FORM NC.DE-AP.ZZ-0002-1
CALCULATION COVER SHEET

Cover Sheet
Page 1 of

CALC. NO.: S-C-RC-MDC-1358 REVISION: 0

CALC. TITLE: LTOP EVENT WITH RH3 VALVE

SHTS.(CALC): 1 To 123 ATTACHMENTS: #/TOTAL SHTS.: 124,125 TOTAL SHTS.: ____

CHECK ONE:

☐ INTERIM (Proposed Plant Change) ☐ VOID

☒ FINAL (Supports Installed Condition)

CONTROLLED FOR REVIEW ONLY
NOT FOR CONSTRUCTION

DESCRIPTION OF CALCULATION REVISION (IF APPL.):

REASON FOR CALCULATION REVISION (IF APPL.):

HOPE CREEK ☐ Q ☐ Qs ☐ Qsh ☐ F ☐ R ☐ N/A

Q - LIST (SALEM) ? ☒ YES ☐ NO

IMPORTANT TO SAFETY ? ☒ YES ☐ NO

FUTURE CONFIRMATION REQUIRED ? ☐ YES ☒ NO

OTHER DOCUMENTS AFFECTED? (CBDs, FSAR, etc.): CALC. SGS/M-DM-CC62, SGS/M-DM-CC42

ORIGINATOR/COMPANY NAME: V. CHANDRA / PSE&G — 11 MAY 1994 (Date)

PEER REVIEWER/COMPANY NAME: R. PANDE / PSE&G — 6/8/94 (Date)

VERIFIER/COMPANY NAME: R. PANDE / PSE&G. — 6/8/94 (Date)

REVIEWED: N/A — Contractor Supervisor (as applicable) — Date

APPROVED: [signature] — PSE&G Supervisor (Req'd) — 6/13/94 (Date)

If the calculation is either Q-List, Q, Qs, Qsh, F, R, or Important to Safety "YES", completion of the Certification for Design Verification (Form NC.DE-AP.ZZ-0010-1) is required.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTD.)

1. INTRODUCTION:

LOW TEMPERATURE OVER PRESSURE EVENTS WERE ANALYZED IN PSE&G CALCULATIONS SGS/M-DM-062 AND SGS/M-DM-042. THESE CALCULATIONS WERE BASED ON WESTINGHOUSE METHODOLOGY DESCRIBED IN REFERENCES 1 AND 2.

WESTINGHOUSE INFORMED PSE&G THROUGH LETTER PSE-93-204 DATED MARCH 15, 1993 THAT WESTINGHOUSE DID NOT CONSIDER THE PRESSURE DIFFERENCE BETWEEN THE PRESSURE SENSED BY THE WIDE RANGE PRESSURE TRANSMITTER AND THE REACTOR BELT LINE PRESSURE. THE REACTOR BELT LINE PRESSURE WOULD BE HIGHER THAN THE PRESSURE SENSED BY THE WIDE RANGE PRESSURE TRANSMITTER BECAUSE OF THE HYDRO-STATIC EFFECT AND PRESSURE DIFFERENCE CAUSED BY RCP OPERATION.

IN THE WESTINGHOUSE METHODOLOGY DESCRIBED IN REFERENCES 1 AND 2 FOLLOWING INITIAL CONDITIONS AND SCENARIOS WERE CONSIDERED FOR HEAT AND MASS INPUT CASES:

MASS INPUT CASE

1. PRESSURIZER AND REACTOR COOLANT SYSTEM BOTH ARE AT APPROXIMATELY 70 TO 100 F
2. ONLY THE FIRST ACTUATION OF PORV WAS CONSIDERED.

"EF" INPUT CASES

1. PRESSURIZER AND THE REST OF REACTOR COOLANT SYSTEM ARE AT THE SAME TEMPERATURE. HOWEVER, THREE TEMPERATURES, NAMELY, 100F, 180F AND 250F WERE CONSIDERED.
2. AGAIN, ONLY THE FIRST ACTUATION OF PORV WAS CONSIDERED.

AFTER REVIEWING REFERENCES 1 AND 2, IT WAS CONCLUDED THAT OTHER SITUATION, WHICH MAY RESULT IN HIGHER REACTOR PRESSURE, ARE LIKELY. THESE SITUATIONS ARE

1. PRESSURIZER HAS A STEAM BUBBLE INITIALLY AND THE REST OF RCS IS PRESSURIZED TO JUST BELOW 375 psig AND ITS TEMPERATURE IS ABOUT 70F. UNDER THIS CONDITION THE PRESSURIZER FLUID WOULD BE SATURATED AND AT A SIGNIFICANTLY HIGHER TEMPERATURE. ONE OR MORE RCP'S COULD BE RUNNING. IF AT THIS TIME SI IS INITIATED THEN ULTIMATELY STEAM BUBBLE WILL DISAPPEAR AND PORV WILL DISCHARGE SATURATED LIQUID.

2. THE PEAK REACTOR PRESSURE WOULD BE HIGHER DURING A SUBSEQUENT ACTUATION BECAUSE OF (a), PRT WOULD BE AT A HIGHER PRESSURE AND (b) SI FLOW WOULD

ALREADY BE ESTABLISHED AT ITS MAXIMUM RATE. NOTE THAT THE SI FLOW BUILDS UP FROM ZERO VALUE BEFORE THE FIRST ACTUATION.

3. IN THE HEAT INPUT CASE ALSO, THE PRESSURE BEFORE THE SUBSEQUENT ACTUATIONS WOULD BE HIGHER THAN THE PEAK PRESSURE BEFORE THE FIRST PORV ACTUATION BECAUSE THE RCP WOULD BE RUNNING AT ITS MAXIMUM SPEED AT THE TIME OF SUBSEQUENT PEAKS. NOTE THAT THE RCP SPEED IS RISING DURING THE OCCURENCE OF FIRST PRESSURE PEAK.

THE ABOVE DESCRIBED SITUATIONS WHICH MAY RESULT IN HIGHER REACTOR PRESSURE THAN THE ONES CONSIDERED IN WESTINGHOUSE REPORTS DESCRIBED IN REFERENCES 1 AND 2. HAVE BEEN CONSIDERED IN THE PRESENT ANALYSIS.

HOWEVER, AS DESCRIBED IN SECTION 2, RH3 RELIEF VALVE IN ADDITION TO PORV IS AVAILABLE TO MITIGATE THE LTOP EVENTS.

2. SYSTEM DESCRIPTION

FIGURE 1. SHOWS THE REACTOR COOLANT SYSTEM, THE RELEVANT PARTS OF RHR SYSTEM, AND THE PRESSURIZER S/R V DISCHARGE PIPING TO PRT, DURING A LOW TEMPERATURE OVERPRESSURE (LTOP) EVENT AT LEAST ONE PUMP AND THE PH2 VALVE IS AVAILABLE TO RELIEVE PRESSURE.

RH3 RELIEF VALVE IS AVAILABLE BECAUSE AUTO-CLOSURE INTERLOCK FROM VALVES RH1 AND PH2 HAS BEEN REMOVED.

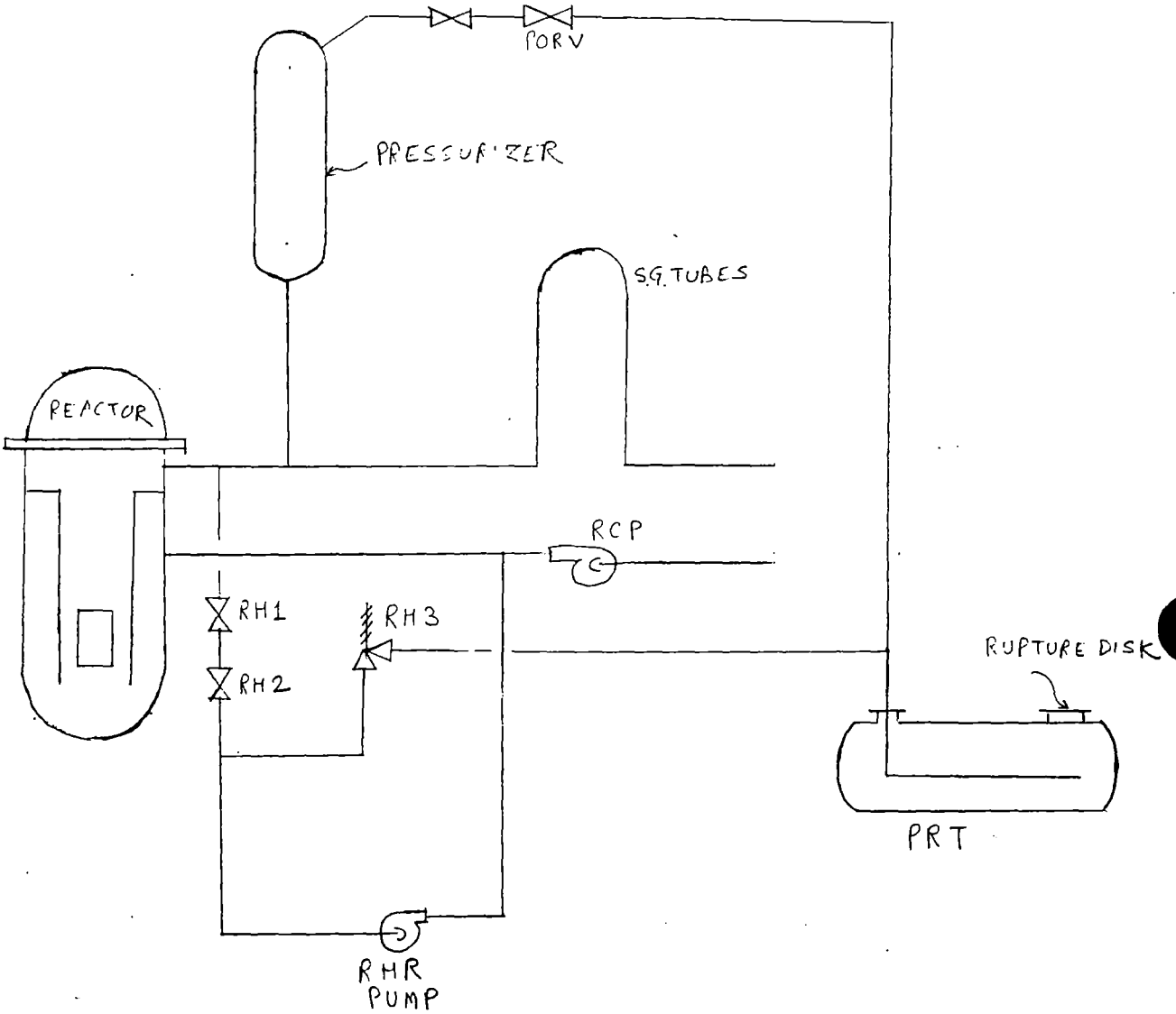


FIGURE 1. SCHEMATING ARRANGEMENT OF RCS, PRESSURIZER, AND RELIEF VALVES.

3. EVENT DESCRIPTION

LTOP EVENTS CAN BE CAUSED BY EITHER MASS INPUT OR HEAT INPUT TO A CLOSED REACTOR COOLANT SYSTEM. MASS INPUT CAN BE CAUSED BY LOSS OF LETDOWN OR INADVERTANT SAFETY INJECTION. HEAT INPUT OCCURS WHEN A RCP STARTS WHILE THE SECONDARY SIDE FLUID IN THE STEAM GENERATOR IS AT A HIGHER TEMPERATURE THAN THE PRIMARY SIDE. THE REVERSE HEAT TRANSFER CAUSES THE PRIMARY SIDE PRESSURE TO INCREASE.

TABLE 1 SUMMARIZES THE CASES THAT WERE CONSIDERED.

TABLE 3.1

DESCRIPTION OF VARIOUS MASS INPUT AND HEAT INPUT CASES

CASE ID	INITIAL CONDITIONS					ADVERTANT ACTION	SINGLE FAILURE
	REACTOR PRESSURE (PSIA)	REACTOR (TEMP.) (F)	PRESS.-URIZER TEMP (F)	PRESSU.-RIZER LIQUID VOL. FRACTION	SECONDARY SIDE TEMP (F)		
M1	380	70	SAT.	1	N A	S. I.	PORV
M2	380	70	70	1	N.A.	S. I.	PORV
M3	380	70	SAT	1	N.A.	S. I	RH
H1	380	150	SAT.	1	200	ONE RCP STARTS	PORV
H2	380	150	SAT.	1	200	ONE RCP STARTS	RH 3
H3	380	200	200	1	250	ONE RCP STARTS	PORV
H4	380	200	SAT.	1	250	ONE RCP STARTS	PORV
H5	380	200	SAT.	1	250	ONE RCP STARTS	RH 3

4.0 ANALYSIS

THE ANALYSIS WAS DONE USING Q.A. VERIFIED VERSION OF GOTHIC COMPUTER PROGRAM.

THE PRESSURIZER WAS MODELED AS ONE VOLUME AND THE REST OF THE RCS WAS MODELED AS ANOTHER VOLUME. THE INTERNAL PRESSURE GRADIENTS CAUSED BY RCP OPERATION AND GRAVITATIONAL EFFECTS WERE NOT MODELED IN THE GOTHIC. HOWEVER, THESE EFFECTS WERE CONSIDERED OUTSIDE OF GOTHIC. NO LOSS OF ACCURACY IN PEAK PRESSURE WOULD OCCUR BY THIS PROCEDURE.

THE DETAILS OF MODEL ARE SHOWN IN SECTIONS 4.3.1, 4.3.2, 4.3.3, 4.4.2.1.4, 4.4.2.1.5, 4.4.2.2.4, 4.4.2.2.5, AND 4.4.2.2.6.

SINGLE FAILURES OF EITHER ONE PORV OR RH3 WERE CONSIDERED SEPARATELY.

PSE&G

CALCULATION CONTINUATION SHEET

TITLE LTOP EVLIT WITH PWR VALVE

ID NO. S-C-RC-MDC-1[illegible]5

REFERENCE

SHEET 12 OF

ORIGINATOR [illegible]

DATE [illegible]

PEER REVIEW

DATE

FOLLOWING [illegible] WERE USED FOR ALL CASES.

PRT PRESSURE = 415 PSIA

(ONE PORV AND FHE) OR (TWO PORV'S) ARE AVAILABLE.

EITHER THERE IS NO STEAM BUBBLE IN THE PRESSURIZER OR THE STEAM BUBBLE DISAPPEARED BECAUSE OBTAINED SI OPERATION AND PREVIOUS PORV ACTUATION.

FOR MASS INPUT CASE THE NET LIQUID INJECTION RATE (SI) = 108.4 lbm/s [PAGE 9 OF REF. 2]

FOR HEAT INPUT CASES THE SECONDARY SIDE TO PRIMARY SIDE TEMPERATURE DIFFERENCE IS 50 F. [Ref. 2]

PRESSURIZER VOLUME = 1800 ft^3 [CBD DE CB. RC 0042 PAGE T8-19]

TOTAL RCS VOLUME INCLUDING THE PRESSURIZER = 12612 ft^3

[CBD DE-CB. RC-0042 PAGE T7-1]

TO MODEL THE SUBSEQUENT ACTUATIONS OF RELIEF VALVES, FOLLOWING ASSUMPTIONS WERE MADE.

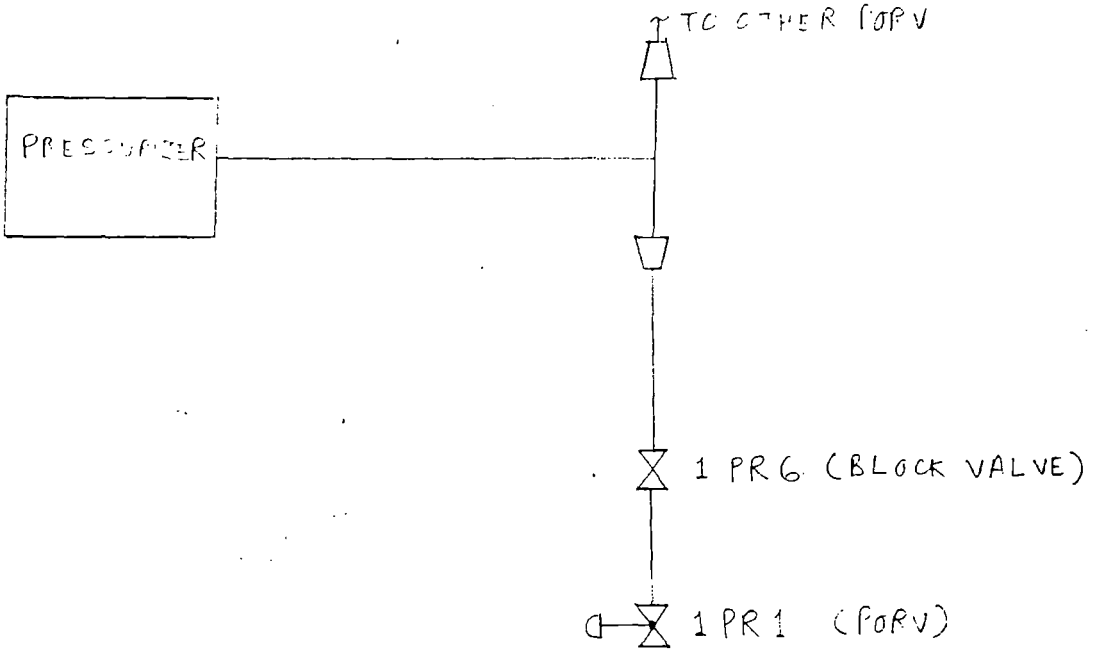
MASS INPUT RATE IS ESTABLISHED INSTANTANEOUSLY.

RCS FLOW RATE IS ESTABLISHED INSTANTANEOUSLY.

PSEG	TITLE LTOPEVENT WITH PRZ VALVE	ID NO. S-C-RC-MSC-1358	SHEET 1 OF
CALCULATION CONTINUATION SHEET		REFERENCE	
	ORIGINATOR [illegible] 0 DATE [illegible] PEER REVIEW DATE		

4.1 PORV AND UPSTREAM PIPING

THE PIPING BETWEEN PRESSURIZER AND THE PORV IS SHOWN BELOW SCHEMATICALLY.



FOLLOWING ARE THE DETAILS OF PIPING.

ITEM	REF AREA (ft^2)	K	$\frac{K}{A^2}$ (ft^{-4})
7 ft 3.5" ID PIPE	0.0668	0.45	
ONE 45° EL	0.0668	0.2	
TWO 90° EL	0.0668	0.5	
ONE TEE RUN	0.0668	0.08	
ONE TEE BR	0.0668	0.62	
	SUBTOTAL	1.85	414.6
15 ft 2.624" ID PIPE	0.03755	1.37	
ONE RED.	0.03755	0.27	
FIVE 90° EL	0.03755	2.15	
ONE GATE VALVE	0.03755	0.16	
	SUBTOTAL	3.95	2801.4

TOTAL $\frac{K}{A^2} = 3216\ ft^{-4}$ FOR PORV UPSTREAM PIPING

FROM WYLIE PHASE 3 DATA FOR COPES VULCAN (316 W/STELLITE PLUG AND 17-4 PH CAGE) EPRI REPORT NP-2628-SR p. 4-63,

PORV FLOW RATE = 388,800 lbm/hr = 108 $\frac{lbm}{sec.}$

UPSTREAM PRESSURE = 638 psia

UPSTREAM TEMPERATURE = 444 F } ENTHALPY = 424 $\frac{BTU}{lbm}$

FLUID = WATER

HENRY-FAUSKE CRITICAL MASS FLUX FOR $p = 638$ psia AND $i = 424\ \frac{BTU}{lbm}$ IS $11200\ \frac{lbm}{ft^2\ sec.}$

$\therefore$ VALVE EFFECTIVE AREA = $\frac{108}{11200}\ ft^2 = 0.0096\ ft^2$

COMBINING THE RESISTANCE OF UPSTREAM PIPING AND THE VALVE THE COMBINED $\frac{K}{A^2} = 3216 + \frac{1}{0.0096^2}\ ft^{-4}$

$= 14067\ ft^{-4}$

$\therefore$ COMBINED EFFECTIVE AREA = $\frac{1}{\sqrt{14067}} = 0.00843\ ft^2$

ACCORDING TO TECH. SPEC.* THE MAXIMUM STROKE TIME OF PORV = 2 SEC. IT IS BEING ASSUMED THAT 0.5 SECOND OF THIS 2 SEC. IS USED UP IN ELECTRONIC SIGNAL PROCESSING AND PRESSURIZATION OF THE DIAPHRAGM. IN OTHER WORDS, THE VALVE STROKE TIME OF 1.5 SEC. WITH A DELAY OF 0.5 SECOND WILL BE USED.#

* REF. 4, 5; # BASED ON P 2-7 OF REF. [1]

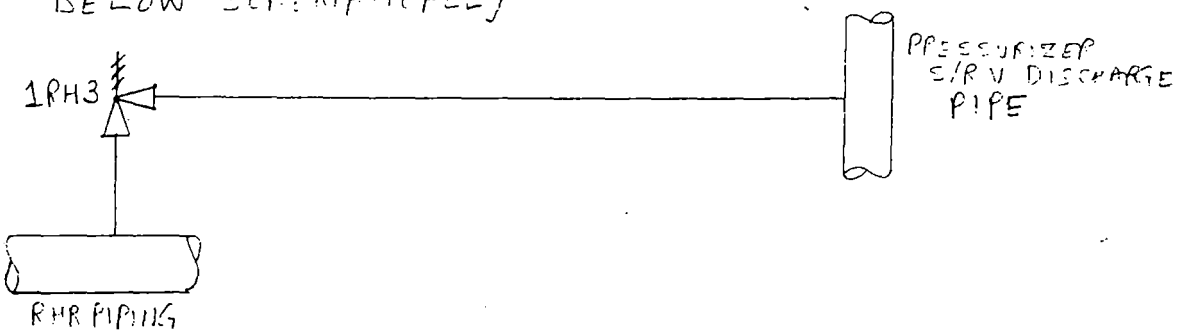
THE FOLLOWING LOSS FACTOR VERSUS STEM TRAVEL CURVE HAVE BEEN PREPARED FOR USE. IT IS BEING ASSUMED THAT VALVE EFFECTIVE AREA INCREASES FROM 0 TO 0.00843 ft^2 LINEARLY. THE REFERENCE AREA FOR THE LOSS FACTOR IS 0.00843 ft^2.

STEM POSITION / FULL OPEN STEM POSITION	OPEN AREA / FULL OPEN AREA	LOSS FACTOR $= \left(\frac{\text{FULL OPEN AREA}}{\text{OPEN AREA}}\right)^2$
0.	0.	1.E10
0.01	0.01	10,000
0.0667	$\frac{1}{15}$	225
0.133	$\frac{2}{15}$	56
0.2	$\frac{3}{15}$	25
0.2667	$\frac{4}{15}$	14
0.337	$\frac{5}{15}$	9
0.4	$\frac{6}{15}$	6.25
0.466	$\frac{7}{15}$	4.59
0.533	$\frac{8}{15}$	3.52
0.6	$\frac{9}{15}$	2.78
0.6667	$\frac{10}{15}$	2.25
0.733	$\frac{11}{15}$	1.86
0.8	$\frac{12}{15}$	1.56
0.867	$\frac{13}{15}$	1.33
0.933	$\frac{14}{15}$	1.15
1.0	1	1.

VALVE FULL OPEN AREA OF 0.00843 ft^2 WITH A CORRESPONDING LOSS FACTOR OF 1 WILL BE USED. WHERE 2 PORVS ARE AVAILABLE, 0.01686 ft^2 AREA WAS USED.

4.2 RH3 PRESSURE RELIEF VALVE AND ASSOCIATED PIPING

THE PIPING BETWEEN THE RHR PIPE AND PRESSURIZER S/RV DISCHARGE PIPING WHICH HAS 1PH3 VALVE IS SHOWN BELOW SCHEMATICALLY



FOLLOWING ARE THE DETAILS OF PIPING

ITEM	REF AREA (ft^2)	K	$\frac{k}{A^2}$ ft^{-4}
ONE T- BRANCH	0.0513	0.66	
0.5 ft 3.068" I D PIPE	0.0513	0.04	
		SUBTOTAL = 0.7	266
166 ft 4.26" I D PIPE	0.099	8.2	
SEVEN 90° ELBOWS	0.099	1.8	
1 T RUN	0.099	0.08	
1 T BRANCH	0.099	0.62	
1 EXIT	0.099	1.0	
		SUBTOTAL = 11.7	1194
		TOTAL	1460 ft^{-4}

PSE&G

CALCULATION CONTINUATION SHEET

TITLE	ID NO.	SHEET
LOOP EVENT WITH RH2 VALVE	S-C-RC-MDC-[illegible]355	17 OF
	REFERENCE	

ORIGINATOR	V. CHUNDER	0		
DATE	11 MAY 1994			
PEER REVIEW				
DATE				

FROM WESTINGHOUSE LETTER DATED PSE-90-540
ATTACHMENT 1 PAGE 4 OF 7 AND VALVE SPEC. NO. 676257
THE RH2 VALVE PASSES 900 GPM AT UPSTREAM PRESSURE OF
450 psig + 10% AND UPSTREAM TEMPERATURE OF 400F.
THE ORIGINAL SET POINT OF THE VALVE WAS 450 psig.
IT WAS LATER REDUCED TO 375 psig*.
VALVE NOW REACHES FULL LIFT AT 375 psig + 10%.

900 GPM AT 509.7 psia [450 + 45 + 14.7 psia] AND 400F

$$= \frac{900}{7.48} * 60 * \frac{1}{0.01861} \frac{\text{GPM}}{\text{FT}^3} \frac{\text{FT}^3}{\text{GAL}} \frac{\text{MIN}}{\text{HR}} \frac{\text{lbm}}{\text{FT}^3}$$

$$= 388{,}000 \frac{\text{lbm}}{\text{hr}}$$

$$= 107.8 \frac{\text{lbm}}{\text{sec}}$$

AT UPSTREAM PRESSURE 509.7 psia
AND ENTHALPY 375.4 $\frac{\text{BTU}}{\text{lbm}}$

FROM H-F CRITICAL FLOW TABLES

p (psia)	h (BTU/lbm)	G (lbm/ft²s)
400	375.4	9199
600	363.6	13996
600	389.8	12730
FROM INTERPOLATION		
600	375.4	13425
510	375.4	11523

* BASED ON THE REVISED SPEC., THE VALVE PASSES 840 GPM OF 400F LIQUID WATER AT 375 psig + 10% PRESSURE. THIS CORRESPONDS TO A VALVE EFFECTIVE AREA OF 0.010 ft². 0.00936 ft² EFFECTIVE AREA AS CALCULATED ON THE NEXT PAGE WAS USED FOR CONSERVATISM. [Ref. 7]

EFFECTIVE AREA OF RH3 VALVE = $\frac{107.8}{11523} \frac{lbm}{s} \frac{ft^2 s}{lbm}$

$= 0.00936\ ft^2$

COMBINING THE RESISTANCE OF PIPING AND THE VALVE

$\left(\frac{K}{A^2}\right)_{COMBINED} = 1460 + \frac{1}{0.00936^2} = 12874\ ft^{-4}$

COMBINED EFFECTIVE AREA OF RH3 AND ITS UPSTREAM AND DOWNSTREAM PIPING = $\frac{1}{\sqrt{12874}}\ ft^2 = 0.0088\ ft^2$

VALVE FULL OPEN AREA OF $0.0088\ ft^2$ WITH A FULL OPEN POSITION LOSS FACTOR OF 1 WILL BE USED.

THE VALVE ATTAINS A FULL LIFT WHEN UPSTREAM PRESSURE REACHES 375 psig + 10% = 412.5 psig = 427.2 psia.

SINCE THE RH3 STEM POSITION IS DEPENDENT ON UPSTREAM PRESSURE, THE STEM POSITION CURVE WILL BE ADJUSTED DEPENDING ON THE CALCULATED UPSTREAM PRESSURE. THIS ADJUSTMENT WILL BE DONE ITERATIVELY. THE VALVE TRAVEL VS. LOSS FACTOR CURVE IS SAME AS FOR THE PORV (SEE SECTION 3.1)

4.3 MASS INPUT PRESSURIZATION

THE NET INJECTION MASS FLOW RATE = 108.2 lbm/s

INJECTION FLUID IS LIQUID AT 70F.

THE FOLLOWING THREE CASES WERE CONSIDERED.

M1. REACTOR IS AT 70 F AND PRESSURIZER IS WATER SOLID AND AT SATURATION TEMP CORRESPONDING TO 364 psia. SINGLE FAILURE IS ONE PORV

M2. REACTOR AND PRESSURIZER BOTH ARE AT 70F. PRESSURIZER IS WATER SOLID. SINGLE FAILURE IS ONE PORV

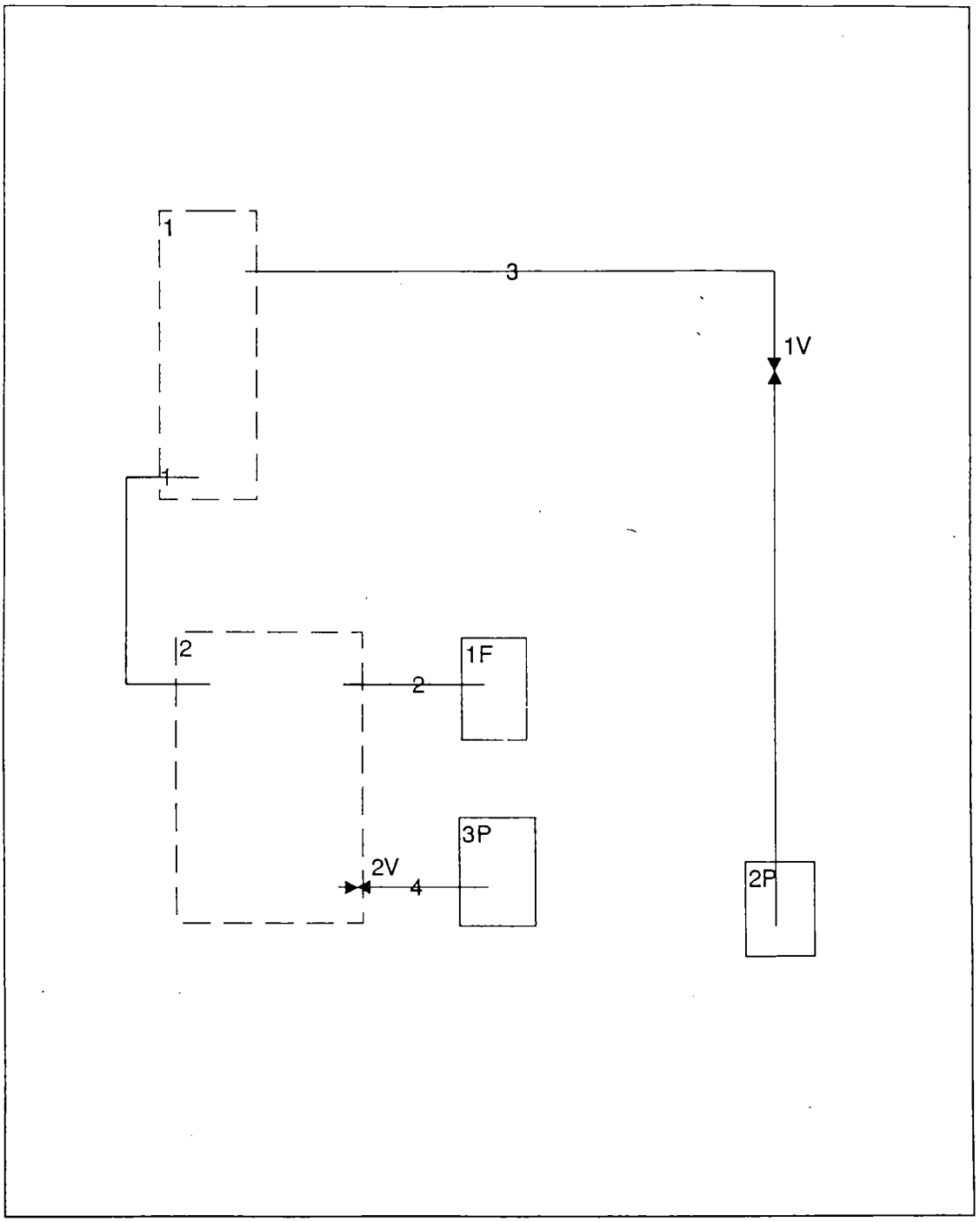
M3. REACTOR IS AT 70F AND PRESSURIZER IS WATER SOLID WITH SATURATED LIQUID. SINGLE FAILURE IS THE RHS RELIEF VALVE.

GOTHIC INPUT AND OUTPUT FOR THESE CASES FOLLOW.

