.684720D+01	5.505730D+02	0.0	0.0	4.330000D+01	2.377500D+02
18	2.238680D+03	3.251940D+04	7.401070D+02	2.501490D+01	6.511640D+02	9.967840D-02	0.0	2.035830D+01	2.927790D+04
19	2.246530D+03	1.095160D+03	6.866850D+02	3.829220D+01	6.453910D+02	0.0	0.0	8.780000D+00	1.095160D+03
20	6.713540D+02	9.528300D+04	6.149930D+02	1.115330D+01	5.281410D+02	1.377080D-01	9.591990D+03	4.949740D+01	6.216170D+04

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	D I F F E R E N T I A L S ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.824040D+04	6.252410D+02	2.352690D-02	4.602900D+00	2.597290D-01	-4.853880D+00	8.755680D-03	0.0
2	2 TO 3		2.816120D+04	6.244140D+02	2.350810D-02	9.366510D+00	-1.162910D+00	-8.375280D+00	-1.716870D-01	0.0
3	3 TO 4		2.818760D+04	6.237680D+02	2.346680D-02	6.768220D+00	-2.992830D+00	-4.349350D+00	-5.739590D-01	0.0
4	4 TO 5		2.820880D+04	5.929460D+02	2.253920D-02	9.884440D+00	-4.569030D+00	-5.216150D+00	9.926140D-02	0.0
5	5 TO 6		2.821230D+04	5.718090D+02	2.195050D-02	5.315170D+00	4.877040D-02	-5.379470D+00	-1.552890D-02	0.0
6	6 TO 7		2.821260D+04	5.572310D+02	2.157550D-02	1.459160D-01	4.778830D+00	-4.855550D+00	6.919010D-02	0.0
7	7 TO 8		2.821210D+04	5.471280D+02	2.133980D-02	1.969210D-01	5.084590D+00	-5.301640D+00	-2.013590D-02	0.0
8	8 TO 9		2.821140D+04	5.471480D+02	2.134210D-02	-3.996950D+01	-4.087470D-02	-1.440610D+00	-1.985800D-02	4.143110D+01
9	9 TO 10		2.821140D+04	5.475100D+02	2.133680D-02	-4.026150D+01	-4.703030D-01	-6.882340D-01	1.107000D-02	4.143110D+01
10	10 TO 11		2.821150D+04	5.474650D+02	2.132790D-02	1.226690D+01	2.121200D+00	-1.436520D+01	2.292590D-02	0.0
11	11 TO 12		2.821200D+04	5.475300D+02	2.132870D-02	-3.955730D-01	4.919610D+00	-4.457240D+00	6.679740D-02	0.0
12	12 TO 13		8.568730D+02	5.475390D+02	2.132980D-02	1.679880D+01	-3.556530D+00	-1.329980D+01	-5.751200D-02	0.0
13	12 TO 14		2.735510D+04	5.475390D+02	2.132980D-02	1.095090D+01	-2.246350D+00	-8.597580D+00	1.069390D-01	0.0
14	14 TO 15		2.734520D+04	5.706270D+02	2.190370D-02	5.998710D+00	-1.262920D+00	-3.845590D+00	8.902070D-01	0.0
15	15 TO 16		2.731710D+04	6.066560D+02	2.292060D-02	2.922570D+00	-1.215730D+00	-3.901470D+00	-2.194630D+02	0.0
16	16 TO 1		2.729570D+04	6.299930D+02	2.368470D-02	1.229960D+01	-2.301760D+00	-8.321950D+00	1.675850D+00	0.0
17	13 TO 1		8.568970D+02	5.475280D+02	2.133450D-02	1.546870D+01	-3.659130D+00	-1.127800D+01	5.314920D-01	0.0
18	10 TO 17		0.0	5.475040D+02	2.132880D-02	3.431070D+01	-7.417720D+00	0.0	0.0	0.0
19	17 TO 18	MOODY	-4.532400D-02	1.120780D+03	1.596470D-01	2.309360D+01	-1.449520D+00	2.107690D+01	5.689370D-01	0.0
20	19 TO 18		5.484240D+01	6.869900D+02	2.613370D-02	8.042550D+00	-5.547000D+00	-2.353760D-01	2.260180D+00	0.0
21	2 TO 19		1.076090D+02	6.244160D+02	2.350790D-02	1.980000D+00	-1.107540D+00	-6.126840D-01	2.597720D-01	0.0
31	0 TO 20		0.0	0.0	0.0	0.0	1.789530D+00	0.0	0.0	0.0
30	0 TO 20		0.0	0.0	0.0	0.0	1.789530D+00	0.0	0.0	0.0

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29	0 TO 20	0.0	0.0	0.0	0.0	1.789530+00	0.0	0.0	0.0
28	0 TO 20	0.0	0.0	0.0	0.0	1.789530+00	0.0	0.0	0.0
27	0 TO 20	0.0	0.0	0.0	0.0	1.789530+00	0.0	0.0	0.0
26	0 TO 18	0.0	0.0	0.0	0.0	1.425400+00	0.0	0.0	0.0
25	0 TO 18	0.0	0.0	0.0	0.0	1.425400+00	0.0	0.0	0.0
24	0 TO 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0 TO 20	-2.739790+03	1.197240+03	5.212720-01	0.0	1.889350+00	0.0	0.0	0.0
22	0 TO 20	2.739790+03	4.174950+02	1.915840-02	0.0	-2.990230+00	0.0	0.0	0.0

EQUIVALENT LIQUID LEVEL IS 1.279930+01 FEET ABOVE THE BOTTOM OF VOLUME 20

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	1.180000+03	9.776610-01	0.0	1.000000+00	3.316080+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	14	1	1.553600+05	8.468730+05	5.342750+03	5.885540+02	2.250220+06	5.540820+06	2.198880+09
2	RIGHT	15	1	2.403590+05	8.497940+05	5.438590+03	6.264780+02	2.248870+06	7.279930+06	3.401910+09
3	RIGHT	16	1	1.547730+05	8.501590+05	5.565800+03	6.315610+02	2.247250+06	5.772430+06	2.190570+09
4	LEFT	4	1	-1.037920+05	7.669330+05	5.445500+03	5.772770+02	2.485730+06		-3.073710+09
	RIGHT	20	2	9.178350+04	2.026030+05	8.401980+03	5.390630+02	2.909510+05	4.047800+06	3.069000+09
5	LEFT	5	1	-7.211370+04	7.681800+05	5.337800+03	5.638500+02	2.486700+06		-2.135590+09
	RIGHT	20	2	6.382560+04	1.111730+05	7.006430+03	5.372490+02	2.909510+05	3.968040+06	2.134160+09
6	LEFT	7	1	-3.477070+04	7.688310+05	5.243830+03	5.473150+02	2.486770+06		-1.029710+09
	RIGHT	20	2	3.077680+04	1.111730+05	4.865320+03	5.344650+02	2.909510+05	3.892250+06	1.029100+09
7	LEFT	6	1	-5.007580+04	7.688200+05	5.277600+03	5.542230+02	2.486610+06		-1.482950+09
	RIGHT	20	2	4.432740+04	2.026030+05	5.838960+03	5.357310+02	2.909510+05	3.924330+06	1.482190+09

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.0	0.0	0.0	1.670080+09	4.455840+07	1.251650+03	1.600080+03
2	2	0.0	0.0	0.0	2.582160+09	6.872710+07	1.625140+03	2.263930+03
3	3	0.0	0.0	0.0	1.670220+09	4.433860+07	1.245190+03	1.650130+03

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
6.099930+00	4.630090+00	1.455220+01	2.923820+00	1.854470+01	1.638920+00	8.500000+00	1.519210+01	1.469500+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-1.163910+00	9.103260-01	8.967390-02	-3.432460-01	-3.217520-01	0.0	0.0	0.0	-2.149440-02

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	18	0.0
2	18	0.0
3	18	0.0

DATA RECORD NUMBER 70 WAS WRITTEN ON TAPE VSN = 081807 ON 78328 AND WAS LABELED UCRW

1757 317

RESTRT-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/24/78
*** EPRI RELEASE 02 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
CPU TIME = 174.073

* *

STANDARD TIME STEP NUMBER = 108 ACTUAL TIME STEP NUMBER = 307 TIME = 5.002481D+00 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
1.321560D-01	2.965581D+02	1.045967D+09	-1.364666D+06	3.172595D+08	4.860588D+05	0.0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	2.22350D+03	4.21761D+04	6.18404D+02	4.28489D+01	6.03489D+02	0.0	0.0	1.15800D+01	4.21761D+04
2	2.20772D+03	1.26158D+04	6.20255D+02	4.27365D+01	6.04663D+02	0.0	0.0	2.82000D+00	1.26158D+04
3	2.20536D+03	1.72462D+04	6.24628D+02	4.24888D+01	6.07569D+02	0.0	0.0	5.05000D+00	1.72462D+04
4	2.19614D+03	2.63398D+04	6.09979D+02	4.33577D+01	5.97436D+02	0.0	0.0	1.48700D+01	2.63398D+04
5	2.18664D+03	2.72714D+04	5.83466D+02	4.48912D+01	5.78085D+02	0.0	0.0	1.48700D+01	2.72714D+04
6	2.18147D+03	2.78754D+04	5.65053D+02	4.58855D+01	5.64037D+02	0.0	0.0	1.48700D+01	2.78754D+04
7	2.18116D+03	2.82889D+04	5.52516D+02	4.65662D+01	5.54130D+02	0.0	0.0	1.48700D+01	2.82889D+04
8	2.17463D+03	3.75360D+04	5.47172D+02	4.68264D+01	5.49893D+02	0.0	0.0	1.64600D+01	3.75360D+04
9	2.22214D+03	2.69853D+04	5.47307D+02	4.68495D+01	5.50065D+02	0.0	0.0	5.19000D+00	2.69853D+04
10	2.25038D+03	1.16140D+04	5.47277D+02	4.68685D+01	5.50078D+02	0.0	0.0	2.30000D+00	1.16140D+04
11	2.24817D+03	3.70198D+04	5.47291D+02	4.68664D+01	5.50087D+02	0.0	0.0	2.67700D+01	3.70198D+04
12	2.25079D+03	3.77822D+04	5.47363D+02	4.68646D+01	5.50147D+02	0.0	0.0	9.85000D+00	3.77822D+04
13	2.23402D+03	2.00069D+03	5.47357D+02	4.68545D+01	5.50120D+02	0.0	0.0	1.20000D+01	2.00069D+03
14	2.23903D+03	7.77601D+03	5.55437D+02	4.64517D+01	5.56532D+02	0.0	0.0	4.00000D+00	7.77601D+03
15	2.23440D+03	7.58603D+03	5.76487D+02	4.53168D+01	5.72910D+02	0.0	0.0	4.00000D+00	7.58603D+03
16	2.23050D+03	7.37287D+03	5.98950D+02	4.40435D+01	5.89643D+02	0.0	0.0	4.00000D+00	7.37287D+03
17	2.23729D+03	2.37681D+02	5.47832D+02	4.68336D+01	5.50501D+02	0.0	0.0	4.33000D+01	2.37681D+02
18	2.21356D+03	3.21013D+04	7.40465D+02	2.46933D+01	6.50335D+02	1.02300D-01	4.82528D+01	2.02261D+01	2.88173D+04
19	2.21217D+03	1.08718D+03	6.89325D+02	3.80133D+01	6.46480D+02	0.0	0.0	8.78000D+00	1.08718D+03
20	8.62470D+02	9.12213D+04	6.23287D+02	1.06779D+01	5.29632D+02	1.47753D-01	9.87994D+03	4.94205D+01	7.77430D+04

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S: STAG. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.77076D+04	6.18658D+02	2.33448D-02	4.23200D+00	2.61926D-01	-4.63392D+00	-1.39995D-01	0.0
2	2 TO 3		2.81565D+04	6.22481D+02	2.34660D-02	1.36012D+01	-1.16329D+00	-8.29466D+00	4.14329D+00	0.0
3	3 TO 4		2.80713D+04	6.24743D+02	2.35396D-02	7.49804D+00	-2.98360D+00	-4.32666D+00	1.87786D-01	0.0
4	4 TO 5		2.80864D+04	5.94523D+02	2.25981D-02	9.50865D+00	-4.55665D+00	-5.19258D+00	-2.40579D-01	0.0
5	5 TO 6		2.81388D+04	5.72628D+02	2.19855D-02	5.17861D+00	5.06082D-02	-5.36270D+00	-1.33480D-01	0.0
6	6 TO 7		2.81779D+04	5.57689D+02	2.16000D-02	4.13256D-01	4.77364D+00	-4.85010D+00	3.36799D-01	0.0
7	7 TO 8		2.82054D+04	5.47477D+02	2.13600D-02	2.34619D-01	5.08069D+00	-5.30394D+00	1.13606D-02	0.0
8	8 TO 9		2.82278D+04	5.46981D+02	2.13510D-02	-3.97922D+01	-4.10546D-02	-1.44313D+00	6.79914D-02	4.13443D+01
9	9 TO 10		2.82328D+04	5.47306D+02	2.13449D-02	-4.06540D+01	-4.70125D-01	-6.90103D-01	1.30104D-01	4.13443D+01
10	10 TO 11		2.82340D+04	5.47258D+02	2.13359D-02	1.24353D+01	2.12038D+00	-1.44071D+01	1.48508D-01	0.0
11	11 TO 12		2.82341D+04	5.47346D+02	2.13372D-02	-3.04024D-01	4.91770D+00	-4.47485D+00	1.38823D-01	0.0
12	12 TO 13		8.50571D+02	5.47356D+02	2.13384D-02	1.67238D+01	-3.55510D+00	-1.31845D+01	-1.57759D-02	0.0
13	13 TO 14		2.73818D+04	5.47356D+02	2.13384D-02	1.08978D+01	-2.24796D+00	-8.64404D+00	5.82628D-03	0.0
14	14 TO 15		2.73709D+04	5.63955D+02	2.17462D-02	4.50000D+00	-1.27442D+00	-3.83694D+00	-6.11362D-01	0.0
15	15 TO 16		2.73294D+04	5.89819D+02	2.24507D-02	3.60980D+00	-1.24079D+00	-3.83950D+00	-1.47048D+00	0.0
16	16 TO 1		2.72489D+04	6.08900D+02	2.30136D-02	7.74534D+00	-2.33088D+00	-8.08236D+00	-2.66790D+00	0.0
17	13 TO 1		8.50435D+02	5.47347D+02	2.13433D-02	1.00902D+01	-3.67165D+00	-1.12040D+01	-4.78539D+00	0.0
18	10 TO 17		0.0	5.47380D+02	2.13369D-02	1.25620D+01	-7.41566D+00	0.0	0.0	0.0
19	17 TO 18		5.74438D-02	5.51435D+02	2.14350D-02	2.41865D+01	-4.85062D+00	-1.96291D+01	-2.93185D-01	0.0
20	19 TO 18		-5.18917D+02	6.97831D+02	2.68287D-02	-1.15656D-01	-5.51296D+00	5.08708D+00	-5.41731D-01	0.0
21	2 TO 19		-5.29239D+02	6.89198D+02	2.62977D-02	-2.97261D+00	-1.09985D+00	5.89752D+00	1.82502D+00	0.0
31	0 TO 20		0.0	0.0	0.0	0.0	1.78953D+00	0.0	0.0	0.0
30	0 TO 20		0.0	0.0	0.0	0.0	1.78953D+00	0.0	0.0	0.0

1757 318

29	0 TO 20	0.0	0.0	0.0	0.0	1.789530+00	0.0	0.0	0.0
28	0 TO 20	0.0	0.0	0.0	0.0	1.789530+00	0.0	0.0	0.0
27	0 TO 20	0.0	0.0	0.0	0.0	1.789530+00	0.0	0.0	0.0
26	0 TO 18	0.0	0.0	0.0	0.0	1.425400+00	0.0	0.0	0.0
25	0 TO 18	0.0	0.0	0.0	0.0	1.425400+00	0.0	0.0	0.0
24	0 TO 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0 TO 20	-2.739790+03	1.196940+03	5.133850-01	0.0	1.889350+00	0.0	0.0	0.0
22	0 TO 20	0.0	0.0	0.0	0.0	-2.990230+00	0.0	0.0	0.0

