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POST TEST ANALYSIS OF ROSA-III
DOUBLE-ENDED BREAK TEST RUN 901

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Post Test Analysis of ROSA-III Double-Ended Break Test RUN 901

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The ROSA-III test facility is a volumetrically scaled (1/424) boiling water reactor (BWR) system with an electrically heated core. The purpose of ROSA-III experiment is to study the thermal-hydraulic behavior and the performance of the emergency core cooling system (ECCS) during a postulated loss-of-coolant accident (LOCA) and to provide the data base for the assessment and improvement of reactor safety analysis codes.

RUN 901 was a first ROSA-III experiment with the fourth fuel assembly and assumed a 200% double-ended break at the recirculation pump section line with full ECCS actuation. Post test analyses of RUN 901 were performed with the computer codes RELAP4J and RELAP5/MOD1/001.

The system pressure response calculated with the two codes agreed well with the data. The agreement was also good for the core inlet flow behavior until the beginning of the lower plenum flashing (LPF).

RELAP4J is a fast running code and calculated well the overall behavior of the mixture level in the core. However, the spray water was accumulated in the upper plenum (UP) due to the inability of the code to calculate counter current flow at the upper tie plate (UTP). While spray water was not accumulated in the upper plenum in the experiment.

RELAP5 with an advanced two-phase flow model calculated well the rewetting of the fuel after the LPF and the top-down quench after the uncovery of the whole core. However, the incorporation of a CCFL model and/or the improvement in the interphase drag correlations are necessary to be able to calculate the mixture level behavior more accurately. An

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appropriate discharge coefficient is also necessary to calculate the break flow accurately with the RELAP5 characteristic analysis break flow model.

Keywords: BWR, ROSA-III, LOCA, 200% Double-ended break, ECCS, RELAP4J, RELAP5/MOD1/001, TRAC-BD1, Analysis, Break Nozzles, Thermal Hydroulic Behavior, Reactor Safety

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ROSA－Ⅲ両端破断実験RUN 901の実験後解析

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（1985年1月24日受理）

ROSA－Ⅲ実験装置は，電気加熱の模擬炉心を有する，1／424の沸騰水型原子炉（BWR）模擬体系である。実験の目的は，BWRの冷却材喪失事故（LOCA）時の熱水力学的挙動および非常用炉心冷却系（ECCS）の作動特性を調べ，原子炉安全性解析コードの検証および改良に寄与する実験データを提供することである。RUN 901は，4次模擬燃料を用いた最初の実験で，全ECCSの作動を仮定した再循環ポンプ吸込配管の200％両端破断を模擬している。この実験結果を，RELAP 4 JコードおよびRELAP 5／MOD 1／001コードを用いて解析を行なった。

両算コード共に，系の圧力挙動，下部プレナムフラッシング（LPF）前の炉心入口流量は実験結果と良い一致を示した。

RELAP 4 J コードは計算速度が速く，また，炉心水位挙動を良く計算することができた。しかし，気液二相流挙動，特に上部タイプレートでの気液対向流の計算ができず，実験結果に反してECCS水が上部プレナムに蓄積された。

RELAP 5コードは，非均質非平衡二相流モデルに依り，LPF後の炉心冷却や炉心露出後の炉心上部からの冷却（top－down quench）を計算することができた。しかし，炉心水位挙動をより正確に計算するためには，気液対向二相流限界（CCFL）モデルを取り入れるか，相間抗力関係式を改良する必要がある。また，正確な破断流計算のために，適当な放出係数が必要である。

＊　日本原子力事業（株）

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Abbreviations

ADS	Automatic Depressurization System
AV	Air Actuation Valve
BWR	Boiling Water Reactor
CCFL	Counter Current Flow Limiting
CV	Control Valve
ECCS	Emergency Core Cooling System
ESF	Engineered Safety Features
Fig.	Figure
FW	Feedwater
FWLF	Feedwater Line Flashing
HPCS	High Pressure Core Spray
JP	Jet Pump
LOCA	Loss-of-Coolant Accident
LP	Lower Plenum
LPCI	Low Pressure Coolant injection
LPCS	Low Pressure Core Spray
LPF	Lower Plenum Flashing
LTP	Lower Tie Plate
LWR	Light Water Reactor
MRP	Main Recirculation pump
MSIV	Main Steam Isolation Valve
MSL	Main Steam Line
OR	Orifice
PCT	Peak Cladding Temperature
PV	Pressure Vessel
ROSA	Rig of Safety Assessment
SEO	Side Entry Orifice
UP	Upper Plenum
UTP	Upper Tie Plate

1. INTRODUCTION

The ROSA (Rig of Safety Assessment)-III program was initiated in 1976 to investigate the thermal-hydraulic behavior of a boiling water reactor (BWR) during a postulated Loss of Coolant Accident (LOCA) and to provide base data to evaluate the predictability of reactor safety analysis codes. The ROSA-III test facility, completed in 1978, consists of a volumetrically scaled (1/424) primary system of a 3800 MW thermal power BWR/6-251 with an electrically heated core and a scaled Emergency Core Cooling System (ECCS).

The objectivies of the ROSA-III experimental program are:
(1) To provide data required for evaluation and improvement of the analytical methods currently used to predict the LOCA transients in large BWRs. The performance of the engineered safety features (ESFs), with particular emphasis on ECCS, and the qualitative margins of safety inherent in performance of the ESFs are of primary interest.
(2) To identify and investigate any unexpected event(s) or threshold(s) in the response of either the plant or the ESFs and to develop analytical techniques that adequately describe such unexpected behaviors.

The ROSA-III experiment RUN 901[1] conducted on April 8, 1981 was the acceptance test of the fourth fuel assembly[2]. The test simulated a 200% double-ended break at the suction of the main recirculation pump (MRP) with all of ECCS function as designed.

RUN 901 was the first test using the fourth fuel assembly and also was the first large break test using the downcomer liquid level signals to initiate the main steam isolation valve (MSIV) closure and to actuate high pressure core spray (HPCS), low pressure core spray (LPCS), low pressure core injection (LPCI) and automatic depressurization system (ADS) in the same manner as BWR/6.

This report presents the results of post test analysis of RUN901 conducted with the RELAP4J and RELAP5/MOD1/001 codes. The RELAP4J code is an JAERI improved version of the RELAP4/MOD2 code and is based on the

homogenious and thermodynamically equilibrium two-phase flow models. The RELAP5/MOD1/001 code is a so-called advanced code based on the nonhomogenious nonequilibrium hydrodynamic models. These analyses with RELAP4J and RELAP5/MOD1/001 will make the features of two codes clear.

2. ROSA-III EXPERIMENT RUN901

2.1 ROSA-III Test Facility

The ROSA-III test facility is a volumetrically scaled (1/424) model of a BWR system with four half-length electrically-heated fuel bundles. It is designed to represent the operation of the ESFs (Engineered Safety Features) in commercial BWR systems during a postulated LOCA. The ROSA-III major components, the pressure vessel internal structure, the pressure vessel instruments arrangement and the piping system are shown in Figs. 2.1 through 2.4, respectively. The primary characteristics of the ROSA-III test facility are compared with those of BWR/6 in Table 2.1.

Heater rod arrangement, radial power distribution and axial power distribution are shown in Figs. 2.5(a), 2.5(b) and 2.6, respectively. A 44mm ID side entry orifice (SEO) is installed between the lower plenum and the lower tieplate for each channel of the fourth fuel assembly. The core inlet flow rate through the SEO can be estimated from the differential pressure across the orifice. Comparison of the design of the first through forth fuel assemblies is shown in Table 2.2. The detailed system description of the ROSA-III with the fourth fuel assembly is given in Reference 2.

Steam is discharged into the atmosphere through the steam line connected to the steam dome. THe steam line has three branches as shown in Fig. 2.7. The first branch has a control valve (CV130) to control the steady state steam flow before the initiation of a blowdown. The second branch simulates the (ADS) Automatic Depressurization System. The third branch has an orifice (OR5) to simulate the flow resistance of the steam turbine-generator. Immediately after the break initiation the steam flow

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is switched from the first to the third branch in RUN 901. Then the main steam isolation valve (MSIV) is simulated by AV165 in the third breanch. The characteristics and control sequences of the steam discharge line valves are described in Tables 2.3 and 2.4.

The feedwater line supplies the feedwater of temperature of 489 K below the steam separator in the downcomer. Since the feedwater line isolation valve (AV112), which is to be closed after the break initiation, is installed far from the pressure vessel, the feedwater remains in the feedwater line between the pressure vessel and the isolation valve. The schematic of the feedwater line between the pressure vessel and the isolation valve (AV112) is shown in Fig. 2.8.

2.2 Test Conditions

RUN 901 was conducted on April 8, 1981. The test conditions actually obtained in RUN 901 are summarized and compared with the specified test conditions in Table 2.5. RUN 901 simulated a 200 % double-ended break at the recirculation pump suction line with all the ECCS functioned as designed. The break was simulated by a nozzle shown in Fig. 2.9. The core power transient in RUN 901 is shown in Fig. 2.10. The core power was held constant for 7.0 s after the break initiation because of the limited electrical power capacity of the facility. Power history during transient simulated the heat transfer rate from nuclear fuel rod to coolant during a LOCA of a BWR. The transient core power after break is composed of the delayed neutron fission power, the decay power of fission products and actinides, and the stored heat release from the nuclear fuel rod[3].

The liquid level signals in the upper downcomer obtained from the water head were used to trip MSIV closure and ECCS actuation as in a BWR/6. The initial L3 liquid level (5.00 m from the botom of the pressure vessel in the dowmcomer of the ROSA-III test facility) was defined so that the liquid volume below this level including the jet pump suction pipings scale the liquid volume below the scram L3 level in a BWR/6. The L2 and

L1 liquid levels in the downcomer of ROSA-III were 4.76 m and 4.25 m, respectively. MSIV closure and HPCS actuation were initiated by the L2 signal with time delays of 3 s and 27 s, respectively. LPCS, LPCI and ADS actuation were initiated by the L1 signal with 40 s, 40 s and 120 s time delays, respectively. Time delays of 3 s, 40 s and 120 s, are used in the safety analysis of a BWR[4]. LPCS and LPCI injections were also specified to initiate at system pressures below 2.16 MPa and 1.57 MPa[4], respectively.

2.3 Test Results

Sequence of major events in RUN 901 are summarized in Table 2.6.

System pressure in the lower plenum is shown in Fig. 2.11, which represents the pressure response in the pressure vessel in RUN 901. The pressure decreased during initial 8 s due to discharge of the coolant from the steam line and the break. The pressure began to recover after the MSIV closure.

The pressure started to drop again after the liquid level in the downcomer lowered to the recirculation line nozzle level at 12.0 s and the volumetric flow rate from the break exceeded the vapor generation rate in the system. When the pressure decreased to the saturation pressure corresponding to the lower plenum fluid temperature at 17 s after the break the Lower Plenum Flashing (LPF) began. Similarly, when the pressure lowered to the saturation pressure of 2.15 MPa corresponding to the feedwater temperature at 64.8 s after the break, the liquid in the feedwater line began to flash. The HPCS, the LPCS, the LPCI and the ADS were initiated at 31.5 s, 65.6 s, 90.9 s and 127.7 s after the break, respectively. However, the ECCS affected the pressure response little.

Steam discharge flow rate is shown in Fig. 2.20. Measuring range of the flow meters are 0.0 kg/s to 1.13 kg/s for a low-range and 0.0 kg/s to 3.00 kg/s for a high-range flow meters, respectively. The steam discharge flow decreased temporarily after the break due to switching over the flow path from the steady flow path to the transient flow path as described before. Steam discharge stopped at 9.2 s after the break because the MSIV

closed and started again at 127.7 s because of the ADS actuation. The anomalous behavior in the ADS steam discharge flow rate was because of error at low flow rate near insensitive range of the flow meter.

Feedwater injection rate is shown in Figs. 2.21(a) and 2.21(b). Figure 2.21(a) shows the flashing in the feedwater line after 64.8 s.

Injection flow rates of HPCS, LPCS and LPCI are shown in Figs. 2.22 and 2.23.

The core inlet flows through the Side Entry Orifice (SEO) of the channels A through D are shown in Fig. 2.24 through 2.27, respectively. The flow decreased rapidly after the break because of the recirculation pump coastdown and the flow stagnated until the LPF initiation. Figure 2.28 shows the flow through the bypass hole which reversed immediately after the break initiation. The flow rate shown in Figs. 2.24 through 2.28 present only a trend in two-phase flow condition after the LPF initiation.

Figure 2.29 shows the transient curves of the electric core power. The core power began to decrease at 7.0 s after the break.

Figure 2.30 shows the liquid level in the downcomer obtained from the downcomer head. Figure 2.30 shows the liquid level in the downcomer which began to drop immediately after break and reached the jet pump suction and the MRP suction line at 10 s and 13 s, respectively. The instantaneous decrease in the lower downcomer collapsed level after the break is probably due to increase in the downward acceleration pressure loss induced by the break. Liquid level transients estimated from the signals of conductivity probes installed in the pressure vessel are shown in Fig. 2.31. The liquid level in the core decreased after the break to Position 3 and temporarily recovered thereafter by the LPF. The liquid level in the core decreased again by the mitigation of the LPF and rapidly dropped temporarily by the Feedwater Line Flashing (FWLF) initiated at 64.8 s after the break. The bottom part of the core was not uncovered. The liquid level began to recover at 70 s after the break because of the mitigation of

the FWLF and accumulation of ECCS water in the core. The reflooding was accelerated by the actuation of LPCI. The liquid level was not formed in the channel inlet chamber since the Counter Current Flow Limiting (CCFL) occured at the SEO from 17 s to 133 s after the break.

Figures 2.32 through 2.39 show comparison of the surface temperatures of the heater rods A11, A22, A24, A33, B22, C11, C22 and C33 measured at seven elevations in the core, respectively. The dryout and quench front behaviors at the heater rod surfaces in the peak-power channel A and the average-power channel C are compared with the liquid level transient in Figs. 2.40 and 2.41, respectively. Figures 2.40 and 2.41 show that the dryout and quench front behaviours are closely related to the liquid level transients in the core. The early dryout in the upper core before the LPF was caused by a liquid level drop due to decrease in the core inlet flow and resulted in a rapid temperature rise at the heater rod surface due to high core power shortly after the break. The heater rods were rewetted by the LPF and began to dryout again following the liquid level fall due to mitigation of the LPF. The top-down quench was observed because of the CCFL breakdown induced by the FWLF and the LPCS actuation. All heater rods were quenched a little later than the whole core reflooding. The liquid level in the average-power channel dropped temporarily after 115 s because of the CCFL breakdown at SEO.

When the core is reflooded after the LPF as well as after the ECCS actuations the cladding surface temperature, which increased during dryout period, turns around to decrease. Therefore, the PCT, which is the highest cladding surface temperature recorded through the test, is usually observed at the time of reflooding of the fuel surface at some location in the core. The PCT in RUN 901 was 779 K observed at Position 2 of A11 rod 18.5 s after the break and 1.6 s after the LPF initiation.

Average fluid densities at the upstream side of the break A (MRP side break) and the break B (PV side break) are shown in Fig. 2.42. The fluid density through the break A decreased rapidly after the break because of

the flashing in the broken recirculation loop piping between the jet pump drive nozzles and the break. After the liquid level in the downcomer decreased to the recirculation pump suction line, the average fluid densities through the breaks A and B decreased almost to the steam density.

The momentum flux and the discharge flow rate at the breaks A and B are shown in Figs. 2.43 through 2.45. Before the break initiation figures show the steady state flow in the recirculation line because the drag disk flow meters are installed in the recirculation loop. The signal from the drag disk flow meters installed in the upstream side of the PV-side break B became saturated until 38 s after break. The break mass flow transients at the breaks A and B are strongly related to the upstream fluid density. The measured break flow has an uncertainty of as large as $\pm$20 %.

Table 2.1 Primary Characteristics of BWR-6 and ROSA-III

	BWR-6	ROSA-III	BWR/ROSA
No. of Recirc. Loops	2	2	1
No. of Jet Pumps	24	4	6
No. of Separators	251	1	251
No. of Fuel Assemblies	848	4	212
Active Fuel Length (m)	3.76	1.88	2
Total Volume (m^3)	621	1.42	437
Power (MW)	3800	4.40	864
Pressure (MPa)	7.23	7.23	1
Core Flow (kg/s)	1.54×10^4	36.4	424
Recirculation Flow (l/s)	2970	7.01	424
Feedwater Flow (kg/s)	2060	4.86	424
Feedwater Temp (K)	489	489	1

Table 2.2 Comparison of Fuel Assemblies from the First to the Fourth

	1st	2nd	3rd	4th
Active Core Length (m)		1.880		
Number of Fuel Rods	252	252	248	248
Number of Water Rods	4	4	8	8
Rods Array		8 x 8 square		
Fuel Rod O.D. (mm)	12.52	12.52	12.27	12.27
Fuel Rod Pitch (mm)	16.26	16.26	16.16	16.16
Peaking Factor				
Local P.F.	1.0	1.0	1.0	1.1
Axial P.F.	1.4	1.4	1.4	1.4
Radial P.F.	1.0	1.0	1.4	1.4
Side Entry Orifices				
Number of Holes	48	48	48	4
Diameter (mm)	9.5	6.29	6.5	44.0
Total Area (cm^2)	34.02	14.92	15.93	60.82
Leak Holes				
Number of Holes	8	8	8	8
Diameter (mm)	8.6	7.66	9.2	9.14
Total Area (cm^2)	4.65	3.69	5.32	5.25
Guide Tube Holes				
Number of Holes	4	4	4	4
Diameter (mm)	5.3	4.9	5.12	7.48
Total Area (cm^2)	0.88	0.75	0.82	1.76
Conducted Test RUNs	701 ~ 703	704 ~ 710	731 ~ 7341 801 ~ 827	901 ~

Table 2.3 Valve Characteristics of Steam Discharge Line

Valve	Close to Open (sec)	Open to Close (sec)
AV165	0.1	1.5
AV168	-	0.1
AV169	0.3	2.0

Orifice	Diameter (mm)	Area (mm^2)
OR3	Not Used	-
OR4	15.5	188.7
OR5	16.8	221.7

Table 2.4 Valve Control Sequence of Steam Discharge Line in RUN 901

Time	t < 0	Break (t=0)	L2 + 3s	L1 + 120s
AV* 168	Open	Close	Close	Close
CV 130	Control to maintain steady state pressure			
AV 165	Close	Open	Close	Close
AV 169	Close	Close	Close	Open

* AV ; Air Actuation Valve (Auto)
CV ; Control Valve (Manual)

Table 2.5 Test Conditions of the ROSA-III Test RUN 901

Parameter		Specified Value	Measured Value
Break Conditions			
Location		Recirculation pump suction	Recirculation pump suction
Type		Double-ended	Double-ended
Break Nozzle Diameter	(mm)	26.2/26.2	26.2/26.2
Initial System Conditions			
Steam Dome Pressure	(MPa)	7.35	7.29
Lower Plenum Temperature	(K)	----	552.0
Lower Plenum Subcooling	(K)	----	10.5
Core Inlet Flow Rate	(kg/s)	16.0	16.0
Broken Loop Flow Rate	(m^3/s)	----	----
Intact Loop Flow Rate	(m^3/s)	----	----
Core Outlet Quality	(%)	----	13.9
Power Level	(kW)	(1400+3000)	(1250+2795)
Maximum Linear Heat Rate	(kW/m)		
of Channel A		18.5	16.5
of Channel B, C and D		13.2	12.3
Power Curve		Fig. 2.10	Fig. 2.29
Water Level in PV	(m)	5.00	5.00
Fuel Assembly		No.4	No.4
Feedwater Conditions			
Temperature	(K)	489	489
Flow Rate	(kg/s)	Steady state value 2.388	Fig. 2.21
Initiation of line closure	(s)	2.0	2.0 (completely close at 3.7 s)

Table 2.5 (Continue)

Parameter		Specified Value	Measured Value
Steam Discharge Conditions			
Steady State Line			
Flow Rate	(kg/s)	Steady State Value (2.388)	2.00
Transient Line			
Flow Rate	(kg/s)	----	Fig. 2.20
Orifice Diameter	(mm)	16.8	16.8
Initiation of line closure			
at Water Level	(m)	4.76*	4.3 (7.5 s after break and completely closed at 9.4 s)
with Time Lag	(s)	3	
ECCS Conditions			
HPCS			
Injection Location		Upper Plenum	Upper Plenum
Initiation			
at Water Level	(m)	4.76	
with Time Lag	(s)	27	28.3 (31.5s after break at 5.21 MPa in PV)
Coolant Temperature	(K)	313	313
Injection Flow Rate	(m^3/s)	6.17×10^{-4} at 6.5 MPa	Fig. 2.22
Injection Duration	(s)	1500	Fig. 2.22
LPCS			
Injection Location		Upper Plenum	Upper Plenum
Initiated			
at Water Level	(m)	4.25 **	
with Time Lag	(s)	40	
and at Pressure in PV	(MPa)	2.16	2.23 (65.6 s after break)
Coolant Temperature	(K)	313	313
Injection Flow Rate	(m^3/s)	1.13×10^{-3}	Fig. 2.22
Injection Duration	(s)	1500	Fig. 2.22

* L2 level
** L1 level

Table 2.5 (Continue)

Parameter		Specified Value	Measured Value
ECCS Conditions (Continued)			
LPCI			
Injection Location		Upper Plenum and Core Bypass	Upper Plenum and Core Bypass
Initiated			
at Water Level	(m)	4.25	
with Time Lag	(s)	4	
and at Pressure in PV	(MPa)	1.57	1.61 (90.9s after break)
Coolant Temperature	(K)	313	313
Injection Flow Rate	(m^3/s)	3.5×10^{-3}	Fig. 2.23
Injection Duration	(s)	1500	Fig. 2.23
ADS Conditions			
Initiation			
at Water Level	(m)	4.25	
with Time Lag	(s)	120	120.3 (127.7 s after break, 0.79 MPa in PV)
Valve Closing Time	(s)	No closure	No closure
Flow Rate	(m^3/s)	----	Fig. 2.20
Orifice Diameter	(mm)	15.5	15.5

Table 2.6 Sequence of Events in RUN 901

Time after break (s)	Events
0.0	Break
	Initiate core power control
	Terminate intact loop recirculation pump power (simple coastdown)
	Terminate broken loop recirculation pump power (simple coastdown)
1.2	Initiation of feedwater line valve closure
3.2	Liquid level in downcomer decreased to L2 level
4.0	Closure of feedwater line
7.0	Initiation of core power curve reduction
7.4	Initiation of steam discharge line valve closure
	Liquid level in downcomer decreased to L1 level
9.2	Closure of steam discharge line
9.5	Liquid level in downcomer decreased to jet pump suction nozzle
12.0	Liquid level in downcomer decreased to recirculation pump suction line
17.0	Initiation of lower plenum flashing
31.5	HPCS initiation (at system pressure 5.21 MPa)
64.8	Feedwater line flashing
65.6	LPCS initiation (at system pressure 2.23 MPa)
90.9	LPCI initiation (at system pressure 1.61 MPa)
127.3	Quench of the whole core
128.2	ADS initiation (at system pressure 0.79 MPa)
490	End of data acquisition

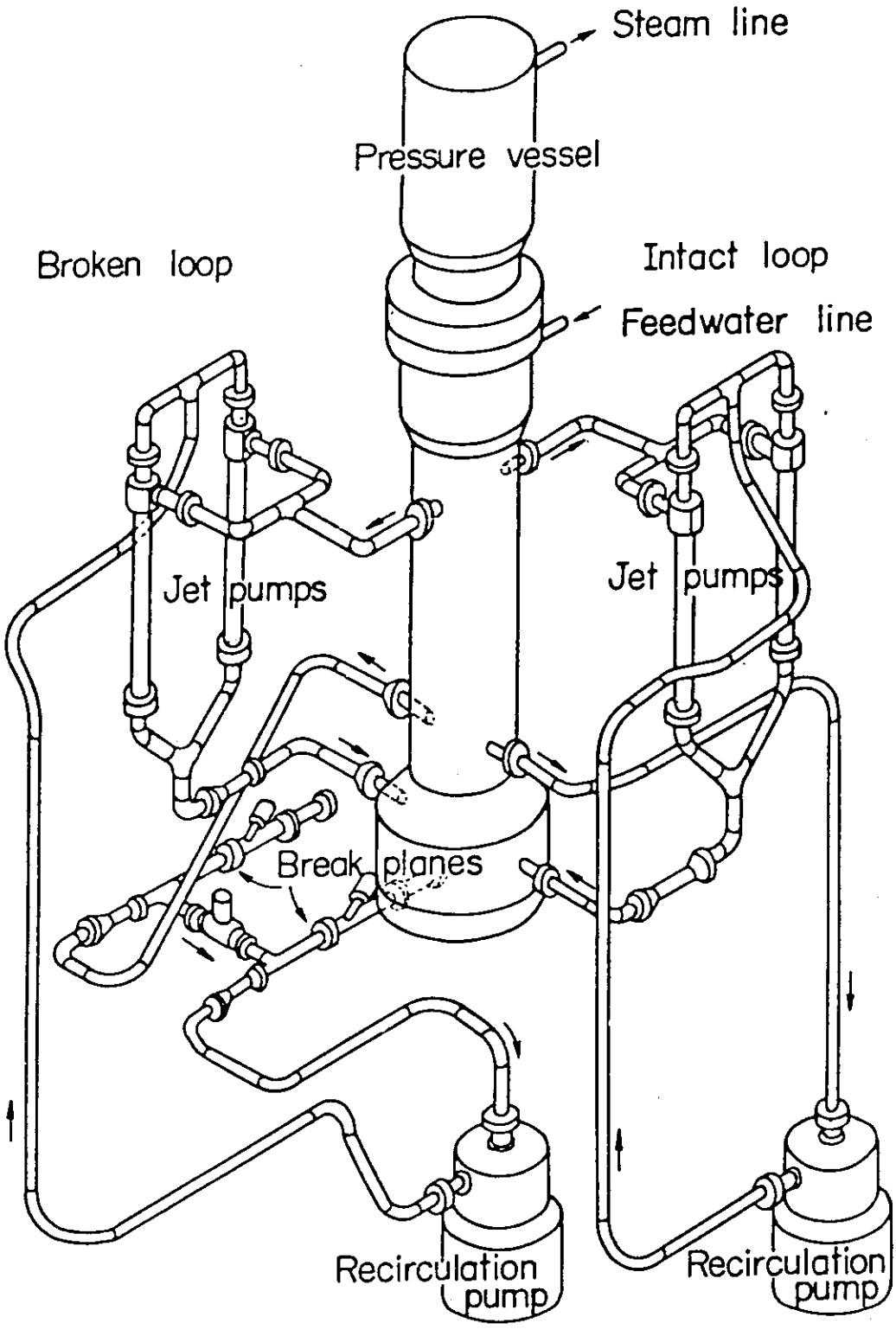


Fig. 2.1 ROSA-III Major Components

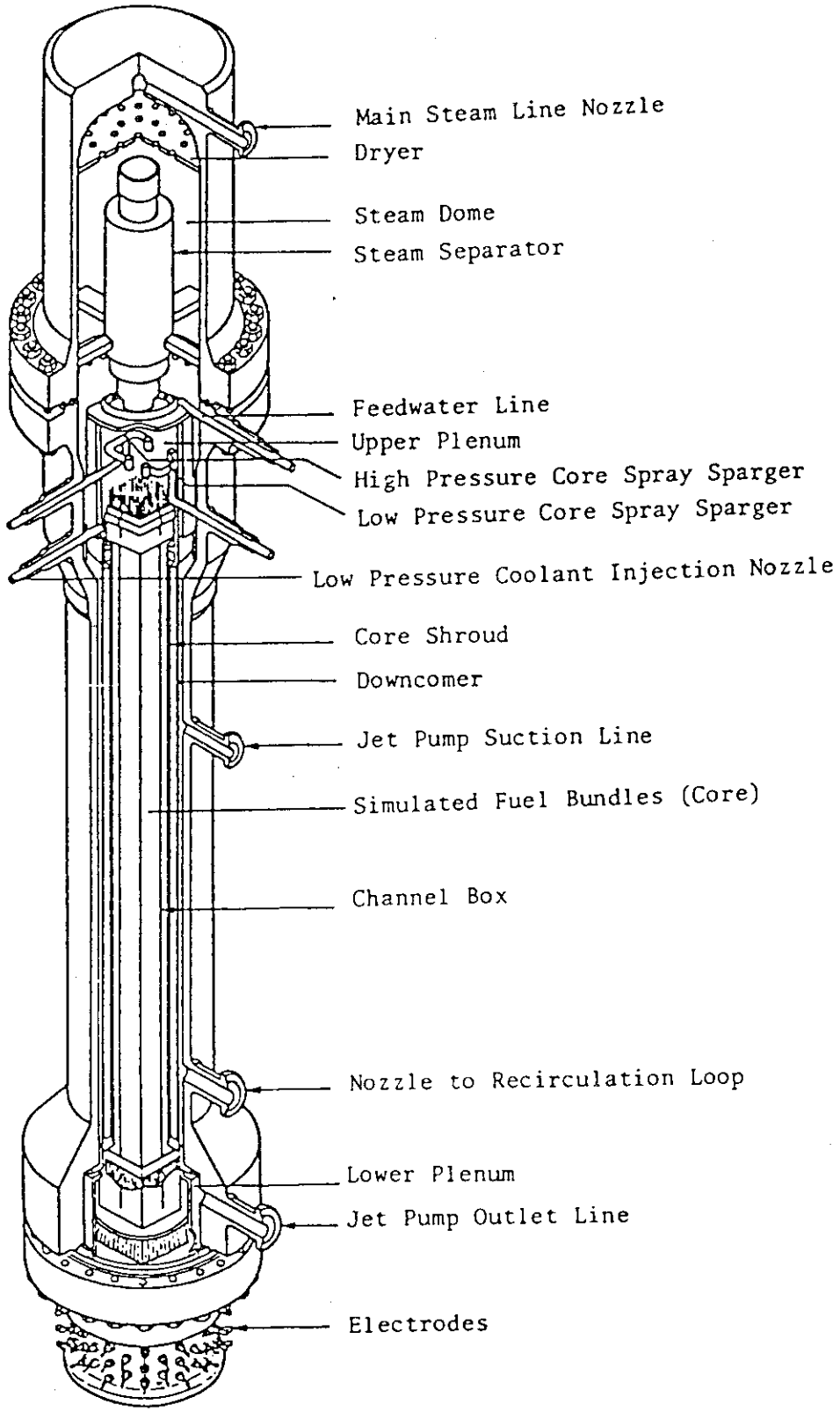


Fig. 2.2 Pressure Vessel Internal Structure

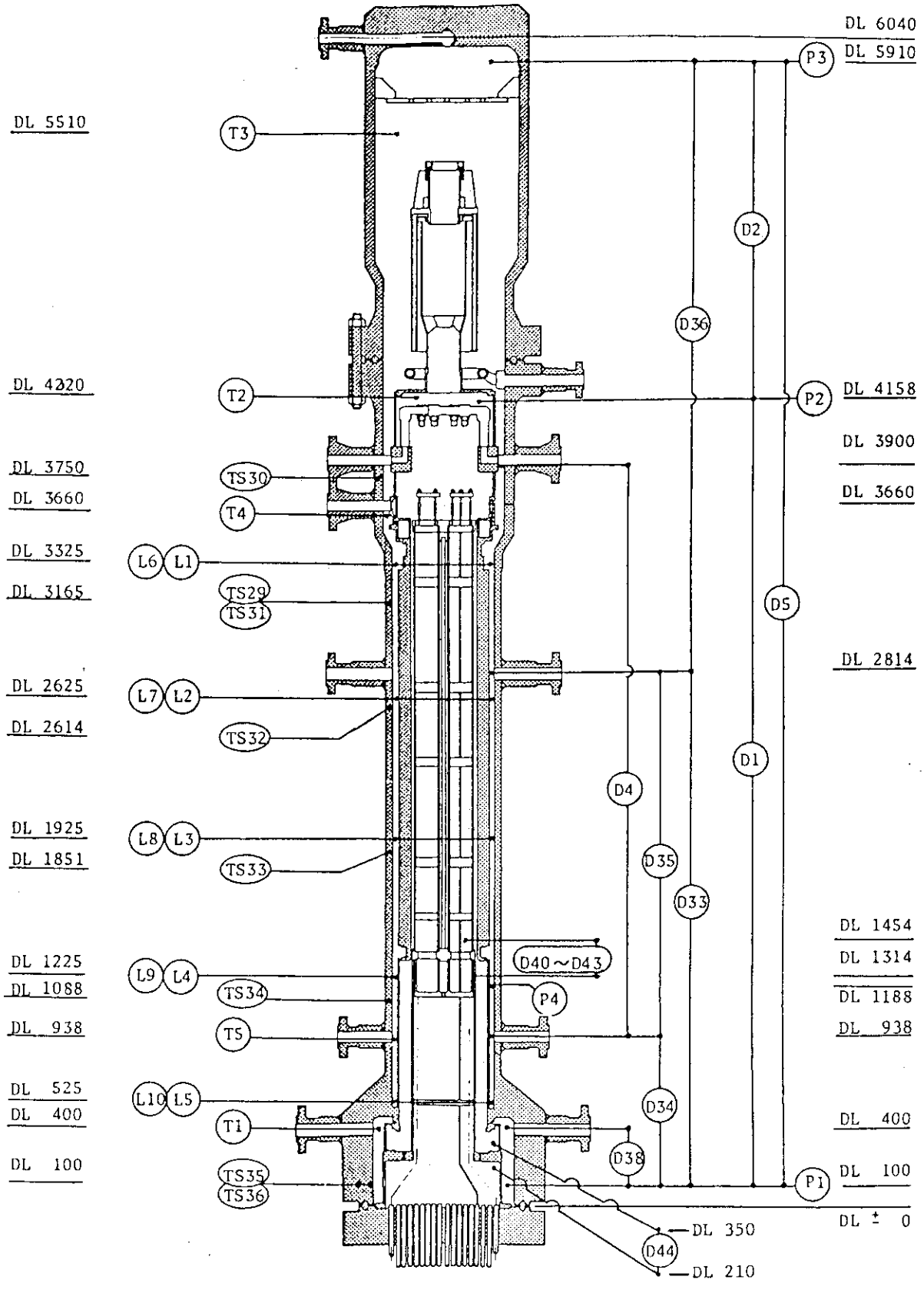


Fig. 2.3 Pressure Vessel Instruments Arrangement

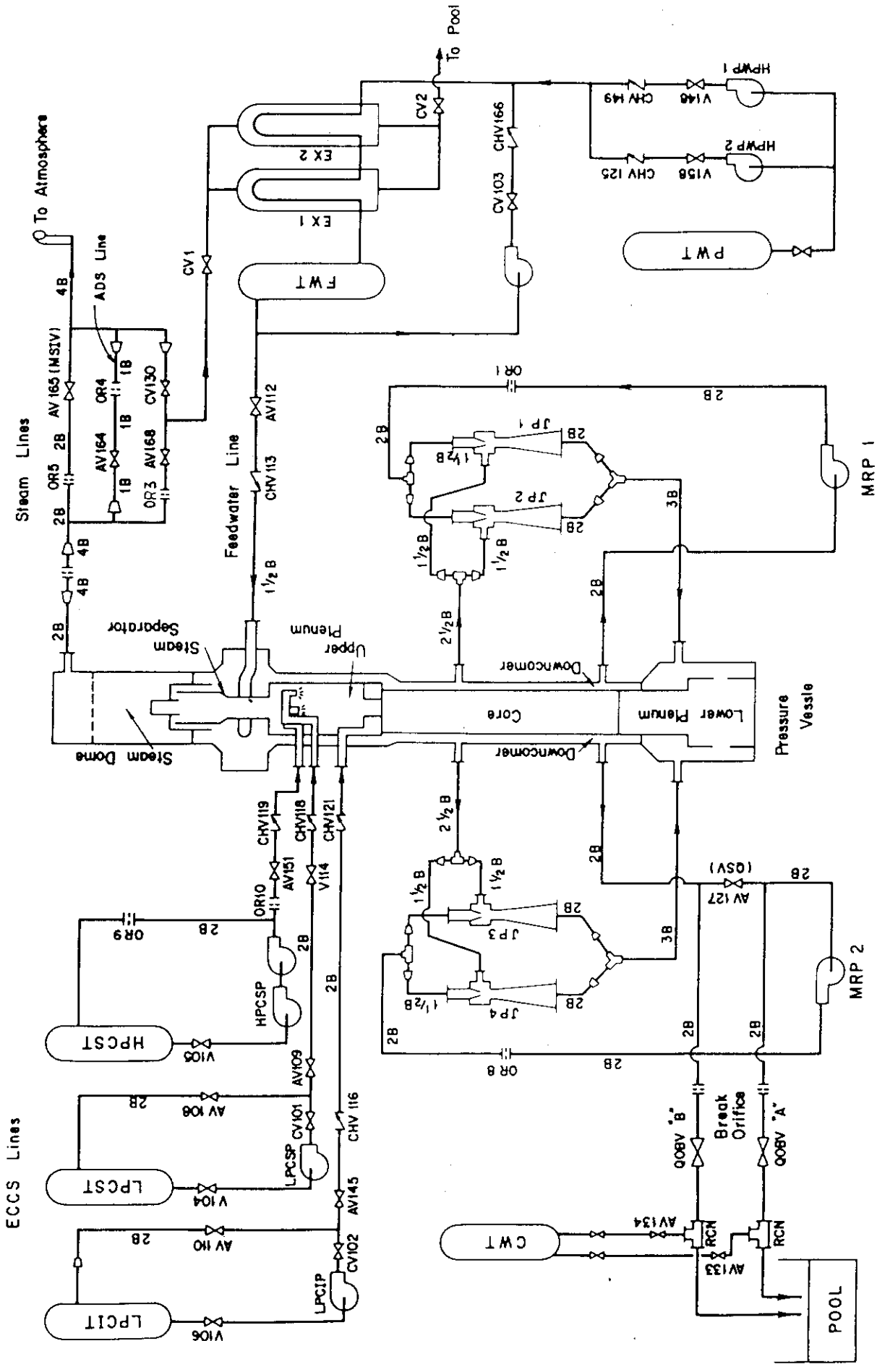
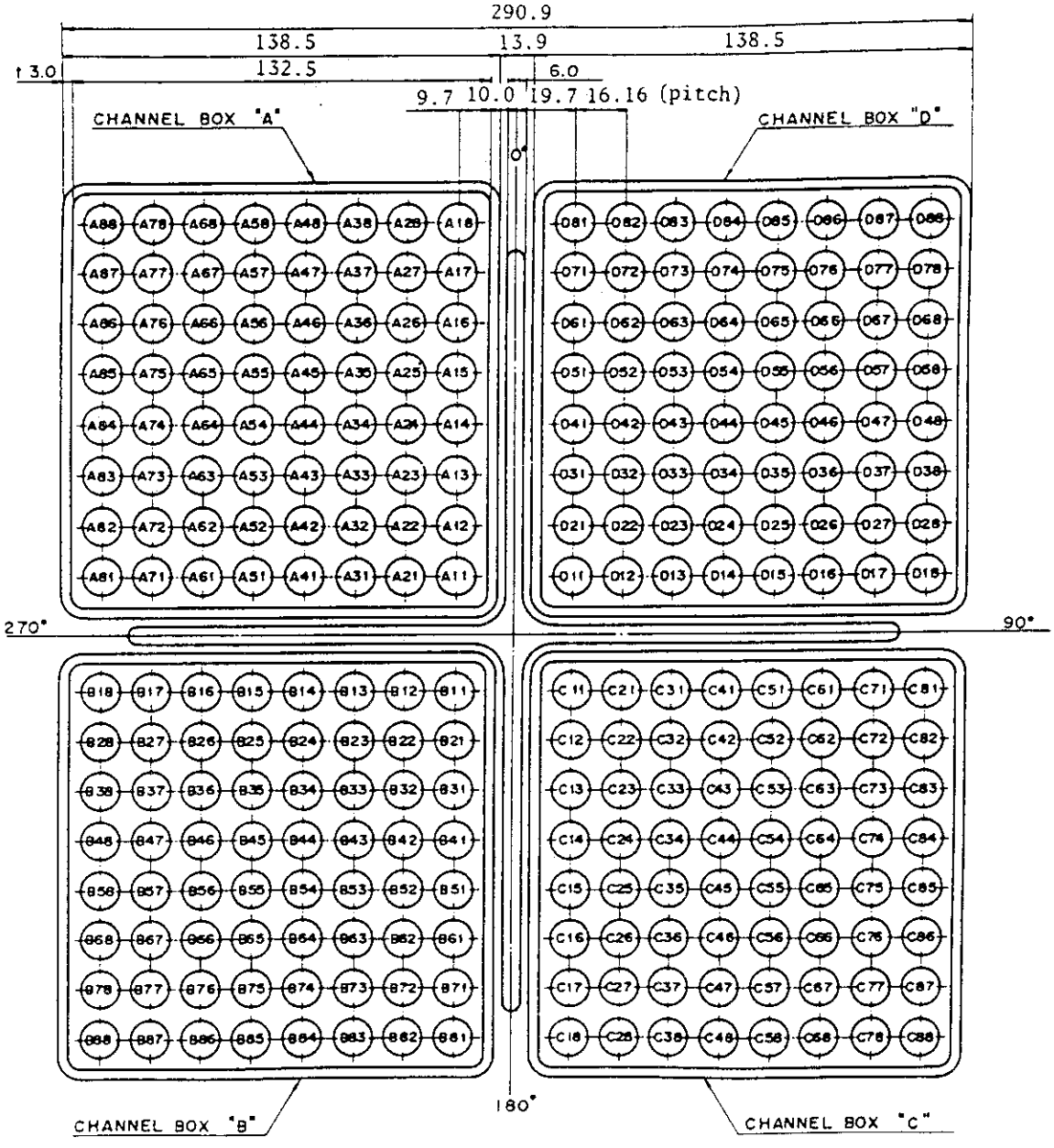


Fig. 2.4 ROSA-III Piping System



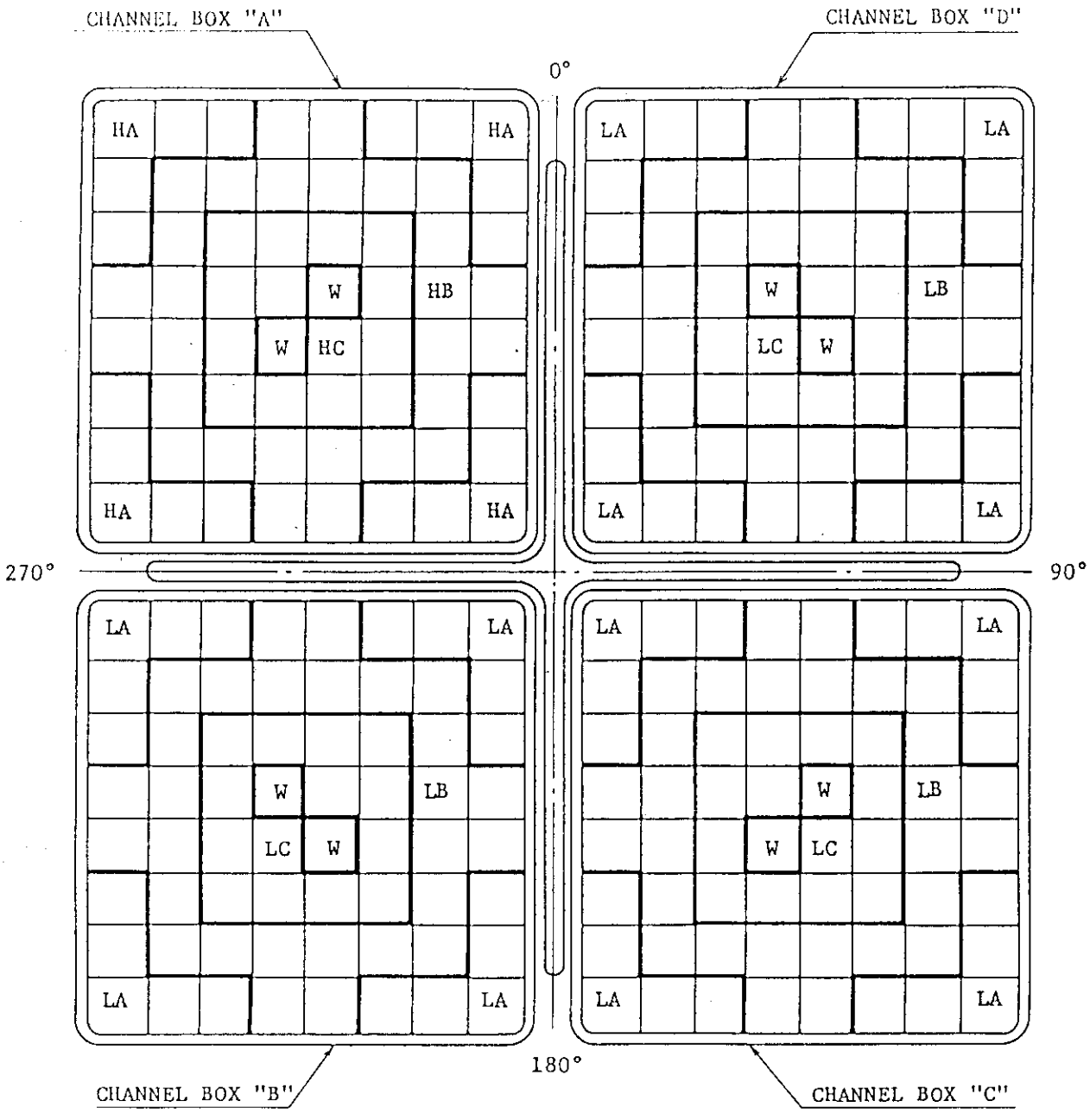
Peaking Factor ; A = 1.4, B, C and D = 1.0

Heater Rod O.D. = 12.27mm

A54,B54,C54 and D54 are water rod simurators with void probes.
O.D. = 15.01mm

A45,B45,C45 and D45 are water rod simurators with thermocouples.
O.D. = 15.01mm

Fig. 2.5 (a) Heater Rod Arrangement



Region	HA	HB	HC	LA	LB	LC	W
Linear Heat Rate (kw/m)*	18.5	16.81	14.41	13.21	12.01	10.29	0.0
Local Peaking factor	1.1	1.0	0.875	1.1	1.0	0.875	0.0
No. of Rods	20	28	14	60	84	42	8

note : Radial Peaking factor is 1.4

* in the case of power = 4.4MW

Fig. 2.5 (b) Radial Power Distribution

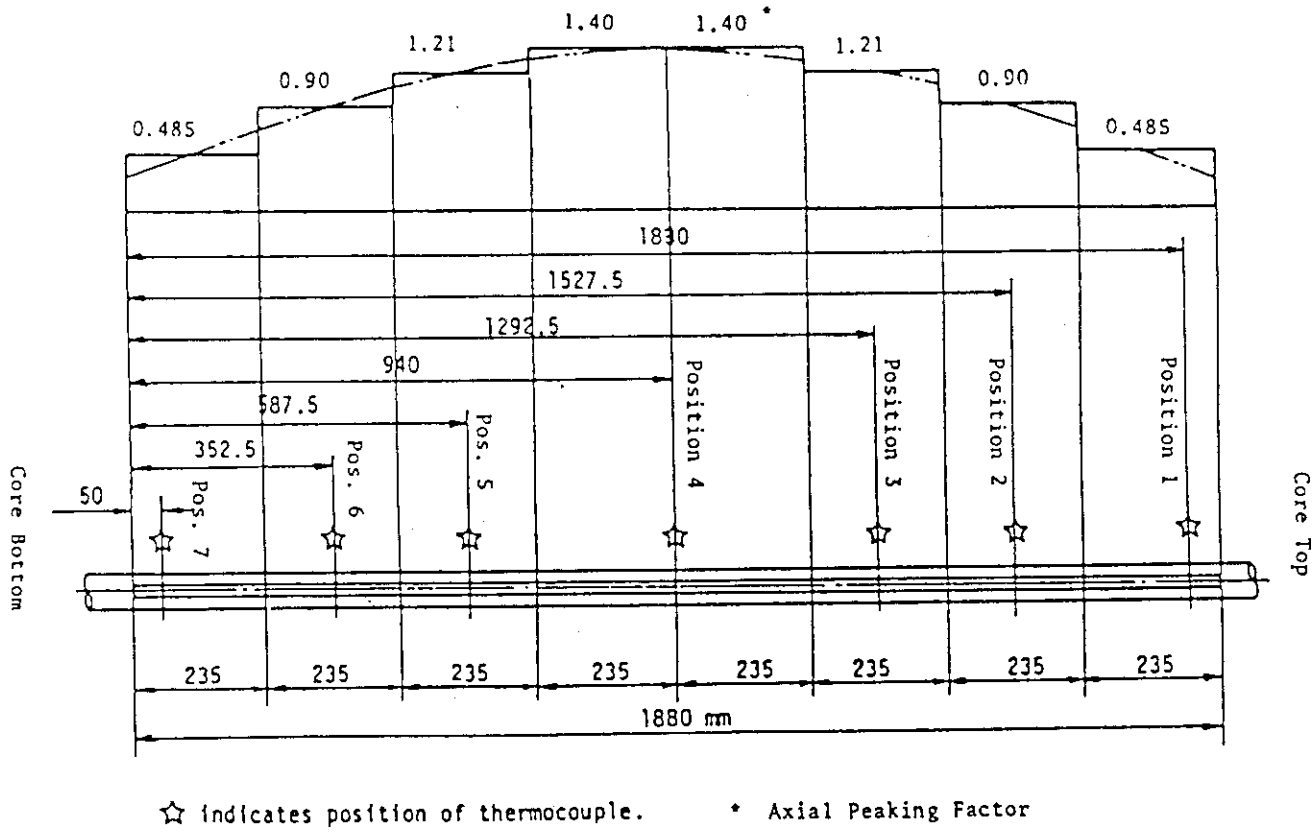


Fig. 2.6 Axial Power Distribution

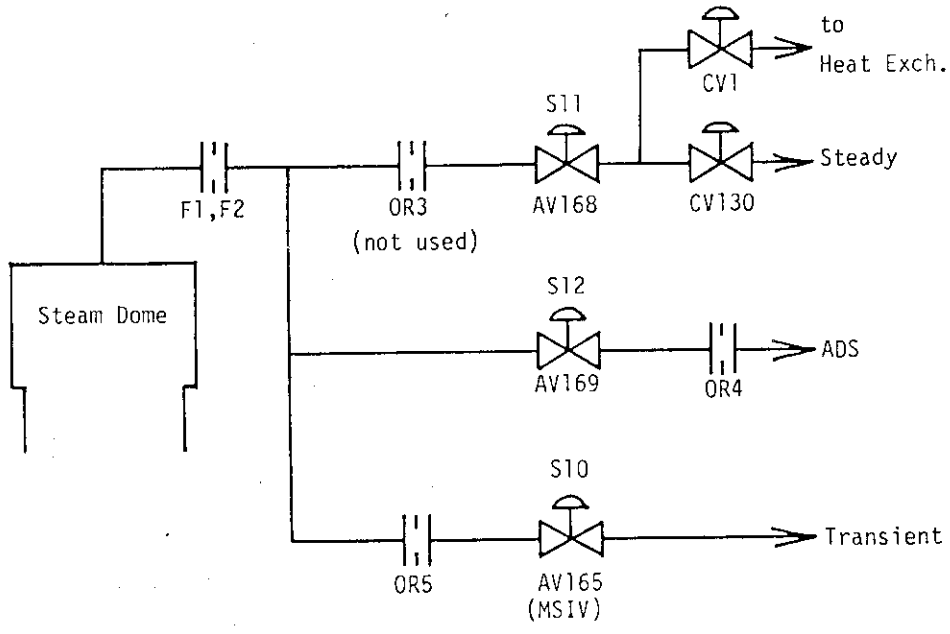


Fig. 2.7 Schematic of Steam Line

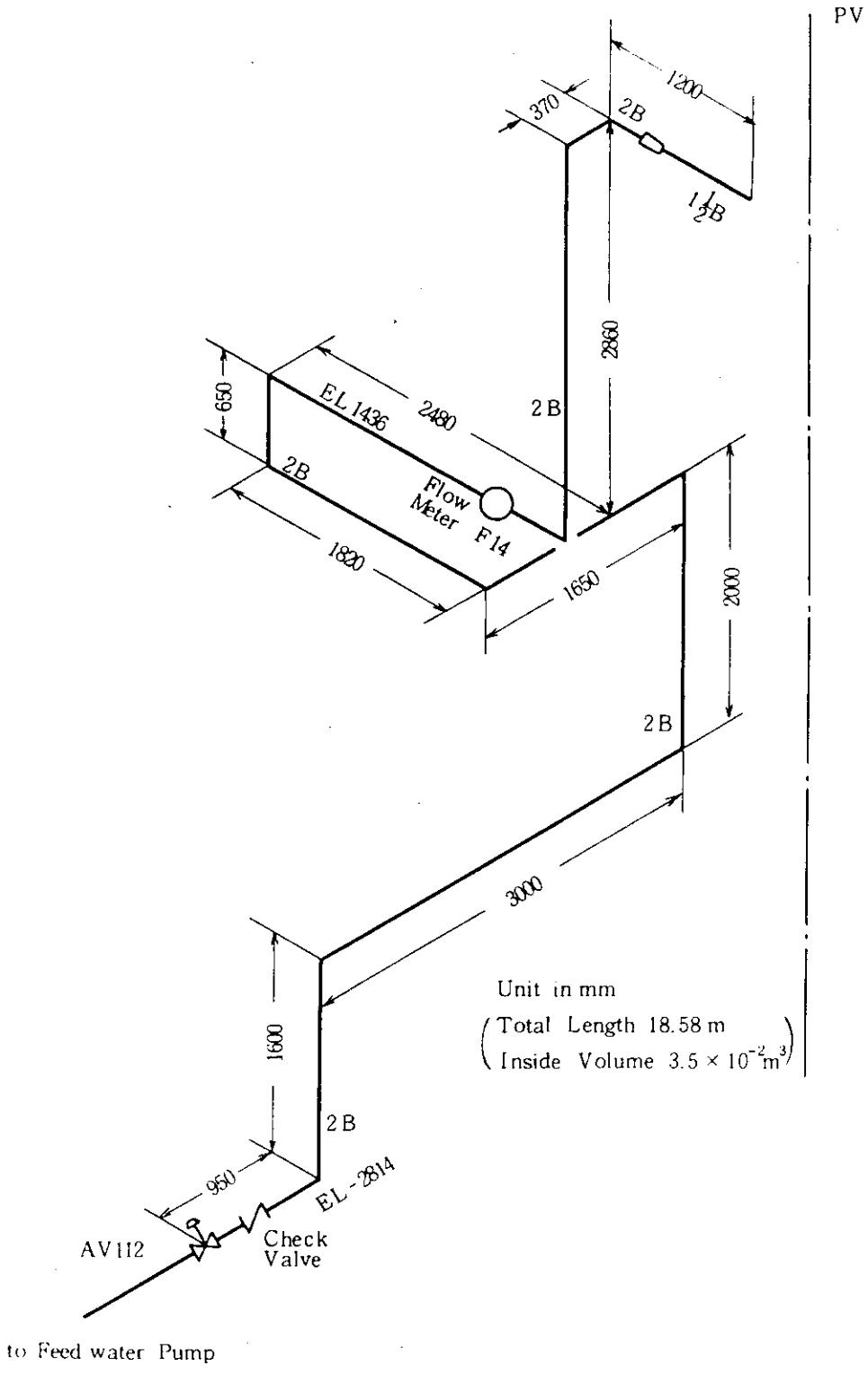
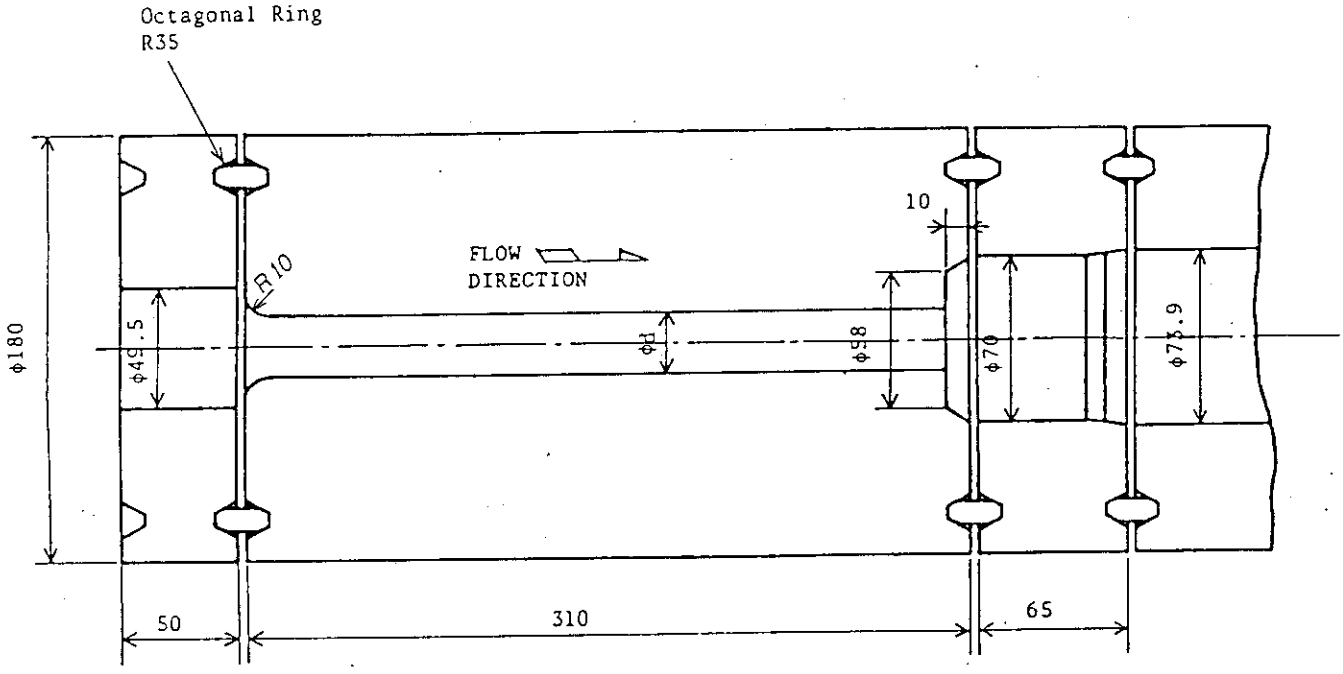


Fig. 2.8 Schematic of Feedwater Line



Material SUS304

Dimension in mm

Break area ratio (%)	d (mm)
100	26.2

Fig. 2.9 Break Nozzle

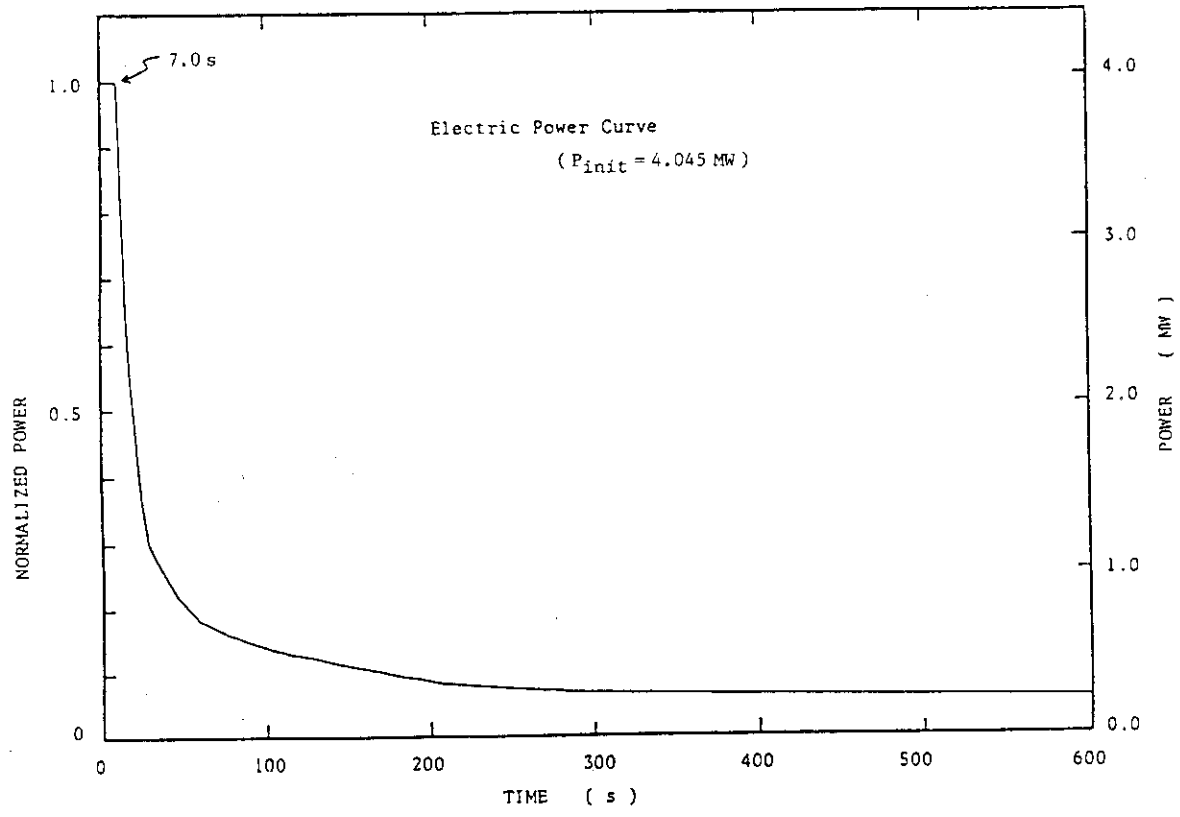


Fig. 2.10 Power Transient

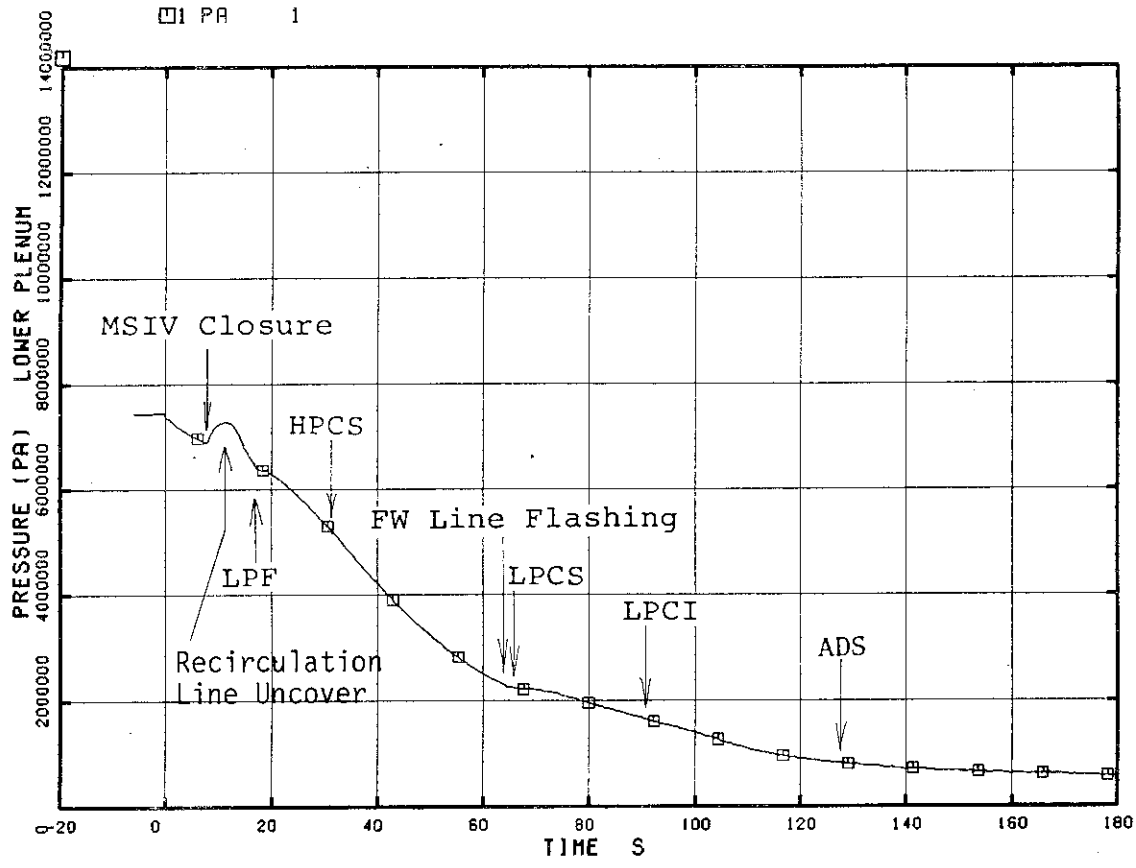


Fig. 2.11 Lower Plenum Pressure

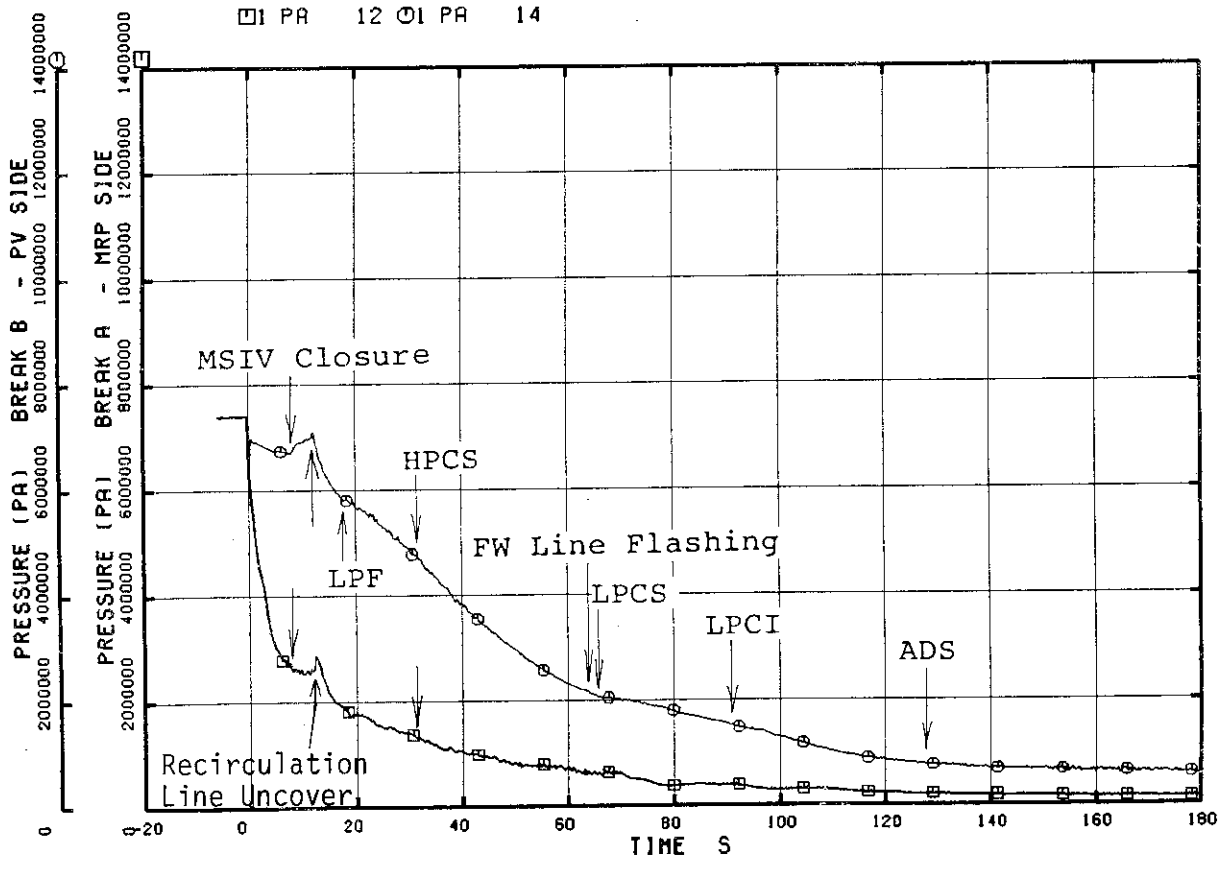


Fig. 2.12 Break Upstream Pressure

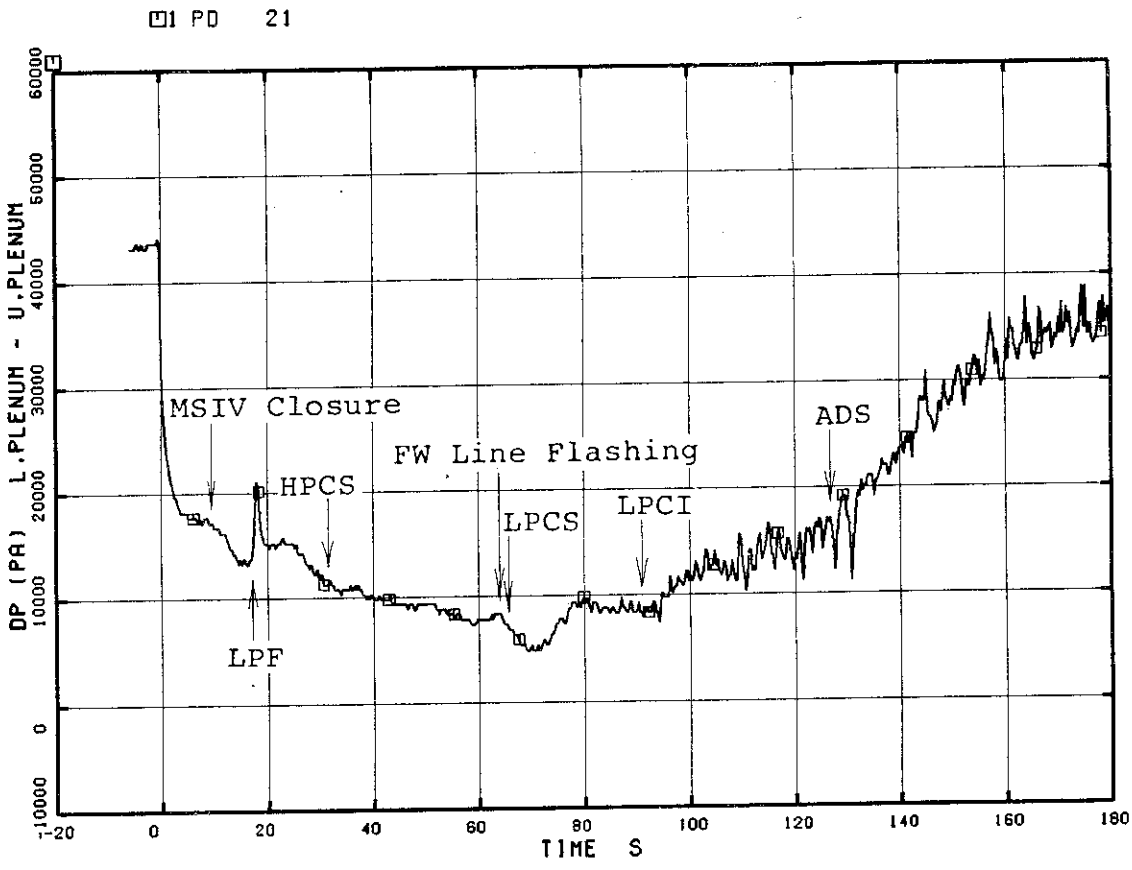


Fig. 2.13 Differential Pressure between Lower and Upper Plena

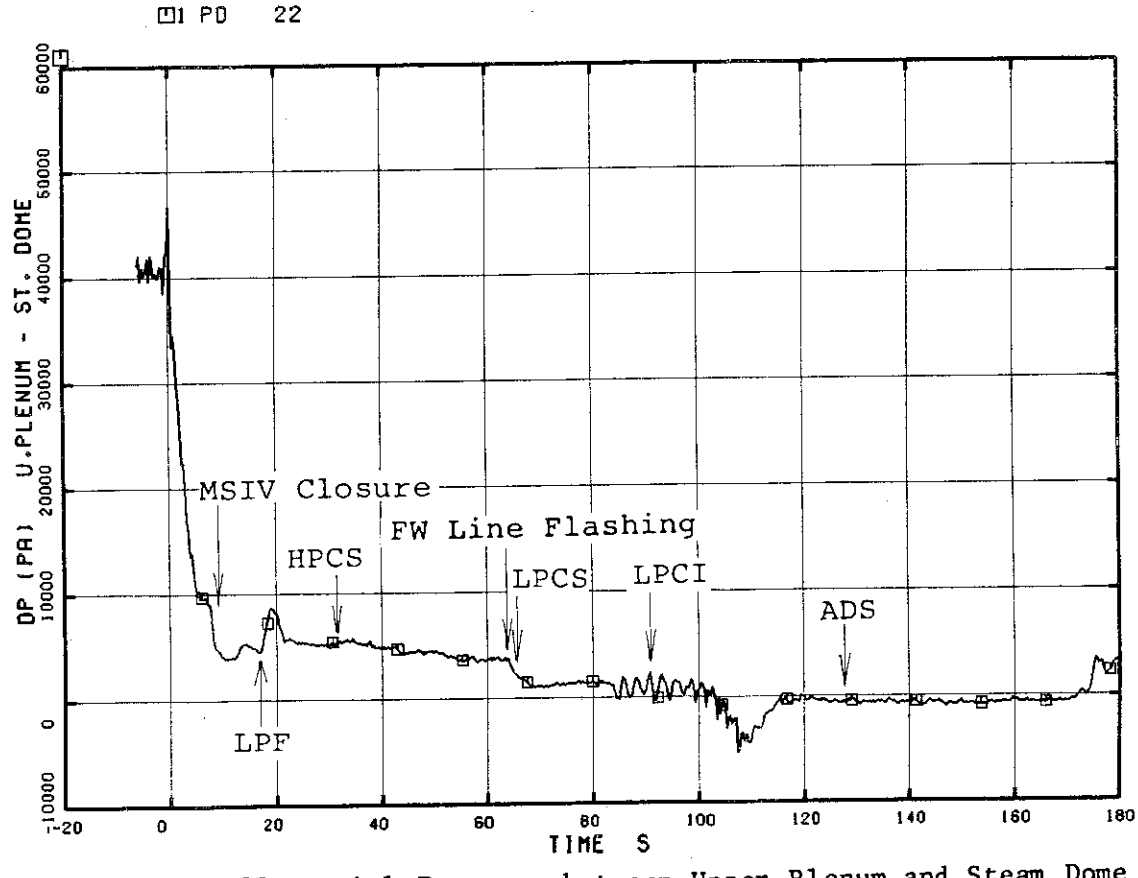


Fig. 2.14 Differential Pressure between Upper Plenum and Steam Dome

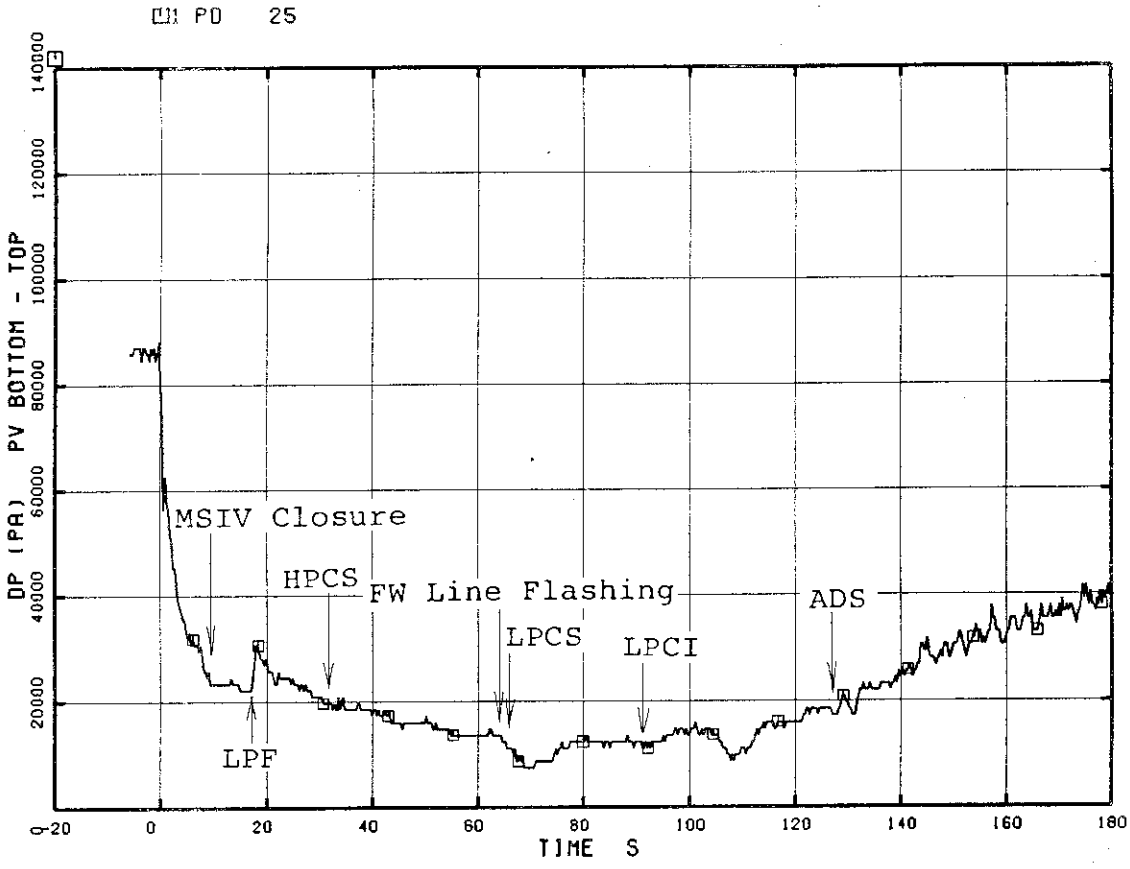


Fig. 2.15　　Differential Pressure between Lower Plenum and Steam Dome

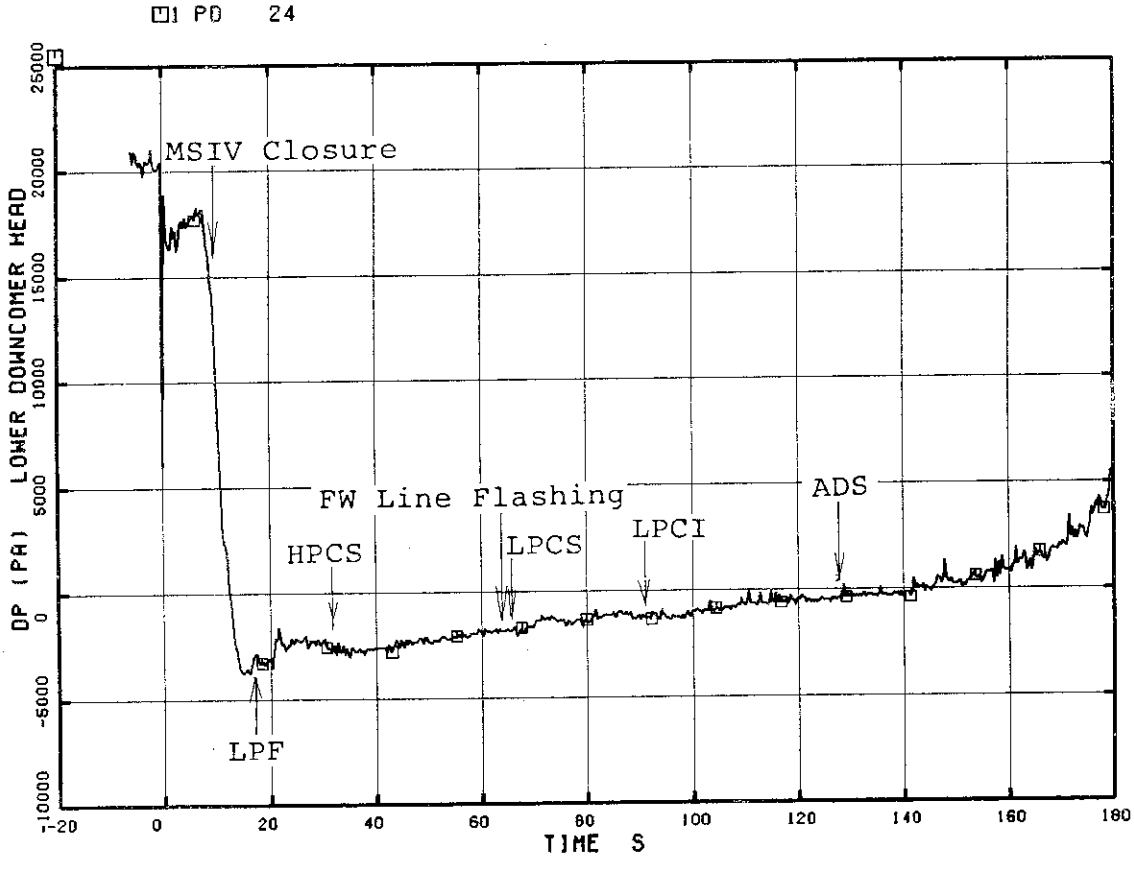


Fig. 2.16　　Lower Downcomer Head

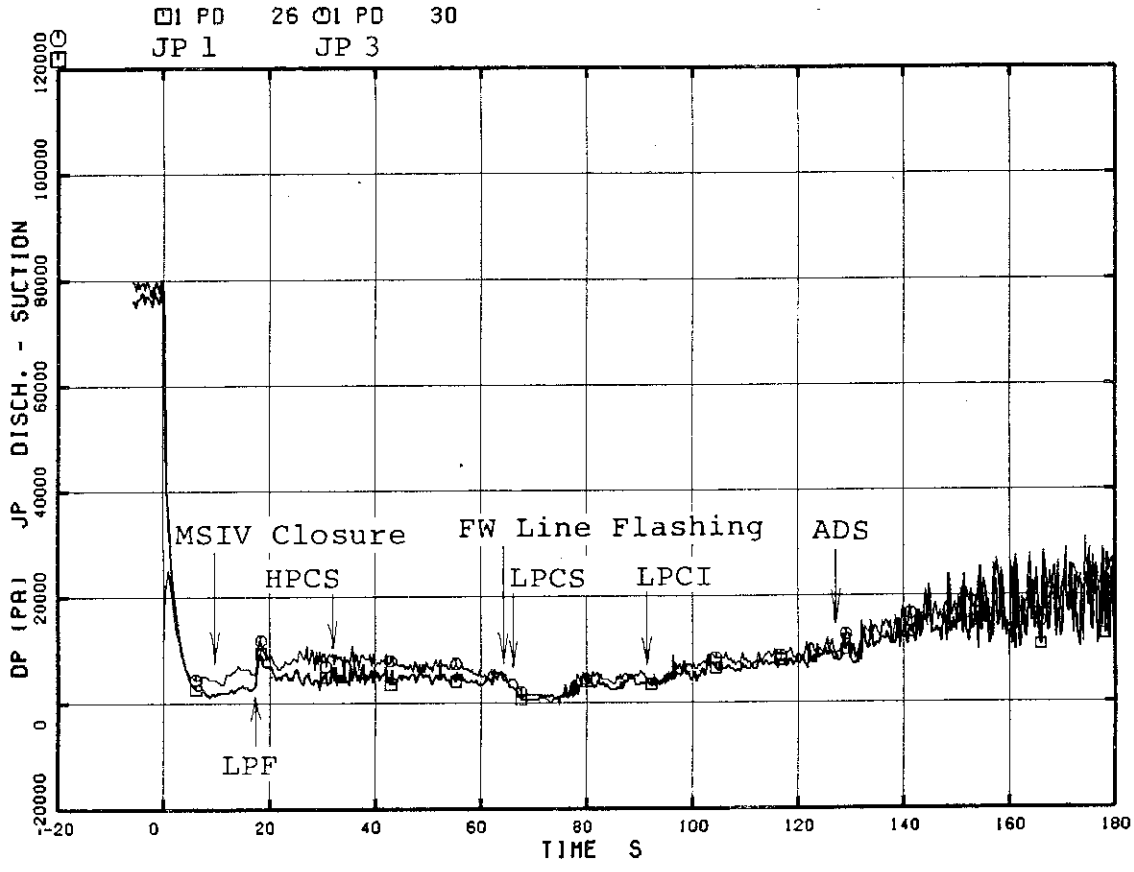


Fig. 2.17 Differential Pressure between Jet Pump Discharge and Suction

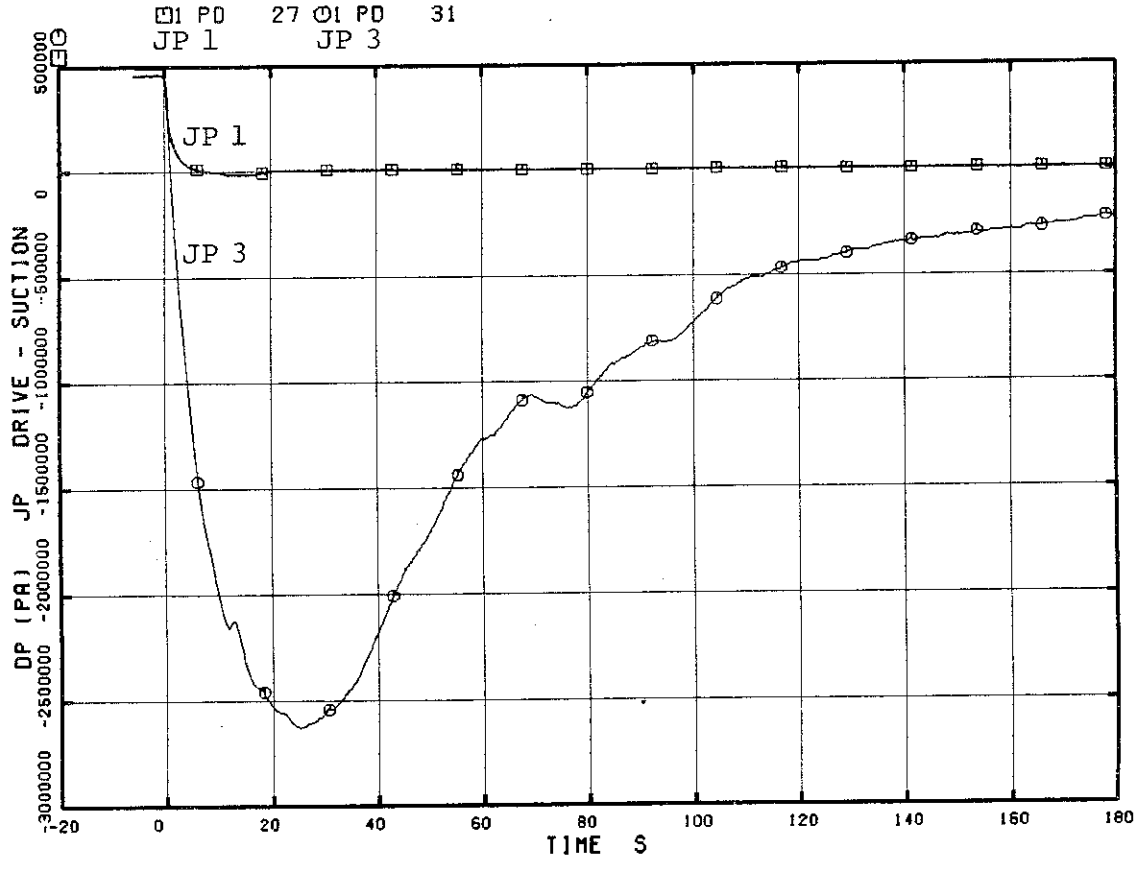


Fig. 2.18 Differential Pressure between Jet Pump Drive and Suction

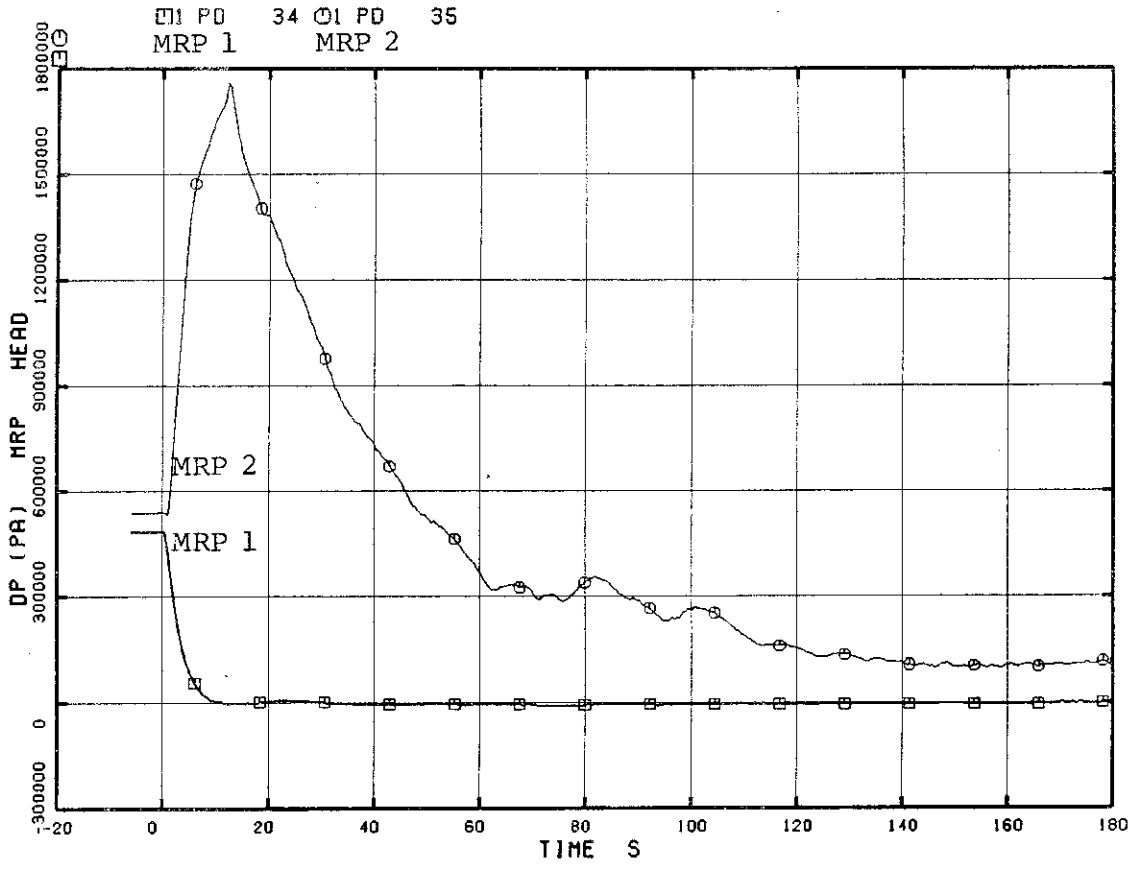


Fig. 2.19 Differential Pressure between MRP Delivery and Suction

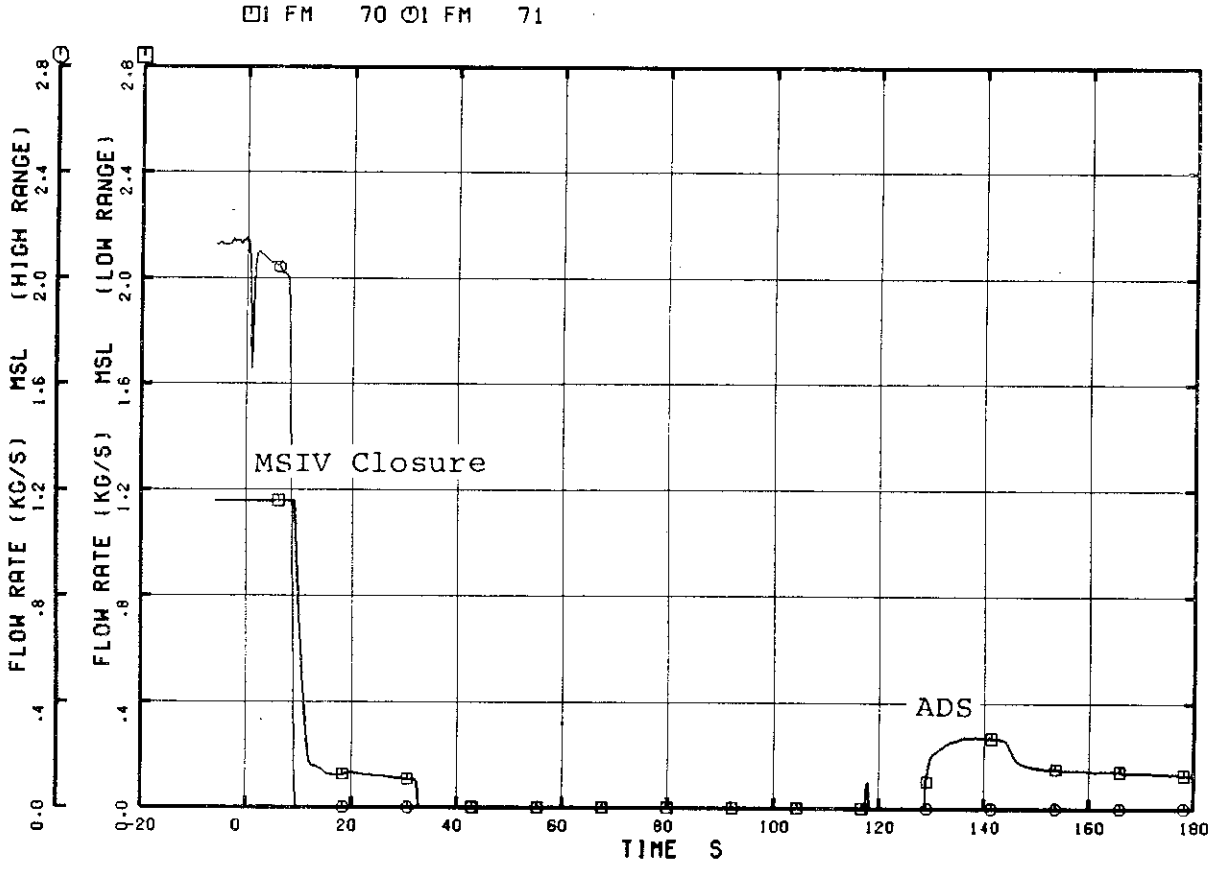


Fig. 2.20 Main Steam Discharge Flow Rate

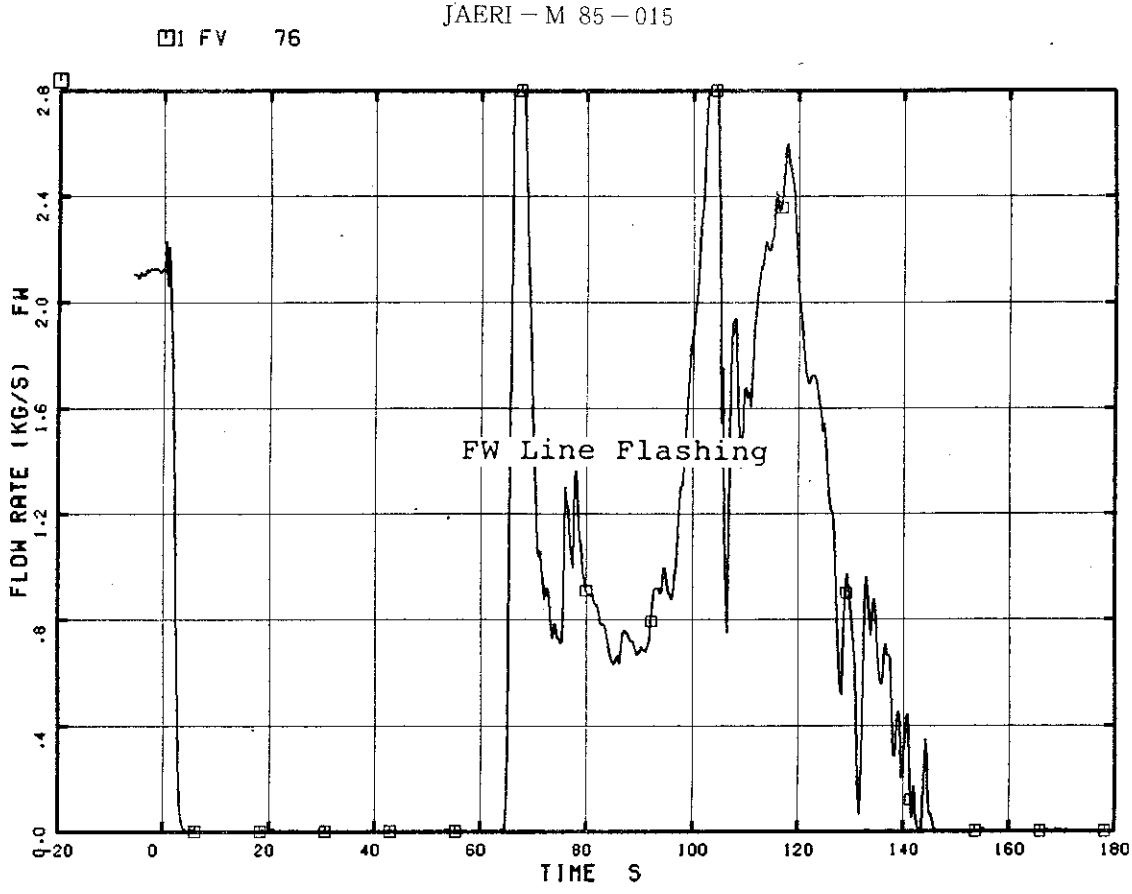


Fig. 2.21(a) Feedwater Flow Rate

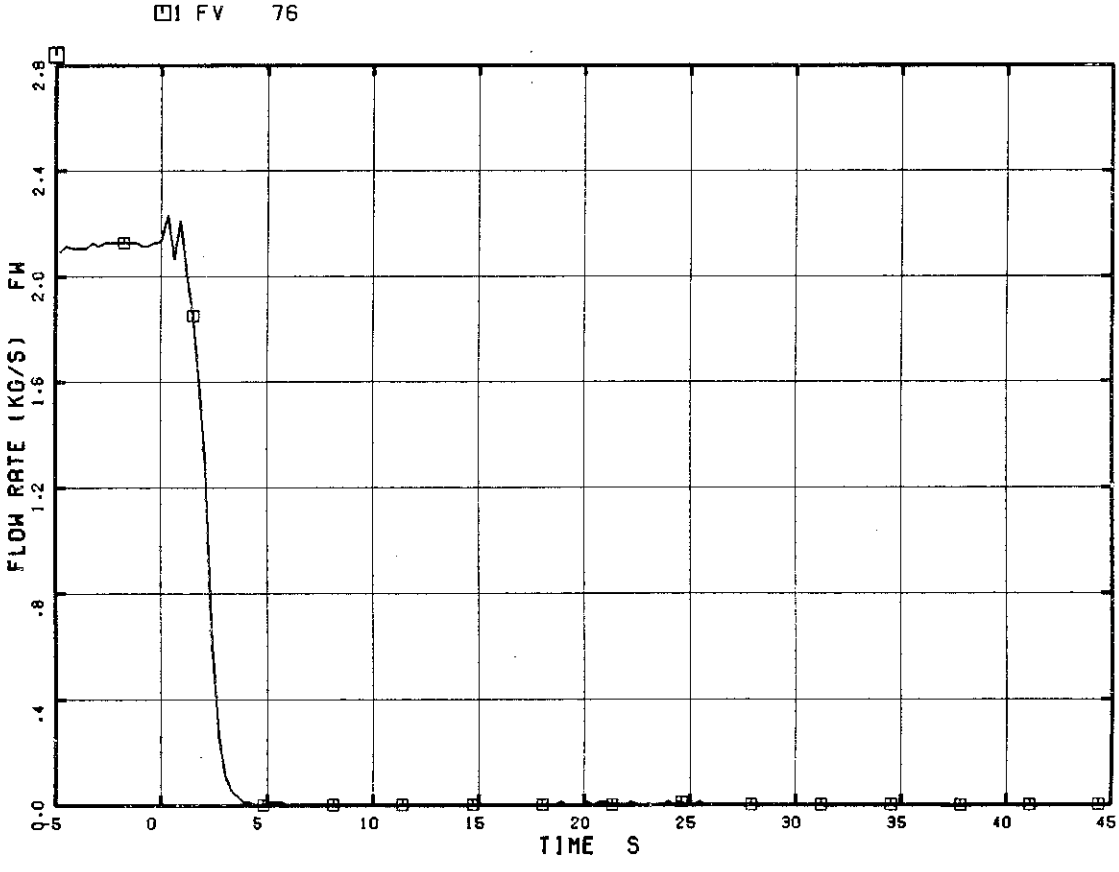


Fig. 2.21(b) Feedwater Flow Rate (Expanded Time History)