4.3.1 GOTHIC INPUT AND OUTPUT, CASE M1*

massin 440
09:54:11 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-13=8



* SEE TABLE 3.1

S-C-RC-MDC-1355

2

CASE M1

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1F	SI INJEC. FLOW	400.		70		108.4			
2P	PORV TO PRT	115.		80					
3P	RH3 TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1F	1.		1.								
2P	1.		0.005								
3P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1F	1.							
2P	1.							
3P	1.							

S-C-RC-MDC-1355

CASE M1

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1F 2P 3P								

S-C-FC-MDC-135.

CASE M1

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	SI LINE	2	97.	0.2	1F	97.	0.2
3	RELIEF LINE	1	155.	0.5	2P	87.	0.22
4	RH3 TO PRT	2	97.	0.2	3P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.1	0.2	10.	10.	NO		-
3	0.00843	0.22	13.	0.1	YES		-
4	0.0088	0.3	20.	0.1	NO		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	OFF
3	1.	1.	ON
4	0.01	0.01	OFF

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	3	1	0	1	2P
2V	RH3 VALVE	4	2		2	3P

S-C-RC-MDC-1358

CASE M1 2

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	3	2	0.0088

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	UNDE		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	RH3 STEM TRAVEL	TIME (SEC)	RH3 STEM T	3

Function 1 PORV STEM TRAVEL Ind. Var.: Time (sec) Dep. Var.: Norm. Stem Position			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

massin440
09:52:06 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE M1

Function 2 PORV LOSS FACTOR Ind. Var.: Norm. Stem Position Dep. Var.: Loss Factor			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5233	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

Function 3 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: RH3 STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.2	0.586
100.	0.586		

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	70.	100.	1.	0.	0.

S-C-RC-MDC-1358

CASE M1

26

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

massin440
09:52:07 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE M1

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	2.3	500.	0.01	6000.	0.

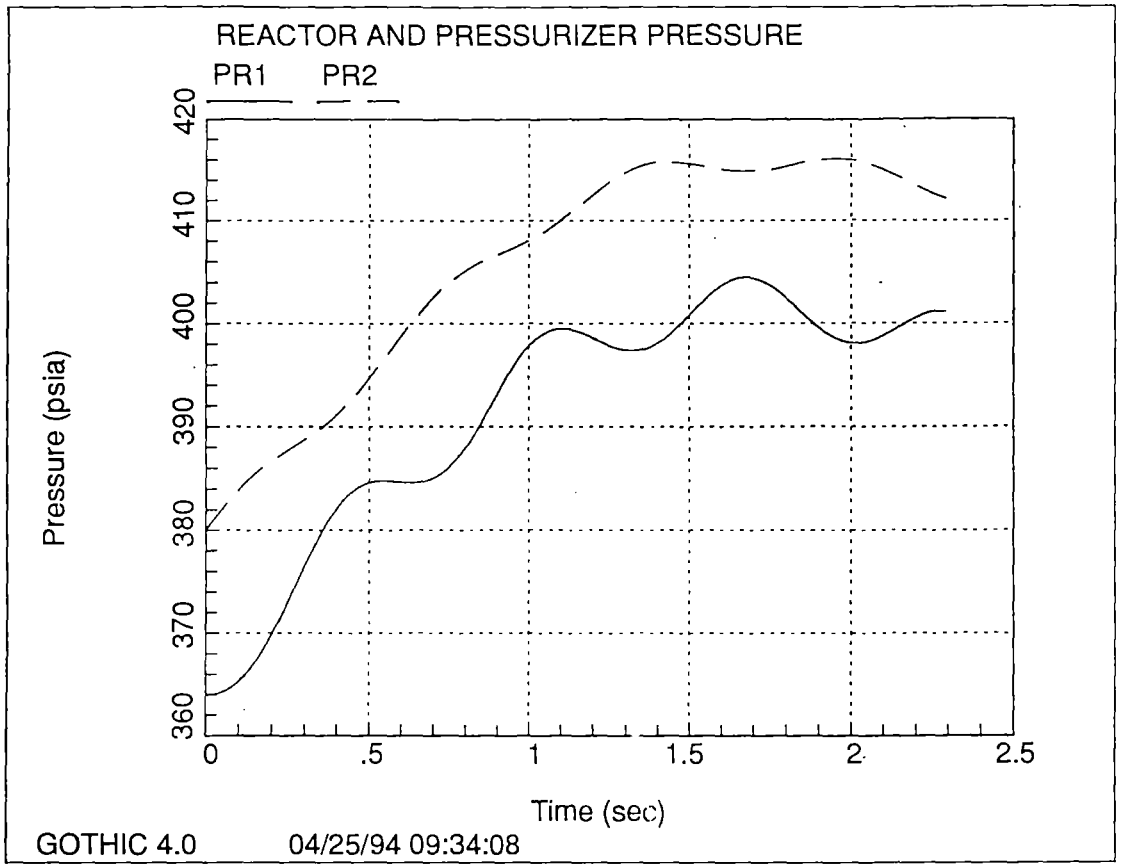
Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV AND RH3 ST		VT1V	VT2V			
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL3	FL4			

massim 44D
09:54:26 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

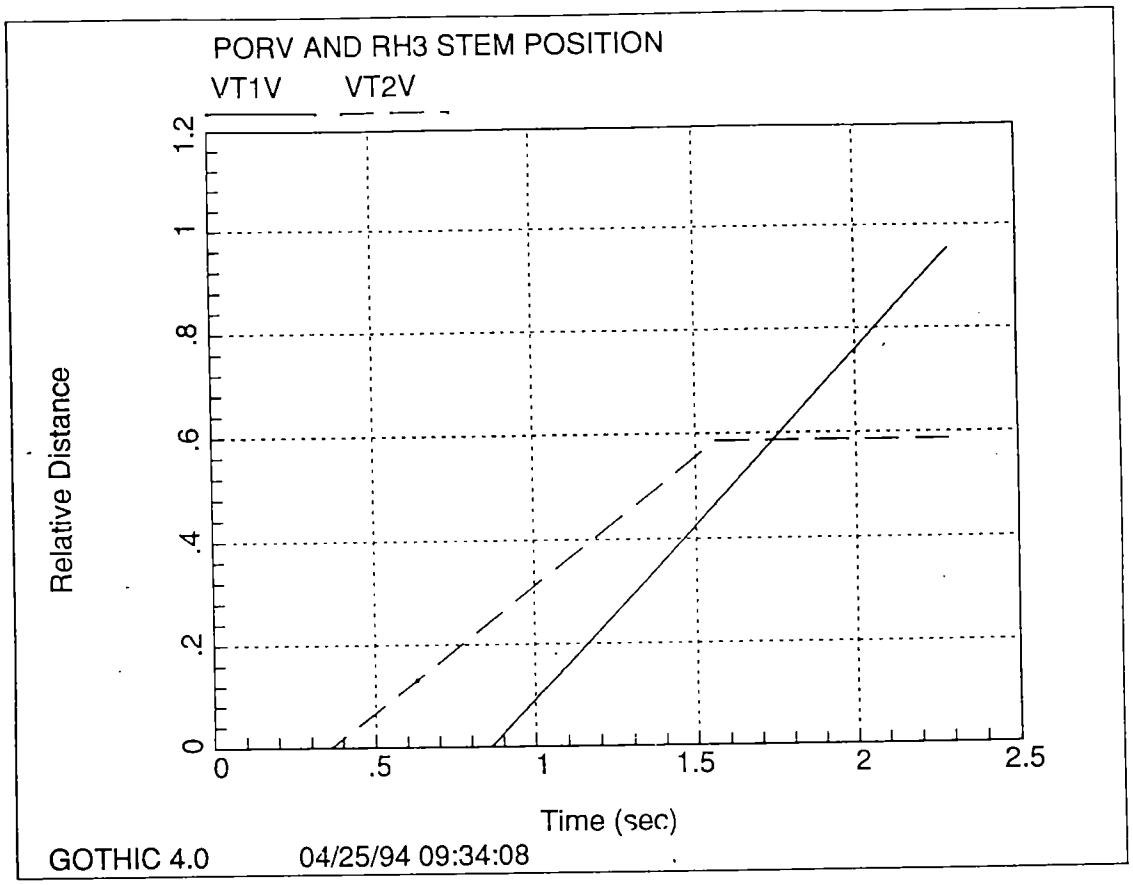
CASE M1



massi440
09:54:28 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-M-DC-1358

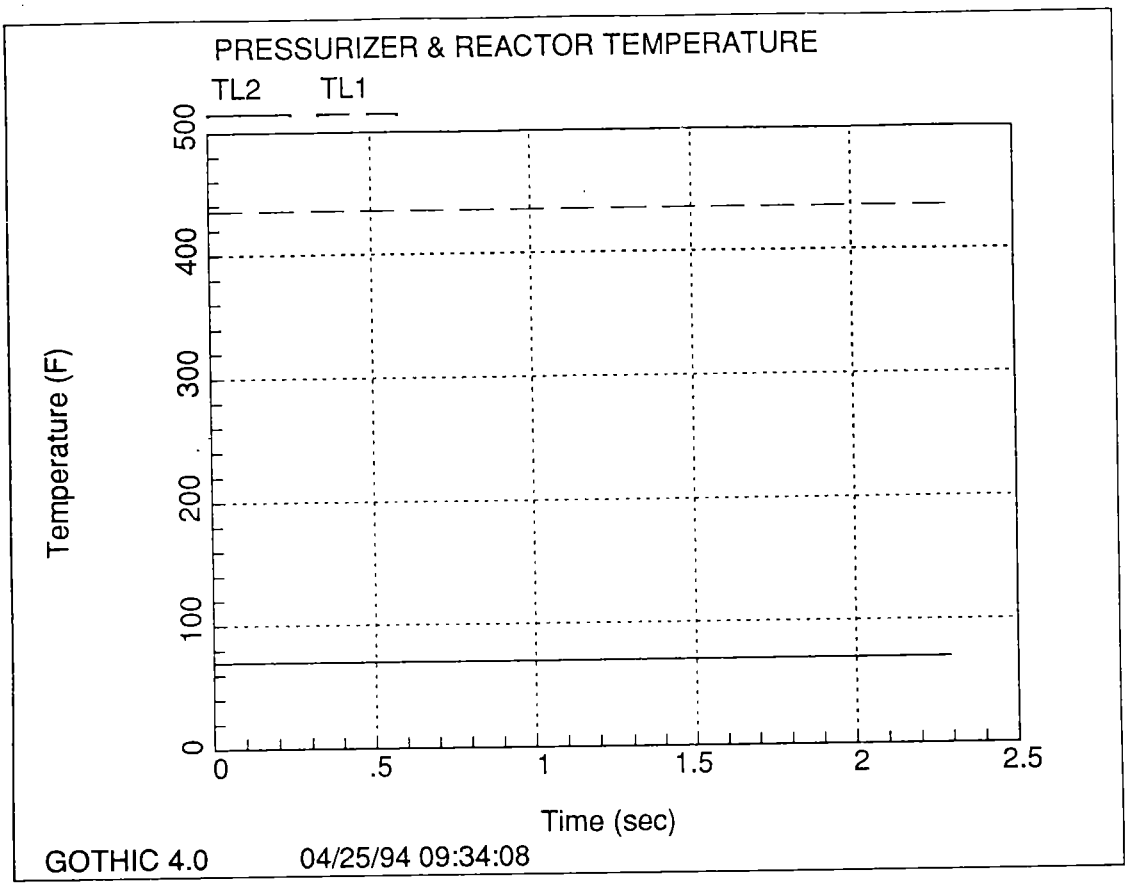
CASE M1



mass2440
09:54:30 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1355

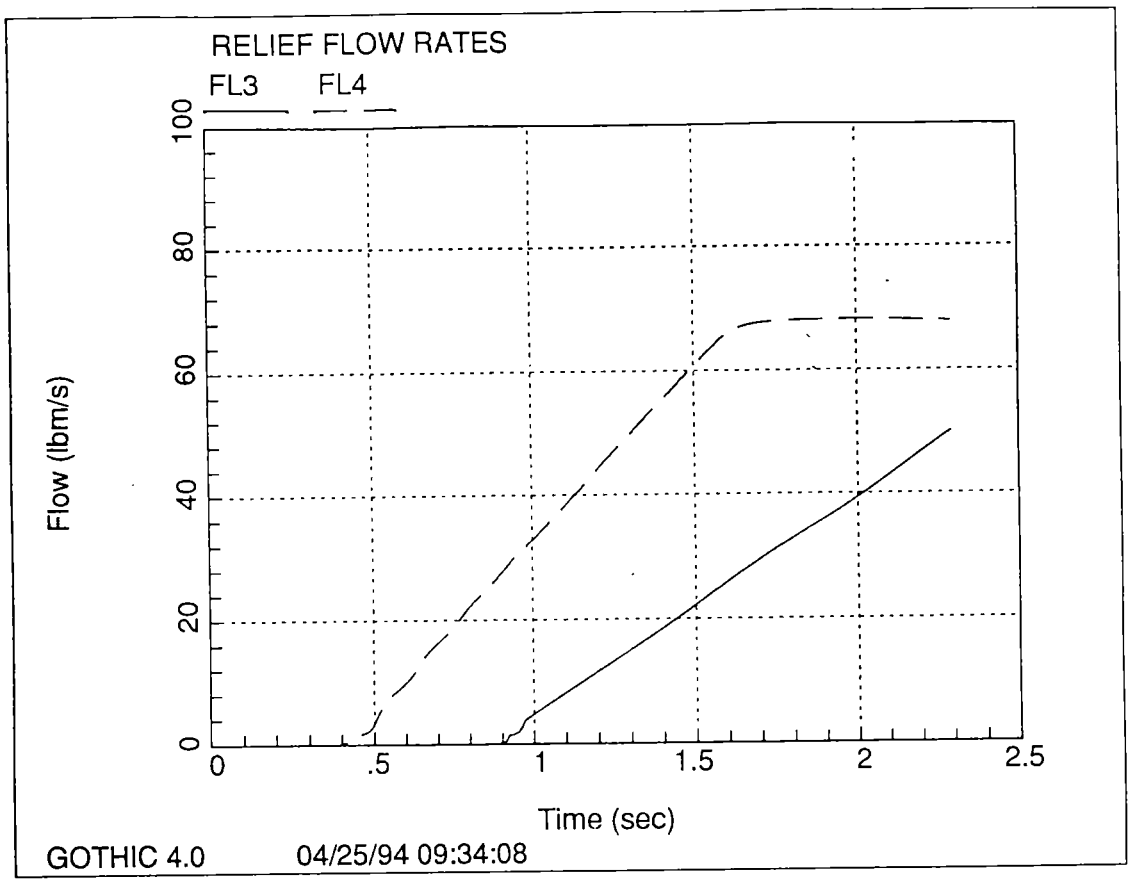
CASE m1



massia 440
09:54:32 25-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

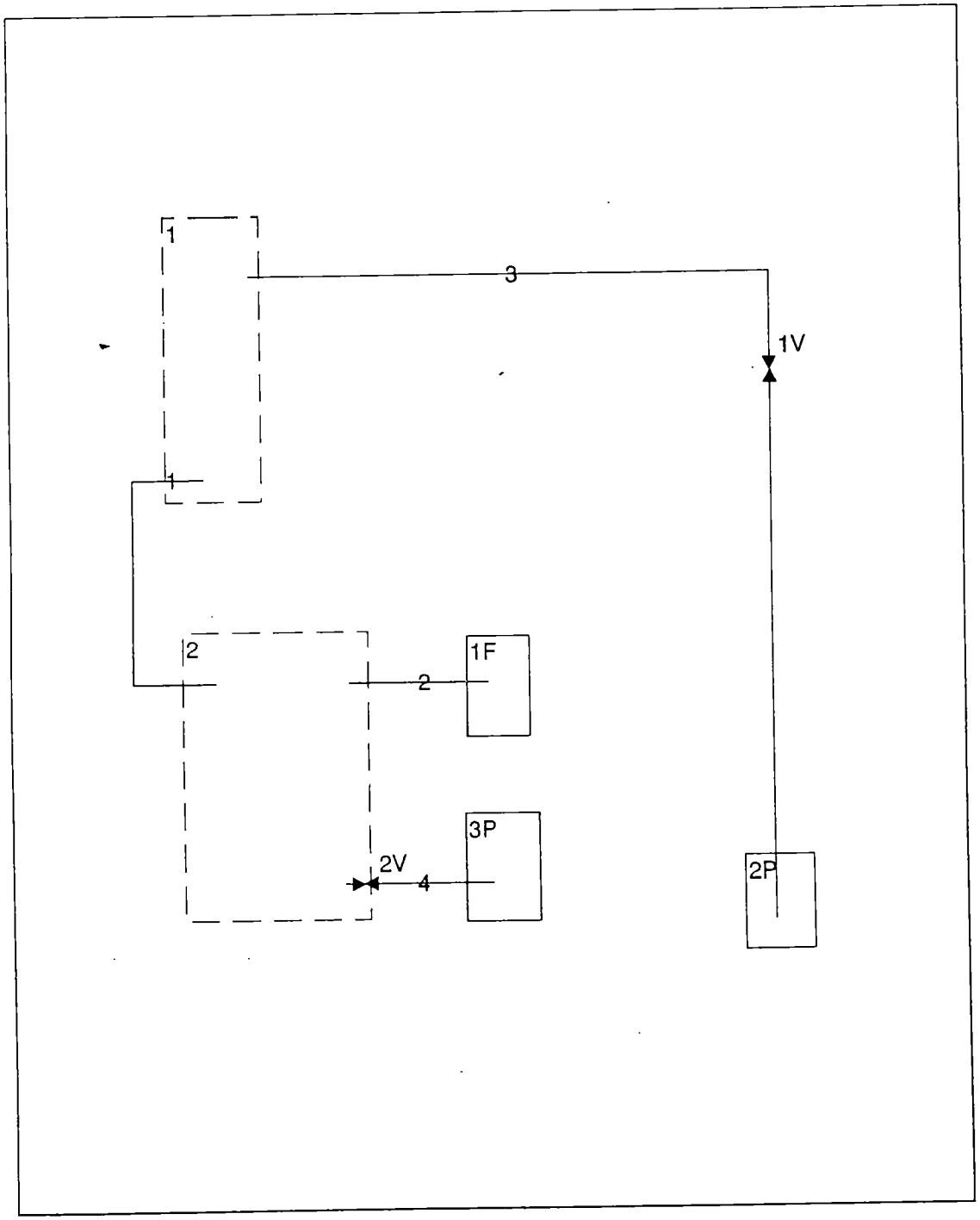
CASE M1



4.3.2 "GOTHIC" INPUT AND OUTPUT (CASE M2)*

mass70
09:26:33 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1365



* SEE TABLE 3.1

mass70
10:01:43 26-APR-94
GOTHIC Version 4.0 - August 1993

SLC-RC-MDC-1385
CASE M2

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1F	SI INJEC. FLOW	400.		70		108.4			
2P	PORV TO PRT	115.		80					
3P	RH3 TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1F	1.		1.								
2P	1.		0.005								
3P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1F	1.							
2P	1.							
3P	1.							

S-C-RC-MDC-1378

CASE M2

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1F 2P 3P								

mass70
10:01:43 26-APR-94
GOTHIC Version 4.0 - August 1993

3-C-PC-MDC-1358

CASE M2

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	SI LINE	2	97.	0.2	1F	97.	0.2
3	RELIEF LINE	1	155.	0.5	2P	87.	0.22
4	RH3 TO PRT	2	97.	0.2	3P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.1	0.2	10.	10.	NO		-
3	0.00843	0.22	13.	0.1	NO		-
4	0.0088	0.3	20.	0.1	NO		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	OFF
3	0.01	0.01	OFF
4	0.01	0.01	OFF

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	3	1	0	1	2P
2V	RH3 VALVE	4	2		2	3P

mass70
10:01:44 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1255

CASE M2

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	3	2	0.0088

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	RH3 STEM TRAVEL	TIME (SEC)	RH3 STEM T	5

Function 1 PORV STEM TRAVEL Ind. Var.: Time (sec) Dep. Var.: Norm. Stem Position			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

S-C-RC-MDC-1358

CASE M2

Function 2 PORV LOSS FACTOR Ind. Var.: Norm. Stem Position Dep. Var.: Loss Factor			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

Function 3 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: RH3 STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	0.7	0.56
1.3	0.56	2.	0.38
100.	0.38		

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	70.	100.	1.	0.	0.
2	380.	70.	100.	1.	0.	0.

mass70
10:01:45 26-APR-94
GOTHIC Version 4.0 - August 1993

E-C-PC-MDC-1335

CASE M2

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

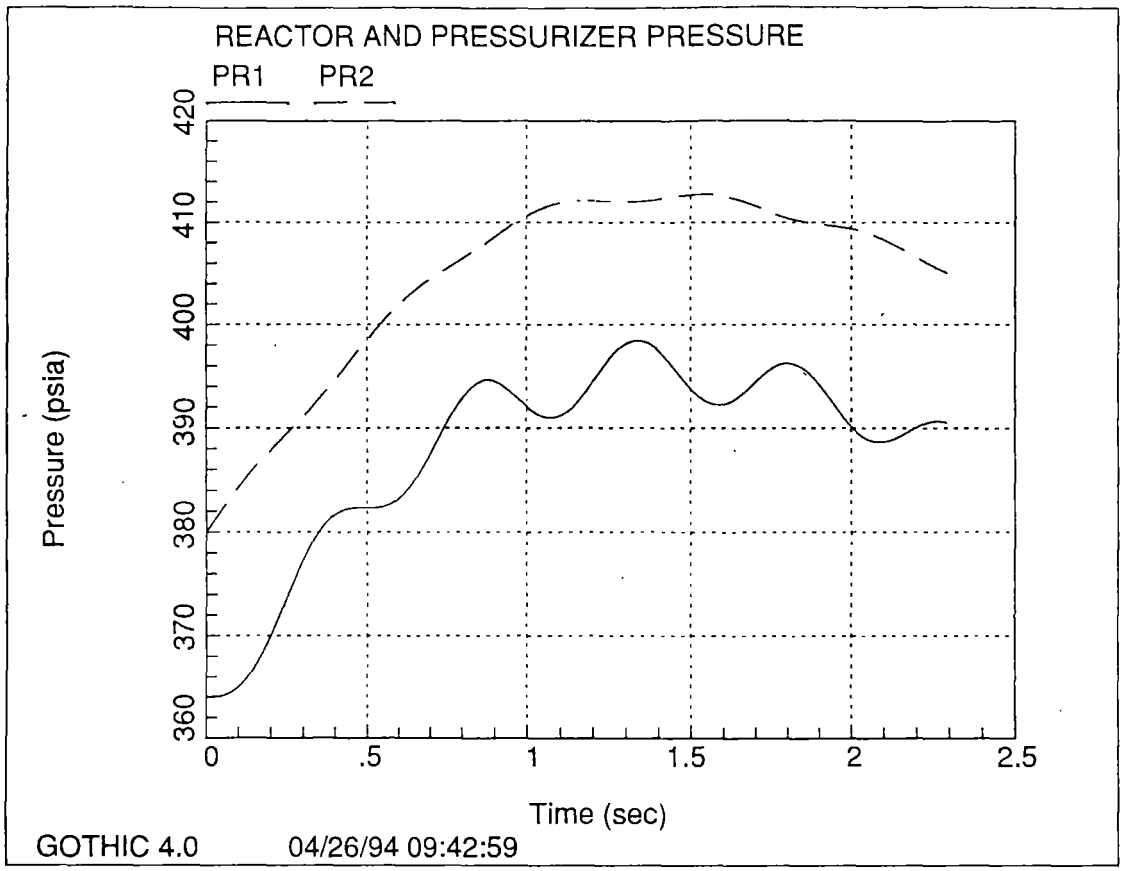
Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	2.3	500.	0.01	6000.	0.

Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV AND RH3 ST		VT1V	VT2V			
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL3	FL4			

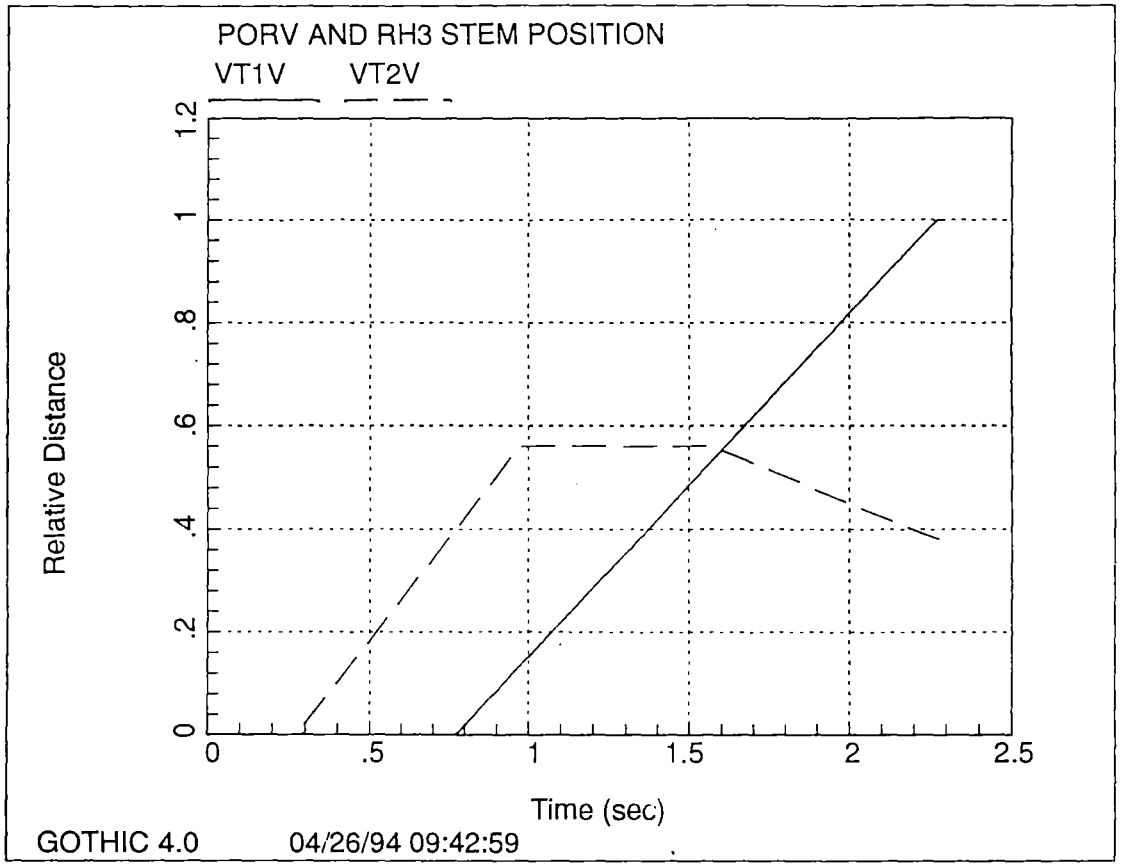
mass70
09:53:14 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE M2



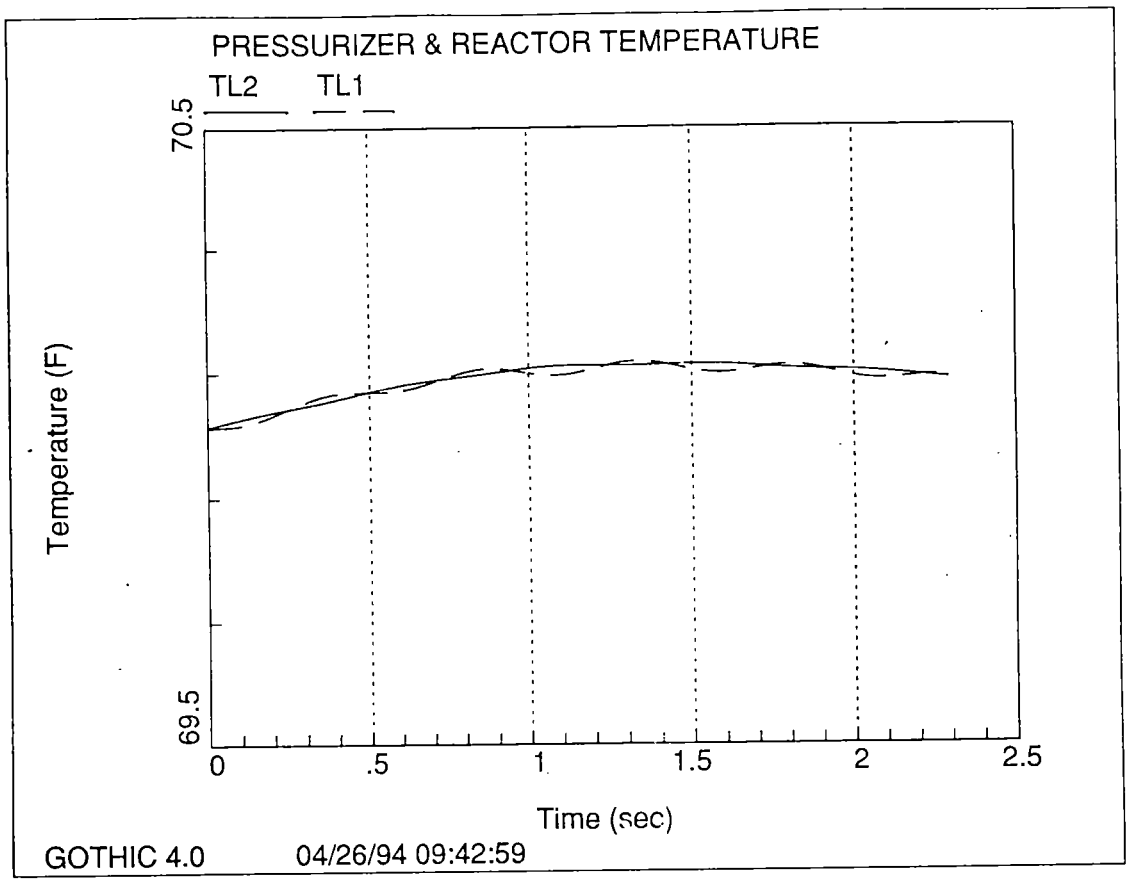
mass70
09:53:16 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1325
CASE M2



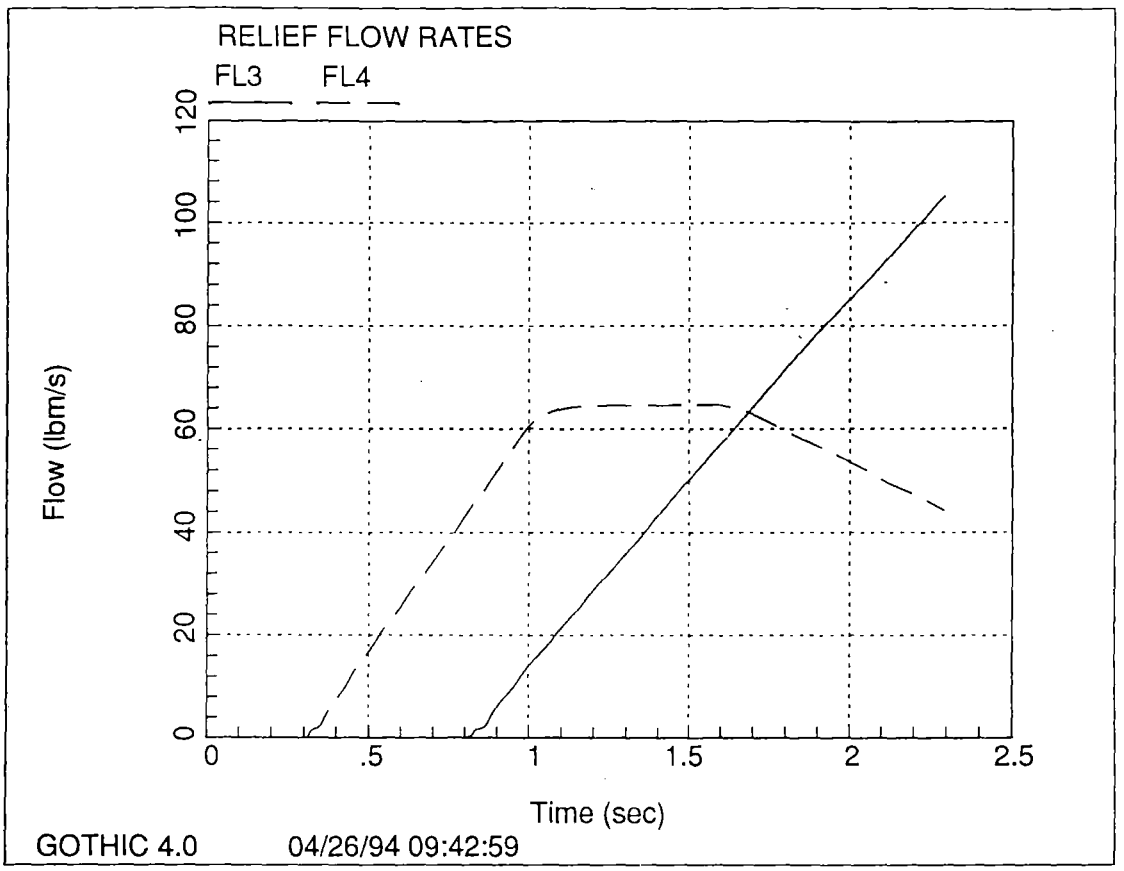
mass70
09:59:07 26-APR-94
GOTHIC Version 4.0 - August 1993