EQUIVALENT LIQUID LEVEL IS 1.21350D+01 FEET ABOVE THE BOTTOM OF VOLUME 20

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	1.180000+03	9.768320-01	0.0	1.000000D+00	3.313200+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)
1	RIGHT	14	1	1.128010+05	8.572310+05	5.347390+03	5.776550+02	2.256130+06	4.825730+06	1.596530+09
2	RIGHT	15	1	1.703730+05	8.578360+05	5.410010+03	6.045130+02	2.254050+06	6.201740+06	2.411370+09
3	RIGHT	16	1	1.156660+05	8.580080+05	5.490630+03	6.109120+02	2.248810+06	5.044690+06	1.637070+09
4	LEFT	4	1	-1.024950+05	7.716080+05	5.441530+03	5.786020+02	2.475440+06		-3.035300+09
	RIGHT	20	2	9.007220+04	1.416450+05	7.870780+03	5.410490+02	1.461320+05	4.040950+06	3.011780+09
5	LEFT	5	1	-7.060350+04	7.729650+05	5.331800+03	5.648170+02	2.478510+06		-2.090860+09
	RIGHT	20	2	6.160070+04	9.000000+04	6.556820+03	5.390000+02	1.461320+05	3.9ɤ8820+06	2.059770+09
6	LEFT	7	1	-3.276320+04	7.740800+05	5.245240+03	5.478700+02	2.485280+06		-9.702560+08
	RIGHT	20	2	2.832990+04	9.000000+04	4.501820+03	5.358980+02	1.461320+05	3.900220+06	9.472790+08
7	LEFT	6	1	-4.812800+04	7.738470+05	5.275000+03	5.548940+02	2.482430+06		-1.425270+09
	RIGHT	20	2	4.182140+04	1.416450+05	5.437910+03	5.372960+02	1.461320+05	3.9ɔ3250+06	1.398400+09

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.0	0.0	0.0	2.779830+08	7.443860+06	1.0ɤ5270+03	1.405390+03
2	2	0.0	0.0	0.0	4.296870+08	1.161170+07	1.3ɤ4490+03	1.970810+03
3	3	0.0	0.0	0.0	2.778500+08	7.577080+06	1.1ɔ8070+03	1.456720+03

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
4.428080+00	6.4ɔ4350+00	1.059280+01	4.263160+00	1.346200+01	2.638640+00	7.750000+00	1.271270+01	2.544720+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FULL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-6.502380+00	5.332270-01	4.667730-01	-8.300230+00	-8.396690+00	0.0	0.0	0.0	9.645570-02

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	18	6.824280+05
2	18	0.0
3	18	0.0

DATA RECORD NUMBER 110 WAS WRITTEN ON TAPE VSN = 081807 ON 78328 AND WAS LABELED UCRW

TRAILER LABEL WRITTEN ON UNIT 14

1757 319

XI. REEDIT SAMPLE PROBLEMS

POOR ORIGINAL

1257 320

XI. REEDIT SAMPLE PROBLEMS

The use of the REEDIT program module is briefly discussed in Section II.3.0. As examples which illustrate the use of REEDIT, the Turbine Trip Without Bypass and the Uncontrolled Rod Withdrawal models have been used. These examples correspond to previous RETRAN sample problems (Sections IX.5.0 and IX.6.0) and to the previous RESTRT sample problems (Section X).

1.0 TURBINE TRIP WITHOUT BYPASS

The Turbine Trip Without Bypass REEDIT example employs the restart-plot tape created by the RESTRT example (Section X.1.0). For this REEDIT example, the frequency for printed output was changed. The input listing is given below as well as output at 0.95 seconds. This major edit was not printed in the RESTRT output but was obtainable with the REEDIT run.

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
010001   -2   -8   2   97
010030   "RETRANBWRTTWOBSHO"  "60776"  "78326"
020000   "PNRM" 0  "RD**" 0  "RV**" 0  "PRES" 10
020001   "WP**" 24  "WP**" 17  "RF**" 0  "MIXL" 9
030010   1   5   1.000
030020   1   5   10.0
.
```

```
REEDIT-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE     EPRI                    22/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
 RETRAN SAMPLE PROBLEM (TURBINE TRIP WITHOUT BY-PASS)
CPU TIME =      .492
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

STANDARD TIME STEP NUMBER =   96   ACTUAL TIME STEP NUMBER =   144   TIME = 9.500000E-01 SECONDS

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	HEAT REMOV. RATE (BTU/HR)	ENERGY BALANCE (BTU)	WATER MASS BALANCE (LBM)	AIR MASS BALANCE (LBM)
3.023804E+00	7.660505E+03	2.617197E+10	0.	2.387386E+11	2.157923E+08	0.

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	BUBB. MASS (LB)	MIX. LEV. (FT)	LIQ. MASS (LB)
1	1.14805E+03	1.26325E+05	5.26705E+02	4.72665E+01	5.32224E+02	0.	0.	1.73800E+01	1.26325E+05
2	1.12873E+03	1.09973E+04	5.51413E+02	4.59215E+01	5.51640E+02	0.	0.	4.00000E+00	1.09973E+04
3	1.12672E+03	5.49580E+03	5.98148E+02	2.29489E+01	5.59263E+02	5.85560E-02	3.21812E+02	4.00000E+00	5.17399E+07
4	1.12211E+03	3.65733E+03	6.34561E+02	1.52720E+01	5.58753E+02	1.1)588E-01	4.30058E+02	4.00000E+00	3.22727E+03
5	1.12328E+03	9.52308E+03	5.34003E+02	4.68840E+01	5.37967E+02	0.	0.	4.00000E+00	9.52308E+03
6	1.12235E+03	9.39226E+03	5.45557E+02	4.62399E+01	5.47101E+02	0.	0.	4.00000E+00	9.39226E+03
7	1.12086E+03	9.24947E+03	5.58205E+02	4.55370E+01	5.56799E+02	0.	0.	4.00000E+00	9.24947E+03
8	1.11947E+03	1.21324E+04	6.44252E+02	1.39842E+01	5.58458E+02	1.33545E-01	1.62023E+03	6.43300E+00	1.05122E+04
9	1.09201E+03	2.97352E+04	6.81531E+02	1.02622E+01	5.55372E+02	1.97708E-01	3.08389E+01	4.45738E+00	2.38563E+04
10	1.09173E+03	8.77812E+03	1.19749E+03	2.42215E+00	5.62078E+02	1.00000E+00	0.	0.	0.
11	1.10308E+03	2.91981E+03	6.42475E+02	1.37980E+01	5.56624E+02	1.33872E-01	3.90882E+02	5.48400E+00	2.52893E+03
12	1.10146E+03	1.64269E+05	5.26917E+02	4.72272E+01	5.32334E+02	0.	0.	3.38200E+01	1.64269E+05
13	1.14283E+03	9.23226E+03	5.26820E+02	4.72577E+01	5.32309E+02	0.	0.	1.64000E+01	9.23226E+03
14	1.08846E+03	1.56344E+03	1.19798E+03	2.41160E+00	5.61970E+02	1.00000E+00	0.	0.	0.
15	1.08437E+03	1.06631E+03	1.19855E+03	2.39882E+00	5.62094E+02	1.00000E+00	0.	0.	0.
16	1.07112E+03	5.46955E+03	1.20089E+03	2.35456E+00	5.63109E+02	1.00000E+00	0.	0.	0.
17	1.07004E+03	2.55210E+02	1.20030E+03	2.35585E+00	5.62533E+02	1.00000E+00	0.	0.	0.
18	1.19268E+03	2.55970E+04	5.27158E+02	4.72722E+01	5.32637E+02	0.	0.	4.21750E+01	2.55970E+04
19	1.26296E+03	2.80652E+04	5.27110E+02	4.73175E+01	5.32678E+02	0.	0.	5.11940E+01	2.80652E+04
20	9.58025E+02	2.15331E+08	1.18966E+03	2.15331E+00	5.39404E+02	9.92994E-01	2.13823E+08	1.00000E+01	1.50852E+06

JUNCTION NUMBER	CONNECTING VOLUMES	CHOKE COND.	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E STAG. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.76689E+04	5.26691E+02	2.11573E-02	1.94245E+01	-3.49040E+00	-1.59772E+01	-4.31031E-02	0.
2	2 TO 3		1.80335E+04	5.72933E+02	2.87397E-02	1.36323E+00	-9.58106E-01	-1.13689E+00	-7.31767E-01	0.
3	3 TO 4		2.03793E+04	6.21535E+02	5.74581E-02	3.91413E+00	-5.32458E-01	-3.25915E+00	1.22520E-01	0.
4	4 TO 8		2.08145E+04	6.48801E+02	7.40579E-02	3.34263E+00	-5.24575E-01	-2.55602E+00	2.62035E-01	0.
5	1 TO 5		1.21858E+03	5.26691E+02	2.11573E-02	2.49715E+01	-3.50357E+00	-2.14651E+01	2.75685E-03	0.
6	5 TO 6		1.24169E+03	5.39667E+02	2.14699E-02	8.86596E-01	-1.29342E+00	-9.86763E-03	-4.16696E-01	0.
7	6 TO 7		1.27096E+03	5.50757E+02	2.17619E-02	1.57280E+00	-1.27463E+00	-1.14669E-02	2.86706E-01	0.
8	7 TO 8		1.16290E+03	6.41909E+02	7.01238E-02	1.35689E+00	-9.44596E-01	-3.88794E-01	2.34989E-02	0.
9	11 TO 9		2.12294E+04	6.42381E+02	7.25691E-02	1.43854E+01	-1.77269E+00	-1.59304E+00	1.10197E+01	0.
10	9 TO 10		2.01493E+03	1.18942E+03	4.04317E-01	2.76234E-01	-1.22751E-01	-1.07956E-02	1.42687E-01	0.
11	18 TO 19		9.35530E+03	5.27173E+02	2.11534E-02	-7.02278E+01	-2.90952E+00	-1.77739E+01	-3.06484E+00	8.78464E+01
12	8 TO 11		2.13940E+04	6.44161E+02	7.15793E-02	1.33636E+01	-5.74508E-01	-1.33510E+00	1.14540E+01	0.
13	12 TO 13		5.60981E+03	5.26905E+02	2.11742E-02	-4.82362E+00	2.85832E+00	-4.06452E+00	-6.02982E+00	0.
14	19 TO 13		9.33508E+03	5.27076E+02	2.11357E-02	4.95555E+01	-4.99569E+00	-4.64024E+01	-1.84262E+00	0.
15	12 TO 18		9.37023E+03	5.26921E+02	2.11734E-02	-9.48787E+01	1.07447E+01	-5.10312E+00	-1.39075E+00	8.78464E+01
16	13 TO 1		1.89428E+04	5.26820E+02	2.11601E-02	-4.57114E+00	2.88143E+00	-8.88304E-01	-2.57801E+00	0.
17	10 TO 14		1.34865E+03	1.19744E+03	4.13133E-01	3.01265E+00	5.14433E-01	-6.88278E-01	2.83880E+00	0.
18	14 TO 15		1.21184E+03	1.19793E+03	4.14940E-01	4.73358E+00	5.18639E-01	-8.30705E-01	4.42152E+00	0.
19	15 TO 16		1.08258E+03	1.19844E+03	4.17361E-01	1.50440E+01	2.44483E-01	-5.05126E+00	1.02372E+01	0.
20	16 TO 17		5.11954E+01	1.20068E+03	4.25640E-01	1.39831E+00	-3.75983E-01	-1.04008E-01	9.18324E-01	0.
21	9 TO 12		1.63102E+04	5.56721E+02	2.20807E-02	-9.76232E+00	6.46709E+00	-1.39825E-01	-3.43505E+00	0.
22	16 TO 20		0.	1.20068E+03	4.25635E-01	1.10567E+02	-3.33203E-01	0.	0.	0.
26	0 TO 14		0.	0.	0.	0.	-3.09109E-01	0.	0.	0.
25	0 TO 14		0.	0.	0.	0.	-3.09109E-01	0.	0.	0.
24	0 TO 12		2.62121E+03	4.03234E+02	1.88949E-02	0.	4.62740E+00	0.	0.	0.
23	0 TO 14		0.	0.	0.	0.	-3.09109E-01	0.	0.	0.

EQUIVALENT LIQUID LEVEL IS 4.36370E+00 FEET ABOVE THE BOTTOM OF VOLUME 9

PUMP NUMBER	VOLUME NUMBER	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H20 (BTU/HR)
1	18	1.66500E+03	9.95387E-01	0.	1.00000E+00	2.66622E+07

HEAT COND. NUMBER		VOL. NUM.	H.T. MODE	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)
1	RIGHT	2	2	2.37126E+05	8.00000E+05	1.65547E+04	5.73719E+02	1.08242E+06	1.22704E+07	3.83619E+09
2	RIGHT	3	2	2.41983E+05	7.41986E+05	1.66981E+04	5.73676E+02	1.15730E+06	1.24012E+07	3.91477E+09
3	RIGHT	4	2	1.36892E+05	6.82706E+05	1.25136E+04	5.69614E+02	1.22899E+06	9.17684E+06	2.21461E+09
4	LEFT	2	1	2.65584E+03	1.32981E+06	2.90894E+03	5.52331E+02	1.08242E+06		1.06250E+07
	RIGHT	5	1	4.15640E+03	1.38102E+05	2.92504E+02	5.52152E+02	8.77185E+04	4.14506E+05	1.66282E+07
5	LEFT	3	1	-7.34111E+02	1.05790E+06	3.09116E+03	5.58946E+02	1.15730E+06		-2.93691E+06
	RIGHT	6	1	3.13075E+03	1.36606E+05	3.00064E+02	5.57508E+02	8.97799E+04	4.19231E+05	1.25250E+07
6	LEFT	4	1	-4.82980E+03	1.06395E+06	3.24206E+03	5.57184E+02	1.22899E+06		-1.93223E+07
	RIGHT	7	1	-3.71756E+02	1.32992E+05	2.95344E+02	5.55603E+02	8.70651E+04	4.17390E+05	-1.48726E+06
7	LEFT	11	1	-2.85118E+04	3.06922E+05	3.29915E+03	5.47896E+02	2.27228E+06		-4.77510E+07
	RIGHT	12	1	3.39778E+03	1.46888E+05	9.45773E+02	5.35915E+02	7.39718E+05	1.21217E+06	6.19246E+06
8	LEFT	8	1	-1.28173E+02	9.00000E+04	5.00000E+00	5.32745E+02	7.68840E-02		-4.83340E+04
	RIGHT	12	1	-1.13703E+03	1.76946E+05	1.53400E+03	5.31581E+02	7.39718E+05	5.47904E+06	-4.38114E+05

CORE SECT. NUMBER	HEAT COND. NUMBER	DEPTH REAC. EXT. ZR-H20 (FT)	DEPTH REAC. INT. ZR-H20 (FT)	HEAT GEN. ZR-H20 (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)
1	1	0.	0.	0.	9.47901E+09	2.51147E+08	1.81919E+03	2.54724E+03
2	2	0.	0.	0.	9.60589E+09	2.95911E+08	1.83274E+03	2.58405E+03
3	3	0.	0.	0.	5.85400E+09	1.75521E+08	1.37095E+03	1.74551E+03
4	4	0.	0.	0.	4.86849E+07	1.34777E+08	5.52619E+02	
5	5	0.	0.	0.	5.01207E+07	1.36557E+08	5.58340E+02	
6	6	0.	0.	0.	2.24390E+07	9.12407E+07	5.56112E+02	

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
9.27806E+00	3.61151E+00	1.53972E+01	1.33892E+00	1.62124E+01	0.	9.00000E+00	1.19498E+01	1.11106E+00

REACTOR PERIOD (SEC)	PROMPT POWER FRAC	DELAYED POWER FRAC	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-1.08879E-01	9.73401E-01	2.65988E-02	4.86848E-01	-6.72461E-01	0.	1.35419E+00	0.	-1.94877E-01

DATA RECORD NUMBER 97 WAS WRITTEN ON TAPE VSN = 60776 ON 78326 AND WAS LABELED RETRANBWRTTWOBSHO

2.0 UNCONTROLLED ROD WITHDRAWAL

The restart-plot tape created by the RESTRT example of Section X.2.0 was used to obtain the REEDIT example. Both minor edits and printer plots were obtained. These parameters differ from those minor edit parameters in the RESTRT output.