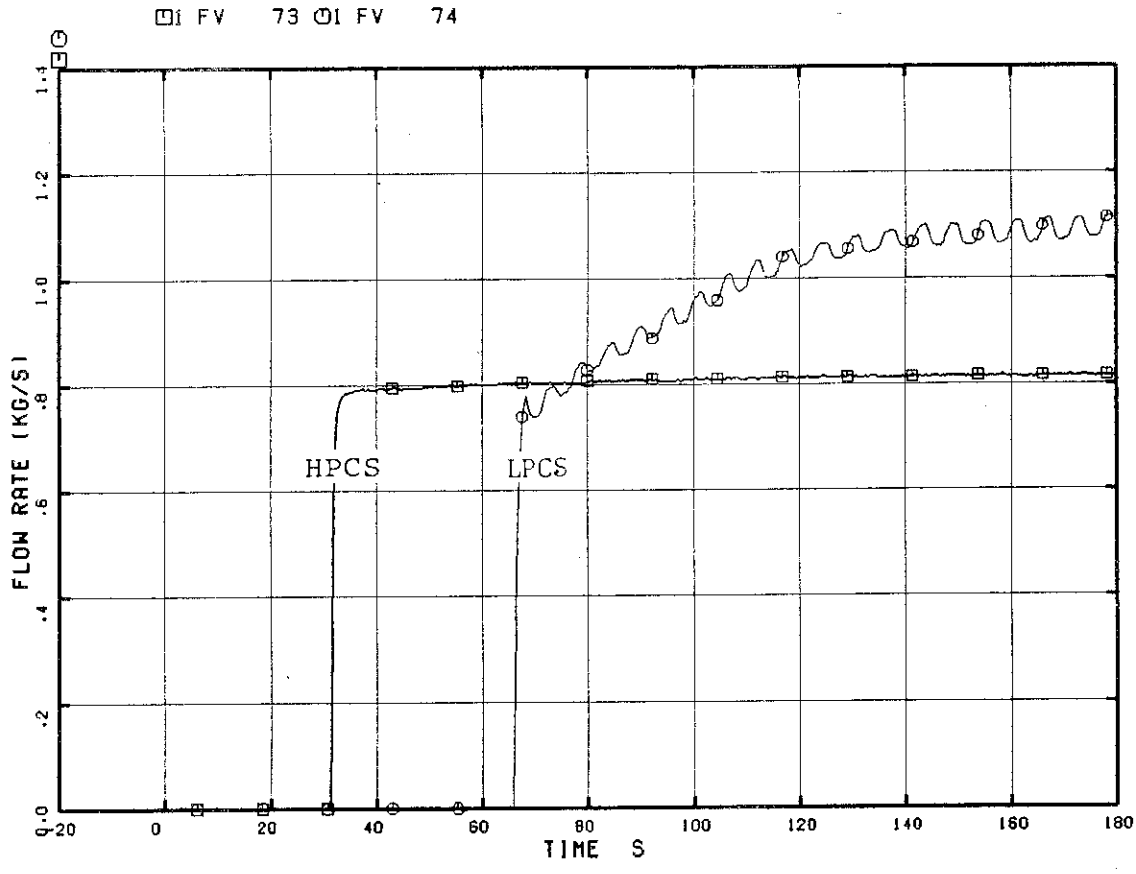


Fig. 2.22 HPCS and LPCS Flow Rates

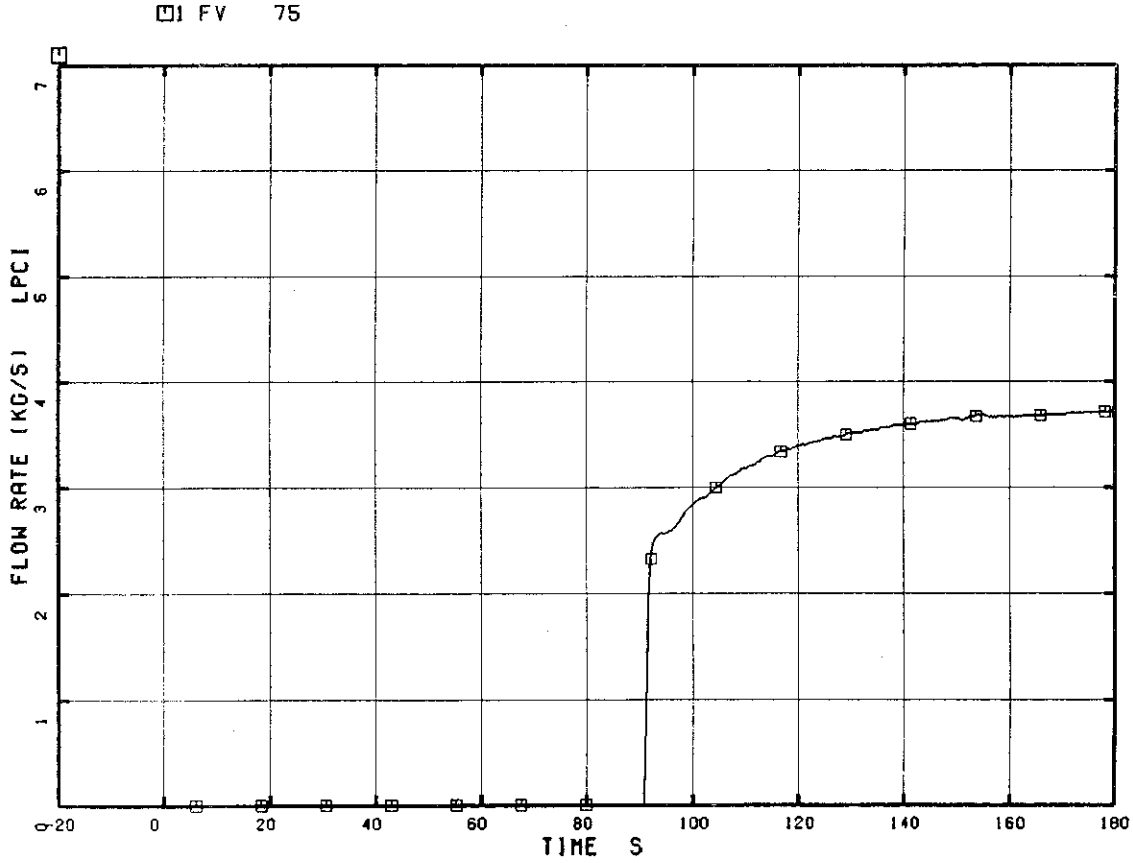


Fig. 2.23 LPCI Flow Rates

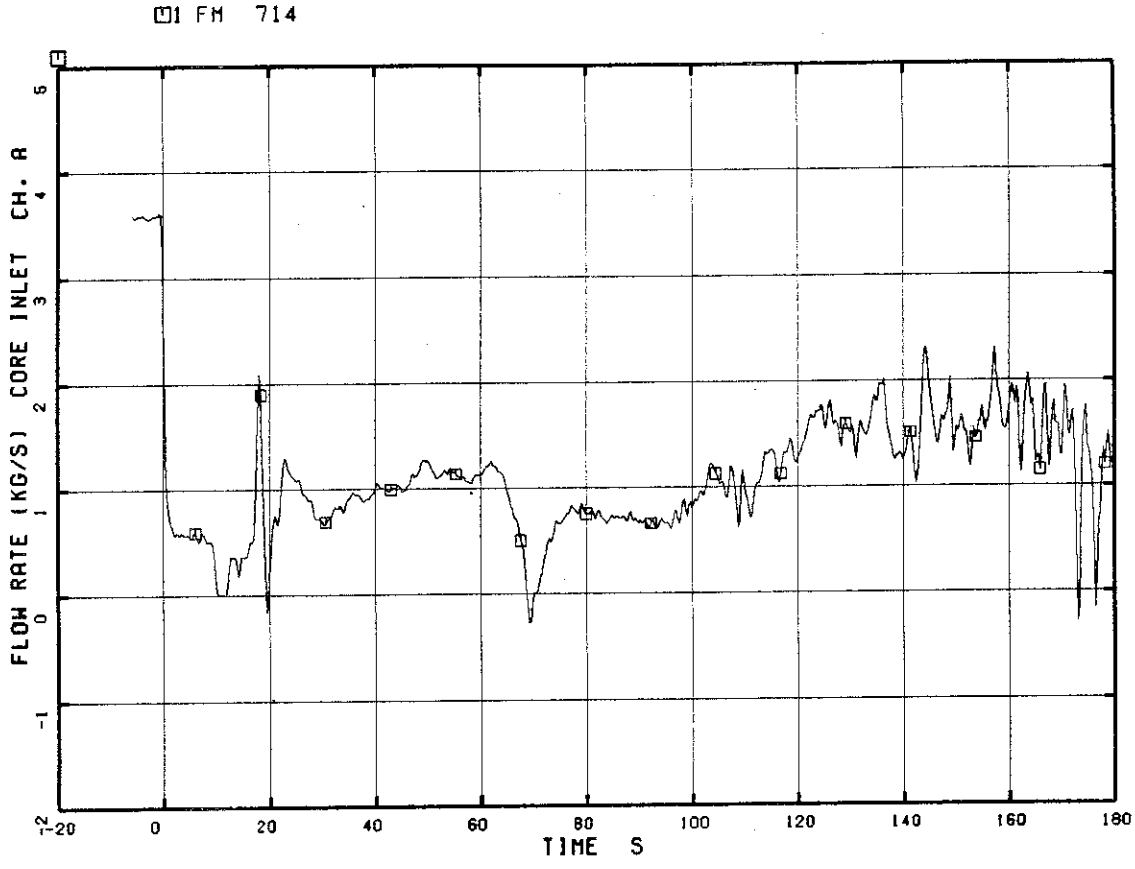


Fig. 2.24 Core Inlet Flow of Channel A

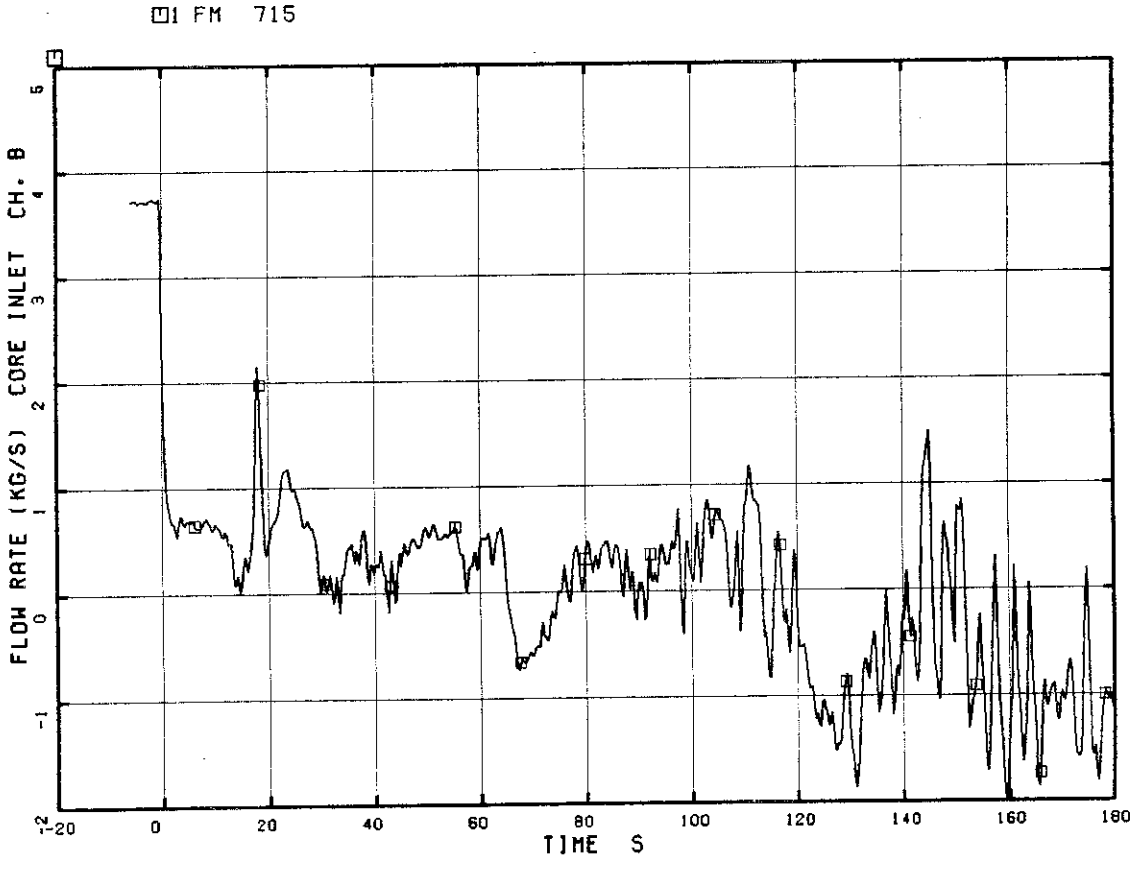


Fig. 2.25 Core Inlet Flow of Channel B

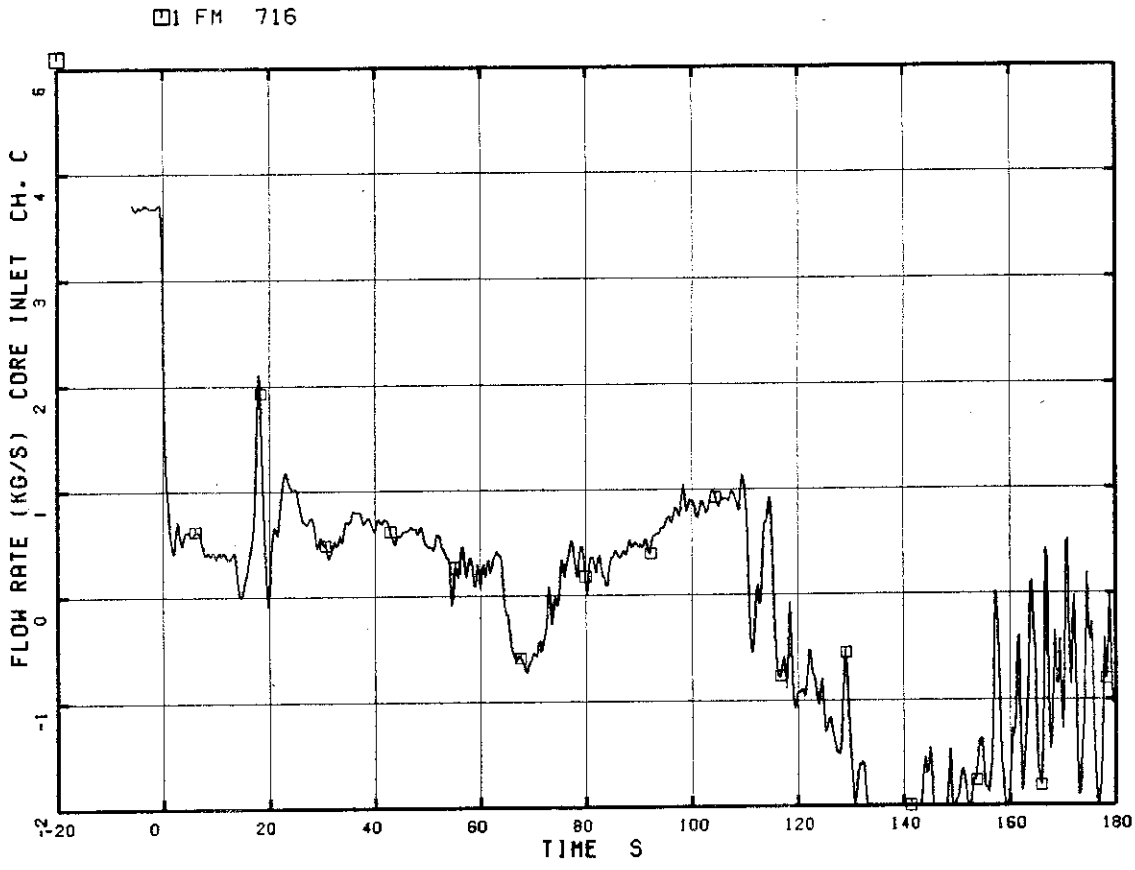


Fig. 2.26 Core Inlet Flow of Channel C

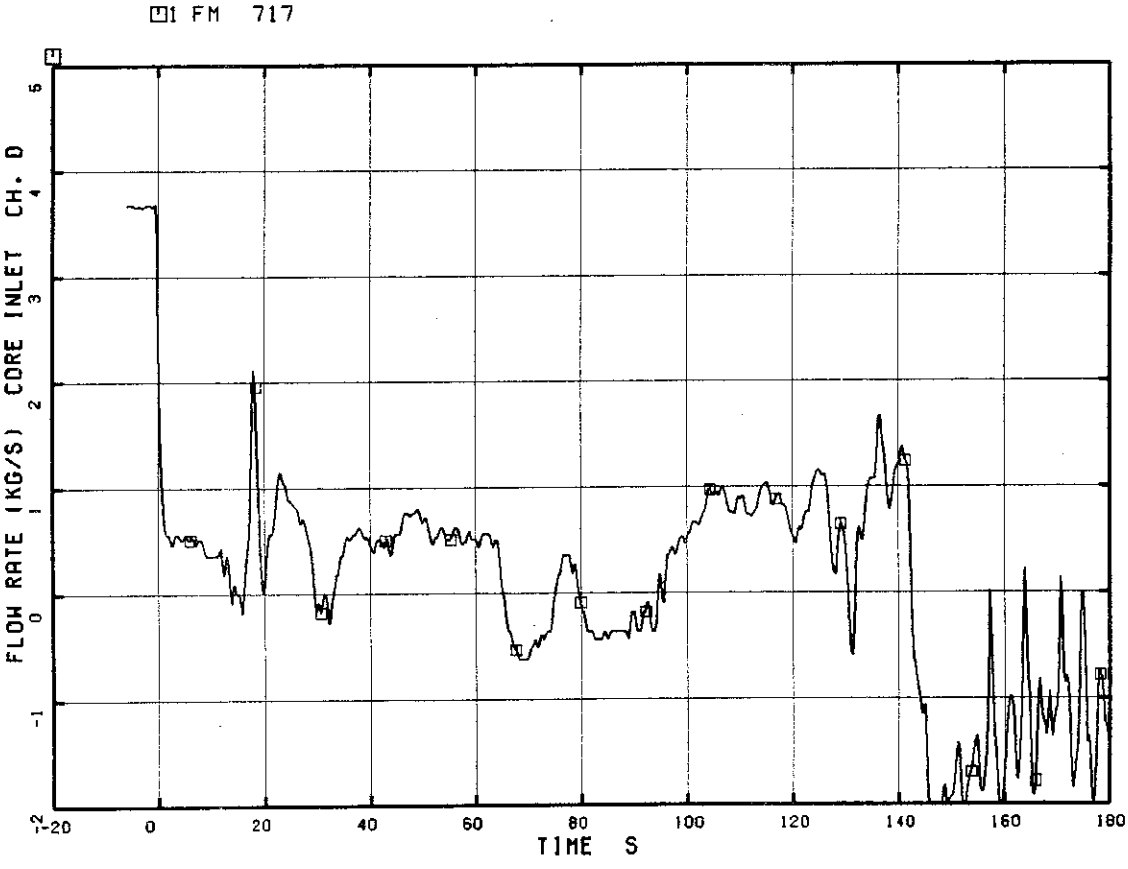


Fig. 2.27 Core Inlet Flow of Channel D

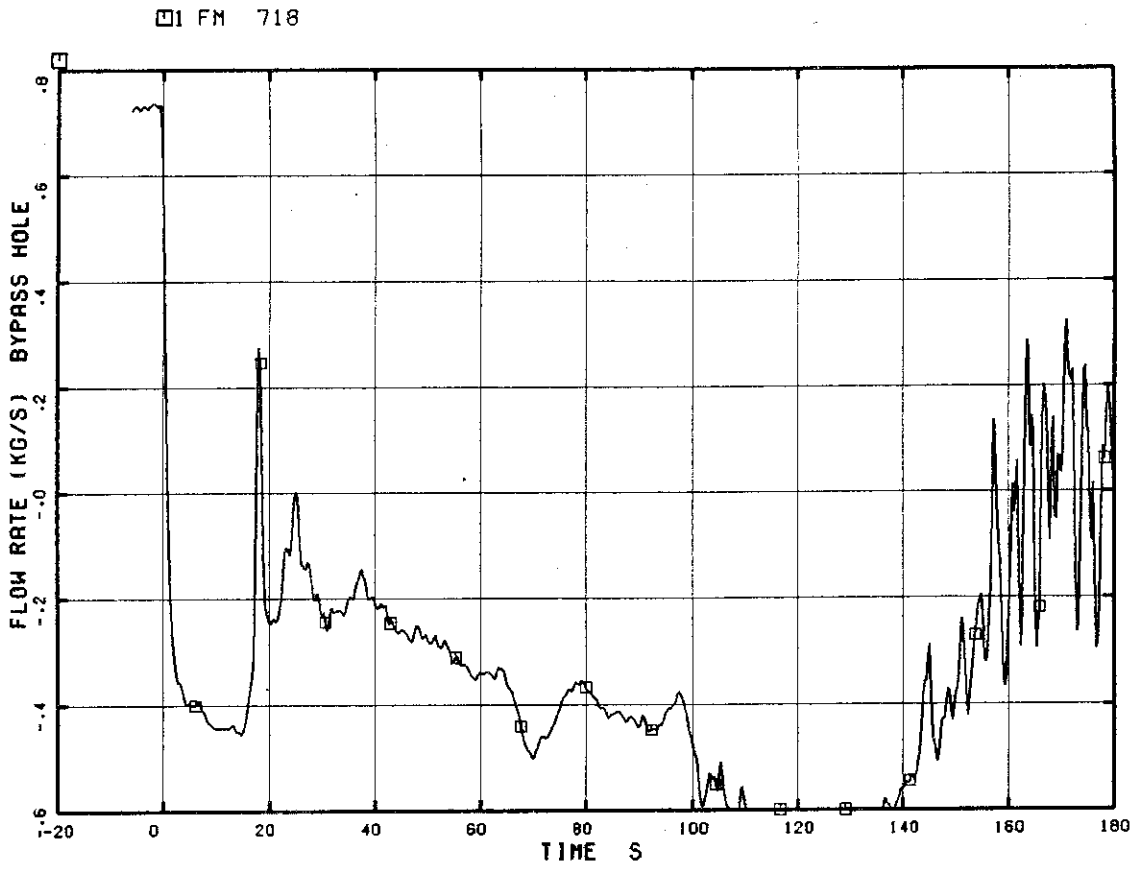


Fig. 2.28 Guide Tube Inlet Flow

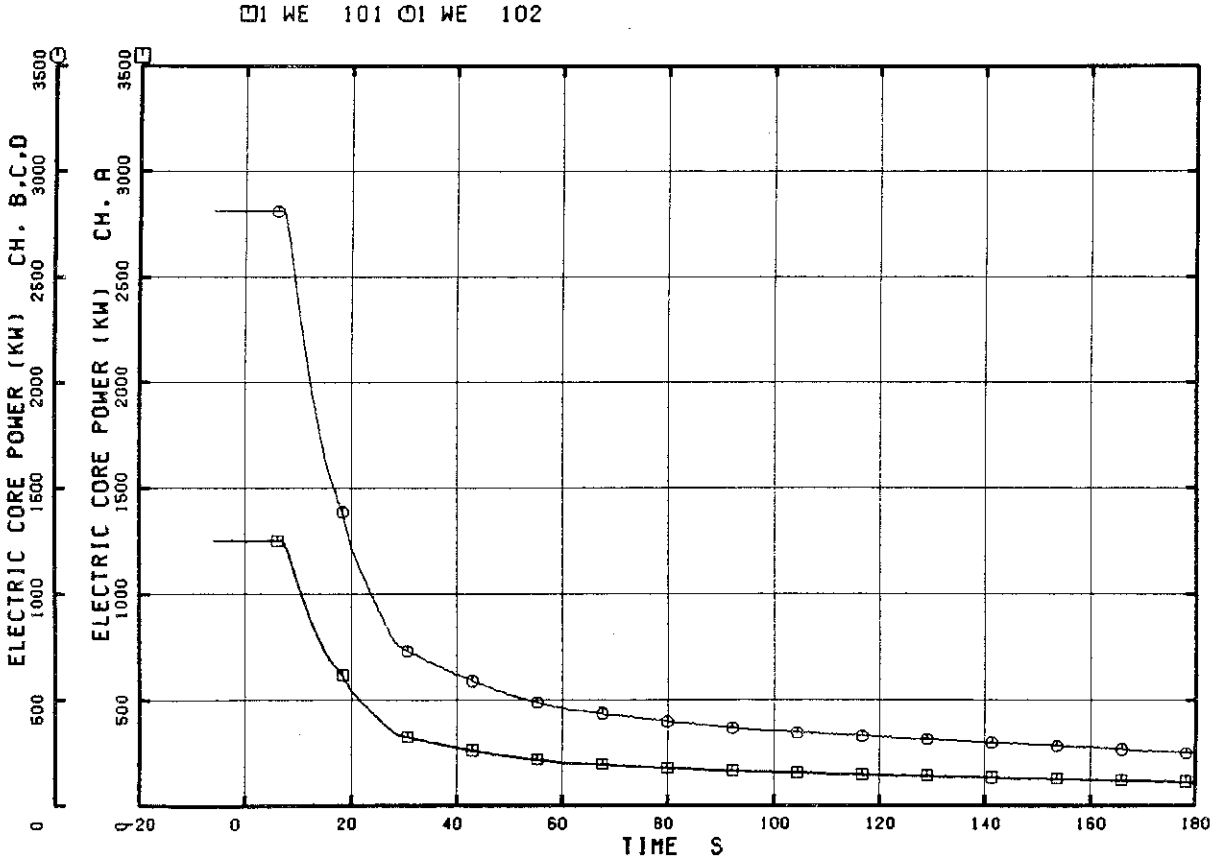


Fig. 2.29 Electric Core Power

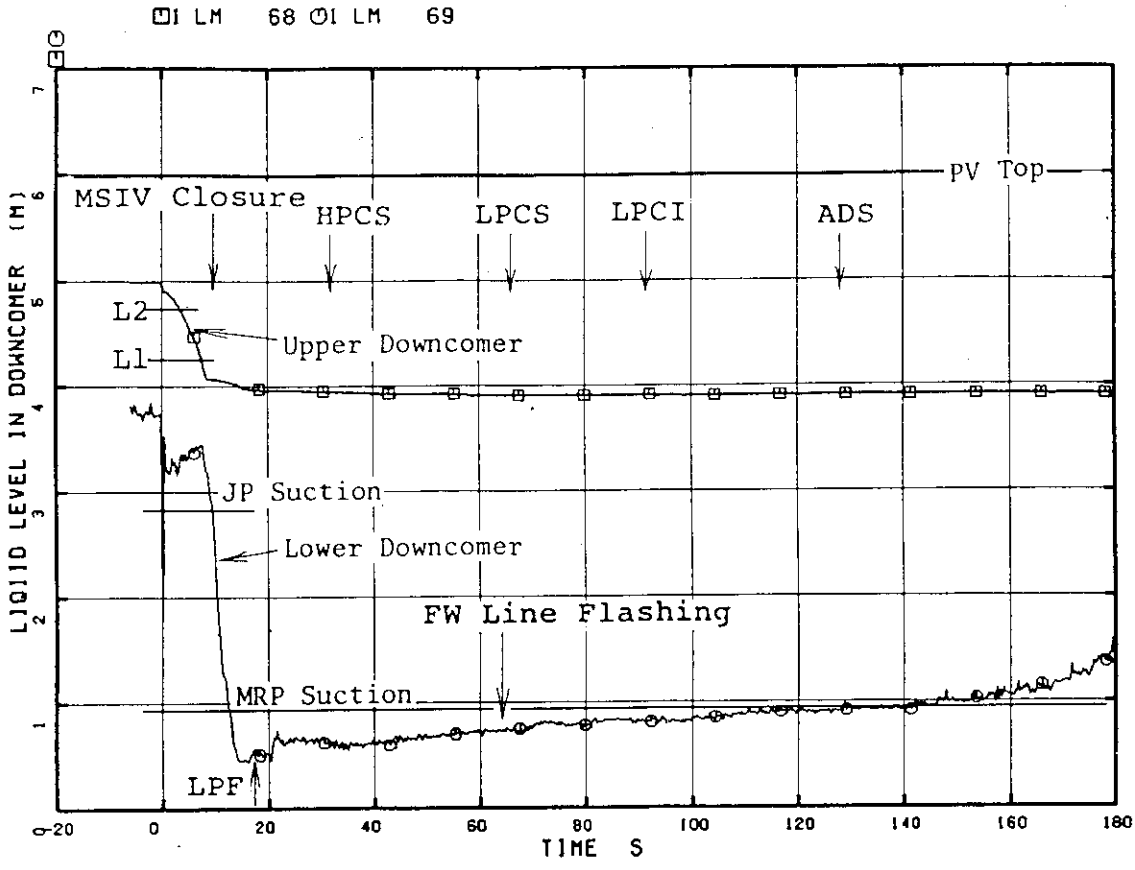


Fig. 2.30 Liquid Level in Downcomer

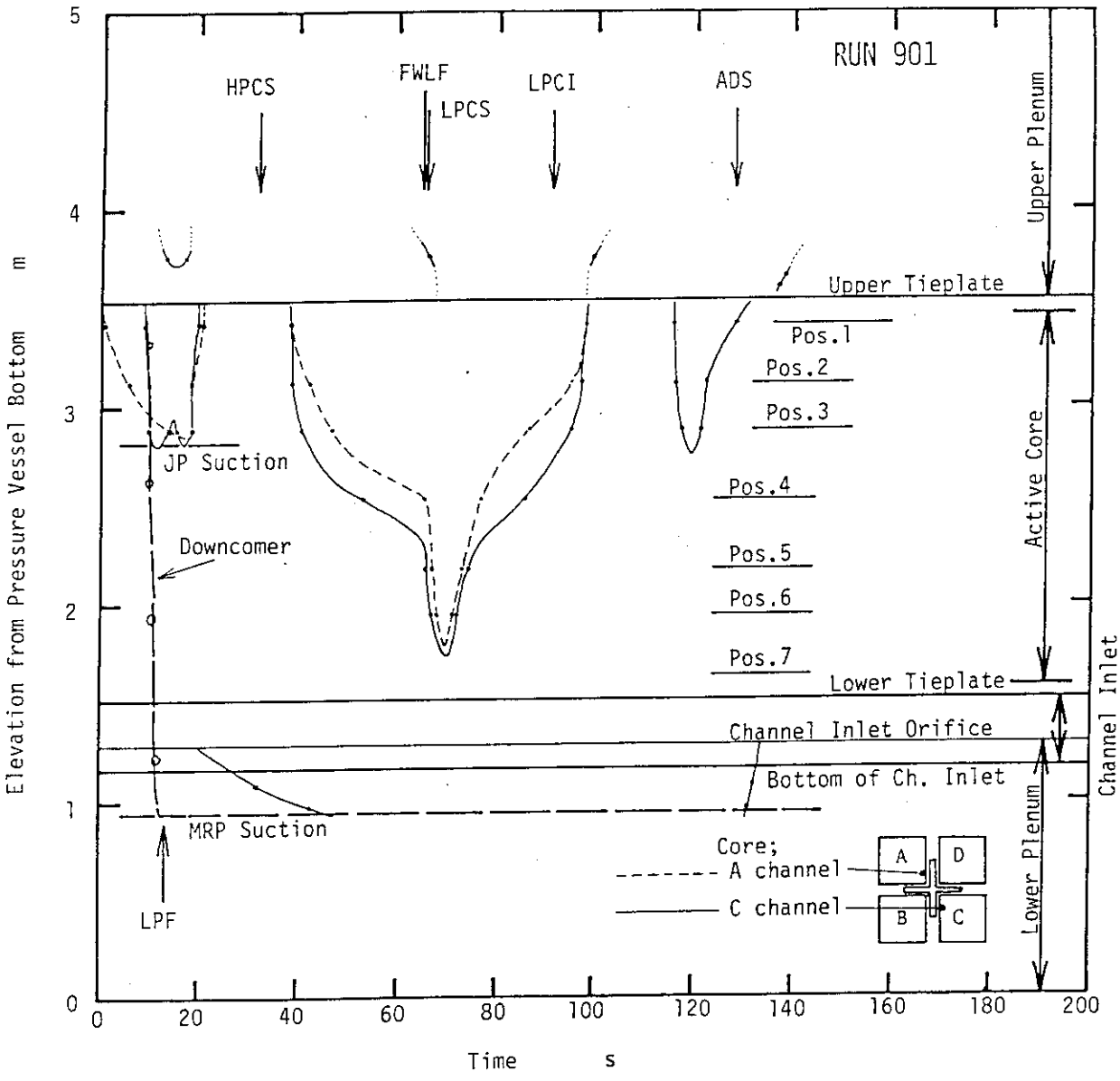


Fig. 2.31 Liquid Level Transients in Pressure Vessel

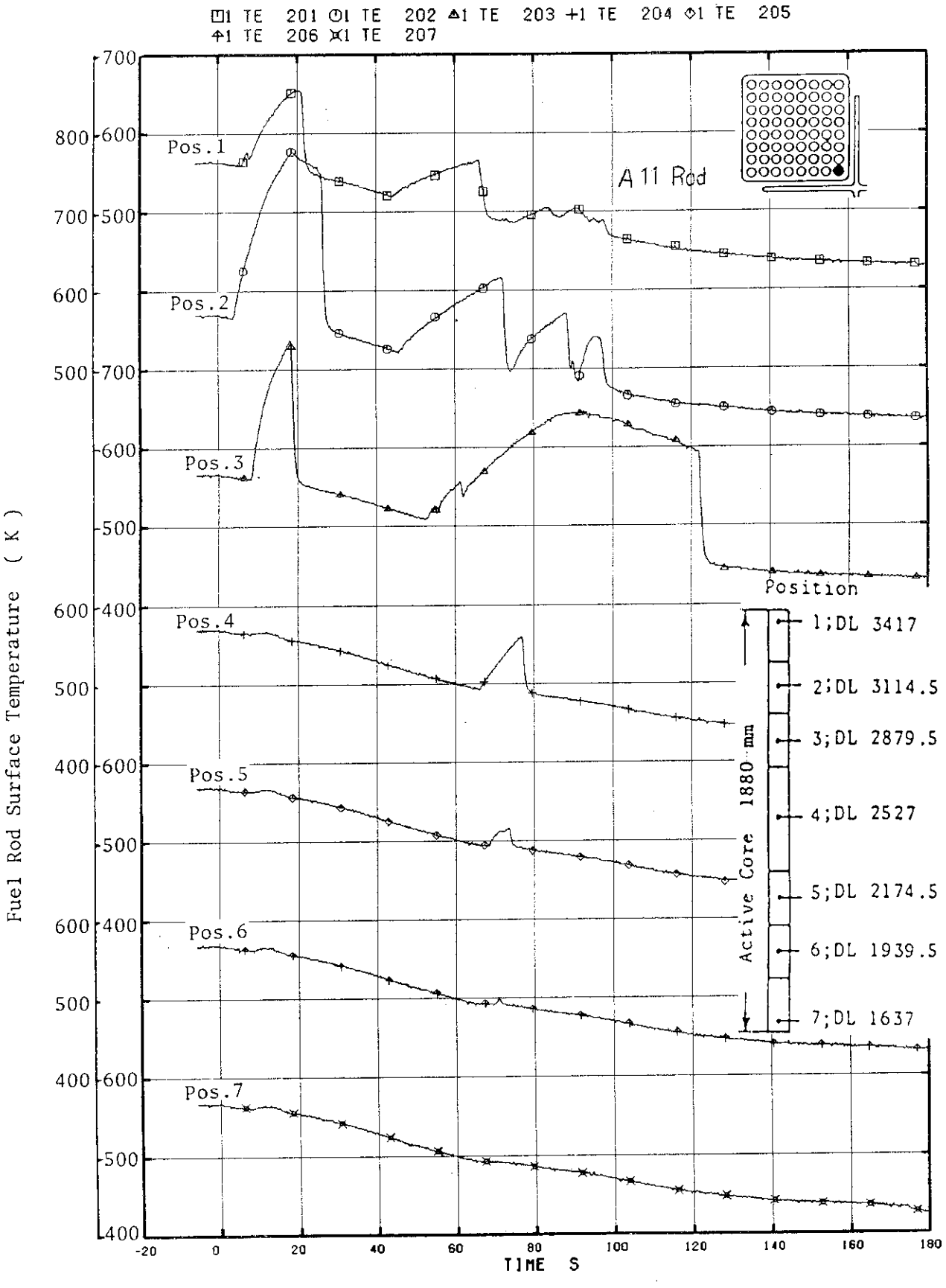


Fig. 2.32 Fuel Rod Surface Temperature A11

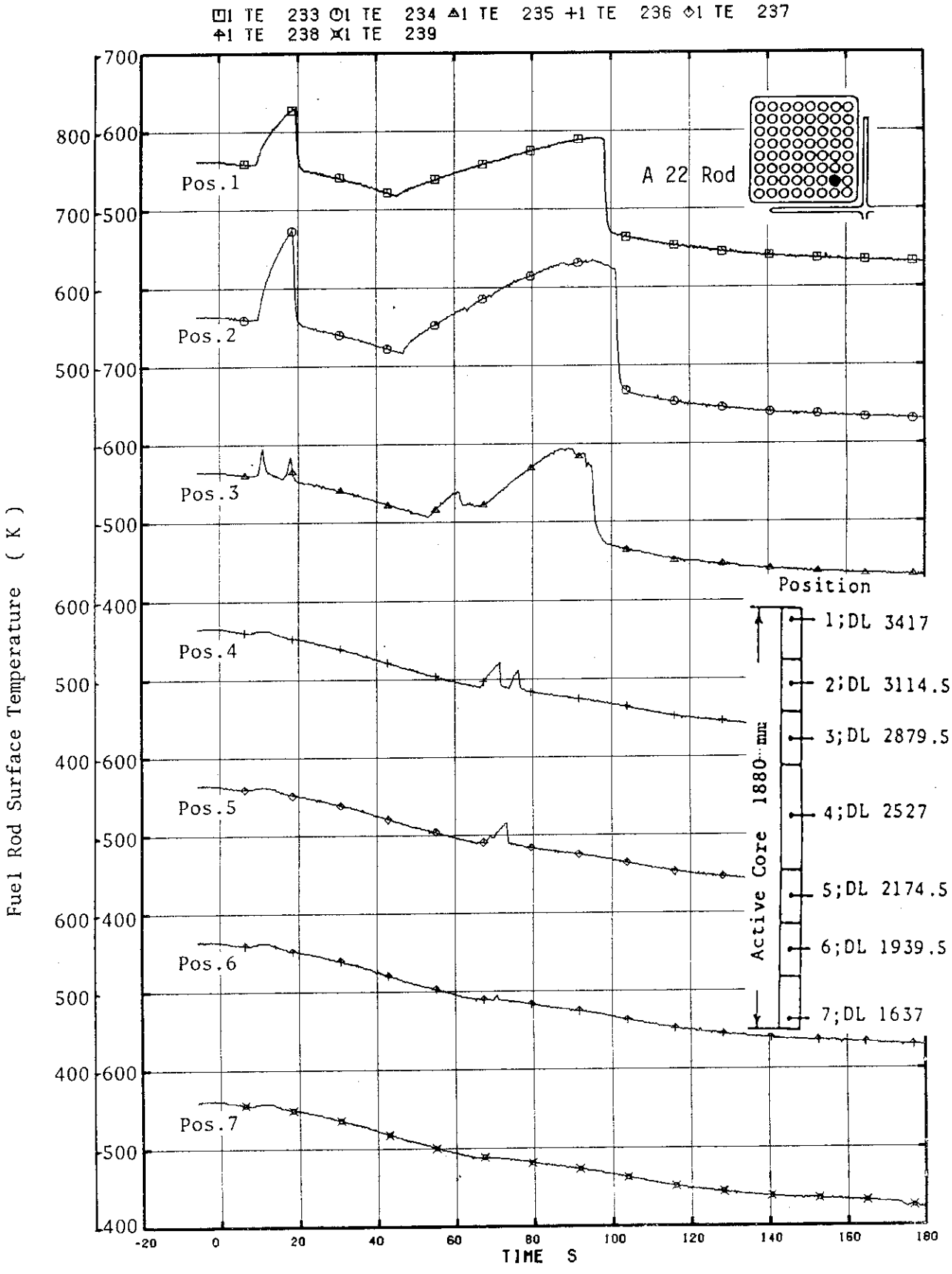


Fig. 2.33 Fuel Rod Surface Temperature A22

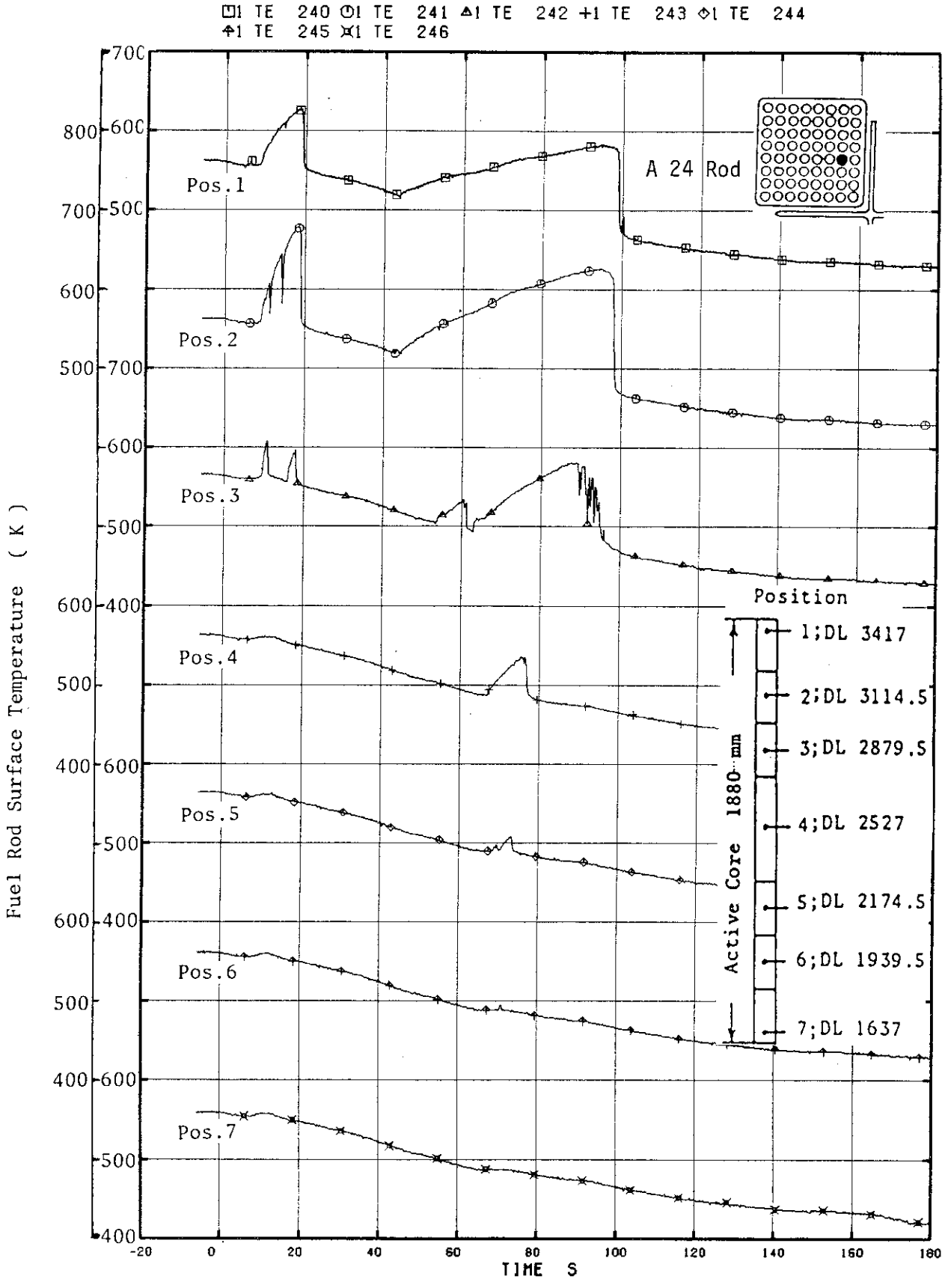


Fig. 2.34 Fuel Rod Surface Temperature A24

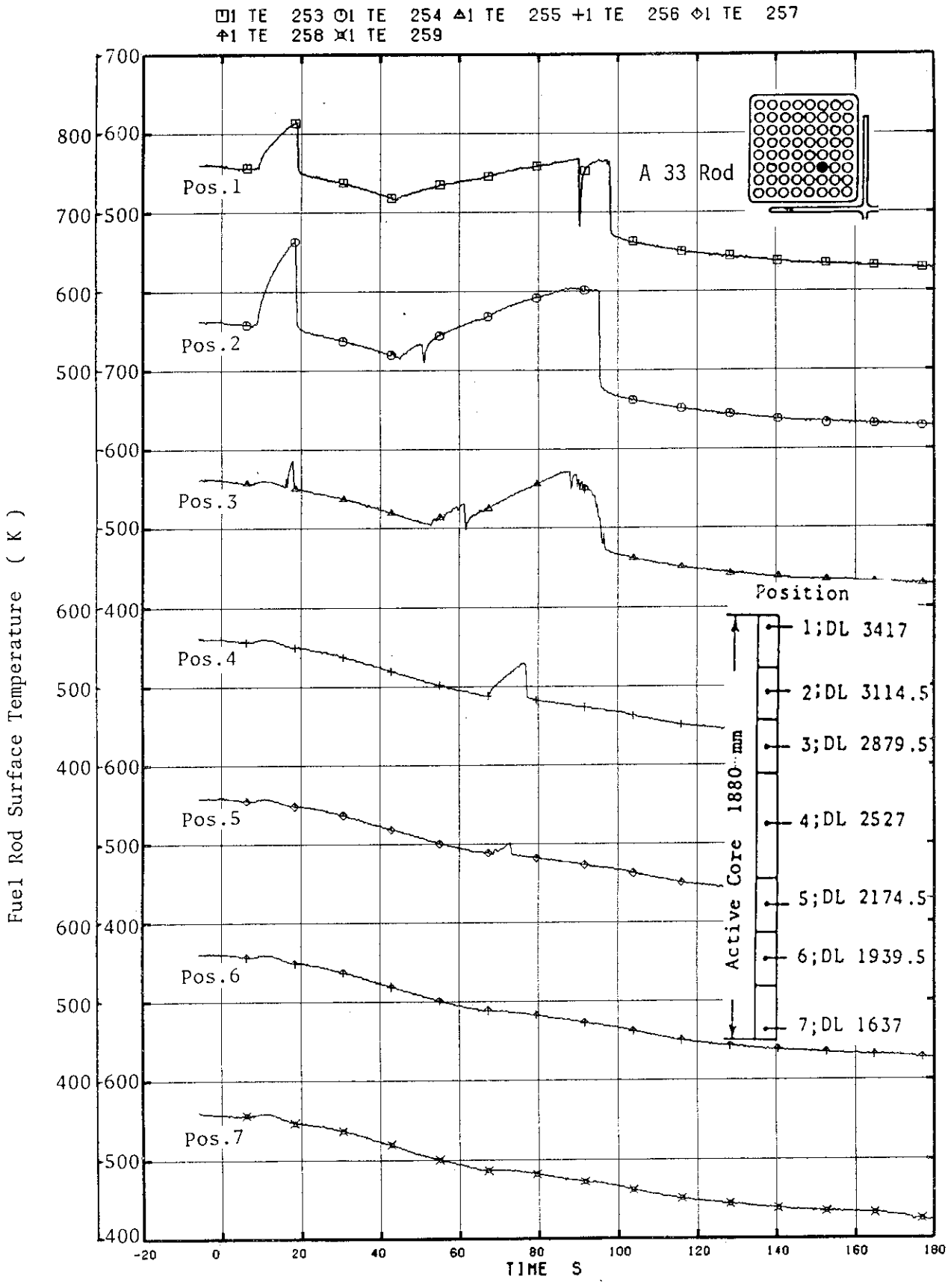


Fig. 2.35 Fuel Rod Surface Temperature A33

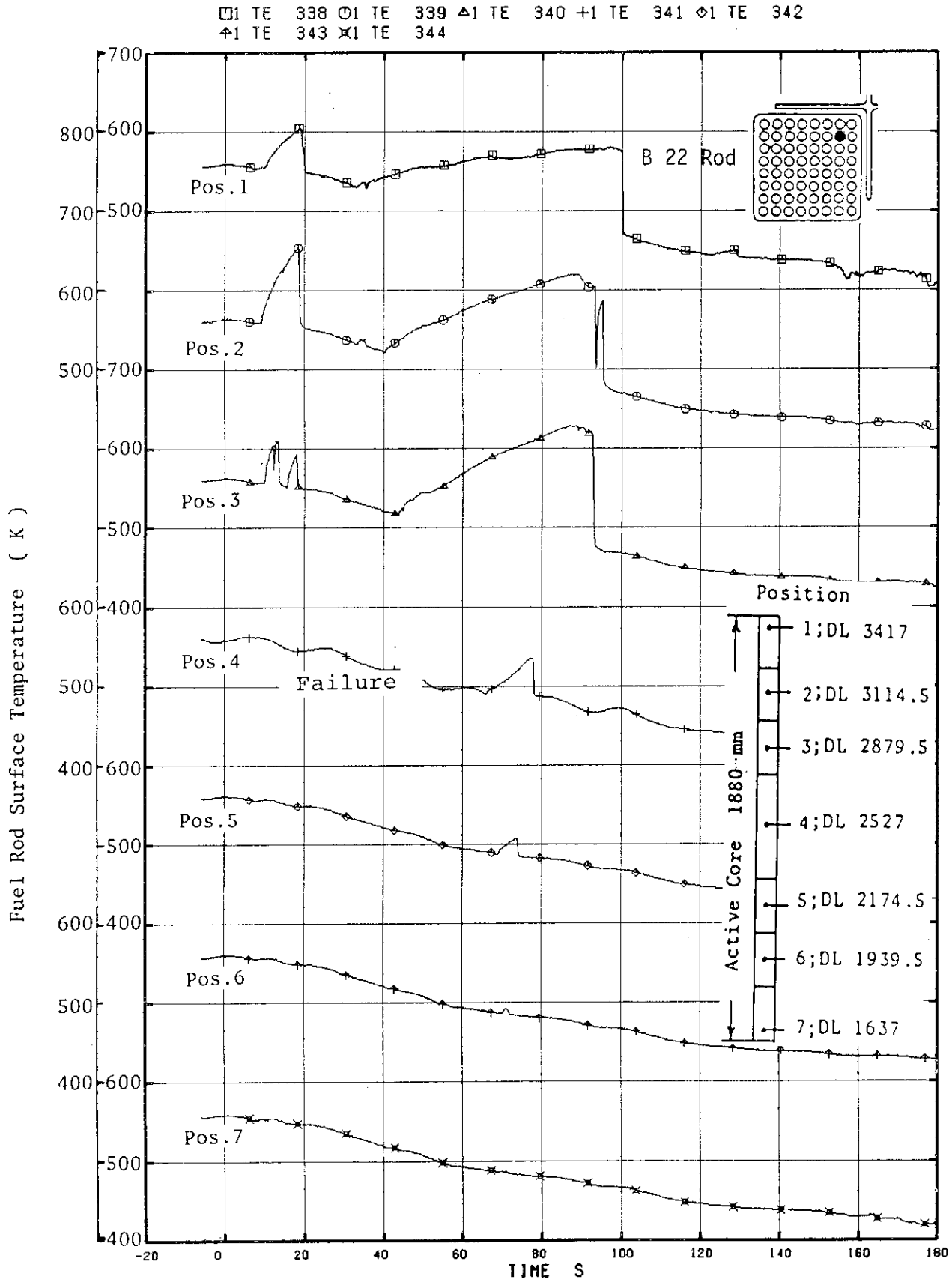


Fig. 2.36 Fuel Rod Surface Temperature B22

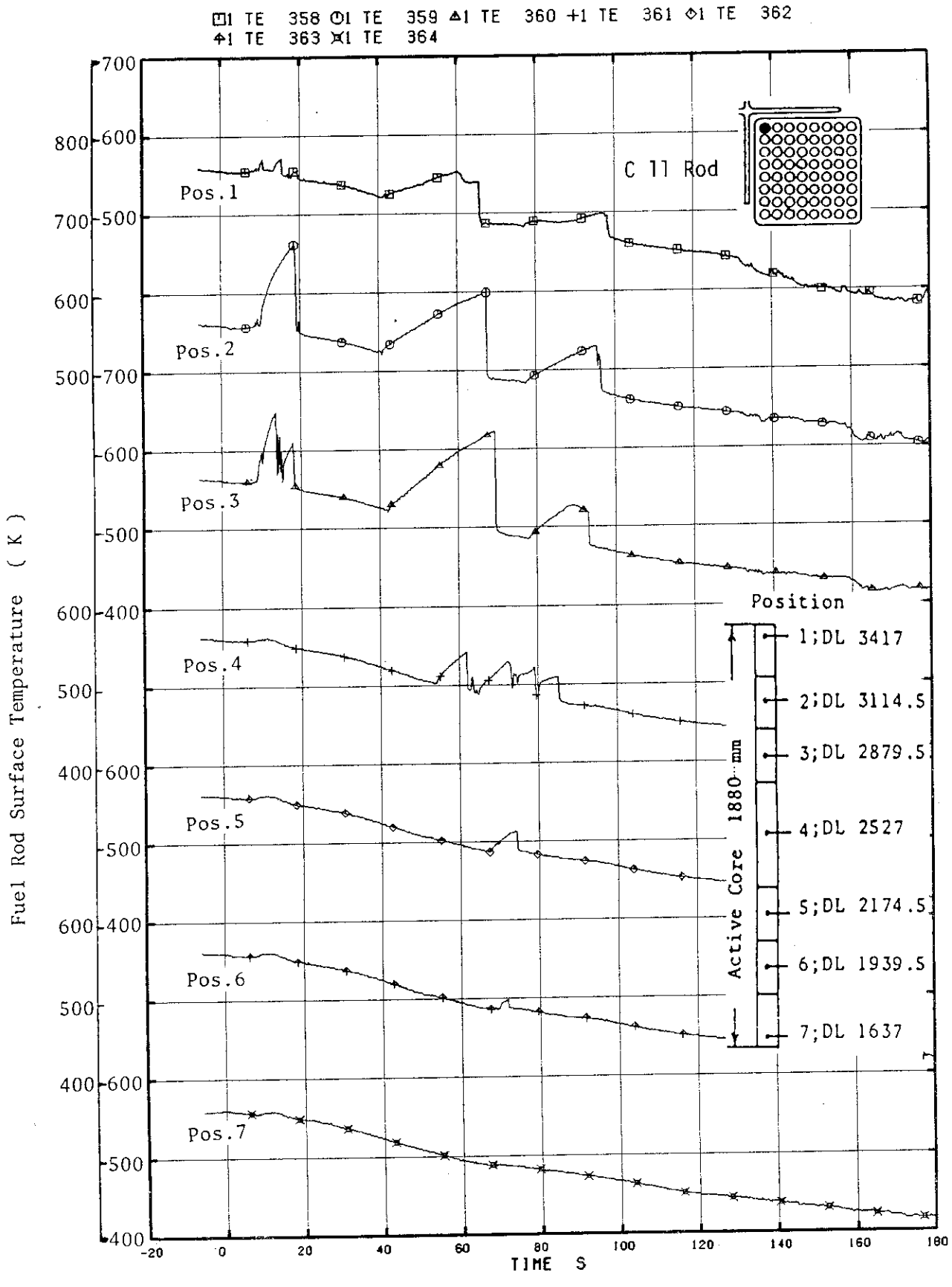


Fig. 2.37 Fuel Rod Surface Temperature C11

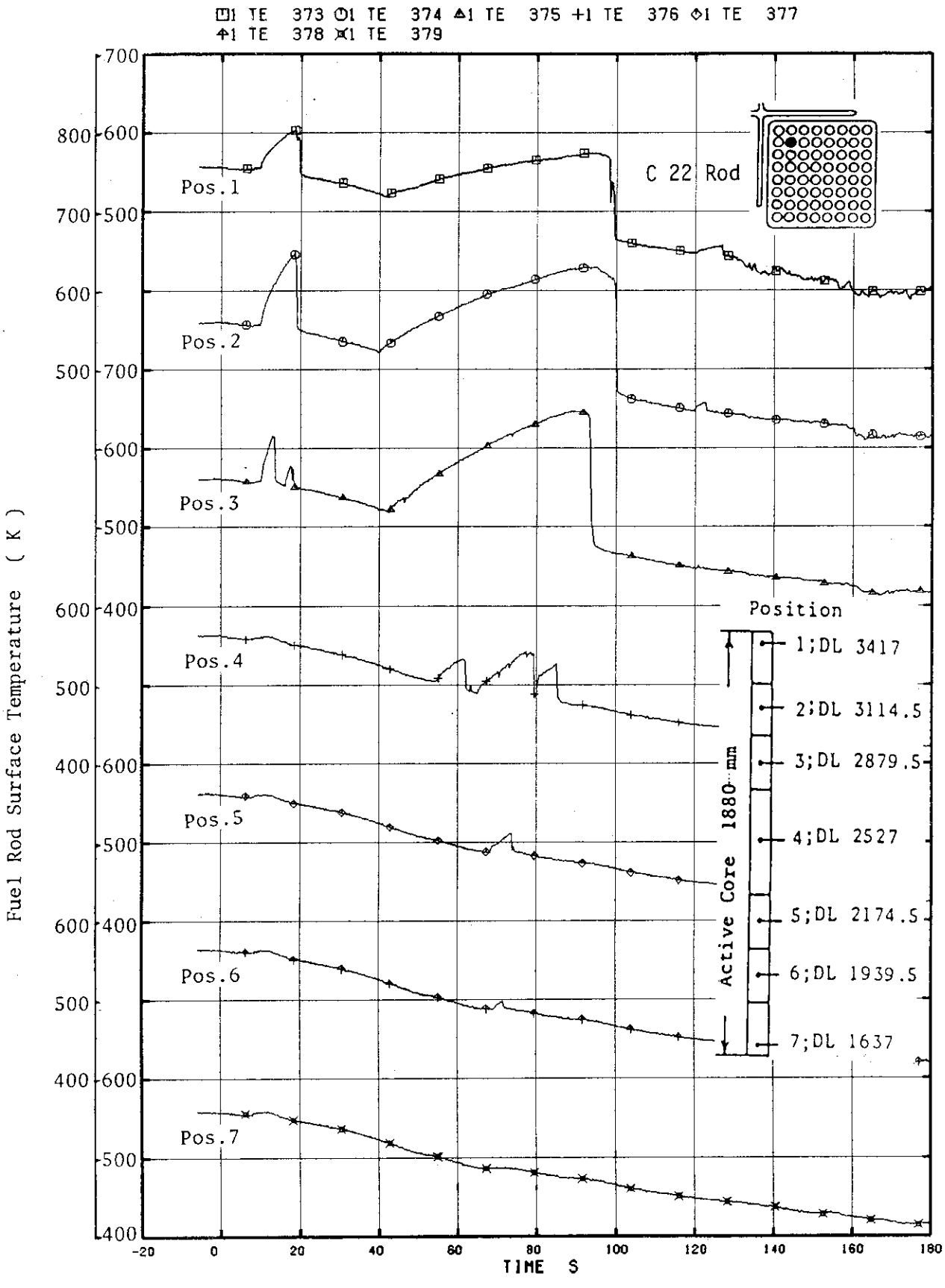


Fig. 2.38　　Fuel Rod Surface Temperature C22

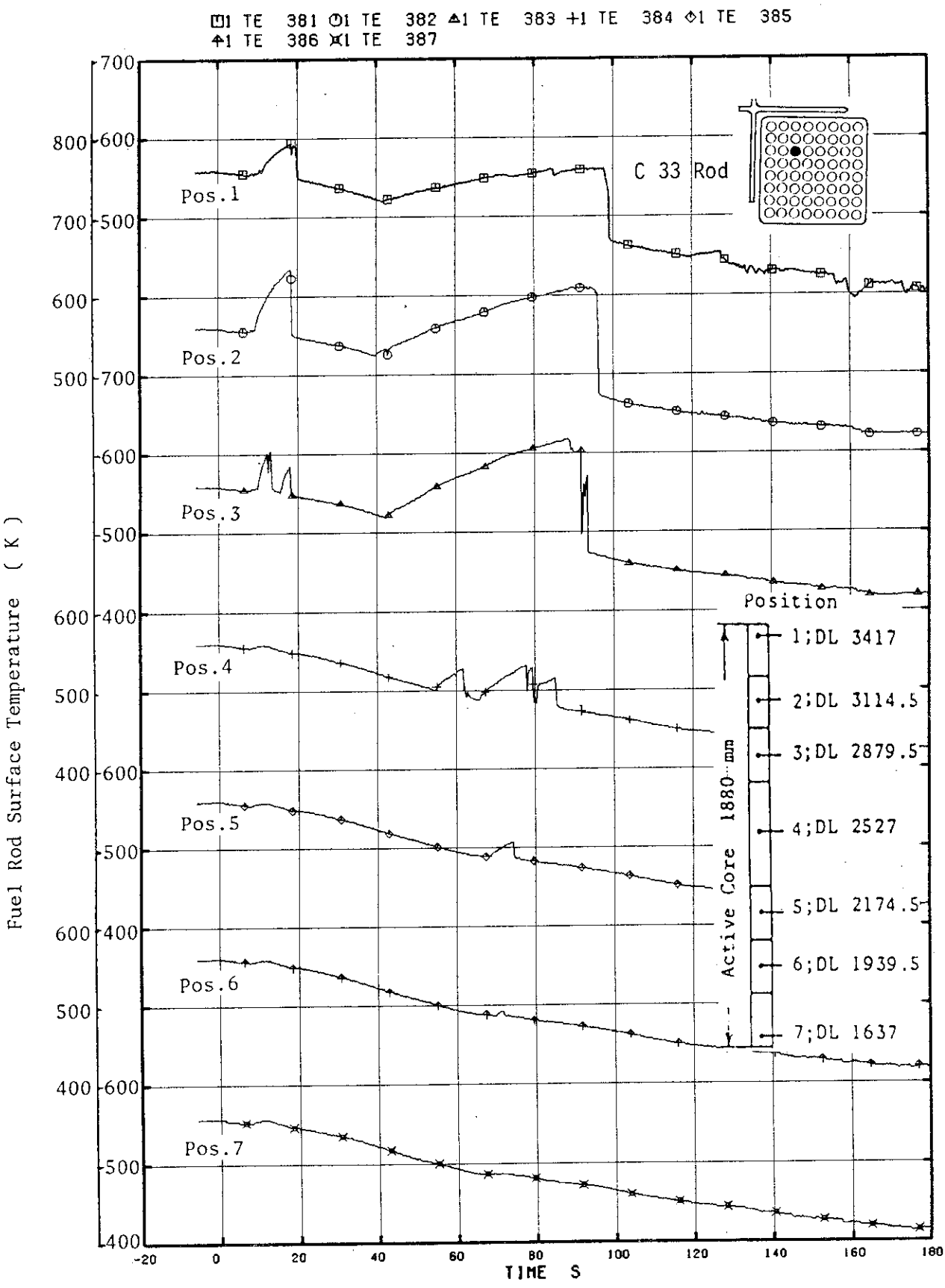


Fig. 2.39 Fuel Rod Surface Temperature C33

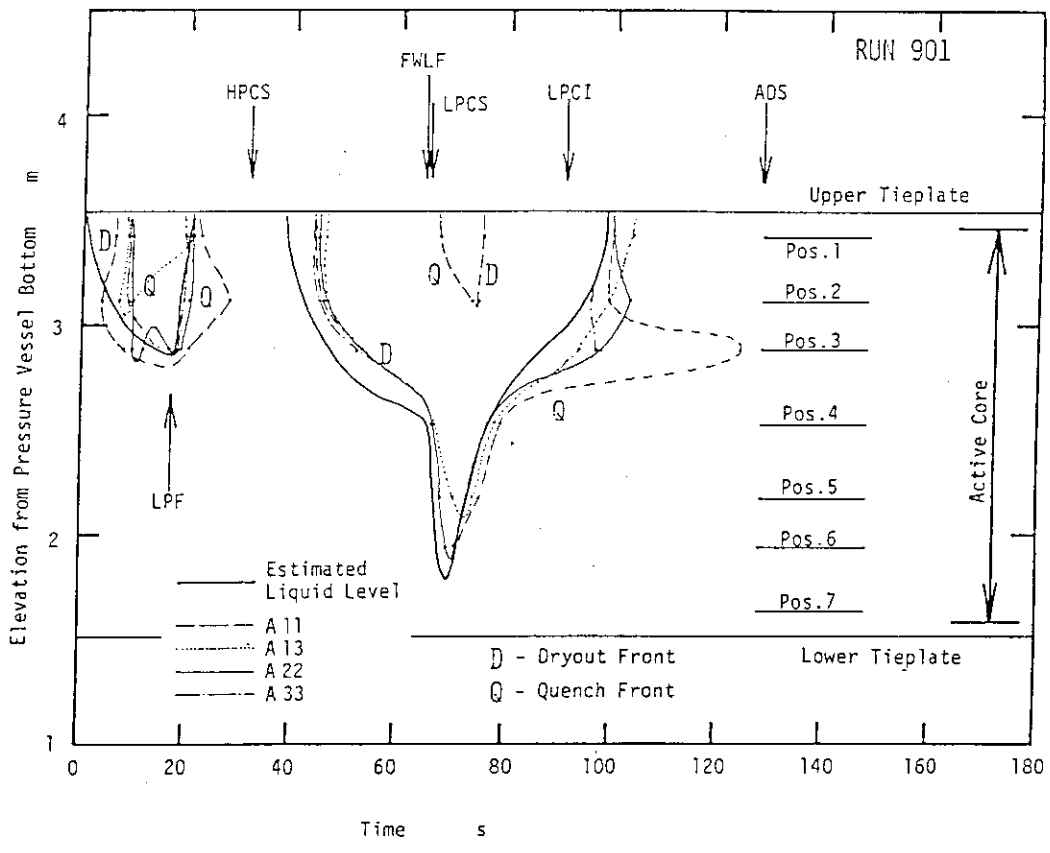


Fig. 2.40 Dryout and Quench Fronts in Channel A

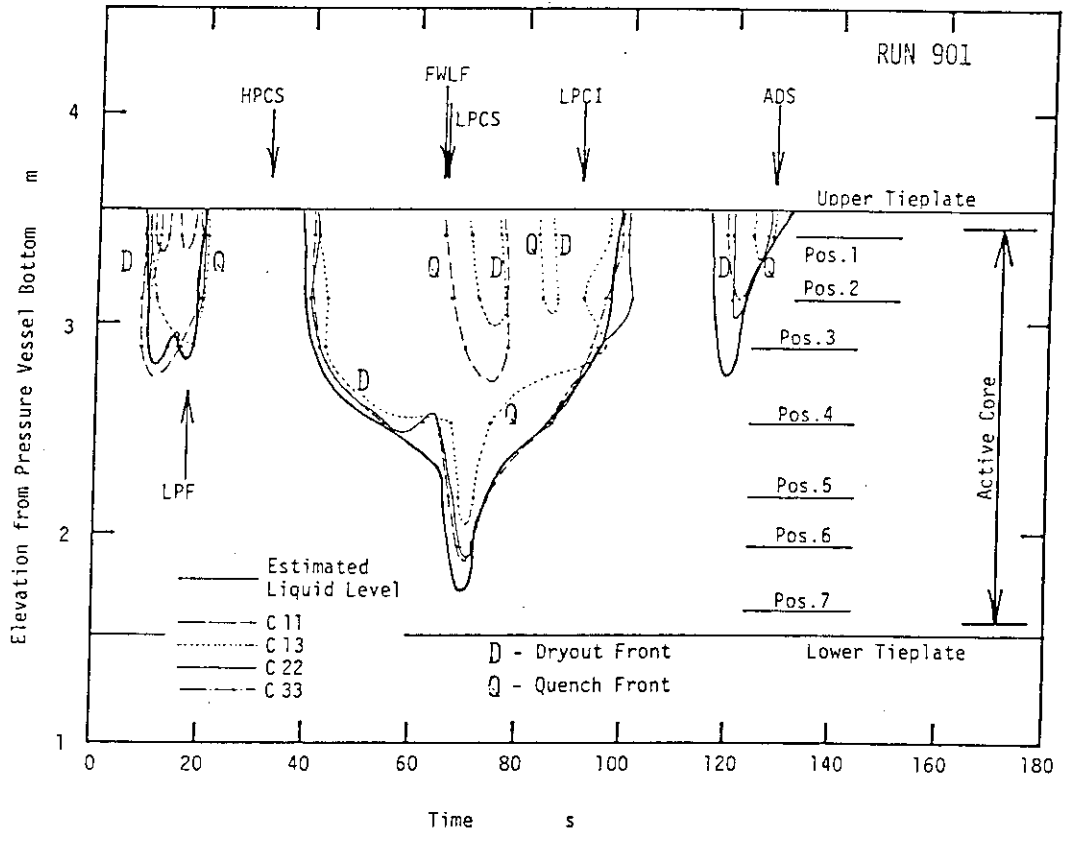


Fig. 2.41 Dryout and Quench Fronts in Channel C

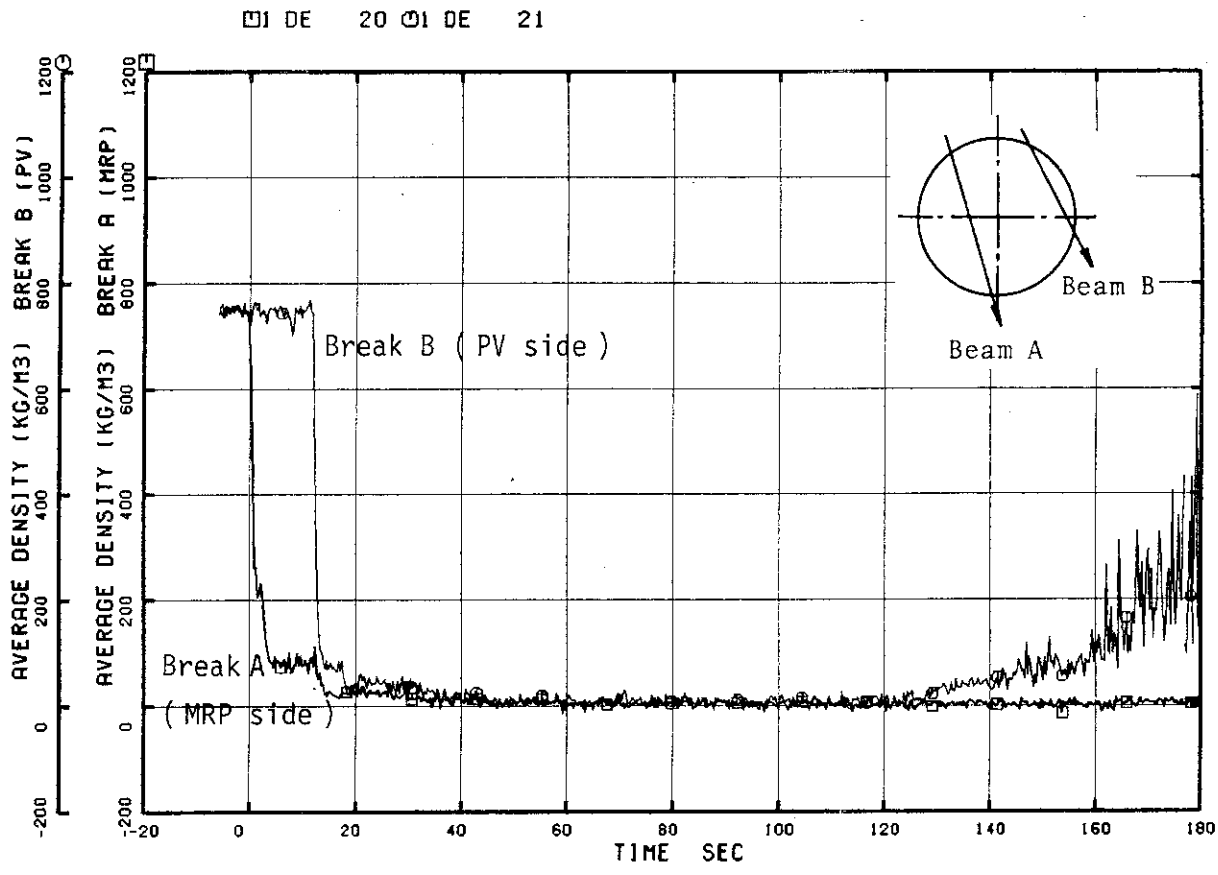


Fig. 2.42 Average Fluid Densities at Break

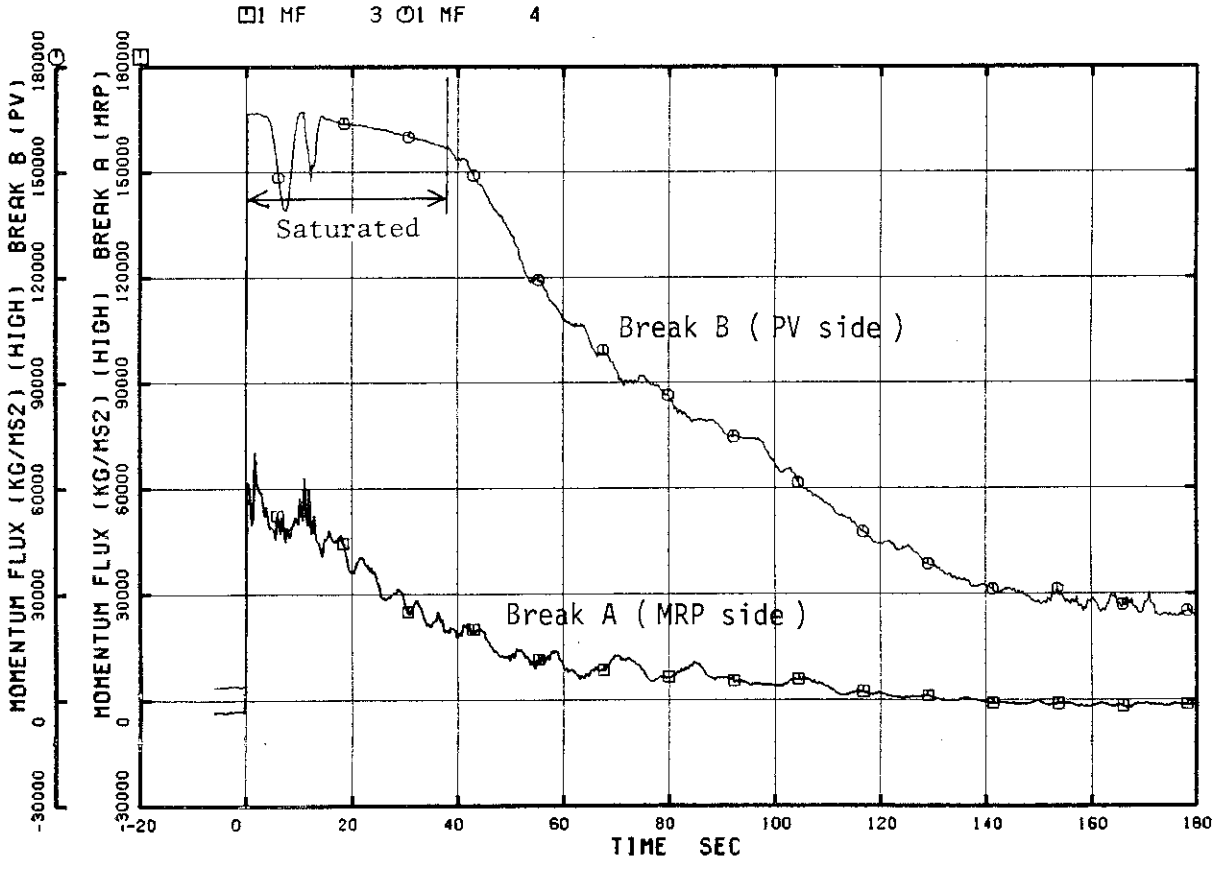


Fig. 2.43 Momentum Fluxes at Break

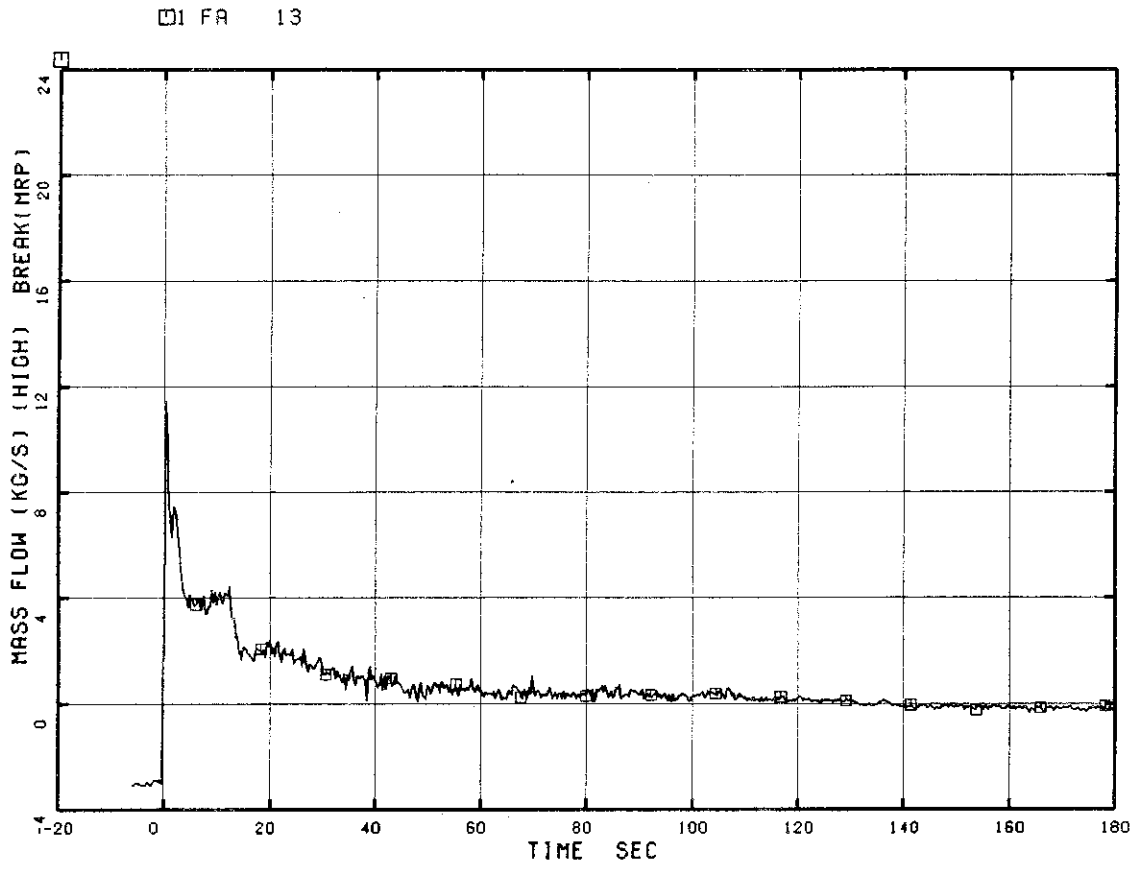


Fig. 2.44 Discharge Flow Rate at Break A (MRP side)

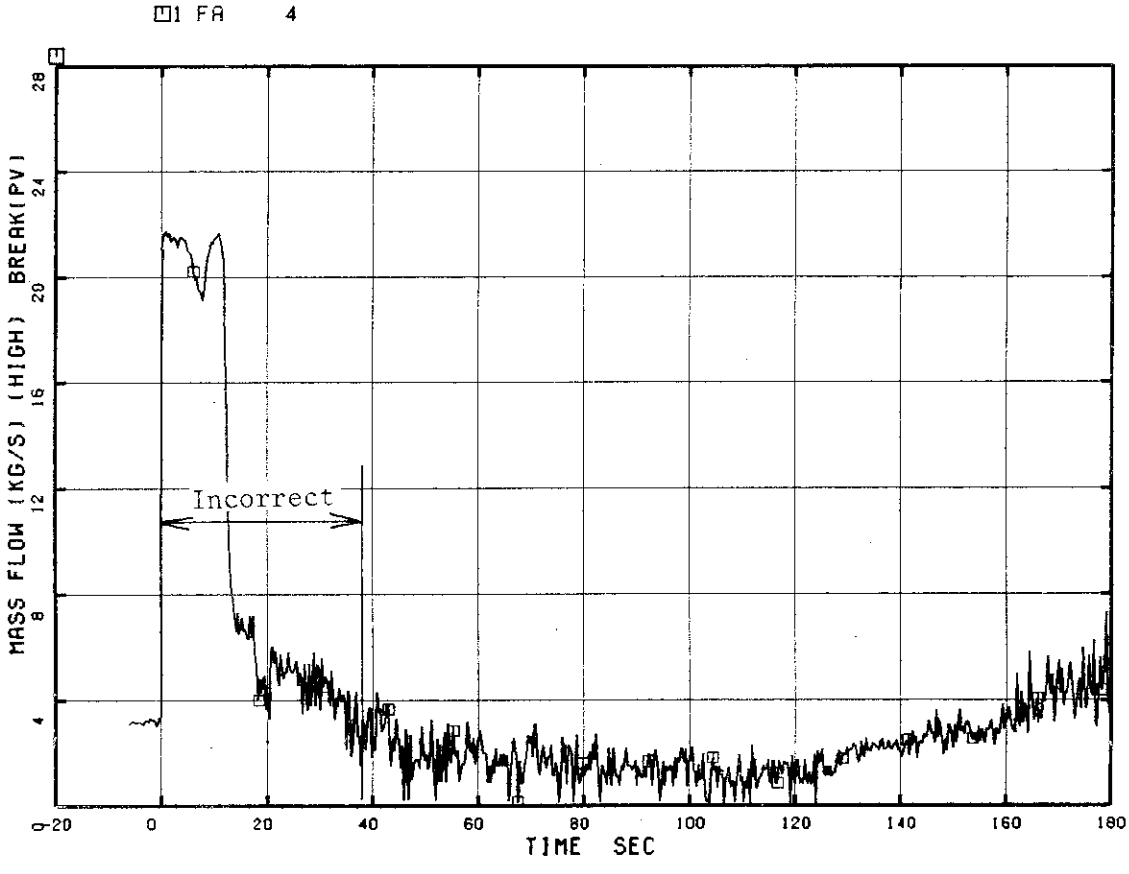


Fig. 2.45 Discharge Flow Rate at Break B (PV side)

3. ANALYSIS OF RUN901 TEST RESULTS BY RELAP4J

3.1 Computer Code

RELAP4J[5] is an improved version of the RELAP4/MOD2 code. RELAP4J calculate the pressure, fluid and heat transport, cladding temperature, etc., during a transient of a light water nuclear reactor modeled with fluid volumes, junctions, heat slabs, pumps and valves, etc. The principal approximations in the RELAP4J calculation include the use of (a) homogenous fluid equations with the phases in thermodynamic equilibrium and (b) one-dimensional fluid and heat conduction transport equations.

Improvements of RELAP4J from RELAP4/MOD2 are as follows;

1) Discharge coefficient C_D for the Moody's choking flow decided from the experimental results is used. The discharge coefficient is given as

$$C_D = 0.57 + 0.002/X,$$

where, X is the quality at the junction.

2) The modified Zaloudeck's corrrelation is used to calculate the subcooled choking flow. When the quality at the junction becomes greater than 0.0 the correlation is smoothly changed to the above Moody's correlation at the input-specifid transition quality 0.05.

3) The choked flow in the high quality region is stipulated to be the greater of the Moody's choking flow or sonic choking flow. The transition quality 0.8 to be high quality region is given as the input data for the junction.

4) The bubble rise model options include the Wilson's correlation[6] for the bubble rise velocity.

5) The liquid condition in the fluid volume is automatically selected between the mixture level formation with the bubble rise model and the homogeneous liquid-vapor mixture by the flow condition in the volume.

RELAP4J is a fast running code but it can not calculate the unequal steam and water velosities (slip) and unequal temperatures of the two-phase flow. The mixture level calculation model is incomplete, therefore, the mixture levels may be formed independently in the piled up fluid

volumes.

3.2 Calculation Model

The RELAP4J nodalization of ROSA-III are shown in Tables 3.1, 3.2 and 3.3 and Figs. 3.1 and 3.2. The core model has two core channels (peak- and average-power channels). Each core channel of one core model shown in Fig. 3.1 is divided vertically into seven volumes and that of another core model shown in Fig. 3.2 has one volume in order to prevent the nonexistent mixture level being calculated in the stacking volumes of the core. Nodalization shown in Fig. 3.1 was used for the base case A and Fig. 3.2 for the simplified case B. The nodalization of case A includes 33 volumes, 47 junctions and 19 heat slabs. The simplified nodalization of case B includes 21 volumes, 35 junctions and 19 heat slabs. The calculation with the simplified nodalization was performed as the sensitivity study.

Initial thermal-hydraulic conditions for the calculations were obtained from the experiments as shown in Table 2.3. The steam dome pressure was 7.35 MPa, the lower plenum temperature 551.8 K and the total core power 4.045 MW. Consistency of the input data were certified by a steady state calculation. Figure 3.3 shows the initial flow distribution.

Input data for axial power distributions of the peak and the average power channels are the same as that of ROSA-III for the average power rods. Therefore, the PCT was not properly calculated.

The experimental data of the steam discharge flow, the feedwater flow and the ECCS flows, which are shown in Fig. 3.4 through 3.6, were used as the input data in the analysis as a function of time.

Optional choking models 1) through 3) presented in the previous section 3.1 were applied to the junctions at the jet pump drive nozzles and the breaks.

The bubble rise model was applied to all volumes in the pressure vessel to calculate the mixture levels. The bubble-gradient parameter (ALPH) was 0.8 in the core and bypass volumes and 0.0 in the other volumes.

The recirculation pump was modeled by the rated values and the homologous curves. As for the torque homologous curves the LOFT bingham pump torque data were used because the torque curves of the ROSA-III recirculation pump were not yet obtained completely.

Form loss coefficient at the junction was calculated in the code from geometrical form change at the junction. Measured reverse flow form loss coefficients were used at the junctions in the jet pump suction line.

The input data list of the RELAP4J calculation having 14 core volumes is presented in Appendix A.

3.3 Comparison with the Experimental Data

Major results of the RELAP4J calculation are compared with the experimental data in this section. Both of two calculations with the base case model having the core model vertically divided into seven volumes per channel and with the simplified model having the core without vertical divide are compared with the experimental data. The case A and case B calculations took 4 and 2 hours of CPU time, respectively, by FACOM M-200 computer at JAERI.

3.3.1 Pressure Transient

Comparison of lower plenum pressure transients between the calculated results and the data is shown in Fig. 3.7. Overall agreement was good between the calculated pressure transient and the data. The results by two RELAP4J models were similar to each other. The pressure recovery after MSIV closure at 9.2s after break calculated in case B was larger than that calculated in case A because the upper core did not dryout in case B to be mentioned in Section 3.3.5.

Temporary hold of the pressure after 64.8s caused by the FWLF was not calculated because the feedwater line of ROSA-III was not modeled in this analysis.

The calculated pressure transients at the upstream side of the breaks B and A in both cases shown in Figs. 3.8 and 3.9 agreed well with the

data. Rapid decrease of the calculated pressure at the break B upstream immediately after the break resulted in flashing in the MRP suction volume as shown in Fig. 3.14.

3.3.2 Differential Pressure

Differential pressure between RELAP4J volumes was calculated using a computer plot program, but the volumes which consist of RELAP4J models are so large that the calculated differential pressure may include error by the head term in comparison with the experimental data.

Differential pressure (DP) between the lower and upper plena shown in Fig. 3.10 presented very good agreement with the data. After the LPCI injection at 90.9 s, the calculated DP decreased temporarily whereas the data did not.

Figure 3.11 presents the calculated DP between the channel inlet chamber and the upper plenum. The DP calculated in case A was lower than that in case B throughout the test, which means that the core flow rate was lower in case A than in case B.

3.3.3 Break Flow

Measured break flow shown in Figs. 2.45 and 2.46 using drag disks and gamma densitometers involved an error of at least ±20 %, and the break flow of the PV side break B was incorrect till 38 s after the break because of the saturation in the drag disk data. Therefore, emphasis was placed on the calculation of the incipient time of the break flow decrease due to uncovering of the recirculation line inlet, which agreed very well with the data as shown in Figs. 3.12 and 3.13.

The calculated density transient at the break upstream agreed well with that of the data except for the temporary decrease in the calculated density at the break B upstream before the rapid decrease at 12.5 s after the break.

The calculation results mentioned above show that the break flow was calculated well using the modified Zaloudeck's correlation and the Moody's

choking in spite that the RELAP4J nodalization did not simulate the break nozzle of ROSA-III. The pressure decrease in the upstream volume of the break might have been compensated with the discharge coefficient C_D for Moody's choking recommended for the thin edge orifice giving good agreement of the calculated break flow with the data.

The nearly equal break flow rates were calculated in cases A and B.

3.3.4 Core Flow and Jet Pump Flow

The calculated total flow rate through the SEO shown in Fig. 3.16 shows that they agree well with the data till LPF initiation. After the LPF initiation the initial temporary increase in the core inlet flow was calculated well by RELAP4J but the calculated flow became very little compared with the data after the LPF mitigation. The discontinuity of the liquid phase at the SEO after the LPF lowered the calculated flow rate through the SEO. The data had also large uncertainties after the initiation of the LPF.

When the whole core was uncovered about 55 s after the break the calculated flow through the SEO began to flow downward. The temporarily downward flow after 64.8 s in the data was caused by the feedwater line flashing and was not calculated because the feedwater piping was not modeled.

The calculated guide tube inlet flow rates are compared in Fig. 3.17 with the data. The flow reversal observed in the data was calculated, but the flow rate was less than a half of the data until the LPCI actuation at 91 s. When the core bypass was filled with LPCI liquid the flow through the guide tube inlet turned upward temporarily and reversed again because the liquid in the upper plenum began to fall through the core bypass to the lower plenum.

Calculated total flow through the Upper Tie Plate (UTP) and the Lower Tie Plate (LTP) of the core in cases A and B are compared in Figs. 3.18 through 3.21. The flow through the UTP was calculated larger than that

through the LTP until the LPF initiation in two cases. The flow through the LTP shown in Fig. 3.19 was larger in case B than in case A till the initiation of the LPF. The peak flow rate at the LPF was larger in case A than in case B, but the total upward flow through the LTP between the initiation and the mitigation of the LPF was calculated larger in case B than in case A. The flow through the LTP turned downward temporarily during the liquid level in the core decreased to the LTP in two cases. The flow through the LTP began to flow upward after the LPCI actuation at 90.9s.

Figures 3.22 through 3.25 show the calculated flow through the Jet Pump (JP) suction, drive nozzle and discharge, which are compared with the measured JP discharge flow. The calculated results in two cases agreed well each other and the JP discharge flow in the broken loop agreed well with the data. But the JP discharge flow in the intact loop was calculated reversely after the LPF initiation compared with the data.

3.3.5 Liquid Levels in the Pressure Vessel

Liquid level transients in the pressure vessel calculated in cases A and B are shown in Figs. 3.26 and 3.27, respectively. Core volume was represented by a vertical train of seven volumes in case A while it was represented by a single volume in case B. Liquid level transients calculated in the two cases showed almost the same behavior except for the mixture levels in the core.

Calculated liquid level decrease after break in the downcomer agreed very well with the data. The difference of the recirculation line (RL) nozzle level between the calculation model and the data was caused by the imcomplete modeling of the downcomer shape adjusting the total height and the fluid volume by just one node in the RELAP4J calculation. Calculated liquid level in the downcomer decreased to the RL nozzle level at 12.6 s after the break and did not recover till 120 s in both cases as was in the data.

Calculated liquid level in the upper plenum began to decrease at 8.4

s after the break and started to recover at 15.7 s due to LPF and the upper plenum level existed throughout the calculation. RELAP4J can not calculate the slip between liquid and steam nor it can calculate the flows of liquid and steam separately through the junctions. Therefore, the liquid in the upper plenum could not drop to the core and the bypass after the liquid levels were formed in the core and the bypass.

The liquid levels were formed in every core volumes before LPF in case A but were not formed in the core volumes before LPF in case B with the same bubble rise model.

After LPF initiation liquid levels were formed in the bypass and lower plenum volumes in both calculation as well as in the data and they began to decrease thereafter. However, the calculated liquid level in the lower plenum decreased faster than the data because RELAP4J could not calculate the steam flow independently through the junction. The steam generated in the lower plenum was accumulated in the lower plenum until the liquid level in the lower plenum decreased to the jet pump discharge.

Liquid levels in peak and average-power core channels of the data began to decrease at the same time as shown in Fig. 2.31. However, the calculated liquid level in the peak-power channel began to decrease about 15 s later than in the average-power channel in both cases. The liquid levels in the core decreased rapidly to the bottom of the core especially in the peak-power channel. The liquid levels in the core decreased finally to the bottom of the channel inlet chaber in both cases while the bottom part of the core was not uncovered in the data evenafter the FWLF. This was because the accumulated liquid in the upper plenum did not flow down into the core in the calculation but fall back liquid was enough in the data. Therefore, the ECCS water accumulated in the upper plenum finally overflew to the downcomer from the top of the steam separator in both cases before the actuation of LPCI. The bypass was filled up with the ECC water 5 s after the LPCI actuation at 90.9 s, and, then, the core began to be reflooded from the bottom and also the liquid level in the

upper plenum dropped because the bypass and the upper plenum were connected. The liquid level in the lower plenum stayed at the jet pump discharge level because the steam did not go out from the lower plenum through the SEO even after the LPCI actuation.

Calculated liquid levels in the core show some difference between two cases A and B. In case B the liquid levels did not decrease before LPF and they started to decrease 5 s after initiation of level falls in the base case A. After the bypass was filled up with liquid the levels in the core recovered very fast in case B while recovered more slowly in case A. These differences came only from the vertical division of the core volumes since the same bubble rise model was used in every core volumes in both cases.

The calculated liquid levels oscillated hard in the reflooding stage in both cases. These liquid level oscillations were also observed in every core volumes when the volume became almost empty even before the LPCI actuation because of higher void fraction in each volume.

3.3.6 Fuel Rod Surface Temperature

Calculated fuel rod surface temperatures are compared with the data in Figs. 3.28 through 3.31 for the average-and peak-power rods in cases A and B.

The dryout and quench front behaviors are closely related with the liquid level transients in the core as mentioned in Section 2.3. By the RELAP4J the fuel rod surface temperature is calculated with reference to the average thermal-hydraulic conditions in the adjacent volume to the heat slab. Therefore, the dryout and quench fronts are calculated to move vertically in accordance with the calculated liquid level transients through the vertically separated core volumes in the base case A, but in case B the dryout and quench occured at the same time at every heat slab in the core. This difference between two calculation resulted in the differenct pressure responce.

As mentioned in the previous section the steam accumulated in the core formed the liquid levels in the vertically stacked core volumes in the base case A. In the peak-power channel the fuel surface above the midplane of the core dried out before LPF initiation whereas no dryout was observed at Position 4 in the data. The accumulated steam in the core prevented the heater rod surface from quenching till the end of the calculation.

Figures 3.32 through 3.39 show the heat transfer coefficients used to obtain the heater rod surface temperature. At about 15 s after the break, the heat transfer mode at the upper part of the core changed from the nucleate boiling to the pool film boiling because the decrease in the core flow brought the DNB. When the whole core was covered with the steam after 95 s after the break the heat transfer mode changed from the superheated vapor to the pool film boiling or the nucleate boiling from the bottom of the core due to the bottom-up reflooding. The top-down quench was not observed in the RELAP4J calculation.

3.4 Conclusions for the RELAP4J Calculations

The post test calculation of the ROSA-III large break test RUN 901 was performed with the RELAP4J code and the following conclusions were obtained.

(1) The overall trends of the system pressure and differential pressure between the top and bottom of the pressure vessel calculated by RELAP4J agreed well with the data.

(2) The time of incipient decrease in the break flow agreed well with the data which indicates the Zaloudeck's and the Moody's choking flow model with the RELAP4J discharge coefficient correlation can predict the break flow accurately.

(3) The homogenous two-phase flow model in RELAP4J was not able to calculate the counter current flow at the upper tie plate. This resulted in the accumulation of the spray water in the upper plenum contrary to the experiment. The core inlet flow rate calculated until the beginning of the

lower plenum flashing agreed well with the data. Therefore, the slip model is necessary for the code to calculate the mixture level more accurately.

(4) The bubble rise model in RELAP4J calculated the mixture level in each volume independently resulting in discontinuous liquid levels in the vertically stacked core volumes. However, the overall trend of the mixture level transient in the core agreed with the data.

(5) The quench behavior of the fuel rod surface was not calculated well by the code.

(6) Simplification of the core nodalization from the seven vertically stacked volumes to one volume eliminated the discontinuity in the liquid level in the core and made the calculation speed faster by a factor of two. However, the same heat transfer coefficient was applied to the seven heat slabs in the core volume, and the dryout or quench behavior of the heater rod was the same in the whole core.