E-C-FC-MDC-1353
CASE M2



mass70
09:53:21 26-APR-94
GOTHIC Version 4.0 - August 1993

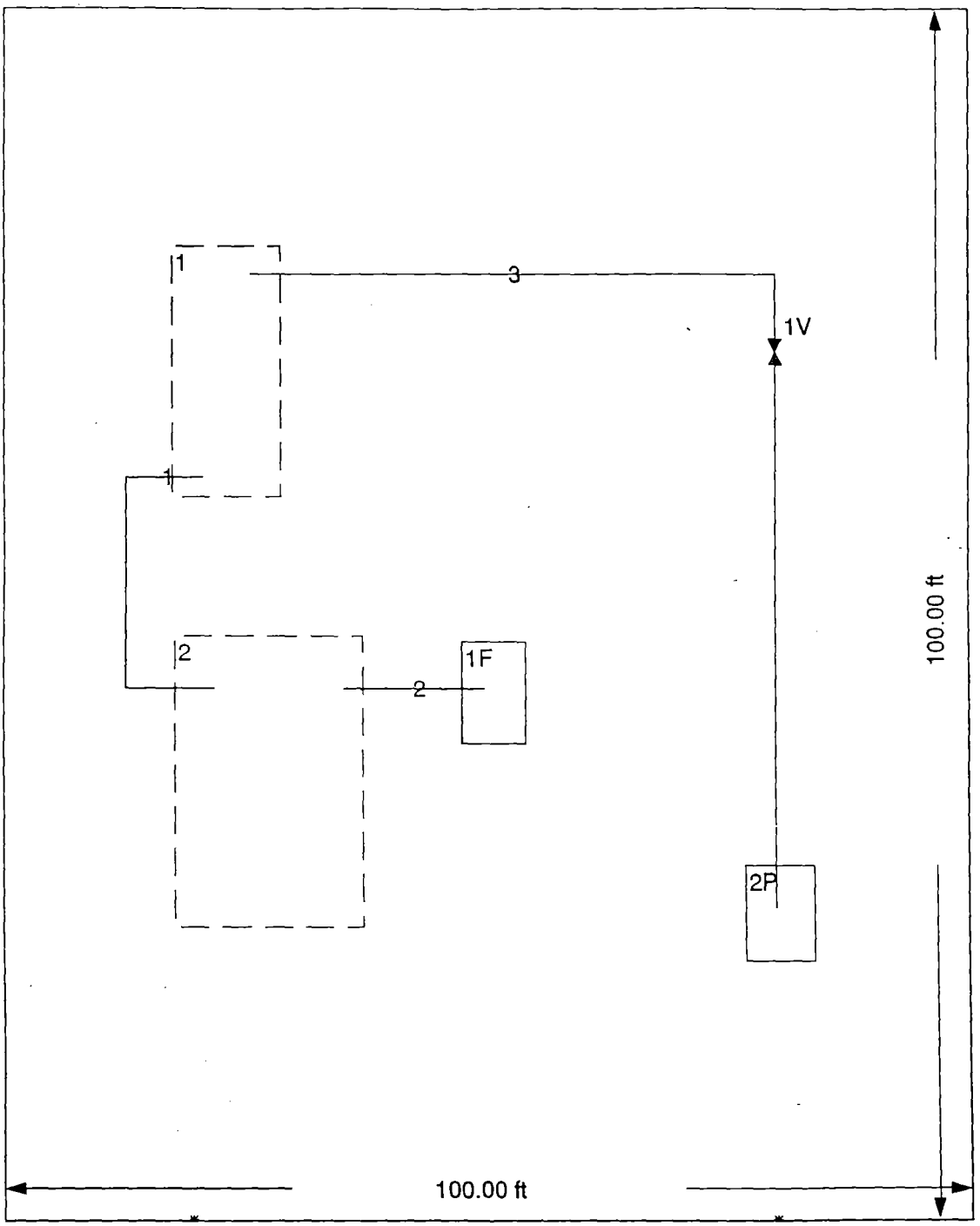
S-C-RC-MDC-1358
CASE M2



4.3.3. "GOTHIC" INPUT AND OUTPUT (CASE M3)

M440RH3F
11:58:36 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-mDC-1358



M440RH3F
12:01:47 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE M3

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1F	SI INJEC. FLOW	400.		70		108.4			
2P	PORV TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1F	1.		1.								
2P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1F	1.							
2P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1F								
2P								

S-C-RC-MDC-1358

CASE M3

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	SI LINE	2	97.	0.2	1F	97.	0.2
3	RELIEF LINE	1	155.	0.5	2P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.1	0.2	10.	10.	NO		-
3	0.01686	0.22	13.	0.1	YES		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	OFF
3	1.	1.	ON

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	3	1	0	1	2P

S-C-RC-MDC-1358

CASE M3

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.01686
2	TIME OPEN	3	2	0.0088

M440RH3F
12:01:48 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE M3

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	UNDE		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	RH3 STEM TRAVEL	TIME (SEC)	RH3 STEM T	3

Function
1
PORV STEM TRAVEL
Ind. Var.: Time (sec)
Dep. Var.: Norm. Stem Position

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function
2
PORV LOSS FACTOR
Ind. Var.: Norm. Stem Position
Dep. Var.: Loss Factor

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

M440RH3F
12:01:49 18-MAY-94
GOTHIC Version 4.0 - August 1993

RC-MDC-1358
CASE M3
+0

Function 3 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: RH3 STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0. 100.	0. 0.586	1.2	0.586

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
2	380.	70.	100.	1.	0.	0.
1	364.	440.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	3.	500.	0.01	6000.	0.

M440RH3F
12:01:49 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-FC-MDC-1365
CASE M3

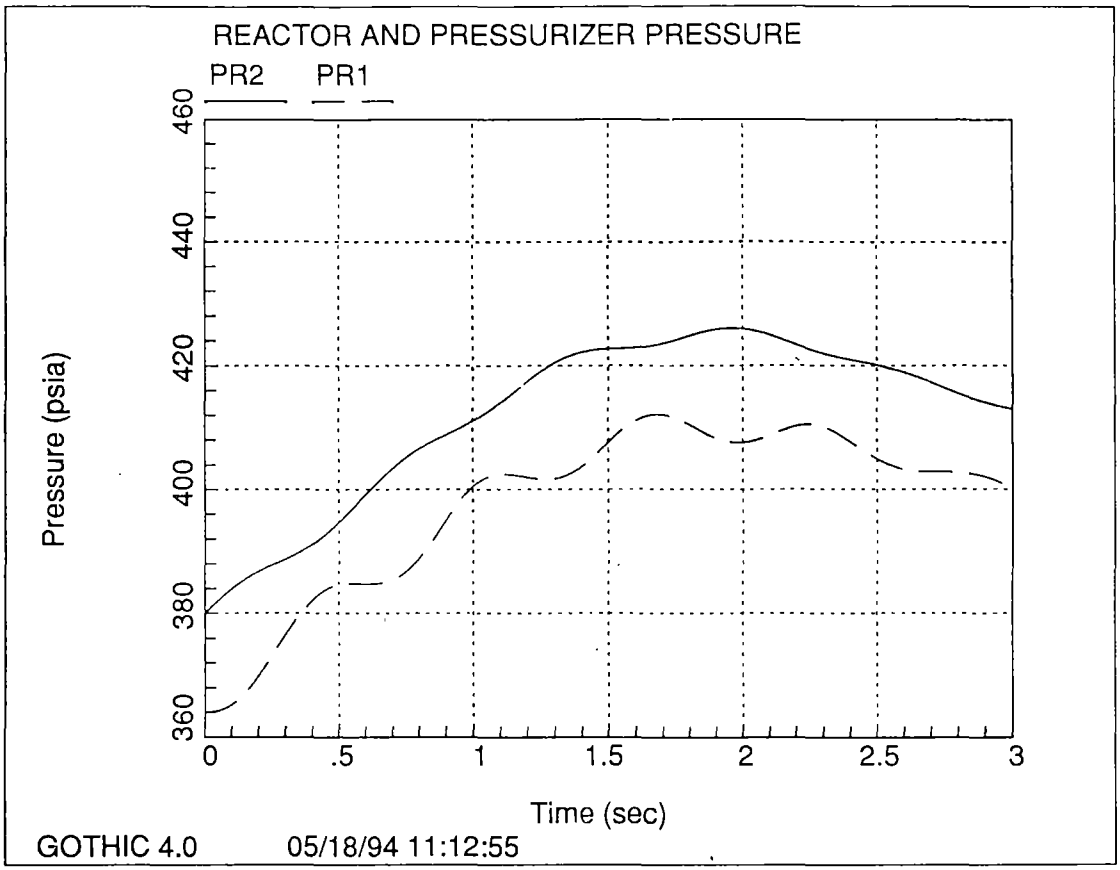
Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR2	PR1			
2	PORV STEM POSIT		VT1V				
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL3				
5	SI FLOW RATE		FV2	FL2			

M440RH3F
11:06:53 20-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE M3

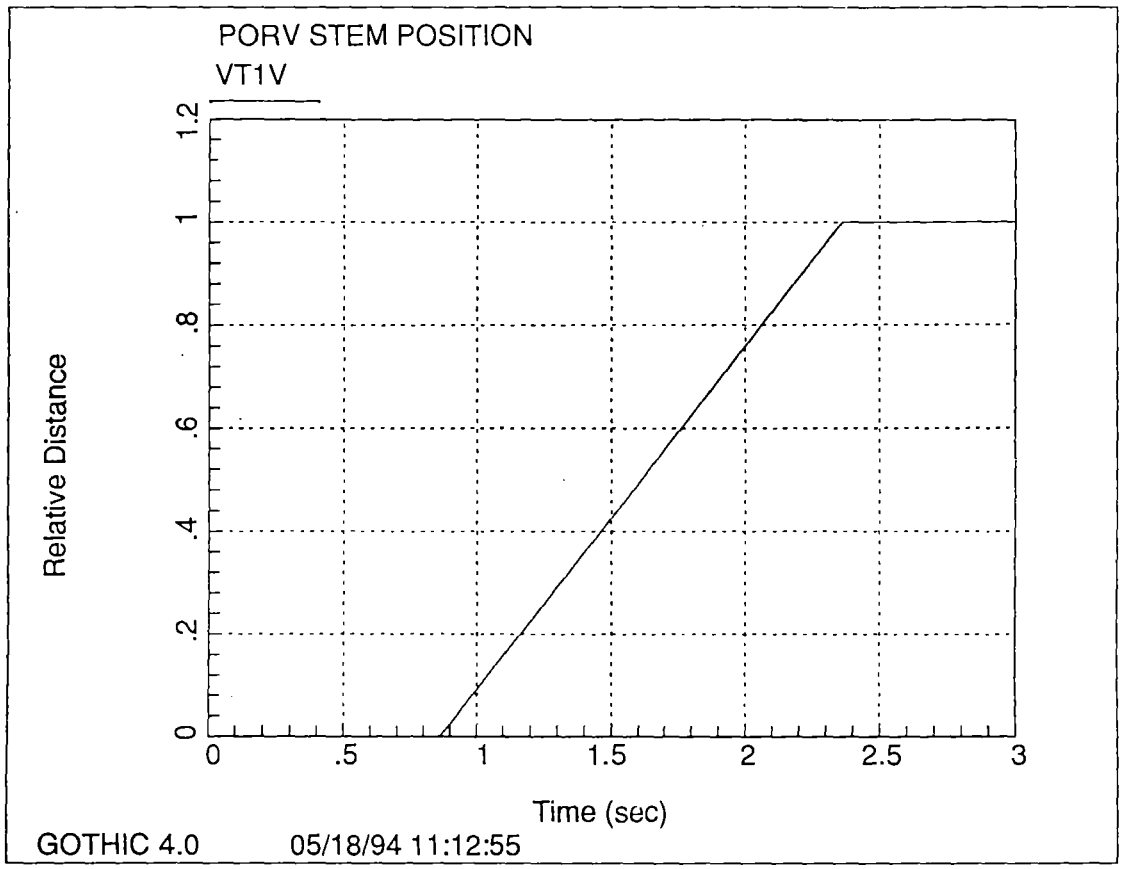


M440RH3F
11:58:50 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

51

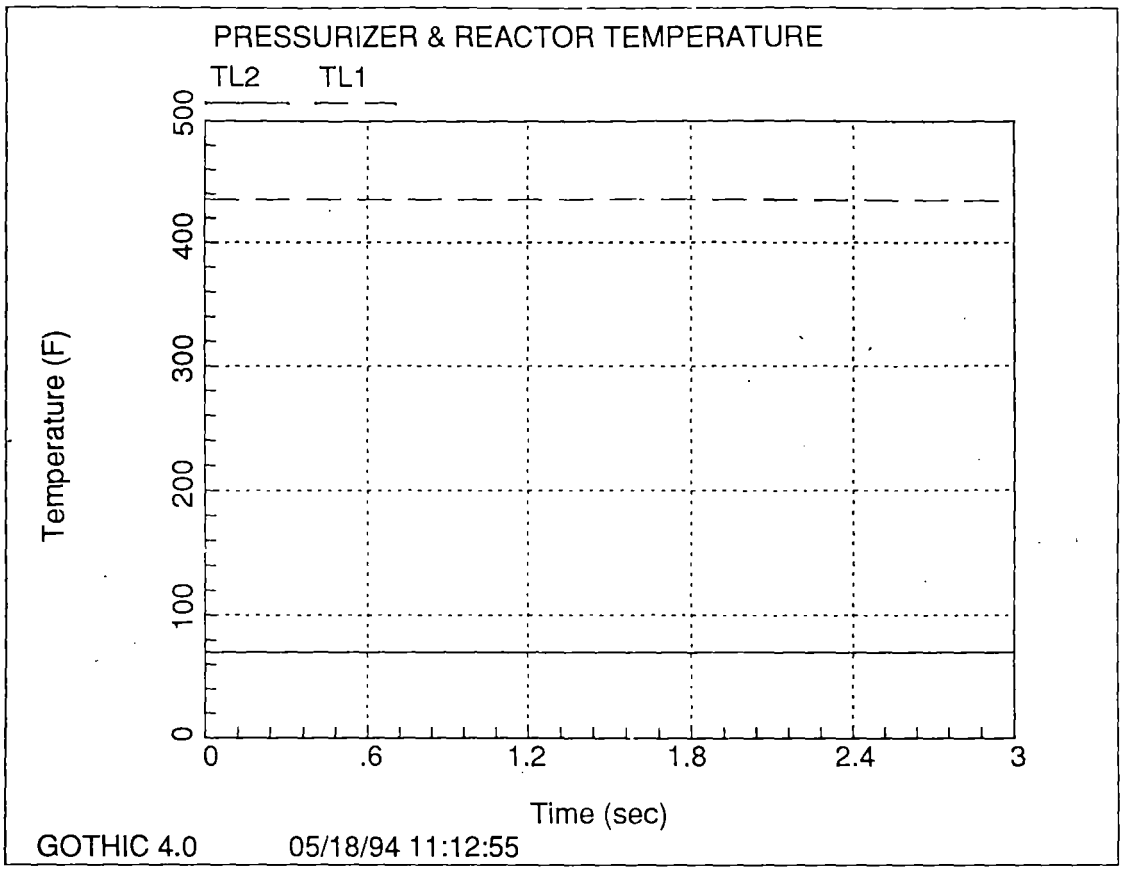
CASE M3



M440RH3F
11:58:52 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-FC-MDC-1358

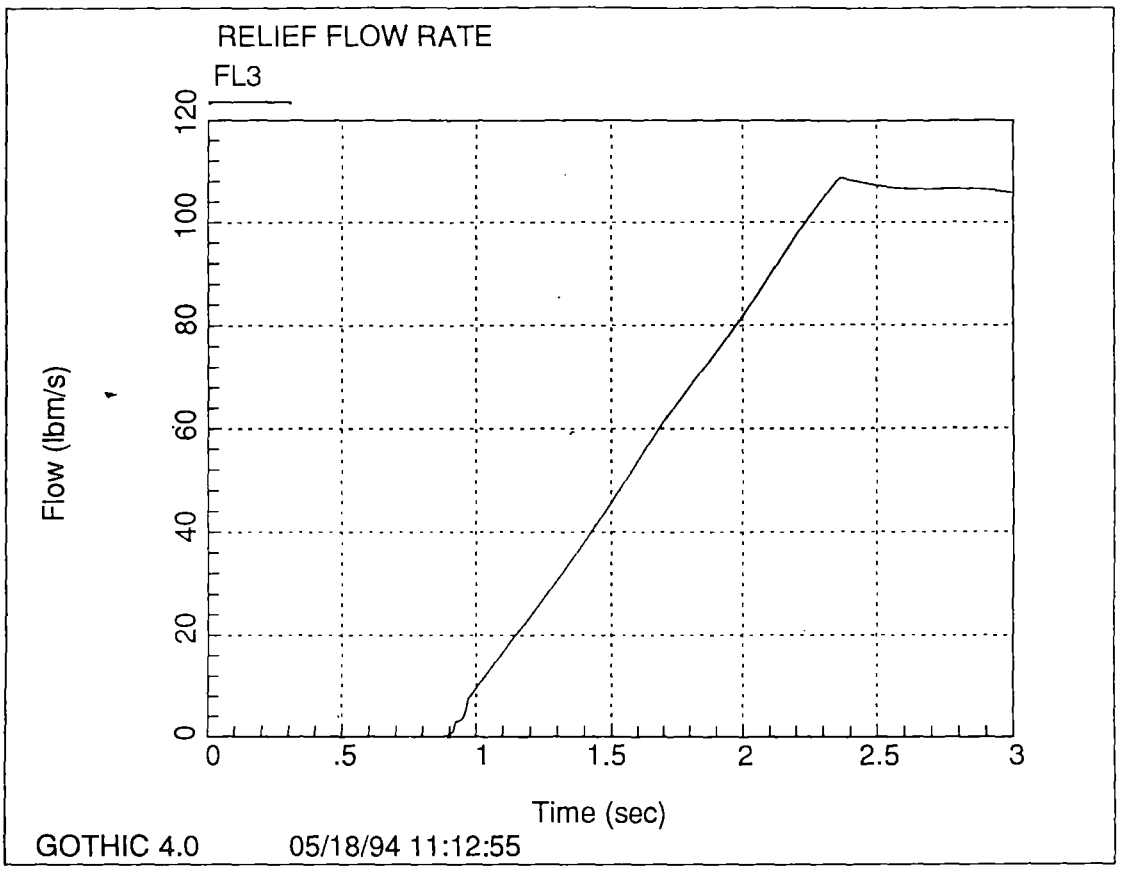
CASE M3



M440RH3F
11:58:54 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

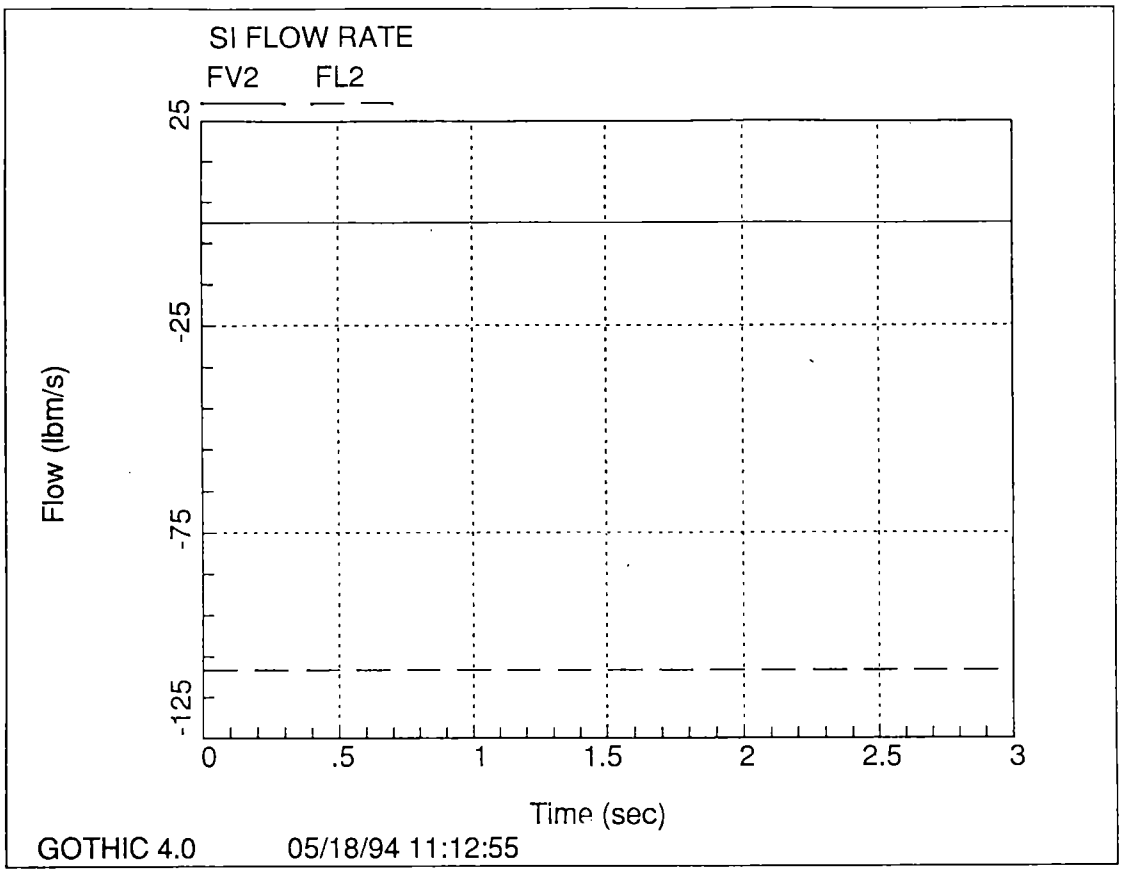
CASE M3



M440RH3F
11:58:56 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE M3



4.4. HEAT INPUT PRESSURIZATION

THE HEAT IS INPUT TO PRIMARY SIDE BY REVERSE HEAT TRANSFER FROM SECONDARY SIDE TO PRIMARY SIDE. THE DESIGN VALUE OF THIS TEMPERATURE DIFFERENCE AT THE BEGINNING OF THE TRANSIENT IS 50F. INITIAL RCS TEMPERATURE OF 150F AND 200F WERE CONSIDERED. [Ref. 2]

THE FOLLOWING FIVE CASES HAVE BEEN CONSIDERED.

CASE H1 — RCS AT 150 F
SECONDARY SIDE FLUID AT 200F
PRESSURIZER CONTAINS SAT. LIQUID
SINGLE FAILURE IS PORV

CASE H2 — RCS AT 150F
SECONDARY SIDE FLUID AT 200F
PRESSURIZER CONTAINS SATURATED LIQUID
SINGLE FAILURE IS RH3 VALVE

CASE H3 — RCS AT 200F
SECONDARY SIDE FLUID AT 250F
PRESSURIZER CONTAINS LIQUID AT 200F.
SINGLE FAILURE IS PORV

CASE H4 — RCS AT 200F, SECONDARY SIDE AT 250F
PRESSURIZER CONTAINS SAT. LIQUID.
SINGLE FAILURE PORV.

CASE H5 — RCS AT 200F, SECONDARY SIDE AT 250F
PRESSURIZER CONTAINS SAT. LIQUID.
SINGLE FAILURE IS RH3

4.4.1 REACTOR COOLANT PUMP (RCP)

WHEN ONLY ONE RCP RUNS THEN FLOW THROUGH OTHER THREE RCP'S IS IN REVERSE DIRECTION. FROM REACTOR COOLANT CBD (DE-CB.RC-0042(Q)) PAGE B-5, FOLLOWING FLOW INFORMATION IS AVAILABLE.

CONDITION	ACTIVE LOOP FLOW	DEAD LOOP FLOW
ZERO POWER 70F, 1 PUMP OPERATION	102,500 GPM	8100 GPM.

THEREFORE FLOW RATE THROUGH PUMP = 102,500 + 3*8100 GPM

= 126800 GPM.

FROM FIGURE F-3 OF CBD (DE-CB.RC-0042&) THE MOTOR POWER CONSUMPTION = 4800 KW. FOR CONSERVATISM 4800 KW WILL BE USED AS PUMP INPUT POWER.

THEREFORE, HEATING EFFECT OF RCP = 4800 KW

$\approx 4549 \frac{BTU}{Sec.}$

THIS ENERGY INPUT WAS CONSIDERED ALONG WITH THE REVERSE HEAT TRANSFER THROUGH S.G. TUBES. (SEE SECTION 3.4.2)

4.4.2 OVERALL HEAT TRANSFER COEFFICIENT AND H.T. RATE

IN THIS SECTION, THE OVERALL HEAT TRANSFER COEFFICIENT FOR REVERSE HEAT TRANSFER PROCESS FROM THE SECONDARY SIDE FLUID TO THE PRIMARY SIDE FLUID THROUGH STEAM GENERATOR TUBES HAS BEEN CALCULATED. TO KEEP THE ANALYSIS CONSERVATIVE, THE RESISTANCE OF TUBE WALLS AND THE FORCED CONVECTION ON THE PRIMARY SIDE WILL BE IGNORED. THE HEAT TRANSFER ON THE SECONDARY SIDE OCCURS BY NATURAL CONVECTION. IN THE WESTINGHOUSE REPORT ENTITLED "PRESSURE MITIGATION SYSTEMS TRANSIENT ANALYSIS REPORT", THE FOLLOWING NATURAL CONVECTION H.T.C. EXPRESSION WAS USED.

$$h_{NC} = 0.13\,K\left[\frac{\rho^2 g \beta\, \Delta T\, P_r}{\mu^2}\right]^{1/3} = 0.13\,K\left[\frac{\rho^2 g \beta C \Delta T}{\mu K}\right]^{1/3}$$

THIS EXPRESSION IS SUITABLE FOR TURBULENT FLOW NATURAL CONVECTION HEAT TRANSFER FROM VERTICAL SURFACES. [PAGE 2-21 OF Ref. 1]

K = THERMAL CONDUCTIVITY
g = ACC. DUE TO GRAVITY
ρ = DENSITY
β = THERMAL EXPANSION COEFFICIENT
C = SP. HEAT
ΔT = TEMP. DIFF
μ = VISCOSITY

PSE&G

CALCULATION CONTINUATION SHEET

TITLE LTSP EVENT WITH RHR VALVE

ID NO. S-C-RC-MDC-1555

REFERENCE

SHEET

ORIGINATOR

DATE

PEER REVIEW

DATE

4.4.2.1. (CASES H1, H2) RCS AT 150 F, SG OUTSIDE FLUID AT 200F

FLUID PROPERTIES AT 175F WILL BE USED TO CALCULATE H.T.C.

$$\rho = 1.888 \ \frac{slug}{ft^3}$$

$$g = 32.174 \ \frac{ft}{s^2}$$

$$\beta = 3.645 * 10^{-4} \ \frac{1}{F}$$

$$C = 32.2 \ \frac{lb-ft}{slug\ F}$$

$$\mu = 7.4 * 10^{-6} \ \frac{slug}{ft\ s}$$

$$k = 0.386 \ \frac{BTU}{hr\text{-}ft\ F} = 1.0722 * 10^{-4} \ \frac{BTU}{sec\text{-}ft\ F}$$

$$\frac{\rho^2 g \beta C}{\mu k} = \frac{1.888^2 * 32.174 * 3.645 * 10^{-4} * 32.2}{7.4 * 10^{-6} * 1.0722 * 10^{-4}} \ \frac{1}{ft^3 F}$$

$$= 1.697 * 10^{9} \ \frac{1}{ft^3 F}$$

$$h_{NC} = 0.13 K \left(\frac{\rho^2 g \beta C \Delta T}{\mu k} \right)^{\frac{1}{3}} = 0.13 * 0.386 * \left(1.697 * 10^{9} * 50 \right)^{\frac{1}{3}} \ \frac{BTU}{hr\text{-}ft^2 F}$$

$$= 220.5 \ \frac{BTU}{hr\ ft^2 F}$$

STEAM GENERATOR TUBE OUTSIDE SURFACE AREA = 51500 ft^2 PER SG. [PSBP 301109]

THE H.T. RESISTANCE OF TUBE WALL AND PRIMARY SIDE FORCED CONVECTION WILL BE IGNORED FOR CONSERVATISM

$$\therefore UA = 220.5 * 51500 \ \frac{BTU}{hr\,F}$$

$$= 1.1356 * 10^7 \ \frac{BTU}{hr\,F}$$

TO KEEP THE ANALYSIS CONSERVATIVE, IT WILL BE ASSUMED THAT SECONDARY SIDE FLUID TEMPERATURE IS UNIFORM AND CONSTANT.

4.4.2.1.1 ACTIVE LOOP S.G

PRIMARY SIDE (RCS) FLOWRATE = 102500 GPM

$$= 5.03 * 10^7 \ \frac{lbm}{hr} = \dot{m}$$

PRIMARY SIDE FLUID SP. HEAT AT 150 F

$$= 0.999 \ \frac{BTU}{lbm\,F} = C$$

$$N = \frac{UA}{(\dot{m}C)_{TUBE}} = \frac{1.1356 * 10^7}{5.03 * 10^7 * 0.999} = 0.226$$

$$\text{EFFECTIVENESS} = \epsilon = 1 - e^{-N} = 1 - e^{-0.226} = 0.2022$$

H.T. RATE ACROSS ACTIVE LOOP SG

$$= Q = \epsilon (\dot{m}C)_{tube} (T_{sec} - T_{PRI})$$

$$= 0.2022 * 5.03 * 10^7 * 0.999 (200 - T_{PRI}) \ \frac{BTU}{hr}$$

$$= 1.0164 * 10^7 (200 - T_{PRI}) \ BTU/hr$$

4.4.2.1.2 INACTIVE LOOP S.G.

PRIMARY SIDE FLOW RATE = 8100 GPM

$= 3.98 * 10^6 \frac{lbm}{hr}$

$$N = \frac{UA}{\dot{m}C} = \frac{1.1356 * 10^7}{3.98 * 10^6 * 0.999}$$

$= 2.856$

$$\epsilon = 1 - e^{-N} = 1 - e^{-2.856} = 0.9425$$

H.T. RATE ACROSS EACH INACTIVE LOOP S.G.