The input listing is given below. Minor edit printout from this example is also given. Note that this is different from the RESTRT minor edit printout given in Section X.2.

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
010001    -2    -8    2    70
010030    'UCRW                    '    '081807'    '78328'
020000    'TEMP' 20   'TEMP' 1    'TEMP' 18   'PRES'  2   'XP**' 21
020001    'XP**' 13   'XP**' 16     'XP**'  3
030010    1   4     4.0
030020    1   5    10.
.
```

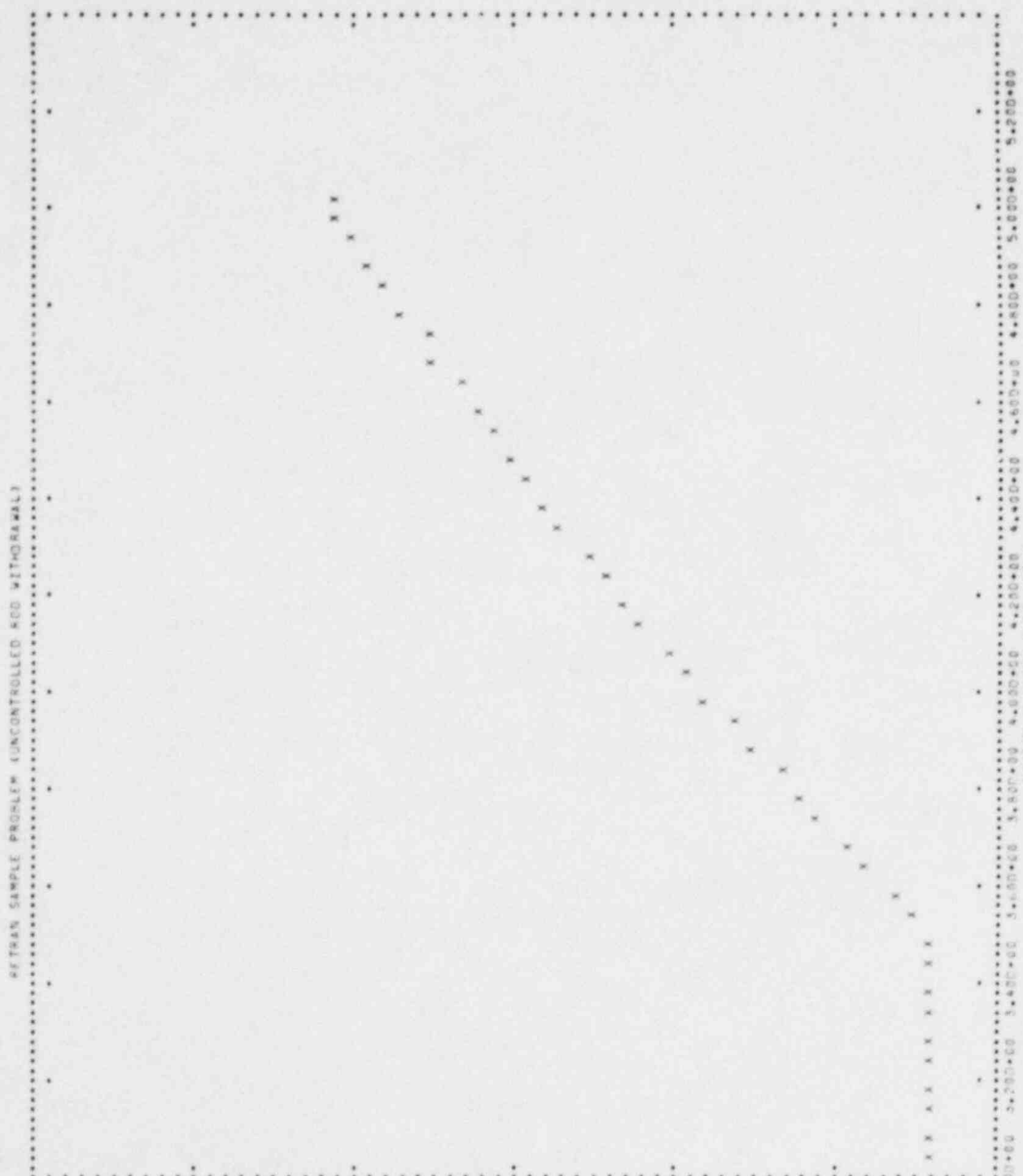
RLEDIT-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 11/24/78
*** EPRI RELEASE 0. -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
CPU TIME = 5.79.
* *

SYSTEM ELAPSED TIME (SEC)	VOL 20 AVG. TEMP. (DEG. F)	VOL 1 AVG. TEMP. (DEG. F)	VOL 18 AVG. TEMP. (DEG. F)	VOL 2 AVG. PRESS. (PSI)	JUN 21 QUALITY	JUN 13 QUALITY	JUN 16 QUALITY	JUN 3 QUALITY
3.050000D+00	5.281410D+02	6.082730D+02	6.511640D+02	2.248060D+03	0.0	0.0	0.0	0.0
3.100000D+00	5.281430D+02	6.083180D+02	6.511900D+02	2.247670D+03	0.0	0.0	0.0	0.0
3.150000D+00	5.281450D+02	6.083580D+02	6.512010D+02	2.247390D+03	0.0	0.0	0.0	0.0
3.200000D+00	5.281470D+02	6.083930D+02	6.512120D+02	2.247020D+03	0.0	0.0	0.0	0.0
3.250000D+00	5.281490D+02	6.084220D+02	6.512200D+02	2.246610D+03	0.0	0.0	0.0	0.0
3.300000D+00	5.281510D+02	6.084440D+02	6.512260D+02	2.246170D+03	0.0	0.0	0.0	0.0
3.350000D+00	5.281540D+02	6.084600D+02	6.512300D+02	2.245670D+03	0.0	0.0	0.0	0.0
3.400000D+00	5.281560D+02	6.084670D+02	6.512340D+02	2.245090D+03	0.0	0.0	0.0	0.0
3.450000D+00	5.281580D+02	6.084650D+02	6.512340D+02	2.244500D+03	0.0	0.0	0.0	0.0
3.500000D+00	5.281600D+02	6.084560D+02	6.512330D+02	2.243800D+03	0.0	0.0	0.0	0.0
3.550000D+00	5.281630D+02	6.084330D+02	6.512290D+02	2.242510D+03	0.0	0.0	0.0	0.0
3.600000D+00	5.282270D+02	6.084000D+02	6.512230D+02	2.241280D+03	0.0	0.0	0.0	0.0
3.650000D+00	5.282880D+02	6.083580D+02	6.512140D+02	2.240050D+03	0.0	0.0	0.0	0.0
3.700000D+00	5.283480D+02	6.083040D+02	6.512020D+02	2.238760D+03	0.0	0.0	0.0	0.0
3.750000D+00	5.284060D+02	6.082390D+02	6.511890D+02	2.237390D+03	0.0	0.0	0.0	0.0
3.800000D+00	5.284640D+02	6.081640D+02	6.511710D+02	2.235970D+03	0.0	0.0	0.0	0.0
3.850000D+00	5.285210D+02	6.080770D+02	6.511540D+02	2.234470D+03	0.0	0.0	0.0	0.0
3.900000D+00	5.285770D+02	6.079790D+02	6.511320D+02	2.232980D+03	0.0	0.0	0.0	0.0
3.950000D+00	5.286330D+02	6.078700D+02	6.511110D+02	2.231280D+03	0.0	0.0	0.0	0.0
4.000000D+00	5.286860D+02	6.077520D+02	6.510830D+02	2.229790D+03	0.0	0.0	0.0	0.0
4.050000D+00	5.287390D+02	6.076300D+02	6.510530D+02	2.228400D+03	0.0	0.0	0.0	0.0
4.100000D+00	5.287910D+02	6.075000D+02	6.510170D+02	2.227150D+03	0.0	0.0	0.0	0.0
4.150000D+00	5.288430D+02	6.073580D+02	6.509770D+02	2.226520D+03	0.0	0.0	0.0	0.0
4.200000D+00	5.288940D+02	6.072070D+02	6.509340D+02	2.225800D+03	0.0	0.0	0.0	0.0
4.250000D+00	5.289440D+02	6.070450D+02	6.508880D+02	2.225030D+03	0.0	0.0	0.0	0.0
4.300000D+00	5.289940D+02	6.068750D+02	6.508420D+02	2.223560D+03	0.0	0.0	0.0	0.0
4.350000D+00	5.290430D+02	6.066900D+02	6.507960D+02	2.222570D+03	0.0	0.0	0.0	0.0
4.400000D+00	5.290920D+02	6.064970D+02	6.507490D+02	2.221250D+03	0.0	0.0	0.0	0.0
4.450000D+00	5.291390D+02	6.062970D+02	6.507220D+02	2.219640D+03	0.0	0.0	0.0	0.0
4.500000D+00	5.291850D+02	6.060860D+02	6.506960D+02	2.218530D+03	0.0	0.0	0.0	0.0
4.550000D+00	5.292310D+02	6.058630D+02	6.506690D+02	2.216550D+03	0.0	0.0	0.0	0.0
4.600000D+00	5.292760D+02	6.056380D+02	6.506410D+02	2.215350D+03	0.0	0.0	0.0	0.0
4.650000D+00	5.293180D+02	6.054080D+02	6.506100D+02	2.214570D+03	0.0	0.0	0.0	0.0
4.700000D+00	5.293640D+02	6.051640D+02	6.505790D+02	2.211710D+03	0.0	0.0	0.0	0.0
4.750000D+00	5.294000D+02	6.049280D+02	6.505460D+02	2.213820D+03	0.0	0.0	0.0	0.0
4.800000D+00	5.294440D+02	6.046840D+02	6.505100D+02	2.211460D+03	0.0	0.0	0.0	0.0
4.850000D+00	5.294870D+02	6.044200D+02	6.504740D+02	2.209270D+03	0.0	0.0	0.0	0.0
4.900000D+00	5.295250D+02	6.041730D+02	6.504370D+02	2.209320D+03	0.0	0.0	0.0	0.0
4.950000D+00	5.295690D+02	6.039080D+02	6.503990D+02	2.207670D+03	0.0	0.0	0.0	0.0
5.000000D+00	5.296050D+02	6.036590D+02	6.503600D+02	2.209400D+03	0.0	0.0	0.0	0.0
5.032480D+00	5.296320D+02	6.034890D+02	6.503350D+02	2.207720D+03	0.0	0.0	0.0	0.0
5.032480D+00	5.296320D+02	6.034890D+02	6.503350D+02	2.207720D+03	0.0	0.0	0.0	0.0

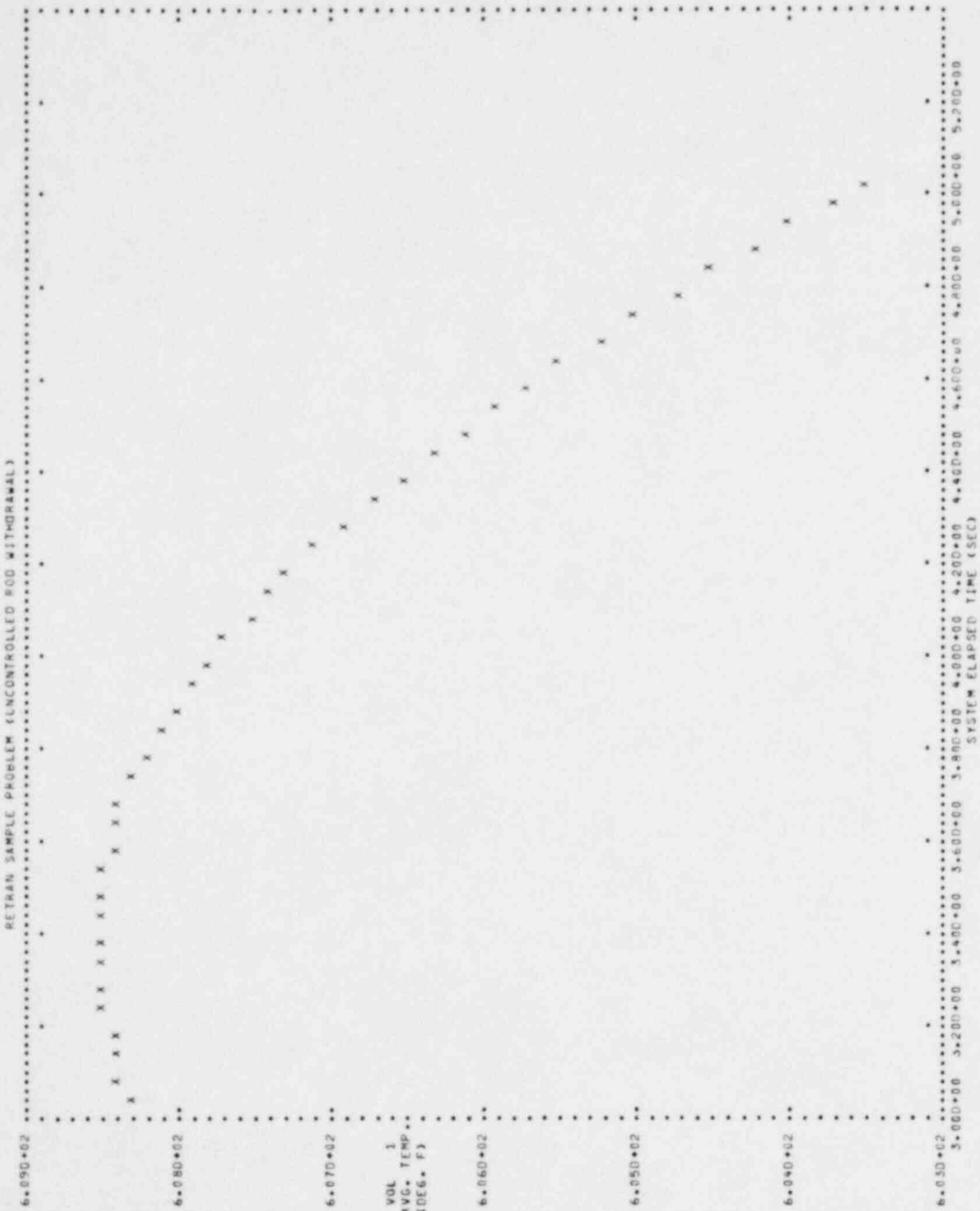
******** TRAILER LABEL ENCOUNTERED ON TAPE 13 WHILE SEARCHING FOR DATA RECORD 111. EDIT FREQUENCY SET 1

TAPE LABEL	VSN	CREATION DATE
UCR.	081807	EA

1757 327


RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
AVG. TEMP.
(DEG. F)
SYSTEM ELAPSED TIME (SEC)

1357 328



RETRAN SAMPLE PROBLEM (UNCONTROLLED ROD WITHDRAWAL)
VOL 1
AVG. TEMP.
(DEG. F)
6.090+02
6.080+02
6.070+02
6.060+02
6.050+02
6.040+02
6.030+02
3.000+00
3.200+00
3.400+00
3.600+00
3.800+00
4.000+00
4.200+00
4.400+00
4.600+00
4.800+00
5.000+00
5.200+00
SYSTEM ELAPSED TIME (SEC)

XII. PLOTTER SAMPLE PROBLEMS

[illegible]7 330

XII. PLØTER SAMPLE PROBLEMS

The PLOTER program module is briefly discussed in Section II.4.0. Two PLOTER examples are given to illustrate the use of this module. These examples are the Turbine Trip Without Bypass and the Uncontrolled Rod Withdrawal.

1.0 TURBINE TRIP WITHOUT BYPASS

An input listing for the TTWOB PLOTER sample problem is presented. The seven frames obtained from this job are given in Figures XII.1-1 through XII.1-7. Tabular data for the first frame is also presented.

LISTING OF INPUT DATA FOR CASE 1

