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International Agreement Report

Test LOBI-BL06: Post-Test Analysis and RELAP5/MOD3.2.1 Code Performance Assessment

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CONTENTS

ABSTRACT

This report deals with the results of the "post-test analysis" of the test BL-06 performed in the LOBI/MOD2 test facility.

LOBI/MOD2 is an integral test facility that represents, at approximately 1:712 scale, a four loop (KWU design, 1300 MWe) PWR.

The test BL-06 simulates a 1% cold leg break LOCA, with the main coolant pumps switched off very late in the transient.

The calculations have been realized with the code Relap5/Mod3.2.1. The uncertainty evaluation of the calculation result has been performed using a specific method developed by Pisa University.

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1. INTRODUCTION

The present work deals with the post-test analysis of the test BL-06 realized at LOBI/MOD2 facility.

The test BL-06 was defined to simulate the phenomena characterized by a cold leg small (1%) break LOCA. The programmatic objectives consisted in the acquisition of the experimental data for the study of the physical phenomena and for the assessment of the predictive capabilities of system codes used in the safety evaluation of LWR.

In particular test BL-06 was projected to analyze the influence of main coolant pumps operation mode during small break LOCAs in PWRs. The operational procedures foresee that for accidents of this type the arrest of pumps happens following the scram signal and therefore within a few seconds after the accidental event. In test BL-06 the pump trip was delayed and was generated on high heater rods surface temperature.

Phenomena of great importance analyzed during the evolution of test BL-06 included among others:

- depletion and distribution of primary system mass;
- performance of the pumps in presence of two-phase flow;
- phase separation in the core region;
- break mass flowrate;
- core uncover and dryout;
- accumulator performance and core reflood.

LOBI/MOD2 test BL-12 was the reference test case for test BL-06 with respect to main coolant pump operation mode. In fact test BL-06 was specified preserving as much as possible, the initial and boundary conditions adopted in test BL-12 (which mainly differed in the early trip of the main coolant pumps). In order to ensure the occurrence of core dryout and the influence of main coolant pump operation, both tests were specified assuming the high pressure safety system not available.

The principal purpose of this report is to evaluate the performances of the code Relap5/Mod3.2.1 in the simulation of this accident.

The performance assessment and validation of large thermal-hydraulic codes and the accuracy evaluation of the safety margins for Light Water Reactors (LWR) are among the objectives of international cooperative programs, such as the Code Applications and Maintenance Program (CAMP).

2. DESCRIPTION OF THE EXPERIMENT

2.1 DESCRIPTION OF THE LOBI FACILITY

The LOBI/MOD2 was a high pressure integral system test facility and represented, at approximately 1:712 scale, a four-loop PWR, (1300 MWe, KWU Design). This facility was designed and realized at the Joint Research Centre (JRC) of the European Community in Ispra.

The purpose of the LOBI/MOD2 facility was to evaluate the performances of the safety systems of nuclear power plant in transient and accidental conditions.

A sketch of the primary and secondary circuit of the facility is reported in Fig. 2.1 and 2.2 respectively.

LOBI/MOD2 primary circuit had two loops, the intact loop representing three loops of the reference NPP and the broken loop representing the loop of the NPP where was located the break.

Each primary loop contained a main coolant circulation pump (MCP) and a steam generator (SG). The two pumps were equal but they ran at different speed to achieve rightly scaled flowrates.

The simulated core consisted of a directly electrically heated 64 rod bundle arranged in a 8 × 8 square matrix inside the pressure vessel; nominal heating power was 5.3 MW. Each heater rod consisted of an internally pressurized hollow tube with an active heated length of 3.9 m. The wall thickness was varied in 5 steps to provide a cosine shaped axial heat flux distribution.

The primary cooling system operated at normal PWR conditions: approximately 15.8 MPa and 567-599 K pressure and temperature, respectively.

Each steam generator contained components such as inverted U-tubes, an annular downcomer and coarse and fine steam separators modelling the geometry of the reference plant. The exchanged power in the two steam generators, at the nominal operating conditions, was of 1.32 MW (8 U-tubes) and 3.96 MW (24 U-tubes) for the broken and the intact loop respectively.

Heat was removed from the primary loops by the secondary cooling system containing a condenser and a cooler, the main feedwater pump and the auxiliary feedwater system. The normal operating conditions of the secondary cooling system were approximately 483 K feedwater temperature and 6.45 MPa pressure.

The pressurizer design was similar to that of the reference plant. It was scaled in volume but not in height. The pressurizer surgeline was connectable to either the intact or broken loop. Simulation of power operated relief valves (PORVs) was provided in the pressurizer relief line.

The LOBI/MOD2 Emergency Core Cooling System (ECCS) included: the High Pressure Injection System (HPIS), the Low Pressure Injection System (LPIS) and the Accumulator (ACC).

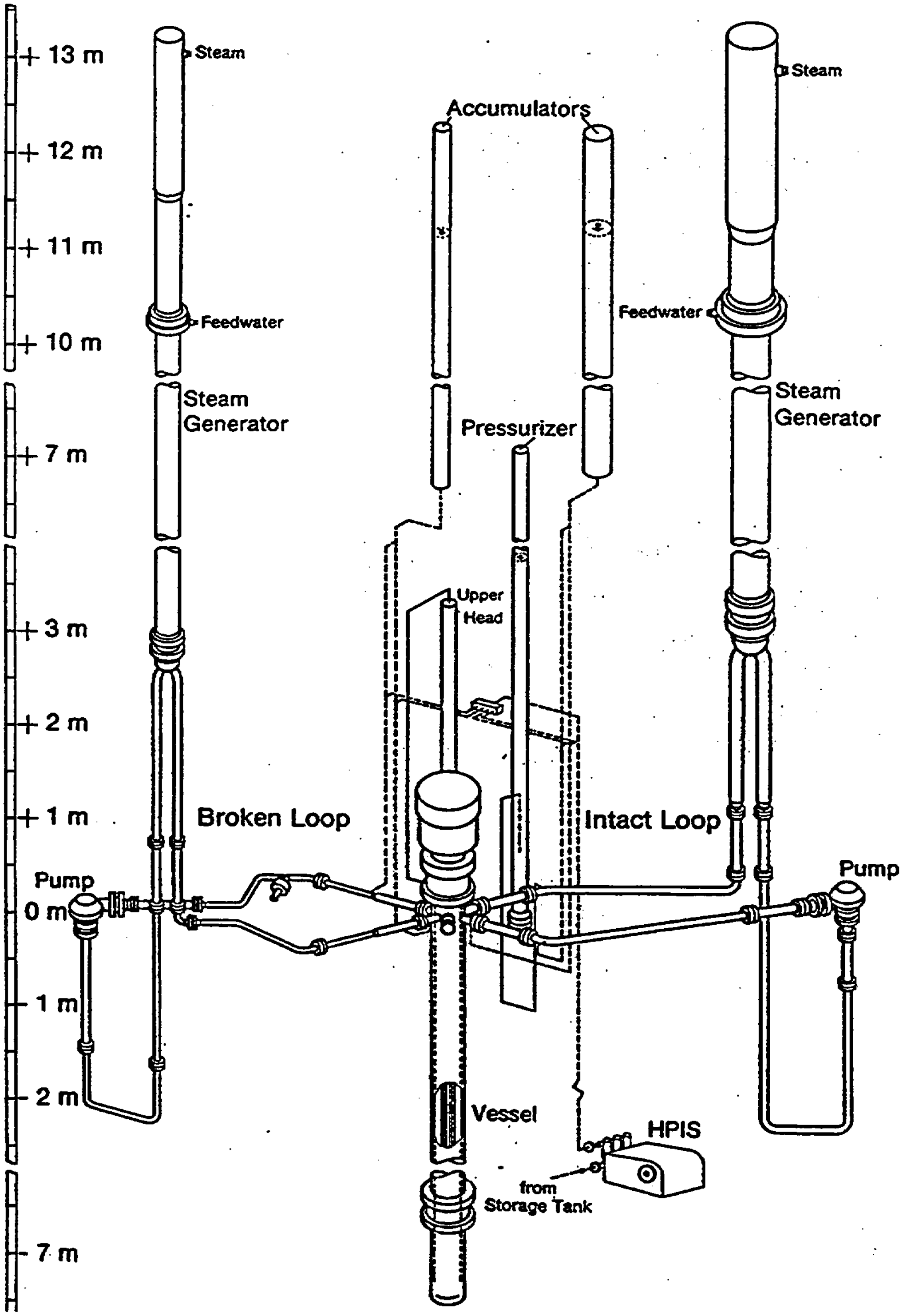

Fig. 2.1 : LOBI/MOD2 facility - primary circuit

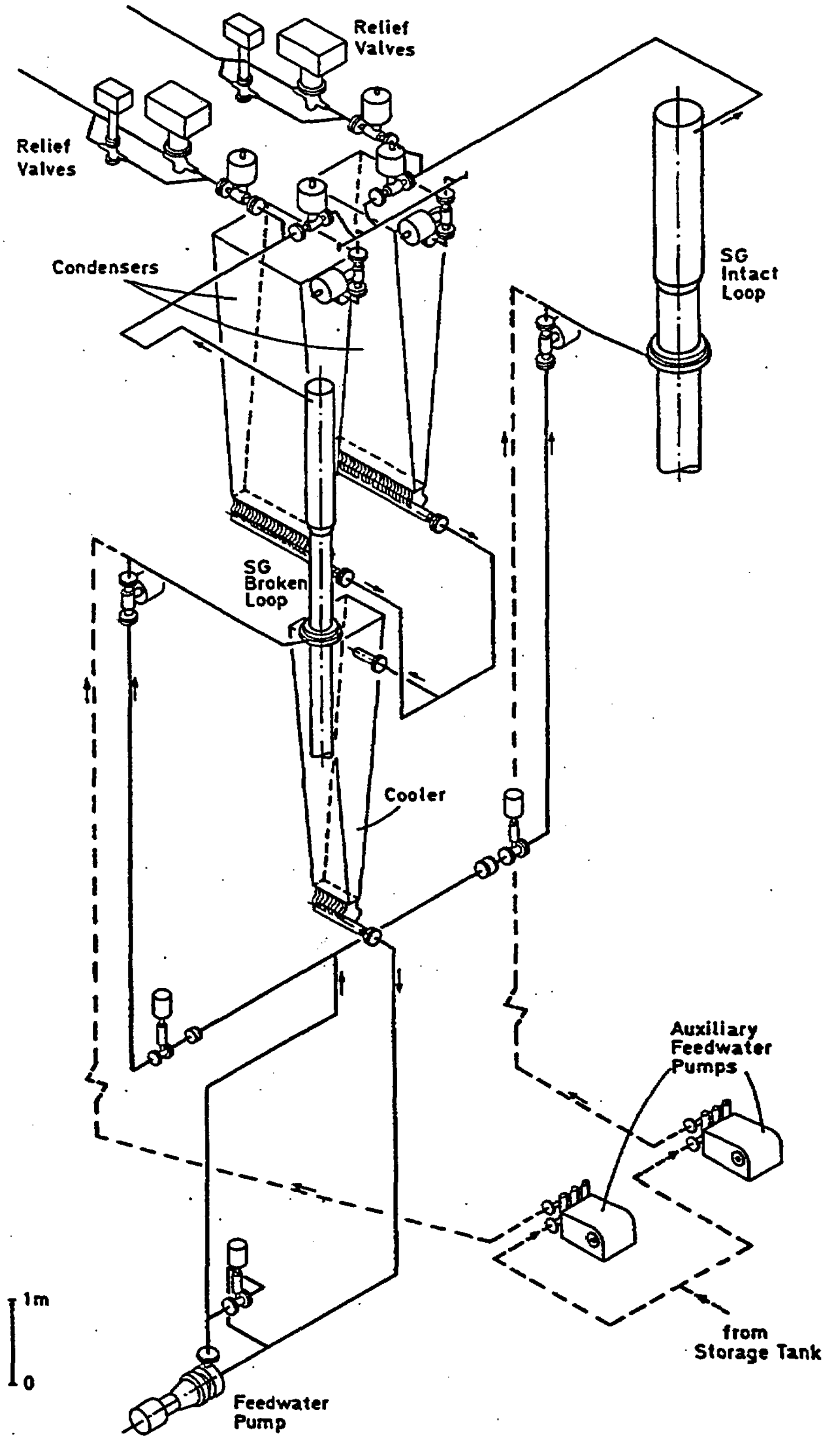

Fig. 2.2 : LOBI/MOD2 facility - secondary circuit

A process control system allowed the simulation of the main coolant pump hydraulic behavior (speed control), of the decay and stored heat (power control to the electrically heated rod), of the high pressure injection system and auxiliary feedwater system mass flow rates.
Table 2.1 summarizes the principal characteristics of the facility.

CHARACTERISTIC	VALUE
Nominal pressurizer pressure (MPa)	15.4
Core active fluid temperature (K)	599
Number of fuel rods	64
Core active height (m)	3.9
Fluid volume (V) (m^3)	0.64
Core power (P) (MW)	5.28
Core inlet flow (kg/s)	0.026
Hot leg diameter (Intact loop) (m)	$7.37\cdot10^{-2}$
Hot leg diameter (Broken loop) (m)	$4.60\cdot10^{-2}$
Hot leg length (Intact loop) (m)	5.475
Hot leg length (Broken loop) (m)	5.511
Number of loops	2
Number of tubes in steam generator (IL)	24
Number of tubes in steam generator (BL)	8

Tab. 2.1 - Significant parameters of the LOBI/MOD2 facility

The scaling criteria used in the LOBI/MOD2 facility brought to the following characteristics:

1) volume, primary circuit coolant mass flow and power input were scaled down from the reference reactor values by a factor of 712;
2) to preserve the gravitational effects, the absolute heights and the relative elevations of the different system components were kept at reactors values with the exception of pressurizer which was shorter, in order to preserve the scaling ratio and to maintain, at the same time, an acceptable flow area.

The LOBI test facility was initially designed to simulate the thermal-hydraulic scenarios in a pressurized water reactor during the large break loss-of-coolant accidents. Subsequent modifications to the original configuration made LOBI/MOD2 facility able to simulate a wide variety of small break LOCA and special transient.

2.2 SYSTEM CONFIGURATION AND TEST OVERVIEW

To realize the test BL-06, the LOBI/MOD2 test facility was predisposed in the basic configuration for cold leg break loss-of-coolant experiments.
Geometrical and operational data of certain subsystems required to meet test specific objectives are summarized in Tab. 2.2.

Break	
- Position	- Cold leg break between MCP and vessel inlet
- Size	- Break orifice 3.0 mm
- Type	- Communicative, side oriented
Upper head	Connected to upper plenum and upper downcomer
Pressurizer	Connected to intact loop hot leg
PORV	
On-Off valve	- orifice 2.74 mm
DN-15 Control valve	
Accumulator Injection System	
- Injection position	- Intact Loop cold leg
- Injection line orifice	- 3.5 mm
- Liquid volume	- 0.137 m^3
- Gas volume	- 0.143 m^3
Low Pressure Injection System	
- Injection position	- Intact Loop cold leg
- Injection rate	- 0.4 kg/s
Main Coolant Pump	
- Seal water drainage	- Before rupture: from upper plenum - After rupture: from lower plenum
- Locked rotor resistance simulator	- Intact Loop: non used - Broken Loop: inserted 4s after pump zero speed
Secondary side	
- SRV set point	- to follow BL-12 secondary side pressure curve

Tab. 2.2 - System configuration for the test BL-06

From the table, it should be noticed that some components, although not reactor typical, were anyway required for either operational reasons or simulation requirements.

The heat loss of the LOBI/MOD2 test facility in nominal conditions are given in Tab. 2.3. The operational set points are listed in Tab. 2.4.

Primary System Heat Loss	
- Intact loop	29 kW
- Broken loop	29 kW
- Vessel and upper head	27 kW
- Pressurizer	2 kW
	87 kW
Secondary System Heat Loss	
- Intact loop	6.8 kW
- Broken loop	5 kW
- Steam lines	3.2 kW
	15.0 kW

Tab. 2.3 - System heat loss for test BL-06

ACTION	REFERENCE	SET POINT
break opening	time	0. s
scram	up. head press. (pr21)	<13.1 MPa
AUXFEED initiation	time after scram	72 s
HPIS	unavailable	
MCP trip	Rod clad temp (K)	>685
end MCP coast down	time	2 s
ACC actuated	time after pump stop	50 s
1° PRZ PORV opening	rod clad temp after ACC quenching	646 K
2° PRZ PORV opening	rod clad temp after ACC quenching	704 K
LPIS initiation	rod clad temp after ACC quenching	745 K
PRZ PORVs closing	time after LPIS on	25 s

Tab. 2.4 - Operational set points

The test was initiated by opening the break valve located in the cold leg of the broken loop. Because of mass loss through the break, the primary system depressurized.

When the primary pressure dropped to 13.1 MPa, the scram signal was generated. Thereafter the secondary system was isolated and the core power started decreasing based on a defined decay curve. The auxiliary feedwater was injected into the secondary side 72 s after scram signal.

The main coolant pumps were kept running at the nominal speed until the core temperature reached 685 K. Then they started to coast down and after 2 s the pumps speed was zero.

The accumulator injection started 50 s after the pump stop (primary system pressure was about 4.1 MPa). When the available mass (about 125 kg) was depleted, the accumulator injection terminated.

Then, due to the mass still loosing from the primary system, the rod temperature reached again values of the order of 643 K. Since the pressure in the primary system was too high to allow the injection of the low pressure injection systems (LPIS), the primary system was depressurized through the PORV using also an additional safety valve. Nevertheless the relief capability was not sufficient to depressurize the RCS up to P=1 MPa, and the LPIS was anyway activated at P=1.8 MPa in order to prevent excessive core temperature rise. The test finished at t=6900 s after that the emergency system LPIS had quenched the core.

The specified system initial conditions are listed in Tab. 2.5.

	Experimental	Units
Primary System		
Upper Plenum Pressure	15.87	MPa
Core Power	5.31	MW
Intact Loop		
- Mass flow	21.0	kg/s
- Vessel Inlet Temperature	569	K
- Vessel Outlet Temperature	601	K
Broken Loop		
- Mass flow	7.2	kg/s
- Vessel Inlet Temperature	570	K
- Vessel Outlet Temperature	603	K
Pressurizer		
- Water Level	c. 5.1	m
- Temperature	621	K
MCP Seal Water Injection		
- Intact loop	0.01	kg/s
- Broken loop	0.005	kg/s
- Temperature	c. 303	K
Secondary System		
SG Intact Loop		
- Steam dome pressure	6.46	MPa
- Mass Flow	2.1	kg/s
- Inlet Temperature	486	K
- Outlet Temperature	553	K
- Downcomer Water Level	8.0	m
- Recirculation ratio	c. 6.4	
SG Broken Loop		
- Steam dome pressure	6.45	MPa
- Mass flow	0.75	kg/s
- Inlet Temperature	482	K
- Outlet Temperature	553	K
- Downcomer Water Level	8.34	m
- Recirculation ratio	c. 4.3	-

Tab. 2.5 - Operational initial conditions for the test BL-06

2.3 ANALYSIS OF THE TEST DATA

From a phenomenological point of view the accident can be divided in three phase:
Phase 1: from the opening of the break to the pumps arrest;
Phase 2: from the pumps arrest to the end of the accumulator injection;
Phase 3: from the end of the accumulator injection to the final core rewetting.

a) Phase 1 : From the opening of the break to the pumps arrest (0-2790 s);

The initial period of the transient is characterized by a fast depressurization of the primary system (Fig. 2.3) due to mass loss through the break (Fig. 2.4). At about t=36 s the primary pressure becomes lower than P=13.1 MPa and the scram is actuated and the MSIVs are closed. From that instant the generated power follows the decay heat curve.

In order to have boundary conditions as close as possible to LOBI test BL-12 the secondary pressure was regulated through the relief valves.

The fast depressurization of the primary system, after the break opening, is reduced when saturation conditions are reached in the hot leg. The primary pressure restarts decreasing when the core power starts to decrease due to the scram.

About 30 s after the scram signal, the pressure is governed by the behavior of the secondary side pressure, since the power lost through the break is not sufficient to remove the residual heat produced in the core. As a consequence, the primary and secondary side are coupled for a while (Fig. 2.5). When the tubes of the SG are empty the heat exchange between primary and secondary side is negligible and the related pressures assume independent trends.

The behavior of the main coolant pumps is of particular interest for this test. In Figs. 2.6 e 2.7 is presented the pump head and void fraction at the inlet of the main coolant pumps. It is clear from those figures that after 700 s the pumps have almost completely lost their efficiency.

The loss of efficiency is connected with the presence of the two-phase flow at the pump inlet. For the intact loop the degradation begins when the inlet void fraction is about 0.1 at about 120 s, while the complete degradation occurs when the void fraction is about 0.5. In the broken loop the degradation begins when the void fraction is about 0.18 but the diminution of efficiency is much greater.

Even if the efficiency is reduced, the pump of the intact loop causes a flow sufficiently high that determines an accumulation of liquid at the entry of the steam generator (CCFL) (Fig. 2.8); this is not occurred in the broken loop because of the stronger pump degradation. That means that the two primary circuits have an asymmetrical behavior (Fig. 2.9).

The decreasing rate of the collapsed liquid level is slow until t=570 s (Fig. 2.10). At that time the pump degradation occurs and the collapsed liquid level has a fast reduction, but it remains above the top of the active fuel zone.

The core dryout is determined by the mixture level in the core. In Fig. 2.10 is possible to observe that as soon as the mixture level is become lower then the top of active fuel zone, the dryout is being occurred.

The Figs. 2.11 and 2.12 show the behavior of rod clad temperature at different levels.

It is possible to note that:

- the dryout begins before the arrest of the pumps;
- the thermal behavior is asymmetrical, in fact the heater rods placed at the same level don't reach the dryout in the same instant;
- the core uncover mode is top-down; in fact in the higher levels the excursion of temperature begins at about t=2400 s while in the lower levels it begins at about t=2800 s;
- the bottom part of the core doesn't experiment dryout (Fig. 2.12).

b) Phase 2: From the pumps stop to the end of the accumulator injection (2790-3850 s)

The arrest of the main coolant pumps determines a redistribution of primary system mass inventory. In particular the core mixture level decreases about 1 m (Fig. 2.10), while the downcomer collapsed level immediately increases (Fig. 2.13).

Besides, when the pumps are stopped, in the intact loop the water located at the entry of steam generator flows back to the core, determining a temporary quenching of the related side of the core (Figs. 2.14, 2.15). The central fuel bundle shows a reduction at the core heat-up rate, but it is not quenched, while in the broken loop side the clad temperature continues to increase, and even at a faster rate (Figs. 2.14, 2.15).

Due to the pumps stop, the primary pressure increases at first, then restarts decreasing because of primary mass loss (Fig. 2.5). At t=2840 s the primary pressure becomes 4.12 MPa and the accumulator is allowed to inject into the primary system.

As a consequence of the accumulator injection, the primary side pressure decreases (Fig 2.5), the primary system mass inventory increases (Fig. 2.16) and, in particular, the core level increases determining core rewetting at t=3050 s. The core rewetting occurs from the lower part to the high part (Fig. 2.14).

c) Phase 3: From the end of the accumulator injection to the final core rewetting (3850-6900 s)

When the accumulator is stopped the primary system restarts pressurizing (Fig. 2.5) because the energy lost through the break is not sufficient to compensate the net input power into the RCS.

However, due to the loss of inventory, the core level restarts to decrease again (Fig. 2.10) and at t=5500 s the core experiments a second core dryout.

When the rod clad temperature reaches 623 K (Fig. 2.17) a valve simulating three PORVs is opened in the pressurizer in order to cause a depressurization of RCS and allow the intervention of the LPIS at P=1 MPa. Being the depressurization rate too low (Fig. 2.18) it has been necessary to modify the operational procedure and to open another valve.

The combined action of the two valves allows a faster depressurization of the primary system. At t=6382 s, with a primary pressure P=1.7 MPa, the LPIS is activated because the temperature of the heater rods has reached 745 K. The intervention of the LPIS determines the core quenching and therefore the end of the test.

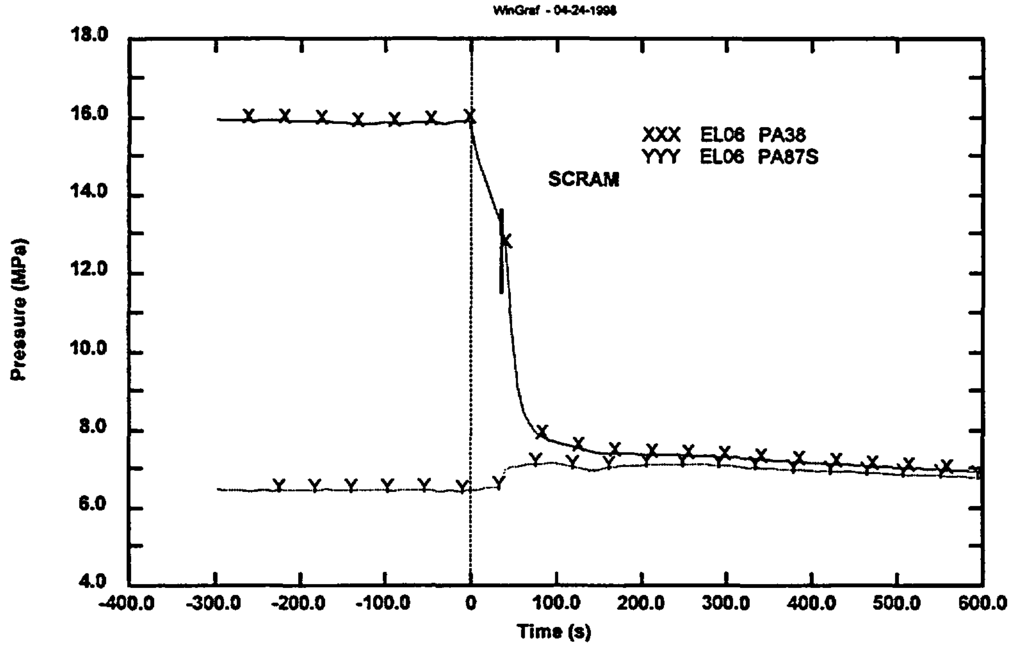

Fig. 2.3 : Primary and secondary pressure

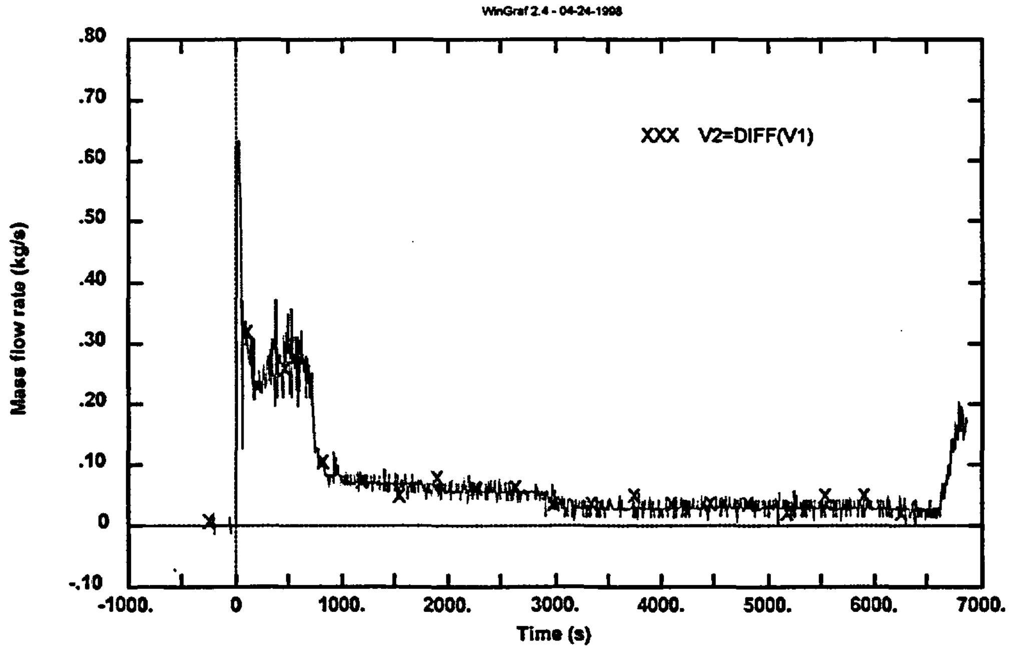

Fig. 2.4 : Break mass flow rate

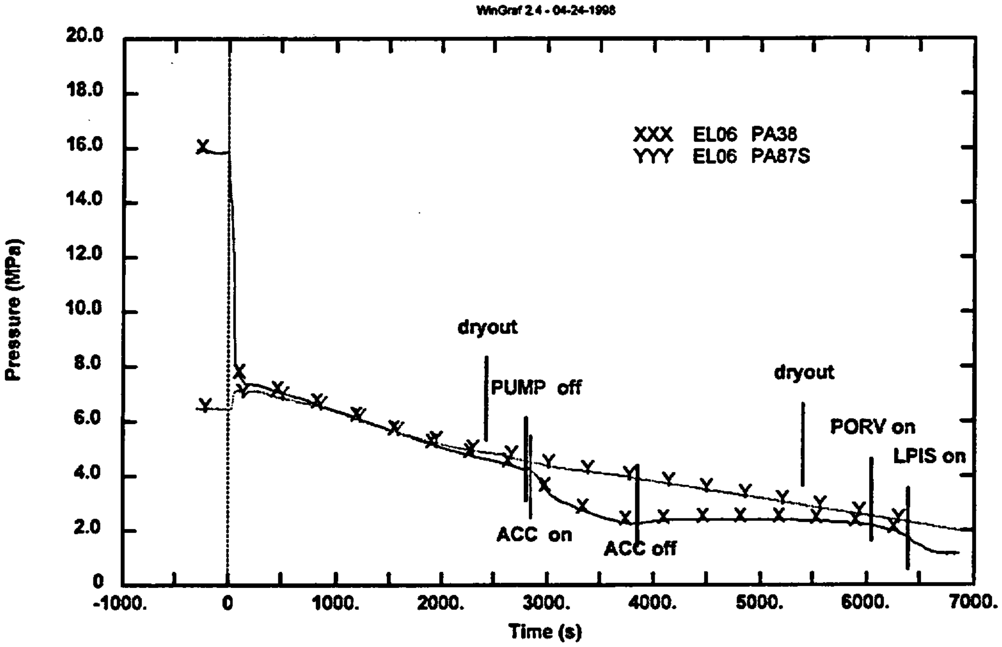

Fig. 2.5 : Primary and secondary pressure

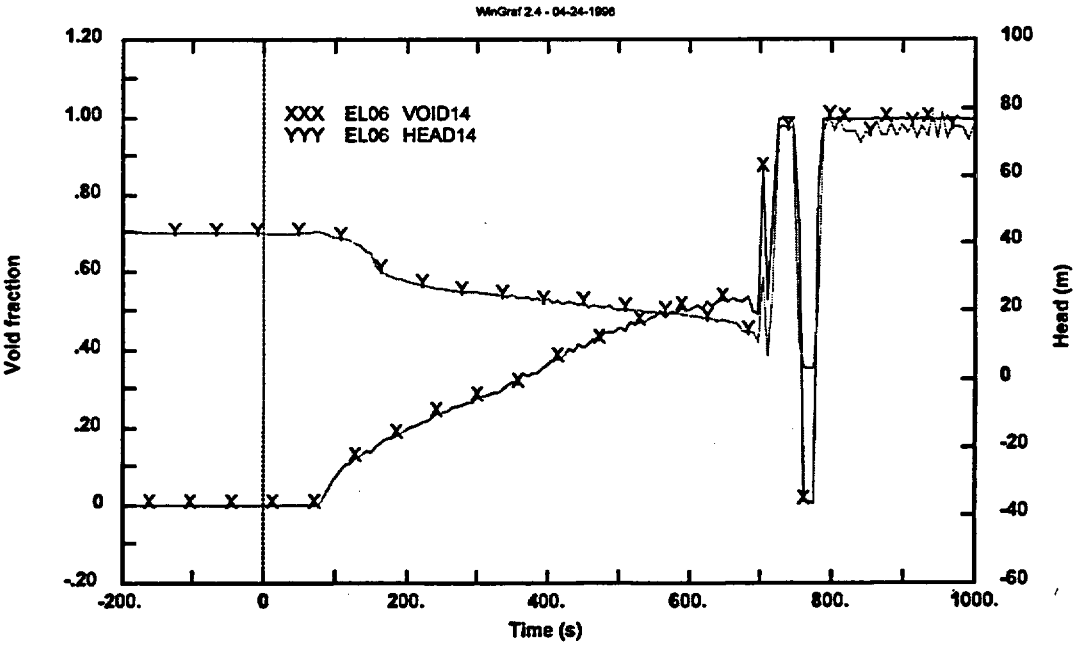

Fig. 2.6 : Void fraction at pump inlet and pump head (IL)

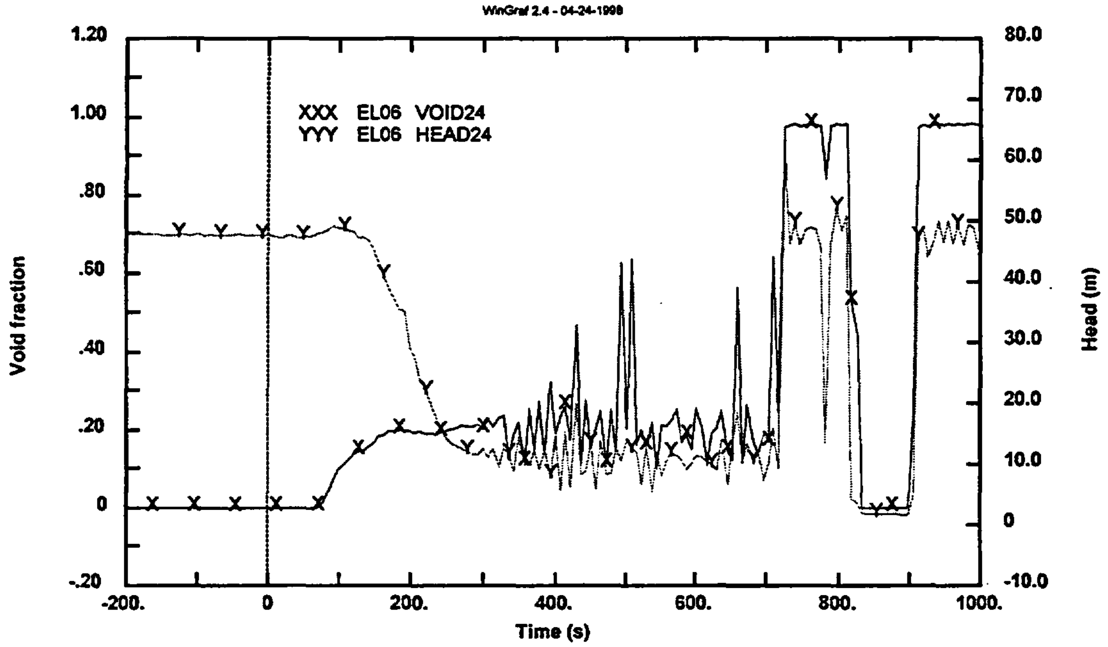

Fig. 2.7 : Void fraction at pump-inlet and pump head (BL)

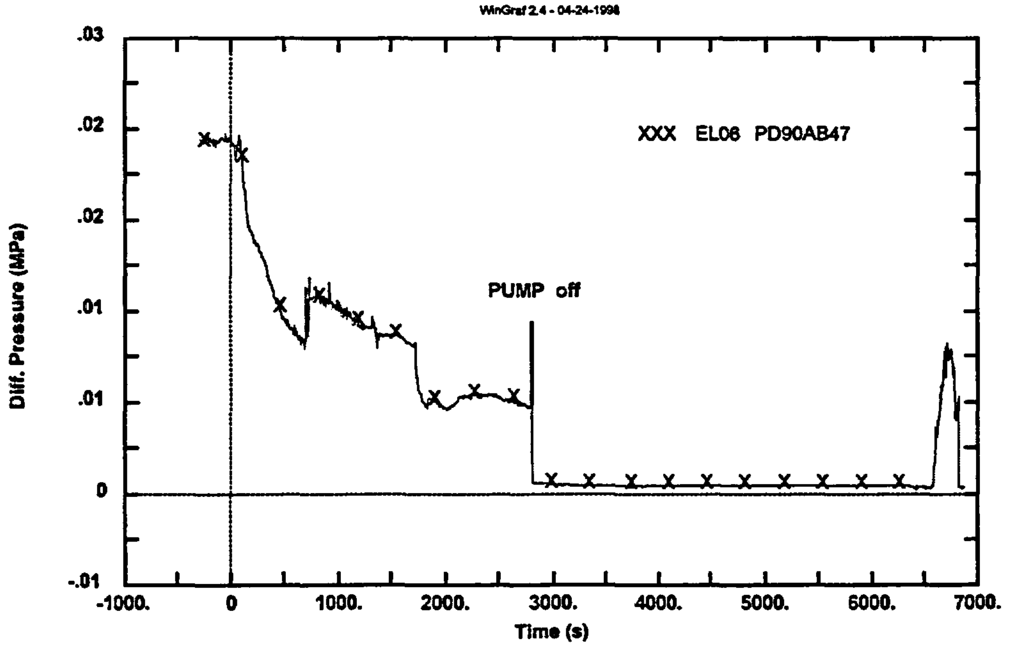

Fig. 2.8 : Pressure difference at steam generator inlet (IL)

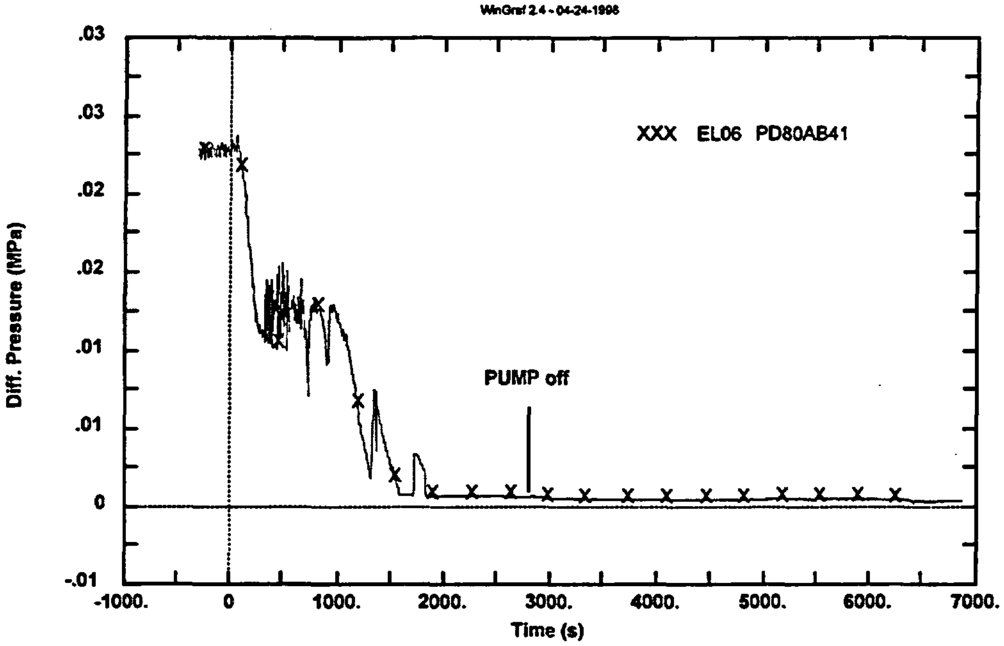

Fig. 2.9: Pressure difference at steam generator inlet (BL)

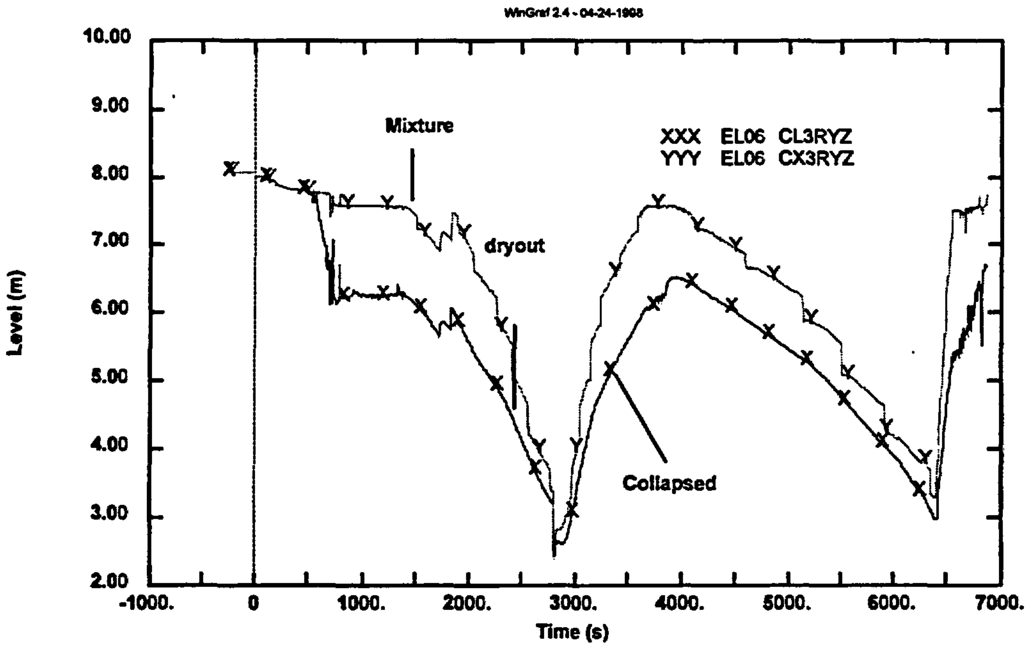

Fig. 2.10 : Mixture and collapsed level in the riser of the vessel

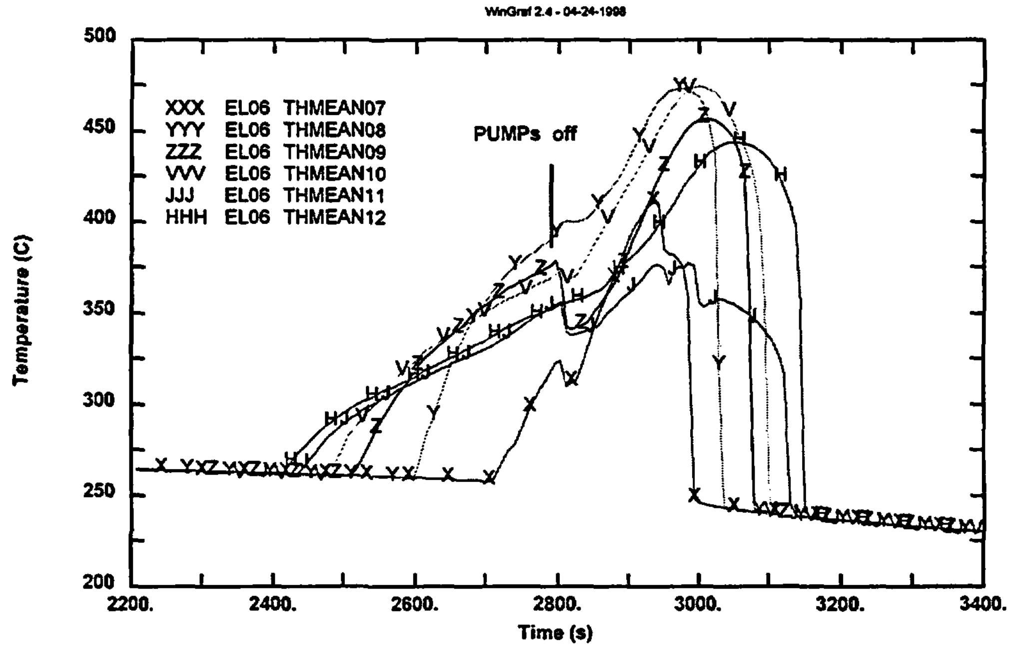

Fig. 2.11 : Heater rod temperature of the superior levels (lev. 12-7)

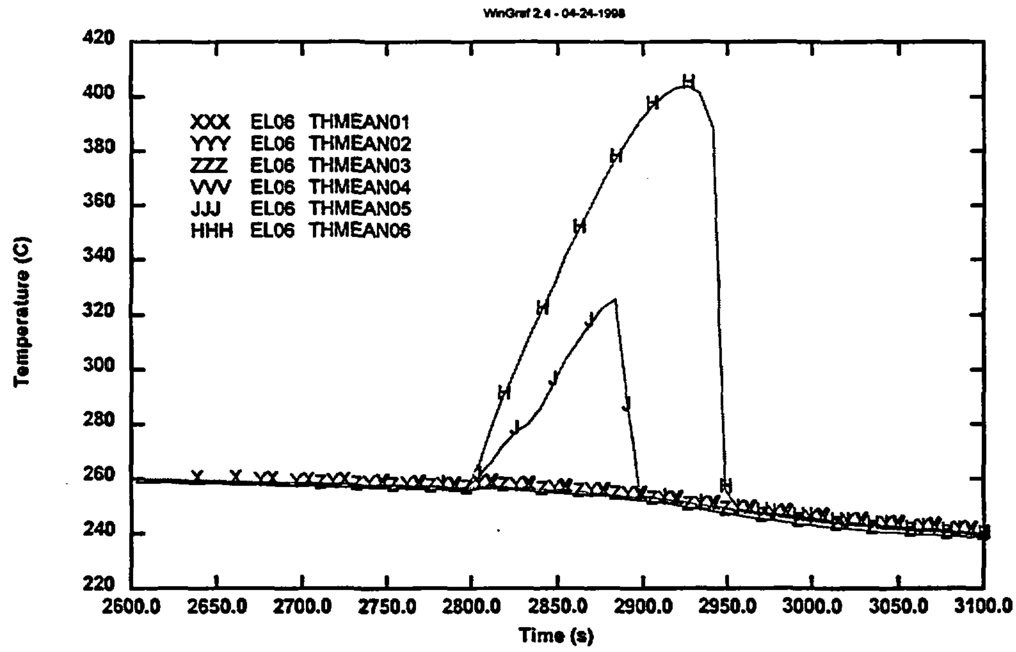

Fig. 2.12 : Heater rod temperature of the inferior levels (lev. 6-1)

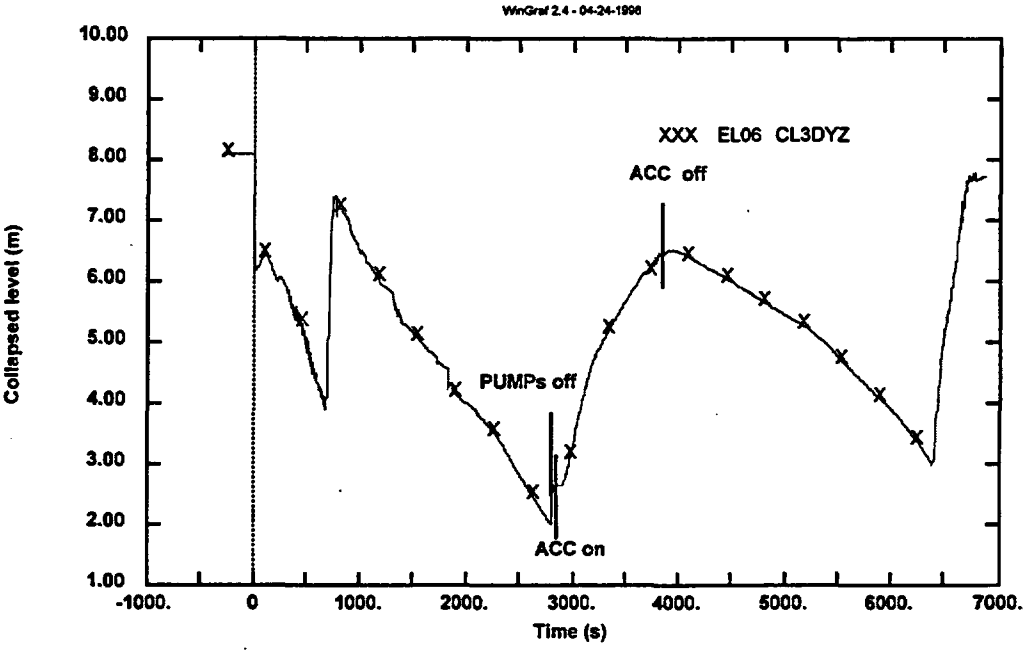

Fig. 2.13 : Collapsed level in the downcomer

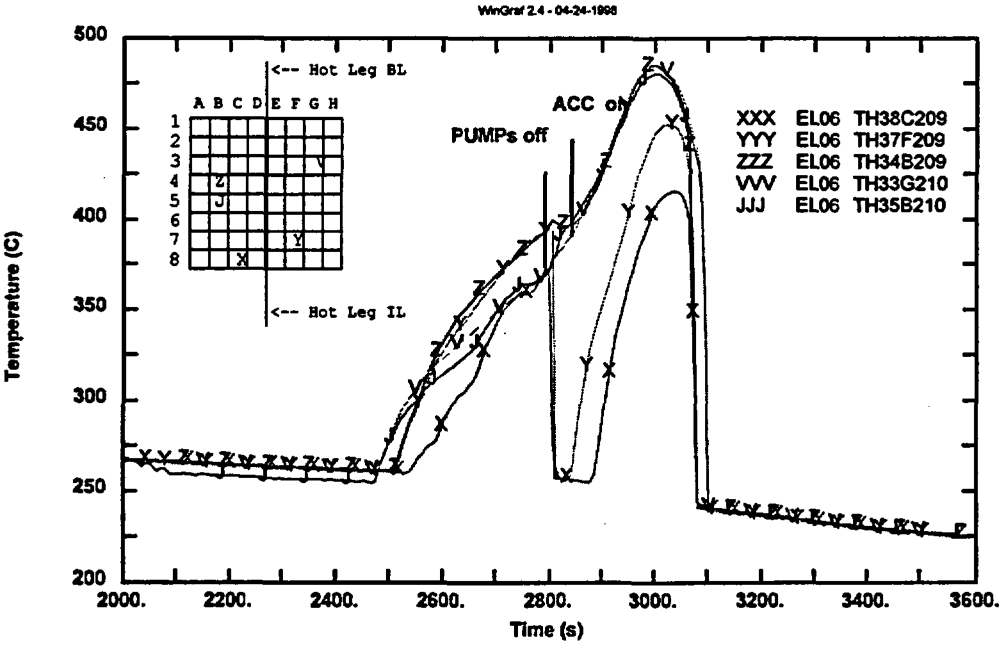

Fig. 2.14 : Heater rod temperature levels 9 and 10

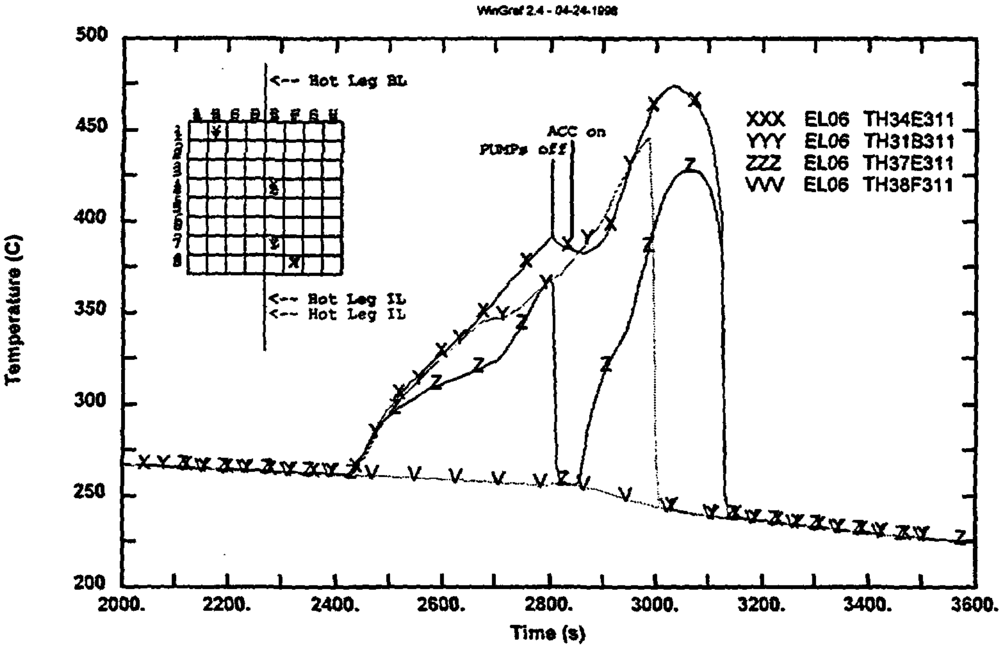

Fig. 2.15 : Heater rod temperature level 11

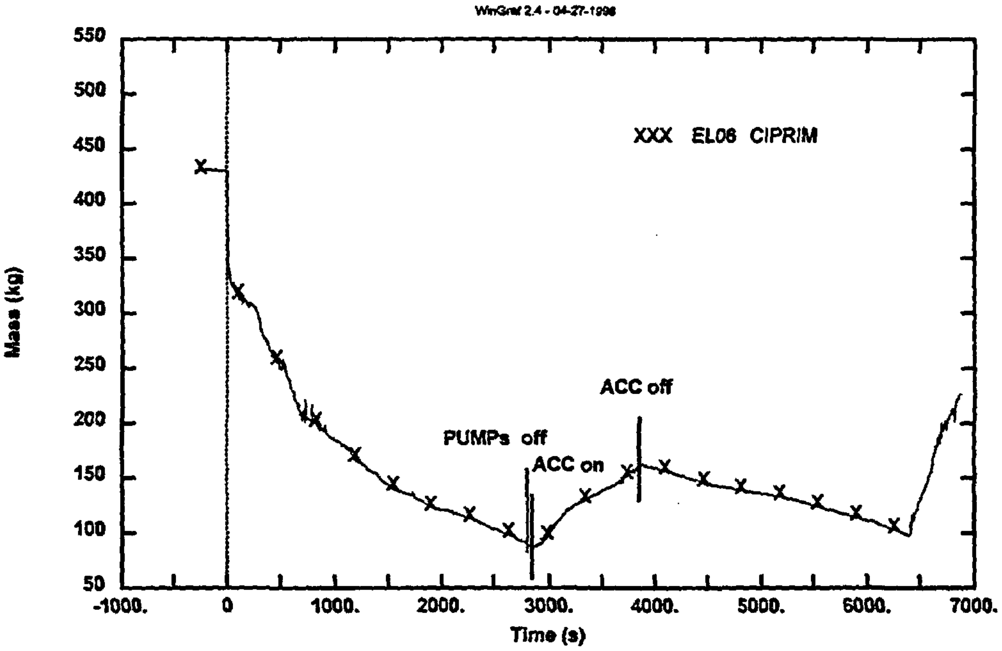

Fig. 2.16 : Primary system mass inventory

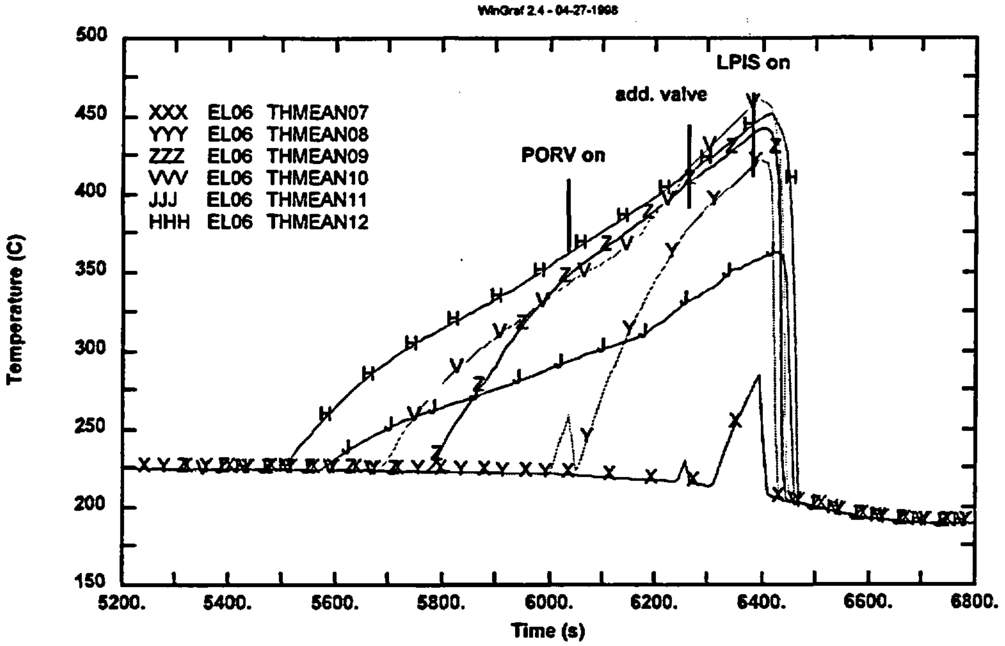

Fig. 2.17 : Heater rod temperature of the superior levels (lev. 12-7)

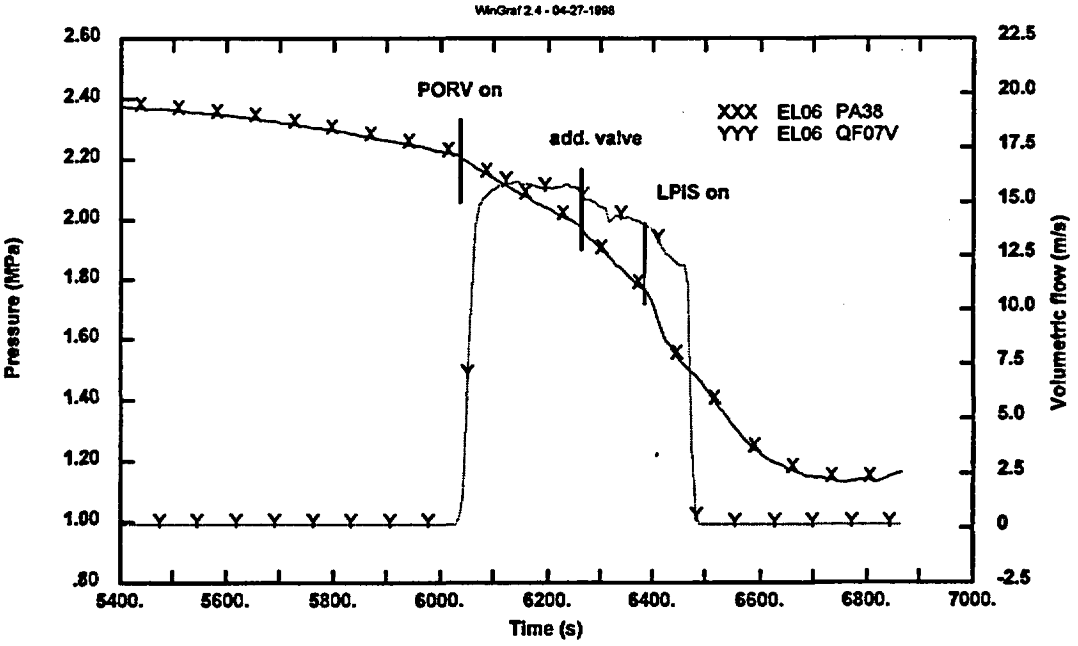

Fig. 2.18 : Primary system pressure and PORV volumetric flow

3. ADOPTED CODE AND NODALIZATION

3.1 CODE RELAP5/MOD3.2

The Relap5/Mod3.2 is a transient analysis code for complex thermal-hydraulic systems. The fluid and energy flow paths are approximated by a one-dimensional stream tube and conduction model. The code contains models peculiar to western light water reactors. In particular the neutronics is simulated by a point kinetics model; other specific models are related to pump turbines, jet pumps, valves, accumulator and separator; the reactor control system can also be simulated.

The code is based on a non-homogeneous non-equilibrium set of 6 partial derivative balance equations for the steam and liquid phases. A non-condensable component in the steam phase and a non-volatile component (boron) in the liquid phase are also treated by the code.

A fast, partially implicit numeric scheme is used to solve the equation inside control volumes connected by junctions.

A direction, associated to the control volume, it's positive from the inlet to the outlet. The fluid scalar properties such as pressure, energy, density, and void fraction are represented by the average fluid conditions and are considered located at the control volume center. The fluid vector properties, i.e. velocities, are located at the junctions and are associated with mass and energy flow between control volumes.

The heat flow is 1-D modeled. The heat conductor or heat structure is thermally connected to the hydrodynamic control volumes through a heat flux . The heat structures are used to simulate pipe walls, heater elements, nuclear fuel pins and heat exchanger surfaces. A specialized two-dimensional heat conduction solution method with an automatic fine mesh rezoning is used for low pressure reflood.

The kinetics model consists of a system of ordinary differential equations that are integrated using a modified Runge-Kutta technique. The feedback effects of fuel temperature, moderator density and boron concentration in the moderator are evaluated using averages over the hydrodynamic control volumes and associated heat structures that represent the core. The averages are weighted averages that are established a priori such that they are representative of the effects on total core power.

Certain non linear or multidimensional effects due to spatial variations of the feedback parameters cannot be accounted for with such a model. Thus, the user must judge whether or not the model is a reasonable approximation to the physical situation being modeled.

3.2 DESCRIPTION OF THE ADOPTED NODALIZATION

The Relap5/Mod3.2.1 LOBI/MOD2 nodalization reproduces in detail the primary and secondary systems, it is shown in Fig. 3.1.
The correspondence between the zones of the facility and the nodes of the code model and relevant input values related to the hydraulic volumes are summarized in Tab. 3.1. In the Tab. 3.2 are summarized the relevant input value related to the connecting junctions of the nodalization.
The following items can be added to clarify Fig. 3.1 and the mentioned tables:

- the nodes 100, 105, 110 represent the intact loop cold leg which is connected with the steam generator through the junction 115 and with the vessel through the junction 350-02, the equivalent for the broken loop are the nodes 200, 203, 206 and the junctions 208 and 350-03. Besides to the node 105 is also connected the pressurizer surge line through the junction 105-03;

- the nodes 120 and 210 represent the steam generator U-tubes of the intact and broken loop respectively. The number of the volumes of the node 120 it is double in comparison to that of the node 210 for allowing a more accurate heat exchange between primary and secondary side;

- the nodes 130 and 133 represent the loop seal of the intact loop, the correspondent for the broken loop are the nodes 220 and 223;

- the two pumps are simulated by the nodes 135 and 225;

- the intact loop cold leg is simulated by nodes 137,140,145 and is connected to the vessel through the junction 305-01, the equivalent for the broken loop are the nodes 230,240,250,260 and the junction 305-02;

- the vessel has been divided into the five zones:
  1) downcomer (simulated by the nodes 300, 305, 310) connected to the upper head through the branch 363;
  2) lower plenum (simulated by the nodes 315 and 320) connected to the downcomer and to the core;
  3) core region (represented by the nodes 325 and 335; among these, the nodes 335-01 to 335-06 constitute the active region). The junction 340 connects the core to the upper plenum;
  4) upper plenum (represented by the nodes 345, 350, 355) connected to the upper head through the branch 380;
  5) upper head (simulated by the volumes 370, 375);

- the junctions 352 and 353 represent the bypass flow between downcomer and upper plenum. They respectively represent the two holes of 5 mm diameter each connecting downcomer and upper plenum at the uppermost elevation and the gap around hot leg nozzles;

- the two accumulators and the respective feed lines are represented by the nodes numbered with the seven hundred; They are connected with the cold legs of the two intact loops;

- in the broken loop the pump locked-rotor resistance simulator is represented through the valve 235;

- the time dependent volumes 226, 136, 360 and 361 connected with the primary system through the time dependent junctions 224, 134, 358 and 359, simulate the two pump seal cooling system. During the steady state the fraction of seal water entering the primary system is drained from the upper plenum, while during the transient period is drained from the lower plenum;

- the pressurizer and his surge line is represented by the nodes 409, 410, 420, 400. An additional system can be noted in the pressurizer nodalization, it allows the primary side pressure to remain constant in the steady-state period and is represented by the time dependent volume 430 and related trip valve 425;

- the two valves 440 and 441 and the related time dependent volumes 910 and 901, connected to the top of the pressurizer, simulate the PORV system;

- the two steam generators have similar secondary side nodalization even if in the intact loop the number of the volumes of the node that represent the zone including the U-tubes is double in comparison to that of the broken loop. Each steam generator can be divided in five zones:
    1) the downcomer (simulated by the nodes 510, 500, 555 for the intact loop and by the nodes 610, 600, 655 for the broken loop);
    2) the riser zone including the spacer grids (represented by the volumes 530 and 545 for the intact loop and by the volumes 630, 645 for the broken loop);
    3) the top of the steam generator including the separator, the dryer and the steam dome region (represented from the volumes 550, 552, 560 for the intact loop and from the volumes 650, 652, 660 for the broken loop). The two separators are necessary in the code model in order to achieve quality equal to one in the steam dome;
    4) the steam line downstream the dome of each steam generator (simulated through the volumes 564 for the intact and 664 for the broken). These two volumes are connected to the volume 565 which in it turn is connected to the condenser, vol. 582, through the valve 580;
    5) the feedwater line connected to the top of downcomer (simulated with the time dependent junction 570 and the time dependent volume 572);

- connected to the steam generator there are different control volumes:
    a) auxiliary feed water: TDV 576 (IL) and 676 (BL) and TDJ 574 (IL) and 674 (BL);

b) the TDVs 567 (IL) and 667 (BL) together with the valves 563 (IL) and 663 (BL) condition the pressure in the secondary side to have the same pressure of the test BL-12;

- the active structures that simulate the hot rods are divided in 5 radial meshes.