$= 0.9425 * 3.98 * 10^6 * 0.999 (200 - T_{PR1}) \frac{BTU}{hr}$

$= 3747 * 10^6 (200 - T_{PR1})$

4.4.2.1.3 TOTAL H.T. RATE

$Q_{4SG} = 1.0164 * 10^7 (200 - T_{PR1}) + 3 * 3.747 * 10^6 (200 - T_{PR1})$

$= 2.1406 * 10^7 (200 - T_{PR1})$ BTU/hr

$= 5946 (200 - T_{PR1}) \frac{BTU}{sec}$

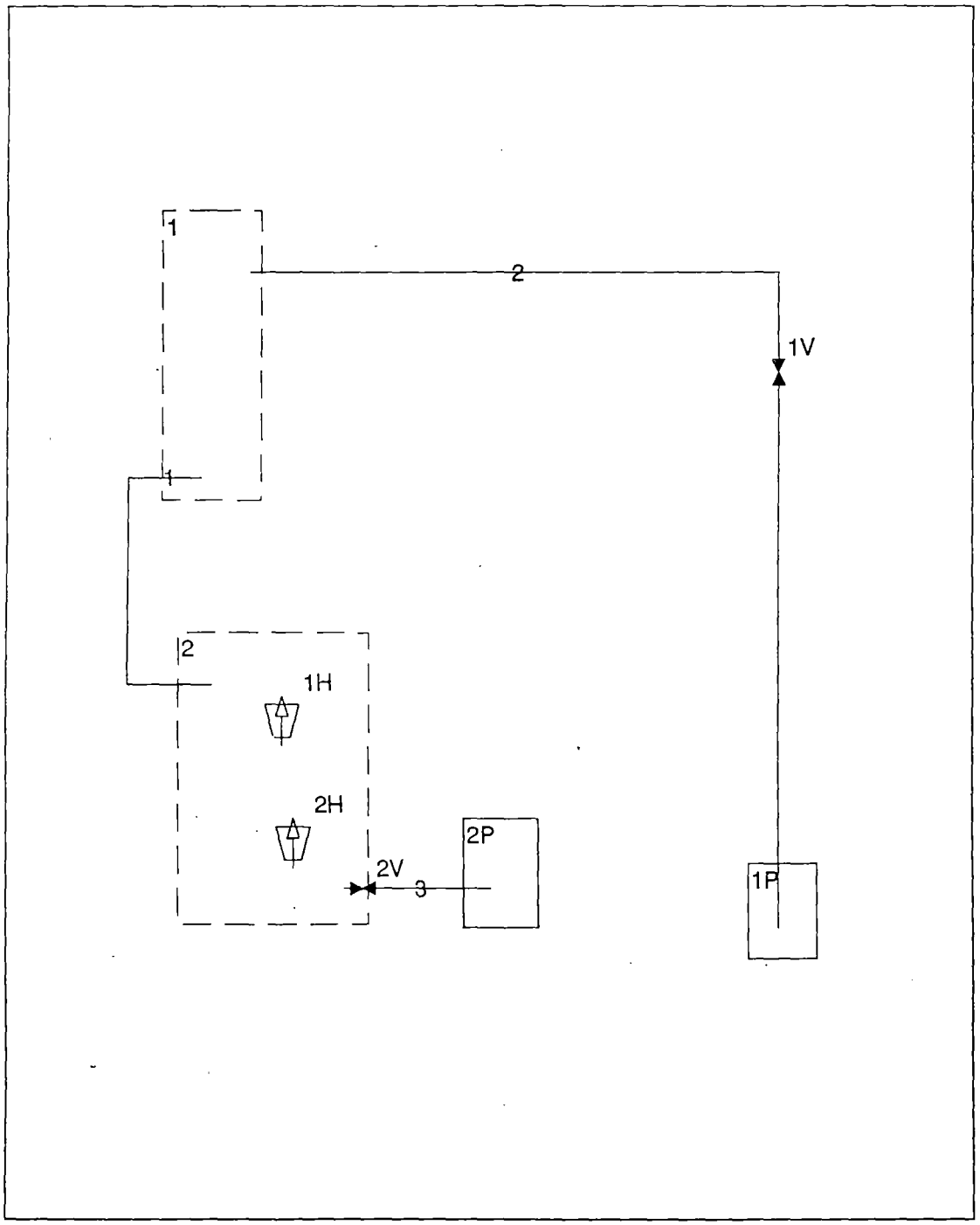
T_{PR1} (F)	Q_{4SG} (BTU/S)
100	594600
200	0

"GOTHIC" INPUT AND OUTPUT FOLLOW

HEAT150 PRZ AT 440F
11:46:27 26-APR-94
GOTHIC Version 4.0 - August 1993

4.4.2.1.4. GOTHIC INPUT AND OUTPUT, CASE H1*

S-C-RC-MDC-1338



* SEE TABLE 3.1

HEAT150 , PRZR AT 440F
11:37:57 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1258 CASE H1

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1P	PORV TO PRT	115.		80					
2P	RH3 TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1P	1.		0.005								
2P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1P	1.							
2P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1P								
2P								

HEAT150 , PRZ AT 440F
11:37:58 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE H1

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	RELIEF LINE	1	155.	0.5	1P	87.	0.22
3	RH3 TO PRT	2	97.	0.2	2P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.00843	0.22	13.	0.1	YES		-
3	0.0088	0.3	20.	0.1	NO		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	ON
3	0.01	0.01	OFF

Cooler/Heater										
Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	Ct I
1H	FOUR SG HEAT	2					1.	3	LTE	
2H	ONE RCP HEAT	2					4549.		LTE	

HEAT150 , PRZ AT 440 F
11:37:58 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE H1

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	2	1	0	1	1P
2V	RH3 VALVE	3	2		2	2P

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	4	2	0.0088

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	FOUR SG HT RATE	RCS TEMPER	HT RATE (B	2
4	RH3 STEM TRAVEL	TIME (SEC)	NORMALIZED	4

HEAT150, PRZ AT 440F
11:37:59 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-12-8

CASE H1

Function 1 PORV STEM TRAVEL Ind. Var.: Time (sec) Dep. Var.: Norm. Stem Position			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function 2 PORV LOSS FACTOR Ind. Var.: Norm. Stem Position Dep. Var.: Loss Factor			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

Function 3 FOUR SG HT RATE Ind. Var.: RCS TEMPERATURE (F) Dep. Var.: HT RATE (BTU/SEC)			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
100.	594600.	200.	0.

HEAT150 , PRZ AT 440F
11:37:59 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-13-8

CASE H.1

Function 4 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: NORMALIZED STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.1	0.6
1.7	0.5	100.	0.5

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	150.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	2.3	500.	0.01	6000.	0.

HEAT150 , PRZ AT 440F
11:37:59 26-APR-94
GOTHIC Version 4.0 - August 1993

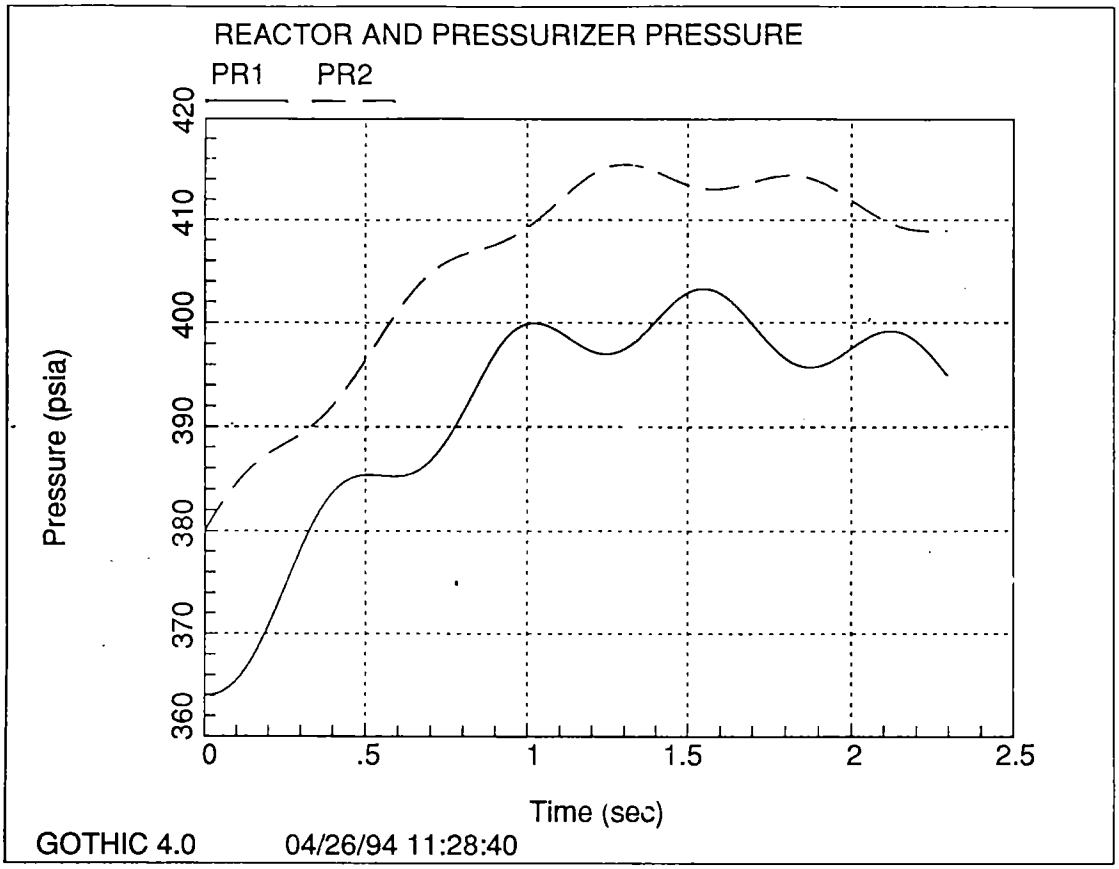
S-C-RC-MDC-1358
CASE H1

Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV AND RH3 ST		VT1V	VT2V			
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL2	FL3			

HEAT150 , PRZ AT 440F
11:46:41 26-APR-94
GOTHIC Version 4.0 - August 1993

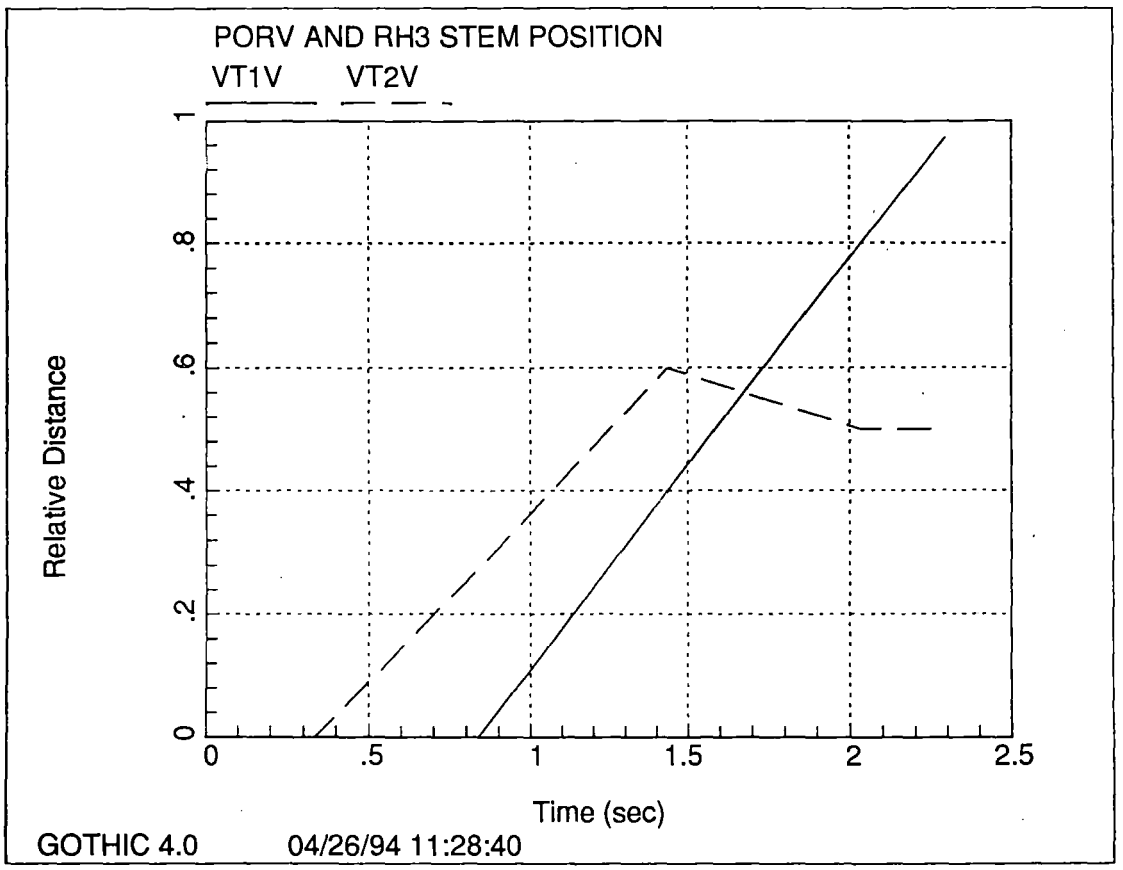
S-C-PC-MDC-1385
CASE H1



HEAT150 PRZ AT 440F
11:46:44 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

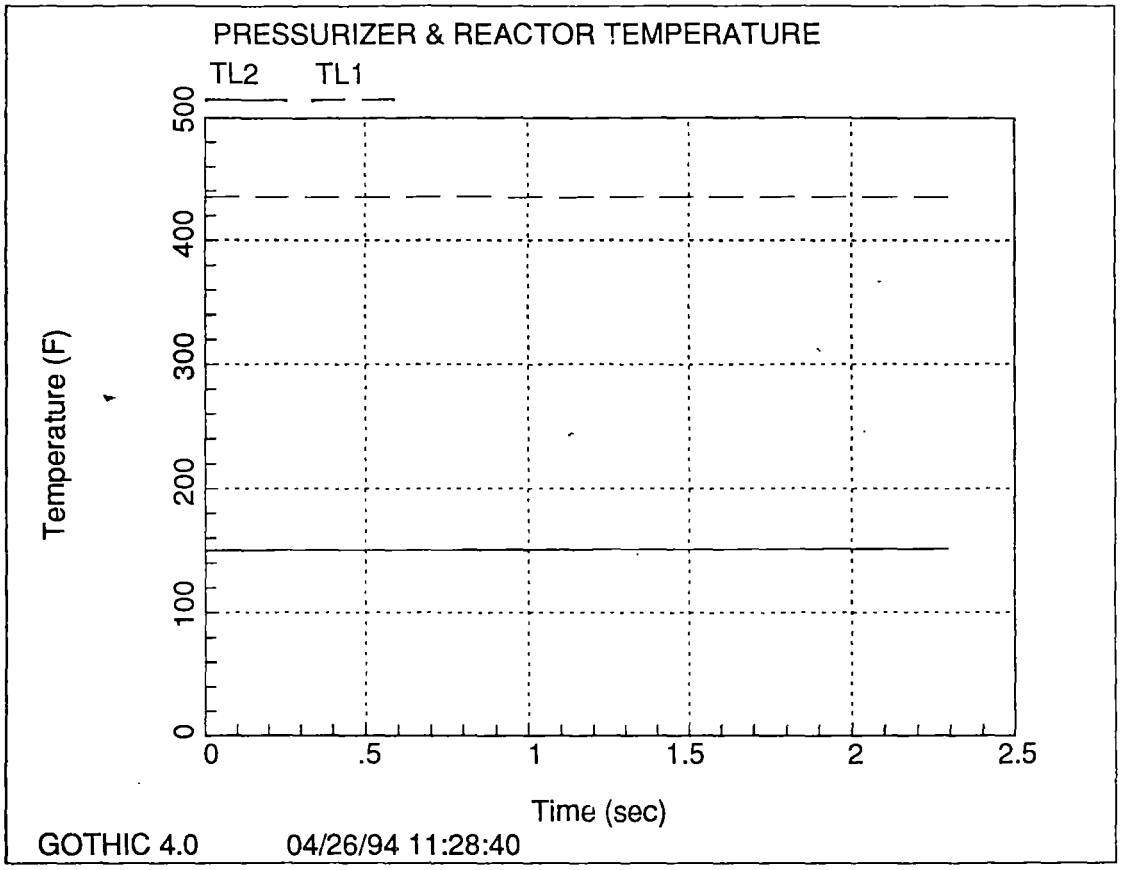
CASE H1



HEAT150 PRZ AT 440F
11:46:46 26-APR-94
GOTHIC Version 4.0 - August 1993

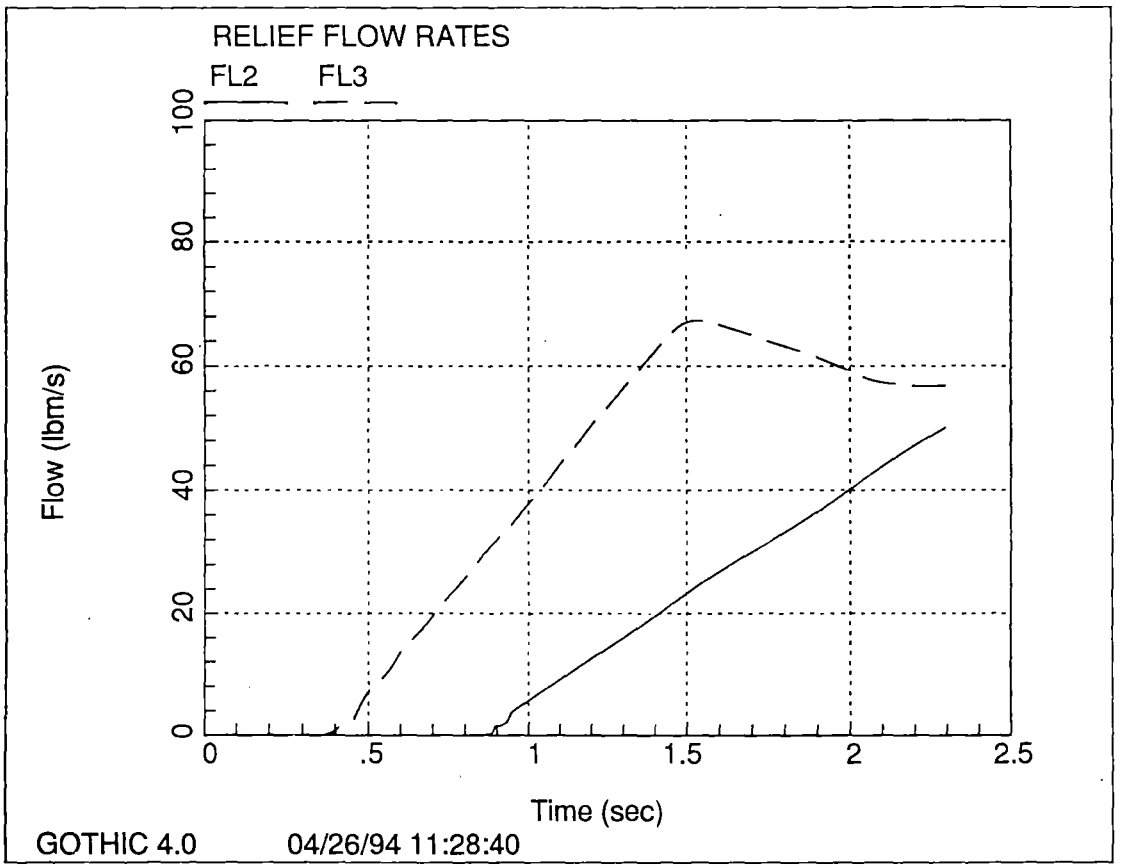
S-C-RC-MDC-13E?

CASE H1



HEAT150 PRZ AT 440 F
11:46:48 26-APR-94
GOTHIC Version 4.0 - August 1993

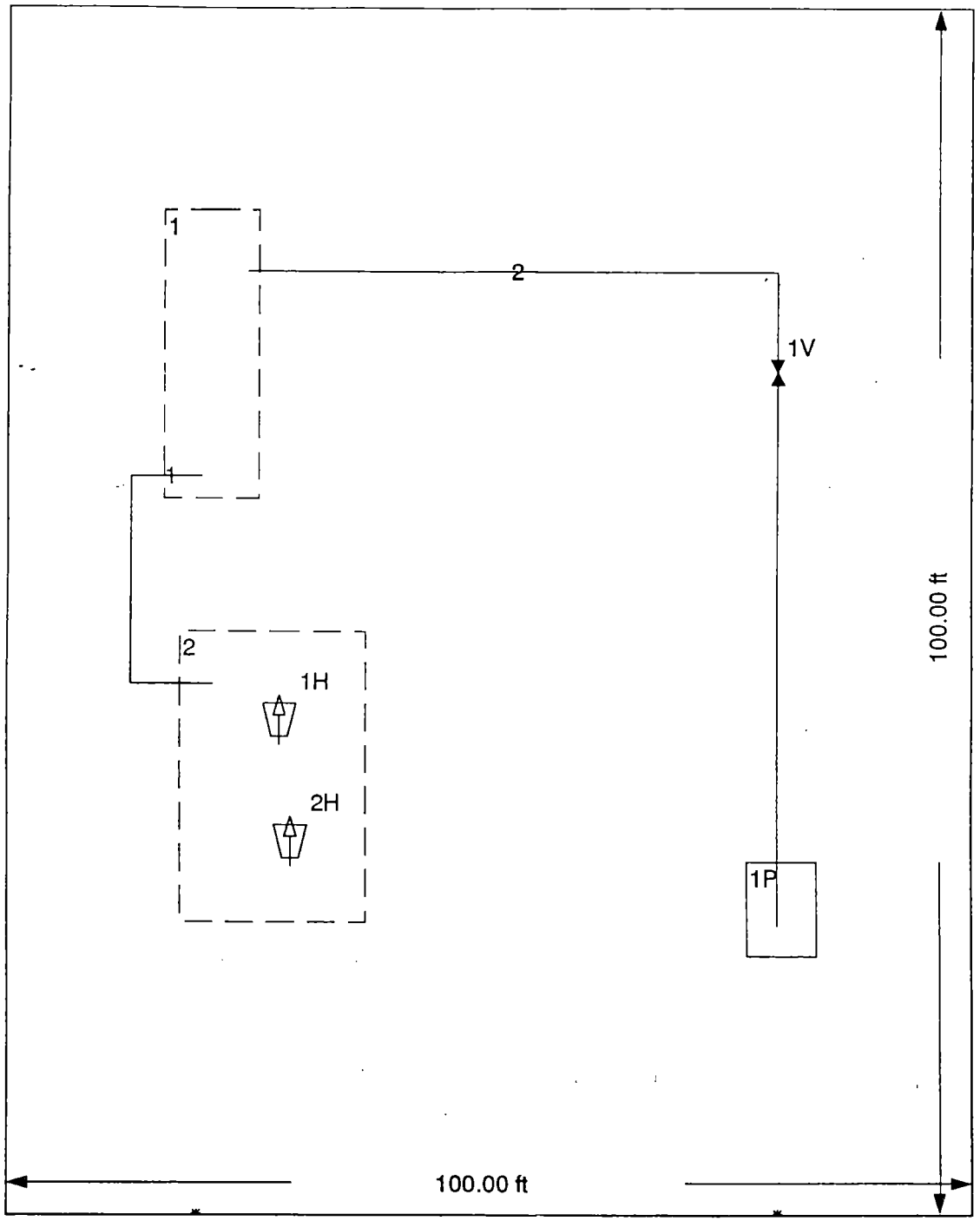
S-C-RC-MDC-1358
CASE H1



4.4.2.1.5 "GOTHIC" INPUT AND OUTPUT, CASE .H2*

H15SATRF
10:11:21 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358



* SEE TABLE 3.1

H15SATRF
10:07:59 18-MAY-94
GOTHIC Version 4.0 - August 1993

73

S-C-PC-MDC-1358 CASE H2

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1P	PORV TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1P								

S-C-RC-MDC-1358
CASE H2

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	RELIEF LINE	1	155.	0.5	1P	87.	0.22

H15SATRF
10:08:00 18-MAY-94
GOTHIC Version 4.0 - August 1993

s-c-RC-MDC-1358
CASE H2

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.01686	0.22	13.	0.1	YES		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	ON

Cooler/Heater										
Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	Ct L
1H	FOUR SG HEAT	2					1.	3	LTE	
2H	ONE RCP HEAT	2					4549.		LTE	

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	TWO PORVS	2	1	0	1	1P

S-C-RC-MDC-1358
CASE H2

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.01686
2	TIME OPEN	4	2	0.0088

H15SATRF
10:08:00 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H2

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	FOUR SG HT RATE	RCS TEMPER	HT RATE (B	2
4	RH3 STEM TRAVEL	TIME (SEC)	NORMALIZED	4

Function
1
PORV STEM TRAVEL
Ind. Var.: Time (sec)
Dep. Var.: Norm. Stem Position

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function
2
PORV LOSS FACTOR
Ind. Var.: Norm. Stem Position
Dep. Var.: Loss Factor

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

H15SATRF
10:08:01 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H2

Function 3 FOUR SG HT RATE Ind. Var.: RCS TEMPERATURE (F) Dep. Var.: HT RATE (BTU/SEC)			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
100.	594600.	200.	0.

Function 4 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: NORMALIZED STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.1	0.6
1.7	0.5	100.	0.5

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	150.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

H15SATRF
10:08:01 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H2

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	3.	500.	0.01	6000.	0.

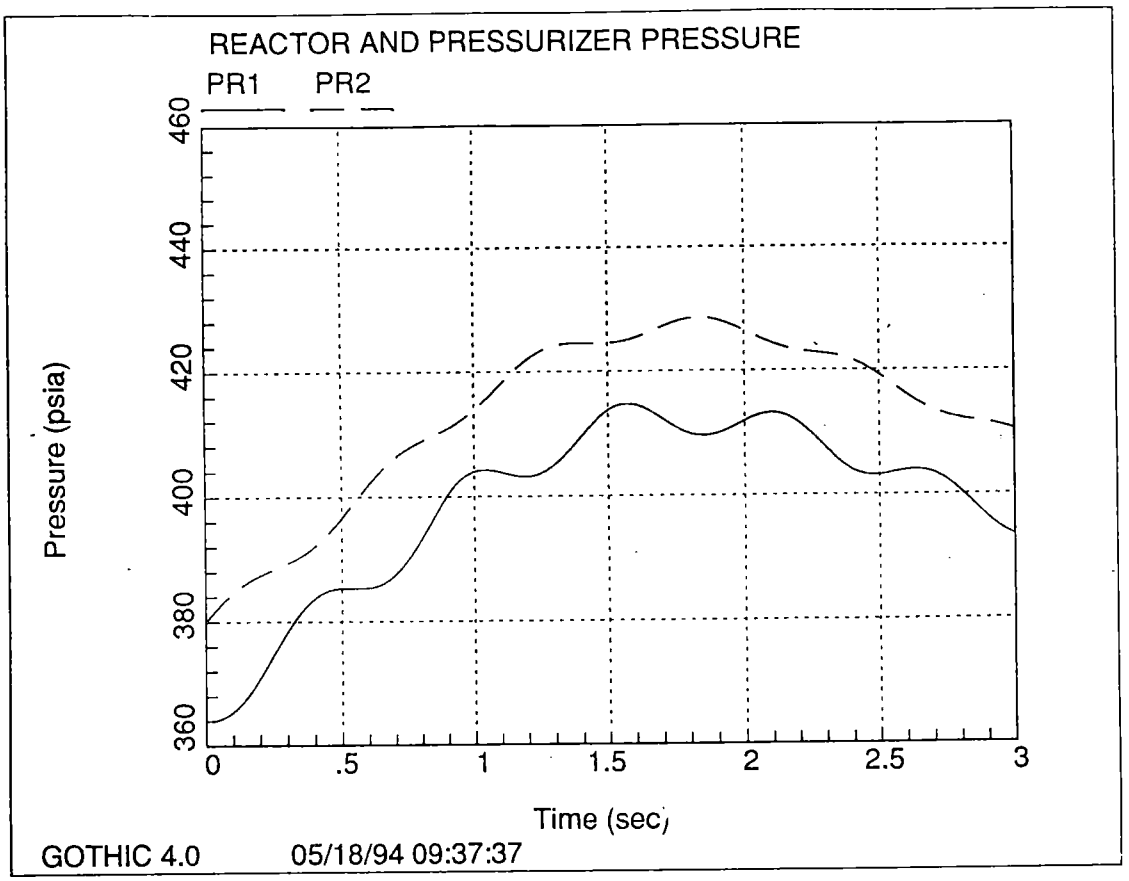
Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV STEM POSIT		VT1V				
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL2				

H15SATRF
10:11:35 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358.

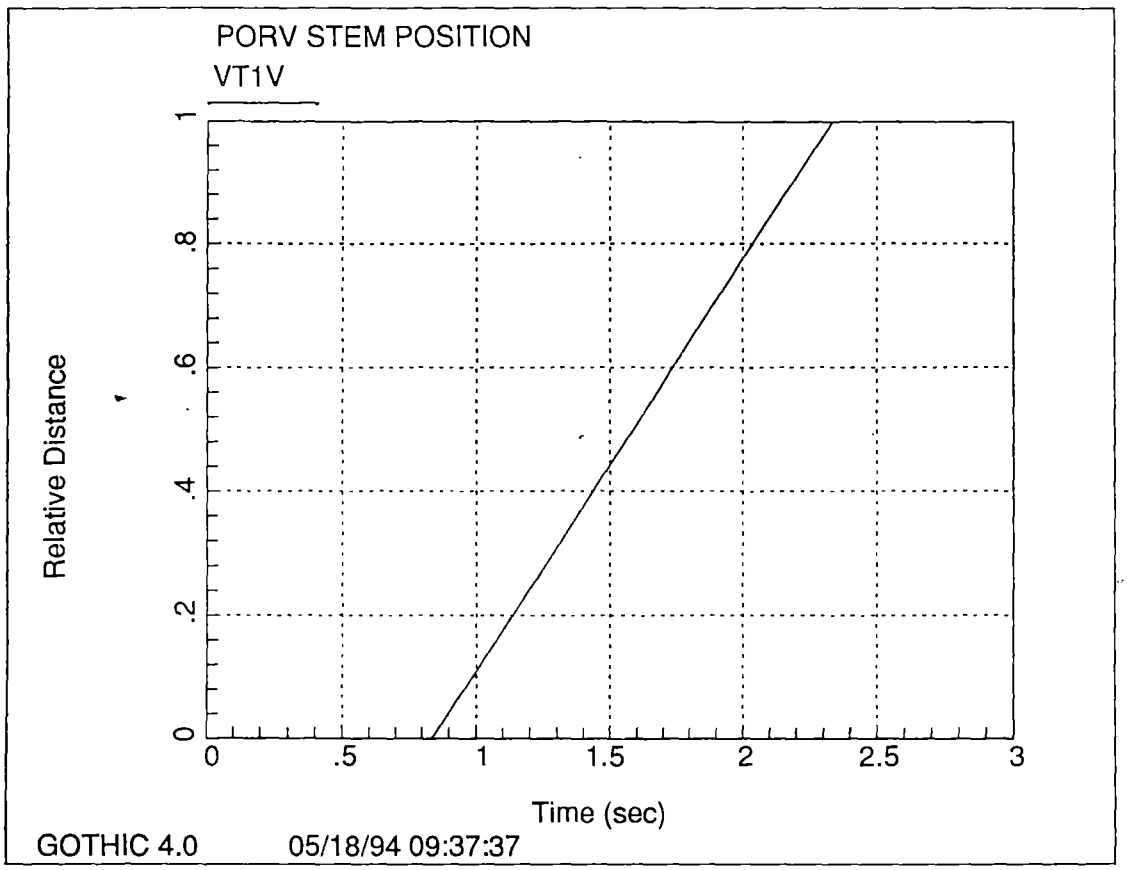
CASE H2



H15SATRF
10:11:38 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

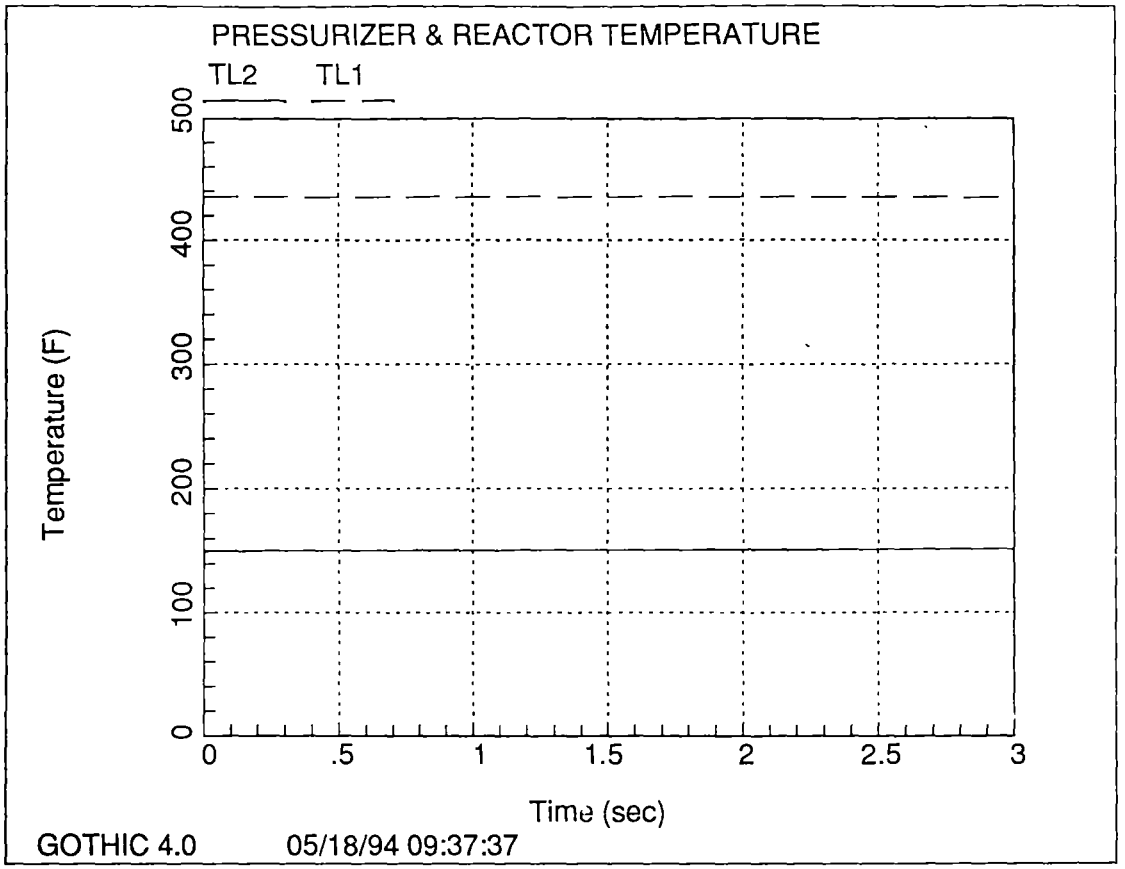
CASE H2



H15SATRF
10:11:39 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

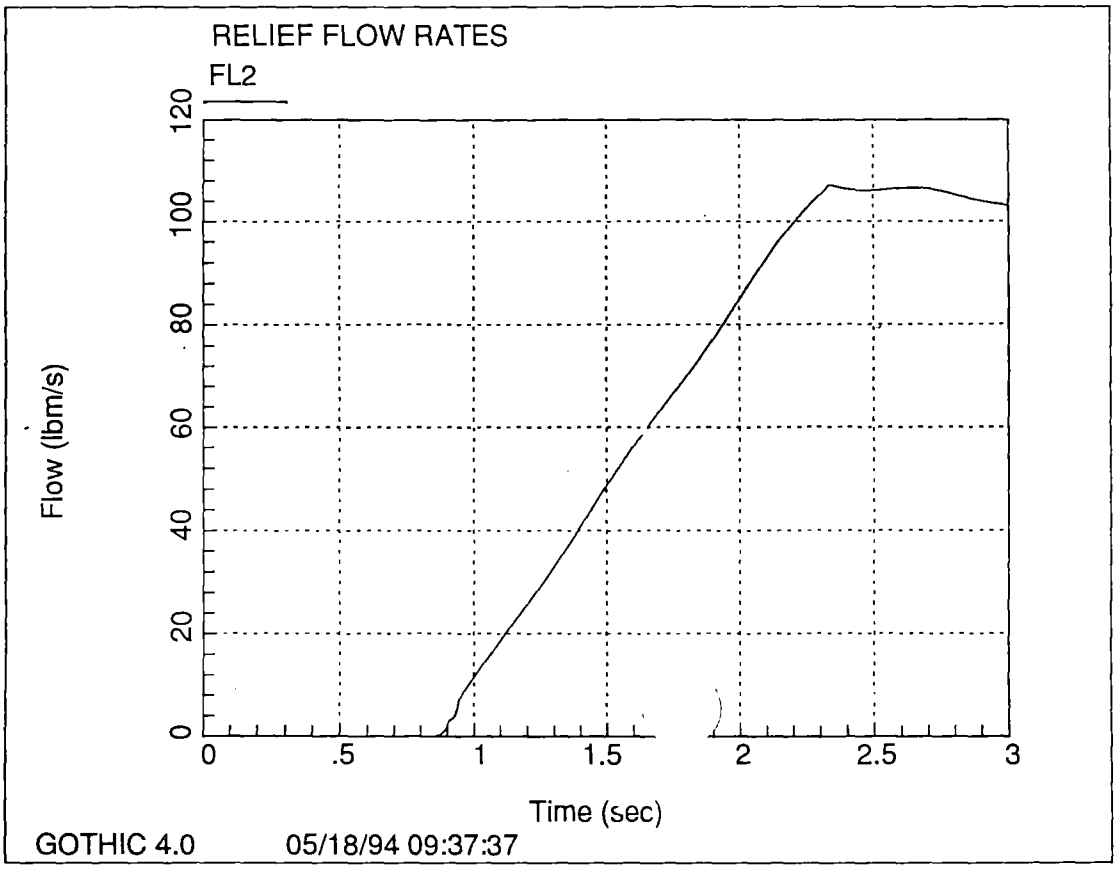
CASE H2



H15SATRF
13:00:50 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE H2



4.4.2.2 CASES H3, H4, H5

INITIAL TEMPERATURE OF REACTOR = 200F

SECONDARY SIDE FLUID TEMPERATURE = 250F

WATER PROPERTIES AT 225F WILL BE USED TO CALCULATE TUBE OUTSIDE H.T.C.

