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PORV BREAK CALCULATIONS FOR THE ROSA-Ⅳ LSTF AND THE REFERENCE PWR WITH RELAP5/MOD1 (CYCLE 1)

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PORV Break Calculations for the ROSA-IV LSTF and the Reference PWR with RELAP5/MOD1 (cycle 1)

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Calculations simulating the failure of a single PORV were made for the ROSA-IV Large Scale Test Facility (LSTF) and the reference PWR with the RELAP5/MOD1, cycle 1, computer program. Comparison of the results showed that the initial higher steam generator secondary pressure and the smaller than scaled primary flow rate in LSTF affected the results for LSTF, however, the LSTF calculation compared well to the one for the PWR as a whole. This indicates LSTF should give results representative of the PWR in this situation. Both the calculation for LSTF and for the PWR showed the reactor pressure vessel upper head would remain voided even though the pressurizer was liquid full.

Keywords: ROSA-IV, LSTF, Reference PWR, PORV Break, RELAP5, Computer Analysis, Comparative Evaluation, Reactor Safety

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ROSA－Ⅳ LSTFとPWRのRELAP 5／MOD 1（cycle 1）コードによる加圧器逃し弁破断事故の解析

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（1983年4月5日受理）

ROSA－Ⅳ LSTFとPWRの加圧器逃し弁破断事故を，RELAP 5／MOD 1（cycle 1）コードにより解析した。LSTFの初期条件はPWRに比して蒸気発生器の2次側圧力が高く，また1次冷却材流量は小さく解析結果に影響を及ぼす。しかしながら，全体としてLSTFに対する計算結果はPWRに対する計算結果と良く一致し，LSTFによる加圧器逃し弁破断実験がPWRの加圧器逃し弁破断事故時の現象を良く表わすことが示された。また，LSTFおよびPWRのいずれの計算においても，加圧器が満水であっても原子炉圧力容器上部ヘッドの蒸気領域は消滅しないことが示された。

＊ 日米軽水炉安全性情報交換協定に基づく派遣研究員（EG & G Idaho, Inc.）

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1. INTRODUCTION

The Japan Atomic Energy Research Institute has initiated the Rig of Safety Assessment, Number 4 (ROSA-IV) program to study the thermal-hydraulics and plant parameters which affect the behavior of a pressurized water reactor (PWR) during a small break loss-of-coolant accident (SBLOCA) or an operational transient. The ROSA-IV program was initiated in response to the accident at Three Mile Island (TMI) which showed the need for more detailed study of these types of accidents and transients. The ROSA-IV program will operate two test facilities. The Two-Phase Test Facility (TPTF)[1] will be used to obtain fundamental two-phase data from separate effects tests in PWR components -- core, horizontal pipe and steam generator. The Large Scale Test Facility (LSTF)[2] will be used to conduct system and integral effects tests. Computer analyses of LSTF used to help in designing the facility and in planning the test matrix are described in this report.

The ROSA-IV program plans to perform TMI simulation tests in LSTF. Detailed planning for these tests is now being done by program personnel, however, at this time there was an interest in performing an analysis to study the response of LSTF to one part of the TMI accident sequence, the failure of a pilot operated relief valve (PORV) on the pressurizer, before beginning more detailed TMI simulations in the future. This report describes the results of calculations performed for both LSTF and the reference PWR with RELAP5/MOD1[3], cycle 1, where the failure of a single PORV and the high pressure injection system were assumed to occur. All other systems were assumed to operate as designed.

Section 2 of this report briefly describes the LSTF design philosophy and ROSA-IV program objectives. Section 3 describes the analysis models used to perform the calculations, the results of the analysis are contained in Section 4 and Section 5 presents the main conclusions of the study.

2. OBJECTIVES AND DESIGN PHILOSOPHY OF ROSA-IV LSTF

2.1 Objectives

The purpose of tests to be performed at LSTF is to provide test data from a large-scale test facility on the transient performance of PWRs under small break loss-of-coolant accident and transient conditions and on the effectiveness of emergency safeguard systems and procedures under such conditions. The tests will also provide experimental data on two-phase fluid flow in PWRs. Specifically, LSTF will be used to:

(1) Study the effectiveness of the ECCS under SBLOCA and plant transient conditions. Both standard and potential alternate ECCS will be evaluated.

(2) Study the effectiveness of secondary side cooling via the steam generators under SBLOCA and plant transient conditions.

(3) Examine the nature of forced and natural circulation cooling in PWRs in various flow regimes and cooling modes and in transition from one flow regime or mode of cooling to another.

(4) Examine the effect of break size and location on system behavior.

(5) Study the effects of non-condensible gases on system behavior during a SBLOCA or plant transient.

(6) Investigate alternate system designs and/or procedures which are being considered to improve system performance during a SBLOCA and/or plant transient.

(7) Provide test data with which to develop/verify the SBLOCA analytical model being developed in connection with the ROSA-IV Program.

2.2 Design philosophy

LSTF is an experimental test facility designed to model a full height primary system of a PWR. The reference PWR for LSTF is a 1100 MWe (3423 MWt) PWR with 50,952 fuel pins arranged in 17 x 17 square lattices.

The scale factor for LSTF is 1/48. Scaling of LSTF is accomplished as follows:

a. Elevations are preserved, i.e., the scaling ratio is 1/1. Preserving correct elevations is important to LSTF, since gravity strongly influences PWR long-term transient behavior, for instance, natural circulation.

b. Volumes are scaled by the facility scale factor of 1/48.

c. Flow Area in the pressure vessel and steam generators are scaled by the facility scale factors of 1/48 and 1/24, respectively. But the flow area of the primary loop, i.e., hot-leg and cold-leg, was determined from the conservation of the volume scaling and the Strouhal number so that flow regime transition could be simulated.

d. Core Power is scaled by the facility scale factor of 1/48 so that the power input per unit volume in the core region is the same as for the reference PWR. Note, for full power operation, the scaled power of the core would be 71 MW. However, heater rod power supply is limited to 10 MW. Hence, proper core power scaling can only be attained for simulated core power starting at about 14% of full power.

e. Fuel Assembly dimensions, i.e., fuel rod diameter, pitch and length, guide thimble diameter, pitch and length, and ratio of number of fuel rods to number of guide thimbles, are the same as for the 17 x 17 fuel assembly of the reference PWR in order to preserve the heat transfer characteristics of the core. The total number of rods is scaled by the facility scale factor and is 1060 heated and 104 unheated rods.

f. Design Pressures for the LSTF fluid systems will be at least the same as those for their counterparts in the reference PWR.

g. Fluid Flow ΔPs of major components, e.g., pumps, pressure vessel and steam generators will be the same as in the reference PWR.

h. Flow Capacities for LSTF systems are scaled by the power scale factor to preserve the enthalpy distribution.

Major characteristics of LSTF are shown in Tables 2.1, 2.2, a flow diagram is shown in Fig.2.1 and a plan view of the primary loop is shown in Fig.2.2.

Table 2.1 Major Characteristics of Large Scale Test Facility (LSTF) as of January 1983.

COMPONENT		PWR	LSTF	SCALE
PRESSURE VESSEL				
VESSEL INSIDE DIAMETER	(mm)	4394	640	1/6.87
VESSEL THICKNESS	(mm)	220	61	1/3.61
CORE BARREL OUTSIDE DIAMETER	(mm)	3874	534	1/7.25
DOWNCOMER LENGTH	(mm)	6147	6658	1/0.923
DOWNCOMER GAP	(mm)	260	53	1/4.91
DOWNCOMER FLOW AREA	(m^2)	3.38	0.0977	1/34.6
LOWER PLENUM FLUID VOLUME	(m^3)	29.6	0.617	1/48
UPPER PLENUM FLUID VOLUME (NOT INCLUDE UPPER HEAD VOLUME)	(m^3)	28.4	0.490	1/58.0
UPPER HEAD FLUID VOLUME	(m^3)	24.6	0.513	1/48
FUEL (HEATER ROD) ASSEMBLY				
NUMBER OF BUNDLES		193	24	
ROD ARRAY		17 x 17	7 x 7	
ROD HEATED LENGTH	(mm)	3660	3660	1/1
ROD PITCH	(mm)	12.6	12.6	1/1
FUEL ROD OUTSIDE DIAMETER	(mm)	9.5	9.5	1/1
THIMBLE TUBE DIAMETER	(mm)	12.24	12.24	1/1
INSTRUMENT TUBE DIAMETER	(mm)	12.24	12.24	1/1
NUMBER OF HEATER RODS		50952	1060	1/48.1
NUMBER OF NON-HEATING RODS		4825	104	1/46.4
CORE FLOW AREA (WITHOUT SPACER LOCATION)	(m^2)	4.75	0.120	1/39.6
CORE FLOW AREA (WITH SPACER LOCATION)	(m^2)	3.70		
CORE FLUID VOLUME	(m^3)	17.5	0.440	1/39.8
PRIMARY LOOP (SAME 2 LOOPS)				
HOT LEG INSIDE DIAMETER	(mm)	736.6	207	
HOT LEG LENGTH	(mm)	6993	3687	$L/\sqrt{D}$ SIMULATED
CROSSOVER LEG				
INSIDE DIAMETER	(mm)	787.4	168	
LENGTH	(mm)	8346	9547	
COLD LEG INSIDE DIAMETER	(mm)	698.5	207	
COLD LEG LENGTH	(mm)	7207	3438	

Table 2.1 (CONTINUED)