```
=RETRAN SAMPLE PROBLEM (TTWOB)
010001    -3   1   7   7   0   1
010010    "RETRANBWRTTWOBSHO"  "60776"  "78326"
401101    PNRM 0  1
402101    RD** 0  1
403101    RV** 0  1
404101    PRES 10  1
405101    WP** 24  1
406101    WP** 17  1
407101    MIXL 9  1
.
```

PLOTER-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE EPRI 22/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
RETRAN SAMPLE PROBLEM (TTWOB)
CPU TIME = 4.104
* *

TABULAR DATA FOR: FRAME NUMBER - 1
Y AXIS NUMBER - 1
X AXIS LABEL - TIME (SEC)
Y AXIS LABEL - SYSTEM NCRM. POWER

X AXIS	Y AXIS	X AXIS	Y AXIS	X AXIS	Y AXIS	X AXIS	Y AXIS
0.	.100000E+01	.490000E+00	.102127E+01	.990000E+00	.213537E+01	.149000E+01	.832292E+00
.100000E-02	.100000E+01	.500000E+00	.103989E+01	.100000E+01	.197136E+01	.150000E+01	.841600E+00
.110000E-01	.100000E+01	.510000E+00	.106139E+01	.101000E+01	.182687E+01	.151000E+01	.851023E+00
.210000E-01	.100000E+01	.520000E+00	.108594E+01	.102000E+01	.169968E+01	.152000E+01	.860509E+00
.310000E-01	.100000E+01	.530000E+00	.111373E+01	.103000E+01	.158751E+01	.153000E+01	.870009E+00
.410000E-01	.100000E+01	.540000E+00	.114491E+01	.104000E+01	.148835E+01	.154000E+01	.879471E+00
.510000E-01	.100000E+01	.550000E+00	.117973E+01	.105000E+01	.140043E+01	.155000E+01	.888840E+00
.610000E-01	.100000E+01	.560000E+00	.121851E+01	.106000E+01	.132232E+01	.156000E+01	.898060E+00
.710000E-01	.100000E+01	.570000E+00	.126173E+01	.107000E+01	.125282E+01	.157000E+01	.907072E+00
.810000E-01	.100000E+01	.580000E+00	.130994E+01	.108000E+01	.119088E+01	.158000E+01	.915809E+00
.910000E-01	.100000E+01	.590000E+00	.136377E+01	.109000E+01	.113562E+01	.159000E+01	.924203E+00
.101000E+00	.100000E+01	.600000E+00	.142381E+01	.110000E+01	.108627E+01	.160000E+01	.932176E+00
.111000E+00	.100000E+01	.610000E+00	.149033E+01	.111000E+01	.104216E+01	.161000E+01	.939645E+00
.121000E+00	.100000E+01	.620000E+00	.156406E+01	.112000E+01	.100268E+01	.162000E+01	.946521E+00
.131000E+00	.100001E+01	.630000E+00	.164624E+01	.113000E+01	.967342E+00	.163000E+01	.952708E+00
.141000E+00	.100001E+01	.640000E+00	.173802E+01	.114000E+01	.935706E+00	.164000E+01	.958107E+00
.151000E+00	.100001E+01	.650000E+00	.184076E+01	.115000E+01	.907389E+00	.165000E+01	.962623E+00
.161000E+00	.100001E+01	.660000E+00	.195606E+01	.116000E+01	.882056E+00	.166000E+01	.966162E+00
.171000E+00	.100002E+01	.670000E+00	.208545E+01	.117000E+01	.859455E+00	.167000E+01	.968641E+00
.181000E+00	.100003E+01	.680000E+00	.223049E+01	.118000E+01	.839341E+00	.168000E+01	.969990E+00
.191000E+00	.100005E+01	.690000E+00	.239285E+01	.119000E+01	.821488E+00	.169000E+01	.970156E+00
.200000E+00	.100008E+01	.700000E+00	.257427E+01	.120000E+01	.805706E+00	.170000E+01	.969100E+00
.210000E+00	.100013E+01	.710000E+00	.277640E+01	.121000E+01	.791835E+00	.171000E+01	.966813E+00
.220000E+00	.100020E+01	.720000E+00	.300064E+01	.122000E+01	.779732E+00	.172000E+01	.960823E+00
.230000E+00	.100031E+01	.730000E+00	.324793E+01	.123000E+01	.769270E+00	.173000E+01	.950020E+00
.240000E+00	.100047E+01	.740000E+00	.351840E+01	.124000E+01	.760337E+00	.174000E+01	.936520E+00
.250000E+00	.100072E+01	.750000E+00	.381118E+01	.125000E+01	.752833E+00	.175000E+01	.921921E+00
.260000E+00	.100100E+01	.760000E+00	.412385E+01	.126000E+01	.746668E+00	.176000E+01	.906695E+00
.270000E+00	.100150E+01	.770000E+00	.445169E+01	.127000E+01	.741767E+00	.177000E+01	.891051E+00
.280000E+00	.100220E+01	.780000E+00	.478673E+01	.128000E+01	.738060E+00	.178000E+01	.875134E+00
.290000E+00	.999553E+00	.790000E+00	.511724E+01	.129000E+01	.735484E+00	.179000E+01	.859064E+00
.300000E+00	.993359E+00	.800000E+00	.542814E+01	.130000E+01	.733983E+00	.180000E+01	.842970E+00
.310000E+00	.986202E+00	.810000E+00	.570171E+01	.131000E+01	.733508E+00	.181000E+01	.826965E+00
.320000E+00	.979155E+00	.820000E+00	.591894E+01	.132000E+01	.734017E+00	.182000E+01	.811148E+00
.330000E+00	.972572E+00	.830000E+00	.606158E+01	.133000E+01	.735469E+00	.183000E+01	.795610E+00
.340000E+00	.966588E+00	.840000E+00	.611478E+01	.134000E+01	.737827E+00	.184000E+01	.780428E+00
.350000E+00	.961265E+00	.850000E+00	.606985E+01	.135000E+01	.740892E+00	.185000E+01	.765663E+00
.360000E+00	.956646E+00	.860000E+00	.592634E+01	.136000E+01	.744033E+00	.186000E+01	.751349E+00
.370000E+00	.952774E+00	.870000E+00	.561823E+01	.137000E+01	.747529E+00	.187000E+01	.737536E+00
.380000E+00	.949689E+00	.880000E+00	.525027E+01	.138000E+01	.751693E+00	.188000E+01	.724264E+00
.390000E+00	.947430E+00	.890000E+00	.489805E+01	.139000E+01	.756520E+00	.189000E+01	.711552E+00
.400000E+00	.946035E+00	.900000E+00	.457044E+01	.140000E+01	.761974E+00	.190000E+01	.699414E+00
.410000E+00	.945545E+00	.910000E+00	.424074E+01	.141000E+01	.768019E+00	.191000E+01	.687853E+00
.420000E+00	.946007E+00	.920000E+00	.391749E+01	.142000E+01	.774613E+00	.192000E+01	.676875E+00
.430000E+00	.956576E+00	.930000E+00	.360447E+01	.143000E+01	.781709E+00	.193000E+01	.666459E+00
.440000E+00	.964545E+00	.940000E+00	.330516E+01	.144000E+01	.789263E+00	.194000E+01	.656600E+00
.450000E+00	.971450E+00	.950000E+00	.302380E+01	.145000E+01	.797231E+00	.195000E+01	.647291E+00
.460000E+00	.979670E+00	.960000E+00	.276447E+01	.146000E+01	.805568E+00	.196000E+01	.638512E+00
.470000E+00	.991585E+00	.970000E+00	.252988E+01	.147000E+01	.814224E+00	.197000E+01	.630240E+00

757 333

```
  .480000E+00    .100534E+01    .980000E+00    .232081E+01    .148000E+01    .823150E+00    .198000E+01    .622454E+00

PLOTER-01-MOD000 12/01/78 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS PACKAGE    EPRI                    22/11/78
*** EPRI RELEASE 01 -- OPERATIONAL TRANSIENT AND BLOWDOWN VERSION ***
 RETRAN SAMPLE PROBLEM (TTWOB)
CPU TIME =     4.230
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

 TABULAR DATA FOR: FRAME NUMBER  -  1
                   Y AXIS NUMBER -  1
                   X AXIS LABEL  - TIME (SEC)
                   Y AXIS LABEL  -  SYSTEM   NCRM. POWER