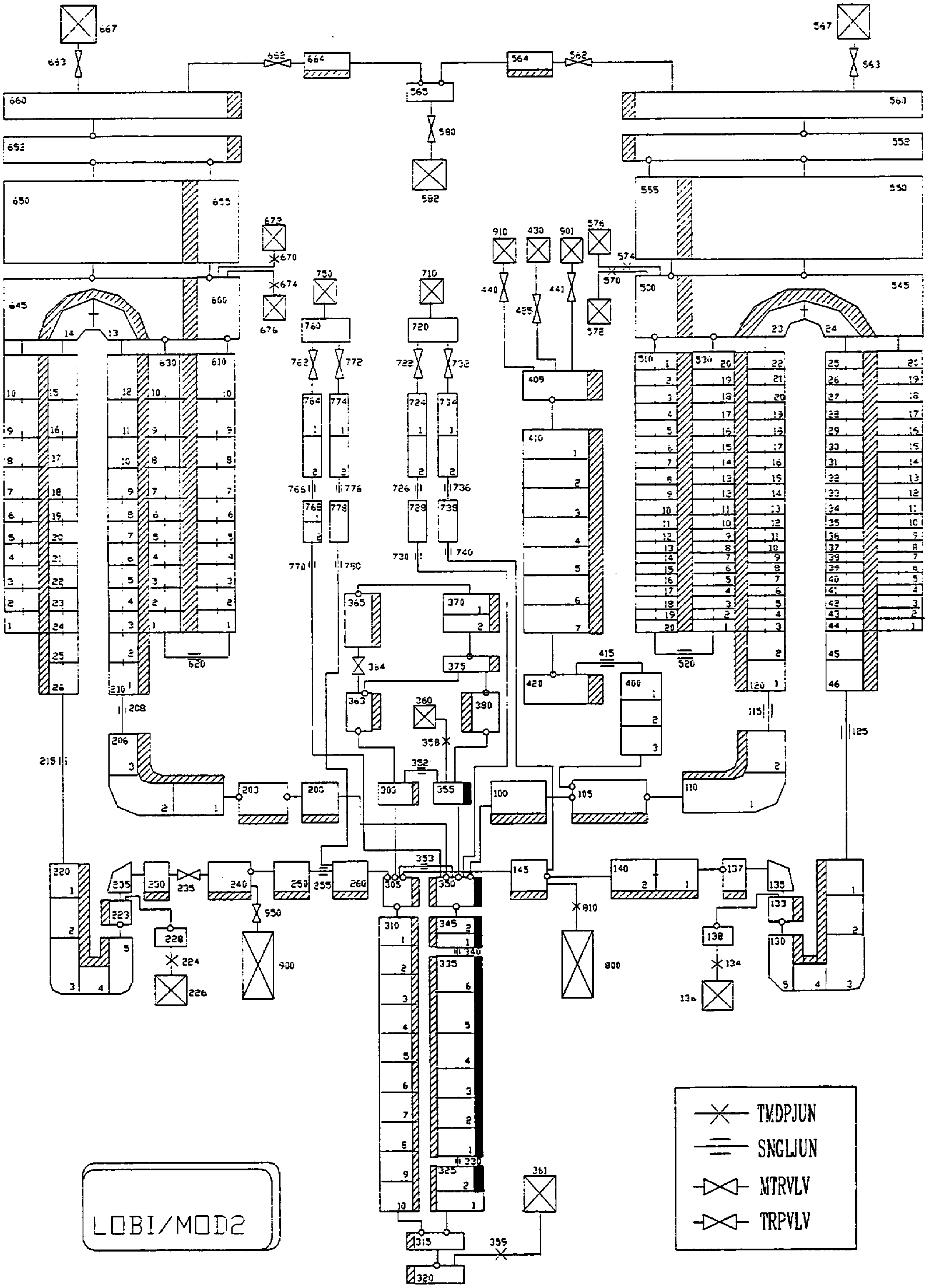

Fig. 3.1 : Relap5/Mod3.2.1 nodalization of LOBI/MOD2 facility

node	volume (m^3x10^3)	height/length (m)	type	zone
INTACT LOOP				
100-01	3.1398	0.736	snglvol	hot leg
105-01	3.1782	0.745	branch	
110-01	6.8256	1.6	pipe	
110-02	2.679	0.628		
120-01	19.28	1.763	pipe	primary side steam generator
120-02	9.932	0.306		
120-03...06	1.0681	0.1475		
120-07...10	0.90516	0.125		
120-11...14	1.8103	0.25		
120-15...22	3.6206	0.5		
120-23,24	7.3487	1.015		
120-25...32	3.6206	0.5		
120-33...36	1.8103	0.25		
120-37...40	0.90516	0.125		
120-41...44	1.0681	0.1475		
120-45	9.932	0.306		
120-46	19.28	1.763		
130-01	4.394	1.03	pipe	loop seal
130-02	3.2806	0.769		
130-03	6.8725	1.611		
130-04	2.6662	0.625		
130-05	6.8725	1.611		
133-01	3.2806	0.769	branch	
135-01	1.9999	0.6027	pump	pump
136-01	1 m^3	1	tmdpvol	seal water
138-01	1.5	5.0	branch	
137-01	3.1526	0.739	branch	cold leg
140-01,02	4.9571	1.162	pipe	
145-01	3.5877	0.841	branch	
BROKEN LOOP				
200-01	1.2502	0.749	snglvol	hot leg
203-01	1.4438	0.865	branch	
206-01	1.1116	0.666	pipe	
206-02	1.1116	0.666		
206-03	1.145	0.686		
210-01	6.9228	1.884	pipe	
210-02	2.7009	0.192		

Tab. 3.1 - Details of nodes geometry in the Relap5 nodalization - correspondences between code nodes and hydraulic zones (cont'ed)

210-03,04	0.67586	0.28		primary side steam generator
210-05,06	0.60345	0.25		
210-07,08	1.2069	0.5		
210-09...12	2.4138	1.0		
210-13,14	2.4435	1.012		
210-15...18	2.4138	1.0		
210-19,20	1.2069	0.5		
210-21,22	0.60345	0.25		
210-23,24	0.67586	0.28		
210-25	2.7009	0.192		
210-26	6.9228	1.884		
220-01	1.7392	1.042	pipe	loop seal
220-02	1.9245	1.153		
220-03	1.2368	0.741		
220-04	1.2218	0.732		
220-05	1.2368	0.741		
223-01	1.9245	1.153	branch	
225-01	2.000935	0.603	pump	pump
226-01	1 m^3	1.0	tmdpvol	seal water
228-01	1.5	5.0	branch	
230-01	1.4354	0.86	branch	cold leg
240-01	2.1081	1.263	branch	
250-01	1.5189	0.91	snglvol	
260-01	1.175	0.704	branch	
PRESSURE VESSEL				
300-01	3.5627	0.315	branch	downcomer region
305-01	5.508	0.487	branch	
310-01,02	6.786	0.6	annulus	
310-03	8.3694	0.74		
310-04	7.4985	0.663		
310-05,06	9.8963	0.875		
310-07	7.4985	0.663		
310-08	6.9217	0.612		
310-09	4.4109	0.39		
310-10	6.967	0.616		
315-01	13.379	0.175	branch	lower plenum
320-01	13.379	0.175	branch	
325-01	14.817	0.616	pipe	core region
325-02	8.9813	0.39		
335-01	4.9665	0.612	pipe	
335-02	5.3804	0.663		
335-03,04	7.1008	0.875		
335-05	5.3804	0.663		

Tab. 3.1 - Details of nodes geometry in the Relap5 nodalization - correspondences between code nodes and hydraulic zones (cont'ed)

335-06	4.9665	0.74		core region
345-01,02	14.989	0.6	pipe	
350-01	12.166	0.487	branch	upper plenum
355-01	7.8693	0.315	branch	
360-01	0.5 m^3	0.5	tmdpvol	seal water drain
361-01	0.5 m^3	0.5	tmdpvol	
363-01	0.44485	1.416	branch	upper head
365-01	0.99557	3.169	branch	
370-01,02	9.67	0.855	pipe	
375-01	9.67	0.855	branch	
380-01	0.44485	1.416	branch	
PRESSURIZER				
400-01	0.23675	1.73	pipe	surge line
400-02	0.35581	2.6		
400-03	0.38318	2.8		
409-01	10.327	0.898	branch	pressurizer vessel
410-01	10.92	0.9	pipe	
410-02...06	10.939	0.9		
410-07	4.6636	0.585		
420-01	6.3634	0.79	branch	pressurizer bottom
430-01	11.5	1.0	tmdpvol	
901-01	1 m^3	1.0	tmdpvol	PORVs
910-01	1 m^3	1.0	tmdpvol	
SECONDARY SIDE				
STEAM GENERATOR INTACT LOOP				
500-01	16.755	1.402	branch	downcomer
510-01...08	5.9755	0.5	annulus	
510-09...12	2.9877	0.25		
510-13...20	1.4939	0.125		
530-01...08	3.7381	0.125	pipe	riser section
530-09...12	7.4763	0.25		
530-13...20	14.953	0.5		
545-01	62.848	1.402	branch	
550-01	34.766	1.105	snglvol	upper plenum
552-01	185.6	1.1	branch	separator
560-01	101.6	0.593	branch	steam dome
564-01	24.232	6.5	snglvol	steam line
565-01	9.0	2.0	branch	
582-01	0.5 m^3	0.5	tmdpvol	
567-01	0.5 m^3	0.5	tmdpvol	
572-01	0.5 m^3	0.5	tmdpvol	main feedwater

Tab. 3.1 - Details of nodes geometry in the Relap5 nodalization - correspondences between code nodes and hydraulic zones (cont'ed)

576-01	0.5 m^3	0.5	tmdpvol	auxiliary feedwater
STEAM GENERATOR BROKEN LOOP				
600-01	5.1618	1.304	branch	downcomer
610-01...04	3.9584	1.0	annulus	downcomer
610-05,06	1.9792	0.5		
610-07...10	0.9896	0.25		
655-01	37.8	1.128	snglvol	
630-01...01	2.3737	0.25	pipe	riser section
630-05,06	4.7474	0.5		
630-07...10	9.4947	1.0		
645-01	23.064	1.304	branch	
650-01	12.309	1.128	snglvol	upper plenum
652-01	59.052	1.1	branch	separator
660-01	38.991	0.681	branch	steam dome
664-01	8.4622	5.8	snglvol	steam line
667-01	0.5 m^3	0.5	tmdpvol	
672-01	0.5 m^3	0.5	tmdpvol	main feedwater
676-01	0.5 m^3	0.5	tmdpvol	auxiliary feedwater
ACCUMULATOR				
710-01	267.0568	5.505	accumulator	accumulator
720-01	0.4831	1.0	branch	dividing branch
724-01	1.8551	3.84	pipe	intact loop
724-02	0.71016	1.47		hot leg
728-01	1.8696	3.87	pipe	feed line
734-01	1.8551	3.84	pipe	intact loop
734-02	0.628	1.3		cold leg
738-01	1.5725	3.255	pipe	feed line
750-01	94.3761	4.924	accumulator	accumulator
760-01	0.4022	2.0	branch	dividing branch
764-01	0.54257	2.698	pipe	broken loop
764-02	0.17134	0.852		hot leg
768-01	0.37606	1.87	pipe	feed line
768-02	0.13077	1.845		
774-01	0.54257	2.698	pipe	broken loop
774-02	0.17134	0.852		cold leg
778-01	0.57716	2.87	pipe	feed line
800-01	1 m^3	1.0	tmdpvol	LPIS

900-01	1 m^3	1.0	tmdpvol	BREAK

Tab. 3.1 - Details of nodes geometry in the Relap5 nodalization - correspondences between code nodes and hydraulic zones

SIGNIFICANT JUNCTION	FLOW AREA m^2	k_D	K_R	POSITION
115	42.66e-2	0.0	0.0	SG inlet IL
125	42.66e-2	0.0	0.0	SG suction leg IL
134	3.0e-4			seal water TDJ IL
208	16.691e-4	0.35	0.16	SG inlet BL
215	0.7288e-3	0.0	0.0	SG suction leg BL
235	16.691e-4	0.3	0.3	penta valve
224	3.0e-4			seal water TDJ BL
305-01	42.66e-2	3.55	3.55	core inlet IL
305-02	16.691e-4	3.24	3.24	core inlet BL
350-02	42.66e-2	0.94	0.94	core outlet IL
350-03	16.691e-4	1.54	1.54	core outlet BL
352	1.131e-2			bypass
353	1.131e-2			bypass
358	6.0e-4			exit seal water
359	6.0e-4			
440	5.896e-6	1.5	1.5	PORV
441	4.3043e-6	1.5	1.5	PORV
563	1.5e-3	1.5	1.5	relief valve
570	1.5e-3			main feedwater inlet valve
574	1.4589e-3			aux. feedwater inlet junction
580	4.5e-3	0.0	0.0	SG common discharge valve
663	5.0e-4	1.5	1.5	relief valve
670	6.0e-4			main feedwater inlet valve
674	6.3794e-4			aux. feedwater inlet junction
722	4.831e-4	0.0	0.0	IL acc. inje. valve to hot leg
732	9.616e-6	0.0	0.0	IL acc. inje. valve to cold leg
762	2.011e-4	0.0	0.0	IL acc. inje. valve to hot leg
	2.011e-4	0.0	0.0	IL acc. inje. valve to cold leg
810	1.131e-4			LPIS
950	7.0686e-6	1.25	1.25	break valve

Tab. 3.2 - Details of relevant junction related parameters of nodalization

4. ANALYSIS OF POST-TEST CALCULATIONS RESULTS

The post-test analysis has been characterized by the following three phases:

1) implementation of a model consistent with the geometric configuration of the experimental facility and with the process data registered in the pre-test phase;
2) definition and execution of a reference calculation on the basis of the model determined in the phase 1 and of the operational procedures that have characterized the experiment;
3) perform sensitivity calculations relating to specific process parameters.

4.1 STEADY STATE CALCULATIONS (PHASE 1 OF THE POST-TEST ANALYSIS)

The model of LOBI-MOD2 test facility used for the post-test calculation was realized starting from an input deck provided by the JRC of Ispra [8] and adapting it to the specific test characteristics.

A first series of calculations was aimed to reproduce, during the steady state, the experimental values of the pressure in the primary and secondary circuits, the curve of heating power, the mass flowrate in the intact and in the broken loop, etc..

In order to get this result the following operations have been performed on the model provided by JRC-Ispra:

- insertion of TDV to force the primary and secondary pressures to the initial values before the opening of the break valve;
- change of heat transfer coefficients to get the experimental heat losses of the primary and secondary circuits (Tab. 2.3);
- modification of the electrical power control curve;
- modification of the pumps speed arrest curve;
- adaptation of the trips that control: the opening of the break valve, the intervention of the scram, the intervention of the auxiliary feedwater, the arrest of the pumps, the intervention of the accumulator, the opening of the PORVs and finally the intervention of the LPIS.
- activation of the CCFL option on the junction 115 and 208.

The steady state calculation results are shown in Tab. 4.1.

From the table results evident the general good agreement between the calculated and experimental values.

		CALC.	EXP.
Primary System			
Upper Plenum Pressure	(MPa)	15.9	15.87
Core Power	(MW)	5.31	5.31
Intact Loop			
- Mass flow	(kg/s)	21.0	21.0
- Vessel Inlet Temperature	(K)	567.2	569
- Vessel Outlet Temperature	(K)	598.5	601
Broken Loop			
- Mass flow	(kg/s)	7.2	7.2
- Vessel Inlet Temperature	(K)	567.3	570
- Vessel Outlet Temperature	(K)	599.4	603
Pressurizer			
- Water Level	(m)	4.8	4.8
- Temperature	(K)	617	621
MCP Seal Water Injection			
- Intact loop	(kg/s)	0.01237	0.01
- Broken loop	(kg/s)	0.00724	0.005
- Temperature	(K)	298	c. 303
Secondary System			
SG Intact Loop			
- Steam dome pressure	(MPa)	6.49	6.46
- Mass Flow	(kg/s)	2.07	2.1
- Inlet Temperature	(K)	486	486
- Outlet Temperature	(K)	553.7	553
- Downcomer Water Level	(m)	6.6	8.0
- Recirculation ratio		6.2	c. 6.4
- Heat exchange power	(MW)	3.91	3.96
SG Broken Loop			
- Steam dome pressure	(MPa)	6.49	6.45
- Mass Flow	(kg/s)	0.7	0.75
- Inlet Temperature	(K)	482	482
- Outlet Temperature	(K)	553.7	553
- Downcomer Water Level	(m)	7.64	8.34
- Recirculation ratio		4.3	c. 4.3
- Heat exchange power	(MW)	1.317	1.32

Tab. 4.1 - Comparison between experimental and calculated initial conditions

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4.2 REFERENCE CALCULATION RESULTS

It is necessary to specify that in the post-test calculations the pressure of the secondary side was forced by a TDV to the experimental values. Besides, during the test, the secondary pressure was been conditioned (through an operational procedure) in order to reproduce the recorded pressure in the test BL-12.

The comparison between the experimental and calculated chronology of the principal events is shown in Tab. 4.2.

From the analysis of the Tab. 4.2, it can be observed:

- all the events have been reproduced in the simulation;
- in the simulation the significant events are slightly delayed in the first part of the test (up to the accumulator emptying), while in the next phase they are anticipated;
- the timing of the events has been well reproduced; in fact the maximum difference (around 300 s) it has registered at the time of the accumulator emptying, while for the other events it is lower than fifty seconds.

Concerning the core power (Fig. 4.1) it was forced to the experimental values.

Besides, it has to be considered that the delay of the PORVs intervention is not due to a bed PORVs action but it is due to the delay of the second dryout.

Aiming to make more meaningful the description of the results of the post-test calculations, the transient has been divided into three phases as it has been done in the paragraph 2.3.

CHRONOLOGY OF THE EVENTS :		
EVENTS	**EXP (s)**	**CALC (s)**
Break valve open	0.	0.
SG isolation start	0.	0.
Break valve fully open	2	2
SCRAM	35.8	34.7
Emergency feedwater	107.8	106.7
1° dryout	2414	2506
Pump coast down (start)	2790	2820
ACC initiation	2840	2870
ACC empty	3850	4050
2° dryout	5400	5045
1° PRZ PORV opening	6035	5469
2° PRZ PORV opening	6262	5661
LPIS initiation	6382	5843
PRZ PORVs off	6466	5903
end of Test	6900	6900

Tab. 4.2 - Chronology of the events

4.2.1 Phase 1: From the opening of the break to the pumps arrest (0-2820 s)

The phenomena that have characterized this phase have been:
- loss to the break;
- primary side depressurization;
- pumps degradation;
- dryout;
- CCFL at the inlet of the intact loop steam generator.

All these phenomena have been well reproduced by the code simulation.
The major results of the most meaningful parameters will be shortly described in the following:

Primary pressure
In Fig. 4.2 the calculated and experimental values of the primary pressure are compared. A good agreement can be observed between the calculated and experimental data; after the decoupling between primary and secondary pressures, the calculated data show an higher primary side depressurization; this means that the combined effect of the enthalpy lost through the break and the heat losses is overestimated in the calculation. The depressurization rate remains constant for the remaining time.

Break flowrate
The break flowrate, Fig. 4.3, is well simulated except for the two-phase period where it is underestimated; the comparison of the integral break flowrate (Fig. 4.4), shows much better agreement.

Pumps degradation
Relating to the pumps performances, from Figs. 4.5 and 4.6, with a given 2phase multiplier, it can be observed that both begins to lose their efficiency when the void fraction is around 0.1 and their degradation is complete when the void fraction is equal to 0.5. However, the pump of the broken loop degrades about 200 s before than in the intact loop. In comparison to the experimental data the complete degradation of the pumps is delayed of about 400 s (Fig. 4.7).

CCFL
The accumulation of mass at the inlet of the steam generator of the intact loop (Fig. 4.8) is well predicted by the code.
Fig. 4.9 shows that it doesn't happen in the broken loop. In that way the code has reproduced the asymmetrical behavior of the primary circuits as recorded in the test.

Vessel levels
In Fig. 4.10 it is evident the effect of the pumps degradation on the collapsed liquid level in the downcomer.
In particular, the increase of the collapsed liquid level corresponding to the pumps degradation is qualitatively well reproduced by the code.

The collapsed liquid level in the riser (Fig. 4.11) is well reproduced only after about 1500 s. Particularly in the first part of the transient (up to about 800 s) the simulation is rather approximate.

Mass inventory

The primary side mass inventory (Fig. 4.12) is well predicted by the code except for the first time period of the transient. Anyway in that time period the measured mass inventory is not significant because experimental data are distorted by the high fluid velocity.

Rod surface temperature

The rod surface temperature is shown in Figs. 4.13,4.14,4.15.
It is proper to observe that the code Relap5 it is not able to reproduce the asymmetrical behavior of the rods at the same level because it is a mono-dimensional code; besides the nodalization is such that every thermal structure includes portions of rods in which are inserted thermocouple at different height.
So, inevitably, there will be a difference between experimental and calculated data.
Observing the calculated data it's evident that:

- the dryout is deferred of about 100 s;
- the beginning of the dryout happens (like in the test) before the pumps stop;
- the core uncovering is of top-down type.

In conclusion therefore the good achievement between experimental and calculated data can be observed.

Fluid temperature

The inlet and outlet vessel fluid temperatures are well predicted by the code (Figs. 4.16 and 4.17).

4.2.2 Phase 2: From the pumps stop to the end of the accumulator injection (2820-4050 s)

The phenomena that have characterized this phase have been:

- redistribution of the primary system mass inventory;
- partial and temporary rods rewetting;
- accumulator injection;
- rods thermal excursion;
- the primary side depressurization;
- break mass loss.

All these phenomena have been well reproduced by the code and particularly the asymmetrical behavior of the two primary circuits has been simulated.
The characteristic of mono-dimensionality of the code has not allowed to represent the diversified behavior of the rods, but the code is able to reproduce the effect of the mass drained from the intact loop hot leg on the rods thermal excursion.

As far as it concerns the specific simulation of most meaningful variables, it can be observed as following:

Primary pressure

Fig 4.18 shows the good achievement between the experimental and calculated data with the only exception in the interval 3150-3400 s. In such interval in fact the experimental values show a constant decreasing, while in the calculated data the pressure remains quite constant. This could be due to the overestimation of the calculated condensation associated to the accumulator injection; that determines accumulator flowrate higher than the experimental value (Figs. 4.19 and 4.20). The temporary great depressurization is then compensated by a lower flowrate to which is associated a slower depressurization.

Rod surface temperature

The heater rod temperature is qualitatively well simulated (Figs. 4.13, 4.14, 4.15) during this phase. Particularly it can be observed that as in the test, the phenomenon of dryout doesn't interest the bottom levels (Fig. 4.15).

As in the test, core rewetting is bottom up type.

The difference between the experimental and calculated values of the peak clad temperature is ranging in the interval 40-80 K while the core rewetting is ranging in the interval 130-200 s.

CCFL

The code has also correctly simulated the end of CCFL conditions and the consequent back flow to the core of liquid mass (Figs. 4.8 and 4.21). As a consequence of that a reduction of the core heat-up rate it is observed (Fig. 4.22).

Accumulator injection

The accumulator flowrate is qualitatively well simulated (Fig. 4.19) even if the time for emptying is about 200 s higher.

However the core rewetting occurs at about t=3200 s.

A disagreement between the experimental and calculated data is that the injected accumulator mass is directed to the loop seal (Fig. 4.23).

Vessel levels

The figures 4.10 and 4.11 show the calculated and experimental data of the downcomer and riser level respectively.

In particular the Fig. 4.10 shows the good performance of the code also from the quantitative point of view since it reproduces the level increase consequent to the pumps arrest.

The riser level is qualitatively good and particularly it is well simulated the liquid level decreasing following the pumps stop.

The sensitive difference of the level in the riser can be partly explained with the fact that, contrarily than happened in the test, the injected accumulator mass flows in the vessel, but also in the loop seal. This is showed by the Figs. 4.24 and 4.23.

Mass inventory

The Fig. 4.12 shows the good agreement between the experimental and calculated data.

Break flowrate

In this phase, the break flowrate is well simulated by the code (Figs. 4.2 and 4.3).

4.2.3 Phase 3: From the end of the accumulator injection to the final core rewetting (4050-6900 s)

The phenomena that have characterized this phase have been:
- repressurization of the primary circuit;
- break mass loss;
- core dryout;
- PORVs opening and LPIS injection;
- core rewetting.

Also this phase has been well reproduced by the code even if the dryout is earlier by about 350 s. This is essentially due to the fact that, in the simulation, the accumulator mass injected into the vessel is lower in comparison to that injected in the experiment.
As a consequence of the earlier occurrence of the second core dryout both the PORVs and LPIS are activated earlier. However, from the table 4.2, it's evident that the time periods of intervention result to be almost the same.
As far as it concerns the specific simulation of most meaningful variables, it can be observed as following:

Primary pressure
The repressurization (Fig. 4.1) following the end of the accumulator injection is well represented by the code.
The depressurization following the PORVs intervention is also well reproduced.

Break mass flowrate
The break mass flowrate increase consequent to the activation of the system LPIS is reproduced by the code (Fig. 4.2).

Rods temperature
Even if the second core dryout is earlier in the calculated data, it has been reproduced with the same modality of the test (Figs. 4.13, 4.14, 4.15). The difference between calculated and test peak clad temperature is ranging in the interval 5-80 K.

Mass inventory
The primary side mass inventory (Fig. 4.12) is very well simulated except for the phase of filling.

Vessel levels
The riser collapsed liquid level has a trend similar to experimental one even if in absolute value it results lower of about one meter (Fig. 4.11). In the downcomer the calculated collapsed liquid level has a most rapid diminution in comparison to the experimental one even if the initial absolute values are equal (Fig. 4.10).
In conclusion it can be stated that the simulation of these variables is quite good.

4.3 SENSITIVITY CALCULATIONS

The reference calculation was aimed to best reproduce the initial and boundary conditions.

The sensitivity calculations have been realized in order:

- to improve the simulation of specific aspects;
- to evaluate the effect of specific parameters changing.

Based on the reference calculation some sensitivity calculations (Tab. 4.3) were realized in order to improve the break flowrate, to verify the on set of the CCFL phenomena, to improve the time of intervention of the second core dryout.

CODE RUN	**CHARACTERISTIC/VARIED PARAMETERS**	**MAIN RESULTS**
R01	-two phase discharge coefficient equal to 1.10 -accumulator pressure equal to 3.83 MPa	- two phase break flowrate higher - less primary mass inventory - earlier occurrence of the dryout - earlier occurrence of the following events
R02	- in junctions 115 and 208, gas intercept coefficient equal to 0.48	- CCFL only in IL - more water flows back to the core -reduction in the core heat-up rate
R03	- in junction 145, reverse flow energy loss coefficient equal to 10^9	- loop seal filling delayed - more water in the vessel - accumulator flowrate more similar to experimental one - increase of outlet vessel mass flowrate - earlier occurrence of the 2° dryout
R04	-intact loop steam generator nodalization change	- increase of secondary circuit thermal dispersions

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4.3.1 R01-case

From the analysis of the reference calculation, it is observed that the calculated break mass flowrate during the two-phase regime is lower than the experimental one. So a sensitivity calculation was realized with two phase discharge coefficient equal to 1.1 instead of 0.95. The consequence of this modification is a great flowrate (Fig. 4.25) and therefore the mass losses through the break is increased (Fig. 4.26). As a consequence the primary side depressurization is increased and the pumps arrest is occurred about 200 s earlier (Fig. 4.27). That is due to the anticipation of the rod thermal excursion (Fig. 4.30) determined by the lower mass inventory in the primary circuit (Fig. 4.28) and in the vessel (Fig. 4.29). The earlier occurrence of the first dryout makes all the following events suffering of the same advancing (Figs. 4.30 and 4.31).

4.3.2 R02-case

To verify the physical borders for the activation of the CCFL model in the two junctions 115 and 208, the parameter c (gas intercept) was increased from 0.4 to 0.48. From the results, it is observed that the CCFL is only verified in the junction 115 of the intact loop (Fig. 4.32) (in fact in the junction 208 of the broken loop, water is present in both the volumes connected by the junction (Fig. 4.33)).

The water that flows back to the core is increased in comparison to the base case (Fig 4.34). This has determined a reduction in the core heat-up rate (Fig 4.35). Besides it is observed that, a little bit earlier of pumps stop, the primary pressure is higher than the base case (Fig. 4.36) of about 0.5 Pa.

4.3.3 R03-case

In the reference case it is observed that part of the accumulator injected water does not go into the core but in the loop seal of the intact loop. Then it was realized a sensitivity case in which the reverse flow energy loss coefficient of the volume in which injects the accumulator, was set equal to 10^9. The consequences of this are:

1) the filling of the loop seal is delayed (Figs. 4.37, 4.38, 4.39);
2) more water goes into the vessel (in fact the collapsed levels are higher (Figs. 4.40 and 4.41));
3) the accumulator injection is shorter and the mass flowrate is more close to the experimental one (Fig. 4.42); as a consequence the core rewetting is about 100 s earlier (Fig. 4.43) respect to the reference calculation and practically at the same instant in which it is observed in the test;

4) the outlet vessel mass flowrate is increased (Figs. 4.44 and 4.45); that determines an earlier occurrence of the second core dryout.

4.3.4 R04-case

This sensitivity was realized to verify the influence of the degree of the mesh size of the steam generator. The selected steam generator was intact loop one because it is representative of three steam generators; the size number of its volumes was halved both in the primary side and in the secondary side. However substantial changes are not recorded in the general course. The only sensitive change concerns the thermal dispersions of the secondary circuit that is increased (Fig. 4.46). It is not noticed, instead, variation of the heat exchanged power (Fig. 4.47).

4.4 QUANTITATIVE ACCURACY EVALUATION

A particular methodology, developed at University of Pisa, it was applied to the different realized calculations in order to evaluate their quantitative accuracy. The methodology is based upon the use of the Fast Fourier Transforms; its main features are detailed in App. 6.

As mentioned in the appendix the application of FFT is characterized by performing several steps and/or verifying certain conditions. In our case we have implemented a simplified application of FFT since many of the steps or conditions can be considered a priori satisfied. That is because both the LOBI facility and the nodalization can be considered qualified.

The results of the application of the methodology are given in Tab. 4.4 and 4.5. From the Tab. 4.4 it can be observed that for the reference calculation is satisfied the criterion of acceptability, $AA_{tot} < 0.4$, therefore the calculation is good.

Following some comments are given on the results obtained.

a) Reference calculation

The high values for AA_{19} (difference of pressure in the ascending side of the loop seal of the BL) AA_{20} (difference of pressure in the ascending side of the loop seal of the IL) AA_{21} (difference of pressure in the descending side of the loop seal of the BL) are due to the uncorrected simulation of the loop seal inventory.

The high value of AA_{10} (integrated mass injected in the primary system from the emergency systems) is due to the earlier of the second core dryout that implicates the earlier intervention of the LPIS. This is testified by the fact that in the temporal window 0-4900 s the parameter AA_{10} is 0.06.

b) Sensitivity calculation, R01

Compared to the base-case, in R01-case the value of AA_1 (pressure in the primary side) is already higher in the temporal window 0-4900. This is due to the increase of the depressurization following to the increase of the break flowrate. The further worsening suffered in the next window is due to the earlier occurrence of the second core dryout.

The doubling of the value of AA_3 (pressure in the accumulator) is due to the earlier injection of the accumulator consequently to the earlier pumps arrest (of about 180 s).

The value of AA_4 (fluid temperature at the core inlet) is increased in the temporal window 0-4900 s. 70 s after the beginning of the test, the primary system reaches the saturation conditions so the fluid temperature (Fig. 4.48) has the same course of the primary pressure, therefore the fluid temperature at the core inlet has the same error of the primary pressure (there is same proportionality in the variations of AA_1 and AA_4).

While the further worsening in the following window is due to the earlier occurrence of the second core dryout.

		BASE	BASE	R01	R01	R02	R02	R03	R03	R04	R04
		WF	AA	WF	AA	WF	AA	WF	AA	WF	AA
1	Primary pressure	0.021	0.0697	0.023	0.0972	0.023	0.0754	0.022	0.0813	0.021	0.0693
2	Secondary pressure	0.046	0.0128	0.046	0.0128	0.046	0.0128	0.046	0.0128	0.046	0.0128
3	ACC pressure	0.012	0.0647	0.01	0.1371	0.013	0.0626	0.012	0.0634	0.011	0.0691
4	core inlet fluid temperature	0.036	0.1536	0.037	0.2182	0.036	0.1565	0.038	0.2768	0.036	0.1516
5	core outlet fluid temperature	0.017	0.3329	0.017	0.3747	0.016	0.3396	0.017	0.3044	0.018	0.3642
6	upper head fluid temperature	0.023	0.2104	0.017	0.194	0.021	0.2007	0.021	0.1924	0.024	0.2153
7	integral break flow rate	0.046	0.1624	0.044	0.3094	0.046	0.1693	0.044	0.3509	0.046	0.1621
8	SG DC bottom fluid temperature	0.034	0.1403	0.034	0.1421	0.034	0.1404	0.035	0.1688	0.035	0.1425
9	break flow rate	0.061	1.1814	0.056	1.3351	0.061	1.1873	0.057	1.2735	0.061	1.1717
10	ECCS integral flow rate	0.04	0.8712	0.04	1.3474	0.04	0.9116	0.039	1.4994	0.04	0.8711
11	rod temperature bottom level	0.011	0.0845	0.014	0.099	0.011	0.0857	0.03	0.1309	0.01	0.0842
12	rod temperature middle level	0.013	0.7555	0.014	0.6804	0.013	0.7825	0.013	0.7025	0.013	0.7304
13	rod temperature high level	0.012	0.8797	0.013	0.7922	0.012	0.861	0.012	0.829	0.013	0.8784
14	primary side total mass	0.035	0.4217	0.035	0.5587	0.035	0.4412	0.036	0.5955	0.036	0.431
15	core level	0.024	0.7421	0.022	0.7728	0.024	0.7479	0.022	0.7593	0.024	0.7057
16	SG DC level (IL)	0.029	0.2544	0.029	0.2548	0.029	0.2544	0.032	0.2621	0.03	0.2588
17	DP in-out SG (IL)	0.016	0.2729	0.023	0.4162	0.016	0.2682	0.046	0.8458	0.017	0.2639
18	core power	0.064	0.0635	0.042	0.1483	0.059	0.0718	0.044	0.1354	0.051	0.0884
19	DP loop seal BL -ascending side	0.019	0.9168	0.021	0.9115	0.02	0.9282	0.02	0.8967	0.02	0.9259
20	DP loop seal IL -ascending side	0.025	1.1916	0.026	1.2197	0.025	1.195	0.022	1.0329	0.028	1.4242
21	DP loop seal BL -descending side	0.03	1.0917	0.029	1.1436	0.029	1.1383	0.028	1.204	0.03	1.0978
22	PRZ level	0.035	0.1535	0.018	0.1507	0.035	0.1535	0.033	0.1531	0.035	0.1524
23	DP SG inlet plenum Utebes top BL	0.027	0.4461	0.029	0.4354	0.027	0.4523	0.027	0.4488	0.028	0.4451
24	DP SG inlet plenum Utebes top IL	0.022	0.2521	0.025	0.2697	0.022	0.2472	0.048	0.6309	0.045	0.3106
25	DP across DC-UH bypass	0.019	0.4308	0.02	0.4318	0.021	0.4701	0.02	0.4566	0.02	0.439
	TOT	0.02621	0.3487	0.02524	0.3886	0.0259	0.3537	0.02776	0.4074	0.02657	0.3546

Tab. 4.4 - Summary of results obtained by application of FFT method on all transient

	FINESTRA 0-4900	BASE	BASE	R01	R01	R02	R02	R03	R03	R04	R04
		WF	AA	WF	AA	WF	AA	WF	AA	WF	AA
1	Primary pressure	0.053	0.0469	0.038	0.0683	0.053	0.0485	0.053	0.0493	0.052	0.0488
2	Secondary pressure	0.056	0.0152	0.056	0.0152	0.056	0.0152	0.056	0.0152	0.056	0.0152
3	ACC pressure	0.014	0.057	0.011	0.1298	0.014	0.0556	0.014	0.0561	0.013	0.0612
4	core inlet fluid temperature	0.036	0.0553	0.025	0.077	0.037	0.0585	0.041	0.0641	0.038	0.0606
5	core outlet fluid temperature	0.02	0.2083	0.018	0.2487	0.02	0.2135	0.025	0.1639	0.023	0.2054
6	upper head fluid temperature	0.041	0.2041	0.041	0.2081	0.041	0.2093	0.041	0.2131	0.041	0.2085
7	integral break flow rate	0.03	0.041	0.013	0.0248	0.028	0.0394	0.029	0.0392	0.03	0.0409
8	SG DC bottom fluid temperature	0.039	0.1575	0.039	0.1645	0.039	0.157	0.039	0.1576	0.041	0.1643
9	break flow rate	0.074	0.812	0.074	0.808	0.074	0.8119	0.074	0.8128	0.074	0.8161
10	ECCS integral flow rate	0.018	0.0613	0.018	0.1012	0.021	0.0558	0.021	0.0622	0.017	0.0631
11	rod temperature bottom level	0.029	0.0545	0.025	0.0702	0.03	0.0572	0.031	0.0602	0.031	0.0568
12	rod temperature middle level	0.01	0.6198	0.012	0.5271	0.01	0.6498	0.012	0.5299	0.011	0.583
13	rod temperature high level	0.01	0.6665	0.013	0.446	0.01	0.6587	0.012	0.5654	0.011	0.6389
14	primary side total mass	0.03	0.245	0.034	0.2636	0.031	0.2469	0.033	0.258	0.029	0.2269
15	core level	0.039	0.4061	0.043	0.4835	0.039	0.4133	0.046	0.4527	0.04	0.3934
16	SG DC level (IL)	0.049	0.3091	0.049	0.3096	0.049	0.3089	0.049	0.309	0.05	0.3152
17	DP in-out SG (IL)	0.024	0.2525	0.028	0.358	0.024	0.2448	0.023	0.2553	0.025	0.2377
18	core power	0.091	0.0544	0.062	0.0946	0.093	0.0528	0.097	0.0506	0.096	0.0499
19	DP loop seal BL -ascending side	0.023	0.7635	0.025	0.7621	0.024	0.7459	0.023	0.7798	0.024	0.7953
20	DP loop seal IL -ascending side	0.036	0.9402	0.035	0.9598	0.036	0.9322	0.037	0.8896	0.036	1.1852
21	DP loop seal BL -descending side	0.038	0.7283	0.039	0.6753	0.038	0.7242	0.037	0.7176	0.038	0.7164
22	PRZ level	0.041	0.1471	0.041	0.1465	0.041	0.1471	0.04	0.1471	0.041	0.1462
23	DP SG inlet plenum Utebes top BL	0.031	0.4359	0.032	0.416	0.031	0.4386	0.031	0.438	0.031	0.4318
24	DP SG inlet plenum Utebes top IL	0.026	0.248	0.029	0.2579	0.026	0.2428	0.026	0.245	0.056	0.3108
25	DP across DC-UH bypass	0.036	0.4629	0.036	0.4607	0.035	0.4617	0.035	0.457	0.035	0.4791
	TOT	0.032	0.2419	0.029	0.2404	0.0327	0.244	0.03409	0.2291	0.03365	0.24336

Tab. 4.5 - Summary of results obtained by application of FFT method (0-4900 s)

The same reason can explain for the value of AA_{11} (rod temperature at the bottom level).

The earlier intervention of the emergency system LPIS, is also reflected on the value of AA_7 (integral break flowrate) since following this intervention the integral break flowrate increases notably. However it can be observed that in the temporal window 0-4900 the value of AA_7 is lower than the base case therefore the purpose of this sensitivity calculation, improving the break flowrate during the two-phase flow, has been reached even if this has a negative consequences in the rest of the test.

The same evaluation are valid for the value of AA_9 (break flowrate).

The parameter that is affected by the earlier intervention of the LPIS is AA_{10} (integrated mass injected in the primary system from the emergency systems).

The values of AA_{12} (rod temperature at middle level) and AA_{13} (rod temperature at high level) are decreased since the earlier pumps stop determines the earlier accumulator injection and then the core rewetting coincides with the experimental time (Figs. in Appendixes).

The high value of AA_{14} (mass in the primary circuit) is due to the earlier intervention of the LPIS; in fact in the temporal window 0-4900 the value of AA_{14} is not different from the value of the reference calculation.

c) Sensitivity calculation, R03

The high value of AA_1 (pressure in the primary side) is due to the earlier occurrence of the second core dryout that in turn determines the earlier operation of depressurization. In fact in the temporal window 0-4900 the value of AA_1 is not different from that of the reference calculation.

Higher values for AA_7 (integral break flowrate), AA_9 (break flowrate) and AA_{10} (integrated mass injected in the primary system from the emergency systems) are due to earlier intervention of the LPIS. In fact owing to the intervention of the system LPIS the break flowrate suffers a noticeable increase and, therefore, also the integral break flowrate is affected. This assumption is confirmed by the fact that they remain unchanged in the temporal window 0-4900.

The high value of AA_{17} (pressure difference between the inlet and the outlet of the intact loop steam generator) is due to an accumulation of liquid in the ascending part of the U-tubes (Fig. 4.49); that is also shown by the high value of AA_{24} (pressure difference at the inlet plenum of the U-tubes in the intact loop steam generator).

The purpose of this sensitivity case was to avoid the accumulation of liquid in the loop seal during the injection of the accumulator. Partly this purpose has been reached; in fact AA_{20} (pressure difference in the ascending side of the loop seal of the intact loop) is lower than the base case in the temporal window 0-4900 s.

d) Sensitivity calculation, R04

The spike registred at about 200 s determines the high value of AA_{20} (pressure difference in the ascending side of the loop seal of the intact loop).

e) General observations

Case R03 has the lowest value of AA_{20} (pressure difference in the ascending side of the loop seal of the intact loop); in fact in R03 being higher the void fraction in the loop seal the pressure difference is lower, and then it is more close to the experimental values.

For the values of AA_7 (integral break flowrate) case R03 has the highest value, and following it R01, R02, R04. This order is due to the earlier intervention of the system LPIS, in fact the case with earliest intervention has the highest value of AA_7 (Fig. 4.51). The same order should be observed for AA_9 (break flow rate), but it is observed that the case R01 has the highest, and following R03, R02, R04. The exchange of position between R03 and R01 is probably due to spikes (Fig. 4.52) during the accumulator injection. These loss have canceled the improvement obtained during the two-phase flow period.

The influence of the fluctuations on the values of AA is noticeable so it can be observed that in the quantitative analysis the presence of spurious peak results more important than in the qualitative analysis.

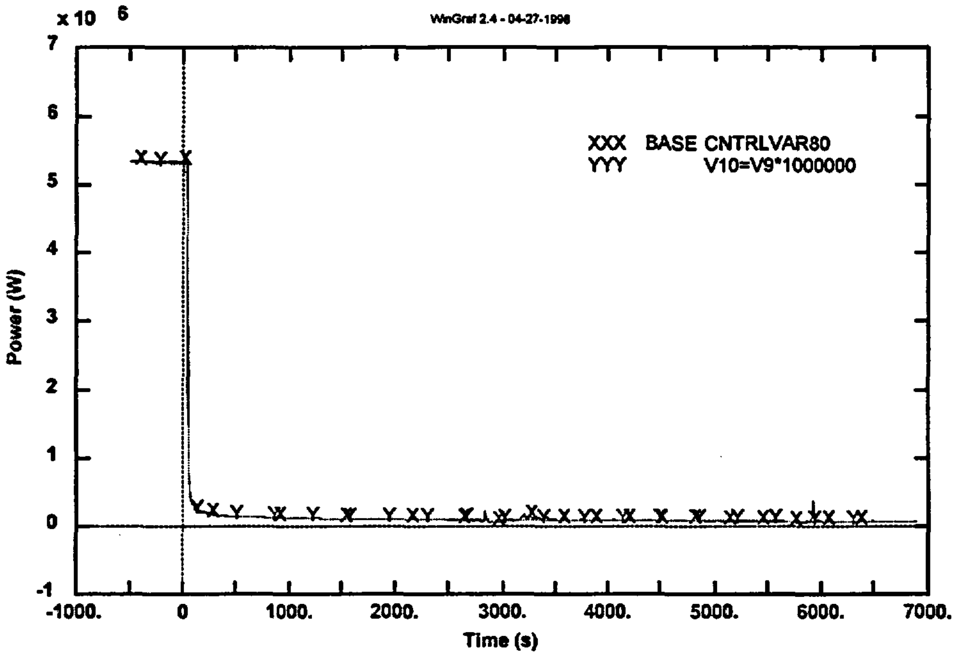

Fig. 4.1 : Heating power

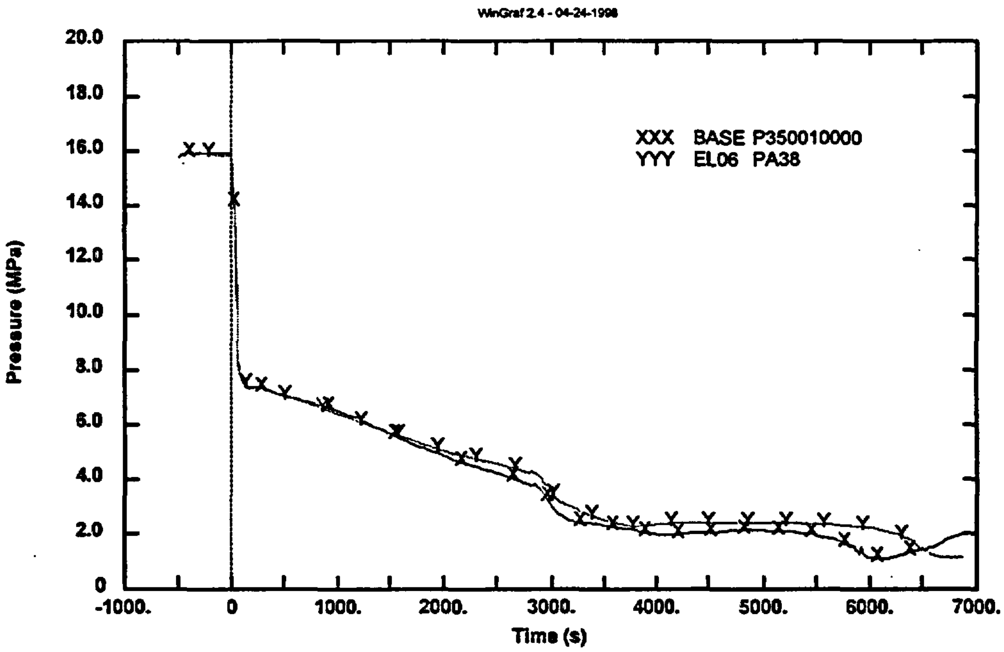

Fig. 4.2 : Primary system pressure

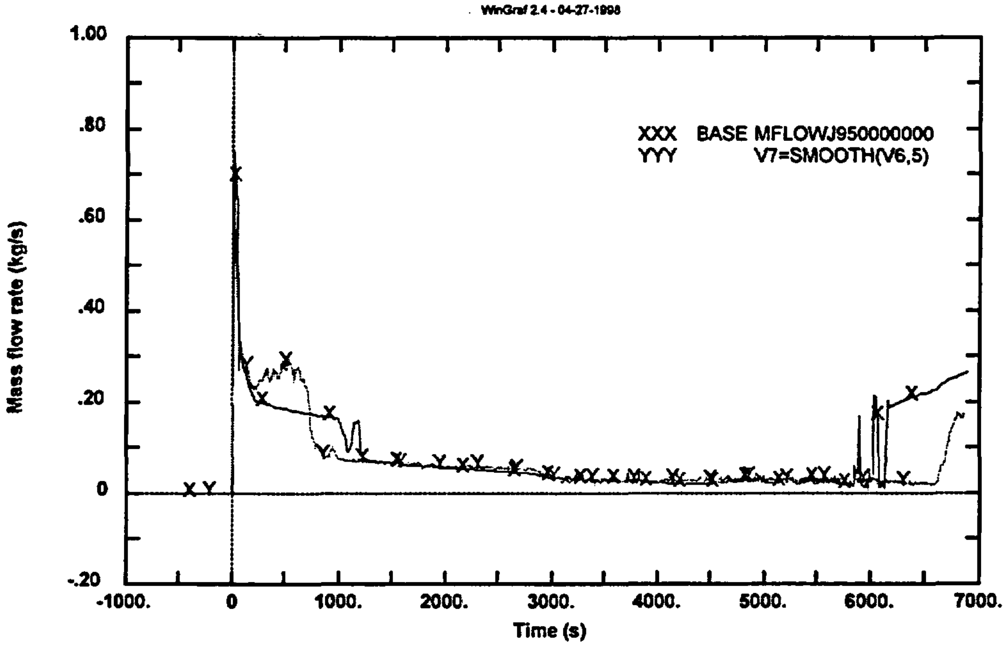

Fig. 4.3 : Break mass flow rate

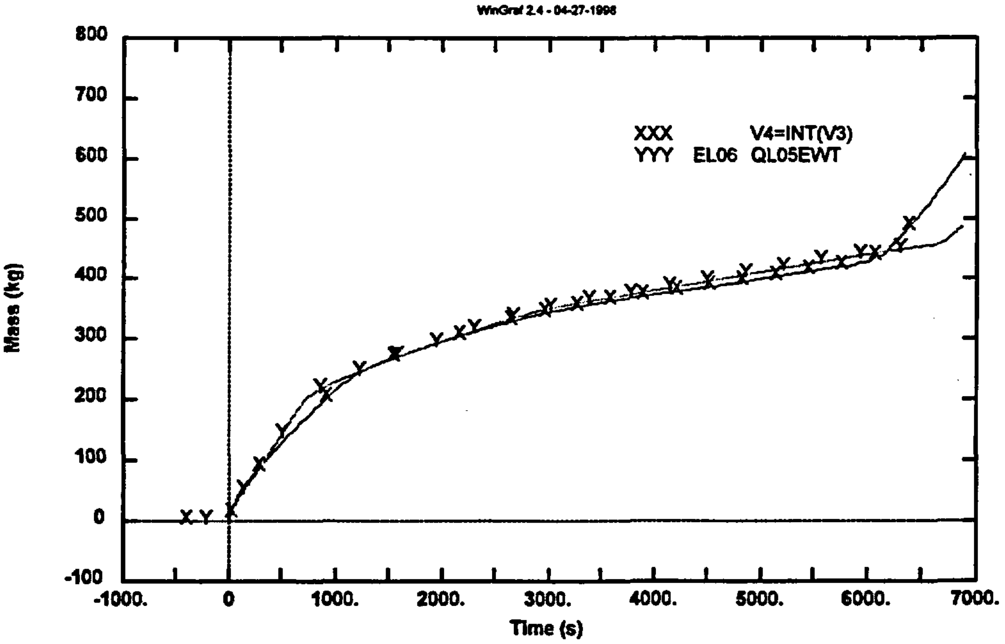

Fig. 4.4 : Break integral flow rate

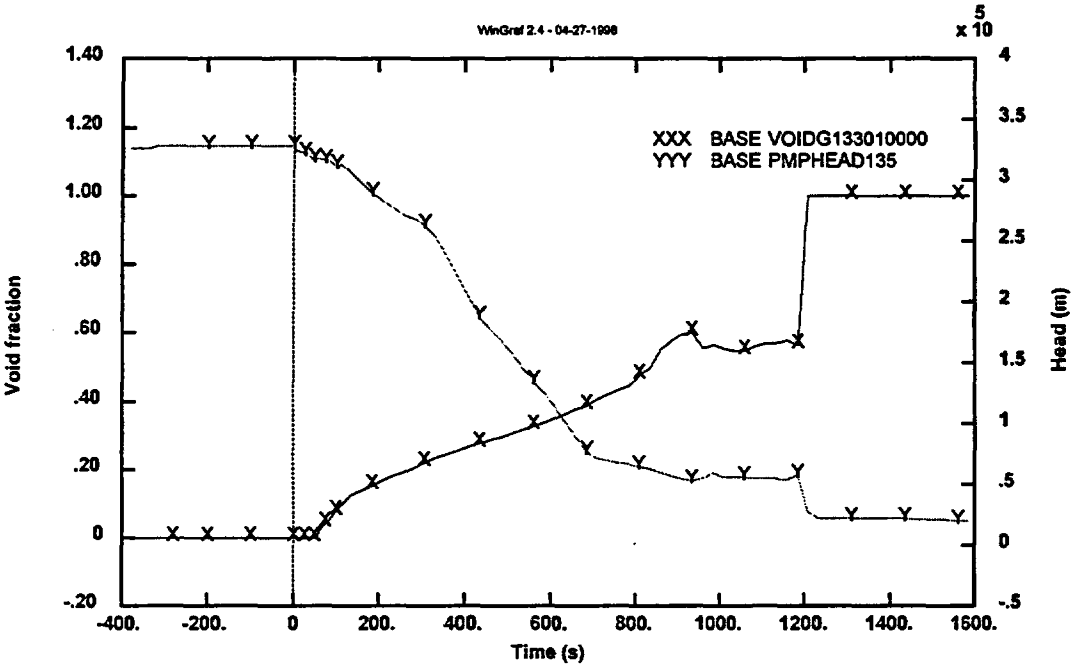

Fig. 4.5 : Void fraction at pump inlet and pump head (IL)

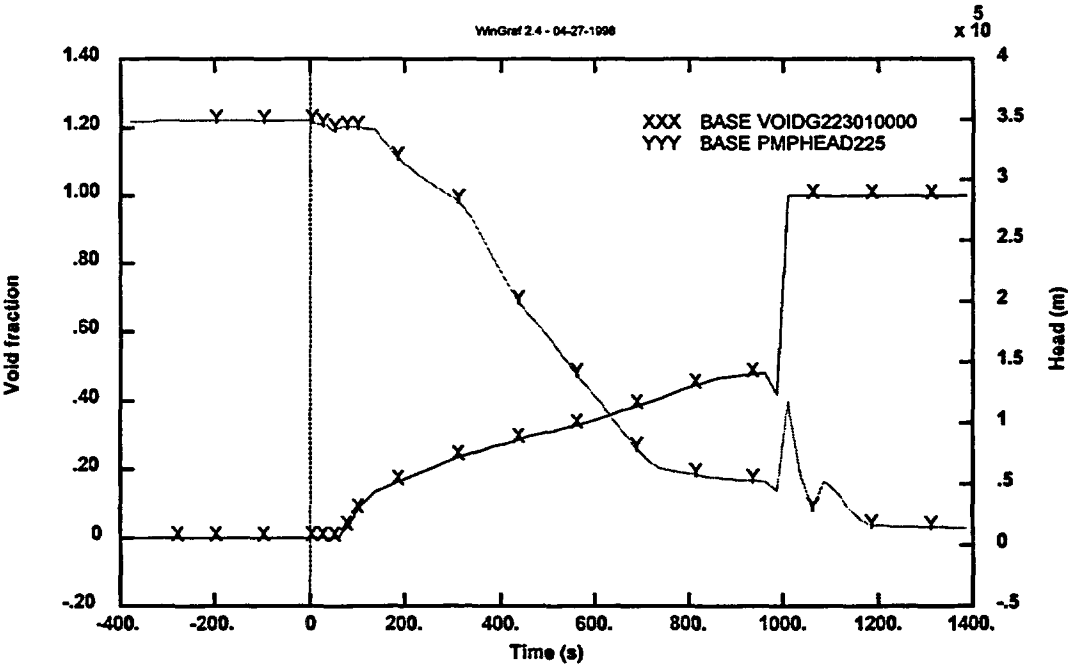

Fig. 4.6 : Void fraction at pump inlet and pump head (BL)

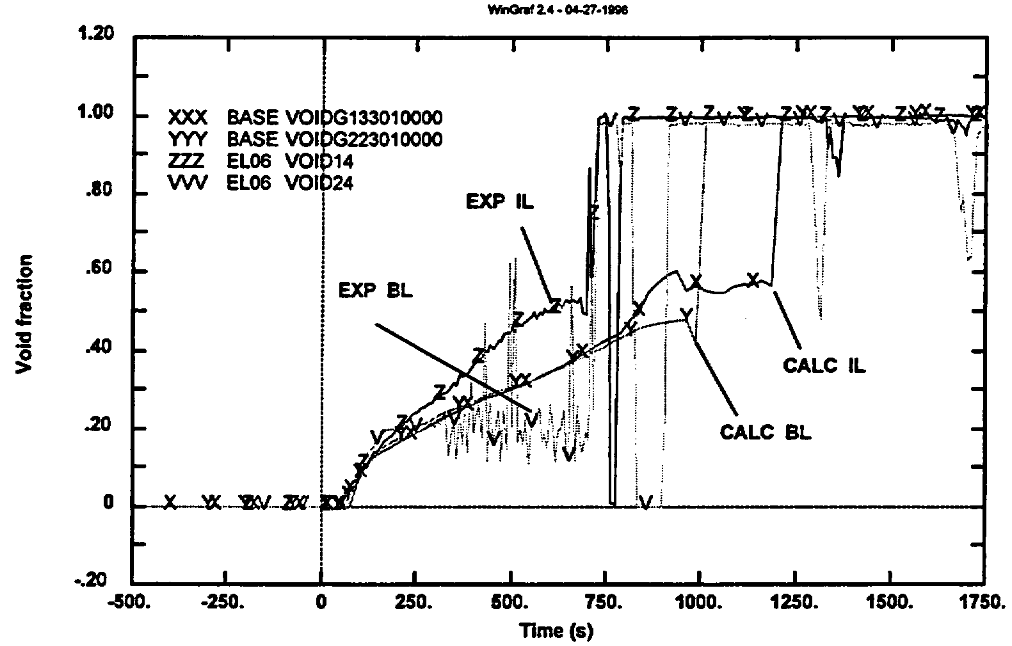

Fig. 4.7 :Void fraction at pumps inlet

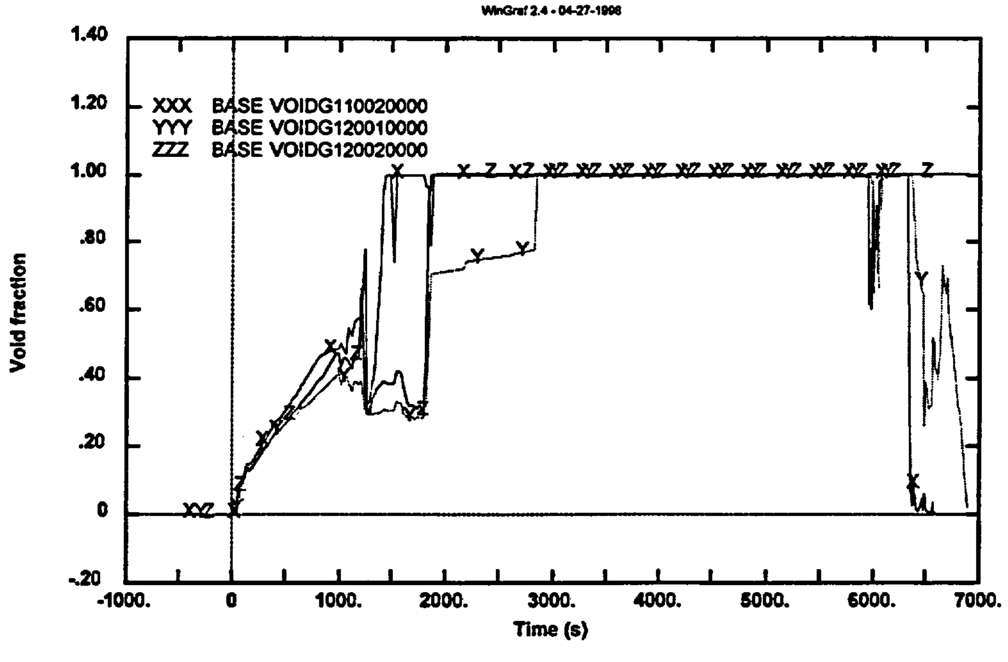

Fig. 4.8 : Void fraction at steam generator inlet (IL)

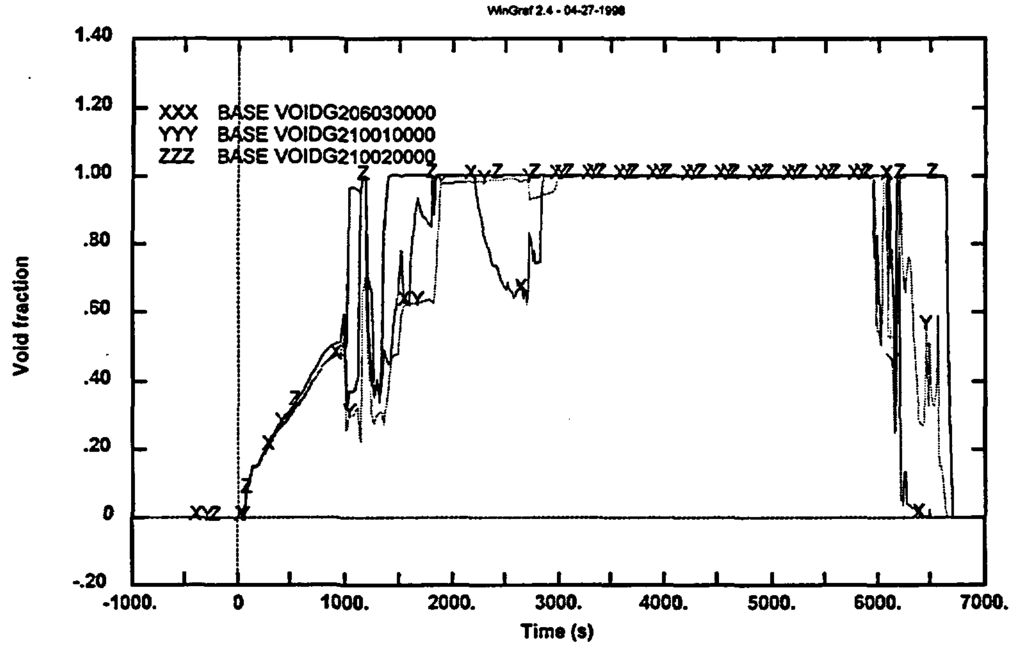

Fig. 4.9 : Void fraction at steam generator inlet (BL)

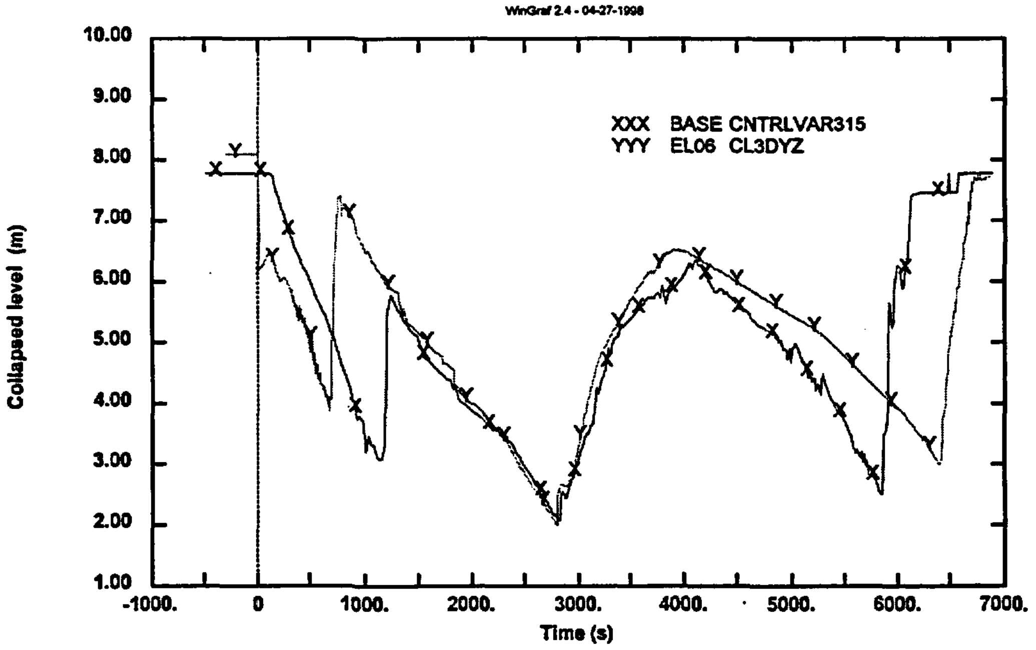

Fig. 4.10 : Collapsed level in the downcomer

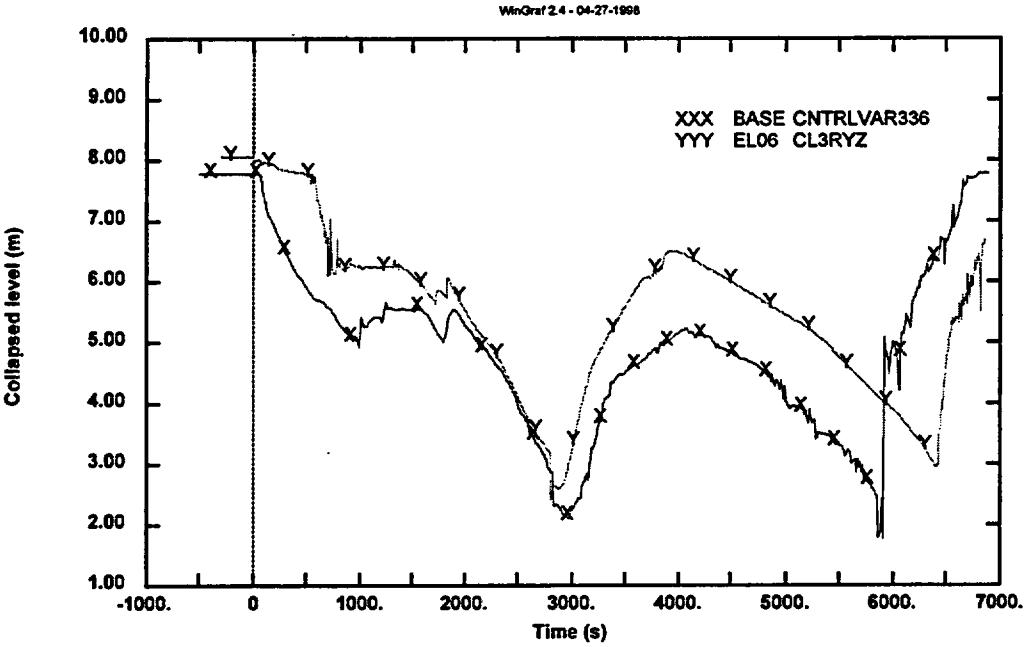

Fig. 4.11 : Collapsed level in the riser

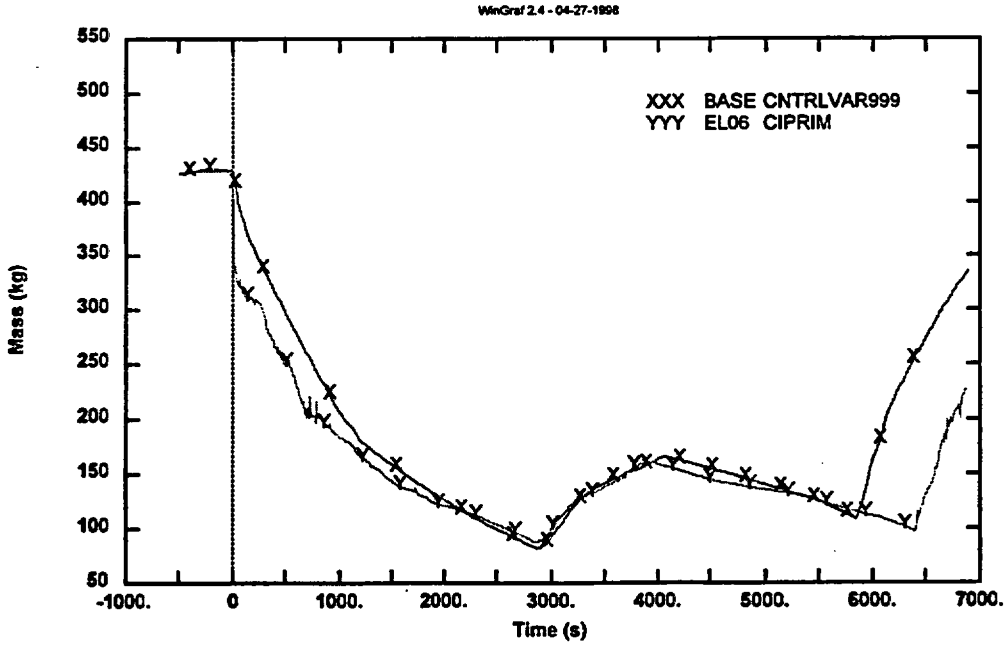

Fig. 4.12 : Primary system mass inventory

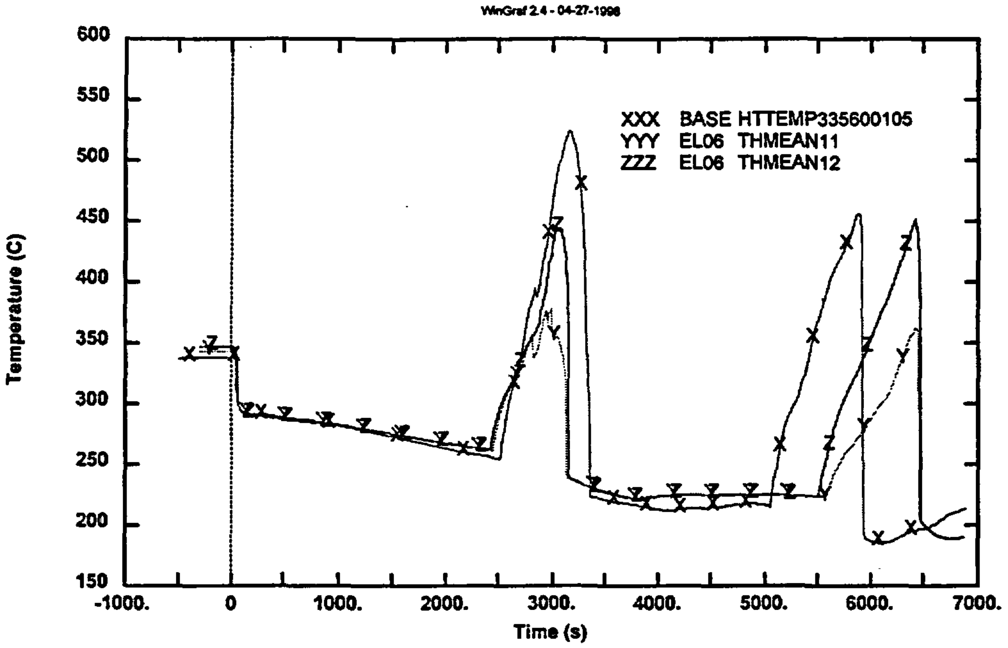

Fig. 4.13 : Rod surface temperature (high level)