COMPONENT		PWR	LSTF	SCALE
PERSSURIZER				
VESSEL INSIDE DIAMETER	(mm)	2126	600	1/3.54
VESSEL HEIGHT	(mm)	15500	4200	1/3.69
TOTAL VOLUME	(m^3)	51	1.1	1/48
FLUID VOLUME	(m^3)	31	0.65	1/48
ACCUMULATOR (COLD AND HOT)				
VESSEL INSIDE DIAMETR	(mm)	3500	950	1/3.68
VESSEL HEIGHT	(mm)	5280	6600	1/0.80
TOTAL VOLUME	(m^3)	38.2	4.8	1/7.96
LIQUID VOLUME	(m^3)	26.9	3.38	1/7.96
RHR HEAT EXCHANGER				
NUMBER OF TUBES/1PASS		568	24	1/23.7
TOTAL U TUBE LENGTH	(mm)	8600	8600	1/1
TUBE OUTSIDE DIAMETER	(mm)	19.0	19.0	
TUBE INSIDE DIAMETER	(mm)	16.6	15.8	
TUBE WALL THICKNESS	(mm)	1.2	1.6	
TUBE PITCH	(mm)	28.5	28.5	1/1
TUBE ARRAY		Δ	Δ	
HEAT TRANSFER AREA (OUTER SURFACE)	(m^2)	590	25	1/23.6
STEAM GENERATOR (SAME 2 S.G s)				
NUMBER OF TUBES		3382	141	1/24
TUBE LENGTH (AVERAGE)	(m)	20.24	19.71	1/1.03
TUBE OUTSIDE DIAMETER	(mm)	22.2	25.4	
TUBE INSIDE DIAMETER	(mm)	19.6	19.6	1/1
TUBE WALL THICKNESS	(mm)	1.3	2.9	
HEAT TRANSFER AREA (OUTER SURFACE OF TUBE)	(m^2)	4780	221.6	1/21.6
INLET PLENUM VOLUME	(m^3)	4.18	0.174	1/24
OUTLET PLENUM VOLUME	(m^3)	4.18	0.174	1/24
PRIMARY SIDE VOLUME	(m^3)	30.14	1.214	1/24.8
SECONDARY SIDE VOLUME	(m^3)	163.12	6.80	1/24

Table 2.2 Elevation of Each Position

POSITION		PWR	LSTF	SCALE
BOTTOM OF HEATER BUNDLE	(mm)	0	0	
TOP OF HEATER BUNDLE	(mm)	3660	3660	1/1
TOP OF DOWNCOMER	(mm)	4889	5399	1/0.906
BOTTOM OF DOWNCOMER	(mm)	-1259	-1259	1/1
CENTER OF COLD LEG	(mm)	5238	5503	1/0.952
TOP OF COLD LEG INSIDE DIAMETER	(mm)	5588	5606	1/0.997
CENTER OF LOOP SEAL LOWER END	(mm)	2095	1786	1/1.17
BOTTOM OF LOOP SEAL LOWER END	(mm)	1703	1703	1/1
CENTER OF HOT LEG	(mm)	5238	5503	1/0.952
TOP OF HOT LEG INSIDE DIAMETER	(mm)	5606	5606	1/1
BOTTOM OF UPPER CORE PLATE	(mm)	3968	3968	1/1
TOP OF LOWER CORE PLATE	(mm)	109		
BOTTOM OF TUBE SHEET OF STEAM GENERATOR	(mm)	7414	7642	1/0.970
PLENUM LOWER END OF STEAM GENERATOR	(mm)	5819	5819	1/1
TOP OF TUBES OF STEAM GENERATOR	(mm)	18584	18584	1/1

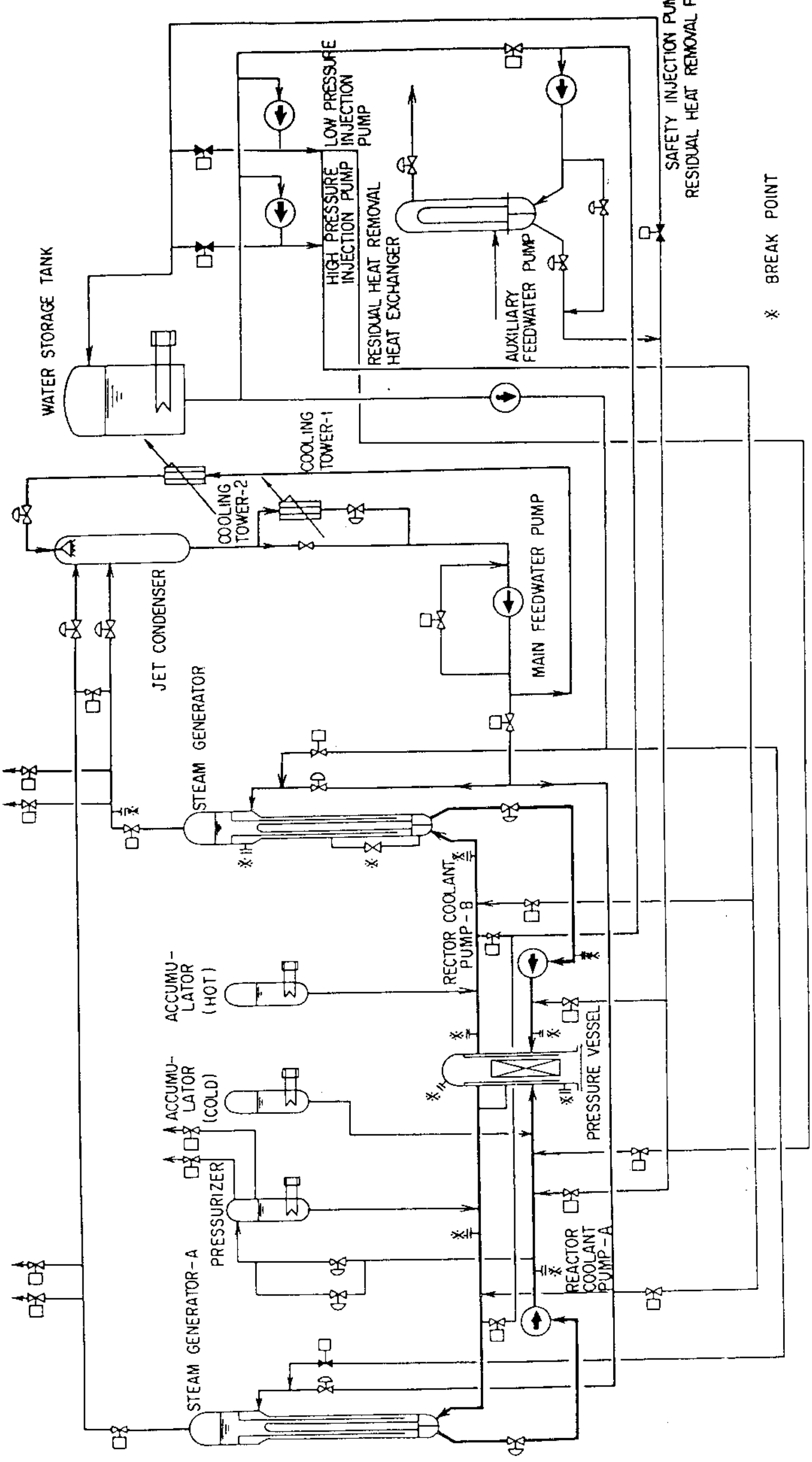

Fig.2.1 Flow Diagram of LSTF

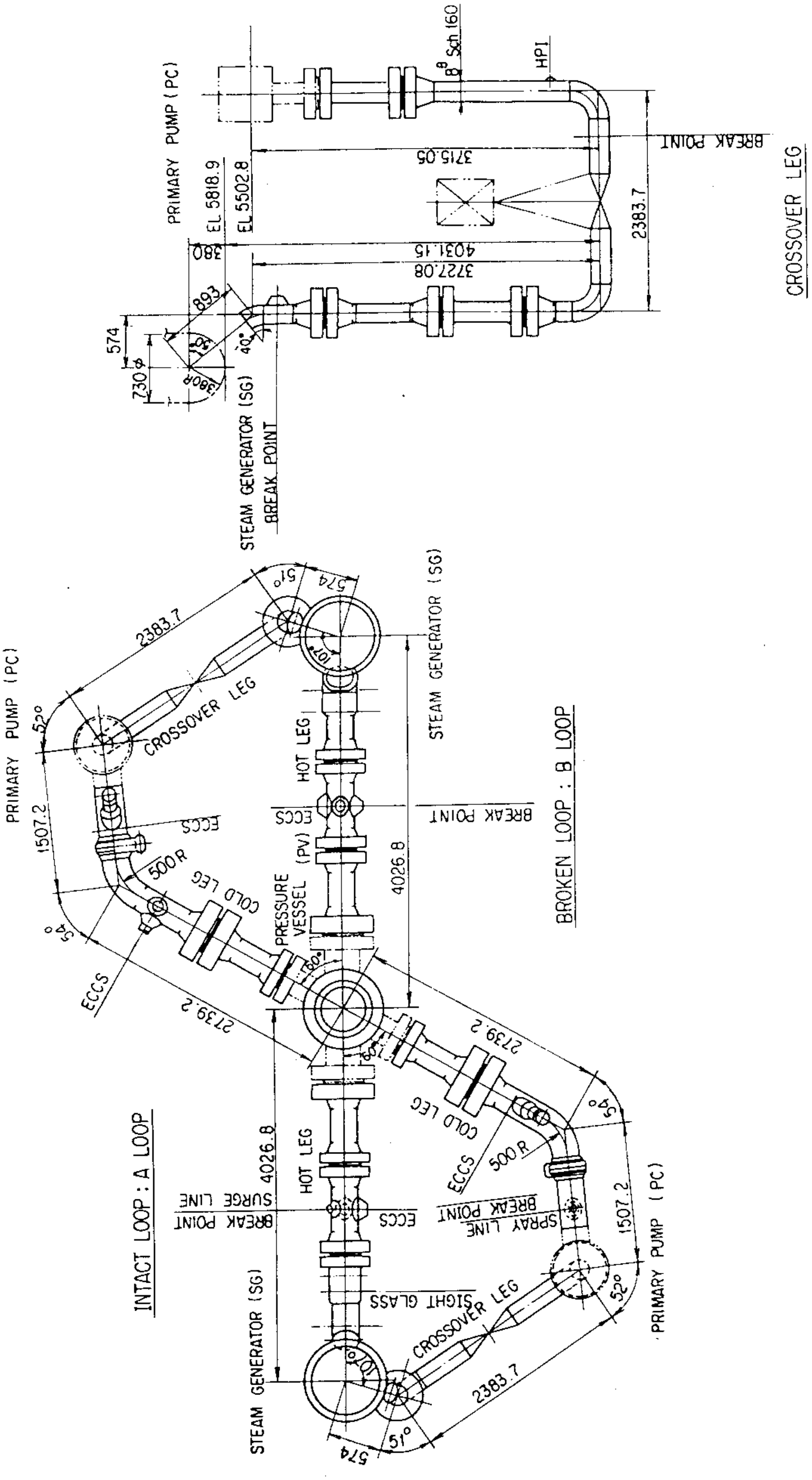

Fig.2.2 Plan View of Primary Loop of LSTF

3. RELAP5 MODEL DESCRIPTIONS

The RELAP5 models used to make the calculations for LSTF and the reference PWR are described in Sections 3.1 and 3.2, respectively. The trip and control logic for the systems is described in Section 3.3.