    X AXIS          Y AXIS         X AXIS         Y AXIS         X AXIS         Y AXIS         X AXIS         Y AXIS
 *************   *************  *************  *************  *************  *************  *************  *************
  .199000E+01     .615136E+00
```

1757 334

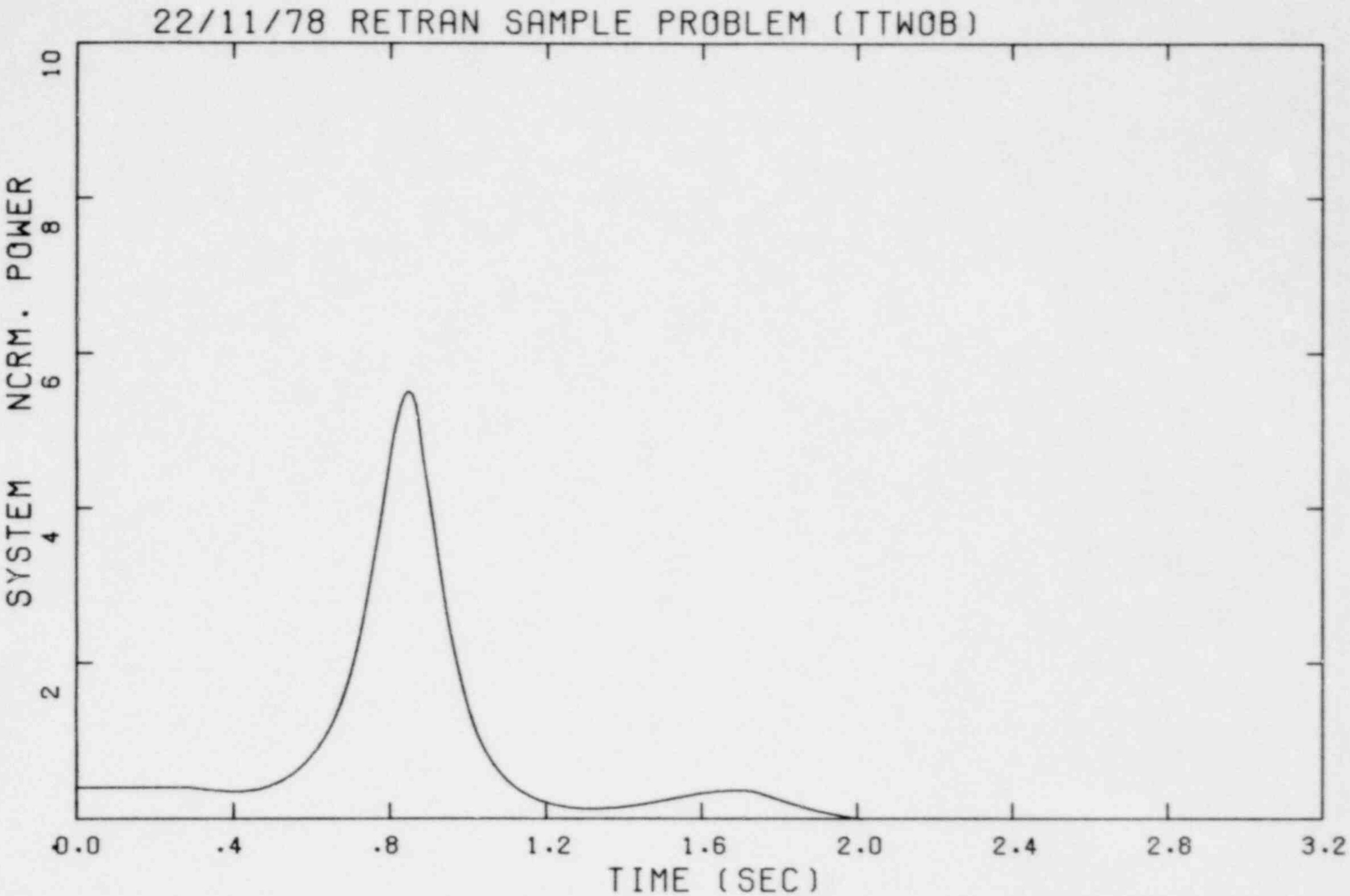


Figure XII.1-1 PLOTER TTWOB, Example 1

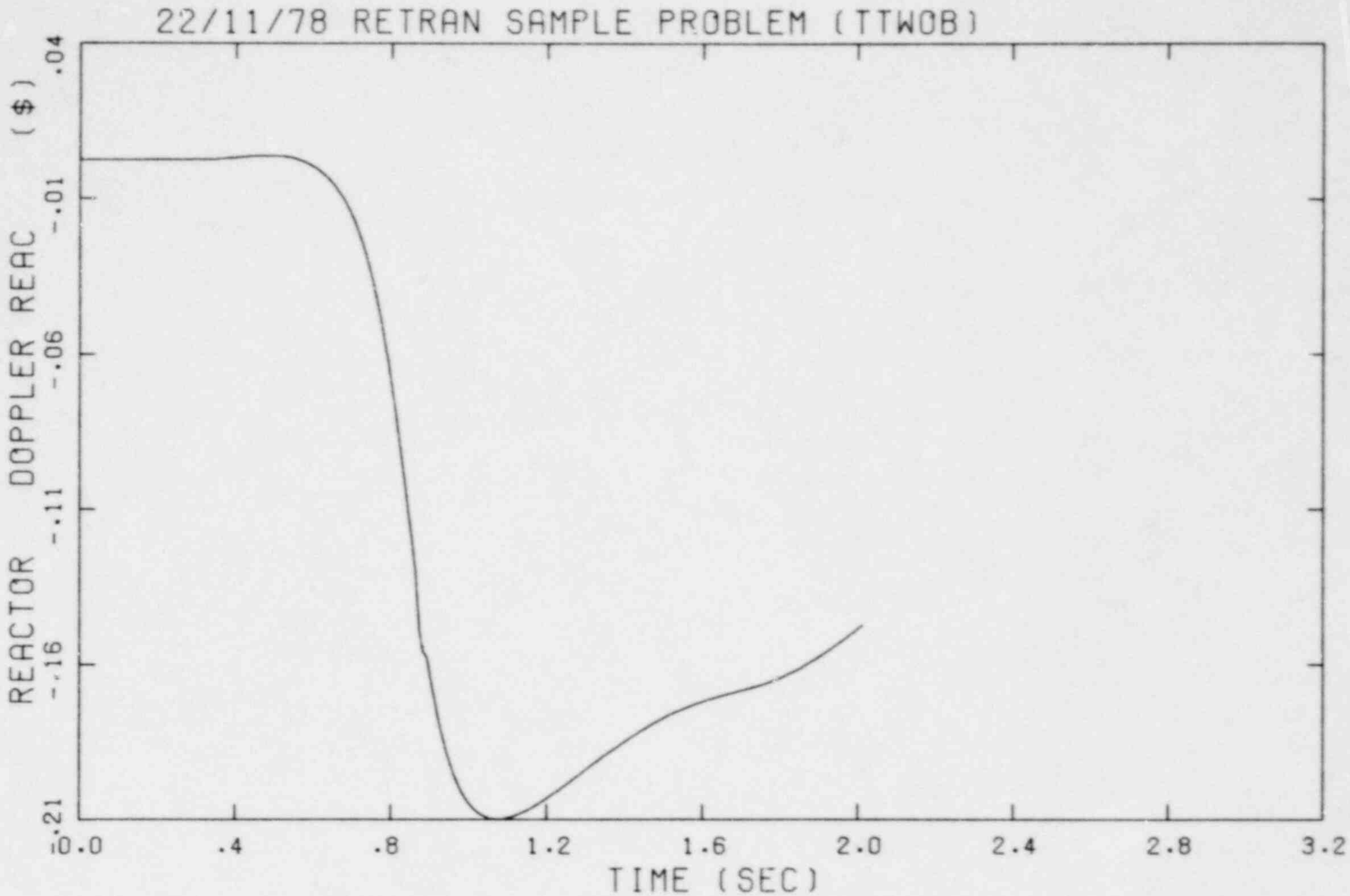


Figure XII.1-2 PLOTER TTWOB, Example 2

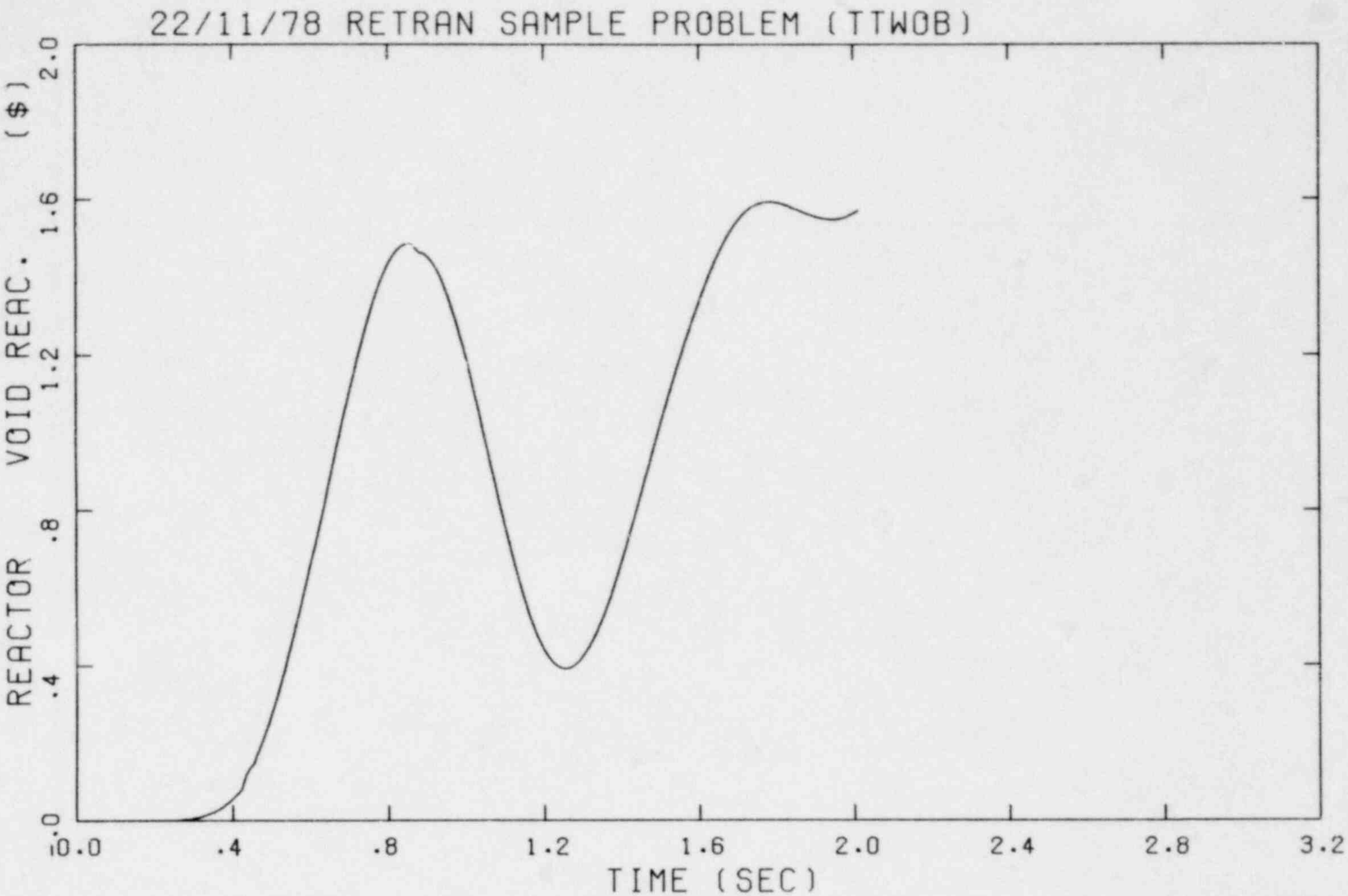


Figure XII.1-3 PLOTER TTWOB, Example 3

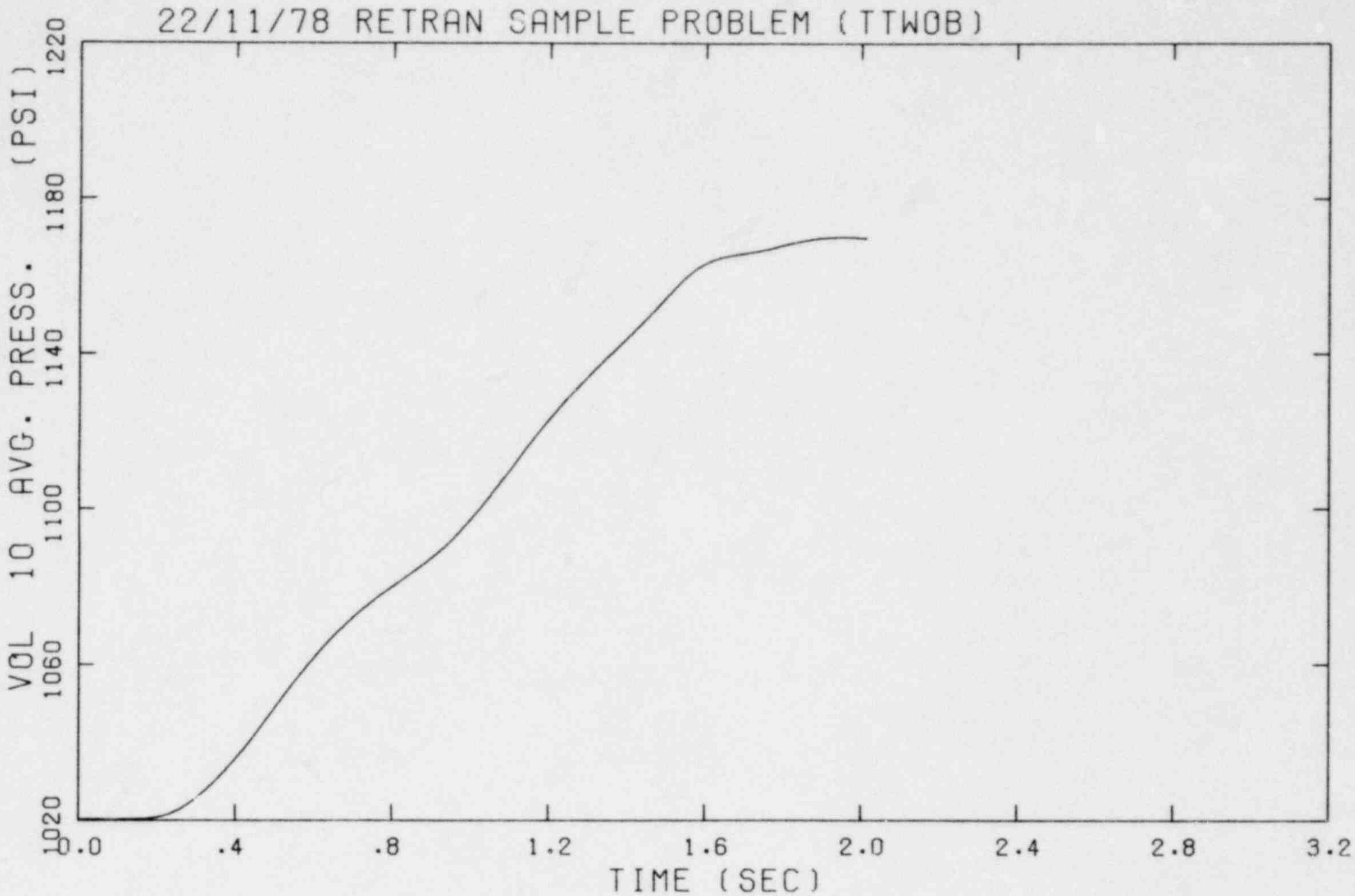


Figure XII.1-4 PLOTER TTWOB, Example 4

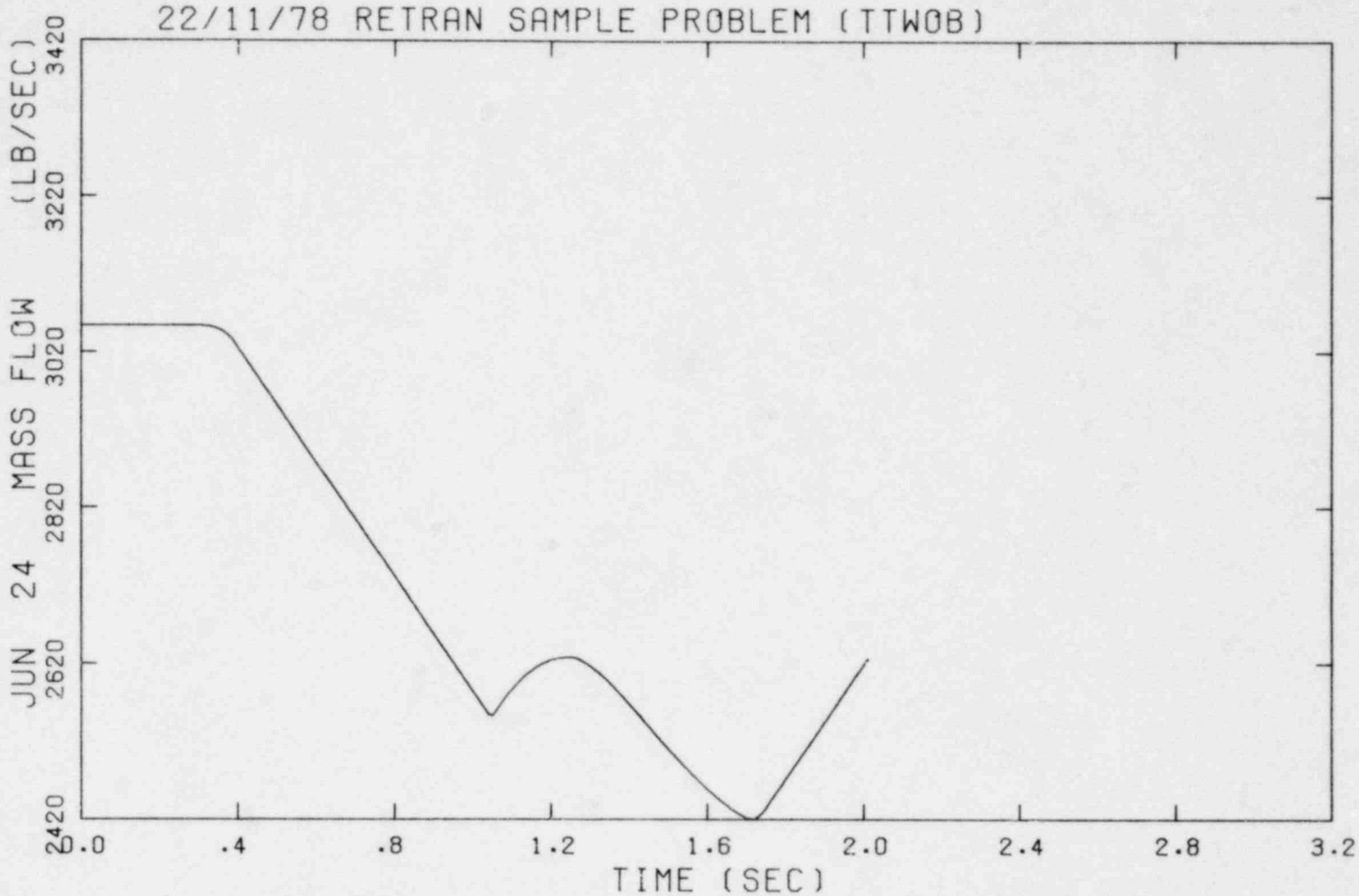


Figure XII.1-5 PLOTER TTWOB, Example 5

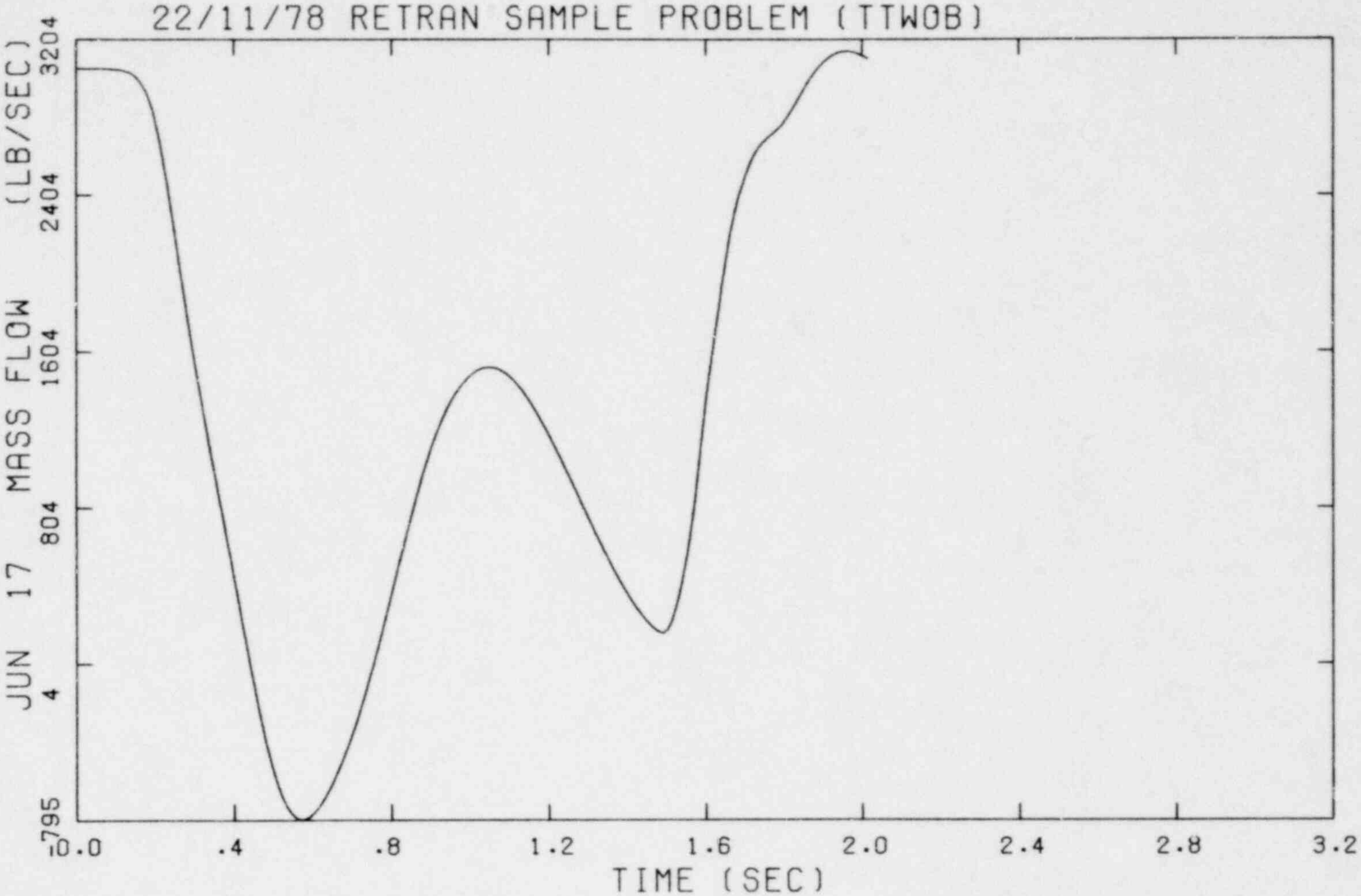


Figure XII.1-6 PLOTER TTWOB, Example 6

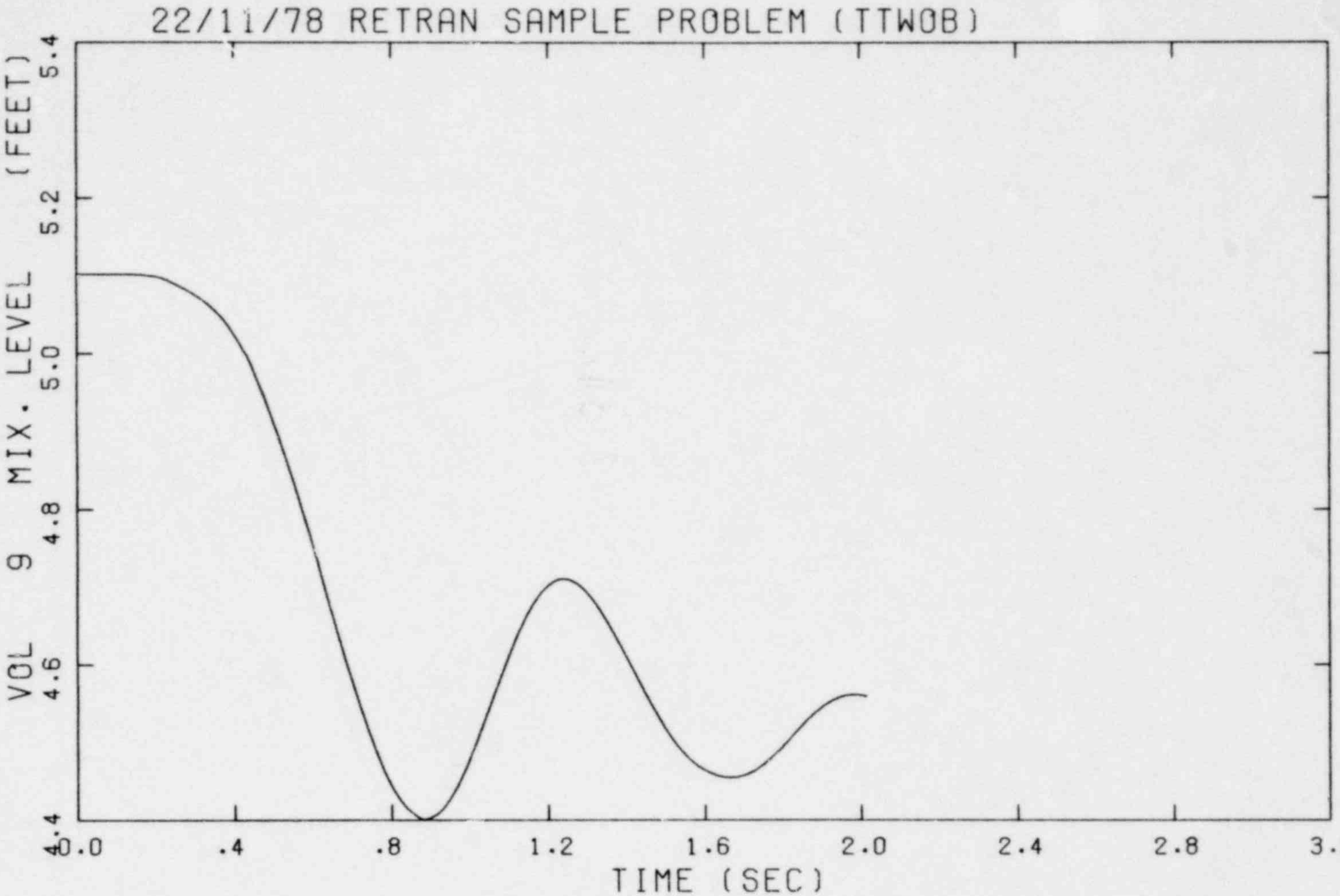


Figure XII.1-7 PLOTER TTWOB, Example 7

7 341

2.0 UNCONTROLLED ROD WITHDRAWAL

The UCRW PLOTER sample problem is used to show some capabilities of the PLOTER program module. An input listing is given and three frames obtained from this job are shown in Figures XII.2-1 through XII.2-3.

Note that scaling is used for Figure XII.2-1, differencing for Figure XII.2-2 and two curves are plotted on Figure XII.2-3.

LISTING OF INPUT DATA FOR CASE 1