$$\text{DENSITY} = \rho = 59.7 \frac{lbm}{ft^3} = 1.855 \, slug/ft^3$$

$$\text{ACC. DUE TO GRAVITY} = g = 32.174 \frac{ft}{s^2}$$

$$\text{VOL. EXP. COEFF.} = \beta = 0.000476 \, F^{-1} = 4.76 \times 10^{-4} \, F^{-1}$$

$$\text{SP. HEAT} = C = 1.008 \frac{BTU}{lbm \, F} = 32.43 \frac{BTU}{slug \, F}$$

$$\text{VISCOSITY} = \mu = 5.6 \times 10^{-6} \frac{lbf \cdot s}{ft^2}$$

$$\text{THERMAL CONDUCTIVITY} = k = 0.39 \frac{BTU}{hr \, ft \, F} = 1.0833 \times 10^{-4} \frac{BTU}{sec \, ft \, F}$$

$$\frac{\rho^2 g \beta C}{\mu k} = \frac{1.855^2 * 32.174 * 4.76 \times 10^{-4} * 32.43}{5.6 \times 10^{-6} * 1.0833 \times 10^{-4}}$$

$$\frac{slug^2}{ft^6} \cdot \frac{ft}{s^2} \cdot \frac{1}{F} \cdot \frac{BTU}{slug \, F} \cdot \frac{ft^2 \, s \cdot ft \, F}{lbf \, s \, BTU}$$

$$= 2.82 \times 10^9 \frac{slug}{ft^2 s^2 lbf \, F}$$

$$= 2.82 \times 10^9 \frac{slug \, s^2}{ft^2 s^2 \, slug \, ft \, F} = \frac{1}{ft^3 F}$$

$$h_{NC} = 0.13 * 0.39 * \left(2.32 * 10^3 * 50\right)^{\frac{1}{3}} \frac{BTU}{hr\ ft^2 F}$$

$$= 263.9 \frac{BTU}{hr\ ft^2 F}$$

$$UA = 263.9 * 51500 \frac{BTU}{hr\ F}$$

$$= 1.3591 * 10^7 \frac{BTU}{hr\ F}$$

4.4.2.2.1 ACTIVE LOOP S.G.

PRIMARY SIDE FLOW RATE = 102500 GPM

$= 228.4\ ft^3/s$

$= \frac{228.4}{0.01662} * 3600 \frac{lbm}{hr}$

$= 4.947 * 10^7 \frac{lbm}{hr}$

SP. HEAT $= 1.004 \frac{BTU}{lbm\ F}$

$$N = \frac{UA}{(mc)_{TUBE}} = \frac{1.3591 * 10^7}{1.004 * 4.947 * 10^7} = 0.2736$$

$$\epsilon = 1 - e^{-N} = 1 - e^{-0.2736} = 0.2394$$

$$H.T.\ RATE = Q = 0.2394 * 4.947 * 10^7 * 1.004 (250 - T_{PR1}) \frac{BTU}{hr}$$

$$= 1.189 * 10^7 (250 - T_{PR1}) \frac{BTU}{hr}$$

$$= 3303 (250 - T_{PR1}) \frac{BTU}{Sec.}$$

4.4.2.2.2 INACTIVE LOOP S.G.

PRIMARY SIDE FLOW RATE = 8100 GPM

$= 18.048\ ft^3/s$

OR $\dot{m} = 3.909 * 10^6\ \frac{lbm}{hr}$

$\dot{m} \cdot C = 3.909 * 10^6 * 1.004\ \frac{BTU}{hr\ F}$

$= 3.925 * 10^6\ \frac{BTU}{hr\ F}$

$$N = \frac{UA}{(\dot{m}C)_{TUBE}} = \frac{1.3591 * 10^7}{3.925 * 10^6} = 3.463$$

$$\epsilon = 1 - e^{-N} = 1 - e^{-3.463} = 0.9672$$

H.T. RATE ACROSS ~~EACH~~ INACTIVE LOOP S.G.

$= 0.9672 * 3.925 * 10^6 (250 - T_{PR1})\ \frac{BTU}{hr}$

$= 3.7963 * 10^6 (250 - T_{PR1})\ \frac{BTU}{hr}$

$= 1054.5 (250 - T_{PR1})\ \frac{BTU}{s}$

4.4.2.2.3 TOTAL H.T. RATE

$Q_{4SG} = 3303 (250 - T_{PR1}) + 3 * 1054.5 (250 - T_{PR1})\ \frac{BTU}{s}$

$= 6466.5 (250 - T_{PR1})$

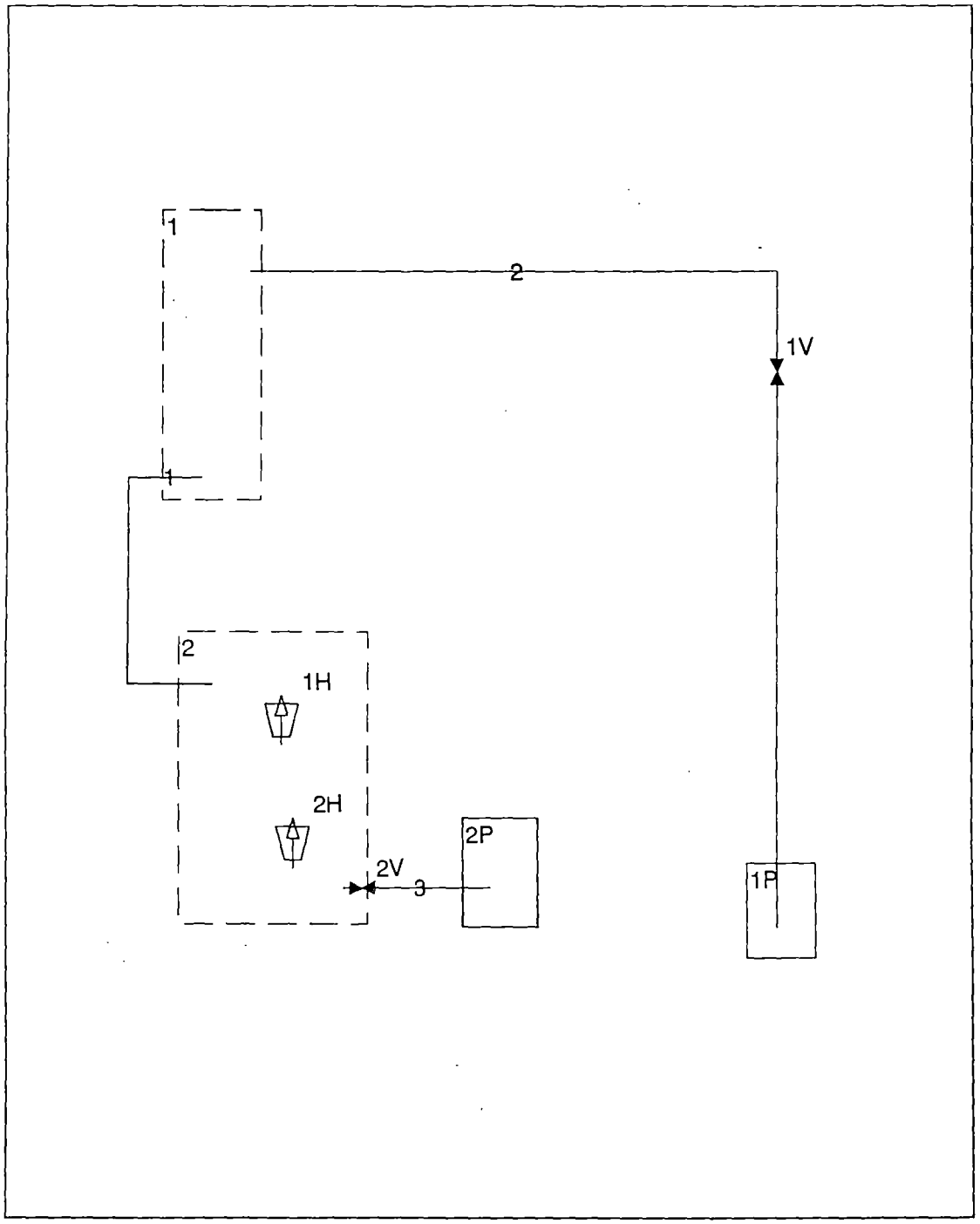
T_{PR1} (F)	Q_{4SG} (BTU/S)
150	646650
250	0

"GOTHIC" INPUT AND OUTPUT FOLLOW

H200P200
14:50:05 04-MAY-94
GOTHIC Version 4.0 - August 1993

4.4.2.2.4 "GOTHIC INPUT AND OUTPUT, CASE H3*

S-C-RC-MDC-13E8



* SEE TABLE 3.1

H200P200
14:47:35 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-1365 CASE

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1P	PORV TO PRT	115.		80					
2P	RH3 TO PRT	115.		80					

Fluid Boundary Conditions - Table 2										
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1P	1.		0.005								
2P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1P	1.							
2P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1P								
2P								

H200P200
14:47:36 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1B=B
CASE H3

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	RELIEF LINE	1	155.	0.5	1P	87.	0.22
3	RH3 TO PRT	2	97.	0.2	2P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.00843	0.22	13.	0.1	NO		-
3	0.0088	0.3	20.	0.1	NO		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	0.01	0.01	OFF
3	0.01	0.01	OFF

Cooler/Heater										
Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	C1
1H	FOUR SG HEAT	2					1.	3	LTE	
2H	ONE RCP HEAT	2					4549.		LTE	

H200P200
14:47:36 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-1355
CASE H3

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	2	1	0	1	1P
2V	RH3 VALVE	3	2		2	2P

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	4	2	0.0088

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	FOUR SG HT RATE	RCS TEMPER	HT RATE (B	2
4	RH3 STEM TRAVEL	TIME (SEC)	NORMALIZED	4

S-C-A-C-MDC-1358
CASE H3

Function 1 PORV STEM TRAVEL Ind. Var.: Time (sec) Dep. Var.: Norm. Stem Position			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function 2 PORV LOSS FACTOR Ind. Var.: Norm. Stem Position Dep. Var.: Loss Factor			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

Function 3 FOUR SG HT RATE Ind. Var.: RCS TEMPERATURE (F) Dep. Var.: HT RATE (BTU/SEC)			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
150.	646650.	250.	0.

H200P200
14:47:37 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H3

Function 4 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: NORMALIZED STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	0.8	0.8
2.1	0.55	100.	0.55

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	200.	100.	1.	0.	0.
2	380.	200.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	2.3	500.	0.01	6000.	0.

H200P200
14:47:38 04-MAY-94
GOTHIC Version 4.0 - August 1993

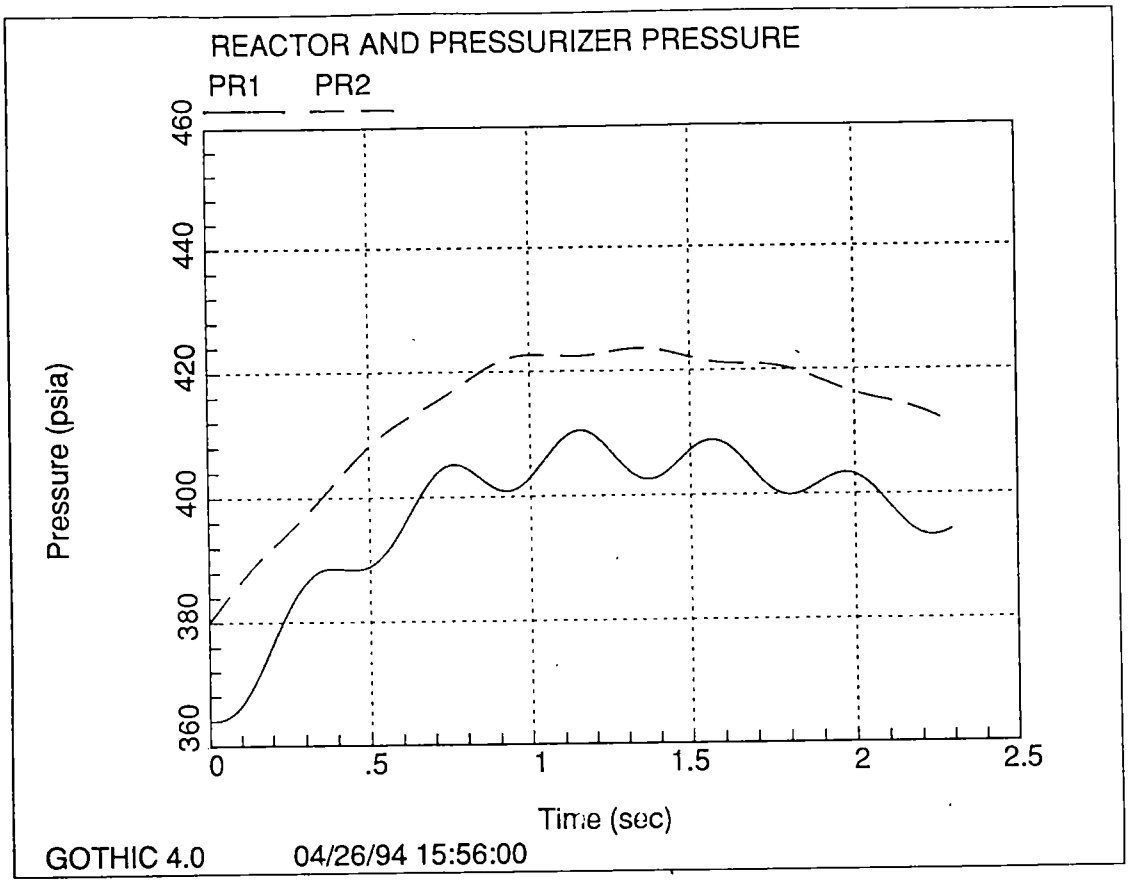
S-C-RC-MDC-1358
CASE 43

Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV AND RH3 ST		VT1V	VT2V			
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL2	FL3			

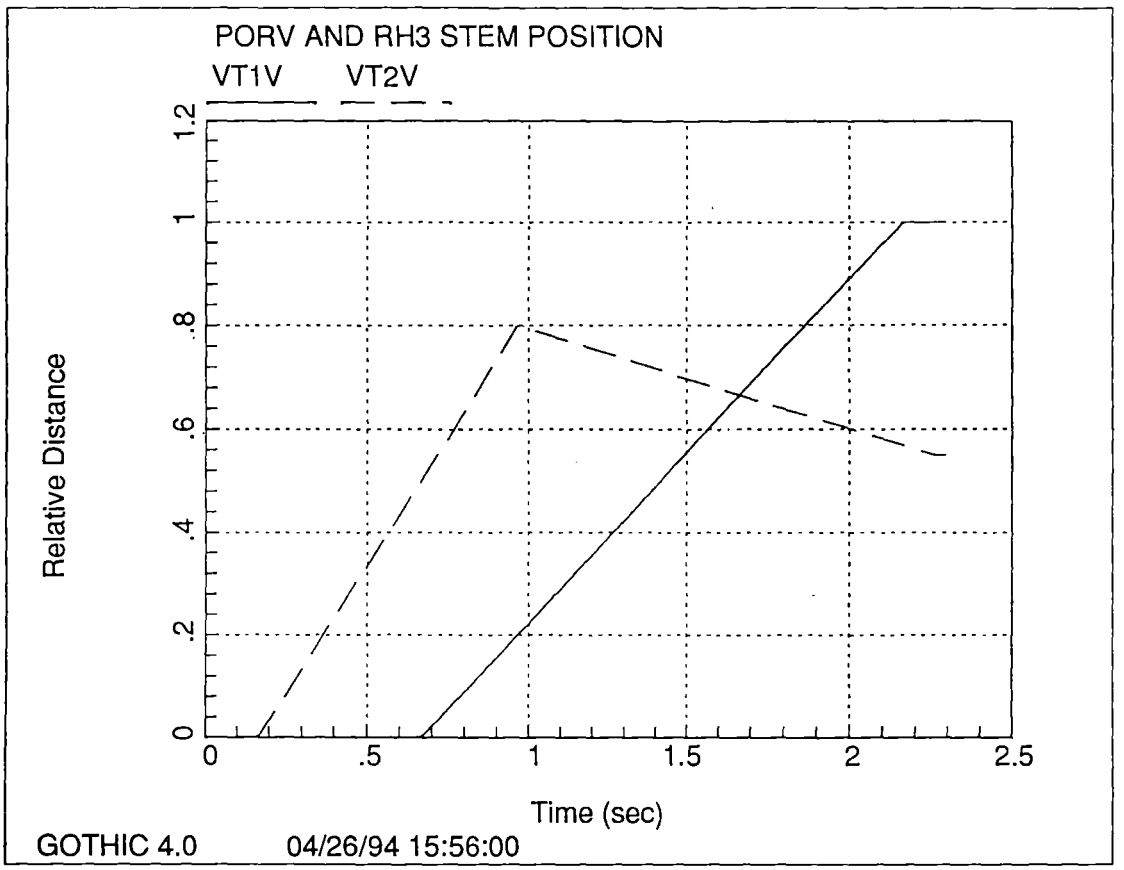
H200P200
14:50:18 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-13E8
CASE H3



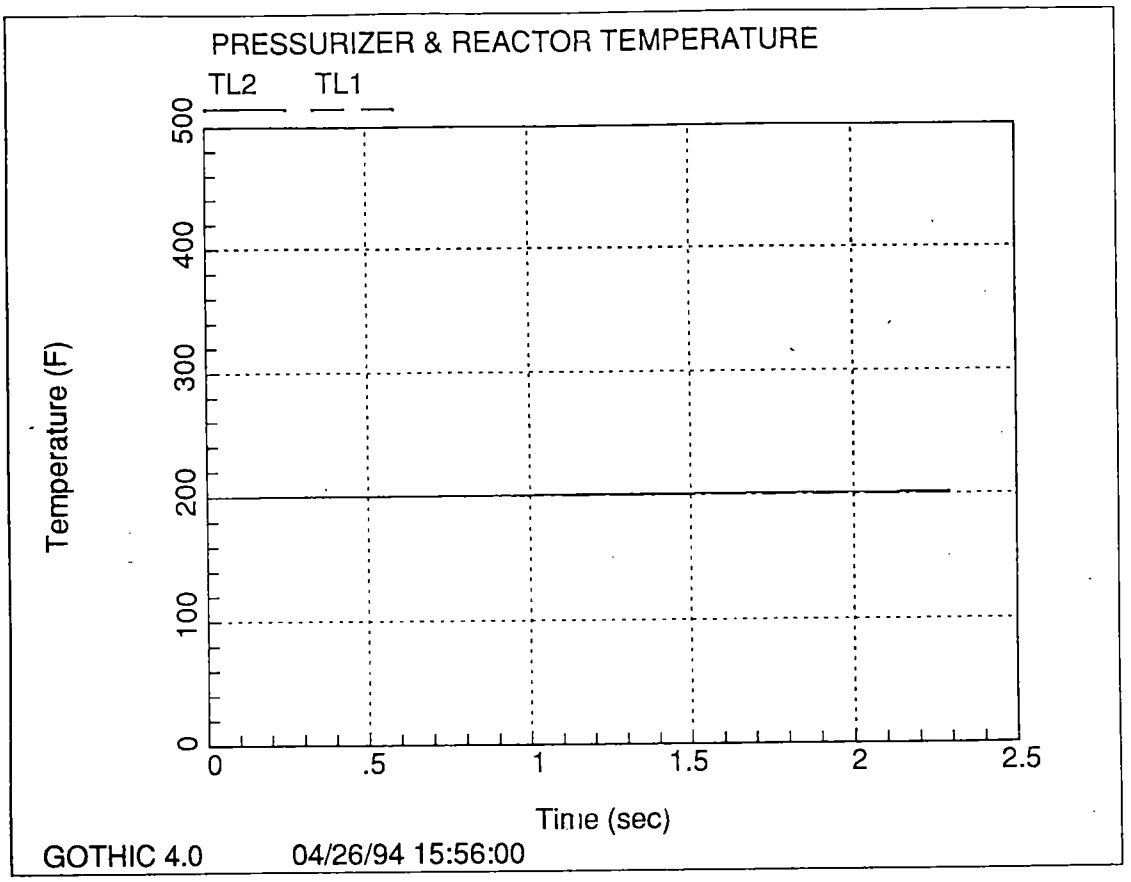
H200P200
14:50:20 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1385
CASE H3



H200P200
14:50:22 04-MAY-94
GOTHIC Version 4.0 - August 1993

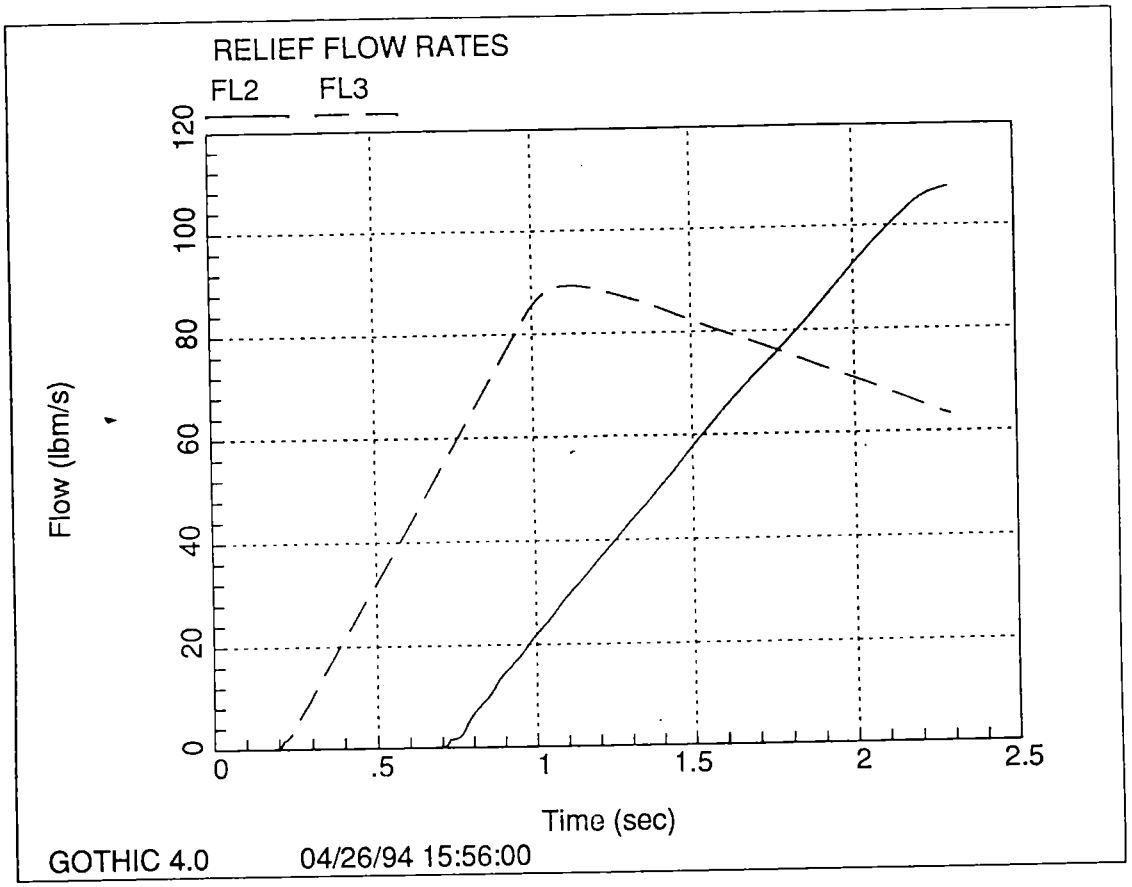
S-C-RC-MDC-1365
CASE H3



H200P200
14:50:24 04-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

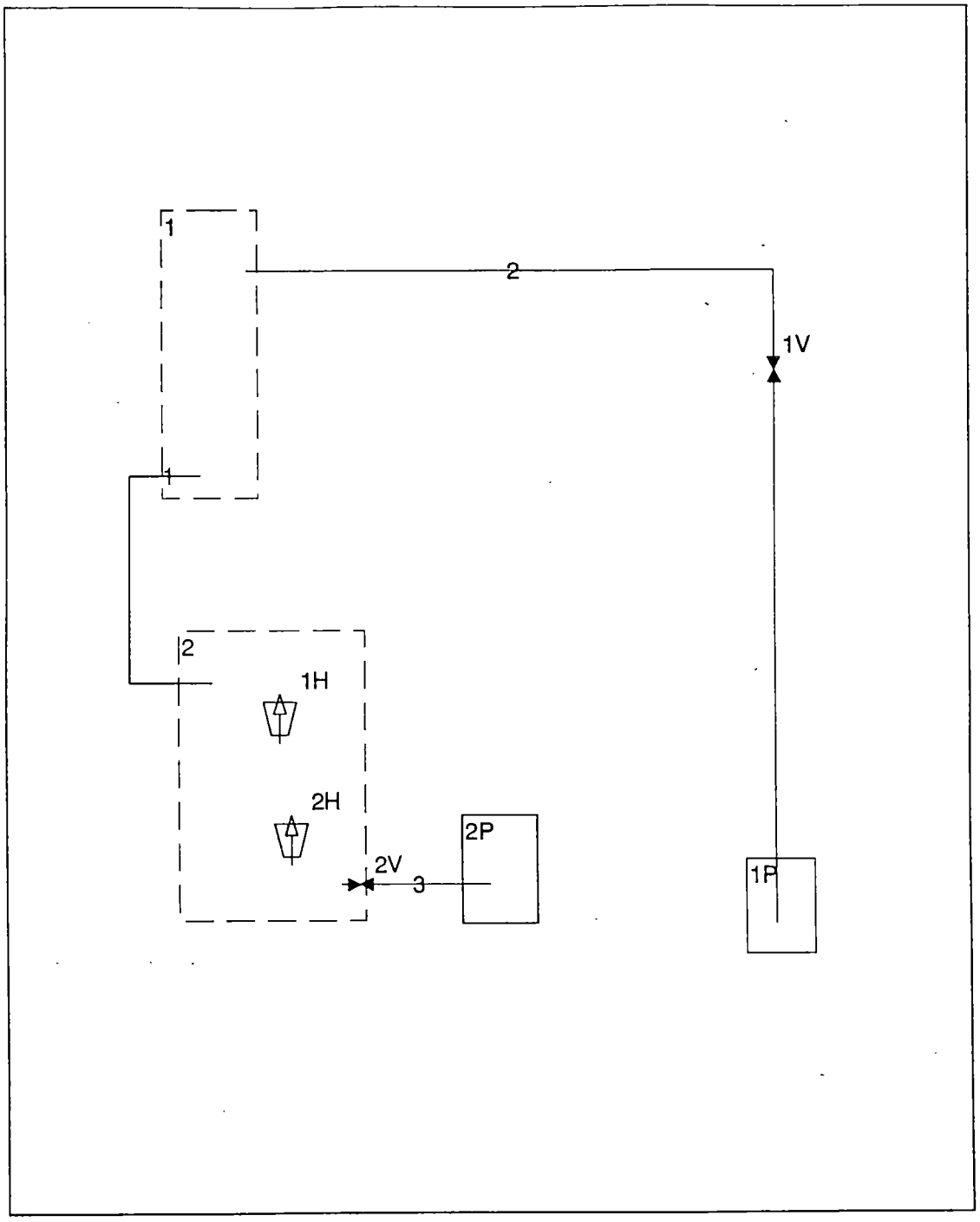
CASE H3



H200P440
13:58:24 26-APR-94
GOTHIC Version 4.0 - August 1993

4 4.2.2.5 GOTHIC INPUT AND OUTPUT, CASE H4*

S-C-PC-MDC-1EES



* SEE TABLE 3.1

H200P440
14:05:38 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358

CASE H4

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1P	PORV TO PRT	115.		80					
2P	RH3 TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1P	1.		0.005								
2P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1P	1.							
2P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1P								
2P								

S-C-RC-MDC-1358
CASE H4

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	RELIEF LINE	1	155.	0.5	1P	87.	0.22
3	RH3 TO PRT	2	97.	0.2	2P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.00843	0.22	13.	0.1	YES		-
3	0.0088	0.3	20.	0.1	NO		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	ON
3	0.01	0.01	OFF

Cooler/Heater										
Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	Ct L
1H	FOUR SG HEAT	2					1.	3	LTE	
2H	ONE RCP HEAT	2					4549.		LTE	

H200P440
14:05:39 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-1358
CASE H4

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	2	1	0	1	1P
2V	RH3 VALVE	3	2		2	2P

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	4	2	0.0088

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	FOUR SG HT RATE	RCS TEMPER	HT RATE (B	2
4	RH3 STEM TRAVEL	TIME (SEC)	NORMALIZED	4

S-C-RC-MDC-13E8
CASE H4

Function 1 PORV STEM TRAVEL Ind. Var.: Time (sec) Dep. Var.: Norm. Stem Position			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function 2 PORV LOSS FACTOR Ind. Var.: Norm. Stem Position Dep. Var.: Loss Factor			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

Function 3 FOUR SG HT RATE Ind. Var.: RCS TEMPERATURE (F) Dep. Var.: HT RATE (BTU/SEC)			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
150.	646650.	250.	0.

H200P440
14:05:39 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H4

Function 4 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: NORMALIZED STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.1	0.85
2.1	0.6	100.	0.6

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	200.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	2.3	500.	0.01	6000.	0.