3.1 LSTF RELAP5 Model

The RELAP5/MOD1, cycle 1, model used to represent the LSTF system is shown in Figure 3.1. The model included 192 volumes and 200 junctions. Heat transfer from vessel structures and in the core and steam generators was modeled using 66 heat structures. Steam generator secondary systems, including the jet condenser, were modeled in detail.

Because of the potential for voiding in the upper head region during this type of accident, the upper head was nodalized to allow junctions at the top of the guide tubes and at the downcomer/upper head nozzles. These are the only flow paths to the upper head.

A discharge coefficient of 1.0 was applied to the RELAP5 critical flow model for both single-phase and two-phase critical flow. The detailed design of the break location has not been completed and, therefore, the information needed to determine whether discharge coefficients (and their size) would be needed to accurately model the break flow was not available.

The RELAP5 control system capability was used to model the control system for the LSTF jet condenser spray and the primary mean temperature control logic for the turbine bypass valve.

The initial conditions for the transient calculation were obtained from a RELAP5 steady-state calculation. The main parameters are listed in Table 3.1. There was a little difference in the initial conditions for LSTF and the PWR, but they did not affect the transient calculations.

3.2 PWR RELAP5 Model

The nodalization diagram for the RELAP5/MOD1, cycle 1, model used to represent the reference PWR is shown in Figure 3.2. The model included 187 volumes and 194 junctions. Heat transfer in the system was modeled using 72 heat structures. Detailed modeling of the steam generator secondary systems was included out to the turbine throttle and turbine bypass valves.

To facilitate comparison of the calculated results to those obtained with the LSTF model, as much as possible, the same modeling approach was applied in setting up the PWR model as the LSTF model. Differences in the models occur where a lack of detailed information was faced when modeling the PWR or where the design of the system is clearly different, as is the case in the secondary systems downstream of the steam generator outlets. In general, however, the description of the LSTF model, above, applies to the PWR model as well.

The initial conditions for the PWR transient calculation were obtained from a RELAP5 steady-state calculation. The initial conditions are listed in Table 3.1 for comparison to the LSTF data.

3.3 Trip and Control Logic

The trip logic used in the LSTF and PWR calculations to control the steam generators and the plant protection systems (core trip and emergency core cooling system (ECCS)) was based on the trip logic of the reference plant. These trips are described below:

	Action	Setpoint
①	PWR scram	P < 12.97 MPa [a]
②	Trip coolant pump and main FW, initiate safety injection and aux. FW trips	P < 12.27 MPa [a]
③	LSTF core power trip	① + 7.1 s
④	Safety injection begins	② + 17.0 s
⑤	Aux. FW begins	② + 28.0 s
⑥	Main steam isolation valve closes	P < 4.235 MPa [b]
⑦	Accumulator injection begins	P < 4.51 MPa [c]

a. Pressurizer pressure

b. Steam generator secondary steam dome pressure

c. Pressure in cold leg downstream of accumulator

The turbine bypass valve control logic based on the primary mean temperature was modeled in both the PWR and the LSTF calculations. This logic is designed to use the turbine bypass valve to maintain a primary mean temperature of 564.9K after the core scrams by opening or closing the valve depending on whether the mean temperature is above or below this setpoint. The same control system was applied to both systems in the calculations.

In addition, in the LSTF model, a control system was setup to control the jet condenser spray. In LSTF, the control system will be used to adjust the spray flow rate in order to maintain the jet condenser pressure at its initial value during an experiment.

Table 3.1 LSTF and PWR Initial Conditions

	LSTF	PWR
System Pressure (MPa)	15.59	15.60
Cold Leg Temperature (K)	562.14	562.24
Hot Leg Temperature (K)	598.11	598.26
Core Temperature Difference (K)	35.97	36.02
Core Flow Rate (kg/s)	48.38 [a]	16514.
Core Power (MW)	10.0 [a]	3423.
Steam Generator Secondary Pressure		
Intact Loop SG (MPa)	7.12 [b]	5.71
Broken Loop SG (MPa)	7.12 [b]	5.71

[a] Both the initial flow rate and core power in LSTF are 14% of the full scaled values based on a system scale factor of 1/48.

[b] The initial SG secondary pressure is higher in LSTF than in the PWR to reduce the steady state heat transfer to 10 MW.