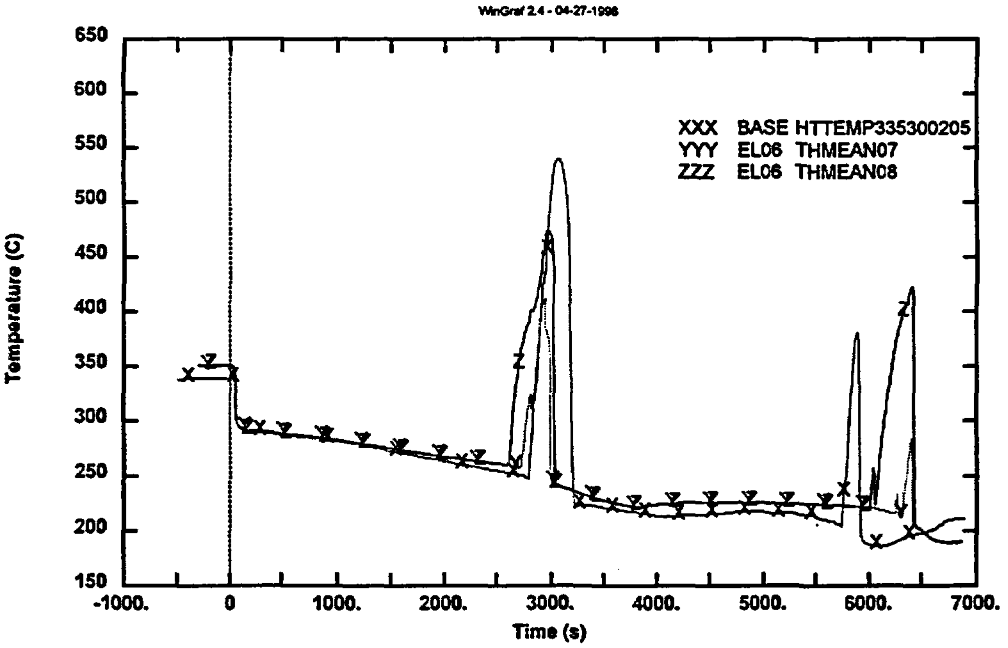

Fig. 4.14 : Rod surface temperature (middle level)

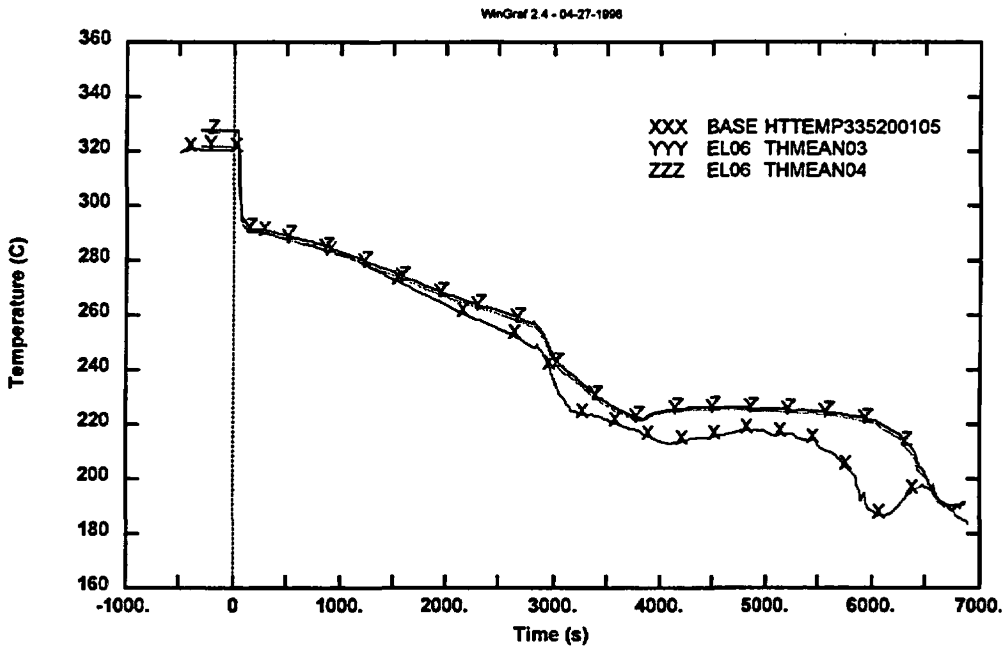

Fig. 4.15 : Rod surface temperature (bottom level)

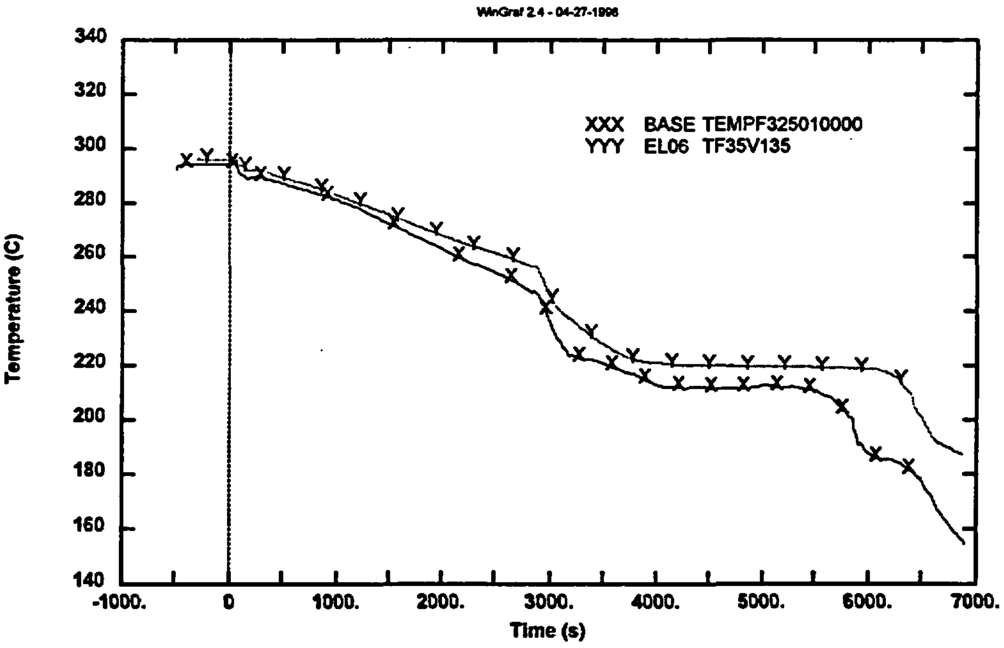

Fig. 4.16 : Core inlet fluid temperature

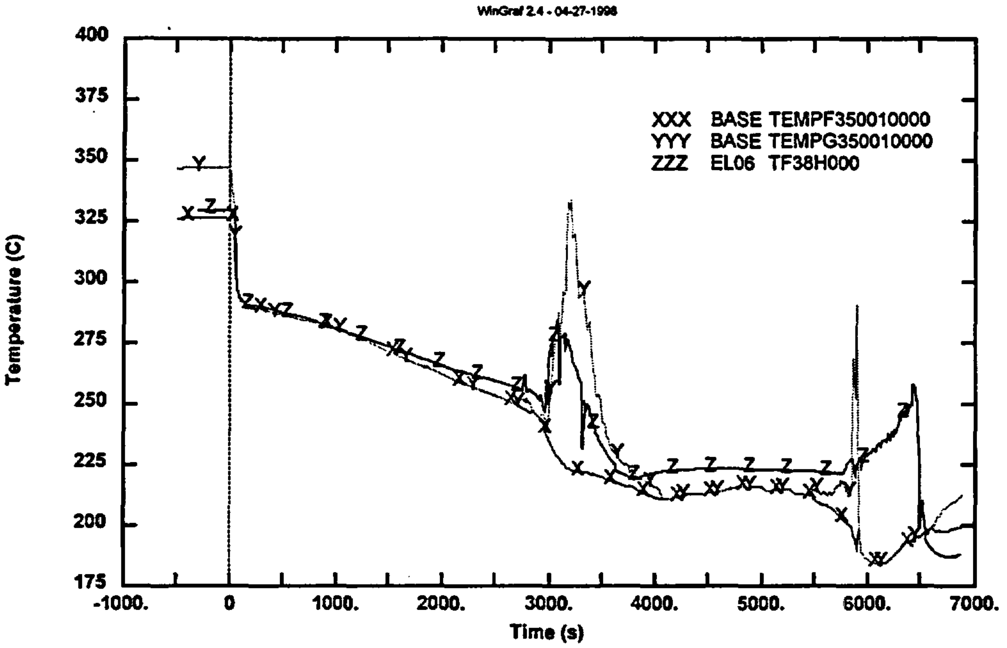

Fig. 4.17 :Core outlet fluid temperature

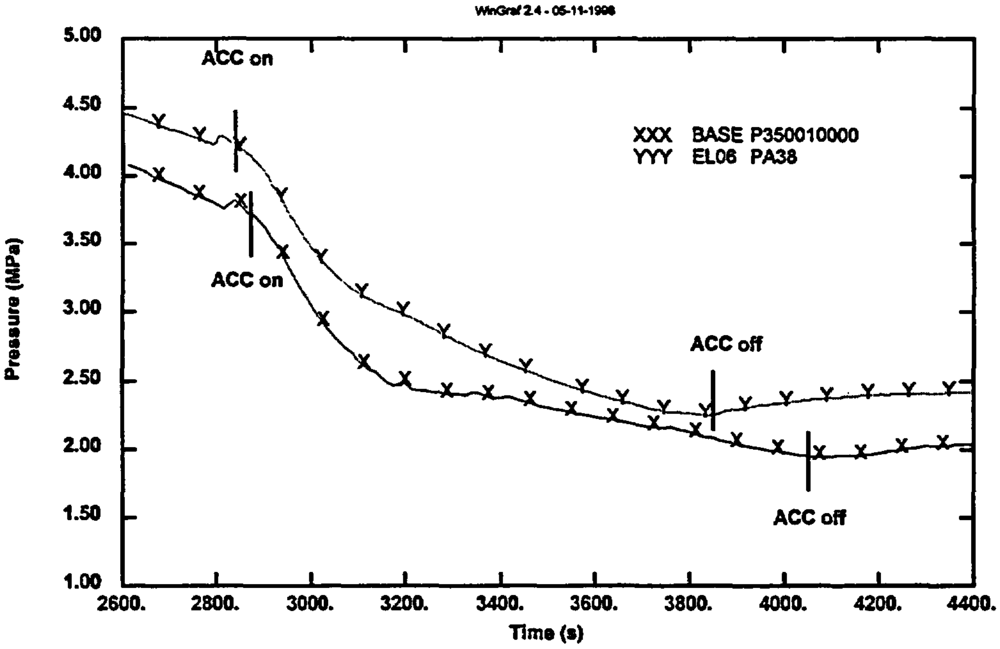

Fig. 4.18 : Primary system pressure

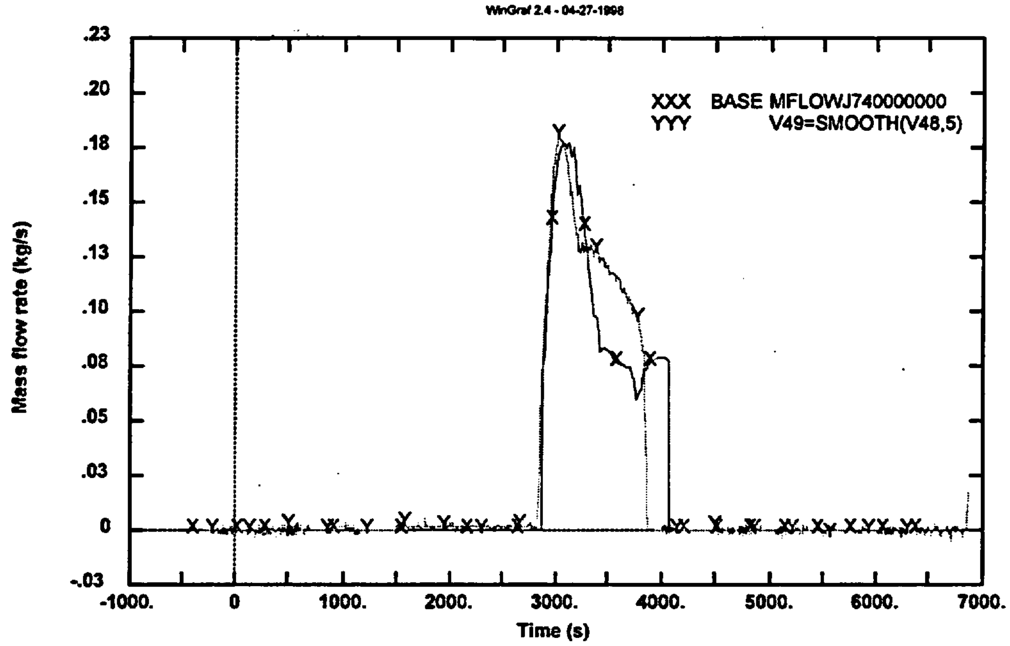

Fig. 4.19 : Accumulator system mass flow rate

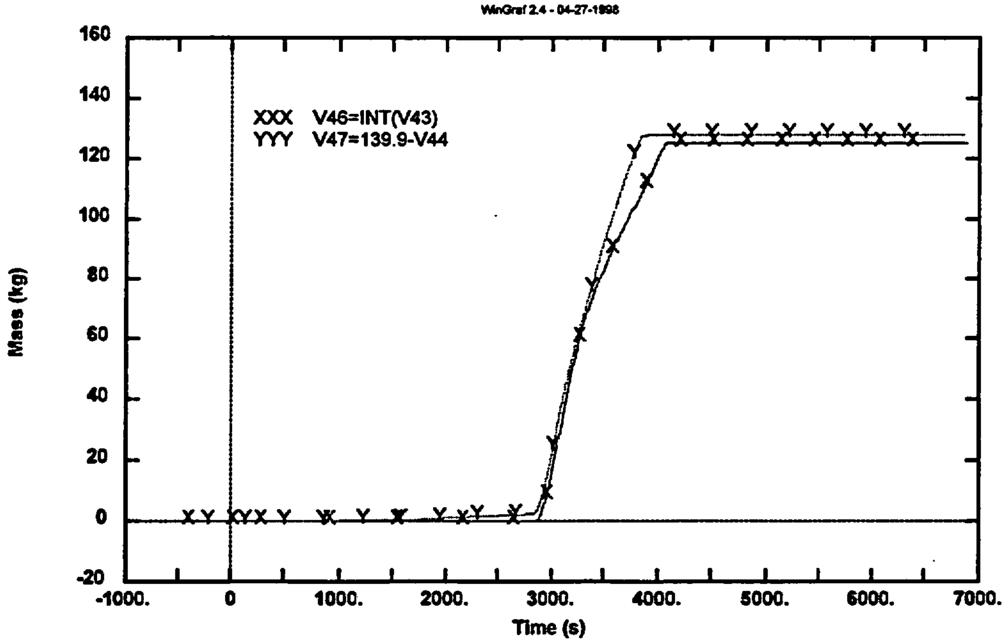

Fig. 4.20 : Integral accumulator system mass flow rate

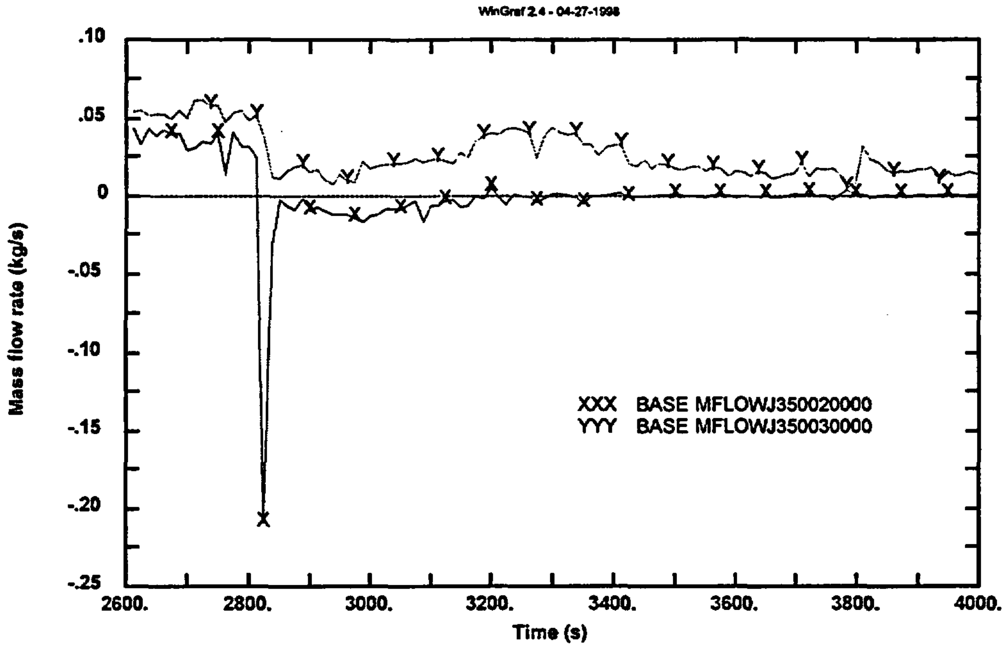

Fig. 4.21 : Mass flow rate of junctions that connect the vessel to the hot leg

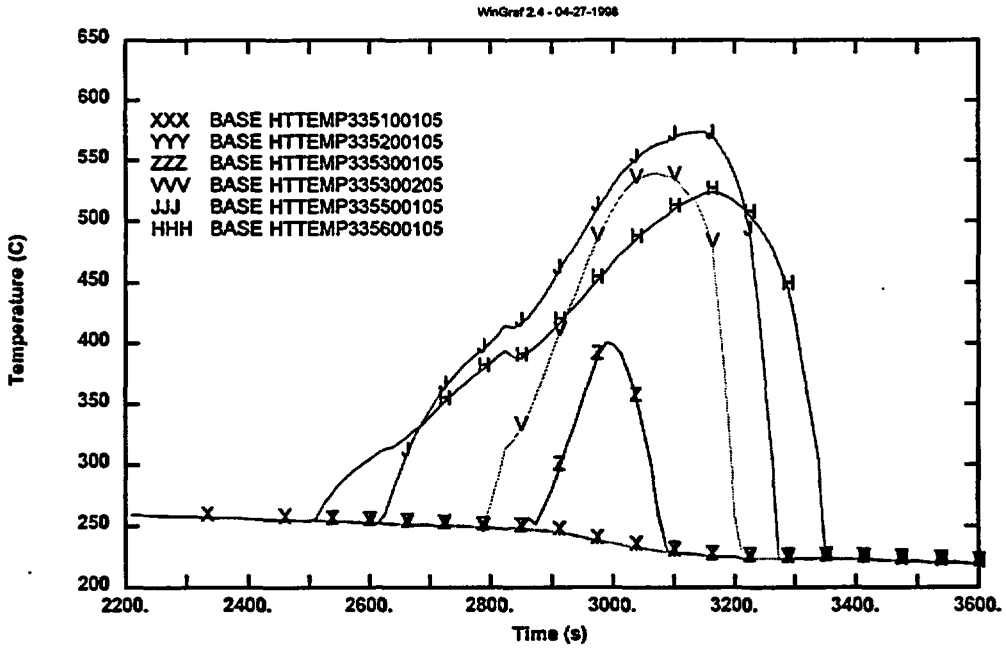

Fig. 4.22 : Heater rod temperature

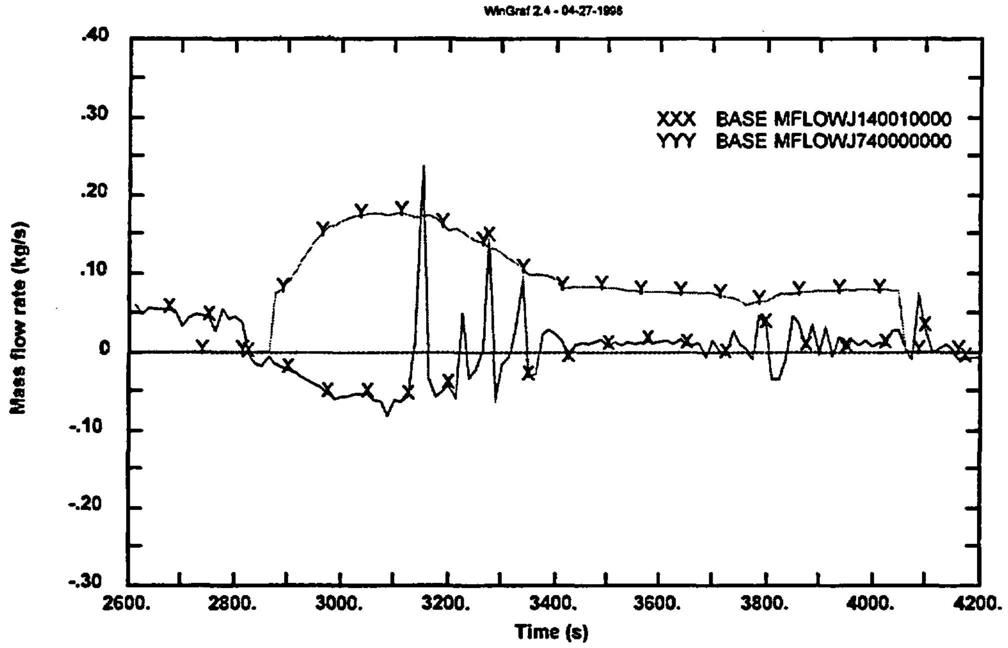

Fig. 4.23 : Accumulator mass flow rate and mass flow rate of the inlet junction of the volume in which the accumulator injects

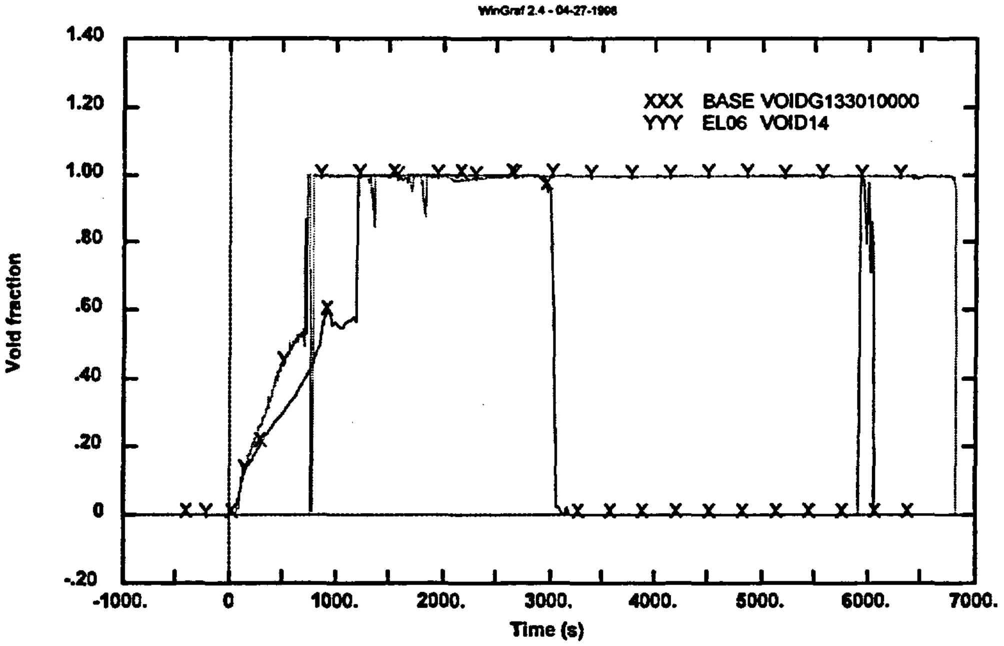

Fig. 4.24 : Void fraction at the pump inlet of the IL

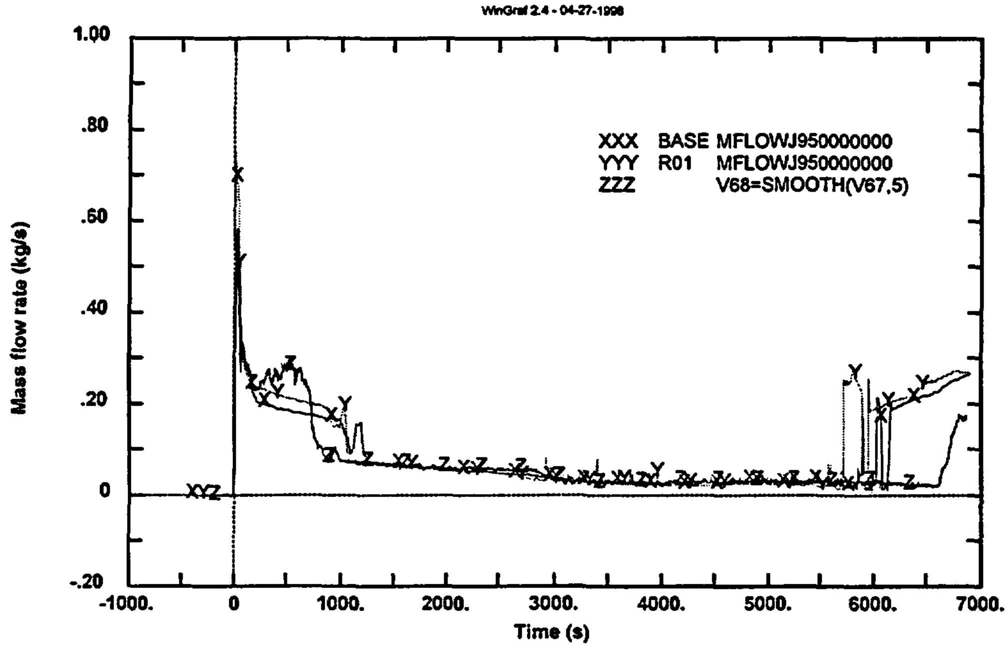

Fig. 4.25 : Break mass flow rate

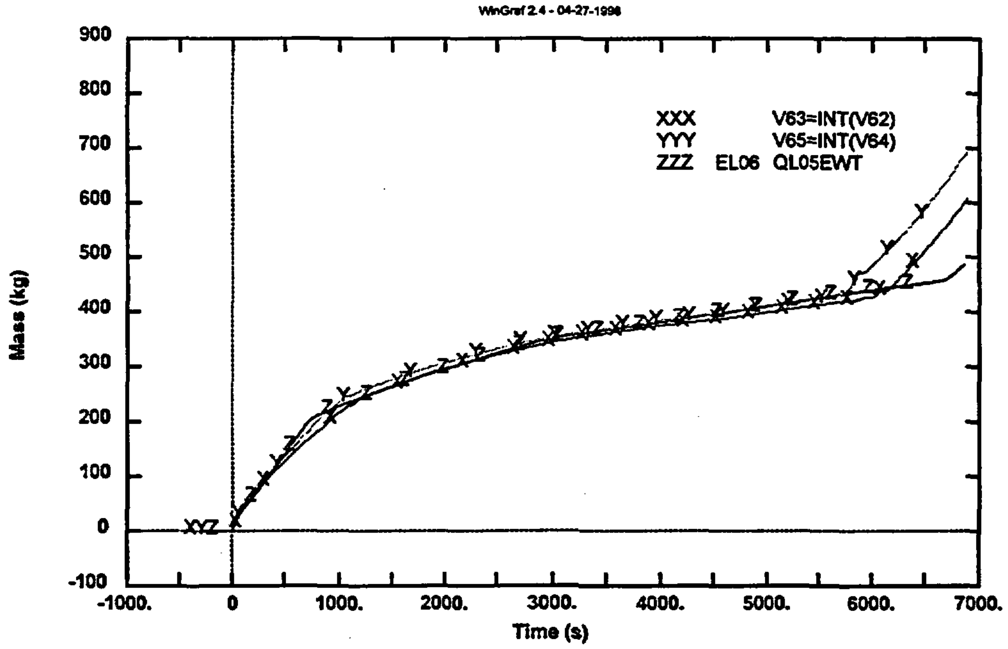

Fig. 4.26 : Break integral flow rate

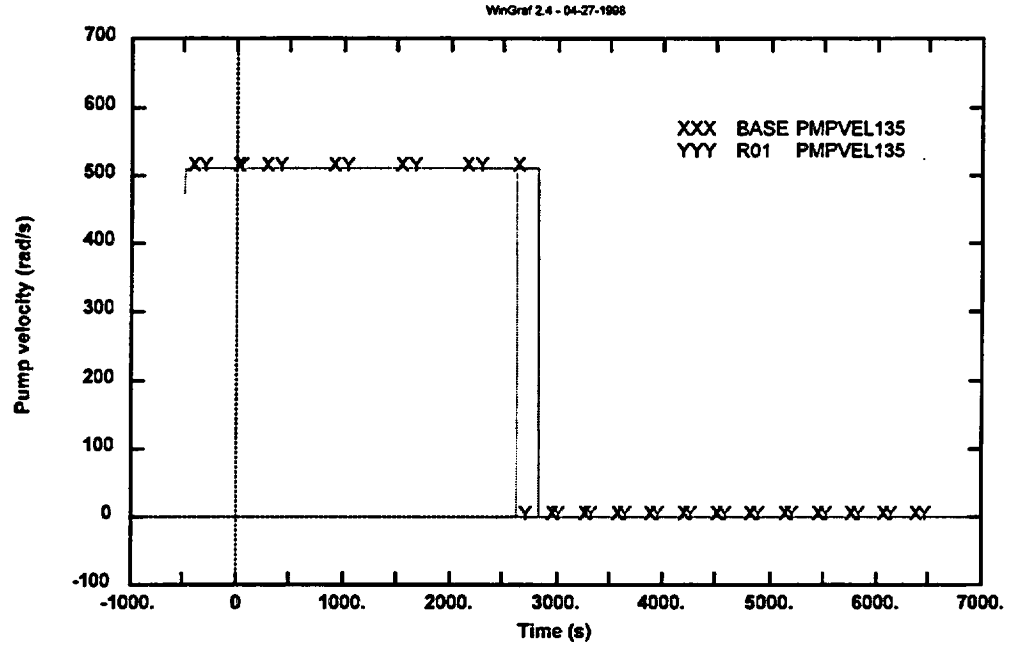

Fig. 4.27 : Main coolant pumps speed

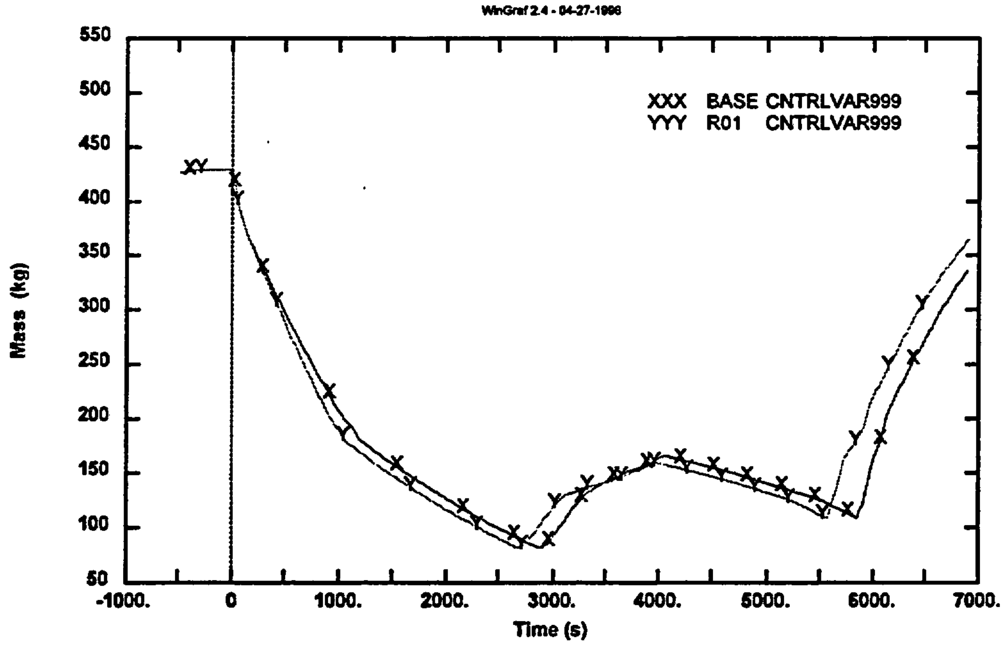

Fig. 4.28 : Primary system mass inventory

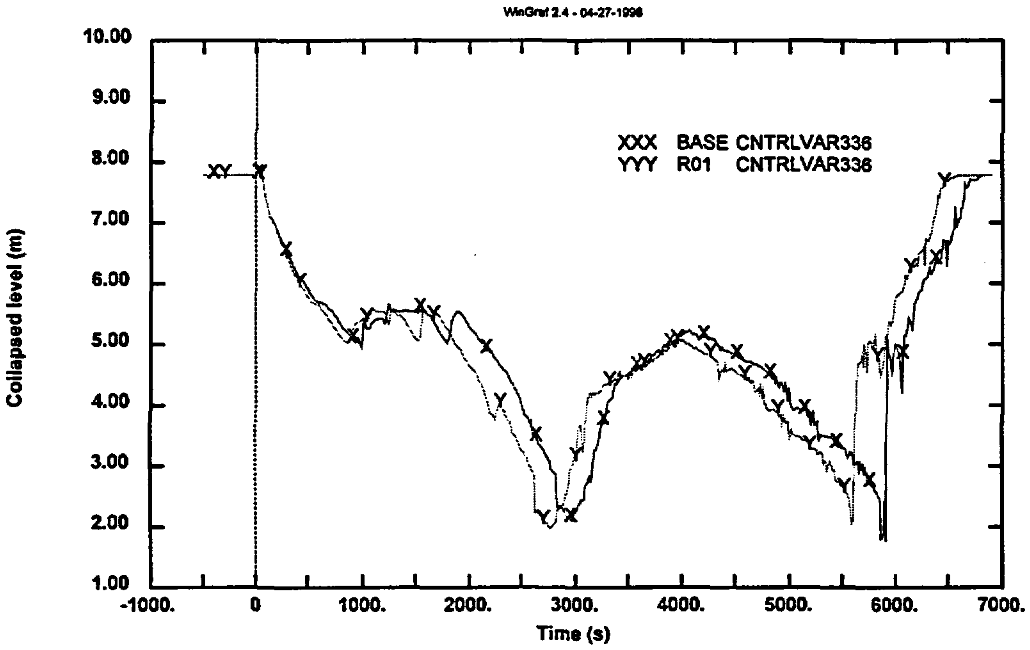

Fig. 4.29 : Collapsed level in the riser

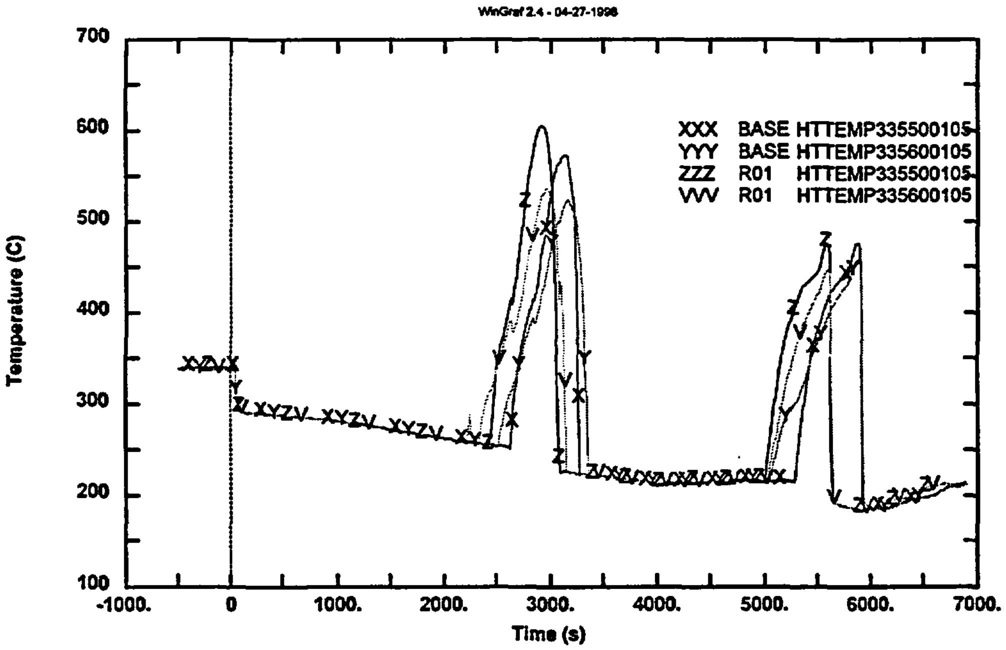

Fig. 4.30 : Rod surface temperature (high level)

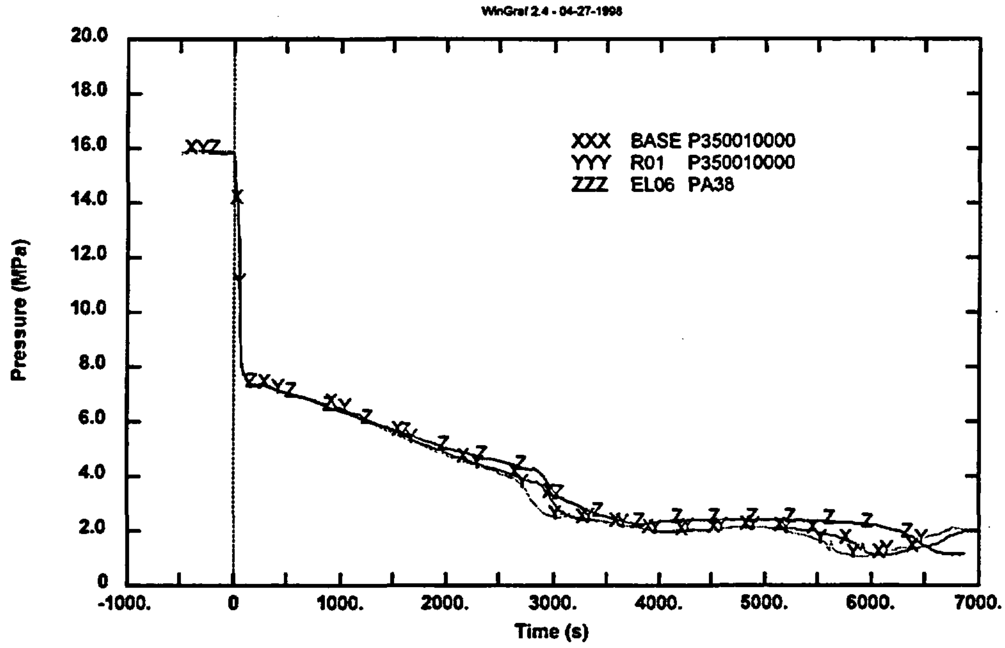

Fig. 4.31 : Primary system pressure

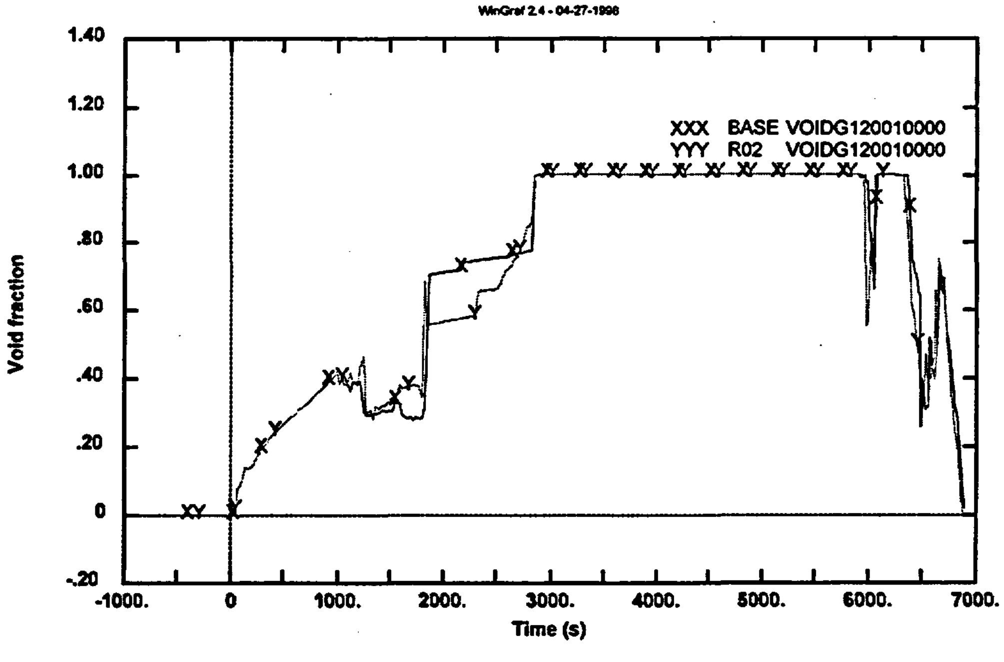

Fig. 4.32 : Void fraction at steam generator inlet (IL)

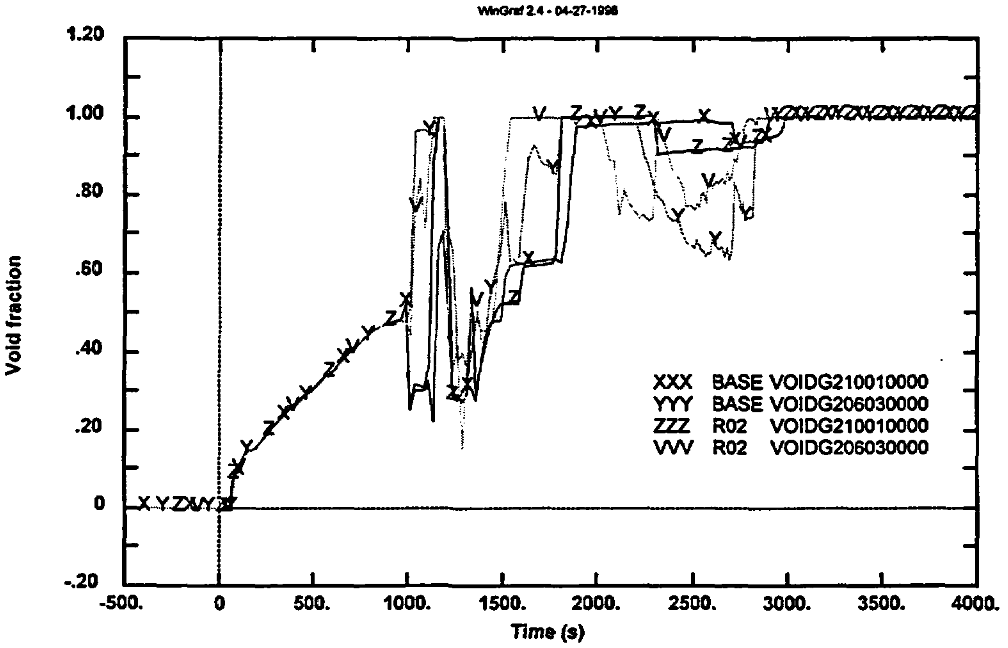

Fig. 4.33 : Void fraction at the upstream and downstream volumes of the junction 208

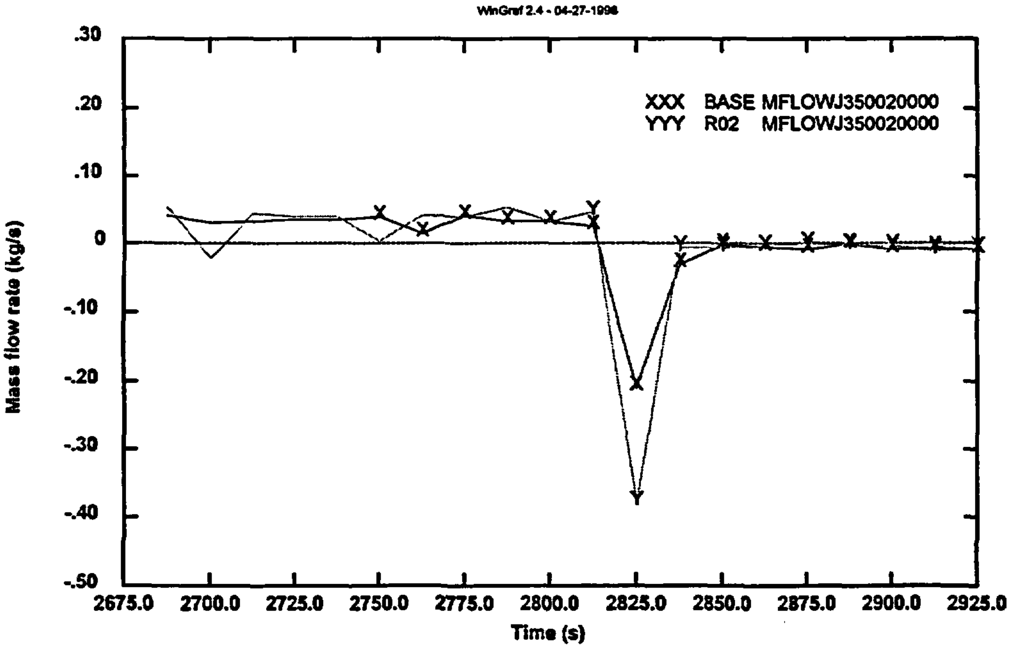

Fig. 4.34 : Mass flow rate of junction that connects the vessel to the hot leg of intact loop

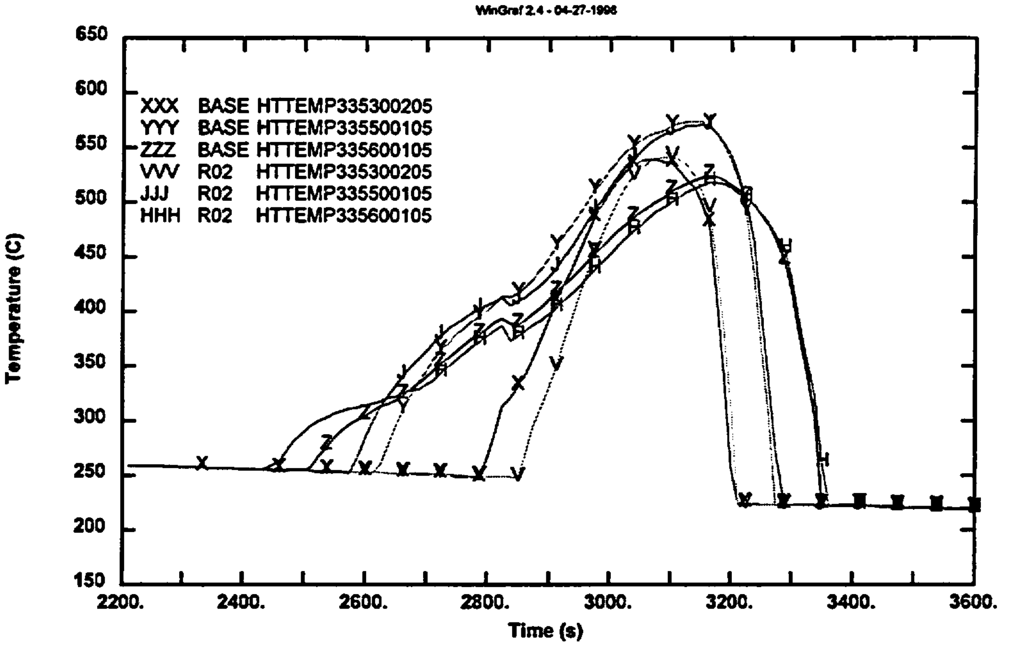

Fig. 4.35 : Heater rod temperature

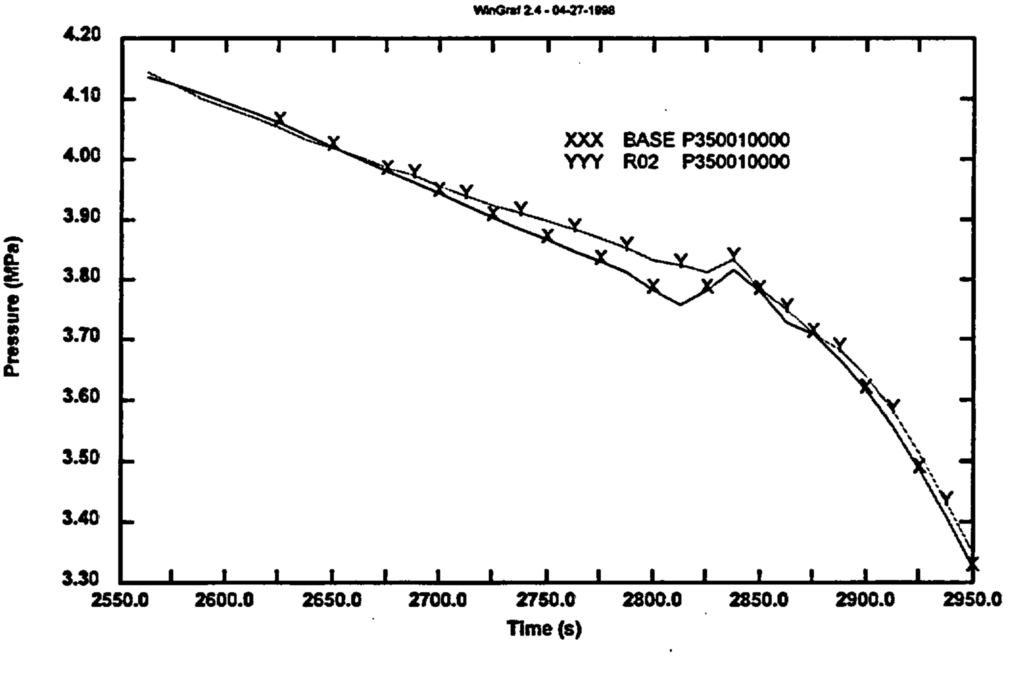

Fig. 4.36 : Primary system pressure

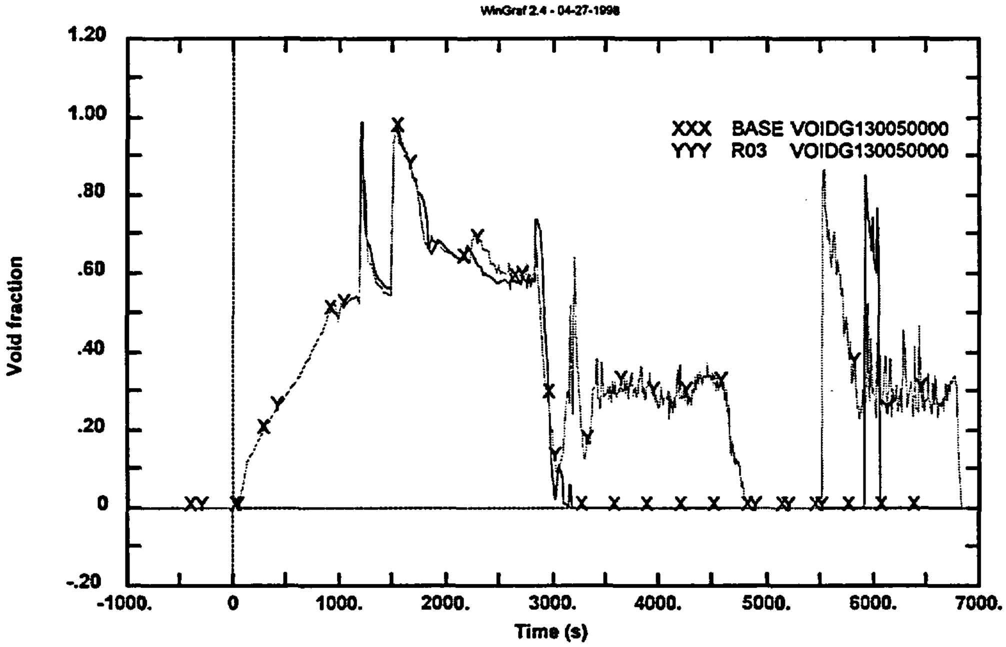

Fig. 4.37 : Void fraction in the loop seal (vol. 13005)

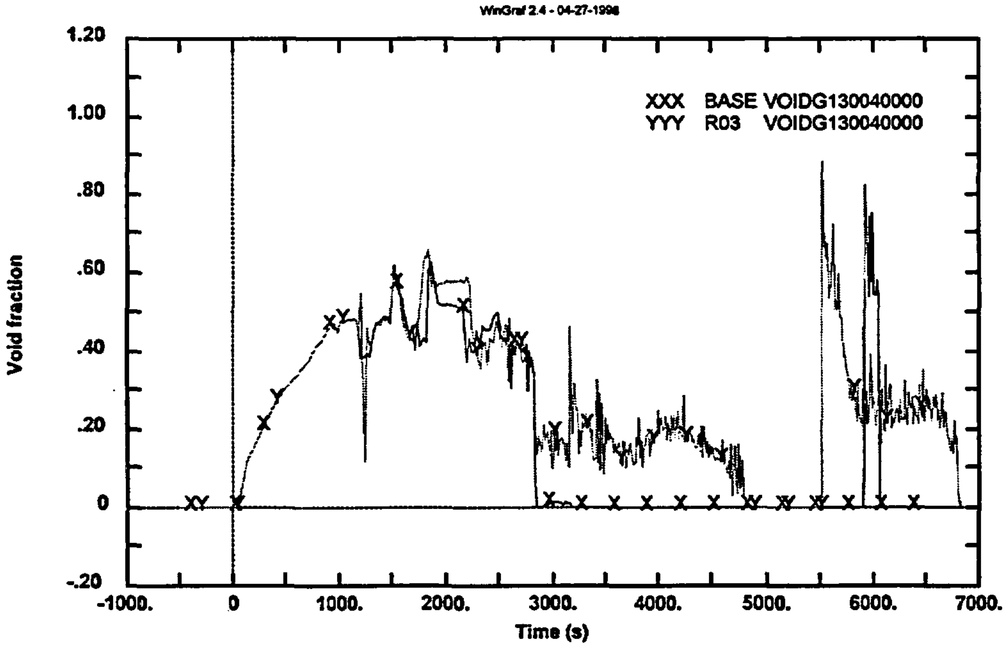

Fig. 4.38 : Void fraction in the loop seal (vol. 13004)

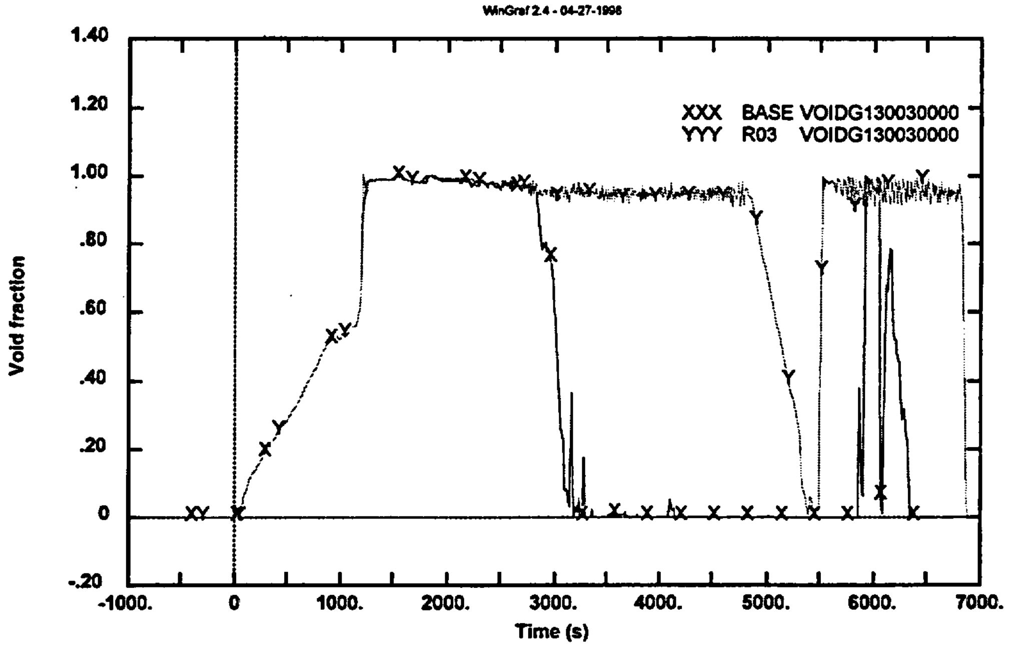

Fig. 4.39 : Void fraction in the loop seal (vol. 13003)

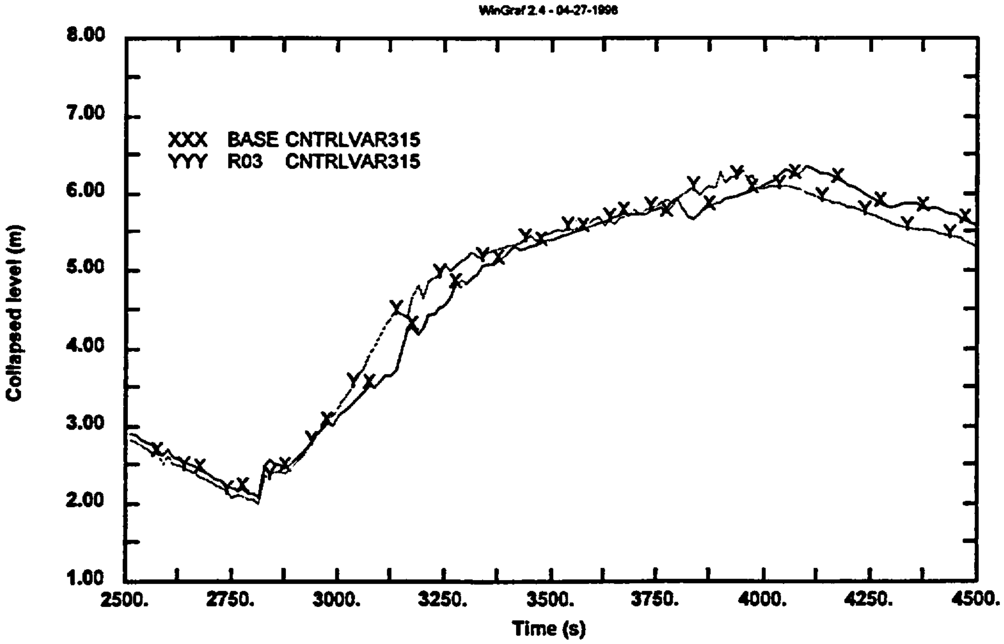

Fig. 4.40 : Collapsed level in the downcomer

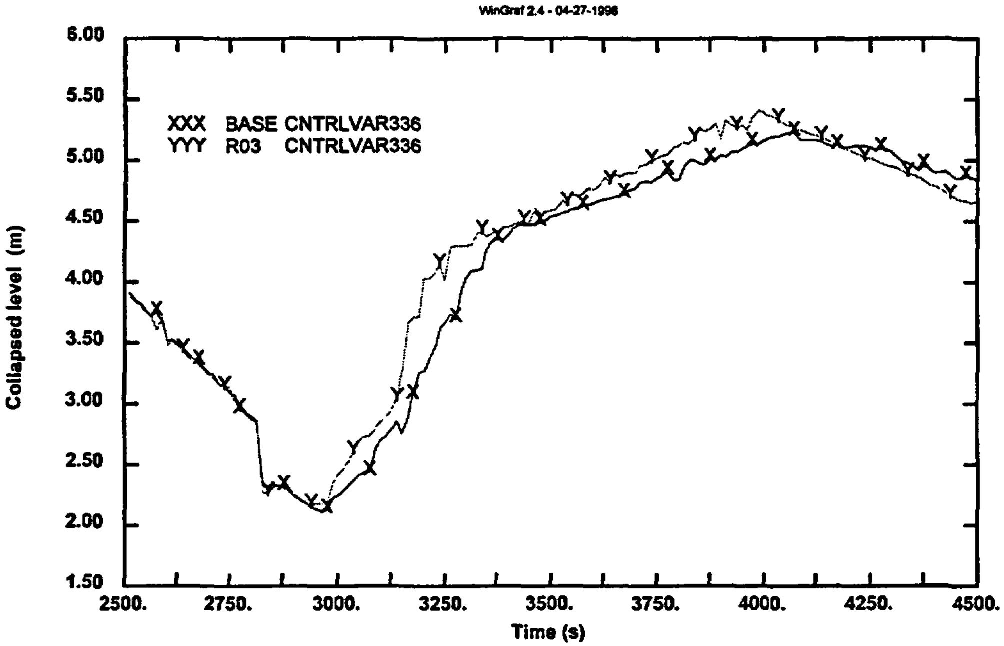

Fig. 4.41 : Collapsed level in the riser

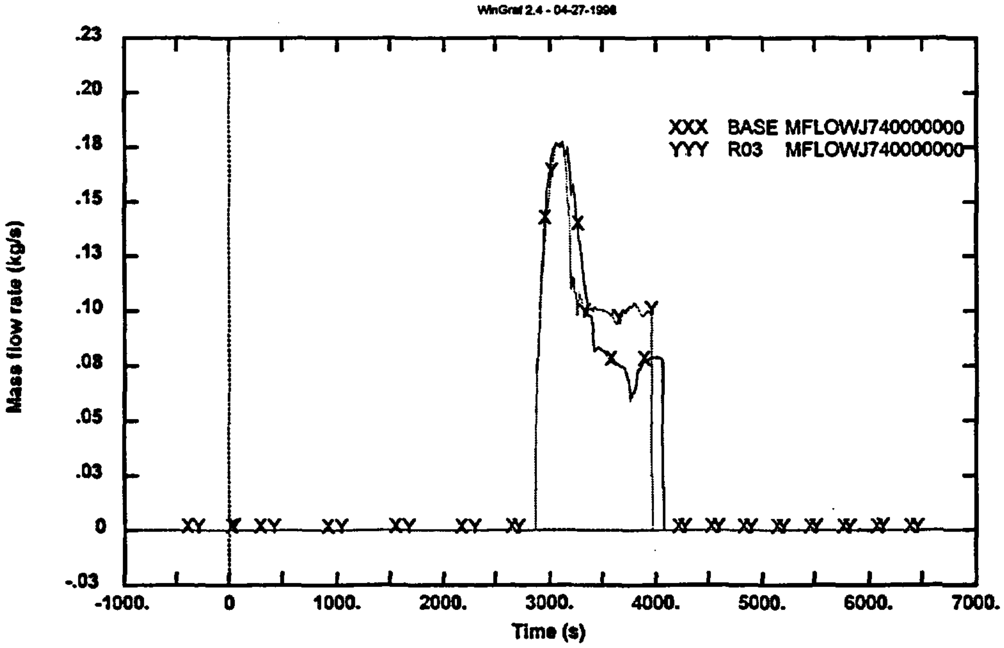

Fig. 4.42 : Accumulator mass flow rate

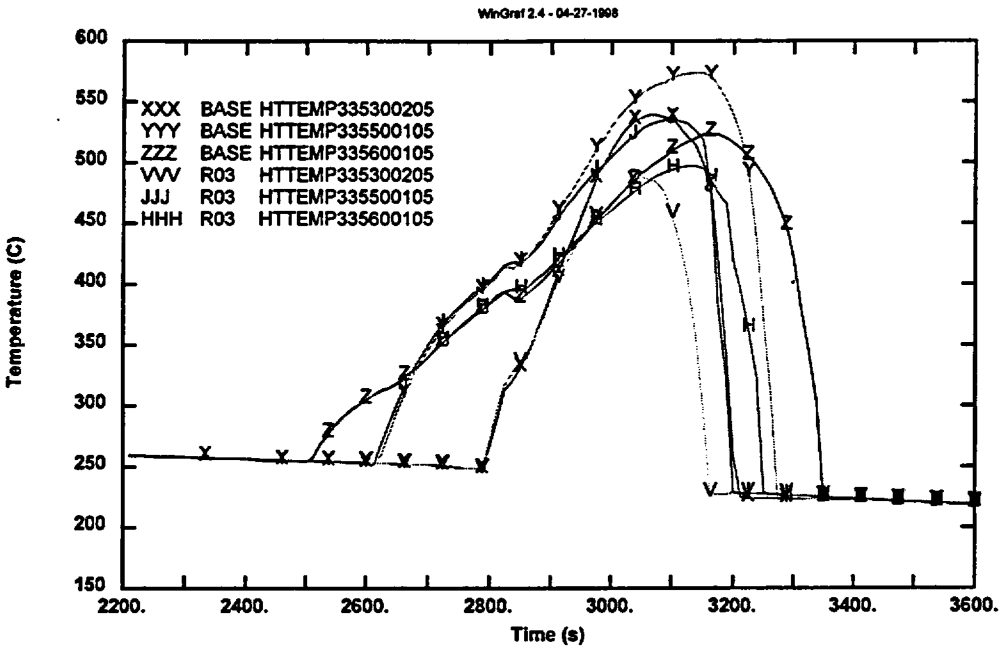

Fig. 4.43 : Heater rod temperature

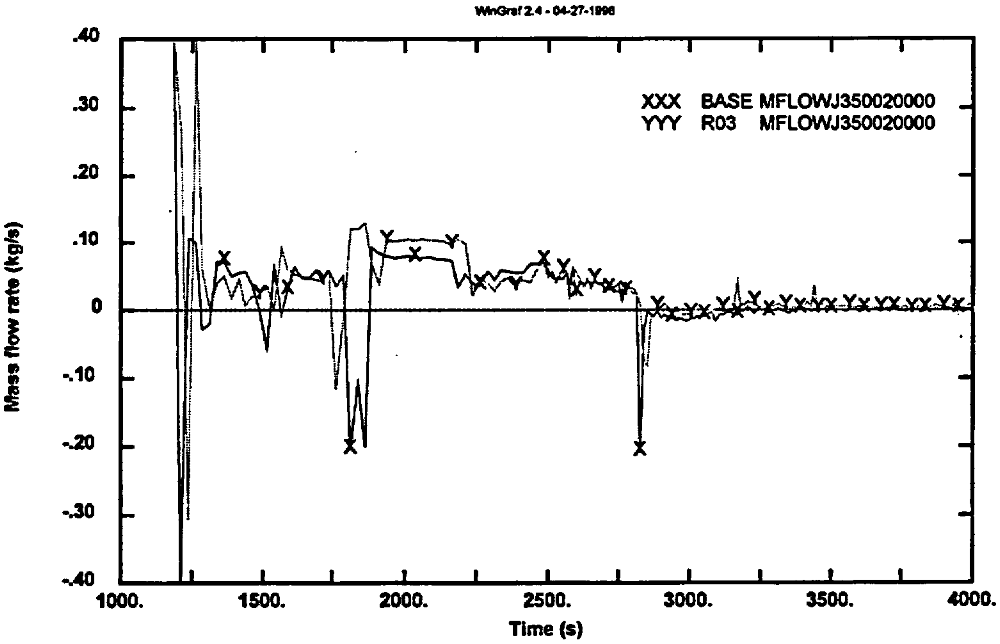

Fig. 4.44 : Mass flow rate of junction that connects the vessel to the hot leg of intact loop