Table 3.1 Description of Volumes for RELAP4J Model

Description		Case A	Case B
Steam Dome		4	4
Upper Plenum and Steam Separator		3	3
Average Power Channel	Pos.1	24	
	2	23	
	3	22	
	4	21	2
	5	20	
	6	19	
	7	2	
Peak Power Channel	Pos.1	31	
	2	30	
	3	29	
	4	28	19
	5	27	
	6	26	
	7	25	
Channel Inlet Chamber		32	20
Lower Plenum		1	1
Core Bypass and Guide Tube		18	18
Downcomer		33	21
Intact Loop MRP Suction Line		12	12
MRP		13	13
MRP Discharge		14	14
Intact Loop JP		15	15
JP Discharge		16	16
JP Suction Line		17	17
Broken Loop MRP Suction Line		5 and 6	5 and 6
MRP		7	7
MRP Discharge Line		8	8
Broken Loop JP		9	9
JP Discharge		10	10
JP Suction Line		11	11

Table 3.2 Description of Junctions for RELAP4J

Description	Case A	Case B
Channel Inlet Orifice (SEO)	38	23
Average Power Channel Lower Tie Plate	1	1
" Upper Tie Plate	2	2
Peak Power Channel Lower Tie Plate	24	24
" Upper Tie Plate	25	25
Steam Separator Outlet	3	3
Channel Inlet to Core Bypass	21	21
Lower Plenum to Core Bypass	37	26
Core Bypass Outlet	22	22
Upper downcomer to Lower Downcomer	39	27
Intact Loop Inlet	13	13
MRP Inlet	14	14
MRP Discharge	15	15
JP Drive	16	16
JP Discharge	17 and 18	17 and 18
JP Suction	19 and 20	19 and 20
Broken Loop Inlet	4	4
QSV	5	5
MRP Inlet	6	6
MRP Discharge	7	7
JP Drive	8	8
JP Discharge	9 and 10	9and 10
JP Suction	11 and 12	11 and 12
Vessel Side Break (Break B)	43	31
Pump Side Break (Break A)	42	30
Main Steam Line	40	28
ADS	47	35
Feedwater Line	41	29
HPCS (not used)	44	32
HPCS + LPCS	45	33
LPCI	46	34

Table 3.3 Description of Heat Slabs for RELAP4J Model

Description		Case A and B
Average-Power Heater Rods	Pos.1	7
	2	6
	3	5
	4	4
	5	3
	6	2
	7	1
Peak-Power Heater Rods	Pos.1	17
	2	16
	3	15
	4	14
	5	13
	6	12
	7	11
Electrode in Channel Inlet		19
Electrode in Lower Plenum		8
Vessel Wall (Steam Dome)		18
(Downcomer)		9
(Lower Plenum)		10

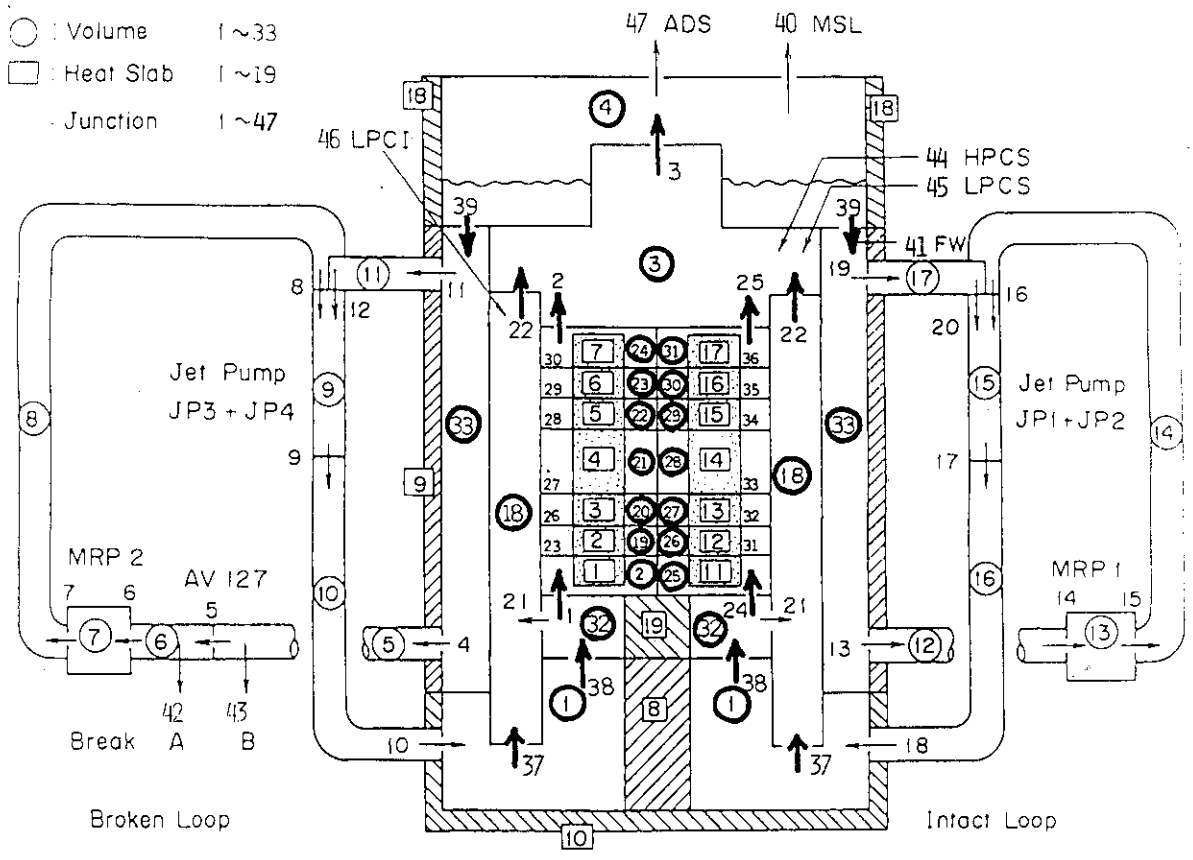


Fig. 3. 1 RELAP4J Nodalization of ROSA-III (Base Case A)

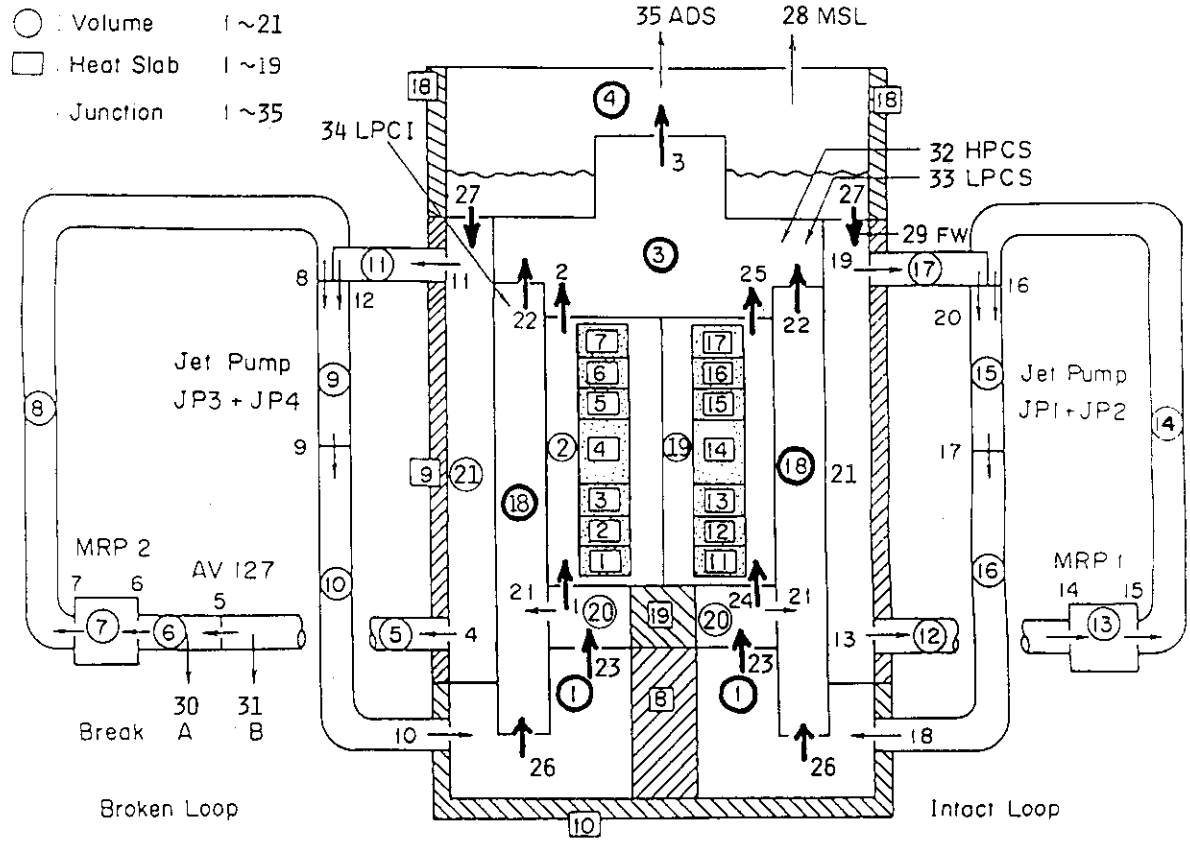
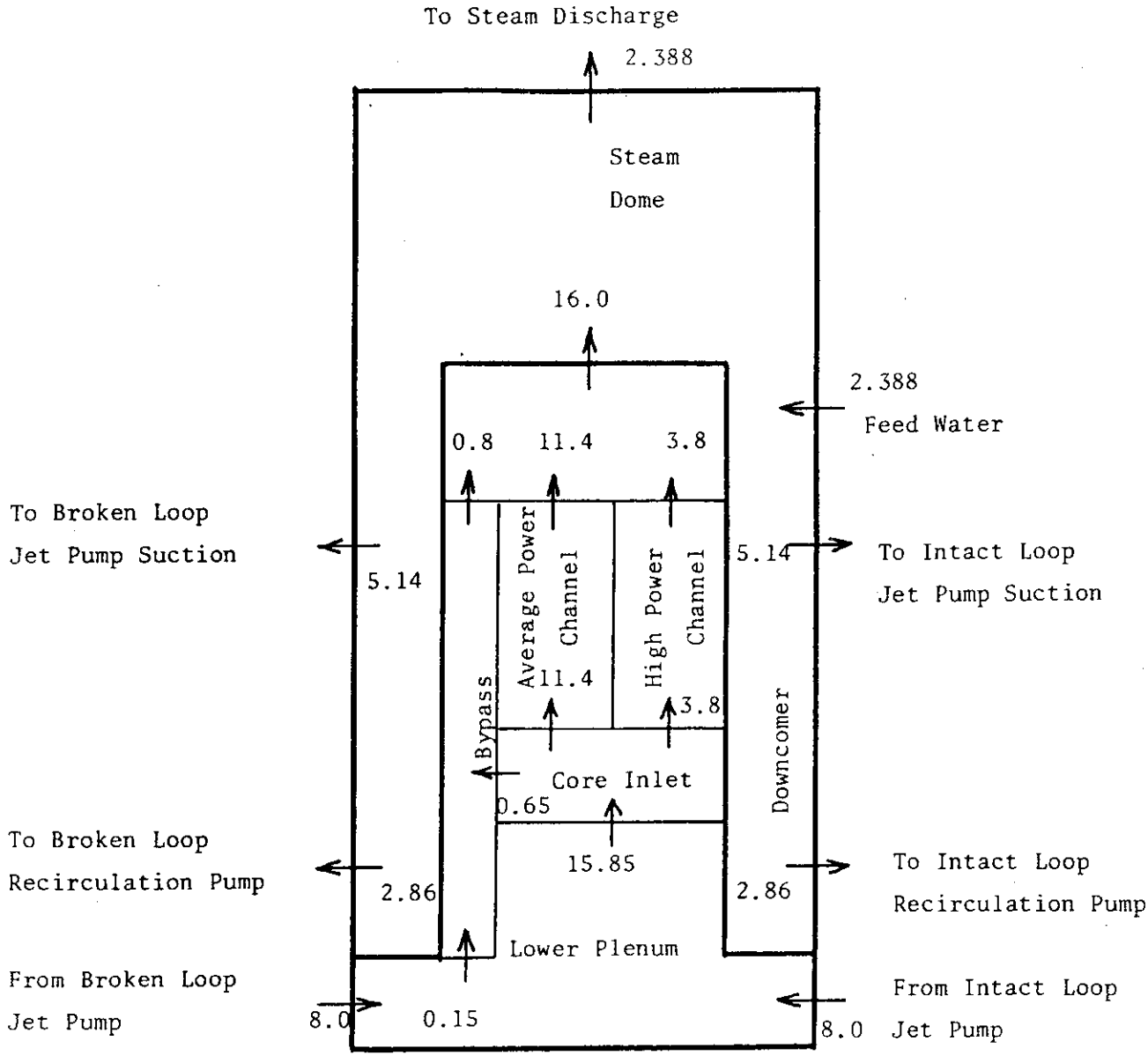


Fig. 3. 2 RELAP4J Nodalization of ROSA-III (Case B) (Reduced Case)



Note : Flow Rate in kg/s

Fig. 3. 3 Initial Flow Distribution of RUN 901

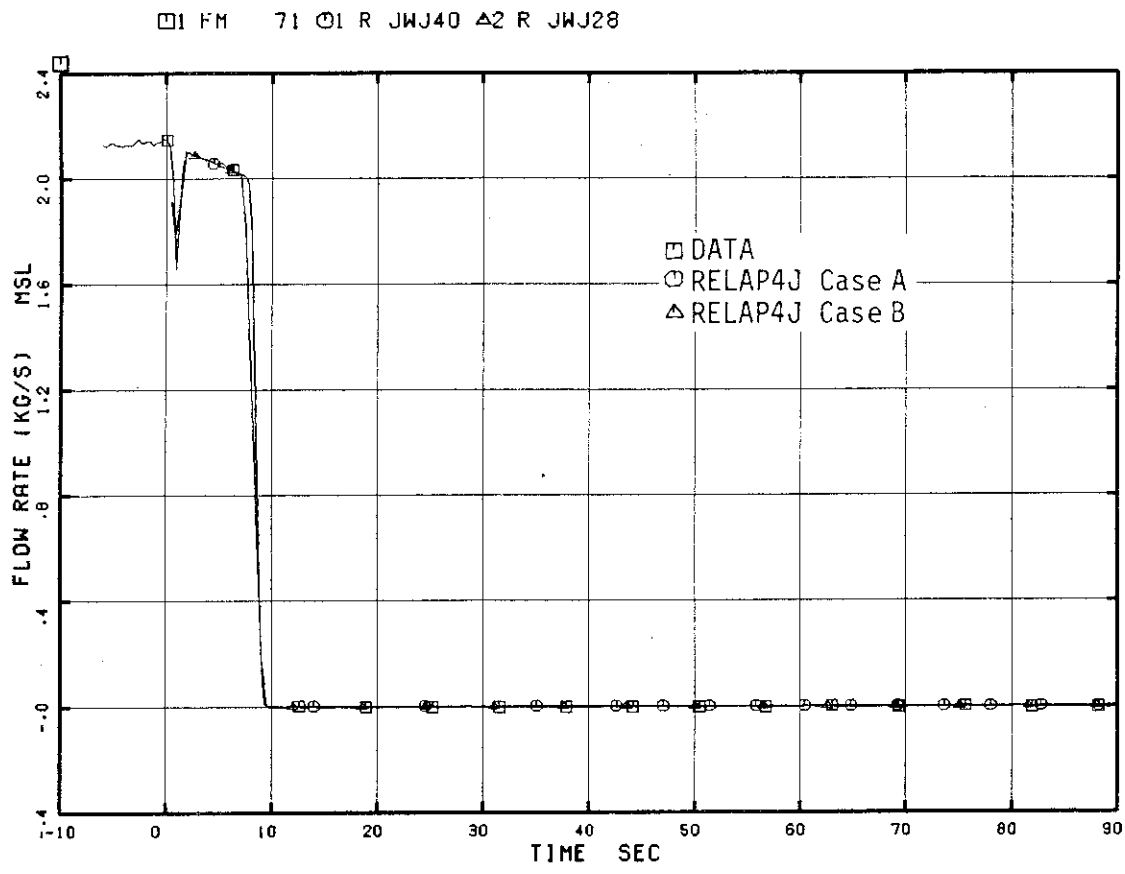


Fig. 3. 4 Main Steam Discharge Flow Rate

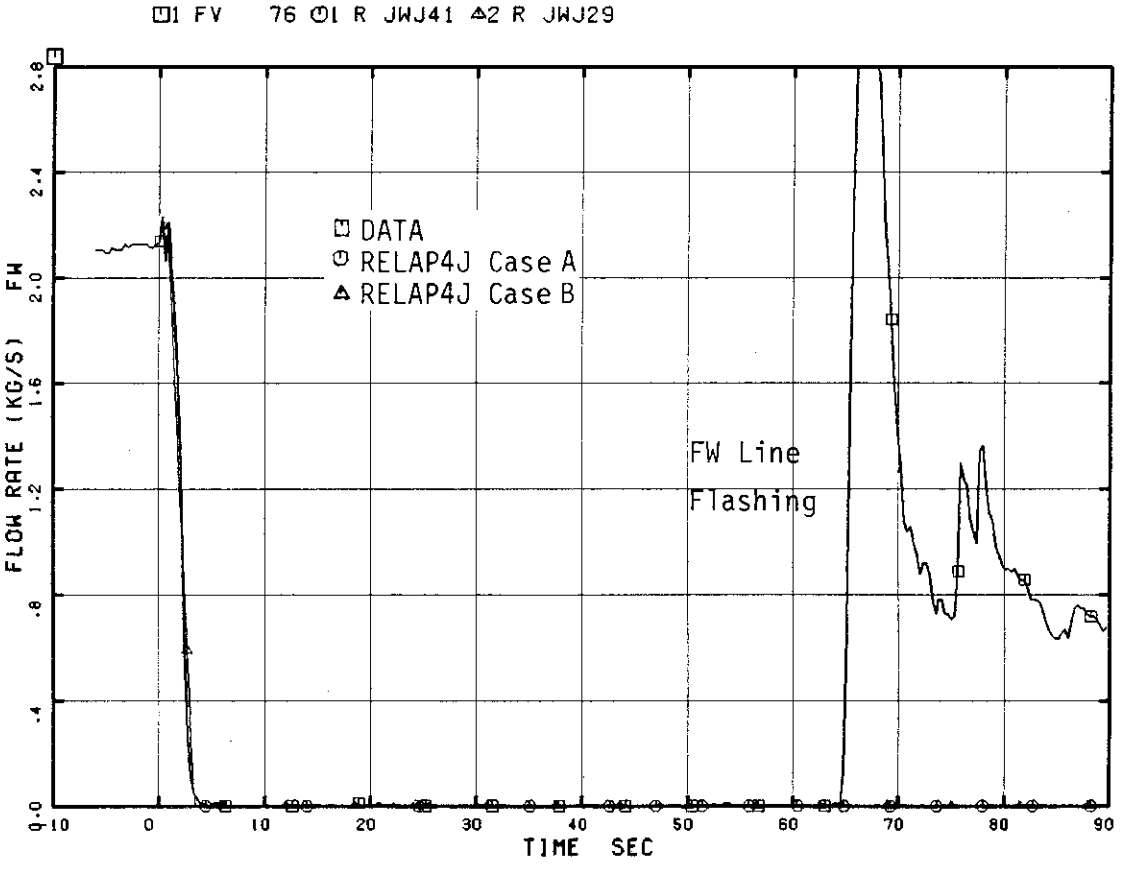


Fig. 3. 5 Feedwater Flow Rate

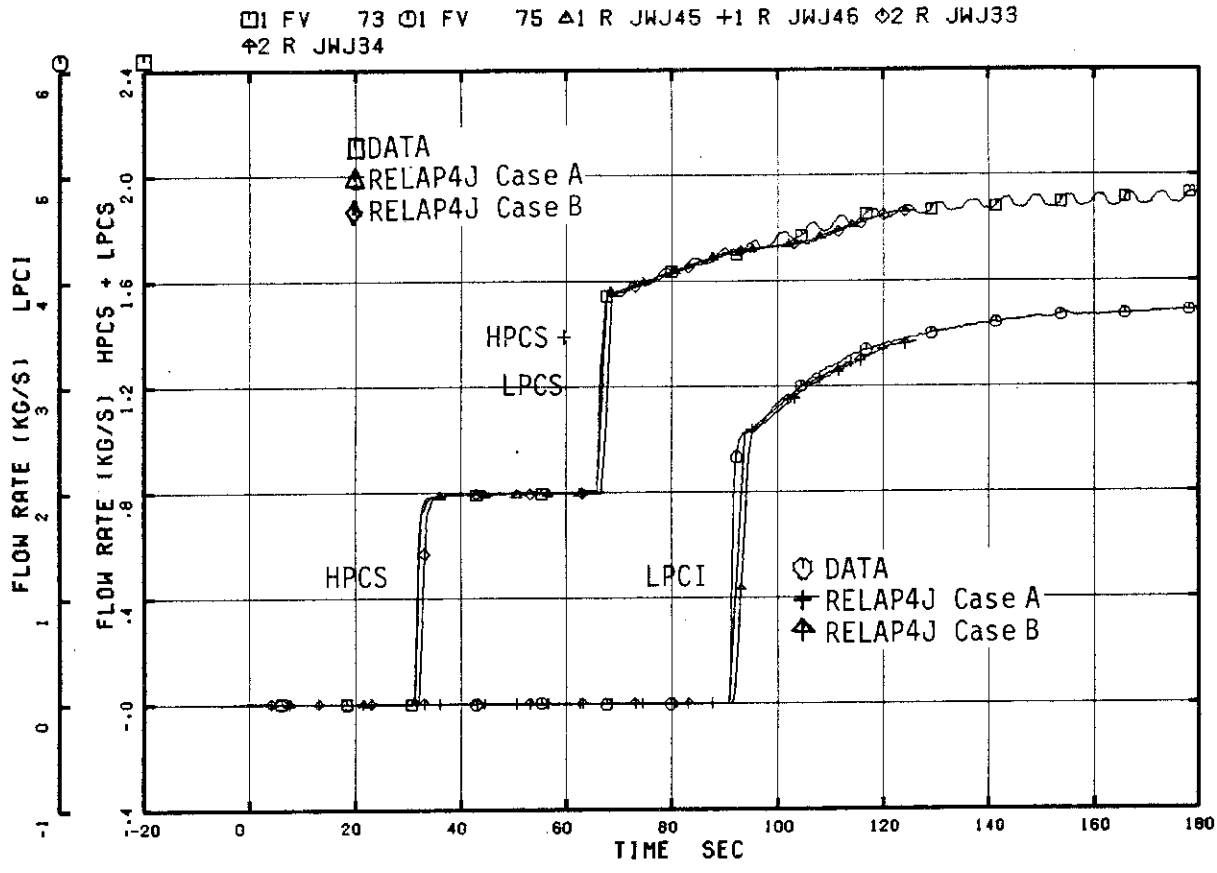


Fig. 3. 6 HPCS + LPCS and LPCI Flow Rate

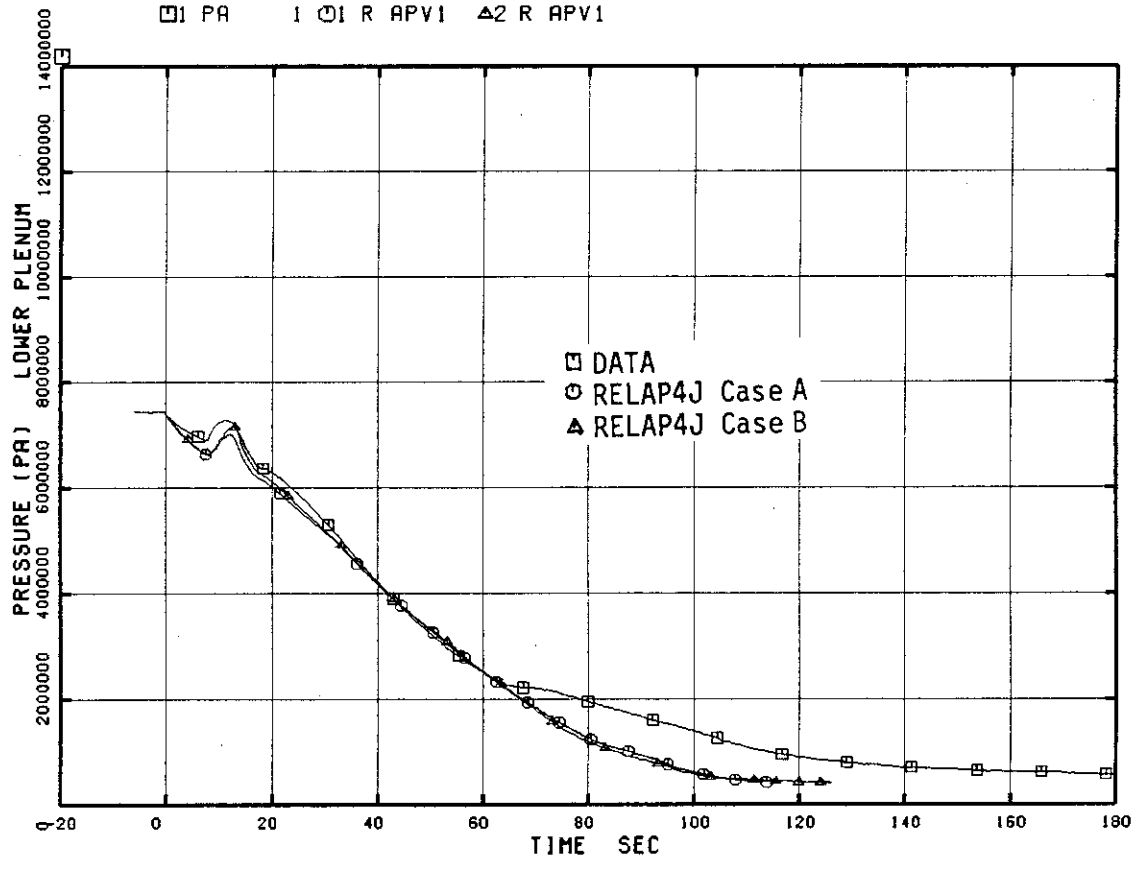


Fig. 3. 7 Lower Plenum Pressure

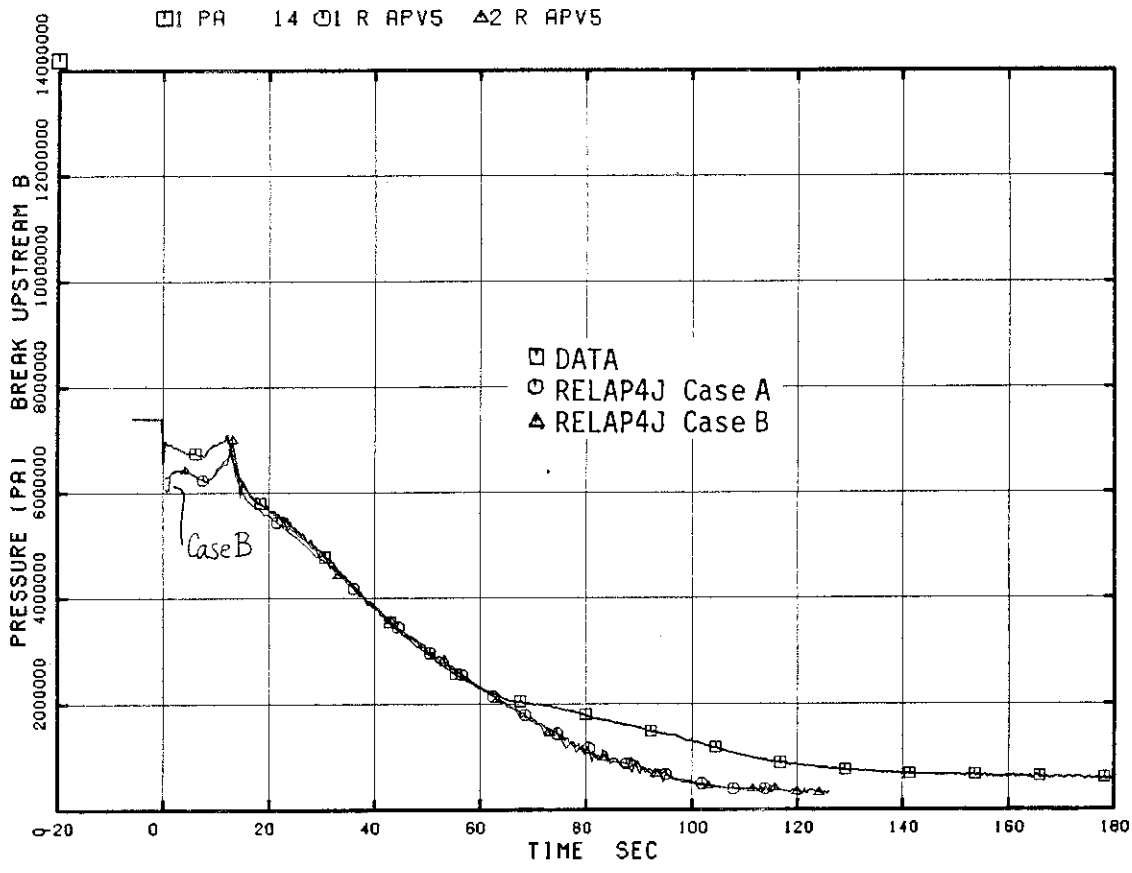


Fig. 3. 8 Pressure at Break B Upstream (PV Side)

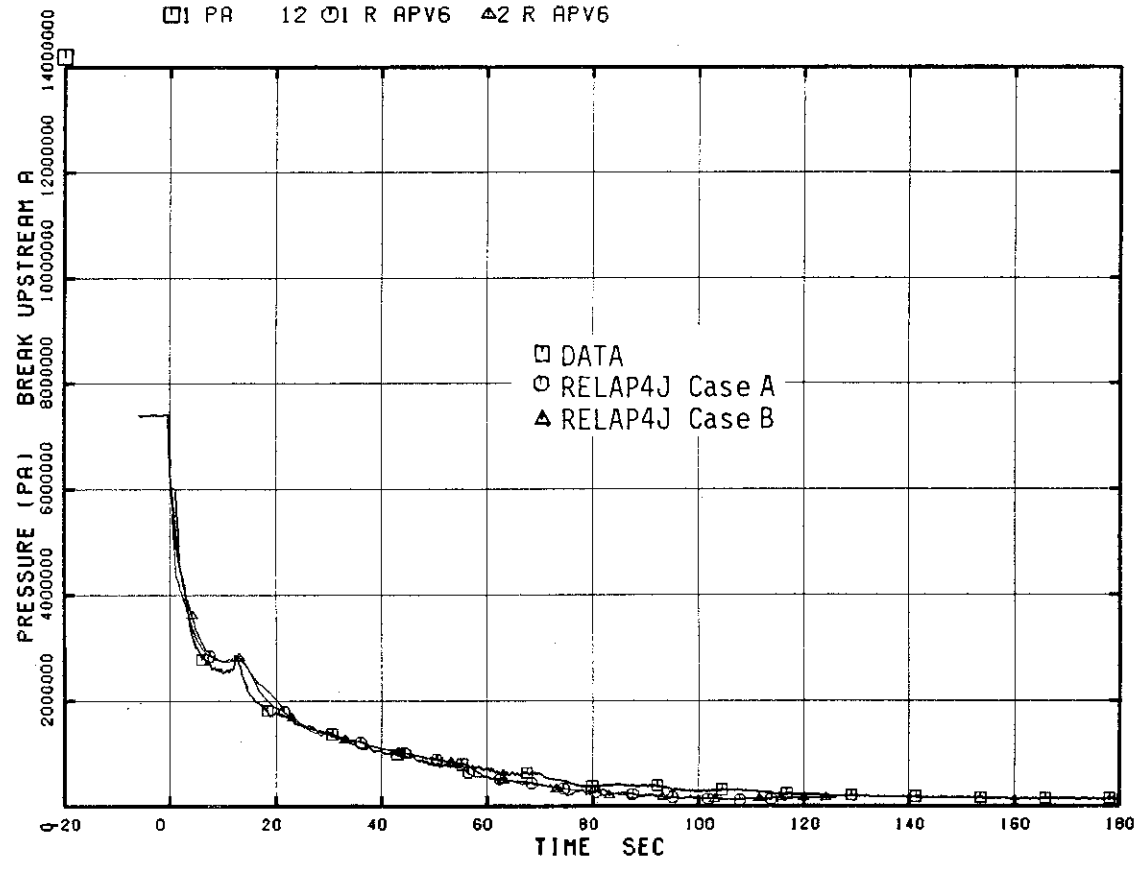


Fig. 3. 9 Pressure at Break A Upstream (MRP Side)

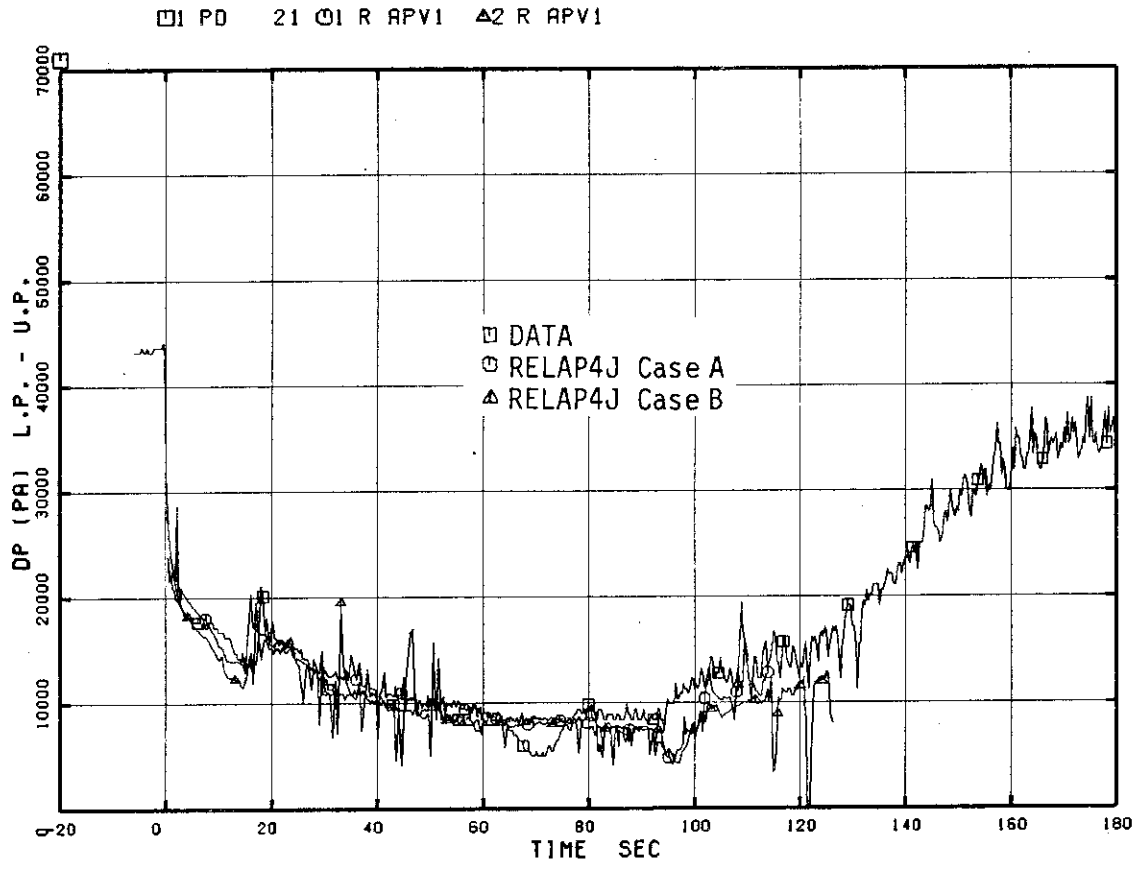


Fig. 3.10 Differential Pressure between Lower and Upper Plena

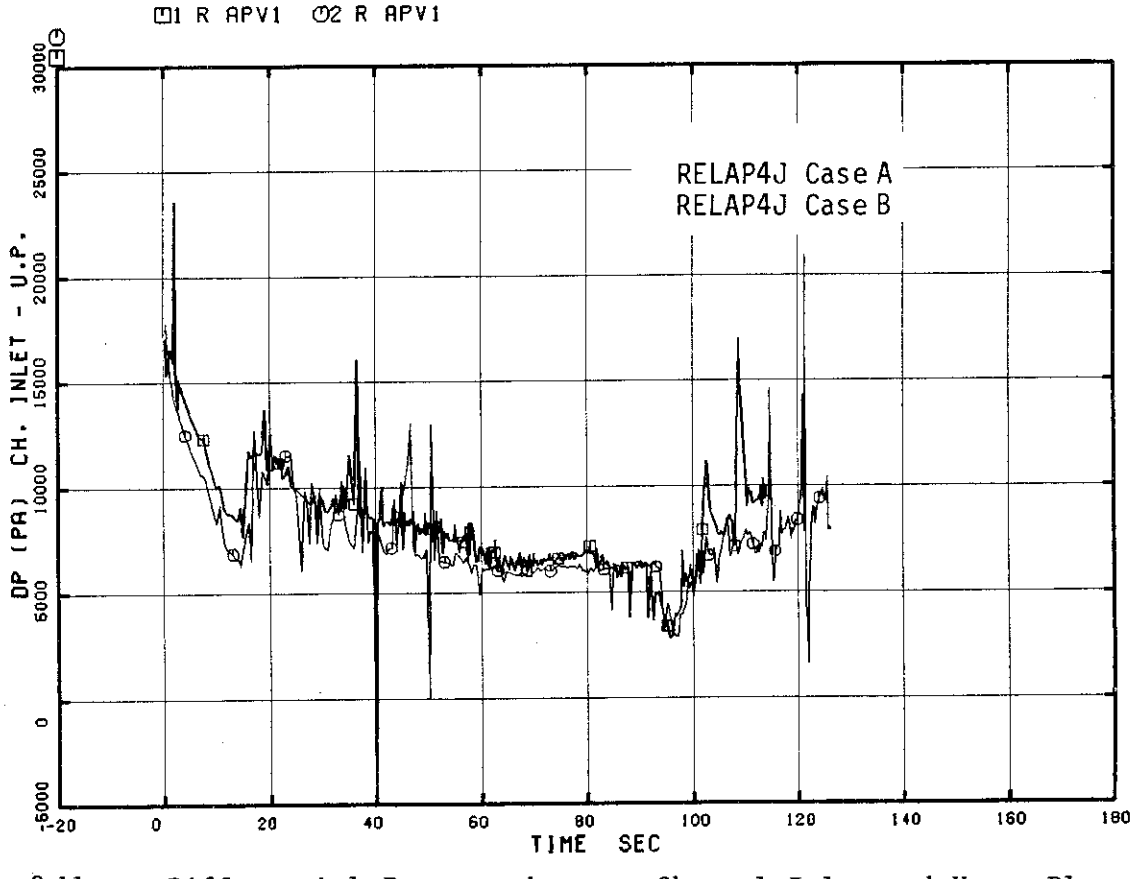


Fig. 3.11 Differential Pressure between Channel Inlet and Upper Plenum

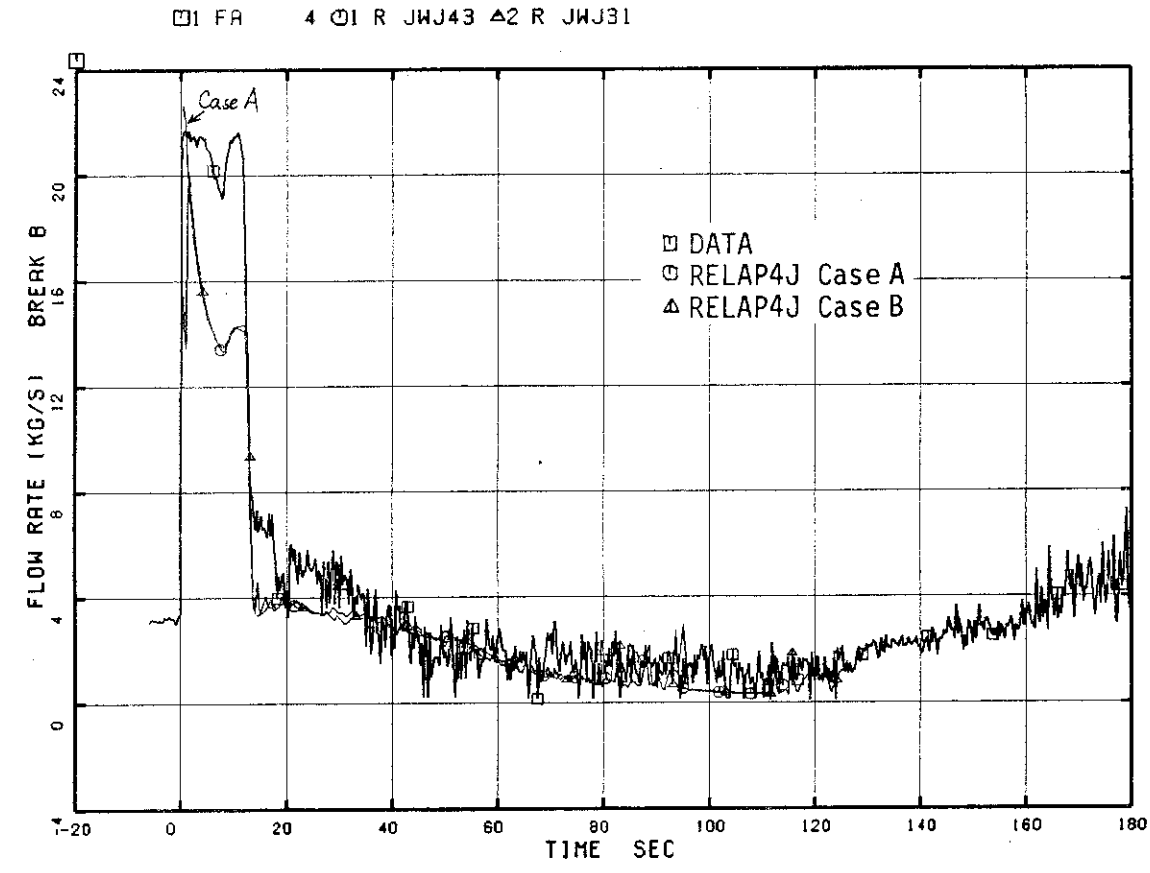


Fig. 3.12 Break Flow from Break B (PV side)

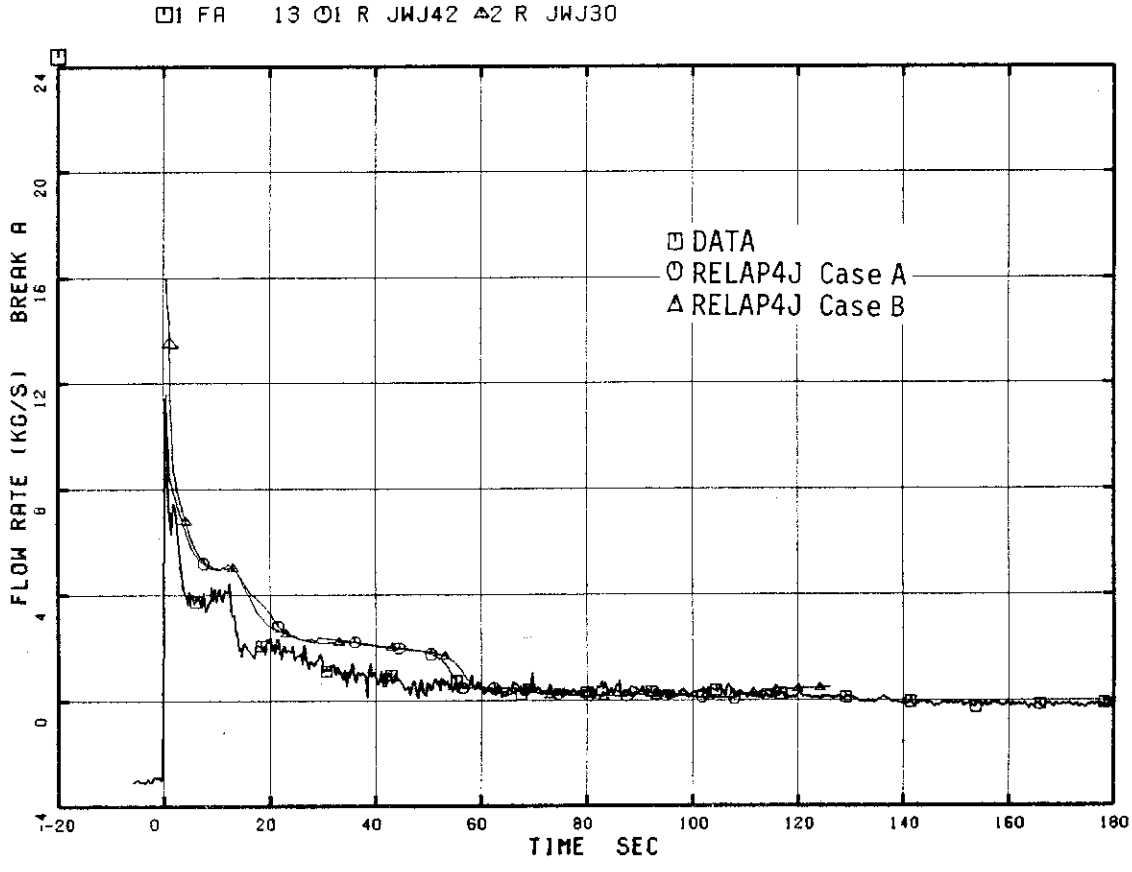


Fig. 3.13 Break Flow from Break A (MRP side)

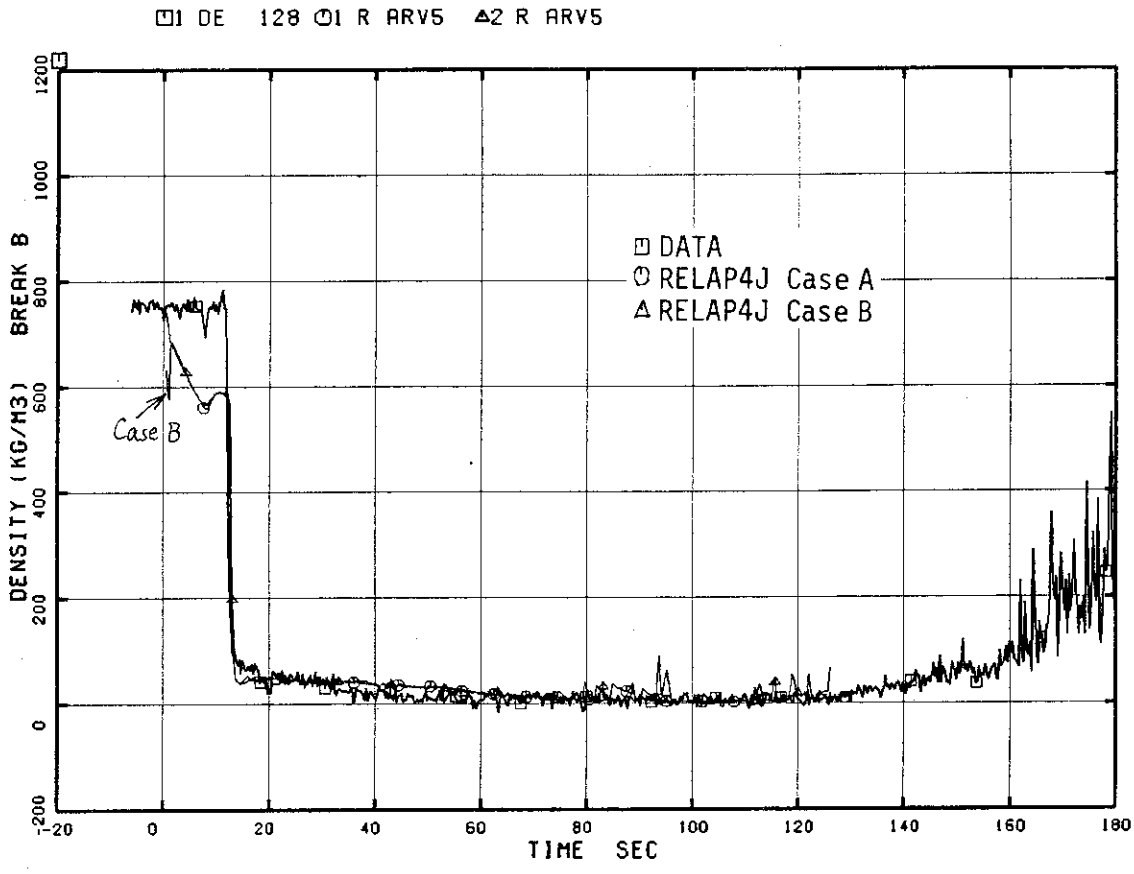


Fig. 3.14 Average Fluid Densities at the Break B Upstream

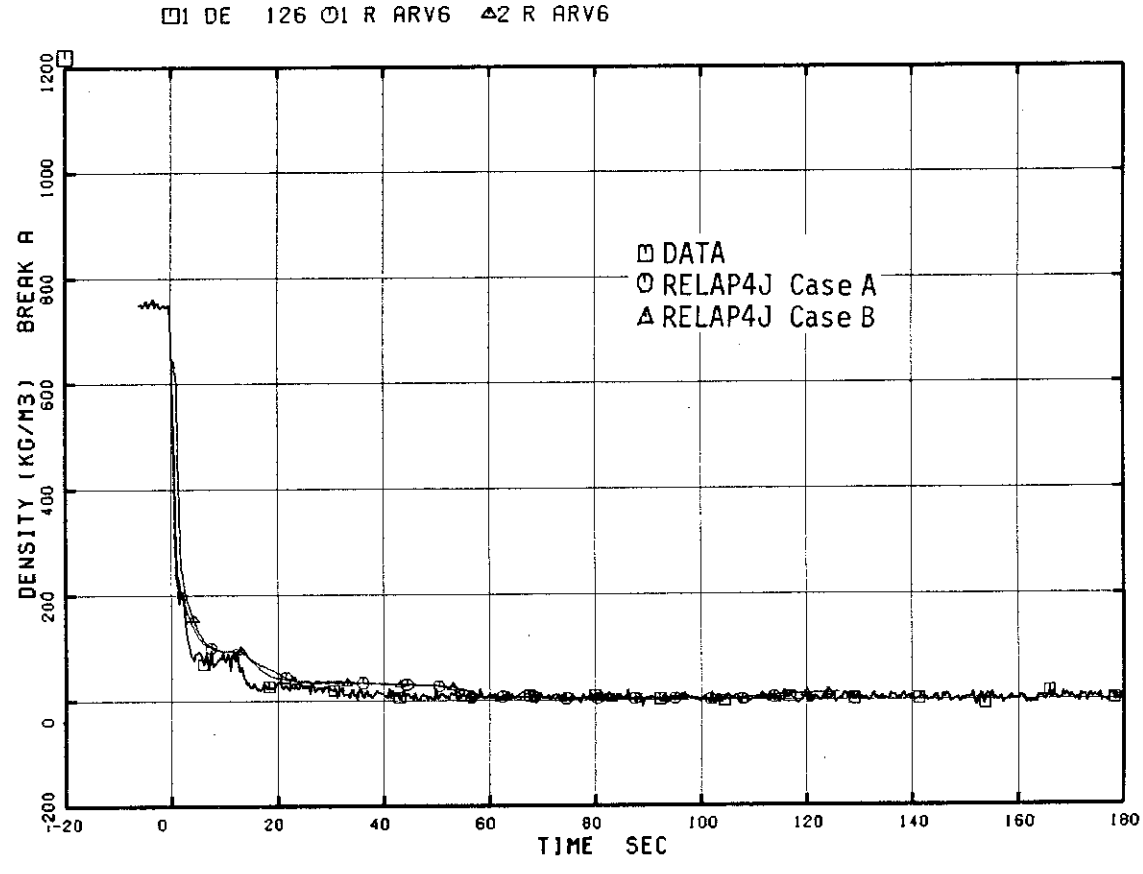


Fig. 3.15 Average Fluid Densities at the Break A Upstream

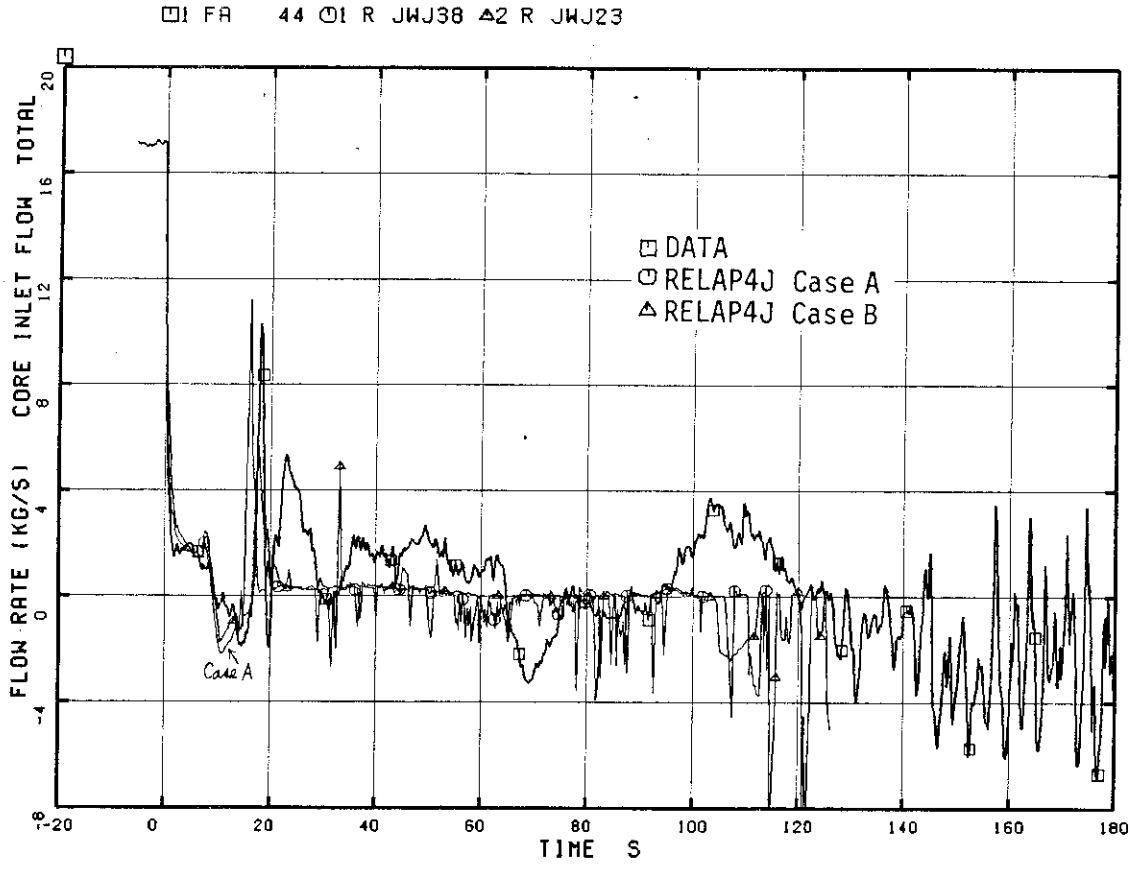


Fig. 3.16 Total Core Inlet Flow through SEO

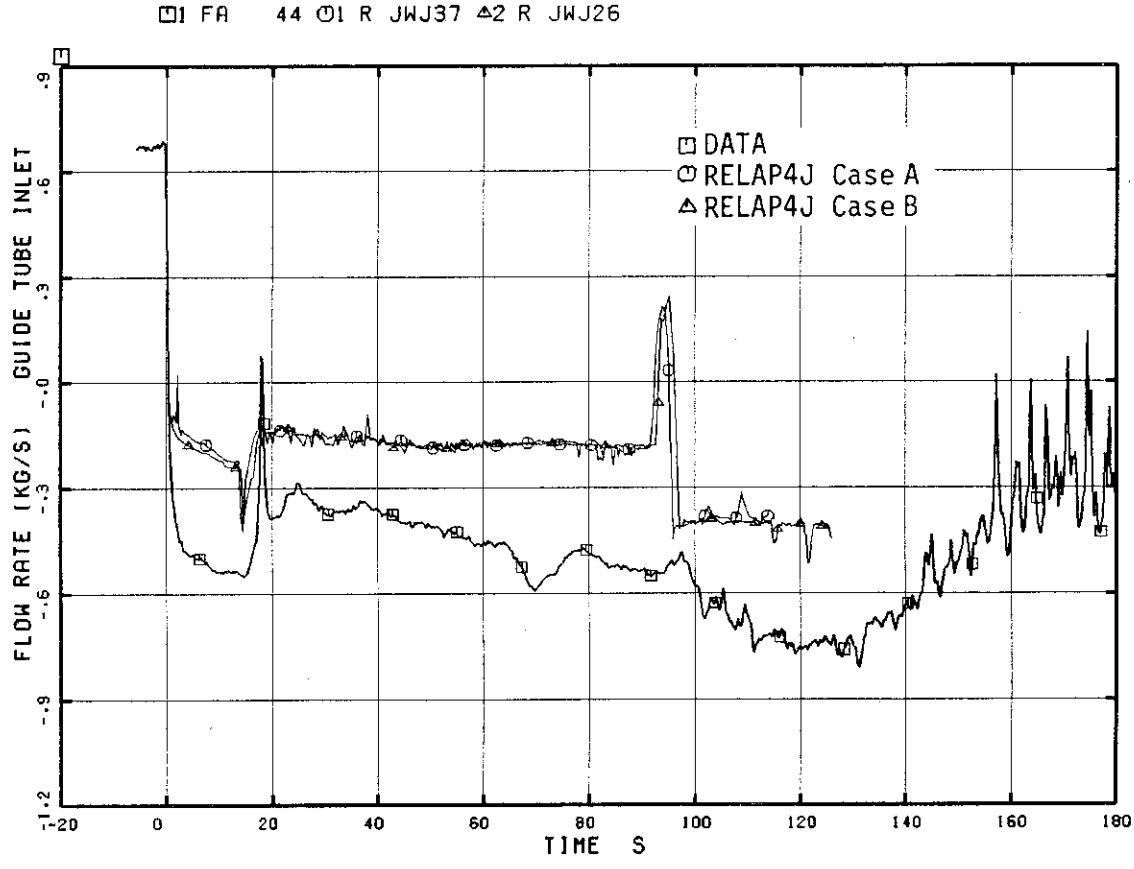


Fig. 3.17 Guide Tube Inlet Flow

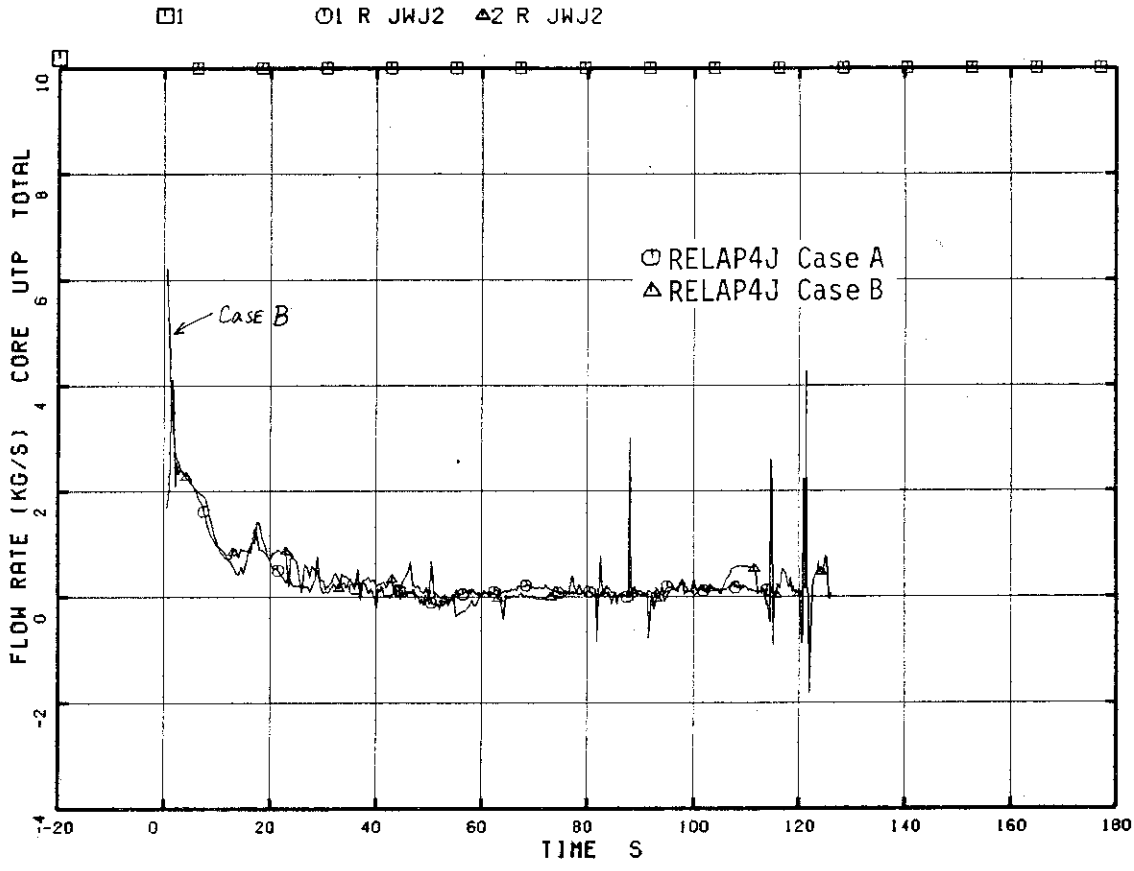


Fig. 3.18 Total Core Flow through UTP

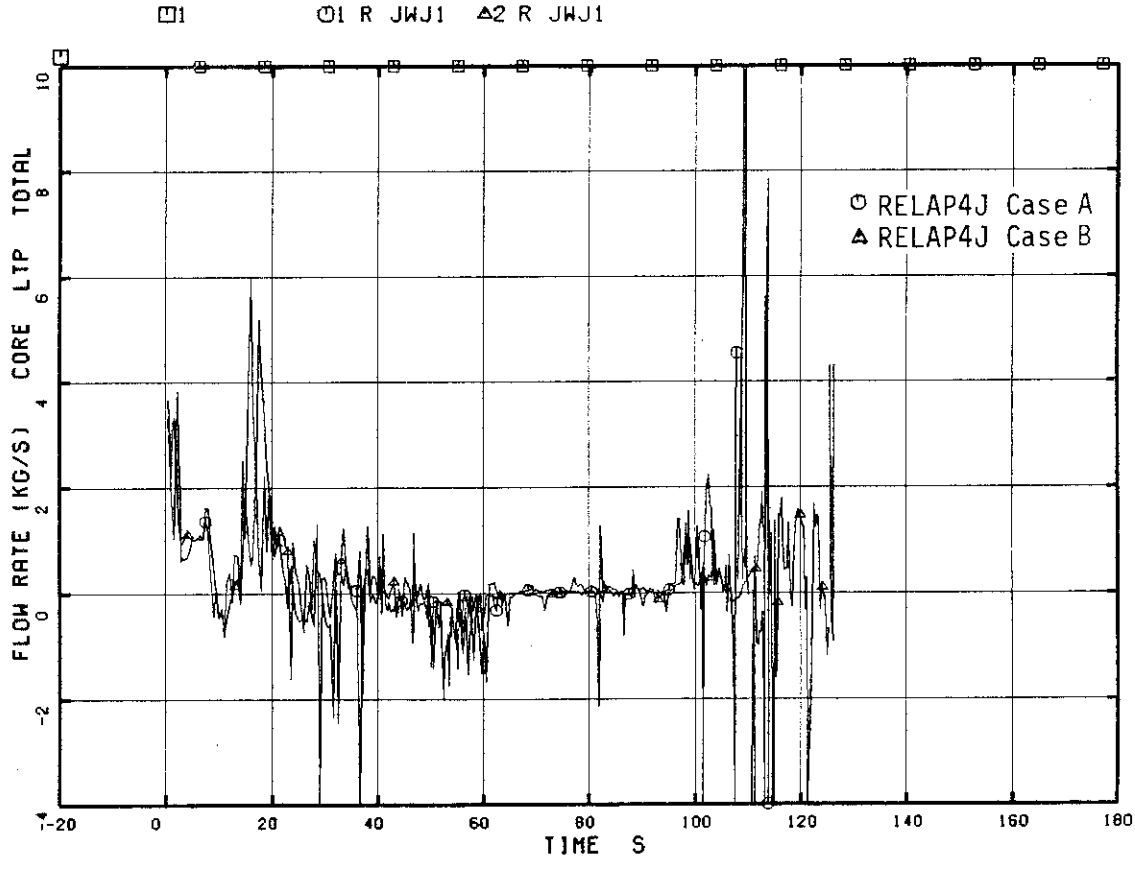


Fig. 3.19 Total Core Flow through LTP

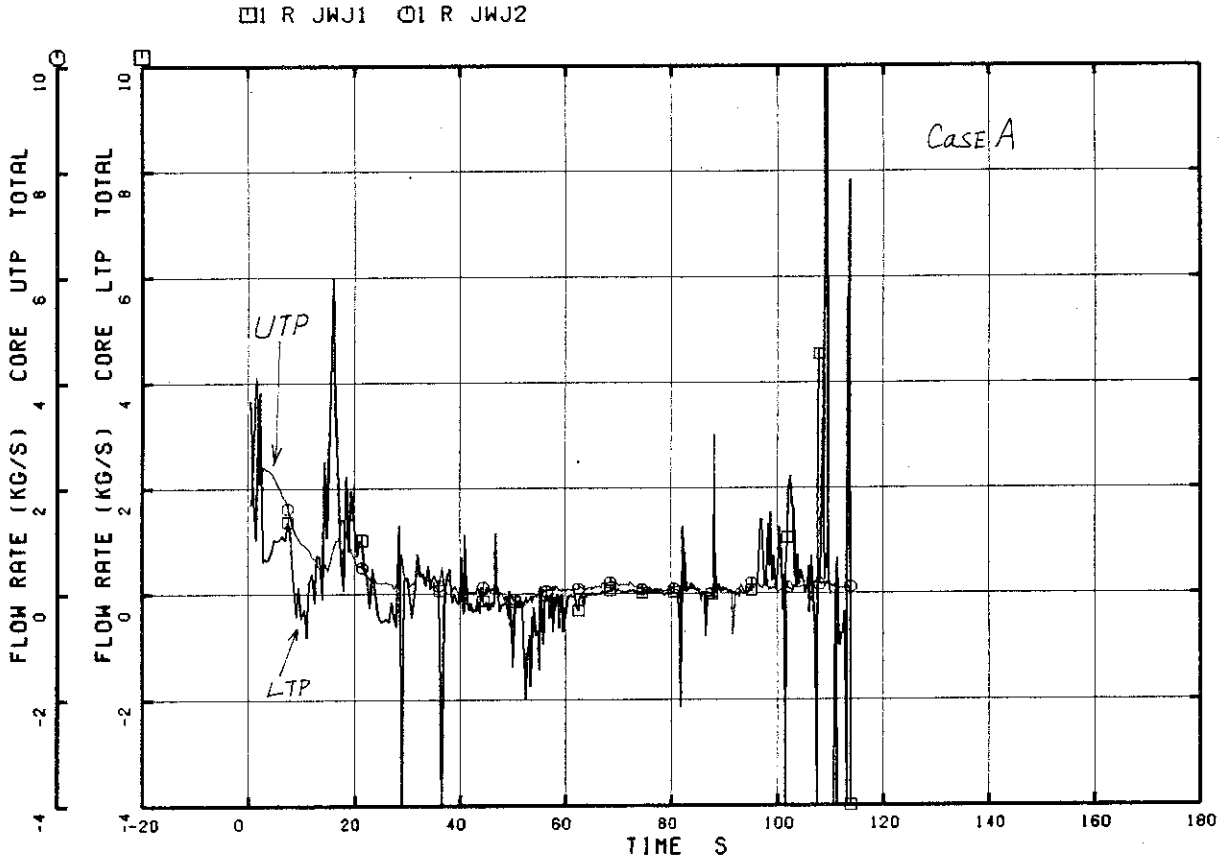


Fig. 3.20 Total Core Flows through UTP and LTP (Case A)

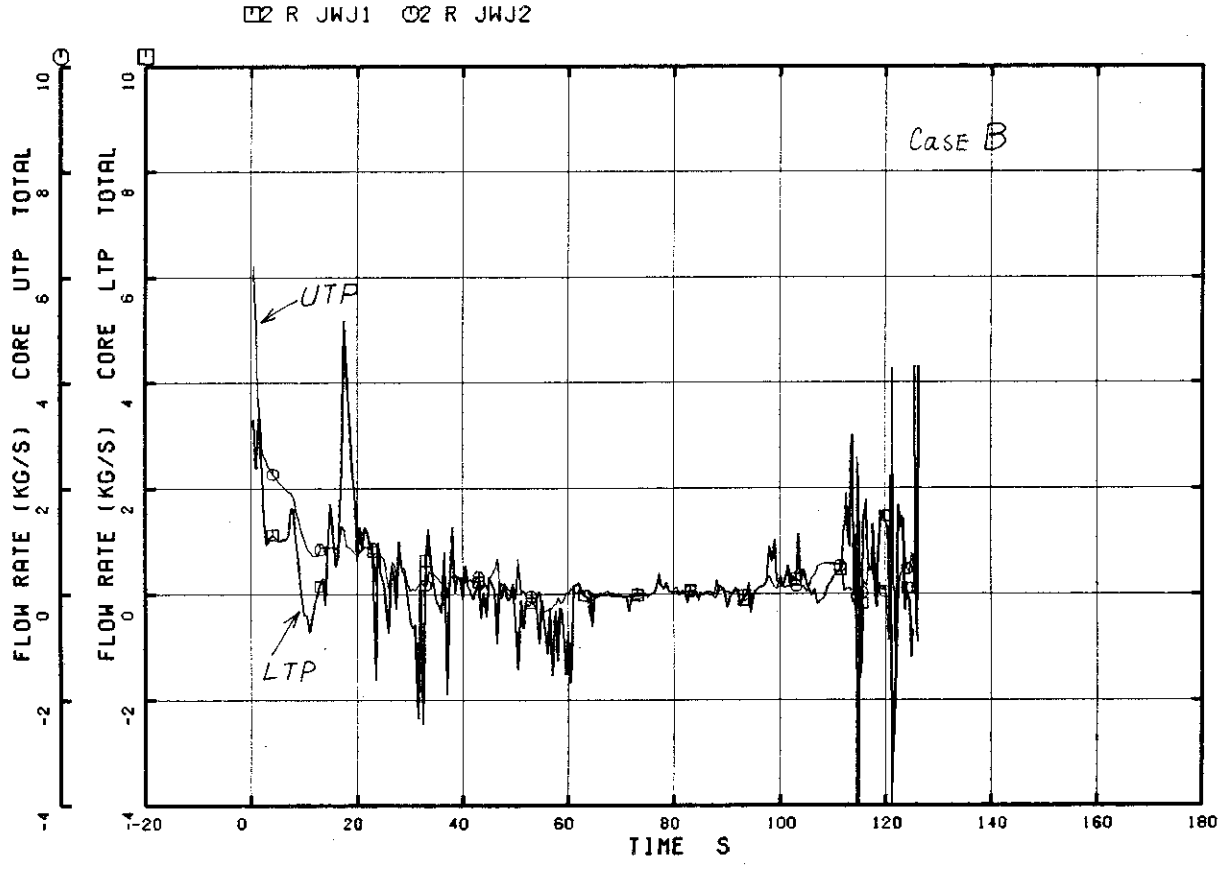


Fig. 3.21 Total Core Flows through UTP and LTP (Case B)

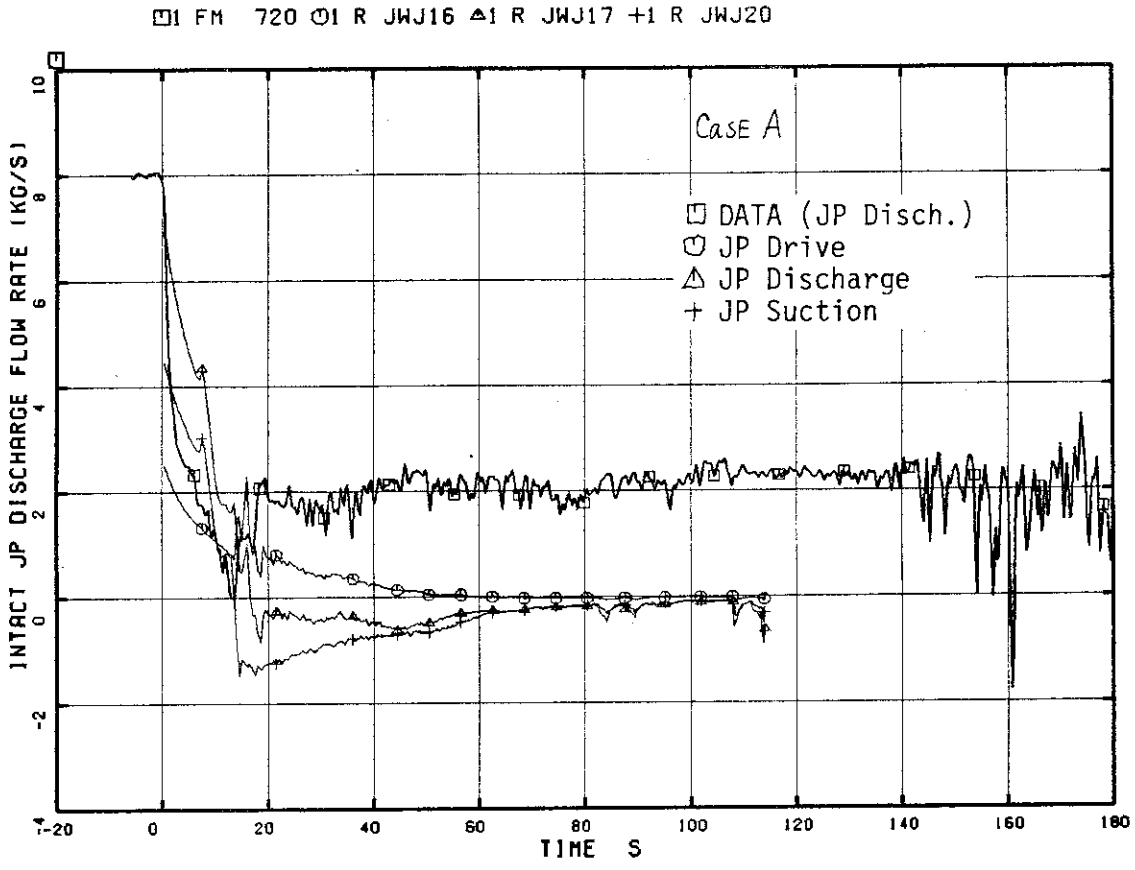


Fig. 3.22 Jet Pump Flow (Intact Loop Side ; Case A)

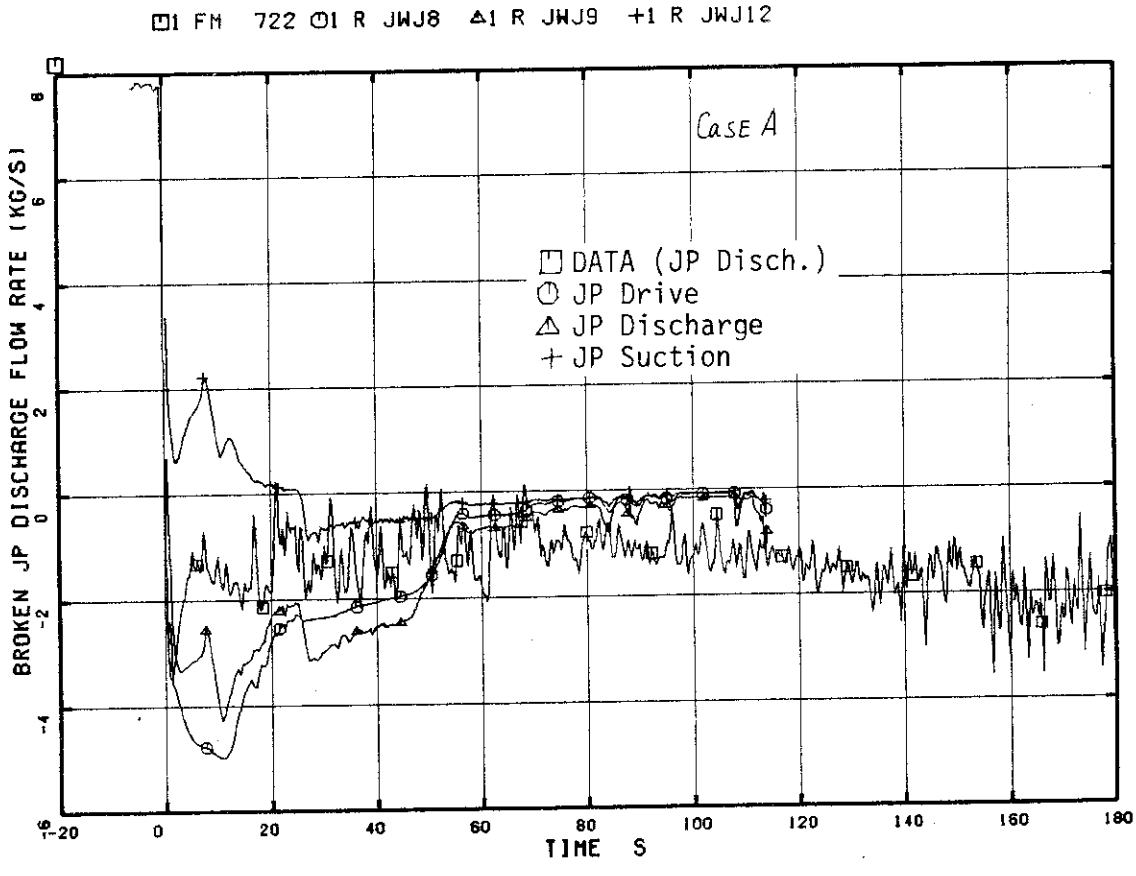


Fig. 3.23 Jet Pump Flow (Broken Loop Side ; Case A)

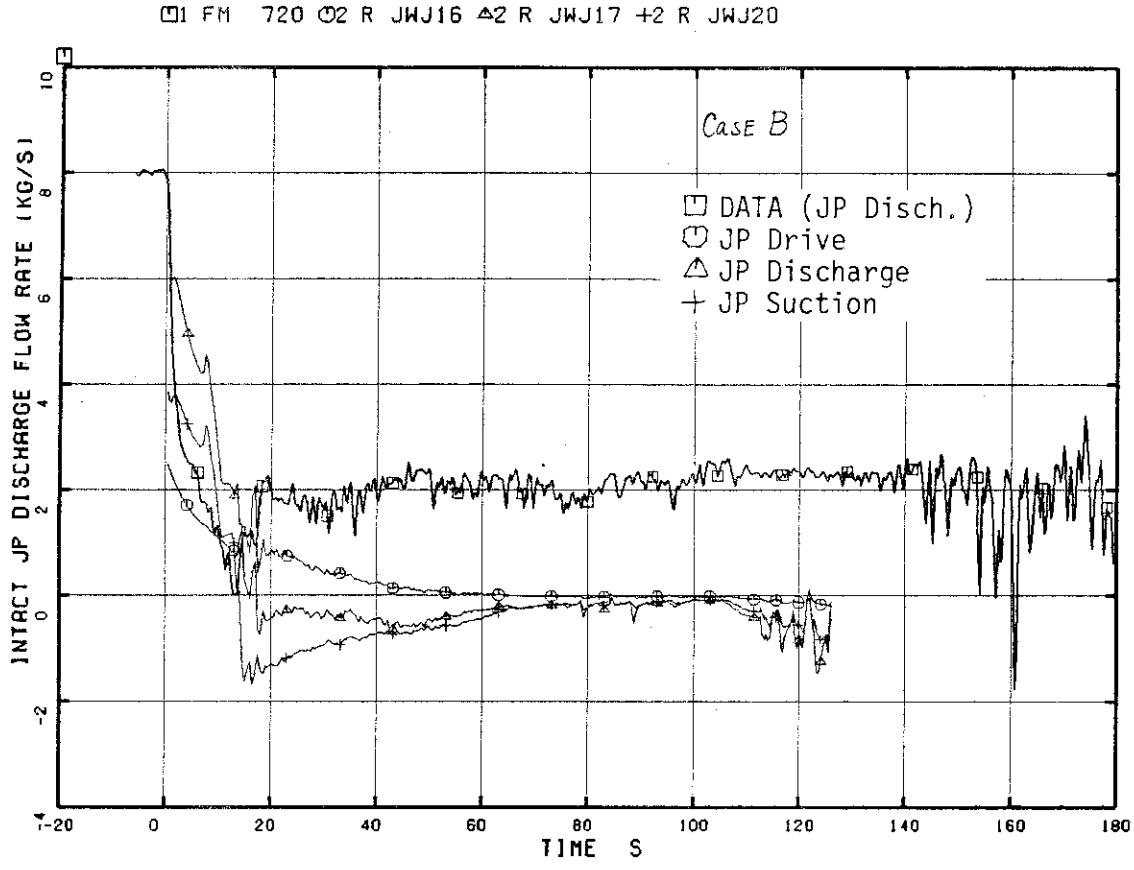


Fig. 3.24 Jet Pump Flow (Intact Loop Side ; Case B)

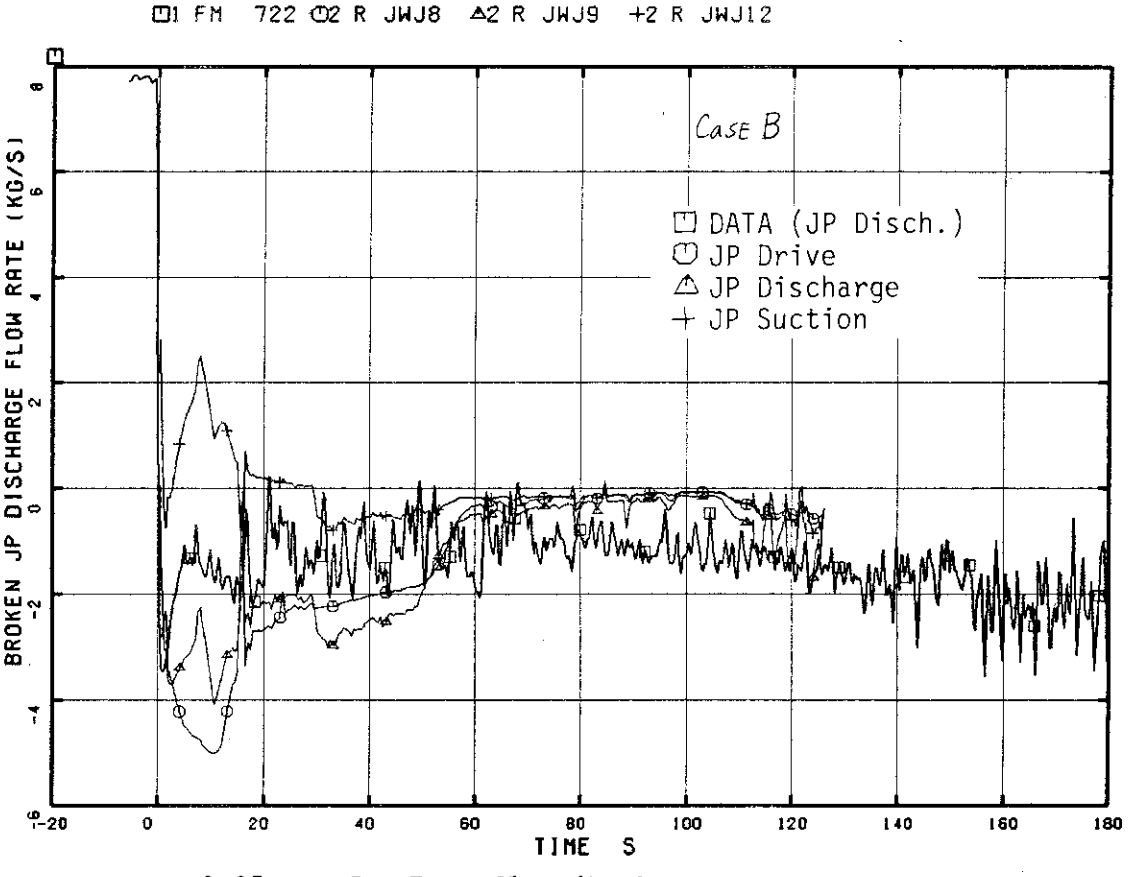


Fig. 3.25 Jet Pump Flow (Broken Loop Side ; Case B)

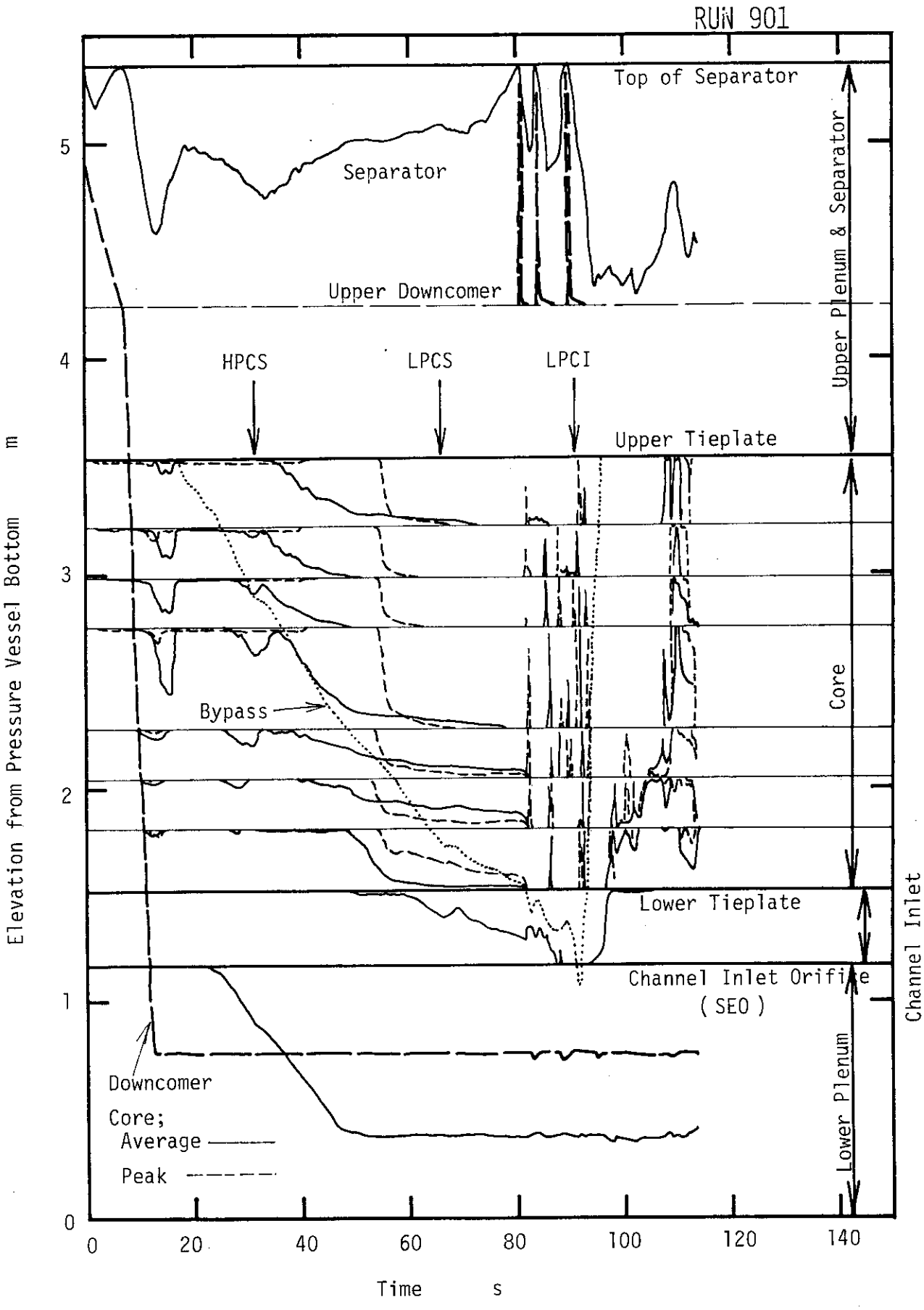


Fig. 3.26 Liquid Levels in the Pressure Vessel (Case A)

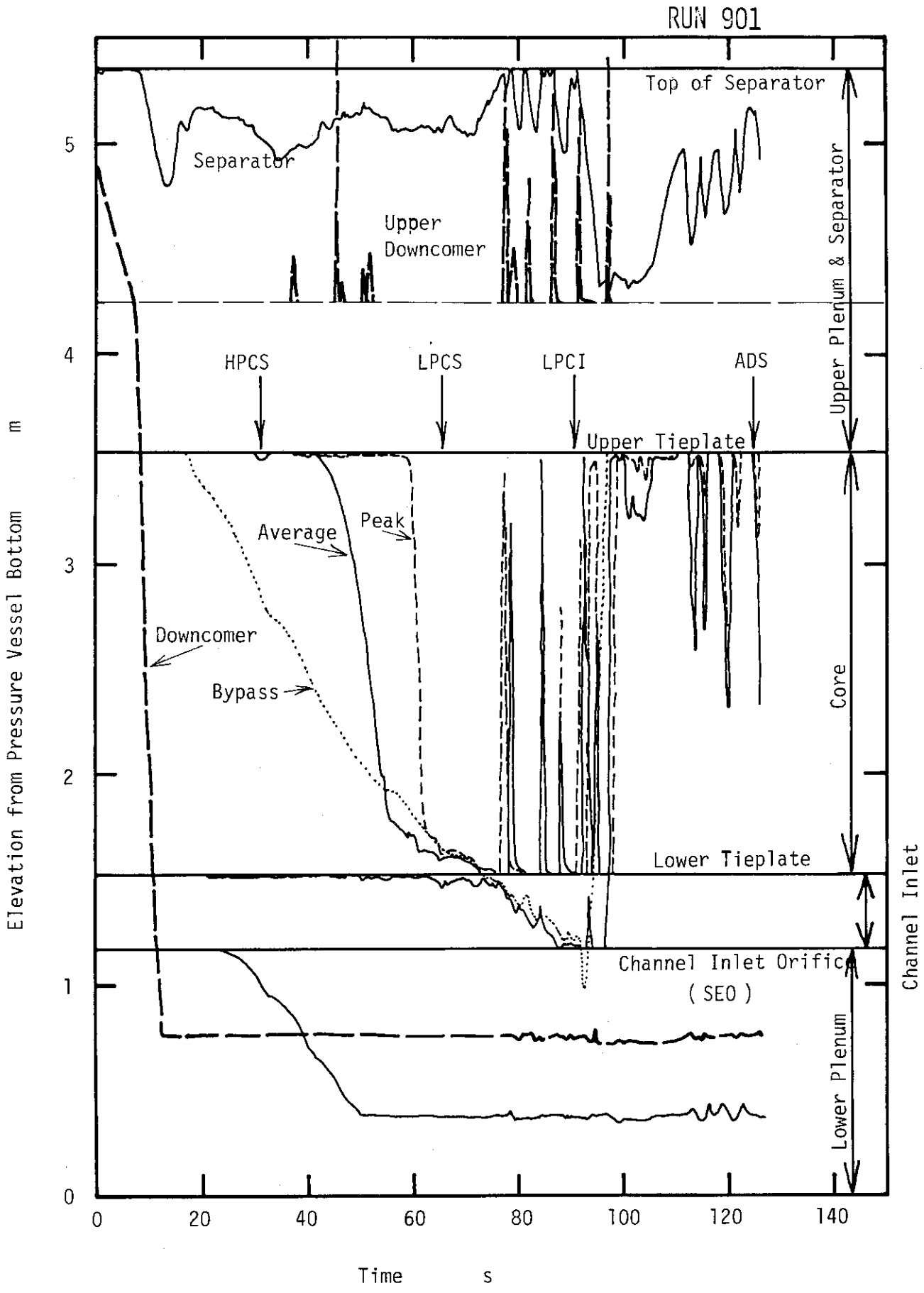


Fig. 3.27 Liquid Levels in the Pressure Vessel (Case B)

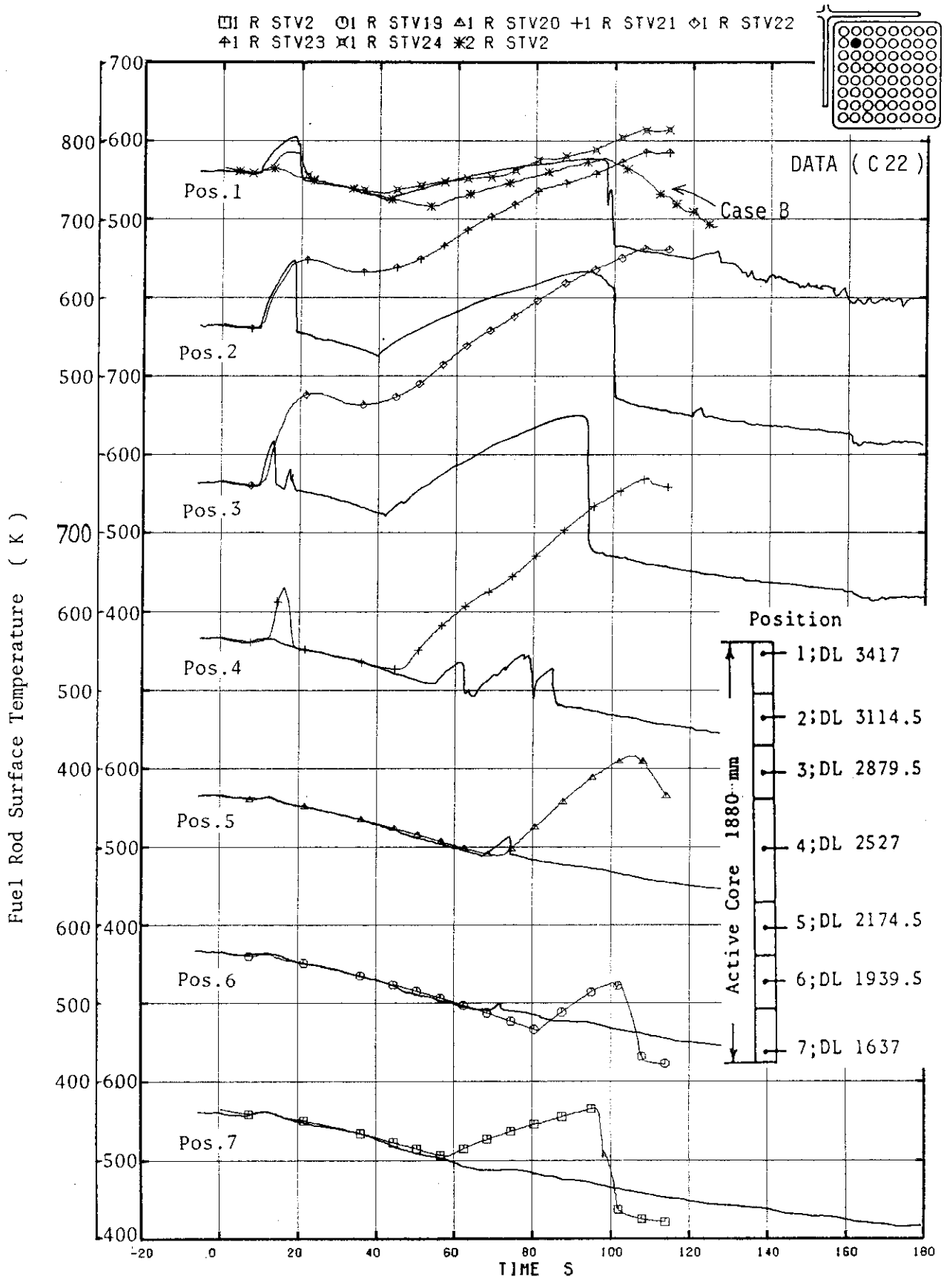


Fig. 3.28 Fuel Rod Surface Temperature in Case A
(Average Power Channel)

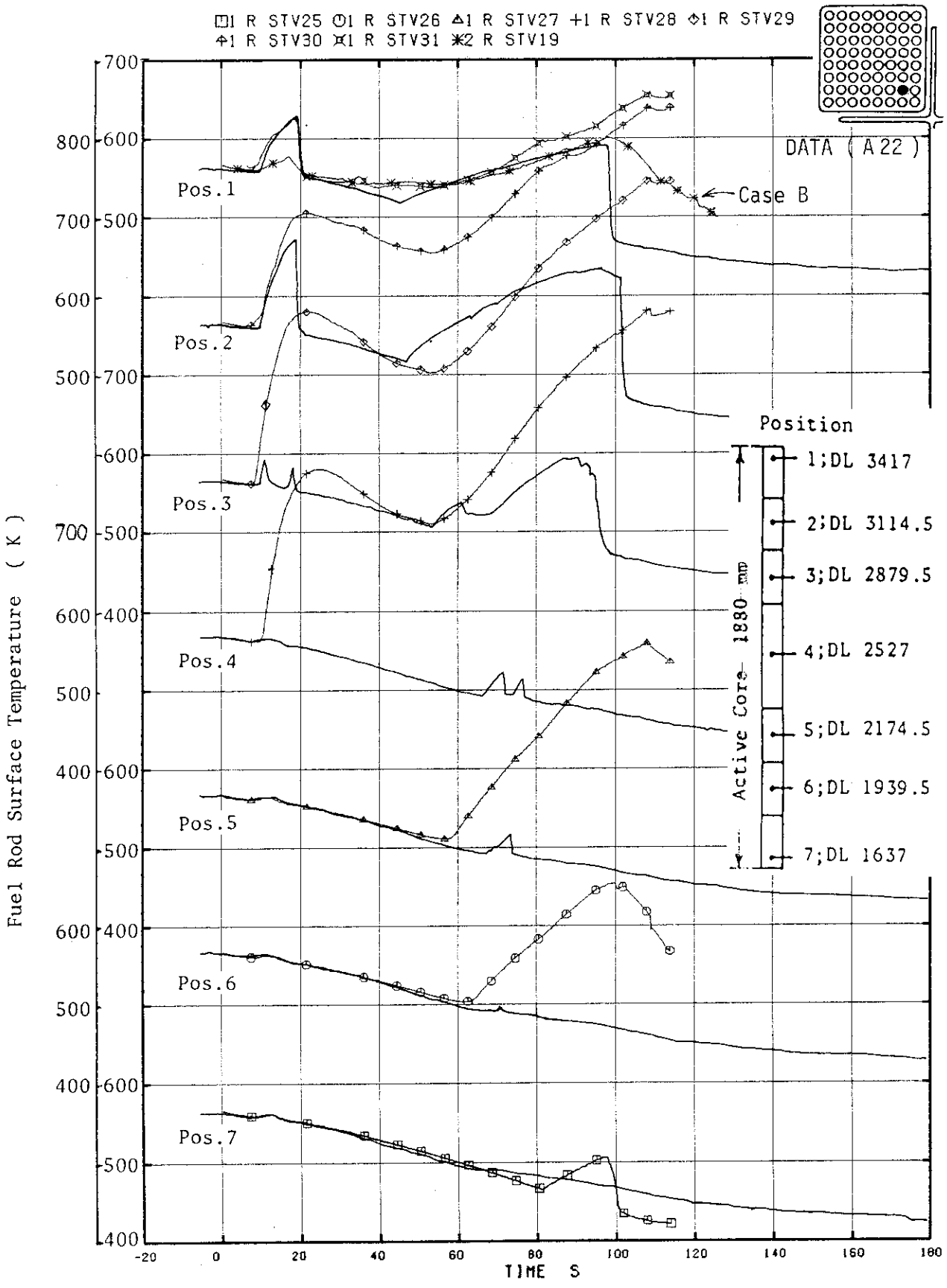


Fig. 3.29 Fuel Rod Surface Temperature in Case A (Peak Power Channel)