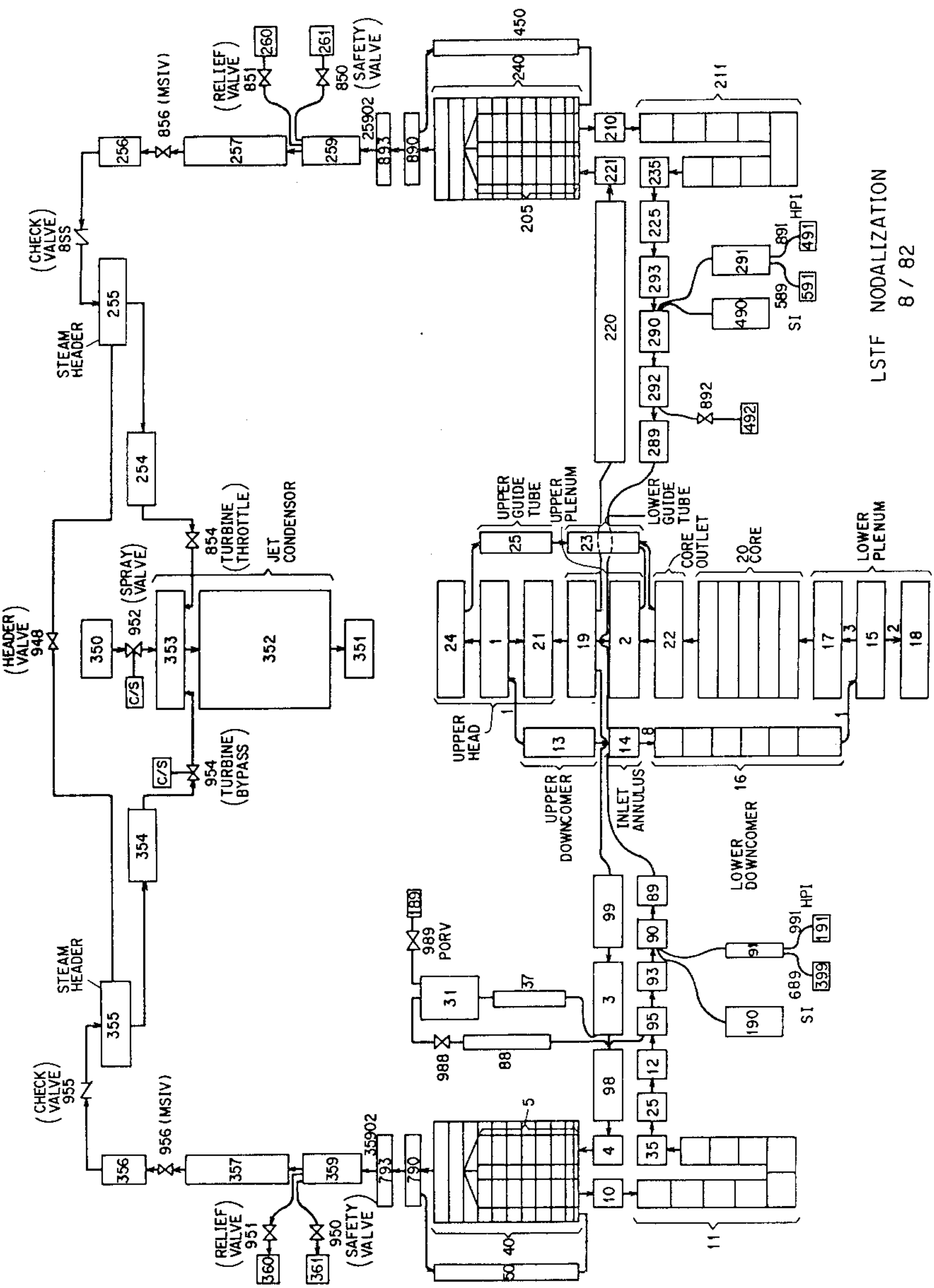

Fig.3.1 Nodalization of LSTF

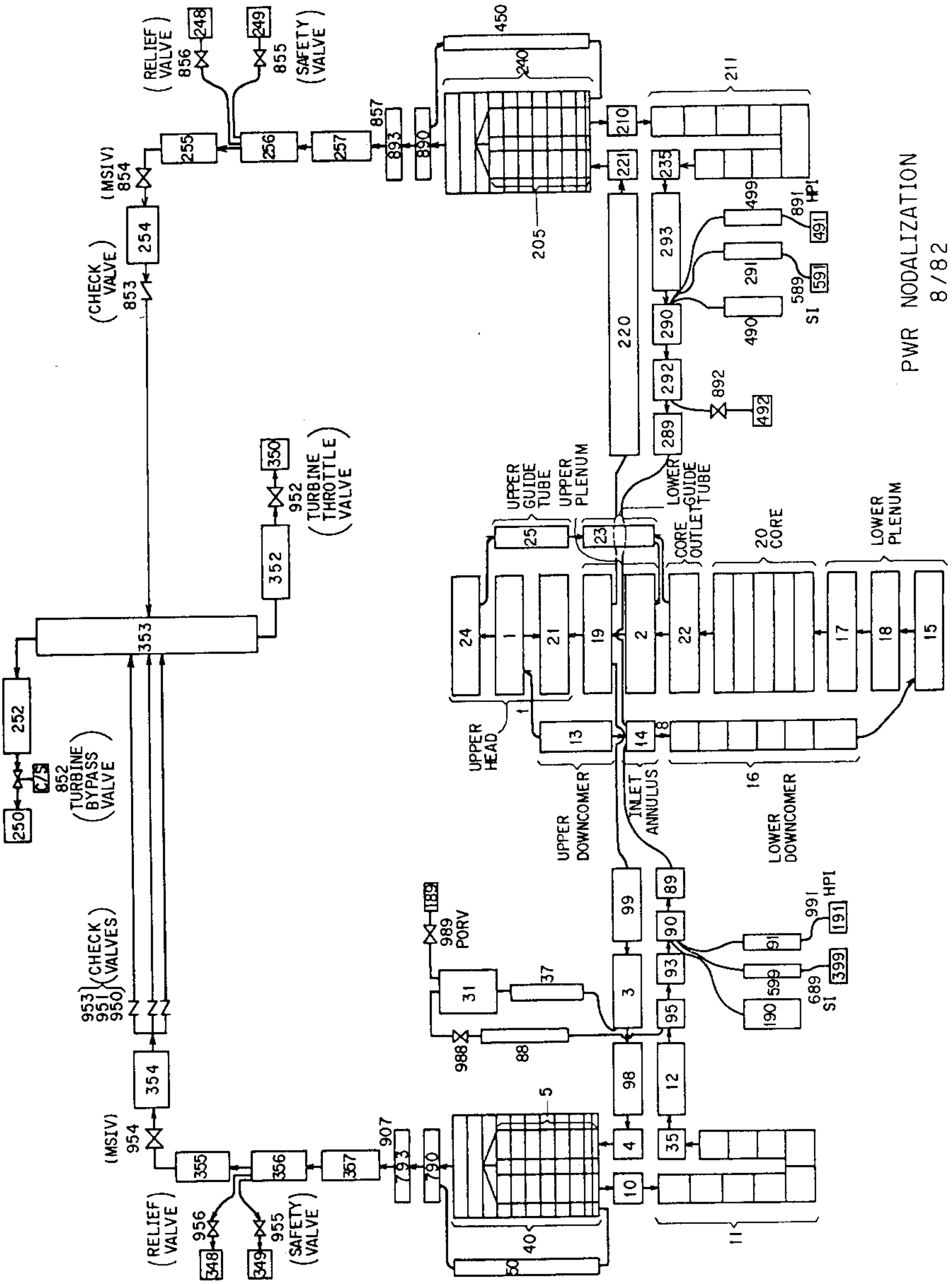

Fig.3.2 Nodalization of PWR

4. ANALYSIS OF CALCULATED RESULTS

A comparison of the calculated sequence of events for the LSTF and the PWR calculations is shown in Table 4.1. This comparison shows that there was good agreement between the two calculations with regards to the time of the PWR scram, but the SI signal, and therefore the trips dependent on it, was delayed by 10 s in the LSTF calculation. Also, the time of the closure of the main steam isolation valve was later in the LSTF calculation.

The reason for these differences can be seen in Figures 4.1 and 4.2 which compare the primary and secondary pressures for the two calculations. In general, the pressure trends of the LSTF calculation were in good agreement with those of the PWR calculation, although both the primary and secondary pressures were a little higher in the LSTF calculation. The difference in the primary pressure occurred at the time the core tripped and was due to the smaller than scaled primary flow rate in LSTF. With the smaller than scaled flow rate in LSTF, the hot leg fluid did not cool as rapidly, once the core scrammed, as in the PWR calculation. This is illustrated in the primary mean temperature shown in Fig.4.3. Since the fluid cooled at a slower rate, the specific volume of the fluid did not decrease as rapidly as in the PWR calculation and therefore the system pressure decreased at a slower rate. The depressurization rate calculated for LSTF and the PWR decreased at 100 s and at 175 s. The first change in the depressurization rate, at 100 s, was due to void formation in the pressure vessel (see Figure 4.4). The knee in both pressure curves at 175 s was due to the break flow changing from single-phase steam to a two-phase mixture. This is shown in Figure 4.5 which compares the void fraction at the top of the pressurizer for the two calculations. Also, the sudden decrease in the pressure in the LSTF calculation at 1750 s was due to the collapse of voids in the pressurizer spray line (see Figure 4.6).

The secondary pressure response in the LSTF calculation was probably affected by a number of things including the higher initial steam generator pressure (the initial pressure in the steam generator secondary in LSTF will be higher than in the PWR to reduce the steadystate heat transfer to 10 MW) and the smaller primary flow rate which influenced (1) the primary depressurization rate and (2) the turbine bypass valve operation (it kept the turbine bypass valve open longer in the LSTF calculation (see Fig.4.7) because of the slower primary fluid cooldown rate). These differences in the system operation and response would all affect the maximum pressure in the steam generator secondary because of the influence they have on primary to secondary heat transfer and energy removal from the secondary.

The break flow for the two calculations is compared in Fig.4.8. This figure shows there was good agreement between the calculated results. The break flow initially decreased in both calculations as the systems depressurized. The increase in the break flow at 200 s is due to the conditions upstream of the break going from single-phase steam to a two-phase mixture (see Figure 4.5). The break flow remainded relatively constant from 200 s to 1400 s, when it increased again because the pressurizer became liquid full. The oscillation in the LSTF break flow at the end of the calculation was due to void formation upstream of the break (see Figure 4.5) when the system pressure decreased for the reason discussed above.

The good comparison between the calculations for the system depressurization rate and the break flow rate was a result of the excellent agreement of the conditions upstream of the break, as is seen in Figure 4.5. The time of the transition from single-phase steam to a two-phase mixture was accurately calculated as well as the time the pressurizer completely filled. The pressurizer filled with liquid because the ECCS flow exceeded the break flow. The rate of change in the void fraction at the top of the pressurizer, as the volume filled, was also calculated well by the LSTF model when compared to the PWR calculation. The overall filling behavior of the pressurizer in the LSTF calculation also compared well as shown in Figure 4.9, which compares the collapsed liquid level in the pressurizer. Athough the absolute value of the levels cannot be compared directly because the LSTF pressurizer was scaled by the L/D ratio (and therefore has a larger flow area than the ratio of 1/48 times the PWR flow area), the same response was seen in both calculations; the level in the pressurizer increased rapidly as voids formed in the system and forced liquid into the pressurizer followed by a more gradual filling of the rest of the pressurizer, because ECCS flow exceeded the break flow, until the pressurizer became liquid full at about 1450 s.

When the system depressurized to the pressure corresponding to a saturation temperature equal to the hot leg temperature, liquid began to flash to steam in the hot leg, upper plenum and in the upper part of the core. This is shown in Figure 4.10 and 4.11 for the LSTF and the PWR calculations, respectively. Figure 4.12, which compares the void fraction, at the top of the core, is representative of the comparisons in the other parts of the system. The data in this figure shows that the time void formation began, the amount of steam formed, and the length of time the voids existed in the PWR calculation were accurately represented in the LSTF calculation. The accurate calculation of these phenomena was important because of the affect they have on the system depressurization rate. The fact that the LSTF model calculated them well indicates the decision to maintain the initial PWR fluid temperature distribution in LSTF at steady-state, by reducing the primary flow rate and increasing the steam generator secondary pressure to compensate for an initial core power of 10 MW (14% of the full scaled value) was reasonable.

Even though voids formed in the upper part of the core, no temperature excursions were calculated to occur in either case. This is seen in Figure 4.13 which compares the rod surface temperatures at the top of the core. In both calculations the temperatures followed the fluid temperature in the core.

One of the most interesting results of the calculations was that the upper head was calculated to remain voided even though the pressurizer became filled with liquid. As seen in Figure 4.14, this was true of both the PWR and the LSTF calculation. This was due to the very small flow paths into the upper head from the rest of the system. The only connections are the downcomer/upper head spray nozzles and at the top of the guide tubes. Based on information from the PWR vendor, the initial flow through the upper head was estimated to be 0.38% of the core flow rate, which is indicative of the small flow areas involved at these junctions. In particular, the flow restriction occurred at the downcomer/upper head junction which has the smaller of the two flow areas.

Table 4.1 Calculated Sequence of Events

Event	Time (s)	
	PWR	LSTF
Break	0.0	0.0
Scram (PWR)	30.6	32.0
LSTF Power Trip	—	39.2
SI Signal	32.8	42.4
SI Begins	49.8	59.4
Aux. FW Began	60.8	70.4
Void Formation Began	86.	115.
MSIV Closed	1073.5	1162.7
Pressurizer Filled	1442.	1500.