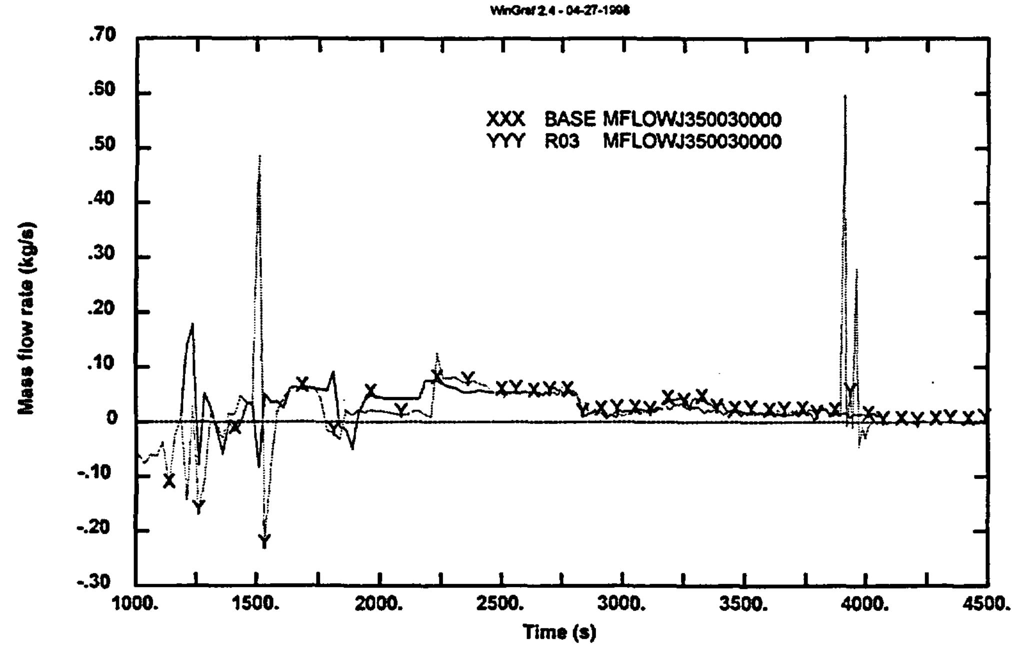

Fig. 4.45 : Mass flow rate of junction that connects the vessel to the hot leg of broken loop

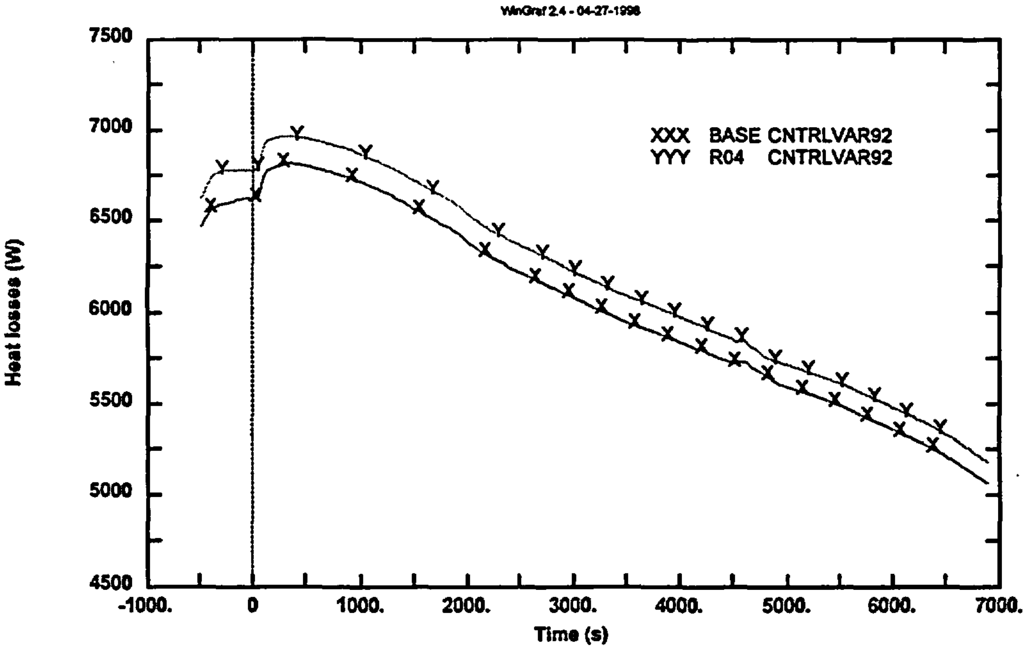

Fig. 4.46 :Heat loss of the secondary system of the steam generator (IL)

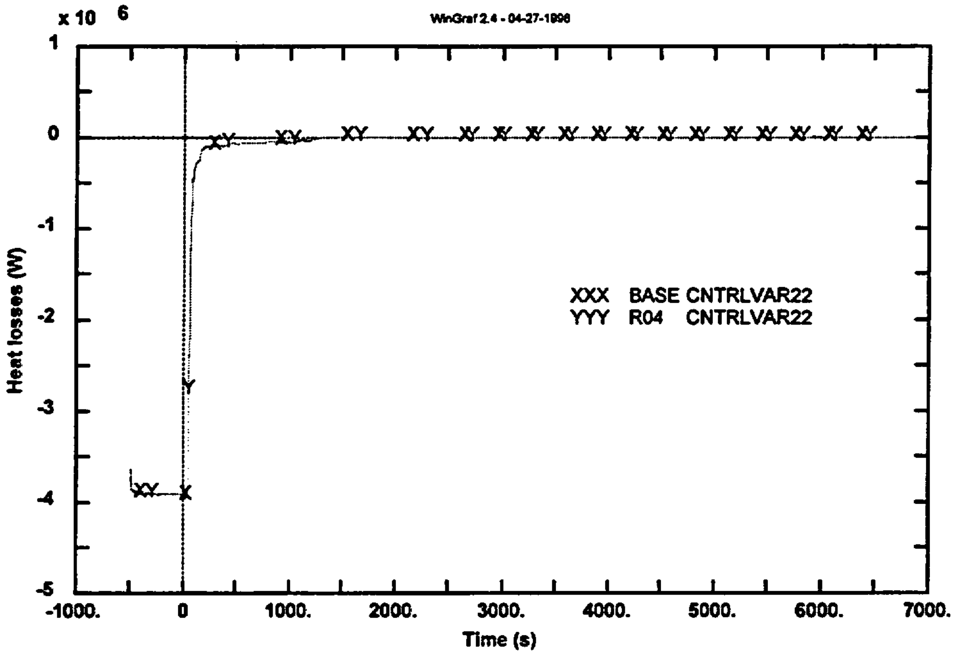

Fig. 4.47 : Heat transfer exchange power for the intact loop steam generator

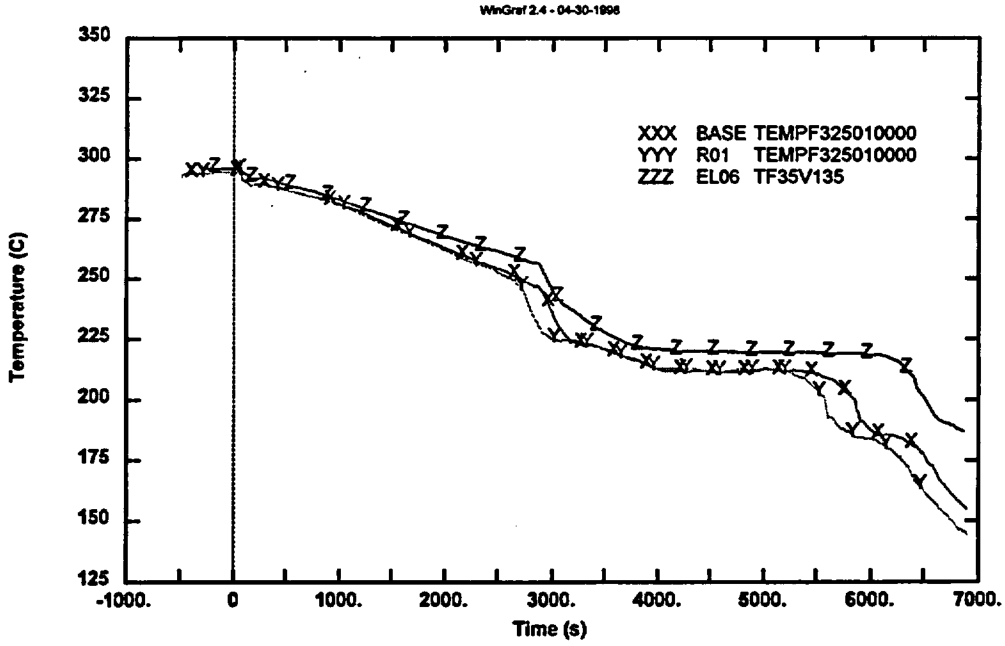

Fig. 4.48 : Core inlet fluid temperature

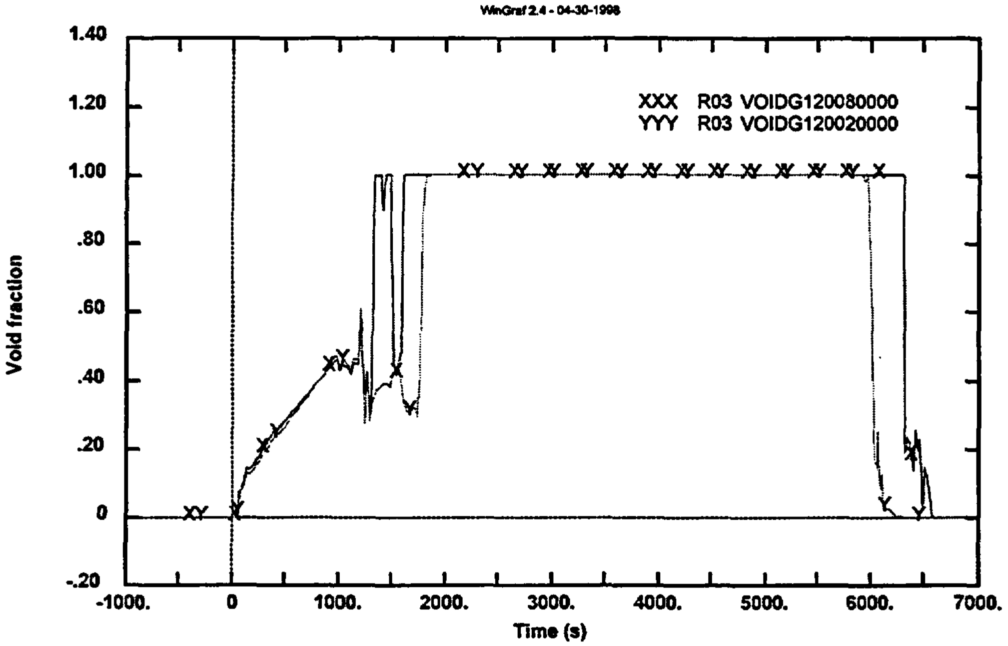

Fig. 4.49 : Void fraction in the U-tubes

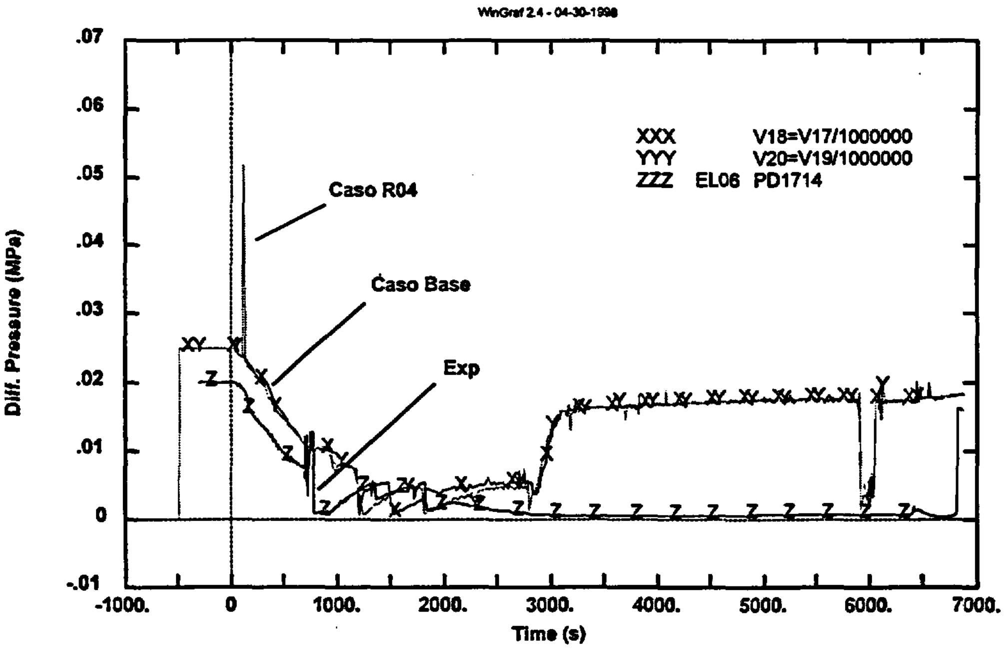

Fig. 4.50 : Pressure difference in the ascending side of the loop seal (IL)

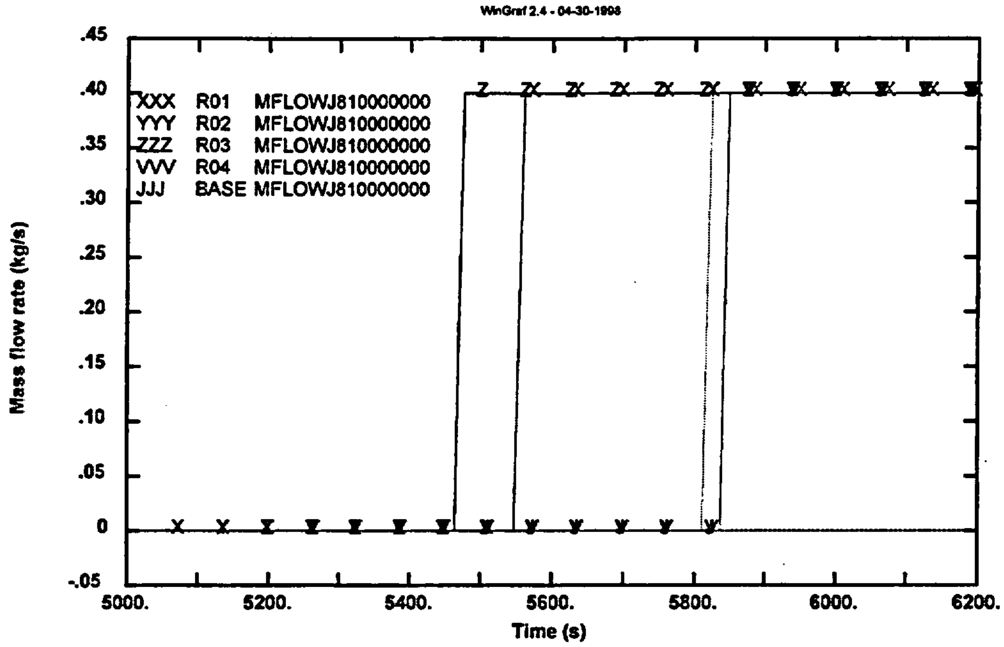

Fig. 4.51 : LPIS mass flowrate

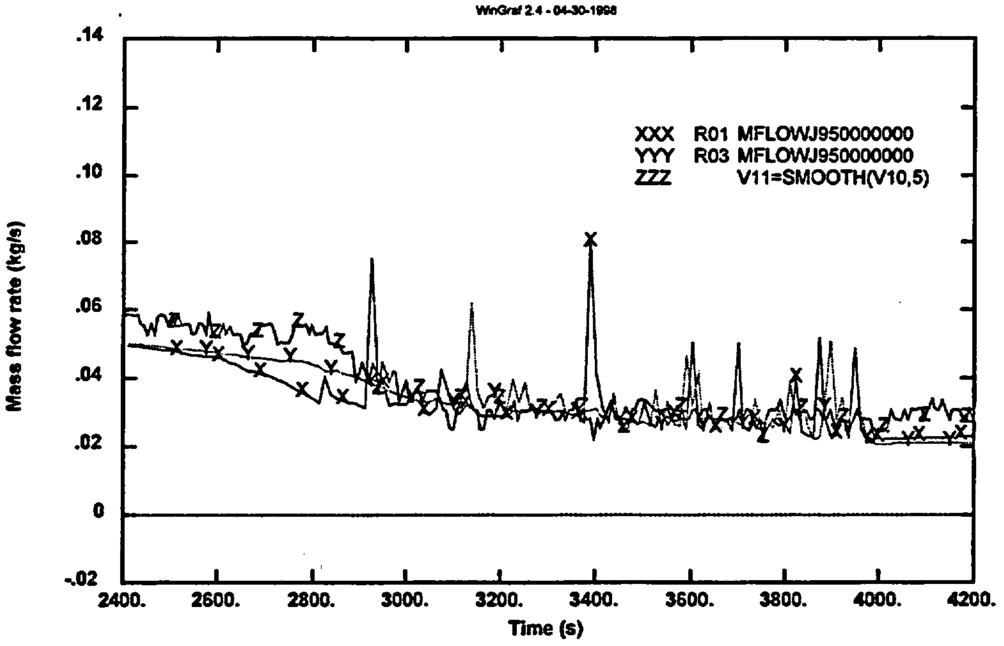

Fig. 4.52 : Break mass flow rate

5. CONCLUSIONS

Conclusion can be considered from two separate points of view:

1 - experimental evidences

2 - performances of the code

With reference to the point 1 it can be observed that:

- the recession of the CCFL conditions determines a reduction in the core heat-up rate;
- in the given scenario, the accumulator is able to terminate the core temperature excursion bringing core in saturation conditions;
- after the emptying of the accumulator, the primary system repressurizes preventing the LPIS actuation and causing a second core dryout;
- the actuation of the LPIS determines the long term quenching of the heater rods.

Regarding to the performances of the code it can be observed that in general all the main phenomena are well reproduced and the timing of the events is good too.

In particular have been simulated:

- primary and secondary side thermal coupling;
- the first core dryout together with the CCFL effect on temperature excursion;
- the asymmetrical loops behavior for the CCFL and pumps degradation;
- the accumulator injection.

The greatest discrepancies have been identified in the break flowrate and in the simulation of the loop seal.

The quantitative analysis has confirmed the goodness of the results showing a best accuracy in the temporal window 0-4900.

The sensitivity calculations present an improvement of the simulation limited to specific and partial aspects. The calculation more accurate is the base case and that is confirmed by the related FFT results.

The FFT method has been applied in order to get quantitative and qualitative evaluations of the code performance.

Based on the FFT results it can be stated that:

- the analytical evaluation of the code performance done comparing the experimental data with the calculated date has been confirmed by the FFT results;
- the FFT is very effective as a tool for a fast screening of the code performances.

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LIST OF ABBREVIATIONS

AUXFEED	Auxiliary feedwater
AA	Average amplitude
ACC	Accumulator
BL	Broken Loop
CCFL	Counter Current Flow Limitation
CSNI	Committee on the Safety of Nuclear Installations
DC	Downcomer
DP	Pressure Drop
ECCS	Emergency Core Cooling Systems
FFT	Fast Fourier Transform
IL	Intact Loop
LPIS	Low Pressure Injection System
MCP	Main Coolant Pump
MSIV	Main Steam Isolation Valve
PORV	Pressurizer Operated Relief Valve
PRZ	Pressurizer
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
SG	Steam Generator
TDJ	Time Dependent Junction
TDV	Time Dependent Volume
UMAE	Uncertainty Methodology based on Accuracy Extrapolation
WF	Weighted Frequency

APPENDIX 1:

Results of the reference calculation

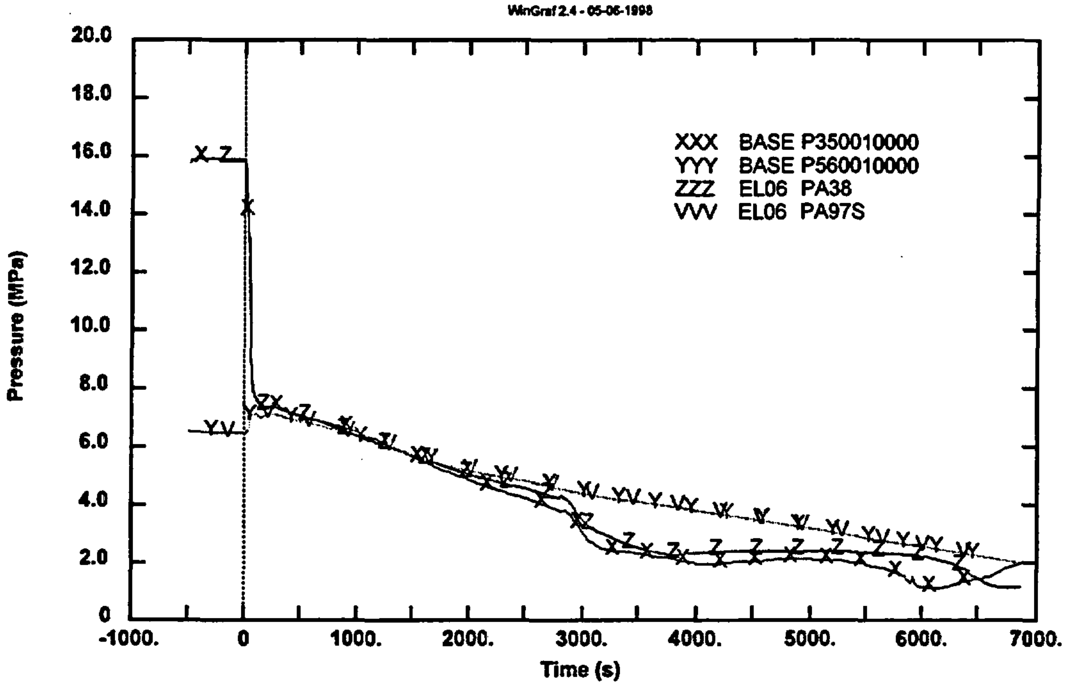

Fig. 1 : Primary and secondary pressure

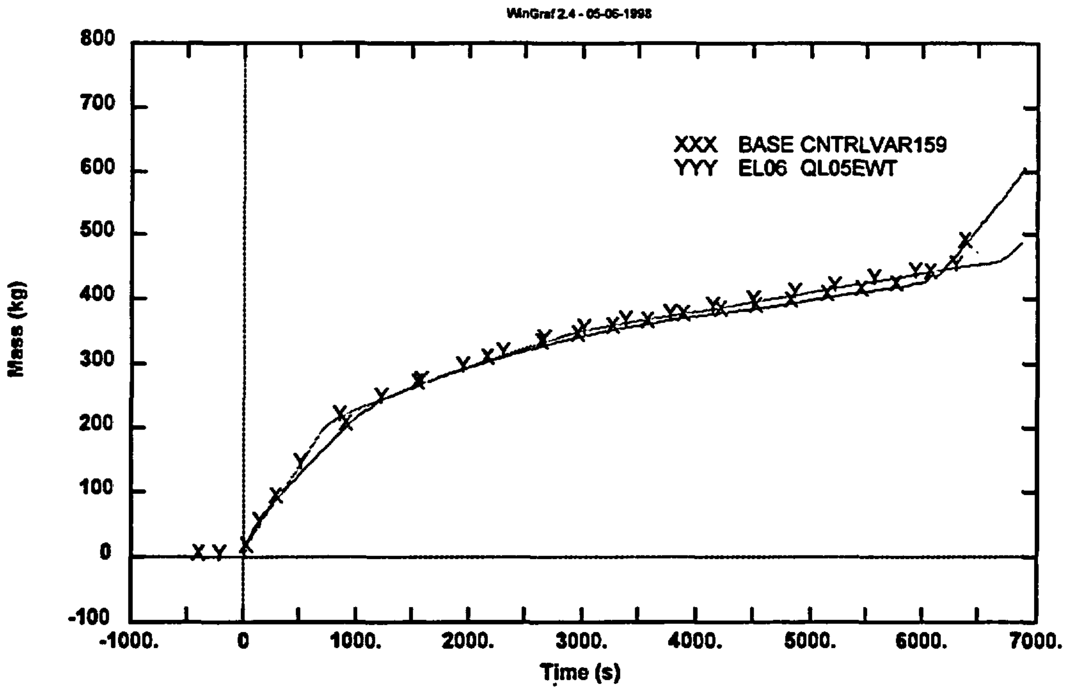

Fig. 2 : Break integral flow rate

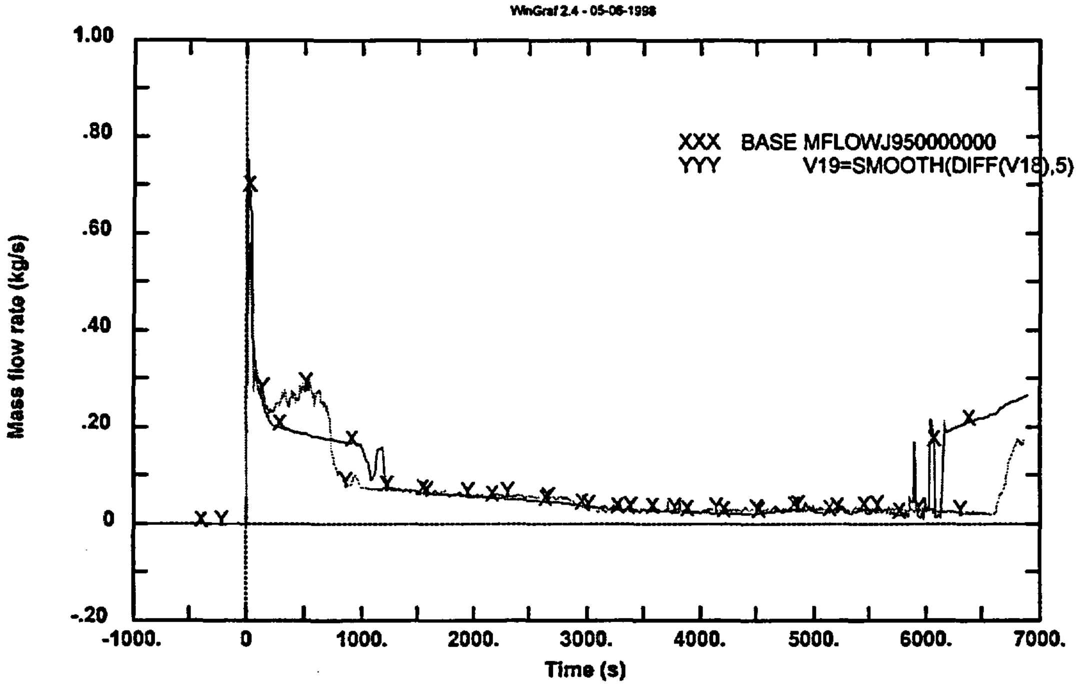

Fig. 3 : Break mass flow rate

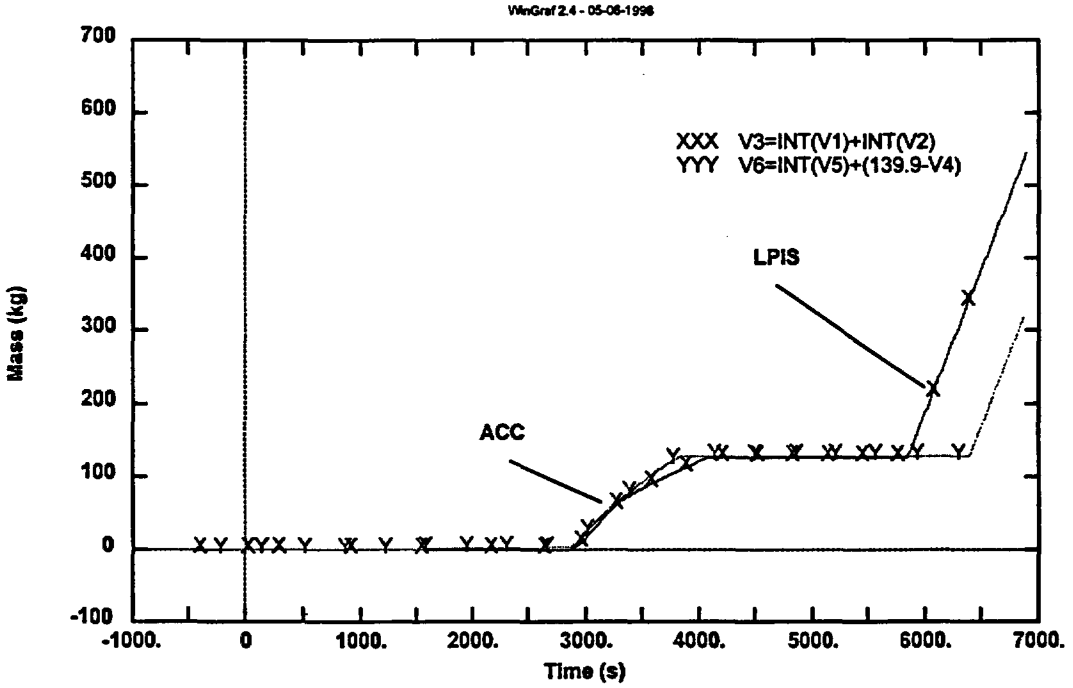

Fig. 4 : Integrated mass injected in the primary system from the emergency systems

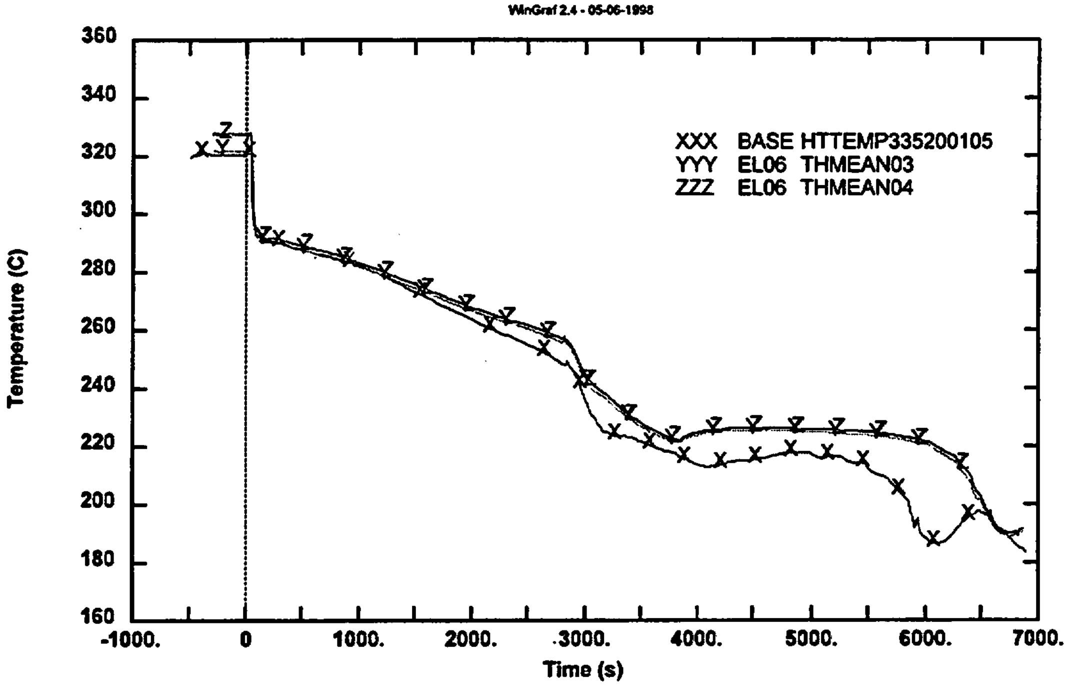

Fig. 5 : Rod surface temperature (bottom level)

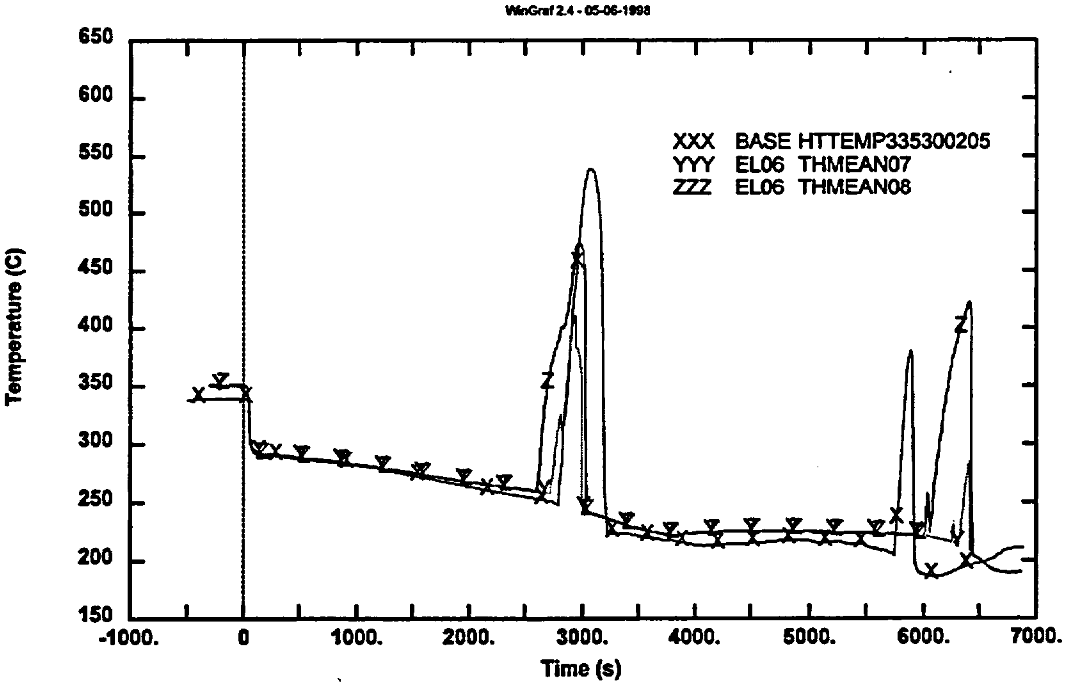

Fig. 6 : Rod surface temperature (middle level)

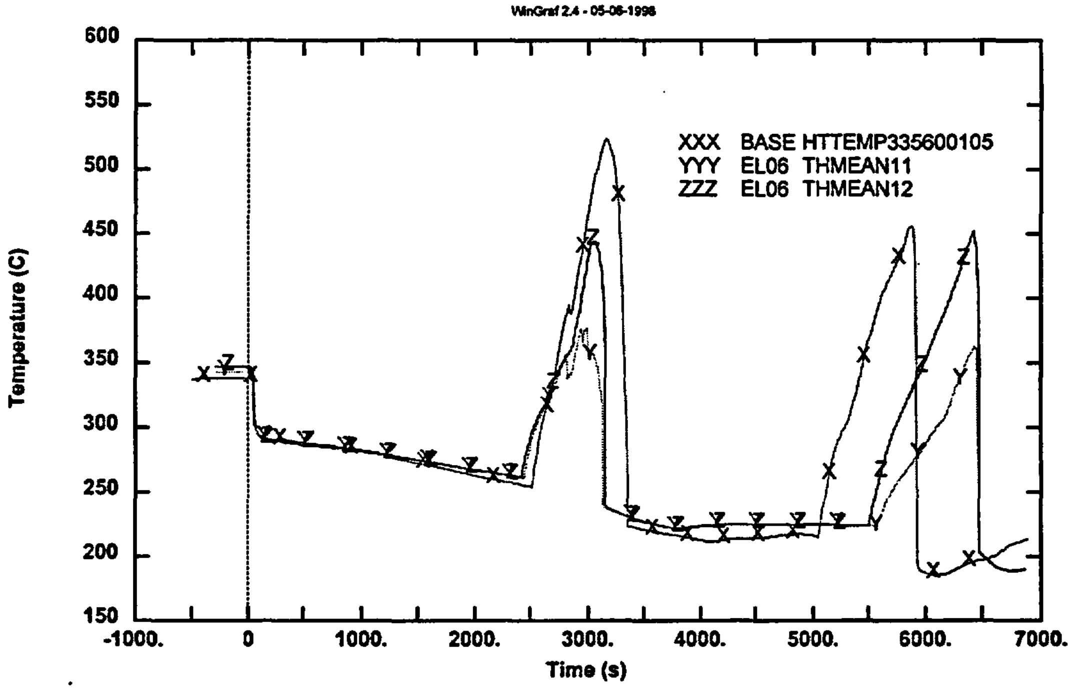

Fig. 7 : Rod surface temperature (high level)

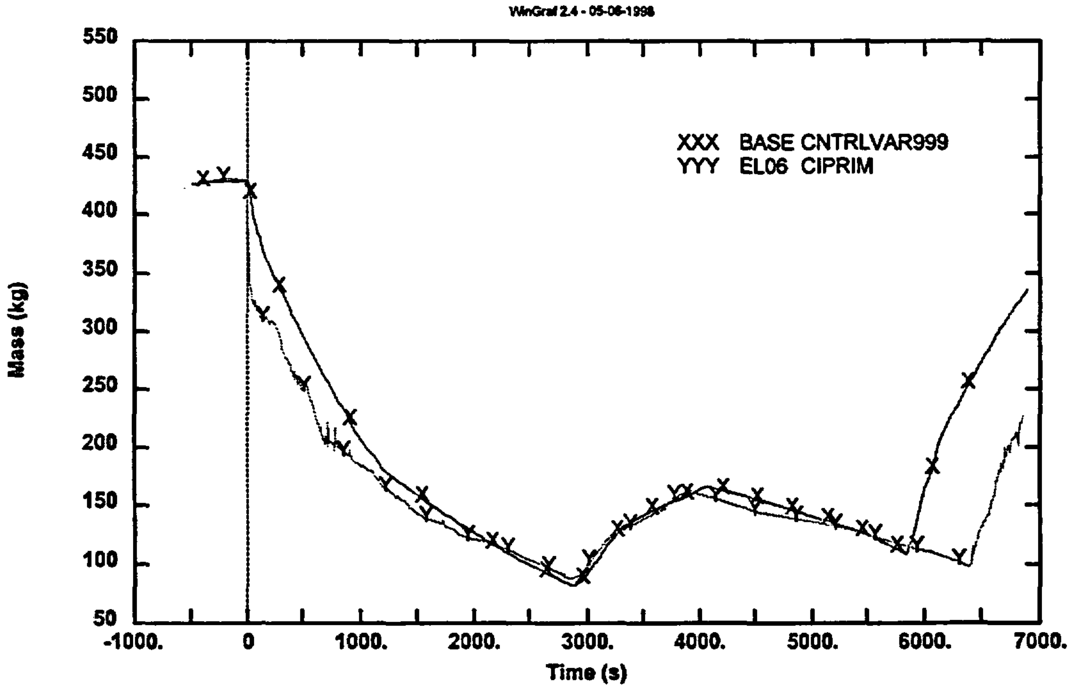

Fig. 8 : Primary system mass inventory

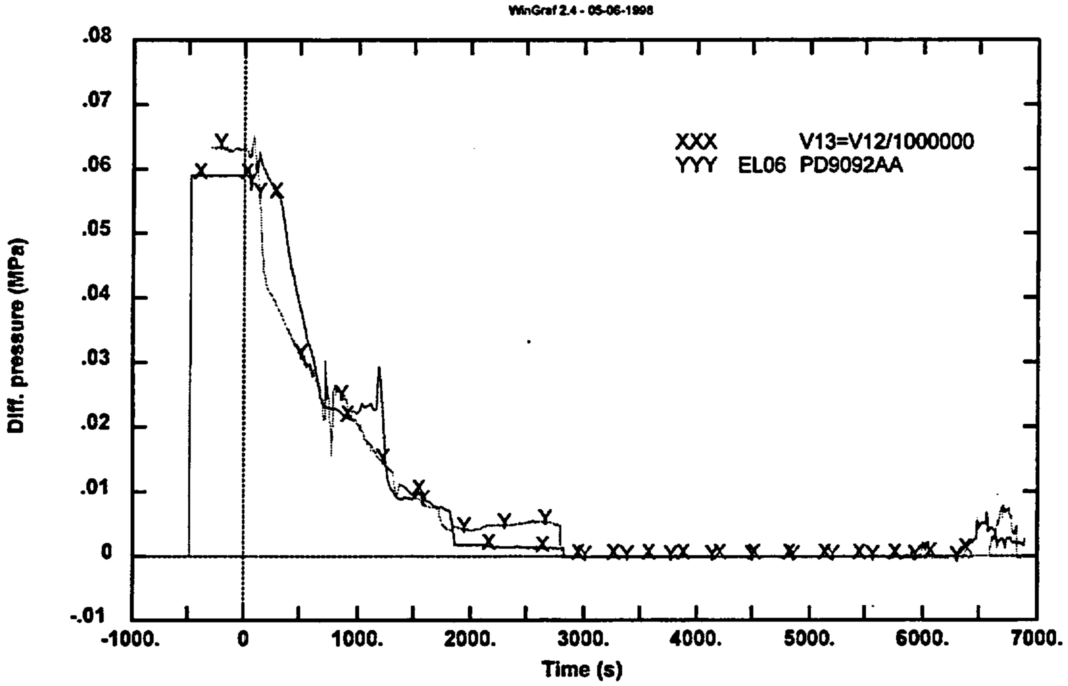

Fig. 9 : Pressure difference between the entry and the exit of the intact loop steam genarator

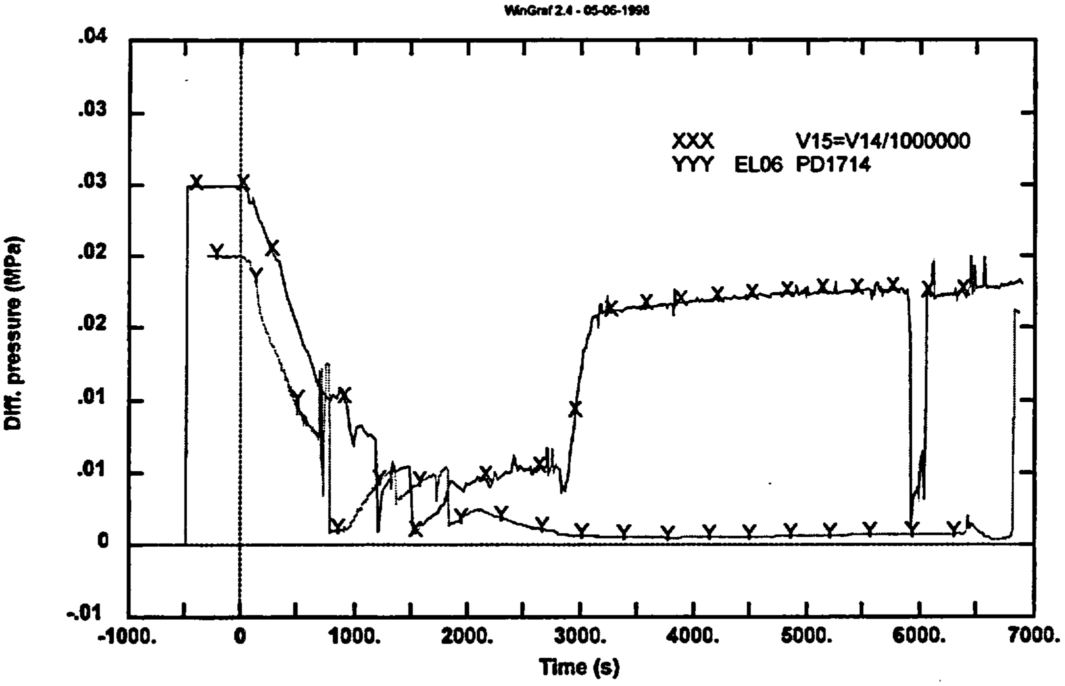

Fig. 10 : Pressure difference in the ascending side of the loop seal of the intact loop

APPENDIX 2:

Results of the sensitivity calculation R01

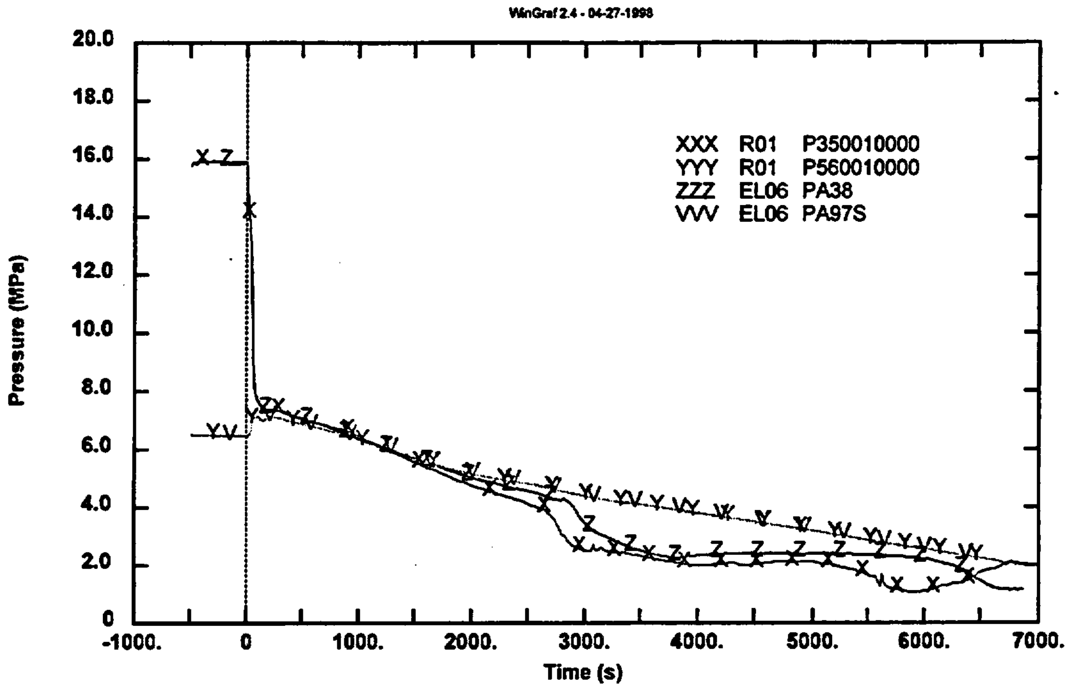

Fig. 1 : Primary and secondary pressure

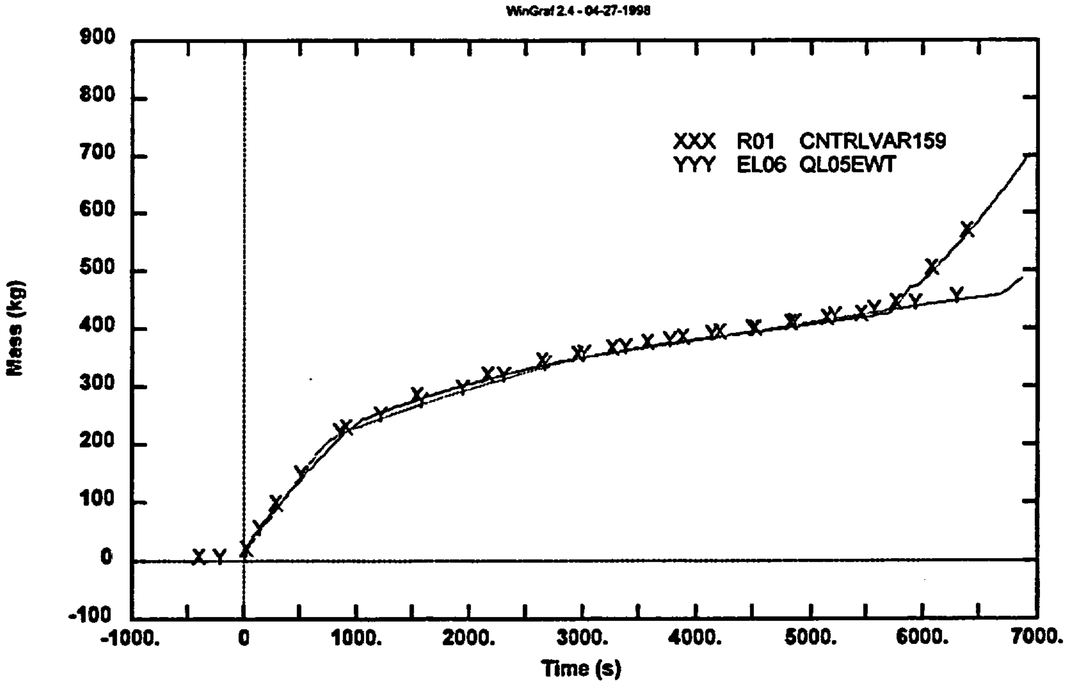

Fig. 2 : Break integral flow rate

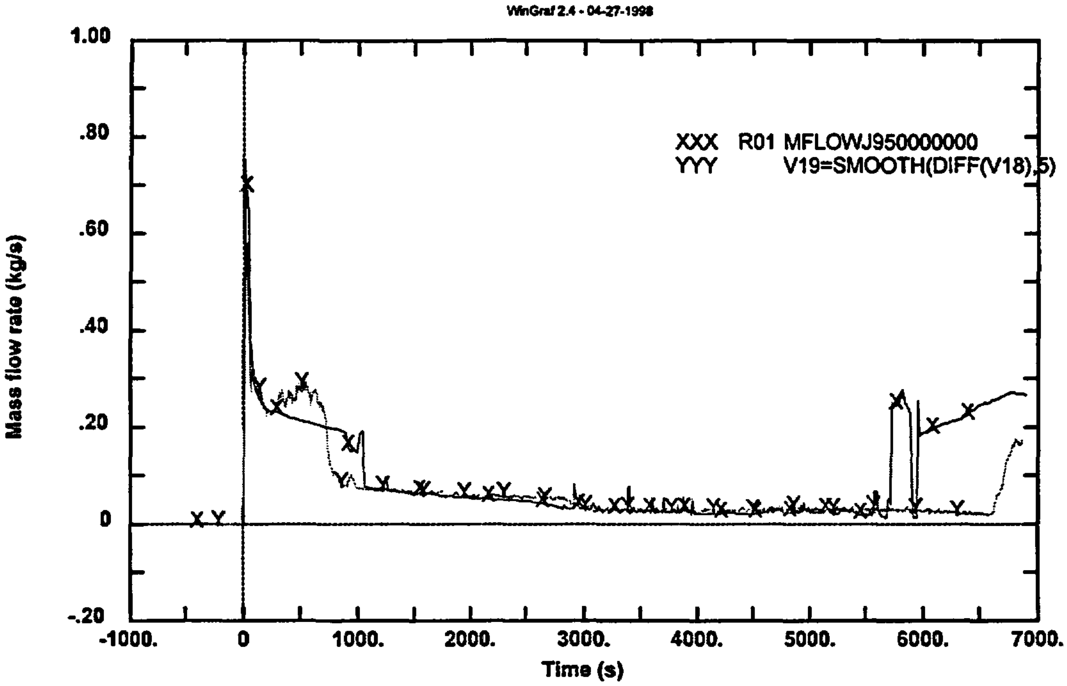

Fig. 3 : Break mass flow rate

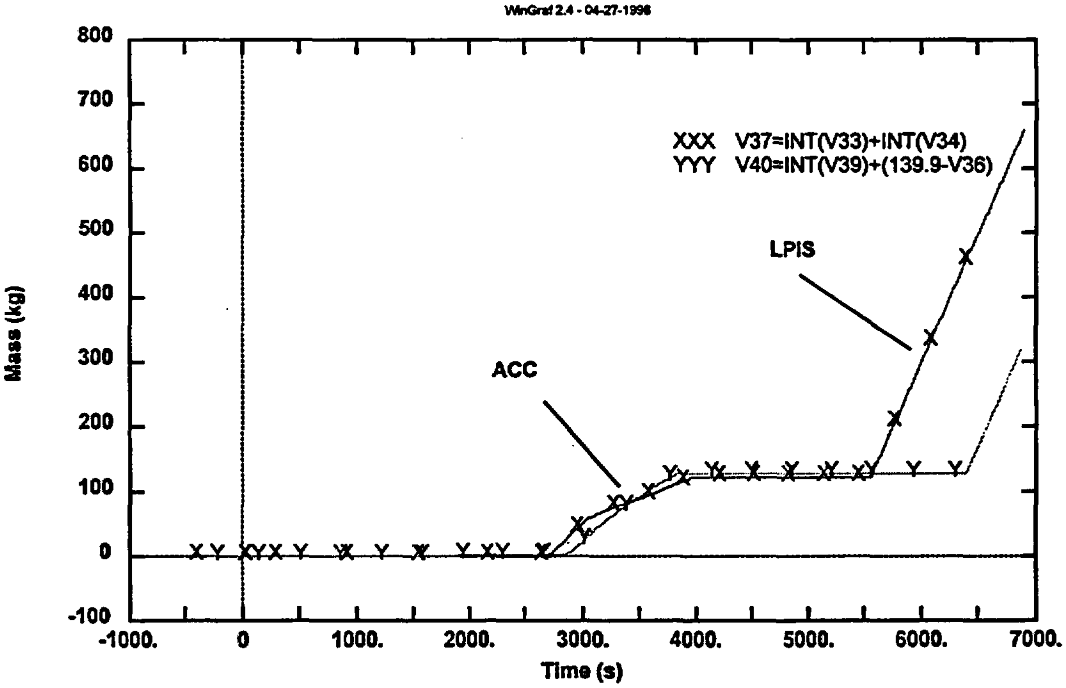

Fig. 4 : Integrated mass injected in the primary system from the emergency systems

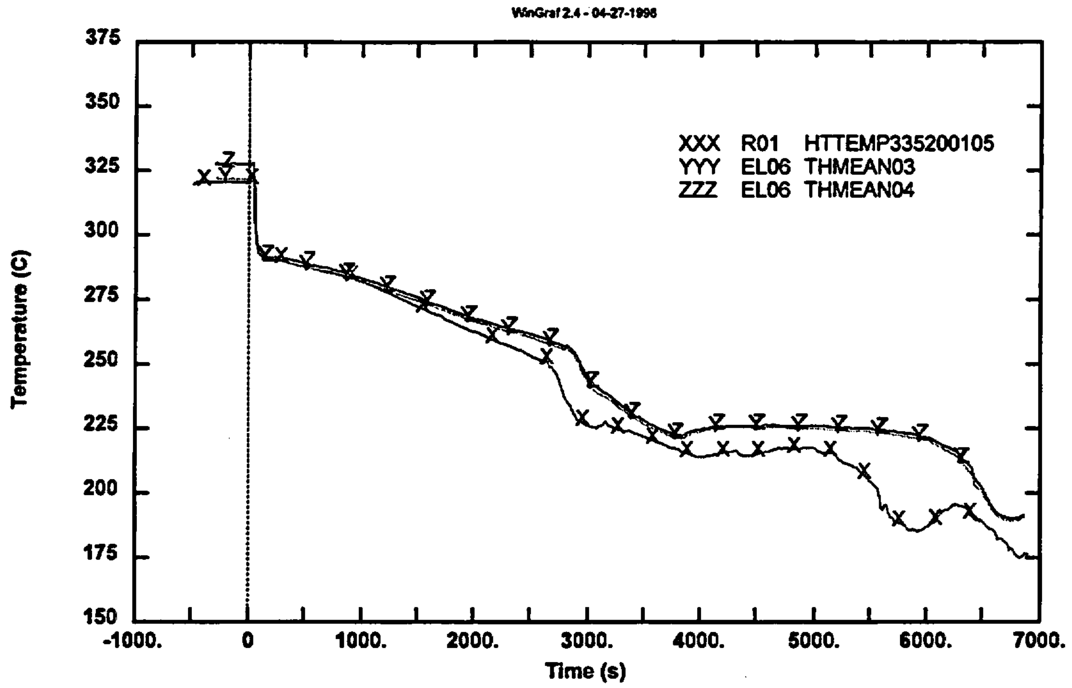

Fig. 5 : Rod surface temperature (bottom level)

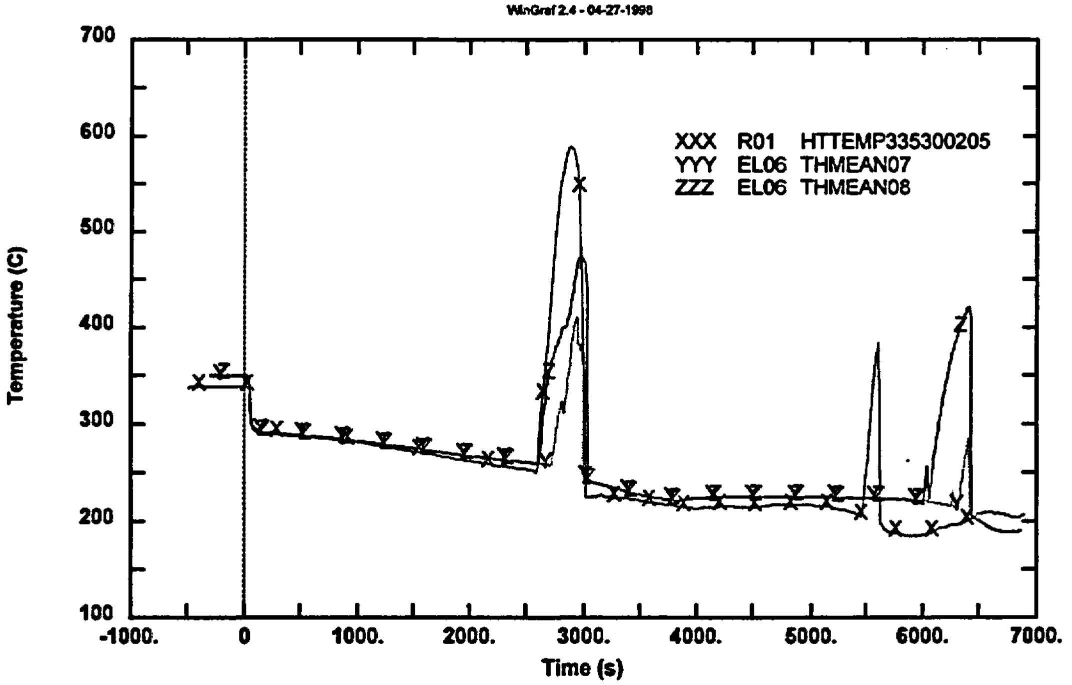

Fig. 6 : Rod surface temperature (middle level)

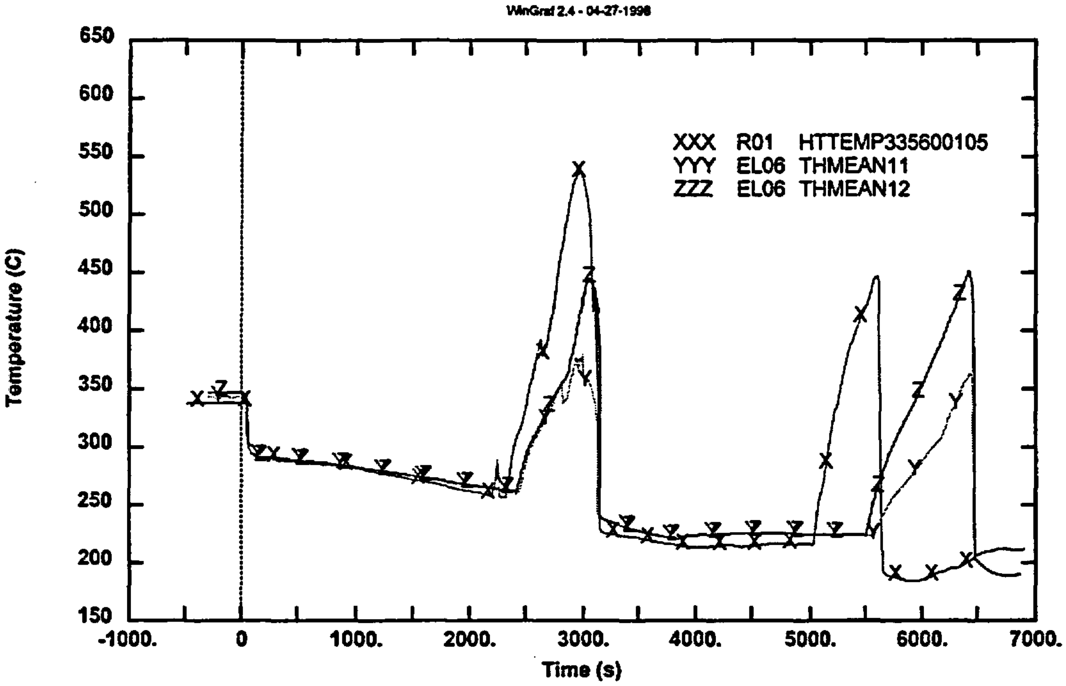

Fig. 7 : Rod surface temperature (high level)

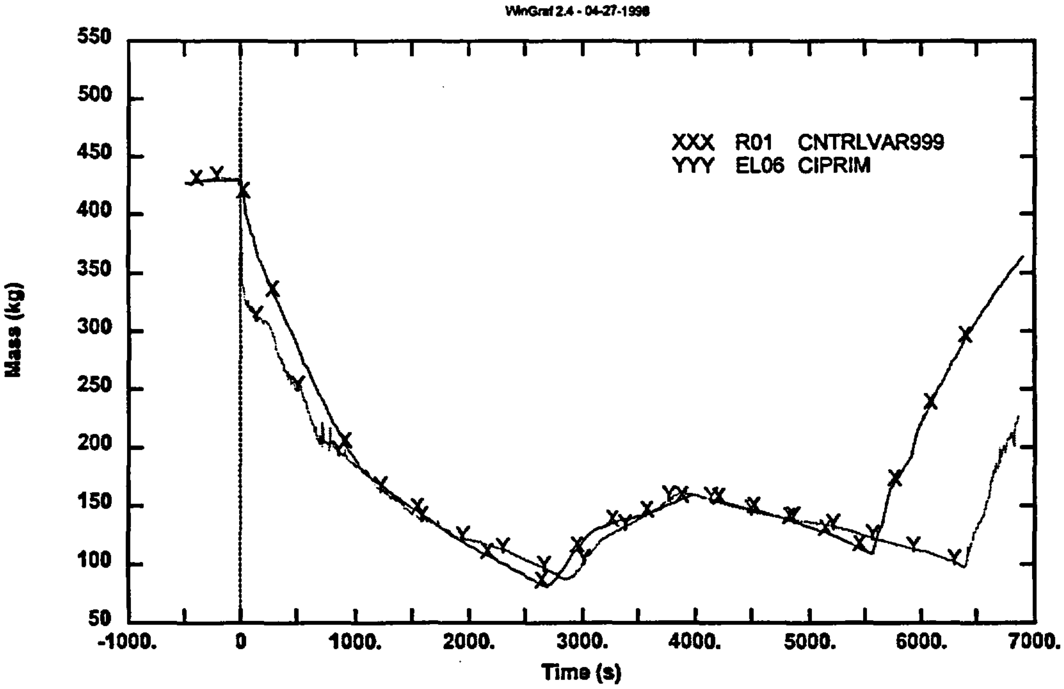

Fig. 8 : Primary system mass inventory

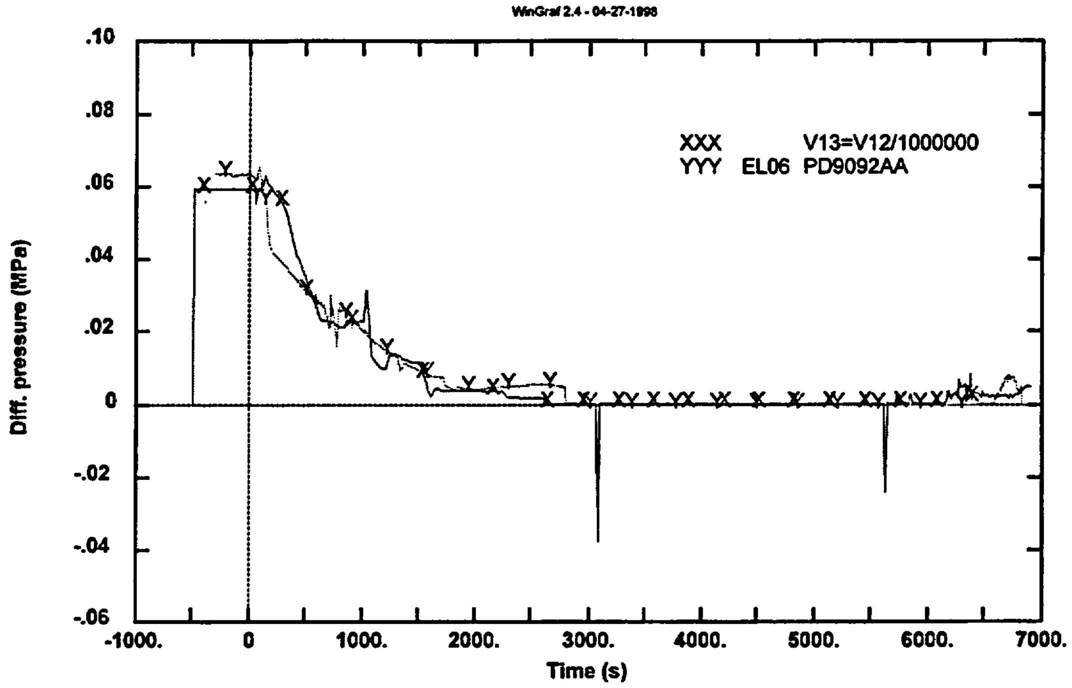

Fig. 9 : Pressure difference between the entry and the exit of the intact loop steam genarator