```
=UNCONTROLLED ROD WITHDRAWAL
010001    -3    1    3    5    1    0
010010    'UCRW                    '    '081807'    '78328'
020000    'TIMX' 0.  'LIN' 5.   0.   5.   'TIME (SEC)'
030110    'LIN' 7.   0.   0.   'COLD LEG FLUID TEMP DEG-C'               * FIGURE XII.2-1
401101    'TEMP' 10   1   -32.   .55556   0.   1.
030210    'LIN' 7.   0.   0.   'DIFFERENTIAL PRESSURE (PSID)1-12'       * FIGURE XII.2-2
402121    'PRES' 1    1   0.   1.   0.   1.
402122    'PRES' 12   1   0.   1.   0.   1.
060210     402121     '-'     402122
030310    'LIN' 7.   400.   750.   'TEMPERATURE (F)2/10'                * FIGURE XII.2-3
403101    'TEMP' 2    1   0.   1.   0.   1.
403102    'TEMP' 10   1   0.   1.   0.   1.
.
```


1757 343

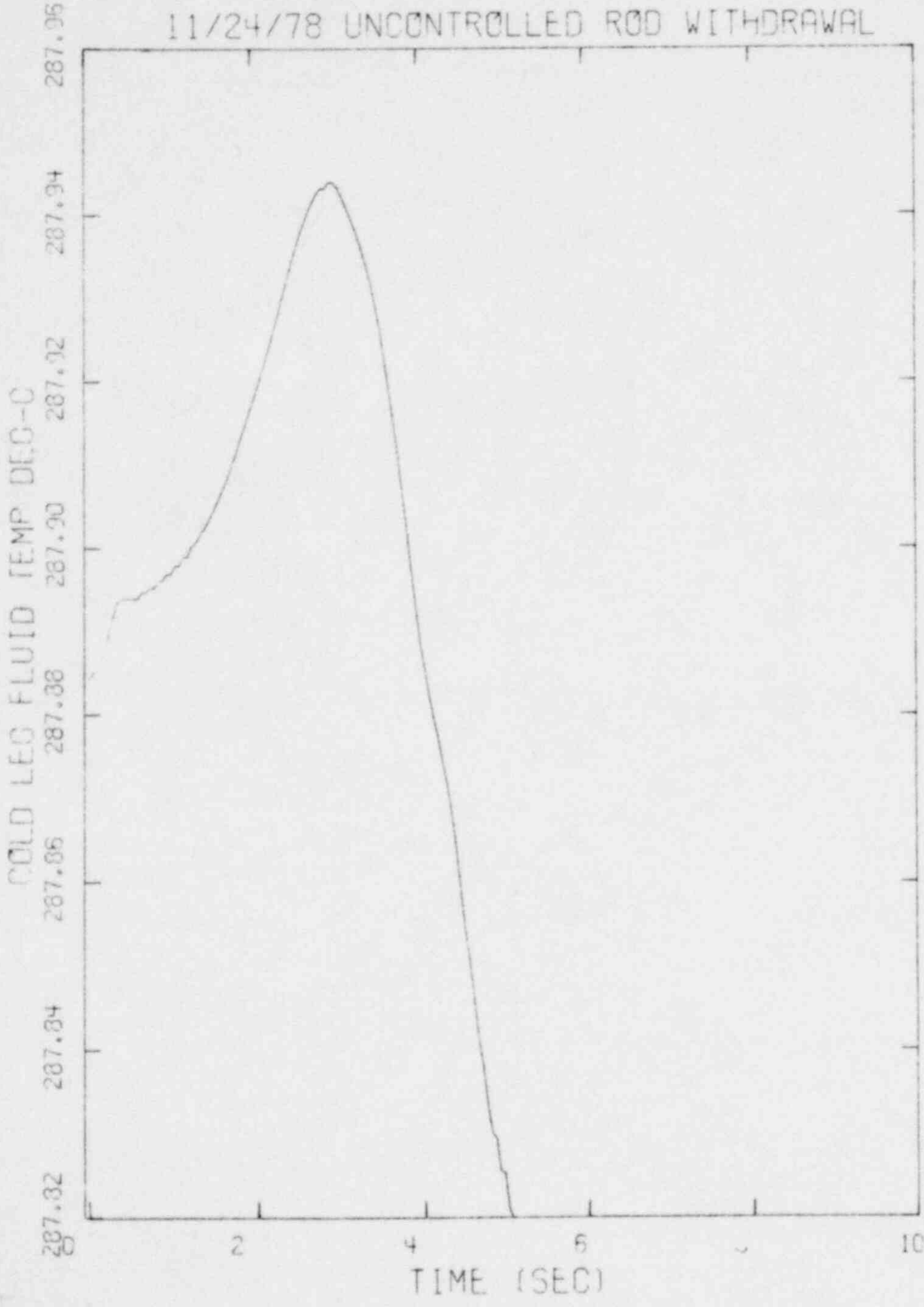


Figure XII.2-1 PLOTER UCRW, Example 1

1757 344

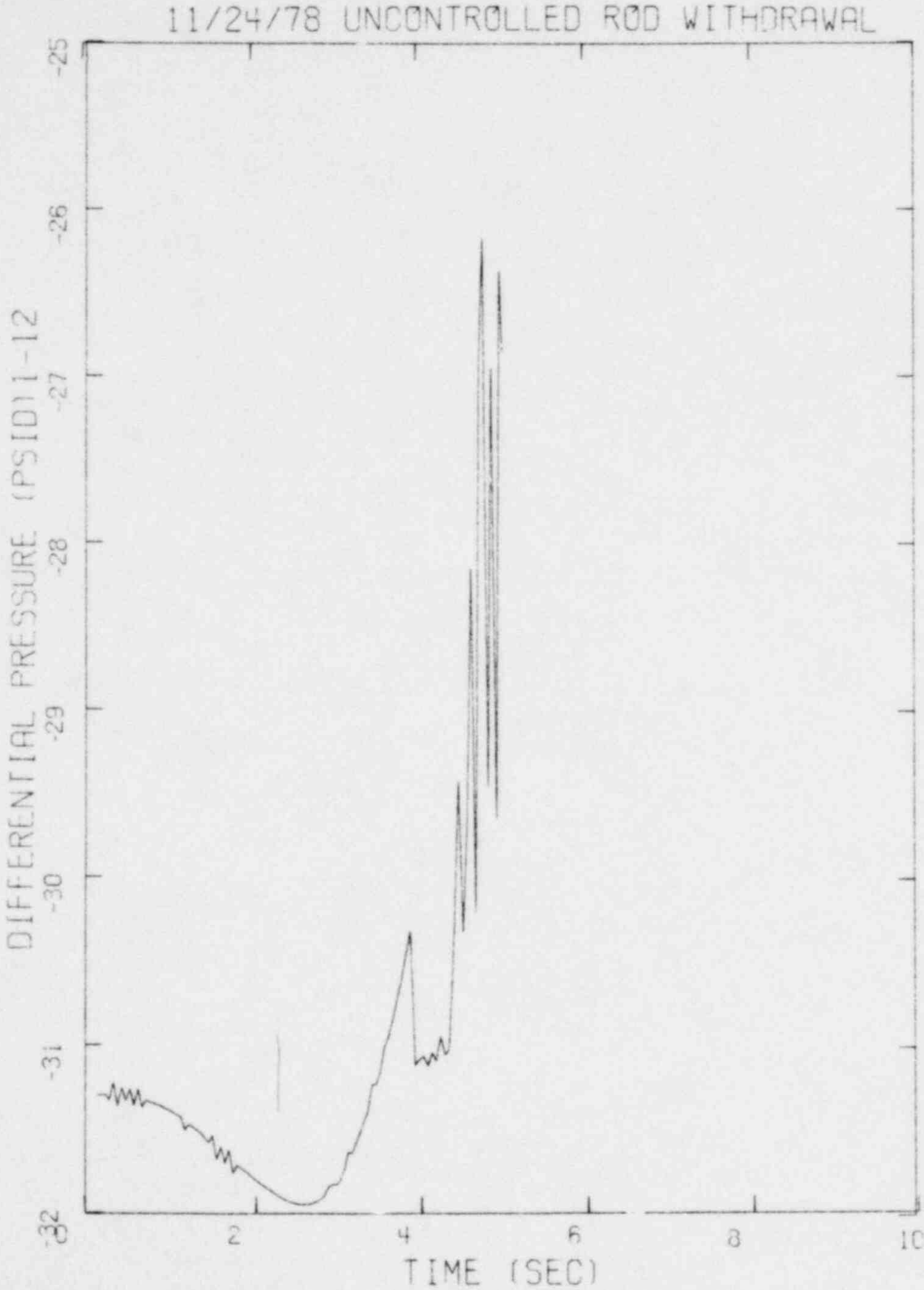


Figure XII.2-2 PLOTER UCRW, Example 2

1757 345

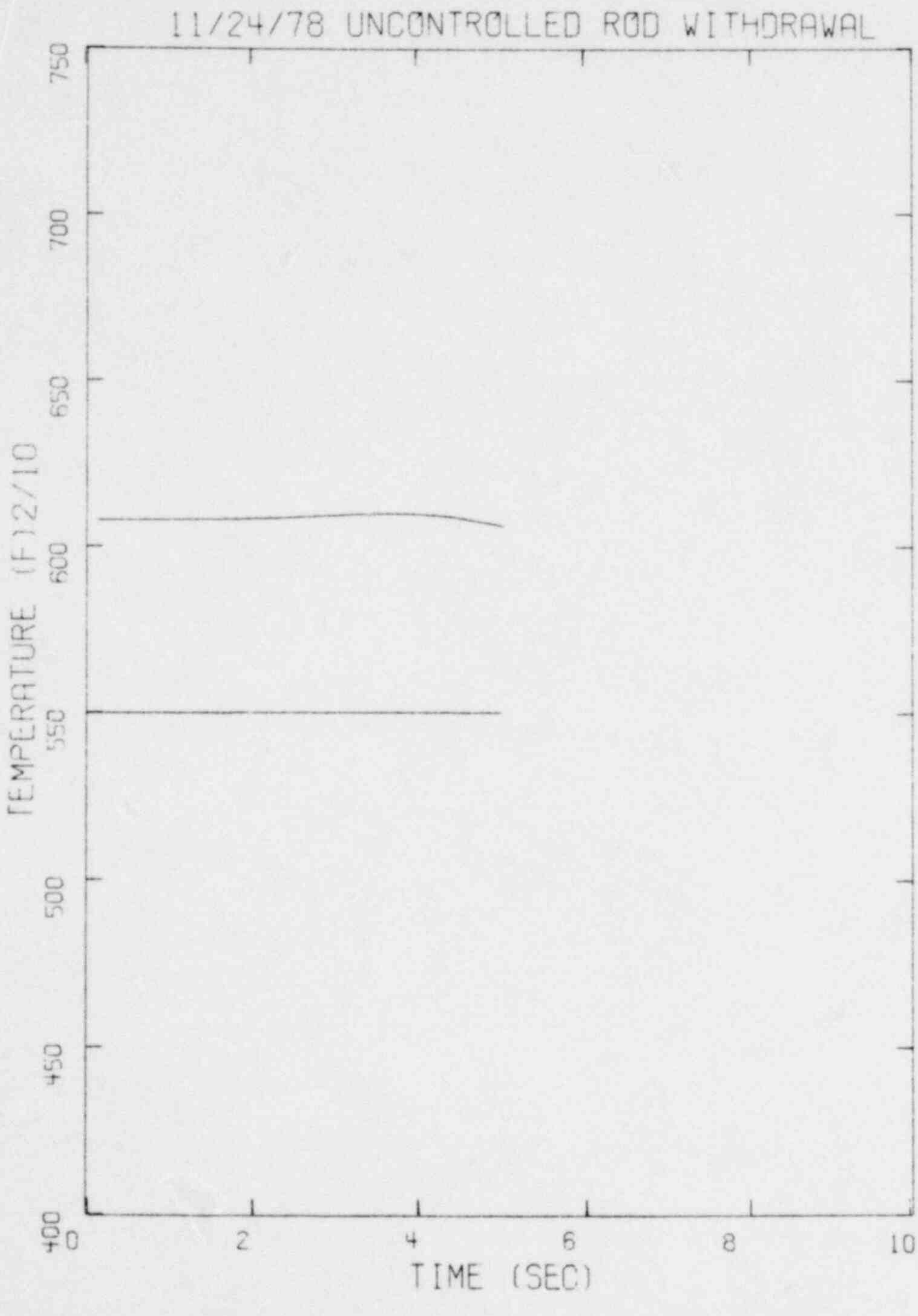


Figure XII.2-3 PLOTER UCRW, Example 3

1257 346

XIII. REFERENCES

XIII. REFERENCES

I-1 Divison of Technical Review, Nuclear Regulatory Commission, "WREM: Water Reactor Evaluation Model", NUREG-75/056, Revision 1, May 1975.

III.1-1 Control Data Corporation, "Scope Reference Manual - 6000 Version 3.4", Revision H, October 5, 1974.

III.1-2 Control Data Corporation, "NOS/BE 1 Reference Manual, CYBER 170 Series and CYBER 70 Series Models 71, 72, 73, and 74, and 6000 Series Computer Systems, 1977.

III.1-3 IBM Corporation, "IBM System/360 Operating System: Job Control Language Reference", GC28-6704-4, August 1976.

III.1-4 IBM Corporation, Systems OS/VS JCL Reference", GC28-0618-2, May 1973.

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IV.6-1 K. V. Moore and W. H. Rettig, "RELAP4 - A Computer Program for Transient Thermal Hydraulic Analysis", ANCR-1127, Revised August 16, 1975.

IV.29-1 R. T. Allemann et al., "Experimental High Enthalpy Water Blowdown from a Simple Vessel Through a Bottom Outlet", BNWL-1411, June 1970.

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1757 348

IX.3-1 R. W. Lyczkowski et al., "The Development of RELAP/SLIP for the Semiscale Blowdown Heat Transfer Test S-02-6 (NRC Standard Problem 6)," EPRI NP-343 Interim Report, December 1976.

IX.3-2 N. Fujita et al,. "A Prediction of the Semiscale Blowdown Heat Transfer Test S-02-8 (NRC Standard Problem Five)," EPRI NP-212 Key Phase Report, October 1976.

IX.4-1 K. V. Moore et al., "Analysis of GE BWR Blowdown Heat Transfer Program, Test 4906 (AEC Standard Problem Four)," EPRI 280R Key Phase Report, November 1975.

IX.4-2 N. S. Burrell et al., "A RELAP4 Analysis of the GE BWR Blowdown Heat Transfer Two-Loop Test Apparatus Experiements, Tests 4902, 4903, 4904 and 4906," EPRI NP-169 Final Report November 1976.

IX.5-1 N. S. Burrell, et al., "RETRAN Sensitivity Studies of Light Water Reactor Transients", EPRI NP-454 Final Report, June 1977.

POOR ORIGINAL

757 550

APP. A. DEF. OF VARIABLES
APPEARING ON RETRAN
MAJOR EDITS

APPENDIX A

DEFINITION OF VARIABLES APPEARING ON RETRAN MAJOR EDITS

Appendix A contains definitions of all variables that may appear on a RETRAN major edit. The definitions are divided into specific groups describing particular features or options in RETRAN.

1.0 OVERALL SYSTEM VARIABLES

Standard Time Step Number

An integer multiple of the maximum time step size DELTM (see Section IV.8.0). Defined as the problem time divided by DETLM.

Actual Time Step Number

Total number of time steps actually taken.

Normalized Core Power

The normalized core power is the core power at time t, normalized to the initial power.

Core Power

The core power in megawatts. The core power is the power produced in the core sections at time t and is the product of the normalized power and the user specified initial power (PØWRI).

Thermal Power

The sum of all heat sources or sinks in the system including the core, pumps, and non-conducting heat exchangers.

Heat Removal Rate

Heat removed from the system due to heat sinks or non-conducting heat exchangers.

Energy Balance

The system energy balance is the sum of fluid internal energy in all control volumes, stored energy in all heat conductors and heat removal rate due to heat sinks or non-conducting heat exchangers minus the energy added in all core sections and fill junctions.

Water Mass Balance

The system water mass balance is the sum of the water mass in all control volumes.

Air Mass Balance

The air mass balance is the sum of the air mass in all control volumes.

1357 552

2.0 VOLUME VARIABLES

RETRAN "volumes" are the fluid control volumes from which solutions to the continuity and energy equations are obtained. The momentum equation is solved about RETRAN junctions. Thus, the volume parameters represent the average thermodynamic state within a control volume. Refer to Figure (A.2-1) for the RETRAN volume/junction orientation.

Volume Average Pressure

The volume average pressure is the pressure corresponding to the average thermodynamic state within at the control volume.

Total Mass

The total mass is the sum of the liquid mass and the vapor mass.

Average Enthalpy

The volume average enthalpy is the enthalpy corresponding to the average thermodynamic state within control volume center.

Average Density

The average fluid density in a RETRAN volume is the total mass divided by the volume displacement.

Average Temperature

The average temperature is the average fluid temperature within a RETRAN control volume.

Average Quality

The average quality is the static quality corresponding to the average thermodynamic state within the control volume. The quality x is determined from

1757 353

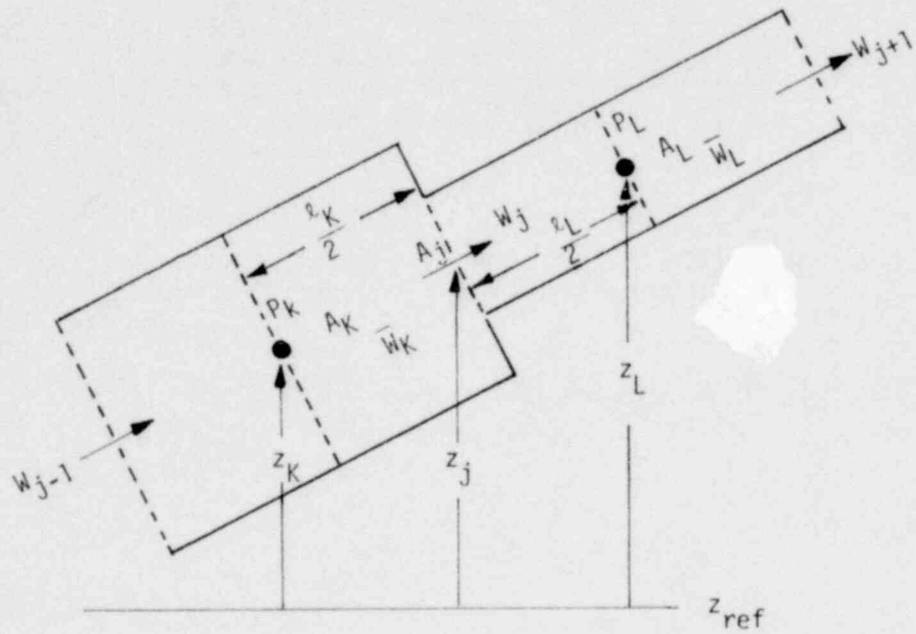