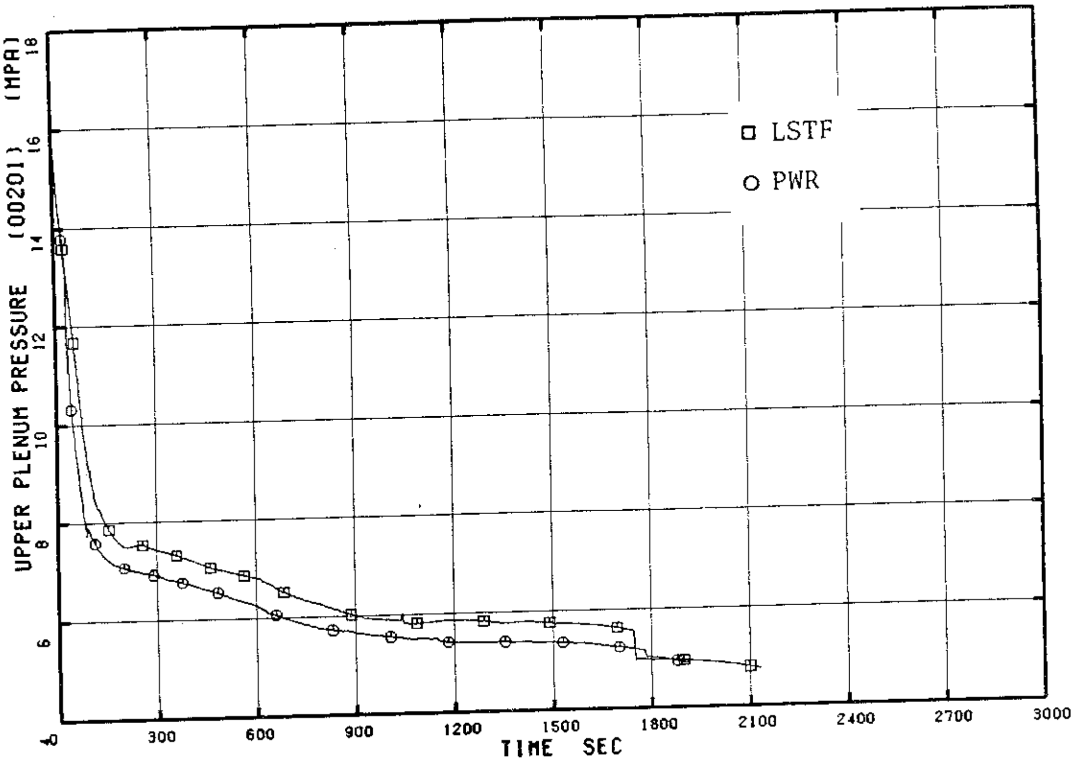

Fig.4.1 Upper Plenum Pressure

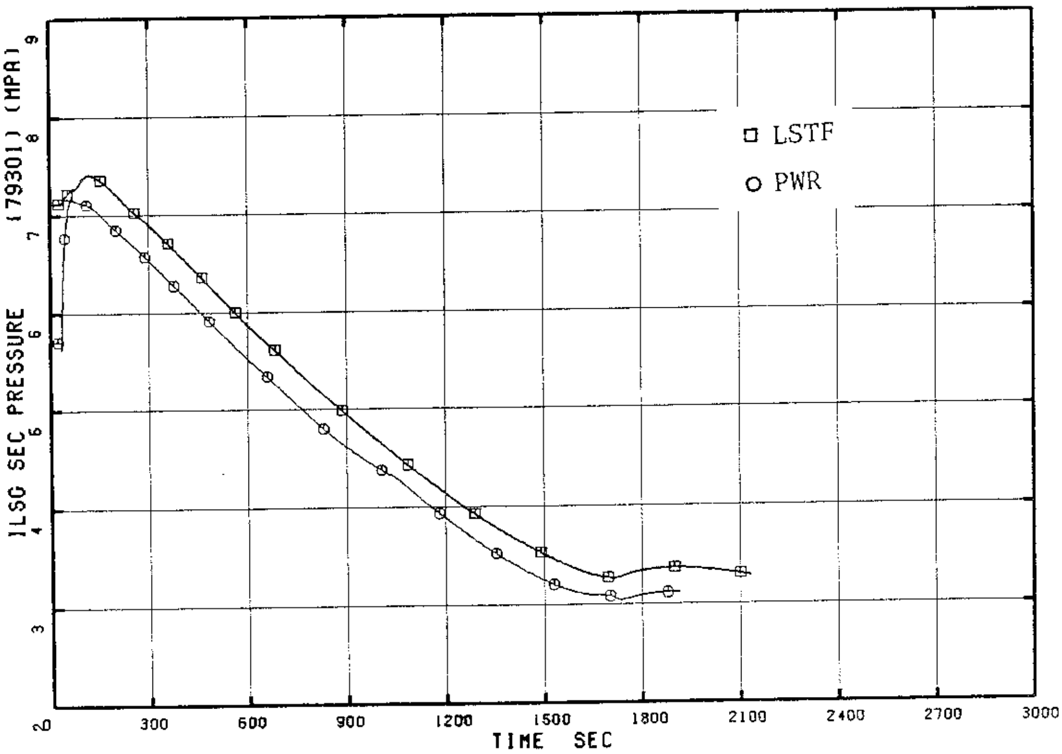

Fig.4.2 Intact Loop Steam Generator Secondary Pressure

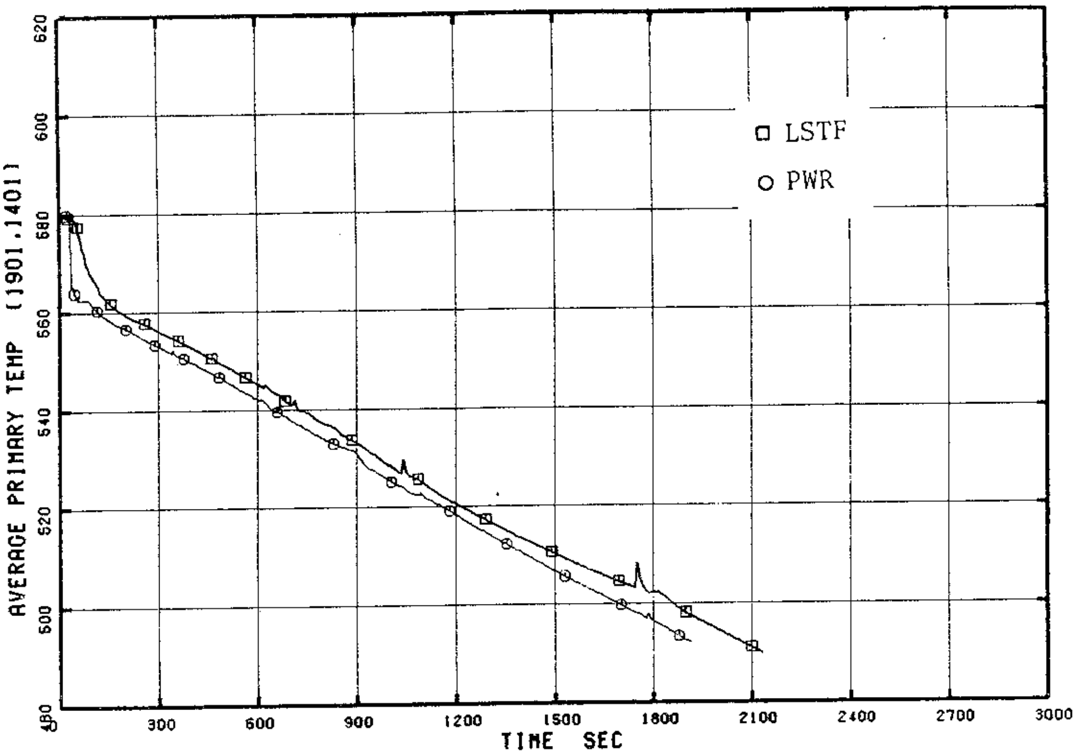

Fig.4.3 Primary Mean Temperature

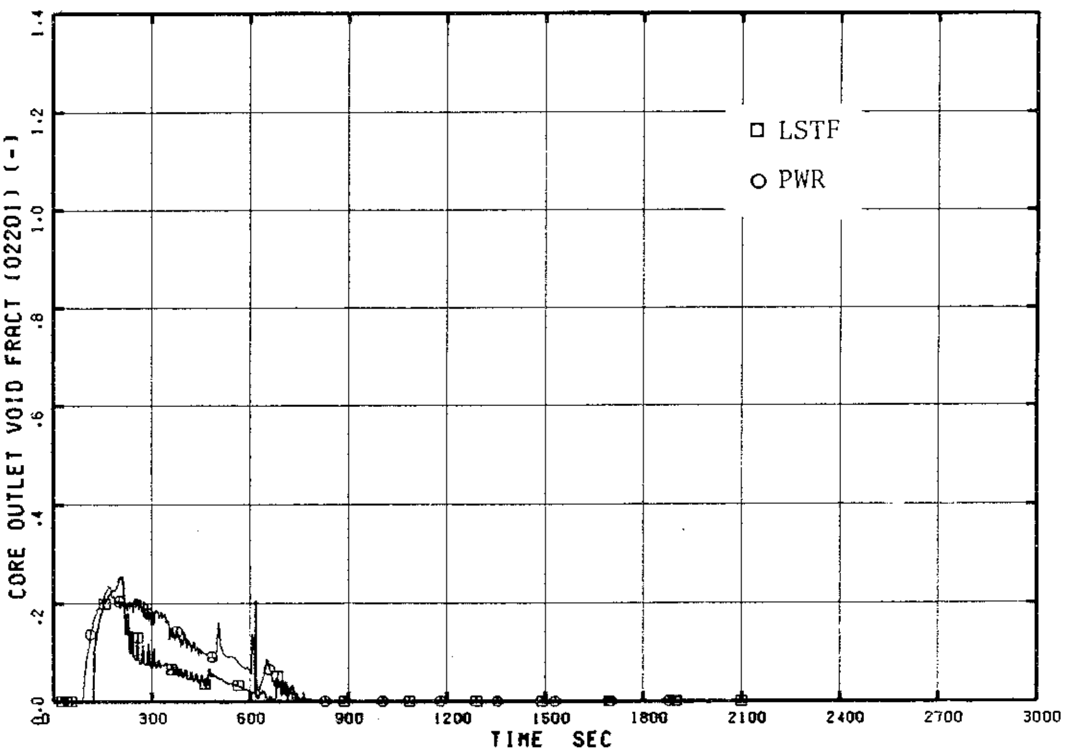

Fig.4.4 Core Outlet Void Fraction

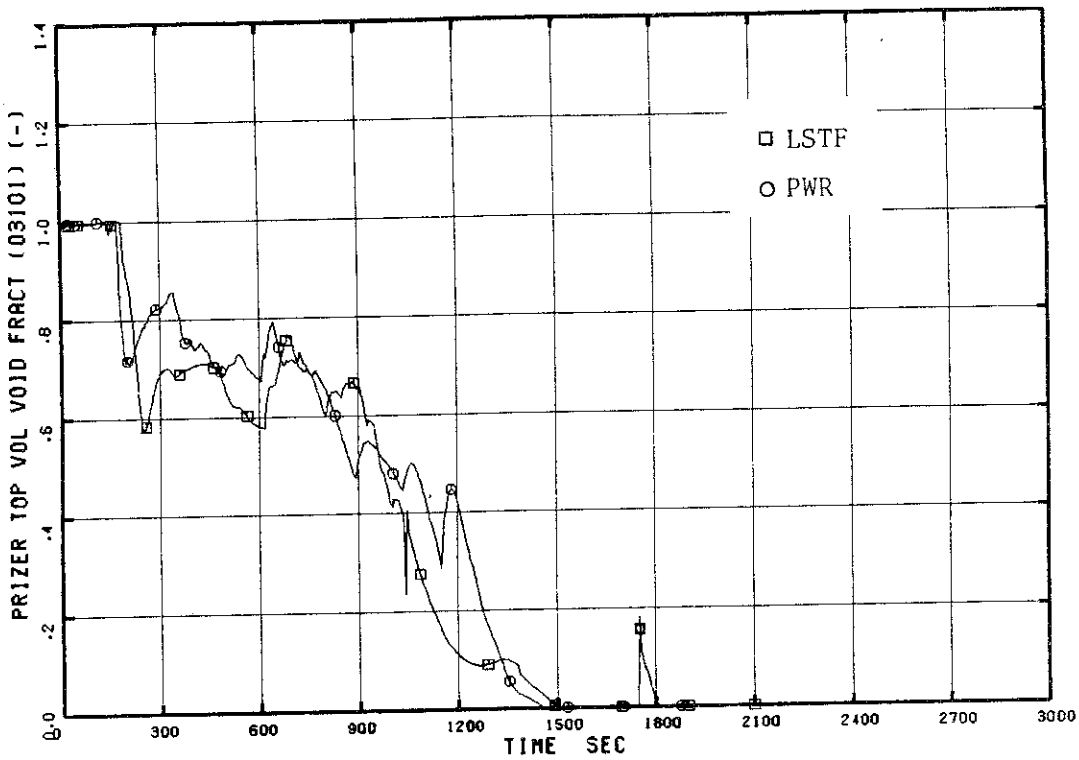

Fig.4.5 Void Fraction at the top of the Pressurizer

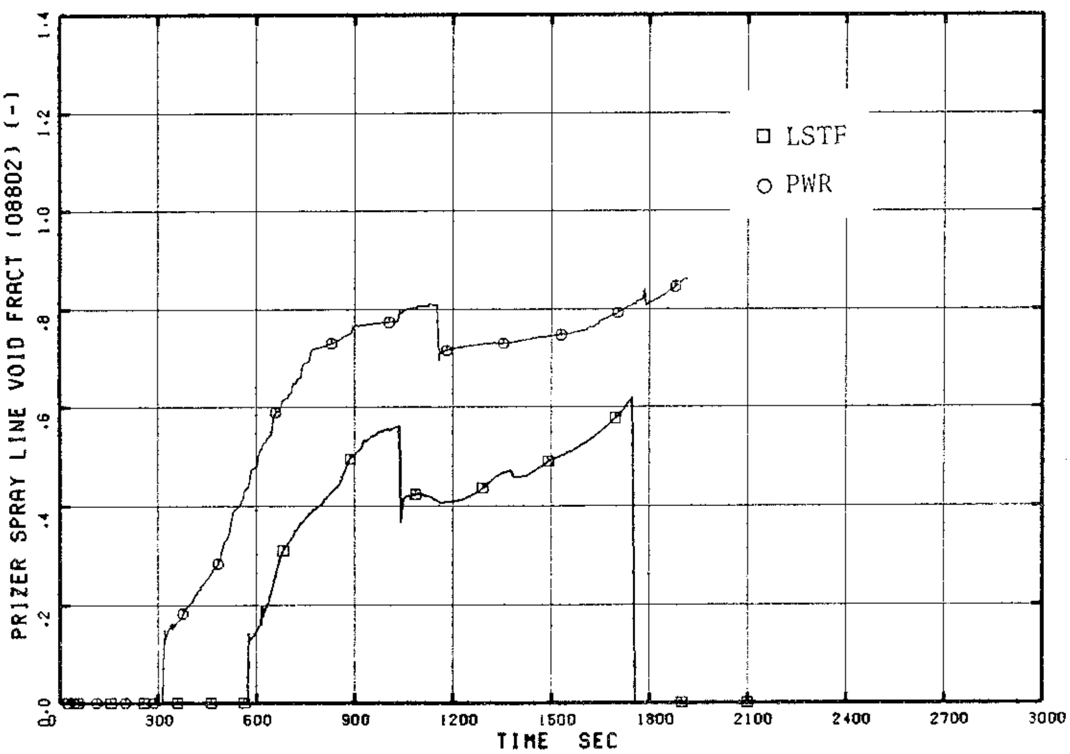

Fig.4.6 Pressurizer Spray Line Void Fraction

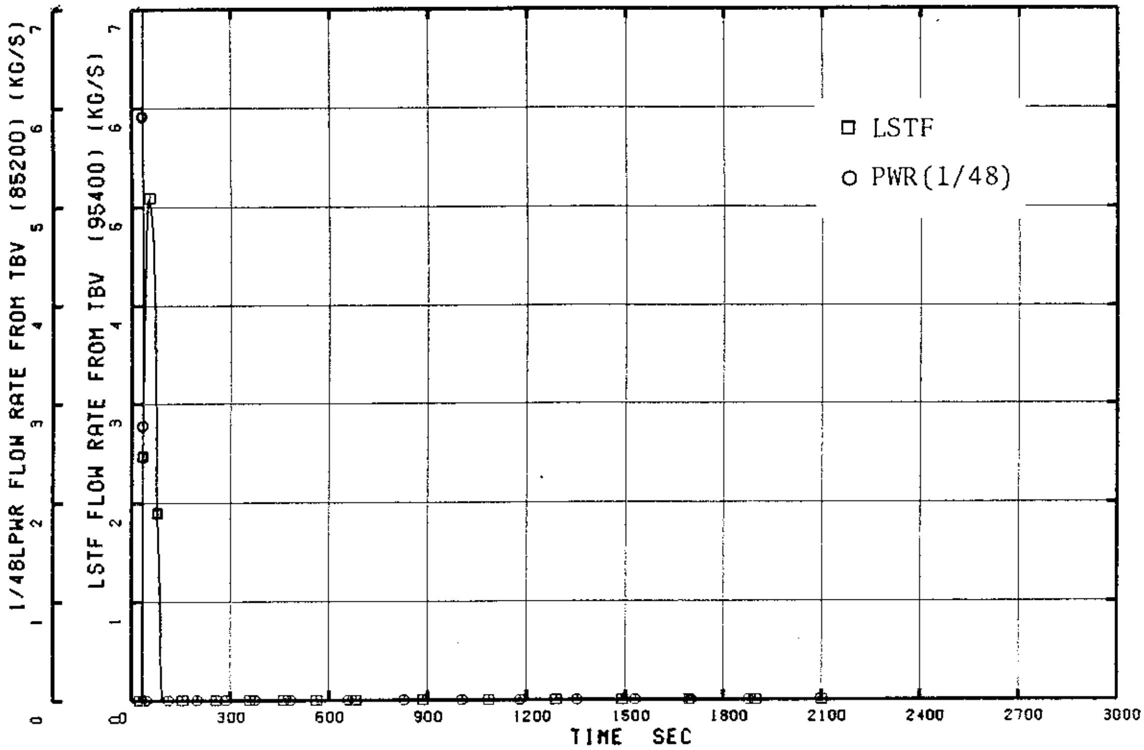

Fig.4.7　　Flow Rate from Turbine Bypass Valve

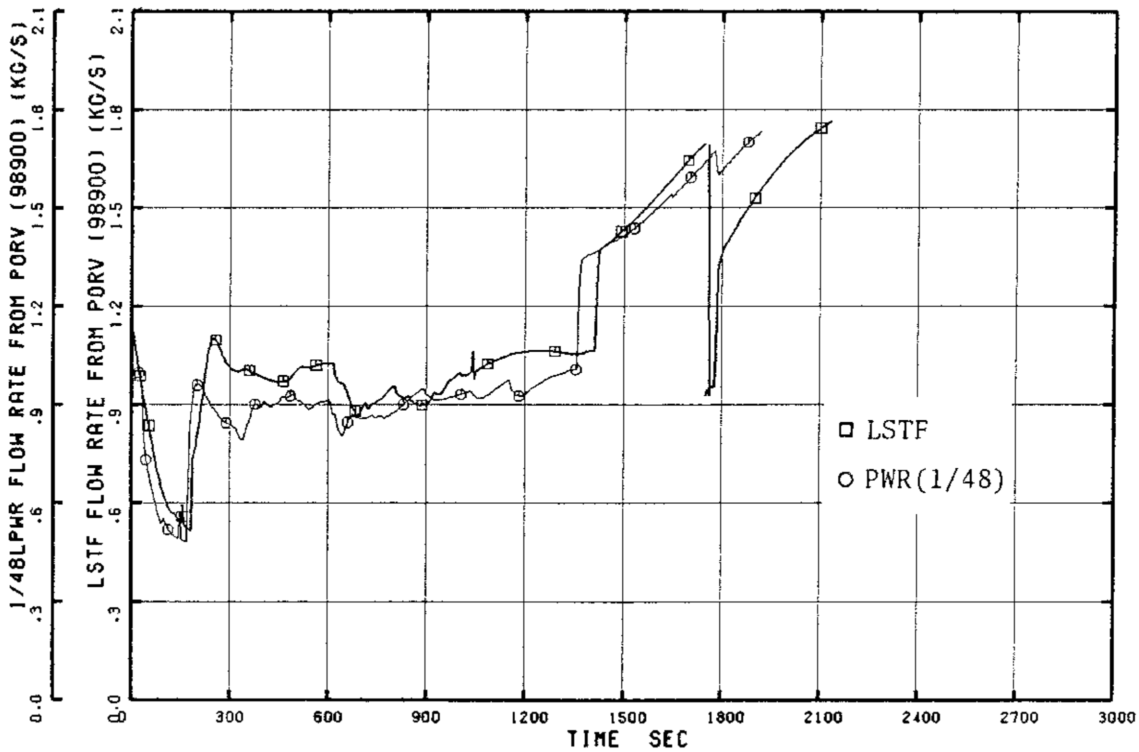

Fig.4.8　　Flow Rate from PORV

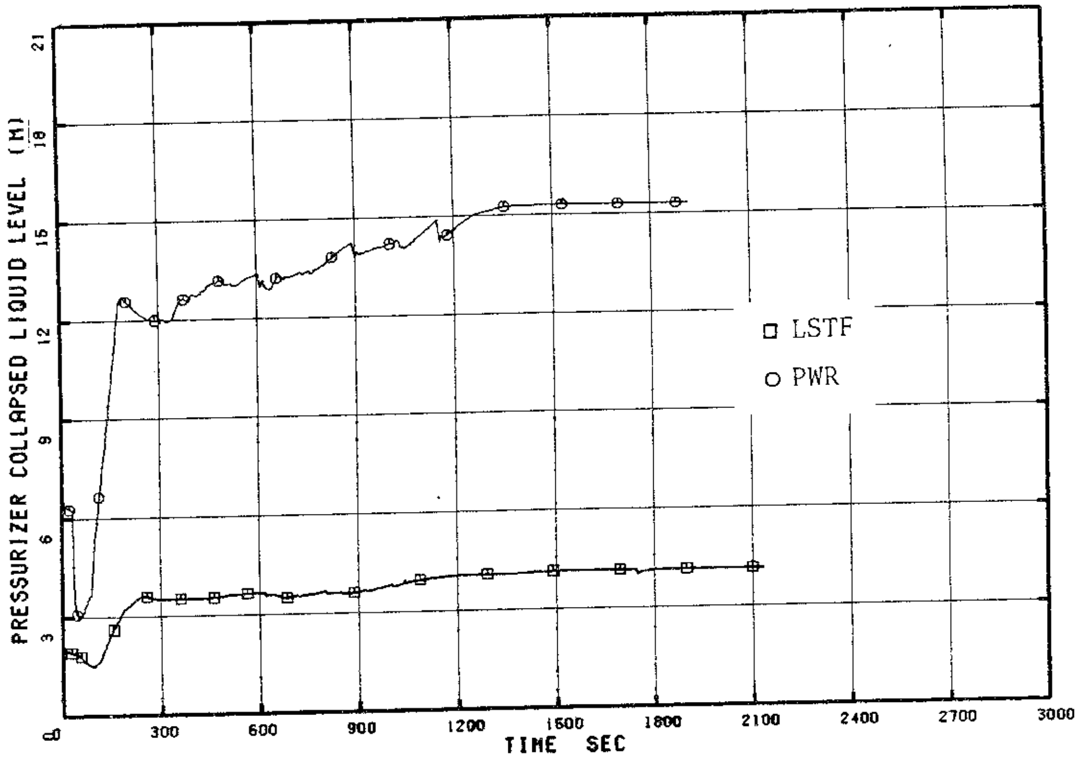