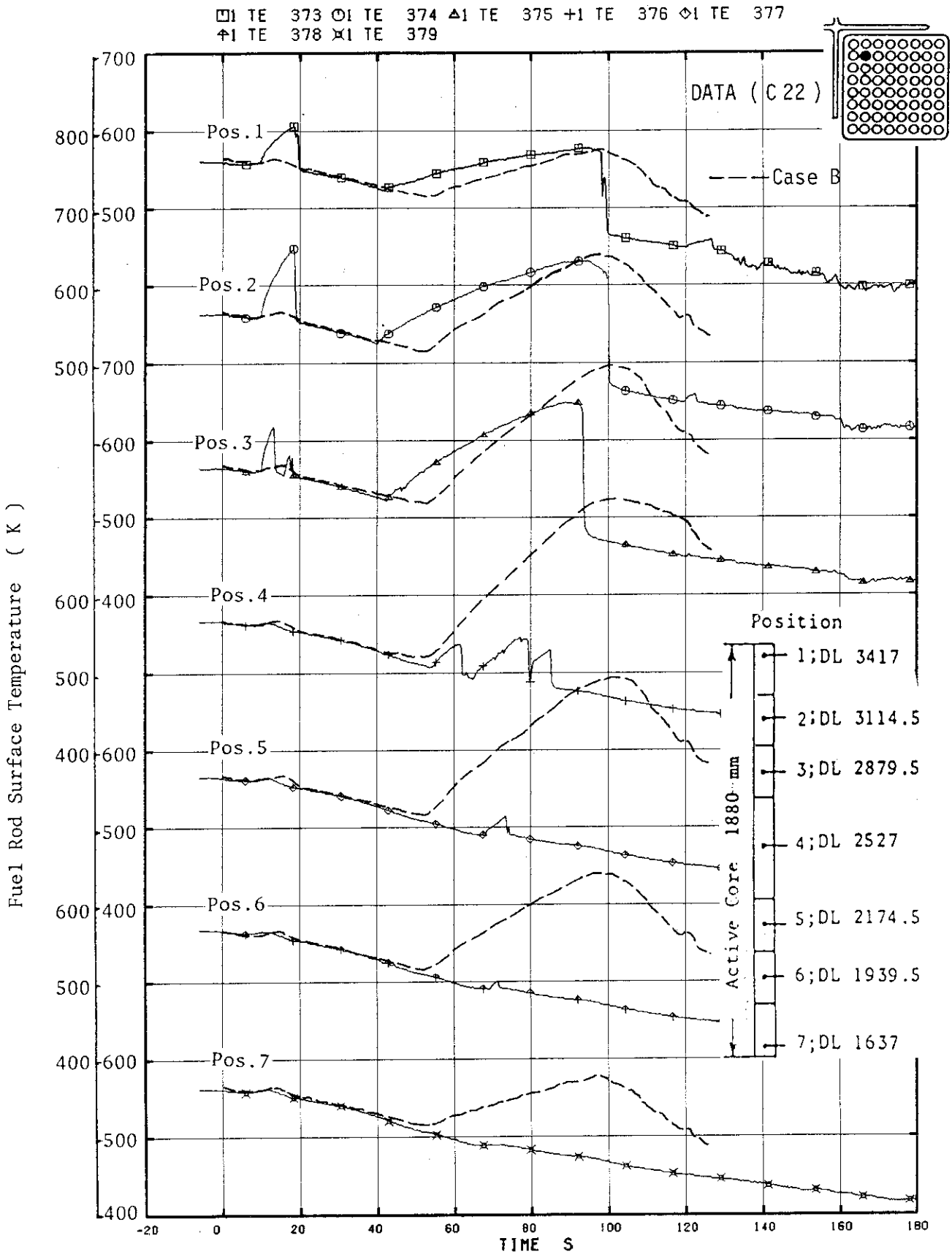


Fig. 3.30 Fuel Rod Surface Temperature in Case B (Average Power Channel)

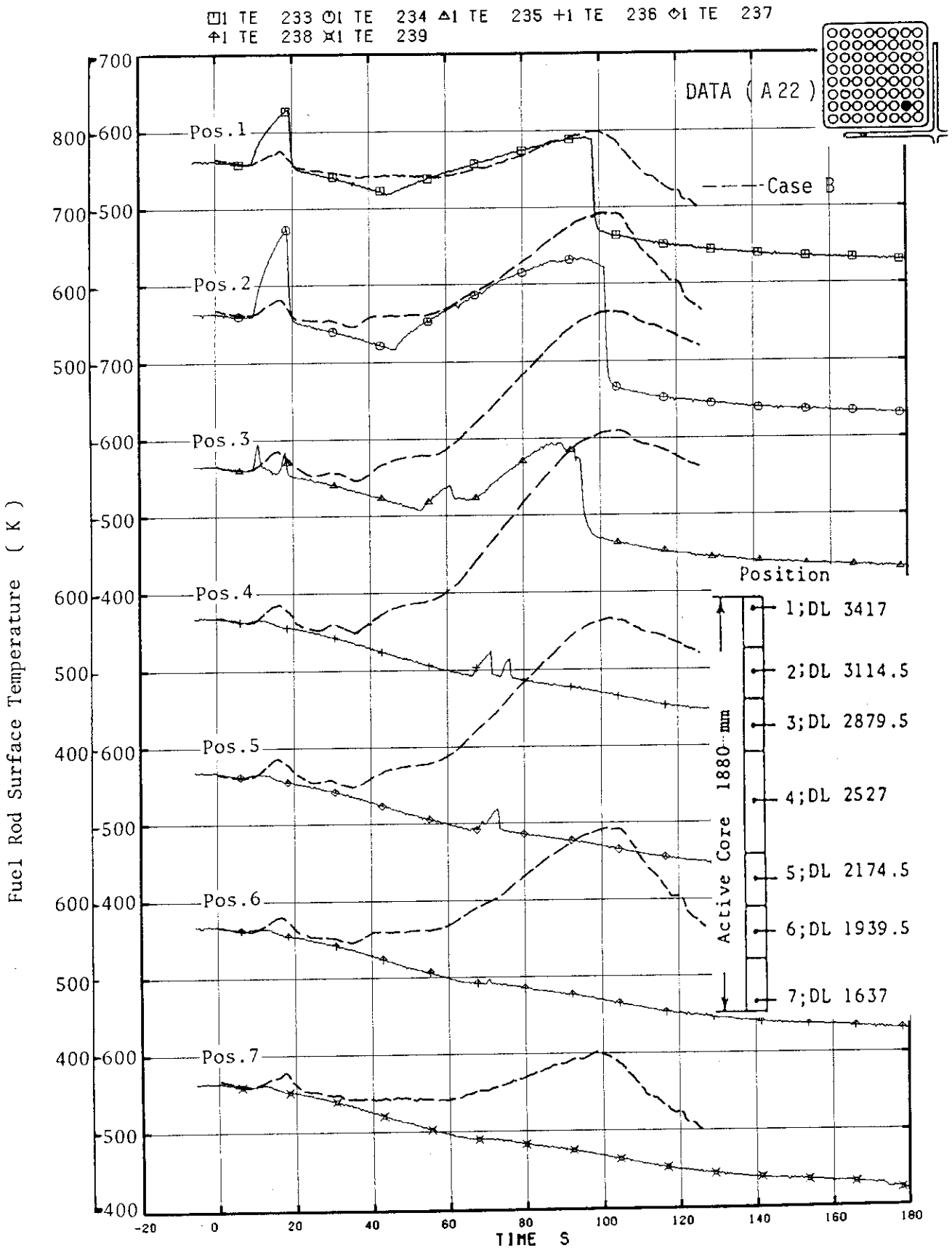


Fig. 3.31 Fuel Rod Surface Temperature in Case B

(Peak Power Channel)

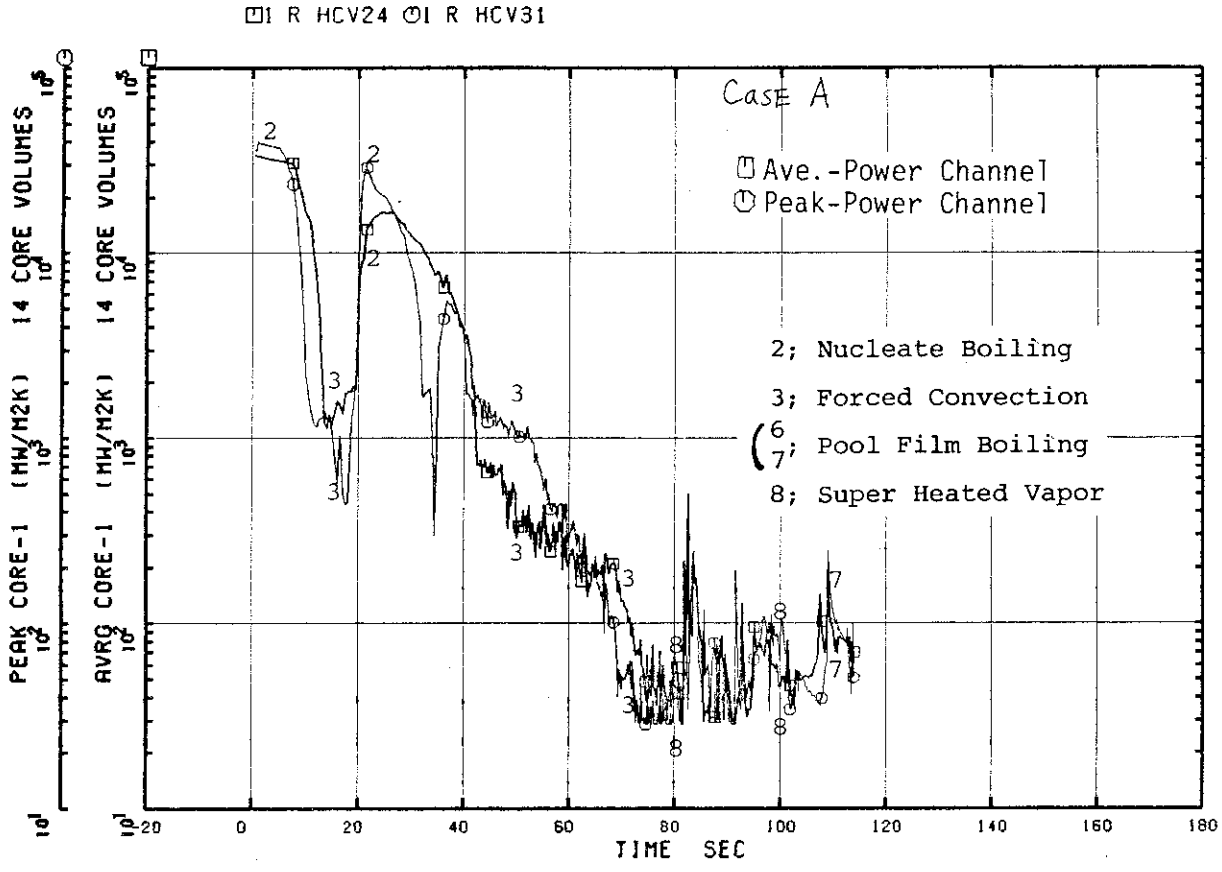


Fig. 3.32 Heat Transfer Coefficient at Position 1 (Case A)

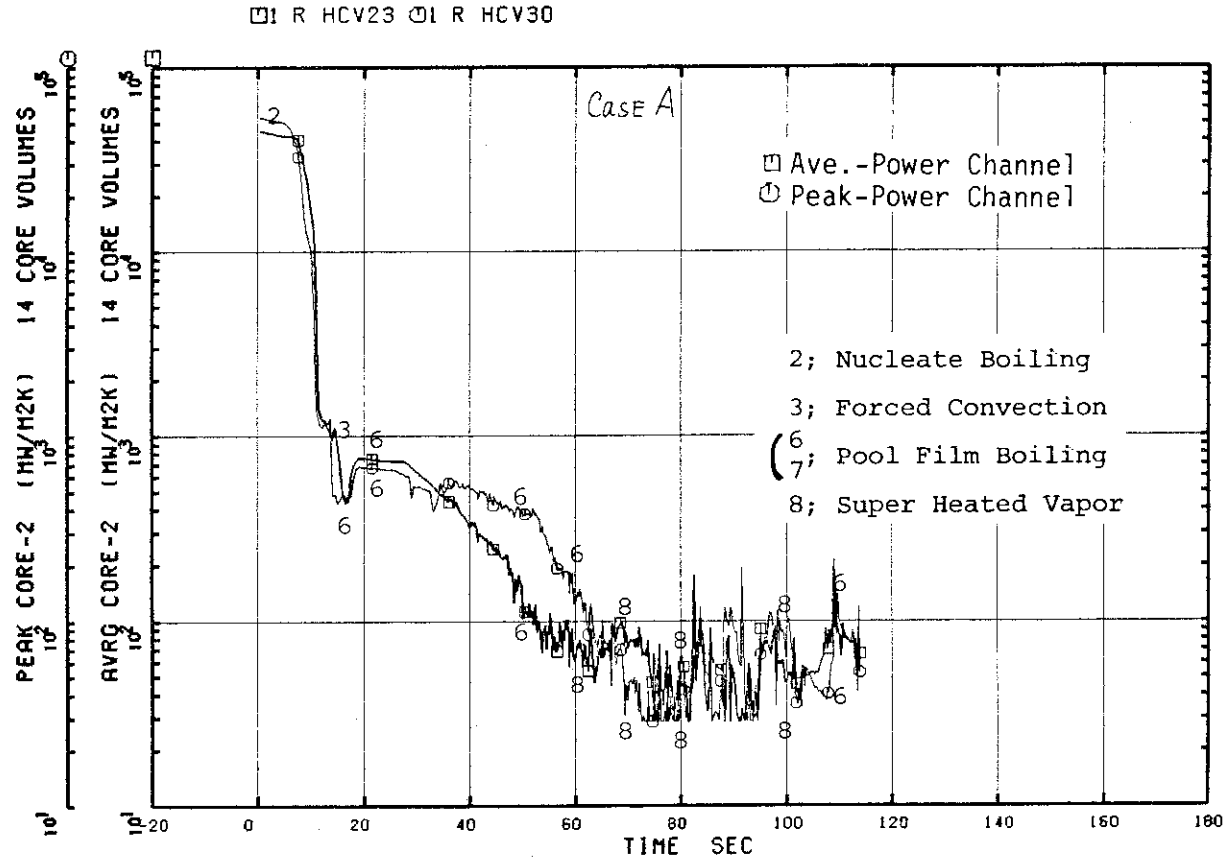


Fig. 3.33 Heat Transfer Coefficient at Position 2 (Case A)

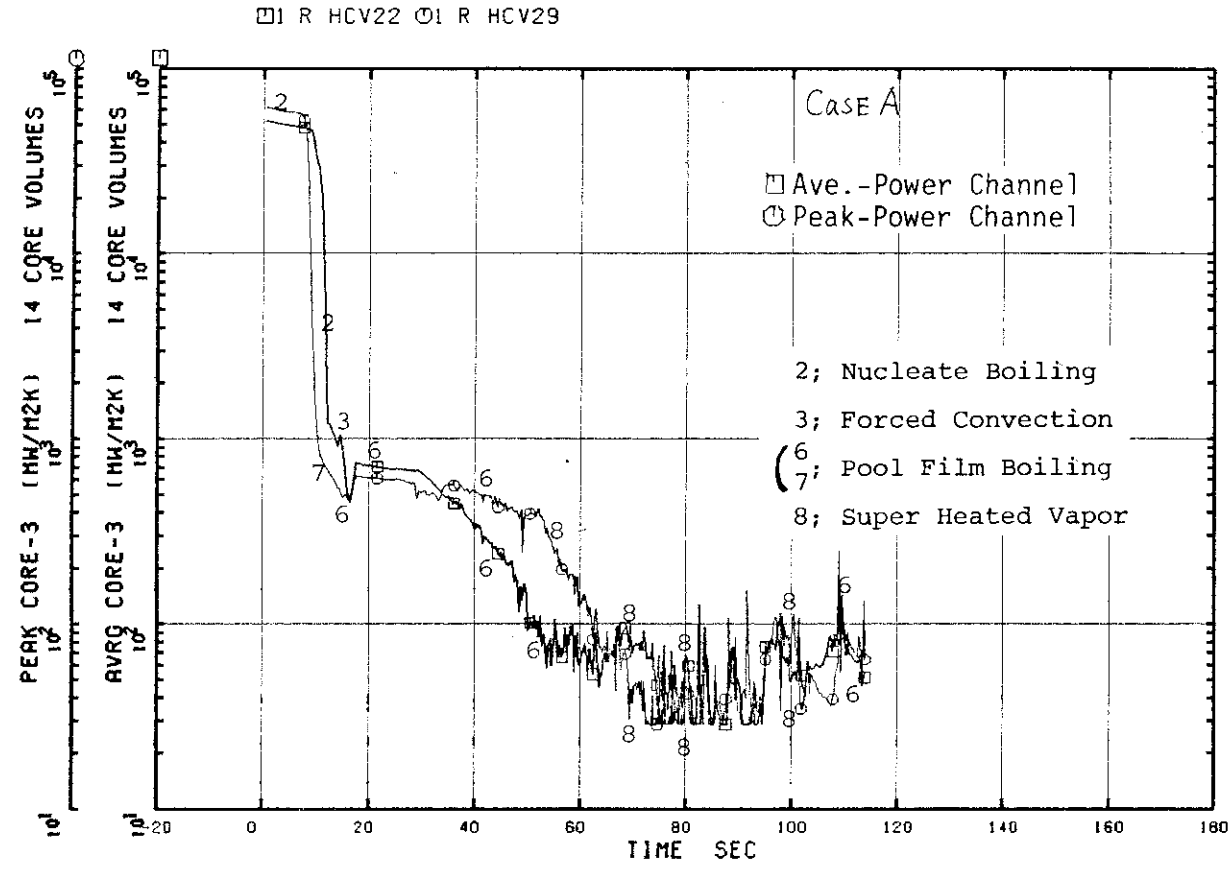


Fig. 3.34 Heat Transfer Coefficient at Position 3 (Case A)

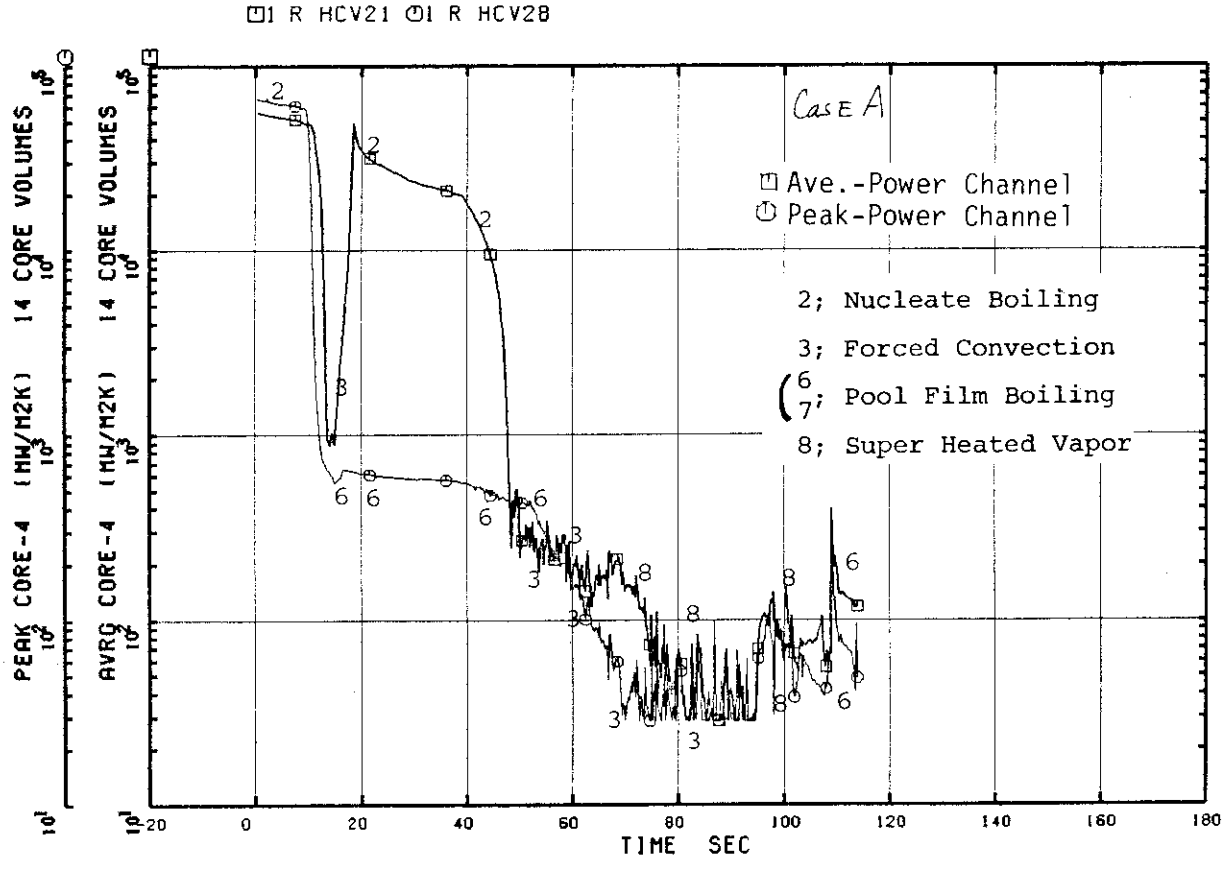


Fig. 3.35 Heat Transfer Coefficient at Position 4 (Case A)

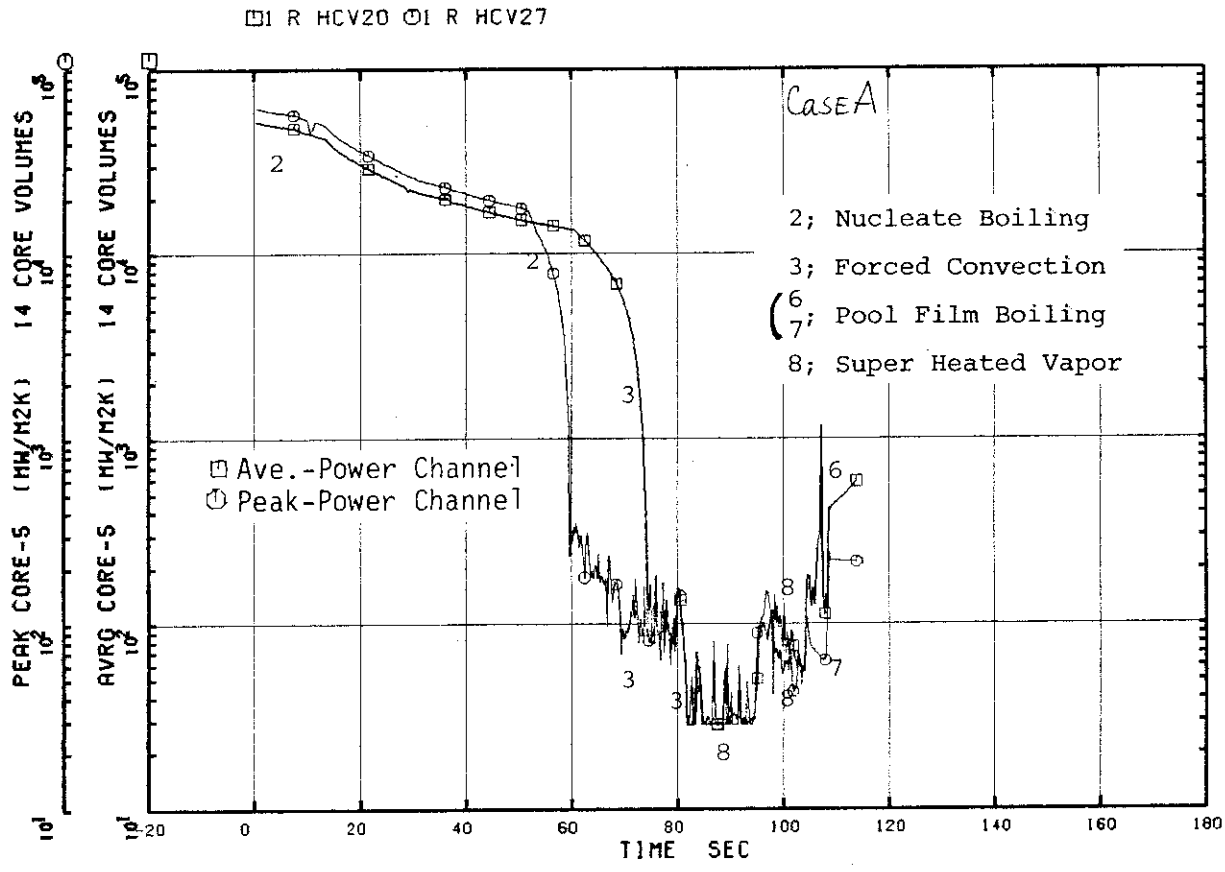


Fig. 3.36 Heat Transfer Coefficient at Position 5 (Case A)

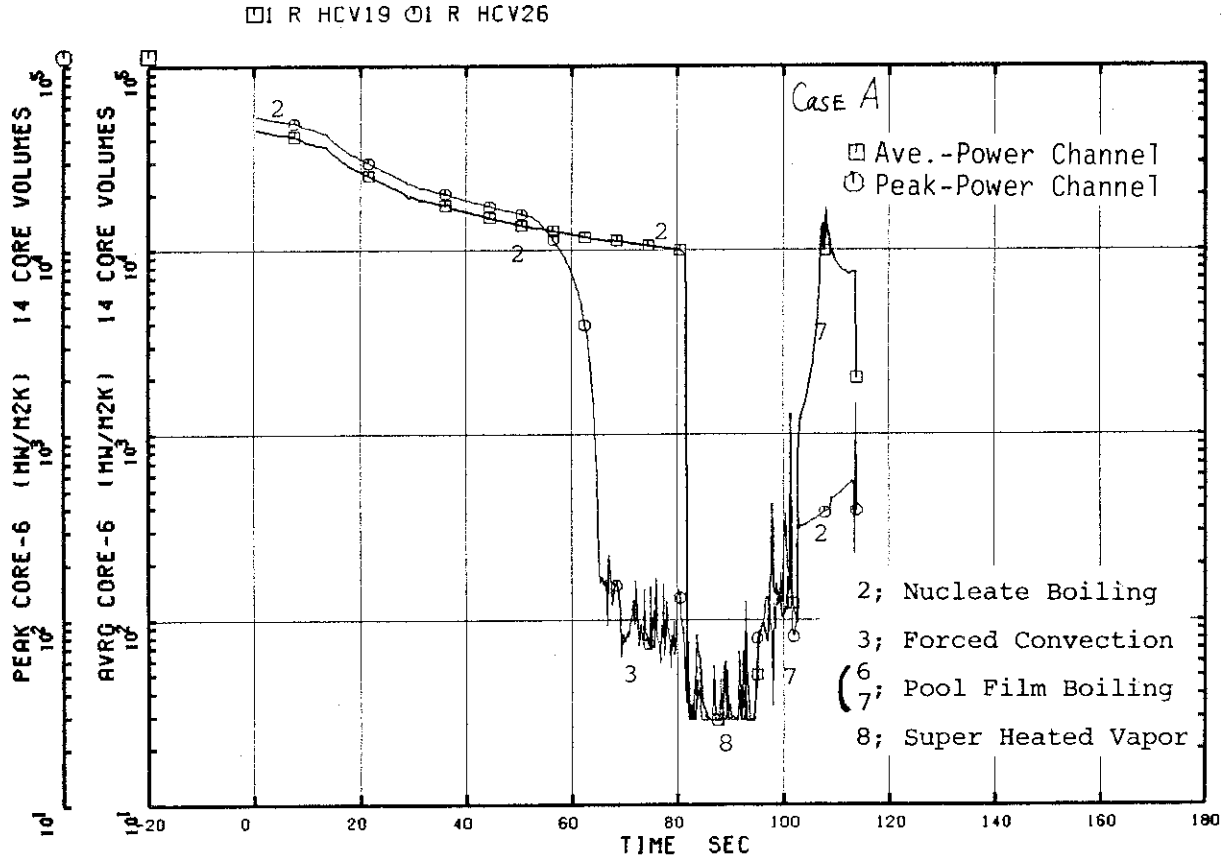


Fig. 3.37 Heat Transfer Coefficient at Position 6 (Case A)

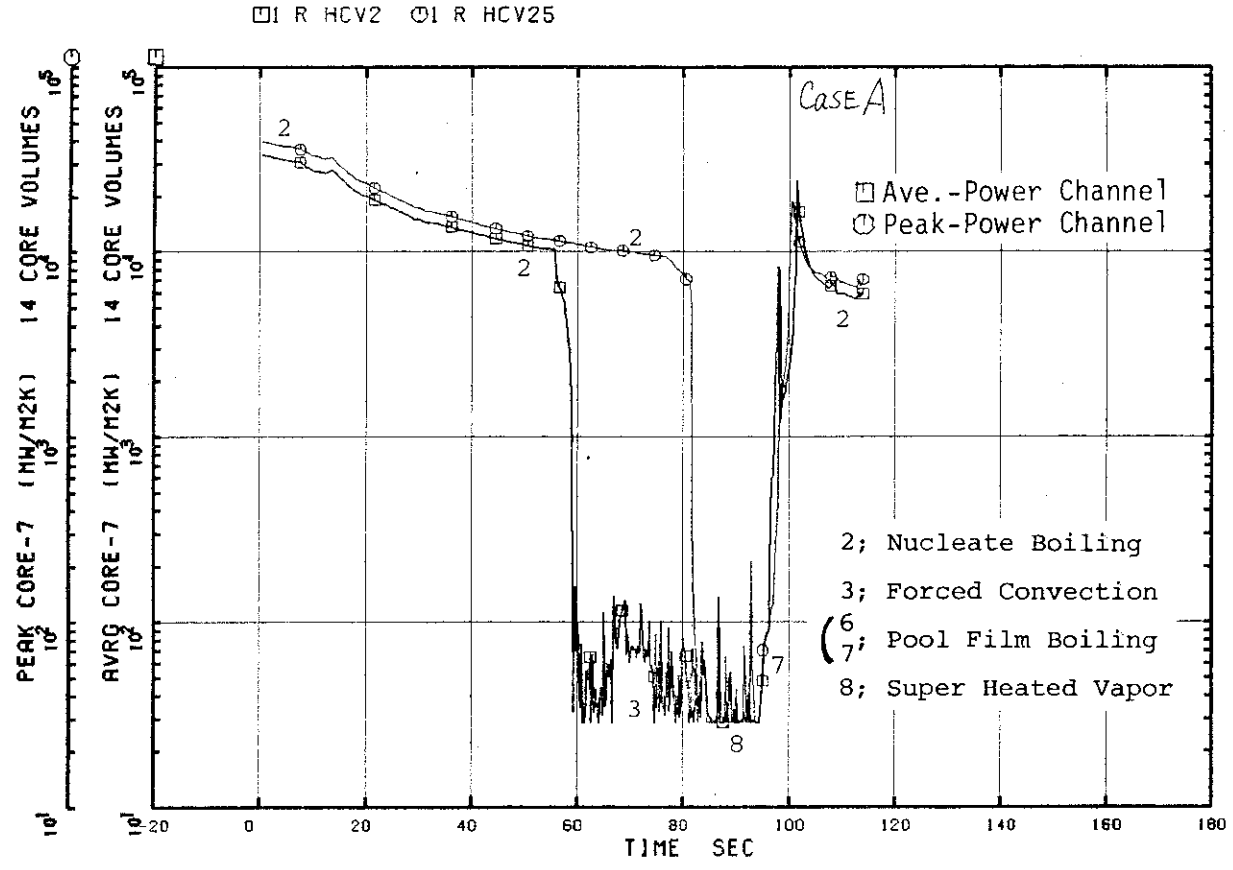


Fig. 3.38 Heat Transfer Coefficient at Position 7 (Case A)

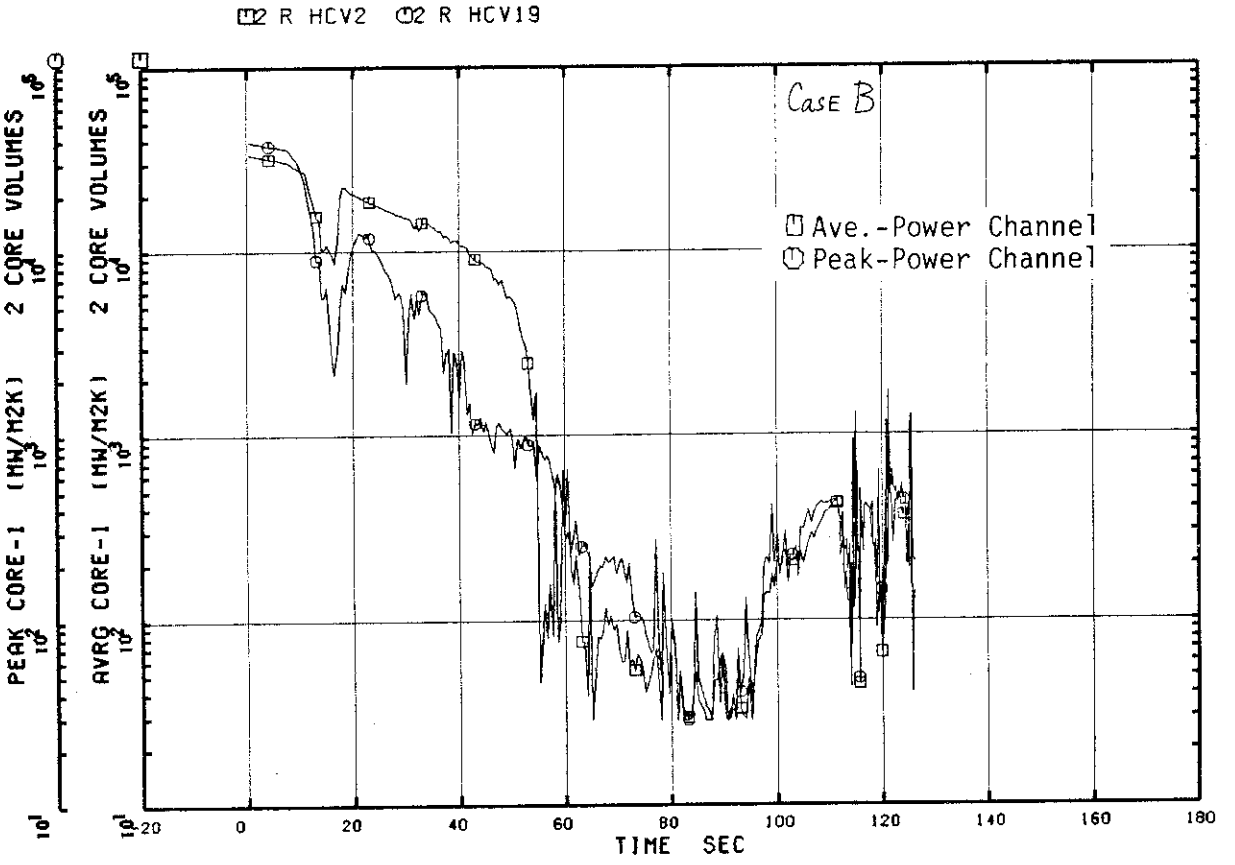


Fig. 3.39 Heat Transfer Coefficient at Position 1 (Case B)

4. ANALYSIS BY RELAP5/MOD1/001

4.1 Computer Code

The RELAP5/MOD1/001 code[7] uses a two-fluid, five-equation model for two-phase flow analysis. The five equations consist of one mass conservation equation for each phase, one momentum conservation equation for each phase and one overall energy conservation equation that is supplemented by the assumption that one of the two phases is saturated.

RELAP5 considers four constitutive relations in its hydrodynamic model. They are constitutive relations for the interphase mass transfer (vaporization and condensation), the interphase drag, the wall friction and the wall heat transfer. The interphase drag consists of dynamic drag and steady drag which depends on the four flow regime maps employed in RELAP5. The wall friction model uses the modified Baroczy two-phase friction multiplier correlation with the Colebrook correlation for the single-phase friction factor including wall roughness effects. The wall heat transfer correlation employs the RELAP4/MOD6 heat transfer correlation.

The RELAP5 numerical scheme is based on a linear, semi-implicit, integration scheme. This numerical scheme contributes to fast execution.

RELAP5 simulates the Light Water Reactor (LWR) with the various components: single volumes, single junctions, pipes, branches, pumps, valves, heat structures, etc. RELAP5 is designed to be primarily a one-dimensional program and has only one-dimensional volumes. The finite difference approximations to the conservation equation assume that fluid enters or leaves a one-dimensional volume only at its ends. RELAP5 does not calculate the mixture level within a volume. Therefore, the mixture level in the volume is assumed to pass downward or upward through the bottom of the volume when the void fraction in the volume exceeds or becomes below 0.96, respectively, in the present analyses.

Other features and models used in RELAP5 are as follow;

1) The critical flow model employs the characteristic analysis.

2) The code has no jet pump (JP) model and even the branch component can not fully simulate the momentum exchange in the JP. Therefore, two methods to simulate a JP are used in the present analyses. One is to assume a circulation pumps with the same coastdown characteristics and homologous curves as those of the MRP at the JP suctions. The other[8] is to apply the calculation model used in JETP components of the TRAC-BD1 code[9] to RELAP5. The steady state flow jet pump model is now under development at JAERI.[10]

3) The code has a separator model with 100% separation efficiency but it is not applied to the separator in the present analyses.

4) Fluid inflow or discharge is modeled by a pair of the time dependent junction and volume as the boundary condition. The fluid condition passing through the time dependent junction refers the fluid condition in the upstream volume. Therefore, the void fraction in the steam dome affects the steam discharge flow rate from the steam dome to the time dependent volume even if the data are given as the input.

4.2 Calculation Model

Five cases A through E were calculated with the RELAP5/MOD1/001 code. Features of these calculated cases are presented in Table 4.1. Case A had a JP model simulating the suction flow using supposed circulation pumps in the JP suctions with the same coastdown characteristics and homologous curves as the MRP. Cases B, C, D and E had the same JP model as used in the JETP components of the TRAC-BD1 code. Cases A, B and C used an orifice for the break simulation and cases D and E simulated the break nozzles of the ROSA-III by a single volume and a valve. Case C was a sensitivity analysis for case B. The orifice area used in case C was 60% of case B so that the calculated differential pressure decrease in the lower downcomer should agree with that of the experimental data shown in Fig. 2.16.

Nodalization diagrams of ROSA-III for the RELAP5/MOD1/001 code are shown in Tables 4.2 and 4.3 and Figs. 4.1, 4. and 4.3. Each nodalization includes two core channels (peak- and average-power channels) vertically divided into seven volumes in a same manner as in the RELAP4J nodalization for the base calculation case A. The ROSA-III was modeled by 94 volumes, 101 junctions and 33 heat slabs for case A, 92 volumes, 99 junctions and 33 heat slabs for cases B and C and 96 volumes, 103 junctions and 33 heat slabs for cases D and E.

Initial thermal-hydraulic conditions for the calculations were obtained from the experimental data shown in Table 2.5. Consistency among the input data were confirmed by a steady state calculation. The initial flow distribution was almost the same as the flow distribution in the RELAP4J calculation. Core power distribution in the RELAP5 calculations was also the same as that in the RELAP4J calculations.

The Experimental flow data were used for the feedwater flow and the ECCS flo and the steam discharge flow through the steam line as a function of time. In the RELAP5 calculation the fluid condition in the upstream volume affects the input flow data for a time dependent junction. Then RELAP5 did not give, for example, the same steam discharge flow rate as the input data when the quality in the steam dome as the upstream volume for the steam line decreased below 1.0 as shown in Fig. 4.4.

In RELAP5 the characteristic analysis model is used as the critical flow model to calculate the break flow. Break flow was discharged from the pipe end to the time dependent volume in cases A through C. In cases D and E the break nozzle was simulated by the volume and valve as shown in Fig. 4.3.

Recirculation pump was modeled by the rated values given in a table and the homologous courves. Input values were almost the same as used in the RELAP4J calculation. In case E the moment of inertia and the rated density were changed because the input values used in cases A through D were proved to be in error.

Form loss coefficients at the junctions were primarily calculated from geometrical form change along the junction and supplementally by abrupt area change model of RELAP5.

Input data of the RELAP5/MOD1/001 calculation are presented in Appendices B, C and D for cases A, C and E, respectively.

4.3 Comparison with the Experimental Data

Major results of the RELAP5/MOD/001 calculation are compared with the experimental data in this section.

The calculations except for case C were not continued after about 35 s because the system pressure decreased too fast resulting in too early LPF initiation. Case C calculation was made for 133 s because the overall transient of the system pressure agreed well with the data.

Case A through E took CPU times of 4, 10, 30, 12 and 24 hours to calculate 35, 32, 132, 47 and 36 s after the break, respectively, with FACOM M-200 Computer in JAERI.

4.3.1 Pressure Transient

The calculated pressure transients in the lower plenum are compared with the data in Fig. 4.8. The calculated pressures decreased much faster than the data. The pressure transients calculated by the models having the same break models gave almost the same pressure transient after the break. The pressure decrease calculated in cases A and B were maximum among the calculated results, and after the MSIV closure the pressure recovered a little because the recirculation lines were uncovered a little after the MSIV closure. The pressure recovery calculated in cases D and E were a half of the measured pressure recovery. The lower pressure recovery calculated in case E than in case D was due to the early core uncovery by the lower core inlet flow rate caused by the small moment of inertia of the MRP. The pressure recovery calculated in case C after the MSIV closure compared well with the data because the recirculation line uncovery was later than in the other calculations to be shown in Figs.

4.57 and 4.58. The LPF initiated 6.3 s, 6.0 s, 0.7 s, 3.7 s and 3.3 s earlier than the data in cases A, B, C, D and E, respectively. The temporary halt in the pressure decrease after the LPF, initiated at 6.25 MPa, was not adequately calculated in all cases because of the inadequate RELAP5 interphase mass transfer (vaporization) model. The mixture inside shroud was spouted out to the downcomer through the separator top after the LPF resulting in the oscillations in the break flow and the pressure shown in Figs. 4.17 and 4.18.

Calculated initial heat loss was 18.0 kW in every case, which was much smaller than the rated ROSA-III heat loss of 140 kW. Therefore, the calculated low pressures were caused by the larger break flow than realistic one.

The temporary halt in the pressure decrease after the feedwater flashing at 64.8 s was not calculated in case C which had no volumes representing the feedwater line.

The pressure upstream of the PV-side break B shown in Fig. 4.9 indicated similar transient to that of the lower plenum except for a sudden decrease after the break in the data. The pressure calculated in case C agreed well with the data. The pressure transients at the upstream of the MRP-side break A are shown in Fig. 4.10. The calculated results presented good agreement with the data until the recirculation line uncovery except for the result of case C calculation. The pressure decrease of case C until the recirculation line uncovery was slower compared with the data. After the JP suction uncovery the pressure decreased very fast in all cases showing that the steam break flow had little relation to the break form.

4.3.2 Differential Pressure

The calculated differential pressures, as mentioned in section 3.3.2, contain incorrect head. However, since the RELAP5 nodalization consists of the small sectioned volumes, the erroneous head in the differential pressure was smaller than the RELAP4 calculations.

Figures 4.11 and 4.12 show the differential pressures between the lower plenum and the upper plenum and between the upper plenum and the steam dome, respectively. The calculated differential pressures between the lower plenum and the upper plenum indicated a good agreement with the data until the calculated LPF initiation except for case A. The larger differential pressure calculated in case A was due to the large discharge flow of the JP. The pressure peaking observed after the LPF initiation in all case was much larger than the data, and it was followed by continuous large oscillations. In case C, after the LPF died away the differential pressure stayed larger than the data showing that the larger amount of liquid remained inside the shroud than the data since very little reverse flow occured through the JP discharge after the LPF.

The calculated differential pressures between the upper plenum and the steam dome decreased steeply after the break because the flow loss through the steam separator was not estimated properly.

The lower downcomer heads are shown in Fig. 4.14. Calculated head in case C indecated good agreement with the data until the recirculation suction uncovery. While the results in cases A and B decreased fast compared with the data. In cases D and E, the downcomer head calculations were improved by use of the break nozzle simulated by the RELAP5 single volume and valve.

MRP-1 and MRP-2 heads are shown in Figs. 4.15 and 4.16. The MRP-1 head decreased after the break faster than the data in case E, but decreased slower than the data in the other cases. The MRP-2 head calculated in case E increased much more than in the other cases and the data. These were because the moment of inertia and the rated fluid density of the MRP had been changed in case E and the moment of inertia was understimated.

4.3.3 Break Flow and Jet Pump Flow

The break flows from the PV-side break B and from the MRP-side break

A are shown in Figs. 4.17 and 4.18, respectively. The measured break flows involved an error of at least ±20 %, and the break flow from the break B was incorrect until 38 s after the break. Therefore, emphasis in comparisons was placed on the timing of the break flow decrease after the recirculation line uncovery.

Calculated break flow rates from the break B in cases A and B were larger than those in the other cases and decreased stepwise at 4s after the break because of decrease in the fluid density upstream of the break as shown in Fig. 4.19 and decreased again due to the MRP suction line uncovery 4 s earlier than the data. Calculation in cases C, D and E presented similar break flow rates from the break B and also presented similar incipient time of the break flow decrease with the data. However, the steam break flow rates after the break flow decrease in cases D and E did not decreased much from those in cases A and B and were rather higher than that in case C. The fast pressure decrease in cases D and E as well as in cases A and B as shown in Fig. 4.8 was the result of this larger steam break flow rate. The simulated break nozzle by the single volume and valve in cases D and E did not work well in the steam break flow region.

Calculated break flow rates from the break A are shown in Fig. 4.18. In the MRP side break, the choking was calculated at the JP nozzle and the break. This two choking condition resulted in the decrease in the initial subcool break flow rate in case C but the similar steam break flow rates among every cases after 13 s. The break flow rate from the break A was smaller than that from B. Therefore, the difference in the break flow rate in each case did not seem to affect much the pressure behavior.

Calculated flow rates around the JP mixing region are compared with the measured JP discharge flow in Fig. 4.21 through 4.30. Flow around the JP connected to the broken loop calculated in case A, in which the model possessed the circulation pump in the JP suction lines, gave a sudden increase in the suction flow, the prolonged discharge flow in the forward

direction which was opposite to the data. The large suction flow in case A lowered the liquid level in the downcomer faster than the case B calculation and resulted in earlier decrease in the break flow through the break B. In case B the JP discharge flow reversed immediately after the break and agreed well with the data. The measured JP discharge flow presents only a trend in two-phase flow condition after the LPF initiation. Flows around the JP connected to the intact loop calculated in case E gave lower flow rates than those in cases B, C and D because of the smaller moment of inertia of the MRP in case E, which resulted in the later decrease of the mixture level in the downcomer and the later uncovery of the recirculation line.

Figure 4.31 through 4.40 show calculated velocity of liquid and steam through the break. The liquid and steam velocity were identical when the orifice break model was used. In cases D and E in which the nozzle break model was used the steam velocity was higher than liquid velocity when break flow was saturated. Oscillations were observed after the recirculation line uncovery in every results except for velocities at the break A in case A. This velosity oscillation was synchronized with the oscillation in the break upstream pressure shown in Figs. 4.9 and 4.10. as mentioned in Sec. 4.3.1.

4.3.4 Core Flow

Figures 4.41 though 4.45 show the total flow rate through the SEO, the LTP and the UTP compared with the data. Difference between the flows through the SEO and the LTP was the flow through the leak hole connecting between the core bypass and the channel inlet chamber.

As shown in Fig. 4.8, the system pressure decreased after the LPF initiation faster in every calculation than the data in spite of larger increase in the calculated core flow rates than the data. These were caused by the incorrect calculations of the vaporization model and the interphase drag. Large oscillations were observed in the core flow after the LPF in every calculation, which were synchronized with the

oscillations in the break flows and the pressure.

Figure 4.46 shows the comparison of the total core inlet flow rates through the SEO. In case A the calculated flow rate was much larger than the data, because the circulation pump assumed in the JP suction pushed water intensely into the lower plenum through the JP. The flow rates calculated in cases B, C and D with the same MRP and JP models were almost the same each other before the LPF initiation independent from the assumed break forms, but were by a factor of two larger than the data. In case E the flow rate agreed very well with the data until the LPF initiation because of the small moment of inertia of the MRP.

Figures 4.47 through 4.56 show the liquid and steam velocity through the UTP of the average and peak power channels in every case. Calculated steam velocity presented upward flow even when liquid velocity presented downward flow. After the HPCS actuation at 31.5 s steam velocity increased much in spite of the downward liquid flow presenting the counter current flow limiting (CCFL) which was observed especially in the peak power channel.

4.3.5 Liquid Levels in the Pressure Vessel

Figures 4.57 and 4.58 show the estimated mixture levels in the pressure vessel (PV). These mixture levels were assumed from the void fraction in the volume as mentioned in Sec. 4.1. The void fraction in the volumes in case C are shown in Figs. 4.59 through 4.66 as a reference. The initial decrease in the liquid level in the downcomer is compared with the data. In cases A and B the calculated downcomer level decreased to the recirculation line nozzle level 4s and 3s earlier than the data, respectively, because of the large calculated break flows. The circulation pump installed in the JP suction in case A pushed intensely the liquid in the downcomer to the JP after the break resulting in the faster level decrease in case A than in case B. In the other cases the liquid level decrease in the downcomer agreed well with the data.

The liquid level in the peak-power channel in the core was not always higher than that in the average-power channel while always in the data especially after the LPF. The temporary decrease in the liquid level in the peak-power channel was calculated after the LPF initiation in every case. In case A the core flow decreased slower after the break and stayed higher than that in the other cases and the data, therefore, the liquid level in the upper plenum stayed higher. But after the JP suction uncovery the JP discharge flow was quickly reversed in case A as shown in Fig. 4.22, while the flow through the UTP stayed upward resulting in that more of core was uncovered than in case B before the LPF initiation.

The large core uncovery before the LPF in case E compared with that in case D was the results of the small moment of inertia of the MRP. However, the trend of the large core uncovery only in case E agreed well with the data as shown in Fig. 2.31.

After the LPF initiation the liquid level was not formed in the lower plenum in any case because the vapor generated in the lower plenum was too small to form the liquid level. In case C the beginning of the core uncovery after the LPF was delayed more than 20 s compared with the data. Whole core was uncovered at 80s, and then the top-down reflooding occured in the peak-power channel in case C. After LPCI actuation at 90.9s the injected liquid in the core bypass flowed into the lower core through the leak hole, while the lower plenum liquid level began to decrease. The core was almost reflooded at the LPCI initiation of 90.0 s by HPCS and the LPCS water in the data, whereas in case C the CCFL at the UTP prevented the spray water from flowing down into the core and bypass from the upper plenum and the core reflooding was much later than the data.

4.3.6 Fuel Rod Surface Temperature

Calculated fuel surface temperatures are compared with the data in Figs. 4.67 through 4.70. Figures 4.69 and 4.70 compares the data with the calculated results in case C. The behavior of the heater rod surface

temperatures was closely related to that of the liquid levels in the core. In the RELAP5 calculation dryout of the fuel rod surface is judged to occur when the void fraction in the adjacent volume to the heat slab is greater than 0.96. Figures 4.71 through 4.90 show the critical heat flux (CHF) and the heat transfer rate compared with the criteria of the void fraction 0.96. The criteria indicate 0.1 when the void fraction increases above 0.96, otherwise indicate 1.0. The boiling transition occured in cases A, C, D and E during the low core flow period after break before the LPF initiation in the upper part of the peak-power channel and the temperature behavior agreed well with the data except for those in case E. In case E the surface temperature above position 4 rose after the boiling transition about 100 K higher than the measured temperature. The LPF terminated the temperature rise but the quench occurred much later.

The dryout after the LPF mitigation was calculated only in case C but was later than the data because the liquid level decrease and the initiation of dryout were calculated to occur comparatively late. However, the calculated temperature behavior agreed well with the data in Pos. 1 through Pos. 3. The top-down quench was calculated in the peak-power channel in case C.

4.4 Conclusions for the RELAP5/MOD1/001 Calculations

The post test calculations of the ROSA-III large break test, RUN 901, were performed with the RELAP5/MOD1/001 code and the following conclusions have been derived.

(1) The pressure calculated by RELAP5 agreed well with the data when the break area was multiplied by a factor of 0.6. With the RELAP5 characteristic analysis model without any adjustment the rate of system pressure decrease was overpredicted because the break flow rate was calculated to be much larger than the data . The liquid break flow before the recirculation line uncovery was calculated well with the break nozzles simulated by the RELAP5 single volume and single valve. However, the steam

break flow rate and the rate of decrease in the system pressure were still larger than the data after the recirculation line uncovery.

(2) The RELAP5 code calculates the liquid and the steam flow rates of the two-phase flow through the junctions rigorously by an advanced two-phase flow model. The top-down quench in the core was calculated because of the counter current flow calculation at the upper tie plate (UTP). However, the ability to calculate the counter current flow at the UTP was still limited so that the spray water was predicted to accumulate in the upper plenum (UP) leading to a delay in reflooding of the core. Therefore, an appropriate counter current flow limiting (CCFL) model is necessary to improve the predictions.

(3) The mixture level behavior which was obtained from the calculated void fractions in volumes agreed well with the data prior to the lower plenum flashing (LPF). However, the drop in the core mixture level after the LPF and the core reflooding were both delayed compared to the data. An improvement in the RELAP5 interphase drag correlations is recommended.

(4) The flow reversal in the jet pump (JP) discharge line in the broken loop was not calculated by the model assuming a circulation pump at the JP suction, and the core inlet flow was predicted to be higher than the data. The JP characteristics calculated by the JETP component model of the TRAC-BD1 code agreed well with the data.

(5) The moment of inertia and the rated liquid density of the main recirculation pump (MRP) are found to be important for accurate calculation of the core inlet flow and the mixture level in the core before the LPF.

Table 4.1 Calculation Condition of RELAP5 Analysis

Case	Jet Pump Type (JP)	Break Form	MRP Data
A	Circulation Pump in JP Suction	Orifices 100% + 100%	
B	JP Model from TRAC-BD1 Code	〃	
C	〃	Orifices 60% + 60%	
D	〃	nozzles 100% + 100%	
E	〃	〃	Correction of Inertia and Rated Density

Table 4.2 Description of Components for RELAP5/MOD1/001

Component Number	Component Type	Number of Volume	Description
010	B		Lower Plenum
011	SV		Lower Plenum Bottom
020	P	2	Lower Plenum
030	B		Channel Inlet Chamber (Ave. Ch.)
031	B		Channel Inlet Chamber (Peak Ch.)
040	P	7	Average Power Channel
045	P	7	Peak Power Channel
050	B		Upper Plenum
051	P	2	Upper Plenum
052	SJ		051→060
060	P	4	Separator
070	SV		Upper Downcomer
071	6		Upper Downcomer
072	SJ		070→080
080	SV		Steam Dome
090	P	3	Guide Tube
095	SJ		090→100
100	P	3	Core Bypass
110	SV		Upper Downcomer
111	B		Upper Downcomer
112	P	3	Middle Downcomer
120	B		Middle Downcomer
130	P	4	Lower Downcomer
131	B		Lower Downcomer
132	SV		Downcomer Bottom
140	P	3	Intact Loop MRP Suction
150	Pu		Intact Loop MRP
160	P	6	Intact Loop MRP Discharge
170	SV		Intact Loop JP Suction
171	Pu*,SV**		Intact Loop JP Suction (Pump)
180	B		Intact Loop JP

Table 4.2 Description of Components for RELAP5/MOD1/001 (Continued)

Component Number	Component Type	Number of Volume	Description
185	P	5*,4**	Intact Loop JP Discharge
190	P	3	Broken Loop MRP Suction
200	P	3	Broken Loop MRP Suction
210	Pu		Broken Loop MRP
220	P	5	Broken Loop MRP Discharge
230	SV		Broken Loop JP Suction
231	Pu*,SV**		Broken Loop Jp Suction (Pump)
240	B		Broken Loop JP
245	P	5*,4**	Broken Loop JP Discharge
250	V		QSV 190→200
260	V		Break B 190→280 (PV Side)
270	V		Break A 270→281 (MRP Side)
280	TDV		Break B Containment (PV Side)
281	TDV		Break A Containment (MRP Side)
290	TDV		Main Steam Reservoir
292	TDV		HPCS Reservoir
300	TDJ		Main Steam 080→290
302	TDJ		HPCS 292→051
310	TDV		Feedwater Reservoir
320	TDJ		Feedwater 310→111
331	TDV		LPCI Reservoir
332	TDV		LPCS Reservoir
401	TDJ		LPCI 331→100
402	TDJ		LPCS 332→051
530**	SJ		230→231
532**	SJ		231→240
533**	SJ		170→171
534**	SJ		171→180
550***	SV		Break Pipe B (PV Side)
551***	SV		Break Pipe A (MRP Side)
555***	V		550→560

Table 4.2 Description of Components for RELAP5/MOD1/001 (Continued)

Component Number	Component Type	Number of Volume	Description
556***	V		551→561
560***	SV		Break Nozzle B (PV Side)
561***	SV		Break Nozzle A (MRP Side)
565***	V		560→280
566***	V		561→281
900	TDV		Heat Sink
910	V		080→900

* Case A

** Case B, C, D and E

*** Case E

Table 4.3 Description of RELAP5 Components (Heat Structure)

STRUCTURE NUMBER	SIDE	BDRY.VOL. NUMBER	HEAT TRF. SURF.AREA (M2)	
10001	LEFT	0	0.0	Average Power Channel
	RIGHT	40010000	1.6849	Heater Rods Position 7
10002	LEFT	0	0.0	
	RIGHT	40020000	1.6849	Position 6
10003	LEFT	0	0.0	
	RIGHT	40030000	1.6849	Position 5
10004	LEFT	0	0.0	
	RIGHT	40040000	3.3698	Position 4
10005	LEFT	0	0.0	
	RIGHT	40050000	1.6849	Position 3
10006	LEFT	0	0.0	
	RIGHT	40060000	1.6849	Position 2
10007	LEFT	0	0.0	
	RIGHT	40070000	1.6849	Position 1
20001	LEFT	0	0.0	Peak Power Channel
	RIGHT	45010000	0.56160	Heater Rods Position 7
20002	LEFT	0	0.0	
	RIGHT	45020000	0.56160	Position 6
20003	LEFT	0	0.0	
	RIGHT	45030000	0.56160	Position 5
20004	LEFT	0	0.0	
	RIGHT	45040000	1.1233	Position 4
20005	LEFT	0	0.0	
	RIGHT	45050000	0.56160	Position 3
20006	LEFT	0	0.0	
	RIGHT	45060000	0.56160	Position 2
20007	LEFT	0	0.0	
	RIGHT	45070000	0.56160	Position 1
1000001	LEFT	80010000	0.51530	Vessel Wall
	RIGHT	900010000	0.51530	
1100001	LEFT	80010000	0.76529	
	RIGHT	900010000	0.88555	
1100002	LEFT	70010000	0.61949	
	RIGHT	900010000	0.71684	
1100003	LEFT	71010000	1.2102	
	RIGHT	900010000	1.4003	
1200001	LEFT	110010000	0.44692	
	RIGHT	900010000	0.51396	
1300001	LEFT	111010000	0.61827	
	RIGHT	900010000	0.70070	
1300002	LEFT	112030000	0.65973	
	RIGHT	900010000	0.74770	
1300003	LEFT	112020000	0.67104	
	RIGHT	900010000	0.76052	
1300004	LEFT	112010000	0.35626	
	RIGHT	900010000	0.40376	
1400001	LEFT	120010000	0.83620	
	RIGHT	900010000	0.97217	

Table 4.3 (Continued)

STRUCTURE NUMBER	SIDE	BDRY.VOL. NUMBER	HEAT TRF. SURF.AREA (M2)	
1400002	LEFT	130040000	0.56417	Vessel Wall
	RIGHT	900010000	0.65590	
1400003	LEFT	130030000	0.56417	
	RIGHT	900010000	0.65590	
1400004	LEFT	130020000	0.56417	
	RIGHT	900010000	0.65590	
1400005	LEFT	130010000	0.56417	
	RIGHT	900010000	0.65590	
1400006	LEFT	131010000	0.64300	
	RIGHT	900010000	0.74755	
1400007	LEFT	132010000	0.68627	
	RIGHT	900010000	0.79786	
1500001	LEFT	10010000	0.26389	
	RIGHT	900010000	0.38076	
1500002	LEFT	11010000	0.29688	
	RIGHT	900010000	0.42836	
1600001	LEFT	900010000	0.80100	
	RIGHT	11010000	0.80100	

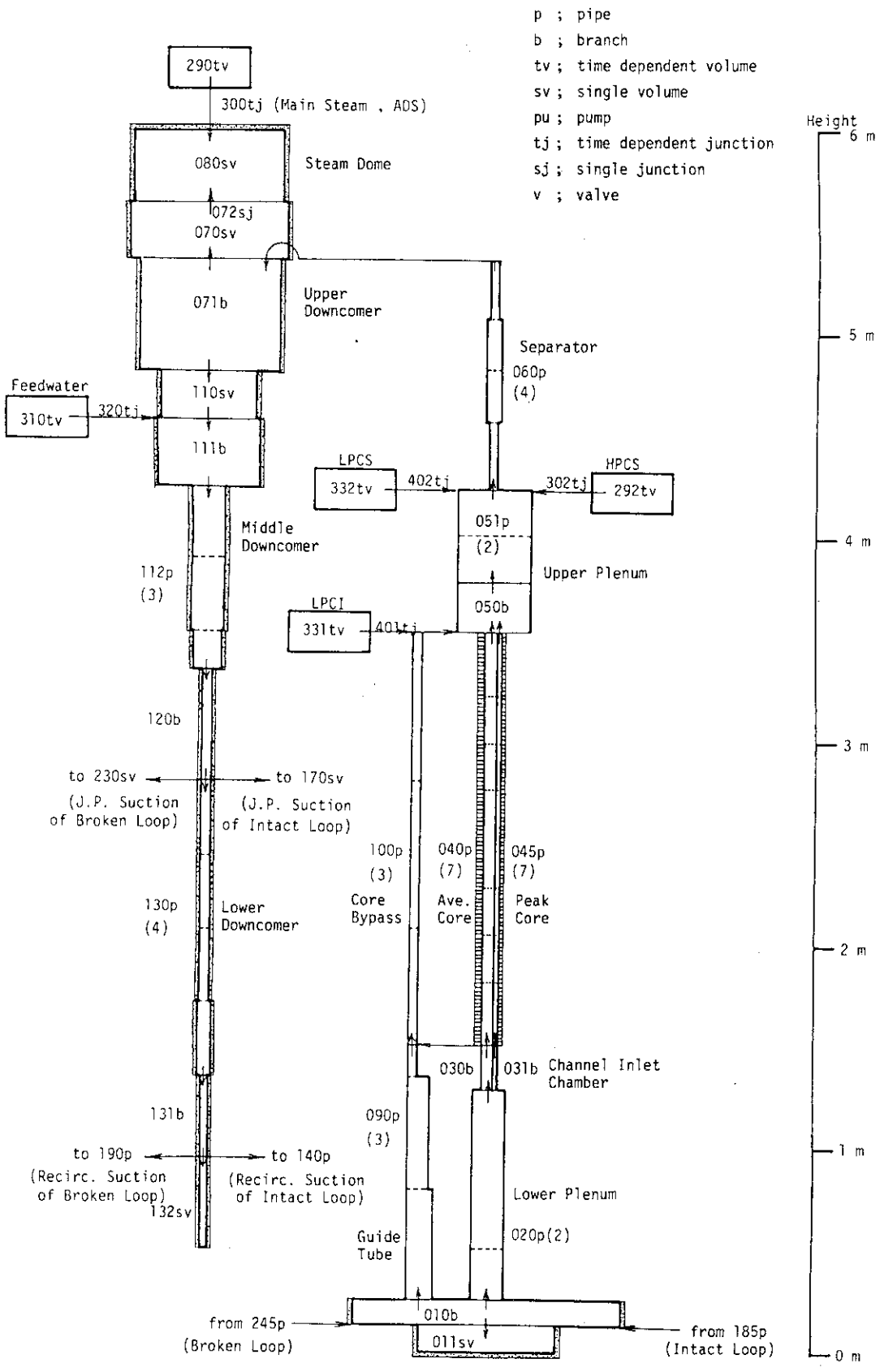


Fig. 4. 1 Nodalization Diagrams of ROSA-III Pressure Vessel for RELAP5/MOD1/001 Model

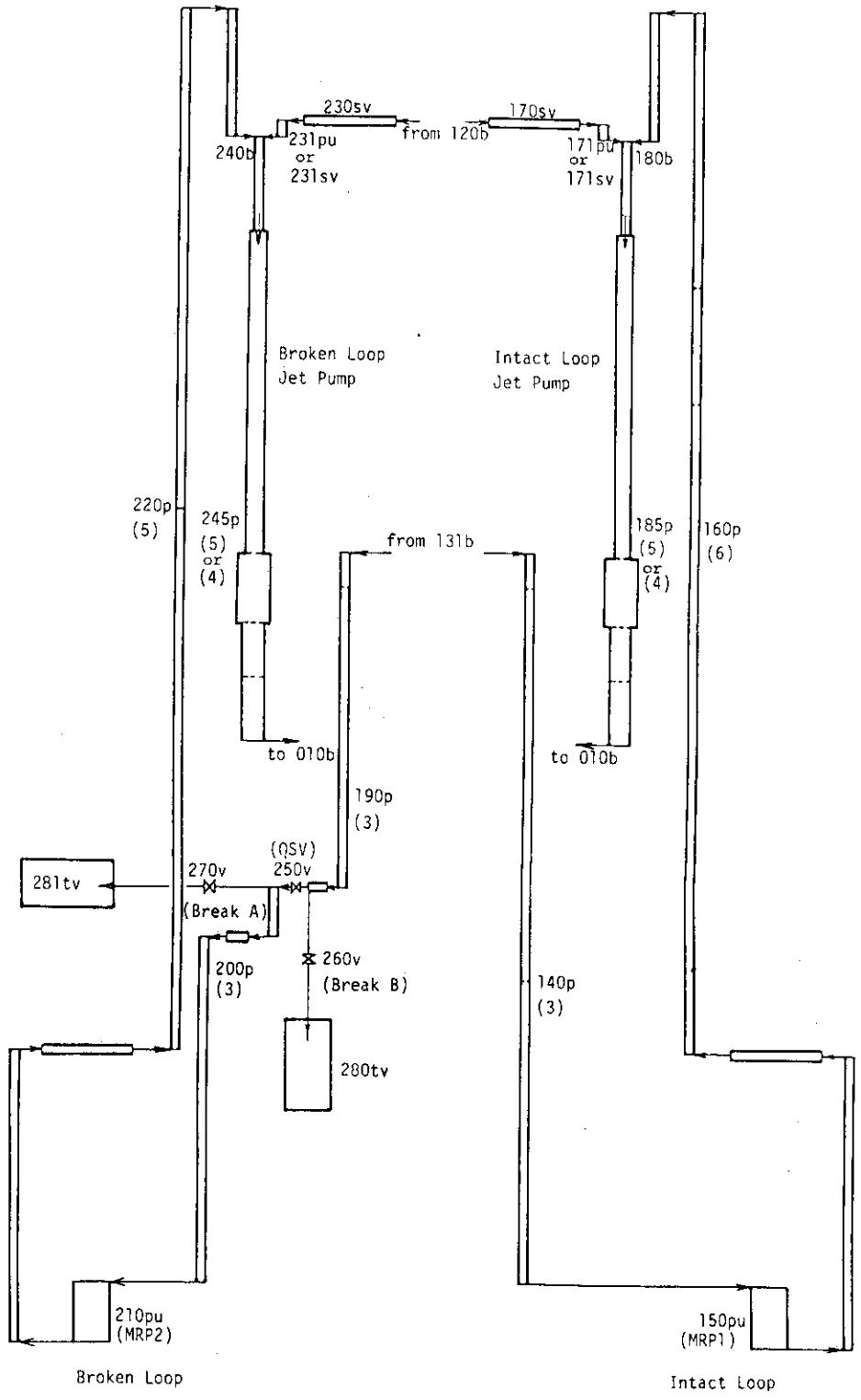


Fig. 4. 2　Nodalization Diagrams of ROSA-III Recirculation Loop

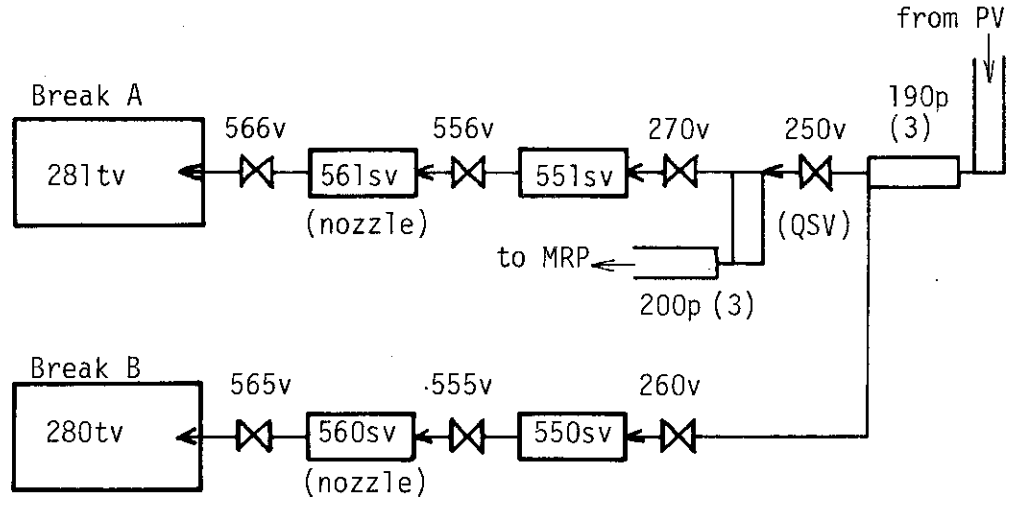


Fig. 4. 3 Nodalization Diagrams of Simulated Break Nozzles in Cases D and E

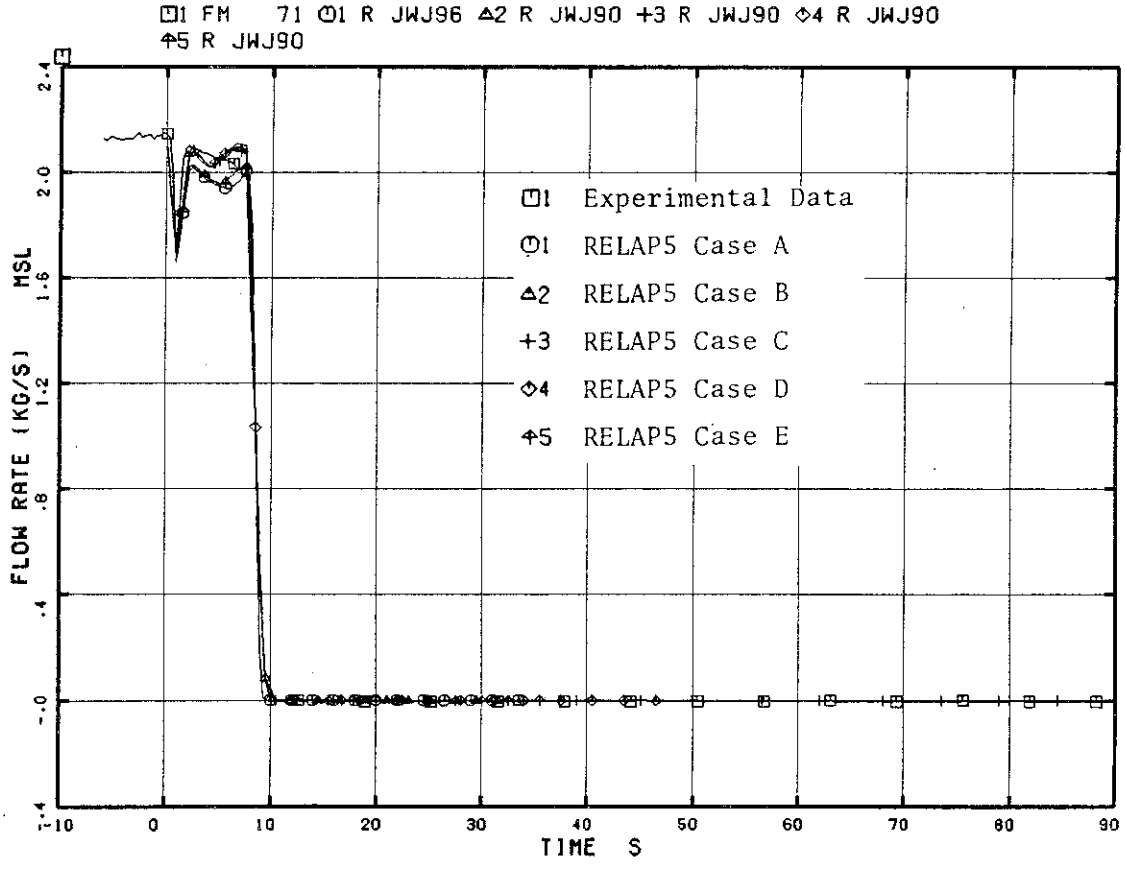


Fig. 4. 4 Main Steam Discharge Flow Rate

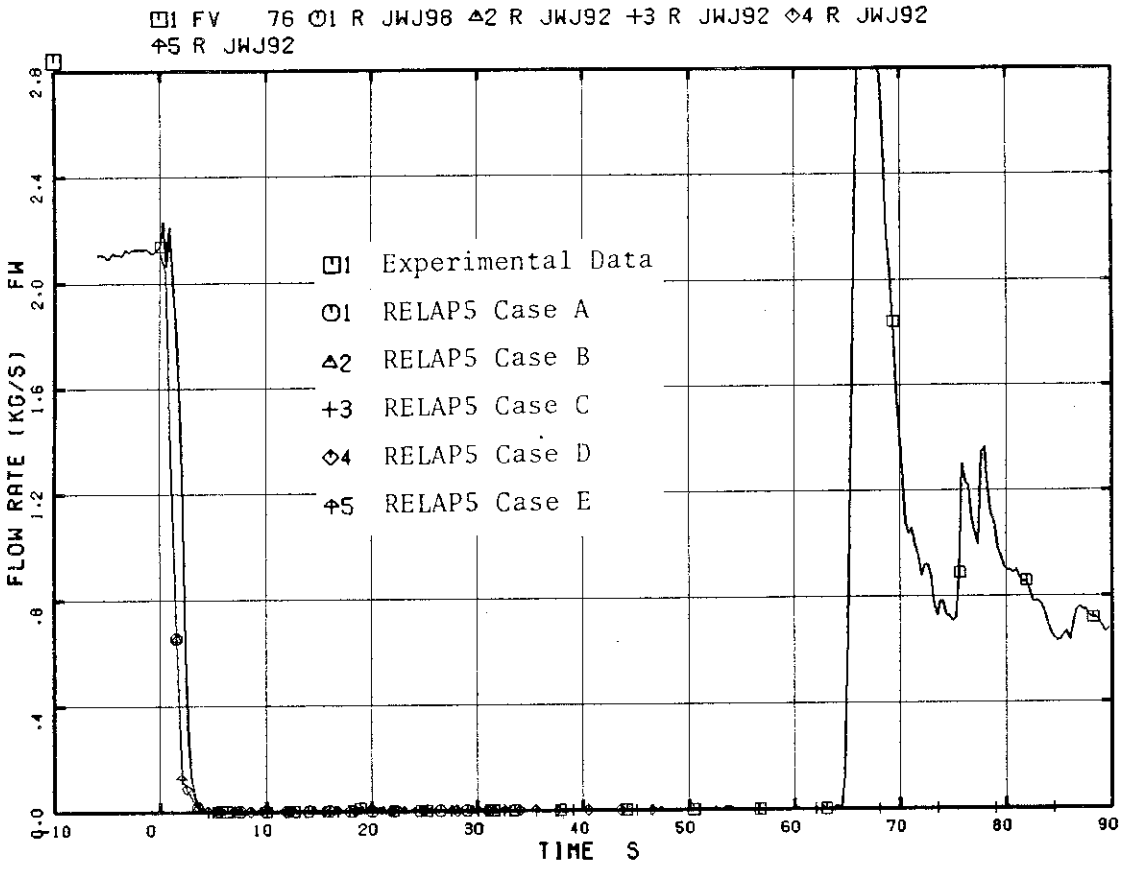


Fig. 4. 5 Feedwater Flow Rate

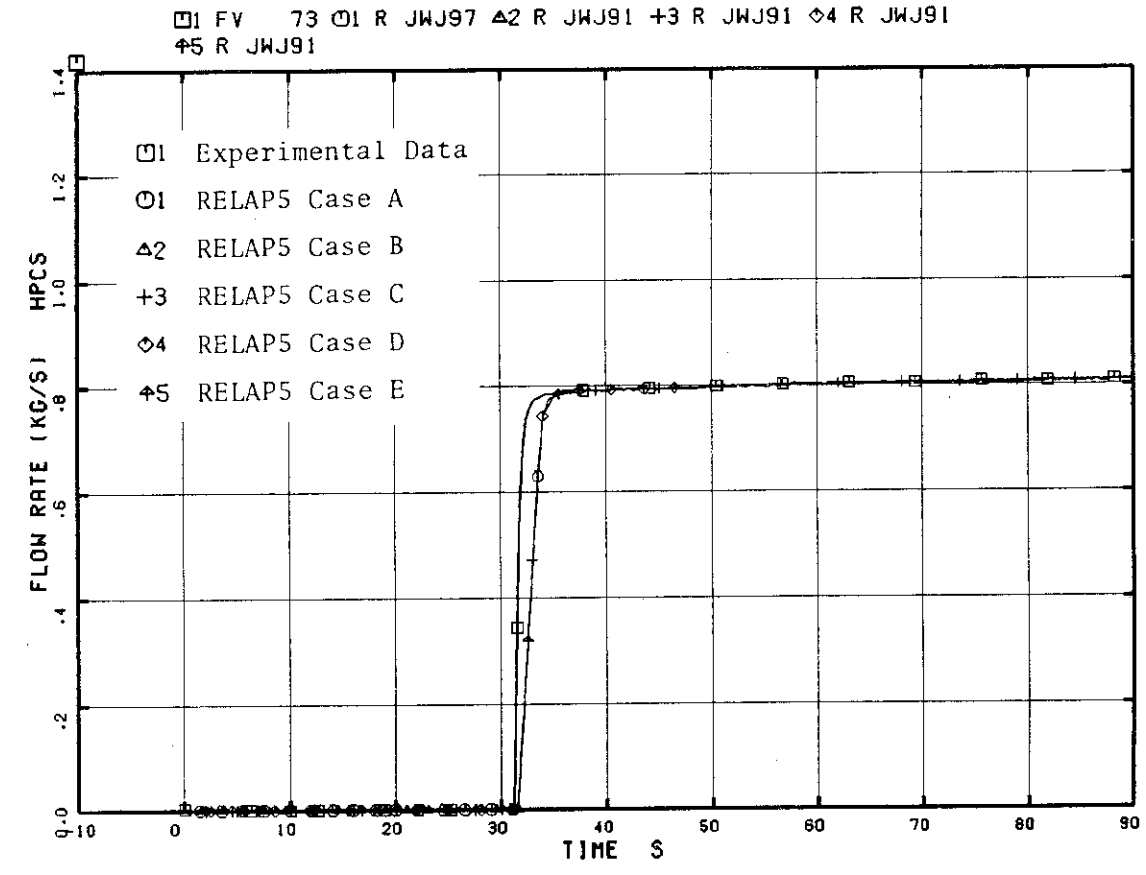


Fig. 4. 6 HPCS Flow Rate

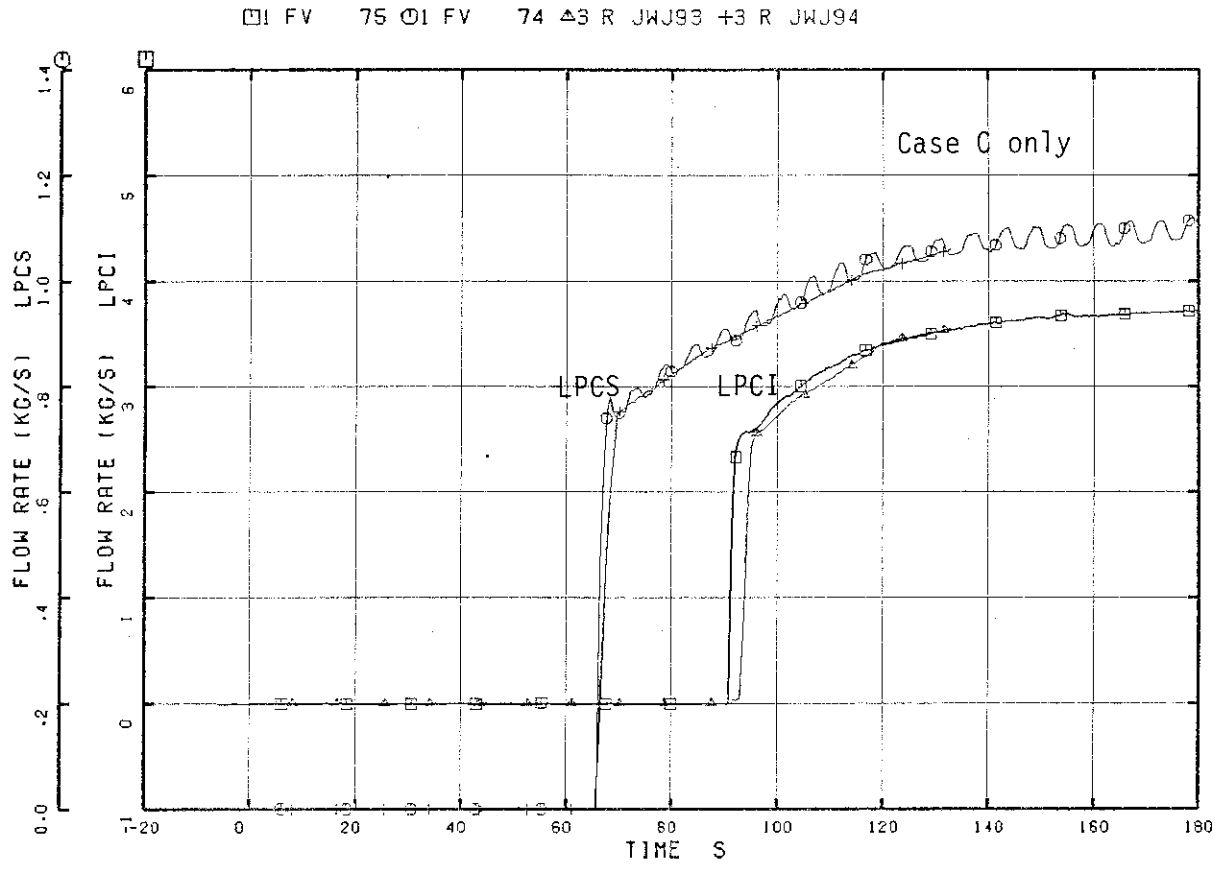


Fig. 4. 7 LPCS and LPCI Flow Rates (Case C)

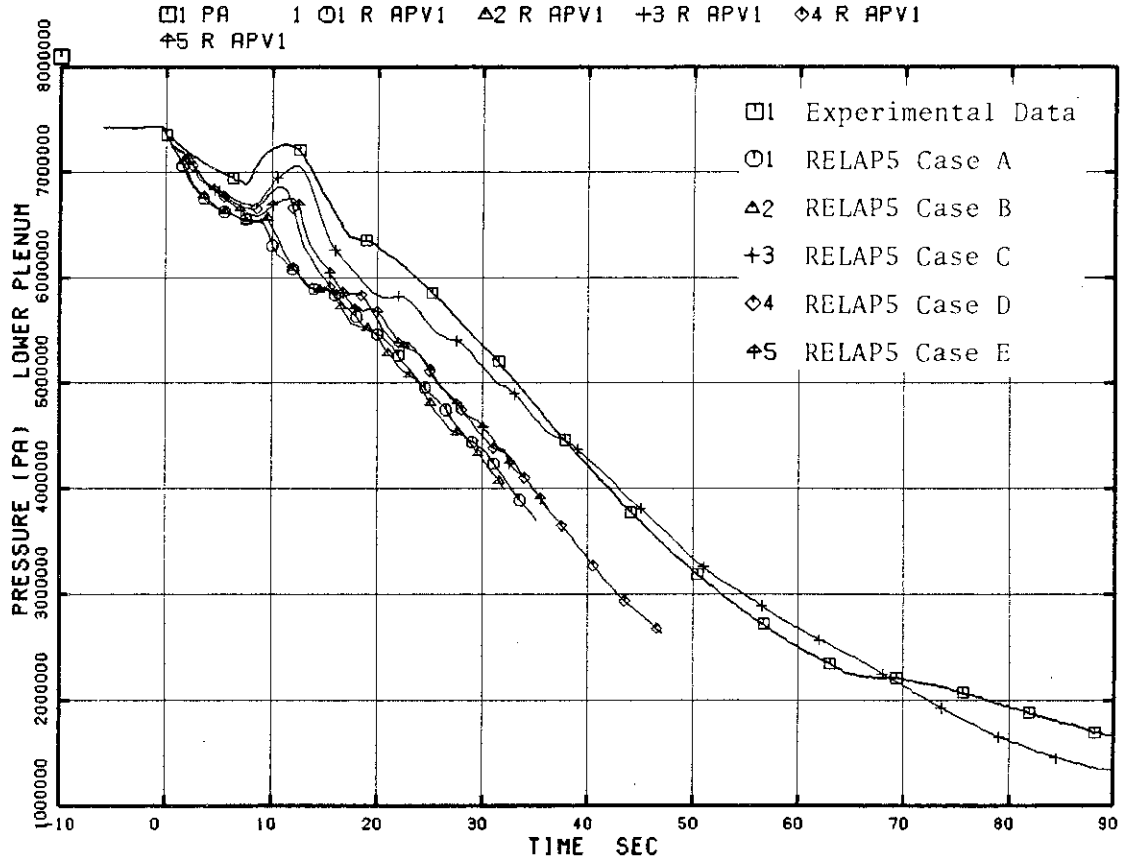


Fig. 4. 8 Lower Plenum Pressure

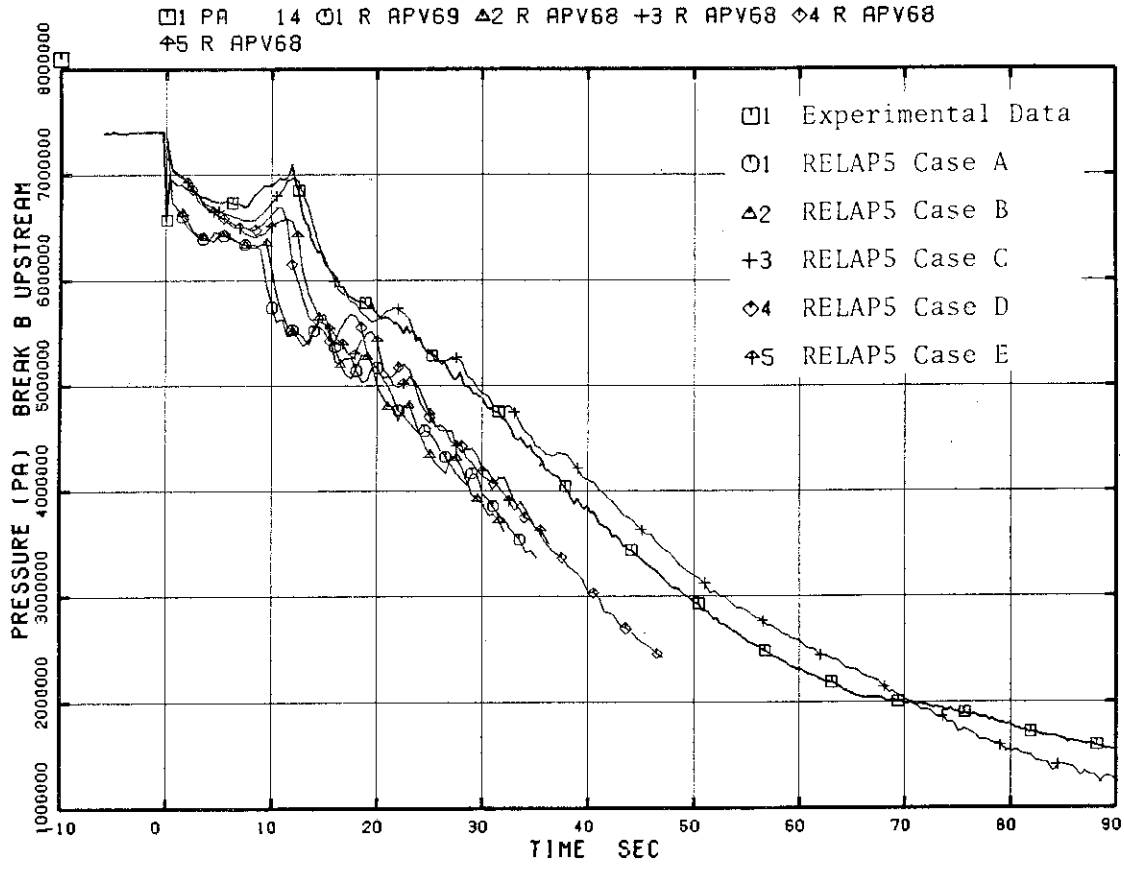


Fig. 4. 9 Pressure at Break B Upstream

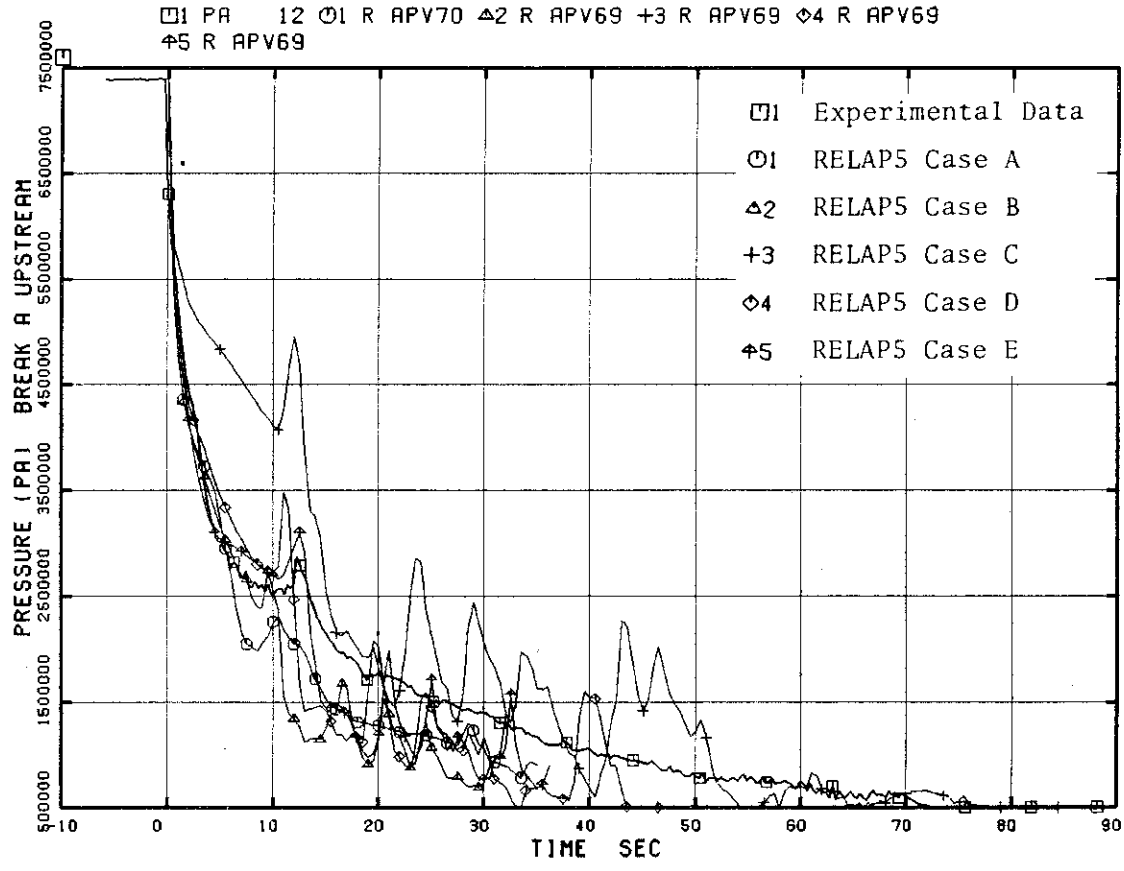


Fig. 4.10 Pressure at Break A Upstream

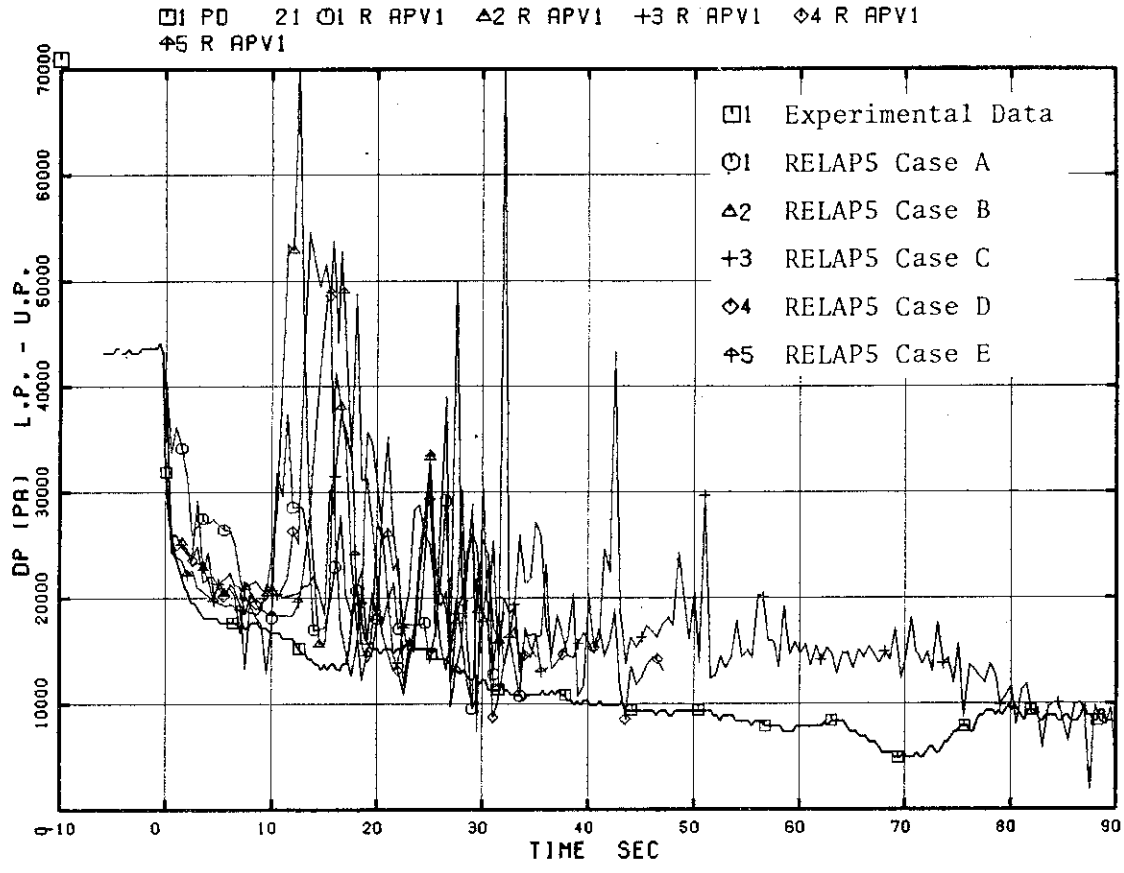


Fig. 4.11 Differential Pressure between Lower and Upper Plena

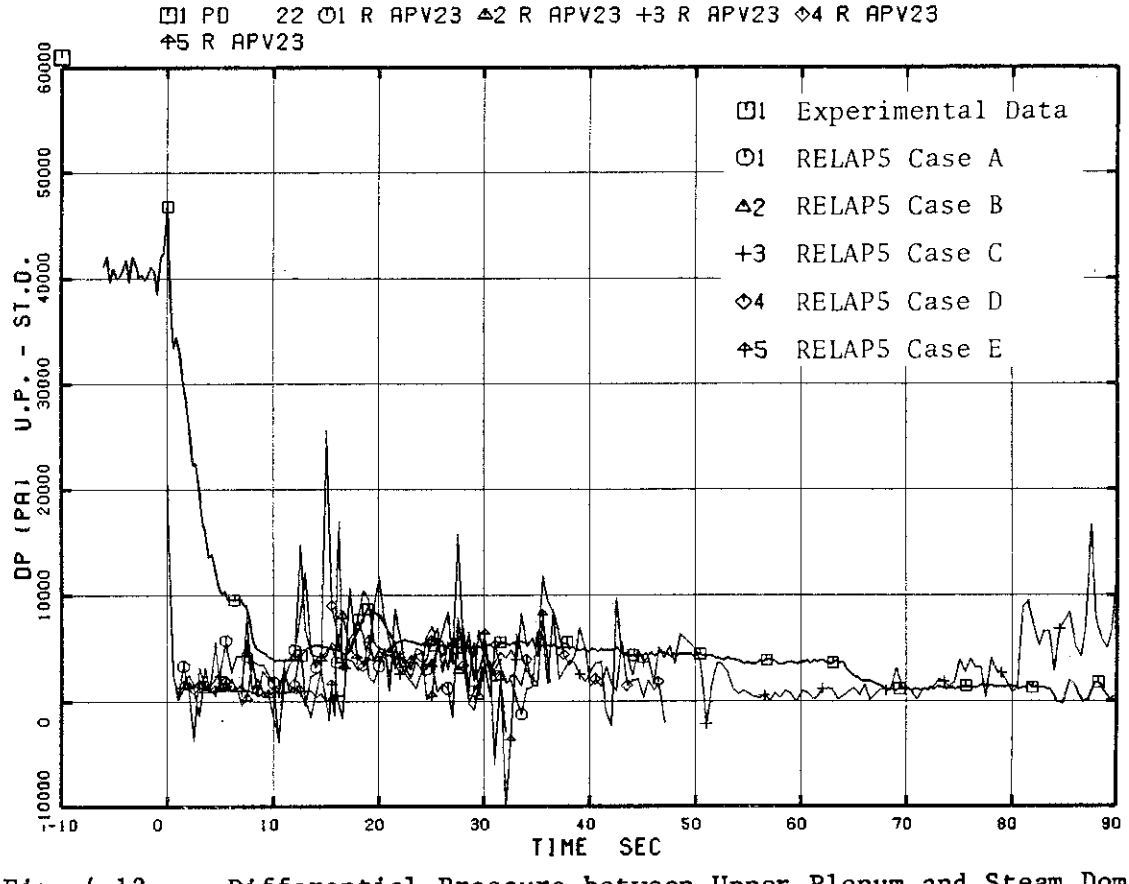


Fig. 4.12 Differential Pressure between Upper Plenum and Steam Dome

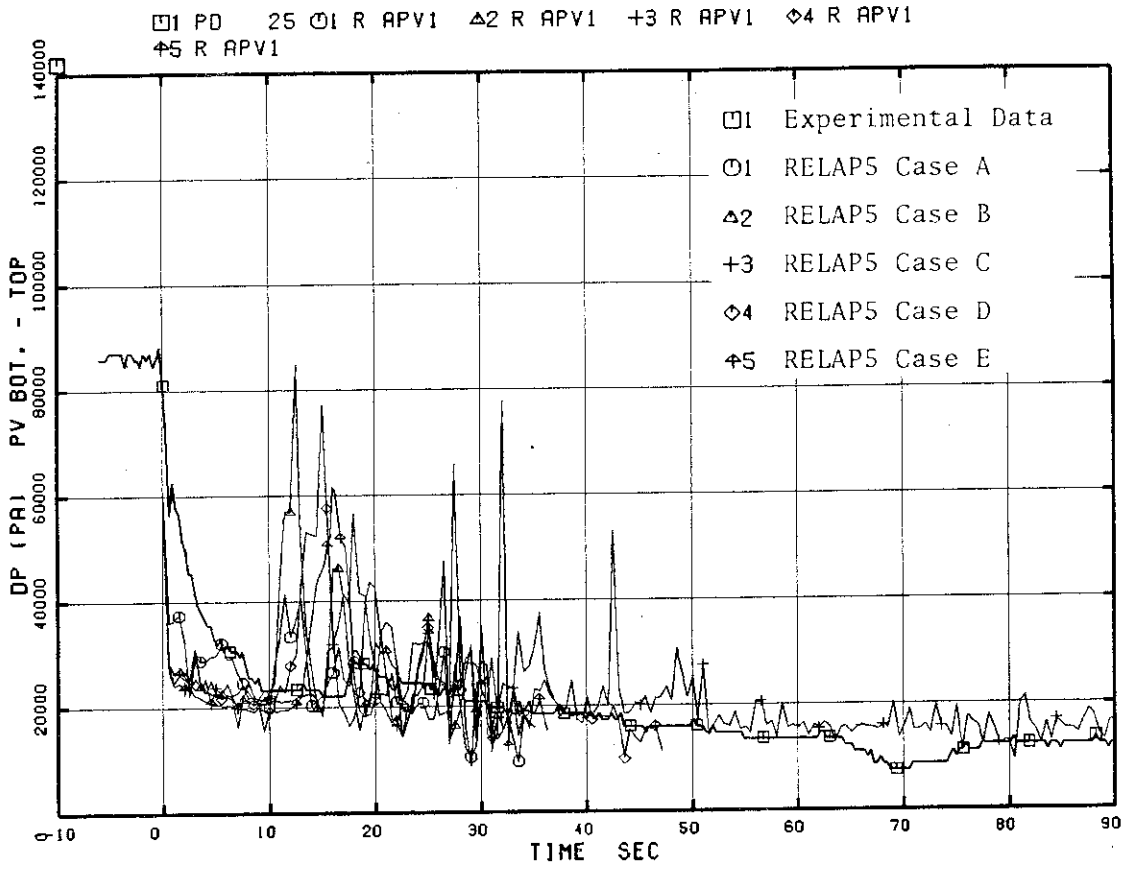


Fig. 4.13 Differential Pressure between Lower Plenum and Steam Dome

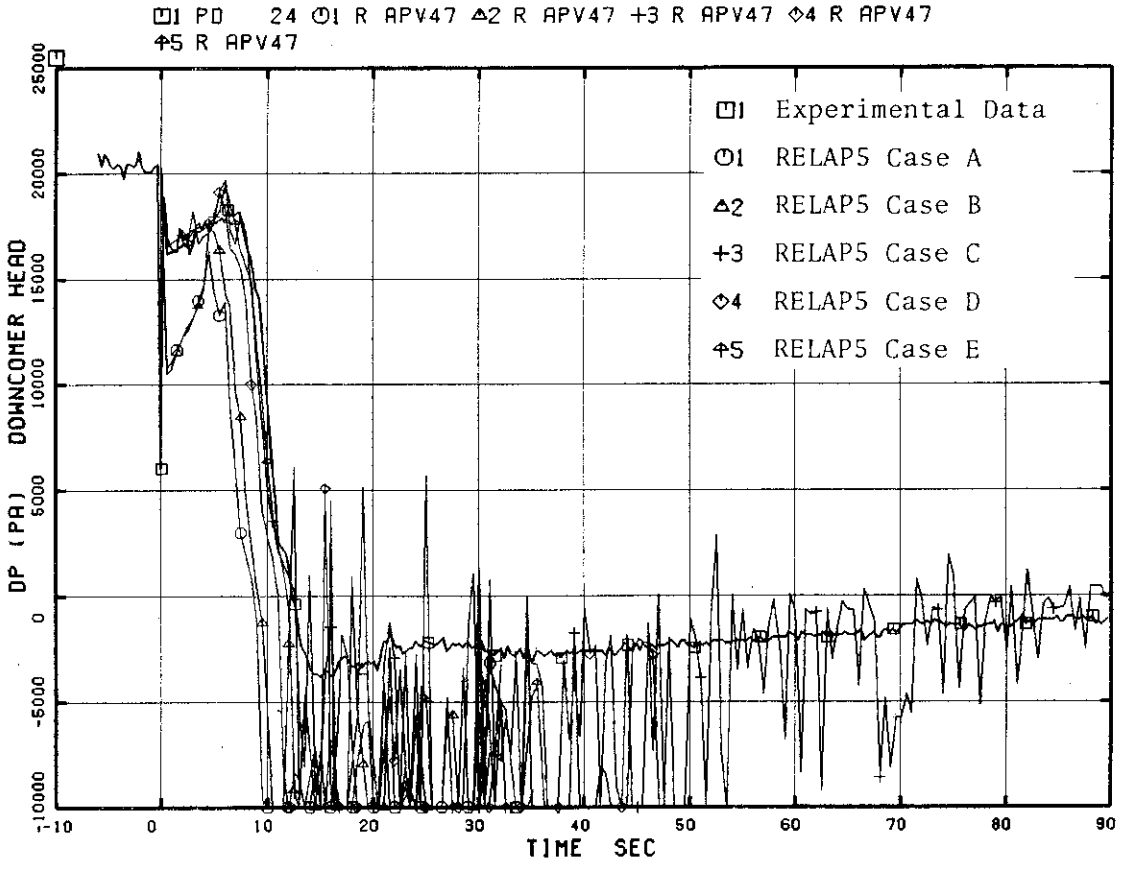


Fig. 4.14 Lower Downcomer Head

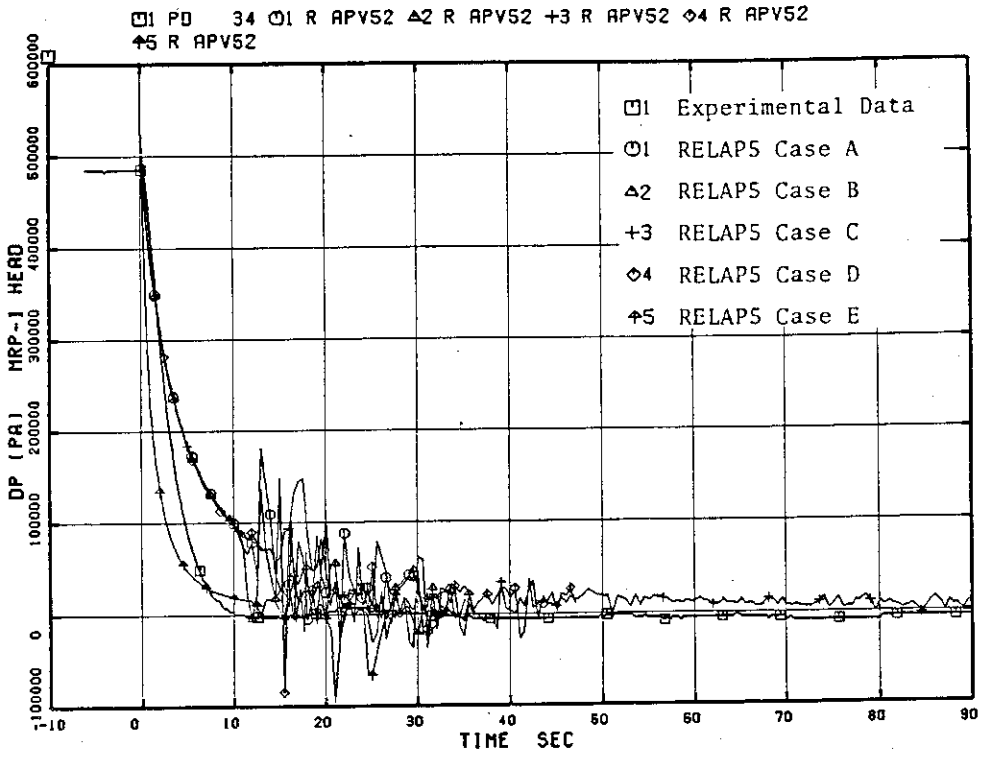


Fig. 4.15 Differential Pressure between MRP1 Delivery and Suction in Intact Loop

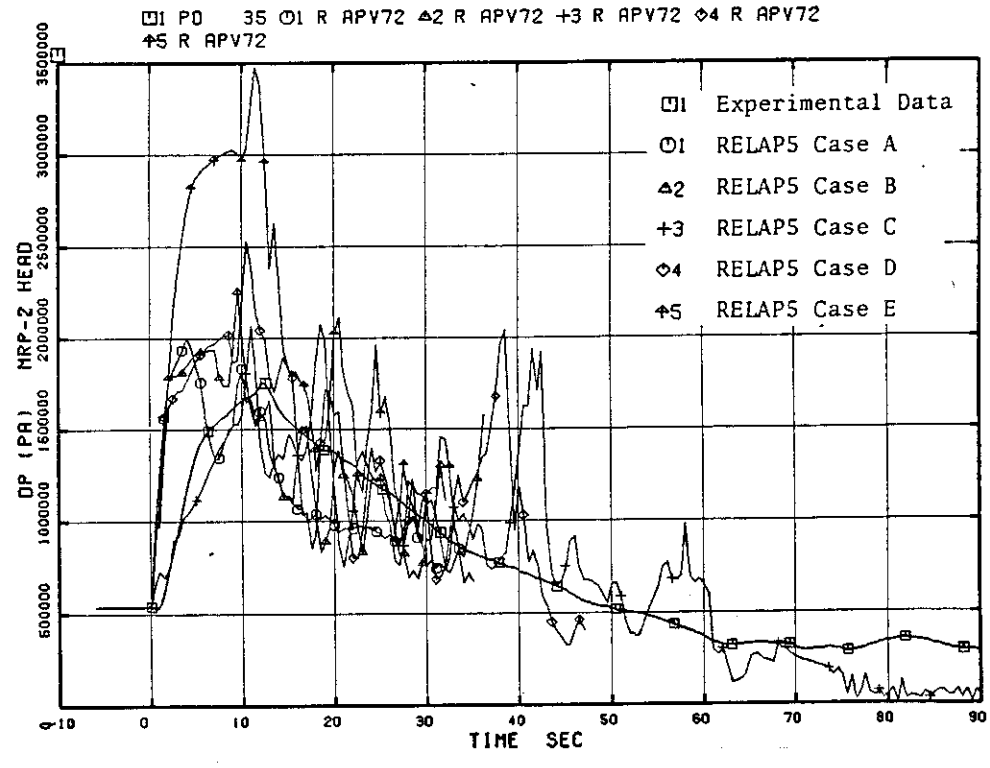


Fig. 4.16 Differential Pressure between MRP2 Delivery and Suction in Broken Loop

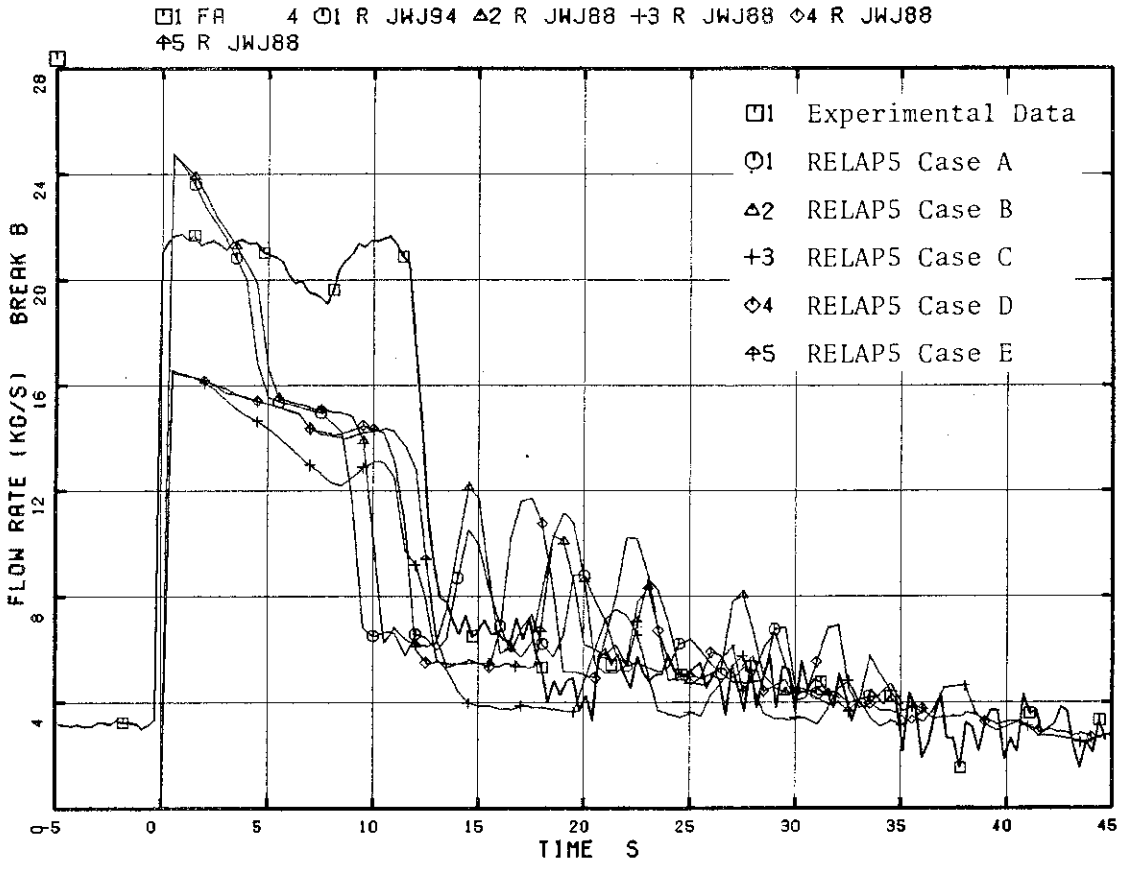


Fig. 4.17 Break Flow from Break B (PV side)