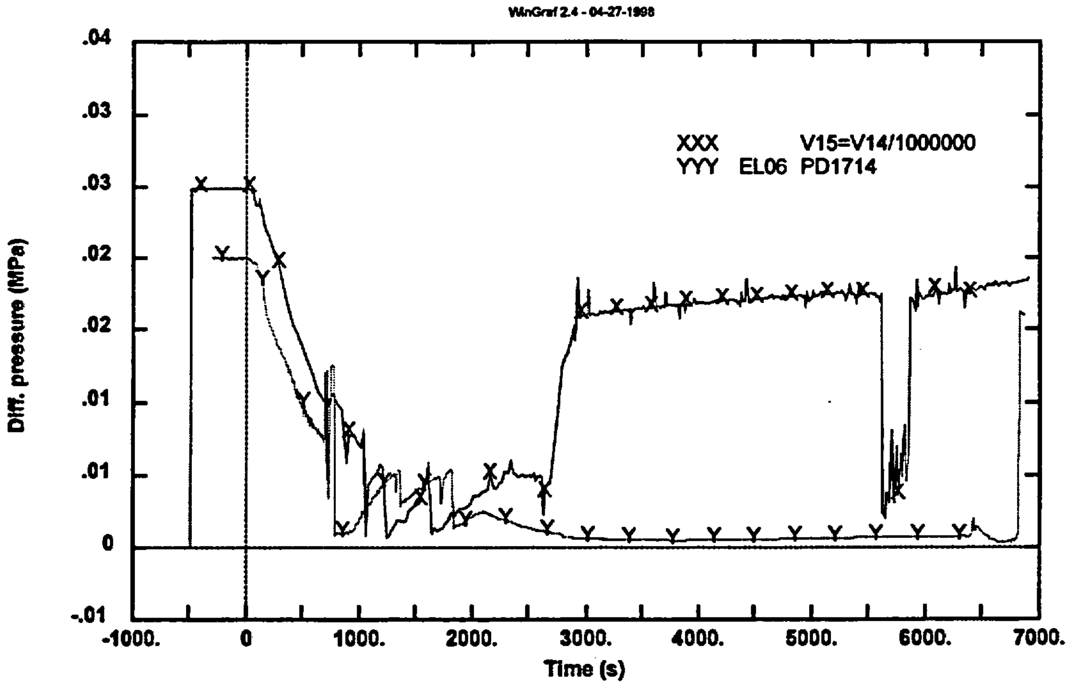

Fig. 10 : Pressure difference in the ascending side of the loop seal of the intact loop

APPENDIX 3:

Results of the sensitivity calculation R02

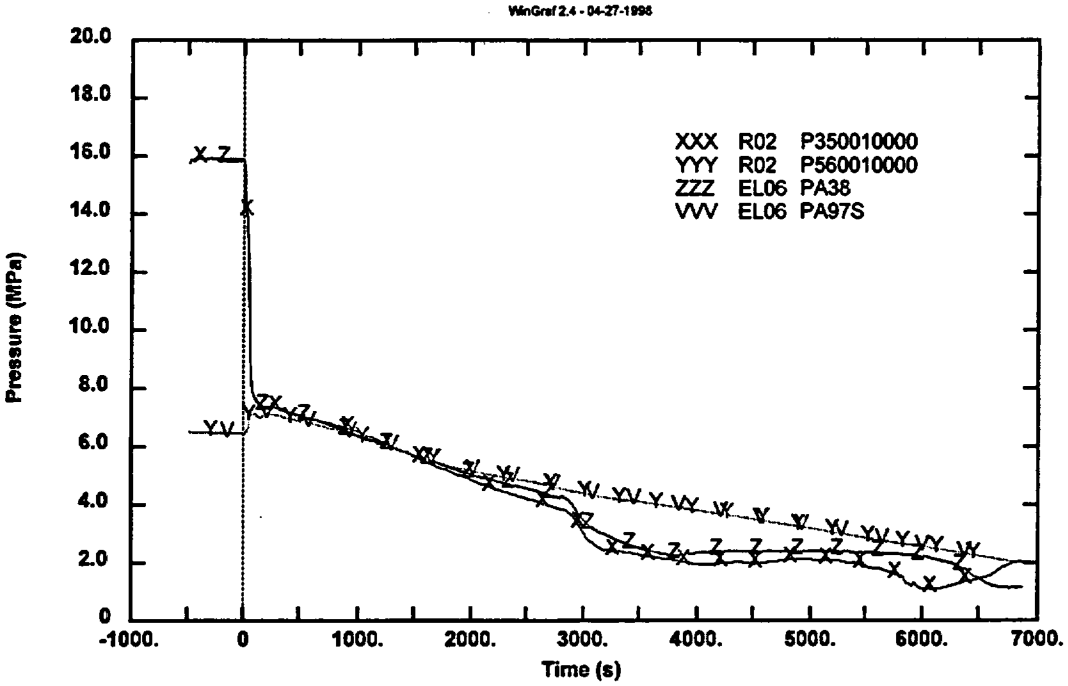

Fig. 1 : Primary and secondary pressure

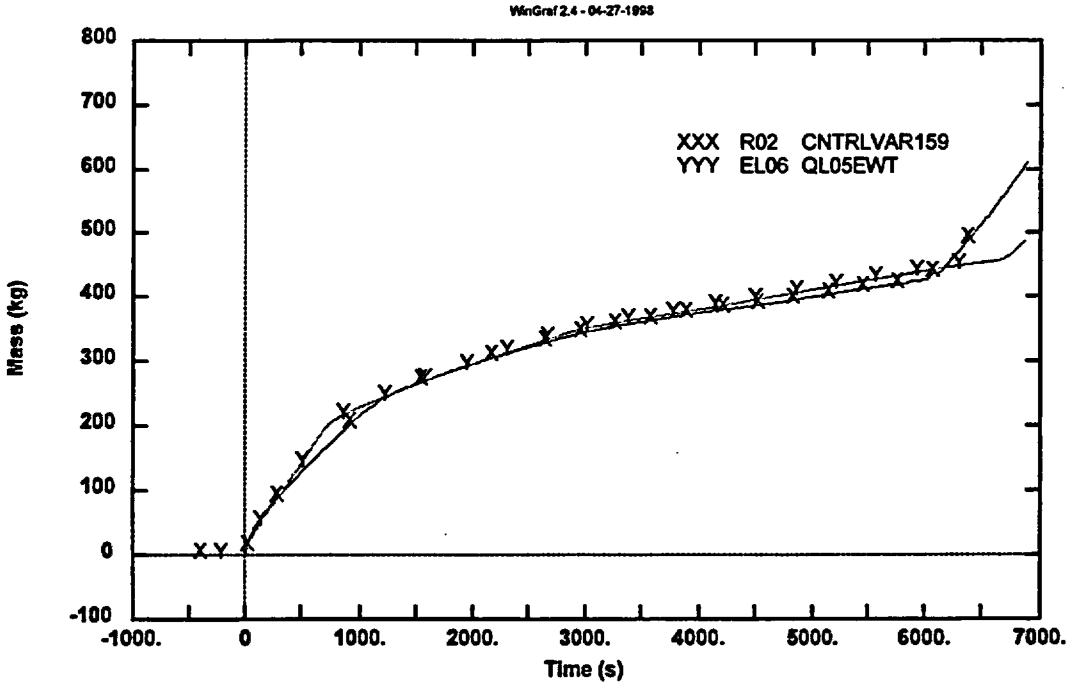

Fig. 2 : Break integral flow rate

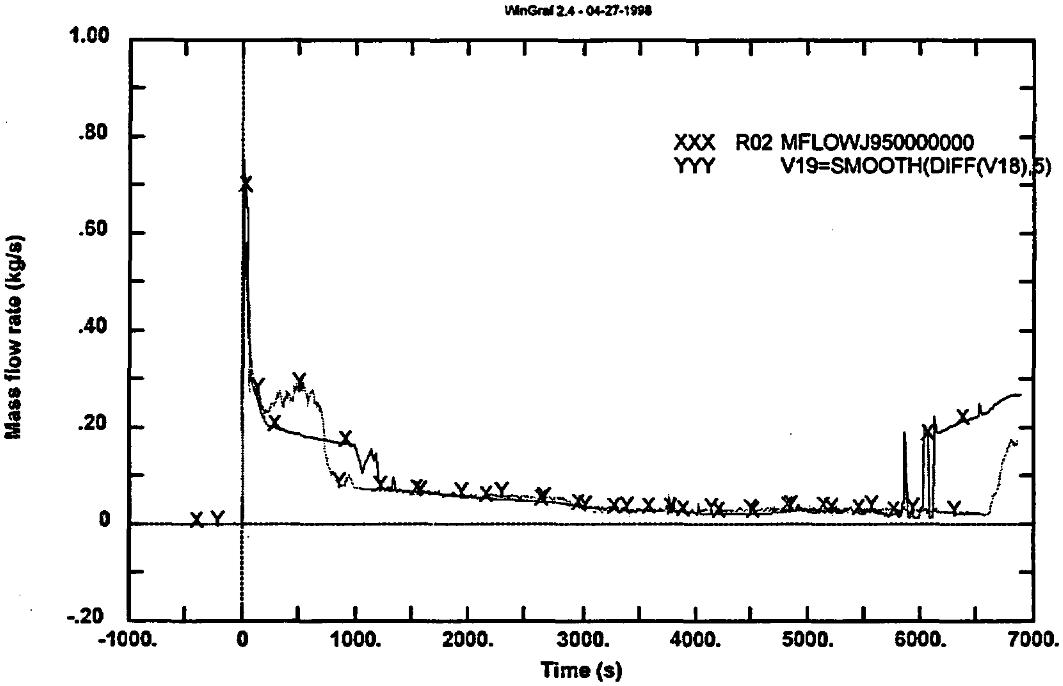

Fig. 3 : Break mass flow rate

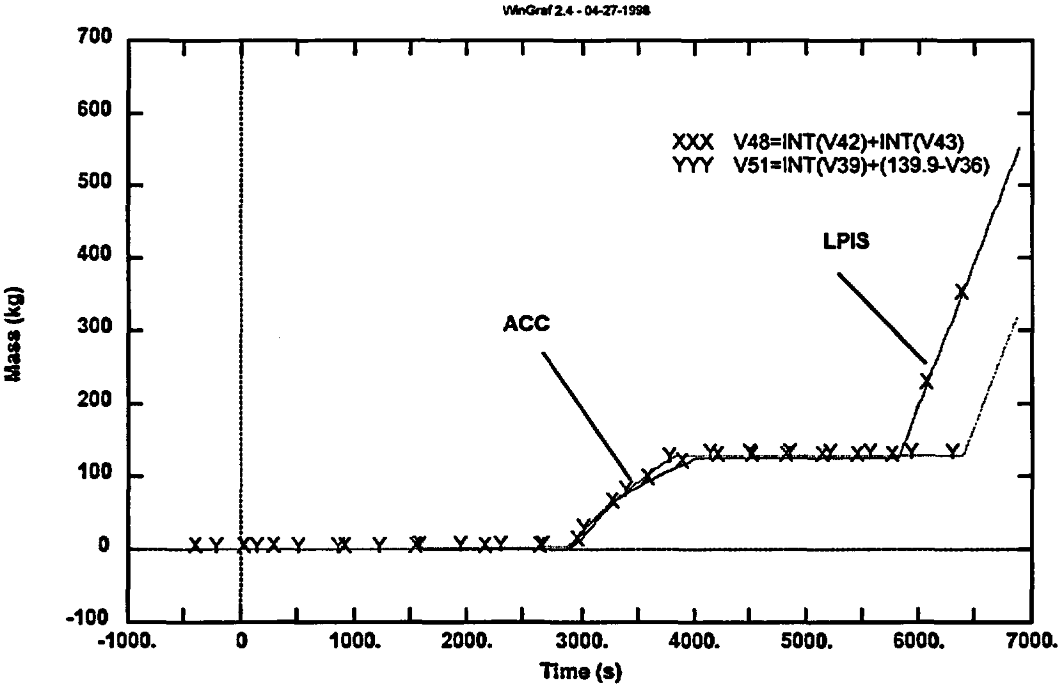

Fig. 4 : Integrated mass injected in the primary system from the emergency systems

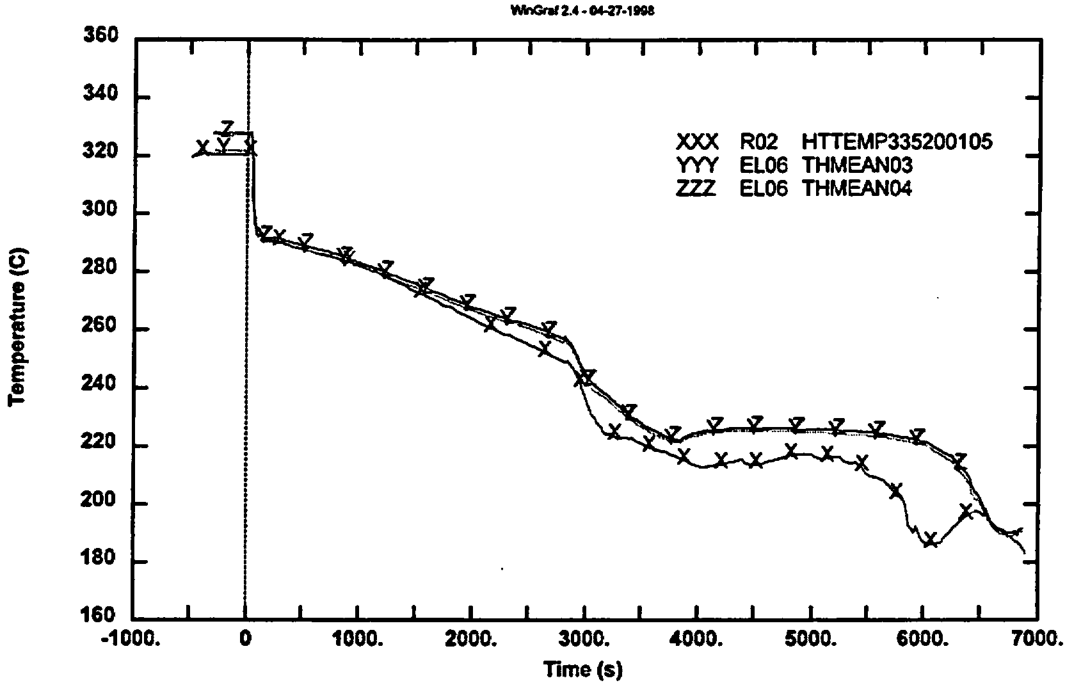

Fig. 5 : Rod surface temperature (bottom level)

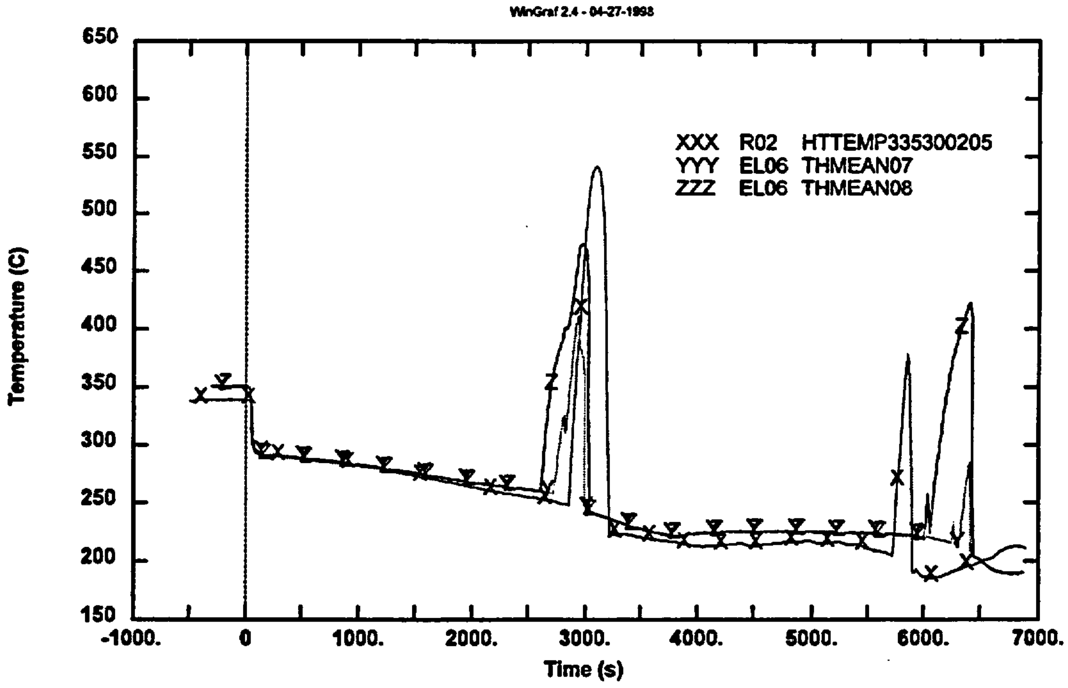

Fig. 6 : Rod surface temperature (middle level)

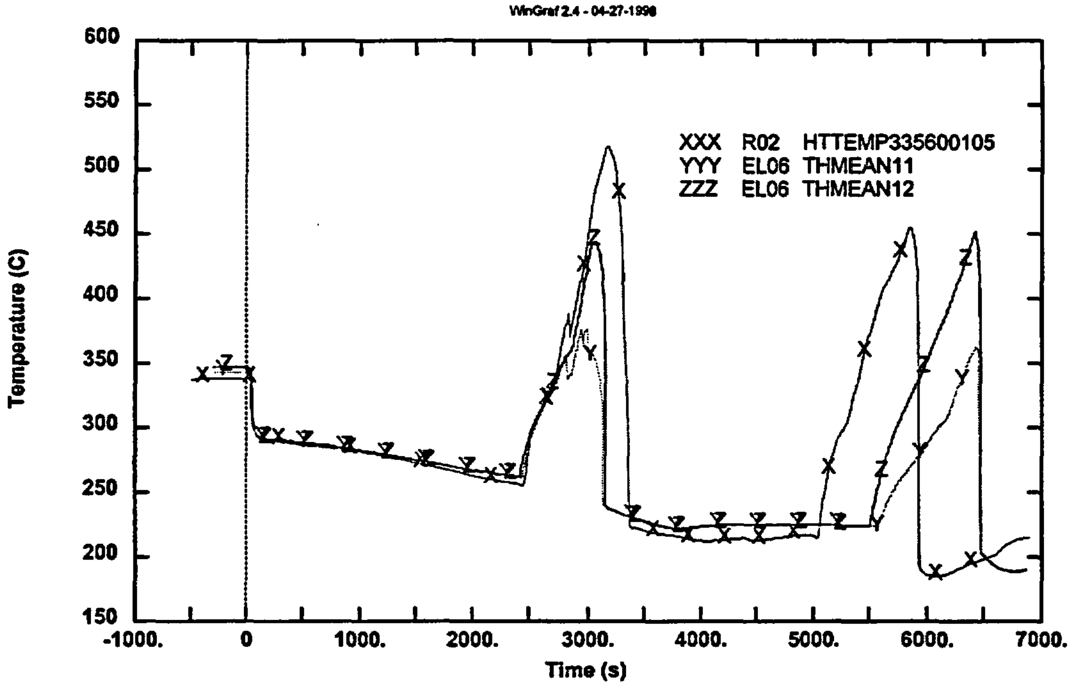

Fig. 7 : Rod surface temperature (high level)

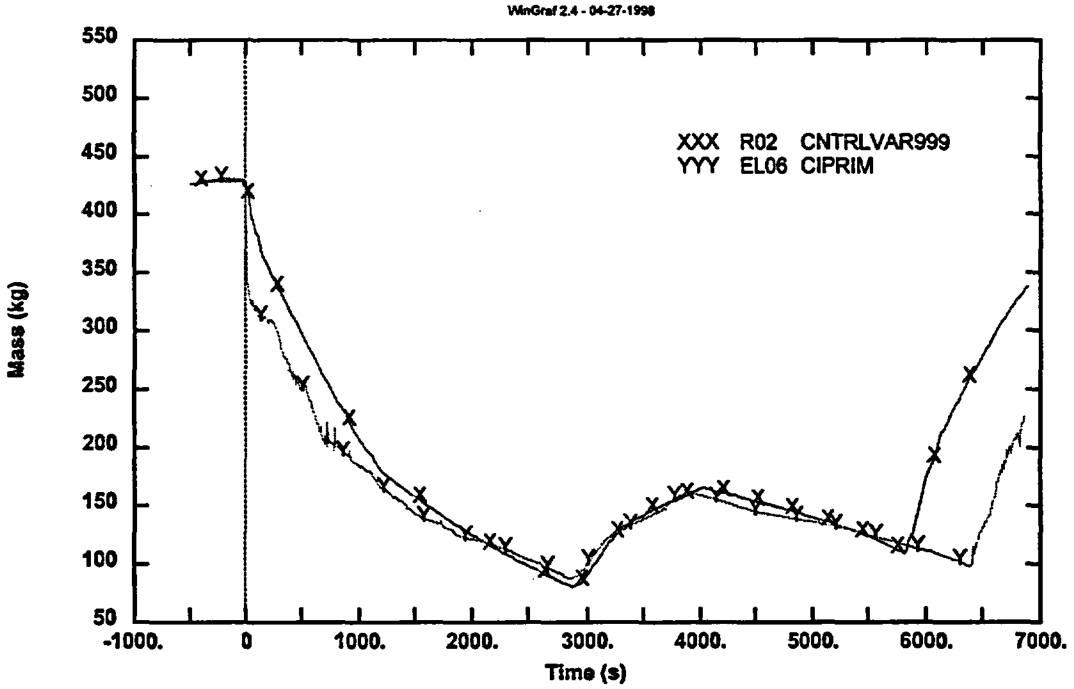

Fig. 8 : Primary system mass inventory

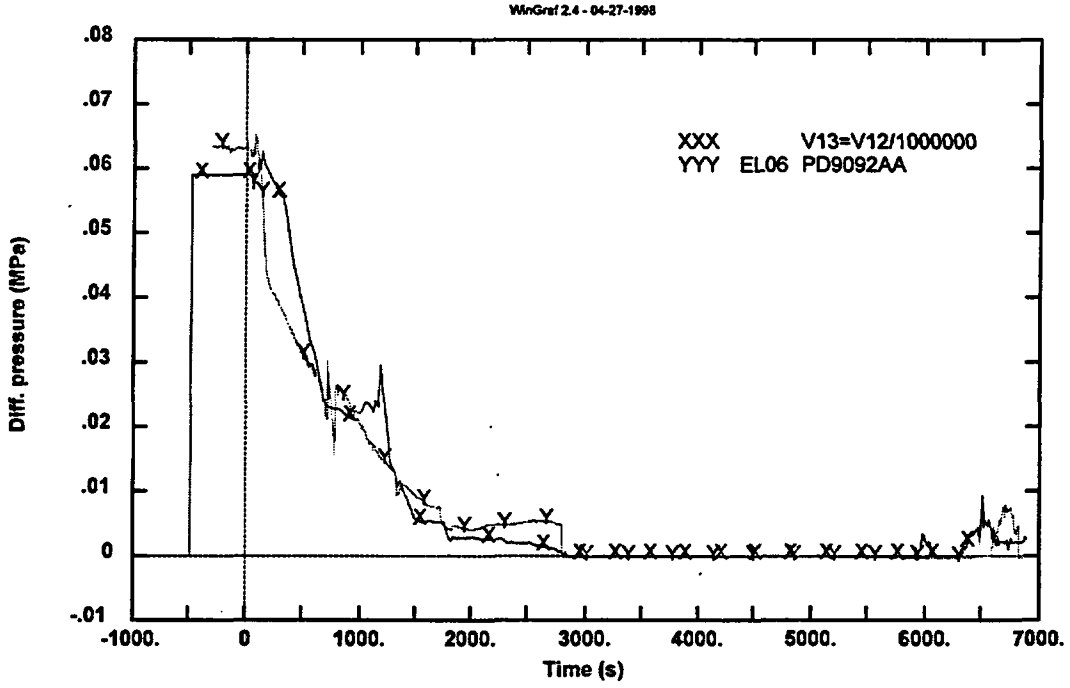

Fig. 9 : Pressure difference between the entry and the exit of the intact loop steam genarator

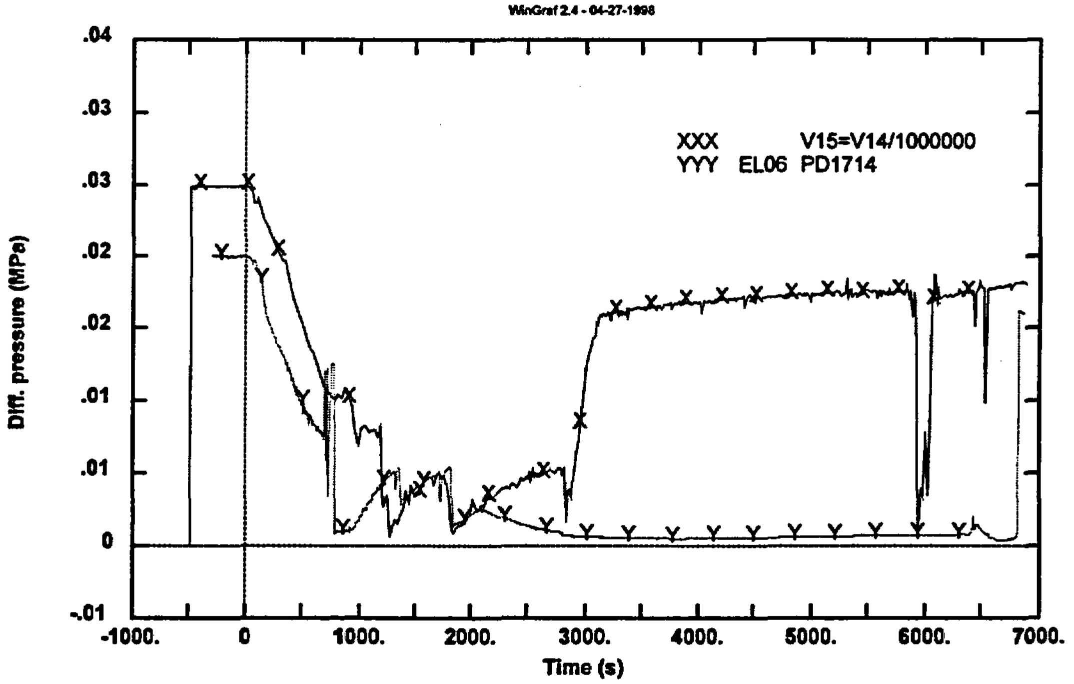

Fig. 10 : Pressure difference in the ascending side of the loop seal of the intact loop

APPENDIX 4:

Results of the sensitivity calculation R03

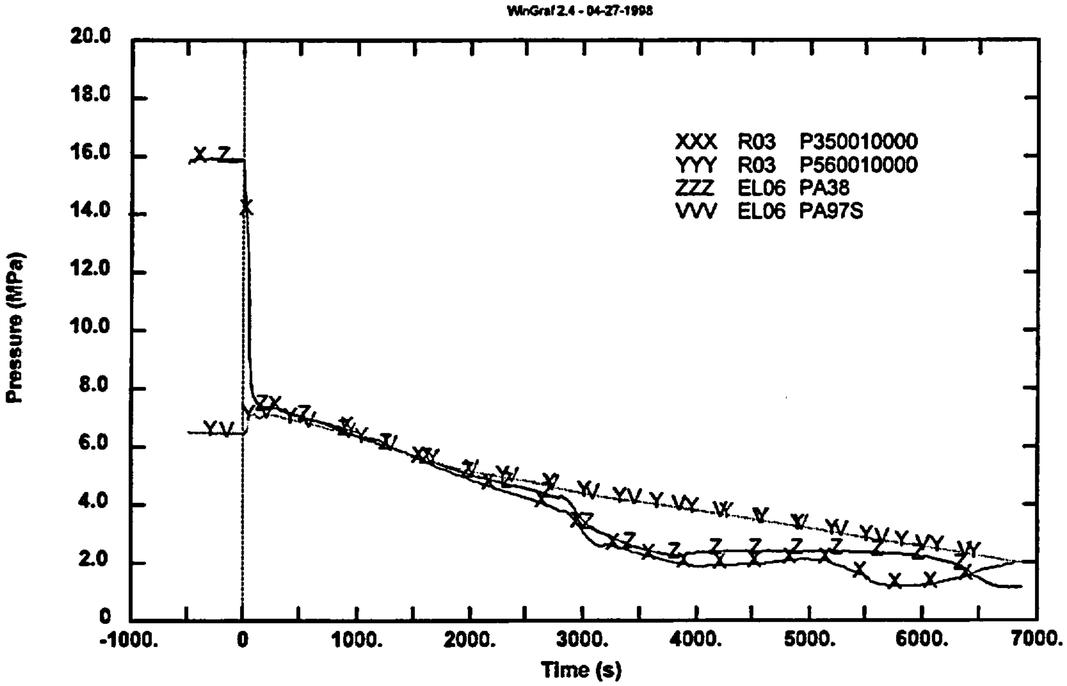

Fig. 1 : Primary and secondary pressure

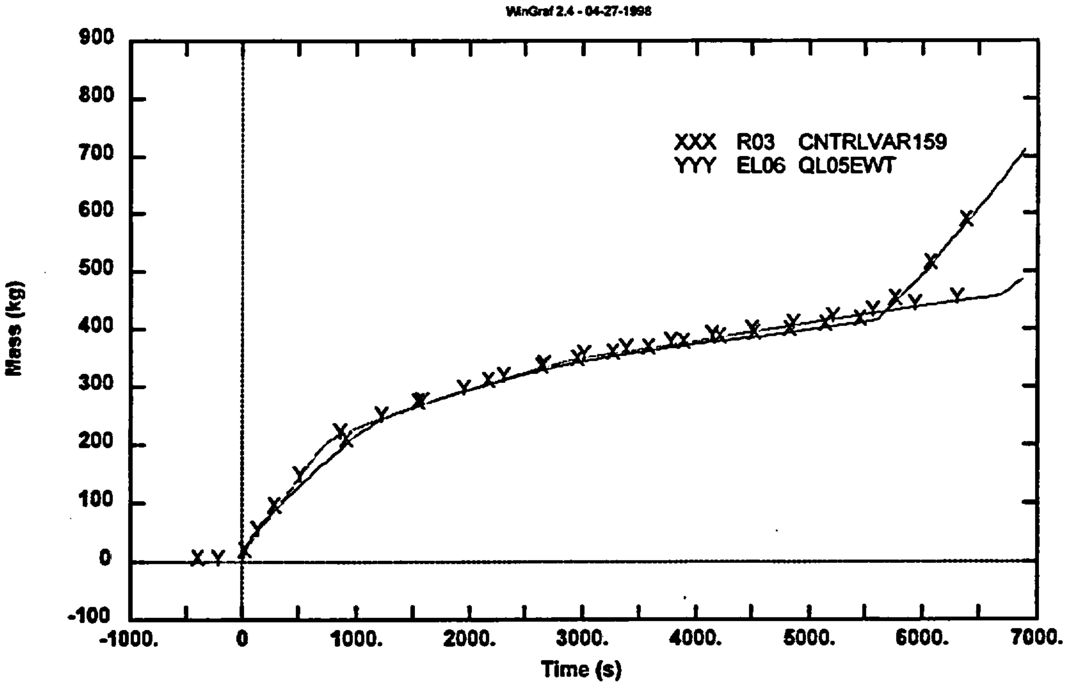

Fig. 2 : Break integral flow rate

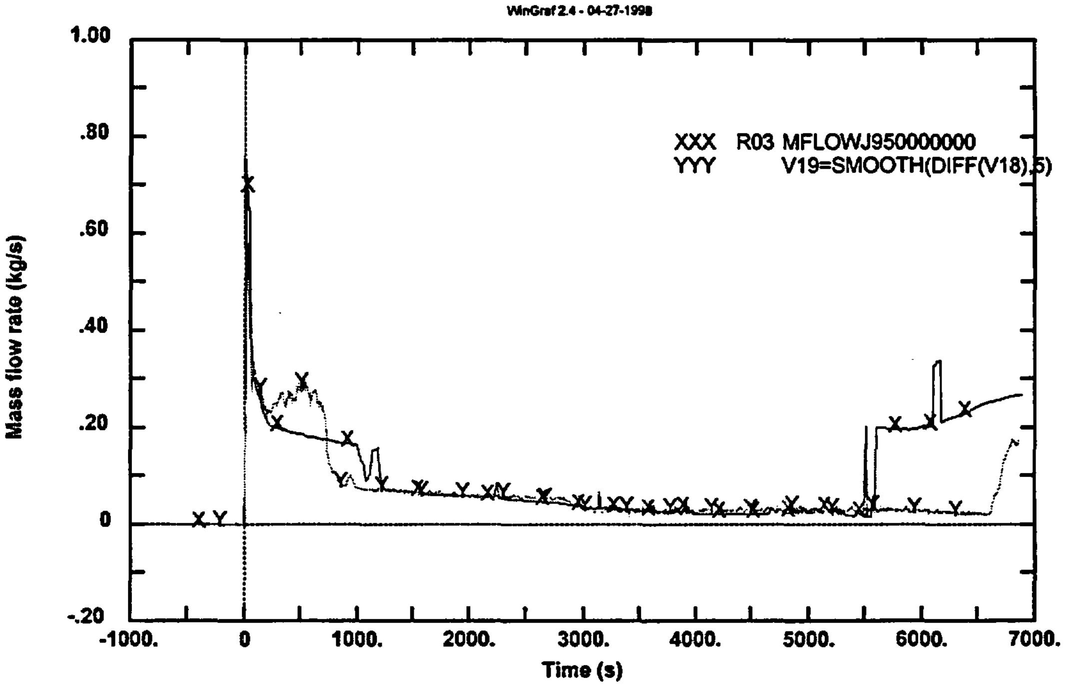

Fig. 3 : Break mass flow rate

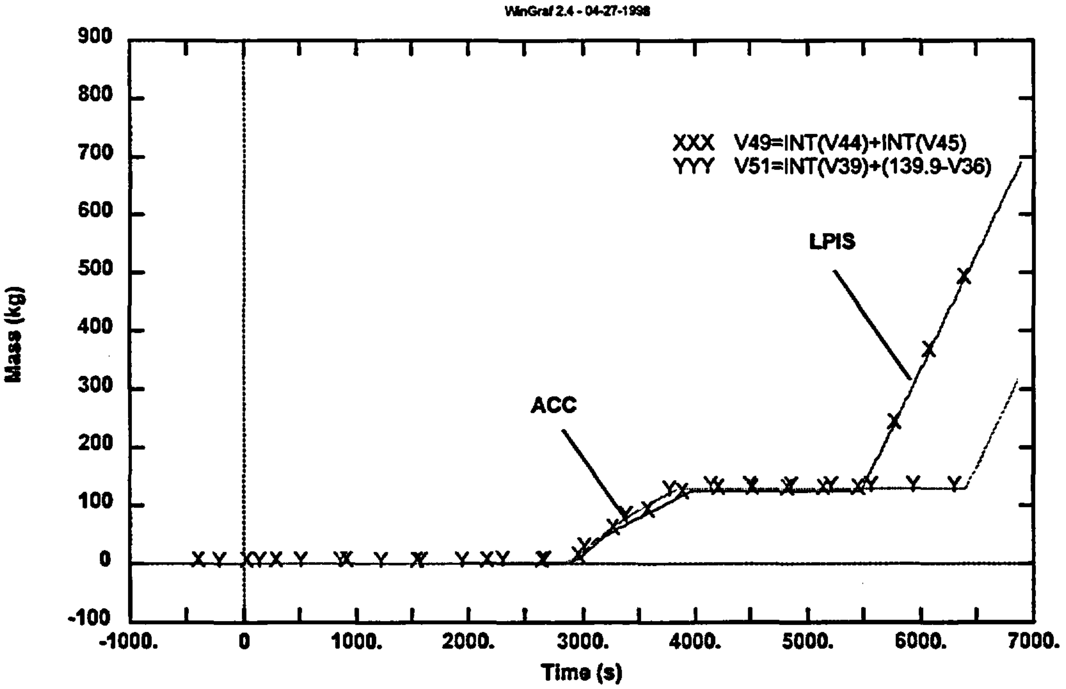

Fig. 4 : Integrated mass injected in the primary system from the emergency systems

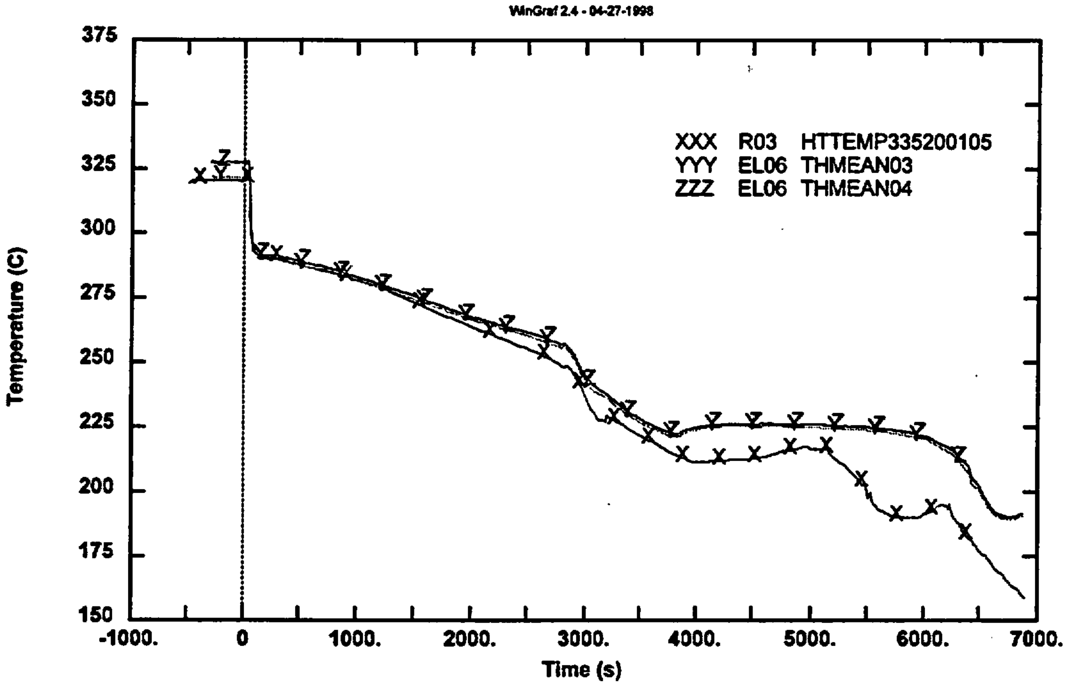

Fig. 5 : Rod surface temperature (bottom level)

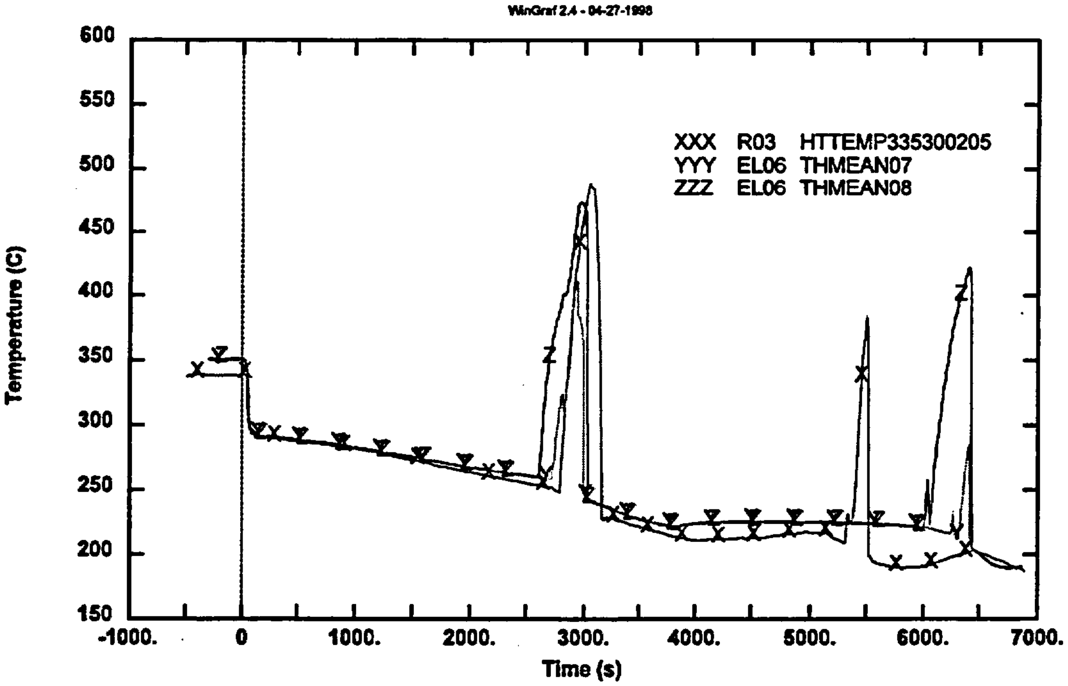

Fig. 6 : Rod surface temperature (middle level)

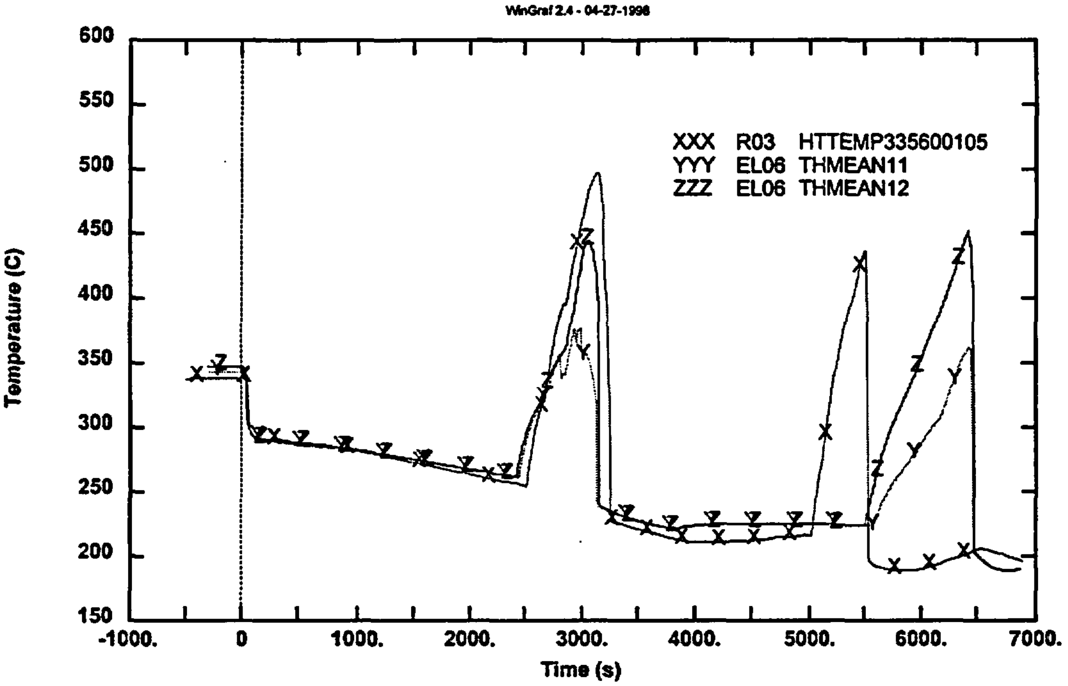

Fig. 7 : Rod surface temperature (high level)

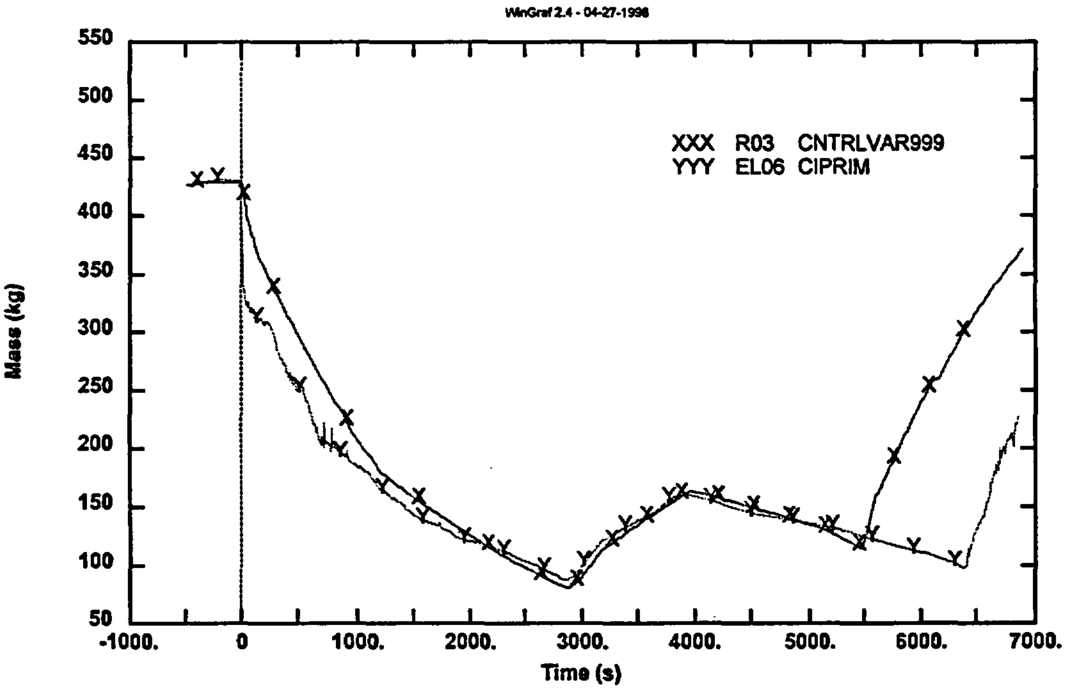

Fig. 8 : Primary system mass inventory

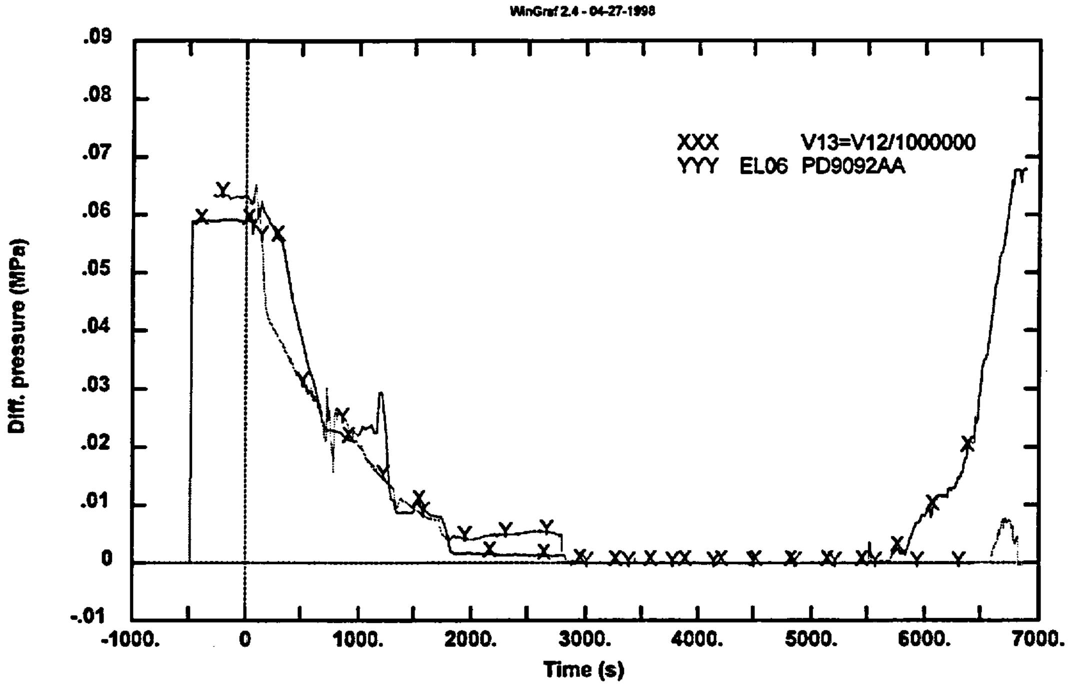

Fig. 9 : Pressure difference between the entry and the exit of the intact loop steam genarator

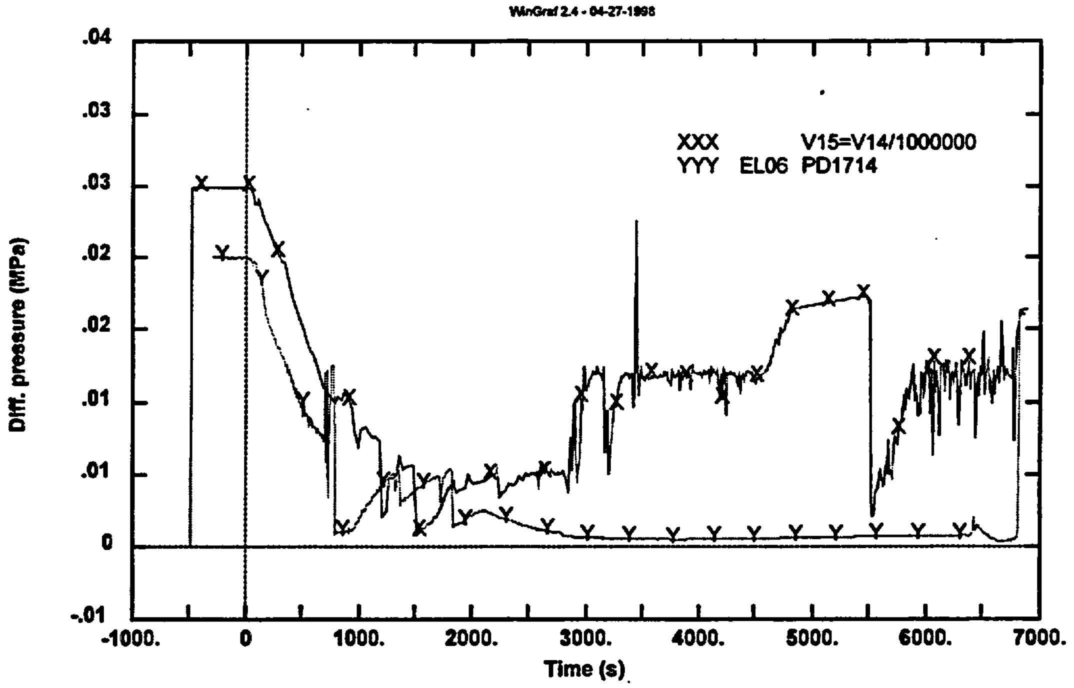

Fig. 10 : Pressure difference in the ascending side of the loop seal of the intact loop

APPENDIX 5:

Results of the sensitivity calculation R04

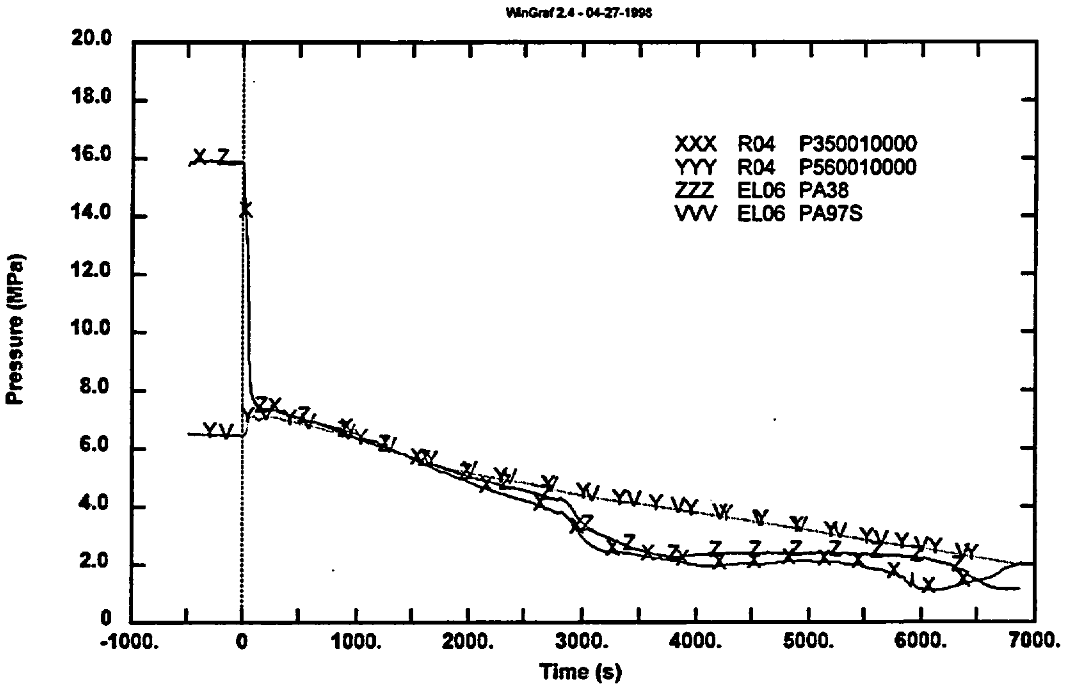

Fig. 1 : Primary and secondary pressure

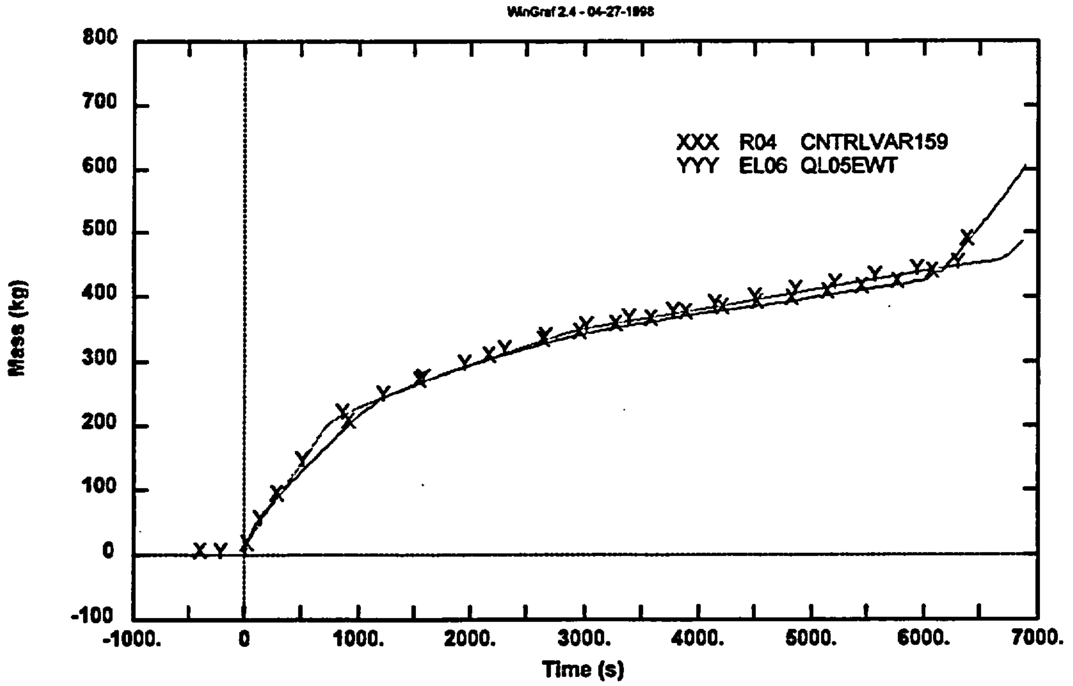

Fig. 2 : Break integral flow rate

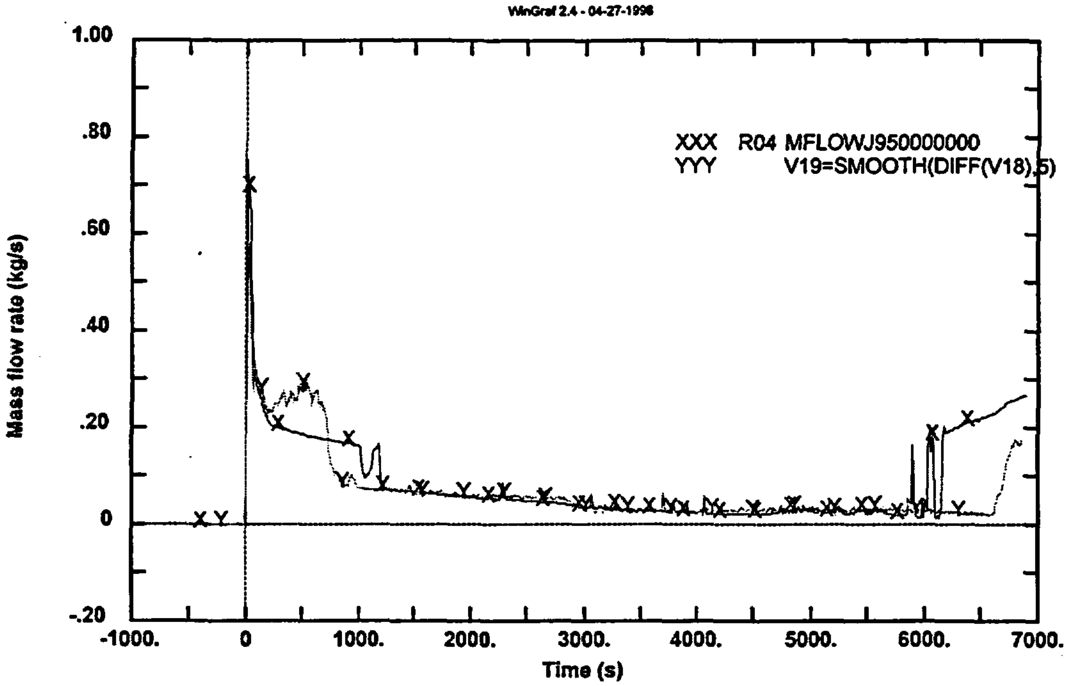

Fig. 3 : Break mass flow rate

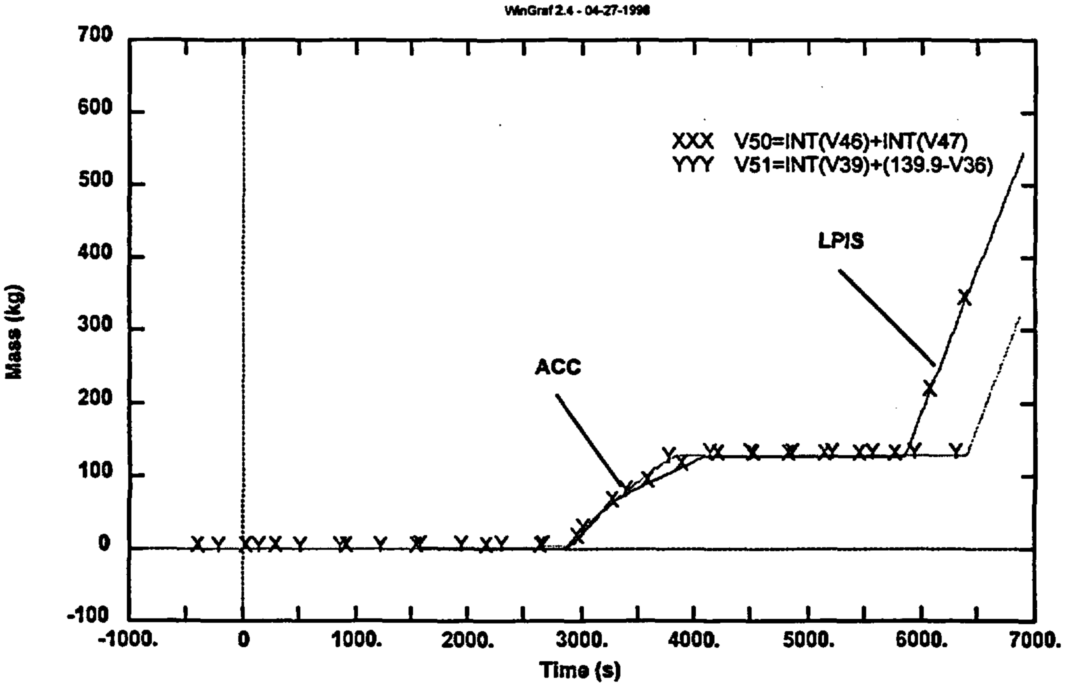

Fig. 4 : Integrated mass injected in the primary system from the emergency systems

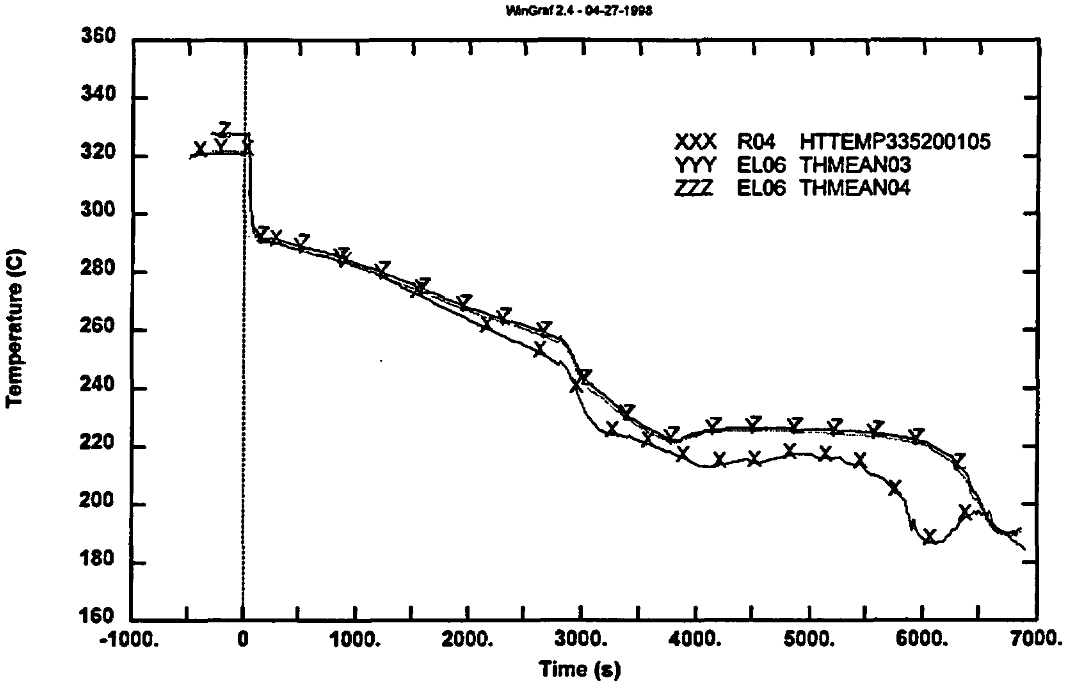

Fig. 5 : Rod surface temperature (bottom level)

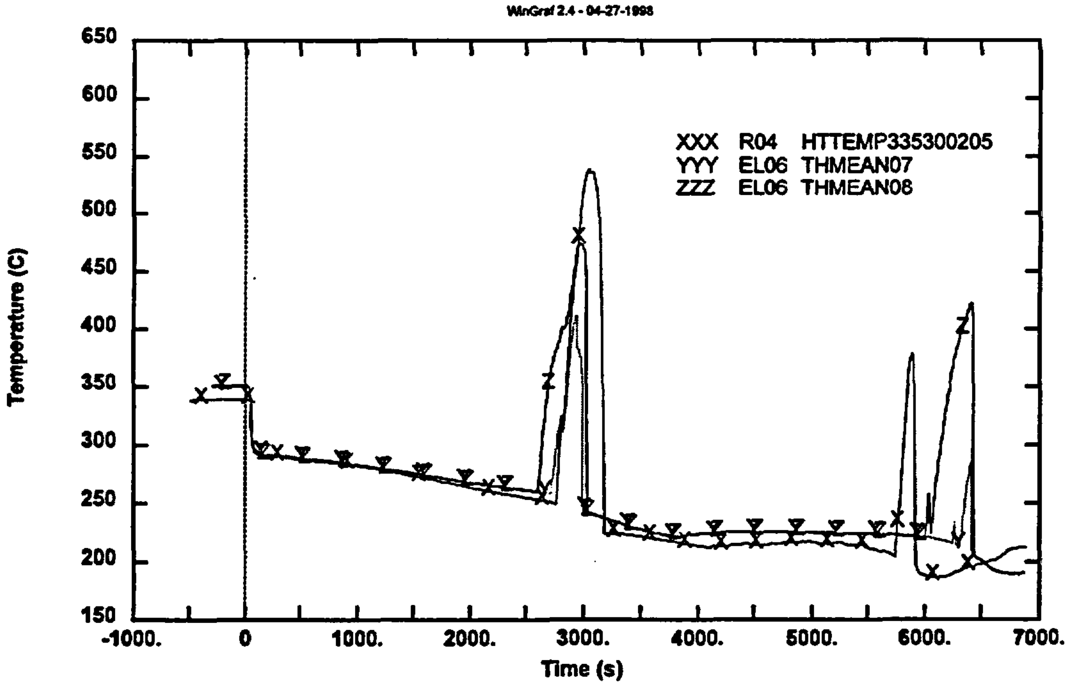

Fig. 6 : Rod surface temperature (middle level)

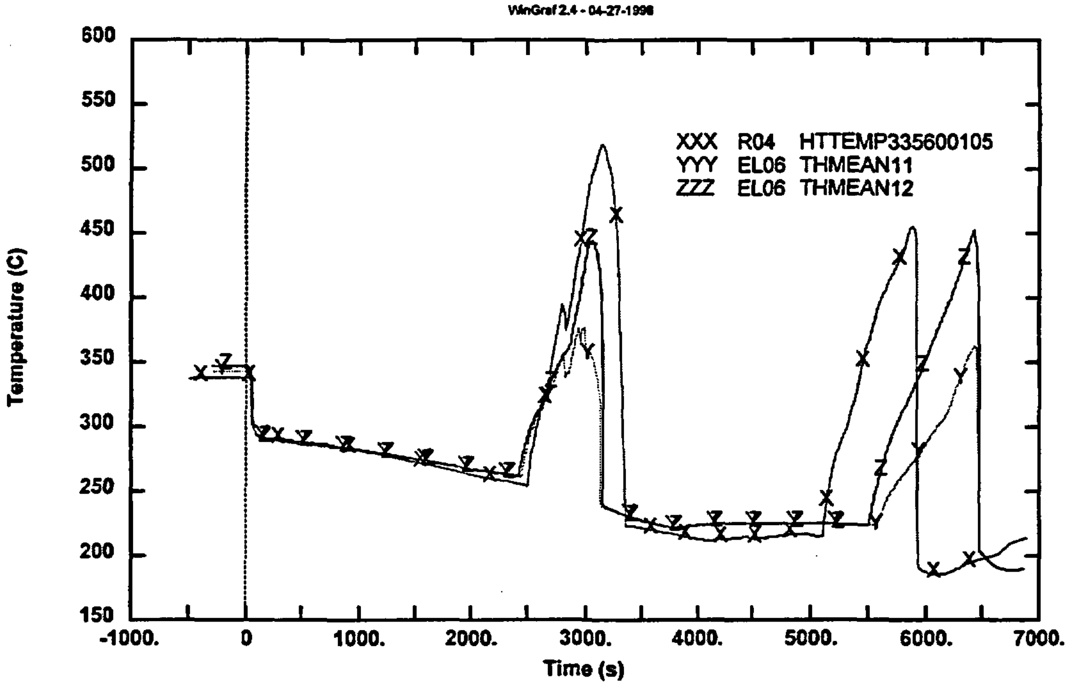

Fig. 7 : Rod surface temperature (high level)

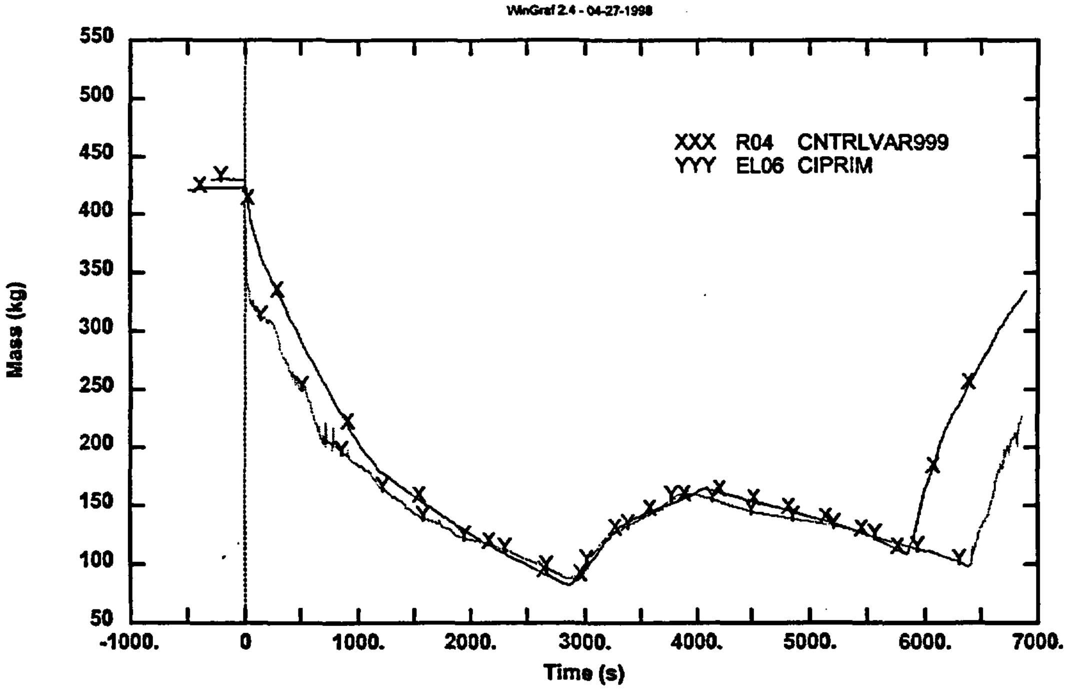

Fig. 8 : Primary system mass inventory

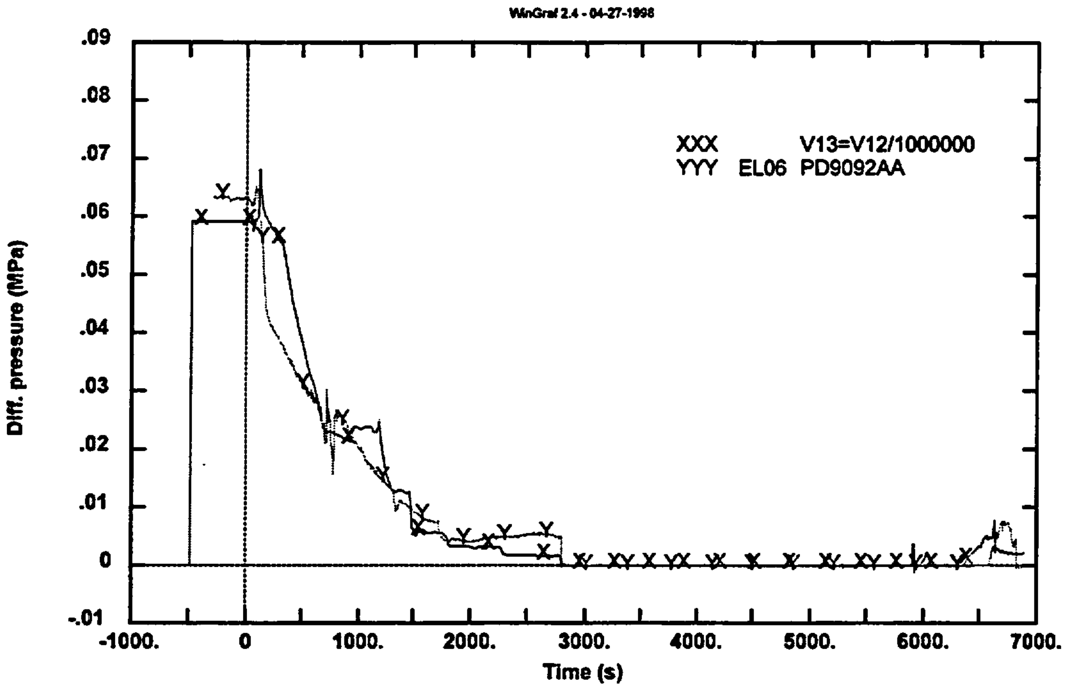

Fig. 9 : Pressure difference between the entry and the exit of the intact loop steam genarator

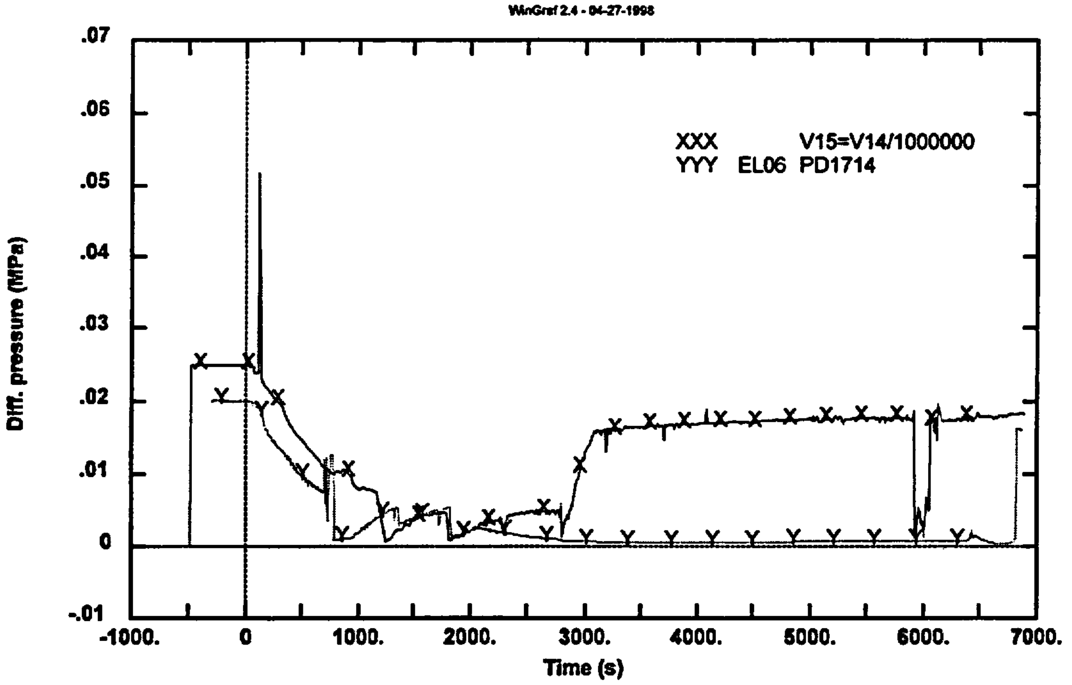

Fig. 10 : Pressure difference in the ascending side of the loop seal of the intact loop

APPENDIX 6:

Short overview of the UMAE basic principles

Short overview of the UMAE basic principles

Different methods have been proposed to quantify the accuracy of thermal-hydraulic codes. Although these methods were able to give information about the accuracy, some were not considered satisfactory because they involved some empiricism and were lacking of a precise mathematical meaning. Besides, engineering subjective judgment is almost always present in these methods.