Fig.4.9 Pressurizer Collapsed Liquid Level

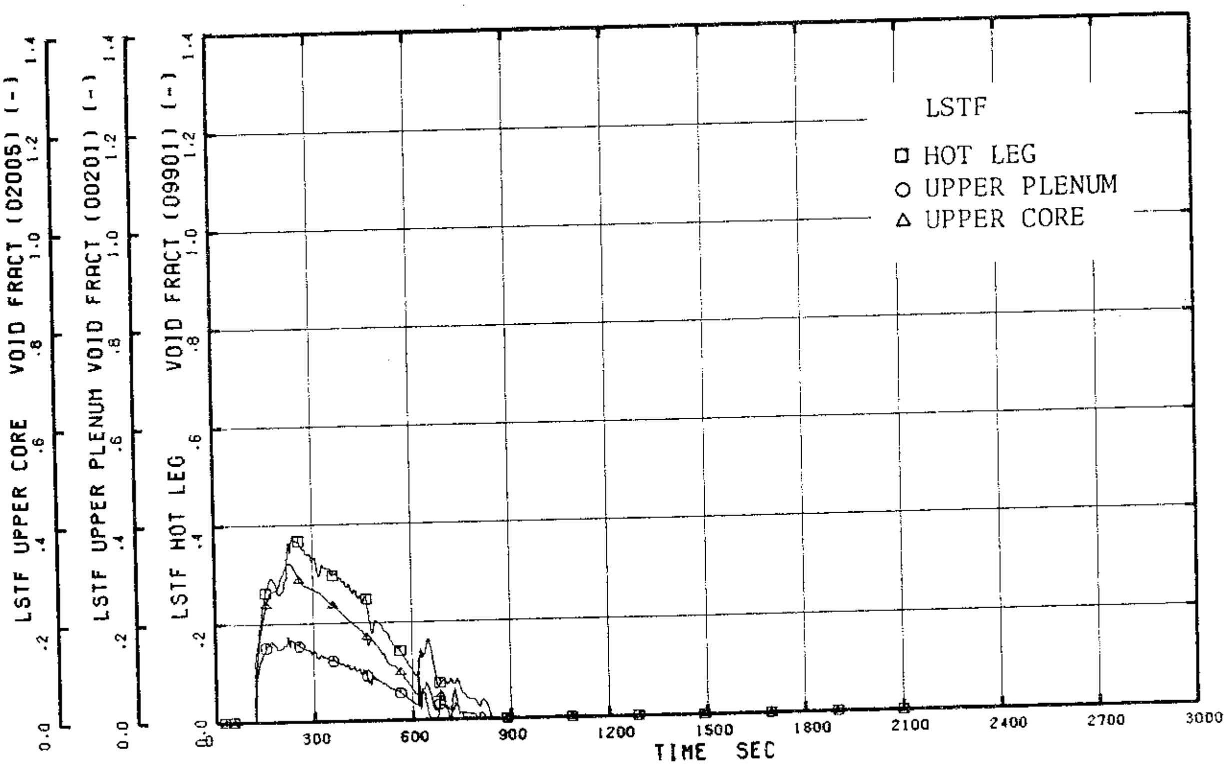

Fig.4.10 LSFT Void Fraction in Hot Leg, Upper Plenum and Upper Core

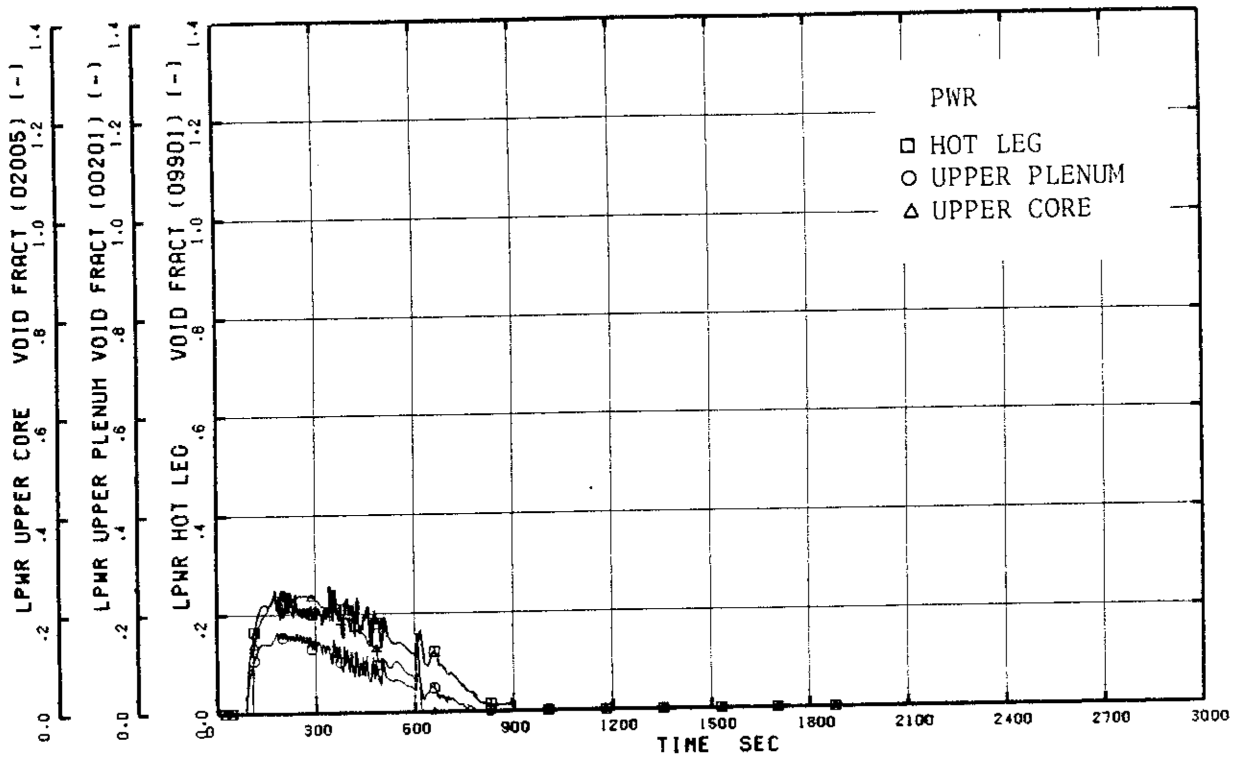

Fig.4.11 PWR Void Fraction in Hot Leg, Upper Plenum and Upper Core

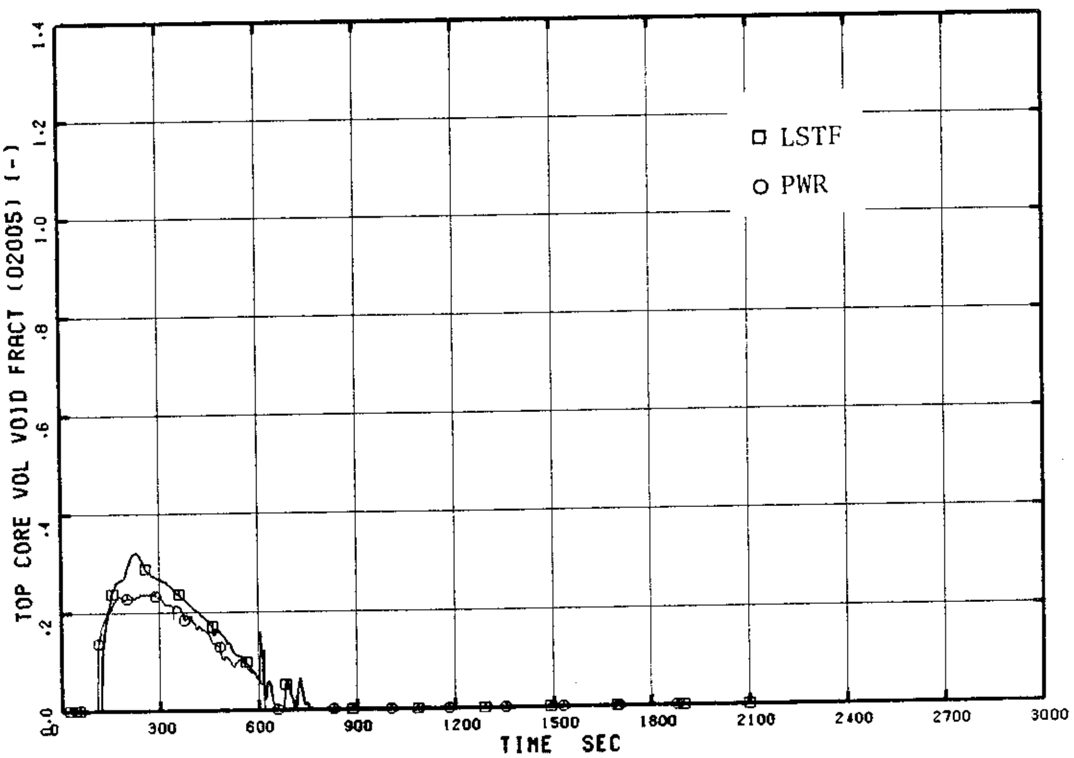

Fig.4.12 Void Fraction at the top of the Core

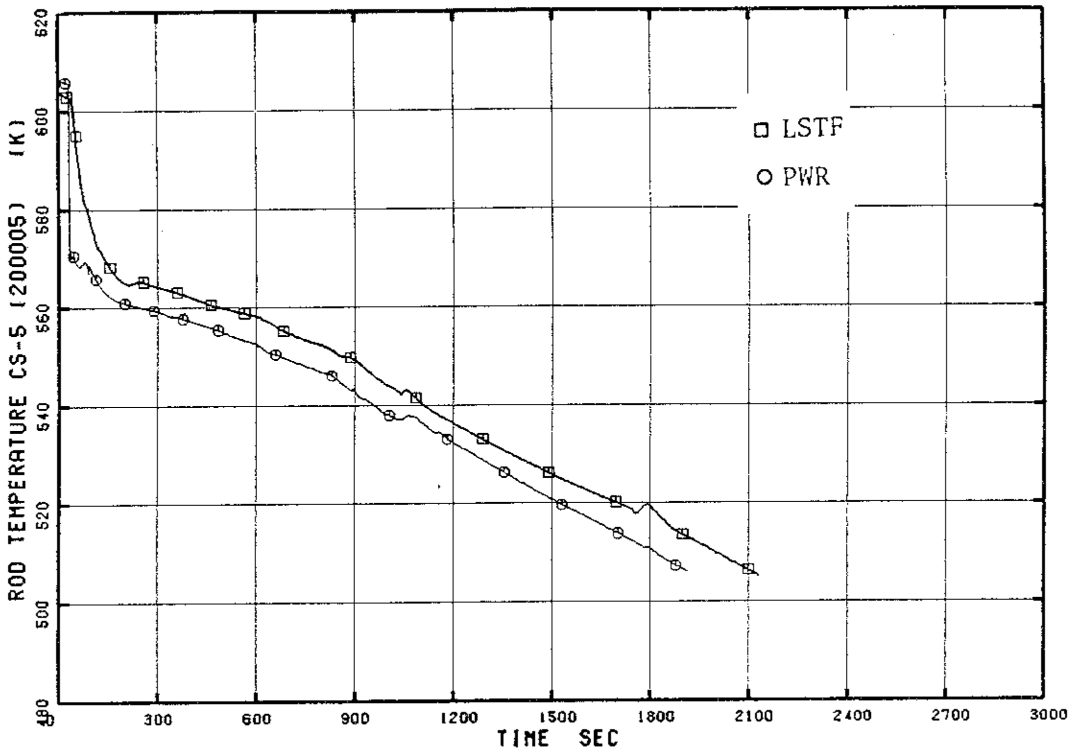

Fig.4.13 Rod Surface Temperature at the top of the Core

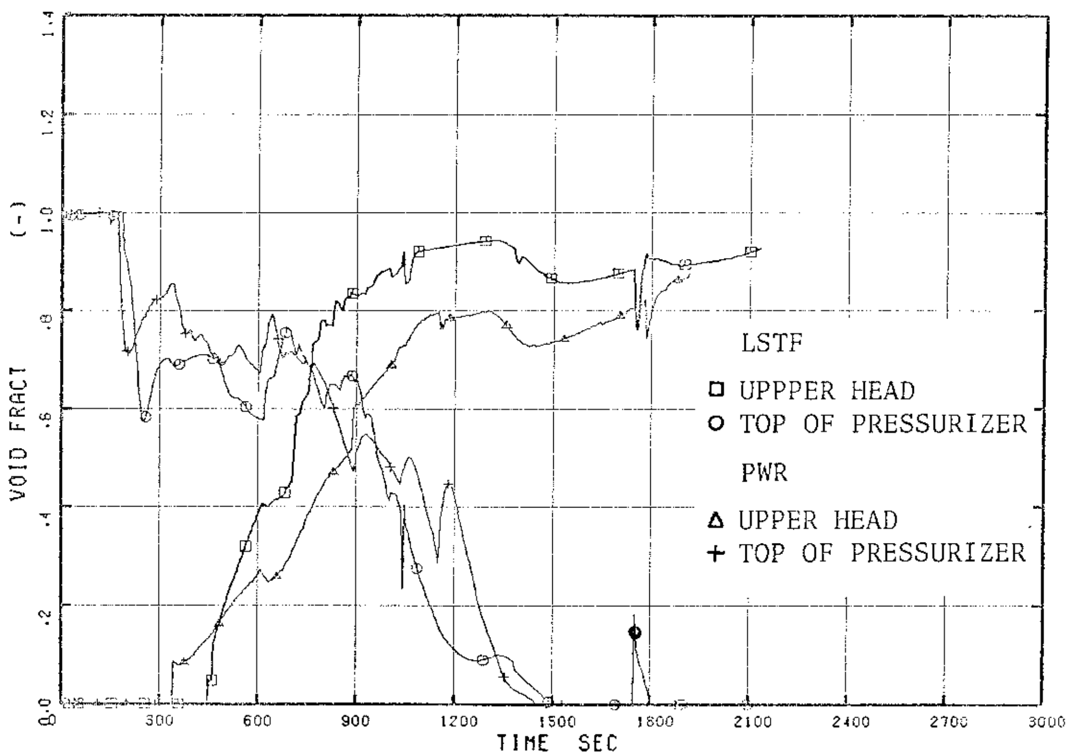

Fig.4.14 Comparison of the Void Fraction in the Upper Head and the top of the Pressurizer

5. CONCLUSIONS