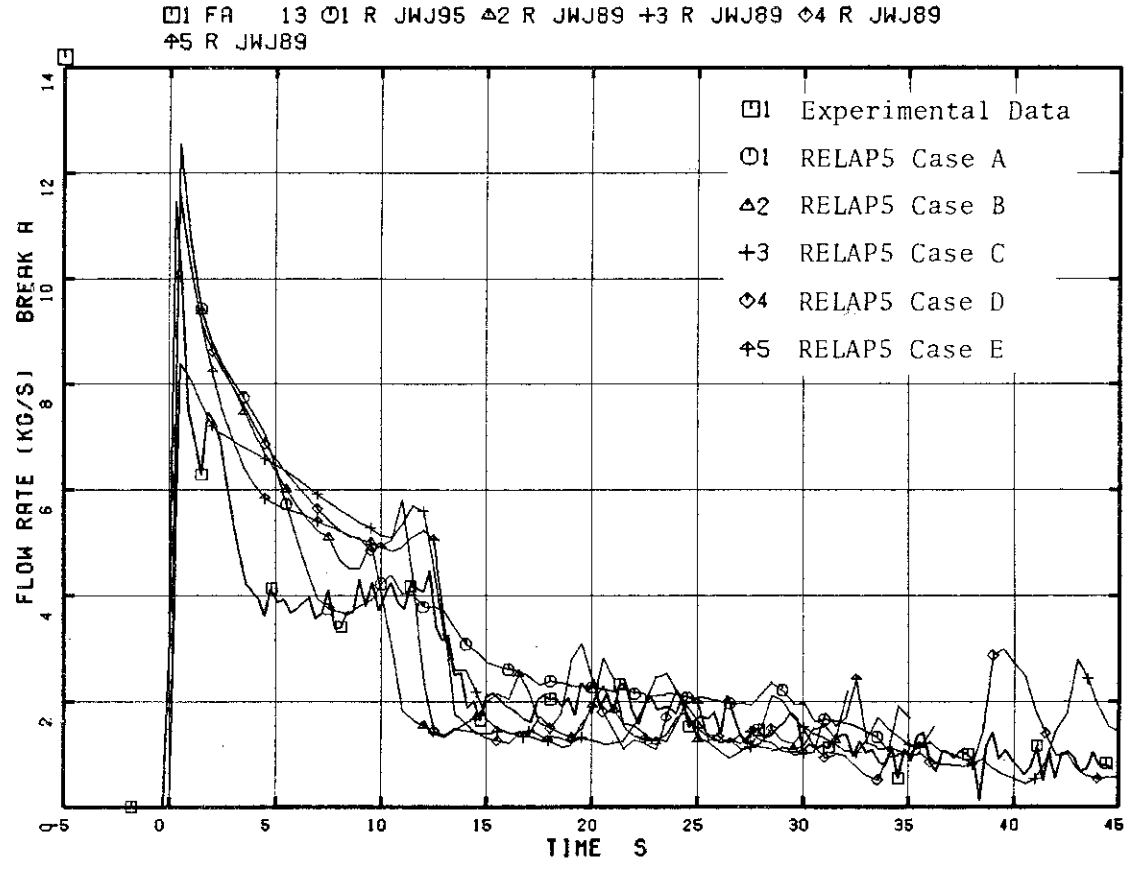


Fig. 4.18 Break Flow from Break A (MRP side)

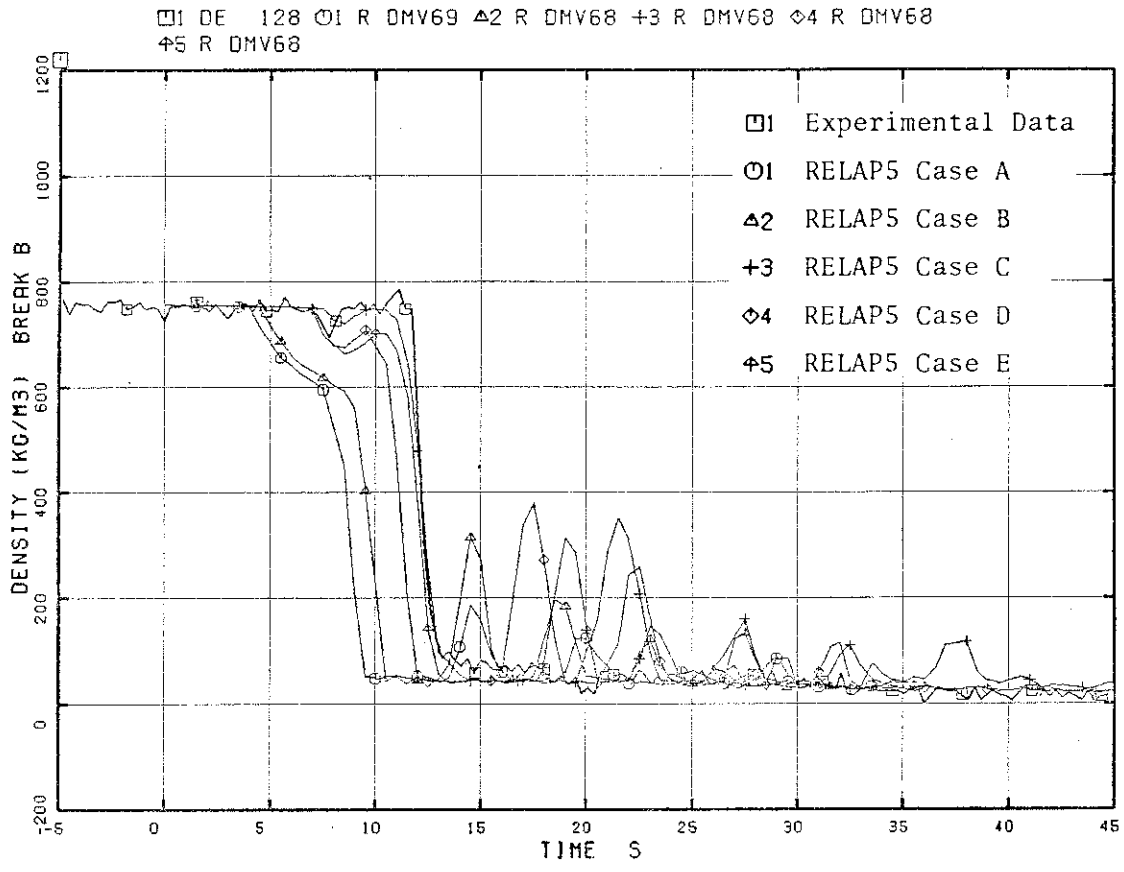


Fig. 4.19 Average Fluid Densities at Break B Upstream

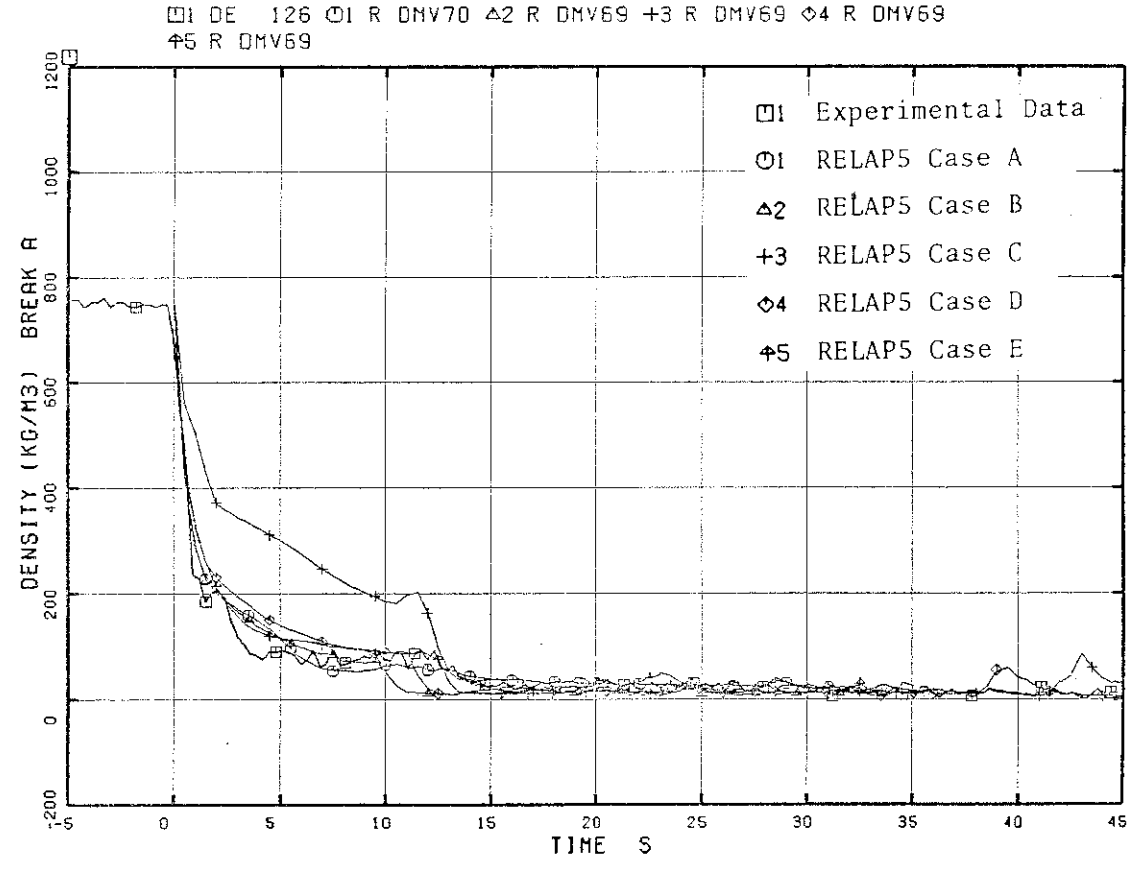


Fig. 4.20 Average Fluid Densities at Break A Upstream

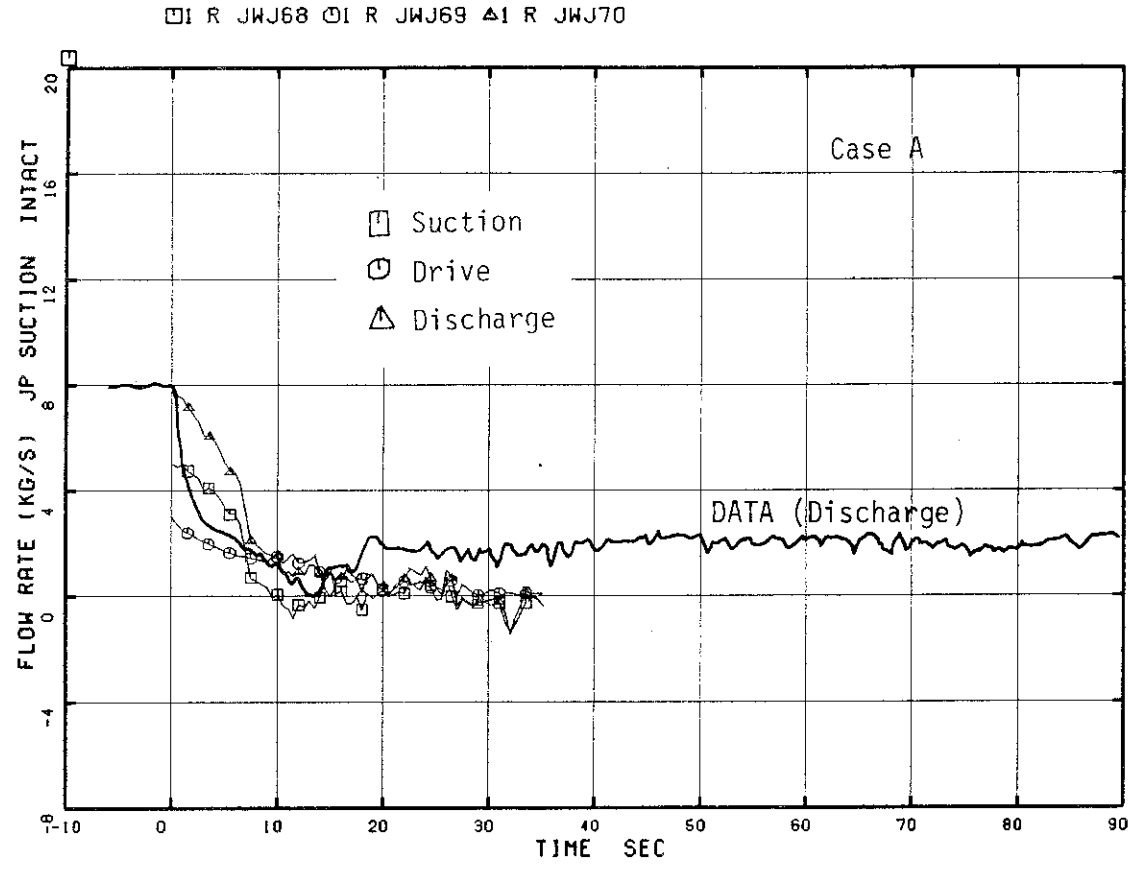


Fig. 4.21 Jet Pump Flow (Intact Loop ; Case A)

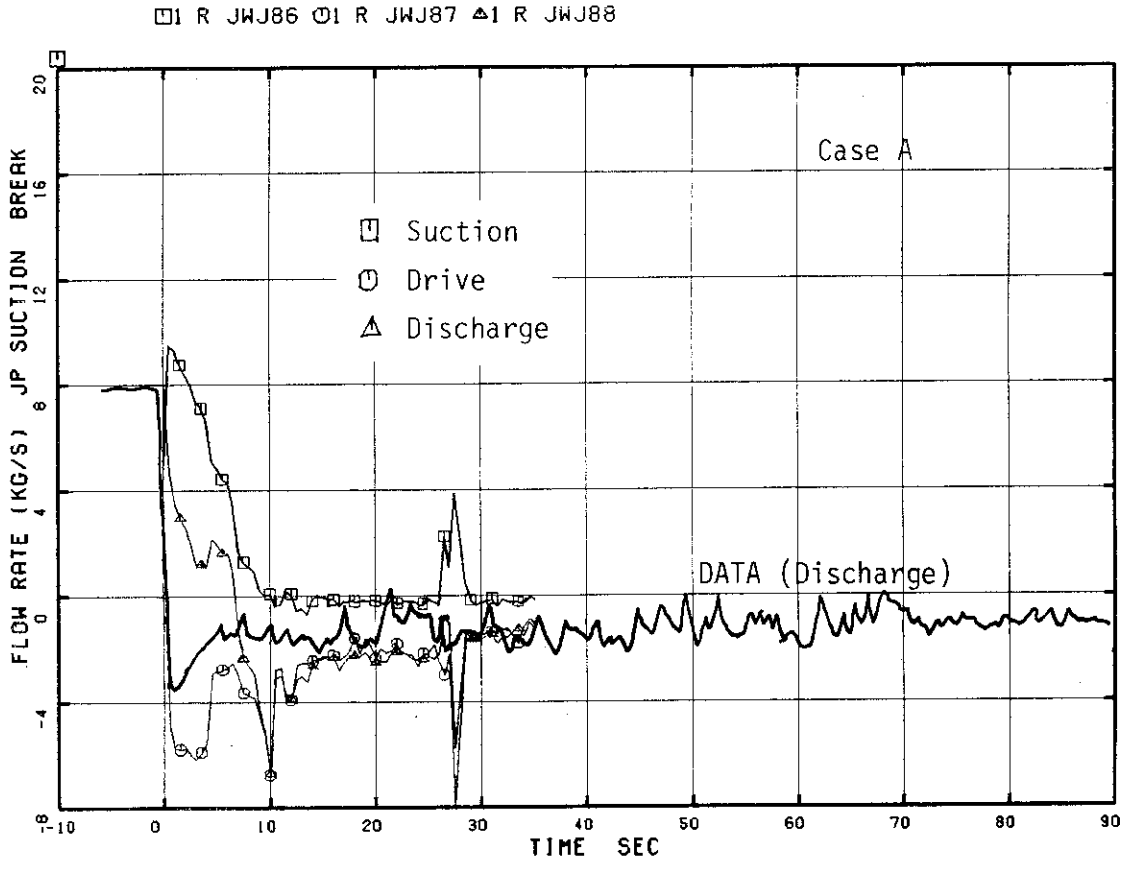


Fig. 4.22 Jet Pump Flow (Broken Loop ; Case A)

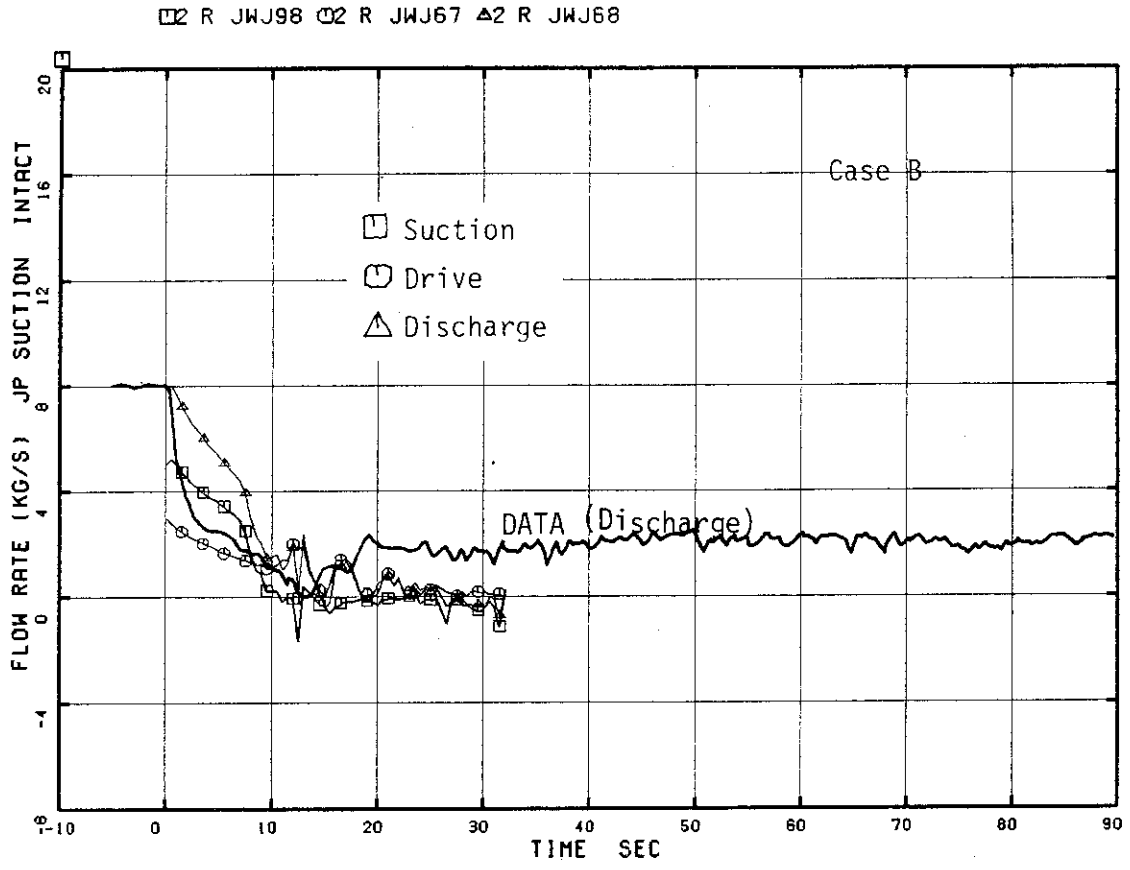


Fig. 4.23 Jet Pump Flow (Intact Loop ; Case B)

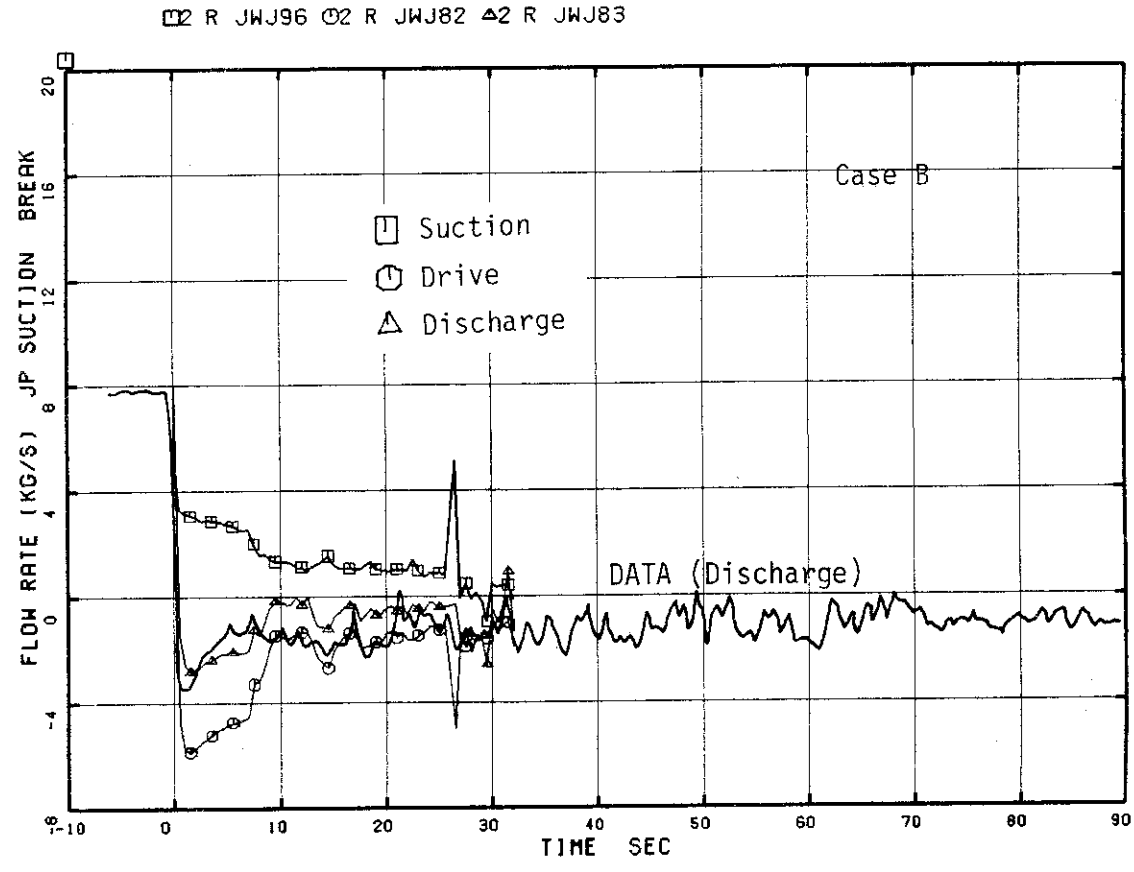


Fig. 4.24 Jet Pump Flow (Broken Loop ; Case B)

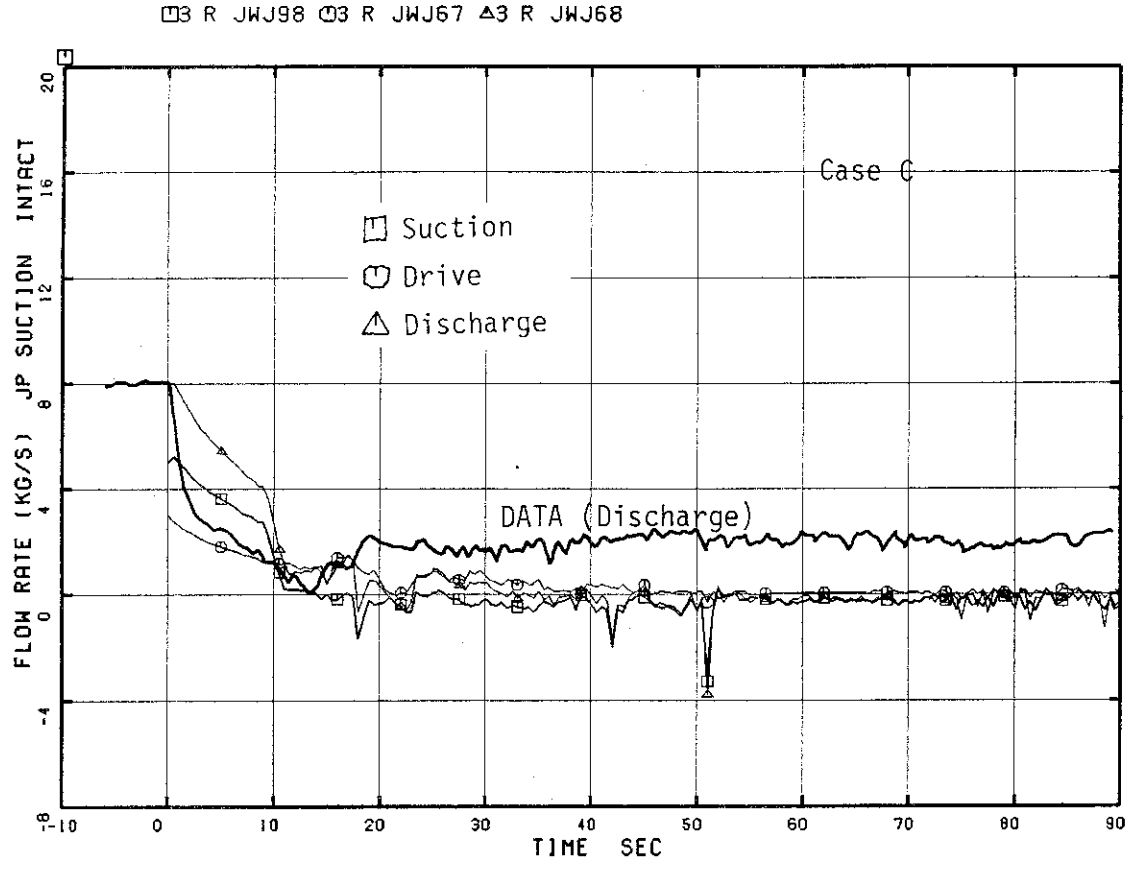


Fig. 4.25 Jet Pump Flow (Intact Loop ; Case C)

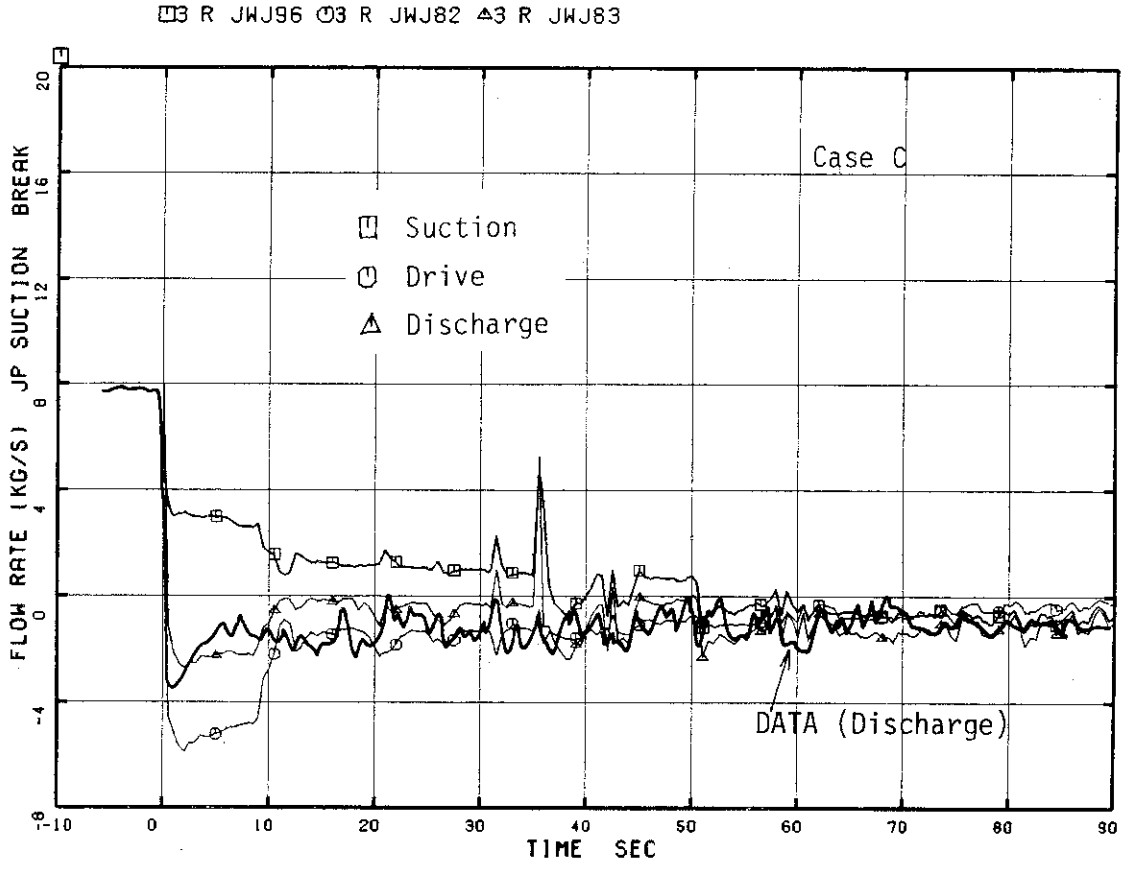


Fig. 4.26 Jet Pump Flow (Broken Loop ; Case C)

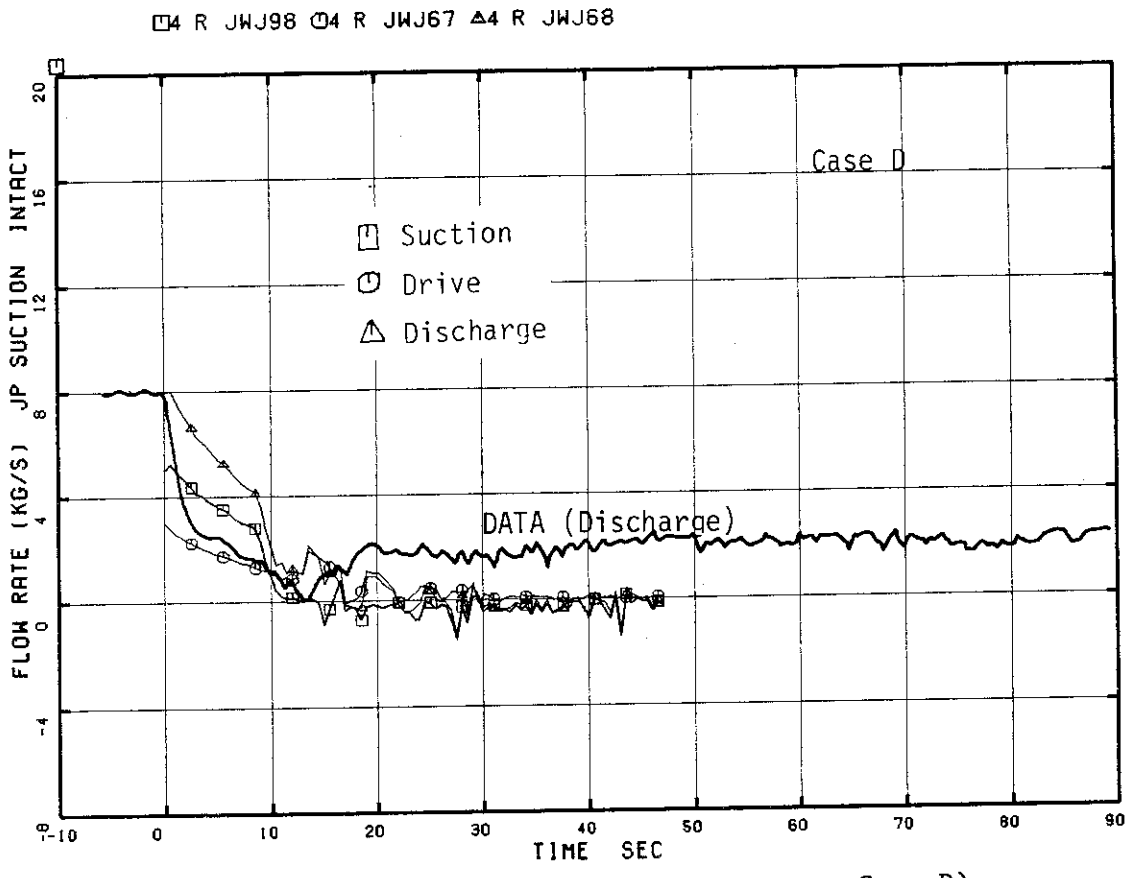


Fig. 4.27 Jet Pump Flow (Intace Loop ; Case D)

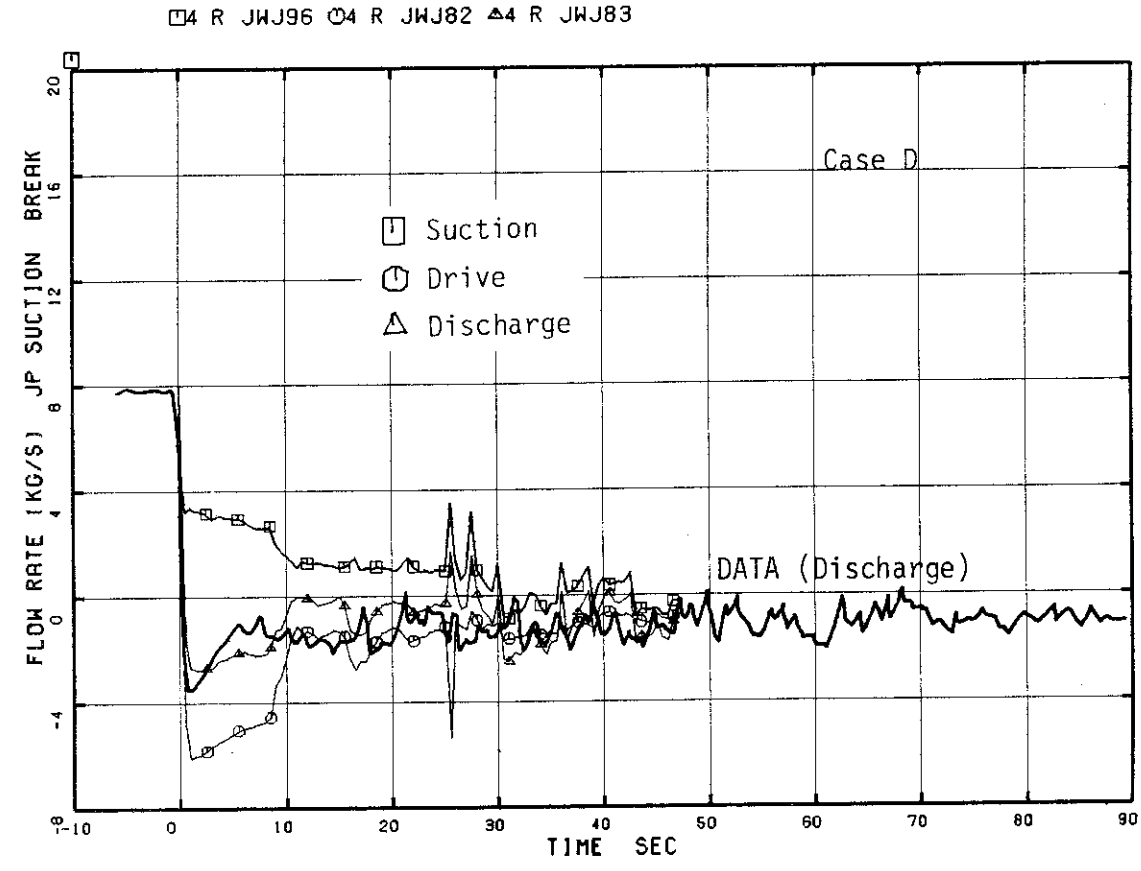


Fig. 4.28 Jet Pump Flow (Broken Loop ; Case D)

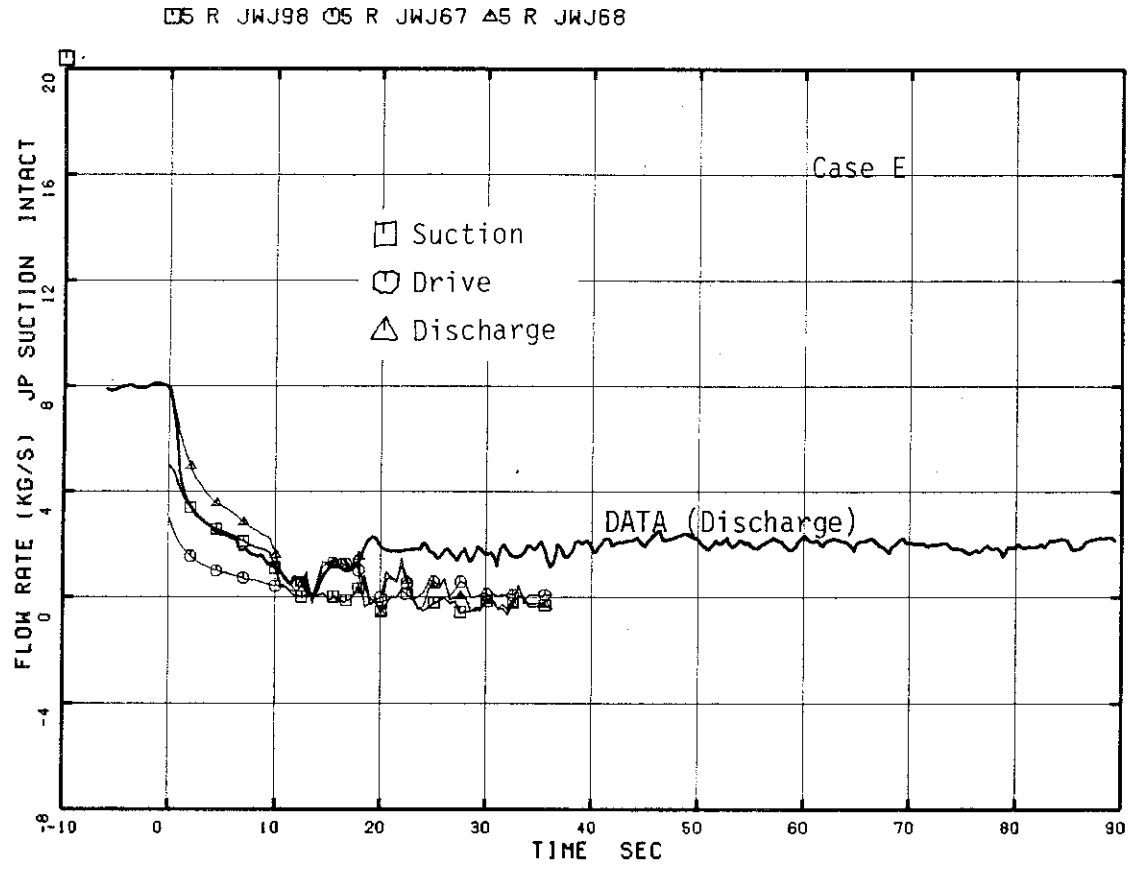


Fig. 4.29 Jet Pump Flow (Intact Loop ; Case E)

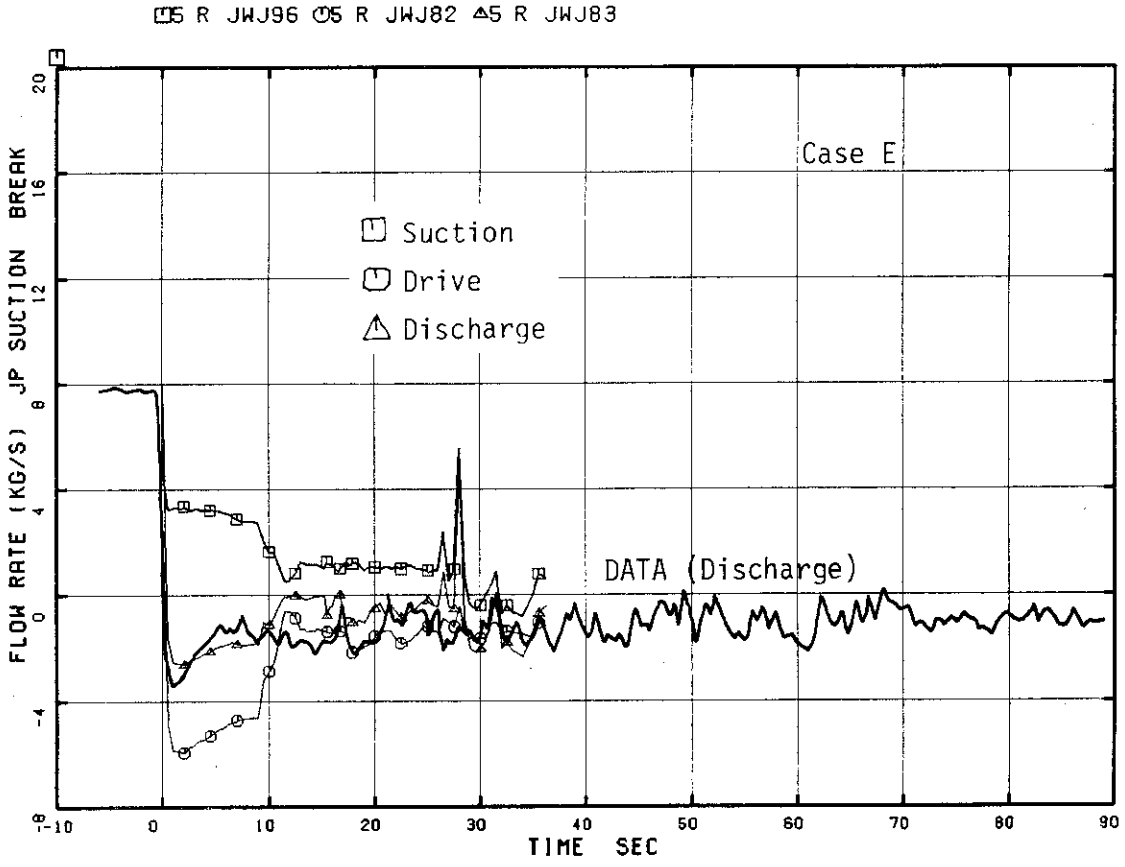


Fig. 4.30 Jet Pump Flow (Broken Loop ; Case E)

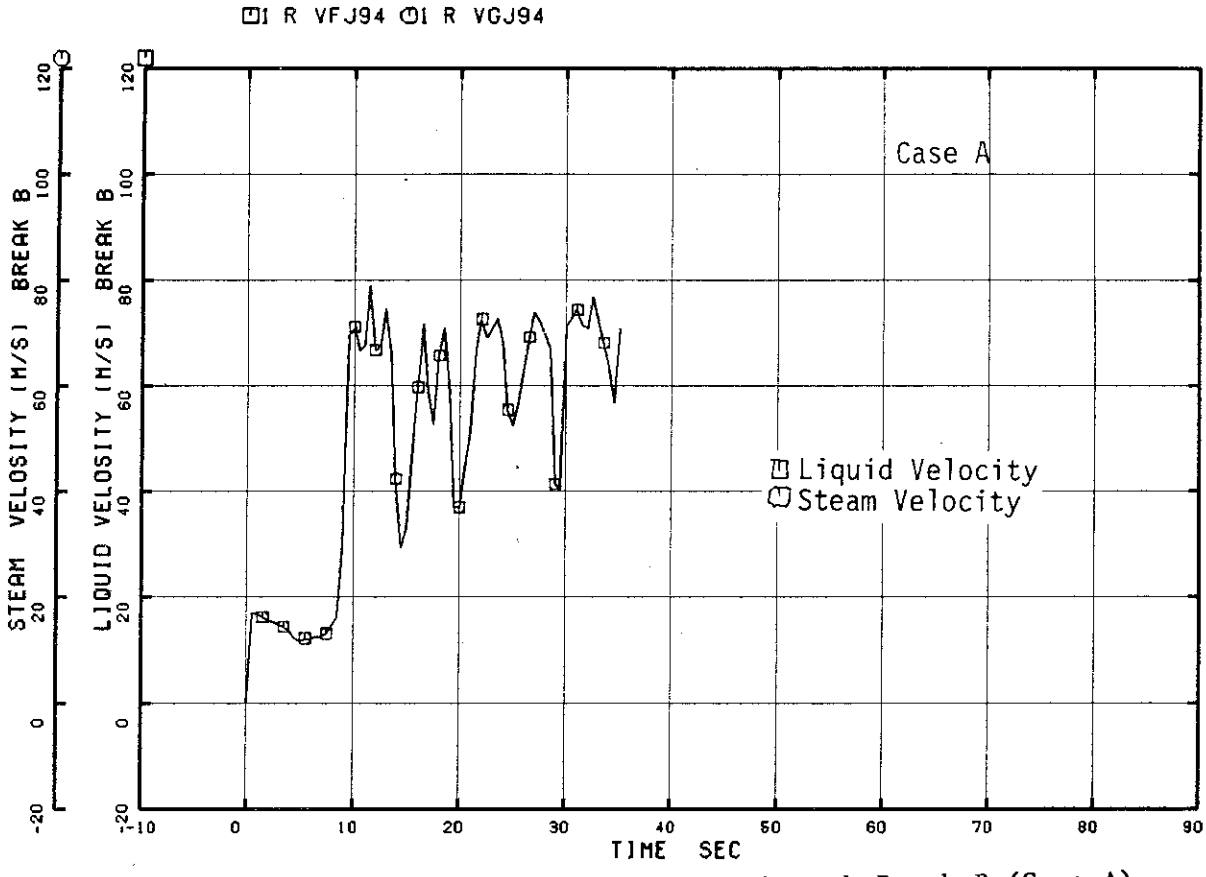


Fig. 4.31 Liquid and Steam Velocities through Break B (Case A)

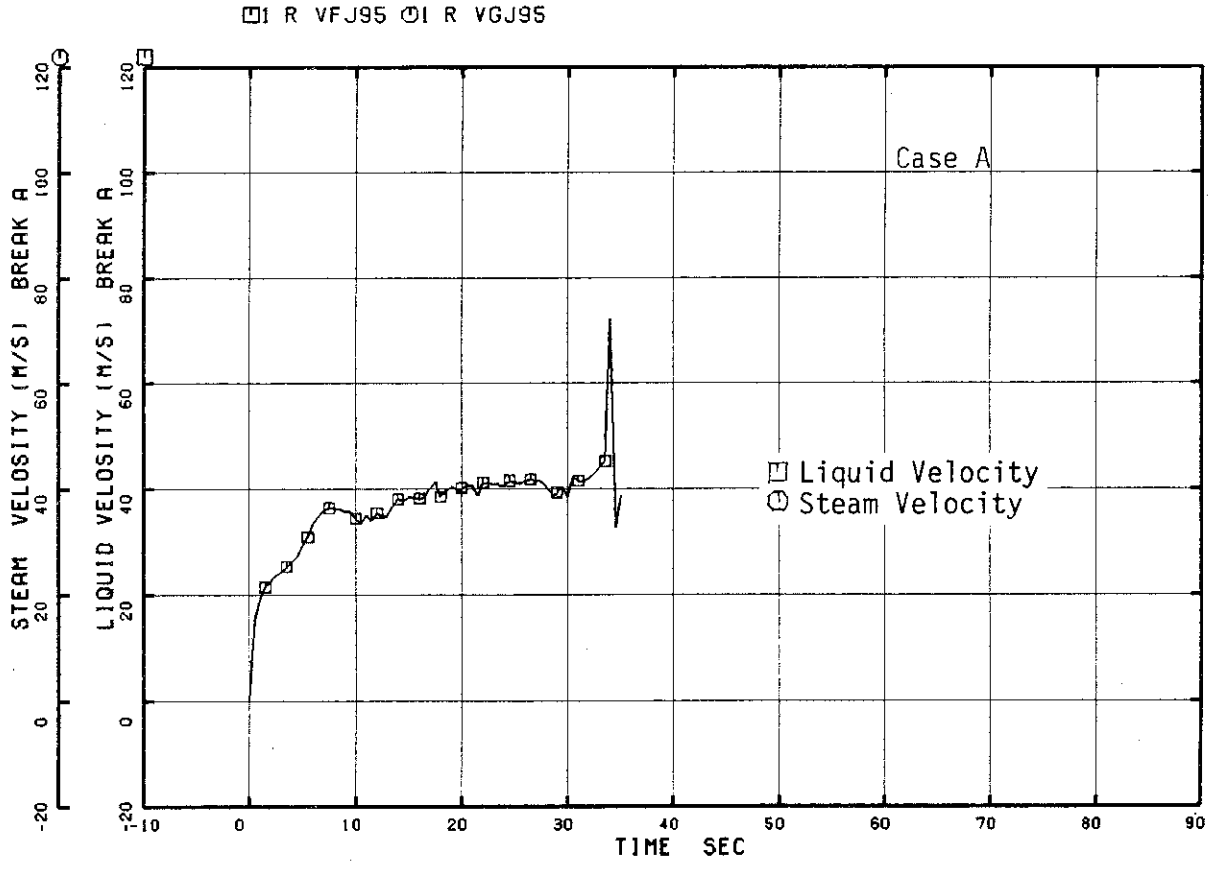


Fig. 4.32 Liquid and Steam Velocities through Break A (Case A)

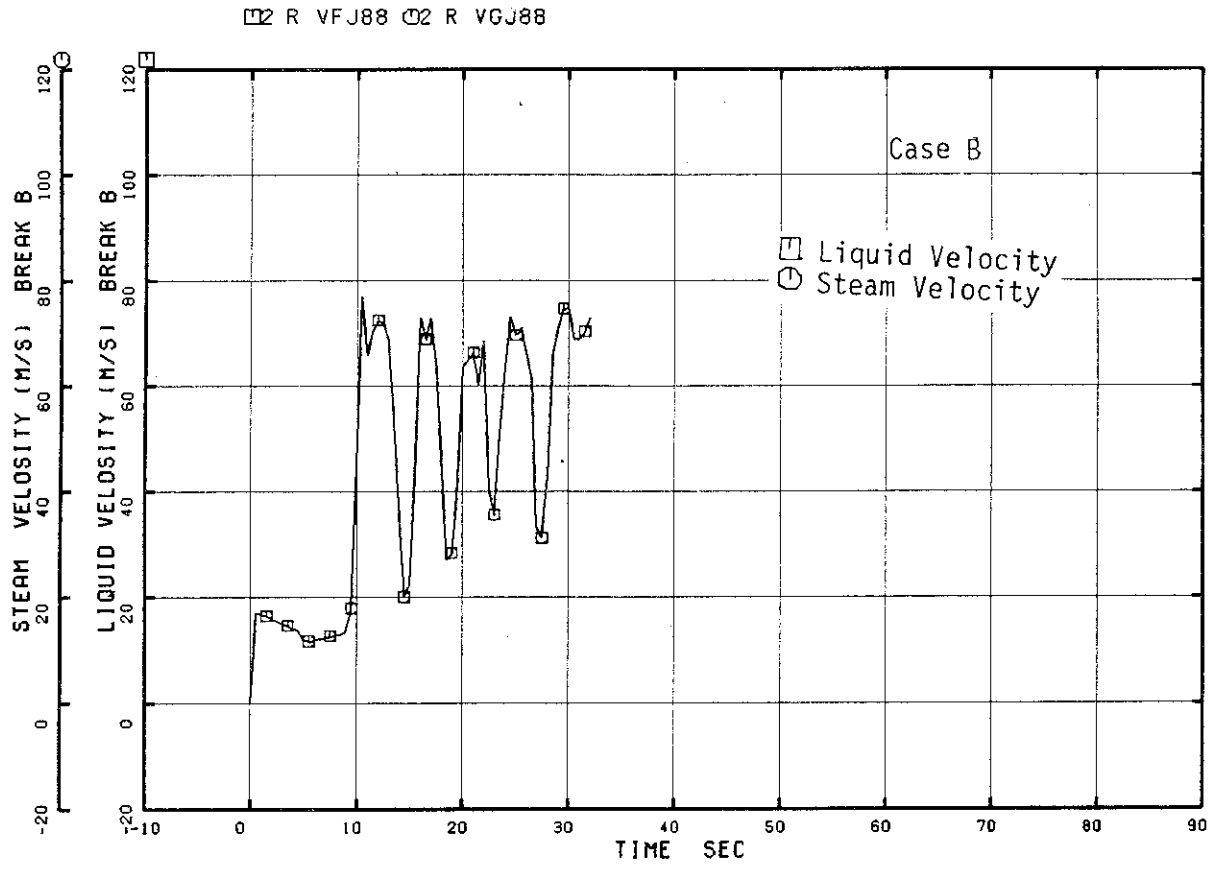


Fig. 4.33 Liquid and Steam Velocities through Break B (Case B)

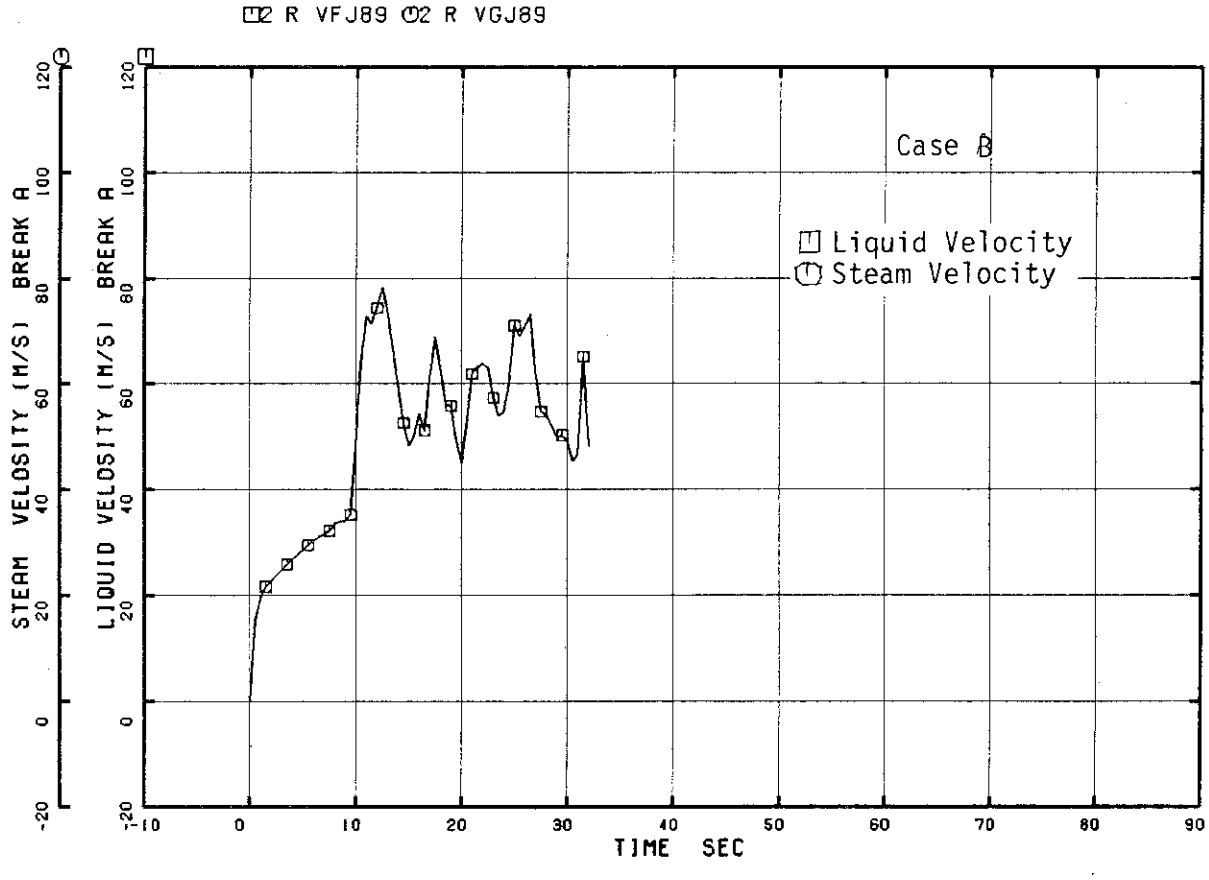


Fig. 4.34 Liquid and Steam Velocities through Break A (Case B)

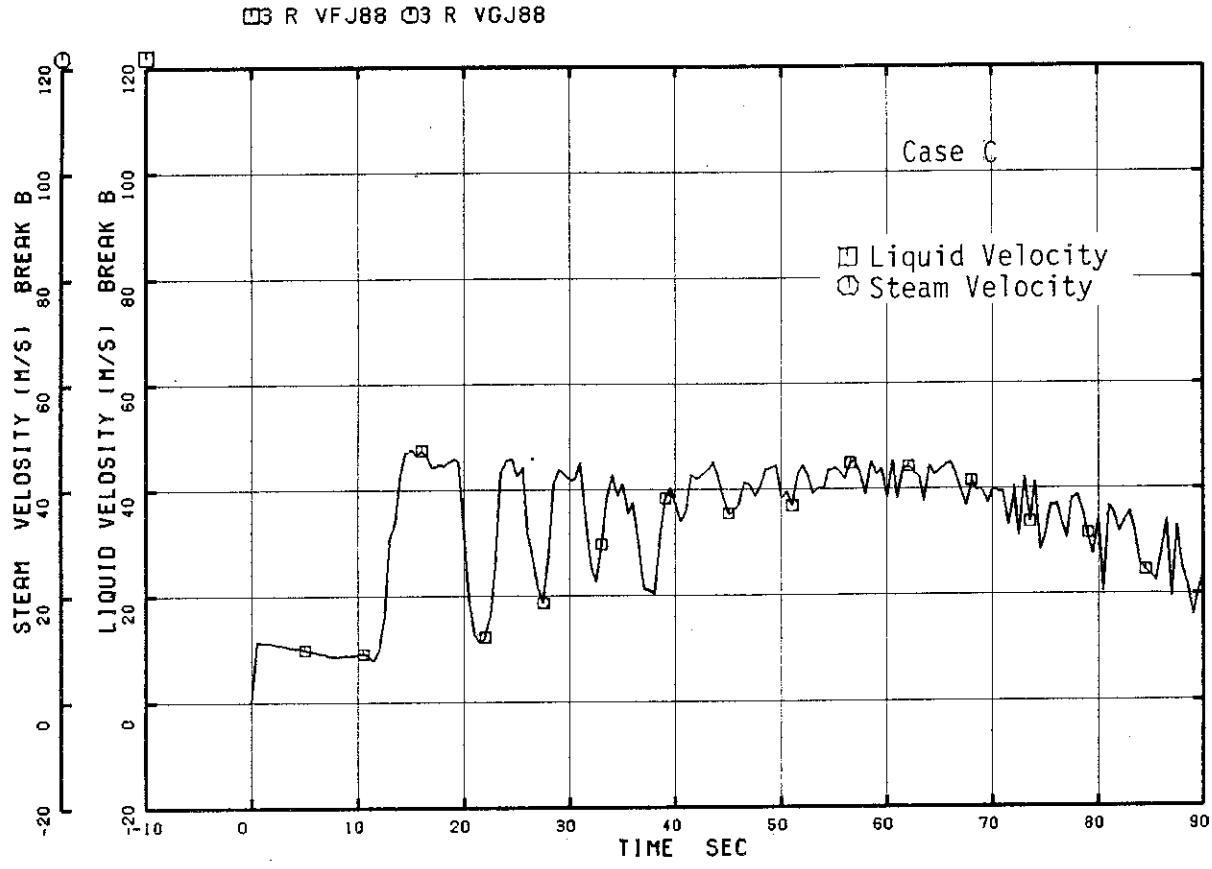


Fig. 4.35 Liquid and Steam Velocities through Break B (Case C)

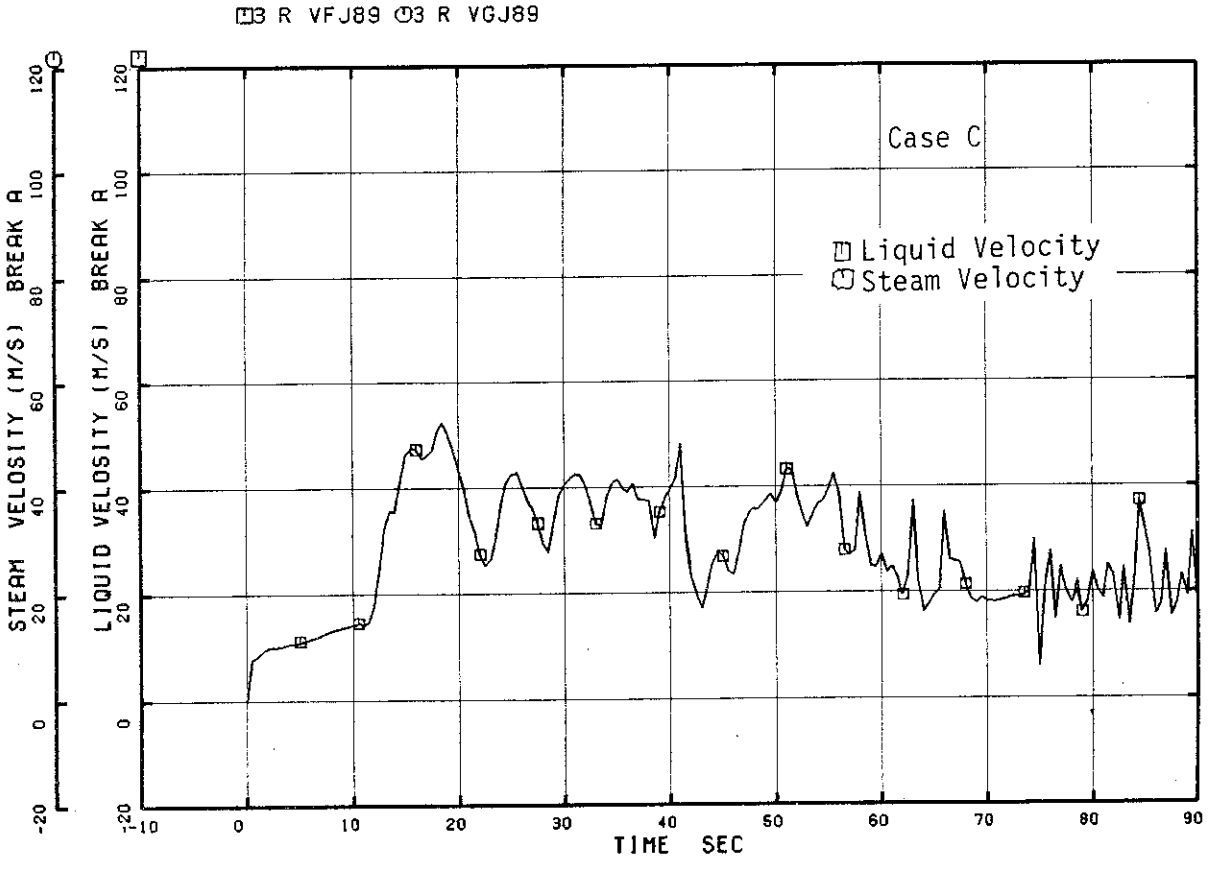


Fig. 4.36 Liquid and Steam Velocities through Break A (Case C)

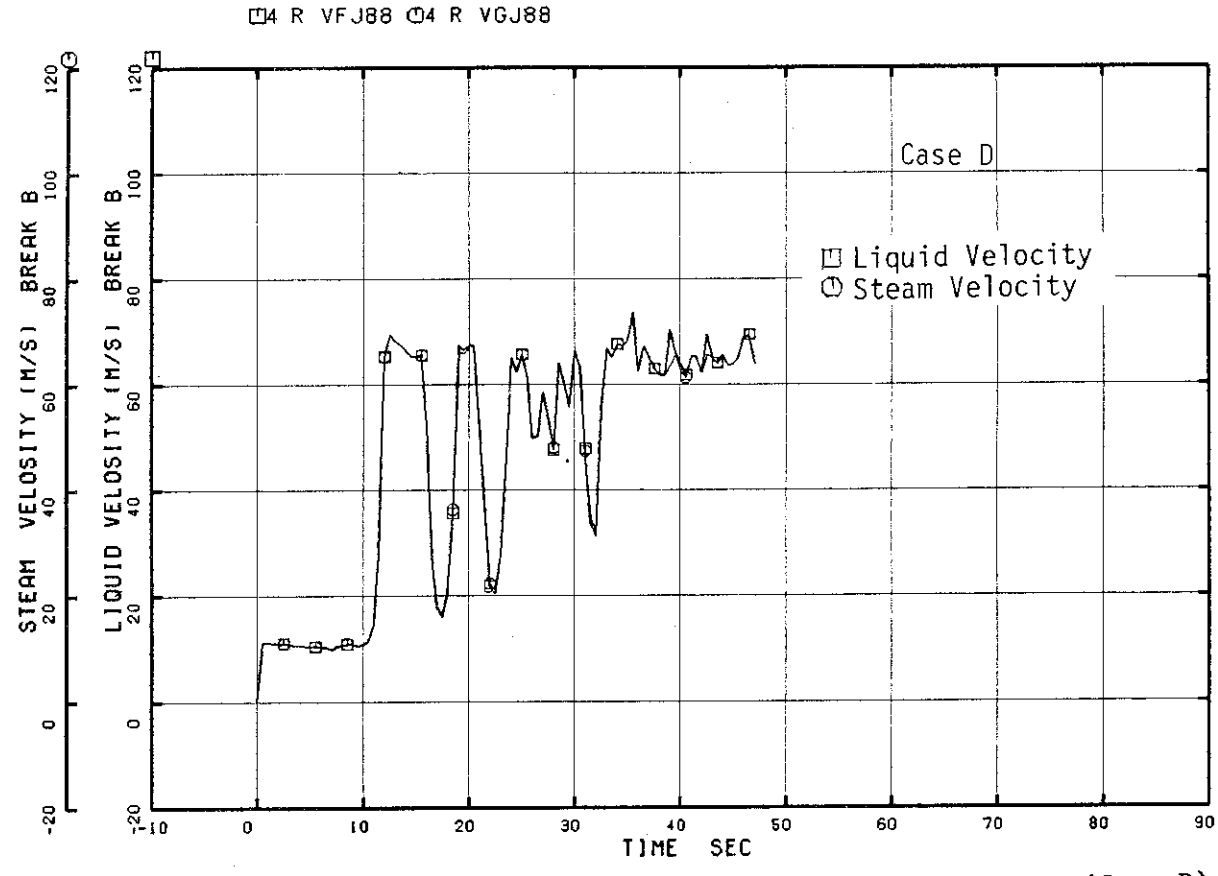


Fig. 4.37 Liquid and Steam Velocities thorugh Break B (Case D)

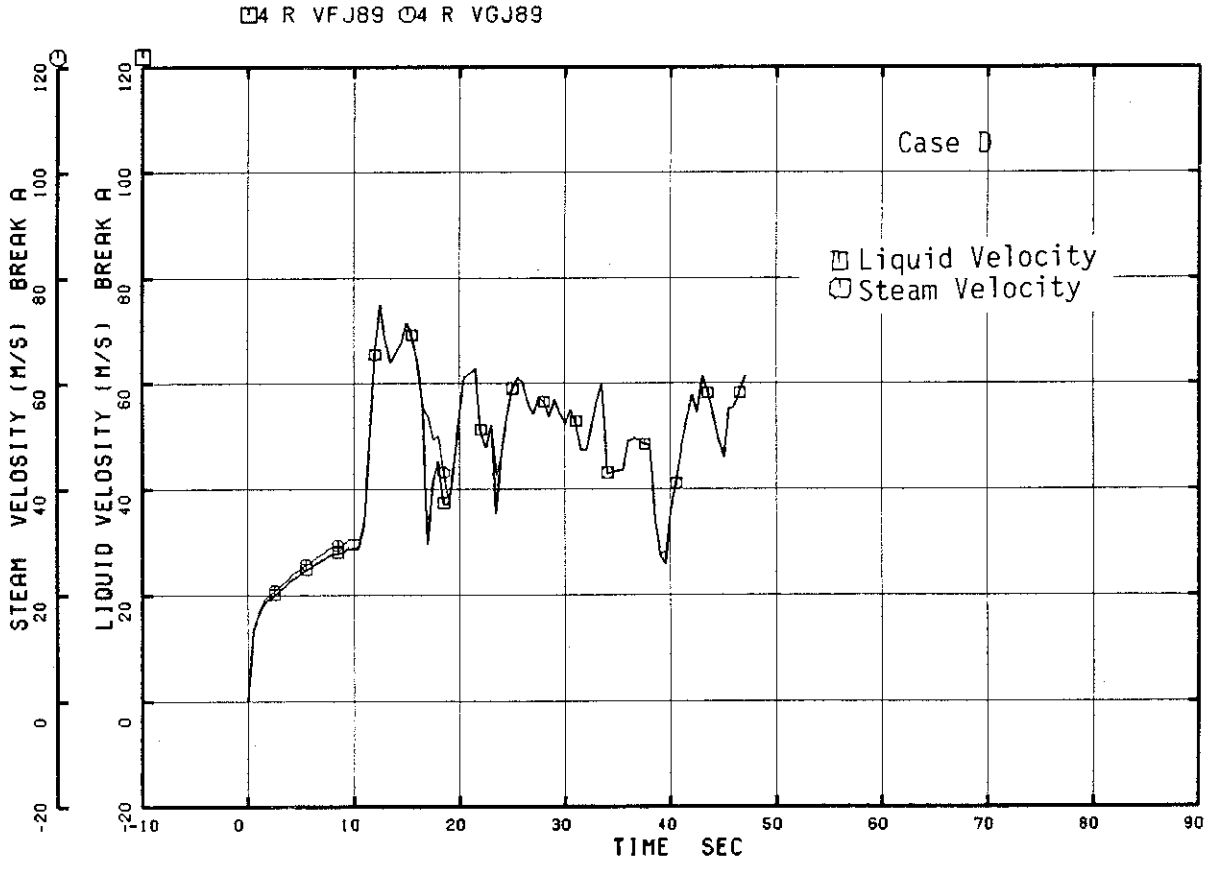


Fig. 4.38 Liquid and Steam Velocities through Break A (Case D)

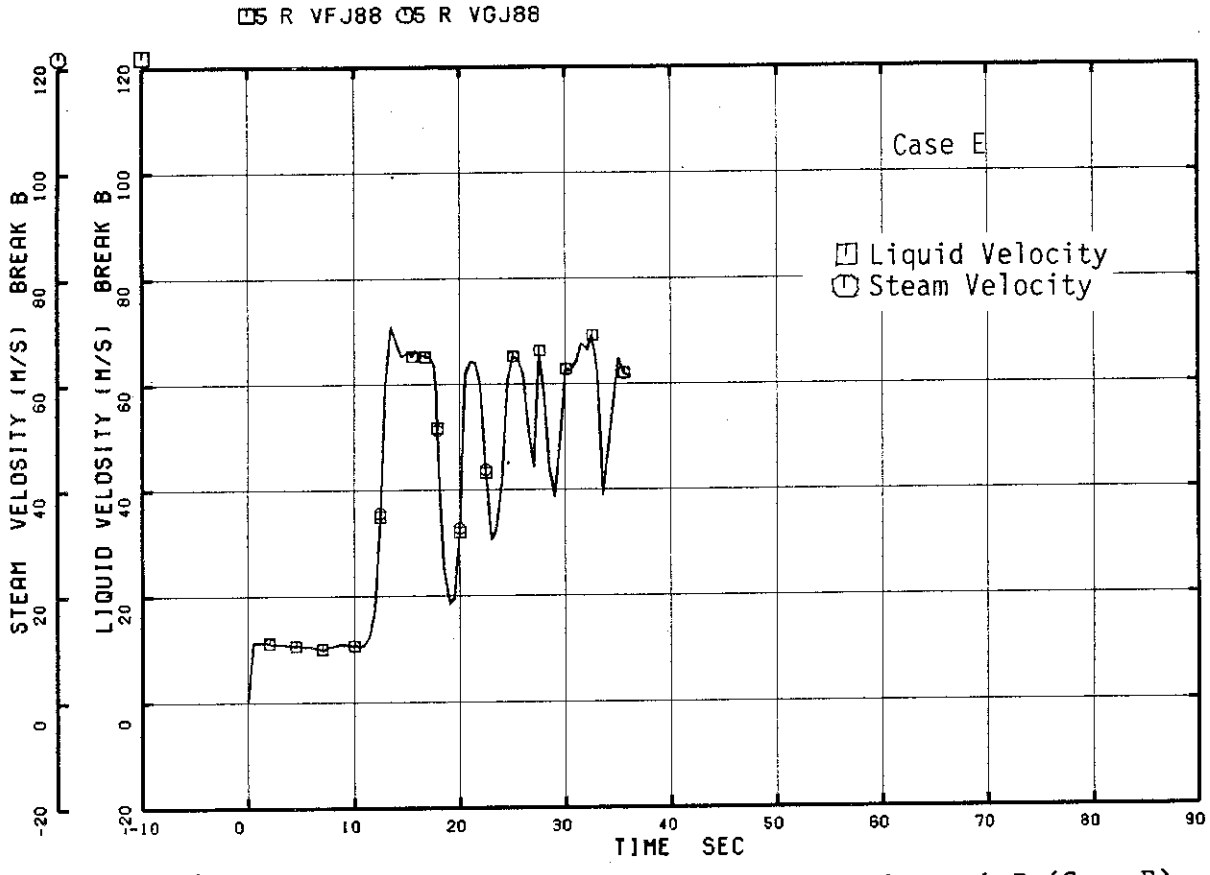


Fig. 4.39 Liquid and Steam Velocities through Break B (Case E)

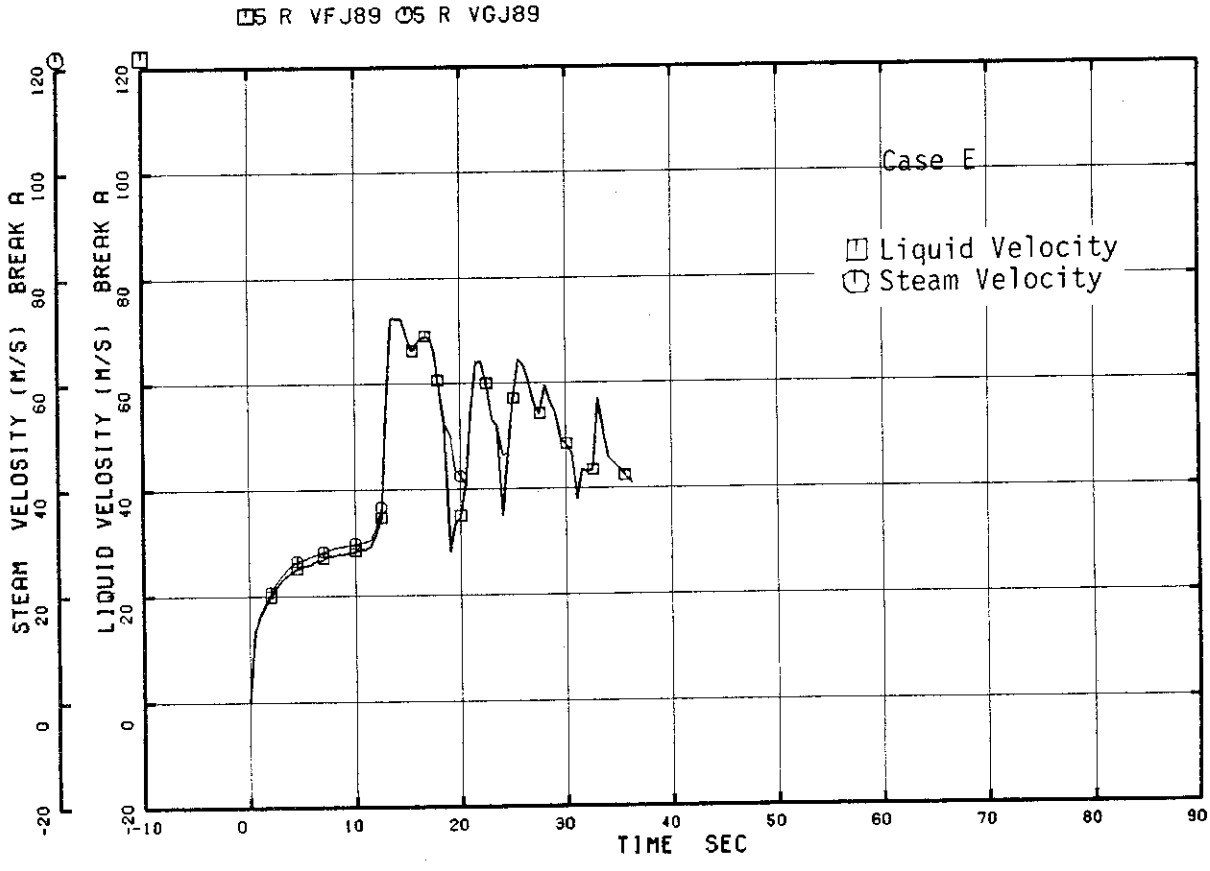


Fig. 4.40 Liquid and Steam Velocities through Break A (Case E)

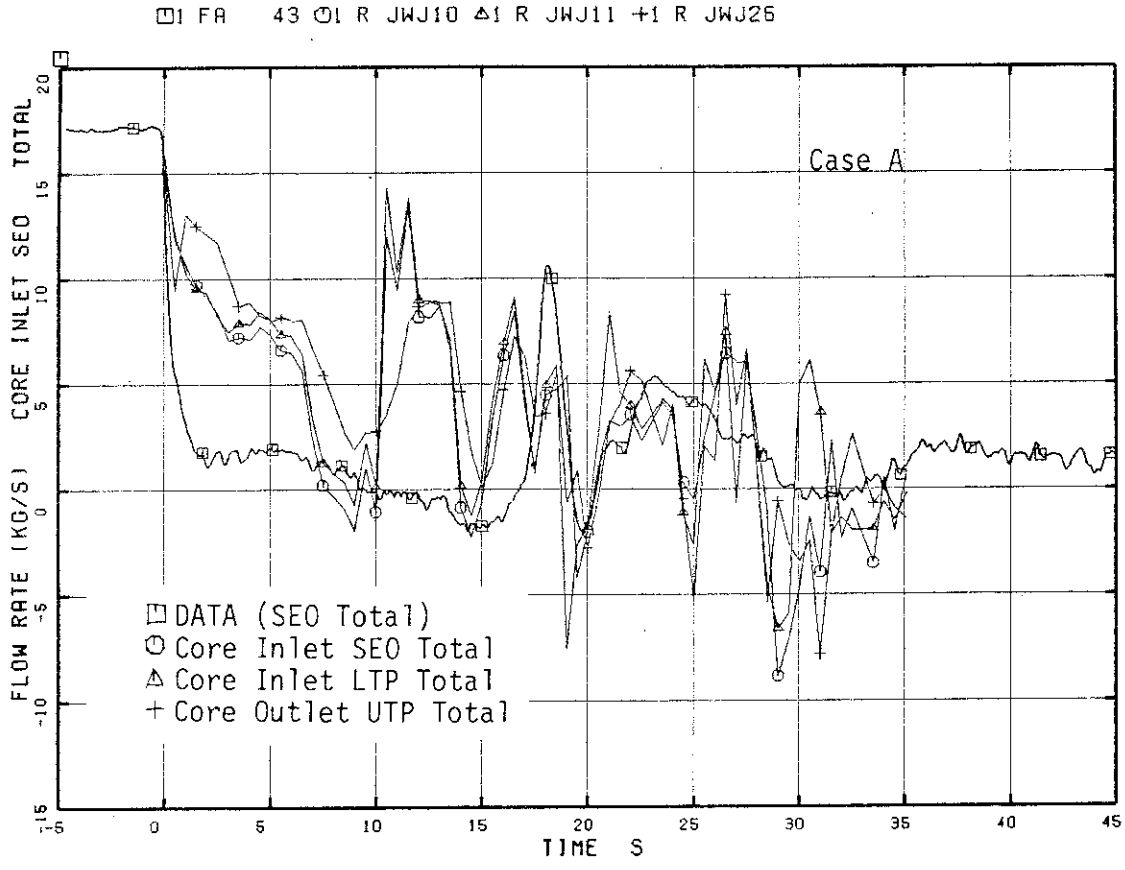


Fig. 4.41 Total Flow Rate through SEO, LTP and UTP (Case A)

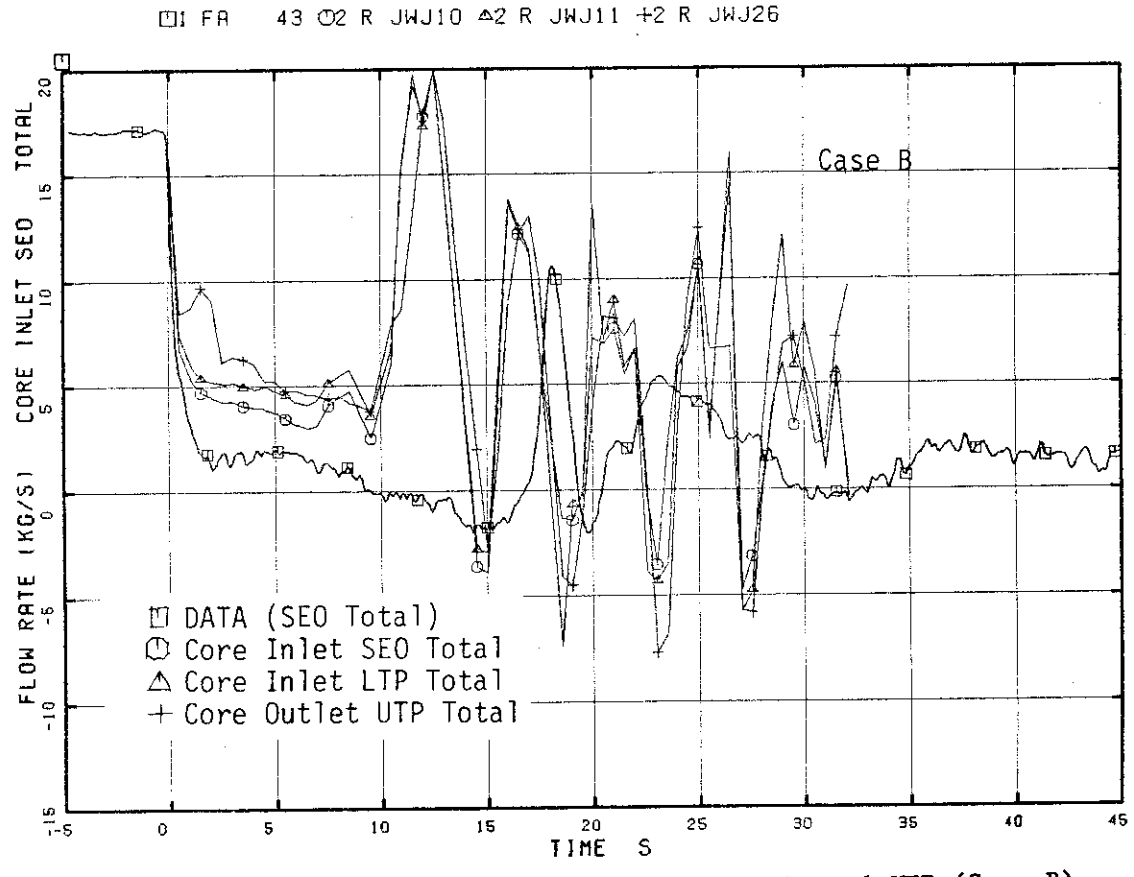


Fig. 4.42 Total Flow Rate through SEO, LTP and UTP (Case B)

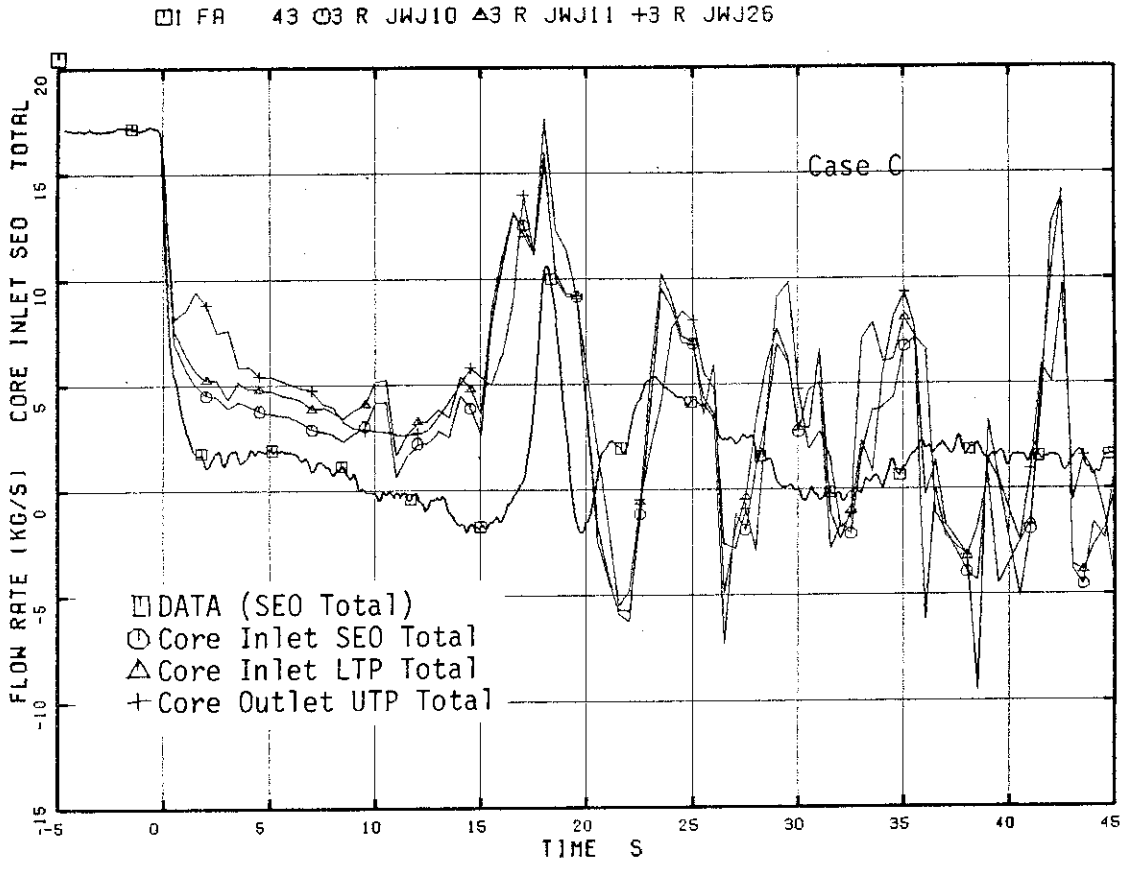


Fig. 4.43 Total Flow Rate through SEO, LTP and UTP (Case C)