Figure A.2-1. Typical Computational Mesh for Two Junctions on a Volume

1757 054

$$x = \frac{v - v_\ell}{v_g - v_\ell}$$

where: v = average specific volume

v_ℓ = saturated liquid specific volume

v_g = saturated vapor spec ic volume

Bubble Mass

The mass of saturated vapor below the fluid mixture level in a RETRAN volume is defined as the bubble mass. In a normal, two-phase volume (i.e. a non-separated volume), the fluid mixture level is equal to the volume height. Thus, the bubble mass and the vapor mass are the same. If the volume is a separated volume, the mixture level may not be equal to the volume height. In this case the bubble mass is not equal to the vapor mass. According to the definition, if the control volume is single phase, the bubble mass is zero. The liquid case is obvious. If the control volume is single phase vapor, the mixture level is zero and therefore the bubble mass is zero, even though the vapor mass is not.

Mixture Level

In a normal volume, the mixture level is equal to the volume height. The fluid is a homogeneous mixture that occupies the total control volume.

If the volume is a separated volume (the bubble rise model is used), the volume is divided into a region of single phase vapor above a region of single-phase or two-phase fluid. The mixture level is the elevation of the vapor-fluid boundary measured from the bottom of the control volume.

Liquid Mass

The liquid mass is the mass of saturated or subcooled liquid mass in a RETRAN control volume.

3.0 JUNCTION VARIABLES

The momentum equation in RETRAN is written about junctions. A junction is a flow path between or into RETRAN volumes. The finite difference form of the momentum equation in RETRAN is (Section VIII.1.1.1 of the RETRAN theory manual for a development of the momentum equation):

$$I_j \frac{dW_j^{n+1}}{dt} = \left[\frac{\bar{W}_k^2}{\bar{\rho}_K A_K^2} - \frac{\bar{W}_L^2}{\bar{\rho}_L A_L^2}\right]^n + \mathfrak{J}_j^n (W_j^2)^{n+1} + (p_K - p_L)^{n+1}$$

$$- \left\{\frac{K_j S_{gn}(W_j)}{2\rho_j [A_j(t)]^2}\right\}^n (W_j^2)^{n+1} - \left[\frac{f_K \ell_K \bar{W}_K |\bar{W}_K|}{D_{hy_K} \bar{\rho}_K A_K^2} \phi_{tp_K}^2 + \frac{f_L \ell_L \bar{W}_L |\bar{W}_L|}{D_{hy_L} \bar{\rho}_L A_L^2} \phi_{tpL}^2\right]^n$$

$$- \left[\int_K^j \rho dz + \int_j^L \rho dz\right] g + \Delta P_p \qquad \text{(A.3-1)}$$

A_j (t) = flow area of junction j (possible time dependent), ft^2

D_{hy_i} = hydraulic diameter of flow area A_i, ft

f = Fanning friction factor, dimensionless

g = gravitational constant = 32.174 ft/s^2

I_j = geometric "inertia" for junction j

$$= \frac{\ell_K}{2A_K} + \frac{\ell_L}{2A_L}, \ ft^{-1}$$

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K_j = junction friction coefficient, dimensionless

ℓ_i = length of volume i, ft

n = iterate or time step index

p_i = thermodynamic pressure at volume V_i center, psi

$S_{gn}(W_j)$ = sign of W_j, ±1

$\bar{W}_i$ = average mass flow for volume i, lb/s

W_j = junction mass flow for junction j, (lb/s)

$\bar{\rho}_i$ = fluid density in volume i, lb/ft^3

ρ_j = fluid density at junction j, lb/ft^3

ϕ_{tpi} = two phase flow friction multiplier, dimensionless

Junction Flow

Junction flow, W_j, is the fluid mass flow rate at junction j in lbm/sec.

Junction Enthalpy

The junction enthalpy, h_j, is the thermodynamic enthalpy at junction j in Btu/lbm. The enthalpy is based on a "donor concept", in which the junction enthalpy is obtained from the upstream volume, modified to reflect any changes in fluid energy between the volume center and the junction.

Junction Specific Volume

The junction specific volume is the specific volume of the fluid moving through junction j corresponding to fluid with enthalpy h_j and a junction pressure p_j. The junction pressure is estimated from the upstream volume pressure ("donor" volume). The donor volume pressure is modified to reflect any Fanning losses and elevation differences between the volume center and the junction.

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Stagnation psi

The junction stagnation psi is the difference of center of volume to center of volume momentum flux, the spatial acceleration due to compressibility and area changes (second and third terms in equation A.3-1 respectively) and the thermodynamic pressure difference between volumes (fourth term).

Elevation psi

The junction elevation psi is the pressure difference due to the gravity head change between the center of volumes on either side of the junction. The elevation psi is given by the seventh term in equation A.3-1.

Friction psi

The junction friction psi represents irreversible pressure losses due to area changes (the fifth term in Equation A.3-1) and Fanning friction (the sixth term). If the junction is choked, the friction psi may be very large due to modification of the loss term in the critical flow calculation.

Acceleration psi

The junction acceleration psi is the total rate of change of momentum. The acceleration psi is represented by the first term in equation A.3-1. Since acceleration psi is simply the left hand side of the momentum equation:

Accl. psi = Stag. psi + Elev. psi + Fric. psi + Pump psi

Pump psi

The pump psi is one-half of the head developed by the pump (the last term in equation A.3-1). The head produced by the pump is distributed equally to the inlet and outlet junction of the pump volume.

4.0 PUMP VARIABLES

Pump Speed

The pump speed refers to the pump impeller speed in rpm.

Normalized Pump Torque

The pump hydraulic torque at time t normalized to the rated hydraulic torque defines the normalized pump torque.

Normalized Frictional Torque

The normalized frictional torque is the time t frictional torque normalized to the time zero or initial value of frictional torque.