The results of the LSTF calculation for a PORV break were in good agreement with the results of the calculation for the reference PWR. The important trends of the data in the PWR calculation, such as system depressurization rate, break flow and void formation, were calculated well by the LSTF model. The results of the LSTF calculation, however, were affected by the smaller than scaled primary flow rate and higher initial steam generator secondary pressure. The main effect they had was a slightly higher primary and secondary pressure in the LSTF calculation when compared to the PWR calculation. Overall, therefore, the analysis indicated that LSTF should give results representative of the reference PWR when investigating a PORV break.

The calculations also showed that it was possible in both LSTF and the reference PWR for a void to exist in the upper head even though the pressurizer was liquid full. This result is interesting in light of the accident at TMI, where the same situation occurred and was one of the factors which lead to the seriousness of that incident.

REFERENCES

1) Nakamura, H., et al., "System Description for ROSA-IV Two-Phase Flow Test Facility (TPTF)," JAERI-M 83-042 (1983).

2) Tasaka, K., et al., "Conceptual Design of Large Scale Test Facility (LSTF) of ROSA-IV Program for PWR Small Break LOCA Integral Experiment," JAERI-M 9849 (1981).

3) Ransom, V.H., et al., "RELAP5/MOD1 Code Manual, Volumes 1 and 2," EGG-2070 (1982).

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