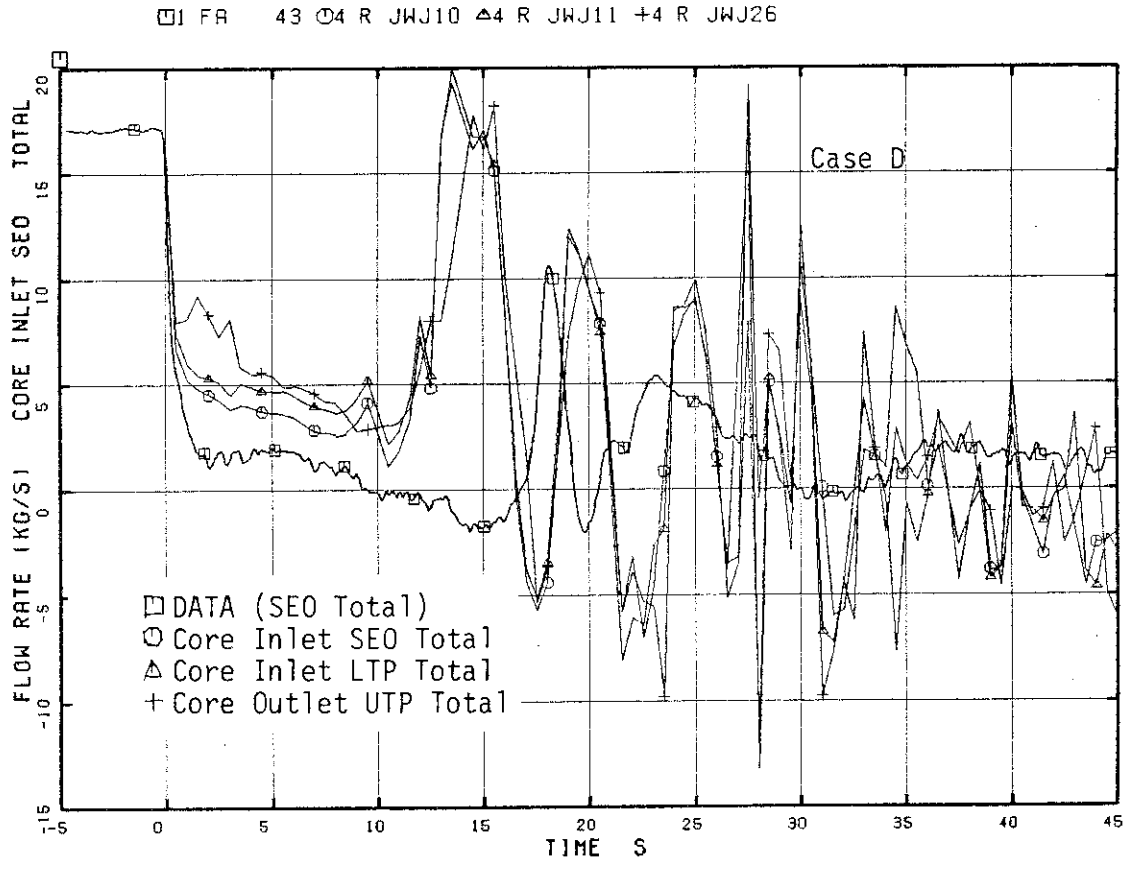


Fig. 4.44 Total Flow Rate through SEO, LTP snd UTP (Case D)

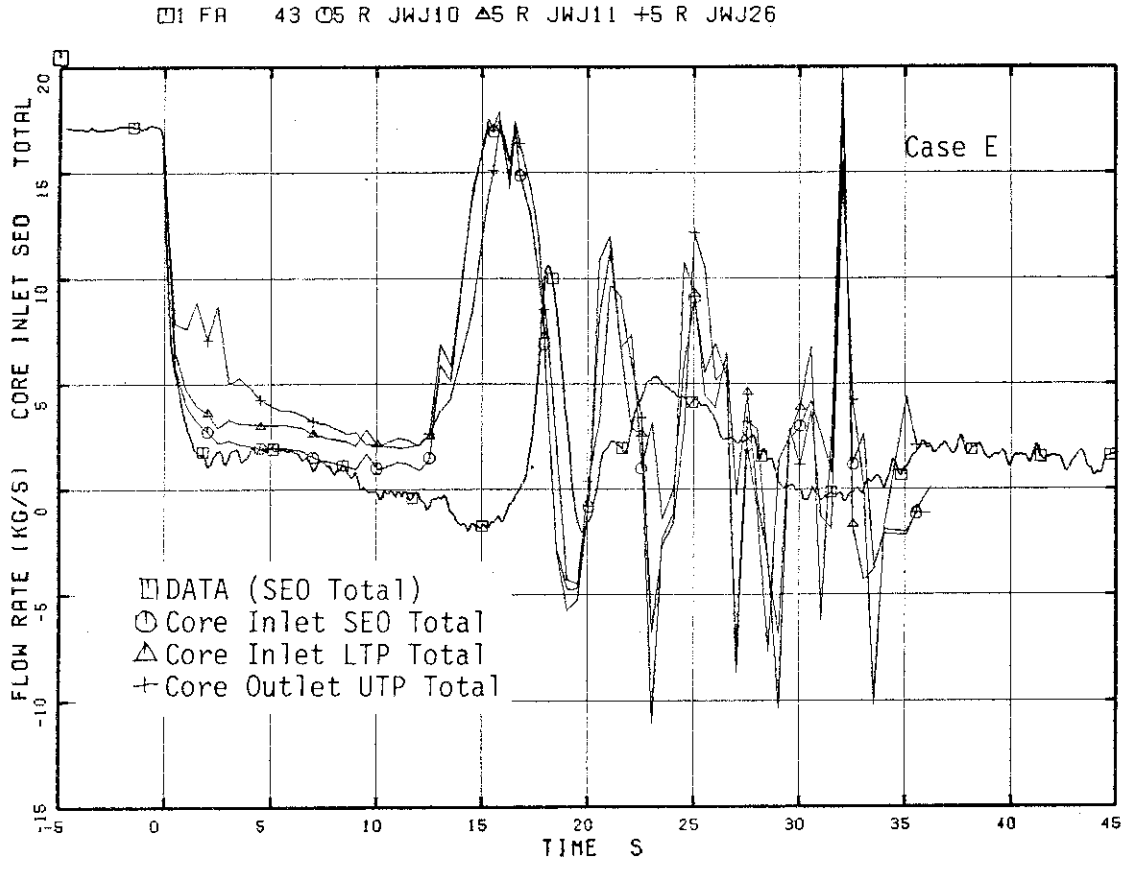


Fig. 4.45 Total Flow Rate through SEO, LTP and UTP (Case E)

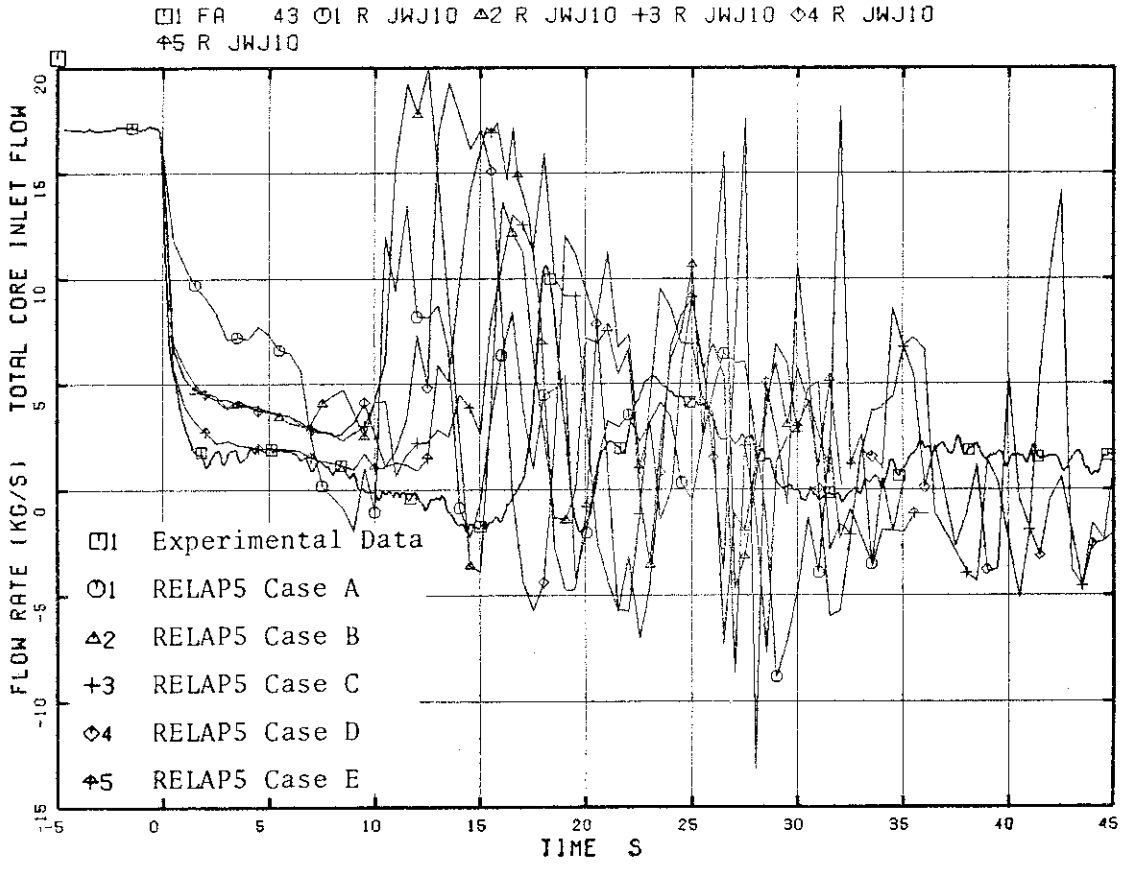


Fig. 4.46 Comparison of Total Flow Rates through SEO

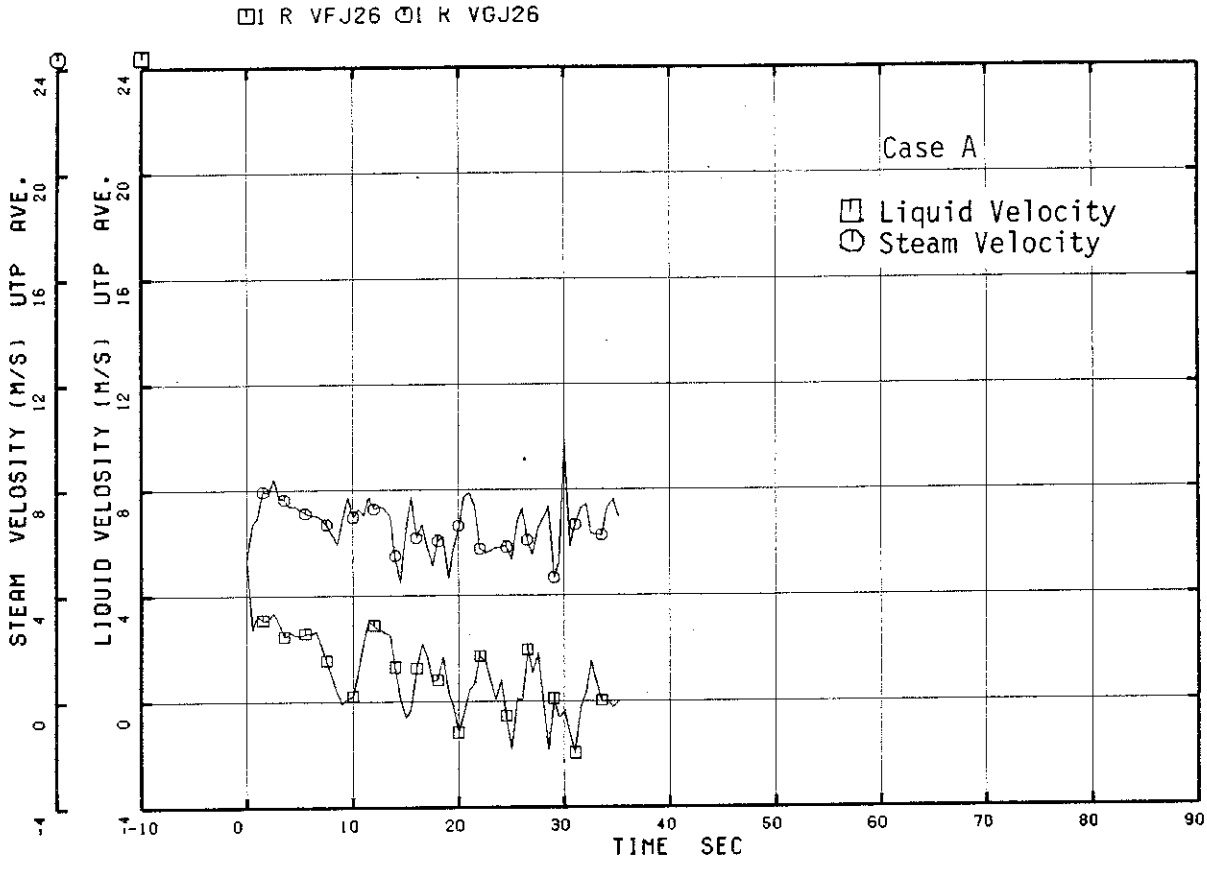


Fig. 4.47 Fluid Velocities through UTP of Average Power Channel (Case A)

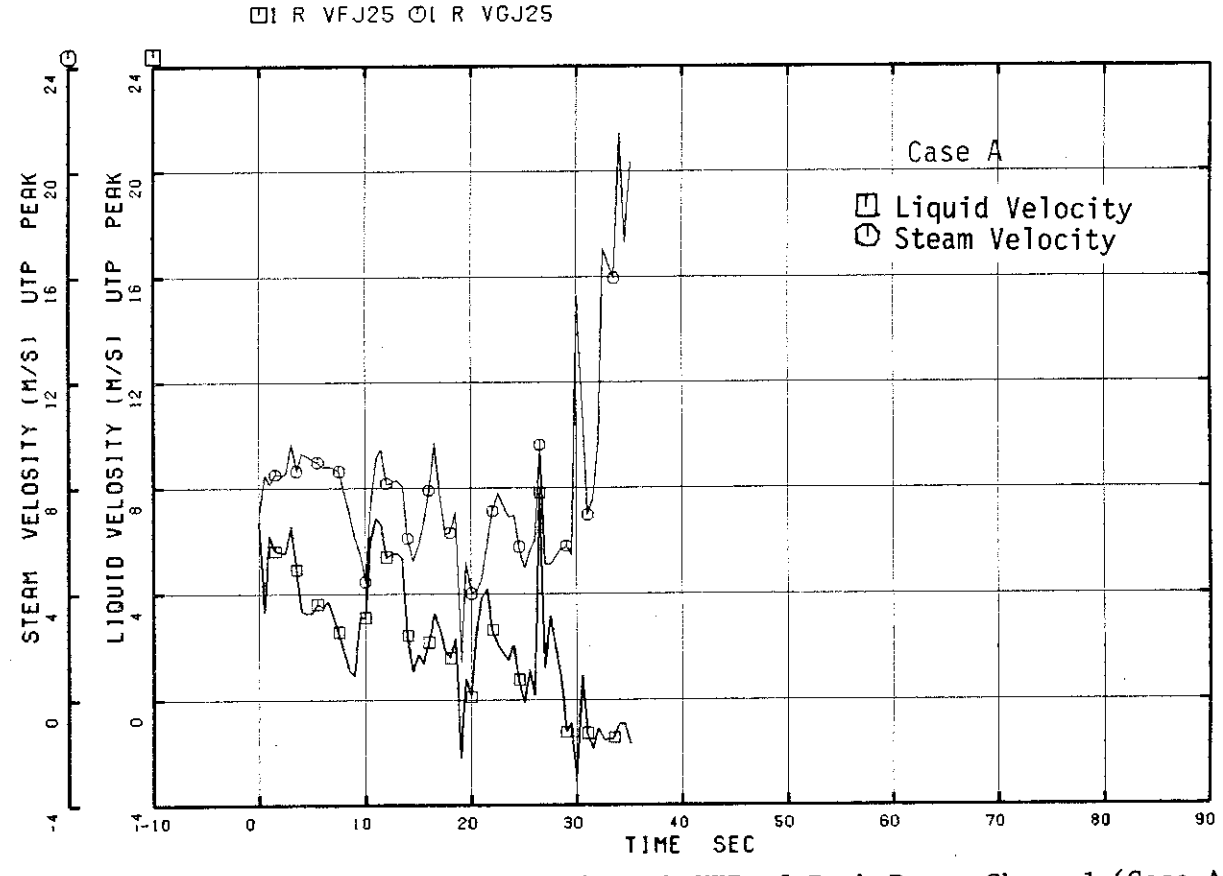


Fig. 4.48 Fluid Velocities through UTP of Peak Power Channel (Case A)

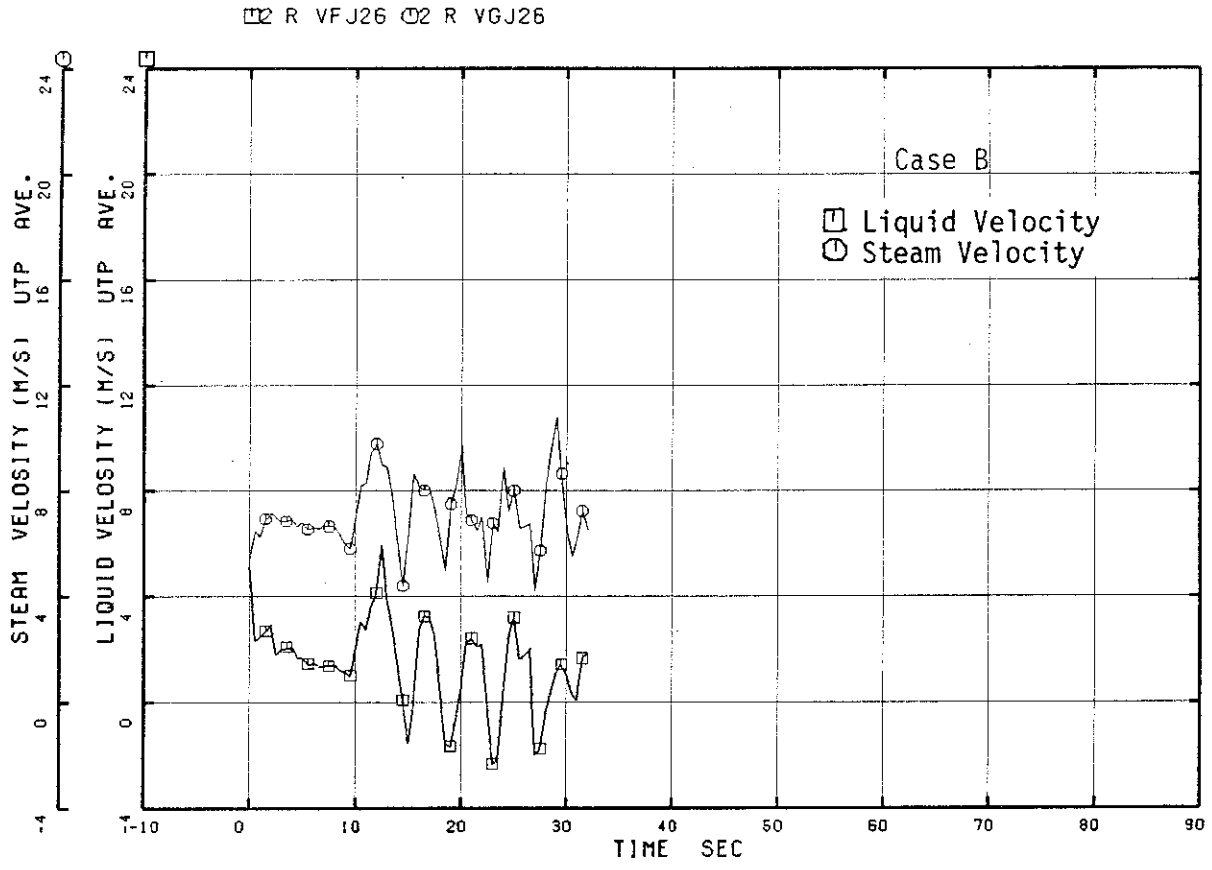


Fig. 4.49 Fluid Velocities through UTP of Average Power Channel (Case B)

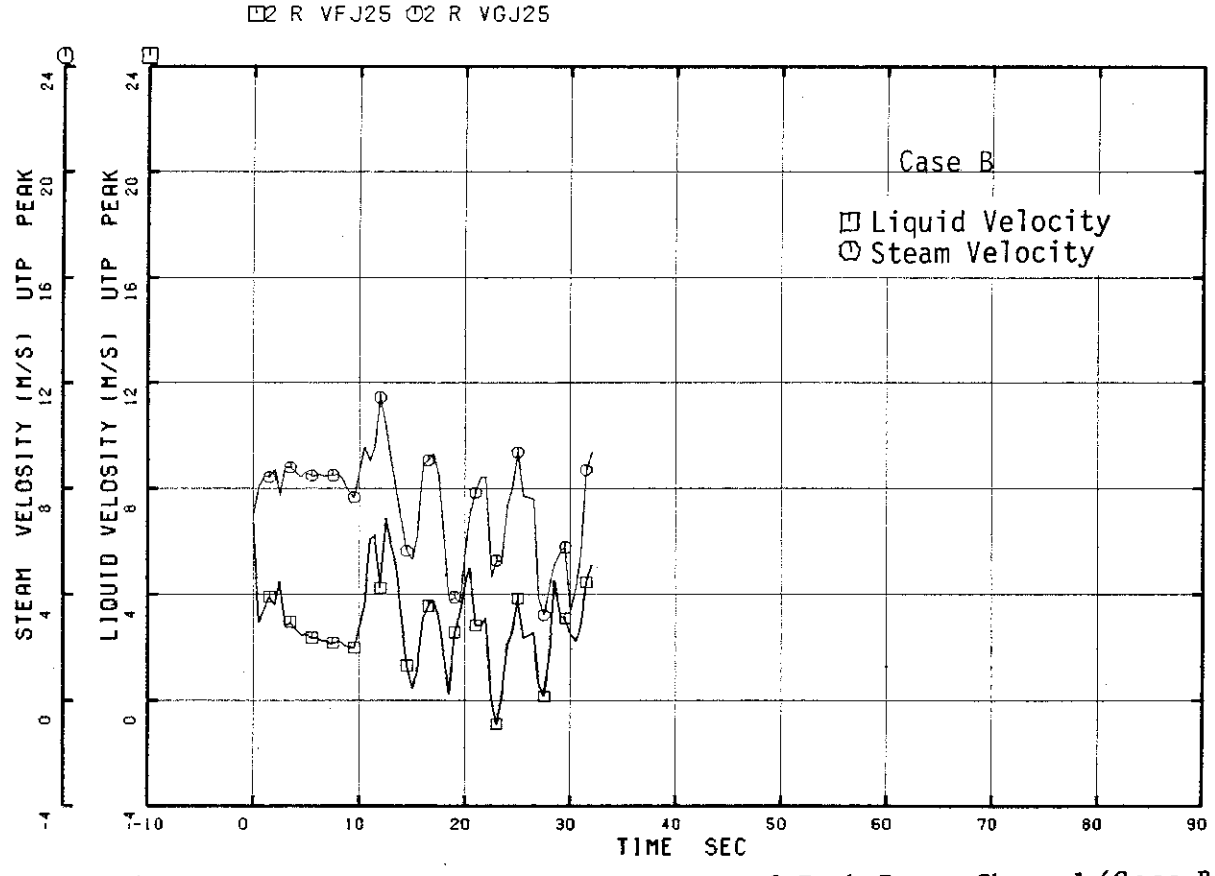


Fig. 4.50 Fluid Velocities through UTP of Peak Power Channel (Case B)

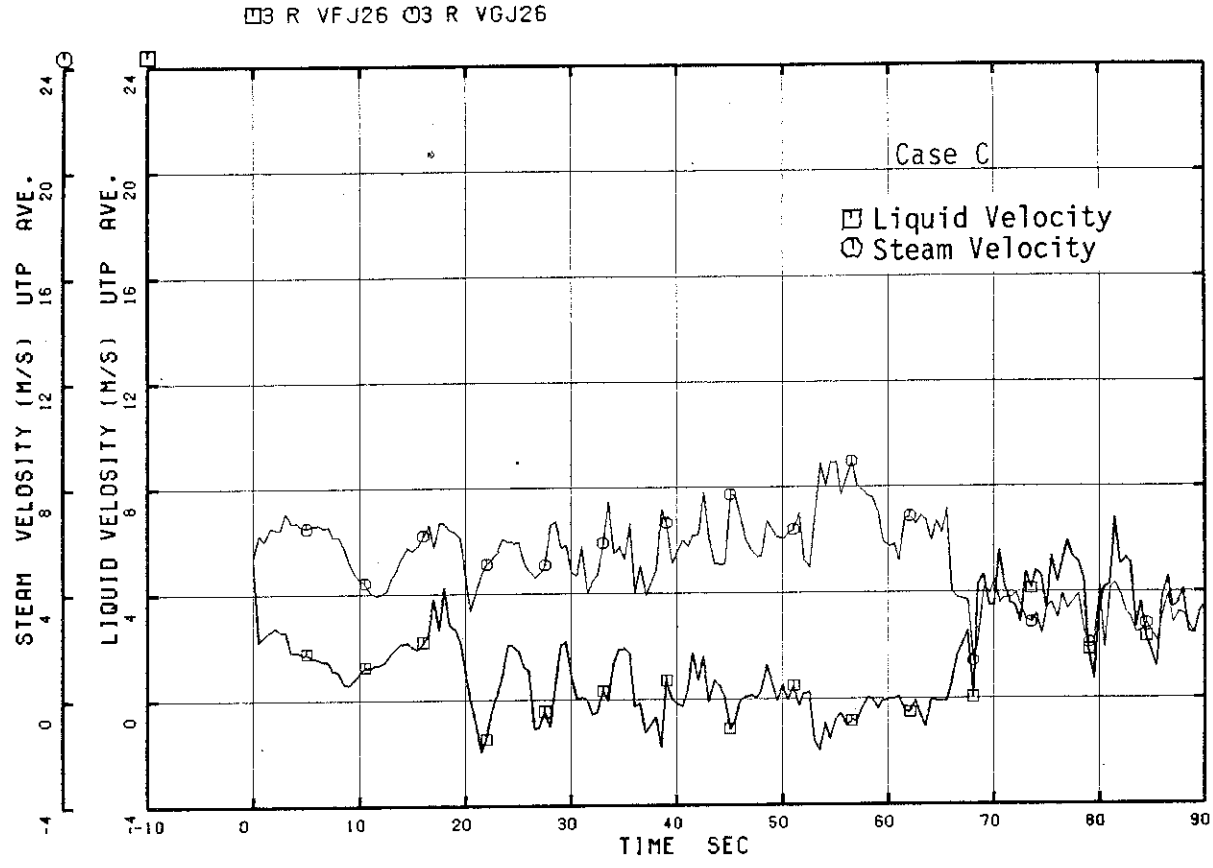


Fig. 4.51 Fluid Velocities through UTP of Average Power Channel (Case C)

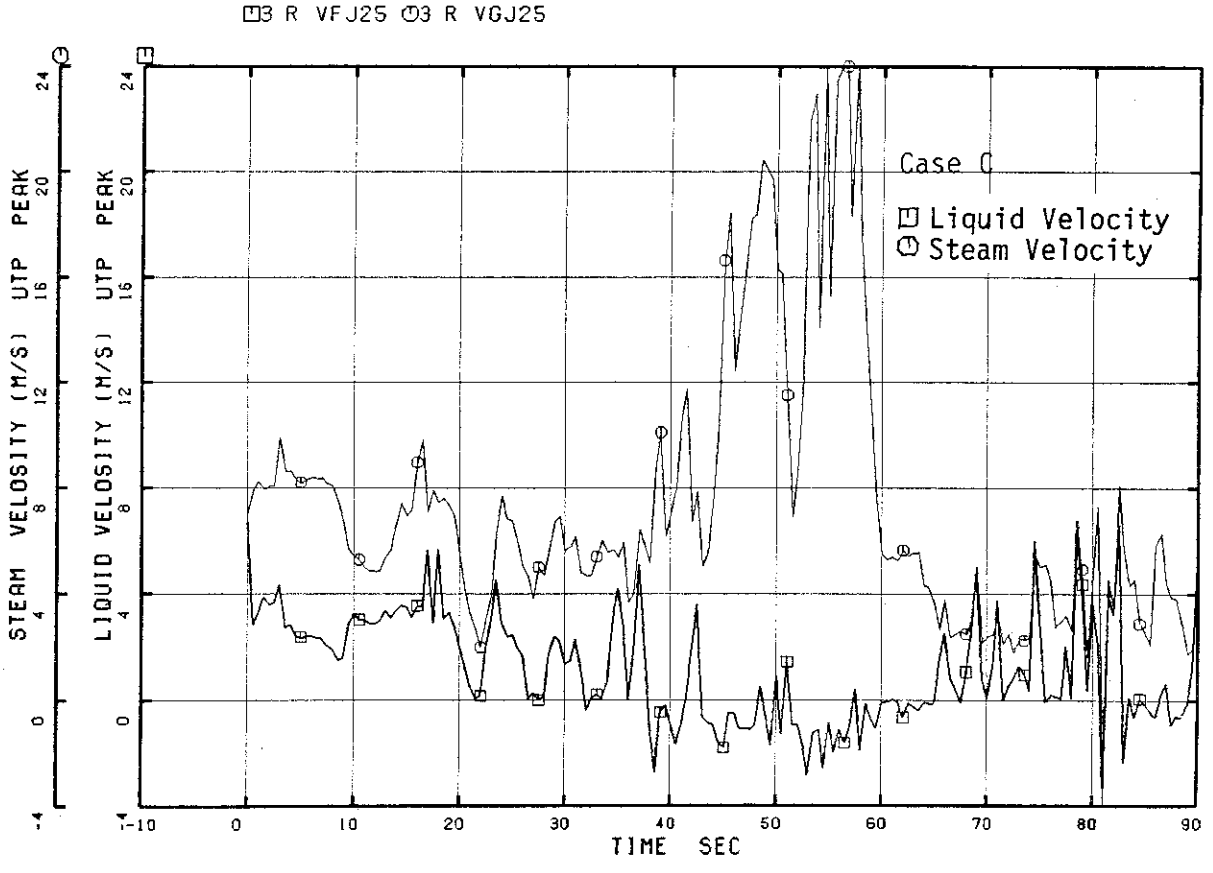


Fig. 4.52 Fluid Velocities through UTP of Peak Power Channel (Case C)

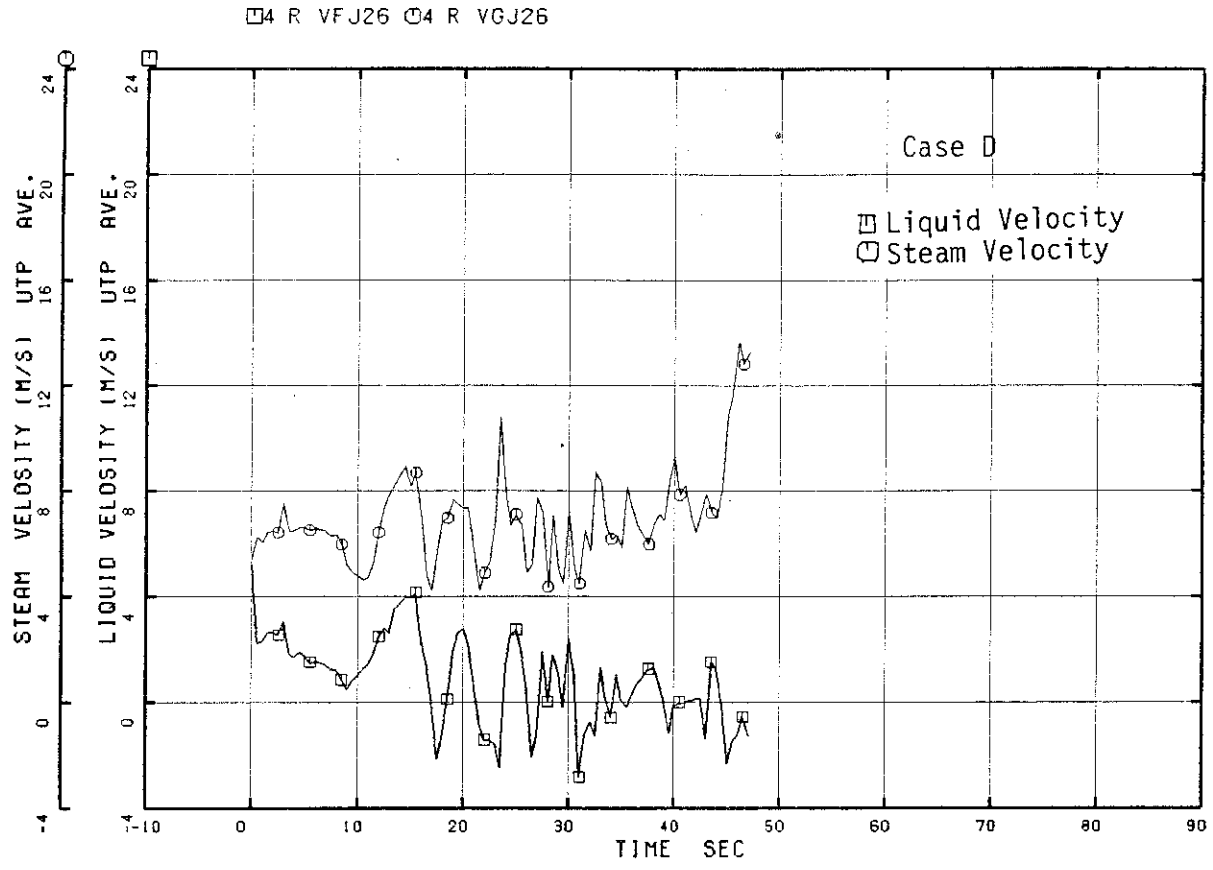


Fig. 4.53 Fluid Velocities through UTP of Average Power Channel (Case D)

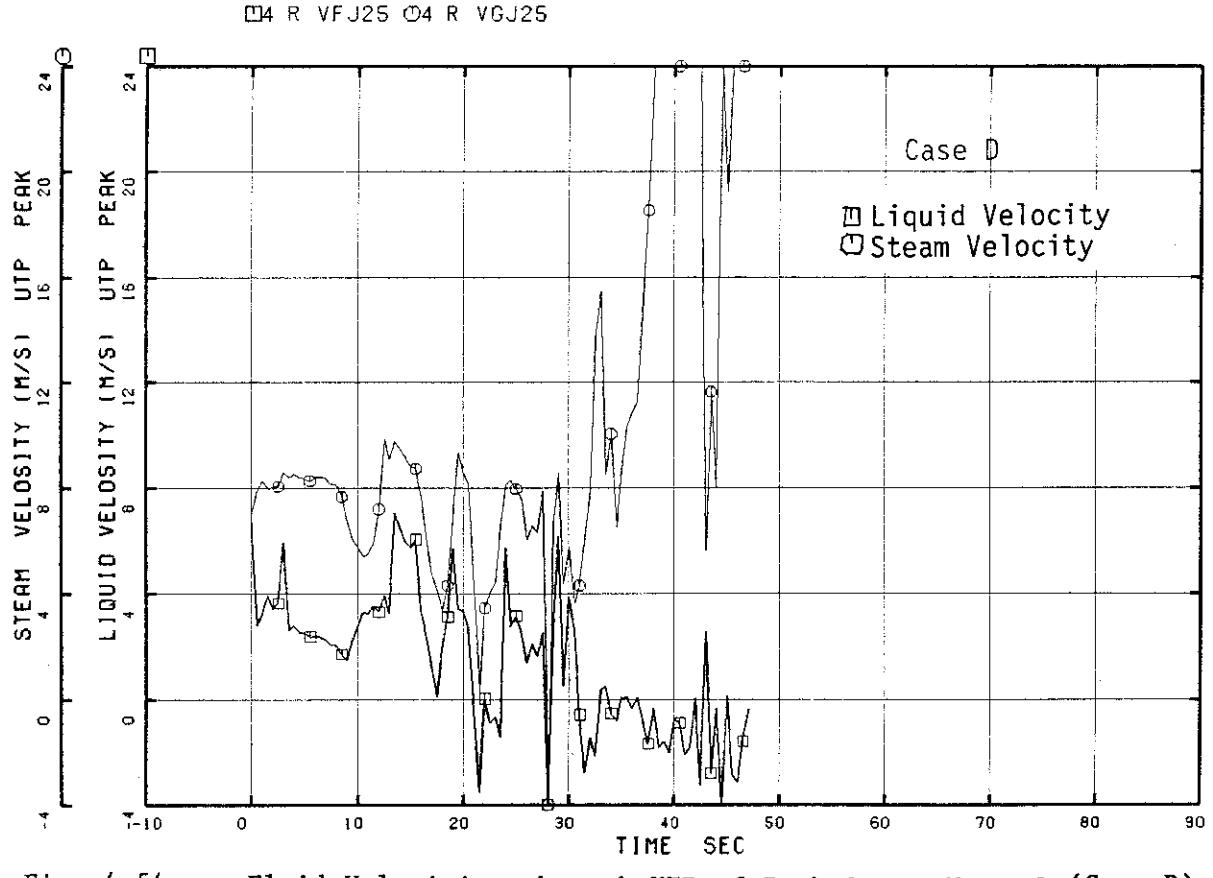


Fig. 4.54 Fluid Velocities through UTP of Peak Power Channel (Case D)

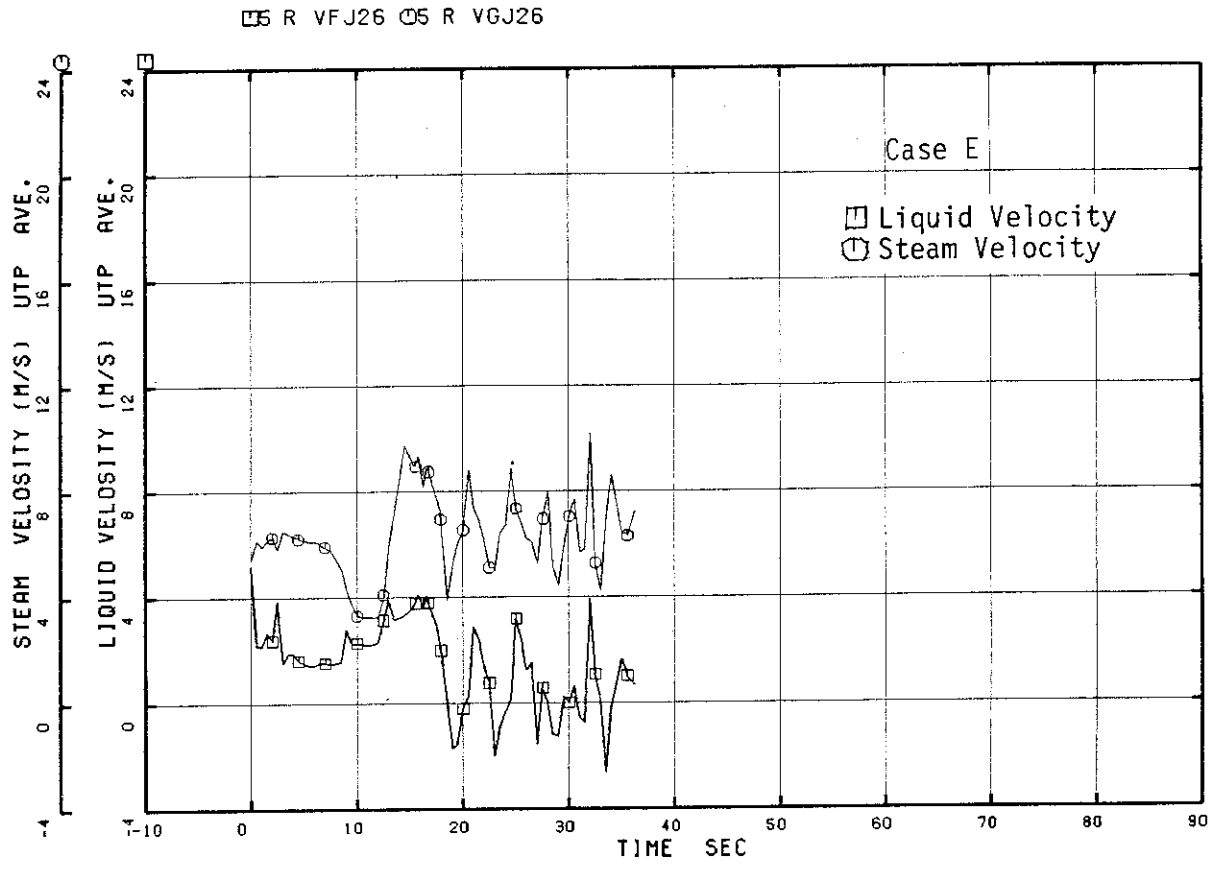


Fig. 4.55 Fluid Velocities through UTP of Average Power Channel (Case E)

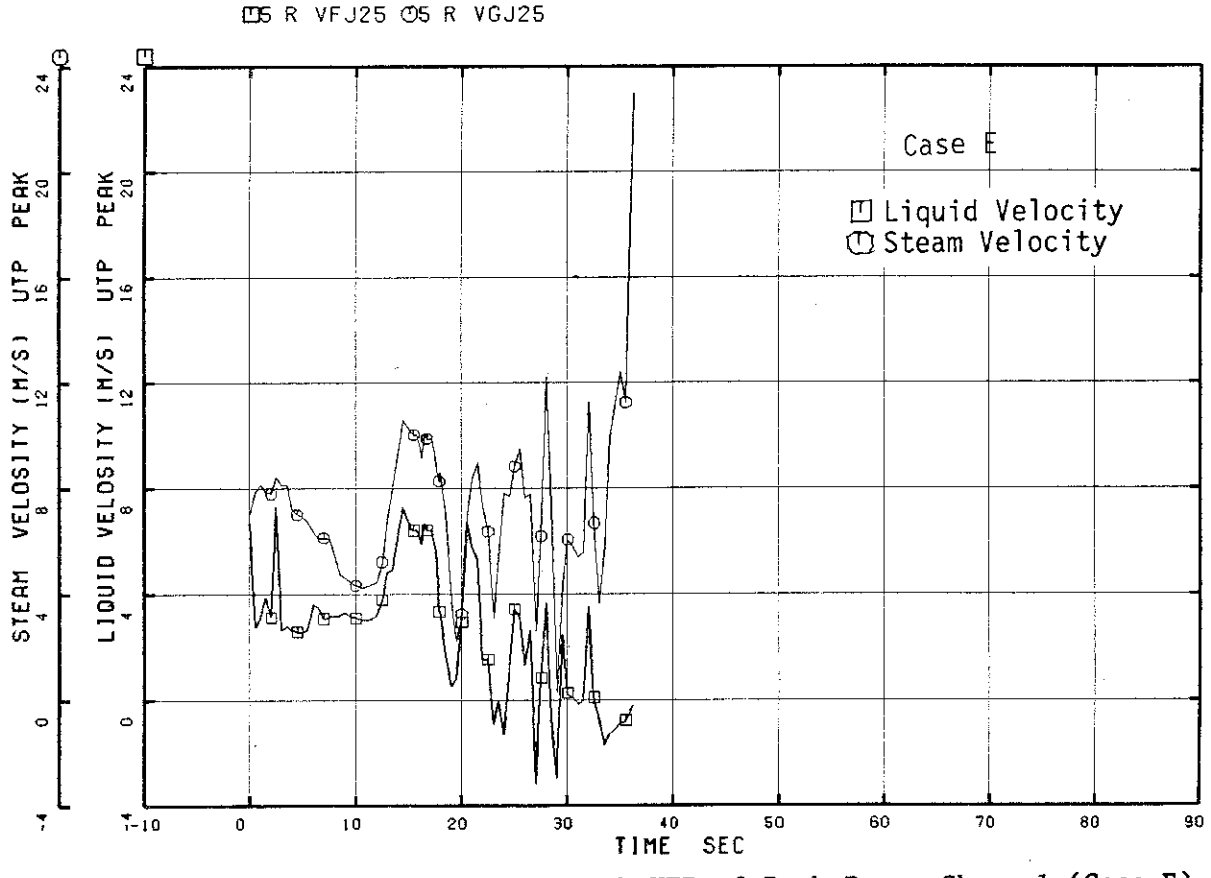


Fig. 4.56 Fluid Velocities through UTP of Peak Power Channel (Case E)

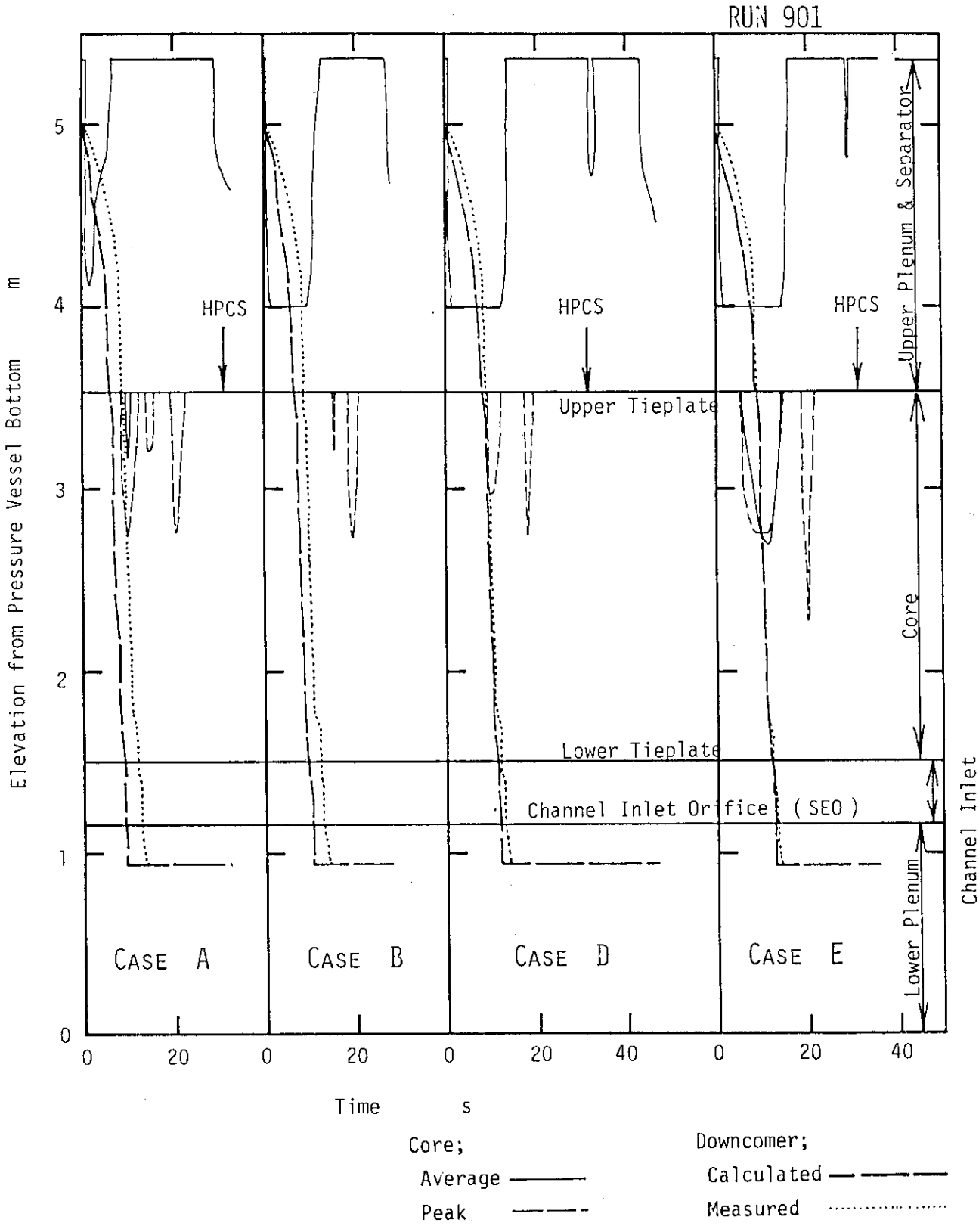


Fig. 4.57 Estimated Liquid Levels in PV (Cases A, B, D and E)

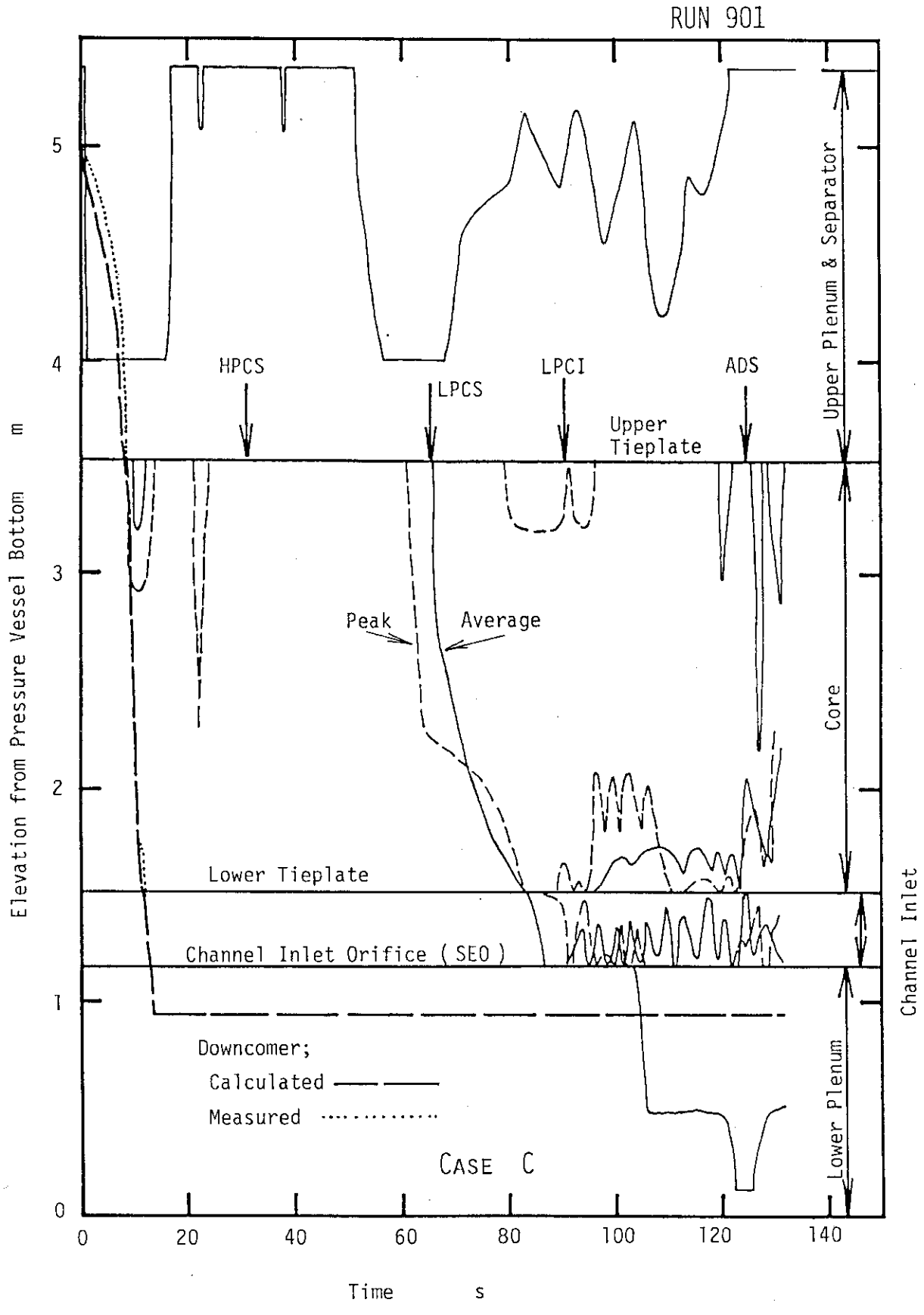


Fig. 4.58 Estimated Liquid Levels in PV (Case C)

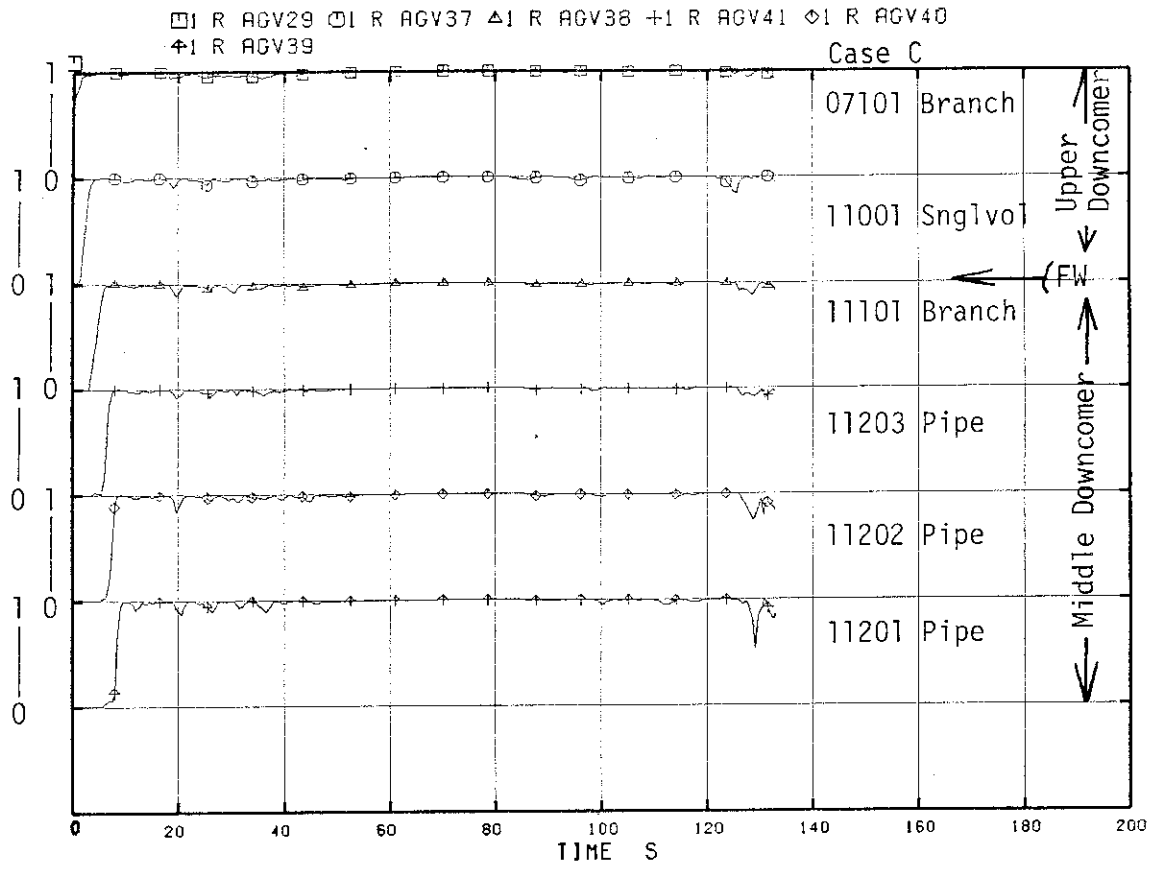


Fig. 4.59 Void Fractions in Upper Downcomer (Case C)

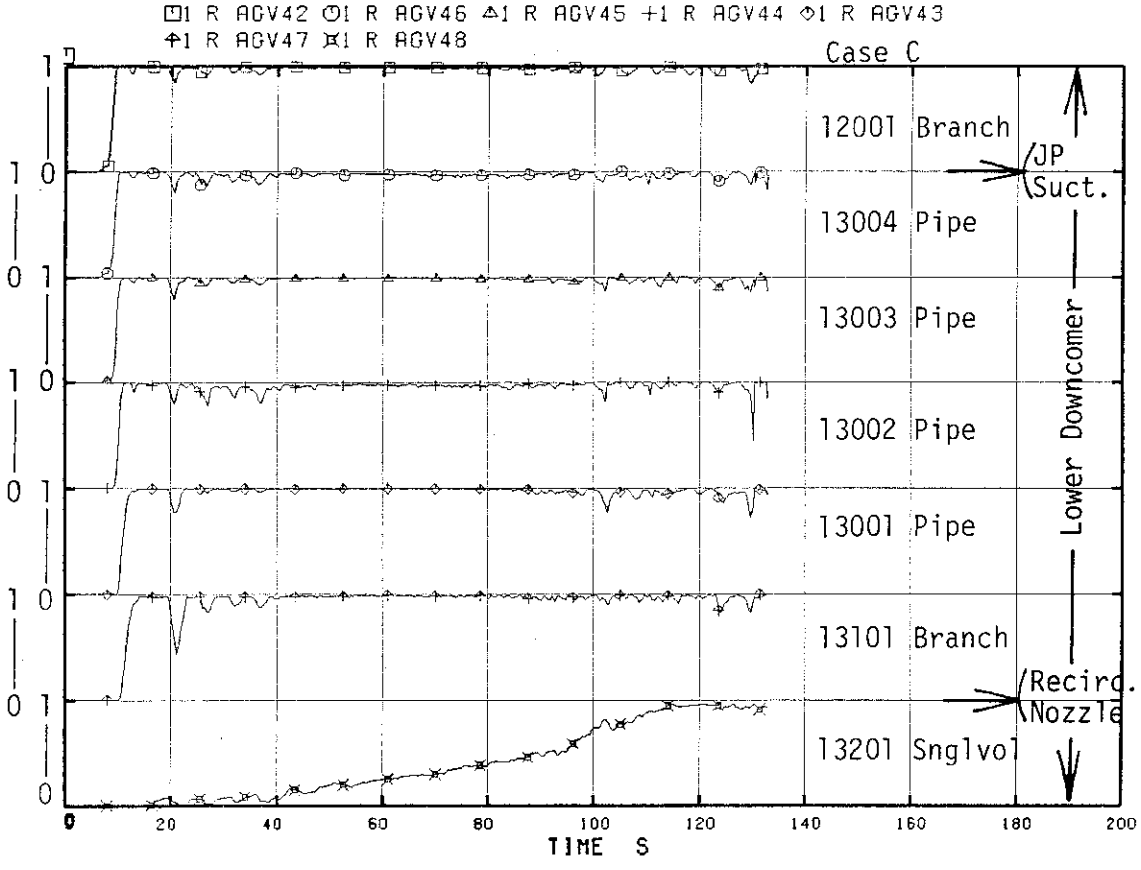


Fig. 4.60 Void Fractions in Lower Downcomer (Case C)

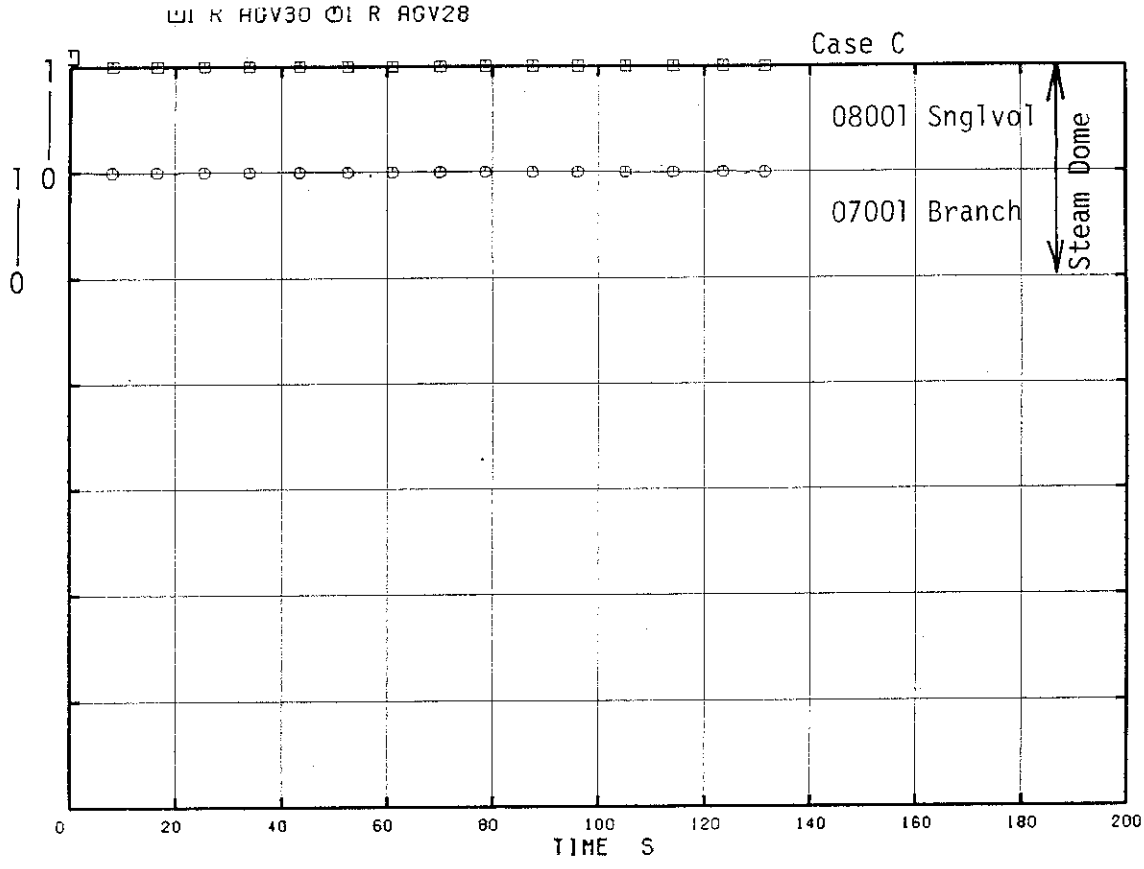


Fig. 4.61 Void Fractions in Steam Dome (Case C)

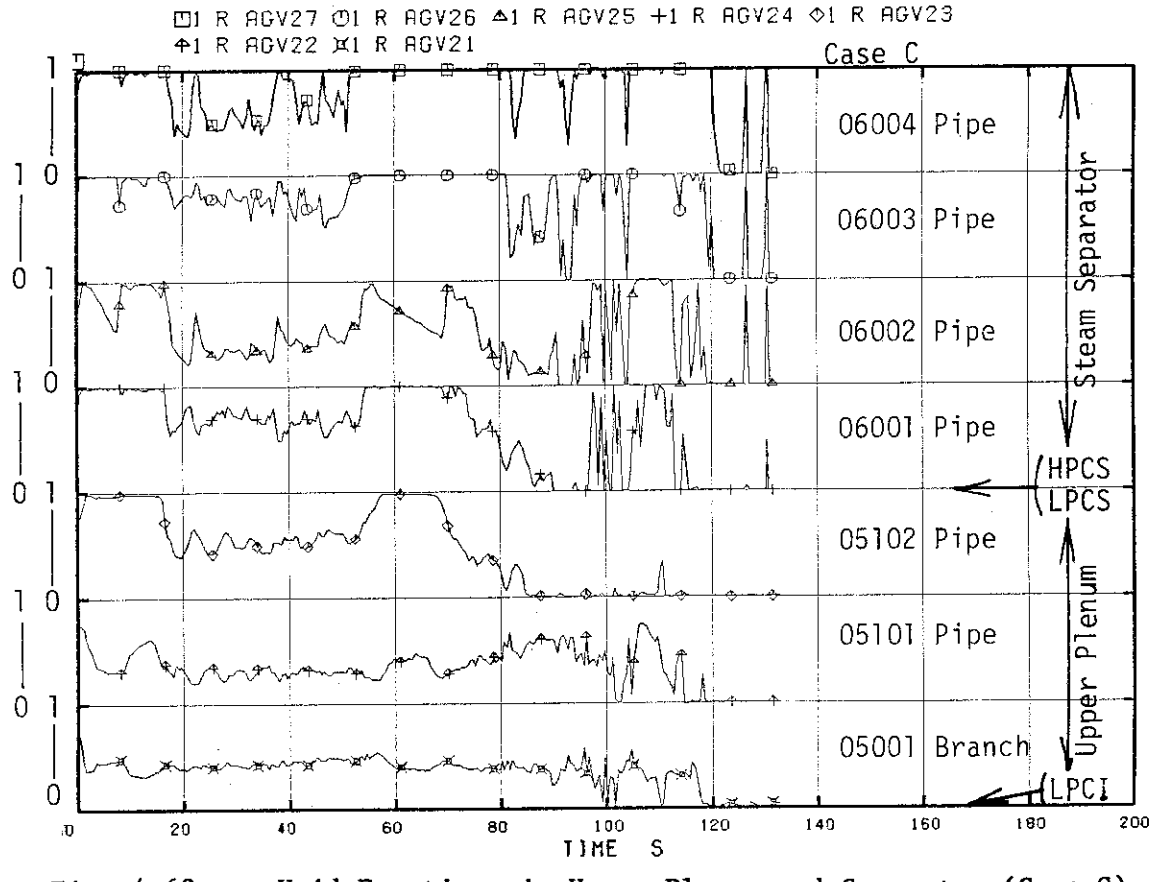


Fig. 4.62 Void Fractions in Upper Plenum and Separator (Case C)

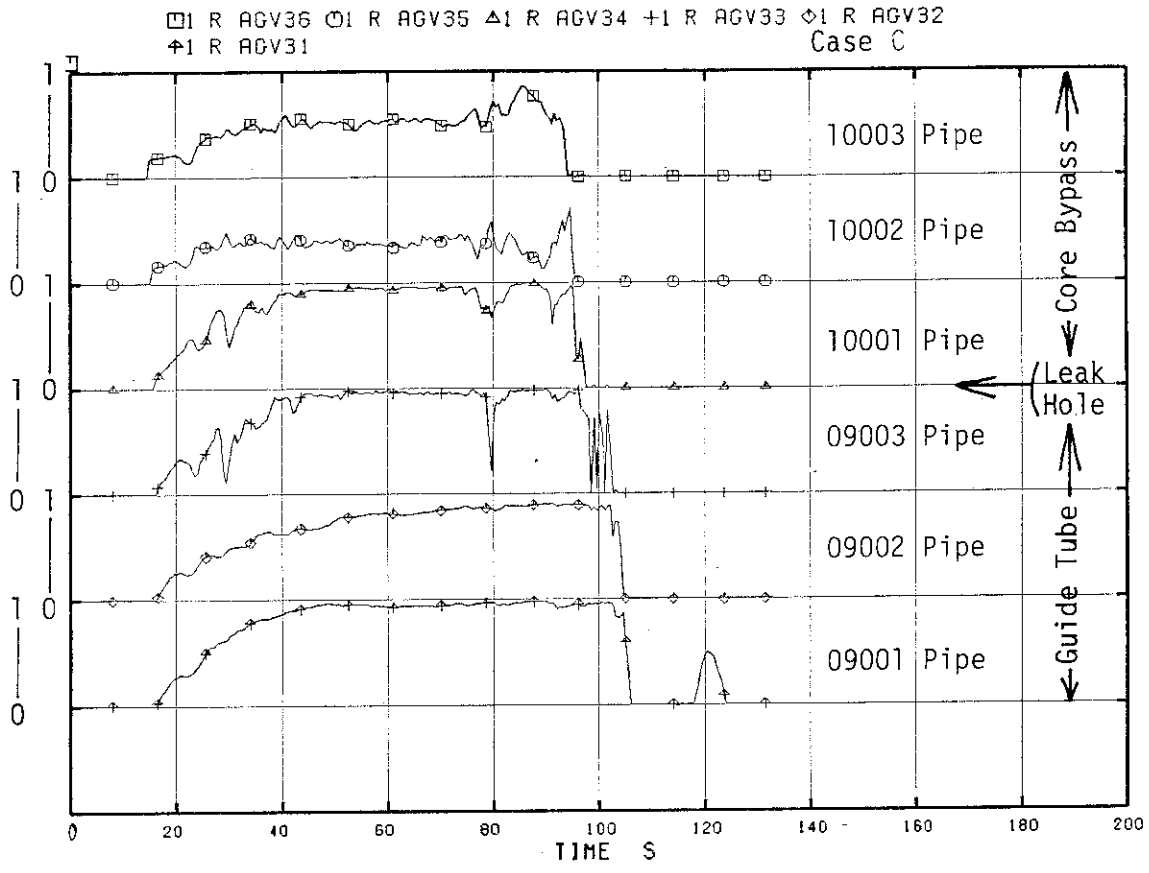


Fig. 4.63 Void Fractions in Bypass and Guide Tube (Case C)

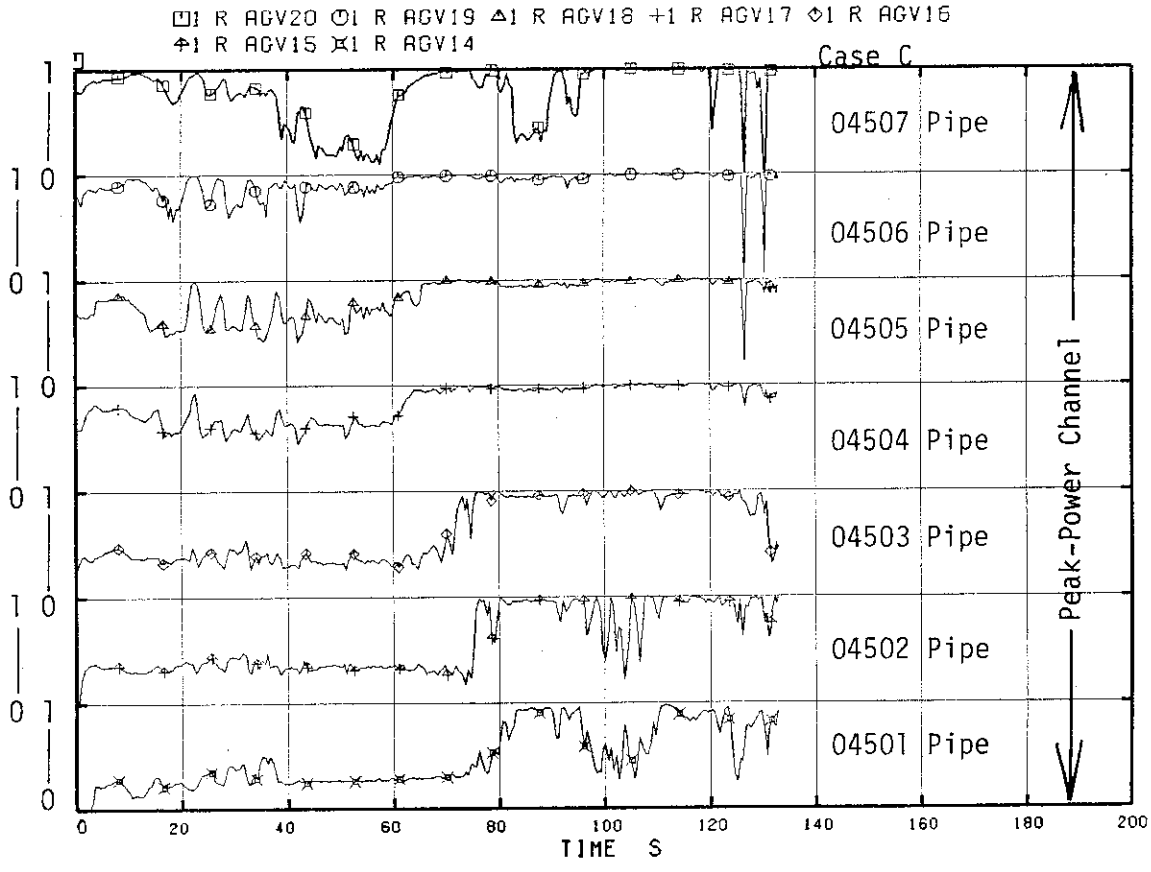


Fig. 4.64 Void Fractions in Peak-Power Channel (Case C)

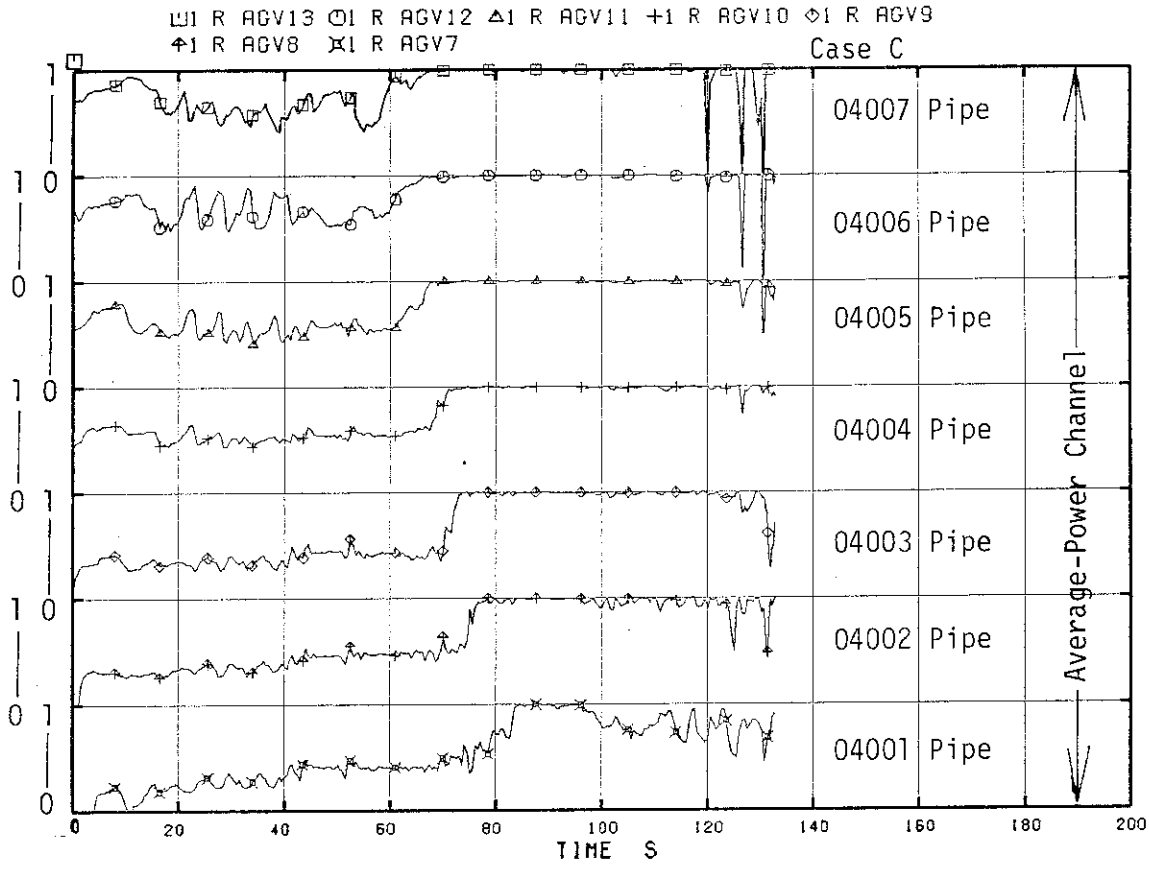


Fig. 4.65 Void Fractions in Average-Power Channel (Case C)

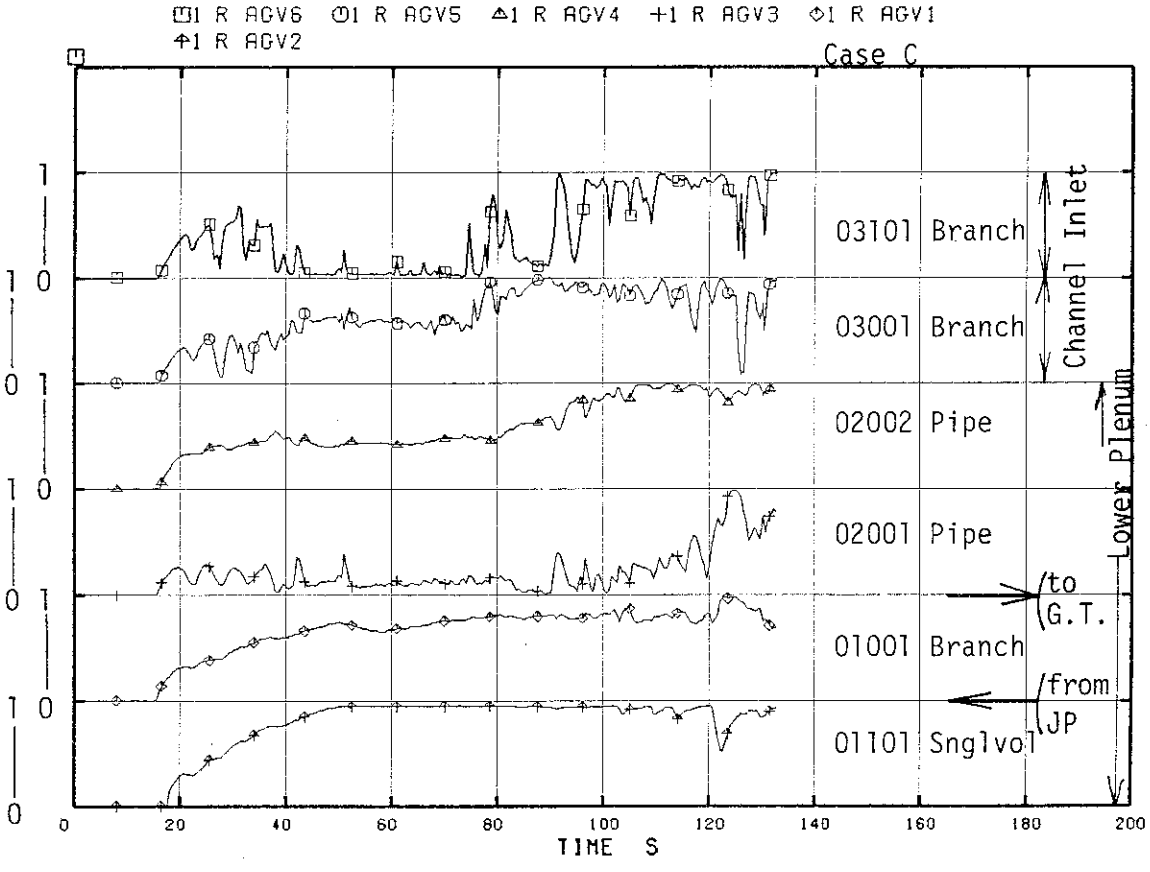


Fig. 4.66 Void Fractions in Lower Plenum (Case C)

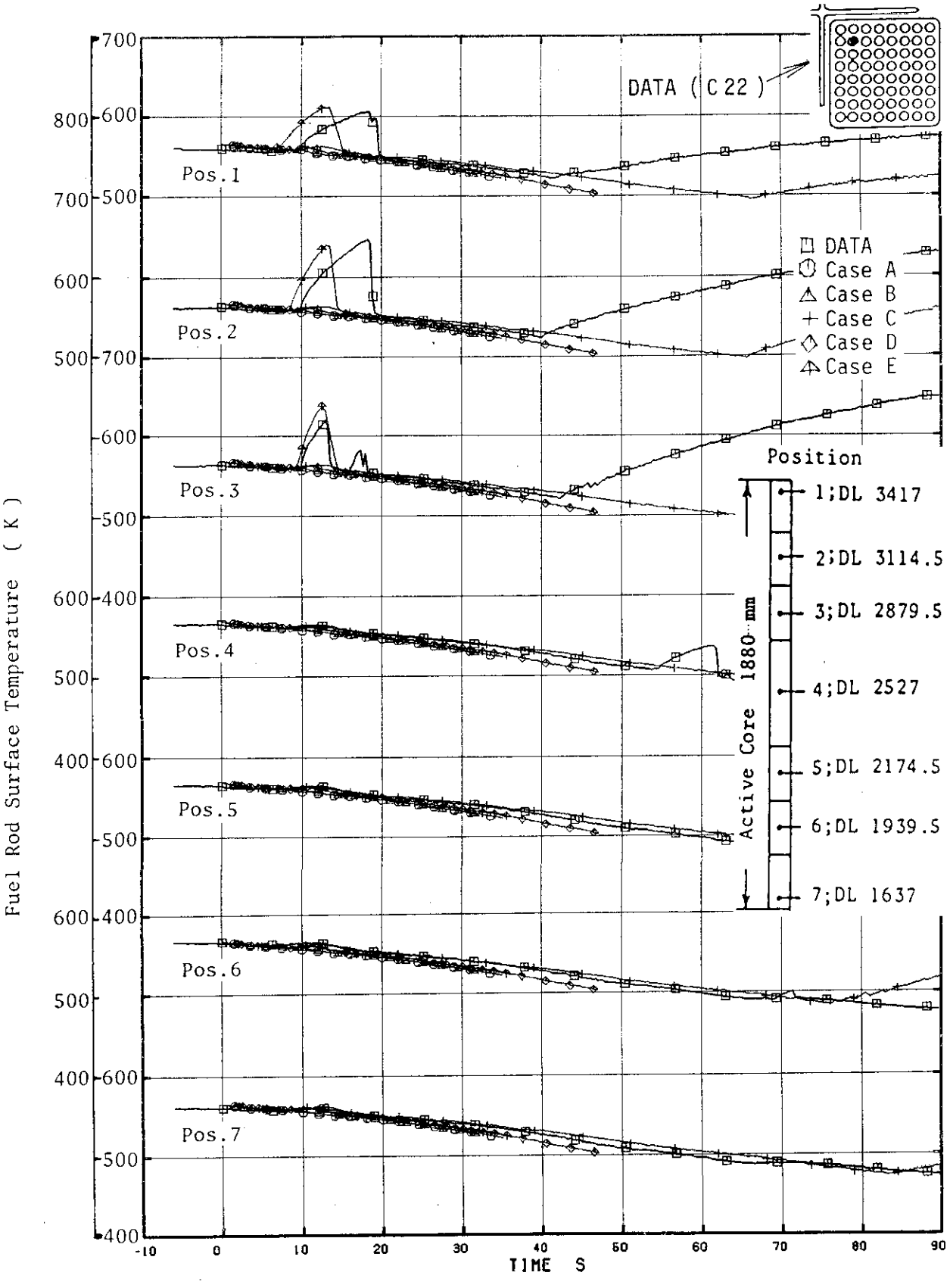


Fig. 4.67 Fuel Surface Temperatures (Average-Power Channel)

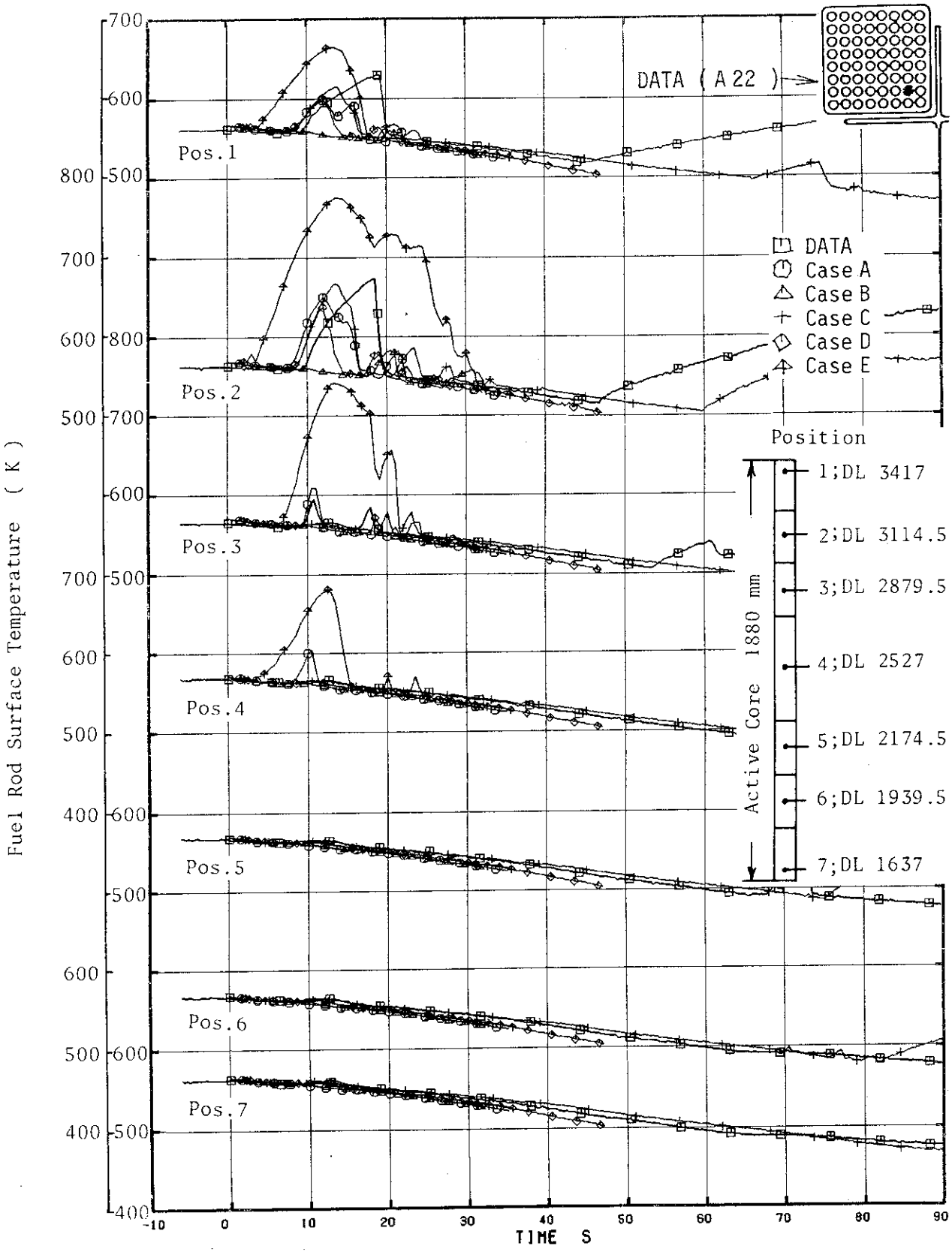


Fig. 4.68 Fuel Surface Temperatures (Peak-Power Channel)

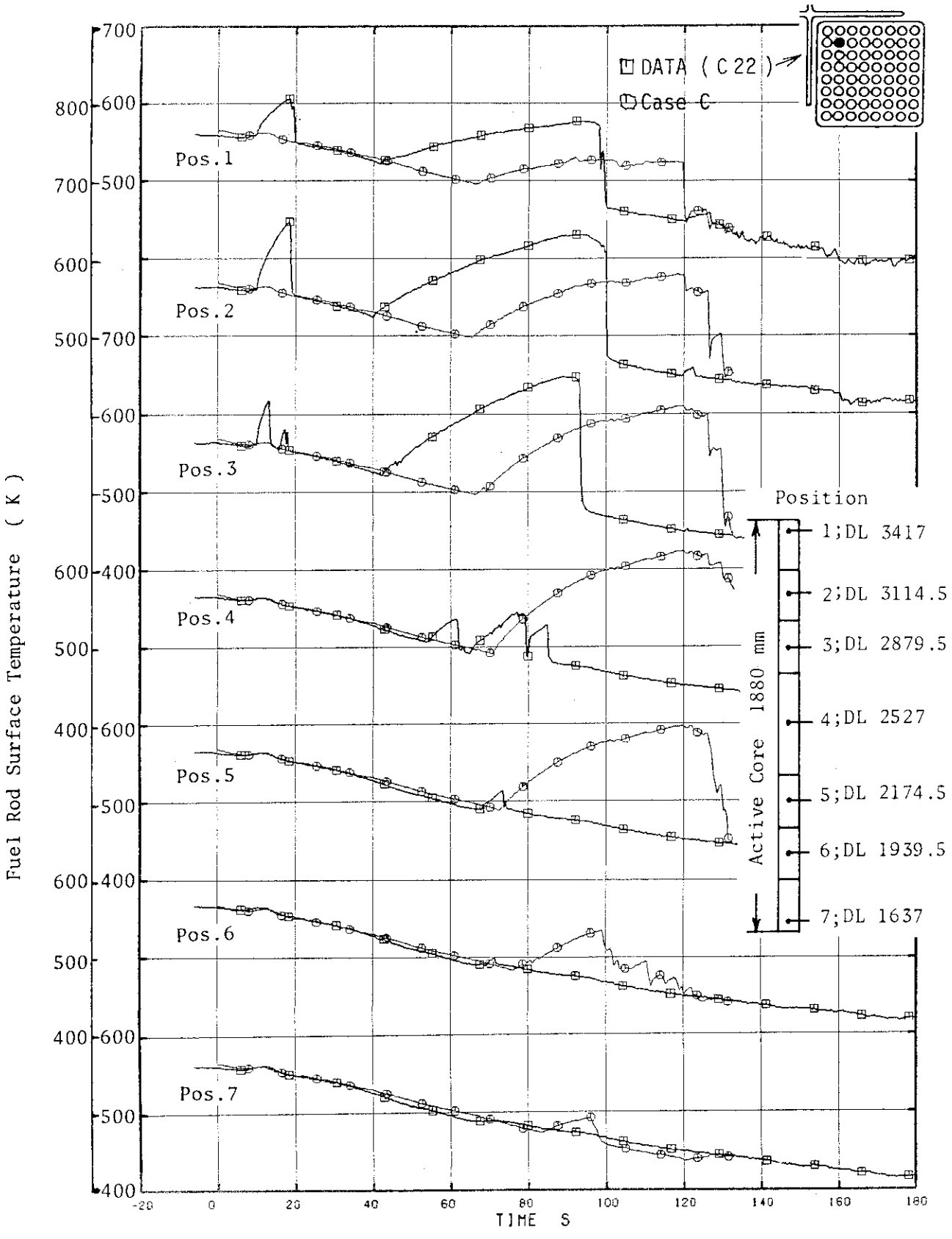


Fig. 4.69 Fuel Surface Temperatures (Average-Power Channel) (Case C)

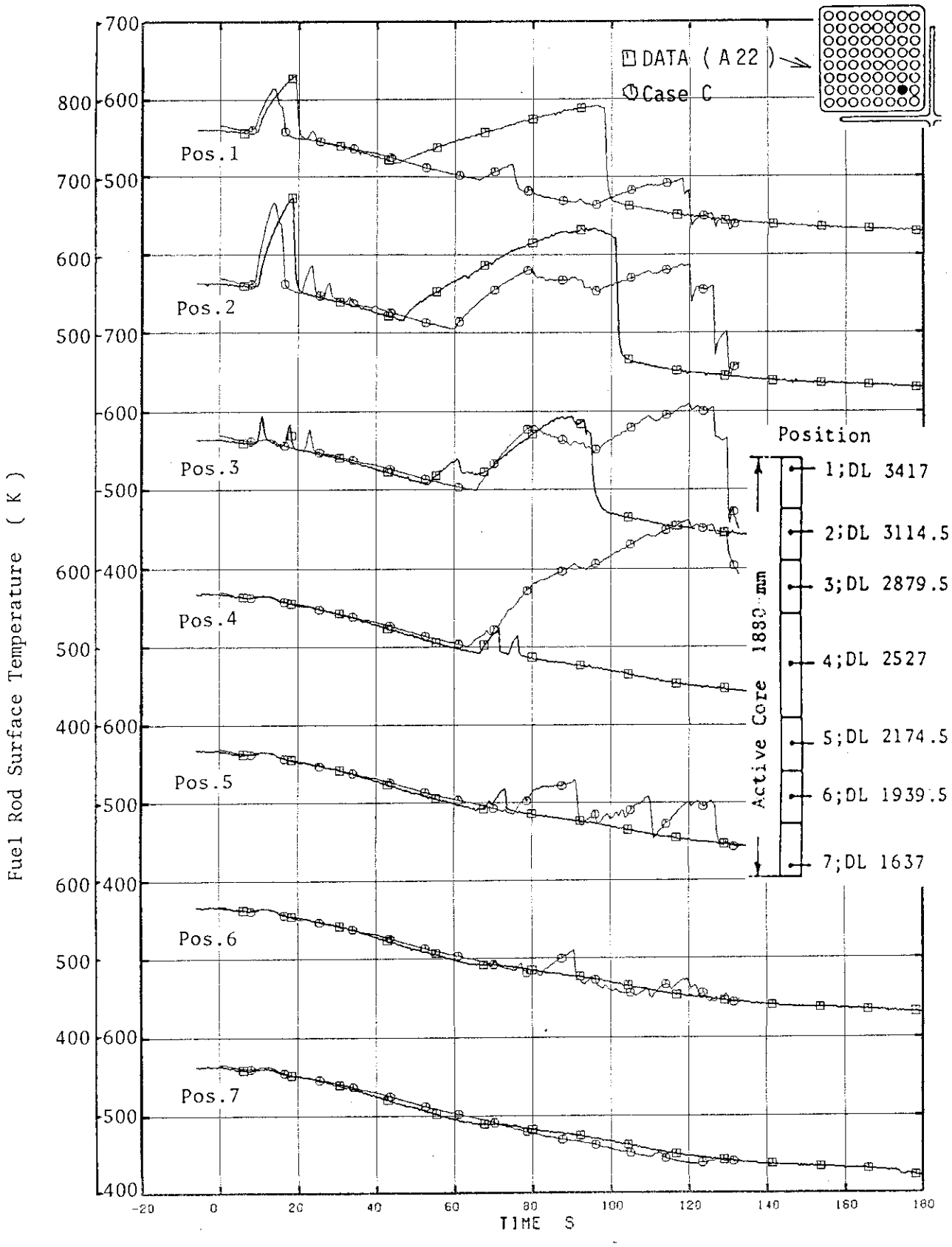


Fig. 4.70 Fuel Surface Temperatures (Peak-Power Channel) (Case C)

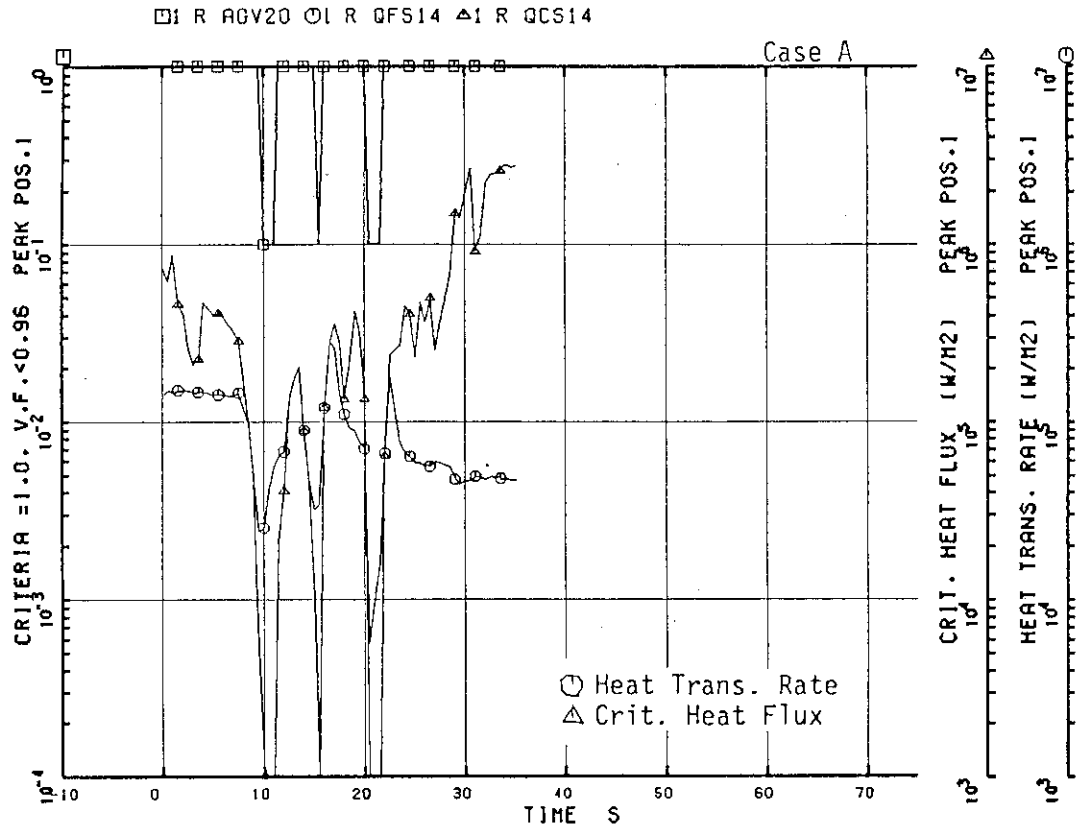


Fig. 4.71 CHF and Heat Transfer Rate at Position 1 in Peak-Power Channel (Case A)

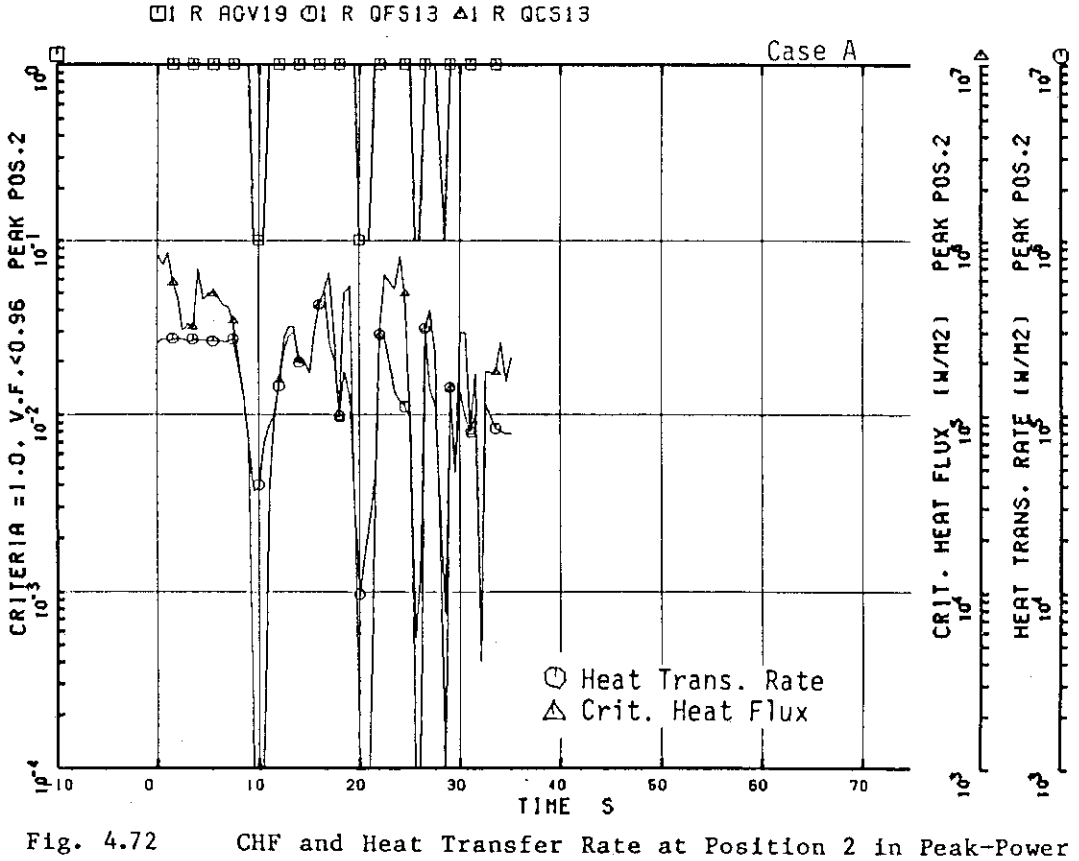


Fig. 4.72 CHF and Heat Transfer Rate at Position 2 in Peak-Power Channel (Case A)