Generally, the starting point of each method is an error function, through which the accuracy is evaluated. The error function should respond to these requirements:

1) to be independent upon the transient duration;
2) its values should be normalized;
3) at any time of the transient this function should remember the previous history;
4) engineering judgment should be avoided or reduced;
5) the mathematical formulation should be simple and the function should be non-dimensional.

The UMAE (Uncertainty Methodology based on Accuracy Extrapolation) is a methodology suitable for evaluating the uncertainty in the prediction of transient scenarios in nuclear reactors when carried out by thermal-hydraulic system codes. It is based on the extrapolation of the accuracy resulting from a comparison between code results and relevant experimental data obtained in small scale facilities.

To apply the UMAE must be verified the following conditions:

- the code must be qualified;
- the experimental data have to reproduce the same phenomena expected in the real plant;
- the nodalizzation has to be qualified;
- the experimental data has to be relative to facility of different scale, but characterized by the same scaling philosophy;
- the experiments must be qualified.

As already tells, the basic idea of the UMAE methodology, is to get the uncertainty from considering the accuracy.

The simplest formulation about the accuracy of a given code calculation, with reference to the experimental measured trend, is obtained by the difference function

$$\Delta F(t) = F_{calc}(t) - F_{\exp}(t) \qquad (1)$$

To get a limited number of values that give an overall judgment about accuracy, it should be resorted to the integration of the function (1). Such integration however it would give a partial information because some interesting details could be lost, for example the presence of perturbations would be hidden for effects of compensation. So it may be useful to study the same phenomenon from other points of view, time independent.

A mathematical algorithm that can translate a given time function, in a corresponding complex function is the Fourier transform.

For the calculation of Fourier transform exists a specific procedure of calculation call FFT (Fast Fourier Trasform).

The FFT procedure is a mathematical tool through which is possible to analyze and to compare, in objective manner, calculated and experimental quantity that are time functions passing in the frequency domain.

In particular, the FFT methodology, applied to the error function $\Delta F(t)$, defined from the equation (1), defines two values characterizing each calculation:

- a dimensionless average amplitude

$$AA = \frac{\sum_{n=0}^{2^m} \left|\tilde{\Delta F}(f_n)\right|}{\sum_{n=0}^{2^m} \left|F_{\exp}(f_n)\right|}$$

- a weighted frequency

$$WF = \frac{\sum_{n=0}^{2^m} \left|\tilde{\Delta F}(f_n)\right| \cdot f_n}{\sum_{n=0}^{2^m} \left|\tilde{\Delta F}(f_n)\right|}$$

The AA factor can be considered a sort of “average fractional error”, it represents the relative magnitude of the discrepancy deriving from the comparison between the calculated and the corresponding experimental trend of each parameter.

The weighted frequency WF gives an idea of the frequencies related with the inaccuracy so it represents the type of error. A small value for WF means that the discrepancy between the measured and calculated trends is more important at low frequencies; when WF is large, the discrepancy comes from various kinds of noise and consequently is less important. So better accuracy is realized for low values of AA associated to large values of WF.

Trying to give an overall picture of the accuracy of a given calculation, it is required to combine the information obtained for the single parameters into average indexes of performance.

This is obtained by defining the following quantities:

$$(AA)_{tor} = \sum_{i=1}^{N\,var} (AA)_i \cdot (w_f)_i$$

$$(WF)_{tot} = \sum_{i=1}^{N\,var} (WF)_i \cdot (w_f)_i$$

with

$$\sum_{i=1}^{N\,var} (w_f)_i = 1$$

where

-N_{var} is the number of selected parameters to which the method has been applied)

-$(w_f)_i$ are weighting factors introduced for each parameter, to take into account their importance from the viewpoint of safety analyses.

For like the factor AA_{tot} has been defined, it is deduced that lower is his value better is the accuracy of the analyzed calculation. From this it springs the following acceptability criterion :

$$AA_{tot} < K$$

where K is an acceptability factor valid for the whole transient. Based on experience gathered in previous applications of this methodology, K=0.4 has been chosen as the reference value that identifies the acceptable accuracy of a code calculation. Because, from precedents applications of the FFT, it was been noticed that results in the range:

1. $AA_{tot} \leq 0.3$ represent a very good simulation;

2. $0.3 \leq AA_{tot} \leq 0.5$ represent a good simulation;
3. $0.5 \leq AA_{tot} \leq 0.7$ represent a poor simulation;
4. $AA_{tot} > 0.7$ represent a very poor simulation.

The same criterion can be used to evaluate the code capability in a single parameter prediction. In particular, an acceptability factor K=0.1 has been fixed for the primary pressure because of its importance.

APPENDIX 7:

Input deck

```
*lobi-mod2 test bl-06  - 1% Cold Leg Break LOCA , MCP s
on
**
*****    revised base input deck     *****
*====>   relap5/mod3.2.1            <====*
*****    post-test calculation      *****
0000100 new  transnt
0000101 run
0000102 si
0000104 cmpress
0000105 10.0  11.0
0000110 nitrogen
***************************************************
****
*  time step control cards                    *
***************************************************
****
201     500.  1.e-7   0.05   3  400   5000 5000
202     610.  1.e-7   0.05  3  100   1000 1000
203     3000.  1.e-7    0.025  3  1000   20000 20000
204     3700.  1.e-7   0.01  3   1250  10000  10000
205     4160.  1.e-7   0.025  3  500   4000 4000
206     6350.  1.e-7   0.05  3   250  2000 2000
207     6425.  1.e-7   0.01  3   1250  10000  10000
208     7400.  1.e-7   0.01  3 1250  50000 50000
***************************************************
****
*   minor edit variables                     *
***************************************************
****
301     p         355010000         * upper plenum
302     p         560010000         * intact loop sg
303     p         660010000         * bl sg
304     cntrlvar  550            * il sg dc level
305     cntrlvar  650            * bl sg dc level
306     mflowj   330000000           * core inlet
307     pmpvel   135              * pump il
308     pmpvel   225              * pump bl
309     cntrlvar  999            * primary fluid mass
310     cntrlvar  500            * il sg fluid mass
311     cntrlvar  600            * bl sg fluid mass
312     cntrlvar  530            * il sg rr error
313     cntrlvar  630            * bl sg rr error
314     httemp   335100105        * htr.rod temp:lvl 2
315     httemp   335200105        * htr.rod temp:lvl 4
316     httemp   335300205        * htr.rod temp:lvl7/8
317     httemp   335500105        * htr.rod temp:lvl 9
318     httemp   335600105        * htr.rod temp:lvl 11
320     tempf  100010000
321     tempf  140010000
322     tempf  200010000
323     tempf  240010000
324     cntrlvar 92   * il heat losses
325     cntrlvar 94   * bl heat losses
326     cntrlvar 96   * steam line heat losses
327     cntrlvar 750  * primary system heat losses
328     cntrlvar 80   * total input power to primary
329     cntrlvar 90   * total power removed from primary
330     cntrlvar 22   * power removed from sg-1
331     cntrlvar 24   * power removed from sg-2
332     mflowj  580000000      * steam line flow
333     cntrlvar 560
***************************************************
****
*  variable trips                          *
***************************************************
****
501      p  350010000  le  null    0  42.1e5   l
502    cntrlvar   158  gt   null   0   125.   l
503      p  350010000  le  null    0  131.0e5   l *SCRAM
504     time    0   ge  timeof 688  60.0     n
505     time    0   ge   null    0  500.0   l
```

```
506     time    0   lt   null     0   160.0    n
507     time    0   ge   null     0  5000.0   l * lp drain
508     time    0   ge   null     0   0.0     l
509     time    0   lt   null     0   400.0    n
510     time    0   lt   timeof 688  25.0      n
511     time    0   gt   null     0   1.0e9    l
512     time    0   ge   timeof   503  0.0     l
513     time    0   ge   timeof   505  0.5     l
515      time     0  ge   timeof 620  50.     n
516       time    0  le   timeof  620  60.    n
517      p  350010000 ge   null     0  131.0e5    n
522     time    0   ge   null     0  -1.0    l
525     time    0   le   null     0  2950.0  l
526     httemp 335100105  ge   null 0  646.15     n
527     httemp 335200105  ge   null 0  646.15     n
528     httemp 335300105  ge   null 0  646.15     n
529     httemp 335300205  ge   null 0  646.15     n
530     httemp 335500105  ge   null 0  646.15     n
531     httemp 335600105  ge   null 0  646.15     n
532     time    0   ge   null     0  500.0    l
534     httemp 335100105  ge   null 0  685.15     n
535     httemp 335200105  ge   null 0  685.15     n
536     httemp 335300105  ge   null 0  685.15     n
537     httemp 335300205  ge   null 0  685.15     n
538     httemp 335500105  ge   null 0  685.15     n
539     httemp 335600105  ge   null 0  685.15     n
540     p  350010000  le  null     0  25.0e5  n
551     time    0    ge    timeof  503   72.0  l
552     p  660010000  le  null     0  21.0e5  l
553     httemp 335100105  ge   null 0  745.15     n
554     httemp 335200105  ge   null 0  745.15     n
555     httemp 335300105  ge   null 0  745.15     n
556     httemp 335300205  ge   null 0  745.15     n
557     httemp 335500105  ge   null 0  745.15     n
558     httemp 335600105  ge   null 0  745.15     n
560     httemp 335100105  ge   null 0  704.15     n
561     httemp 335200105  ge   null 0  704.15     n
562     httemp 335300105  ge   null 0  704.15     n
563     httemp 335300205  ge   null 0  704.15     n
564     httemp 335500105  ge   null 0  704.15     n
565     httemp 335600105  ge   null 0  704.15     n
575     time    0   lt   null    0   500.0   n
590     time    0   ge   timeof   620 4.0   l
591     time    0   ge   timeof   590  5.0    l
592     time     0   ge   timeof 640  0.   n
593     time    0  le   timeof  640  10.   n
***************************************************
****
*  logical trips                            *
*  logical & variable trips used in combination to    *
*  allow more complex generalised trips to be used     *
***************************************************
****
601     592     and       593      n
602      515     and  516      n
603     -517    and -517   l
605     534    or   535    n
606     536    or   537    n
607     538    or   539    n
608     605    or   606    n
609     607    or   608    n
610     608    or   609    n
620     610      and      501       l
621     -620     and      -620      n
622     -620     and      -620      n
631     501      and      531      n
633     560      or       561   n
634     562      or       563   n
635     564      or       565   n
636     633      or       634   n
637     635      or       636   n
638     636      or       637   n
```

```
639   638    and    540   n
640   507    and    639    l
641   620    and    620    l
642   620    and    620    l
643   526    or     527   n
644   528    or     529   n
645   530    or     531   n
646   643    or     644   n
647   645    or     646   n
648   646    or     647   n
649   648    and    540   n
650   507    and    649    l
651   650    and    -504   n
654   552    and    551    n
661   505    and    -662    n
662   505    and    505    l
664   -503   and    -503    n
665   552    and    -666    n
666   552    and    552    l
675   -575   or     -575    n
681   553    or     554     n
682   555    or     556     n
683   557    or     558     n
684   681    or     682     n
685   683    or     684     n
686   684    or     685     n
687   686    and     540    n
688   687    and     507    l
690   590    and    -591    n
**************************************************
****
*                                       *
*                                       *
*                intact loop                *
*                                       *
*                                       *
**************************************************
****
*  pressure vessel outlet - sp 11                *
**************************************************
****
1000000  voutil   snglvol
1000101  42.660d-4 0.736   0.0    0.0    +0.0
1000102  +0.0    2.3d-5   0.0737   00
1000200  3       158.00d+5 599.15
**************************************************
****
*  pressurizer connection tee                 *
**************************************************
****
1050000  prcoil   branch
1050001  3      1
1050101  42.660d-4 0.745   0.0    0.0    +0.0
1050102  +0.0    2.3d-5   0.0737   00
1050200  3       158.00d+5 599.15
1051101  100010000 105000000 42.660d-4 0.33    0.33
0000
1052101  105010000 110000000 42.660d-4 0.0     0.0
0000
1053101  400010000 105000000 1.3685d-4 0.0     0.0
0100
1051201  21.00    0.0     0.0
1052201  21.00    0.0     0.0
1053201  0.0     0.0     0.0
**************************************************
****
*  steam generator inlet piping - sp12            *
**************************************************
****
1100000  sgipil   pipe
1100001  2
1100101  42.660d-4 2
```

```
1100201  0.0     1
1100301  1.600    1
1100302  0.628    2
1100401  0.0     2
1100501  0.0     2
1100601  +6.892   1
1100602  +90.0    2
1100701  +0.192   1
1100702  +0.628   2
1100801  2.3d-5   0.0737   2
1100901  0.164    0.164    1
1101001  00      2
1101101  0000     1
1101201  3       158.00d+5 599.15   0.0     0.0  0.0 2
1101300  1
1101301  21.00    0.0     0.0     1
**************************************************
****
*  steam generator inlet                     *
**************************************************
****
1150000  sginil   sngljun
1150101  110010000 120000000 0.0     0.0     0.0   100100
1150110  0.  0.  0.4  0.8
1150201  1      21.00    0.0     0.0
**************************************************
****
*  steam generator primary side                 *
**************************************************
****
*  fine nodalisation at lower part of sg u-tubes      *
**************************************************
****
1200000  sgpril   pipe
1200001  46
1200101  109.36d-4 1
1200102  0.0     2
1200103  72.413d-4 44
1200104  0.0     45
1200105  109.36d-4 46
1200201  0.0     45
1200301  1.763    1
1200302  0.306    2
1200303  0.1475   6
1200304  0.125    10
1200305  0.250    14
1200306  0.500    22
1200307  1.014832  24
1200308  0.500    32
1200309  0.25    36
1200310  0.1250    40
1200311  0.1475   44
1200312  0.306    45
1200313  1.763    46
1200401  0.0     1
1200402  9.932d-3  2
1200403  0.0     44
1200404  9.932d-3  45
1200405  0.0     46
1200501  0.0     46
1200601  +90.0    22
1200602  +87.50   23
1200603  -87.50   24
1200604  -90.0    46
1200701  +1.763   1
1200702  +0.306   2
1200703  +0.1475  6
1200704  +0.125   10
1200705  +0.250   14
1200706  +0.500   22
1200707  +0.907696 23
1200708  -0.907696 24
```

```
1200709 -0.500   32
1200710 -0.250   36
1200711 -0.125   40
1200712 -0.1475  44
1200713 -0.306   45
1200714 -1.763   46
1200801 2.3d-5   0.118    1
1200802 2.3d-5   0.176695 2
1200803 0.0      0.0196   44
1200804 2.3d-5   0.176695 45
1200805 2.3d-5   0.118    46
1200901 0.0      0.0      1
1200902 0.0      0.0      2
1200903 0.0      0.0      22
1200904 0.120    0.120    23
1200905 0.0      0.0      43
1200906 0.0      0.0      44
1200907 0.0      0.0      45
1201001 00       46
1201101 0100     2
1201102 0000     43
1201103 0100     45
1201201 3        158.00d+5 599.15  0.0   0.0   0.0 2
1201202 3        158.00d+5 593.00  0.0   0.0   0.0 14
1201203 3        158.00d+5 588.00  0.0   0.0   0.0 18
1201204 3        158.00d+5 583.00  0.0   0.0   0.0 22
1201205 3        158.00d+5 579.00  0.0   0.0   0.0 23
1201206 3        158.00d+5 575.00  0.0   0.0   0.0 24
1201207 3        158.00d+5 572.00  0.0   0.0   0.0 28
1201208 3        158.00d+5 569.00  0.0   0.0   0.0 32
1201209 3        158.00d+5 565.15  0.0   0.0   0.0 46
1201300 1
1201301 21.00    0.0      0.0     45
**************************************************
****
*  steam generator suction leg                   *
**************************************************
****
1250000 sgouil   sngljun
1250101 120010000 130000000 0.0    0.0     0.0   0000
1250201 1        21.00    0.0     0.0
**************************************************
****
*  loop seal                                     *
**************************************************
****
1300000 lsealil  pipe
1300001 5
1300101 42.660d-4 5
1300201 0.0      4
1300301 1.030    1
1300302 0.769    2
1300303 1.611    3
1300304 0.625    4
1300305 1.611    5
1300401 0.0      5
1300501 0.0      5
1300601 -90.0    2
1300602 -87.15   3
1300603 0.0      4
1300604 +87.55   5
1300701 -1.030   1
1300702 -0.769   2
1300703 -1.545   3
1300704 0.0      4
1300705 +1.545   5
1300801 2.3d-5   0.0737   5
1300901 0.0      0.0      2
1300902 0.20     0.20     3
1300903 0.20     0.20     4
1301001 00       5
1301101 0000     4
```

```
1301201 3        158.00d+5 565.15  0.0   0.0   0.0 5
1301300 1
1301301 21.00    0.0      0.0     4
**************************************************
****
*  pump inlet volume                             *
**************************************************
****
1330000 pinil    branch
1330001 1        1
1330101 42.660d-4 0.769    0.0     0.0      +90.0
1330102 +0.769   2.3d-5   0.0737  00
1330200 3        158.00d+5 565.15
1331101 130010000 133000000 0.0    0.0     0.0   0000
1331201 21.00    0.0      0.0
**************************************************
****
*  pump intact loop                              *
**************************************************
****
1350000 pumpil   pump
1350101 33.183d-4 0.6027  0.0     0.0      +90.0
1350102 +0.210   1
1350108 133010000 42.660d-4 0.06   0.02     0000
1350109 137000000 42.660d-4 0.02   0.06     0000
1350200 3        158.00d+5 565.15
1350201 1        21.00    0.0     0.0
1350202 1        21.00    0.0     0.0
1350301 0    0   0   -1   0   522  1
1350302 745.605  0.63280  0.0280  139.9    45.47
1350303 1.444    747.3    0.0     0.0      0.0
1350304 0.0      0.0
1350310 0.0      0.0      0.0
**************************************************
****
*  cold leg pipe - pump outlet                   *
**************************************************
****
1370000 poutil   branch
1370001 1        1
1370101 42.660d-4 0.739   0.0     0.0      +0.0
1370102 +0.0     2.3d-5   0.0737  00
1370200 3        158.00d+5 565.15
1371101 137010000 140000000 0.0    0.0     0.0   0000
1371201 21.00    0.0      0.0
**************************************************
****
*  pump seal water common manifold  intact loop pump  *
**************************************************
****
1380000 pswilman branch
1380001 1        1
1380101 3.0d-4   5.0      0.0     0.0      +0.0
1380102 +0.0     0.0      0.02    00
1380200 3        158.00d+5 373.15
1381101 138010000 133010000 0.0    0.0     1.0e6 0000
1381201 0.75d-2  0.0      0.0
**************************************************
****
*  cold leg pipe                                 *
**************************************************
****
1400000 clpiil   pipe
1400001 2
1400101 42.660d-4 2
1400201 0.0      1
1400301 1.162    2
1400401 0.0      2
1400501 0.0      2
1400601 0.0      2
1400701 +0.0     2
1400801 2.3d-5   0.0737   2
```

```
1400901 0.0     0.0     1
1401001 00      2
1401101 0000    1
1401201 3       158.00d+5 565.15   0.0   0.0  0.0 2
1401300 1
1401301 21.00   0.0     0.0     1
**************************************************
****
*  pressure vessel inlet                         *
**************************************************
****
1450000 vinil   branch
1450001 1       1
1450101 42.660d-4 0.841   0.0     0.0     +0.0
1450102 +0.0    2.3d-5   0.0737   00
1450200 3       158.00d+5 565.15
1451101 140010000 145000000 0.0     0.0     0.0   0000
1451201 21.00   0.0     0.0
**************************************************
****
*                                *
*                                *
*            broken loop                 *
*                                *
*                                *
**************************************************
****
*  pressure vessel outlet - sp21                 *
**************************************************
****
2000000 voutbl  snglvol
2000101 16.691d-4 0.749   0.0     0.0     +0.0
2000102 +0.0    2.3d-5   0.0461   00
2000200 3       158.00d+5 599.15
**************************************************
****
*  pressurizer connection tee                    *
**************************************************
****
2030000 prcobl  branch
2030001 2       1
2030101 16.691d-4 0.865   0.0     0.0     +0.0
2030102 +0.0    2.3d-5   0.0461   00
2030200 3       158.00d+5 599.15
2031101 200010000 203000000 16.691d-4 0.12     0.12
0000
2032101 203010000 206000000 16.691d-4 0.05     0.05
0000
2031201 7.00    0.0     0.0
2032201 7.00    0.0     0.0
**************************************************
****
*  steam generator inlet piping - sp22               *
**************************************************
****
2060000 sgipbl  pipe
2060001 3
2060101 16.691d-4 3
2060201 0.0     2
2060301 0.666   2
2060302 0.686   3
2060401 0.0     3
2060501 0.0     3
2060601 +0.0    1
2060602 +13.46  2
2060603 +90.0   3
2060701 +0.0    1
2060702 +0.155  2
2060703 +0.686  3
2060801 2.3d-5  0.0461   3
2060901 0.10    0.10    1
2060902 0.80    0.80    2
```

```
2061001 00      3
2061101 000000    2
2061201 3       158.00d+5 599.15   0.0   0.0  0.0 3
2061300 1
2061301 7.00    0.0     0.0     2
**************************************************
****
*  steam generator inlet                         *
**************************************************
****
2080000 sginbl  sngljun
2080101 206010000 210000000 16.691d-4 0.35     0.16
100000
2080110 0. 0. 0.4 0.8
2080201 1       7.00    0.0     0.0
**************************************************
****
*  steam generator primary side                    *
**************************************************
****
*  fine nodalisation at lower part of sg u-tubes     *
**************************************************
****
2100000 sgprbl  pipe
2100001 26
2100101 36.745d-4 1
2100102 0.0     2
2100103 24.138d-4 24
2100104 0.0     25
2100105 36.745d-4 26
2100201 0.0     25
2100301 1.884   1
2100302 0.192   2
2100303 0.280   4
2100304 0.250   6
2100305 0.500   8
2100306 1.000   12
2100307 1.012322 14
2100308 1.000   18
2100309 0.500   20
2100310 0.250   22
2100311 0.280   24
2100312 0.192   25
2100313 1.884   26
2100401 0.0     1
2100402 2.70093d-3 2
2100403 0.0     24
2100404 2.70093d-3 25
2100405 0.0     26
2100501 0.0     26
2100601 +90.0   12
2100602 +88.06  13
2100603 -88.06  14
2100604 -90.00  26
2100701 +1.884  1
2100702 +0.192  2
2100703 +0.280  4
2100704 +0.250  6
2100705 +0.500  8
2100706 +1.000  12
2100707 +0.906098 13
2100708 -0.906098 14
2100709 -1.000  18
2100710 -0.500  20
2100711 -0.250  22
2100712 -0.280  24
2100713 -0.192  25
2100714 -1.884  26
2100801 2.3d-5  0.0684   1
2100802 2.3d-5  0.1134163 2
2100803 0.0     0.0196   24
2100804 2.3d-5  0.1134163 25
```

```
2100805 2.3d-5   0.0684   26
2100901 0.0      0.0      1
2100902 0.25     0.25     2
2100903 0.0      0.0      12
2100904 0.142    0.142    13
2100905 0.0      0.0      23
2100906 0.25     0.25     24
2100907 0.0      0.0      25
2101001 00       26
2101101 0100     2
2101102 0000     23
2101103 0100     25
2101201 3        158.00d+5 599.15   0.0    0.0   0.0 2
2101202 3        158.00d+5 593.00   0.0    0.0   0.0 8
2101203 3        158.00d+5 587.00   0.0    0.0   0.0 10
2101204 3        158.00d+5 582.00   0.0    0.0   0.0 12
2101205 3        158.00d+5 577.00   0.0    0.0   0.0 13
2101206 3        158.00d+5 573.00   0.0    0.0   0.0 14
2101207 3        158.00d+5 571.00   0.0    0.0   0.0 15
2101208 3        158.00d+5 569.00   0.0    0.0   0.0 17
2101209 3        158.00d+5 565.15   0.0    0.0   0.0 26
2101300 1
2101301 7.00     0.0      0.0      25
*******************************************************
****
*  steam generator outlet                        *
*******************************************************
****
2150000 sgoubl   sngljun
2150101 210010000 220000000 0.0     0.0     0.0   0000
2150201 1        7.00     0.0      0.0
*******************************************************
****
*  loop seal                                *
*******************************************************
****
2200000 lsealbl  pipe
2200001 5
2200101 16.691d-4 5
2200201 16.691d-4 4
2200301 1.042    1
2200302 1.153    2
2200303 0.741    3
2200304 0.732    4
2200305 0.741    5
2200401 0.0      5
2200501 0.0      5
2200601 -90.0    2
2200602 -79.17   3
2200603 0.0      4
2200604 +79.17   5
2200701 -1.042   1
2200702 -1.153   2
2200703 -0.622   3
2200704 0.0      4
2200705 +0.622   5
2200801 2.3d-5   0.0461   5
2200901 0.0      0.0      2
2200902 0.30     0.30     3
2200903 0.30     0.30     4
2201001 00       5
2201101 0000     4
2201201 3        158.00d+5 565.72   0.0    0.0   0.0 5
2201300 1
2201301 7.00     0.0      0.0      4
*******************************************************
****
*  pump inlet volume                             *
*******************************************************
****
2230000 pinbl    branch
2230001 1        1
2230101 16.691d-4 1.153    0.0      0.0      +90.0
2230102 +1.153   2.3d-5   0.0461   00
2230200 3        158.00d+5 565.72
2231101 220010000 223000000 0.0     0.0     0.0   0000
2231201 7.00     0.0      0.0
*******************************************************
****
*  pump broken loop                              *
*******************************************************
****
2250000 pumpbl   pump
2250101 33.183d-4 0.603    0.0      0.0      +90.0
2250102 +0.201   1
2250108 223010000 0.0      0.03     0.08     0000
2250109 230000000 0.0      0.08     0.03     0000
2250200 3        158.00d+5 565.72
2250201 1        7.00     0.0      0.0
2250202 1        7.00     0.0      0.0
2250301 135  135   135  -1   0   522  1
2250302 745.605  0.44973  0.028    139.9    45.47
2250303 1.444    747.3    0.0      0.0      0.0
2250304 0.0      0.0
2250310 0.0      0.0      0.0
*******************************************************
****
*  pump seal water common manifold   broken loop pump
*
*******************************************************
****
2280000 pswblman  branch
2280001 1        1
2280101 3.0d-4   5.0      0.0      0.0      +0.0
2280102 +0.0     0.0      0.02     00
2280200 3        158.00d+5 373.15
2281101 228010000 223010000 0.0     0.0     1.0e6  0000
2281201 0.50d-2  0.0      0.0
*******************************************************
****
*  cold leg pipe - pump outlet                   *
*******************************************************
****
2300000 poutbl   branch
2300001 0        1
2300101 16.691d-4 0.860    0.0      0.0      +0.0
2300102 +0.0     2.3d-5   0.0461   00
2300200 3        158.00d+5 565.15
*******************************************************
****
*  cold leg pipe - pump side                     *
*******************************************************
****
2400000 col1bl   branch
2400001 1        1
2400101 16.691d-4 1.263    0.0      0.0      +0.0
2400102 +0.0     2.3d-5   0.0461   00
2400200 3        158.00d+5 565.15
2401101 240010000 250000000 16.691d-4 0.0      0.0
0000
2401201 7.00     0.0      0.0
*******************************************************
****
*  penta valve flow restrictor & controller      *
*******************************************************
****
2350000 pentavlv  valve
2350101 230010000 240000000 16.691d-4 0.3      0.3
0100
2350102 1.0      1.0
2350201 1        7.0      0.0      0.0
2350300 mtrvlv
2350301 511      690      0.162308  1.0
```

```
**************************************************
****
*  cold leg pipe - rpv side                    *
**************************************************
****
2500000  col2bl   snglvol
2500101  16.691d-4 0.91    0.0     0.0     +0.0
2500102  +0.0    2.3d-5   0.0461   00
2500200  3       158.00d+5 565.15
**************************************************
****
2550000  col3bl   sngljun
2550101  250010000 260000000 16.691d-4 0.37     0.37
0000
2550102  1.0     1.0
2550201  1       7.00    0.0     0.0
**************************************************
****
*  vessel inlet - sp 26                    *
**************************************************
****
2600000  veinbl   branch
2600001  0
2600101  16.691d-4 0.704   0.0     0.0     +0.0
2600102  +0.0    2.3d-5   0.0461   00
2600200  3       158.00d+5 565.15
**************************************************
****
*                                 *
*                                 *
*               pressure vessel         *
*                                 *
*                                 *
**************************************************
****
*  downcomer - above nozzle center line           *
**************************************************
****
3000000  updownc   branch
3000001  0
3000101  113.10d-4 0.315   0.0     0.0     +90.0
3000102  +0.315  2.3d-5  0.024    00
3000200  3       158.00d+5 566.63
**************************************************
****
*  downcomer upper annulus - below centre line       *
**************************************************
****
3050000  updownc   branch
3050001  4       1
3050101  113.10d-4 0.487   0.0     0.0     -90.00
3050102  -0.487  2.3d-5  0.0240    00
3050200  3       158.00d+5 566.68
3051101  145010000 305000000 42.660d-4 3.55     3.55
0000
3052101  260010000 305000000 16.691d-4 3.24     3.24
0000
3053101  305010000 310000000 113.10d-4 0.0      0.0
0000
3054101  305000000 300000000 113.10d-4 0.0      0.0
0000
3051201  21.00    0.0      0.0
3052201  7.00     0.0      0.0
3053201  28.00    0.0      0.0
3054201  0.0     0.0      0.0
**************************************************
****
*  downcomer                              *
**************************************************
****
3100000  downc    annulus
3100001  10
3100101  113.10d-4 10
3100201  113.10d-4 9
3100301  0.600    2
3100302  0.740    3
3100303  0.663    4
3100304  0.875    6
3100305  0.663    7
3100306  0.612    8
3100307  0.390    9
3100308  0.616    10
3100401  0.0      10
3100501  0.0      10
3100601  -90.0    10
3100701  -0.600   2
3100702  -0.740   3
3100703  -0.663   4
3100704  -0.875   6
3100705  -0.663   7
3100706  -0.612   8
3100707  -0.390   9
3100708  -0.616   10
3100801  5.3d-6   0.024    10
3100901  0.0      0.0      9
3101001  00       10
3101101  0000     9
3101201  3        158.00d+5 566.71    0.0   0.0   0.0 10
3101300  1
3101301  28.00    0.0      0.0      9
**************************************************
****
*  lower plenum - upper part                   *
**************************************************
****
3150000  loplup    branch
3150001  3        1
3150101  764.54d-4 0.175    0.0      0.0      +90.0
3150102  +0.175   2.3d-5   0.312    00
3150200  3        158.00d+5 566.70
3151101  310010000 315010000 113.10d-4 1.0      1.0
0100
3152101  315010000 325000000 240.53d-4 4.5      4.5
0100
3153101  315000000 320000000 764.54d-4 0.0      0.0
0000
3151201  28.0     0.0      0.0
3152201  28.00    0.0      0.0
3153201  0.0      0.0      0.0
**************************************************
****
*  lower plenum - lower part                   *
**************************************************
****
3200000  lopllp    branch
3200001  0   1
3200101  764.54d-4 0.175    0.0      0.0      -90.0
3200102  -0.175   2.3d-5   0.312    00
3200200  3        158.00d+5 565.27
**************************************************
****
*  core inlet box                        *
**************************************************
****
3250000  coinb    pipe
3250001  2
3250101  240.53d-4 1
3250102  230.29d-4 2
3250201  230.29d-4 1
3250301  0.616    1
3250302  0.390    2
3250401  0.0      2
3250501  0.0      2
3250601  +90.00   2
```

```
3250701 +0.616   1
3250702 +0.390   2
3250801 2.3d-5   0.175    1
3250802 2.3d-5   0.0632   2
3250901 0.0      0.0      1
3251001 00       2
3251101 0100     1
3251201 3        158.00d+5 565.50   0.0    0.0  0.0 2
3251300 1
3251301 28.00    0.0      0.0      1
************************************************
****
*  core inlet junction                          *
************************************************
****
3300000 corinj   sngljun
3300101 325010000 335000000 81.152d-4 1.77     1.77
3300102 0100
3300201 1        28.00    0.0      0.0
************************************************
****
*  core region                                  *
************************************************
****
3350000 correg   pipe
3350001 6
3350101 81.152d-4 6
3350201 81.152d-4 5
3350301 0.612    1
3350302 0.663    2
3350303 0.875    4
3350304 0.663    5
3350305 0.740    6
3350401 0.0      6
3350501 0.0      6
3350601 +90.0    6
3350701 +0.612   1
3350702 +0.663   2
3350703 +0.875   4
3350704 +0.663   5
3350705 +0.740   6
3350801 0.0      0.0123   6
3350901 0.5      0.5      1
3350902 0.8      0.8      4
3350903 0.5      0.5      5
3351001 00       6
3351101 0000     5
3351201 3        158.00d+5 571.05   0.0    0.0  0.0 1
3351202 3        158.00d+5 576.11   0.0    0.0  0.0 2
3351203 3        158.00d+5 584.03   0.0    0.0  0.0 3
3351204 3        158.00d+5 591.66   0.0    0.0  0.0 4
3351205 3        158.00d+5 596.22   0.0    0.0  0.0 5
3351206 3        158.00d+5 598.63   0.0    0.0  0.0 6
3351300 1
3351301 28.00    0.0      0.0      5
************************************************
****
*  core outlet junction                         *
************************************************
****
3400000 corouj   sngljun
3400101 335010000 345000000 81.152d-4 1.2      1.2
3400102 0100
3400201 1        28.00    0.0      0.0
************************************************
****
*  upper plenum - lower part                    *
************************************************
****
3450000 uppllo   pipe
3450001 2
3450101 249.82d-4 2
3450201 249.82d-4 1
3450301 0.600    2
3450401 0.0      2
3450501 0.0      2
3450601 +90.0    2
3450701 +0.60    2
3450801 5.0d-5   0.0359   2
3450901 0.0      0.0      1
3451001 00       2
3451101 0000     1
3451201 3        158.00d+5 599.55   0.0    0.0  0.0 2
3451300 1
3451301 28.00    0.0      0.0      1
************************************************
****
*  upper plenum - intermediate part             *
************************************************
****
3500000 upplin   branch
3500001 4        1
3500101 249.82d-4 0.487   0.0      0.0      +90.0
3500102 +0.487   5.0d-5   0.0359   00
3501101 345010000 350000000 249.82d-4 0.0      0.0
0000
3502101 350010000 100000000 42.660d-4 0.94     0.94
0000
3503101 350010000 200000000 16.691d-4 1.54     1.54
0000
3504101 355010000 350010000 249.82d-4 0.0      0.0
0000
3501201 28.00    0.0      0.0
3502201 21.00    0.0      0.0
3503201 7.00     0.0      0.0
3504201 0.0      0.0      0.0
3500200 3        158.00d+5 599.10
************************************************
****
*  upper plenum - upper part                    *
************************************************
****
3550000 upplup   branch
3550001 0
3550101 249.82d-4 0.315   0.0      0.0      -90.0
3550102 -0.315   5.0d-5   0.0359   00
3550200 3        158.00d+5 574.16
************************************************
****
*  bypass, downcomer to upper plenum, via two paths:-  *
*  :two 5.0mm dia holes (junction 35200 = 1.3%)        *
*  :gap around hot leg nozzles (junction 35300 = 2.2%)  *
*  based on total loop flowrate of 28kg/s              *
************************************************
****
3520000 dcholes  sngljun
3520101 300010000 355000000 1.131d-2  215654.0
215654.0
3520102 0000
3520201 1        0.0      0.0      0.0
3530000 dcgap    sngljun
3530101 305000000 350010000 1.131d-2  81388.0  81388.0
3530102 0000
3530201 1        0.0      0.0      0.0
************************************************
****
*  isolation valve, upper plenum to upper head pipework  *
*  valve closes 240 sec before start of transient        *
************************************************
****
3640000 uhvalve  valve
3640101 363010000 365000000 3.1416d-4 10.0     10.0
0000
3640102 1.0      1.0
```

```
3640201 1       0.0     0.0     0.0
3640300 trpvlv
3640301 506
**************************************************
****
*  pump sealwater drain from upper plenum          *
*  valve closes at start of blowdown, time = 0.0 sec    *
**************************************************
****
3580000 upbleed  tmdpjun
3580101 355000000 360000000 6.0d-4
3580200 1       575     cntrlvar 755
3580201 -5.0    0.0     0.0     0.0
3580202 0.0     0.0     0.0     0.0
3580203 0.01    0.10    0.0     0.0
3580204 5.0     0.10    0.0     0.0
**************************************************
****
*  pump sealwater drain from lower plenum          *
*  valve opens at start of blowdown, time = 0.0 sec     *
**************************************************
****
3590000 lpbleed  tmdpjun
3590101 320000000 361000000 6.0d-4
3590200 1       505     cntrlvar 760
3590201 0.0     0.0     0.0     0.0
3590202 1.0     1.0     0.0     0.0
**************************************************
*  pump seal bleed flow reservoir  -  upper plenum drain *
**************************************************
****
3600000 upbleedr tmdpvol
3600101 1.0     0.5     0.0     0.0     +90.0
3600102 +0.5    0.0     0.0     00
3600200 3       508
3600201 0.0     1.0d5   298.0
3600202 10000.0  1.0d5   298.0
**************************************************
****
*  pump seal bleed flow reservoir  -  lower plenum drain *
**************************************************
****
3610000 lpbleedr tmdpvol
3610101 1.0     0.5     0.0     0.0     +90.0
3610102 +0.5    0.0     0.0     00
3610200 3       508
3610201 0.0     1.0d5   298.0
3610202 10000.0  1.0d5   298.0
**************************************************
****
*  connecting pipes to upper head                  *
**************************************************
****
3630000 uphepi1  branch
3630001 2       1
3630101 3.1416d-4 1.416   0.0     0.0     +65.31
3630102 +0.970  1.0d-5  0.020   00
3630200 3       158.0d5  566.62
3631101 300010000 363000000 3.1416d-4 23.0    23.0
0100
3632101 363010000 375010000 3.1416d-4 83.0    83.0
0000
3631201 0.0     0.0     0.0
3632201 0.0     0.0     0.0
**************************************************
****
3650000 uphepi2  branch
3650001 1       1
3650101 3.1416d-4 3.169   0.0     0.0     +54.04
3650102 +2.565  1.0d-5  0.020   00
3650200 3       158.00d+5 566.61
```

```
3651101 365010000 370000000 3.1416d-4 2.0     2.0
0000
3651201 0.0     0.0     0.0
**************************************************
****
*  upper head vessel                               *
**************************************************
****
3700000 upheves  pipe
3700001 2
3700101 113.10d-4 2
3700201 113.10d-4 1
3700301 0.855   2
3700401 0.0     2
3700501 0.0     2
3700601 -90.0   2
3700701 -0.855  2
3700801 2.3d-5  0.120   2
3700901 0.0     0.0     1
3701001 00      2
3701101 0000    1
3701201 3       158.00d+5 566.65   0.0     0.0   0.0 2
3701300 1
3701301 0.0     0.0     0.0     1
**************************************************
****
*  bottom volume of upper head vessel              *
**************************************************
****
3750000 uphevsb  branch
3750001 1       1
3750101 113.10d-4 0.855   0.0     0.0     -90.0
3750102 -0.855  2.3d-5  0.120   00
3750200 3       158.00d+5 566.65
3751101 370010000 375000000 113.10d-4 0.0     0.0
0000
3751201 0.0     0.0     0.0
**************************************************
****
*  connecting pipe upper head - to upper plenum    *
**************************************************
****
3800000 uphepi3  branch
3800001 2       1
3800101 3.1416d-4 1.416   0.0     0.0     -65.31
3800102 -0.970  1.0d-5  0.020   00
3800200 3       158.00d+5 566.67
3801101 375010000 380000000 3.1416d-4 0.1     0.1
0000
3802101 380010000 355000000 3.1416d-4 39.0    39.0
0100
3801201 0.0     0.0     0.0
3802201 0.0     0.0     0.0
**************************************************
****
*                                                  *
*                                                  *
*                  pressurizer                     *
*                                                  *
*                                                  *
**************************************************
****
*  pressurizer surge line - connection to intact loop  *
**************************************************
****
4000000 surgeli  pipe
4000001 3
4000101 1.3685d-4 3
4000201 1.3685d-4 2
4000301 1.730   1
4000302 2.600   2
4000303 2.800   3
```

```
4000401 0.0     3
4000501 0.0     3
4000601 -8.98   1
4000602 -74.06  2
4000603 +63.23  3
4000701 -0.270  1
4000702 -2.500  2
4000703 +2.500  3
4000801 2.3d-5  0.0132  3
4000901 0.5     0.5     2
4001001 00      3
4001101 0000    2
4001201 3       158.00d+5 599.15  0.0  0.0  0.0 3
4001300 1
4001301 0.0     0.0     0.0     2
**************************************************
****
*  pressurizer vessel                        *
**************************************************
****
*  top of pressurizer, valve connection point        *
**************************************************
****
4090000 przrtop  branch
4090001 1
4090101 115.00d-4 0.898   0.0     0.0     -90.0
4090102 -0.898  2.3d-5  0.1244  00
4090200 2       158.00d+5 1.0
4091101 409010000 410000000 115.00d-4 0.0  0.0  0000
4091201 0.0     0.0     0.0
**************************************************
****
4100000 pressuri  pipe
4100001 7
4100101 121.33d-4 1
4100102 121.54d-4 6
4100103 79.720d-4 7
4100201 0.0     6
4100301 0.9     6
4100302 0.585   7
4100401 0.0     7
4100501 0.0     7
4100601 -90.0   7
4100701 -0.9    6
4100702 -0.585  7
4100801 2.3d-5  0.1244  6
4100802 2.3d-5  0.0297  7
4100901 0.0     0.0     6
4101001 00      7
4101101 0000    5
4101102 0100    6
4101201 2       158.00d+5 0.9958  0.0   0.0  0.0 1
4101202 2       158.00d+5 0.9945  0.0   0.0  0.0 2
4101203 2       158.00d+5 0.8     0.0   0.0  0.0 3
4101204 2       158.00d+5 0.0     0.0   0.0  0.0 4
4101205 2       158.00d+5 0.0     0.0   0.0  0.0 7
4101300 1
4101301 0.0     0.0     0.0     6
**************************************************
****
*  inlet to surge line                       *
**************************************************
****
4150000 insurge  sngljun
4150101 420000000 400000000 1.3685d-4 0.0     0.0
4150102 0100
4150201 1       0.0     0.0     0.0
**************************************************
****
*  pressurizer bottom                        *
**************************************************
****
```

```
4200000 pressbt  branch
4200001 1       1
4200101 80.549d-4 0.790   0.0     0.0     -90.0
4200102 -0.790  2.3d-5  0.0323  00
4200200 2       158.00d+5 0.0
4201101 410010000 420000000 79.720d-4 0.0     0.0
0100
4201201 0.0     0.0     0.0
**************************************************
****
*  time depend. volume for pressure initialization     *
*  trip valve has to be closed for transient run      *
*  used in combination with pressurizer power controller *
**************************************************
****
4250000 cntjpre  valve
4250101 430000000 409000000 0.0     0.0     0.0   0000
4250201 1       0.0     0.0     0.0
4250300 trpvlv
4250301 575
*
4300000 cntvpre  tmdpvol
4300101 115.00d-4 1.00    0.0     0.0     -90.0
4300102 -1.00   0.0     0.0     00
4300200 2       575     cntrlvar 823
4300201 136.0d5  136.0d5  1.00
4300202 162.0d5  162.0d5  1.0
**************************************************
****
*  pressuriser porv discharge line, isolation valve    *
*  --  orifice diameter of 2.74 mm assumed  --        *
**************************************************
****
4400000 porvsr1  valve
4400101 409000000 910000000 5.896e-6  1.5     1.5   0000
4400201 1       0.0     0.0     0.0
4400300 trpvlv
4400301 651
**************************************************
****
4410000 porvsr2  valve
4410101 409000000 901000000 4.3043e-6 1.5     1.5
0100
4410201 1       0.0     0.0     0.0
4410300 mtrvlv
4410301 601  504  2.  0.
**************************************************
*                                      *
*       lobi mod2 steam generators               *
*                                      *
**************************************************
****
*                                      *
*       sg intact loop - secondary side          *
*                                      *
**************************************************
****
*  sg1 - feedwater inlet annulus                  *
**************************************************
****
5000000 sg1fwia  branch
5000001 2       1
5000101 119.51d-4 1.402   0.0     0.0   -90.0  -1.402
5000102 1.5d-5  0.024   00
5000200 2       65.40d5  2.5d-5
5001101 555010000 500000000 119.51d-4 0.0     0.0
0100
5002101 500010000 510000000 119.51d-4 0.0     0.0
0000
5001201 6.032   0.0     0.0
5002201 8.10    0.0     0.0
```

```
************************************************
****
*  sg1 - downcomer annulus                      *
************************************************
****
5100000  sg1down   annulus
5100001  20
5100101  119.51d-4 20
5100201  119.51d-4 19
5100301  0.500    8
5100302  0.2500   12
5100303  0.1250   20
5100401  0.0      20
5100601  -90.0    20
5100701  -0.500   8
5100702  -0.2500   12
5100703  -0.1250   20
5100801  4.6d-5   0.024    20
5101001  00       20
5101101  0000     19
5101201  3        65.0d5   535.88   0.0    0.0   0.0 20
5101300  1
5101301  8.4      0.0      0.0      19
************************************************
****
*  sg1 - adjustable throttle valve              *
*  controller used to set recirculation ratio        *
************************************************
****
5200000  sg1slva   valve
5200101  510010000 530000000 119.51d-4  0.0     0.0
1100
5200201  1        8.1      0.0      0.0
5200300  srvvlv
5200301  535
************************************************
****
*  sg1 - riser section (including spacer grids)      *
************************************************
****
5300000  sg1rise   pipe
5300001  20
5300101  299.05d-4 20
5300201  299.05d-4 19
5300301  0.1250   8
5300302  0.2500   12
5300303  0.500    20
5300401  0.0      20
5300601  +90.0    20
5300701  +0.1250   8
5300702  +0.2500   12
5300703  +0.500    20
5300801  4.6d-5   0.024263 20
5300901  0.9384   0.9384  19
5301001  00       20
5301101  0000     19
5301201  2        65.0d5   0.054    0.0    0.0   0.0 12
5301202  2        65.0d5   0.128    0.0    0.0   0.0 16
5301203  2        65.0d5   0.197    0.0    0.0   0.0 20
5301300  1
5301301  8.148    0.252    0.0      15
5301302  7.413    0.987    0.0      19
************************************************
****
*  sg1 - riser outlet                           *
*  loss at top of u-tubes based on jacob's formula       *
************************************************
****
5450000  sg1rout   branch
5450001  2        0
5450101  0.0      1.402    0.0628484 0.0      +90.0
5450102  +1.402   1.5d-5   0.047395 00
5450200  2        65.40d5  0.18
5451101  530010000 545000000 299.05d-4 2.47     2.47
0100
5452101  545010000 550000000 314.62d-4 0.0      0.0
0000
5451201  0.7371   2.9289   0.0
5452201  0.6137   3.4704   0.0
************************************************
****
*  sg1 - conical inlet section to separator             *
************************************************
****
5500000  sg1sepin  snglvol
5500101  0.0      1.105    0.034766 0.0      +90.0
5500102  +1.105   1.5d-5   0.112    00
5500200  2        65.40d5  0.216
************************************************
****
*  sg1 - separator component  (specified as a branch)    *
************************************************
****
5520000  sg1septr  branch
5520001  3        0
5520101  0.0      1.10     0.185637 0.0      +90.0
5520102  +1.10    1.5d-5   0.169    00
5520200  2        65.40d5  0.66
5521101  552010000 560000000 0.16876  0.0      0.0
0100
5522101  552000000 555000000 0.0      0.0      0.0     0100
5523101  550010000 552000000 98.52d-4  0.0      0.0
0000
5521201  0.0      0.37460  0.0
5522201  3.4330   1.02d-2  0.0
5523201  1.3097   17.055   0.0
************************************************
****
*  sg1 - outer annulus surrounding coarse separator     *
************************************************
****
5550000  sg1spoa   snglvol
5550101  0.0      1.105    0.11753  0.0      -90.0
5550102  -1.105   1.5d-5   0.105    00
5550200  2        65.40d5  9.0d-3
************************************************
****
*  sg1 - upper part of steam dome                  *
************************************************
****
5600000  sg1stdo   branch
5600001  0        1
5600101  0.0      0.593    0.101573 0.0      +90.0
5600102  +0.593   1.5d-5   0.467    00
5600200  2        65.40d5  1.0
************************************************
****
*  sg1 - steam outlet     isolation valve, stays open   *
************************************************
****
5620000  sg1sout   valve
5620101  560010000 564000000 3.728d-3  0.0      0.0
0100
5620102  1.0      1.0
5620201  1        0.0      2.1      0.0
5620300  trpvlv
5620301  522
************************************************
****
*  il sg safety valve opens to control sec-side pressure  *
************************************************
****
5630000  ilsgsv    valve
5630101  560010000 567000000 1.5d-3   1.5      1.5    0000
```

```
5630201 1       0.0     0.0     0.0
5630300 trpvlv
5630301 522
***************************************************
****
*  sg1 - steam line                         *
***************************************************
****
5640000 sg1sline  sngIvol
5640101 3.728d-3 6.5     0.0     0.0     +0.0
5640102 +0.0     2.3d-5  0.0689  00
5640200 2       65.40d5  1.0
***************************************************
****
*  common steam discharge manifold                 *
***************************************************
****
5650000 sgcommon  branch
5650001 2       1
5650101 45.000d-4 2.0     0.0     0.0     0.0     0.0
5650102 2.3e-5  0.0761  11
5650200 2       65.40d5  0.9999
5651101 564010000 565000000 37.280d-4 0.5     0.5
0100
5652101 664010000 565000000 14.590d-4 0.5     0.5
0100
5651201 0.0     2.1     0.0
5652201 0.0     0.7     0.0
***************************************************
****
*  sec-side prv dump volume                   *
***************************************************
****
5670000 secpress  tmdpvol
5670101 1.0     0.5     0.0     0.0     +90.0
5670102 +0.5    0.0     0.0     00
5670200 2  505
5670201 0.0     64.5d5   1.0
5670202 3.54    64.62d5  1.0
5670203 10.7    64.56d5  1.0
5670204 17.9    65.05d5  1.0
5670205 25.12   65.2d5   1.0
5670206 32.28   65.08d5  1.0
5670207 39.66   69.42d5  1.0
5670208 46.81   70.49d5  1.0
5670209 53.97   70.46d5  1.0
5670210 61.02   70.76d5  1.0
5670211 68.40   71.03d5  1.0
5670212 75.5    71.18d5  1.0
5670213 82.7    71.25d5  1.0
5670214 90.09   71.34d5  1.0
5670215 97.14   71.38d5  1.0
5670216 104.3   71.17d5  1.0
5670217 111.457  70.73d5  1.0
5670218 118.83   70.46d5  1.0
5670219 126.0    70.15d5  1.0
5670220 133.0    69.8d5   1.0
5670221 140.4    69.53d5  1.0
5670222 147.57   69.50d5  1.0
5670223 154.7    70.01d5  1.0
5670224 161.9    70.4d5   1.0
5670225 169.16   70.6d5   1.0
5670226 176.31   70.73d5  1.0
5670227 183.47   70.82d5  1.0
5670228 190.85   70.89d5  1.0
5670229 198.01   70.95d5  1.0
5670230 219.59   71.06d5  1.0
5670231 233.90   71.09d5  1.0
5670232 241.28   71.12d5  1.0
5670233 255.5    71.13d5  1.0
5670234 277.18   71.13d5  1.0
5670235 284.34   70.88d5  1.0
5670236 305.9    70.75d5  1.0
5670237 320.46   70.57d5  1.0
5670238 334.6    70.39d5  1.0
5670239 349.2    70.11d5  1.0
5670240 363.5    69.85d5  1.0
5670241 377.94   69.64d5  1.0
5670242 392.1    69.5d5  1.0
5670243 421.21   69.26d5  1.0
5670244 428.37   69.38d5  1.0
5670245 497.65   68.7d5  1.0
5670246 584.37   67.8d5  1.0
5670247 675.78   67.02d5  1.0
5670248 778.9    66.01d5  1.0
5670249 864.5    65.1d5  1.0
5670250 989.58   63.44d5  1.0
5670251 1156.0   61.32d5  1.0
5670252 1343.0   59.0d5  1.0
5670253 1490.0   57.0d5  1.0
5670254 1614.5   55.6d5  1.0
5670255 1760.0   53.91d5  1.0
5670256 1927.0   52.4d5  1.0
5670257 2125.0   50.74d5  1.0
5670258 2312.0   49.28d5  1.0
5670259 2500.0   48.21d5  1.0
5670260 2644.0   46.96d5  1.0
5670261 2877.0   44.84d5  1.0
5670262 3073.0   43.35d5  1.0
5670263 3346.0   41.45d5  1.0
5670264 3606.0   40.39d5  1.0
5670265 3919.0   38.28d5  1.0
5670266 4153.0   37.01d5  1.0
5670267 4440.0   35.31d5  1.0
5670268 4635.0   34.04d5  1.0
5670269 5052.0   31.50d5  1.0
5670270 5273.0   30.02d5  1.0
5670271 5651.0   27.48d5  1.0
5670272 6067.7   25.15d5  1.0
5670273 6484.3   22.40d5  1.0
5670274 6848.9   19.86d5  1.0
***************************************************
****
*  sg1 - main feedwater system                 *
***************************************************
****
5700000 sg1mfwv  tmdpjun
5700101 572000000 500000000 15.0d-4
5700200 1       522     cntrlvar 560
5700201 0.0     0.0     0.0     0.0
5700202 3.0     3.0     0.0     0.0
***************************************************
****
5720000 sg1mfco  tmdpvol
5720101 1.0     0.5     0.0     0.0     +90.0
5720102 +0.5    0.0     0.0     00
5720200 3       522
5720201 0.0     65.40d5  486.16
5720202 20000.0 65.43d5  486.16
***************************************************
****
*  sg1 - auxiliary feedwater system             *
***************************************************
****
5740000 sg1affl  tmdpjun
5740101 576000000 500000000 14.5896d-4
5740200 1       551
5740201 0.0     0.0     0.0     0.0
5740202 0.001   0.0565  0.0     0.0
5740203 5000.0  0.0565  0.0     0.0  * no step
***************************************************
****
5760000 sg1afco  tmdpvol
5760101 1.0     0.5     0.0     0.0     +90.0
```

```
5760102 +0.5    0.0     0.0     00
5760200 3       522
5760201 0.0     65.40d5  423.0
5760202 50000.0  65.40d5  423.0
**************************************************
****
*  sg common discharge line                       *
**************************************************
****
5800000 sgflocv  valve
5800101 565010000 582000000 4.500d-3 0.0     0.0  0100
5800201 1       0.0     2.8     0.0
5800300 srvvlv
5800301 526     580
**************************************************
****
*  condenser                                *
**************************************************
****
5820000 condensr tmdpvol
5820101 1.0     0.5     0.0     0.0     +0.0
5820102 +0.0    0.0     0.0     11
5820200 2       522
5820201 0.0     60.0d5   1.0
5820202 20000.0  1.013d5  1.0
**************************************************
****
*                                          *
*      broken loop steam generator - secondary side      *
*                                          *
**************************************************
****
*  sg2 - feedwater inlet annulus                  *
**************************************************
****
6000000 sg2fwia  branch
6000001 2       1
6000101 39.584d-4 1.304   0.0     0.0     -90.0
6000102 -1.304   1.5d-5   0.012    00
6000200 2       65.40d5  2.5d-5
6001101 655010000 600000000 39.584d-4 0.0     0.0
0100
6002101 600010000 610000000 39.584d-4 0.0     0.0
0000
6001201 1.9527   0.0     0.0
6002201 2.6413   0.0     0.0
**************************************************
****
*  sg2 - downcomer annulus                        *
**************************************************
****
6100000 sg2down  annulus
6100001 10
6100101 39.584d-4 10
6100201 39.584d-4 9
6100301 1.000    4
6100302 0.500    6
6100303 0.250    10
6100401 0.0      10
6100601 -90.0    10
6100701 -1.000   4
6100702 -0.500   6
6100703 -0.250   10
6100801 4.6d-5   0.012    10
6101001 00       10
6101101 0000     9
6101201 3       65.0d5   535.88   0.0     0.0  0.0 10
6101300 1
6101301 2.8     0.0     0.0     9
**************************************************
****
*  sg2 - adjustable throttle valve                *
*  controller used to set recirculation ratio     *
**************************************************
****
6200000 sg2slva  valve
6200101 610010000 630000000 39.584d-4  0.0     0.0
1100
6200201 1       2.6413   0.0     0.0
6200300 srvvlv
6200301 635
**************************************************
****
*  sg2 - riser section (including spacer grids)        *
**************************************************
****
6300000 sg2rise  pipe
6300001 10
6300101 94.947d-4 10
6300201 94.947d-4 9
6300301 0.2500   4
6300302 0.500    6
6300303 1.000    10
6300401 0.0      10
6300601 +90.0    10
6300701 +0.2500  4
6300702 +0.500   6
6300703 +1.000   10
6300801 4.6d-5   0.016403 10
6300901 0.8513   0.8513   9
6301001 00       10
6301101 0000     9
6301201 2       63.0d5   0.057    0.0     0.0  0.0 6
6301202 2       63.0d5   0.128    0.0     0.0  0.0 8
6301203 2       63.0d5   0.200    0.0     0.0  0.0 10
6301300 1
6301301 2.716    0.084    0.0     7
6301302 2.471    0.329    0.0     9
**************************************************
****
*  sg2 - riser outlet                        *
**************************************************
****
6450000 sg2rout  branch
6450001 2       0
6450101 0.0      1.304    0.0230638 0.0     +90.0
6450102 +1.304   1.5d-5   0.05308  00
6450200 2       65.40d5  0.169
6451101 630010000 645000000 94.947d-4 0.394    0.394
0100
6452101 645010000 650000000 109.12d-4 0.0     0.0
0000
6451201 0.84894  2.8992   0.0
6452201 0.53715  3.4805   0.0
**************************************************
****
*  sg2 - conical inlet section to separator       *
**************************************************
****
6500000 sg2sepin snglvol
6500101 0.0      1.128    0.012309 0.0     +90.0
6500102 +1.128   1.5d-5   0.065    00
6500200 2       65.40d5  0.239
**************************************************
****
*  sg2 - separator component, specified as a branch     *
**************************************************
****
6520000 sg2septr branch
6520001 3       0
6520101 0.0      1.10     0.0590521 0.0     +90.0
6520102 +1.10    1.5d-5   0.103    00
6520200 2       65.40d5  0.66
```

```
6521101 652010000 660000000 0.05368  0.0     0.0
0100
6522101 652000000 655000000 0.0     0.0     0.0    0100
6523101 650010000 652000000 33.183d-4 0.0     0.0
0000
6521201 0.0     0.31982  0.0
6522201 2.7663    1.08d-2  0.0
6523201 1.4385    13.959   0.0
**************************************************
****
*  sg2 - outer annulus surrounding coarse separator     *
**************************************************
****
6550000 sg2spoa  snglvol
6550101 0.0     1.128    0.0378   0.0     -90.0
6550102 -1.128   1.5d-5   0.035    00
6550200 2       65.40d5  9.0d-3
**************************************************
****
*  sg2 - upper part of steam dome                   *
**************************************************
****
6600000 sg2stdo  branch
6600001 0    1
6600101 0.0     0.681    0.0389911 0.0     +90.0
6600102 +0.681   1.5d-5   0.270    00
6600200 2       65.40d5  1.0
**************************************************
****
*  sg2 - steam outlet     isolation valve, stays open    *
**************************************************
****
6620000 sg2sout  valve
6620101 660010000 664000000 1.459d-3 0.0     0.0
0100
6620102 1.0     1.0
6620201 1       0.0     0.7     0.0
6620300 trpvlv
6620301 522
**************************************************
****
*  bl sg safety valve opens to control sec-side pressure*
**************************************************
****
6630000 blsgsv   valve
6630101 660010000 667000000 0.5d-3   1.5     1.5    0000
6630201 1       0.0     0.0     0.0
6630300 trpvlv
6630301 522
**************************************************
****
*  sg2 - steam line                             *
**************************************************
****
6640000 sg2sline snglvol
6640101 1.459d-3 5.8     0.0     0.0     +0.0
6640102 +0.0     2.3d-5   0.0431   00
6640200 2       65.40d5  1.0
**************************************************
****
* sec-side prv dump volume*
**************************************************
****
6670000 atmos    tmdpvol
6670101 1.0     0.5     0.0     0.0     +90.0
6670102 +0.5     0.0     0.0     00
6670200 2  505
6670201 0.0     64.5d5   1.0
6670202 3.54     64.62d5  1.0
6670203 10.7     64.56d5  1.0
6670204 17.9     65.05d5  1.0
6670205 25.12    65.2d5   1.0
6670206 32.28    65.08d5  1.0
6670207 39.66    69.42d5  1.0
6670208 46.81    70.49d5  1.0
6670209 53.97    70.46d5  1.0
6670210 61.02    70.76d5  1.0
6670211 68.40    71.03d5  1.0
6670212 75.5     71.18d5  1.0
6670213 82.7     71.25d5  1.0
6670214 90.09    71.34d5  1.0
6670215 97.14    71.38d5  1.0
6670216 104.3    71.17d5  1.0
6670217 111.457  70.73d5  1.0
6670218 118.83   70.46d5  1.0
6670219 126.0    70.15d5  1.0
6670220 133.0    69.8d5   1.0
6670221 140.4    69.53d5  1.0
6670222 147.57   69.50d5  1.0
6670223 154.7    70.01d5  1.0
6670224 161.9    70.4d5   1.0
6670225 169.16   70.6d5   1.0
6670226 176.31   70.73d5  1.0
6670227 183.47   70.82d5  1.0
6670228 190.85   70.89d5  1.0
6670229 198.01   70.95d5  1.0
6670230 219.59   71.06d5  1.0
6670231 233.90   71.09d5  1.0
6670232 241.28   71.12d5  1.0
6670233 255.5    71.13d5  1.0
6670234 277.18   71.13d5  1.0
6670235 284.34   70.88d5  1.0
6670236 305.9    70.75d5  1.0
6670237 320.46   70.57d5  1.0
6670238 334.6    70.39d5  1.0
6670239 349.2    70.11d5  1.0
6670240 363.5    69.85d5  1.0
6670241 377.94   69.64d5  1.0
6670242 392.1    69.5d5   1.0
6670243 421.21   69.26d5  1.0
6670244 428.37   69.38d5  1.0
6670245 497.65   68.7d5   1.0
6670246 584.37   67.8d5   1.0
6670247 675.78   67.02d5  1.0
6670248 778.9    66.01d5  1.0
6670249 864.5    65.1d5   1.0
6670250 989.58   63.44d5  1.0
6670251 1156.0   61.32d5  1.0
6670252 1343.0   59.0d5   1.0
6670253 1490.0   57.0d5   1.0
6670254 1614.5   55.6d5   1.0
6670255 1760.0   53.91d5  1.0
6670256 1927.0   52.4d5   1.0
6670257 2125.0   50.74d5  1.0
6670258 2312.0   49.28d5  1.0
6670259 2500.0   48.21d5  1.0
6670260 2644.0   46.96d5  1.0
6670261 2877.0   44.84d5  1.0
6670262 3073.0   43.35d5  1.0
6670263 3346.0   41.45d5  1.0
6670264 3606.0   40.39d5  1.0
6670265 3919.0   38.28d5  1.0
6670266 4153.0   37.01d5  1.0
6670267 4440.0   35.31d5  1.0
6670268 4635.0   34.04d5  1.0
6670269 5052.0   31.50d5  1.0
6670270 5273.0   30.02d5  1.0
6670271 5651.0   27.48d5  1.0
6670272 6067.7   25.15d5  1.0
6670273 6484.3   22.40d5  1.0
6670274 6848.9   19.86d5  1.0
**************************************************
****
*  sg2 - main feedwater system                     *
```

```
*****************************************************
****
6700000 sg2mfwv  tmdpjun
6700101 672000000 600000000 6.0d-4
6700200 1       522     cntrlvar 660
6700201 0.0     0.0     0.0     0.0
6700202 1.5     1.5     0.0     0.0
*****************************************************
****
6720000 sg2mfco  tmdpvol
6720101 1.0     0.5     0.0     0.0     +90.0
6720102 +0.5     0.0     0.0     00
6720200 3       522
6720201 0.0     65.40d5  482.16
6720202 20000.0  65.40d5  482.16
*****************************************************
****
*  sg2 - auxiliary feedwater system                  *
*****************************************************
****
6740000 sg1affl  tmdpjun
6740101 676000000 600000000 6.3794d-4
6740200 1       551
6740201 0.0     0.0  0.0     0.0
6740202 0.001    0.0195   0.0     0.0
6740203 5000.0   0.0195   0.0     0.0  * no step
*****************************************************
****
6760000 sg2afco  tmdpvol
6760101 1.0     0.5     0.0     0.0     +90.0
6760102 +0.5     0.0     0.0     00
6760200 3       522
6760201 0.0     65.40d5  433.0
6760202 50000.0  65.40d5  433.0
*****************************************************
****
*  accumulator injection system  -  intact loop       *
*****************************************************
****
7100000 accuilcl  accum
7100101 0.0     4.580    266.61d-3 0.0     +90.0
7100102 +4.580   2.3d-5   0.0     10  *** r5ml
7100200 37.5d5  298.0
7101101 720000000 4.830d-4   2.0    2.0      0
7102200 127.0d-3  0.0  0.925  +0.0   0.010  0  0.0  0.0  0.0
*****************************************************
****
*  accu il - dividing branch to hot & cold leg feed-lines  *
*****************************************************
****
7200000 accudiv1  branch
7200001 0       0
7200101 4.831d-4  1.000    0.0     0.0     -90.0
7200102 -1.0     1.5d-5   0.0248   00
7200200 3       37.5d5   400.0
*****************************************************
****
*  isolation valve for hot leg injection line          *
*****************************************************
****
7220000 achlvlvi  valve
7220101 720010000 724000000 0.0      0.0      0.0   0020
7220201 1       0.0     0.0     0.0
7220300 trpvlv
7220301 511  * valve stays shut
*****************************************************
****
*  accu il hot leg feed-line,  turbine flow meter section  *
*****************************************************
****
7240000 achlturi  pipe
7240001 2
7240101 4.831d-4 2
7240201 4.831d-4 1
7240301 3.84     1      1.47     2
7240401 0.0     2
7240601 -90.0    1      0.0      2
7240701 -3.84    1      0.0      2
7240801 1.5d-5   0.0248   2
7240901 8.0     8.0     1
7241001 00      2
7241101 0020     1
7241201 3       158.00d+5 460.0    0.0    0.0   0.0 2
7241300 1
7241301 0.0     0.0     0.0     1
*****************************************************
****
*  accu hot leg feed-line orifice  (nom 8.8 mm dia)     *
*****************************************************
****
7260000 achlori   sngljun
7260101 724010000 728000000 0.0      115.0    115.0
7260102 0120
7260201 1       0.0     0.0     0.0
*****************************************************
****
*  accu il hot leg feed-line,  orifice to upper plenum    *
*****************************************************
****
7280000 achlinjl  pipe
7280001 1
7280101 4.831d-4  1
7280301 3.87     1
7280401 0.0     1
7280601 -29.57   1
7280701 -1.910   1
7280801 1.5d-5   0.0248   1
7281001 00      1
7281201 3       158.00d+5 463.0    0.0    0.0   0.0 1
*****************************************************
****
*  accu hot leg injection point (into upper plenum)       *
*****************************************************
****
7300000 achlupi   sngljun
7300101 728010000 350010000 4.831d-4  30.0     30.0
7300102 0020
7300201 1       0.0     0.0     0.0
*****************************************************
****
7320000 acclvlvi  valve
7320101 720010000 734000000 9.616d-6  0.0      0.0   0120
7320201 1       0.0     0.0     0.0
7320300 mtrvlv
7320301 602   502    2.    0.
*****************************************************
****
*  accu il cold leg feed-line,  turbine flow meter section *
*****************************************************
****
7340000 acclturb  pipe
7340001 2
7340101 4.831d-4  2
7340201 4.831d-4  1
7340301 3.84     1      1.30     2
7340401 0.0     2
7340601 -90.0    1      0.0      2
7340701 -3.84    1      0.0      2
7340801 1.5d-5   0.0248   2
7340901 8.0     8.0     1
7341001 00      2
7341101 0020     1
7341201 3       158.00d+5 460.0   0.0    0.0   0.   2
7341300 1
```

```
7341301 0.0     0.0     0.0     1
**************************************************
****
*  accu cold leg feed-line orifice  (nom 8.1 mm dia)     *
*  use pipe area = 4.831d-4 with calculated loss coeffs.  *
**************************************************
****
7360000  acclori   sngljun
7360101  734010000 738000000 4.831d-4  95.0      95.0
7360102  0120
7360201  1       0.0     0.0     0.0
**************************************************
****
*  accu il cold leg feed-line,  orifice to cold leg       *
**************************************************
****
7380000  acclinjl  pipe
7380001  1
7380101  4.831d-4  1
7380301  3.255    1
7380401  0.0      1
7380601  -35.93   1
7380701  -1.910   1
7380801  1.5d-5   0.0248   1
7381001  00       1
7381201  3       158.00d+5 463.0   0.0    0.0  0.   1
**************************************************
****
*  accu cold leg injection point into cold leg, rpv inlet  *
**************************************************
****
7400000  acclrpvi  sngljun
7400101  738010000 145000000 4.831d-4  8.0   8.0  * 15.0
15.0
7400102  0020
7400201  1       0.0     0.0     0.0
**************************************************
****
*  accumulator low level trip control logic            *
**************************************************
****
20571000 accuflo1  integral  1.0     0.0     1
20571001 mflowj    710010000
*
20571100 liqmass1  sum     0.92     0.0     1
20571101 0.0      211.8d-3  rhof     720010000
**************************************************
****
*  accu trip pressure corrections                    *
**************************************************
****
20571200 dpaccufl  sum      9.80665   0.0      1
20571201 0.0       2.29     rho      710010000
20571202           1.0      rho      720010000
20571203           3.84     rho      734010000
20571204           1.91     rho      738010000
*
20571300 dpacclp   sum      1.0      0.0     1
20571301 0.0       1.0      p        710010000
20571302           1.0      cntrlvar  712
*20571303          -1.0     p        305010000
20571303          -1.0     p        145010000
**************************************************
****
*                                         *
*  accumulator injection system  -  broken loop         *
*                                         *
**************************************************
****
7500000  accubl    accum
7500101  0.0      4.794    94.35d-3  0.0     +90.0
7500102  +4.794   2.3d-5   0.0      10  *** r5m1
```

```
7500200  27.00d+5  298.00
7501101  760000000 2.011d-4   2.0   2.0      0
7502200  61.00d-3  0.0  0.130  +0.0  0.005  0  0.0  0.0  0.0
**************************************************
****
*  accu bl - dividing branch to hot & cold leg feed-lines  *
**************************************************
****
7600000  accudiv2  branch
7600001  0       0
7600101  2.011d-4  2.000    0.0      0.0      -90.0
7600102  -2.0     1.5d-5   0.0160   00
7600200  3       27.0d5   400.0
**************************************************
****
*  isolation valve for hot leg injection line            *
**************************************************
****
7620000  achlvlvb  valve
7620101  760010000 764000000 0.0      0.0      0.0   0020
7620201  1       0.0     0.0     0.0
7620300  trpvlv
7620301  511  * valve stays shut
**************************************************
****
*  accu bl hot leg feed-line,  turbine flow meter section  *
**************************************************
****
7640000  achlturb  pipe
7640001  2
7640101  2.011d-4  2
7640201  2.011d-4  1
7640301  2.698    1       0.852    2
7640401  0.0      2
7640601  -90.0    1       0.0      2
7640701  -2.698   1       0.0      2
7640801  1.5d-5   0.0160   2
7640901  2.0      2.0      1
7641001  00       2
7641101  0020     1
7641201  3       158.00d+5 460.0    0.0    0.0  0.    2
7641300  1
7641301  0.0      0.0      0.0      1
**************************************************
****
*  accu hot leg feed-line orifice  (nom 5.3 mm dia)      *
**************************************************
****
7660000  achlorb   sngljun
7660101  764010000 768000000 0.0      130.0    130.0
7660102  0120
7660201  1       0.0     0.0     0.0
**************************************************
****
*  accu bl hot leg feed-line,  orifice to upper plenum     *
**************************************************
****
7680000  achlinjl  pipe
7680001  2
7680101  2.011d-4  1        7.088d-5  2
7680201  7.088d-5  1
7680301  1.870    1       1.845    2
7680401  0.0      2
7680601  -32.33   1       -28.13   2
7680701  -1.00    1       -0.870   2
7680801  1.5d-5   0.0160   1
7680802  1.5d-5   0.0095   2
7680901  0.0      0.0      1
7681001  00       2
7681101  0020     1
7681201  3       158.00d+5 463.0    0.0    0.0  0.    2
7681300  1
```

```
7681301 0.0     0.0     0.0     1
*****************************************************
****
*  accu hot leg injection point (into upper plenum)     *
*****************************************************
****
7700000 achlupb  sngljun
7700101 768010000 350010000 7.088d-5 2.5     2.5
7700102 0020
7700201 1       0.0     0.0     0.0
*****************************************************
****
*  isolation valve for cold leg injection line          *
*****************************************************
****
7720000 acclvlvb  valve
7720101 760010000 774000000 0.0     0.0     0.0  0020
7720201 1       0.0     0.0     0.0
7720300 trpvlv
7720301 511     *** valve stays shut
*****************************************************
****
*  accu bl cold leg feed-line,  turbine flow meter section *
*****************************************************
****
7740000 accIturb  pipe
7740001 2
7740101 2.011d-4  2
7740201 2.011d-4  1
7740301 2.698    1      0.852     2
7740401 0.0      2
7740601 -90.0    1      0.0       2
7740701 -2.698   1      0.0       2
7740801 1.5d-5   0.0160   2
7740901 2.0      2.0      1
7741001 00       2
7741101 0020     1
7741201 3        158.00d+5 460.0    0.0     0.0 0.    2
7741300 1
7741301 0.0      0.0      0.0      1
*****************************************************
****
*  accu cold leg feed-line orifice  (nom 5.0 mm dia)     *
*****************************************************
****
7760000 acclorb   sngljun
7760101 774010000 778000000 0.0      160.0    160.0
7760102 0120
7760201 1        0.0      0.0      0.0
*****************************************************
****
*  accu bl cold leg feed-line,  orifice to cold leg      *
*****************************************************
****
7780000 acclinjb  pipe
7780001 1
7780101 2.011d-4  1
7780301 2.870     1
7780401 0.0       1
7780601 -40.66    1
7780701 -1.870    1
7780801 1.5d-5    0.0160    1
7781001 00        1
7781201 3        158.00d+5 463.0    0.0     0.0 0.    1
*****************************************************
****
*  accu cold leg injection point into cold leg, rpv inlet *
*****************************************************
****
7800000 acclrpvb  sngljun
7800101 778010000 260000000 2.011d-4  10.0     10.0
7800102 0020
7800201 1       0.0     0.0     0.0
*****************************************************
****
*                                            *
*  lower pressure injection system
*****************************************************
****
8000000 hpistank  tmdpvol
8000101 1.0      1.0      0.0      0.0      -90.0
8000102 -1.0     0.0      0.0      10
8000200 3
8000201 0.0      1.0d5    303.0
*
8100000 hpispump  tmdpjun
8100101 800000000 145000000 1.131d-4
8100200 1        688      cntrlvar  805
8100201  0.0     0.0      0.0      0.0
8100202 200.0  200.0     0.0      0.0
*****************************************************
****
*                                            *
*                                            *
*     break & pressurizer porv containment volumes      *
*                                            *
*                                            *
*****************************************************
****
*  containment volume 1 -- not scaled --               *
*****************************************************
****
9000000 contvol   tmdpvol
9000101 1.0      1.0      0.0      0.0      -90.0
9000102 -1.0     0.0      0.0      00
9000200 2
9000201 0.0      1.0d+5   1.0
*****************************************************
****
*  containment volume 2 -- not scaled --               *
*****************************************************
****9010000  contvob   tmdpvol
9010101 1.0      1.0      0.0      0.0      -90.0
9010102 -1.0     0.0      0.0      00
9010200 2
9010201 0.0      1.0d+5   1.0
*****************************************************
****
*  containment volume 3 -- not scaled --               *
*****************************************************
****
9100000 contvo2   tmdpvol
9100101 1.0      1.0      0.0      0.0      -90.0
9100102 -1.0     0.0      0.0      00
9100200 2
9100201 0.0      1.0d+5   1.0
*****************************************************
****
*  main break assembly  --    *
*****************************************************
****
9500000 mainori   valve
* simulates a leak in the pcs
9500101 240010006 900000000 7.0686d-6 1.25     1.25
0100
9500102 1.00     0.95
9500201 1        0.0      0.0      0.0
9500300 mtrvlv
9500301 505      511      0.25     0.0      150
*****************************************************
****
*                                            *
*                                            *
*                  pump data                      *
```

```
*                                  *
*                                  *
**************************************************
****
*                                  *
* single phase head curves - lobi tech. note 1.06.01.79.80 *
*                                  *
**************************************************
****
* head curve no. 1                        *
**************************************************
****
1351100   1    1
1351101   0.00  1.055
1351102   0.05  1.064
1351103   0.10  1.079
1351104   0.20  1.102
1351105   0.30  1.120
1351106   0.40  1.131
1351107   0.50  1.131
1351108   0.60  1.123
1351109   0.70  1.104
1351110   0.80  1.0785
1351111   0.90  1.043
1351112   1.00  1.000
**************************************************
****
* head curve no. 2                        *
**************************************************
****
1351200   1    2
1351201   0.00  -0.780
1351202   0.10  -0.6285
1351203   0.20  -0.478
1351204   0.31  -0.308
1351205   0.40  -0.169
1351206   0.5015  0.0
1351207   0.60  0.173
1351208   0.70  0.365
1351209   0.80  0.556
1351210   0.90  0.768
1351211   0.95  0.881
1351212   1.00  1.00
**************************************************
****
* head curve no. 3                        *
**************************************************
****
1351300   1    3
1351301   -1.00  2.110
1351302   -0.90  1.927
1351303   -0.80  1.759
1351304   -0.70  1.6105
1351305   -0.60  1.489
1351306   -0.50  1.380
1351307   -0.40  1.282
1351308   -0.30  1.20
1351309   -0.20  1.133
1351310   -0.10  1.0805
1351311    0.0  1.055
**************************************************
****
* head curve no. 4                        *
**************************************************
****
1351400   1    4
1351401   -1.00  2.11
1351402   -0.90  1.862
1351403   -0.80  1.65
1351404   -0.70  1.474
1351405   -0.60  1.332
1351406   -0.50  1.212
1351407   -0.40  1.105
1351408   -0.30  1.002
1351409   -0.20  0.911
1351410   -0.10  0.830
1351411    0.0  0.761
**************************************************
****
* head curve no. 5                        *
**************************************************
****
1351500   1    5
1351501   0.0   0.424
1351502   0.1   0.489
1351503   0.20  0.543
1351504   0.30  0.603
1351505   0.40  0.660
1351506   0.487  0.702
1351507   0.55  0.7305
1351508   0.65  0.762
1351509   0.75  0.789
1351510   0.85  0.828
1351511   0.95  0.901
1351512   1.00  0.948
**************************************************
****
* head curve no. 6                        *
**************************************************
****
1351600   1    6
1351601   0.0   0.761
1351602   0.10  0.710
1351603   0.20  0.664
1351604   0.30  0.664
1351605   0.40  0.653
1351606   0.50  0.6795
1351607   0.60  0.707
1351608   0.70  0.746
1351609   0.80  0.799
1351610   0.90  0.861
1351611   1.00  0.948
**************************************************
****
* head curve no. 7                        *
**************************************************
****
1351700   1    7
1351701   -0.60  -0.283
1351702   -0.50  -0.147
1351703   -0.45  -0.081
1351704   -0.384  0.0
1351705   -0.30  0.106
1351706   -0.25  0.170
1351707   -0.20  0.233
1351708   -0.15  0.290
1351709   -0.10  0.3395
1351710    0.0  0.424
**************************************************
****
*                                  *
* single phase torque data                *
*                                  *
**************************************************
****
* torque curve no. 1                      *
**************************************************
****
1351800   2    1
1351801   0.0   0.439
1351802   0.05  0.442
1351803   0.10  0.460
1351804   0.20  0.515
1351805   0.30  0.5825
```

```
1351806   0.40   0.647
1351807   0.50   0.706
1351808   0.60   0.764
1351809   0.70   0.823
1351810   0.80   0.882
1351811   0.90   0.9415
1351812   1.00   1.00
****************************************************
****
* torque curve no. 2                          *
****************************************************
****
1351900   2     2
1351901   0.00   -0.518
1351902   0.10   -0.350
1351903   0.20   -0.184
1351904   0.31    0.0
1351905   0.40   0.151
1351906   0.5015 0.320
1351907   0.60   0.464
1351908   0.70   0.5985
1351909   0.80   0.731
1351910   0.95   0.9305
1351911   1.00   1.00
****************************************************
****
* torque curve no. 3                          *
****************************************************
****
1352000   2     3
1352001   -1.00  1.182
1352002   -0.90  1.037
1352003   -0.80  0.911
1352004   -0.70  0.804
1352005   -0.60  0.712
1352006   -0.50  0.632
1352007   -0.40  0.567
1352008   -0.30  0.513
1352009   -0.20  0.473
1352010    0.0   0.439
****************************************************
****
* torque curve no. 4                          *
****************************************************
****
1352100   2     4
1352101   -1.00  1.182
1352102   -0.90  1.120
1352103   -0.80  1.093
1352104   -0.70  1.104
1352105   -0.60  1.240
1352106   -0.50  1.323
1352107   -0.40  1.3400
1352108   -0.30  1.256
1352109   -0.20  1.122
1352110   -0.10  1.041
1352111    0.0   0.984
****************************************************
****
* torque curve no. 5                          *
****************************************************
****
1352200   2     5
1352201   0.0    -0.569
1352202   0.10   -0.439
1352203   0.20   -0.318
1352204   0.30   -0.202
1352205   0.40   -0.098
1352206   0.487   0.0
1352207   0.55   0.0695
1352208   0.65   0.173
1352209   0.75   0.284
1352210   0.85   0.409
1352211   0.95   0.549
1352212   1.00   0.630
****************************************************
****
* torque curve no. 6                          *
****************************************************
****
1352300   2     6
1352301   0.0    0.984
1352302   0.10   0.9505
1352303   0.20   0.929
1352304   0.30   0.905
1352305   0.40   0.873
1352306   0.50   0.840
1352307   0.60   0.802
1352308   0.70   0.761
1352309   0.80   0.7205
1352310   0.90   0.678
1352311   1.00   0.630
****************************************************
****
* torque curve no. 7                          *
****************************************************
****
1352400   2     7
1352401   -0.60  -1.59
1352402   -0.50  -1.39
1352403   -0.45  -1.297
1352404   -0.384 -1.18
1352405   -0.30  -1.040
1352406   -0.25  -0.956
1352407   -0.20  -0.870
1352408   -0.15  -0.7905
1352409   -0.10  -0.716
1352410   -0.05  -0.640
1352411    0.0   -0.569
****************************************************
****
*                                    *
* two-phase multiplier data - based on lobi pump data    *
*                                    *
****************************************************
****
* head multiplier                             *
****************************************************
****
1353000   0
1353001   0.00   0.00
1353002   0.20   0.00
1353003   0.43   1.00
1353004   0.86   1.00
1353005   1.00   0.00
****************************************************
****
* torque curve - based on semiscale pump (see pg-r-77.08  *
* by m. s. sahota)                            *
****************************************************
****
1353100   0
1353101   0.0    0.0
1353102   0.15   0.0
1353103   0.24   0.56
1353104   0.80   0.56
1353105   0.96   0.45
1353106   1.00   0.0
****************************************************
****
*                                    *
* pump 2-phase difference data - computed  from lobi     *
* tech. note no. 1.06.01.79.80 and                   *
* techn. note no. 1.06.01.81.13                     *
```

```
*                                       *
**************************************************
****
* head curve no. 1                          *
**************************************************
****
1354100   1     1
1354101   0.0   .165
1354102   0.05  .774
1354103   0.1   .810
1354104   0.3   .773
1354105   0.5   .804
1354106   0.7   .828
1354107   1.0   .816
**************************************************
****
* head curve no. 2                          *
**************************************************
****
1354200   1     2
1354201   0.0    .220
1354202   0.1    .2285
1354203   0.3    .248
1354204   0.5   0.329
1354205   0.7   0.477
1354206   1.00  0.816
**************************************************
****
* head curve no. 3                          *
**************************************************
****
1354300   1     3
1354301   -1.0  -0.820
1354302   -0.8  -1.4910
1354303   -0.7  -1.670
1354304   -0.5  -1.780
1354305   -0.3  -1.50
1354306   -0.2  -1.137
1354307   -0.1  -0.585
1354308    0.0   .165
**************************************************
****
* head curve no. 4                          *
**************************************************
****
1354400   1     4
1354401   -1.00  -0.820
1354402   -0.70  -0.186
1354403   -0.50  -0.058
1354404   -0.30  -0.018
1354405   -0.10  -0.030
1354406   0.00   -0.039
**************************************************
****
* head curve no. 5                          *
**************************************************
****
1354500   1     5
1354501   0.0   -.046
1354502   0.2   -.366
1354503   0.4   -.580
1354504   0.6   -.6805
1354505   0.8   -.676
**************************************************
****
* head curve no. 6                          *
**************************************************
****
1354600   1     6
1354601   0.0   -.039
1354602   0.2   -.066
1354603   0.4   -.097
1354604   0.6   -.173
1354605   0.8   -.331
1354606   1.0   -.481
**************************************************
****
* head curve no. 7                          *
**************************************************
****
1354700   1     7
1354701   -0.6  .7970
1354702   -0.4  .5092
1354703   -0.2  .233
**************************************************
****
* torque curve no. 1                        *
**************************************************
****
1354800   2     1
1354801   0.0   .54
1354802   0.2   .59
1354803   0.4   .65
1354804   0.6   .77
1354805   0.8   .95
1354806   0.9   .98
1354807   0.95  .96
1354808   1.0   .87
**************************************************
****
* torque curve no. 2                        *
**************************************************
****
1354900   2     2
1354901   0.0   -.15
1354902   0.2    .02
1354903   0.4    .22
1354904   0.6    .46
1354905   0.8    .71
1354906   0.9    .81
1354907   0.95   .85
1354908   1.0    .87
**************************************************
****
* torque curve no. 3                        *
**************************************************
****
1355000   2     3
1355001   -1.0  .62
1355002   -0.8  .68
1355003   -0.6  .53
1355004   -0.4  .46
1355005   -0.2  .49
1355006    0.0  .54
**************************************************
****
* torque curve no. 4                        *
**************************************************
****
1355100   2     4
1355101   -1.0  .62
1355102   -0.8  .53
1355103   -0.6  .46
1355104   -0.4  .42
1355105   -0.2  .39
1355106    0.0  .36
**************************************************
****
* torque curve no. 5                        *
**************************************************
****
1355200   2     5
1355201   0.0   -.63
1355202   0.2   -.51
```

```
1355203   0.4   -.39
1355204   0.6   -.29
1355205   0.8   -.20
1355206   0.9   -.16
1355207   1.0   -.13
***********************************************
****
* torque curve no. 6                    *
***********************************************
****
1355300   2     6
1355301   0.0   .36
1355302   0.2   .32
1355303   0.4   .27
1355304   0.6   .18
1355305   0.8   .05
1355306   1.0   -.13
***********************************************
****
* torque curve no. 7                    *
***********************************************
****
1355400   2     7
1355401   -1.0  -1.44
1355402   -0.8  -1.25
1355403   -0.6  -1.08
1355404   -0.4  -0.92
1355405   -0.2  -0.77
1355406   0.0   -0.63
***********************************************
****
*                               *
*       pump speed-time curves          *
*                               *
***********************************************
****
*  intact & broken loop pump speed-time curve      *
***********************************************
****
20213500  reac-t
20213501  0.00      1.00
20213502  0.5       0.75
20213503  1.0       0.5
20213504  1.5       0.25
20213505  2.0       0.0
20213506  10000.0     0.0
***********************************************
****
*                               *
*                               *
*          core heat structures         *
*                               *
*                               *
***********************************************
****
*  lower power connection - cables  ni-201         *
***********************************************
****
13251000 1      5      2      1      0.0
13251100 0      1
13251101 4      0.002257
13251201 4      4
13251301 1.0    4
13251401 640.0  1  639.18 2  636.75 3  632.68  4  627.0  5
13251501 0      0      0      1      24.96    1
13251601 325020000 0      1      1      24.96    1
13251701 100      0.047    0.0      0.0      1
13251901  0.1015  0.390  0.390  0.  0.  0.  0.  1.  1
***********************************************
****
*  lower extension of heater rods  ni-201          *
```

```
***********************************************
****
13341000 1      5      2      1      0.0
13341100 0      1
13341101 4      0.005375
13341201 4      4
13341301 1.0    4
13341401 575.00   5
13341501 0      0      0      1      12.8     1
13341601 335010000 0      1      1      12.8     1
13341701 100      0.005    0.0      0.0      1
13341901  0.01502  0.20  0.20  0.  0.  0.  0.  1.  1
***********************************************
****
*  heated length - lower section  st-1.4948          *
***********************************************
****
13351000 1      5      2      1      0.003225
13351100 0      1
13351101 4      0.005375
13351201 3      4
13351301 1.0    4
13351401 605.73 1  604.19 2  599.84 3  592.96 4  583.7  5
13351501 0      0      0      1      26.368    1
13351601 335010000 0      1      1      26.368    1
13351701 100      0.065    0.0      0.0      1
13351901  0.01502  0.412  0.412  0.  0.  0.  0.  1.  1
***********************************************
****
*  heated length - lower intermediate section  st-1.4948  *
***********************************************
****
13352000 1      5      2      1      0.003875
13352100 0      1
13352101 4      0.005375
13352201 3      4
13352301 1.0    4
13352401 612.64 1  611.29 2  607.38 3  601.1  4  592.52 5
13352501 0      0      0      1      42.432    1
13352601 335020000 0      1      1      42.432    1
13352701 100      0.144106  0.0      0.0      1
13352901  0.01502  0.663  0.663  0.  0.  0.  0.  1.  1
***********************************************
****
*  heated length - middle section  st-1.4948         *
***********************************************
****
13353000 2      5      2      1      0.004175
13353100 0      1
13353101 4      0.005375
13353201 3      4
13353301 1.0    4
13353401 622.77 1  621.49 2  617.75 3  611.69 4  603.4  5
13353501 0      0      0      1      56.00    2
13353601 335030000 10000   1      1      56.00    2
13353701 100      0.2255   0.0      0.0      2
13353901  0.01502  0.875  0.875  0.  0.  0.  0.  1.  2
***********************************************
****
*  heated length - upper intermediate section  st-1.4948  *
***********************************************
****
13355000 1      5      2      1      0.003875
13355100 0      1
13355101 4      0.005375
13355201 3      4
13355301 1.0    4
13355401 631.77 1  630.4  2  626.5  3  620.2  4  611.6  5
13355501 0      0      0      1      42.432    1
13355601 335050000 0      1      1      42.432    1
13355701 100      0.142    0.0      0.0      1
13355901  0.01502  0.663  0.663  0.  0.  0.  0.  1.  1
```

```
************************************************
****
*  heated length - upper section  st-1.4948        *
************************************************
****
13356000 1      5      2      1      0.003225
13356100 0      1
13356101 4      0.005375
13356201 3      4
13356301 1.0     4
13356401 631.97 1  630.43 2  626.1  3  619.2  4  609.9  5
13356501 0      0      0      1      26.368   1
13356601 335060000 0      1      1      26.368   1
13356701 100     0.066    0.0     0.0      1
13356901  0.01502  0.412  0.412  0.  0.  0.  0.  1.  1
************************************************
****
*  upper extension of heater rods  ni-201          *
************************************************
****
13366000 1      5      2      1      0.0025
13366100 0      1
13366101 4      0.005375
13366201 4      4
13366301 1.0     4
13366401 602.0  5
13366501 0      0      0      1      20.992   1
13366601 335060000 0      1      1      20.992   1
13366701 100     0.011413  0.0     0.0      1
13366901  0.01502  0.328  0.328  0.  0.  0.  0.  1.  1
************************************************
****
13451000 4      5      2      1      0.0025
13451100 0      1
13451101 4      0.005375
13451201 4      4
13451301 1.0     4
13451401 608.0  5
13451501 0      0      0      1      38.400   2
13451502 0      0      0      1      31.168   3
13451503 0      0      0      1      20.160   4
13451601 345010000 10000    1      1      38.400   2
13451602 350010000 0      1      1      31.168   3
13451603 355010000 0      1      1      20.160   4
13451701 100     0.020544  0.0     0.0      2
13451702 100     0.016645  0.0     0.0      3
13451703 100     0.010748  0.0     0.0      4
13451901  0.04623  0.600  0.600  0.  0.  0.  0.  1.  2
13451902  0.04623  0.487  0.487  0.  0.  0.  0.  1.  3
13451903  0.04623  0.315  0.315  0.  0.  0.  0.  1.  4
************************************************
****
*                                            *
*                                            *
*     steam generator heat structures - intact loop    *
*                                            *
*                                            *
************************************************
****
*  steam generator u-tubes  incoloy 800            *
*  no crud layer, 1 space interval between mesh points   *
*  wall thickness set to 1.1 mm instead of 1.2 mm       *
************************************************
****
11203000 42      2      2      1      0.0098
11203100 0      1
11203101 1      0.0109
11203201 7      1
11203301 0.0     1
11203401 573.00   1      569.00   2
11203501 120030000 10000    1      0      0.18472565  8
11203502 120110000 10000    1      0      0.3694513  12
11203503 120150000 10000    1      0      0.7389026  20
11203504 120230000 10000    1      0      1.4997240 22
11203505 120250000 10000    1      0      0.7389026 30
11203506 120330000 10000    1      0      0.3694513 34
11203507 120370000 10000    1      0      0.18472565 42
11203601 530010000 10000    1      0      0.2054601754 8
11203602 530090000 10000    1      0      0.410920325
12
11203603 530130000 10000    1      0      0.82184065   20
11203604 545010000 0      1      0      1.6680604  22
11203605 530200000 -10000   1      0      0.82184065   30
11203606 530120000 -10000   1      0      0.410920325
34
11203607 530080000 -10000   1      0      0.205460175 42
11203701 0      0.0     0.0     0.0     42
11203801  0.0196  0.1250  0.1250 0.  0.  0.  0.  1.  8
11203802  0.0196  0.25  0.25 0.  0.  0.  0.  1.  12
11203803  0.0196  0.500  0.500 0.  0.  0.  0.  1.  20
11203804  0.0196  1.014832  1.014832 0.  0.  0.  0.  1.  22
11203805  0.0196  0.500  0.500 0.  0.  0.  0.  1.  30
11203806  0.0196  0.2500  0.2500 0.  0.  0.  0.  1.  34
11203807  0.0196  0.125  0.125 0.  0.  0.  0.  1.  42
11203901  0.02  0.1250  0.1250 0.  0.  0.  0.  1.  8
11203902  0.02  0.2500  0.2500 0.  0.  0.  0.  1.  12