H200P440
14:05:40 26-APR-94
GOTHIC Version 4.0 - August 1993

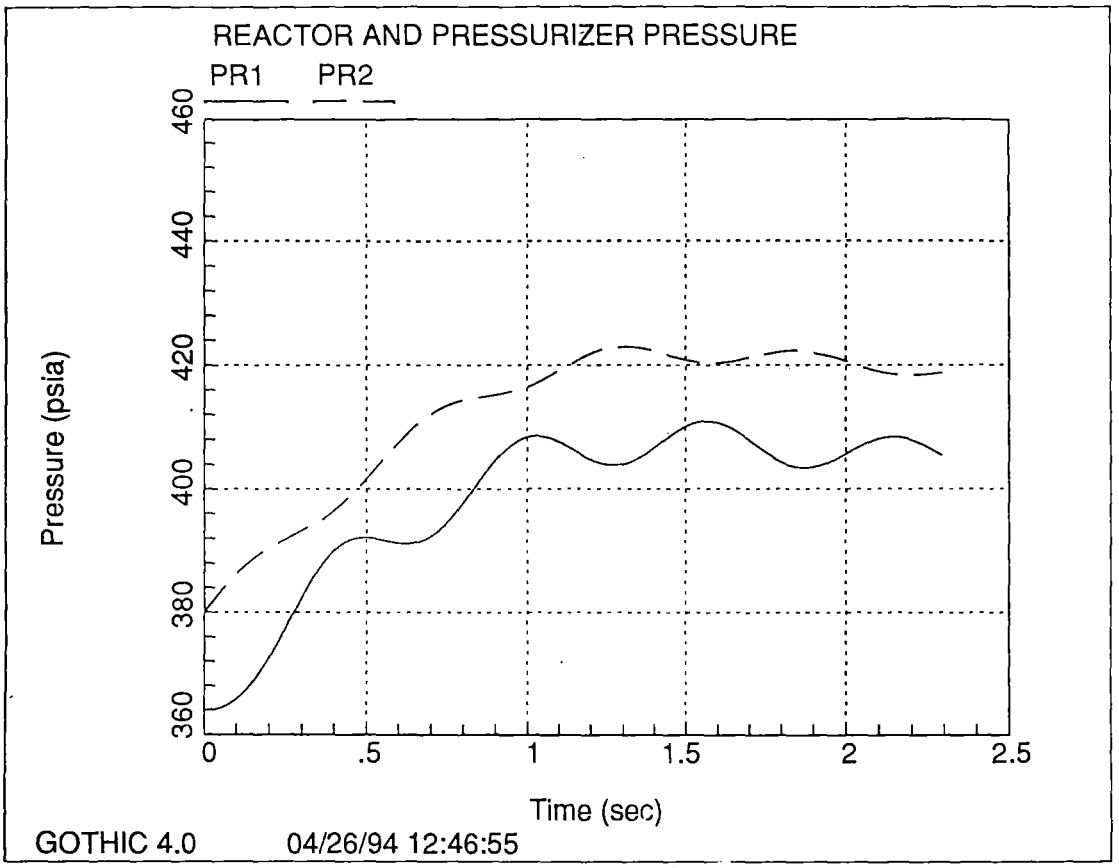
E-C-RC-MDC-1358
CASE H4

Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV AND RH3 ST		VT1V	VT2V			
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL2	FL3			

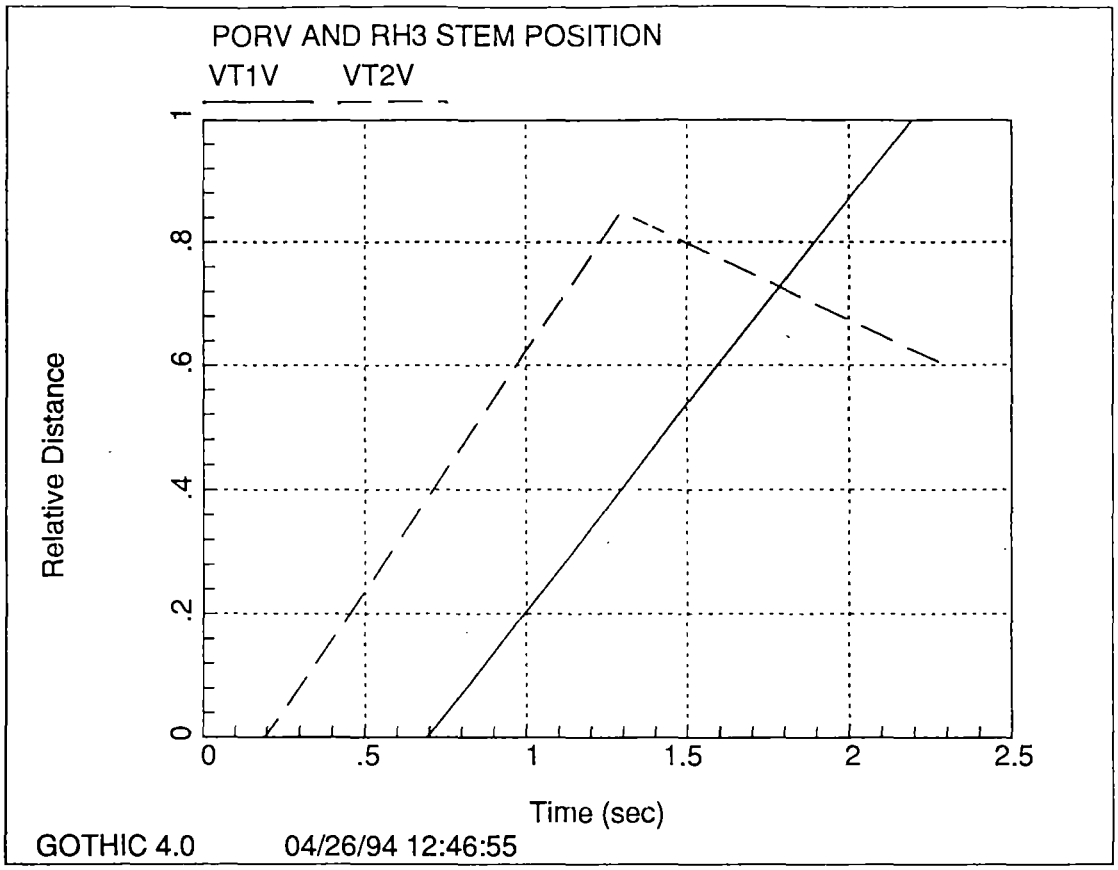
H200P440
13:57:25 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H4



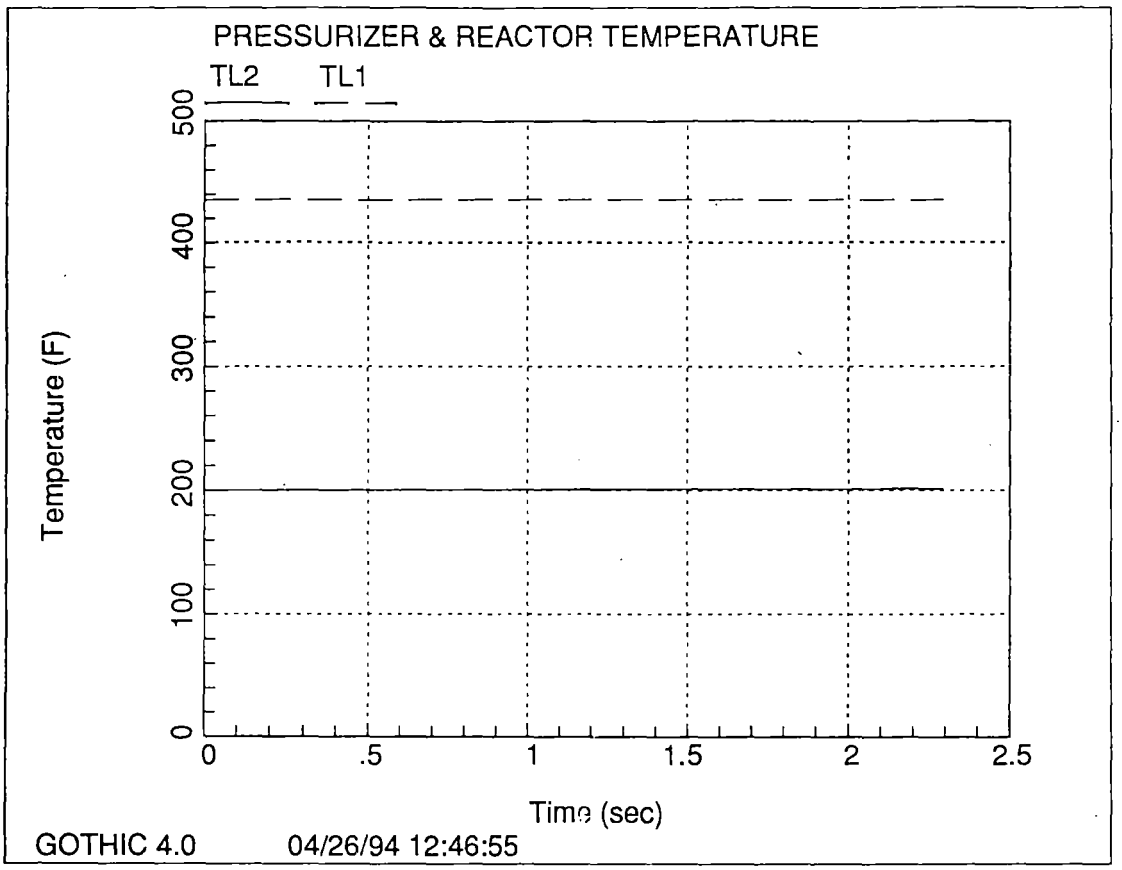
H200P440
13:57:27 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H4



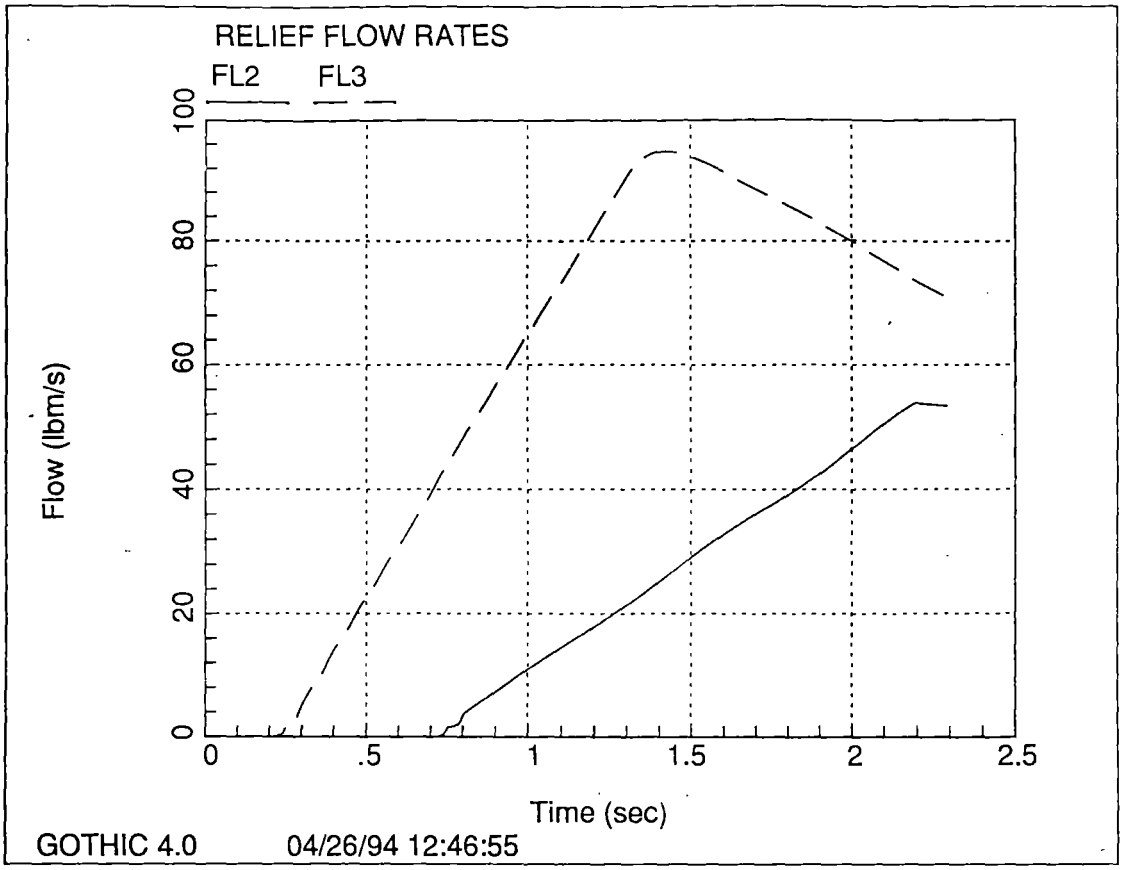
H200P440
13:57:29 26-APR-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-13E8
CASE H4



H200P440
13:57:31 26-APR-94
GOTHIC Version 4.0 - August 1993

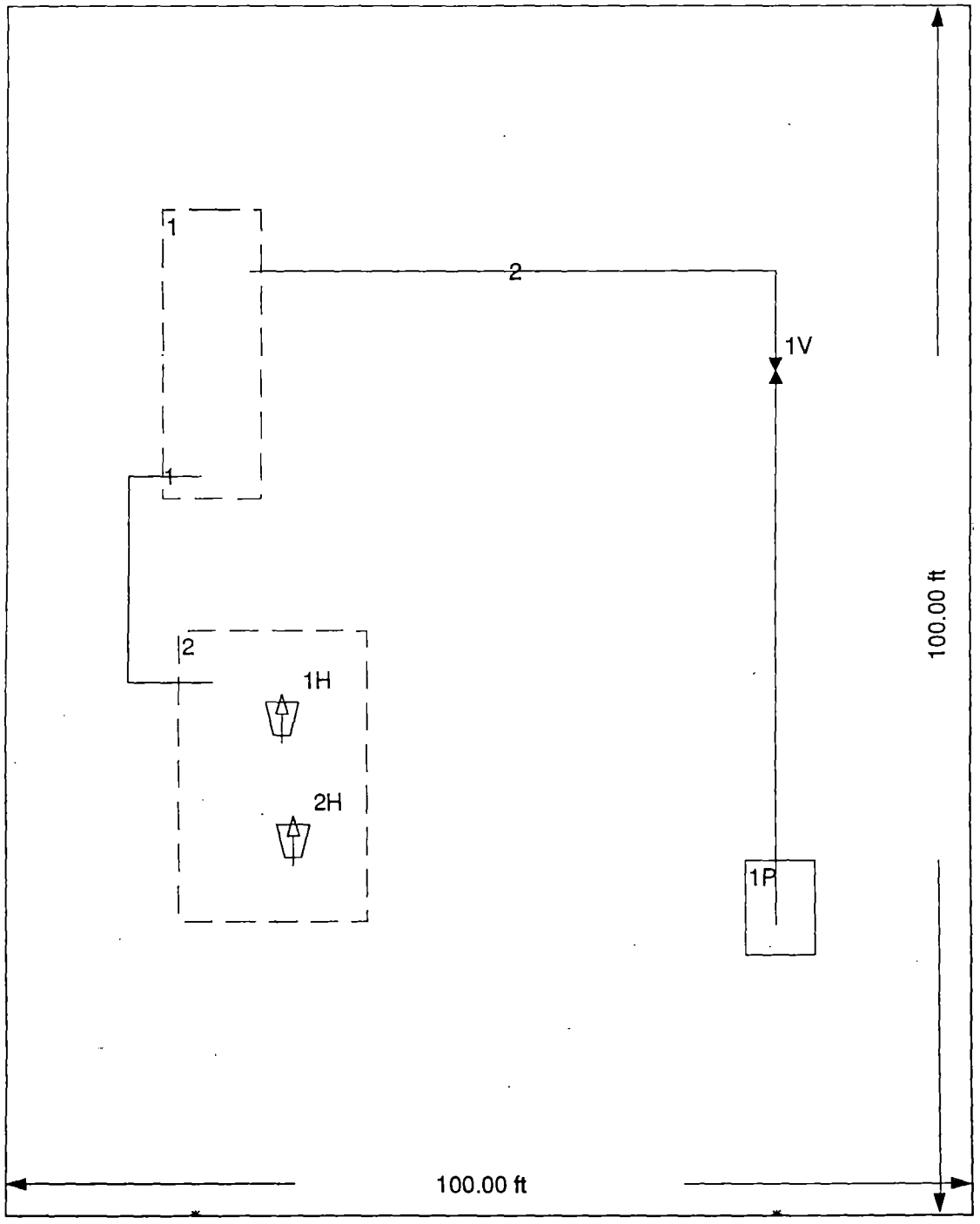
S-C-RC-MDC-1358
CASE H4



4.4.2.2.6 "GOTHIC. INPUT AND OUTPUT CASE H5

S-C-RC-MDC-1358

H20SATRF
12:53:09 18-MAY-94
GOTHIC Version 4.0 - August 1993



H20SATRF
12:50:05 18-MAY-94
GOTHIC Version 4.0 - August 1993

>-C-RC-MDC-1358

CASE H5

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1P	PORV TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1P								

S-C-RC-MDC-1358
CASE H5

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	RELIEF LINE	1	155.	0.5	1P	87.	0.22

S-C-RC-MDC-1358
CASE H5

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.01686	0.22	13.	0.1	YES		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	ON

Cooler/Heater										
Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	Ct L
1H	FOUR SG HEAT	2					1.	3	LTE	
2H	ONE RCP HEAT	2					4549.		LTE	

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	2	1	0	1	1P

S-C-RC-MDC-1358
CASE H5

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.01686
2	TIME OPEN	4	2	0.0088

S-C-RC-MDC-1358
CASE H5

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	FOUR SG HT RATE	RCS TEMPER	HT RATE (B	2
4	RH3 STEM TRAVEL	TIME (SEC)	NORMALIZED	4

Function
1
PORV STEM TRAVEL
Ind. Var.: Time (sec)
Dep. Var.: Norm. Stem Position

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function
2
PORV LOSS FACTOR
Ind. Var.: Norm. Stem Position
Dep. Var.: Loss Factor

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

H2OSATRF
12:50:07 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE #5

Function 3 FOUR SG HT RATE Ind. Var.: RCS TEMPERATURE (F) Dep. Var.: HT RATE (BTU/SEC)			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
150.	646650.	250.	0.

Function 4 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: NORMALIZED STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0. 2.1	0. 0.6	1.1 100.	0.85 0.6

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	200.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

H2OSATRF
12:50:07 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H5

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.002	1.	3.	500.	0.01	6000.	0.

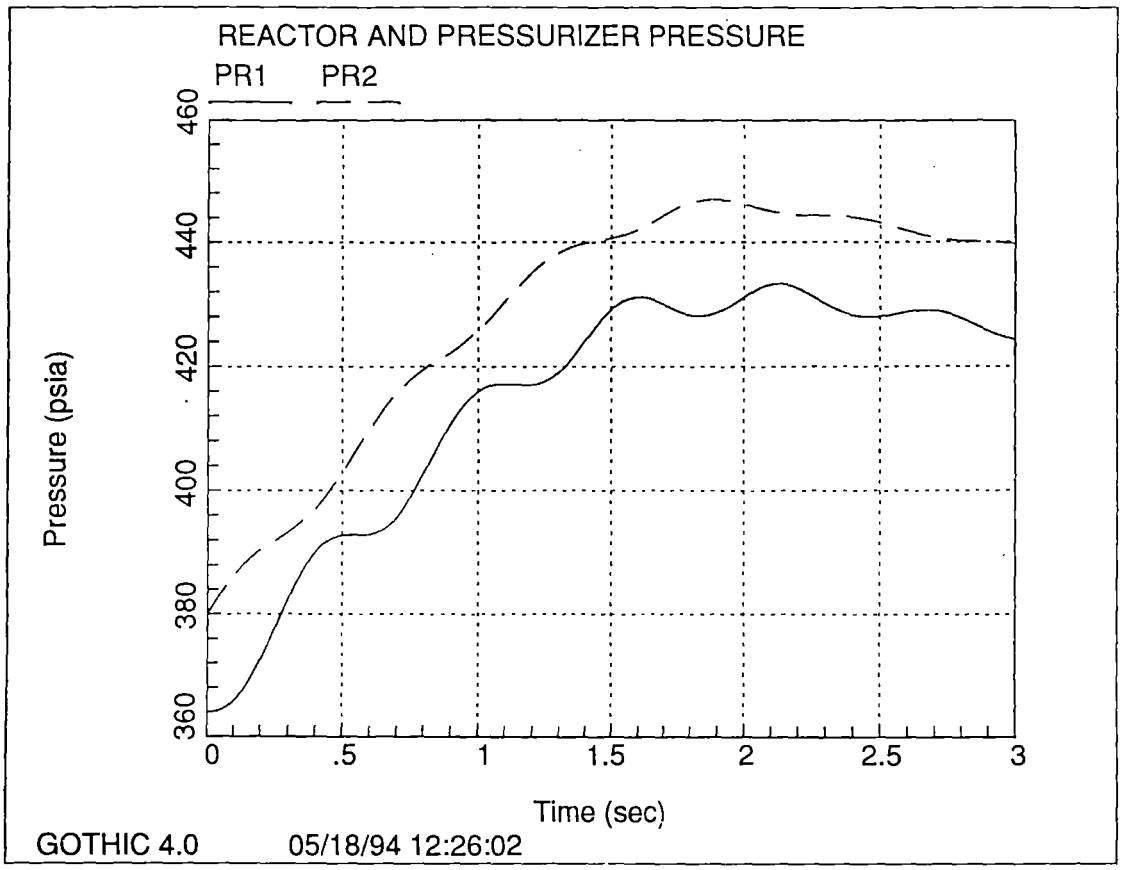
Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	REACTOR AND PRE		PR1	PR2			
2	PORV STEM POSIT		VT1V				
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL2				

S-C-RC-MDC-1358

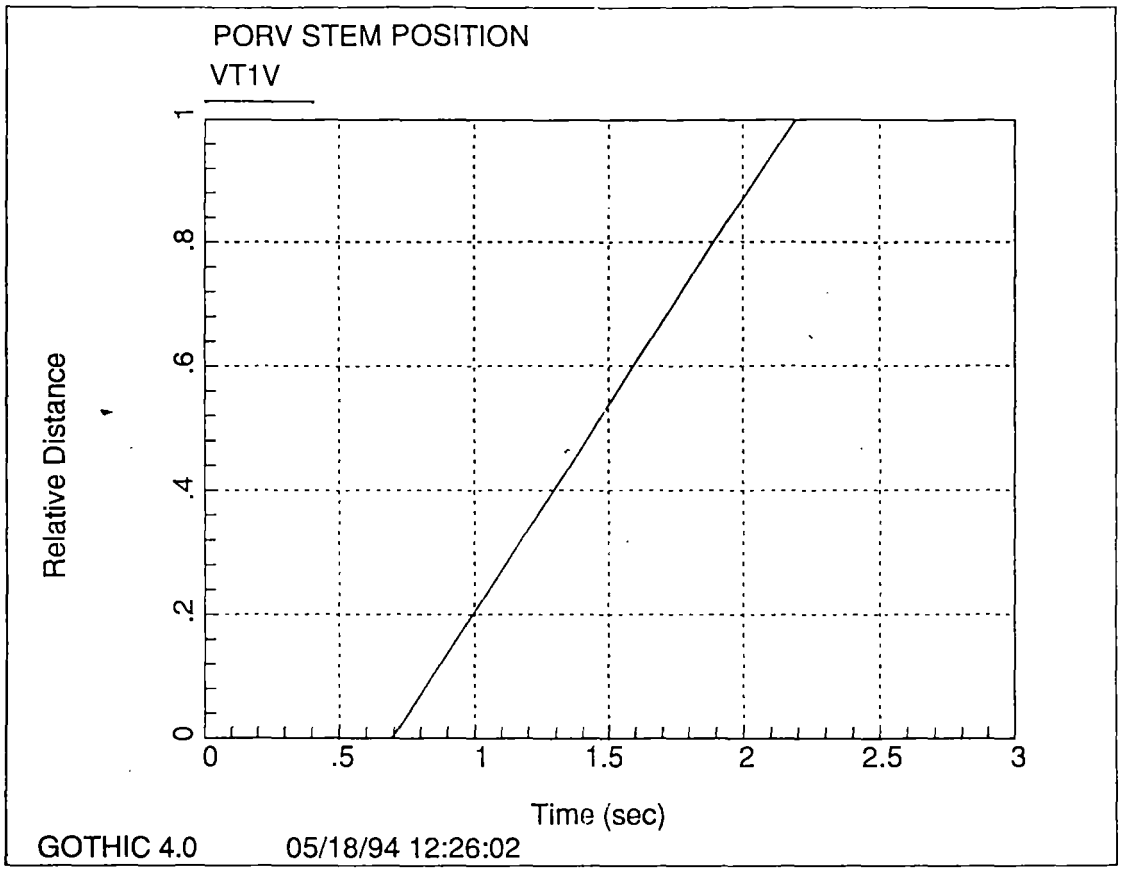
CASE H5

H20SATRF
12:53:25 18-MAY-94
GOTHIC Version 4.0 - August 1993



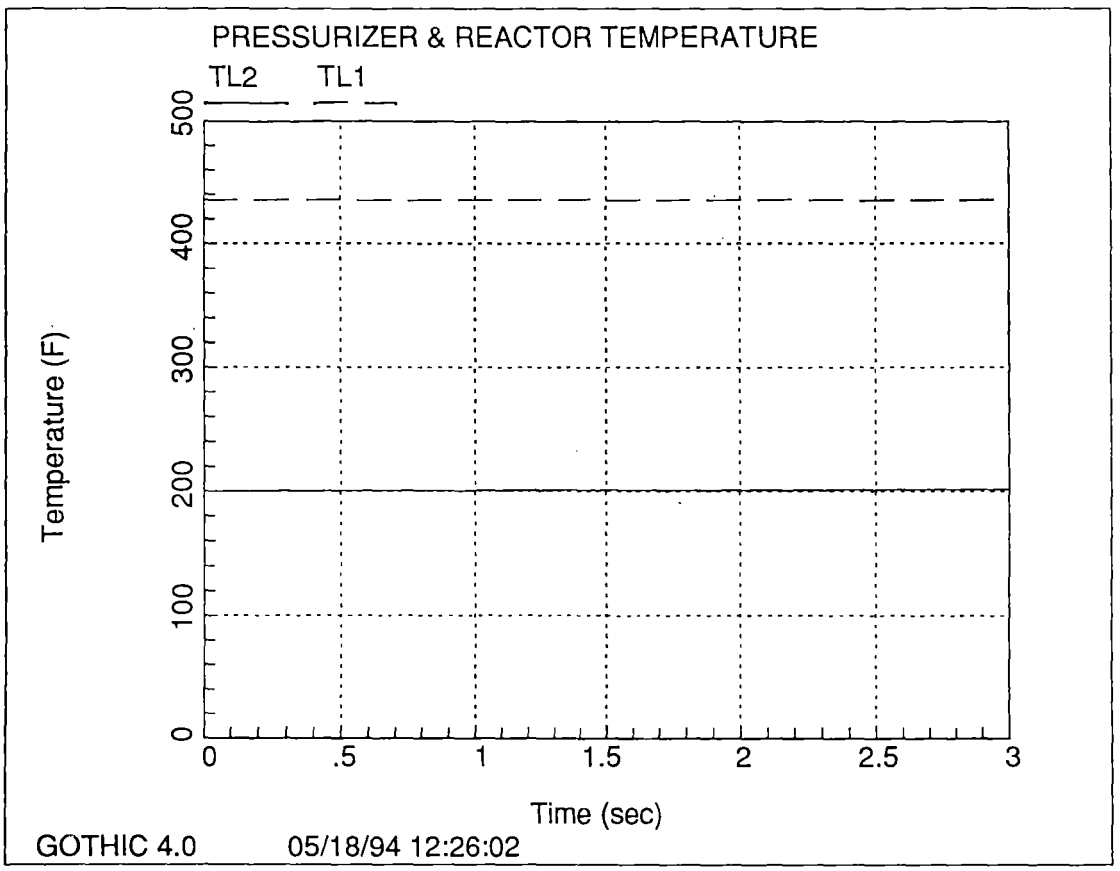
H20SATRF
12:53:28 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H5



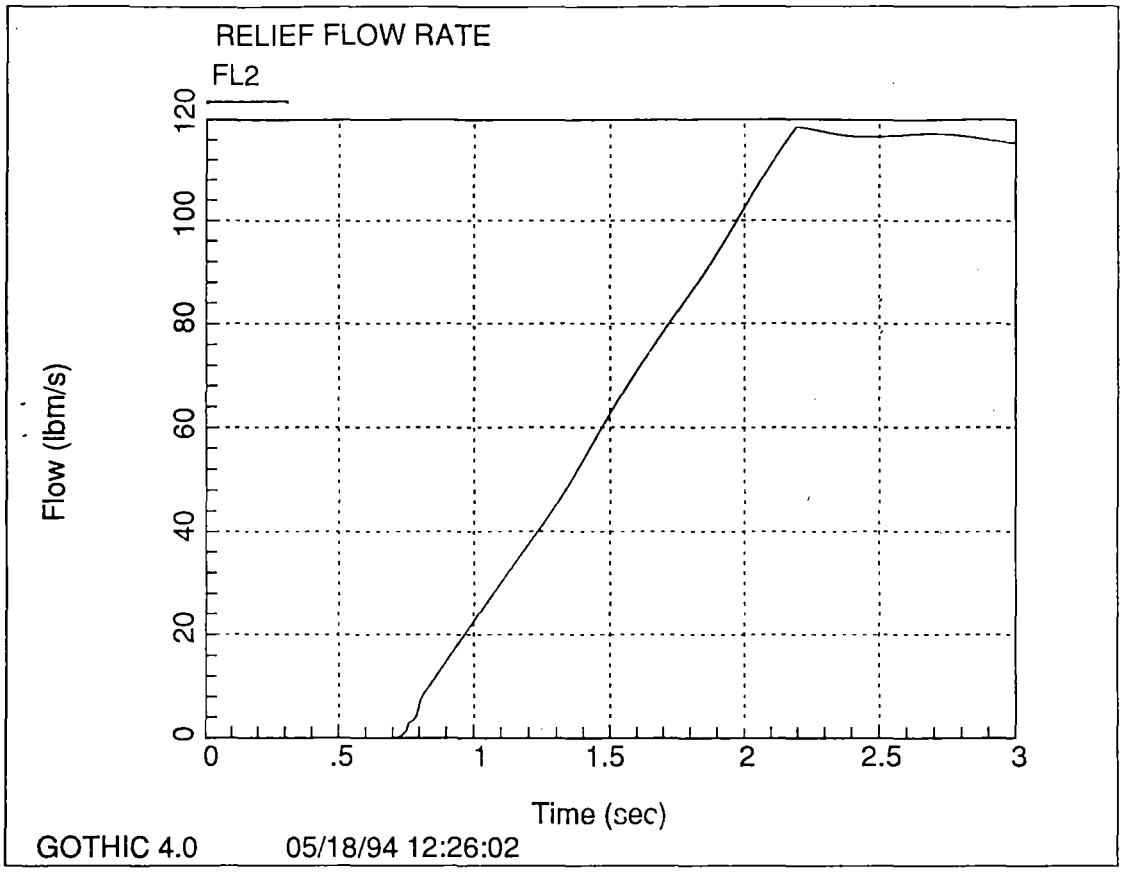
H20SATRF
12:53:29 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE #5



H20SATRF
12:53:32 18-MAY-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1358
CASE H5



5. RESULTS:

IN SECTION 3 OF THIS CALCULATION, EIGHT DIFFERENT CASES WERE CONSIDERED. THESE CASES ARE LISTED IN TABLE 3.1. TABLE 5.1 SHOWS THE PEAK REACTOR PRESSURE CALCULATED IN SECTION 3. IN THE CALCULATIONS DONE SO FAR THE EFFECT OF RCP OPERATION AND THE HYDROSTATIC EFFECT ON RPV BELT LINE PRESSURE WERE NOT CONSIDERED. THIS EFFECT HAS BEEN ACCOUNTED FOR BY ADDING AN ADDITIONAL PRESSURE TO THE CALCULATED PRESSURE. NOTE THAT THE CALCULATED PRESSURE IS AT 97 ft. ELEVATION.

ACCORDING TO WESTINGHOUSE LETTER PSE-93-707* (DT. SEP 29, 1993) THE FOLLOWING PRESSURES MUST BE ADDED TO THE CALCULATED PRESSURE.

NO. OF RCP'S RUNNING	ADDITIONAL PRESSURE* (psid)
1	31
2	39
4	73

* 2 PSI WAS ADDED TO WESTINGHOUSE NUMBERS. THE EXPLANATION IS GIVEN IN REF. 6. (THE PRESSURE SHOWN ABOVE = WESTINGHOUSE PRESSURE + 2 PSI).