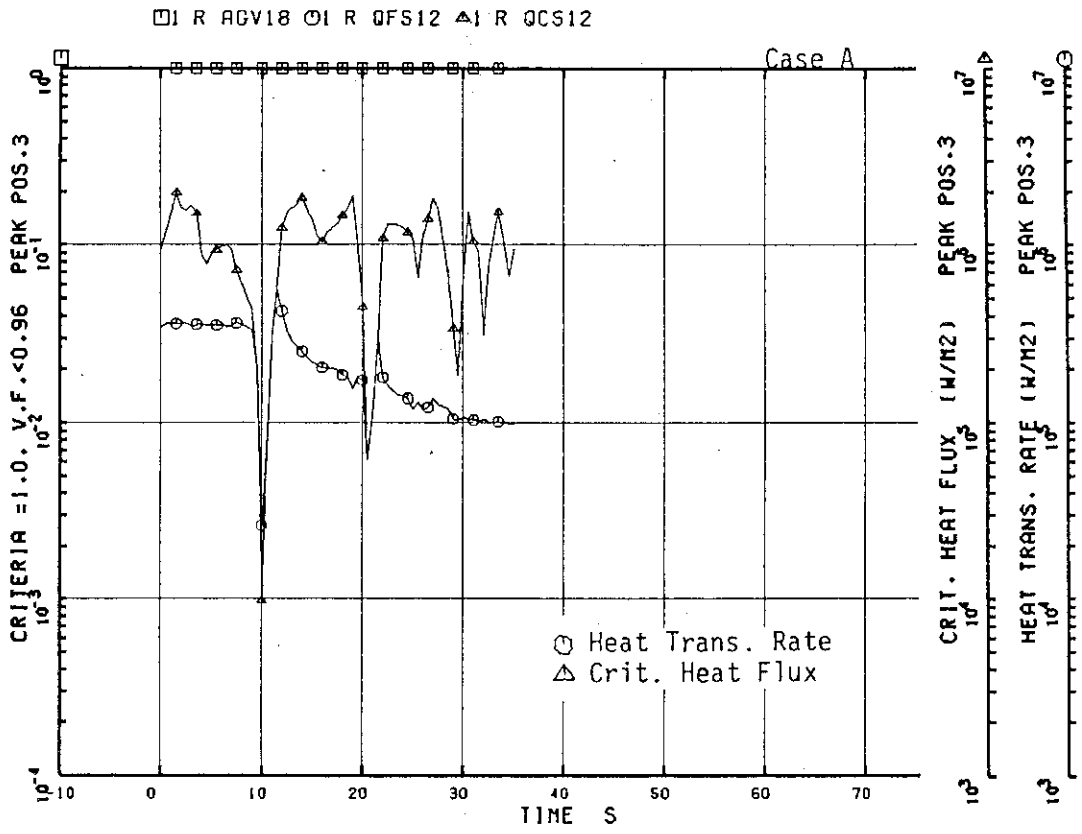


Fig. 4.73 CHF and Heat Transfer Rate at Position 3 in Peak-Power Channel (Case A)

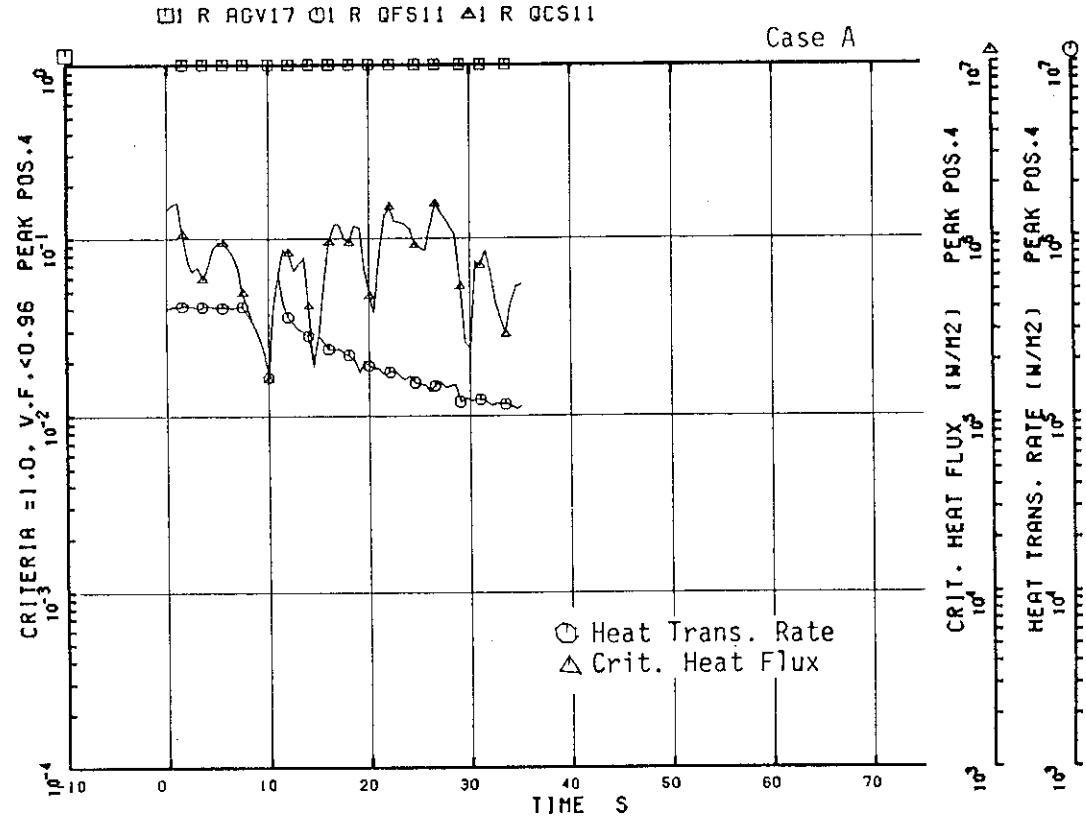


Fig. 4.74 CHF and Heat Transfer Rate at Position 4 in Peak-Power Channel (Case A)

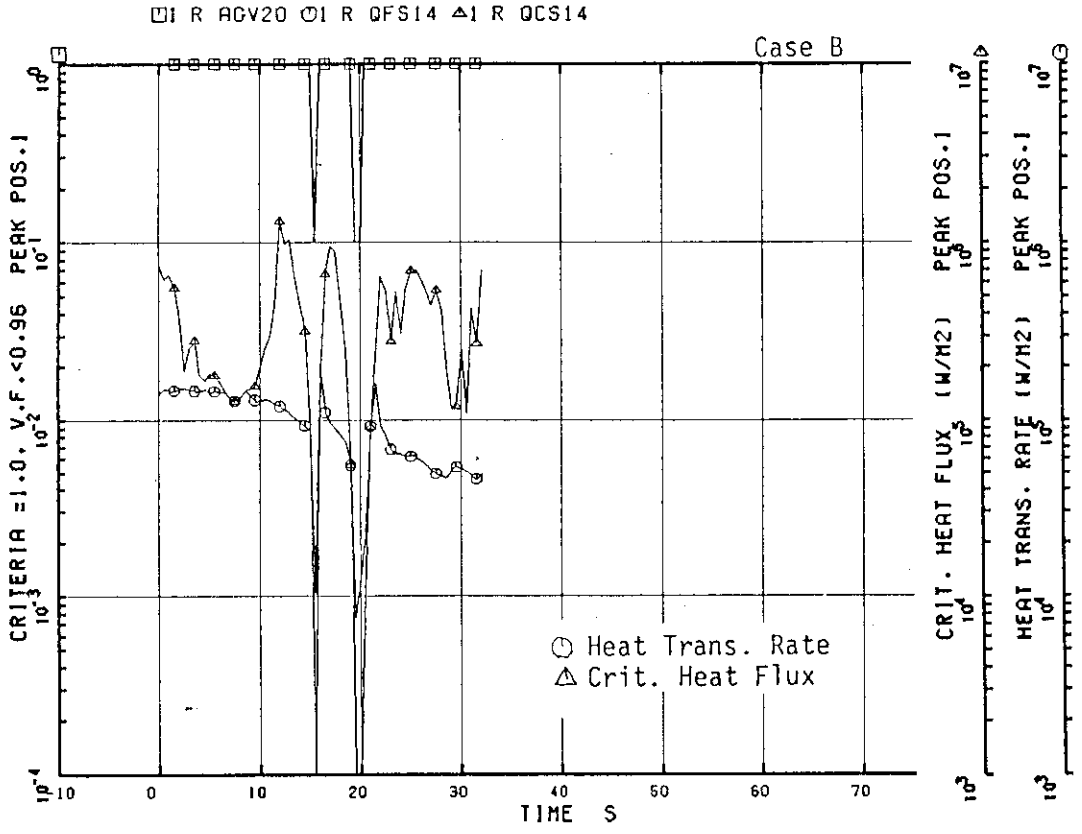


Fig. 4.75 CHF and Heat Transfer Rate at Position 1 in Peak-Power Channel (Case B)

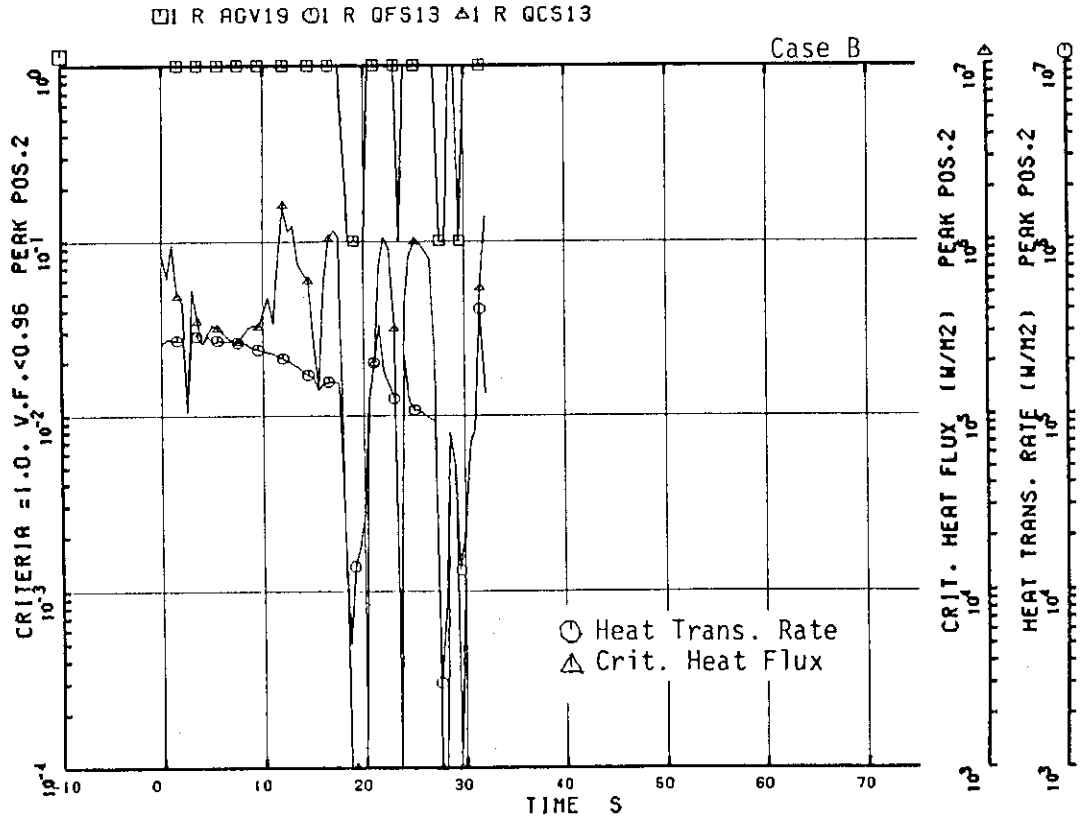


Fig. 4.76 CHF and Heat Transfer Rate at Position 2 in Peak-Power Channel (Case B)

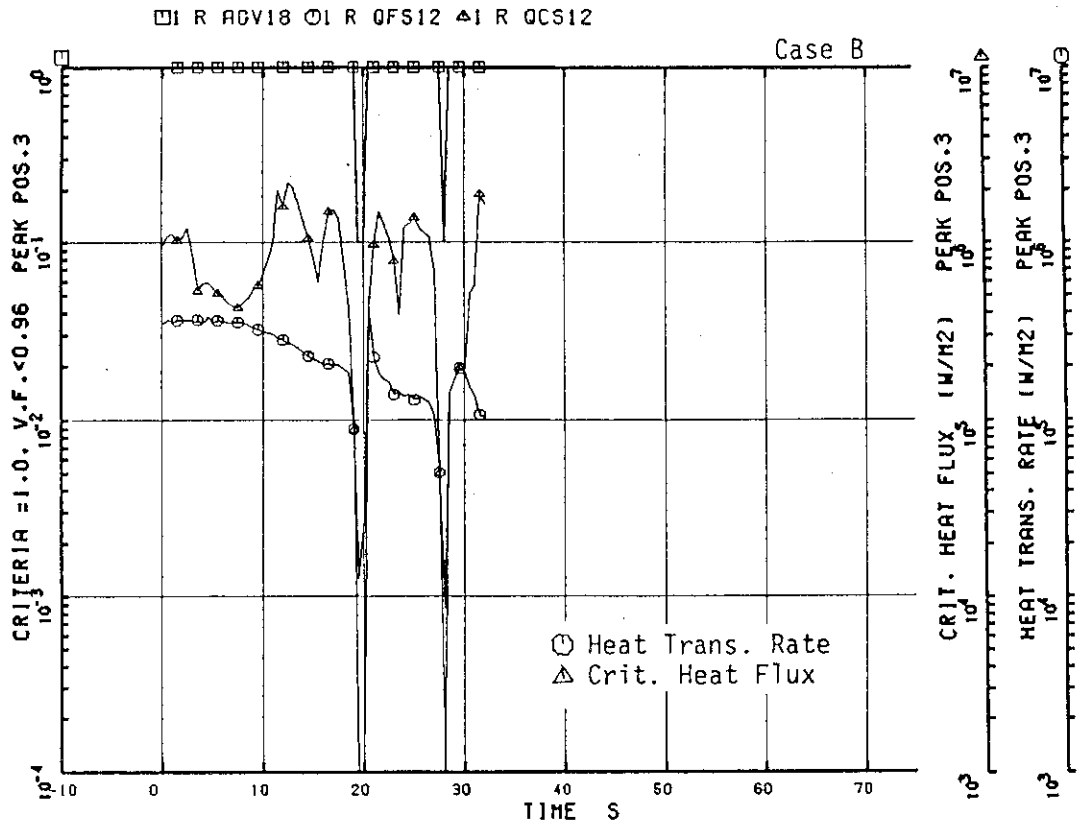


Fig. 4.77 CHF and Heat Transfer Rate at Position 3 in Peak-Power Channel (Case B)

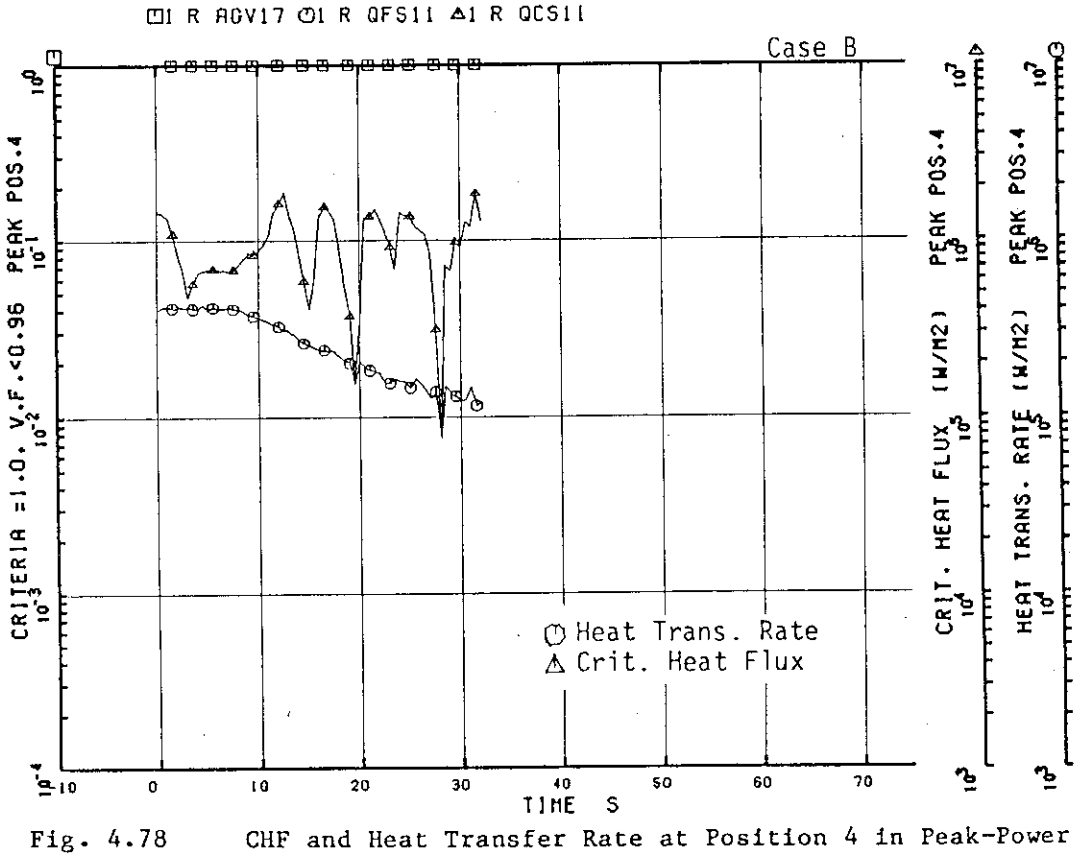


Fig. 4.78 CHF and Heat Transfer Rate at Position 4 in Peak-Power Channel (Case B)

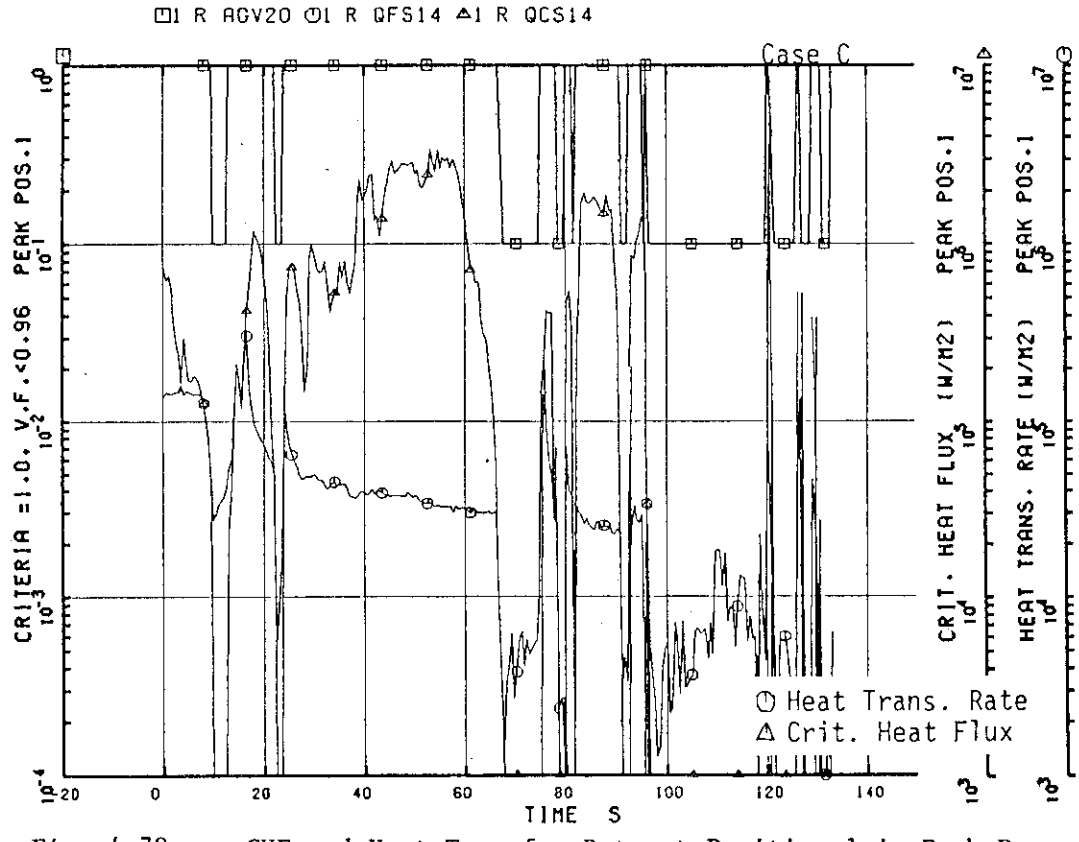


Fig. 4.79 CHF and Heat Transfer Rate at Position 1 in Peak-Power Channel (Case C)

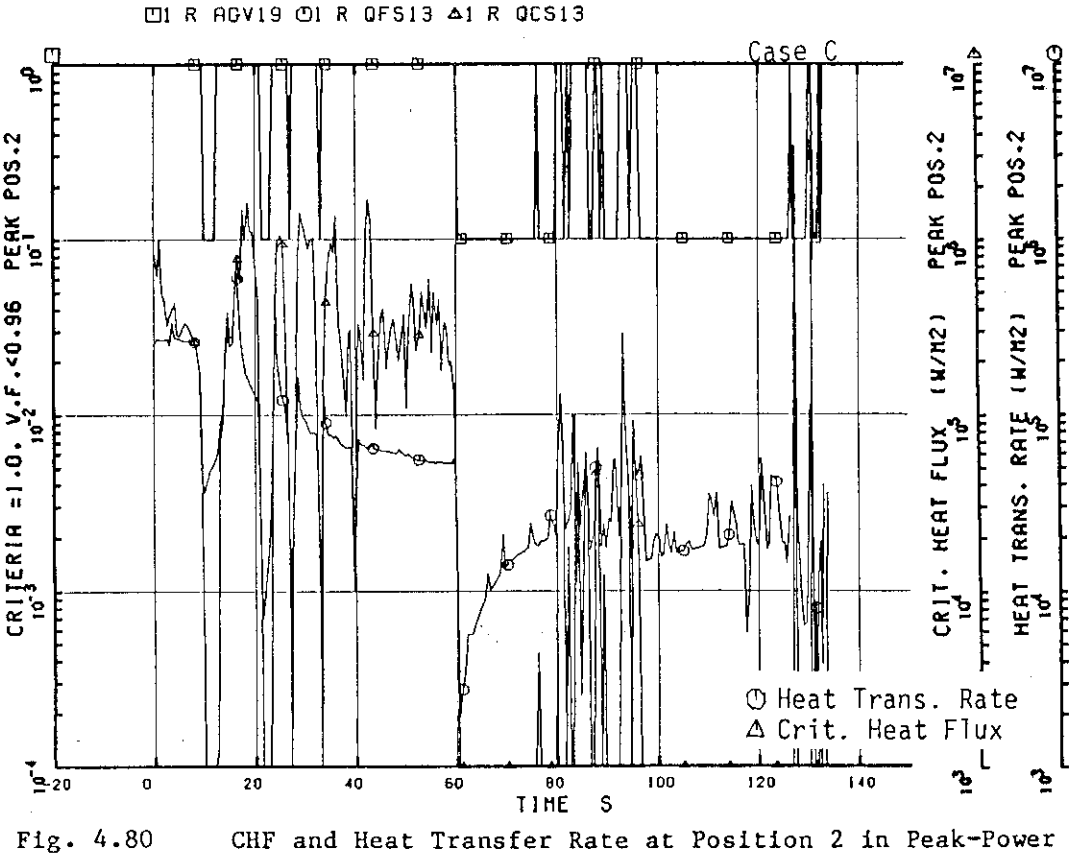


Fig. 4.80 CHF and Heat Transfer Rate at Position 2 in Peak-Power Channel (Case C)

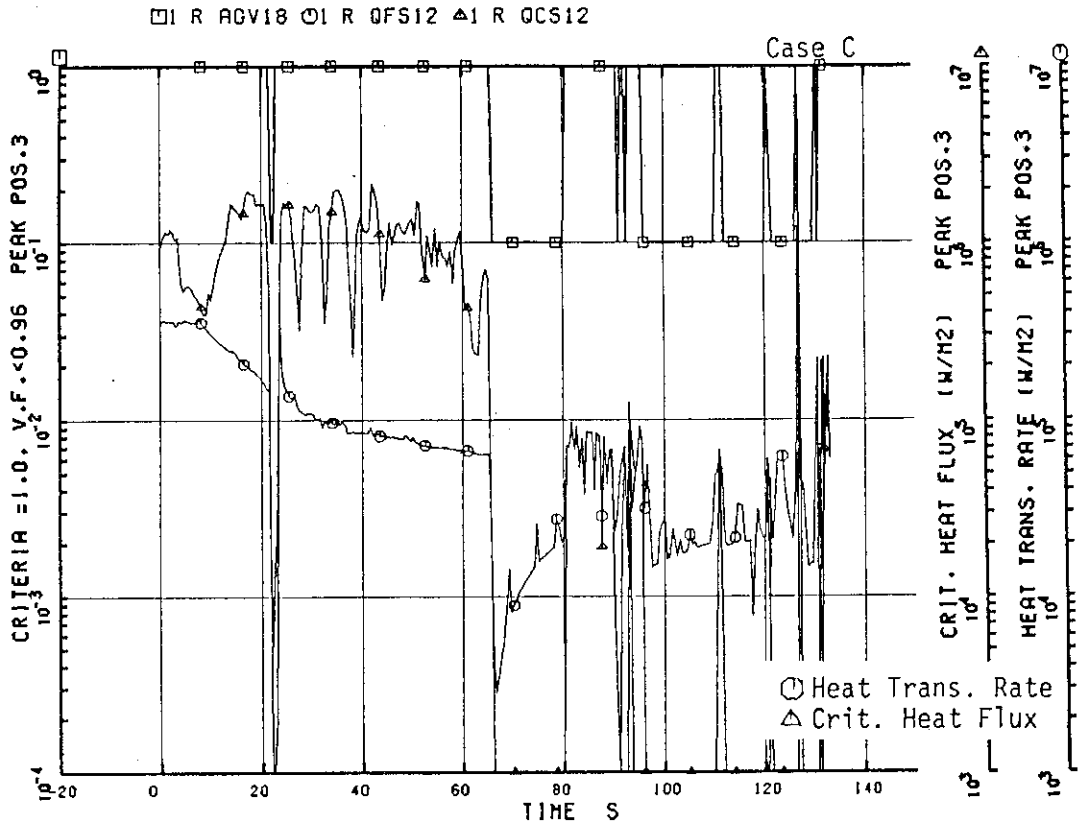


Fig. 4.81 CHF and Heat Transfer Rate at Position 3 in Peak-Power Channel (Case C)

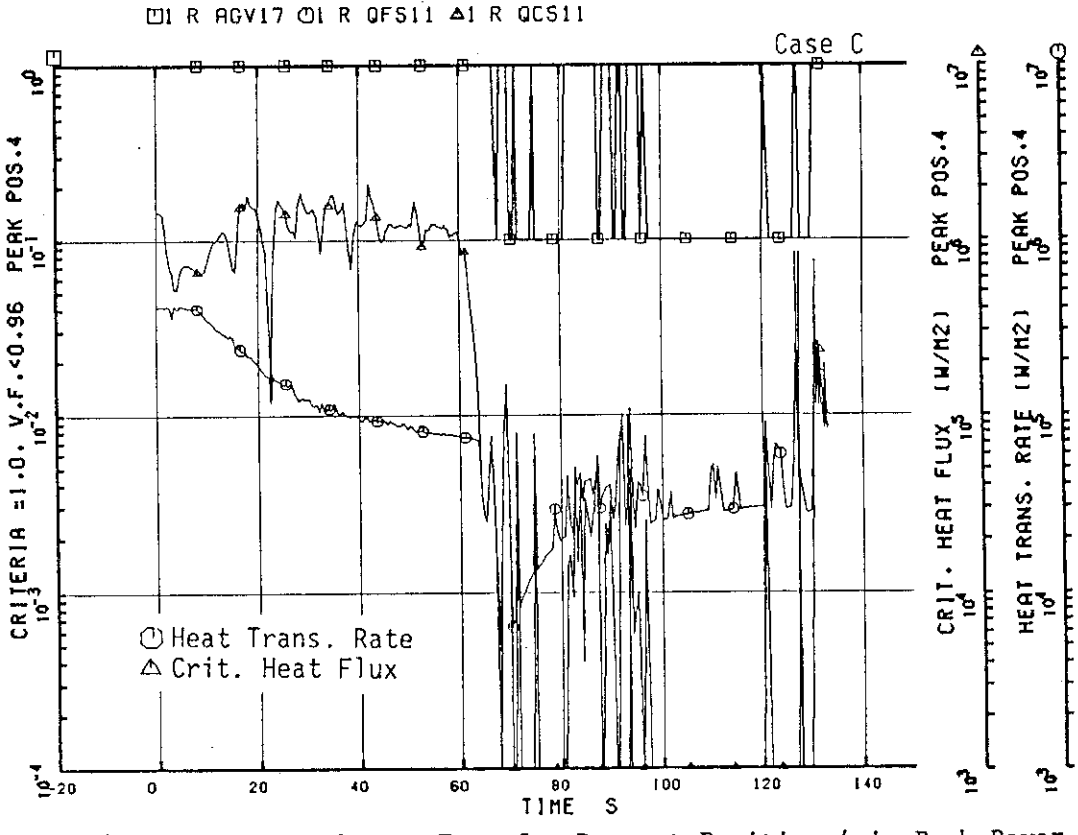


Fig. 4.82 CHF and Heat Transfer Rate at Position 4 in Peak-Power Channel (Case C)

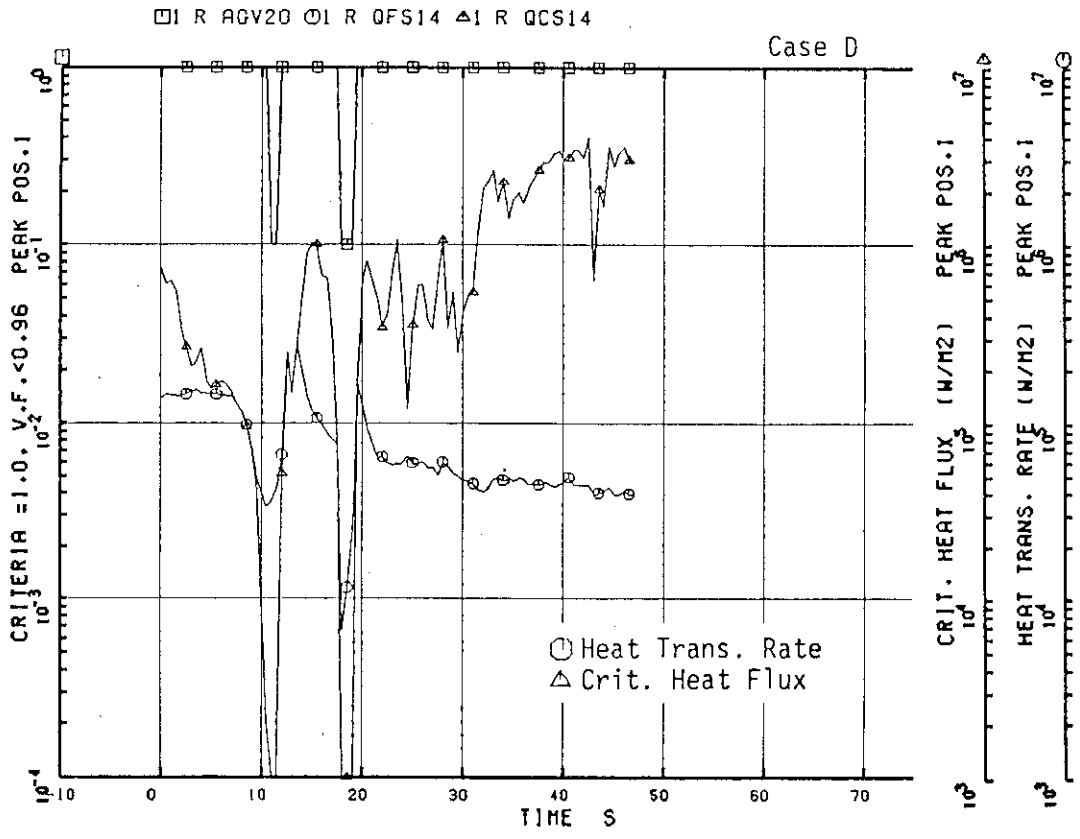


Fig. 4.83 CHF and Heat Transfer Rate at Position 1 in Peak-Power Channel (Case D)

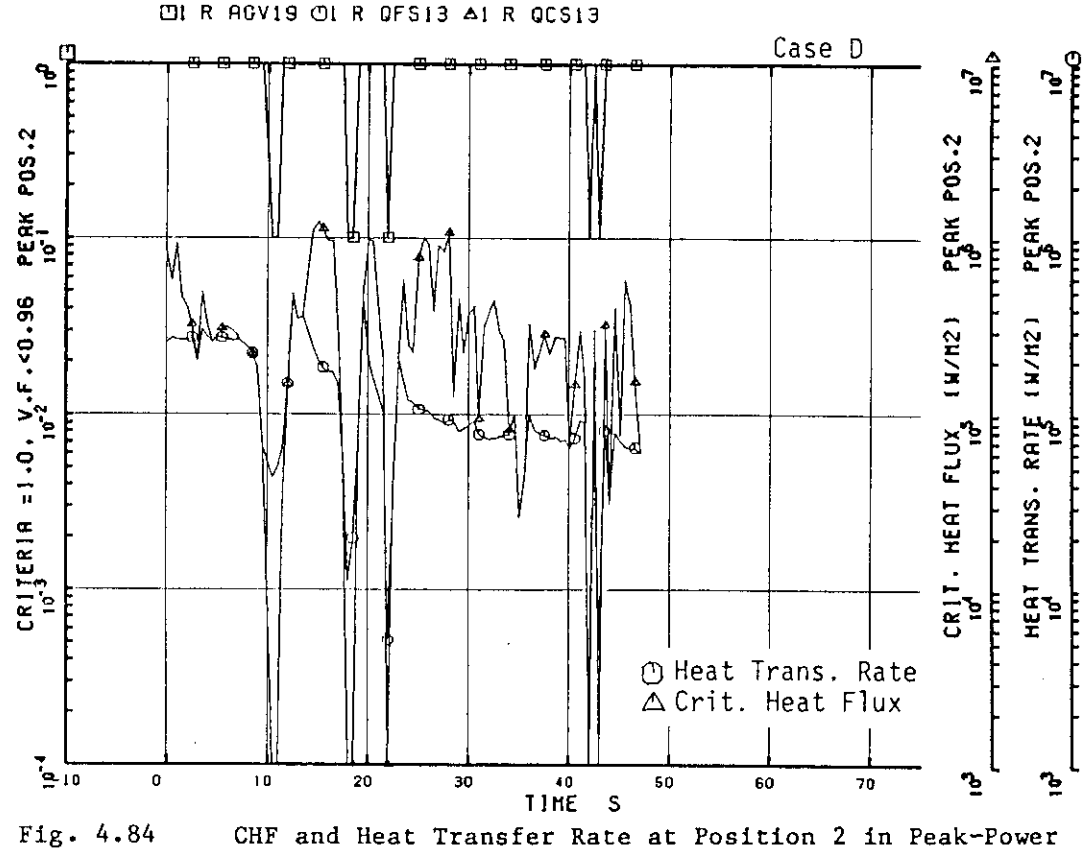


Fig. 4.84 CHF and Heat Transfer Rate at Position 2 in Peak-Power Channel (Case D)

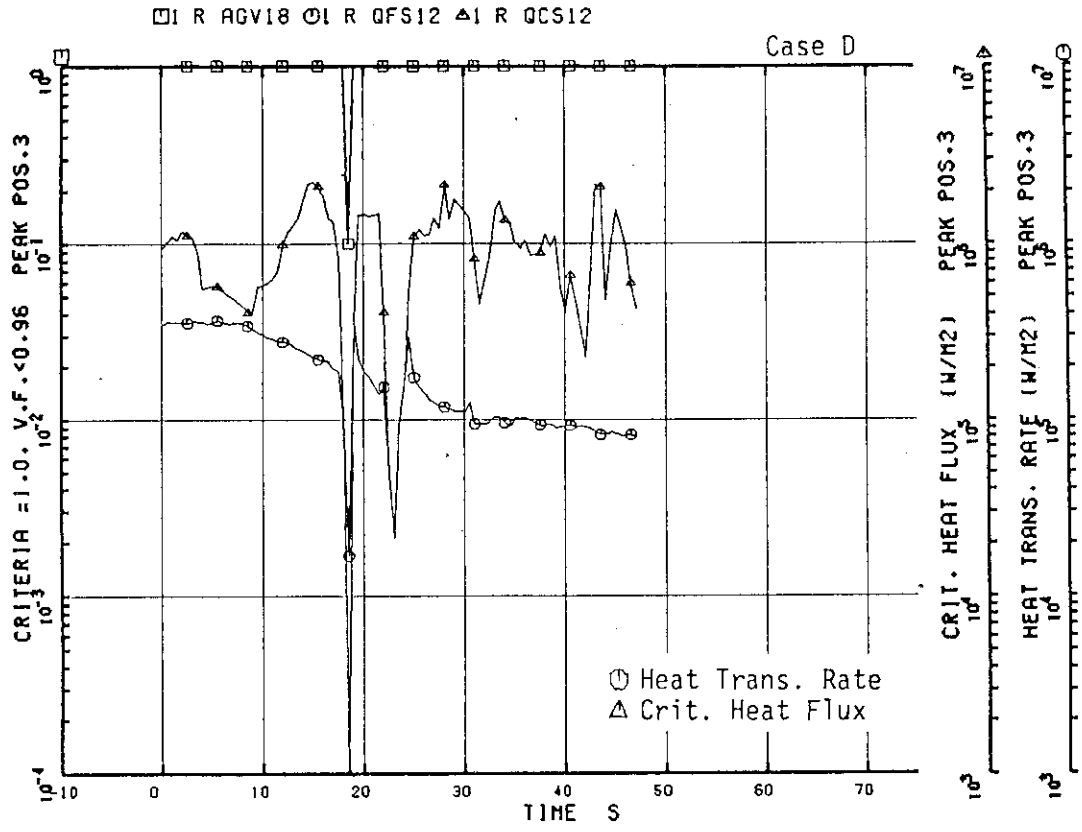


Fig. 4.85 CHF and Heat Transfer Rate at Position 3 in Peak-Power Channel (Case D)

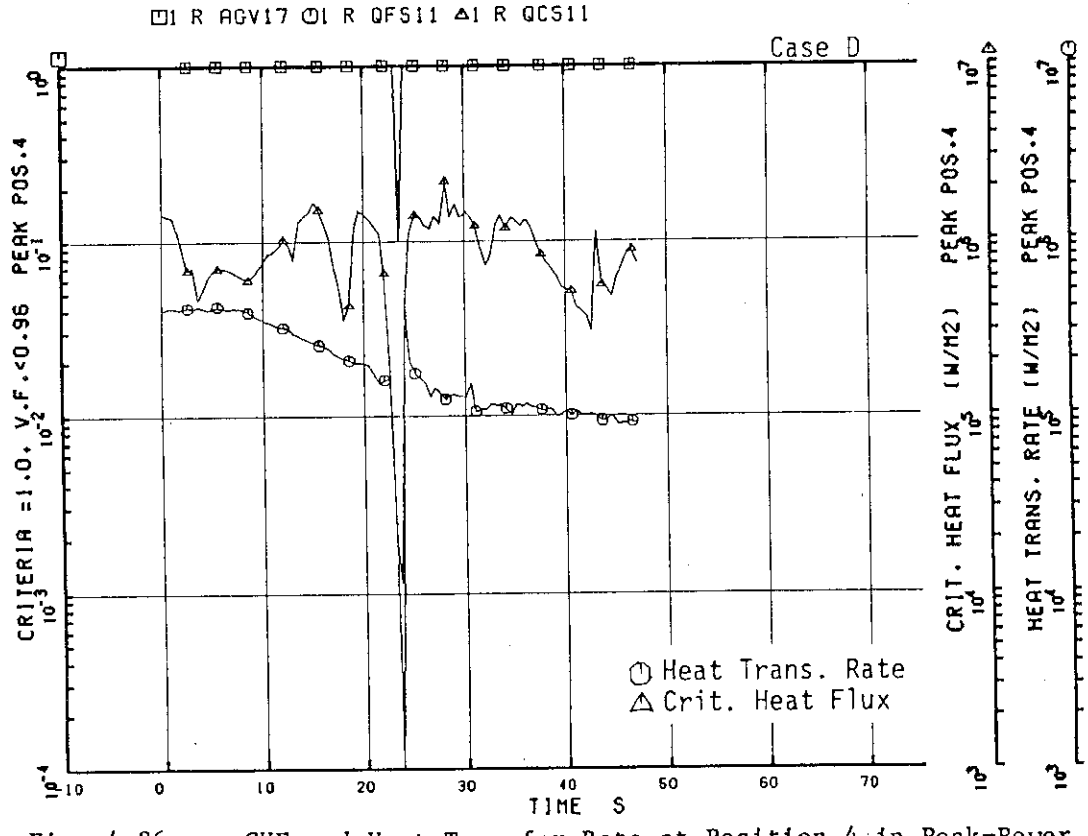


Fig. 4.86 CHF and Heat Transfer Rate at Position 4 in Peak-Power Channel (Case D)

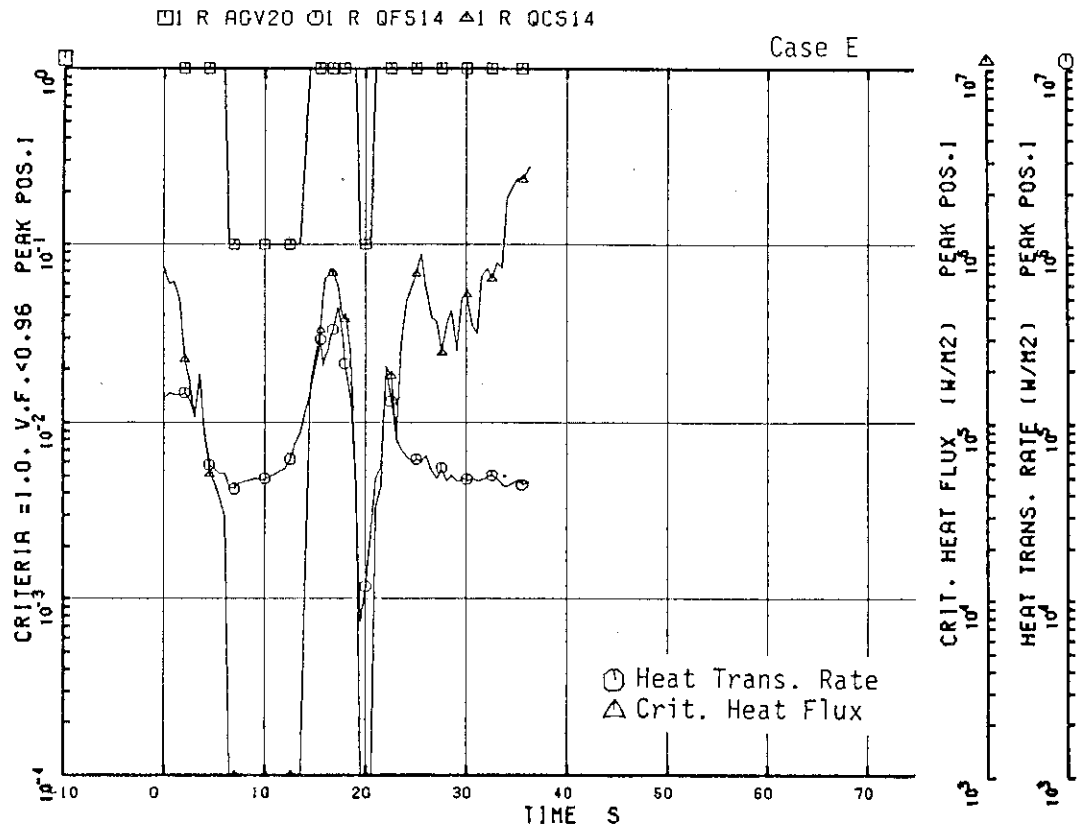


Fig. 4.87 CHF and Heat Transfer Rate at Position 1 in Peak-Power Channel (Case E)

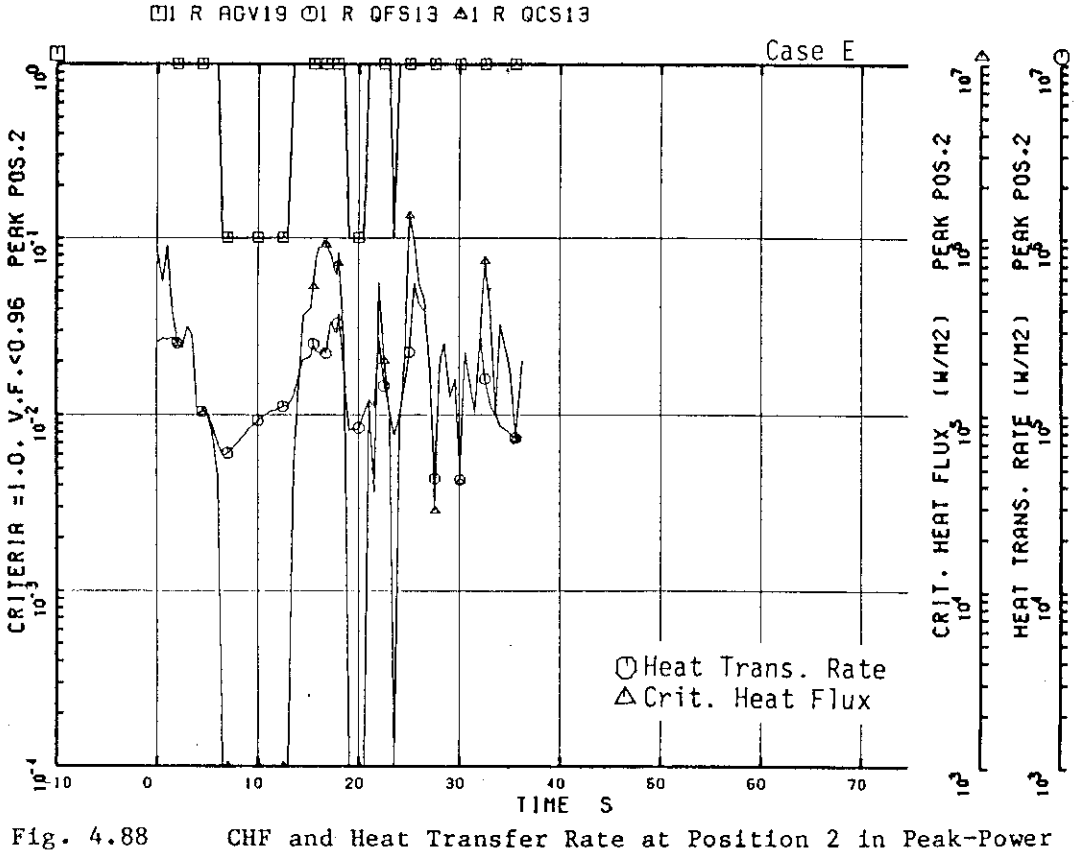


Fig. 4.88 CHF and Heat Transfer Rate at Position 2 in Peak-Power Channel (Case E)

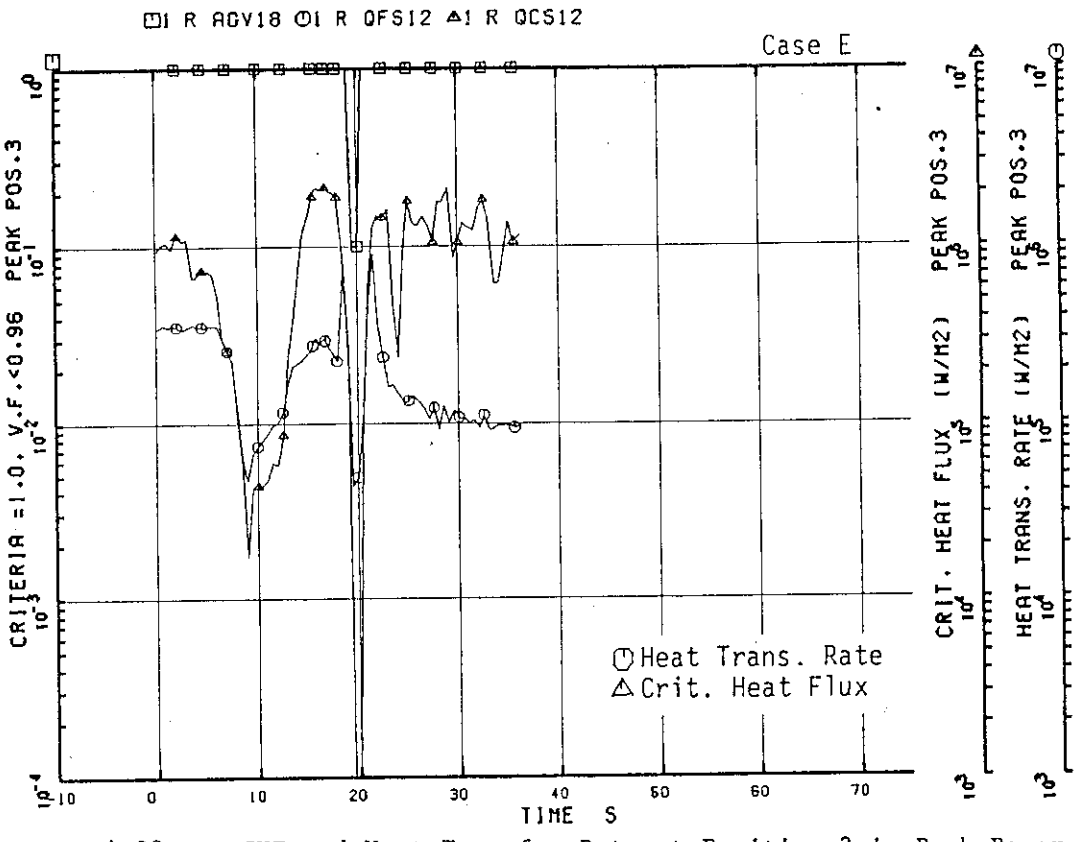


Fig. 4.89 CHF and Heat Transfer Rate at Position 3 in Peak-Power Channel (Case E)

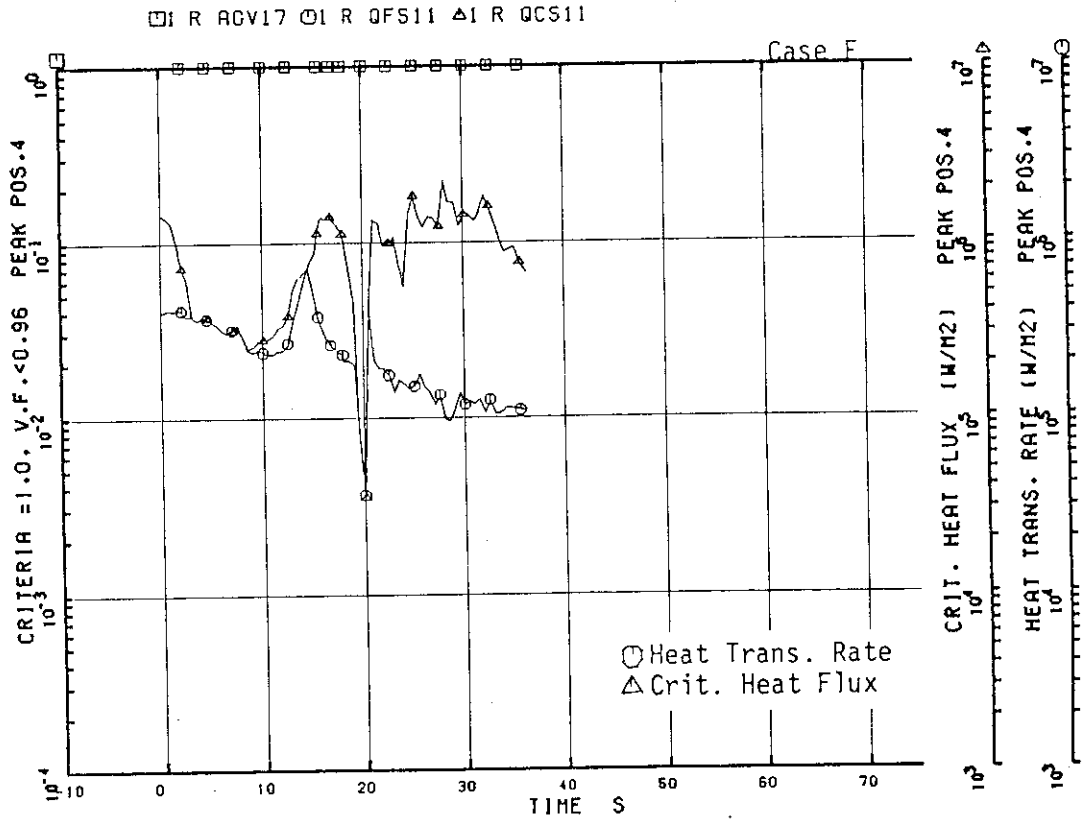


Fig. 4.90 CHF and Heat Transfer Rate at Position 4 in Peak-Power Channel (Case E)

5. CONCLUSIONS

The post test calculations of the ROSA-III large break test, RUN 901, were performed with the RELAP4J and the RELAP5/MOD1/001 codes and the following conclusions were obtained.

(1) The system pressure calculated with the two codes agreed well with the data.

(2) RELAP4J satisfactorily calculated the overall behavior of the mixture level in the core and the core inlet flow behavior until the beginning of the lower plenum flashing (LPF). However, the homogenous two-phase flow model was not able to predict the water penetration into the core through the upper tie plate. As a result, the spray water was calculated to accumulate in the upper plenum.

(3) RELAP5 satisfactorily calculated the rewet in the core after the LPF. The top-down quench following the whole core uncovery was calculated by the advanced two-phase flow model in the code. However, the counter current flow calculation was inadequate and this resulted in the accumulation of the spray water in the upper plenum and a delay in the reflooding of the core. The beginning of the fall in core mixture level after the LPF was also delayed. Incorporation of the counter current flow limiting (CCFL) model and/or the inprovement in the interphase drag correlation should enable more accurate calculation of the mixture level behavior.

(4) The break flow rate was overpredicted with the RELAP5 characteristic analysis model. Therefore, an appropriate discharge coefficient or improvement in the break flow model is necessary.

(5) The use of the jet pump model of the TRAC-BD1 code and the change in the moment of inertia and the rated liquid density data of the ROSA-III main recirculation pump, resulted in good agreement between the calculated and measured core inlet flow rate.

Acknowledgment

The authors wish to express their appreciation Ms. T. Kurosawa of Nihon Computer Bureau Corporation for her help in preparing the report.

References

(1) H. Nakamura, et al., "ROSA-III 200% Double-ended Break Integral Test RUN 901 (Full ECCS Actuation)", JAERI-M 84-007, (1984).

(2) Y. Anoda, et al., "ROSA-III System Description for Fuel Assembly No. 4", JAERI-M 9363, (1981).

(3) N. Abe, et al., "Electric Power Transient Curve for ROSA-III Test", JAERI-M 8728 (1980).

(4) "General Electric Standard Safety Analysis Report BWR/6", DOCKET-STN-50447-48, GE, Co. (1975).

(5) Y. Motizuki, et al. "LOCA Analysis Program RELAP4J for Water Cooled Nuclear Relactors (Modification of RELAP4-Mod 2)", JAERI-M 7506 (1978).

(6) J. F. Wilson, et al., "The Velocity of Rising Steam in a Bubbling Two-Phase Mixture", ANS Transaction 5(1), 151-152, (1962).

(7) EG&G, "RELAP5/MOD1 Code Manual", NUREG/CO-1826 (Volume 1,2) (1980).

(8) M. Katoh, et al., "ROSA-III Small Break Test Analysis by RELAP5/MOD1 Code", International Meeting on Thermal Nuclear Reactor Safety, Chicago, USA, (August 1982).

(9) EG&G, "TRAC-BD1: An Advanced Best Estimate Computer Program for Boiling Water Reactor Loss-of-Coolant Accident Analysis", NUREG/CR-2178 EGG-2109 (Volume 1,2) (1981).

(10) M. Okazaki, et al., "Development of JAERI Jet Pump Model for RELAP5/MOD1 Code", internal report, (1984).

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(1) H. Nakamura, et al., "ROSA-III 200% Double-ended Break Integral Test RUN 901 (Full ECCS Actuation)", JAERI-M 84-007, (1984).

(2) Y. Anoda, et al., "ROSA-III System Description for Fuel Assembly No. 4", JAERI-M 9363, (1981).

(3) N. Abe, et al., "Electric Power Transient Curve for ROSA-III Test", JAERI-M 8728 (1980).

(4) "General Electric Standard Safety Analysis Report BWR/6", DOCKET-STN-50447-48, GE, Co. (1975).

(5) Y. Motizuki, et al. "LOCA Analysis Program RELAP4J for Water Cooled Nuclear Relactors (Modification of RELAP4-Mod 2)", JAERI-M 7506 (1978).

(6) J. F. Wilson, et al., "The Velocity of Rising Steam in a Bubbling Two-Phase Mixture", ANS Transaction 5(1), 151-152, (1962).

(7) EG&G, "RELAP5/MOD1 Code Manual", NUREG/CO-1826 (Volume 1,2) (1980).

(8) M. Katoh, et al., "ROSA-III Small Break Test Analysis by RELAP5/MOD1 Code", International Meeting on Thermal Nuclear Reactor Safety, Chicago, USA, (August 1982).

(9) EG&G, "TRAC-BD1: An Advanced Best Estimate Computer Program for Boiling Water Reactor Loss-of-Coolant Accident Analysis", NUREG/CR-2178 EGG-2109 (Volume 1,2) (1981).

(10) M. Okazaki, et al., "Development of JAERI Jet Pump Model for RELAP5/MOD1 Code", internal report, (1984).

```
*                                                                              *
* ROSA-III RUN901 POST-TEST ANALYSIS BY RELAP4J ,CASE A1 (7*2-VOLUMES)         *
*  TITLE                 **   200% DOUBLE ENDED BREAK          WILSON MODEL  *
*                        **   FULL ECCS ACTUATED                             *
=ROSA3K                                                                       *
*                                                                             *
***PROBLEM DIMENSIONS***                                                      *
*                                                                             *
*     LDMP  NTC   NVOL  NTDV  NPMPC NLK   NSLB  NMAT  NHTX  IUNITS           *
*       NEDI  NTRP  NBUB  NJUN  NCKV  NFLL  NGOM  NCOR  ISPROG               *
010001 -2  9  5 17 33  3  0 47  2  4 5  5 19  5  7 14  0                     *
*      -2                                                                     *
***PROBLEM CONSTANTS***                                                       *
*     POWER OMEGA PQUITL PQUITH TQUITL TQUITH                                 *
010002 4.045  1.0                                                             *
*                                                                             *
***PROGRAM OPTION***                                                          *
*                                                                             *
10005     0    0                                                              *
*                                                                             *
10007    10  0.4  0.05  0.8                          *
*      IPROG IEMHT IEMPS IEMEC                                                *
***EDIT VARIABLES***                                                          *
*                                                                             *
020000 ML  4   ML 33  JW 24  JW 25  JW 43  JW  1  JW  2  ML  3  AP  1         *
*                                                                             *
***TIME STEP CONTROL CARDS***                                                 *
*                                                                             *
*      NMIN  NMAJ  NDMP  NCHK  DELTM   DTMIN  TLAST  ENDCPU                   *
030010   10     1     1    -1  1.0-3   1.0-6   0.03                           *
030020   20    10     2     0  1.0-2   1.0-6   5.0                            *
030030   50    10     2     0  1.0-2   1.0-7  40.0                            *
030040  100    10     1     0  2.0-3   1.0-8  250.0                           *
030050   10     4     2     0  5.0-2   1.0-6 1000.0                           *
*                                                                             *
*                                                                             *
***DETAILED EDIT  030002***       = NOT USED =                                *
*                                                                             *
***WATER PACKING ETC. 030003 ***   = NOT USED =                                *
*                                                                             *
***MIXTURE LEVEL SMOOTHING  030004 ***     = NOT USED =                       *
*                                                                             *
***TRIP CONTROLES***                                                          *
*                                                                             *
*     IDTRP  IDSIG  IX1  IX2    SETPT    DELAY                                *
040010   1     1     0    0    1000.      1.0+6  * END BY TIME                 *
040020   2     1     0    0    0.020      0.0    * START OF BREAK              *
040030   3     1     0    0    0.021      0.0    * FW L2 OR HPCS LEAK          *
040040   4     1     0    0    0.021      0.0    * MAIN STM VALV OPN,FW*       *
040050   5     1     0    0    0.021      0.0    * HPCS    NO USED             *
040060   6     1     0    0    0.021      0.0    * LPCS + HPCS                 *
040070   7     1     0    0    0.021      0.0    * LPCI                        *
040080   8     1     0    0    0.021      0.0    * ADS                         *
040090   1    -4     4    0     14.22     0.0    * END BY LOW PRESS            *
040100   4    10     4    0    1300.      0.0    * END BY HI CLD TEMP          *
040110   9     1     0    0    0.021      0.0    * MPR1 PUMP TRIP              *
040120  10     1     0    0    0.021      0.0    * MPR2 PUMP TRIP              *
040130  11     1     0    0    0.021      0.0    * PWT TRIP                    *
040140  12     1     0    0    0.021      0.0    * MSIV L2                     *
040150  13     1     0    0    0.021      0.0    * AV127 TRIP                  *
040160  14     4     4    0    1178.0     0.0    * SRV                         *
040170  15     1     0    0    0.0         1.0+6 *                            **
*                                                                             *
***VOLUME DATA***                                                             *
*                                                                             *
*      IBUB TREAD    P     @ TEMP    HORX     V       ZVOL    ZM             *
*                  (PSIA)  (DEGF)          (FT**3)  (FT)    (FT)            *
050011  1     0  1071.05   533.5     -1.    6.566     3.8612  3.8612         *
050031  1     0  1066.90    -1.   0.1329    5.495     5.989   5.989          *
050041  1     0  1066.54    -1.   0.0      19.81      5.73    2.106          *
* BROKEN LOOP                                                                 *
050051  0     0  1068.05   533.5     -1.    0.460     4.884   4.884          *
050061  0     0  1068.13   533.5     -1.    0.5205    5.771   5.771          *
050071  0     0  1102.54   533.5     -1.    0.187     0.955   0.955          *
050081  0     0  1133.80   533.5     -1.    0.7228   19.20   19.20           *
050091  0     0  1071.63   533.5     -1.    0.2996    6.893   6.893          *
050101  0     0  1071.62   533.5     -1.    0.5953    0.9090  0.9090         *
050111  0     0  1067.00   533.5     -1.    0.2312    6.4218  6.4218         *
* INTACT LOOP                                                                *
050121  0     0  1070.03   533.5     -1.    0.3732   10.49   10.49           *
050131  0     0  1104.61   533.5     -1.    0.187     0.955   0.955          *
050141  0     0  1134.50   533.5     -1.    0.8743   19.197  19.197          *
050151  0     0  1071.70   533.5     -1.    0.2974    6.842   6.842          *
050161  0     0  1071.32   533.5     -1.    0.5429    0.96    0.96           *
050171  0     0  1066.93   533.5     -1.    0.2312    6.4218  6.4218         *
* CORE SECTION                                                                *
050181  1     0  1068.98   533.5     -1.    4.276    10.904  10.904          *
*    * CORE NEW VOLUME *    * CORE , BCD AVERAGE  **********************     *
050021  2     0 1069.24 536.6    -1.0     0.3193    1.011   1.011  *POS,7*    *
050191  2     0 1068.94 545.6    -1.0     0.2436    0.771   0.771  *POS,6*    *
050201  2     0 1068.69 -1.0   0.00302    0.2436    0.771   0.771  *POS,5*    *
050211  2     0 1068.40 -1.0   0.04359    0.4872    1.542   1.542  *POS,4*    *
050221  2     0 1068.17 -1.0   0.08488    0.2436    0.771   0.771  *POS,3*    *
050231  2     0 1068.04 -1.0   0.10647    0.2436    0.771   0.771  *POS,2*    *
050241  2     0 1067.89 -1.0   0.12058    0.3193    1.011   1.011  *POS,1*    *
*  CORE , A                                                                   *
050251  2     0 1069.23 537.9    -1.0     0.1064    1.011   1.011  *POS,7*    *
050261  2     0 1068.93 550.5    -1.0     0.08120   0.771   0.771  *POS,6*    *
050271  2     0 1068.69  -1.0 0.01926     0.08120   0.771   0.771  *POS,5*    *
050281  2     0 1068.44  -1.0 0.07658     0.1624    1.542   1.542  *POS,4*    *
050291  2     0 1068.23  -1.0 0.1339      0.08120   0.771   0.771  *POS,3*    *
050301  2     0 1068.09  -1.0 0.1641      0.08120   0.771   0.771  *POS,2*    *
050311  2     0 1067.93  -1.0 0.1839      0.1064    1.011   1.011  *POS,1*    *
* CORE INLET                                        **********************     *
050321  1     0 1069.78 533.5    -1.0     0.4768    1.132    1.132           *
* DOWNCOMER                                                                   *
050331  1     0 1068.27 533.5    -1.0     4.893    12.32    12.32            *
*                                                                             *
*      JTPMV   FLOWA   DIAMV   ELEV   ALMBLO                                  *
```

```
*             (FT**2)   (FT)     (FT)  (SLIP,VRTCL,STK IND)
050012  0     1.701     0.0      -0.0252
050032  0     0.9175    0.0      11.615
050042  0     3.458     0.0       13.94
* BROKEN LOOP
050052  0     0.2264    0.1624   -1.725
050062  0     0.02383   0.1646   -7.333
050072  0     0.1958    0.4944   -8.288
050082  0     0.02135   0.1607   -8.288
050092  1     0.04102   0.1049    2.1
050102  1     0.04613   0.2425    1.191
050112  0     0.03095   0.1865    2.9452
* INTACT LOOP
050122  0     0.02346   0.1657   -7.333
050132  0     0.1958    0.4944   -8.288
050142  0     0.0219    0.163    -8.288
050152  1     0.04102   0.1048    2.151
050162  1     0.04613   0.2425    1.191
050172  0     0.03095   0.1865    2.9452
* CORE SECTION
050182  0     0.3947    0.0       0.8764
*CORE BCD   AVERAGE                    ********************************
050022    0     0.3159  0.04285 4.967
050192    0     0.3159  0.04285 5.978
050202    0     0.3159  0.04285 6.749
050212    0     0.3159  0.04285 7.520
050222    0     0.3159  0.04285 9.062
050232    0     0.3159  0.04285 9.833
050242    0     0.3159  0.04285 10.604
*CORE  A    PEAK
050252    0   0.1053  0.04285 4.967
050262    0   0.1053  0.04285 5.978
050272    0   0.1053  0.04285 6.749
050282    0   0.1053  0.04285 7.520
050292    0   0.1053  0.04285 9.062
050302    0   0.1053  0.04285 9.833
050312    0   0.1053  0.04285 10.604
* CORE INLET                          ********************************
050322    0   0.4212  0.04285 3.836
* DOWNCOMER
050332    0   0.397     0.0     1.621
*
***LIQUID LEVEL  060000 ***       = NOT USED =
*
***SLIP VELOCITY  060001 ***      = NOT USED =
***WALLIS  060002 ***             = NOT USED =
***WALLIS CROWLEY  060003 ***       = NOT USED =
*
***DOWNCOMER PENETRATION  060004 *** =NOT USED =
*
***DOWNCOMER PENETRATION COEFF. 060005 *** = NOT USED =
*
*** BUBBLE DATA CARDS ***
*
*
*       ALPH      VBUB       VOLUME
*                (FT/SEC)
060011  0.0     -1.0          21
060021  0.8     -1.0          21
060031  0.8     16.4          21
*
***TIME DEPENDENT VOLUME  07XXYY ***     = NOT USED =
*
***FLOW SMOOTHING  080001 THRU 080009 *** = NOT USED =
*** JUNCTION DATA ***
*
*       IW1 IW2 IPUMP IVALVE    WP       AJUN      ZJUN      INERTA(L/A)
*      FROM TO                (LB/SEC) (FT**2)    (FT)      (1/FT)
080031  3   4     0     0     35.28     0.161     17.60       0.0
* BROKEN LOOP
080041  33  5     0     0      6.3      0.0207    2.556       0.0
080051  5   6     0     1      6.3      0.0207   -1.643       1.143+3
080061  6   7    -2     0      6.3      0.0207   -7.333       6.092+2
080071  7   8     2     0      6.3      0.0207   -8.186       8.884+2
080081  8   9     0     0      6.3      1.192-3   8.993       1.062+3
080091  9  10     0     0     17.64     0.0656    2.1         4.313+2
080101 10   1     0     0     17.64     0.04616   1.312       0.0
080111 33  11     0     0     11.34     0.0328    6.506       0.0
080121 11   9     0     0     11.34     0.01802   8.993       2.708+2
* INTACT LOOP
080131 33  12     0     0      6.3      0.0207    2.556       0.0
080141 12  13    -1     0      6.3      0.0207   -7.333       4.363+2
080151 13  14     1     0      6.3      0.0207   -8.186       1.061+3
080161 14  15     0     0      6.3      1.192-3   8.993       1.236+3
080171 15  16     0     0     17.64     0.0656    2.151       4.054+2
080181 16   1     0     0     17.64     0.04616   1.312       0.0
080191 33  17     0     0     11.34     0.0328    6.506       0.0
080201 17  15     0     0     11.34     0.01802   8.993       2.708+2
* CORE SECTION
080211 32  18     0     0      1.433    0.005648  4.771      44.0
080221 18   3     0     0      1.764    0.1557   11.78       31.3
*  CORE BCD   AVERAGE
080011 32   2     0     0     25.137    0.1022    4.967       0.0
080231  2  19     0     0     25.137    0.3159    5.978       0.0
080261 19  20     0     0     25.137    0.3159    6.749       0.0
080271 20  21     0     0     25.137    0.3159    7.520       0.0
080281 21  22     0     0     25.137    0.3159    9.062       0.0
080291 22  23     0     0     25.137    0.3159    9.833       0.0
080301 23  24     0     0     25.137    0.3159   10.604       0.0
080021 24   3     0     0     25.137    0.1021   11.615       0.0
* CORE  A      PEAK
080241 32  25     0     0      8.379    0.03407   4.967       0.0
080311 25  26     0     0      8.379    0.1053    5.978       0.0
080321 26  27     0     0      8.379    0.1053    6.749       0.0
080331 27  28     0     0      8.379    0.1053    7.520       0.0
080341 28  29     0     0      8.379    0.1053    9.062       0.0
080351 29  30     0     0      8.379    0.1053    9.833       0.0
080361 30  31     0     0      8.379    0.1053   10.604       0.0
080251 31   3     0     0      8.379    0.03405  11.615       0.0
*                                                  *
080371  1  18     0     0      0.331    0.001892  0.8764      0.0
080381  1  32     0     0     34.989    0.07678   3.836       0.0
* DOWNCOMER
080391  4  33     0     0     35.28     0.397    13.94        0.0
*  FILL, LEAK
080401  0   4     4     0     -4.652    3.382-3  19.67        0.0      * MSL *
080411  0   4     3     0      4.652    0.01246  14.217       0.0      * FW  *
080421  6   0     1     0      0.0      5.803-3  -1.643       9.900+3  * B-A *
```

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080431  5   0    2     0      0.0      5.803-3  -1.643      1.500+4 * B-B *
080441  3   0    5     0      0.0      0.01246  13.39       0.0 *HPCS,LEAK*
080451  0   3    1     0      0.0      0.01246  13.39       0.0 *HPCS+LPCS*
080461  0  18    2     0      0.0      0.0207   11.66       0.0     * LPCI*
080471  0   4    5     0      0.0      2.029-3  19.67       0.0     * ADS *
*
*      FJUNF     FJUNR  JVERTL  MVMIX     CONCO     IHQCOR                  *
*                       JCHOKE    DIAMJ   (CD)         SRCOS                *
*                                                      IFLOOD               *
*                          JCALC  (FT)        ICHOKE          IADJUN        *
080032  0.665     1.036 0  1  2  0  0.0    1.0     1  0                      *
* BROKEN LOOP                                                               *
080042  8.22      8.22  1  1  2  0  0.0    1.0     1  0                      *
080052  6.52      6.52  1  1  0  0  0.0    1.0     1  0                      *
080062  6.982     6.982 1  1  0  0  0.0    1.0     1  0                      *
080072  4.490     4.490 1  1  0  0  0.0    1.0     1  0                      *
080082  0.069     1.4   0  1  0  2  0.0    0.57    1  0    1                 *
080092  7.511     16.2  0  1  0  0  0.0    1.0     1  0                      *
080102  2.449     2.449 1  1  2  0  0.0    1.0     1  0                      *
080112  7.22      60.0  1  1  2  0  0.0    1.0     1  0                      *
080122  6.923     7.9   0  1  0  2  0.0    1.0     1  0                      *
* INTACT LOOP                                                               *
080132  3.052     3.052 1  1  2  0  0.0    1.0     1  0                      *
080142  3.052     3.052 1  1  0  0  0.0    1.0     1  0                      *
080152  5.489     5.489 1  1  0  0  0.0    1.0     1  0                      *
080162  0.069     1.4   0  1  0  2  0.0    0.57    1  0    1                 *
080172  4.285     16.2  0  1  0  0  0.0    1.0     1  0                      *
080182  1.409     1.409 1  1  2  0  0.0    1.0     1  0                      *
080192  7.22      60.0  1  1  2  0  0.0    1.0     1  0                      *
080202  6.923     7.9   0  1  0  2  0.0    1.0     1  0                      *
* CORE SECTION                                                              *
080212  1.5       1.5   0  1  0  0  0.0    1.0     1  0                      *
080222  2.65      2.65  1  1  0  0  0.0    1.0     1  0                      *
*CORE  BCD                                                                  *
080012  0.0       0.0   0  1  3  0  0.0    1.0     1  2                      *
080232  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080262  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080272  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080282  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080292  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080302  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080022  1.036     1.008 0  1  2  0  0.0    1.0     1  1                      *
*  CORE A                                                                   *
080242  0.0       0.0   0  1  3  0  0.0    1.0     1  2                      *
080312  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080322  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080332  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080342  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080352  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080362  0.0       0.0   0  1  2  0  0.0    1.0     1  3                      *
080252  1.036     1.0   0  1  2  0  0.0    1.0     1  1                      *
*                                                     *                     *
080372  1.0       1.0   1  1  2  0  0.0    1.0     1  0                      *
080382  1.165     12.27 0  1  2  0  0.0    1.0     1  0                      *
* DOWNCOMER                                                                 *
080392  0.0       0.0   0  1  3  0  0.0    1.0     1  0                      *
* FILLX LEAK                                                                *
080402  0.0       0.0   0  1 -3 -2  0.0    0.57    1  0    1                 *
080412  0.0       0.0   0  1 -3  0  0.0    1.0     1  0                      *
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080422  1.698     0.0   0  1  0  0  0.0    0.57    1  0    1                 *
080432  1.743     0.0   0  1  0  0  0.0    0.57    1  0    1                 *
080442  0.0       0.0   0  1 -3  0  0.0    1.0     1  0                      *
080452  0.0       0.0   0  1 -3  0  0.0    1.0     1  0                      *
080462  0.0       0.0   0  1 -3  0  0.0    1.0     1  0                      *
080472  116.6     0.0   0  1  2  0  0.0    1.0     1  0                      *
*** STAGNATION PROPERTIES CARD ***      = NOT USED =                        *
*       HEM       H-F       XT      *                                       *
*      ISTAG                                                                *
*                                                                           *
*                                                                           *
*** DIAL CARDS  082001 THRU 082006, 082011,082012,082020,082021***          *
***            082030 THRU 082032                                      ***  *
***                                          ARE NOT USED.              ***  *
*                                                                           *
*** PUMP DESCRIPTION ***                                                   *
*                                                                           *
*                                                                           *
*     IPC ITPMP IRP IPM IMT  POMGAR  PRSAT  PFLOW  PHEAD  PTORKR            *
*                           (RPM)  (RATIO) (GPM)  (FT)   (LBF.FT)           *
090011 3    9    1   1      3600.    .53   118.9  859.6  135.0               *
090021 3   10    1   1      3600.    .53   118.9  859.6  135.0               *
*                                                                           *
*                                                                           *
*     PINRTA    VRHOI    TORKF(3) TORKMR  TORKF(1) TORKF(2) TORKF(4)        *
*    (LBM.FT2) (LBM/FT3)          (LBF.FT)                                  *
090012 45.09     0.       13.5     .                                        *
090022 45.09     0.       13.5                                              *
*                                                                           *
*** PUMP HEAD MULTIPLIER                                                   *
*                                                                           *
*      NPHM  PHDM(1), PHDM(2),------                                        *
*            (VOID)  (NLTPLR)                                               *
091001 -11    0.0   .0   .1   .0    .15   .05   .24   .8    .3   .96        *
091002         .4   .98  .6   .97   .8    .9    .9    .8    .96  .5         *
091003        1.0   .0                                                      *
*                                                                           *
*** PUMP TORQUE MULTIPLIER ***                                             *
*                                                                           *
*      NPTM  PTKM(1),PTKM(2),-----                                          *
*            (VOID) (MLTPLR)                                                *
092001  -2    0.0      0.0    1.0   0.0     * NOT USED                      *
*                                                                           *
*   PUMP STOP DATA ***     = NOT USED =                                     *
*                                                                           *
*      CAVCON    FPUMP   SPUMP                                              *
*      (SEC)     (RPM)   (RPM)                                              *
*                                                                           *
*** PUMP MOTOR TORQUE ***                                                  *
*                                                                           *
*      NTMO   PTMO(1), PTMO(2),-----                                        *
*             (RPM)    (TORQUE)                                            *
*          *** NOT USED ***                                                 *
*                                                                           *
*                                                                           *
*** PUMP CURVE INPUT INDICATOR ***                                         *
*                                                                           *
*       NC(1)  NC(2)  NC(3)  NC(4)                                          *
100000    0      0     16     0                                            *
```

```
*
*** PUMP HEAD OR TORQUE DATA CARDS ***
*      HEAD= ROSA-III MRP PUMP
*    TORQUE= BINGHAM PUMP
*
*      IT IC N  PHEAD(1) OR PTORK(1), PHEAD(2) OR PTORK(2) -----
* HEAD
103011  1  1   5  0.0   0.92  0.2   0.94  0.4   0.97
103012             0.6   1.0   1.0   1.0
103021  1  2  5   0.0  -0.2   0.25  0.0   0.4   0.12
103022             0.7   0.5   1.0   1.0
103031  1  3  5  -1.0   1.2  -0.8   0.98 -0.6   0.94
103032            -0.3   0.92  0.0   0.92
103041  1  4  5  -1.0   1.2  -0.8   0.7  -0.5   0.34
103042            -0.2   0.18  0.0   0.18
103051  1  5  5   0.0   0.62  0.20  0.69  0.40  0.77
103052             0.6   0.85  1.0   1.00
103061  1  6  5   0.0   0.18  0.20  0.22  0.40  0.32
103062             0.65  0.52  1.00  1.00
103071  1  7  5  -1.0   0.00 -0.80  0.16 -0.4   0.45
103072            -0.2   0.56  0.0   0.62
103081  1  8  5  -1.0   0.00 -0.80 -0.14 -0.50 -0.24
103082            -0.20 -0.24  0.0  -0.20
* TORQUE
103091  2  1 5   .0    .46   .2    .54   .5    .67
103092             .8    .86   1.    1.
103101  2  2  5   0.0  -0.1   0.2   0.08  0.5   0.34
103102             0.8   0.65  1.0   1.0
103111  2  3  5  -1.0   0.7  -0.8   0.68 -0.5   0.48
103112            -0.3   0.44  0.0   0.46
103121  2  4 5  -1.    .7    -.7    .45   -.4    .38
103122            -.2   .32   .0    .28
103131  2  5  5   0.0  -0.66  0.2  -0.53  0.6  -0.3
103132             0.8  -0.2   1.0  -0.1
103141  2  6 5    .0   .28   .2     .22    .5    .1
103142             .8   .0   1.     -.1
103151  2  7  5  -1.0  -1.4  -0.8  -1.25 -0.5  -1.0
103152            -0.2  -0.8   0.0  -0.66
103161  2  8 5  -1.   -1.4  -.6    -.8     -.5   -.66
103162            -.2  -.3    .0    -.1
*
*** VALVE DATA CARDS ***
*
*      ITCV  IACV  LATCH  PCV  CV1  CV2  CV3
110010  13                 0.   0.   0.   0.      * AV 127 TRIP
110020  12                 0.   0.   0.   0.      * MSIV L2 TRIP
110030   3                 0.   0.0  0.   0.      * FW L2 TRIP
110040 -15                 0.   0.0  0.   0.      * NO USED
*
*** LEAK TABLE CARDS ***
*     NAREA     SINK     TAREA(1),TAREA(2),----
*       ITLEAK (PSIA)
120100 -3   2   14.7    0.0   1.0 1000. 1.0 100000. 1.0  * BREAK A START*
120200 -3   2   14.7    0.0   1.0 1000. 1.0 100000. 1.0  * BREAK B START*
120300 -6   8   14.7    0.0   0.0 129.3 0.0  130.1  1.0   145.6  1.0    *
120301                 146.0   0.0  2000.0  0.0           * ADS         *
120401 -3  12   14.7   0.0  1.0   9.15  0.0  1000. 0.0   * MSIV L2 TRIP *
120501 -3   3   14.7    0.0   0.0   3.30  0.0   1000.0  0.0 * FW L2 TRIP*
*                                                        *HPCS,LEAK*
```

```
*** FILL TABLE DATA ***
*
*     NFILL ITFILL IX IY                PORX   TEMP AFRAC TAUMIX
*                                             (F)
130100 14      6     0  1               14.22   103.73       *LPCS + HPCS*
130200  7      7     0  1               14.22   103.73       *LPCI 3PUMPS*
130300  4      4     0  1             1087.8    420.53       *FW          *
130400  6      4     0 -1                1.0    550.0        *MSL AFT BRK*
130500  8      8     0 -1                1.0    493.0        *ADS         *
*
*      FILTBL(1),FILTBL(2),----
*
130101     0.0      0.0     31.1      0.0     32.19  903.2   33.66  996.1   *
130102    37.13 1015.1      60.0   1019.0     65.7   1020.2   67.50 1980.66  *
130103    90.0  2185.5     105.0   2235.1    120.0   2378.8  135.0  2406.8   *
130104   180.0  2455.2     210.0   2464.1              * HPCS + LPCS    *****
130201     0.0      0.0     90.7      0.0     93.7   1952.6   105.0 2320.13  *
130202   120.0  2603.4     150.0   2802.5    210.0   2894.42        * 3 LPCI  *
130301     0.0  3180.3       0.7   3320.2      3.3      0.0                  *
130302 1000.0      0.0                                          * FW ******
130401     0.0 -1388.5       0.7  -1147.3      1.8  -1368.9      7.3 -1310.2  *
130402     9.15     0.0   1000.0      0.0                          * M STEAM *
130501     0.0      0.0     129.33    0.0    130.06  -210.8   135.0  -279.2   *
130502   141.95 -279.2     145.61  -231.4    145.97     0.0                   *
130503 2000.0      0.0                                  * ADS***************
*
*** KINETIC CONSTANTS ***
*
*      NODEL  KMUL  BOVL  RHOIN  UDUF  PROMPT  LAMBDA  TAU
*
140000  0             0.    0.
*
*
*
*** SCRAM TABLE ***
*
*      NSCR ITSCR
*                 TSCR(1),TSCR(2),----
141000 -17  11    0.0 1.0       7.5 1.0      10.0 0.824      14.0 0.614    *
141001           20.0 0.429    24.0 0.348    30.0 0.262      40.0 0.219    *
141002           50.0 0.184    70.0 0.151   100.0 0.125     150.0 0.102    *
141003          210.0 0.077   300.0 0.062   480.0 0.056     600.0 0.053    *
141004         1800.0 0.041              * POWER TRANSIENT                  *
*** DENSITY REACTIVITY, DOPPLER TABLE, REACTIVITY COEFF.                   *
***   142OXX,143OXX,140XX0   ARE NOT USED.                                 *
*
*** HEAT SLAB DATA ***
*
*     IVSL   IGOM  IXLO  IMCR     AHTL    AHTR    VOLS    HDML    HDMR     *
*        IVSR    ISB    IMCL      (FT2)   (FT2)   (FT3)   (FT)    (FT)     *
150011  0  2  1  0                0.0    18.13  0.1825  0.0    0.04285   *
150021  0 19  1  1                0.0    18.13  0.1825  0.0    0.04285   *
150031  0 20  1  1                0.0    18.13  0.1825  0.0    0.04285   *
150041  0 21  1  1                0.0    36.26  0.3650  0.0    0.04285   *
150051  0 22  1  1                0.0    18.13  0.1825  0.0    0.04285   *
150061  0 23  1  1                0.0    18.13  0.1825  0.0    0.04285   *
150071  0 24  1  1                0.0    18.13  0.1825  0.0    0.04285   *
150081  0  1  2  0                0.0    91.96  0.755   0.0    0.07769   *
150091 -1 33  3  0               70.47   70.47 10.31    1.88   0.0       *
```

```
150101 -1  1  4  0              4.17    4.17 14.14     3.31  0.0
150111  0 25  1  0              0.0     6.043 0.06083 0.0   0.04285
150121  0 26  1  1              0.0     6.043  .06083 0.0   0.04285
150131  0 27  1  1              0.0     6.043  .06083 0.0   0.04285
150141  0 28  1  1              0.0     12.09  .1217  0.0   0.04285
150151  0 29  1  1              0.0     6.043  .06083 0.0   0.04285
150161  0 30  1  1              0.0     6.043  .06083 0.0   0.04285
150171  0 31  1  1              0.0     6.043  .06083 0.0   0.04285
150181 -1  4  5  0             41.41   41.41 11.08     2.66  0.0
150191  0 32  2  0              0.0     17.51  0.143    0.0   0.04718
*
*         PFR      HTC
*
150092    0.0264   8.74
150102    0.0015   8.74
150182    0.0155   8.74
*
*** CORE SLAB DATA ***
*
*       ISLB   NODT1   NODT2   NODT3   CHAN(FT) CLTI    HEDIAN   QFRAC
160010    1       1       4       9       0.771  0.0   0.04718  0.04109
160020    2       1       4       9       0.771  0.0   0.04718  0.07690
160030    3       1       4       9       0.771  0.0   0.04718  0.10360
160040    4       1       4       9       1.541  0.0   0.04718  0.23860
160050    5       1       4       9       0.771  0.0   0.04718  0.10360
160060    6       1       4       9       0.771  0.0   0.04718  0.07690
160070    7       1       4       9       0.771  0.0   0.04718  0.04109
160080   11       1       4       9       0.771  0.0   0.04718  0.01918
160090   12       1       4       9       0.771  0.0   0.04718  0.03589
160100   13       1       4       9       0.771  0.0   0.04718  0.04833
160110   14       1       4       9       1.542  0.0   0.04718  0.11140
160120   15       1       4       9       0.771  0.0   0.04718  0.04833
160130   16       1       4       9       0.771  0.0   0.04718  0.03589
160140   17       1       4       9       0.771  0.0   0.04718  0.01918
*
*** CORE SLAB FOR EM  16XXXYY  NOT USED  ***
*
*
*** SLAB GEOMETRY DATA ***
*
*   01     IG  NR        IM   NDX   XO      XR          PF
*   02             IGP   IM   NDX           XR          PF
*                                  (FT)    (FT)
170101      2   4         1    3    0.0     0.01001     0.0
170102              0     2    1             0.002297    1.0
170103              0     3    1             0.003557    0.0
170104              0     4    3             0.004265    0.0
170201      2   3   7     1         0.0     0.008203    0.0
170202              0     6    1             0.004922    0.0
170203              0     4    1             0.00328     0.0
170301      1   1   5    10         0.0     0.13        0.0
170401      1   1   5    10         0.0     0.509       0.0
170501      1   1   5    10         0.0     0.18        0.0
*
*** THERMAL CONDUCTIVITY DATA
*
*
*       NKP   TPK(1),TPK(2) -----
*           (DEGF)  (BTU/FTHRF)
*
180101 -5   572.  16.7   932.  16.2   1292.  15.7   1652.  15.2  * BN
180102     1832.  15.5
180201 -3    68.   10.1   212.   8.     4712.   6.72
180301  1    32.    3.36
180401 -9    70.   8.58   200.   9.08   400.   10.1 600. 11.1 *INCONEL 600
180402      800.  12.1    1000.  13.2   1200.  14.3 1400. 15.5
180403     1600.  16.7
180501 -2    32.   9.41   932.  12.1                          *SUS
180601 -11  392.  15.4   572.  11.9   752.  9.92   932.  8.13  *MGO
180602     1112.   6.77  1292.   5.81  1472.  5.08   1832.  3.99
180603     2192.   3.63  2252.   3.87  2912.  4.23
180701  1   32.   8.42
*
*
*** VOLUMETRIC HEAT CAPACITY ***
*
*       NCP   TPC(1),TPC(2) -----
*             (DEGF) (BTU/FFT3)
*
190101 -4    680.  5.28 950.  5.98 1562.  7.55 2300.  9.47  * BN
190201 -3     68.   57.4 212.  55.6 4712.  57.4
190301 -4    680.  5.28 950.  5.99 1562.  7.56 2300.  9.47  * BN
190401 -9     70.   55.7 200.  58.3 400.   60.9 600.   63.6  * INC600
190402       800.  66.2 1000. 69.3 1200.  73.5 1400.  76.2
190403      1600.  78.3
190501  1    32.   59.3                                      * SUS
190601  1    32.   50.3                                      * MGO
190701  1    32.   54.3
*
*
*** LINEAR EXPANSION COEFF., HEAT EXCHANGER DATA
***      20XXYY, 21XXYY   ARE NOT USED.
*
*** OTHER INPUT OPTIONS ARE NOT USED. ***
*
***              **** END OF INPUT DATA CARDS ****
*
.          * LAST DATA CARD
 0 0       *
```

Appendix B Input Data List; RELAP5/MOD1/001 Case A

```
*ROSA-III RUN901 POST-TEST ANALYSIS ( TRANSIENT S.P. CASE 3 )          *
*****************************************************************************
*                                                                           *
* RRRRRRRRR   0000000000   SSSSSSSSS     AAAA          IIIIIIIIIIIIIIII  *
* RRRRRRRRR   0000000000   SSSSSSSSS     AAAA          IIIIIIIIIIIIIIII  *
* RR      RR  00      00  SS            AA  AA           II  II  II    *
* RR      RR  00      00  SS            AA  AA           II  II  II    *
* RRRRRRRRR   00      00   SSSSSSSS    AA    AA         II  II  II    *
* RRRRRRRRR   00      00    SSSSSSSS   AA    AA    ===  II  II  II    *
* RR    RR    00      00          SS  AAAAAAAAAA  ===  II  II  II    *
* RR    RR    00      00          SS  AAAAAAAAAA       II  II  II    *
* RR     RR   00      00          SS  AA      AA       II  II  II    *
* RR     RR   00      00          SS  AA      AA       II  II  II    *
* RR      RR  0000000000  SSSSSSSSS  AA      AA  IIIIIIIIIIIIIIII  *
* RR      RR  0000000000  SSSSSSSSS  AA      AA  IIIIIIIIIIIIIIII  *
*                                                                           *
*****************************************************************************
*                                                                           *
*   BASE INPUT DATA              CREATED 1982/02/22                         *
*           BASE INPUT J0797.R910PD02.DATA(RLP5M0A2)                        *
*           BASE INPUT J9268.R5M1PA01.DATA(R5M1CA21)                        *
*           PUMP AT JET PUMP SUCTION                                        *
*                                                                           *
*                                                                           *
*RELAP5/MOD1 INPUT DATA                                                     *
*                                                                           *
*           TYPE        OPTION                                            *
0000100     NEW         TRANSNT                                           *
*                                                                           *
*                INPUT CHECK                                              *
0000101          RUN                                                       *
*                                                                           *
*            INPUT       OUTPUT                                           *
0000102     SI          SI                                                *
*                                                                           *
*          T END    MIN      MAX     CON   MIE   MAE    MR                 *
0000201    1000.0   1.0-20   0.001    1    500   4000   4000               *
*                                                                           *
*                                                                           *
0000502     TIME     0       GE     NULL    0      0.05        L   *BREAK  *
0000509     TIME     0       GE     NULL    0      0.05        L   *MRP1   *
0000510     TIME     0       GE     NULL    0      0.05        L   *MRP2   *
0000513     TIME     0       LT     NULL    0      0.05        N   *QSV    *
0000527     TIME     0       GE     NULL    0   1000.0         L   *BREAK P*
*                                                                           *
*****************************************************************************
*****************************************************************************
*                                                                           *
**********          HYDRODYNAMIC COMPONENTS            ******************
*                                                                           *
*     REFERENCES                                                            *
*       1. JAERI-M 8588   RELAP4J INPUT DATA FOR ROSA-III RUN 704           *
*       2. JAERI-M 8499   PIPING ETC                                        *
*       3. MECHANICAL ENGINEERING HANDBOOK                                  *
*       4. RELAP5 USERS MANUAL VOL 1,2,3                                    *
*       5. LOFT INPUT DATA FOR RELAP5 CALCULATION                           *
*                                                                           *
*     FUNDAMENTAL ASSUMPTION                                                *
*          NONHOMOGENEOUS, NONEQUILIBRIUM ..... INSIDE VESSEL               *
*                                                                           *
*     NOTE                                                                  *
*       ALL BEND RESISTANCES ARE CALCULATED FROM REFERENCE 3                *
*       ALL WALL ROUGHNESS ARE CONSTANT                                     *
*           E = 0.00005  (M)                                                **
*                                                                           *
*****************************************************************************
*                                                                           *
*  LOWER PLENUM (1)                                                         *
*                                                                           *
*           NAME        TYPE                                              *
0100000     C010        BRANCH                                            *
*                                                                           *
*           NO JUN      INITIAL C.C                                       *
0100001     5           1                                                 *
*                                                                           *
*         AREA  LEN    VOL       HZ    VR    ELV    ROUG      HYD  FE     *
0100101   0.0   0.120  0.07959   0.0   90.0  0.120  0.00005   0.0  00     *
*                                                                           *
*          CTL    PRESSURE      TEMP     ZERO                              *
0100200    3     7.35100+6     551.7    0.0                               *
*                                                                           *
*            FR        TO       AREA     F-LOSS R-LOSS CAHS               *
0101101   010000000 011010000  0.0      0.0    0.0    0100                *
0102101   185010000 010000000  0.0      1.0    0.432  0000                *
0103101   245010000 010000000  0.0      1.0    0.432  0000                *
0104101   010010000 020000000  0.0      4.323  4.323  0000                *
0105101   010010000 090000000  1.758-4  1.55   1.55   0000                *
*                                                                           *
*           FLOW-F  FLOW-G   VELJ                                          *
0101201    0.0      0.0      0.0                                          *
0102201    8.00     0.0      0.0                                          *
0103201    8.00     0.0      0.0                                          *
0104201   15.85     0.0      0.0                                          *
0105201    0.15     0.0      0.0                                          *
*                                                                           *
*****************************************************************************
*                                                                           *
0110000     C011        SNGLVOL                                           *
0110101   0.3374  0.1350 0.0  0.0  90.0  0.1350 0.00005  0.0951  00       *
*                                                                           *
0110200    3     7.3524+6     551.7    0.0                               *
*                                                                           *
*****************************************************************************
*                                                                           *
*  LOWER PLENUM (2)                                                         *
*                                                                           *
*           NAME        TYPE                                              *
0200000     C020        PIPE                                              *
0200001    2                                                              *
```

```
0200101   0.07849      2                                                  *
0200201   0.04366      1                                                  *
0200301   0.2550       1                                                  *
0200302   0.7819       2                                                  *
0200401   0.0          2                                                  *
0200501   0.0          2                                                  *
0200601   90.0         2                                                  *
0200701   0.2550       1                                                  *
0200702   0.7819       2                                                  *
0200801   0.00005    0.03714    2                                         *
0200901   2.77     2.77       1                                          *
0201001   00         2                                                    *
0201101   0000       1                                                    *
0201201   3      7.34788+6    551.7    0.0 0.0 1                         *
0201202   3      7.34475+6    551.7    0.0 0.0 2                         *
0201300   1                                                              *
0201301   15.85     0.0      0.0      1                                  *
*                                                                        *
**************************************************************************
*                                                                        *
*  CORE INLET CHAMBER    (2 VOLUMES)     (VOLUME 3 .... RELAP4J)         *
*                                                                        *
*           NAME          TYPE                                         *
0300000     C030          BRANCH                                         *
*                                                                        *
*           NO JUN        INITIAL C.C                                  *
0300001      3              1                                           *
*                                                                        *
*          AREA     LEN       VOL  HZ   VR     ELV      ROUG      HYD      FE *
0300101   0.029355 0.3350   0.0  0.0  90.0   0.2300   0.00005   9.795-3 00 *
*                                                                        *
*          CTL    PRESSURE      TEMP      ZERO                          *
0300200    3      7.34132+6     551.7     0.0                           *
*                                                                        *
*            FR          TO          AREA    F-LOSS R-LOSS CAHS        *
0301101   020010000 030000000  0.005352    4.38    4.38    0000         *
0302101   030010000 040000000  0.009498    1.75    1.75    0000         *
0303101   030010000 100000000  3.937-4     2.64    2.64    0000         *
*                                                                        *
*          FLOW-F  FLOW-G   VELJ                                        *
0301201    11.8875  0.0      0.0                                        *
0302201    11.40    0.0      0.0                                        *
0303201     0.4875  0.0      0.0                                        *
*                                                                        *
0310000     C031          BRANCH                                         *
0310001     3               1                                            *
0310101     0.009785  0.335  0.0  0.0  90.0  0.23  0.00005  3.265-3 00 *
0310200     3     7.34132+6     551.7     0.0                           *
0311101     020010000 031000000  0.001784  4.38  4.38  0000            *
0312101     031010000 045000000  0.003166  1.75  1.75  0000            *
0313101     031010000 100000000  1.312-4   2.64  2.64  0000            *
0311201     3.9625    0.0    0.0                                         *
0312201     3.8       0.0    0.0                                         *
0313201     0.1625    0.0    0.0                                         *
**************************************************************************
*                                                                        *
*  CORE                                      (VOLUME 32-37,4 .. RELAP4J)*
*     **** AVERAGE POWER CHANNEL                                         *
*                                                                        *
```

```
*           NAME          TYPE                                         *
0400000     C040          PIPE                                         *
*                                                                        *
*           NO.VOL                                                     *
0400001      7                                                         *
*                                                                        *
*          AREA          VOL NO                                       *
0400101   0.02936          7                                           *
*                                                                        *
*          AREA          JUN NO                                       *
0400201   0.0              6                                           *
*                                                                        *
*          LEN           VOL NO                                       *
0400301   0.308            1                                           *
0400302   0.235            3                                           *
0400303   0.470            4                                           *
0400304   0.235            6                                           *
0400305   0.308            7                                           *
*                                                                        *
*          VOL           VOL NO                                       *
0400401   0.0              7                                           *
*                                                                        *
*          HZ            VOL NO                                       *
0400501   0.0              7                                           *
*                                                                        *
*          VR            VOL NO                                       *
0400601   90.0             7                                           *
*                                                                        *
*          ELV           VOL NO                                       *
0400701   0.308            1                                           *
0400702   0.235            3                                           *
0400703   0.470            4                                           *
0400704   0.235            6                                           *
0400705   0.308            7                                           *
*                                                                        *
*          ROUGH          HYD     VOL NO                               *
0400801   0.00005      0.01306     7                                   *
*                                                                        *
*          F-LOSS      R-LOSS      JUN NO                               *
0400901    1.361       1.361         6                                 *
*                                                                        *
*          FE            VOL NO                                       *
0401001   00               7                                           *
*                                                                        *
*          CAHS          JUN NO                                       *
0401101   0000             6                                           *
*                                                                        *
*          CTL     PRESSURE      TEMP      ZERO          VOL           *
0401201    3      7.33881+6     553.1     0.0  0.0      1              *
0401202    3      7.33631+6     557.1     0.0  0.0      2              *
0401203    2      7.33255+6     0.00330   0.0  0.0      3              *
0401204    2      7.32879+6     0.04434   0.0  0.0      4              *
0401205    2      7.32503+6     0.08537   0.0  0.0      5              *
0401206    2      7.32128+6     0.10704   0.0  0.0      6              *
0401207    2      7.31752+6     0.12123   0.0  0.0      7              *
*          CTL                                                         *
0401300    1                                                           *
*                                                                        *
*          FLOW-F  FLOW-G   VELJ    JUN NO                            *
```