Normalized Motor Torque

The normalized motor torque is defined as the time t pump motor torque normalized to the rated motor torque.

Power To H_2O

The power to H_2O is the thermal power (Btu/hr) dissipated in the pump fluid volume by the pump impeller.

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5.0 HEAT CONDUCTOR VARIABLES

Heat Transfer Mode

The heat transfer mode determines the correlation used for calculating heat transfer coefficients. The RETRAN logic presently includes the following heat transfer regimes.

H. T. Mode	Description
1	Forced convection in subcooled liquid
2	Nucleate boiling
3	Forced convection vaporization
4	Flow transition boiling
5	Flow film boiling
6	Pool film boiling
7	Pool transition boiling
8	Forced convection in superheated vapor
9	Low pressure flow film boiling

Surface Heat Flux

The surface heat flux is the rate of heat transfer per unit area through a surface of a given conductor.

Critical Heat Flux

The critical heat flux is the heat flux at which the boiling crisis occurs. The boiling crisis is characterized by a sudden drop in the boiling heat transfer coefficient due to the change in heat transfer mechanisms.

Heat Transfer Coefficient

The heat transfer coefficient is defined as:

$$\frac{\text{Surface Heat Flux}}{\text{Surface Temperature - Fluid Temperature}} \text{ Per Unit Area}$$

Surface Temperature

The surface temperature is the temperature at the outer or right side of the heat conductor.

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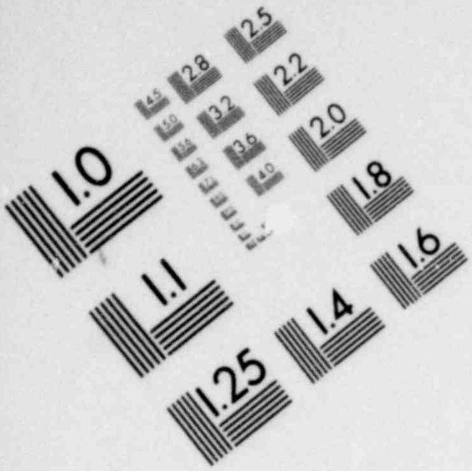

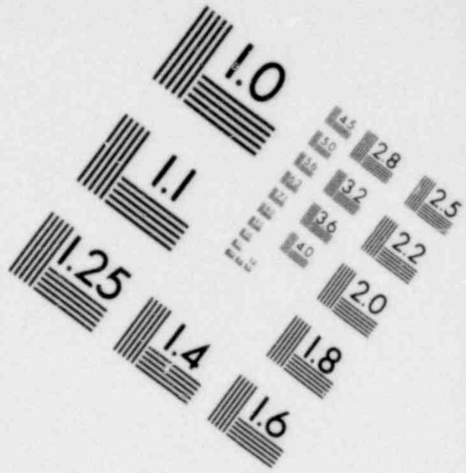

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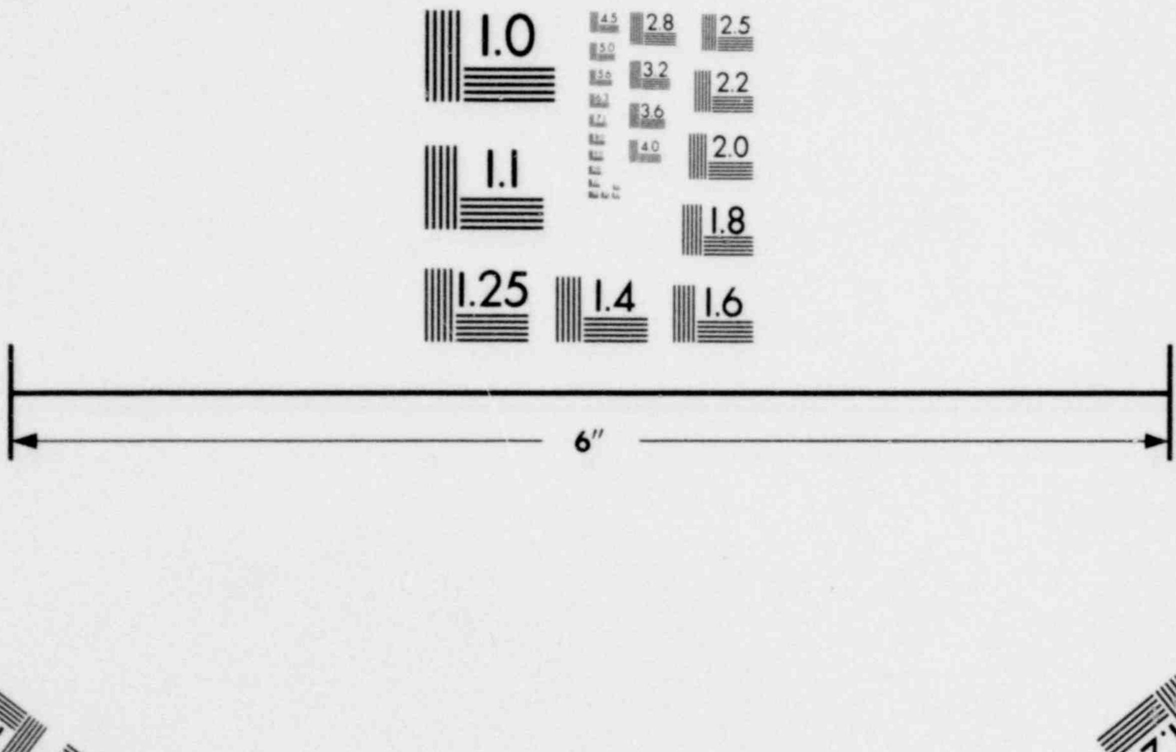

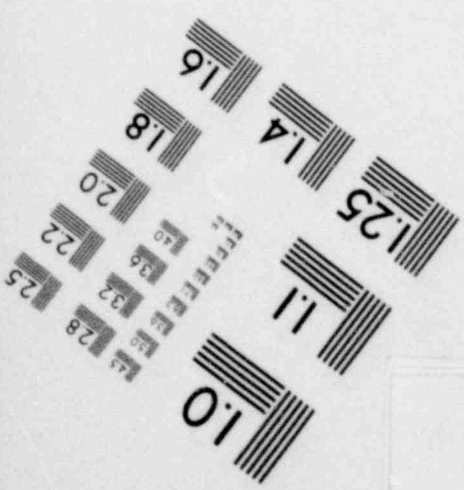

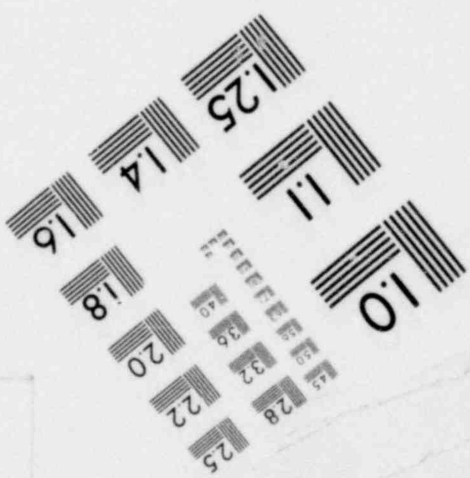

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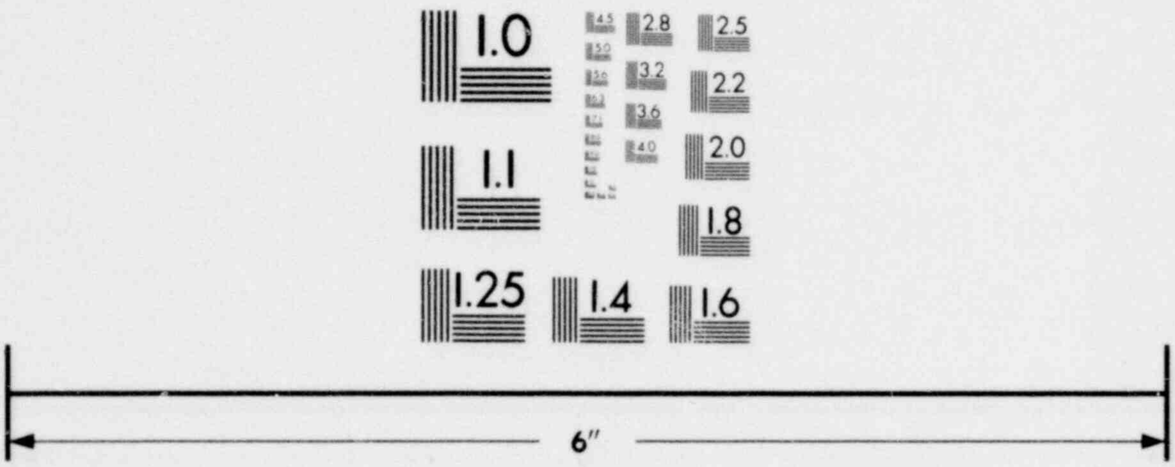

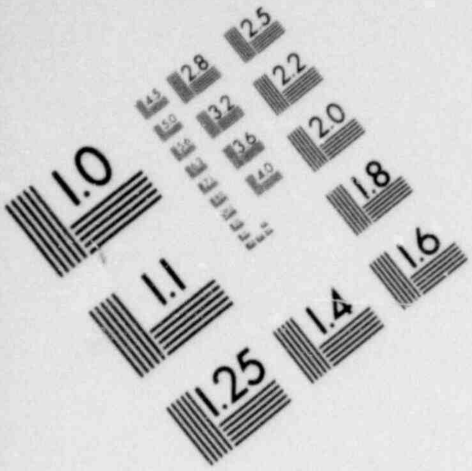

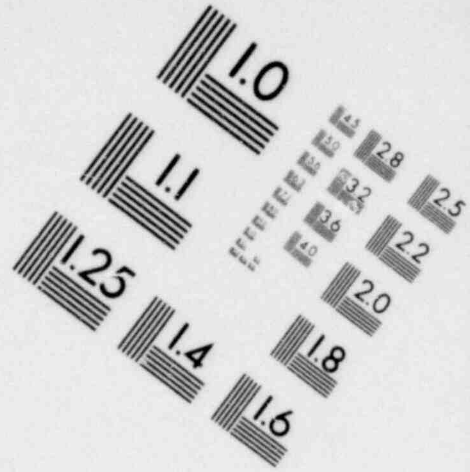

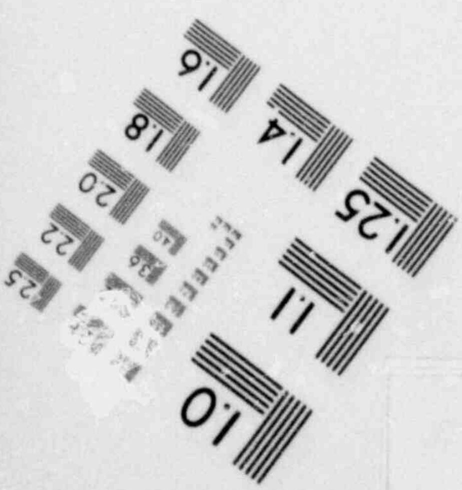

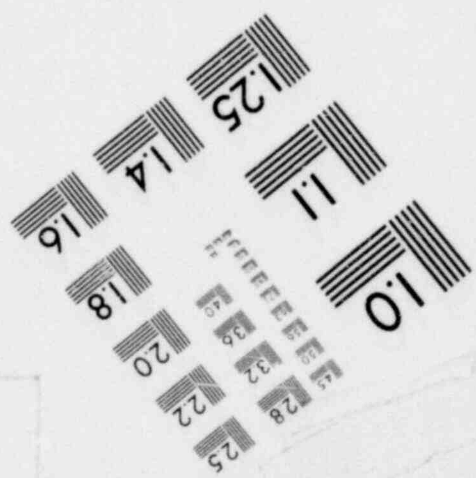

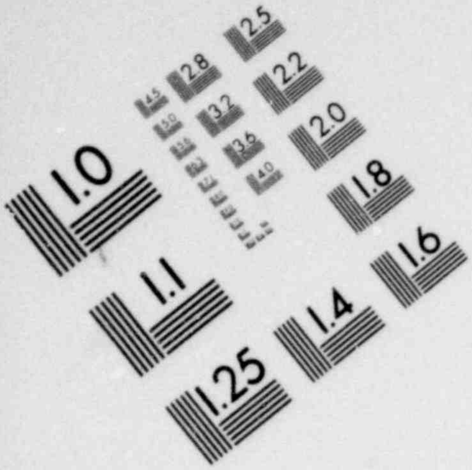

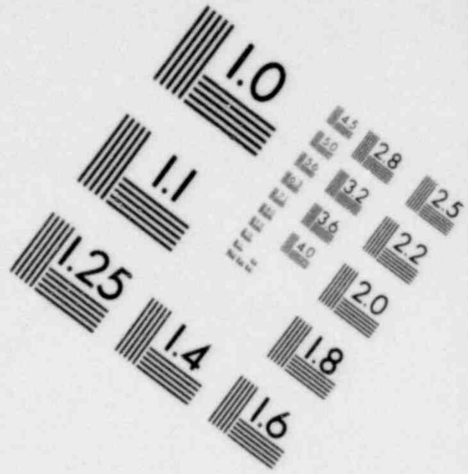

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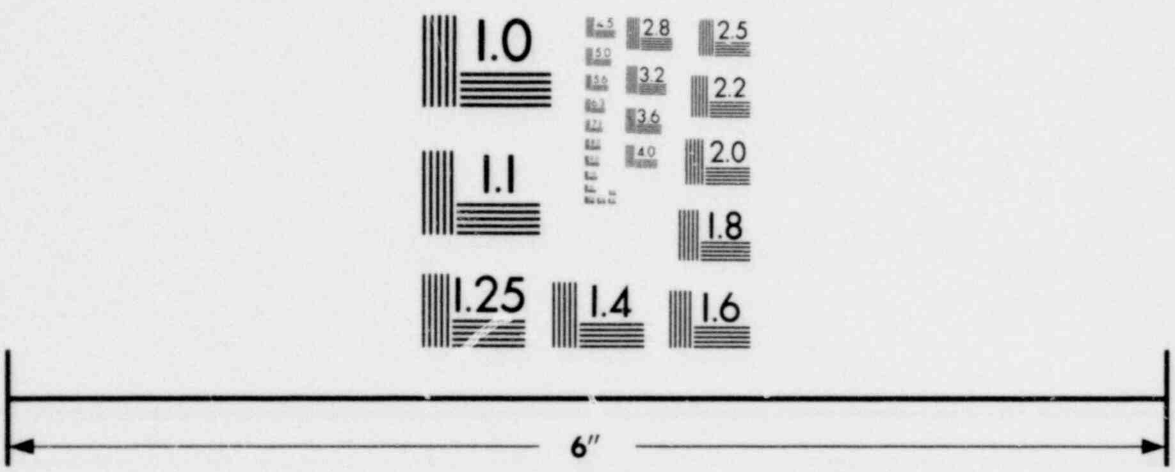

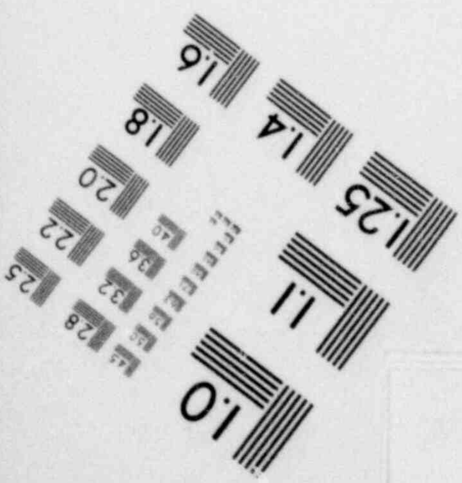

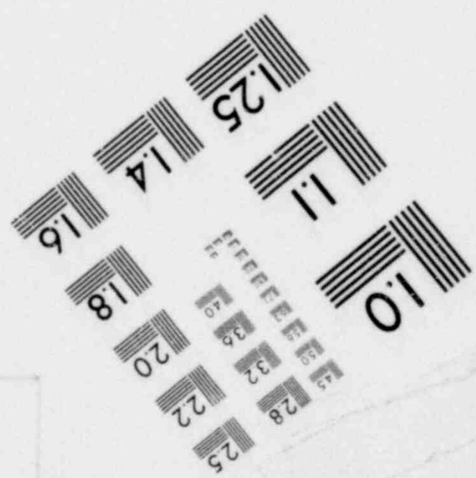

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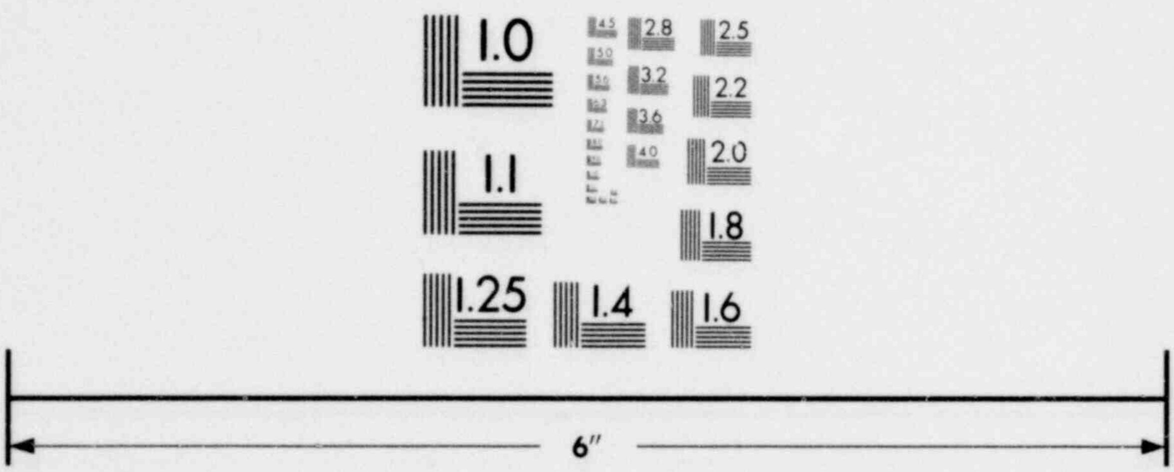

Mass Flux

The mass flux refers to the volume average mass flux of the fluid in the volume adjacent to the heat conductor.

Stored Energy

The stored energy is the energy in the conductor at time t, given by:

$$\text{Stored energy} = \sum_{i}^{N} (\rho_i Cp_i \Delta T_i) \Delta V_i \qquad \text{(BTU)}$$

Where the summation is over the number of conductor mesh points.

Power To H_2O

The power to H_2O is the energy transferred from the heat conductor to the adjacent fluid volume. The energy transferred is the product of the surface flux and the conductor surface area.

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6.0 CORE CONDUCTOR VARIABLES

Depth Of Reaction ($Zr-H_2O$)

The depth of reaction is the depth that the metal-water reaction has penetrated the cladding. The words Ext. and Int. are used to reflect the external depth and the internal depth.

Heat Generation ($Zr - H_2O$)

The heat generation is the rate of heat produced by the reaction between zirconium and steam.

Conductor Heating Rate

The conductor heating rate is the rate of heat generation internal to the conductor.

Direct Moderator Heating Rate

The direct moderator heating rate represents the energy directly deposited into the adjacent fluid volume.

Average Metal Temperature

The average metal temperature is the volume weighted average temperature of the left (or the conductor's inner surface) material region. The volume used to compute the average is only the inner region which is normally the fuel. The total conductor volume is not used.

Centerline Temperature

The centerline temperature is the temperature of a conductor's left surface.

7.0 POINT KINETICS VARIABLES

Reactor Period

The reactor period is the time constant of the exponential time behavior of the reactor power level. The period describes the amount of time required for the power level to increase (or decrease if negative) by a factor e.

Total Reactivity

The total reactivity is the sum of the feedback reactivity, the control reactivity and any initial reactivity bias.

Control Reactivity

The control reactivity is the reactivity obtained from the user specified Scram Table.

Coolant Temperature Reactivity

The coolant temperature reactivity is the change in reactivity due to a change in the adjacent bulk fluid temperature. The change is specified by a coefficient defined by the user.

Void Reactivity

The void reactivity is the change in reactivity due to a change in the adjacent volume bulk fluid density. A void reactivity table is specified by the user.

Fuel Temperature Reactivity

The fuel temperature reactivity is the change in reactivity due to a change in the fuel rod temperature. The change is specified by a coefficient defined by the user.

Doppler Reactivity

The Doppler reactivity is a change in reactivity due to a change in the fuel rod temperature. A Doppler reactivity table is specified by the user.

Prompt Power Fraction

The prompt power fraction is prompt power normalized to the total power generated in the core sections.

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Delayed Power Fraction

The delayed power fraction is the power produced by delayed neutrons normalized to the total power generated in the core sections.