TABLE 5.1
PEAK PRESSURES AT PRESSURE TRANSMITTER TAP AND AT THE RPV CRITICAL WELD LOCATION

CASE I.D	LTOP EVENT TYPE	INITIAL RCS TEMP. (F)	INITIAL PRESSURIZER TEMP. (F)	SINGLE FAILURE	PEAK RCS PRESSURE AT PRESSURE TRANSMITTER LOCATION (PSIA)	PEAK PRESSURE AT RPV CRITICAL WELD LOCATION (PSIA)		
						1 RCP OPERATION	2 RCP OPERATION	4 RCP OPERATION
M1	MASS INPUT	70	437	PORV	416	447	455	489
M2	"	70	70	PORV	414	445	453	489
M3	"	70	437	RH3	426	457	465 (both)	500
H1	HEAT INPUT	150	437	PORV	416	447	NA	NA
H2	"	150	437	RH3	428	459	N.A.	N.A.
H3	"	200	200	PORV	424	455	N.A.	N.A.
H4	"	200	437	PORV	424	455	N.A.	N.A.
H5	"	200	437	RH3	448	479 (465/PT)	N.A. (450)	N.A

Tech Spec say 2 PORVs 1 PORV

2 PORVs & RH3 - okay w/a single failure

(1) 2 PORVs or

1 PORV & RH3

6. REFERENCES

1. PRESSURE MITIGATION SYSTEM TRANSIENT ANALYSIS RESULTS, PREPARED BY WESTINGHOUSE JULY 1977.
2. SUPPLEMENT TO THE JULY 1977 REPORT OF REF. 1. SEPT. 1977
3. PSE&G CALC SGS/M-DM-042 DATE SEPT 1, 1977 "REACTOR COOLANT SYSTEM OVERPRESSURIZATION."
4. SALEM 1 TECH SPEC SECTION 4.4.9.3.1.d, SPEC. 4.0.5
5. SALEM 2 TECH SPEC SECTION 4.4.10.3.1.d SPEC 4.0.5
6. PSE&G INTERNAL MEMORANDUM NO. MEC-93-917 DT. DEC. 30, 1993; FROM HOWARD BEFFICI TO F. SCHNARR.
7. REVISED RH3 VALVE SPEC. (ATTACHMENT 1 OF THIS CALCULATION).

7. ATTACHMENT 1. S-C-PC-MDC-1285

PSE&G

NE-87-3567

Public Service Electric and Gas Company P.O. Box 236 Hancocks Bridge, New Jersey 08038

Nuclear Department

April 10, 1987

To: AHR

Crosby Valve Company
43 Kendrick Street
P.O. Box 308
Wrentham, MA 02093

ATTN: Mr. S. Shivers

Dear Mr. Shivers:

PSE&G P.O. NO. P1-146795
CROSBY FACTORY ORDER NO. N-70631
SALEM GENERATING STATION

Per your conversation of April 1, 1987 with Mr. Hawkins please find attached the revised data sheet which will allow Crosby to initiate a new DS-C drawing and applicable valve assembly number for existing valve assembly H-53237, for which the spring pressure setting has been changed to 375 psig.

The following spring and washer information may be of value in assigning the new spring and washer part numbers.

PSE&G Purchase Order No. 901850, Spring P/N 460, Washer P/N 86698.

Sincerely,

R. L. Gura
Manager - Engineering

RDH:cdc

Attachment

C A. Rollo - Crosby Valve and Gage Company
E&PB Controls Records Center

eg5

FORM 58897A

S-C-RC-MDC-1358

WPI

PAGE REV. NO. 4 ISSUED 12/17/70

~~ENG 27, NOTES~~
~~REV. 2 - LINES 23, 24~~
REV. 3 - LINES 26, 27
REV. 4 - LINES 23, 24, 31, 32, 35

NUCLEAR POWER PLANT COMPONENTS
DESIGN SPECIFICATION DATA SHEET
SALEM GENERATING STATION
NO. 1 & 2 UNITS

AUXILIARY RELIEF VALVES
SYSTEM RHR

MULTI PROJECT

VALVE TAG NOS.

E - SPEC. NO. 676257

SPEC. SHEET NO. 1 OF 1

1	BODY MATERIAL	A351 CF8M	SS	19	SERVICE CONDITIONS FLUID | RADIOACTIVITY		H2O | YES
2	SIZE INLET	OUTLET	3 | 4	20	REQUIRED CAPACITY & UNITS	GPM	840
3	USAS PRESS. RATING INLET	OUTLET	600 | 150	21	MOL. WT. OR SP. GR. @ F.T.		
4	END CONNECTION TYPE		FLDG	22	VISCOSITY @ F.T.		
5	ORIFICE DESIGNATION	*	L	23	PRESS. PSIG. NORM. | RELIEVING	PSIG	350 | 375
6				24	TEMP °F NORM. | RELIEVING	°F	350 | 400
	TRIM MATERIAL			25	CONSTANT BACK PRESSURE	PSIG	3
7	SEAT & DISC.		**	26	DEVELOPED BACK PRESSURE	PSIG	50
8	GUIDE & RING(S)		**	27	SPRING SET PRESSURE	PSIG	375
9	SPRING		**	28	OVERPRESSURE - %		10
10				29			
	ACCESSORIES			30			
11	CAP & NO LEVER				ORIFICE AREA		
12	LEVER PLAIN	PACKED	NO | NO	31	CALCULATED SQ. INS.	*	2.853
13	GAG		**	32	SELECTED SQ. INS.	*	2.853
14	BALANCED BELLOWS		YES	33	MANUFACTURER	*	CROSBY
15	OTHERS			34	MFG'S ASS'Y DWG. NO.	*	H-[illegible]
	BASIS OF SELECTION			35	OUTLINE DWG. NO.	*	H-53937
16	CODE		**	36	IDENTIFICATION NUMBER		3-RV8[illegible]LW
17	OTHER			37			
18				38	SPECIAL REQUIREMENTS		
				39			
				40	ADDITIONAL INFORMATION		DA-13

117339

NOTES

ACCORDING TO ALAN ROLLO OF CROSBY VALVE, THE DESIGN EXTERNAL PRESSURE FOR THE BELLOWS IS 170 psig.

VIJAY CHANDRA
08 JUNE 1994

FORM NC.DE-AP.ZZ-0010-1

CERTIFICATION FOR DESIGN VERIFICATION

REFERENCE DOCUMENT NO. /REV. S-C-RC-MDC-1358

COMMENTS	RESOLUTION	
ALL COMMENTS HAVE BEEN PROVIDED IN DRAFT AND HAVE BEEN RESOLVED.	N/A	N/A.
R Pande 6-7-94 SUBMITTED BY DATE	RESOLVED BY DATE	Acceptance of Resolution

Page ___ of ___

FORM NC.DE-AP.ZZ-0010-1

CERTIFICATION FOR DESIGN VERIFICATION

Reference No. S-C-RC-MDC-1358

SUMMARY STATEMENT

CALCULATION S-C-RC-MDC-1358 WAS PERFORMED TO DETERMINE THE REACTOR BELT-LINE PEAK PRESSURE BY CALCULATING THE RCS PRESSURE AT THE LOCATION OF THE TRANSMITTER. THIS CALCULATION WAS PERFORMED USING GOTHIC COMPUTER CODE. FOR THE LOW TEMPERATURE OVER PRESSURE (LTOP) EVENT, EIGHT SEPARATE CASES (3 MASS AND 5 TEMPERATURE) WERE CONSIDERED. FAILURES OF PORV AND THE RHR SYSTEM RELIEF VALVES WERE CONSIDERED FOR VARIOUS CONDITIONS OF PRESSURE AND TEMPERATURE FOR THE PRESSURIZER AND THE REACTOR.

EFFECTIVE AREAS OF VALVES WERE CALCULATED UTILIZING PIPING AND VALVE GEOMETRY. A TABLE CO-RELATING STEM POSITION VS LOSS FACTOR WAS DEVELOPED FOR THE VALVES USING THEIR RESPECTIVE EFFECTIVE AREAS. THE NATURAL HEAT TRANSFER CO-EFFICIENT BETWEEN SECONDARY AND PRIMARY SIDE WAS OBTAINED FROM A WESTINGHOUSE REPORT.

SEE CONTINUATION SHEET

The undersigned hereby certifies that the design verification for the subject document has been completed, the questions from the generic checklist have been reviewed and addressed as appropriate, and all comments have been adequately incorporated.

H. BERRICK	Rajendra P. Pande / 6/8/94
Design Verifier Assigned By	**Signature of Design Verifier / Date**
Design Verifier Assigned By	**Signature of Design Verifier / Date**
Design Verifier Assigned By	**Signature of Design Verifier / Date**
Design Verifier Assigned By	**Signature of Design Verifier / Date**

FORM NC.DE-AP.ZZ-0010-1

CERTIFICATION FOR DESIGN VERIFICATION

CONTINUATION

INPUTS USED FOR GOTHIC COMPUTER PROGRAM SUCH AS FLOW RATE, FLOW AREA, LINE SIZES, SYSTEM PRESSURES AND TEMPERATURES ETC. WERE VERIFIED. THE SYSTEM CURVE FOR THE PRESSURE DEPENDANT STEM POSITION OF THE RH3 RELIEF VALVE, WHICH WAS DEVELOPED USING ITERATIVE PROCESS WAS ALSO VERIFIED. CO-RELATION BETWEEN PRESSURE AND MASS FLOW RATE ON THE OUTPUT GRAPHS WERE VERIFIED USING HAND CALCULATION.

THE OUTPUT OF GOTHIC APPEARS CONSISTENT WITH THE INPUT VALUES USED. ASSUMPTIONS USED IN THE CALCULATION FOR THE HEAT INPUT TO THE PRIMARY SIDE, ON RESISTANCE OF TUBEWALL AND THE FORCED CONVECTION, ARE CONSERVATIVE.

Cover Sheet
Page 1 of 35

CALCULATION COVER SHEET INSTRUCTIONS

CALC. NO.: S-C-RC-MDC-1413 REVISION: 0

CALC. TITLE: LTOP EVENTS WITH ONE PORV

SHTS.(CALC): 37 ATTACHMENTS: #/TOTAL SHTS.: — TOTAL SHTS.: 35

CHECK ONE:
☐ INTERIM (Proposed Plant Change) ☐ VOID

☒ FINAL (Supports Installed Condition)

DESCRIPTION OF CALCULATION REVISION (IF APPL.): N/A

REASON FOR CALCULATION REVISION (IF APPL.): N/A.

HOPE CREEK	☐Q	☐Qs	☐Qsh	☐F	☐R	☒N/A
Q - LIST (SALEM) ?		☒ YES		☐ NO		
IMPORTANT TO SAFETY ?		☒ YES		☐ NO		
FUTURE CONFIRMATION REQUIRED ?		☐ YES		☒ NO	If YES list page No(s).	

OTHER DOCUMENTS AFFECTED? (CBDs, FSAR, etc.): None

ORIGINATOR/COMPANY NAME: VIJAY CHANDRA / PSE&G — Date: 16 DEC 1994

PEER REVIEWER/COMPANY NAME: Gita Narasimhan — Date: 12/16/94

VERIFIER/COMPANY NAME: Rajendra P. Pande — Date: 12/16/94

REVIEWED: N/A
Contractor Supervisor (as applicable) — Date

APPROVED: Howard G. Scmidt
PSE&G Supervisor (Req'd) — Date: 12/16/94

If the calculation is either Q-List, Q, Qs, Qsh, F, R, or Important to Safety "YES", completion of the Certification for Design Verification (Form NC.DE-AP.ZZ-0010-1) is required.

TABLE OF CONTENTS

1. INTRODUCTION:

VARIOUS LTOP EVENTS AND THEIR MITIGATION WAS STUDIED IN PSE&G CALCULATION S-C-RC-MDC-1388 [Ref. 1]. FOR EACH EVENT, THE PEAK REACTOR PRESSURE WAS CALCULATED. IN REF [1] TRANSIENTS, EITHER TWO PORV'S OR ONE PORV AND RH3 COMBINATION WAS AVAILABLE TO RELIEVE PRESSURE. THE UNAVAILBLE VALVE WAS CONSIDERED TO HAVE FAILED (SINGLE ACTIVE FAILURE CRITERION).

HOWEVER, ACCORDING TO SALEM 1 TECH SPEC PAGE B 3/4 4-11 AMENDMENT NO. 108 AND SALEM 2 TECH. SPEC. PAGE B 3/4 4-12 AMENDMENT NO 86, EITHER PCPS HAS ADEQUATE RELIEVING CAPACITY TO PROTECT THE RCS FROM OVERPRESSURIZATION WHEN THE TRANSIENT IS LIMITED TO EITHER (1) THE START OF AN IDLE RCP WITH THE SECONDARY WATER TEMPERATURE OF THE STEAM GENERATOR LESS THAN OR EQUAL TO 50F ABOVE THE RCS COLD LEG TEMPERATURE, OR (2) THE START OF SAFETY INJECTION PUMP AND ITS INJECTION INTO A WATER SOLID RCS. IN OTHER WORDS, AT THIS TIME, WE ARE NOT PERMITTED TO TAKE CREDIT FOR PRESSURE RELIEVING CAPABILITY OF RH3 VALVE.

THEREFORE CERTAIN TRANSIENTS WILL BE CONSIDERED WITHOUT TAKING CREDIT FOR THE PRESSURE RELIEVING CAPABILITY OF RH3 VALVE.

THE FOLLOWING TWO CASES HAVE BEEN CONSIDERED.

M4. INADVERTANT ACTUATION OF A CHARGING PUMP.

M5. SAFETY INJECTION SIGNAL STARTS ONE CHARGING PUMP, LETDOWN FLOW IS ISOLATED AND THE POSITIVE DISPLACEMENT PUMP CONTINUES TO RUN.

IN EACH OF THESE TRANSIENTS, ONLY ONE PORV IS AVAILABLE TO RELIEVE THE PRESSURE.

THE INITIAL CONDITIONS, GEOMETRICAL DETAILS, SYSTEM DESCRIPTION, METHOD OF ANALYSIS ARE ALL DESCRIBED IN DETAIL IN CALCULATION S-C-RC-MDC-1358 [Ref. 1]. THE PRESENT CALCULATION SHOULD BE TREATED AS AN ADDENDUM TO REF [1]. TABLE 1.1 SHOWS THE THE DETAILS OF TRANSIENTS.

TABLE 1.1
DESCRIPTION OF MASS INPUT TRANSIENTS

CASE I.D.	INITIAL CONDITIONS				INADVERTENT ACTION	RELIEF VALVES AVAILABLE (SET POINT = 375 PSIG)
	REACTOR PRESSURE (PSIA)	REACTOR TEMP. (F)	PRESSURIZER TEMP.	PRESSURIZER LIQUID VOL. FRACTION		
M4	380	70	SAT.	1	START OF A CHARGING PUMP	1 PORV
M5	380	70	SAT.	1	S.I. WITH LETDOWN ISOLATION	1 PORV

2. ANALYSIS

GOTHIC COMPUTER PROGRAM INPUT AND OUTPUT ARE PRESENTED IN THIS SECTION. CASES M4 AND M5 HAVE BEEN ANALYZED.

2.1 CASE M4: INADVERTENT START OF A CENTRIFUGAL CHARGING PUMP.

THE MAXIMUM FLOW RATE THRUGH A CHARGING PUMP IS 560 GPM Ref. [2]. ALTHOUGH ALL THE FLOW DOES NOT GO TO THE RCS, AN INJECTION FLOW OF 560 GPM WILL BE USED. BESIDES 560 GPM IS THE CHARGING PUMP FLOW WHEN THE REACTOR IS AT ATMOSPHERIC PRESSURE. DURING AN LTOP EVENT, THE PEAK REACTOR PRESSURE IS OF THE ORDER OF 450 psia. UNDER THESE CONDITIONS THE INJECTION FLOW RATE WILL BE LESS THAN 560 GPM.

560 GPM OF 70F = 77.78 lbm/S.

THE GOTHIC INPUT AND OUTPUT ARE GIVEN IN THE FOLLOWING PAGES.

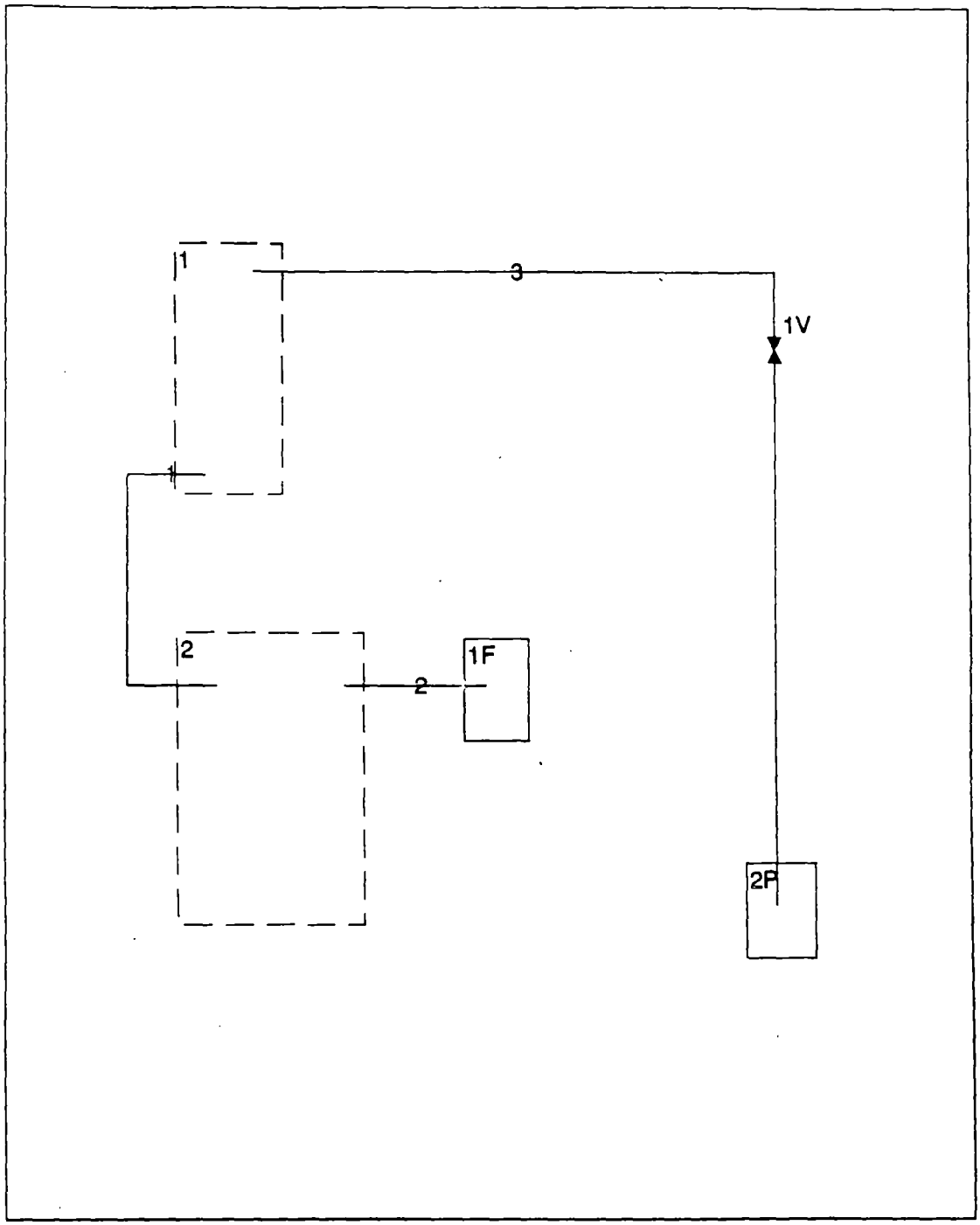
THE PRESSURES CALCULATED USING GOTHIC DO NOT ACCOUNT FOR RCP EFFECT. THIS EFFECT HAS BEEN ADDED TO CALCULATED PEAK PRESSURE. THE EFFECT OF ONE RCP OPERATION AND ELEVATION DIFFERENCE BETWEEN TRANSMITTER LOCATION AND CRITICAL WELD = 31 psi. [Ref 1]

S-C-RC-MDC-14.3

6/25

V1SAT560
08:31:16 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE M4



V1SAT560
08:33:40 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-1412 T/35

CASE M4

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1F	SI INJEC. FLOW	400.		70		77.78			
2P	PORV TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1F	1.		1.								
2P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1F	1.							
2P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1F								
2P								

V1SAT560
08:33:41 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-1413

CASE M4

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	SI LINE	2	97.	0.2	1F	97.	0.2
3	RELIEF LINE	1	155.	0.5	2P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.1	0.2	10.	10.	NO		-
3	0.00843	0.22	13.	0.1	YES		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	OFF
3	0.01	0.01	ON

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	3	1	0	1	2P

CASE M4

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	3	2	0.0088

V1SAT560
08:33:41 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1413

175

CASE M4

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	0		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	RH3 STEM TRAVEL	TIME (SEC)	RH3 STEM T	3

Function
1
PORV STEM TRAVEL
Ind. Var.: Time (sec)
Dep. Var.: Norm. Stem Position

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function
2
PORV LOSS FACTOR
Ind. Var.: Norm. Stem Position
Dep. Var.: Loss Factor

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

S-C-RC-MDC-1413

125

CASE M4

Function 3 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: RH3 STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0. 100.	0. 0.586	1.2	0.586

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	70.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.01	1.	5.	500.	0.05	10000	0.
2	0.000	0.05	1.	10.	500.	0.05	10000	0.

V1SAT560
08:33:42 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1413

12/35

CASE m4

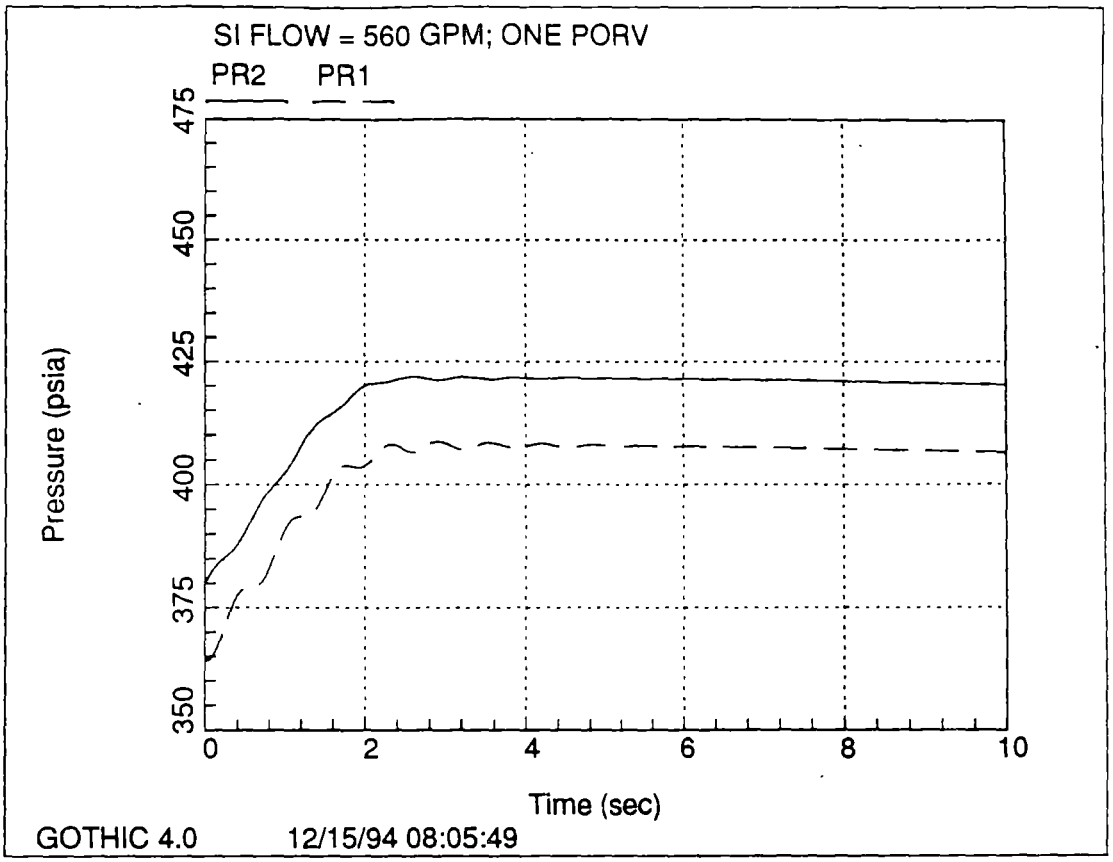
Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	SI FLOW = 560 G		PR2	PR1			
2	PORV STEM POSIT		VT1V				
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL3				
5	SI FLOW RATE		FV2	FL2			

S-C-RC-MDC-1413

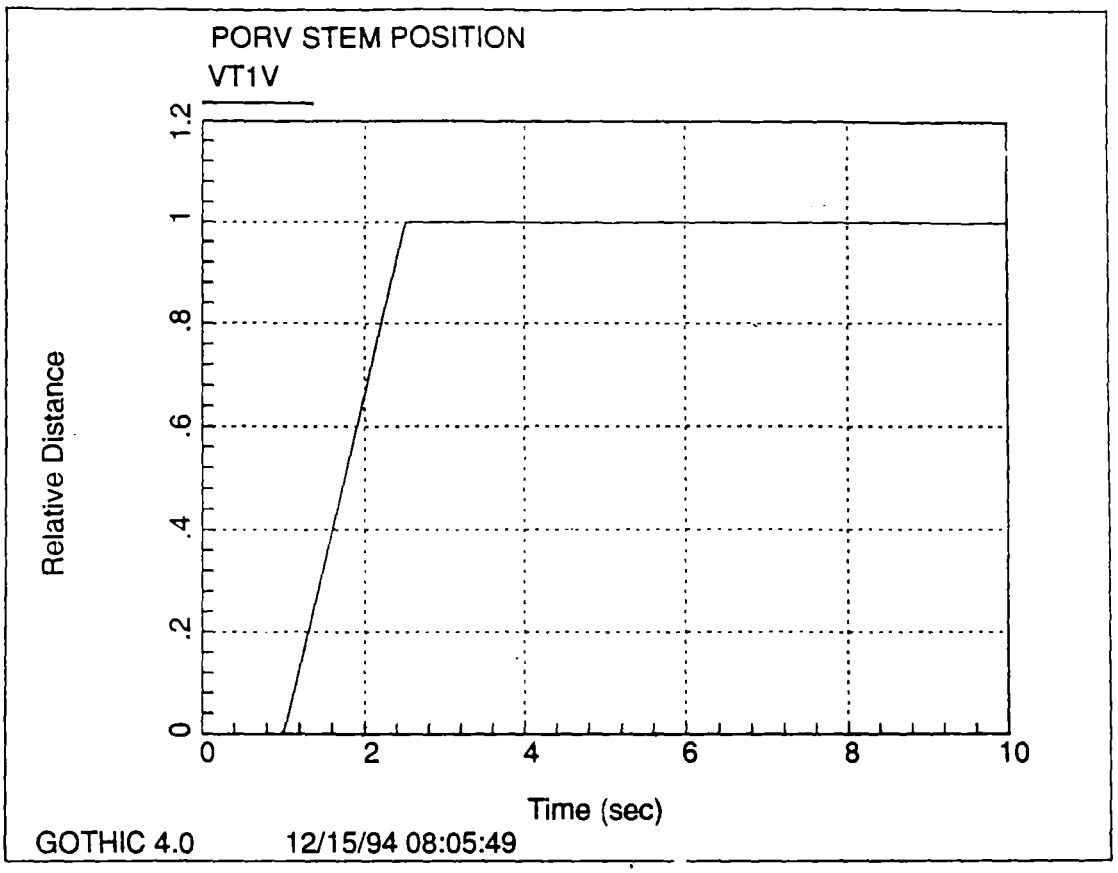
V1SAT560
08:29:31 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE M4



V1SAT560
08:29:47 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE M4

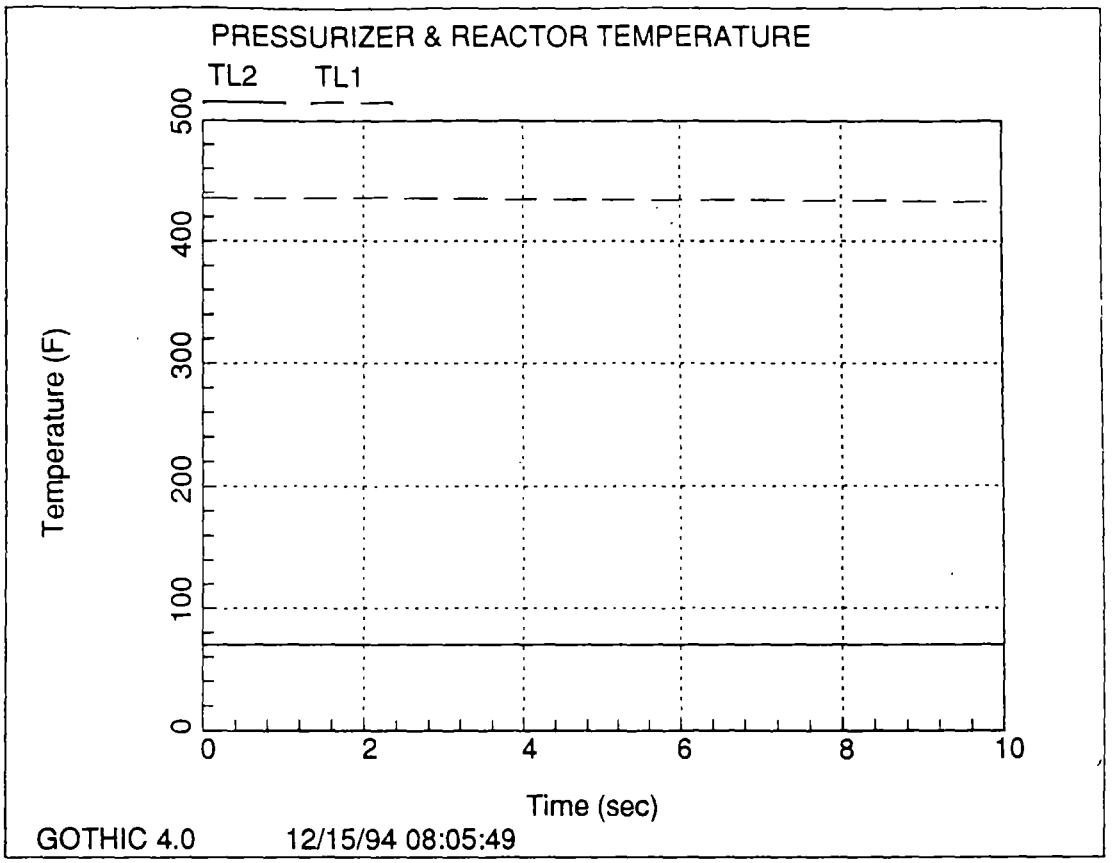


S-C-RC-MDC-1413

5
175

V1SAT560
08:29:58 15-DEC-94
GOTHIC Version 4.0 - August 1993

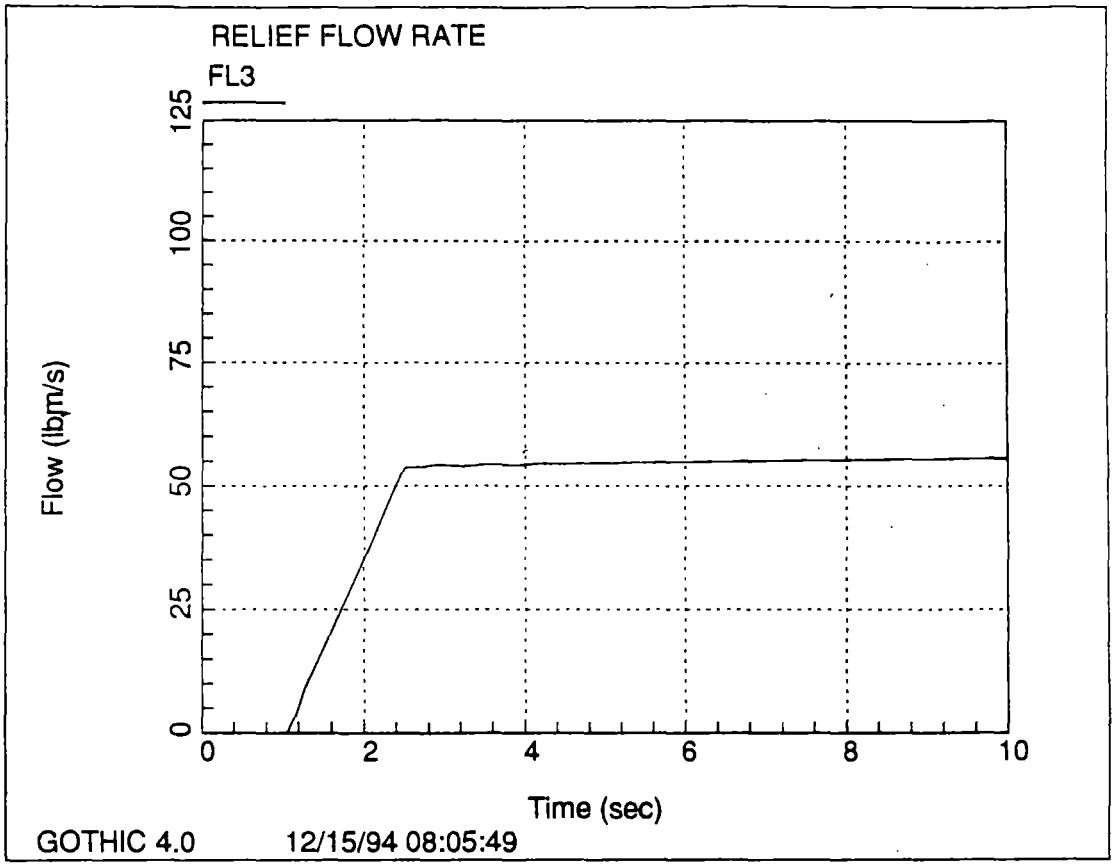
CASE M4



V1SAT560
08:30:12 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-PC-MDC-1413 5/35

CASE m4

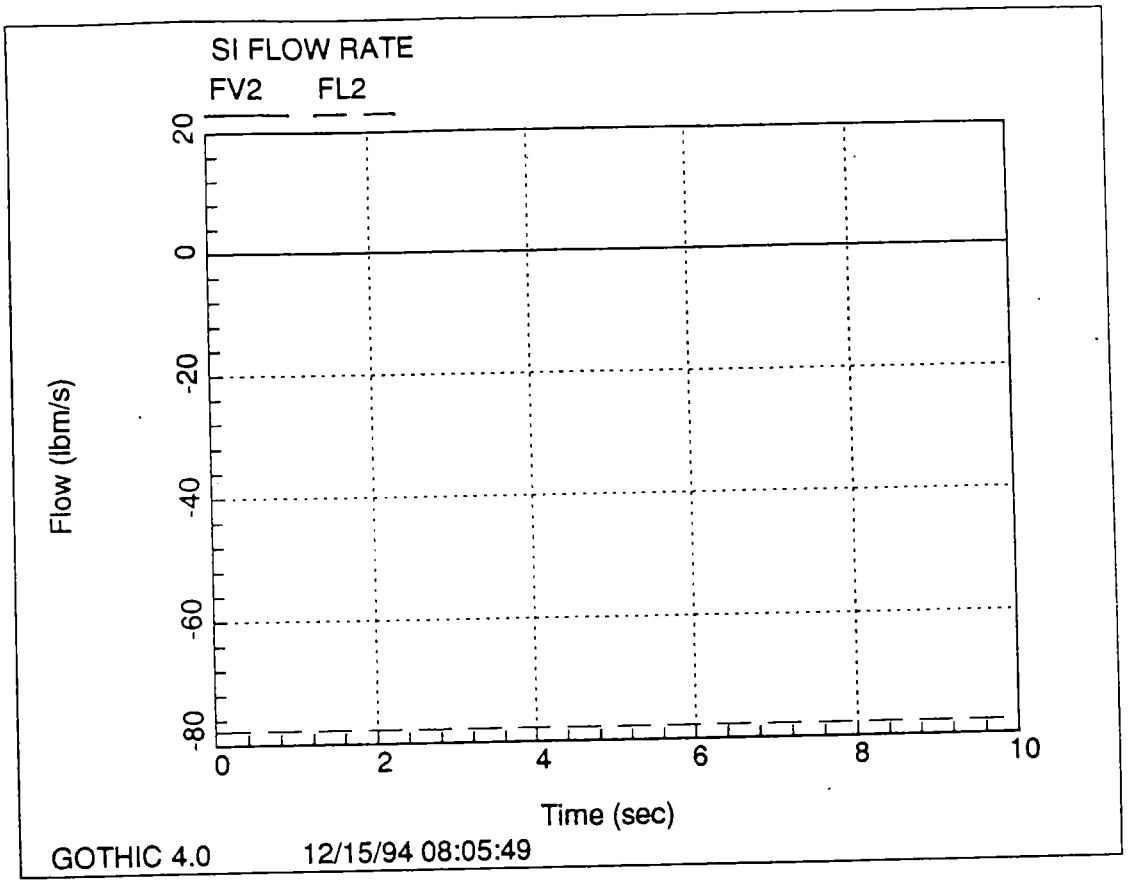


S-C-RC-MDC-1413

7/13

V1SAT560
08:30:23 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE m4



2.2 CASE M5: SAFETY INJECTION WITH LET DOWN ISOLATION

IN THIS CASE ONE CHARGING PUMP STARTS WHILE LETDOWN IS ISOLATED. THE POSITIVE DISPLACEMENT PUMP CONTINUES TO RUN.