```
0401301     11.40     0.0      0.0      1                                  *
0401302     11.40     0.0      0.0      2                                  *
0401303     11.2210   0.1790   0.0      3                                  *
0401304     10.5696   0.8304   0.0      4                                  *
0401305     10.2855   1.1145   0.0      5                                  *
0401306     10.0753   1.3247   0.0      6                                  *
*                                                                         *
***************************************************************************
*                                                                         *
*  CORE                                                                   *
*      **** HIGH POWER CHANNEL                                            *
*                                                                         *
0450000     C045      PIPE                                               *
0450001     7                                                            *
0450101     0.009785      7                                              *
0450201     0.0           6                                              *
0450301     0.308         1                                              *
0450302     0.235         3                                              *
0450303     0.470         4                                              *
0450304     0.235         6                                    *         *
0450305     0.308         7                                    *         *
0450401     0.0           7                                              *
0450501     0.0           7                                              *
0450601     90.0          7                                              *
0450701     0.308         1                                              *
0450702     0.235         3                                              *
0450703     0.470         4                                              *
0450704     0.235         6                                    *         *
0450705     0.308         7                                    *         *
0450801     0.00005   0.01306  7                                         *
0450901     1.361  1.361  6                                             *
0451001     00            7                                              *
0451101     0000          6                                              *
0451201     3     7.33861+6     553.5      0.0  0.0  1                   *
0451202     3     7.33621+6     558.8      0.0  0.0  2                   *
0451203     2     7.33235+6     0.01678    0.0  0.0  3                   *
0451204     2     7.32859+6     0.07123    0.0  0.0  4                   *
0451205     2     7.32483+6     0.12559    0.0  0.0  5                   *
0451206     2     7.32108+6     0.15433    0.0  0.0  6                   *
0451207     2     7.31732+6     0.17317    0.0  0.0  7                   *
0451300     1                                                            *
0451301     3.80     0.0     0.0     1                                   *
0451302     3.80     0.0     0.0     2                                   *
0451303     3.6740   0.1260  0.0     3                                   *
0451304     3.3854   0.4146  0.0     4                                   *
0451305     3.2603   0.5397  0.0     5                                   *
0451306     3.1670   0.6330  0.0     6                                   *
*                                                                         *
***************************************************************************
*                                                                         *
*  UPPER PLENUM                          (VOLUME 5 .... RELAP4J)          *
*                                                                         *
*           NAME          TYPE                                          *
0500000     C050          BRANCH                                        *
*                                                                         *
*           NO JUN        INITIAL C.C                                   *
0500001      4             1                                            *
*                                                                         *
*          AREA  LEN   VOL   HZ   VR    ELV   ROUG    HYD   FE          *
0500101    0.0  0.234 0.04137 0.0  90.0  0.234  0.00005  0.5  00         *
*                                                                         *
*           CTL    PRESSURE    QUALITY    ZERO                           *
0500200     2     7.31376+6    0.13380    0.0                            *
*                                                                         *
*             FR          TO         AREA     F-LOSS R-LOSS  CAHS       *
0501101   045010000 050000000  0.003164     1.298  1.216  0000         *
0502101   040010000 050000000  0.009492     1.298  1.216  0000         *
0503101   100010000 050000000  0.01447      1.0    0.41   0000         *
0504101   050010000 051000000  0.0          0.0    0.0    0000         *
*                                                                         *
*           FLOW-F    FLOW-G   VELJ                                      *
0501201     3.1171    0.6829    0.0                                      *
0502201     9.9619    1.4381    0.0                                      *
0503201     0.80      0.0       0.0                                      *
0504201    13.8592    2.1408    0.0                                      *
*                                                                         *
0510000     C051      PIPE                                   *           *
0510001     2                                                *           *
0510101     0.0         2                                    *           *
0510201     0.0         1                                    *           *
0510301     0.2345      2                                    *           *
0510401     0.041365    2                                    *           *
0510501     0.0         2                                    *           *
0510601      90.0       2                                                *
0510701      0.2345     2                                      *         *
0510801      0.00005  0.5  2                                  *           *
0510901      0.0     0.0     1                                *           *
0511001      00       2                                       *           *
0511101      0000     1                                       *           *
0511201      2   7.31210+6   0.1338   0.0   0.0   1*                     *
0511202      2   7.31045+6   0.1338   0.0   0.0   2*                     *
0511300      1                                                *           *
0511301      13.8592   2.1408   0.0   1                      *           *
*                                                             *           *
0520000     C052      SNGLJUN                                *           *
0520101     051010000 060000000  0.02165  0.407  0.792  0000*           *
0520201     1   13.8592   2.1408   0.0                       *           *
***************************************************************************
*                                                                         *
*  STEAM SEPARATOR                                                        *
*                                                                         *
*           NAME          TYPE                                          *
0600000     C060          PIPE                                          *
0600001     4                                                *           *
0600101     0.0         1                                    *           *
0600102     0.04101     3                                    *           *
0600103     0.0         4                                    *           *
0600201     0.0         2                                    *           *
0600202     0.017789    3                                    *           *
0600301     0.335       1                                    *           *
0600302     0.2497      3                                    *           *
0600303     0.288       4                                    *           *
0600401     0.006416    1                                    *           *
0600402     0.0         3                                    *           *
0600403     0.005564    4                                    *           *
0600501     0.0         4                                    *           *
0600601     90.0        4                                    *           *
0600701     0.335       1                                    *           *
```

```
0600702     0.2497    3                                          *
0600703     0.288     4                                          *
0600801     0.00005   0.15616  1                                 *
0600802     0.00005   0.22312  3                                 *
0600803     0.00005   0.1585   4                                 *
0600901     0.0   0.0   3                                        *
0601001     00  4                                                *
0601101     0000  3                                             *
0601201     2   7.30879+6   0.1338   0.0   0.0   1*
0601202     2   7.30548+6   0.1338   0.0   0.0   2*
0601203     2   7.30217+6   0.1338   0.0   0.0   3*
0601204     2   7.29886+6   0.1338   0.0   0.0   4*
0601300     1                                                    *
0601301     13.8592    2.1408   0.0   1                         *
0601302     13.8592    2.1408   0.0   2                         *
0601303     13.8592    2.1408   0.0   3                         *
*****************************************************************
*                                                               *
*  UPPER DOWNCOMER                                              *
*                                                               *
*           NAME         TYPE                                   *
0710000     C071         BRANCH                                 *
0710001   3  1                                                   *
0710101   0.0  0.5503  0.1891  0.0  90.0  0.5503  0.00005  0.6615  00  *
0710200   2  7.29220+6  0.1338   0.0                            *
0711101   060010000  071010000  0.0        0.0  0.0  0000      *
0712101   071010000  070000000  0.0        0.0  0.0  0000      *
0713101   071000000  110010000  0.2316     0.0  0.0  0100      *
0711201   13.8592  2.1408   0.0                                 *
0712201   0.0      2.1408   0.0                                 *
0713201   13.8592  0.0      0.0                                 *
*                                                               *
*****************************************************************
*                                                               *
*  UPPER HEAD (ABOVE SEPARATOR)                                 *
*                                                               *
0700000   C070          SNGLVOL                                 *
0700101   0.38485  0.2817  0.0  0.0  90.0  0.2817  0.00005  0.7   00  *
0700200   2     7.29110+6  0.99999  0.0                        *
*                                                               *
*****************************************************************
*                                                               *
0720000     C072         SNGLJUN                                *
0720101     070010000  080000000  0.01914  0.0  0.0  0100      *
0720201     1  0.0  2.1408  0.0                                 *
*                                                               *
*****************************************************************
*                                                               *
*  STEAM DOME                          (VOLUME 8 .... RELAP4J)  *
*                                                               *
*           NAME         TYPE                                   *
0800000     C080         SNGLVOL                                *
*                                                               *
*          AREA  LEN     VOL        HZ   VR    ELV    ROUG     HYD  FE  *
0800101    0.0   0.348   0.126748  0.0  90.0  0.348  0.00005  0.7  00  *
*                                                               *
*          CTL   PRESSURE     QUALITY    ZERO                   *
0800200     2    7.29000+6    0.99999     0.0                   *
*                                                               *
*****************************************************************
*                                                               *
*  GUIDE TUBE                          (VOLUME 9 .... RELAP4J)  *
*                                                               *
*           NAME         TYPE                                   *
0900000     C090         PIPE                                   *
0900001     3                                                   *
0900101   0.0      2                                            *
0900102   0.02515  3                                            *
0900201   0.0      1                                            *
0900202   0.00193  2                                            *
0900301   0.5529   1                                            *
0900302   0.554    2                                            *
0900303   0.16  3                                              *
0900401   0.036298  1                                           *
0900402   0.028296  2                                           *
0900403   0.0  3                                               *
0900501   0.0        3                                          *
0900601   90.0       3                                          *
0900701   0.5529     1                                          *
0900702   0.554      2                                          *
0900703   0.16  3                                              *
0900801   0.00005 0.05567   2                                  *
0900802   0.00005 0.02284   3                                  *
0900901   0.0     0.0       2                                  *
0901001   00        3                                          *
0901101   0000      1                                          *
0901102   0100      2                                          *
0901201   3      7.34728+6   551.7    0.0  0.0  1              *
0901202   3      7.34311+6   551.7    0.0  0.0  2              *
0901203   3      7.33834+6   551.7    0.0  0.0  3              *
0901300    1                                                  *
0901301   0.15    0.0       0.0       2                       *
*                                                               *
*****************************************************************
*                                                               *
0950000     C095     SNGLJUN                                    *
0950101     090010000 100000000  0.0       0.0    0.0    0000  *
0950201     1      0.15    0.0    0.0                          *
*                                                               *
*****************************************************************
*                                                               *
*  CORE BYPASS                         (VOLUME10 .... RELAP4J)  *
*                                                               *
*           NAME         TYPE                                   *
1000000     C100         PIPE                                   *
1000001     3                                                   *
1000101     0.02515     3                                       *
1000201     0.0         2                                       *
1000301     0.676       1                                       *
1000302     0.675       2                                       *
1000303     0.675       3                                       *
1000401     0.0         3                                       *
1000501     0.0         3                                       *
1000601     90.0        3                                       *
1000701     0.676       1                                       *
1000702     0.675       2                                       *
1000703     0.675       3                                       *
1000801     0.00005 0.02284   3                                 *
```

```
1000901    0.0       0.0       2                                          *
1001001    00          3                                                  *
1001101    0000        2                                                  *
1001201    3      7.33424+6    551.7     0.0   0.0   1                   *
1001202    3      7.33014+6    551.7     0.0   0.0   2                   *
1001203    3      7.32195+6    551.7     0.0   0.0   3                   *
1001300    1                                                             *
1001301    0.80      0.0       0.0       2                               *
*                                                                        *
**************************************************************************
*                                                                        *
*  UPPER DOWNCOMER-1                        (VOLUME27 .... RELAP4J)      *
*                                                                        *
*            NAME          TYPE                                        *
1100000     C110          SNGLVOL                                       *
1100101   0.0  0.2371  0.05588  0.0   90.0   0.2371   0.00005   0.5478  00 *
1100200   2   7.29410+6    0.0    0.0                                    *
**************************************************************************
*                                                                        *
*  UPPER DOWNCOMER        (FEEDWATER SPAGER)                             *
*                                                                        *
*            NAME          TYPE                                        *
1110000     C111          BRANCH                                        *
*                                                                        *
1110001   2         1                                                    *
1110101   0.0  0.328  0.081672  0.0   90.0   0.328   0.00005   0.56306  00 *
1110200   3      7.29739+6  551.7    0.0                                 *
1111101   110000000 111010000  0.0         0.0     0.0    0000          *
1112101   111000000 112010000  0.08006     0.0     0.0    0000          *
1111201     13.8881 0.0      0.0                                         *
1112201     16.00   0.0      0.0                                         *
**************************************************************************
*                                                                        *
1120000     C112          PIPE                                          *
1120001     3                                                           *
1120101     0.0           1                                             *
1120102     0.08006       2                                             *
1120103     0.08006       3                                             *
1120201     0.0           2                                             *
1120301     0.189         1                                             *
1120302     0.356         2                                             *
1120303     0.35          3                                             *
1120401     0.013658      1                                             *
1120402     0.0           3                                             *
1120501     0.0           3                                             *
1120601     90.0          3                                             *
1120701     0.189         1                                             *
1120702     0.356         2                                             *
1120703     0.35          3                                             *
1120801     0.00005 0.303     1                                         *
1120802     0.00005 0.092     3                                         *
1120901     0.0     0.0       2                                         *
1121001     00            3                                             *
1121101     0000          2                                             *
1121201     3      7.30077+6    551.7     0.0   0.0   1                 *
1121202     3      7.30416+6    551.7     0.0   0.0   2                 *
1121203     3      7.30754+6    551.7     0.0   0.0   3                 *
1121300     1                                                           *
1121301    -16.00     0.0      0.0      2                               *
```

```
**************************************************************************
*                                                                        *
*  LOWER DOWNCOMER (JET PUMP INLET)     (VOLUME11 .... RELAP4J)          *
*                                                                        *
*            NAME          TYPE                                        *
1200000     C120          BRANCH                                        *
*                                                                        *
*            NO JUN        INITIAL C.C                                 *
1200001      4              1                                           *
*                                                                        *
*           AREA      LEN     VOL  HZ   VR    ELV    ROUG      HYD    FE *
1200101    0.022478  0.541   0.0  0.0  90.0  0.541  0.00005   0.030  00 *
*                                                                        *
*           CTL   PRESSURE     TEMP      ZERO                           *
1200200     3     7.31093+6    551.7     0.0                            *
*                                                                        *
*             FR          TO          AREA   F-LOSS R-LOSS CAHS        *
1201101   112000000 120010000  0.0      0.0     0.0     0100            *
1202101   120000000 130010000  0.0      0.0     0.0     0000            *
1203101   120000000 170000000  0.0      0.75    1.0     0000            *
1204101   120000000 230000000  0.0      0.75    1.0     0000            *
*                                                                        *
*           FLOW-F    FLOW-G  VELJ                                     *
1201201   16.0        0.0     0.0                                       *
1202201    6.00       0.0     0.0                                       *
1203201    5.00       0.0     0.0                                       *
1204201    5.00     0.0       0.0                                       *
*                                                                        *
**************************************************************************
*                                                                        *
*  LOWER DOWNCOMER                          (VOLUME11 .... RELAP4J)      *
*                                                                        *
*            NAME          TYPE                                        *
1300000     C130          PIPE                                          *
1300001     4                                                           *
1300101     0.0           1                                             *
1300102     0.022478      4                                             *
1300201     0.0           3                                             *
1300301     0.365         4                                             *
1300401     0.014181      1                                             *
1300402     0.0           4                                             *
1300501     0.0           4                                             *
1300601     90.0          4                                             *
1300701     0.365         4                                             *
1300801     0.00005   0.070333  1                                       *
1300802     0.00005   0.030     4                                       *
1300901     0.0       0.0       3                                       *
1301001     00            4                                             *
1301101     0000          3                                             *
1301201     3         7.32447+6     551.7     0.0   0.0   1             *
1301202     3         7.32108+6     551.7     0.0   0.0   2             *
1301203     3         7.31770+6     551.7     0.0   0.0   3             *
1301204     3         7.31431+6     551.7     0.0   0.0   4             *
1301300     1                                                           *
1301301    -6.00      0.0       0.0       3                             *
**************************************************************************
*  RECIRCULATION INLET PIPE TEE                                          *
1310000     C131     BRANCH                                             *
1310001     4            1                                              *
```

```
1310101    0.019563  0.416  0.0  0.0  90.0  0.416  0.00005  0.026  00
1310200    3     7.32785+6   551.7    0.0
1311101    130000000 131010000 0.009161 0.0     0.0     0100
1312101    131000000 140000000   0.0     0.75   1.0     0000
1313101    131000000 190000000   0.0     0.75   1.0     0000
1314101    131000000 132010000   0.0     0.0    0.0     0000
1311201     6.00      0.0       0.0
1312201     3.00      0.0       0.0
1313201     3.00      0.0       0.0
1314201     0.0       0.0       0.0
*****************************************************************
*   DEAD ZONE UNDER RECIRCULATION INLET PIPE                    *
1320000    C132      SNGLVOL                                    *
1320101    0.019563  0.444  0.0  0.0  90.0  0.444  0.00005  0.026  00
1320200    3     7.3312+6    551.7    0.0
*                                                               *
*****************************************************************
*                                                               *
*  INTACT RECIRCULATION INLET LINE      (VOLUME23 .... RELAP4J) *
1400000     C140         PIPE                                   *
1400001     3                                                   *
1400101    0.0019244        3                                  *
1400201    0.0              2                                  *
1400301    2.0445           1                                  *
1400302    1.9894           2                                  *
1400303    1.7939           3                                  *
1400401    0.0              3                                  *
1400501    0.0              3                                  *
1400601    -90.0            3                                  *
1400701    -0.154           1                                  *
1400702    -1.704           2                                  *
1400703    -1.315           3                                  *
1400801    0.00005  0.0495    3                                *
1400901    0.25     0.25    1                                  *
1400902    0.19     0.19    2                                  *
1401001    00               3                                  *
1401101    0000             2                                  *
1401201    3     7.34807+6   551.7    0.0  0.0   1             *
1401202    3     7.36830+6   551.7    0.0  0.0   2             *
1401203    3     7.38852+6   551.7    0.0  0.0   3             *
1401300    1                                                   *
1401301    3.00      0.0       0.0       2                     *
*****************************************************************
*                                                               *
*  INTACT RECIRCULATION PUMP            (VOLUME24 .... RELAP4J) *
*                                                               *
*           NAME         TYPE                                  *
1500000     C150         PUMP                                   *
*                                                               *
*          AREA   LEN    VOL    HZ     VR      ELV  CTL        *
1500101   0.0    0.26   0.005295   0.0   -90.0   -0.26   0      *
*                                                               *
*          VOL NO    AREA    F-LOSS R-LOSS  CAHS                *
1500108   140010000  0.0019244   5.28  5.28   0000             *
*                                                               *
*          VOL NO    AREA    F-LOSS R-LOSS  CAHS                *
1500109   160000000  0.0019244   5.28  5.28   0000             *
*                                                               *
*          CTL    PRESSURE     TEMP       ZERO                 *
1500200     3     7.65292+6    551.7     0.0                    *
*                                                               *
*          CTL    FLOW-F  FLOW-G   VEL                         *
1500201     1     3.00     0.0      0.0                        *
*                                                               *
*          CTL    FLOW-F  FLOW-G   VEL                         *
1500202     1     3.00     0.0      0.0                        *
*                                                               *
*         TAB-D  TWO-P  DIF-T  MOTOR   TAB-S  TRIP   REVER     *
1500301     0      0.      0      -1     -1     509     1       *
*                                                               *
*          R-SP   I/R    R-FL   R-HD   R-TOR M-IN  R-DEN       *
1500302   376.99  0.5092 0.0075 262.0  184.24 1.9   766.52     *
*                                                               *
*         R-M-TR   FR-TF2    FR-TF0    FR-TF1    FR-TF3       *
1500303    0.0       0.0       0.0       0.0       0.0        *
*                                                               *
*         ELS TM  MX-F    MX-R                                *
1500310   0.0     0.0     0.0                                   *
*                                                               *
* SINGLE PHASE 4 QUADRANT HEAD TABLES                           *
*                                                               *
1501100 1  1                                                   *
1501101  0.00  0.92  0.20  0.94  0.40  0.97  0.60  1.00  1.00  1.00
1501200 1  2                                                   *
1501201  0.00 -0.20  0.25  0.00  0.40  0.12  0.70  0.50  1.00  1.00
1501300 1  3                                                   *
1501301 -1.00  1.20 -0.80  0.98 -0.60  0.94 -0.30  0.92  0.00  0.92
1501400 1  4                                                   *
1501401 -1.00  1.20 -0.80  0.70 -0.50  0.34 -0.20  0.18  0.00  0.18
1501500 1  5                                                   *
1501501  0.00  0.62  0.20  0.69  0.40  0.77  0.60  0.85  1.00  1.00
1501600 1  6                                                   *
1501601  0.00  0.18  0.20  0.22  0.40  0.32  0.65  0.52  1.00  1.00
1501700 1  7                                                   *
1501701 -1.00  0.00 -0.80  0.16 -0.40  0.45 -0.20  0.56  0.00  0.62
1501800 1  8                                                   *
1501801 -1.00  0.00 -0.80 -0.14 -0.50 -0.24 -0.20 -0.24  0.00 -0.20
*                                                               *
* SINGLE PHASE 4 QUADRANT TORQUE TABLES                         *
*                                                               *
1501900 2  1                                                   *
1501901  0.00  0.46  0.20  0.54  0.50  0.67  0.80  0.86  1.00  1.00
1502000 2  2                                                   *
1502001  0.00 -0.10  0.20  0.08  0.50  0.34  0.80  0.65  1.00  1.00
1502100 2  3                                                   *
1502101 -1.00  0.70 -0.80  0.68 -0.50  0.48 -0.30  0.44  0.00  0.46
1502200 2  4                                                   *
1502201 -1.00  0.70 -0.70  0.45 -0.40  0.38 -0.20  0.32  0.00  0.28
1502300 2  5                                                   *
1502301  0.00 -0.66  0.20 -0.53  0.60 -0.30  0.80 -0.20  1.00 -0.10
1502400 2  6                                                   *
1502401  0.00  0.28  0.20  0.22  0.50  0.10  0.80  0.00  1.00 -1.00
1502500 2  7                                                   *
1502501 -1.00 -1.40 -0.80 -1.25 -0.50 -1.00 -0.20 -0.80  0.00 -0.66
1502600 2  8                                                   *
1502601 -1.00 -1.40 -0.60 -0.80 -0.50 -0.66 -0.20 -0.30  0.00 -0.10
*                                                               *
* 2-PHASE MULTIPLIER TABLES                                     *
```

```
*
1503000 0
1503001  0.0  0.0  0.1  0.0  0.15  0.05  0.24  0.8  0.3  0.96
1503002  0.4  0.98 0.6  0.97 0.80  0.90  0.90  0.8  0.96 0.50
1503003  1.0  1.0
1503100 0
1503101  0.0  0.0  1.0  0.0
*
* 2-PHASE HEAD DIFFERENCE TABLES          * BUILT-IN RELAP4J
*
1504100 1  1
1504101  0.00  0.00  0.10  0.67  0.25  0.91  0.50  1.12
1504102  0.75  1.28  1.00  1.34
1504200 1  2
1504201  0.00  0.31  0.25  0.42  0.50  0.57  0.75  0.97  1.00  1.34
1504300 1  3
1504301 -1.00 -1.18 -0.75 -1.30 -0.50 -1.08 -0.25 -0.93
1504302 -0.10 -0.71  0.00  0.00
1504400 1  4
1504401 -1.00 -1.18 -0.75 -0.24 -0.50 -0.07 -0.25 -0.08  0.00 -0.19
1504500 1  5
1504501  0.00  0.00  0.10 -0.39  0.25 -0.71  0.50 -0.71
1504502  0.75 -0.58  1.00 -0.47
1504600 1  6
1504601  0.00 -0.19  0.25 -0.45  0.50 -0.55  0.75 -0.59  1.00 -0.47
1504700 1  7
1504701 -1.00  0.51 -0.75  0.55 -0.50  0.51 -0.25  0.39  0.00  0.00
1504800 1  8
1504801 -1.00  0.51 -0.75  0.31 -0.50  0.22 -0.25  0.21  0.00  0.31
*
* 2-PHASE TORQUE DIFFERENCE TABLES        * BUILT-IN RELAP4J
*
1504900 2  1
1504901  0.00  0.00  0.10  0.67  0.25  0.91  0.50  1.12
1504902  0.75  1.28  1.00  1.34
1505000 2  2
1505001  0.00  0.31  0.25  0.42  0.50  0.57  0.75  0.97  1.00  1.34
1505100 2  3
1505101 -1.00 -1.18 -0.75 -1.30 -0.50 -1.08 -0.25 -0.93
1505102 -0.10 -0.71  0.00  0.00
1505200 2  4
1505201 -1.00 -1.18 -0.75 -0.24 -0.50 -0.07 -0.25 -0.08  0.00 -0.19
1505300 2  5
1505301  0.00  0.00  0.10 -0.39  0.25 -0.71  0.50 -0.71
1505302  0.75 -0.58  1.00 -0.47
1505400 2  6
1505401  0.00 -0.19  0.25 -0.45  0.50 -0.55  0.75 -0.59  1.00 -0.47
1505500 2  7
1505501 -1.00  0.51 -0.75  0.55 -0.50  0.51 -0.25  0.39  0.00  0.00
1505600 2  8
1505601 -1.00  0.51 -0.75  0.31 -0.50  0.22 -0.25  0.21  0.00  0.31
*
*
*************************************************************************
*
* INTACT RECIRCULATION OUTLET LINE     (VOLUME25,26 .... RELAP4J)
*
*          NAME        TYPE
1600000     C160       PIPE
*
1600001    6
1600101    0.0019244      5
1600102    0.0            6
1600201    0.0            4
1600202    0.0023162      5
1600301    2.425          1
1600302    2.5762         2
1600303    3.125          3
1600304    2.221          4
1600305    1.780          5
1600306    0.859          6
1600401    0.0            5
1600402    0.001776       6
1600501    0.0            6
1600601    90.0           1
1600602    0.0            2
1600603    90.0           5
1600604    -90.0          6
1600701    1.275          1
1600702    0.0            2
1600703    2.830          3
1600704    0.50           4
1600705    1.190          5
1600706   -0.559          6
1600801    0.00005 0.0495    5
1600802    0.00005 0.0513    6
1600901    0.295     0.295      1
1600902   13.903    13.903      2
1600903    0.085     0.085      3
1600904    0.112     0.112      4
1600905    0.336     0.336      5
1601001    00              6
1601101    0000            4
1601102    0000            5
1601201    3    7.91733+6    551.7    0.0  0.0   1
1601202    3    7.88306+6    551.7    0.0  0.0   2
1601203    3    7.84880+6    551.7    0.0  0.0   3
1601204    3    7.81453+6    551.7    0.0  0.0   4
1601205    3    7.78027+6    551.7    0.0  0.0   5
1601206    3    7.74600+6    551.7    0.0  0.0   6
1601300    1
1601301    3.00     0.0      0.0      5
*
*************************************************************************
*  INTACT JET PUMP SUCTION LINE                                         *
1700000     C170       SNGLVOL                                         *
1700101     0.003048  1.304  0.0  0.0  0.0  0.0  0.00005  0.0623  00   *
1700200     3   7.29093+6   551.7   0.0                                 *
*                                                                       *
*************************************************************************
*
*   INTACT JET PUMP SUCTION     ....    SMALL PUMP ASSUMED
1710000     C171       PUMP
1710101     0.0   0.973  0.002225  0.0  -90.0  -0.073  0
1710108     170010000    0.003048  0.6438 0.6438 0000
1710109     180000000    0.000474  0.042  0.021  0000
1710200     3   7.39435+6   551.7   0.0
1710201     1    5.00   0.0   0.0
```

```
1710202     1     5.00    0.0    0.0
1710301     150   150   150 -1   -1   509  1
1710302     376.99  0.5092 0.01250  26.0    184.24  1.9  765.76
1710303     0.0   0.0   0.0   0.0   0.0
1710310     0.0   0.0   0.0
*
*******************************************************************************
*
*   INTACT JET PUMP
*
1800000   C180     BRANCH
*
1800001   2      1
*
1800101  0.000585 0.121 0.0   0.0   -90.0   -0.121   0.00005   0.0273   00
*
1800200  3   7.38813+6    551.7    0.0
*
1801101  160010000 180000000  0.000111    0.936 0.510 0000
1802101  180010000 185000000  0.000585    0.07  0.0   0000
*
1801201   3.00    0.0   0.0
1802201   8.00    0.0   0.0
*
*******************************************************************************
*
*  INTACT JET PUMP OUTLET LINE          (VOLUME22 .... RELAP4J)
*
*           NAME          TYPE
1850000     C185          PIPE
1850001     5
1850101     0.0           1
1850102     0.003849      2
1850103     0.0           3
1850104     0.004289      5
1850201     0.003849      1
1850202     0.003849      2
1850203     0.004289      3
1850204     0.0           4
1850301     0.285         1
1850302     1.396         2
1850303     0.4243        3
1850304     2.0864        4
1850305     1.8464        5
1850401     0.0005636     1
1850402     0.0           2
1850403     0.003073      3
1850404     0.0           5
1850501     0.0           5
1850601     -90.0         5
1850701     -0.285        1
1850702     -1.396        2
1850703     -0.300        3
1850704     -0.240        4
1850705     -0.2729       5
1850801     0.00005 0.0502    1
1850802     0.00005 0.0700    2
1850803     0.00005 0.0960    3
1850804     0.00005 0.0739    4
1850805     0.00005 0.0739    5
1850901     0.0     0.46    1
1850902     3.597   3.597   2
1850903     0.3     1.0     3
1850904     0.832   0.832   4
1851001     00            5
1851101     0000          4
1851201     3     7.38000+6    551.7     0.0   0.0   1
1851202     3     7.37500+6    551.7     0.0   0.0   2
1851203     3     7.37000+6    551.7     0.0   0.0   3
1851204     3     7.36500+6    551.7     0.0   0.0   4
1851205     3     7.36000+6    551.7     0.0   0.0   5
1851300     1
1851301     8.00      0.0     0.0     4
*
*******************************************************************************
*
*  BROKEN RECIRCULATION INLET LINE      (VOLUME15 .... RELAP4J)
*
*           NAME          TYPE
1900000     C190          PIPE
1900001     3
1900101     0.0019244       3
1900201     0.0             2
1900301     2.1317          1
1900302     2.5127          2
1900303     2.5424          3
1900401     0.0             3
1900501     0.0             3
1900601     -90.0           2
1900602     0.0             3
1900701     -0.154          1
1900702     -1.285          2
1900703     -0.0            3
1900801     0.00005   0.0495    3
1900901     0.185     0.185     1
1900902     0.345     0.345     2
1901001     00              3
1901101     0000            2
1901201     3     7.33639+6    551.7     0.0   0.0   1
1901202     3     7.34492+6    551.7     0.0   0.0   2
1901203     3     7.35346+6    551.7     0.0   0.0   3
1901300     1
1901301     3.00      0.0       0.0     2
*
*******************************************************************************
*
*  BROKEN RECIRCULATION INLET LINE      (VOLUME16 .... RELAP4J)
*
*           NAME          TYPE
2000000     C200          PIPE
2000001     3
2000101     0.0019244       3
2000201     0.0             2
2000301     2.0659          1
2000302     2.6398          2
2000303     2.3574          3
2000401     0.0             3
2000501     0.0             3
```

```
2000601    -90.0          1                                              *
2000602    0.0            2                                              *
2000603    -90.0          3                                              *
2000701    -0.219         1                                              *
2000702    -0.0           2                                              *
2000703    -1.515         3                                              *
2000801    0.00005 0.0495   3                                            *
2000901    0.325    0.325    1                                           *
2000902    0.17     0.17     2                                           *
2001001    00             3                                             *
2001101    0000           2                                             *
2001201    3     7.36200+6   551.7    0.0  0.0  1                       *
2001202    3     7.37053+6   551.7    0.0  0.0  2                       *
2001203    3     7.37907+6   551.7    0.0  0.0  3                       *
2001300    1                                                            *
2001301    2.86     0.0      0.0      2                                  *
*                                                                        *
**************************************************************************
*                                                                        *
*  BROKEN RECIRCULATION PUMP           (VOLUME17 .... RELAP4J)           *
*                                                                        *
*          NAME         TYPE                                           *
2100000    C210         PUMP                                           *
*                                                                        *
*         AREA   LEN    VOL    HZ     VR     ELV    CTL                 *
2100101  0.0  0.26   0.005295  0.0  -90.0  -0.26   0                    *
*                                                                        *
*          VOL NO     AREA     F-LOSS R-LOSS CAHS                      *
2100108    200010000  0.0019244   5.28   5.28   0000                   *
*                                                                        *
*          VOL NO     AREA     F-LOSS R-LOSS CAHS                      *
2100109    220000000  0.0019244   5.28   5.28   0000                   *
*                                                                        *
*          CTL     PRESSURE      TEMP        ZERO                      *
2100200     3      7.64350+6     551.7       0.0                       *
*                                                                        *
*          CTL     FLOW-F  FLOW-G   VELJ                               *
2100201     1      3.00    0.0      0.0                                *
*                                                                        *
*          CTL     FLOW-F  FLOW-G   VELJ                               *
2100202     1      3.00    0.0      0.0                                *
*                                                                        *
*          TAB-D   TWO-P    DIF-T   MOTOR  TAB-S  TRIP  REVER           *
2100301     150     150      150     -1     -1     510     1            *
*                                                                        *
*          R-SP   I/R    R-FL   R-HD   R-TOR M-IN  R-DEN                *
2100302    376.99  0.5344 0.0075 262.0 184.24 1.9  766.52              *
*                                                                        *
*         R-M-TR   FR-TF2    FR-TF0    FR-TF1    FR-TF3                 *
2100303    0.0       0.0       0.0       0.0       0.0                 *
*                                                                        *
*         ELS TM  MX-F    MX-R                                           *
2100310   0.0     0.0     0.0                                            *
*                                                                        *
**************************************************************************
*                                                                        *
*  BROKEN RECIRCULATION OUTLET LINE    (VOLUME18,19.. RELAP4J)           *
*                                                                        *
*          NAME         TYPE                                           *
```

```
2200000    C220         PIPE                                           *
*                                                                        *
*          NO.VOL                                                        *
2200001     5                                                          *
2200101    0.0019244       4                                           *
2200102    0.0             5                                           *
2200201    0.0             3                                           *
2200202    0.0023162       4                                           *
2200301    2.0046          1                                           *
2200302    2.5762          2                                           *
2200303    2.6315          3                                           *
2200304    2.2613          4                                           *
2200305    0.859           5                                           *
2200401    0.0             4                                           *
2200402    0.001776        5                                           *
2200501    0.0             5                                           *
2200601    90.0            1                                           *
2200602    0.0             2                                           *
2200603    90.0            4                                           *
2200604    -90.0           5                                           *
2200701    1.275           1                                           *
2200702    0.0             2                                           *
2200703    2.3485          3                                           *
2200704    2.1715          4                                           *
2200705    -0.559          5                                           *
2200801    0.00005 0.0495   4                                          *
2200802    0.00005 0.0513   5                                          *
2200901    0.26     0.26      1                                        *
2200902   13.903   13.903     2                                        *
2200903    0.085    0.085     3                                        *
2200904    0.414    0.414     4                                        *
2201001    00             5                                           *
2201101    0000           4                                           *
2201201    3     7.90790+6   551.7    0.0  0.0  1                       *
2201202    3     7.86740+6   551.7    0.0  0.0  2                       *
2201203    3     7.82700+6   551.7    0.0  0.0  3                       *
2201204    3     7.78650+6   551.7    0.0  0.0  4                       *
2201205    3     7.74600+6   551.7    0.0  0.0  5                       *
2201300    1                                                            *
2201301    3.00     0.0      0.0      4                                  *
*                                                                        *
**************************************************************************
*                                                                        *
*  BROKEN JET PUMP SUCTION LINE                                          *
2300000    C230         SNGLVOL                                        *
2300101    0.003048  1.304  0.0  0.0  0.0  0.0  0.00005  0.0623  00     *
2300200    3   7.29093+6   551.7   0.0                                  *
*                                                                        *
**************************************************************************
*                                                                        *
*  BROKEN JET PUMP SUCTION   ....  SMALL PUMP ASSUMED                    *
2310000    C231         PUMP                                           *
2310101    0.0  0.973  0.002225  0.0  -90.0  -0.073  0                  *
2310108    230010000   0.003048  0.6438 0.6438 0000                     *
2310109    240000000    0.000474   0.042 0.021 0000                     *
2310200    3    7.39435+6   551.7   0.0                                *
2310201    1     5.00     0.0     0.0                                   *
2310202    1     5.00     0.0     0.0                                   *
2310301    150   150   150  -1   -1   510   1                          *
```

```
2310302    376.99  0.5344 0.01250 28.0    184.24  1.9  765.76
2310303    0.0    0.0    0.0    0.0    0.0
2310310    0.0    0.0    0.0
*
*******************************************************************************
*
*   BROKEN JET PUMP
*
2400000   C240     BRANCH
*
2400001   2      1
*
2400101  0.000585  0.121   0.0   0.0   -90.0   -0.121   0.00005   0.0273   00
*
2400200  3     7.38813+6    551.7     0.0
*
2401101  220010000 240000000  0.000111    0.936    0.510    0000
2402101  240010000 245000000  0.000585    0.07     0.0      0000
*
2401201   3.00     0.0      0.0
2402201   8.00     0.0      0.0
*
*******************************************************************************
*
*  BROKEN JET PUMP OUTLET LINE          (VOLUME14 .... RELAP4J)
*
*           NAME          TYPE
2450000     C245          PIPE
2450001     5
2450101     0.0           1
2450102     0.003849      2
2450103     0.0           3
2450104     0.004289      5
2450201     0.003849      1
2450202     0.003849      2
2450203     0.004289      3
2450204     0.0           4
2450301     0.285         1
2450302     1.396         2
2450303     0.4243        3
2450304     2.0864        4
2450305     1.8464        5
2450401     0.0005636     1
2450402     0.0           2
2450403     0.003073      3
2450404     0.0           5
2450501     0.0           5
2450601     -90.0         5
2450701     -0.285        1
2450702     -1.396        2
2450703     -0.3000       3
2450704     -0.240        4
2450705     -0.2729       5
2450801     0.00005 0.0502    1
2450802     0.00005 0.0700    2
2450803     0.00005 0.0960    3
2450804     0.00005 0.0739    5
2450901     0.0       0.46      1
2450902     5.369     5.369     2
2450903     0.3       1.0       3
2450904     0.832     0.832     4
2451001     00          5
2451101     0000        4
2451201     3      7.38000+6    551.7    0.0  0.0  1
2451202     3      7.37500+6    551.7    0.0  0.0  2
2451203     3      7.37000+6    551.7    0.0  0.0  3
2451204     3      7.36500+6    551.7    0.0  0.0  4
2451205     3      7.36000+6    551.7    0.0  0.0  5
2451300     1
2451301     8.00      0.0       0.0      4
*
*******************************************************************************
*  QUICK SHUTT-OFF VALVE      NOT USED IN THE SMALL BREAK TEST SERIES
2500000      C250         VALVE
2500101     190010000 200000000  2.0019244  2.0    2.0    0000
2500201     1     3.00    0.0    0.0
2500300      TRPVLV
2500301                  513
*
*******************************************************************************
*
*  VESSEL SIDE BREAK  (BRK B)            (JUNCTION55 .... RELAP4J)
*
*           NAME          TYPE
2600000     C260          VALVE
*
*            FR           TO          AREA     F-LOS   R-LOS CAHS
2600101   190010000 280000000  5.391-4    0.0     0.0    0100
*
*           CTL     FLOW-F FLOW-G  VELJ
2600201      1       0.0     0.0     0.0
*
*           VALVE TYPE     TRIP.NO
2600300      TRPVLV
2600301                     502
*
*******************************************************************************
*  PUMP SIDE BREAK  ( BRK A)       NOT USED IN THE SMALL BREAK TEST
2700000     C270          VALVE
2700101     200000000 281000000  5.391-4    0.0     0.0    0100
2700201     1     0.0    0.0    0.0
2700300     TRPVLV
2700301                   502
*******************************************************************************
*
*  CONTAINTMENT
*           NAME          TYPE
2800000     C280          TMDPVOL
*
*           AREA  LEN    VOL     HZ    VR   ELV   ROU   HYD   FE
2800101   1.0+3  0.0   1.0+6   0.0   0.0   0.0   0.0   0.0   11
*
*           CTL
2800200      3
*
*           TIME      PRESSURE   TEMP
2800201      0.0       9.8043+4    303.15       * CONSTANT
*
```

```
*****************************************************************************
*                                                                           *
*  MAIN STEAM RESERVOIR                  * ENTHALPY CALCULATION             *
*                                                                           *
*           NAME         TYPE                                              *
2900000     C290         TMDPVOL                                           *
*                                                                           *
*                                                                           *
2900101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11                    *
*                                                                           *
*          CTL                                                              *
2900200     2                                                               *
*                                                                           *
*          TIME     PRESSURE   TEMP                                         *
2900201    0.0      7.2900+6   1.0          * CONSTANT                      *
*                                                                           *
*****************************************************************************
*                                                                           *
*  MAIN STEAM                                                               *
*                                                                           *
*           NAME         TYPE                                              *
3000000     C300         TMDPJUN                                           *
*                                                                           *
*            FR          TO         AREA                                   *
3000101   290000000 080010000  3.141-4                                      *
*                                                                           *
*          CTL                                                              *
3000200     0                                                               *
*                                                                           *
*          TIME       FLOW-F    FLOW-G   VELJ                              *
3000201     0.0         0.0      -175.9    0.0          *
3000202     0.9         0.0      -139.3    0.0          *
3000203     2.1         0.0      -179.1    0.0          *
3000204     3.0         0.0      -179.4    0.0          *
3000205     3.9         0.0      -179.1    0.0          *
3000206     4.8         0.0      -179.6    0.0          *
3000207     5.7         0.0      -179.7    0.0          *
3000208     6.6         0.0      -178.9    0.0          *
3000209     7.8         0.0      -176.4    0.0          *
3000210     8.7         0.0       -62.4    0.0          *
3000211     9.6         0.0        -0.3    0.0          *
3000212     9.8         0.0         0.0    0.0          *
3000213   128.9         0.0         0.0    0.0          *
3000214   129.0         0.0       -74.7    0.0          *
3000215   130.2         0.0      -153.6    0.0          *
3000216   135.0         0.0      -205.7    0.0          *
3000217   144.6         0.0      -202.8    0.0          *
3000218   146.4         0.0      -153.0    0.0          *
3000219   150.0         0.0      -136.9    0.0          *
3000220   201.9         0.0        -1.7    0.0          *
3000221   202.0         0.0         0.0    0.0          *
3000222  1000.0         0.0         0.0    0.0                           *
*                                                                           *
*****************************************************************************
*                                                                           *
*  HPCS RESERVOIR                                                           *
*                                                                           *
2920000     C292     TMDPVOL                                               *
2920101     1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11                  *
2920200     3                                                               *
2920201     0.0    0.09804+6    303.15       * CONSTANT                     *
*                                                                           *
*****************************************************************************
*                                                                           *
*  HPCS                                                                     *
*                                                                           *
3020000     C302     TMDPJUN                                               *
3020101   292000000  050000000   1.157-3                                    *
3020200     0                                                               *
3020201     0.0        0.0       0.0      0.0     *
3020202    31.5        0.0       0.0      0.0     *
3020203    33.8        0.628     0.0      0.0     *
3020204    34.3        0.670     0.0      0.0     *
3020205    35.6        0.681     0.0      0.0     *
3020206    37.5        0.686     0.0      0.0     *
3020207    60.0        0.696     0.0      0.0     *
3020208    90.0        0.702     0.0      0.0     *
3020209   180.0        0.712     0.0      0.0     *
3020210  1000.0        0.712     0.0      0.0     *
*                                                                           *
*****************************************************************************
*                                                                           *
*      FEEDWATER RESERVOIR                * ENTHALPY CALCULATION           *
*                                                                           *
*           NAME         TYPE                                              *
3100000     C310         TMDPVOL                                           *
*                                                                           *
*          AREA  LEN   VOL   HZ   VR   ELV  ROU  HYD  FE                   *
3100101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11                    *
*                                                                           *
*          CTL                                                              *
3100200     3                                                               *
*                                                                           *
*          TIME    PRESSURE  TEMP                                          *
3100201    0.0     7.5001+6   489.0        * CONSTANT                      *
*                                                                           *
*****************************************************************************
*                                                                           *
*      FEEDWATER                          *JUNCTION51 .... RELAP4J         *
*                                                                           *
*           NAME         TYPE                                              *
3200000     C320         TMDPJUN                                           *
*                                                                           *
*            FR          TO         AREA                                   *
3200101   310000000 111010000   1.157-3                                    *
*                                                                           *
*          CTL                                                              *
3200200     0                                                               *
*                                                                           *
*          TIME       FLOW-F    FLOE-G   VELJ                              *
3200201     0.0        2.147     0.0      0.0                              *
3200202     0.375      2.251     0.0      0.0                              *
3200203     1.875      0.138     0.0      0.0                              *
3200204     2.25       0.105     0.0      0.0          *
3200205     3.0        0.053     0.0      0.0          *
3200206     3.7        0.0       0.0      0.0                              *
3200207  1000.0        0.0       0.0      0.0                              *
*                                                                           *
```

```
*********************************************************************
*                                                                   *
*  LPCI                                                             *
*                                                                   *
4010000     C401        TMDPJUN                                     *
4010101   331000000 100010000   1.923-3                            *
4010200     0                                                       *
4010201     0.0       0.0       0.0     0.0                       *
4010202    90.9       0.0       0.0     0.0          *            *
4010203    93.0       0.025     0.0     0.0          *            *
4010204    94.9       1.259     0.0     0.0          *            *
4010205    95.8       1.337     0.0     0.0          *            *
4010206    97.5       1.357     0.0     0.0          *            *
4010207   103.1       1.498     0.0     0.0          *            *
4010208   118.1       1.742     0.0     0.0          *            *
4010209   120.0       1.789     0.0     0.0          *            *
4010210   135.0       1.867     0.0     0.0          *            *
4010211   150.0       1.914     0.0     0.0          *            *
4010212   165.0       1.940     0.0     0.0          *            *
4010213   180.0       1.961     0.0     0.0          *            *
4010214   195.0       1.966     0.0     0.0          *            *
4010215   210.0       1.981     0.0     0.0          *            *
4010216  1000.0       1.981     0.0     0.0                       *
*                                                                   *
*********************************************************************
*                                                                   *
*  LPCS                                                             *
*                                                                   *
4020000     C402        TMDPJUN                                     *
4020101     332000000   050000000   1.157-3                         *
4020200    0                                                      *
*                                                                   *
4020201     0.0       0.0       0.0       0.0                     *
4020202    65.6       0.0       0.0       0.0          *          *
4020203    67.5       0.419     0.0       0.0          *          *
4020204    69.4       0.650     0.0       0.0          *          *
4020205    86.3       0.754     0.0       0.0          *          *
4020206   116.3       0.880     0.0       0.0          *          *
4020207   146.3       0.953     0.0       0.0          *          *
4020208   210.0       0.953     0.0       0.0          *          *
4020209  1000.0       0.953     0.0       0.0          *          *
*                                                                   *
*********************************************************************
*********************************************************************
*                                                                   *
**********          HEAT SLABS                          ***********
*                                                                   *
*********************************************************************
*                                                                   *
*  CORE     **** COMPOSED OF BN,HEATER,BN,INC600 ****               *
*     ***** HIGH POWER CHANNEL    (A CHANNEL)    10010000  ********** *
*     ***** AVERAGE POWER CHANNEL (B,C,D CHANNEL)10020000  ********** *
*                                                                   *
****** AVERAGE POWER CHANNEL HEAT STRUCTURE ************************
*                                                                   *
*          NH     NP     TYPE  S-FLG  L-COR                        *
10010000    7      9      2     1      0.0                         *
*                                                                   *
*          LOC-F MESH-F                                             *
```

```
*                                                                   *
10010100    0     1                                                 *
*                                                                   *
*          NO ITV R-COR      NO ITV  R-COR       NO ITV  R-COR     *
10010101    3      0.003051 ,  1     0.0037511,  1      0.004835,  *
10010102    3      0.006135                                         *
*                                                                   *
*          FLG                                                      *
*0010200    0                                                      *
*                                                                   *
*          CMP NO                                                   *
10010201    1    3, 2    4, 3    5, 4    8                         *
*                                                                   *
*          FLG                                                      *
*0010300    0                                                      *
*                                                                   *
*          SOURCE                                                   *
10010301    0.0  3, 1.0  4, 0.0  5, 0.0  8                         *
*                                                                   *
*          FLG                                                      *
10010400    0                                                      *
*                                                                   *
*           TEMP      NP                                           *
10010401    554.8      9                                           *
*                                                                   *
*LEFT       B.V.  INC    BCT   A-C     AREA    NH                  *
10010501    0     0      0     0       0.0     7                   *
*                                                                   *
*RIGHT        B.V          INC    BCT  A-C  SARFACE  NH            *
10010601   040010000    10000     1    0    1.6849   3            *
10010602   040040000        0     1    0    3.3698   4            *
10010603   040050000    10000     1    0    1.6849   7            *
*                                                                   *
*           TYPE    IS MULTI    L-D-H   R-D-H      NH             *
10010701    900     0.04109      0.0     0.0        1              *
10010702    900     0.07690      0.0     0.0        2              *
10010703    900     0.10360      0.0     0.0        3              *
10010704    900     0.23860      0.0     0.0        4              *
10010705    900     0.10360      0.0     0.0        5              *
10010706    900     0.07690      0.0     0.0        6              *
10010707    900     0.04109      0.0     0.0        7              *
*                                                                   *
*LEFT       CHF     HYD      HEQ      CHAN    NH                   *
10010801    0       0.0      0.0      0.0     7                    *
*                                                                   *
*RIGHT      CHF     HYD      HEQ      CHAN      NH                 *
10010901    0       0.01306 0.01348 0.2350     3                  *
10010902    0       0.01306 0.01348 0.4700     4                  *
10010903    0       0.01306 0.01348 0.2350     7                  *
*                                                                   *
********** HIGH POWER CHANNEL HEAT STRUCTURE ************************
*                                                                   *
10020000    7   9   2   1   0.0                                     *
10020100    0010                                                    *
*0020200    0010                                                   *
*0020300    0010                                                   *
10020400    0010                                                    *
10020501    0   0   0   0   0.0   7                                 *
10020601    045010000   10000   1   0   0.5616   3                 *
10020602    045040000       0   1   0   1.1233   4                 *
```

```
10020603    045050000   10000   1   0   0.5616   7
10020701    900     0.01918   0.0     0.0     1
10020702    900     0.03589   0.0     0.0     2
10020703    900     0.04833   0.0     0.0     3
10020704    900     0.11140   0.0     0.0     4
10020705    900     0.04833   0.0     0.0     5
10020706    900     0.03589   0.0     0.0     6
10020707    900     0.01918   0.0     0.0     7
10020801    0     0.0     0.0     0.0     7
10020901    0   0.01306  0.01348  0.2350    3
10020902    0   0.01306  0.01348  0.4700    4
10020903    0   0.01306  0.01348  0.2350    7
*
*****************************************************************************
*                                                                           *
**********          HEAT STRUCTURES  ( VESSEL WALL )       ***************
*
11000000    1  4  1  1  0.0
11000100    0  1
11000101    3  0.21
*1000200    0
11000201    5  3
*1000300    0
11000301    0.0   3
11000400    0
11000401    560.0   4
11000501    080010000   0   1   0   0.5153   1
11000601    900010000   0   1   0   0.5153   1
11000701    0   0.0   0.0   0.0   1
11000801    0   0.7   0.0   0.5   1
11000901    0   0.7   0.0   0.5   1
*
11100000    3  4  2  1  0.35
11100100    0  1
11100101    3  0.405
*1100200    0
11100201    5  3
*1100300    0
11100301    0.0   3
11100400    0
11100401    560.0   4
11100501    080010000   0   1   1   0.348    1
11100502    070010000   0   1   1   0.2817   2
11100503    071010000   0   1   1   0.5503   3
11100601    900010000   0   1   1   0.348    1
11100602    900010000   0   1   1   0.2817   2
11100603    900010000   0   1   1   0.5503   3
11100701    0   0.0   0.0   0.0   3
11100801    0   0.7   0.0   0.5   3
11100901    0   0.81  0.0   0.5   3
*
11200000    1  4  2  1  0.3
11200100    0  1
11200101    3  0.345
*1200200    0
11200201    5  3
*1200300    0
11200301    0.0   3
11200400    0
11200401    560.0   4
11200501    110010000   0   1   1   0.2371   1
11200601    900010000   0   1   1   0.2371   1
11200701    0   0.0   0.0   0.0   1
11200801    0   0.6   0.0   0.5   1
11200901    0   0.69  0.0   0.5   1
*
11300000    4  4  2  1  0.3
11300100    0  1
11300101    3  0.340
*1300200    0
11300201    5  3
*1300300    0
11300301    0.0   3
11300400    0
11300401    560.0   4
11300501    111010000   0   1   1   0.328    1
11300502    112030000   0   1   1   0.35     2
11300503    112020000   0   1   1   0.356    3
11300504    112010000   0   1   1   0.189    4
11300601    900010000   0   1   1   0.328    1
11300602    900010000   0   1   1   0.35     2
11300603    900010000   0   1   1   0.356    3
11300604    900010000   0   1   1   0.189    4
11300701    0   0.0   0.0   0.0   4
11300801    0   0.6   0.0   0.5   4
11300901    0   0.68  0.0   0.5   4
*
11400000    7  4  2  1  0.246
11400100    0  1
11400101    3  0.286
*1400200    0
11400201    5  3
*1400300    0
11400301    0.0   3
11400400    0
11400401    560.0   4
11400501    120010000   0   1   1   0.541    1
11400502    130040000   0   1   1   0.365    2
11400503    130030000   0   1   1   0.365    3
11400504    130020000   0   1   1   0.365    4
11400505    130010000   0   1   1   0.365    5
11400506    131010000   0   1   1   0.416    6
11400507    132010000   0   1   1   0.444    7
11400601    900010000   0   1   1   0.541    1
11400602    900010000   0   1   1   0.365    2
11400603    900010000   0   1   1   0.365    3
11400604    900010000   0   1   1   0.365    4
11400605    900010000   0   1   1   0.365    5
11400606    900010000   0   1   1   0.416    6
11400607    900010000   0   1   1   0.444    7
11400701    0   0.0   0.0   0.0   7
11400801    0   0.492 0.0   0.5   7
11400901    0   0.572 0.0   0.5   7
*
11500000    2  4  2  1  0.350
11500100    0  1
11500101    3   0.505
*1500200    0
```

```
11500201    5  3                                                          *
*1500300    0                                                           *
11500301    0.0   3                                                     *
11500400    0                                                           *
11500401    560.0   4                                                   *
11500501    010010000   0   1   1   0.12     1                          *
11500502    011010000   0   1   1   0.135    2                          *
11500601    900010000   0   1   1   0.12     1                          *
11500602    900010000   0   1   1   0.135    2                          *
11500701    0   0.0   0.0   0.0   2                                     *
11500801    0   0.7   0.0   0.5   2                                     *
11500901    0   1.01  0.0   0.5   2                                     *
*                                                                       *
11600000    1  4  1  1  0.0                                             *
11600100    0  1                                                        *
11600101    3   0.180                                                   *
*1600200    0                                                           *
11600201    5  3                                                        *
*1600300    0                                                           *
11600301    0.0  3                                                      *
11600400    0                                                           *
11600401    560.0   4                                                   *
11600501    900010000   0   1   0   0.801    1                          *
11600601    011010000   0   1   0   0.801    1                          *
11600701    0   0.0   0.0   0.0   1                                     *
11600801    0   0.7   0.0   0.5   1                                     *
11600901    0   0.7   0.0   0.5   1                                     *
*                                                                       *
************************************************************************
*                                                                       *
**********         HEAT STRUCTURE THERMAL PROPERTY DATA    ************ *
*                                                                       *
************************************************************************
*                                                                       *
* INNER BN          TYPE        K-FLAG    CV-FLAG                     *
20100100          TBL/FCTN       1         1                           *
*                                                                       *
* HEATER                                                               *
20100200          TBL/FCTN       1         1                           *
*                                                                       *
* OUTER BN                                                             *
20100300          TBL/FCTN       1         1                           *
*                                                                       *
* INCONEL600                                                           *
20100400          TBL/FCTN       1         1                           *
*                                                                       *
* SUS                                                                  *
20100500          TBL/FCTN       1         1                           *
*                                                                       *
* MGO                                                                  *
20100600          TBL/FCTN       1         1                           *
*                                                                       *
* LEAD                                                                 *
20100700          TBL/FCTN       1         1                           *
*                                                                       *
**********   THERMAL CONDUCTIVITY   BTU/(S*FT*F)           ************ *
*                                                                       *
* INNER BN   TEMP    COND       TEMP    COND       TEMP    COND        *
20100101     293.15 29.7824     773.15 28.0379    973.15 27.1656        *
20100102    1173.15 26.2933    1273.15 26.8541                         *
*                                                                       *
* HEATER                                                               *
20100201     293.15 17.5081     373.15 13.8320   2873.15 11.6513        *
*                                                                       *
* OUTER BN                                                             *
20100301             5.7945          * CONSTANT                       *
*                                                                       *
* INCONEL600                                                           *
20100401     294.26 14.8289     366.48 15.7012    477.59 17.5081        *
20100402     588.71 19.1904     699.82 20.9350    810.93 22.8665        *
20100403     922.04 24.7357    1033.15 26.8541   1144.26 28.9102        *
*                                                                       *
* SUS                                                                  *
20100501     273.15 16.2620     773.15 20.9350                         *
*                                                                       *
* MGO                                                                  *
20100601     293.15 26.6672     573.15 20.6234    673.15 17.1966        *
20100602     773.15 14.0813     873.15 11.7136    973.15 10.0313        *
20100603    1073.15  8.7852    1273.15  6.9160   1473.15  6.2930        *
20100604    1506.48  6.7291    1873.15  7.3522                         *
*                                                                       *
* LEAD                                                                 *
20100701             14.5798          * CONSTANT                       *
*                                                                       *
**********   VOLUMETRIC HEAT CAPACITY     BTU/(FT3*F)       ************ *
*                                                                       *
* INNER BN   TEMP     CAP        TEMP     CAP        TEMP     CAP      *
20100151     293.15  3.0716+5    783.15  4.0106+5   1123.15  5.0635+5   *
20100152    1533.15  6.3512+5                                           *
*                                                                       *
* HEATER                                                               *
20100252     293.15  3.8496+6    373.15  3.7289+6   2873.15  3.8496+6   *
*                                                                       *
* OUTER BN                                                             *
20100351     293.15  3.0649+5    783.15  4.0173+5   1123.15  5.0702+5   *
20100352    1533.15  6.3512+5                                           *
*                                                                       *
* INCONEL600                                                           *
20100451     294.26  3.7355+6    366.48  3.9100+6    477.60  4.0843+6   *
20100452    588.71   4.2654+6    699.82  4.4398+6    810.93  4.6477+6   *
20100453    922.04   4.9294+6   1033.15  5.1104+6   1144.26  5.2513+6   *
*                                                                       *
* SUS                                                                  *
20100551             3.9770+6          * CONSTANT                      *
*                                                                       *
* MGO                                                                  *
20100651             3.3734+6          * CONSTANT                      *
*                                                                       *
*                                                                       *
20100751             3.6417+6          * CONSTANT                      *
*                                                                       *
************************************************************************
************************************************************************
*                                                                       *
**********  POWER  TRANSIENT DATA                          ************ *
*                                                                       *
20290000    POWER                                                       *
*             TIME       POWER                                        *
```

```
20290001       0.0       4.045+6                                          *
20290002       7.5       4.045+6                                          *
20290003      10.0       3.333+6                                          *
20290004      14.0       2.484+6                                          *
20290005      20.0       1.735+6                                          *
20290006      24.0       1.408+6                                          *
20290007      30.0       1.060+6                                          *
20290008      40.0       0.886+6                                          *
20290009      50.0       0.744+6                                          *
20290010      70.0       0.611+6                                          *
20290011     100.0       0.506+6                                          *
20290012     150.0       0.413+6                                          *
20290013     210.0       0.311+6                                          *
20290014     300.0       0.251+6                                          *
20290015     480.0       0.227+6                                          *
20290016     600.0       0.214+6                                          *
20290017    1800.0       0.166+6                                          *
*                                                                         *
**************************************************************************
*                                                                         *
*  CONTAINTMENT                                                           *
*           NAME          TYPE                                           *
2810000     C281          TMDPVOL                                        *
*                                                                         *
*          AREA  LEN   VOL     HZ   VR  ELV  ROU  HYD  FE                *
2810101   1.0+3  0.0  1.0+6   0.0  0.0  0.0  0.0  0.0  11                 *
*                                                                         *
*          CTL                                                            *
2810200     3                                                            *
*                                                                         *
*          TIME      PRESSURE  TEMP                                       *
2810201     0.0      0.09804+6  303.15      * CONSTANT                    *
*                                                                         *
**************************************************************************
*                                                                         *
*  LPCI RESERVOIR           *  ENTHALPY CALCULATION                      *
*                                                                         *
*           NAME          TYPE                                           *
3310000     C331          TMDPVOL                                        *
*                                                                         *
*          AREA  LEN   VOL     HZ   VR  ELV  ROU  HYD  FE                *
3310101   1.0+3  0.0  1.0+6   0.0  0.0  0.0  0.0  0.0  11                 *
*                                                                         *
*          CTL                                                            *
3310200     3                                                            *
*                                                                         *
*          TIME     PRESSURE     TEMP                                     *
3310201    0.0       2.47+6        313.0      * CONSTANT                  *
*                                                                         *
**************************************************************************
*                                                                         *
*   LPCS RESERVOIR                      * ENTHALPY CALCULATION            *
*                                                                         *
*           NAME          TYPE                                           *
3320000     C332          TMDPVOL                                        *
*                                                                         *
*          AREA  LEN   VOL     HZ   VR  ELV  ROU  HYD  FE                *
3320101   1.0+3  0.0  1.0+6   0.0  0.0  0.0  0.0  0.0  11                 *
*                                                                         *
*          CTL                                                            *
3320200     3                                                            *
*                                                                         *
*          TIME     PRESSURE     TEMP                                     *
3320201    0.0       3.76+6        313.0      * CONSTANT                  *
*                                                                         *
**************************************************************************
*                                                                         *
******   HEAT SINK FOR HEAT LOSS   ***************************************
*                                                                         *
9000000     C900      TMDPVOL                                            *
9000101     1.+3  0.0  1.+6  0.0  90.0  10.0  0.0  0.0  11               *
9000200     3                                                            *
9000201     0.0      0.09804+4     303.15       * CONSTANT                *
*                                                                         *
**************************************************************************
9100000     C910      VALVE                                              *
9100101     080010000    900000000  1.0-3   0.0  0.0   0100      *
9100201     1     0.0   0.0   0.0                    *
9100300     TRPVLV                                                       *
9100301              527                                                *
*                                                                         *
**************************************************************************
**************************************************************************
*  MINOR EDIT                                                             *
*                                                                         *
0000301  P         010010000                                             *
0000302  MFLOWJ    171020000                                             *
0000303  MFLOWJ    185010000                                             *
0000304  MFLOWJ    180010000                                             *
0000305  MFLOWJ    180020000                                             *
0000306  MFLOWJ    231020000                                             *
0000307  MFLOWJ    245010000                                             *
0000308  MFLOWJ    240010000                                             *
0000309  MFLOWJ    240020000                                             *
0000310  P         080010000                                             *
0000311  MFLOWJ    300000000                                             *
0000312  MFLOWJ    320000000                                             *
0000313  MFLOWJ    302000000                                             *
0000314  MFLOWJ    402000000                                             *
0000315  MFLOWJ    401000000                                             *
0000316  MFLOWJ    260000000                                             *
0000317  MFLOWJ    270000000                                             *
0000318  MFLOWJ    030020000                                             *
0000319  MFLOWJ    030020000                                             *
0000320  HTTEMP    001000109                                             *
0000321  HTTEMP    001000209                                             *
0000322  HTTEMP    001000309                                             *
0000323  HTTEMP    001000409                                             *
0000324  HTTEMP    001000509                                             *
0000325  HTTEMP    001000609                                             *
0000326  HTTEMP    001000709                                             *
0000327  MFLOWJ    050020000                                             *
0000328  VOIDGJ    030020000                                             *
0000329  VOIDG     040010000                                             *
0000330  VOIDG     040020000                                             *
0000331  VOIDG     040030000                                             *
0000332  VOIDG     040040000                                             *
0000333  VOIDG     040050000                                             *
```

```
0000334  VOIDG    040060000
0000335  VOIDG    040070000
0000336  VOIDGJ   050020000
0000337  MFLOWJ   031020000
0000338  HTTEMP   002000109
0000339  HTTEMP   002000209
0000340  HTTEMP   002000309
0000341  HTTEMP   002000409
0000342  HTTEMP   002000509
0000343  HTTEMP   002000609
0000344  HTTEMP   002000709
0000345  MFLOWJ   050010000
0000346  VOIDGJ   031020000
0000347  VOIDG    045010000
0000348  VOIDG    045020000
0000349  VOIDG    045030000
0000350  VOIDG    045040000
0000351  VOIDG    045050000
0000352  VOIDG    045060000
0000353  VOIDG    045070000
0000354  VOIDGJ   050010000
0000355  VOIDG    100010000
0000356  VOIDG    100020000
0000357  VOIDG    100030000
0000358  VOIDG    090010000
0000359  VOIDG    090020000
0000360  VOIDG    090030000
0000361  VOIDG    060040000
0000362  VOIDG    060010000
0000363  VOIDG    051020000
0000364  VOIDG    050010000
0000365  VOIDG    030010000
0000366  VOIDG    020020000
0000367  VOIDG    020010000
0000368  VOIDG    010010000
0000369  VOIDG    080010000
0000370  VOIDG    070010000
0000371  VOIDG    071010000
0000372  VOIDG    110010000
0000373  VOIDG    110010000
0000374  VOIDG    111010000
0000375  VOIDG    112030000
0000376  VOIDG    112020000
0000377  VOIDG    112010000
0000378  VOIDG    120010000
0000379  VOIDG    130040000
0000380  VOIDG    130030000
0000381  VOIDG    130020000
0000382  VOIDG    130010000
0000383  VOIDG    131010000
0000384  MFLOWJ   010010000
0000385  MFLOWJ   010020000
0000386  MFLOWJ   010030000
0000387  MFLOWJ   010040000
0000388  MFLOWJ   010050000
0000389  MFLOWJ   030010000
0000390  MFLOWJ   030020000
0000391  MFLOWJ   030030000
0000392  MFLOWJ   031010000
0000393  MFLOWJ   050010000
0000394  MFLOWJ   050020000
0000395  MFLOWJ   050030000
0000396  MFLOWJ   050040000
0000397  VELFJ    050010000
0000398  VELGJ    050010000
```

```
1600401    0.0            5                                                  *
1600402    0.001776       6                                                  *
1600501    0.0            6                                                  *
1600601    90.0           1                                                  *
1600602    0.0            2                                                  *
1600603    90.0           5                                                  *
1600604    -90.0          6                                                  *
1600701    1.275          1                                                  *
1600702    0.0            2                                                  *
1600703    2.830          3                                                  *
1600704    0.50           4                                                  *
1600705    1.190          5                                                  *
1600706   -0.559          6                                                  *
1600801    0.00005 0.0495    5                                               *
1600802    0.00005 0.0513    6                                               *
1600901    0.295      0.295      1                                           *
1600902   13.903     13.903      2                                           *
1600903    0.085      0.085      3                                           *
1600904    0.112      0.112      4                                           *
1600905    0.336      0.336      5                                           *
1601001    00             6                                                  *
1601101    0000           4                                                  *
1601102    0000           5                                                  *
1601201    3     7.91733+6    551.7     0.0   0.0    1                       *
1601202    3     7.88306+6    551.7     0.0   0.0    2                       *
1601203    3     7.84880+6    551.7     0.0   0.0    3                       *
1601204    3     7.81453+6    551.7     0.0   0.0    4                       *
1601205    3     7.78027+6    551.7     0.0   0.0    5                       *
1601206    3     7.74600+6    551.7     0.0   0.0    6                       *
1601300    1                                                                 *
1601301    3.00      0.0       0.0       5                                   *
*                                                                            *
******************************************************************************
*  INTACT JET PUMP SUCTION LINE                                              *
1700000     C170        SNGLVOL                                              *
1700101     0.003048  1.304  0.0  0.0  0.0  0.0  0.00005  0.0623  00         *
1700200     3   7.29093+6    551.7    0.0                                     *
*                                                                            *
******************************************************************************
*                                                                            *
*   INTACT JET PUMP SUCTION     ....    SMALL PUMP ASSUMED                   *
*710000     C171       PUMP                                                  *
*710101     0.0   0.973  0.002225  0.0  -90.0  -0.073  0                     *
*710108     170010000    0.003048  0.6438 0.6438 0000                       *
*710109     180000000    0.000474  0.042  0.021  0000                       *
*710200     3   7.39435+6    551.7    0.0                                   *
*710201     1     5.00    0.0    0.0                                        *
*710202     1     5.00    0.0    0.0                                        *
*710301     150  150  150 -1   -1   509  1                                  *
*710302     376.99  0.5092 0.01250  20.0   184.24  1.9  765.76              *
*710303     0.0  0.0  0.0  0.0  0.0                                          *
*710310     0.0  0.0  0.0                                                   *
*                                 ....   NAIG JET PUMP MODEL                *
1710000     C171       SNGLVOL                                              *
1710101     4.743-4  0.203   0.0  0.0  -90.0  -0.0605  0.00005  0.0 00     *
1710200     3  7.29093+6  551.7  0.0                                        *
*                                                                            *
******************************************************************************
*                                                                            *
*   INTACT JET PUMP                                                          *
*                                                                            *
1800000   C180     BRANCH                                                    *
*                                                                            *
1800001   2      1                                                           *
*                                                                            *
1800101  5.851-4  0.406 0.0  0.0  -90.0  -0.406  0.00005  0.0273  00        *
*                                                                            *
1800200  3   7.38813+6    551.7    0.0                                      *
*                                                                            *
1801101  160010000 180000000  1.108-4     0.936 0.510 0000                 *
1802101  180010000 185000000  5.851-4     0.07  0.01  0000                 *
*                                                                            *
1801201   3.00    0.0  0.0                                                  *
1802201   8.00    0.0  0.0                                                  *
*                                                                            *
******************************************************************************
*                                                                            *
*  INTACT JET PUMP OUTLET LINE          (VOLUME22 .... RELAP4J)              *
*                                                                            *
*            NAME          TYPE                                            *
1850000     C185          PIPE                                             *
1850001    4                                                                 *
1850101    0.003849    1                                                     *
1850102    0.0         2                                                     *
1850103    0.004289    4                                                     *
1850201    0.003849    1                                                     *
1850202    0.004289    2                                                     *
1850203    0.0         3                                                     *
1850301    1.396       1                                                     *
1850302    0.4243      2                                                     *
1850303    2.0864      3                                                     *
1850304    1.8464      4                                                     *
1850401    0.0         1                                                     *
1850402    0.003073    2                                                     *
1850403    0.0         4                                                     *
1850501    0.0         4                                                     *
1850601    -90.0       4                                                     *
1850701    -1.396      1                                                     *
1850702    -0.300      2                                                     *
1850703    -0.240      3                                                     *
1850704    -0.2729     4                                                     *
1850801    0.00005 0.0700    1                                              *
1850802    0.00005 0.0960    2                                              *
1850803    0.00005 0.0739    3                                              *
1850804    0.00005 0.0739    4                                              *
1850901    3.597  3.597  1                                                  *
1850902    0.3    1.0    2                                                  *
1850903    0.832  0.832  3                                                  *
```

```
1851001     00          4
1851101     0000        3
1851201     3     7.37500+6    551.7     0.0   0.0   1
1851202     3     7.37000+6    551.7     0.0   0.0   2
1851203     3     7.36500+6    551.7     0.0   0.0   3
1851204     3     7.36000+6    551.7     0.0   0.0   4
1851300     1
1851301     8.00      0.0      0.0       3
*
*******************************************************************************
*
*  BROKEN RECIRCULATION INLET LINE      (VOLUME15 .... RELAP4J)
*
*            NAME          TYPE
1900000      C190          PIPE
1900001      3
1900101     0.0019244        3
1900201     0.0              2
1900301     2.1317           1
1900302     2.5127           2
1900303     2.5424           3
1900401     0.0              3
1900501     0.0              3
1900601     -90.0            2
1900602     0.0              3
1900701     -0.154           1
1900702     -1.285           2
1900703     -0.0             3
1900801     0.00005   0.0495     3
1900901     0.185     0.185      1
1900902     0.345     0.345      2
1901001     00               3
1901101     0000             2
1901201     3      7.33639+6    551.7     0.0   0.0   1
1901202     3      7.34492+6    551.7     0.0   0.0   2
1901203     3      7.35346+6    551.7     0.0   0.0   3
1901300     1
1901301     3.00      0.0       0.0       2
*
*******************************************************************************
*
*  BROKEN RECIRCULATION INLET LINE      (VOLUME16 .... RELAP4J)
*
*            NAME          TYPE
2000000      C200          PIPE
2000001     3
2000101     0.0019244        3
2000201     0.0              2
2000301     2.0659           1
2000302     2.6398           2
2000303     2.3574           3
2000401     0.0              3
2000501     0.0              3
2000601     -90.0            1
2000602     0.0              2
2000603     -90.0            3
2000701     -0.219           1
2000702     -0.0             2
2000703     -1.315           3
2200201     0.0              3
2200202     0.0023162        4
2200301     2.0046           1
2200302     2.5762           2
2200303     2.6315           3
2200304     2.2613           4
2200305     0.859            5
2200401     0.0              4
2200402     0.001776         5
2200501     0.0              5
2200601     90.0             1
2200602     0.0              2
2200603     90.0             4
2200604     -90.0            5
2200701     1.275            1
2200702     0.0              2
2200703     2.3485           3
2200704     2.1715           4
2200705     -0.559           5
2200801     0.00005 0.0495    4
2200802     0.00005 0.0513    5
2200901     0.26      0.26       1
2200902    13.903    13.903      2
2200903     0.085     0.085      3
2200904     0.414     0.414      4
2201001     00                5
2201101     0000              4
2201201     3     7.90790+6    551.7     0.0   0.0   1
2201202     3     7.86740+6    551.7     0.0   0.0   2
2201203     3     7.82700+6    551.7     0.0   0.0   3
2201204     3     7.78650+6    551.7     0.0   0.0   4
2201205     3     7.74600+6    551.7     0.0   0.0   5
2201300     1
2201301     3.00      0.0       0.0       4
*
*******************************************************************************
*
*  BROKEN JET PUMP SUCTION LINE
2300000     C230          SNGLVOL
2300101     0.003048  1.304   0.0   0.0   0.0   0.0   0.00005   0.0623   00
2300200     3    7.29093+6    551.7    0.0
*
*******************************************************************************
*
*  BROKEN JET PUMP SUCTION    ....  SMALL PUMP ASSUMED
*310000     C231          PUMP
*310101     0.0   0.973   0.002225   0.0   -90.0   -0.073   0
*310108     230010000     0.003048   0.6438  0.6438  0000
*310109     240000000      0.000474    0.042  0.021  0000
*310200     3     7.39435+6    551.7    0.0
*310201     1      5.00      0.0      0.0
*310202     1      5.00      0.0      0.0
*310301     150    150    150   -1    -1    510    1
*310302     376.99   0.5344  0.01250  20.0    184.24   1.9   765.76
*310303     0.0    0.0    0.0    0.0    0.0
*310310     0.0    0.0    0.0
*                                ....  NAIG JET PUMP MODEL
2310000     C231          SNGLVOL
2310101     4.743-4   0.203    0.0    0.0    90.0   -0.0605   0.00005   0.0   00
```

```
2310200    3  7.29093+6  551.7  0.0
*
*****************************************************************
*                                                               *
*   BROKEN JET PUMP                                             *
*                                                               *
2400000   C240     BRANCH                                       *
*                                                               *
2400001   2      1                                              *
*                                                               *
2400101  5.851-4   0.406  0.0  0.0  -90.0  -0.406  0.00005  0.0273  00 *
*                                                               *
2400200  3    7.38813+6    551.7     0.0                       *
*                                                               *
2401101  220010000 240000000  1.108-4     0.936    0.510    0000  *
2402101  240010000 245000000  5.851-4     0.07     0.01     0000  *
*                                                               *
2401201   3.00     0.0      0.0                                 *
2402201   8.00     0.0      0.0                                 *
*                                                               *
*****************************************************************
*                                                               *
*  BROKEN JET PUMP OUTLET LINE          (VOLUME14 .... RELAP4J) *
*                                                               *
*            NAME          TYPE                                 *
2450000     C245          PIPE                                 *
2450001     4                                                  *
2450101    0.003849     1                                      *
2450102    0.0          2                                      *
2450103    0.004289     4                                      *
2450201    0.003849     1                                      *
2450202    0.004289     2                                      *
2450203    0.0          3                                      *
2450301    1.396        1                                      *
2450302    0.4243       2                                      *
2450303    2.0864       3                                      *
2450304    1.8464       4                                      *
2450401    0.0          1                                      *
2450402    0.003073     2                                      *
2450403    0.0          4                                      *
2450501    0.0          4                                      *
2450601    -90.0        4                                      *
2450701    -1.396       1                                      *
2450702    -0.3000      2                                      *
2450703    -0.240       3                                      *
2450704    -0.2729      4                                      *
2450801    0.00005 0.0700    1                                 *
2450802    0.00005 0.0960    2                                 *
2450803    0.00005 0.0739    4                                 *
2450901    5.369     5.369     1                              *
2450902    0.3       1.0       2                              *
2450903    0.832     0.832     3                              *
2451001    00           4                                     *
2451101    0000         3                                     *
2451201    3      7.37500+6   551.7   0.0  0.0  1             *
2451202    3      7.37000+6   551.7   0.0  0.0  2             *
2451203    3      7.36500+6   551.7   0.0  0.0  3             *
2451204    3      7.36000+6   551.7   0.0  0.0  4             *
2451300    1                                                  *
2451301    8.00      0.0      0.0      3                      *
*                                                               *
*****************************************************************
*  QUICK SHUTT-OFF VALVE     NOT USED IN THE SMALL BREAK TEST SERIES *
2500000     C250          VALVE                                *
2500101    190010000 200000000  0.0019244  2.0    2.0    0000  *
2500201    1     3.00    0.0    0.0                            *
2500300     TRPVLV                                             *
2500301                 513                                    *
*                                                               *
*****************************************************************
*                                                               *
*  VESSEL SIDE BREAK  (BRK B)          (JUNCTION55 .... RELAP4J) *
*                                                               *
*            NAME          TYPE                                 *
2600000     C260          VALVE                                *
*                                                               *
*             FR           TO          AREA     F-LOS  R-LOS CAHS  *
2600101   190010000 280000000  3.2348-4  0.0    0.0    0100    *
*                                                               *
*           CTL     FLOW-F FLOW-G  VELJ                       *
2600201     1       0.0    0.0     0.0                         *
*                                                               *
*           VALVE TYPE     TRIP.NO                            *
2600300     TRPVLV                                             *
2600301                      502                               *
*                                                               *
*****************************************************************
*  PUMP SIDE BREAK  ( BRK A)       NOT USED IN THE SMALL BREAK TEST *
2700000     C270          VALVE                                *
2700101    200000000 281000000  3.2438-4  0.0    0.0    0100  *
2700201    1     0.0    0.0    0.0                            *
2700300    TRPVLV                                             *
2700301                    502                                 *
*****************************************************************
*                                                               *
*  CONTAINTMENT                                                 *
*            NAME          TYPE                                 *
2800000     C280          TMDPVOL                              *
*                                                               *
*           AREA  LEN   VOL     HZ   VR  ELV  ROU  HYD  FE     *
2800101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11       *
*                                                               *
*           CTL                                                 *
2800200     3                                                  *
*                                                               *
*           TIME      PRESSURE  TEMP                           *
2800201     0.0       9.8043+4   303.15      * CONSTANT        *
*                                                               *
*****************************************************************
*                                                               *
*  MAIN STEAM RESERVOIR                  * ENTHALPY CALCULATION *
*                                                               *
*            NAME          TYPE                                 *
2900000     C290          TMDPVOL                              *
*                                                               *
*                                                               *
2900101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11       *
*                                                               *
```

```
20290011     100.0       0.506+6                                          *
20290012     150.0       0.413+6                                          *
20290013     210.0       0.311+6                                          *
20290014     300.0       0.251+6                                          *
20290015     480.0       0.227+6                                          *
20290016     600.0       0.214+6                                          *
20290017    1800.0       0.166+6                                          *
*                                                                         *
**************************************************************************
*                                                                         *
*  CONTAINTMENT                                                           *
*           NAME          TYPE                                           *
2810000     C281          TMDPVOL                                        *
*                                                                         *
*          AREA  LEN   VOL    HZ   VR  ELV  ROU  HYD  FE                 *
2810101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11                 *
*                                                                         *
*          CTL                                                            *
2810200     3                                                            *
*                                                                         *
*          TIME      PRESSURE  TEMP                                       *
2810201     0.0       0.09804+6  303.15      * CONSTANT                   *
*                                                                         *
**************************************************************************
*                                                                         *
*  LPCI RESERVOIR           *  ENTHALPY CALCULATION                      *
*                                                                         *
*           NAME          TYPE                                           *
3310000     C331          TMDPVOL                                        *
*                                                                         *
*          AREA  LEN   VOL    HZ   VR  ELV  ROU  HYD  FE                 *
3310101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11                 *
*                                                                         *
*          CTL                                                            *
3310200     3                                                            *
*                                                                         *
*          TIME     PRESSURE     TEMP                                     *
3310201    0.0       2.47+6        313.0      * CONSTANT                  *
*                                                                         *
**************************************************************************
*                                                                         *
*   LPCS RESERVOIR                      * ENTHALPY CALCULATION            *
*                                                                         *
*           NAME          TYPE                                           *
3320000     C332          TMDPVOL                                        *
*                                                                         *
*          AREA  LEN   VOL    HZ   VR  ELV  ROU  HYD  FE                 *
3320101   1.0+3  0.0  1.0+6  0.0  0.0  0.0  0.0  0.0  11                 *
*                                                                         *
*          CTL                                                            *
3320200     3                                                            *
*                                                                         *
*          TIME     PRESSURE     TEMP                                     *
3320201    0.0      3.76+6        313.0       * CONSTANT                  *
*                                                                         *
**************************************************************************
*     JET PUMP SUCTION AT BROKEN LOOP                                     *
5300000     C530      SNGLJUN                                           *
5300101     230010000  231000000  4.743-4  0.1     0.1     0000        *
5300201     1      5.0      0.0      0.0                                  *
5320000     C532      SNGLJUN                                           *
5320101     231010000  240000000  4.743-4  0.042  0.021  0000          *
5320201     1      5.0      0.0      0.0                                  *
*     JET PUMP SUCTION AT INTACT LOOP                                     *
5330000     C533      SNGLJUN                                           *
5330101     170010000  171000000  4.743-4  0.1     0.1     0000        *
5330201     1      5.0      0.0      0.0                                  *
5340000     C534      SNGLJUN                                           *
5340101     171010000  180000000  4.743-4  0.042  0.021  0000          *
5340201     1      5.0      0.0      0.0                                  *
**************************************************************************
*                                                                         *
******   HEAT SINK FOR HEAT LOSS   ***************************************
*                                                                         *
9000000     C900      TMDPVOL                                           *
9000101     1.+3  0.0  1.+6  0.0  90.0  10.0  0.0  0.0  11               *
9000200     3                                                           *
9000201     0.0     0.09804+4     303.15       * CONSTANT                *
*                                                                         *
**************************************************************************
9100000     C910      VALVE                                             *
9100101     080010000   900000000  1.0-3   0.0  0.0   0100     *
9100201     1     0.0    0.0    0.0                    *
9100300     TRPVLV                                                      *
9100301              527                                                *
*                                                                         *
**************************************************************************
**************************************************************************
*  MINOR EDIT                                                             *
*                                                                         *
0000301  P          010010000                                           *
0000302  MFLOWJ    534000000                                           *
0000303  MFLOWJ    185010000                                           *
0000304  MFLOWJ    180010000                                           *
0000305  MFLOWJ    180020000                                           *
0000306  MFLOWJ    532000000                                           *
0000307  MFLOWJ    245010000                                           *
0000308  MFLOWJ    240010000                                           *
0000309  MFLOWJ    240020000                                           *
0000310  P          080010000                                           *
0000311  MFLOWJ    300000000                                           *
0000312  MFLOWJ    320000000                                           *
0000313  MFLOWJ    302000000                                           *
0000314  MFLOWJ    402000000                                           *
0000315  MFLOWJ    401000000                                           *
0000316  MFLOWJ    260000000                                           *
0000317  MFLOWJ    270000000                                           *
0000318  MFLOWJ    030010000                                           *
0000319  MFLOWJ    030020000                                           *
0000320  HTTEMP    001000109                                           *
0000321  HTTEMP    001000209                                           *
0000322  HTTEMP    001000309                                           *
0000323  HTTEMP    001000409                                           *
0000324  HTTEMP    001000509                                           *
0000325  HTTEMP    001000609                                           *
0000326  HTTEMP    001000709                                           *
0000327  MFLOWJ    050020000                                           *
0000328  VOIDG     030020000                                           *
```

Appendix D Input Data List; RELAP5/MOD1/001 Case E

(modified part)

```
*************************************************************************
*   DEAD ZONE UNDER RECIRCULATION INLET PIPE                            *
1320000    C132     SNGLVOL                                             *
1320101    0.019563  0.444   0.0   0.0   90.0   0.444   0.00005   0.026   00  *
1320200    3      7.33124+6    551.7     0.0                           *
*                                                                       *
*************************************************************************
*                                                                       *
*  INTACT RECIRCULATION INLET LINE      (VOLUME23 .... RELAP4J)         *
1400000     C140          PIPE                                          *
1400001     3                                                           *
1400101     0.0019244          3                                        *
1400201     0.0                2                                        *
1400301     2.0445             1                                        *
1400302     1.9894             2                                        *
1400303     1.7939             3                                        *
1400401     0.0                3                                        *
1400501     0.0                3                                        *
1400601     -90.0              3                                        *
1400701     -0.154             1                                        *
1400702     -1.704             2                                        *
1400703     -1.315             3                                        *
1400801     0.00005  0.0495     3                                       *
1400901     0.25     0.25      1                                        *
1400902     0.19     0.19      2                                        *
1401001     00                 3                                        *
1401101     0000               2                                        *
1401201     3      7.34807+6    551.7     0.0   0.0    1                *
1401202     3      7.36830+6    551.7     0.0   0.0    2                *
1401203     3      7.38852+6    551.7     0.0   0.0    3                *
1401300     1                                                           *
1401301     3.00      0.0       0.0        2                           *
*************************************************************************
*                                                                       *
*  INTACT RECIRCULATION PUMP            (VOLUME24 .... RELAP4J)         *
*                                                                       *
*           NAME          TYPE                                        *
1500000     C150          PUMP                                          *
*                                                                       *
*          AREA    LEN     VOL     HZ      VR       ELV   CTL          *
1500101   0.0    0.26    0.005295    0.0    -90.0    -0.26    0         *
*                                                                       *
*           VOL NO      AREA     F-LOSS R-LOSS  CAHS                   *
1500108   140010000  0.0019244    5.28   5.28   0000                   *
*                                                                       *
*           VOL NO      AREA     F-LOSS R-LOSS  CAHS                   *
1500109   160000000  0.0002746    0.1    0.1    0000                   *
*                                                                       *
*          CTL     PRESSURE      TEMP        ZERO                      *
1500200     3      7.65292+6     551.7      0.0                         *
*                                                                       *
*          CTL     FLOW-F   FLOW-G   VEL                               *
1500201     1       3.00      0.0      0.0                             *
*                                                                       *
*          CTL     FLOW-F   FLOW-G   VEL                               *
1500202     1       3.00      0.0      0.0                             *
*                                                                       *
*         TAB-D   TWO-P   DIF-T   MOTOR   TAB-S   TRIP    REVER       *
1500301     0       0       0       -1      -1      509      1          *
*                                                                       *
*          R-SP    I/R     R-FL    R-HD    R-TOR  M-IN    R-DEN        *
1500302   376.99  0.5092  0.0075  262.0   184.2  0.475   1000.0        *
*                                                                       *
*         R-M-TR    FR-TF2     FR-TF0     FR-TF1     FR-TF3           *
1500303    0.0       7.56       0.001      0.0        42.7             *
*                                                                       *
*         ELS TM   MX-F     MX-R                                      *
1500310   0.0      0.0       0.0                                       *
*                                                                       *
* SINGLE PHASE 4 QUADRANT HEAD TABLES                                   *
*                                                                       *
1501100 1  1                                                           *
1501101  0.00  0.92  0.20  0.94  0.40  0.97  0.60  1.00  1.00  1.00     *
1501200 1  2                                                           *
1501201  0.00 -0.20  0.25  0.00  0.40  0.12  0.70  0.50  1.00  1.00     *
1501300 1  3                                                           *
1501301 -1.00  1.20 -0.80  0.98 -0.60  0.94 -0.30  0.92  0.00  0.92     *
1501400 1  4                                                           *
1501401 -1.00  1.20 -0.80  0.70 -0.50  0.34 -0.20  0.18  0.00  0.18     *
1501500 1  5                                                           *
1501501  0.00  0.62  0.20  0.69  0.40  0.77  0.60  0.85  1.00  1.00     *
1501600 1  6                                                           *
1501601  0.00  0.18  0.20  0.22  0.40  0.32  0.65  0.52  1.00  1.00     *
1501700 1  7                                                           *
1501701 -1.00  0.00 -0.80  0.16 -0.40  0.45 -0.20  0.56  0.00  0.62     *
1501800 1  8                                                           *
1501801 -1.00  0.00 -0.80 -0.14 -0.50 -0.24 -0.20 -0.24  0.00 -0.20     *
*                                                                       *
* SINGLE PHASE 4 QUADRANT TORQUE TABLES                                 *
*                                                                       *
1501900 2  1                                                           *
1501901  0.00  0.69                0.50                 0.84  1.00  1.00  *
1502000 2  2                                                           *
1502001  0.00 -0.03  0.10  0.01  0.30  0.13  0.80  0.71  1.00  1.00     *
1502100 2  3                                                           *
1502101 -1.00  0.76 -0.80  0.44 -0.40  0.44                0.00  0.69  *
1502200 2  4                                                           *
1502201 -1.00  0.76 -0.70  0.39 -0.20  0.10                0.00  0.10  *
1502300 2  5                                                           *
1502301  0.00 -0.72  0.54 -0.69  0.70 -0.58  0.90 -0.48  1.00 -0.33     *
1502400 2  6                                                           *
1502401  0.00  0.10  0.10  0.10  0.44  0.18  0.70 -0.10  1.00 -1.33     *
1502500 2  7                                                           *
1502501 -1.00 -1.23 -0.92 -0.82 -0.66 -0.90 -0.26 -0.72  0.00 -0.72     *
1502600 2  8                                                           *
1502601 -1.00 -1.23 -0.90 -0.95 -0.70 -0.60 -0.24 -0.10  0.00 -0.03     *
*                                                                       *
* 2-PHASE MULTIPLIER TABLES                                             *
```

```
*
1503000 0
1503001  0.0  0.0  0.1  0.0  0.15  0.05  0.24  0.8  0.3  0.96
1503002  0.4  0.98 0.6  0.97 0.80  0.90  0.90  0.8  0.96 0.50
1503003  1.0  1.0
1503100 0
1503101  0.0  0.0  0.125 0.07 0.165 0.125 0.24 0.56 0.80 0.56
1503102  0.96 0.45 1.0   0.0
*
* 2-PHASE HEAD DIFFERENCE TABLES          * BUILT-IN RELAP4J
*
1504100 1  1
1504101  0.00  0.00  0.10  0.67  0.25  0.91  0.50  1.12
1504102  0.75  1.28  1.00  1.34
1504200 1  2
1504201  0.00  0.31  0.25  0.42  0.50  0.57  0.75  0.97  1.00  1.34
1504300 1  3
1504301 -1.00 -1.18 -0.75 -1.30 -0.50 -1.08 -0.25 -0.93
1504302 -0.10 -0.71  0.00  0.00
1504400 1  4
1504401 -1.00 -1.18 -0.75 -0.24 -0.50 -0.07 -0.25 -0.08  0.00 -0.19
1504500 1  5
1504501  0.00  0.00  0.10 -0.39  0.25 -0.71  0.50 -0.71
1504502  0.75 -0.58  1.00 -0.47
1504600 1  6
1504601  0.00 -0.19  0.25 -0.45  0.50 -0.55  0.75 -0.59  1.00 -0.47
1504700 1  7
1504701 -1.00  0.51 -0.75  0.55 -0.50  0.51 -0.25  0.39  0.00  0.00
1504800 1  8
1504801 -1.00  0.51 -0.75  0.31 -0.50  0.22 -0.25  0.21  0.00  0.31
*
* 2-PHASE TORQUE DIFFERENCE TABLES        * BUILT-IN RELAP4J
*
1504900 2  1
1504901  0.00  0.00  0.10  0.67  0.25  0.91  0.50  1.12
1504902  0.75  1.28  1.00  1.34
1505000 2  2
1505001  0.00  0.31  0.25  0.42  0.50  0.57  0.75  0.97  1.00  1.34
1505100 2  3
1505101 -1.00 -1.18 -0.75 -1.30 -0.50 -1.08 -0.25 -0.93
1505102 -0.10 -0.71  0.00  0.00
1505200 2  4
1505201 -1.00 -1.18 -0.75 -0.24 -0.50 -0.07 -0.25 -0.08  0.00 -0.19
1505300 2  5
1505301  0.00  0.00  0.10 -0.39  0.25 -0.71  0.50 -0.71
1505302  0.75 -0.58  1.00 -0.47
1505400 2  6
1505401  0.00 -0.19  0.25 -0.45  0.50 -0.55  0.75 -0.59  1.00 -0.47
1505500 2  7
1505501 -1.00  0.51 -0.75  0.55 -0.50  0.51 -0.25  0.39  0.00  0.00
1505600 2  8
1505601 -1.00  0.51 -0.75  0.31 -0.50  0.22 -0.25  0.21  0.00  0.31
*
*
*****************************************************************
*
* INTACT RECIRCULATION OUTLET LINE     (VOLUME25,26 .... RELAP4J)
*
*           NAME         TYPE
*
*  2000701     -0.219          1
*  2000702     -0.0            2
*  2000703     -1.515          3
*  2000801     0.00005 0.0495    3
*  2000901     0.325     0.325     1
*  2000902     0.17      0.17      2
*  2001001     00              3
*  2001101     0000            2
*  2001201     3      7.36200+6    551.7     0.0  0.0  1
*  2001202     3      7.37053+6    551.7     0.0  0.0  2
*  2001203     3      7.37907+6    551.7     0.0  0.0  3
*  2001300     1
*  2001301     3.00      0.0       0.0       2
*
*****************************************************************
*
*  BROKEN RECIRCULATION PUMP            (VOLUME17 .... RELAP4J)
*
*           NAME         TYPE
*  2100000     C210         PUMP
*
*          AREA   LEN    VOL    HZ     VR     ELV    CTL
*  2100101  0.0  0.26   0.005295  0.0  -90.0  -0.26    0
*
*           VOL NO     AREA     F-LOSS R-LOSS CAHS
*  2100108    200010000  0.0019244    5.28   5.28    0000
*
*           VOL NO     AREA     F-LOSS R-LOSS CAHS
*  2100109    220000000  0.0002746    0.1    0.1     0000
*
*           CTL     PRESSURE      TEMP        ZERO
*  2100200    3      7.64350+6     551.7       0.0
*
*           CTL     FLOW-F  FLOW-G   VELJ
*  2100201    1      3.00    0.0       0.0
*
*           CTL     FLOW-F  FLOW-G   VELJ
*  2100202    1      3.00    0.0       0.0
*
*           TAB-D   TWO-P     DIF-T    MOTOR  TAB-S  TRIP  REVER
*  2100301    150      150       150      -1     -1     510     1
*
*           R-SP    I/R     R-FL    R-HD    R-TOR M-IN   R-DEN
*  2100302  376.99  0.5344 0.0075 262.0 184.2 0.475 1000.0
*
*          R-M-TR   FR-TF2     FR-TF0     FR-TF1     FR-TF3
*  2100303  0.0      7.56       0.001      0.0        42.7
*
*          ELS TM  MX-F     MX-R
*  2100310  0.0     0.0      0.0
*
*****************************************************************
*
*  BROKEN RECIRCULATION OUTLET LINE     (VOLUME18,19.. RELAP4J)
*
*           NAME         TYPE
*  2200000     C220         PIPE
*
*           NO.VOL
```

```
2451203    3      7.36500+6    551.7    0.0   0.0   3
2451204    3      7.36000+6    551.7    0.0   0.0   4
2451300    1
2451301    8.00      0.0       0.0      3
*
*************************************************************************
*  QUICK SHUTT-OFF VALVE      NOT USED IN THE SMALL BREAK TEST SERIES   *
2500000     C250         VALVE
2500101    190010000 200000000  0.0019244  2.0    2.0    0000
2500201    1     3.00    0.0    0.0
2500300     TRPVLV
2500301                 513
*
*************************************************************************
*
*  VESSEL SIDE BREAK  (BRK B)           (JUNCTION55 .... RELAP4J)
*
*           NAME          TYPE
2600000     C260          VALVE
*
*            FR           TO         AREA     F-LOS  R-LOS CAHS
2600101   190010000 550000000  19.24-4    0.0    0.0   0100
*
*          CTL     FLOW-F FLOW-G  VELJ
2600201     1        0.0     0.0    0.0
*
*          VALVE TYPE     TRIP.NO
2600300     TRPVLV
2600301                    502
*
*************************************************************************
5500000     C550         SNGLVOL
5500101     19.24-4  0.4  0.0  0.0   0.0   0.0   0.00005  0.0495  00
5500200     3    7.35346+6    511.7    0.0
*
5550000     C555         VALVE
5550101     550010000 560000000  5.391-4     0.0     0.0     0100
5550201     1    0.0    0.0    0.0
5550300     TRPVLV
5550301                    502
*
5600000     C560         SNGLVOL
5600101     5.391-4  0.3  0.0  0.0   0.0   0.0   0.00005  0.0262  00
5600200     3    7.35346+6    511.7    0.0
*
5650000     C565         VALVE
5650101     560010000 280000000  5.391-4     0.0     0.0     0100
5650201     1    0.0    0.0    0.0
5650300     TRPVLV
5650301                    502
*************************************************************************
*  PUMP SIDE BREAK  ( BRK A)       NOT USED IN THE SMALL BREAK TEST      *
2700000     C270         VALVE
2700101     200000000 551000000  19.24-4    0.0    0.0    0100
2700201     1     0.0    0.0    0.0
2700300     TRPVLV
2700301                    502
*************************************************************************
5510000     C551         SNGLVOL
5510101     19.24-4  0.4  0.0  0.0   0.0   0.0   0.00005  0.0495  00
5510200     3    7.35346+6    511.7    0.0
*
5560000     C556         VALVE
5560101     551010000 561000000  5.391-4     0.0     0.0     0100
5560201     1    0.0    0.0    0.0
5560300     TRPVLV
5560301                    502
*
5610000     C561         SNGLVOL
5610101     5.391-4  0.3  0.0  0.0   0.0   0.0   0.00005  0.0262  00
5610200     3    7.35346+6    511.7    0.0
*
5660000     C566         VALVE
5660101     561010000 281000000  5.391-4     0.0     0.0     0100
5660201     1    0.0    0.0    0.0
5660300     TRPVLV
5660301                    502
*************************************************************************
*
*  CONTAINTMENT
*           NAME          TYPE
2800000     C280          TMDPVOL
*
*          AREA  LEN   VOL     HZ    VR   ELV  ROU  HYD  FE
2800101   1.0+3  0.0  1.0+6   0.0   0.0  0.0  0.0  0.0  11
*
*          CTL
2800200     3
*
*          TIME      PRESSURE   TEMP
2800201     0.0       9.8043+4   303.15      * CONSTANT
*
*************************************************************************
*
*  MAIN STEAM RESERVOIR                  * ENTHALPY CALCULATION
*
*           NAME          TYPE
2900000     C290          TMDPVOL
*
*
2900101   1.0+3  0.0  1.0+6   0.0   0.0  0.0  0.0  0.0  11
*
*          CTL
2900200     2
*
*          TIME     PRESSURE    TEMP
2900201     0.0      7.2900+6    1.0          * CONSTANT
*
*************************************************************************
*
*  MAIN STEAM
*
*           NAME          TYPE
3000000     C300          TMDPJUN
*
*            FR           TO         AREA
3000101   290000000 080010000  3.141-4
*
```