THE P.D.P. DESIGN FLOW RATE = 98 GPM [Pg 1.3]
THE CHARGING PUMP MAXIMUM FLOW = 560 GPM [Pg 2]

WHEN BOTH PUMPS OPERATE SIMULTANEOUSLY, THE INJECTION FLOW WILL BE LESS THAN THE SUM OF THESE TWO FLOWS. THE SUM OF THESE TWO FLOWS = 98+560 GPM = 658 GPM. HOWEVER, TO KEEP THE ANALYSIS CONSERVATIVE 675 GPM FLOW RATE HAS BEEN USED

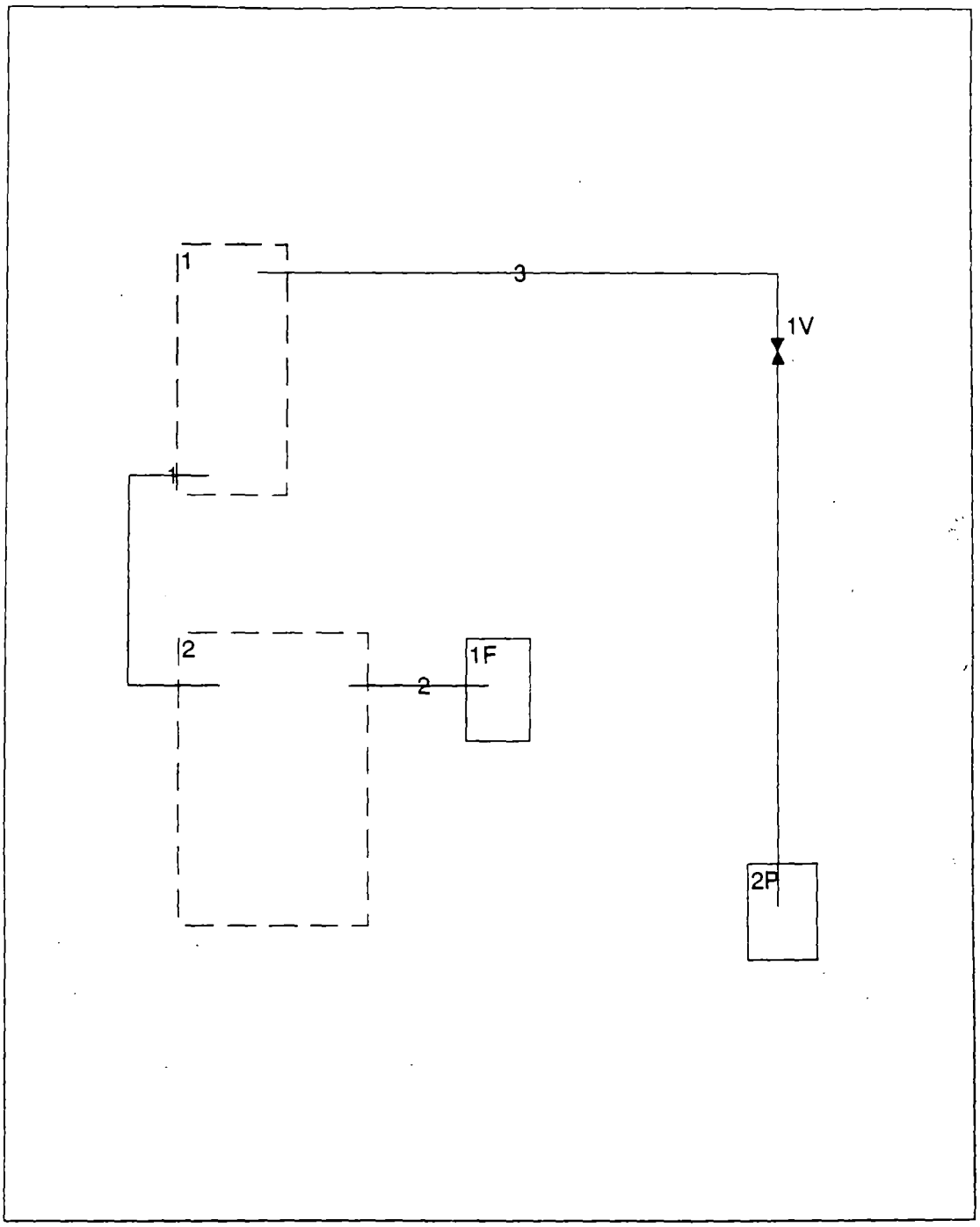
675 GPM OF 70F WATER = 93.75 lbm/S.

THE GOTHIC INPUT AND OUTPUT FOR THIS CASE IS GIVEN IN THE FOLLOWING PAGES

S-C-RC-MDC-1412

v1sat675
08:40:49 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE M 5



v1sat675
08:55:48 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-P1-MDC-14.3

CASE M5

Control Volumes						
Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	Pl Area (ft2)
1	PRESSURIZER	1800.	104.	60.	7.	40.
2	RCS	10812.	90.	14.	10.	80.

Fluid Boundary Conditions - Table 1									
BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1F	SI INJEC. FLOW	400.		70		93.75			
2P	PORV TO PRT	115.		80					

Fluid Boundary Conditions - Table 2											
BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF
1F	1.		1.								
2P	1.		0.005								

Fluid Boundary Conditions - Table 3 Gas Pressure Ratios								
BC#	Air	FF	Ar	FF	He	FF	H2	FF
1F	1.							
2P	1.							

Fluid Boundary Conditions - Table 4 Gas Pressure Ratios								
BC#	Kr	FF	N2	FF	O2	FF	Xe	FF
1F								
2P								

v1sat675
08:55:48 15-DEC-94
GOTHIC Version 4.0 - Augus- 1993

S-C-FC-MDC- - 2

-1/25

CASE M5

Flow Paths - Table 1							
F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	SURGE LINE	2	97.	1.	1	105.	1.
2	SI LINE	2	97.	0.2	1F	97.	0.2
3	RELIEF LINE	1	155.	0.5	2P	87.	0.22

Flow Paths - Table 2							
Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Critical Flow Model	De-Entrmt Frac.	Mom Trn Opt
1	0.75	1.	60.	100.	NO		-
2	0.1	0.2	10.	10.	NO		-
3	0.00843	0.22	13.	0.1	YES		-

Flow Paths - Table 3			
Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.
1	1.	1.	OFF
2	1.	1.	OFF
3	0.01	0.01	ON

Valves & Doors						
Valve #	Description	Flow Path #	Open Trip #	Close Trip #	Valve Type #	Disch. Vol.
1V	PORV	3	1	0	1	2P

CASE M 5

Valve/Door Types				
Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	TIME OPEN	1	2	0.00843
2	TIME OPEN	3	2	0.0088

CASE M5

Component Trips									
Trip #	Sense Var.	Sensor 1 Loc.	Sensor 2 Loc.	Var. Limit	Set Point	Delay Time	Rset Trip	Cond Trip	Cond Type
1	PRESS	2		UPPER	390.	0.5	UNDE		AND
2	PRESS	2		UPPER	390.	0.			AND

Functions				
FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	PORV STEM TRAVE	Time (sec)	Norm. Stem	3
2	PORV LOSS FACTO	Norm. Stem	Loss Facto	17
3	RH3 STEM TRAVEL	TIME (SEC)	RH3 STEM T	3

Function
1
PORV STEM TRAVEL
Ind. Var.: Time (sec)
Dep. Var.: Norm. Stem Position

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	1.5	1.
100.	1.		

Function
2
PORV LOSS FACTOR
Ind. Var.: Norm. Stem Position
Dep. Var.: Loss Factor

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1e+10	0.01	10000.
0.0667	225.	0.1333	56.
0.2	25.	0.2667	14.
0.337	9.	0.4	6.25
0.4667	4.59	0.5333	3.52
0.6	2.78	0.6667	2.25
0.7333	1.86	0.8	1.56
0.867	1.33	0.933	1.15
1.	1.		

v1sat675
08:55:49 15-DEC-94
GOTHIC Version 4.0 - August 1993

5-C-RC-MDC-1413

24/35

CASE M5

Function 3 RH3 STEM TRAVEL Ind. Var.: TIME (SEC) Dep. Var.: RH3 STEM TRAVEL			
Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0. 100.	0. 0.586	1.2	0.586

Volume Initial Conditions						
Vol #	Pressure (psia)	Temp. (F)	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf. A. (ft2)
def	14.7	80.	60.	0.	0.	0.
1	364.	440.	100.	1.	0.	0.
2	380.	70.	100.	1.	0.	0.

Initial Gas Pressure Ratios								
Vol #	Air	Ar	He	H	Kr	N	O	Xe
def	1.	0.	0.	0.	0.	0.	0.	0.
1	1.	0.	0.	0.	0.	0.	0.	0.
2	1.	0.	0.	0.	0.	0.	0.	0.

Run Control Parameters (Seconds)								
Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int
1	0.000	0.01	1.	5.	500.	0.05	10000	0.
2	0.000	0.1	1.	100.	500.	0.5	10000	0.

v1sat675
08:55:49 15-DEC-94
GOTHIC Version 4.0 - August 1993

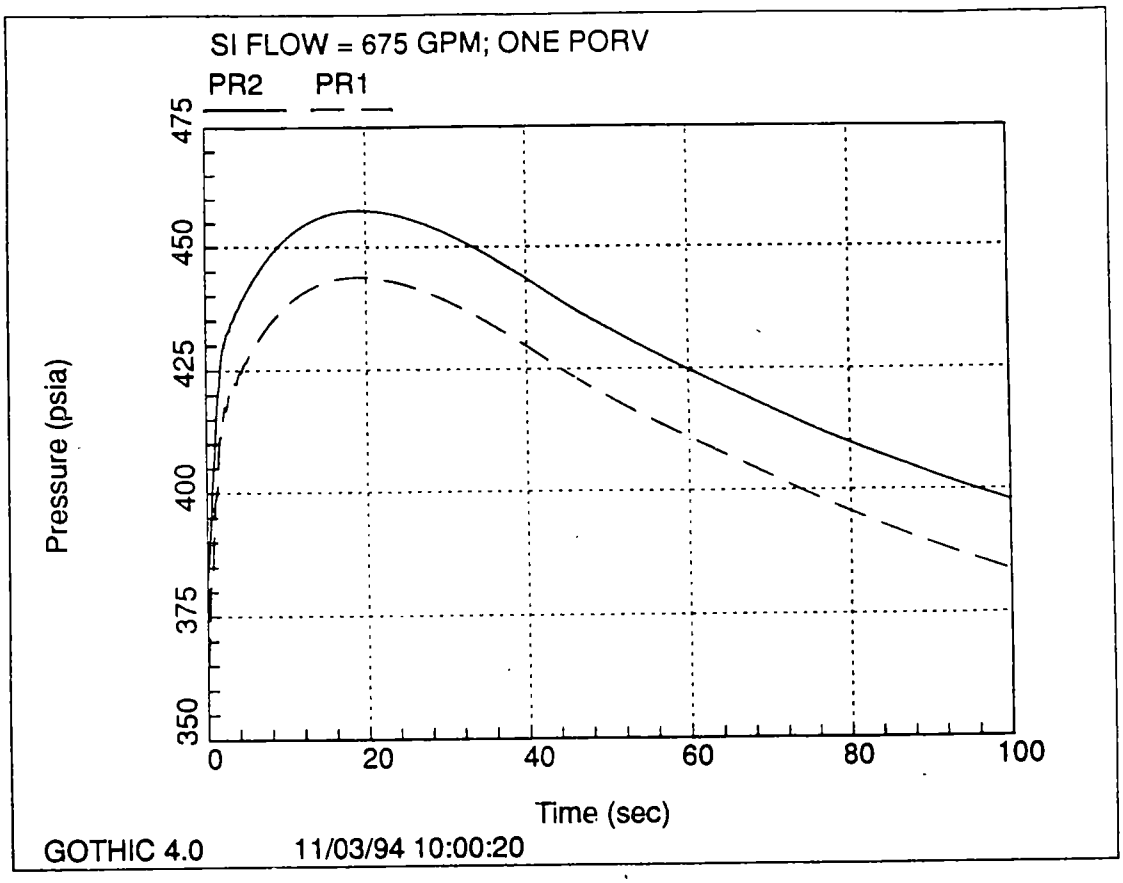
CASE M5

Control Parameters Menu	
Parameter	Value
Restart Time (sec)	0
Restart Time Step #	0
Restart Time Control	NEW
Revap. Fraction	0
Min. NC HT Coeff.	0
Reference Pressure	0
Ice Temperature	0
Ice Density	0

Graphs							
Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	SI FLOW = 675 G		PR2	PR1			
2	PORV STEM POSIT		VT1V				
3	PRESSURIZER & R		TL2	TL1			
4	RELIEF FLOW RAT		FL3				
5	SI FLOW RATE		FV2	FL2			

v1sat675
08:50:23 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE M5

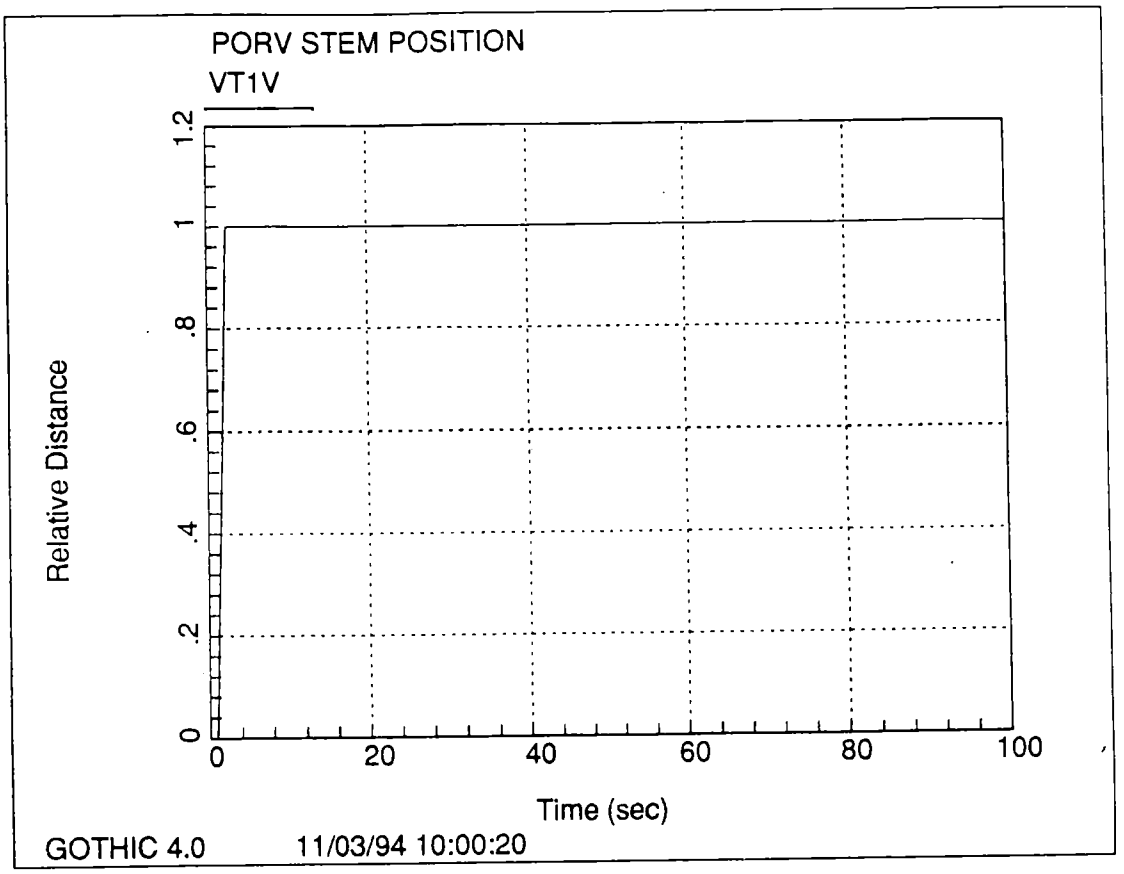


v1sat675
08:50:39 15-DEC-94
GOTHIC Version 4.0 - August 1993

S-C-RC-MDC-1413

27/35

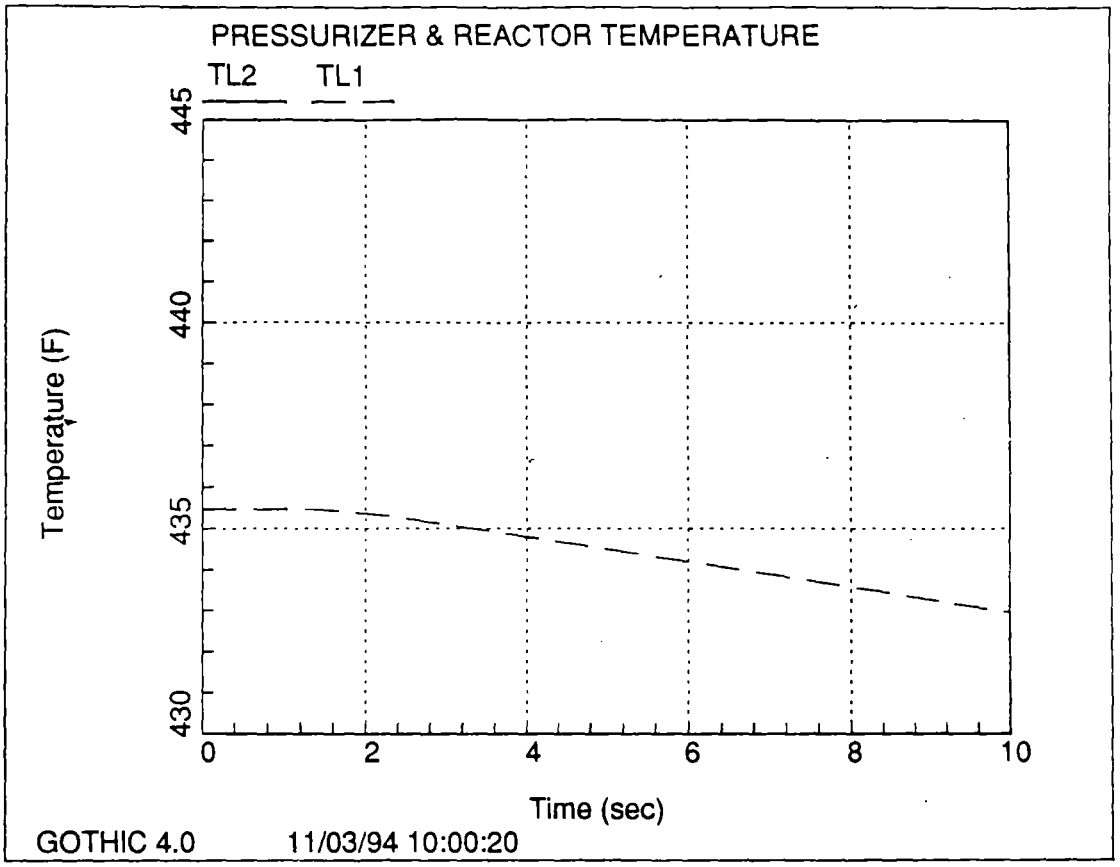
CASE M3



S-C-RC-MDC-1413

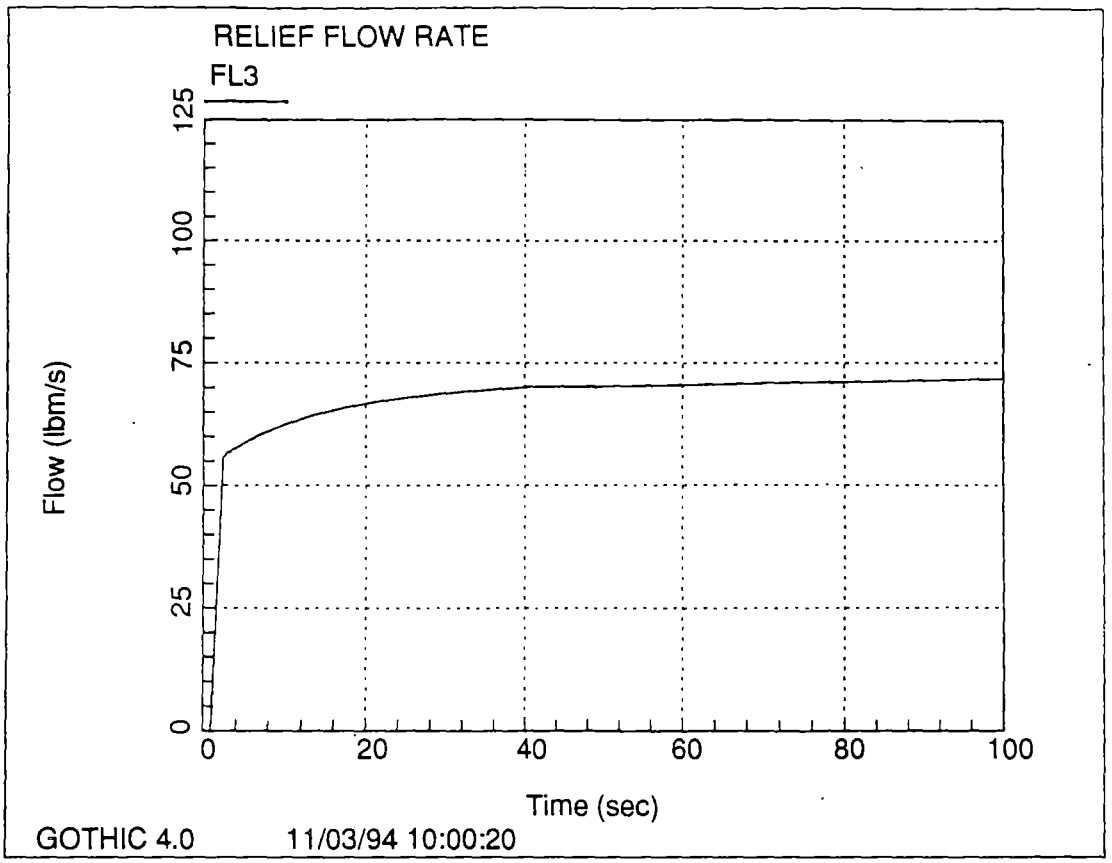
v1sat675
08:50:51 15-DEC-94
GOTHIC Version 4.0 - August 1993

CASE M5



v1sat675
08:51:15 15-DEC-94
GOTHIC Version 4.0 - August 1993

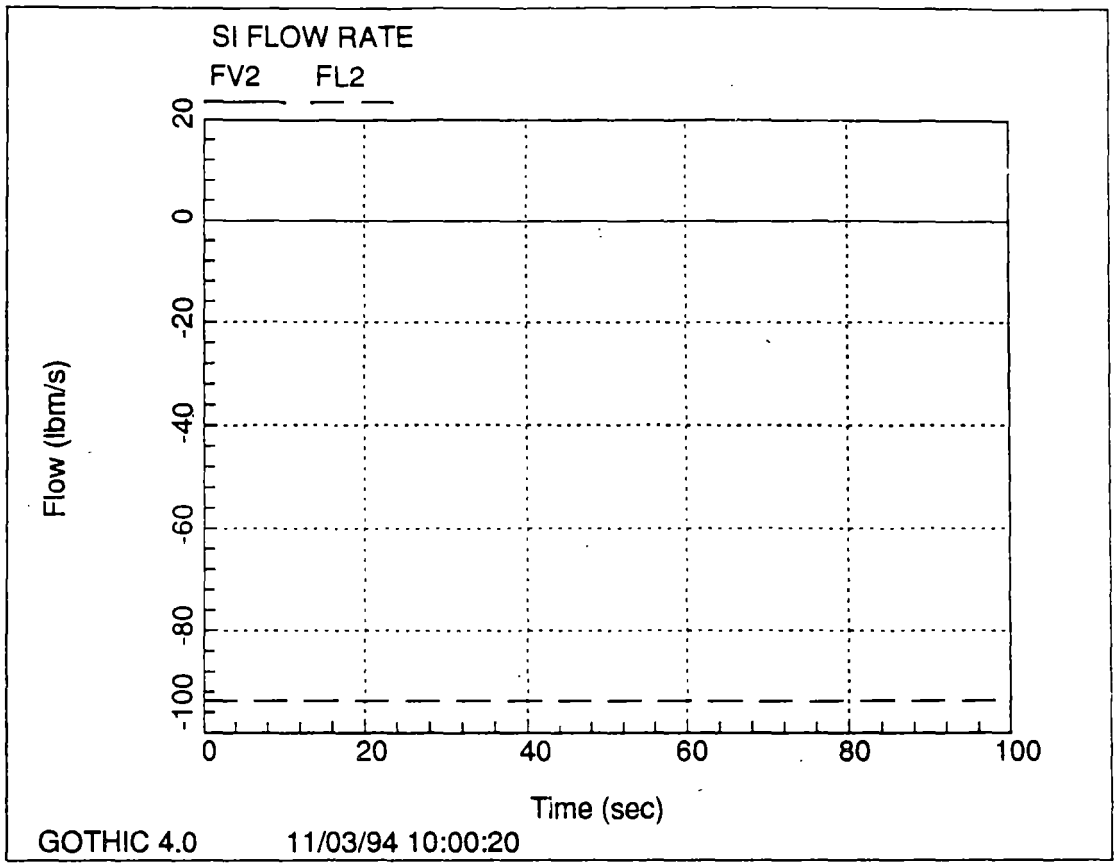
CASE M5



S-C-RC-MDC-1413

v1sat675
08:53:03 15-DEC-94
GOTHIC Version 4.0 · August 1993

CASE M5



3. RESULTS:

THE PEAK RCS PRESSURES AS CALCULATED IN SECTION 2 ARE SHOWN IN TABLE 3.1.

TABLE 3.1 PEAK RCS PRESSURE WITH ONE PORV

CASE I.D	LTOP EVENT	NET INJECTION FLOW RATE (GPM)	INITIAL RCS TEMP (F)	INITIAL PRESSURIZER TEMP. (F)	PEAK RCS PRESSURE AT PRESSURE TRANSMITTER LOCATION (PSIA)	PEAK RCS PRESSURE AT CRITICAL WELD LOCATION WITH ONE RCP RUNNING	
						(PSIA)	(PSIG)
M4	MASS INPUT	560	70	437	422	453	438
M5	MASS INPUT	675	70	437	458	489	474

4. REFERENCES:

1. P.S.E.&G. CALCULATION S-C-RC-MDC-1358 Rev. 0.
2. SALEM 1 TECH. SPEC. SECTION 4.5.2.h.2 (d) PAGE 3/4 5-5b, AMENDMENT 143.

   SALEM 2 TECH. SPEC. SECTION 4.5.2.h.2(d) PAGE 3/4 5-6a, AMENDMENT NO. 118.
3. CVCS CBD DE-CB.CVC-0037(Q) Rev. 1, p 5-60

CERTIFICATION FOR DESIGN VERIFICATION

Reference No. S-C-RC-MDC-1413

SUMMARY STATEMENT

Peak RCS pressure at the transmitter location was calculated using GOTHIC computer model similar to the way it was done in reference 1. Effect of RCP was added to determine RCS pressure at the critical weld location. This analysis was done using charging pump flows. Input to GOTHIC model was checked and found acceptable. Output from GOTHIC model is consistant with the input.

The undersigned hereby certifies (in the right column) that the design verification for the subject document has been completed, the questions from the generic checklist have been reviewed and addressed as appropriate, and all comments have been adequately incorporated.

Howard G Benik	Rajendra P. Pande / 12/16/94
Design Verifier Assigned By (signature of Manager/Supervisor)	Signature of Design Verifier / Date
Design Verifier Assigned By (signature of Manager/Supervisor)	Signature of Design Verifier / Date
Design Verifier Assigned By (signature of Manager/Supervisor)	Signature of Design Verifier / Date
Design Verifier Assigned By (signature of Manager/Supervisor)	Signature of Design Verifier / Date

*If the Functional Manager/Supervisor acts as the Design Verifier, the signature of the next higher level of technical management is required.

CERTIFICATION FOR DESIGN VERIFICATION

CERTIFICATION FOR DESIGN VERIFICATION

REFERENCE DOCUMENT NO. /REV. S-C-RC-MDC-1413

COMMENTS	RESOLUTION	
None	N/A.	
R Pandl 12/16/94 SUBMITTED BY DATE	RESOLVED BY DATE	Acceptance of Resolution