11203903  0.02  0.500  0.500 0.  0.  0.  0.  1.  20
11203904  0.02  1.014832  1.014832 0.  0.  0.  0.  1.  22
11203905  0.02  0.500  0.500 0.  0.  0.  0.  1.  30
11203906  0.02  0.2500  0.2500 0.  0.  0.  0.  1.  34
11203907  0.02  0.1250  0.1250 0.  0.  0.  0.  1.  42
************************************************
****
*  sg riser/downcomer shroud tube - material 1.4571    *
************************************************
****
15301000 22      2      2      1      0.1505
15301100 0      1
15301101 1      0.1525
15301201 5      1
15301301 0.0     1
15301401 568.13   2
15301501 530010000 10000    1      0      0.118202425 8
15301502 530090000 10000    1      0      0.23640485 12
15301503 530130000 10000    1      0      0.4728097  20
15301504 545010000 0      1      0      1.3257584   21
15301505 550010000 0      1      0      0.561459    22
15301601 510200000 -10000   1      0      0.119773225 8
15301602 510120000 -10000   1      0      0.23954645 12
15301603 510080000 -10000   1      0      0.479092875 20
15301604 500010000 0      1      0      1.3433764   21
15301605 555010000 0      1      0      0.568921    22
15301701 0      0.0     0.0     0.0     22
15301801  0.1265  0.1250  0.1250  0.  0.  0.  0.  1.  8
15301802  0.1265  0.250  0.250  0.  0.  0.  0.  1.  12
15301803  0.1265  0.500  0.500  0.  0.  0.  0.  1.  20
15301804  0.2206  1.402  1.402  0.  0.  0.  0.  1.  21
15301805  0.13017  0.59375  0.59375  0.  0.  0.  0.  1.  22
15301901  0.04989  0.1250  0.1250  0.  0.  0.  0.  1.  8
15301902  0.04989  0.250  0.250  0.  0.  0.  0.  1.  12
15301903  0.04989  0.2500  0.2500  0.  0.  0.  0.  1.  20
15301904  0.04989  1.402  1.402  0.  0.  0.  0.  1.  21
15301905  0.484026  0.59375  0.59375  0.  0.  0.  0.  1.  22
************************************************
****
*  sg filler tube - material 1.4571                 *
************************************************
****
15302000 11      2      2      1      0.07615
15302100 0      1
15302101 1      0.08415
15302201 5      1
15302301 0.0     1
15302401 568.13   2
```

```
15302501 0      0      0      1      0.25    4
15302502 0      0      0      1      0.5     6
15302503 0      0      0      1      1.0     10
15302504 0      0      0      1      0.705   11
15302601 530010000 10000   1      1      0.25    4
15302602 530050000 10000   1      1      0.5     6
15302603 530070000 10000   1      1      1.0     10
15302604 545010000 0      1      1      0.705   11
15302701 0      0.0    0.0    0.0    11
15302801  0.1523  0.25  0.25  0.  0.  0.  0.  1.  4
15302802  0.1523  0.5  0.5  0.  0.  0.  0.  1.  6
15302804  0.1523  1.0  1.0  0.  0.  0.  0.  1.  10
15302805  0.1523  0.705  0.705  0.  0.  0.  0.  1.  11
15302901  0.016  0.25  0.25  0.  0.  0.  0.  1.  4
15302902  0.016  0.5  0.5  0.  0.  0.  0.  1.  6
15302903  0.016  1.0  1.0  0.  0.  0.  0.  1.  10
15302904  0.016  0.705  0.705  0.  0.  0.  0.  1.  11
**************************************************
****
*  sg filler tube top plate - material 1.4571          *
**************************************************
****
15303000 1      3      1      1      0.0
15303100 0      1
15303101 2      0.03
15303201 5      2
15303301 0.0    2
15303401 568.13   3
15303501 0      0      0      0      0.022246  1
15303601 545010000 0      1      0      0.022246  1
15303701 0      0.0    0.0    0.0    1
15303801  0.0  1.402  1.402  0.  0.  0.  0.  1.  1
15303901  0.0  1.402  1.402  0.  0.  0.  0.  1.  1
**************************************************
****
*  lower connecting flange, sg walls      material 1.4571  *
**************************************************
****
15100000 4      3      2      1      0.1645
15100100 0      1
15100101 2      0.2625
15100201 5      2
15100301 0.0    2
15100401 568.13   3
15100501 510090000 10000    3124    0      0.03876  4
15100601 -1     0      3501    0      0.06185  4
15100701 0      0.0    0.0    0.0    4
15100801  0.329  0.0375  0.0375  0.  0.  0.  0.  1.  4
15100901  0.525  0.0375  0.0375  0.  0.  0.  0.  1.  4
**************************************************
****
*  sg walls - lower section       material 1.4571        *
**************************************************
****
15101000 21     3      2      1      0.1645
15101100 0      1
15101101 2      0.1865
15101201 5      2
15101301 0.0    2
15101401 535.15   3
15101501 510200000 -10000   3124    0      0.0904386 4
15101502 510160000 -10000   3124    0      0.129198  8
15101503 510120000 -10000   3124    0      0.258396 12
15101504 510080000 -10000   3124    0      0.516792  20
15101505 500010000 0      3124    0      1.4490847 21
15101601 -1     0      3501    0      0.102533725 4
15101602 -1     0      3501    0      0.14647675  8
15101603 -1     0      3501    0      0.292953525 12
15101604 -1     0      3501    0      0.585907025 20
15101605 -1     0      3501    0      1.6428833  21
15101701 0      0.0    0.0    0.0    21
15101801  0.04625  0.0875  0.0875 0.  0.  0.  0.  1.  4
15101802  0.04625  0.1250  0.1250  0.  0.  0.  0.  1.  8
15101803  0.04625  0.2500  0.2500  0.  0.  0.  0.  1.  12
15101804  0.05625  0.500  0.500  0.  0.  0.  0.  1.  20
15101805  0.04625  1.402  1.402  0.  0.  0.  0.  1.  21
15101901  0.373  0.0875  0.0875 0.  0.  0.  0.  1.  4
15101902  0.373  0.1250  0.1250  0.  0.  0.  0.  1.  8
15101903  0.373  0.2500  0.2500  0.  0.  0.  0.  1.  12
15101904  0.373  0.500  0.500  0.  0.  0.  0.  1.  20
15101905  0.373  1.402  1.402  0.  0.  0.  0.  1.  21
**************************************************
****
*  htc. vs time, set to high value for trial run          *
**************************************************
****
20212400 htc-t
20212401 0.0       10000.0
20212402 1.0e6     10000.0
**************************************************
****
*  sg feedwater inlet manifold & flange    material 1.4571  *
**************************************************
****
15550000 1      3      2      1      0.205
15550100 0      1
15550101 2      0.400
15550201 5      2
15550301 0.0    2
15550401 568.13   3
15550501 555010000 0      1      0      0.28208   1
15550601 -1     0      3501    0      0.55041   1
15550701 0      0.0    0.0    0.0    1
15550801  0.410  0.219  0.219  0.  0.  0.  0.  1.  1
15550901  0.800  0.219  0.219  0.  0.  0.  0.  1.  1
**************************************************
****
*  sg walls - middle section      material 1.4571        *
**************************************************
****
15551000 1      3      2      1      0.205
15551100 0      1
15551101 2      0.230
15551201 5      2
15551301 0.0    2
15551401 568.13   3
15551501 555010000 0      1      0      0.89391   1
15551601 -1     0      3501    0      1.00292   1
15551701 0      0.0    0.0    0.0    1
15551801  0.36007  0.694  0.694  0.  0.  0.  0.  1.  1
15551901  0.460  0.694  0.694  0.  0.  0.  0.  1.  1
**************************************************
****
*  sg walls - upper section       material 1.4571        *
**************************************************
****
15601000 2      3      2      1      0.2335
15601100 0      1
15601101 2      0.2625
15601201 5      2
15601301 0.0    2
15601401 568.13   3
*  steam dome section  **
15601501 560010000 0      1      1      0.593    1
15601601 -1     0      3503    1      0.593    1
15601701 0      0.0    0.0    0.0    1
15601801  0.46179  0.593  0.593  0.  0.  0.  0.  1.  1
15601901  0.525  0.593  0.593  0.  0.  0.  0.  1.  1
*  separator section
15601502 552010000 0      1      1      1.10     2
15601602 -1     0      3501    1      1.10     2
15601702 0      0.0    0.0    0.0    2
15601802  0.46179  1.10  1.10  0.  0.  0.  0.  1.  2
15601902  0.525  1.10  1.10  0.  0.  0.  0.  1.  2
```

```
***************************************************
****
*  top of il sg steam dome, part spherical  material 1.4571*
***************************************************
****
15602000 1      3      3      1      0.525
15602100 0      1
15602101 2      0.605
15602201 5      2
15602301 0.0     2
15602401 568.13   3
15602501 560010000 0      1      1      0.0625   1
15602601 -1      0      3503     1      0.0625   1
15602701 0      0.0      0.0      0.0      1
15602801   0.0  0.25  0.25 0.  0.  0.  0.  1.  1
15602901   0.0  0.25  0.25 0.  0.  0.  0.  1.  1
***************************************************
****
*     steam line, intact loop sg to manifold          *
*     typical heat loss along both steam lines assumed   *
***************************************************
****
15641000 1      3      2      1      0.03445
15641100 0      1
15641101 2      0.03805
15641201 5      2
15641301 0.0     2
15641401 568.13   3
15641501 564010000 0      1      1      6.5      1
15641601 -1      0      3602     1      6.5      1
15641701 0      0.0      0.0      0.0      1
15641801   0.0  6.5  6.5 0.  0.  0.  0.  1.  1
15641901   0.0  6.5  6.5 0.  0.  0.  0.  1.  1
***************************************************
****
*     steam line, broken loop sg to manifold          *
***************************************************
****
16641000 1      3      2      1      0.02155
16641100 0      1
16641101 2      0.02415
16641201 5      2
16641301 0.0     2
16641401 568.13   3
16641501 664010000 0      1      1      5.8      1
16641601 -1      0      3602     1      5.8      1
16641701 0      0.0      0.0      0.0      1
16641801   0.0  5.8  5.8 0.  0.  0.  0.  1.  1
16641901   0.0  5.8  5.8 0.  0.  0.  0.  1.  1
***************************************************
****
*                                            *
*                                            *
*     steam generator heat structures - broken loop     *
*                                            *
*                                            *
***************************************************
****
*  steam generator u-tubes  incoloy 800                *
*  no crud layer, 1 space interval between mesh points    *
*  wall thickness set to 1.1 mm instead of 1.2 mm        .*
***************************************************
****
12103000 22      2      2      1      0.0098
12103100 0      1
12103101 1      0.0109
12103201 7      1
12103301 0.0     1
12103401 573.0    1      569.00   2
12103501 210030000 10000    1      0      0.12315045 4
12103502 210070000 10000    1      0      0.2463009  6
12103503 210090000 10000    1      0      0.49260175 10
12103504 210130000 10000    1      0      0.4986716  12
12103505 210150000 10000    1      0      0.49260175 16
12103506 210190000 10000    1      0      0.2463009  18
12103507 210210000 10000    1      0      0.12315045 22
12103601 630010000 10000    1      0      0.13697345 4
12103602 630050000 10000    1      0      0.2739469  6
12103603 630070000 10000    1      0      0.54789375 10
12103604 645010000 0      1      0      0.5546449  12
12103605 630100000 -10000   1      0      0.54789375 16
12103606 630060000 -10000   1      0      0.2739469  18
12103607 630040000 -10000   1      0      0.13697345 22
12103701 0      0.0      0.0      0.0      22
12103801   0.0196  0.2500  0.2500 0.  0.  0.  0.  1.  4
12103802   0.0196  0.5  0.5 0.  0.  0.  0.  1.  6
12103803   0.0196  1.000  1.000 0.  0.  0.  0.  1.  10
12103804   0.0196  1.012322  1.012322 0.  0.  0.  0.  1.  12
12103805   0.0196  1.000  1.000 0.  0.  0.  0.  1.  16
12103806   0.0196  0.500  0.500 0.  0.  0.  0.  1.  18
12103807   0.0196  0.2500  0.2500 0.  0.  0.  0.  1.  22
12103901   0.02  0.2500  0.2500 0.  0.  0.  0.  1.  4
12103902   0.02  0.500  0.500 0.  0.  0.  0.  1.  6
12103903   0.02  1.000  1.000 0.  0.  0.  0.  1.  10
12103904   0.02  1.012322  1.012322 0.  0.  0.  0.  1.  12
12103905   0.02  1.000  1.000 0.  0.  0.  0.  1.  16
12103906   0.02  0.500  0.500 0.  0.  0.  0.  1.  18
12103907   0.02  0.2500  0.2500 0.  0.  0.  0.  1.  22
***************************************************
****
*  sg riser/downcomer shroud tube      material 1.4571    *
***************************************************
****
16301000 12      2      2      1      0.1005
16301100 0      1
16301101 1      0.1020
16301201 5      1
16301301 0.0     1
16301401 568.13   2
16301501 630010000 10000    1      0      0.15786505 4
16301502 630050000 10000    1      0      0.3157301  6
16301503 630070000 10000    1      0      0.63146015 10
16301504 645010000 0      1      0      0.8234240 11
16301505 650010000 0      1      0      0.328621  12
16301601 610100000 -10000   1      0      0.16022125 4
16301602 610060000 -10000   1      0      0.32044245 6
16301603 610040000 -10000   1      0      0.6408849  10
16301604 600010000 0      1      0      0.8357139 11
16301605 655010000 0      1      0      0.333526  12
16301701 0      0.0      0.0      0.0      12
16301801   0.060144  0.2500  0.2500 0.  0.  0.  0.  1.  4
16301802   0.060144  0.500  0.500 0.  0.  0.  0.  1.  6
16301803   0.060144  1.000  1.000 0.  0.  0.  0.  1.  10
16301804   0.157657  1.304  1.304 0.  0.  0.  0.  1.  11
16301805   0.06863  0.5204  0.5204 0.  0.  0.  0.  1.  12
16301901   0.024706  0.2500  0.2500 0.  0.  0.  0.  1.  4
16301902   0.024706  0.500  0.500 0.  0.  0.  0.  1.  6
16301903   0.024706  1.000  1.000 0.  0.  0.  0.  1.  10
16301904   0.024706  1.304  1.304 0.  0.  0.  0.  1.  11
16301905   0.21192  0.5204  0.5204 0.  0.  0.  0.  1.  12
***************************************************
****
*  sg filler tube - material 1.4571                 *
***************************************************
****
16302000 11      2      2      1      0.0629
16302100 0      1
16302101 1      0.07
16302201 5      1
16302301 0.0     1
16302401 568.13   2
16302501 0      0      0      1      0.25     4
16302502 0      0      0      1      0.5      6
16302503 0      0      0      1      1.0      10
```

```
16302504 0      0       0       1       0.71    11
16302601 630010000 10000    1       1       0.25    4
16302602 630030000 0    1       1       0.5     6
16302603 630040000 10000    1       1       1.0     10
16302604 645010000 0    1       1       0.71    11
16302701 0      0.0     0.0     0.0     11
16302801  0.1258  0.25  0.25  0.  0.  0.  0.  1.  4
16302802  0.1258  0.5  0.5  0.  0.  0.  0.  1.  6
16302803  0.1258  1.0  1.0  0.  0.  0.  0.  1.  10
16302804  0.1258  0.71  0.71  0.  0.  0.  0.  1.  11
16302901  0.007  0.25  0.25  0.  0.  0.  0.  1.  4
16302902  0.007  0.5  0.5  0.  0.  0.  0.  1.  6
16302903  0.007  1.0  1.0  0.  0.  0.  0.  1.  10
16302904  0.007  0.71  0.71  0.  0.  0.  0.  1.  11
****************************************************
****
*  sg filler tube top plate - material 1.4571          *
****************************************************
****
16303000 1      3       1       1       0.0
16303100 0      1
16303101 2      0.026
16303201 5      2
16303301 0.0    2
16303401 568.13   3
16303501 0      0       0       0       0.015394  1
16303601 645010000 0    1       0       0.015394  1
16303701 0      0.0     0.0     0.0     1
16303801  0.0  1.304  1.304  0.  0.  0.  0.  1.  1
16303901  0.0  1.304  1.304  0.  0.  0.  0.  1.  1
****************************************************
****
*  lower connecting flange, sg walls    material 1.4571     *
****************************************************
****
16100000 2      3       2       1       0.108
16100100 0      1
16100101 2      0.1775
16100201 5      2
16100301 0.0    2
16100401 568.13   3
16100501 610050000 10000        3124    0       0.0271435
2
16100601 -1     0       3601    0       0.0446105 2
16100701 0      0.0     0.0     0.0     2
16100801  0.216  0.040  0.040  0.  0.  0.  0.  1.  2
16100901  0.355  0.040  0.040  0.  0.  0.  0.  1.  2
****************************************************
****
*  sg walls - lower section        material 1.4571       *
****************************************************
****
16101000 11     3       2       1       0.108
16101100 0      1
16101101 2      0.122
16101201 5      2
16101301 0.0    2
16101401 535.15   3
16101501 610100000 -10000   3124    0       0.14250265 2
16101502 610080000 -10000   3124    0       0.16964625 4
16101503 610060000 -10000   3124    0       0.3392925  6
16101504 610040000 -10000   3124    0       0.678585   10
16101505 600010000 0    3124    0       0.88487   11
16101601 -1     0       3601    0       0.1609752 2
16101602 -1     0       3601    0       0.1916375 4
16101603 -1     0       3601    0       0.383275  6
16101604 -1     0       3601    0       0.76655   10
16101605 -1     0       3601    0       0.99958   11
16101701 0      0.0     0.0     0.0     11
16101801  0.023333  0.21  0.21  0.  0.  0.  0.  1.  2
16101802  0.023333  0.25  0.25  0.  0.  0.  0.  1.  4
16101803  0.023333  0.5  0.5  0.  0.  0.  0..  1.  6
16101804  0.023333  1.0  1.0  0.  0.  0.  0.  1.  10
16101805  0.023333  1.304  1.304  0.  0.  0.  0.  1.  11
16101901  0.244  0.21  0.21  0.  0.  0.  0.  1.  2
16101902  0.244  0.25  0.25  0.  0.  0.  0.  1.  4
16101903  0.244  0.5  0.5  0.  0.  0.  0.  1.  6
16101904  0.244  1.0  1.0  0.  0.  0.  0.  1.  10
16101905  0.244  1.304  1.304  0.  0.  0.  0.  1.  11
****************************************************
****
*  sg feedwater inlet manifold & flange    material 1.4571  *
****************************************************
****
16550000 1      3       2       1       0.1195
16550100 0      1
16550101 2      0.250
16550201 5      2
16550301 0.0    2
16550401 568.13   3
16550501 655010000 0    1       0       0.15017   1
16550601 -1     0       3601    0       0.31416   1
16550701 0      0.0     0.0     0.0     1
16550801  0.239  0.200  0.200  0.  0.  0.  0.  1.  1
16550901  0.500  0.200  0.200  0.  0.  0.  0.  1.  1
****************************************************
****
*  sg walls - middle section        material 1.4571       *
****************************************************
****
16551000 1      3       2       1       0.1195
16551100 0      1
16551101 2      0.1345
16551201 5      2
16551301 0.0    2
16551401 568.13   3
16551501 655010000 0    1       0       0.80791   1
16551601 -1     0       3601    0       0.90932   1
16551701 0      0.0     0.0     0.0     1
16551801  0.180885  1.076  1.076  0.  0.  0.  0.  1.  1
16551901  0.269  1.076  1.076  0.  0.  0.  0.  1.  1
****************************************************
****
*  sg walls - upper section        material 1.4571       *
****************************************************
****
16601000 2      3       2       1       0.1350
16601100 0      1
16601101 2      0.1520
16601201 5      2
16601301 0.0    2
16601401 568.13   3
*  steam dome section
16601501 660010000 0    1       1       0.681    1
16601601 -1     0       3603    1       0.681    1
16601701 0      0.0     0.0     0.0     1
16601801  0.26061  0.681  0.681  0.  0.  0.  0.  1.  1
16601901  0.304  0.681  0.681  0.  0.  0.  0.  1.  1
*  separator section
16601502 652010000 0    1       1       1.10    2
16601602 -1     0       3601    1       1.10    2
16601702 0      0.0     0.0     0.0     2
16601802  0.26061  1.10  1.10  0.  0.  0.  0.  1.  2
16601902  0.304  1.10  1.10  0.  0.  0.  0.  1.  2
****************************************************
****
*  top of bl sg steam dome, part spherical  material 1.4571*
****************************************************
****
16602000 1      3       3       1       0.304
16602100 0      1
16602101 2      0.324
16602201 5      2
16602301 0.0    2
```

```
16602401 568.13   3
16602501 660010000 0     1     1      0.0625   1
16602601 -1      0      3603     1      0.0625   1
16602701 0       0.0     0.0      0.0      1
16602801  0.0  0.150  0.150  0. 0. 0. 0. 1. 1
16602901  0.0  0.150  0.150  0. 0. 0. 0. 1. 1
*************************************************
****
*
*    this section contains all the heat structures which
*    define the pipe walls in the intact and broken loops.
*
*    it excludes the large bulks of metal contained in
*    the flanges. pump, gamma densitometers and supports,
*
* components defined in this section:-
*
*    heat structure geometries:  1000,1001   2000,2001
*
* components referenced in this section:-
*
*    snglvol:     100               200,260
*
*    branch:     105,133,137,145   203,223,230,235
*
*    pump:        135               225
*
*    pipe:       110,130,140       206,220
*
*    tables:  001  101,102,103       201,202,203
*
* implementation:-
*
*    the pipes in the loops are either small or large bore and
*    either thin or thick walled. these 4 different geometries
*    are defined with separate heat structure geometries. then
*    each section of pipe is defined as a heat structure number
*    within each geometry.
*    the instrumented spools also have an outer wall heat loss
*    defined to mimic instrument cooling, if required this can
*    be 'turned off' by specifying ' 0  0  0' as the first 3
*    words on the 601 series of cards.
*    the rest of the loop metalwork such as flanges is
*    specified in a separate section to facilitate the
*    construction of different input decks for small and
*    large break problems. (for large breaks this section
*    by itself will be adequate.)
*
*
*    thick walled tubes in the intact loop
*
*
* basic thick wall geometry
*
11000000    6   7   2   1   36.85d-3
11000100    0   1
11000101    6   53.85d-3
11000201    5   6
11000301    0.0 6
11000401    572. 7
*
* heat structures using the basic geometry
*
*
*
* structure number  1    dhss cylinder number(s):- 1,3
*
* links to:-           component 100
*
11000501    100010000  0  1    1  .682   1
11000601   -2          0  3101  1  .682   1
11000701    0        0.0  0.0  0.0        1
11000801  0.0  .682  .682  0.  0.  0.  0.  1.  1
*
*
* structure number  2    dhss cylinder number(s):- 10
*
* links to:-           component 110
*
11000502    110020000  0  1    1  .626   2
11000602   -2          0  3102  1  .626   2
11000702    0        0.0  0.0  0.0        2
11000802  0.0  .626  .626  0.  0.  0.  0.  1.  2
*
*
*
* structure number  3    dhss cylinder number(s):- 13
*
* links to:-           component 130
*
11000503    130010000  0  1    1  .626   3
11000603   -2          0  3103  1  .626   3
11000703    0        0.0  0.0  0.0        3
11000803  0.0  .626  .626  0.  0.  0.  0.  1.  3
*
*
* structure number  4    dhss cylinder number(s):- 19,23
*
* links to:-           component 133
*
11000504    133010000  0  1    1  .767   4
11000604   -2          0  3104  1  .767   4
11000704    0        0.0  0.0  0.0        4
11000804  0.0  .767  .767  0.  0.  0.  0.  1.  4
*
*
* structure number  5    dhss cylinder number(s):- 26,29
*
* links to:-           component 137
*
11000505    137010000  0  1    1  .737   5
11000605   -2          0  3105  1  .737   5
11000705    0        0.0  0.0  0.0        5
11000805  0.0  .737  .737  0.  0.  0.  0.  1.  5
*
*
* structure number  6    dhss cylinder number(s):- 35,39
*
* links to:-           component 145
*
11000506    145010000  0  1    1  .687   6
11000606   -2          0  3106  1  .687   6
11000706    0        0.0  0.0  0.0        6
11000806  0.0  .687  .687  0.  0.  0.  0.  1.  6
*
*
*    thin walled tubes in the intact loop
*
*
* basic thin wall geometry
*
11001000    8   5   2   1   36.85d-3
11001100    0   1
11001101    4   44.45d-3
11001201    5   4
11001301    0.0 4
11001401    572. 5
*
* heat structures using the basic geometry
*
*
*
* structure number  1    dhss cylinder number(s):- 7 (part)
*
```

```
* links to:-          component 105
*
11001501   105010000 0 1   1  .682  1
11001601   0         0 0   1  .682  1
11001701   0        0.0 0.0 0.0      1
11001801  0.0  .682  .682 0. 0. 0. 0. 1. 1
*
*
* structure number  2    dhss cylinder number(s):- 7 (part)
*
* links to:-          component 110
*
11001502   110010000 0 1   1  1.60  2
11001602   0         0 0   1  1.60  2
11001702   0        0.0 0.0 0.0      2
11001802  0.0  1.60  1.60 0. 0. 0. 0. 1. 2
*
*
*
* structure number  3    dhss cylinder number(s):- 16 (part)
*
* links to:-          component 130
*
11001503   130020000 0 1   1  1.171 3
11001603   0         0 0   1  1.171 3
11001703   0        0.0 0.0 0.0      3
11001803  0.0  1.171  1.171 0. 0. 0. 0. 1. 3
*
*
* structure number  4    dhss cylinder number(s):- 16 (part)
*
* links to:-          component 130
*
11001504   130030000 0 1   1  1.611  4
11001604   0         0 0   1  1.611 4
11001704   0        0.0 0.0 0.0      4
11001804  0.0  1.611  1.611 0. 0. 0. 0. 1. 4
*
*
* structure number  5    dhss cylinder number(s):- 16 (part)
*
* links to:-          component 130
*
11001505   130040000 0 1   1  .625  5
11001605   0         0 0   1  .625  5
11001705   0        0.0 0.0 0.0      5
11001805  0.0  .625  .625 0. 0. 0. 0. 1. 5
*
*
* structure number  6    dhss cylinder number(s):- 16 (part)
*
* links to:-          component 130
*
11001506   130050000 0 1   1  1.61   6
11001606   0         0 0   1  1.61  6
11001706   0        0.0 0.0 0.0      6
11001806  0.0  1.61  1.61 0. 0. 0. 0. 1. 6
*
*
* structure number  7    dhss cylinder number(s):- 23 (part)
*
* links to:-          component 140
*
11001507   140010000 0 1   1  1.161  7
11001607   0         0 0   1  1.161  7
11001707   0        0.0 0.0 0.0      7
11001807  0.0  1.161  1.161 0. 0. 0. 0. 1. 7
*
*
* structure number  8    dhss cylinder number(s):-  23 (part)
*
* links to:-          component 140
*
11001508   140020000 0 1   1  1.31  8
11001608   0         0 0   1  1.31  8
11001708   0        0.0 0.0 0.0      8
11001808  0.0  1.31  1.31  0. 0. 0. 0. 1. 8
*
*
*   thick walled tubes in the broken loop
*
*
* basic thick wall geometry
*
12000000    6   7   2   1   23.05d-3
12000100    0   1
12000101    6   40.05d-3
12000201    5   6
12000301    0.0 6
12000401    572. 7
*
* heat structures using the basic geometry
*
*
*
* structure number  1    dhss cylinder number(s):- 41,43
*
* links to:-          component 200
*
12000501   200010000 0 1   1  .624  1
12000601  -2         0 3207 1  .624  1
12000701   0        0.0 0.0 0.0      1
12000801  0.0  .624  .624 0. 0. 0. 0. 1. 1
*
*
* structure number  2    dhss cylinder number(s):- 56
*
* links to:-          component 206
*
12000502   206030000 0 1   1  .684  2
12000602  -2         0 3202 1  .684  2
12000702   0        0.0 0.0 0.0      2
12000802  0.0  .684  .684 0. 0. 0. 0. 1. 2
*
*
*
* structure number  3    dhss cylinder number(s):- 60
*
* links to:-          component 220
*
12000503   220010000 0 1   1  .684  3
12000603  -2         0 3203 1  .684  3
12000703   0        0.0 0.0 0.0      3
12000803  0.0  .684  .684 0. 0. 0. 0. 1. 3
*
*
* structure number  4    dhss cylinder number(s):- 71
*
* links to:-          component 223
*
12000504   223010000 0 1   1  1.161  4
12000604  -2         0 3204 1  1.161  4
12000704   0        0.0 0.0 0.0      4
12000804  0.0  1.161  1.161  0. 0. 0. 0. 1. 4
*
*
* structure number  5    dhss cylinder number(s):- 76,79
*
* links to:-          component 230
*
12000505   230010000 0 1   1  .858  5
12000605  -2         0 3205 1  .858  5
12000705   0        0.0 0.0 0.0      5
12000805  0.0  .858  .858 0. 0. 0. 0. 1. 5
```

```
*
*
* structure number 6   dhss cylinder number(s):- 88,94
*
* links to:-          component 260
*
12000506   260010000 0 1   1 .624  6
12000606  -2         0 3206 1  .624  6
12000706   0       0.0 0.0 0.0      6
12000806  0.0  .624  .624 0. 0. 0. 0. 1. 6
*
*
*    thin walled tubes in the broken loop
*
*
* basic thin wall geometry
*
12001000    9   5   2   1   23.05d-3
12001100    0   1
12001101    4   30.15d-3
12001201    5   4
12001301    0.0 4
12001401    572. 5
*
* heat structures using the basic geometry
*
*
*
* structure number 1   dhss cylinder number(s):- 48
*
* links to:-          component 203
*
12001501   203010000 0 1    1  .885  1
12001601  -1         0 3208 1  .885  1
12001701   0       0.0 0.0 0.0       1
12001801  0.0  .885  .885 0. 0. 0. 0. 1. 1
*
*
* structure number 2   dhss cylinder number(s):- 49
*
* links to:-          component 206
*
12001502   206010000 0 1    1 0.686 2
12001602  -1         0 3208 1  0.686 2
12001702   0       0.0 0.0 0.0       2
12001802  0.0  0.686  0.686 0. 0. 0. 0. 1. 2
*
*
*
* structure number 3   dhss cylinder number(s):- 53
*
* links to:-          component 206
*
12001503   206020000 0 1    1  .686  3
12001603   0        0 0   1  .686  3
12001703   0       0.0 0.0 0.0       3
12001803  0.0  .686  .686 0. 0. 0. 0. 1. 3
*
*
* structure number 4   dhss cylinder number(s):- 64
*
* links to:-          component 220
*
12001504   220020000 0 1    1  1.502  4
12001604   0        0 0   1  1.502  4
12001704   0       0.0 0.0 0.0       4
12001804  0.0  1.502  1.502 0. 0. 0. 0. 1. 4
*
*
* structure number 5   dhss cylinder number(s):- 68 (part)
*
* links to:-          component 220
*
12001505   220030000 0 1    1  .741  5
12001605   0        0 0   1  .741  5
12001705   0       0.0 0.0 0.0       5
12001805  0.0  .741  .741 0. 0. 0. 0. 1. 5
*
*
* structure number 6   dhss cylinder number(s):- 68 (part)
*
* links to:-          component 220
*
12001506   220040000 0 1    1  .732  6
12001606   0        0 0   1  .732  6
12001706   0       0.0 0.0 0.0       6
12001806  0.0  .732  .732 0. 0. 0. 0. 1. 6
*
*
* structure number 7   dhss cylinder number(s):- 68 (part)
*
* links to:-          component 220
*
12001507   220050000 0 1    1  .741  7
12001607   0        0 0   1  .741  7
12001707   0       0.0 0.0 0.0       7
12001807  0.0  .741  .741 0. 0. 0. 0. 1. 7
*
*
* structure number 8   dhss cylinder number(s):- 83
*
* links to:-          component 240
*
12001508   240010000 0 1    1  1.263  8
12001608   0        0 0   1  1.263  8
12001708   0       0.0 0.0 0.0       8
12001808  0.0  1.263  1.263 0. 0. 0. 0. 1. 8
*
*
* structure number 9   dhss cylinder number(s):- 89
*
* links to:-          component 260
*
12001509   250010000 0 1    1  .988  9
12001609   0        0 0   1  .988  9
12001709   0       0.0 0.0 0.0       9
12001809  0.0  .988  .988 0. 0. 0. 0. 1. 9
*
*************************************************
*****
*
*    this section contains all the heat structures which
*    define the flanges in the intact and broken loops.
*
* components defined in this section:-
*
*    heat structure geometries:  1010,1011  2010,2011
*
* components referenced in this section:-
*
*    snglvol:    100         260
*
*    branch:     133,137,145   223,230,235
*
*    pipe:       110,130,140   200,220
*
* implementation:-
*
*    four kinds of heat structure are defined:-
*    'a' and 'b' flanges  for intact and broken loops
*
*    gamma densitometer in intact and broken loop
*
*    all the flanges defined in the dhss are expressed
```

```
*    in terms of these structures, despite a loss of
*    correctness in the thermal time constants,
*    to reduce the number of heat structures needed.
*    the heat structures so defined are then lumped
*    together to form composite structures having the
*    same total mass as the individual flanges. the flanges
*    so defined are completely distinct from the metal in
*    the pipework which is defined in a separate section.
*    in this way input decks can be taylored to fit the
*    problem being studied,  either large break, small
*    break or special transient.
*
*    the process of lumping the flanges together is governed
*    by the following constraints:-
*
*       metal masses in horizontal and vertical sections
*       cannot be lumped together (incorrect buoyancy)
*
*       metal masses on different sides of heat sources
*       or sinks cannot be lumped together.
*
*
*    'b' type flanges in the intact loop
*
*
* basic 'b' type flange geometry
*
11010000    6  7  2  1  36.85d-3
11010100    0  1
11010101    6  97.5d-3
11010201    5  6
11010301    0.0 6
11010401    572. 7
*
* heat structures using the basic geometry
*
*
*
* structure no. 1    dhss cylinder number(s):- 2,4,5,8
*
* links to:-         component 100
*
11010501   100010000  0  1    1  .182  1
11010601   0        0  0    1  .182  1
11010701   0      0.0 0.0 0.0      1
11010801   0.0  .182  .182  0.  0.  0.  0.  1.  1
*
*
* structure no. 2    dhss cylinder number(s):- 9,11,12,12a
*
* links to:-         component 110
*
11010502   110020000  0  1    1  .125  2
11010602   0        0  0    1  .125  2
11010702   0      0.0 0.0 0.0      2
11010802   0.0  .125  .125  0.  0.  0.  0.  1.  2
*
*
*
* structure no. 3    dhss cylinder number(s):- 14a,14,15,17
*
* links to:-         component 130
*
11010503   130010000  0  1    1  .125  3
11010603   0        0  0    1  .125  3
11010703   0      0.0 0.0 0.0      3
11010803   0.0  .125  .125  0.  0.  0.  0.  1.  3
*
*
* structure no. 4    dhss cylinder number(s):- 18,20,21,24,25
*
*
```

```
* links to:-         component 133
*
11010504   133010000  0  1    1  .316  4
11010604   0        0  0    1  .316  4
11010704   0      0.0 0.0 0.0      4
11010804   0.0  .316  .316  0.  0.  0.  0.  1.  4
*
*
* structure no.  5    dhss cylinder number(s):- 27,30,31,33,109
*
* links to:-         component 137
*
11010505   137010000  0  1    1  .241  5
11010605   0        0  0    1  .241  5
11010705   0      0.0 0.0 0.0      5
11010805   0.0  .241  .241  0.  0.  0.  0.  1.  5
*
* structure no.  6    dhss cylinder number(s):- 34,36,37,40
*
* links to:-         component 145
*
11010506   145010000  0  1    1  .106  6
11010606   0        0  0    1  .106  6
11010706   0      0.0 0.0 0.0      6
11010806   0.0  .106  .106  0.  0.  0.  0.  1.  6
*
*    gamma densitometer in intact loop
*    measurement locations 11, 14, 16
*
* basic geometry
*
11011000    3  7  2  1  36.85d-3
11011100    0  1
11011101    6  90.0d-3
11011201    21  6
11011301    0.0 6
11011401    572. 7
*
* heat structures using the basic geometry
*
*
*
* structure no.  1    dhss cylinder number(s):- 6
*
* links to:-         component 100
*
11011501   100010000  0  1    1  .170  1
11011601   0        0  0    1  .170  1
11011701   0      0.0 0.0 0.0      1
11011801   0.0  .170  .170  0.  0.  0.  0.  1.  1
*
*
* structure no.  2    dhss cylinder number(s):- 22
*
* links to:-         component 133
*
11011502   133010000  0  1    1  .170  2
11011602   0        0  0    1  .170  2
11011702   0      0.0 0.0 0.0      2
11011802   0.0  .170  .170  0.  0.  0.  0.  1.  2
*
*
* structure no.  3    dhss cylinder number(s):- 38
*
* links to:-         component 145
*
11011503   145010000  0  1    1  .170  3
11011603   0        0  0    1  .170  3
11011703   0      0.0 0.0 0.0      3
11011803   0.0  .170  .170  0.  0.  0.  0.  1.  3
*
*
```

```
*   'a' type flanges in the broken loop
*
*
* basic 'a' type flange geometry
*
12010000   6   7   2   1   23.05d-3
12010100   0   1
12010101   6   80.0d-3
12010201   5   6
12010301   0.0  6
12010401   572. 7
*
* heat structures using the basic geometry
*
*
*
* structure no.  1    dhss cylinder number(s):- 42,44,45,46
*                                       50,51,52,54
*
* links to:-          component 200
*
12010501   200010000  0  1     1  .409   1
12010601   0          0  0     1  .409   1
12010701   0          0.0  0.0  0.0      1
12010801   0.0  .409  .409  0.  0.  0.  0.  1.  1
*
*
* structure no.  2    dhss cylinder number(s):- 55,57,58,58a
*
* links to:-          component 200
*
12010502   206030000  0  1     1  .128   2
12010602   0          0  0     1  .128   2
12010702   0          0.0  0.0  0.0      2
12010802   0.0  .128  .128  0.  0.  0.  0.  1.  2
*
*
*
* structure no.  3    dhss cylinder number(s):- 61a,61,62,65
*                                       66,67,69
*
* links to:-          component 220
*
12010503   220010000  0  1     1  .227   3
12010603   0          0  0     1  .227   3
12010703   0          0.0  0.0  0.0      3
12010803   0.0  .227  .227  0.  0.  0.  0.  1.  3
*
*
* structure no.  4    dhss cylinder number(s):- 70,72,73,74,110
*
* links to:-          component 223
*
12010504   223010000  0  1     1  .380   4
12010604   0          0  0     1  .380   4
12010704   0          0.0  0.0  0.0      4
12010804   0.0  .380  .380  0.  0.  0.  0.  1.  4
*
*
* structure no.  5    dhss cylinder number(s):- 77,78,80,81,84
*                                       111
*
* links to:-          component 230
*
12010505   230010000  0  1     1  .420   5
12010605   0          0  0     1  .420   5
12010705   0          0.0  0.0  0.0      5
12010805   0.0  .420  .420  0.  0.  0.  0.  1.  5
*
*
*
* structure no.  6    dhss cylinder number(s):- 85,90,91,92,95
*
* links to:-          component 260
*
12010506   260010000  0  1     1  .219   6
12010606   0          0  0     1  .219   6
12010706   0          0.0  0.0  0.0      6
12010806   0.0  .219  .219  0.  0.  0.  0.  1.  6
*
*
*   gamma densitometer in broken loop
*   measurement locations 21, 24, 25, 26
*
* basic geometry
*
12011000   4   7   2   1   23.05d-3
12011100   0   1
12011101   6   90.0d-3
12011201   21  6
12011301   0.0  6
12011401   572. 7
*
* heat structures using the basic geometry
*
*
*
* structure no.  1    dhss cylinder number(s):- 47
*
* links to:-          component 200
*
12011501   200010000  0  1     1  .170   1
12011601   0          0  0     1  .170   1
12011701   0          0.0  0.0  0.0      1
12011801   0.0  .170  .170  0.  0.  0.  0.  1.  1
*
*
* structure no.  2    dhss cylinder number(s):- 59
*
* links to:-          component 200
*
*12011502   206030000  0  1     1  .170   2
*12011602   0          0  0     1  .170   2
*12011702   0          0.0  0.0  0.0      2
*12011802   0          0.0  0.0       .170   2
*
*
* structure no.  3    dhss cylinder number(s):- 63
*
* links to:-          component 220
*
*12011503   220010000  0  1     1  .170   3
*12011603   0          0  0     1  .170   3
*12011703   0          0.0  0.0  0.0      3
*12011803   0          0.0  0.0       .170   3
*
*
* structure no.  2    dhss cylinder number(s):- 75
*
* links to:-          component 223
*
12011502   223010000  0  1     1  .170   2
12011602   0          0  0     1  .170   2
12011702   0          0.0  0.0  0.0      2
12011802   0.0  .170  .170  0.  0.  0.  0.  1.  2
*
*
* structure no.  3    dhss cylinder number(s):- 82
*
* links to:-          component 230
*
12011503   230010000  0  1     1  .170   3
12011603   0          0  0     1  .170   3
12011703   0          0.0  0.0  0.0      3
```

```
12011803  0.0  .170  .170 0. 0. 0. 0. 1. 3
*
*
* structure no. 4    dhss cylinder number(s):- 93
*
* links to:-          component 260
*
12011504   260010000 0 1    1  .170   4
12011604   0          0 0    1  .170  4
12011704   0       0.0 0.0 0.0       4
12011804  0.0  .170  .170 0. 0. 0. 0. 1. 4
*************************************************
**********
*
*    this section contains the heat structures for
*    the pressure vessel. the data covers the vessel
*    walls, the mounting brackets, stub pipes other than
*    the hot and cold leg pipes, the instrument cooling
*    effects ,the honeycomb downcomer, ceramic filler and
*    upper head cooling.
*
*    it does not include the heater rods.
*
* components defined in this section:-
*
*    heat structure geometries:-   3100,3101,3102,3103,3104
*                              3105,3106,3107,3550
*
* components referenced in this section:-
*
*    pipes:-                    310,325,335
*
*    single volumes:-              320,350
*
*    branches:-                300,305,315,355
*
* implementation:-
*
*    the vessel walls  are modelled as cylinders .
*    the stub pipes are modelled separately with heat losses
*    to allow for the differential pressure cooling adaptors.
*    the upper vessel steel plate with the heater rods in is
*    modelled as a part of a sphere to account for the 2d
*    conduction effects. it has a fraction of the total
*    power dissipated in it which at full power is some
*    22 kw. it models the bulk heat input not the actual
*    temperatures reached by the heater rods.
*    the honeycomb downcomer is modelled as a cylinder
with
*    three regions, inner and outer steel with the centre
*    region being a pseudo material which allows for
*    partial conduction and radiation effects. the properties
*    for this region are a function of t**3. in parts
*    the ceramic filler is modelled as an extra inner region
*    to this cylinder with the correct outer diameter and
*    volume and with an adjusted inner diameter.
*    the vessel flanges and power connector are separately
*    modelled with heat loss for the copper connector.
*
* main geometry for vessel wall
*
*
13100000   14  5   2   1   156.0d-3
13100100   0   1
13100101   4  171.8d-3
13100201   1   4
13100301   0.0 4
13100401   566.7  5
*
* upper part of downcomer  links to component 300
*
13100501   300010000   0      1   1   0.315   1
13100601  -1        0        3301 1   0.315   1
13100701   0        0.0      0.0 0.0         1
13100801  0.0  0.315  0.315  0. 0. 0. 0. 1. 1
*
*
* downcomer annulus  links to component 305
*
13100502   305010000   0      1   1  0.487   2
13100602  -1        0        3301 1   0.487   2
13100702   0        0.0      0.0 0.0         2
13100802  0.0  0.487  0.487 0. 0. 0. 0. 1. 2
*
* 10 downcomer segments  linking to component 310
*
13100503   310010000   0      1   1   0.170   3
13100603  -1        0        3301 1   0.170   3
13100703   0        0.0      0.0 0.0         3
13100803  0.0  0.170  0.170 0. 0. 0. 0. 1. 3
*
13100504   310020000   0      1   1   0.600   4
13100604  -1        0        3301 1   0.600   4
13100704   0        0.0      0.0 0.0         4
13100804  0.0  0.600  0.600 0. 0. 0. 0. 1. 4
*
*
13100505   310030000   0      1   1   0.740   5
13100605  -1        0        3301 1   0.740   5
13100705   0        0.0      0.0 0.0         5
13100805  0.0  0.740  0.740 0. 0. 0. 0. 1. 5
*
13100506   310040000   0      1   1   0.663   6
13100606  -1        0        3301 1   0.663   6
13100706   0        0.0      0.0 0.0         6
13100806  0.0  0.663  0.663 0. 0. 0. 0. 1. 6
*
13100507   310050000   10000   1   1   0.875   8
13100607  -1        0        3301 1   0.875   8
13100707   0        0.0      0.0 0.0         8
13100807  0.0  0.875  0.875 0. 0..0. 0. 1. 8
*
13100508   310070000   0      1   1   0.663   9
13100608  -1        0        3301 1   0.663   9
13100708   0        0.0      0.0 0.0         9
13100808  0.0  0.663  0.663 0. 0. 0. 0. 1. 9
*
13100509   310080000   0      1   1   0.282   10
13100609  -1        0        3301 1   0.282   10
13100709   0        0.0      0.0 0.0         10
13100809  0.0  0.282  0.282 0. 0. 0. 0. 1. 10
*
13100510   310090000   0      1   1   0.390   11
13100610  -1        0        3301 1   0.390   11
13100710   0        0.0      0.0 0.0         11
13100810  0.0  0.390  0.390 0. 0. 0. 0. 1. 11
*
13100511   310100000   0      1   1   0.616   12
13100611  -1        0        3301 1   0.616   12
13100711   0        0.0      0.0 0.0         12
13100811  0.0  0.616  0.616 0. 0. 0. 0. 1. 12
*
* top of lower plenum   links to component 315
*
13100512   315010000   0      1   1   0.175   13
13100612  -1        0        3301 1   0.175   13
13100712   0        0.0      0.0 0.0         13
13100812  0.0  0.175  0.175 0. 0. 0. 0. 1. 13
*
* bottom of lower plenum   links to component 320
*
13100513   320010000   0      1   1   0.285   14
13100613  -1        0        3301 1   0.285   14
13100713   0        0.0      0.0 0.0         14
```

```
13100813  0.0  0.285  0.285 0. 0. 0. 0. 1. 14
*
* main geometry - ceramic filler plus honeycomb
downcomer
*
* links between components 335 and 310
*
13101000 6     15     2     1      66.57d-3
13101100 0     1
13101101 4  99.0d-3, 4  106.0d-3, 2  137.0d-3, 4  144.0d-3
13101201 6     4, 5     8, 22     10, 5     14
13101301 0.0   14
13101401 572.00  15
13101501 335010000 0       1     1      0.612   1
13101502 335020000 0       1     1      0.663   2
13101503 335030000 10000   1     1       0.875   4
13101504 335050000 0       1     1      0.663   5
13101505 335060000 0       1     1      0.740   6
13101601 310080000 0       1     1      0.612   1
13101602 310070000 0       1     1      0.663   2
13101603 310060000 -10000  1     1       0.875   4
13101604 310040000 0       1     1      0.663   5
13101605 310030000 0       1     1      0.740   6
13101701 0      0.0      0.0      0.0     6
13101801   0.06877  0.612  0.612 0. 0. 0. 0. 1. 1
13101802   0.06877  0.663  0.663 0. 0. 0. 0. 1. 2
13101803   0.06877  0.875  0.875 0. 0. 0. 0. 1. 4
13101804   0.06877  0.663  0.663 0. 0. 0. 0. 1. 5
13101805   0.06877  0.740  0.740 0. 0. 0. 0. 1. 6
13101901   50.0d-3  0.612  0.612 0. 0. 0. 0. 1. 1
13101902   50.0d-3  0.663  0.663 0. 0. 0. 0. 1. 2
13101903   50.0d-3  0.875  0.875 0. 0. 0. 0. 1. 4
13101904   50.0d-3  0.663  0.663 0. 0. 0. 0. 1. 5
13101905   50.0d-3  0.740  0.740 0. 0. 0. 0. 1. 6
* main geometry -  honeycomb downcomer
*
* links between components 300 and 355
*                  305   350
*                  310   345
*                  310   325
*
13102000 5     11     2     1      99.0d-3
13102100 0     1
13102101 4  106.0d-3, 2  137.0d-3, 4  144.0d-3
13102201 5     4, 22     6, 5      10
13102301 0.0   10
13102401 572.00  11
13102501 325010000 0       1     1      0.420   1
13102502 345010000 10000   1     1       0.600   3
13102503 350010000 0       1     1      0.487   4
13102504 355010000 0       1     1      0.210   5
13102601 310100000 0       1     1      0.420   1
13102602 310020000 -10000  1     1       0.600   3
13102603 305010000 0       1     1      0.487   4
13102604 300010000 0       1     1      0.210   5
13102701 0      0.0      0.0      0.0     5
13102801   160.0d-3  0.420  0.420 0. 0. 0. 0. 1. 1
13102802   160.0d-3  0.600  0.600 0. 0. 0. 0. 1. 3
13102803   160.0d-3  0.487  0.487 0. 0. 0. 0. 1. 4
13102804   160.0d-3  0.210  0.210 0. 0. 0. 0. 1. 5
13102901   50.0d-3  0.420  0.420 0. 0. 0. 0. 1. 1
13102902   50.0d-3  0.600  0.600 0. 0. 0. 0. 1. 3
13102903   50.0d-3  0.487  0.487 0. 0. 0. 0. 1. 4
13102904   50.0d-3  0.210  0.210 0. 0. 0. 0. 1. 5
*
* geometry for solid parts of downcomer
*
*   first for top and part above bottom connector
*
*   links components     300 and 355
*                   310 and 325
13103000 2     7     2     1      99.0d-3
13103100 0     1
13103101 6  144.0d-3
13103201 5     6
13103301 0.0     6
13103401 572.00  7
13103501 325020000 0      1      1      0.426   1
13103502 355010000 0      1      1      0.105   2
13103601 310090000 0      1      1      0.426   1
13103602 300010000 0      1      1      0.105   2
13103701 0      0.0      0.0      0.0     2
13103801   194.0d-3  0.426  0.426  0. 0. 0. 0. 1. 1
13103802   160.0d-3  0.105  0.105  0. 0. 0. 0. 1. 2
13103901   50.0d-3  0.426  0.426  0. 0. 0. 0. 1. 1
13103902   50.0d-3  0.105  0.105  0. 0. 0. 0. 1. 2
*
* second part for bottom connector
*
*   links components     310 and 325
*
13104000 1     7     2     1      65.0d-3
13104100 0     1
13104101 6  144.0d-3
13104201 5     6
13104301 0.0     6
13104401 572.00  7
13104501 325020000 0      1      1      0.160   1
13104601 310090000 0      1      1      0.160   1
13104701 0      0.0      0.0      0.0     1
13104801   130.0d-3  0.160  0.160  0. 0. 0. 0. 1. 1
13104901   50.0d-3  0.160  0.160  0. 0. 0. 0. 1. 1
*
* main geometry for stubpipes on vessel
* enhanced cooling from all 12 stub-pipes is assumed
* to improve condensation of steam in vessel downcomer.
* the direct heating term is used to input -1.2kw to
* the whole heat structure, distributed equally as
* -0.1 kw per stub-pipe.
*
13105000   12  5  2  1   40.0d-3
13105100   0  1
13105101   4  122.0d-3
13105201   1  4
13105301   0.0 4
13105401   550. 5
*
* upper part of downcomer  links to component 300
*
13105501   300010000   0      1  1  0.144   1
13105601   -2        0       3302 1   0.144   1
13105701   310       1.0      0.08333  0.0    1
13105801   0.0  0.144  0.144  0. 0. 0. 0. 1. 1
*
*
* downcomer annulus  links to component 305
*
13105502   305010000   0      1  1  0.144   2
13105602   -2        0       3302 1   0.144   2
13105702   310       1.0      0.08333  0.0    2
13105802   0.0  0.144  0.144  0. 0. 0. 0. 1. 2
*
* 10 downcomer segments  linking to component 310
*
13105503   310010000   10000   1  1  0.144   4
13105603   -2        0       3302 1   0.144   4
13105703   310       1.0      0.08333  0.0    4
13105803   0.0  0.144  0.144  0. 0. 0. 0. 1. 4
*
13105504   310030000   10000   1  1  0.288   8
13105604   -2        0       3302 1   0.288   8
13105704   310       1.0      0.08333  0.0    8
13105804   0.0  0.288  0.288  0. 0. 0. 0. 1. 8
*
```

```
13105505  310070000  10000   1  1  0.144  12
13105605  -2         0       3302 1  0.144  12
13105705  310        1.0     0.08333  0.0   12
13105805  0.0  0.144  0.144  0.  0.  0.  0.  1.  12
*
*
*   geometry for thickened vessel walls at supports
*
13106000   2   5   2   1   156.0d-3
13106100   0   1
13106101   4   187.6d-3
13106201   1   4
13106301   0.0  4
13106401   565. 5
*
* upper support structure
*
13106501   310010000   0      1   1   0.430   1
13106601   -1          0      3303 1  0.430   1
13106701   0           0.0    0.0  0.0        1
13106801   0.0  0.430  0.430  0.  0.  0.  0.  1.  1
*
*
* lower support structure
*
13106502   310080000   0      1   1   0.330   2
13106602   -1          0      3303 1  0.330   2
13106702   0           0.0    0.0  0.0        2
13106802   0.0  0.330  0.330  0.  0.  0.  0.  1.  2
*
*   geometry for vessel flange and power connector
*
13107000   2   5   2   1   156.0d-3
13107100   0   1
13107101   4   280.0d-3
13107201   1   4
13107301   0.0  4
13107401   550. 5
*
* flange at top of vessel
*
13107501   300010000   0      1   1   0.070   1
13107601   -1          0      3304 1  0.070   1
13107701   0           0.0    0.0  0.0        1
13107801   0.0  0.070  0.070  0.  0.  0.  0.  1.  1
*
*
* bottom flange and power connector
*
13107502   310100000   0      1   1   0.200   2
13107602   -1          0      3305 1  0.200   2
13107702   0           0.0    0.0  0.0        2
13107802   0.0  0.200  0.200  0.  0.  0.  0.  1.  2
*
* upper vessel mounting plate with heater rods in it
*
*
13550000   1   9   3   1   370.0d-3
13550100   0   1
13550101   6   500.0d-3  2   565.0d-3
13550201   8   6  20   8
13550301   1.0  6   0.0  8
13550401   620.5 1, 733.9 2, 783.7 3, 777.8 4, 721.8 5
13550402   620.7 6, 477.9 7, 457.8 8, 440.0 9
13550501   355010000   0      1   1   0.01823  1
13550601   -2          0      1002 1  0.01823  1
13550701   100         .004106  0.0  0.0      1
13550801   0.0  90.0d-3  90.0d-3  0.  0.  0.  0.  1.  1
*
*
****************************************************
****
```

```
*
*    this section contains the heat structures for the
*    pressurizer
*
* components defined in this section:-
*
*    heat structure geometries:   4100,4101
*
* components referenced in this section:-
*
*    pipes:        400,410
*
*    branches:      409, 420
*
*
* implementation:
*
*    the structures defined are the vessel walls,
*    and surge-line pipe walls (included but not used)
*    a 6 cm layer of rockwool insulation is used
*    around the outer vessel wall, but this is
*    removed in this deck to enhance the pressurizer
*    heat losses to a value of about 8kw, concentrated
*    at top of pressurizer.
*
* main geometry for top of pressurizer
*
14100000   9   5   2   1   62.2d-3
14100100   0   1
14100101   4   80.0d-3
14100201   5   4
14100301   0.5  2   0. 4 * ext. heaters
14100401   619.0  5
*
* top segment
*
14100501   409010000   0      1   1   0.775   1
14100601   -1          0      3402 1  0.775   1
14100701   0           0.0    0.0  0.0        1
14100801   0.0  0.775  0.775  0.  0.  0.  0.  1.  1
*
*
* middle segments
* pressuriser heaters modelled by lower-most 5 slabs
* each producing 20% of total pressuriser heating power
* of up to 20 kw, and this power goes directly into fluid
* adjacent to slab. the total power is switched on or off
* in steps to maintain liquid at saturation temperature.
* table 401 gives external heat loss coeff as a function
* of time for all slabs in top, middle & bottom segments
* for the purpose of collapsing the steam bubble
* and reducing system pressure.
*
14100502   410010000   10000   1   1   0.900   7
14100503   410070000   0       1   1   0.585   8
14100504   420010000   0       1   1   0.690   9
14100602   -1          0      3401 1   0.900   7
14100603   -1          0      3401 1   0.585   8
14100604   -1          0      3401 1   0.690   9
14100702   0           0.0    0.0  0.0         4
14100703  400      0.2   0.       0.0          9
14100802   0.0  0.900  0.900  0.  0.  0.  0.  1.  9
*
*
*
*
* bottom part with thick flange
*
*
*
* connects to component 420
*
```

```
14101000  1  5  3  1  91.2d-3
14101100  0  1
14101101  4  154.6d-3
14101201  5  4
14101301  0.0 4
14101401  619. 5
14101501  420010000  0     1  1  0.5   1
14101601  -1       0     3401 1  0.5   1
14101701  0        0.0     0.0    0.0    1
14101801  0.0  0.5  0.5  0.  0.  0.  0.  1.  1
*
*
*
*
**************************************************
****
*
*   this section contains the heat structures for the
*   vessel upper head.
*
* components defined in this section:-
*
*   heat structure geometries:   3650,3700,3800
*
* components referenced in this section:-
*
*   pipes:          370
*
*   snglvols:       363,365,380
*
* implementation:
*
*   the structures defined are simply the tube walls.
*
*
* inlet pipe
*
* connects to component 365
*
13650000  2  5  2  1  0.010
13650100  0  1
13650101  4  0.013
13650201  5  4
13650301  0.0 4
13650401  571. 5
*
* structure no. 1
*
*
13650501  363010000  0  1  1  1.416  1
13650601  0        0  0  1  1.416  1
13650701  0        0.0 0.0 0.0      1
13650801  0.0  1.416  1.416  0.  0.  0.  0.  1.  1
*
* structure no. 2
*
*
13650502  365010000  0     1  1  3.169  2
13650602  0        0      0  1  3.169  2
13650702  0        0.0     0.0 0.0       2
13650802  0.0  3.169  3.169  0.  0.  0.  0.  1.  2
*
*
* upper head   links to component 370
*
13700000  3  5  2  1  60.0d-3
13700100  0  1
13700101  4  80.0d-3
13700201  5  4
13700301  0.0 4
13700401  571. 5
*
* structure n0. 1
*
*
13700501  370010000  0     1  1  .923   1
13700601  0        0      0  1  .923   1
13700701  0        0.0     0.0 0.0       1
13700801  0.0  .923  .923  0.  0.  0.  0.  1.  1
*
* structure n0. 2
*
*
13700502  370020000  0     1  1  .855   2
13700602  0        0      0  1  .855   2
13700702  0        0.0     0.0 0.0       2
13700802  0.0  .855  .855  0.  0.  0.  0.  1.  2
*
* structure n0. 3
*
13700503  375010000  0     1.  1  .923   3
13700603  0        0      0  1  .923   3
13700703  0        0.0     0.0 0.0       3
13700803  0.0  .923  .923  0.  0.  0.  0.  1.  3
*
* outlet pipe
*
* connects to component 380
*
13800000  1  5  2  1  0.010
13800100  0  1
13800101  4  0.013
13800201  5  4
13800301  0.0 4
13800401  571. 5
13800501  380010000  0     1  1  1.504   1
13800601  0        0      0  1  1.504   1
13800701  0        0.0     0.0 0.0       1
13800801  0.0  1.504  1.504  0.  0.  0.  0.  1.  1
*
**************************************************
****
*
*   this section contains the heat structures for the inlet
*   and outlet piping & the inlet and outlet plena for both
*   intact and broken loop steam generators.
*   it does does include the u tubes or any of the secondary
*   side heat structures.
*
* components defined in this section:-
*
*   heat structure geometries:   1200,1202,1204,1205
*                                2100,2102,2104,2105
*
* components referenced in this section:-
*
*   pipes:          120 210 530 630
*
*
* implementation:
*
*   the 8 geometries defined cover the piping, plenum
*   walls, dividing plate between the plena and the tube
*   sheet for both loops. the plenum walls are arranged
*   to have the correct internal surface area despite
*   being the wrong shape. the wall thickness is adjusted
*   to give the correct total mass.
*
* intact loop geometries
*
* inlet and outlet piping geometries
*
11200000  2  5  2  1  58.85d-3
11200100  0  1
```

```
11200101   4   70.6d-3
11200201   5   4
11200301   0.0 4
11200401   572. 5
*
* structure n0. 1 and 2   dhss cylinder(s):- 96 and 101
*
* links to:-            component 120
*
11200501   120010000   450000   1   1   1.734   2
11200601   0           0        0   1   1.734   2
11200701   0           0.0      0.0 0.0         2
11200801   0.0   1.734   1.734  0.  0.  0.  0.  1.  2
*
*
* plenum walls
*
11202000   2   5   2   1   156.0d-3
11202100   0   1
11202101   4   185.5d-3
11202201   5   4
11202301   0.0 4
11202401   571. 5
*
* structure n0. 1 and 2   dhss cylinder(s):- 97 and 99
*
* links to:-            component 120
*
11202501   120020000   430000   1   1   .171    2
11202601   0           0        0   1   .171    2
11202701   0           0.0      0.0 0.0         2
11202801   0.0   .340   .340    0.  0.  0.  0.  1.  2
*
* tube plate
*
11204000   2   5   1   1   0.0
11204100   0   1
11204101   4   90.0d-3
11204201   5   4
11204301   0.0 4
11204401   590.0 1, 581.0 2, 572.0 3, 563.0 4, 554.0 5
*
* structure n0. 1 and 2   dhss rectangle(s):- 4 and 6
*
* links to:-            components 120 and 530
*
11204501   120020000   430000   1   0   40.2d-3 2
11204601   530010000   0        1   0   40.2d-3 2
11204701   0           0.0      0.0 0.0         2
11204801   0.0   .1000   .1000  0.  0.  0.  0.  1.  2
11204901   0.0   .1000   .1000  0.  0.  0.  0.  1.  2
*
* dividing plate
*
11205000   1   5   1   1   0.0
11205100   0   1
11205101   4   25.0d-3
11205201   5   4
11205301   0.0 4
11205401   572. 5
*
* structure n0. 1         dhss rectangle(s):- 5
*
* links to:-            component 120
*
11205501   120020000   0        1   0   96.3d-3 1
11205601   120430000   0        1   0   96.3d-3 1
11205701   0           0.0      0.0 0.0         1
11205801   0.0   .340   .340    0.  0.  0.  0.  1.  1
11205901   0.0   .340   .340    0.  0.  0.  0.  1.  1
*
* broken loop geometries
```

```
*
* inlet and outlet piping geometries
*
12100000   2   5   2   1   34.15d-3
12100100   0   1
12100101   4   41.75d-3
12100201   5   4
12100301   0.0 4
12100401   572. 5
*
* structure n0. 1 and 2   dhss cylinder(s):- 102 and 106
*
* links to:-            component 210
*
12100501   210010000   250000   1   1   1.909   2
12100601   0           0        0   1   1.909   2
12100701   0           0.0      0.0 0.0         2
12100801   0.0   1.909   1.909  0.  0.  0.  0.  1.  2
*
*
* plenum walls
*
12102000   2   5   2   1   102.0d-3
12102100   0   1
12102101   4   121.35d-3
12102201   5   4
12102301   0.0 4
12102401   572. 5
*
* structure n0. 1 and 2   dhss cylinder(s):- 97 and 99
*
* links to:-            component 210
*
12102501   210020000   230000   1   1   .107    2
12102601   0           0        0   1   .107    2
12102701   0           0.0      0.0 0.0         2
12102801   0.0   .214   .214    0.  0.  0.  0.  1.  2
*
* tube plate
*
12104000   2   5   1   1   0.0
12104100   0   1
12104101   4   60.0d-3
12104201   5   4
12104301   0.0 4
12104401   590.0 1, 581.0 2, 572.0 3, 563.0 4, 554.0 5
*
* structure n0. 1 and 2   dhss rectangle(s):- 4 and 6
*
* links to:-            components 210 and 650
*
12104501   210020000   230000   1   0   19.4d-3 2
12104601   630010000   0        1   0   19.4d-3 2
12104701   0           0.0      0.0 0.0         2
12104801   0.0   .1000   .1000  0.  0.  0.  0.  1.  2
12104901   0.0   .1000   .1000  0.  0.  0.  0.  1.  2
*
* dividing plate
*
12105000   1   5   1   1   0.0
12105100   0   1
12105101   4   20.0d-3
12105201   5   4
12105301   0.0 4
12105401   572. 5
*
* structure n0. 1         dhss rectangle(s):- 5
*
* links to:-            component 210
*
12105501   210020000   0        1   0   39.2d-3 1
12105601   210250000   0        1   0   39.2d-3 1
```

```
12105701  0        0.0    0.0 0.0       1
12105801  0.0  .214  .214  0.  0.  0.  0.  1.  1
12105901  0.0  .214  .214  0.  0.  0.  0.  1.  1
*
************************************************
****
*
*   this section contains the heat structures for
*   the two pumps not included in the loop piping.
*   the inlet and outlet parts of the pumps, and both
*   flanges are incorporated in the loop piping on either
*   side of the pumps.
*
*
*
* components defined in this section:-
*
*   heat structure geometries:-   1370,2300
*
* components referenced in this section:-
*
*   branches:-               137,230
*
* implementation:-
*
*  the heat slabs model the metalwork around the pump
*  bowl plus the cooling due to the pump cooling water
*  which flows in a jacket at the top of the pump body.
*
*  the modelling is fairly crude, and only roughly
*  represents the complex conduction paths through
*  the pump by using spherical goemetry to account
*  in part for the 3d effects.
*  the heat slabs have to be linked to the branches
*  downstream of the pumps because the program does
*  not allow heat slabs on pump volumes.
*
*  the seal flow for the pump is modelled separately
*  in the next section.
*
*
* intact loop pump   links to component   137
*
*
11370000  1  5  3  1  100.0d-3
11370100  0  1
11370101  4  160.0d-3
11370201  5  4
11370301  0.0  4
11370401  565.0 1, 479.0 2, 408.0 3, 349.0 4, 298.0 5
11370501  137010000  0     1  1  1.0    1
11370601  -2        0      3107 1  1.0    1
11370701  0         0.0     0.0 0.0        1
11370801  0.0  300.0d-3  300.0d-3  0.  0.  0.  0.  1.  1
*
* broken loop pump   links to component   230
*
12300000  1  5  3  1  100.0d-3
12300100  0  1
12300101  4  160.0d-3
12300201  5  4
12300301  0.0  4
12300401  565.0 1, 479.0 2, 408.0 3, 349.0 4, 298.0 5
12300501  230010000  0     1  1  1.0    1
12300601  -2        0      3207 1  1.0    1
12300701  0         0.0     0.0 0.0        1
12300801  0.0  300.0d-3  300.0d-3  0.  0.  0.  0.  1.  1
************************************************
****
*
*  this section contains the pump seal flow model
*  for both the intact and broken loop pumps
```

```
*
* components defined in this section:-
*
*   cntrlvar  :- 135,136,137   225,226,227
*                138,139       228,229
*   tmdpvol   :- 136           226
*   tmdpjun   :- 134           224
*
* components referenced in this section:-
*
*   branch   :  133          223
*
*   pump     :  135          225
*
*
* implementation:-
*
*   the seal flow is modelled as a flow from a time
dependent
*   volume through a time dependent junction. the flow rate
*   is a tabulated function of pressure difference between
*   the seal water and primary loop fluid, and the
temperature
*   of the seal water is adjusted to allow for heating up
*   effects before it contacts the primary fluid. the heat-up
*   is a function of pump speed and system fluid
temperature.
*
*   the term representing conduction from primary fluid as
*   5 * fluid temp in pump volume has been removed for
*   both pumps
*
* note:
*    the supply pressure for the sealwater is assumed fixed
*    at 194 bar for this model. this corresponds to the present
*    system used during the new small break test program.
*    if the pressure is controlled manually during any test
*    then a table of time versus seal injection pressure
*    should be included.
*
*
* intact loop:
* ---------
*    calculate pressure difference
*
20513500   seal.dp   sum   1.0e-5 0.0   1
20513501   0.0  1.0  p  136010000  -1.0  p  135010000
*
*    set up table of flow versus pressure difference
*    table values based on measured flow vs press.diff
*
1340000    sealflow   tmdpjun
1340101    136000000  138000000   3.0d-4
1340200    1  0     cntrlvar    135
1340201   0.0   .01d-3   0.0   0.0
1340202   30.0  12.1d-3   0.0   0.0
1340203   60.0  13.7d-3   0.0   0.0
1340204   65.0  15.1d-3   0.0   0.0
1340205   72.5  16.2d-3   0.0   0.0
1340206   96.0  12.86-3   0.0   0.0
1340207  120.0  12.8d-3   0.0   0.0
1340208  145.0  11.2d-3   0.0   0.0
1340209  165.0   8.8d-3   0.0   0.0
1340210  166.0   9.6d-3   0.0   0.0
1340211  180.0   8.0d-3   0.0   0.0
1340212  200.0   6.0d-3   0.0   0.0
*
*   define the dependence between seal water
*   temperature, pump speed and system temperature
*
20502500   ilpvelab   stdfnctn  1.0  468.4  0
20502501   abs        pmpvel   135
```

```
*
20513600   sealfric   powerr   8.5d-5  0.0   1
20513601   cntrlvar   025      2.65
20513700   energyin   sum      1.0    0.0   1
20513701   0.0   * not used    * conversion to centigrade
20513702   4.4        cntrlvar  025
20513703   1.0        cntrlvar  136
20513800   temprise   div      0.24e-3 50.0  0
20513801   mflowj     134000000 cntrlvar 137
20513900   sealtemp   sum  1.0  0.0  1  3  0.0  300.0
20513901   25.0       * seal water inlet temperature
20513902   1.e-9         cntrlvar  138
*    now define the time dependent volume for seal water
*
1360000    sealwatr   tmdpvol
1360101    1.0 1.0  0.0  0.0  0.0  0.0
1360102    2.3d-5   0.0   00
1360200    3   0   cntrlvar    139
1360201    1.0     194.0d5    274.0  *conversion to kelvin
1360202  330.0     194.0d5    603.0
*
* broken loop:
* ----------
*     calculate pressure difference
*
20522500   seal.dp   sum    1.0e-5 0.0   1
20522501   0.0  1.0  p  226010000  -1.0  p  225010000
*
*     set up table of flow versus pressure difference
*     table values based on measured flow vs press.diff
*
2240000    sealflow   tmdpjun
2240101    226000000 228000000   3.0d-4
2240200    1   0     cntrlvar     225
2240201    0.0   .01d-3   0.0   0.0
2240202   30.0   6.8d-3   0.0   0.0
2240203   72.0  10.6d-3   0.0   0.0
2240204   84.0  10.4d-3   0.0   0.0
2240205   94.0  10.8d-3   0.0   0.0
2240206  113.0   9.8d-3   0.0   0.0
2240207  114.0   9.0d-3   0.0   0.0
2240208  120.0   8.8d-3   0.0   0.0
2240209  165.0   5.7d-3   0.0   0.0
2240210  166.0   6.6d-3   0.0   0.0
2240211  175.0   5.6d-3   0.0   0.0
2240212  176.0   5.6d-3   0.0   0.0
2240213  200.0   4.5d-3   0.0   0.0
*
*    define the dependence between seal water
*    temperature, pump speed and system temperature
*
20502600   blpvelab   stdfnctn  1.0    332.24 0
20502601   abs        pmpvel   225
*
20522600   sealfric   powerr   8.5d-5  0.0   1
20522601   cntrlvar   026      2.65
20522700   energyin   sum      1.0    0.0   1
20522701   0.0   * not used    * conversion to centigrade
20522702   4.4        cntrlvar  026
20522703   1.0        cntrlvar  226
20522800   temprise   div      .24e-3  50.0  0
20522801   mflowj     224000000 cntrlvar 227
20522900   sealtemp   sum  1.0  0.0  1  3  0.0  300.0
20522901   25.0       * seal water inlet temperature
20522902   1.d-9         cntrlvar  228
*    now define the time dependent volume for seal water
*
2260000    sealwatr   tmdpvol
2260101    1.0 1.0  0.0  0.0  0.0  0.0
2260102    2.3d-5   0.0   00
2260200    3   0   cntrlvar    229
2260201    1.0     194.0d5    274.0  *conversion to kelvin
```

```
2260202  330.0    194.0d5    603.0
*
20576000   pmpsealt   sum    1.0     0.0     1
20576001   0.0025   1.0    mflowj   134000000
20576002            1.0    mflowj   224000000
*
*************************************************
****
*                                          *
*            heat loss heat transfer             *
*                                          *
*************************************************
****
*
* contents of this section:-
*
*     this section contains tables for heat transfer coef-
*     ficients and for ambient temperature and cooling wa-
*     ter temperature as needed for the modelling of the
*     the heat losses from the insulated parts and from
*     the instrument cooling.
*
* tables defined in this section:-
*
*   tables:      ht-coefficients for:
*
*   101 to 107    intact loop
*   201 to 207    broken loop
*   301 to 306    vessel
*   401           pressurizer
*   501           intact loop steam generator secondary side
*   601           broken loop steam generator secondary side
*
*   tables:      anticipated temperatures for:
*
*   001           the ambient
*   002           the cooling water
*
* components referenced by this section:-
*
*     none
*
* implementation:-
*
*     the heat losses found in the heat loss experi-
*     ments hl-1 and hl-2, form the basis for the
*     following tables of heat transfer coefficients.
*
*     for all cylindrical heat structures the heat
*     loss heat transfer coefficient is found as:
*
*      h = 1/((tin-tac)/q+rou/k*ln(rin/rou))
*
*     where:   h   = heat transfer coefficient
*              tin = inner wall temperature
*              tac = ambient or cooling water temperature
*              q   = heat loss heat flux (= heatflow/area)
*              rou = outer tube radius
*              rin = inner tube radius
*              k   = wall heat conduction coefficient
*
* table of ambient temperature vs time (25 c assumed)
20200100   temp
20200101   0.0   298.15
*
* table of cooling water temperature vs time (15 c)
20200200   temp
20200201   0.0   288.15
*
* intact loop
* ----------
* referenced by heat structure 1000001
```

```
20210100   htc-t
20210101   0.0  81.147
*
* referenced by heat structure 1000002
20210200   htc-t
20210201   0.0  37.358
*
* referenced by heat structure 1000003
20210300   htc-t
20210301   0.0  56.87
*
* referenced by heat structure 1000004
20210400   htc-t
20210401   0.0  89.128
*
* referenced by heat structure 1000005
20210500   htc-t
20210501   0.0  29.044
*
* referenced by heat structure 1000006
20210600   htc-t
20210601   0.0  80.26
*
* referenced by heat structure 1370001
20210700   htc-t
20210701   0.0  85.69
*
* broken loop
* ----------
* referenced by heat structure 2000001
20220100   htc-t
20220101   0.0  88.01
*
* referenced by heat structure 2000002
20220200   htc-t
20220201   0.0   83.369
*
* referenced by heat structure 2000003
20220300   htc-t
20220301   0.0  45.7
*
* referenced by heat structure 2000004
20220400   htc-t
20220401   0.0  54.9
*
* referenced by heat structure 2000005
20220500   htc-t
20220501   0.0  24.7
*
* referenced by heat structure 2000006
20220600   htc-t
20220601   0.0  92.47
*
* referenced by heat structure 2300001 & 2000001
20220700   htc-t
20220701   0.0   156.66
*
* referenced by heat structure 2001001 & 2001002
* insulated pipework in bunker, ht.loss set to zero
20220800   htc-t
20220801   0.0   0.0
*
*   vessel
*   ------
*
* insulated parts
* referenced by heat structures 3100001-014
20230100   htc-t
20230101   0.0  0.75
*
* stub pipes
* referenced by heat structures 3105001-012
20230200   htc-t
20230201   0.0  6.0
*
* supports
* referenced by heat structures 3106001-002
20230300   htc-t
20230301   0.0  4.06
*
* upper flange
* referenced by heat structure 3107001
20230400   htc-t
20230401   0.0  39.93
*
* lower flange and power connector
* referenced by heat structure 3107002
20230500   htc-t
20230501  0.  117.97
*
* upper mounting plate
* referenced by heat structure 3550001
20230600   htc-t
20230601   0.0   1311.54
*
*   pressurizer
*   -----------
* referenced by structures 4100002-009
20240100   htc-t
20240101   0.0   1.61
*
* referenced by structures 4100001
20240200   htc-t
20240201   0.0   1.61
*
*   steam generator secondary sides
*   ================================
*
*   intact loop
*   -----------
20250100   htc-t
20250101   0.0    1.956
*
* referenced by heat structures  5601001, 5602001
* heat loss in steam dome slightly higher
20250300   htc-t
20250301   0.0     2.25
*
*
*   broken loop
*   -----------
*
* referenced by heat structures  6101001-004,
* 6551001 and 6601001-002
20260100   htc-t
20260101   0.0   2.246
*
* referenced by heat structures  6601001
* heat loss in steam dome slightly higher
20260300   htc-t
20260301   0.0   2.568
*
*   steam lines
*   -----------
*
* referenced by heat structures  5641001,
* and 6641001
20260200   htc-t
20260201 · 0.0   5.1
*
***************************************************
****
*                                    *
*                                    *
```

```
*      heat structure thermal property data          *
*                                       *
*                                       *
************************************************
****
20100100 tbl/fctn 1     1    *inconel 625
20100200 tbl/fctn 1     1    *inconel 718
20100300 tbl/fctn 1     1    *1.4948
20100400 tbl/fctn 1     1    *ni 201
20100500 tbl/fctn 1     1    *1.4571
20100600 tbl/fctn 1     1    *al2o3
20100700 tbl/fctn 1     1    *incoloy 800
20100800 tbl/fctn 1     1    *60%inco718+40%ni201
20100900 tbl/fctn 1     1    *crud layer (fe3 o4)
20101000 tbl/fctn 1     1    *rockwool insulation
20102000 tbl/fctn 1     1    *copper
20102100 'c-steel' 0    0    *mild steel for y-beam
20102200 tbl/fctn 1     1    *psuedo matl. for gap
*
* inconel 625 - thermal conductivity
* ------------------------------
20100101 293.0    10.01
20100102 473.0    12.5
20100103 573.0    13.9
20100104 673.0    15.3
*
* inconel 625 - volumetric heat capacity
* ---------------------------------
20100151 293.0    3.460e6
20100152 373.0    3.671e6
20100153 473.0    3.866e6
20100154 573.0    4.051e6
20100155 673.0    4.262e6
*
* inconel 718 - thermal conductivity
* ------------------------------
20100201 293.0    11.1
20100202 373.0    12.4
20100203 473.0    14.0
20100204 573.0    15.7
20100205 2273.    44.0
*
* inconel 718 - volumetric heat capacity
* ---------------------------------
20100251 293.0    3.522e6
20100252 1366.0   3.522e6
*
* 1.4948 - thermal conductivity
* --------------------------
20100301 293.0    16.9
20100302 300.0    17.0
20100303 400.0    18.3
20100304 500.0    18.9
20100305 600.0    20.1
20100306 700.0    21.2
20100307 800.0    22.4
20100308 900.0    23.5
20100309 1000.0   24.7
20100310 1050.0   25.3
*
* 1.4948 - volumetric heat capacity
* ------------------------------
20100351 293.0    3.966e6
20100352 300.0    3.988e6
20100353 400.0    4.125e6
20100354 500.0    4.261e6
20100355 600.0    4.401e6
20100356 700.0    4.535e6
20100357 800.0    4.669e6
20100358 900.0    4.792e6
20100359 1000.0   4.968e6
20100360 1050.0   5.066e6
*
* ni 201 - thermal conductivity
* --------------------------
20100401 293.0    79.2
20100402 533.0    61.9
20100403 813.0    59.0
20100404 1088.0   64.8
*
* ni 201 - volumetric heat capacity
* ------------------------------
20100451 293.0    4.0425e6
20100452 1366.0   4.0425e6
*
* 1.4571 - thermal conductivity
* --------------------------
20100501 293.0    14.0
20100502 400.0    15.5
20100503 600.0    18.3
20100504 800.0    21.0
20100505 1000.0   23.7
*
* 1.4571 - volumetric heat capacity
* ------------------------------
20100551 293.0    3.578e6
20100552 400.0    3.762e6
20100553 600.0    4.090e6
20100554 800.0    4.363e6
20100555 1000.0   4.615e6
*
* al2o3 - thermal conductivity
* -------------------------
20100601 293.0    41.9
20100602 373.0    35.6
20100603 773.0    12.6
20100604 1073.0   8.4
*
* al2o3 - volumetric heat capacity
* -------------------------
20100651 293.0    4.0425d+6
20100652 1073.0   4.0425d+6
*
* incoloy 800 - thermal conductivity
* ------------------------------
20100701 294.0    11.5
20100702 533.0    15.7
20100703 811.0    20.1
20100704 1089.0   25.1
*
* incoloy 800 - volumetric heat capacity
* ---------------------------------
20100751 294.0    4.174e6
20100752 1366.0   4.174e6
*
* 60% inconel 718 + 40% ni201  -  thermal conductivity
* ------------------------------------------------
20100801 293.0    38.5
20100802 373.0    36.9
20100803 473.0    35.0
20100804 533.0    33.8
20100805 573.0    34.1
20100806 813.0    33.5
20100807 1088.0   40.6
*
* 60% inconel 718 + 40% ni201  -  volumetric heat capacity
* ---------------------------------------------------
20100851 293.0    3.736d6
20100852 1366.0   3.736d6
*
* crud layer (magnetite fe3o4) - thermal conductivity
* ------------------------------------------------
20100901 1.5
*
```

```
* crud layer - volumetric heat capacity
* ------------------------------
20100951  2.366e6
*
* rockwool insulation - thermal conductivity
* ------------------------------------
20101001  273.0   0.04
20101002  373.0   0.05
20101003  573.0   0.11
20101004  873.0   0.15
*
* rockwool insulation - volumetric heat capacity
* ------------------------------------------
20101051  1.34e5
*
* copper - thermal conductivity
* ------------------------
20102001  386.0
*
* copper - volumetric heat capacity
* ---------------------------
20102051  3.43e6
*
* gap psuedo matl. - thermal conductivity
* ---------------------------------
20102201  293.0    3.06
20102202  400.0    3.55
20102203  600.0    4.80
20102204  800.0    6.65
20102205  1000.0   9.33
*
* gap psuedo heat capacity
* -------------------
20102251  293.0    .783e6
20102252  400.0    .860e6
20102253  600.0    1.072e6
20102254  800.0    1.380e6
20102255  1000.0   1.818e6
**************************************************
****
*                                       *
*              general tables                *
*                                       *
**************************************************
****
*  electrical power control curve                *
*  as specified by mr.seeberger, siemens/kwu report r212  *
*  dated 9.01.90 and modified on 25.01.90 at jrc ispra   *
**************************************************
****
20210000 power    512     1.  1.e3
20210001 0.00      5307.9
20210002 3.8       4249.9
20210003 11.0      1651.0
20210004 18.1      748.9
20210005 25.2      561.9
20210006 32.6      417.9
20210007 39.7      346.9
20210008 46.9      310.9
20210009 54.2      288.9
20210010 61.3      266.9
20210011 75.6      241.0
20210012 97.2      221.9
20210013 118.9     205.9
20210014 140.5     197.9
20210015 169.3     187.9
20210016 270.1     158.9
20210017 320.5     150.9
20210018 414.2     139.9
20210019 515.0     135.9
20210020 867.7     123.0
20210021 1346.2    109.9
20210022 1969.2    98.9
20210023 2970.1    92.9
20210024 3967.5    85.9
20210025 4969.2    79.0
20210026 5969.2    72.9
20210027 6826.2    71.9
**************************************************
****
*  rpv stub-pipe cooling to enhance condensation in the  *
*  vessel downcomer annulus.                        *
**************************************************
****
20231000  power    522     1.0     -0.0012d+6
20231001 -1.0      1.0
20231002  0.0      1.0
20231003  50000.0  1.0
**************************************************
****
*  pressuriser heating power control system -- 2 kw max  *
*  power on during steady-state to maintain saturation.  *
*  zero power applied during trip off period & transient.  *
**************************************************
****
20240000  power    509     1.0     2.1d+3
20240001 -1.0      0.0
20240002 -0.01     0.0
20240003  0.0      0.0
20240004  0.1      0.05
20240005  1.0      0.05
20240006  1.01     0.10
20240007  2.0      0.10
20240008  2.01     0.25
20240009  3.0      0.25
20240010  3.01     0.50
20240011  4.0      0.50
20240012  4.01     0.75
20240013  5.0      0.75
20240014  5.01     1.00
20240015  20000.0  1.00
**************************************************
****
*  pressure-temperature curve used for warm-up transients *
**************************************************
****
20240300  htc-temp       * pressure-temperature curve
20240301  300.0   50.0d5
20240302  423.0   55.0d5
20240303  473.0   65.0d5
20240304  538.0   100.0d5
20240305  548.0   158.0d5
20240306  1000.0  158.0d5
**************************************************
****
*  argus ball valve opening characteristics.          *
*  normalised stem position against normalised free area. *
*  based on idel'chik spherical ball-valve data         *
**************************************************
****
20215000 normarea
20215001 0.0000   0.00
20215002 0.2556   0.05
20215003 0.3889   0.11
20215004 0.4444   0.19
20215005 0.5000   0.27
20215006 0.5556   0.35
20215007 0.6111   0.44
20215008 0.6667   0.52
20215009 0.7222   0.60
20215010 0.7778   0.69
20215011 0.8333   0.77
20215012 0.8889   0.85
20215013 0.9444   0.93
```

```
20215014 1.0000   1.00
************************************************
****
*                                   *
*         control systems              *
*         ------------                   *
* control variable functions for control & regulation  *
* & additional output variables              *
*                                   *
************************************************
****
* total core power                      *
* electrical heater rod bundle                *
************************************************
****
20501000 topower  sum     1.0     0.0     1
20501001 0.0      0.35396  htrnr   325100101
20501002          0.43228  htrnr   334100101
20501003          0.89050  htrnr   335100101
20501004          1.43300  htrnr   335200101
20501005          1.8912   htrnr   335300101
20501006          1.8912   htrnr   335300201
20501007          1.4330   htrnr   335500101
20501008          0.89050  htrnr   335600101
20501009          0.70894  htrnr   336600101
20501010          1.2968   htrnr   345100101
20501011          1.2968   htrnr   345100201
20501012          1.0526   htrnr   345100301
20501013          0.68085  htrnr   345100401
20501014          0.031362 htrnr   355000100
************************************************
**********
* pressurizer heating power controller           *
************************************************
****
*
* heating power is applied in steps to ensure water in
* pressurizer remains at saturation during steady-state.
* a time-dependent volume with constant pressure used to
* initialize primary system pressure during steady-state.
* tables referenced:
*     400  heating power increments
*     403  required pressure at given temperature
*
20541500 reqdpres  function 1.0     0.0     1
20541501 tempf    350010000  403
*
20541600 tempgprz  sum     1.0     0.0     1
20541601 0.0      1.0     tempg    409010000
*
20541700 tempfprz  sum     1.0     0.0     1
20541701 0.1      1.0     tempf    410070000
*
20542000 pr.htrpw  sum     1.0     0.0     1
20542001 0.0      0.26966  htrnr   410000900
20542002          0.22863  htrnr   410000800
20542003          0.35173  htrnr   410000700
20542004          0.35173  htrnr   410000600
20542005          0.35173  htrnr   410000500
*
* determination of time step size
* ----------------------
20500100  dt      sum      1.0  1.0d-6  1
20500101  0.0     1.0      time    0
20500102          -1.0     cntrlvar 002
*
20500200  time    sum      1.0  0.0  1
20500201  0.0     1.0      time    0
*
*
* pressurizer pressure control
* ----------------------
```

```
20582100  priz01   sum      0.05  0.0  1
20582101  159.0d5  -1.0     p       350010000
*
20582200  priz02   mult     1.0  0.0  1
20582201  cntrlvar 001      cntrlvar 821
*
20582300  priz03   sum    1.0 157.56d5  0  1  150.0d5
20582301  0.0      1.0     p      430010000
20582302           1.0     cntrlvar 822
*
**************************************************
****
*           mass inventory                   *
*           ------------                  *
* mass intact loop without pressurizer              *
**************************************************
****
20510800 massil1  sum     1.0     0.0     1
20510801 0.0      3.13978d-3   rho 100010000
20510802          3.17817d-3   rho 105010000
20510803          6.82560d-3   rho 110010000
20510804          2.67905d-3   rho 110020000
20510805          1.928017d-2  rho 120010000
20510806          9.93200d-3   rho 120020000
20510807          1.0681d-3    rho 120030000
20510808          1.0681d-3    rho 120040000
20510809          1.0681d-3    rho 120050000
20510810          1.0681d-3    rho 120060000
20510811          9.05d-4  rho 120070000
20510812          9.05d-4  rho 120080000
20510813          9.05d-4  rho 120090000
20510814          9.05d-4  rho 120100000
20510815          1.81d-3  rho 120110000
20510816          1.81d-3   rho 120120000
20510817          1.81d-3   rho 120130000
20510818          1.81d-3   rho 120140000
20510819          3.62d-3   rho 120150000
20510820          3.62d-3   rho 120160000
*
20510700  massil2 sum     1.0     0.0     1
20510701  0.0     3.62d-3   rho 120170000
20510702          3.62d-3   rho 120180000
20510703          3.62d-3   rho 120190000
20510704          3.62d-3   rho 120200000
20510705          3.62d-3   rho 120210000
20510706          3.62d-3   rho 120220000
20510707          7.348d-3  rho 120230000
20510708          7.348d-3  rho 120240000
20510709          3.62d-3   rho 120250000
20510710          3.62d-3   rho 120260000
20510711          3.62d-3   rho 120270000
20510712          3.62d-3   rho 120280000
20510713          3.62d-3   rho 120290000
20510714          3.62d-3   rho 120300000
20510715          3.62d-3   rho 120310000
20510716          3.62d-3   rho 120320000
20510717          1.81d-3   rho 120330000
20510718          1.81d-3   rho 120340000
20510719          1.81d-3   rho 120350000
20510720          1.81d-3   rho 120360000
*
20510600  massil3 sum     1.0     0.0     1
20510601  0.0     9.05d-4  rho 120370000
20510602          9.05d-4  rho 120380000
20510603          9.05d-4  rho 120390000
20510604          9.05d-4  rho 120400000
20510605          1.0681d-3   rho 120410000
20510606          1.0681d-3   rho 120420000
20510607          1.0681d-3   rho 120430000
20510608          1.0681d-3   rho 120440000
20510609          1.928017d-2  rho 120460000
20510610          9.93200d-3   rho 120450000
```

```
*
20510900 massil2   sum     1.0     0.0     1
20510901 0.0     4.39398d-3    rho  130010000
20510902         3.28055d-3   rho  130020000
20510903         6.87253d-3   rho  130030000
20510904         2.66625d-3   rho  130040000
20510905         6.87253d-3   rho  130050000
20510906         3.28055d-3   rho  133010000
20510907         1.99994d-3   rho  135010000
20510908         3.15257d-3   rho  137010000
20510909         4.95709d-3   rho  140010000
20510910         4.95709d-3   rho  140020000
20510911         3.58771d-3   rho  145010000
*
20511000 massil   sum     1.0     0.0     1
20511001 0.0     1.0     cntrlvar  108
20511002         1.0     cntrlvar  109
20511003         1.0     cntrlvar  106
20511004         1.0     cntrlvar  107
************************************************
****
*  mass pressurizer                            *
************************************************
****
20540000 masspr   sum     1.0     0.0     1
20540001 0.0     1.03270d-2    rho  409010000
20540002         1.09197d-2   rho  410010000
20540003         1.09386d-2   rho  410020000
20540004         1.09386d-2   rho  410030000
20540005         1.09386d-2   rho  410040000
20540006         1.09386d-2   rho  410050000
20540007         1.09386d-2   rho  410060000
20540008         4.66362d-3   rho  410070000
20540009         6.36337d-3   rho  420010000
20540010         2.36751d-4   rho  400010000  * il
20540011         3.55810d-4   rho  400020000  * hot
20540012         3.83180d-4   rho  400030000  * leg
************************************************
****
*  mass broken loop                            *
************************************************
****
20520700 massbl1   sum     1.0     0.0     1
20520701 0.0     1.25016d-3    rho  200010000
20520702         1.44380d-3   rho  203010000
20520703         1.11164d-3   rho  206010000
20520704         1.11164d-3   rho  206020000
20520705         1.14500d-3   rho  206030000
************************************************
20520800 massbl3   sum     1.0     0.0     1
20520801 0.0     6.922758d-3   rho  210010000
20520802         2.700930d-3   rho  210020000
20520803         6.75864d-4   rho  210030000
20520804         6.75864d-4   rho  210040000
20520805         6.0345d-4    rho  210050000
20520806         6.0345d-4   rho  210060000
20520807         12.069d-4   rho  210070000
20520808         12.069d-4  rho  210080000
20520809         24.138d-4   rho  210090000
20520810         24.138d-4   rho  210100000
20520811         24.138d-4   rho  210110000
20520812         24.138d-4   rho  210120000
20520813         24.43542d-4   rho  210130000
20520814         24.43542d-4    rho  210140000
20520815         2.700930d-3   rho  210250000
20520816         6.922758d-3   rho  210260000
20520817         24.138d-4   rho  210150000
20520818         24.138d-4   rho  210160000
20520819         24.138d-4   rho  210170000
20520820         24.138d-4   rho  210180000
*
20520600 massbl3   sum     1.0     0.0     1
20520601  0.0     12.069d-4   rho  210190000
20520602          12.069d-4   rho 210200000
20520603          6.0345d-4    rho  210210000
20520604          6.0345d-4    rho  210220000
20520605          6.75864d-4    rho  210230000
20520606          6.75864d-4    rho  210240000
*
20520900 massbl2   sum     1.0     0.0     1
20520901 0.0     1.73920d-3    rho  220010000
20520902         1.92447d-3   rho  220020000
20520903         1.23680d-3   rho  220030000
20520904         1.22178d-3   rho  220040000
20520905         1.23680d-3   rho  220050000
20520906         1.92447d-3   rho  223010000
20520907         2.00093d-3   rho  225010000
20520908         1.43543d-3   rho  230010000
20520909         2.10812d-3   rho  240010000
20520910         1.51891d-3   rho  250010000
20520911         1.17507d-3   rho  260010000
*
20521000 massbl   sum     1.0     0.0     1
20521001 0.0     1.0     cntrlvar  208
20521002         1.0     cntrlvar  209
20521003         1.0     cntrlvar  207
20521004         1.0     cntrlvar  206
************************************************
****
*  mass pressure vessel                        *
************************************************
****
20531800 massves1  sum     1.0   0.0     1
20531801 0.0     3.5627d-3    rho  300010000
20531802         5.50797d-3   rho  305010000
20531803         6.78600d-3   rho  310010000
20531804         6.78600d-3   rho  310020000
20531805         8.36940d-3   rho  310030000
20531806         7.49853d-3   rho  310040000
20531807         9.89625d-3   rho  310050000
20531808         9.89625d-3   rho  310060000
20531809         7.49853d-3   rho  310070000
20531810         6.92172d-3   rho  310080000
20531811         4.41090d-3   rho  310090000
20531812         6.96696d-3   rho  310100000
20531813         1.33794d-2   rho  315010000
20531814         1.33794d-2   rho  320010000
20531815         1.48166d-2   rho  325010000
20531816         8.98131d-3   rho  325020000
*
20531900 massves2  sum     1.0     0.0     1
20531901 0.0     4.96650d-3    rho  335010000
20531902         5.38038d-3   rho  335020000
20531903         7.10080d-3   rho  335030000
20531904         7.10080d-3   rho  335040000
20531905         5.38038d-3   rho  335050000
20531906         4.9665d-3   rho  335060000
20531907         1.49892d-2   rho  345010000
20531908         1.49892d-2   rho  345020000
20531909         1.21662d-2   rho  350010000
20531910         7.86933d-3   rho  355010000
20531911         4.44851d-4   rho  363010000
20531912         9.95573d-4   rho  365010000
20531913         9.67005d-3   rho  370010000
20531914         9.67005d-3   rho  370020000
20531915         9.67005d-3   rho  375010000
20531916         4.44851d-4   rho  380010000
*
20532000 massves   sum     1.0     0.0     1
20532001 0.0     1.0     cntrlvar  318
20532002         1.0     cntrlvar  319
************************************************
****
*  total mass primary system - without accumulators     *
```

```
**************************************************
****
20599900 massprsy  sum      1.0     0.0     1
20599901 0.0      1.0      cntrlvar 110
20599902          1.0      cntrlvar 210
20599903          1.0      cntrlvar 320
20599904          1.0      cntrlvar 400
**************************************************
****
*  sg1 - secondary side                          *
**************************************************
****
20550000 masssg1   sum      1.0     0.0     1
20550001 0.0      1.67552d-2    rho  500010000
20550002          5.9755d-3   rho  510010000
20550003          5.9755d-3   rho  510020000
20550004          5.97550d-3    rho  510030000
20550005          5.97550d-3    rho  510040000
20550006          5.97550d-3    rho  510050000
20550007          5.97550d-3    rho  510060000
20550008          5.97550d-3    rho  510070000
20550009          5.97550d-3    rho  510080000
20550010          2.9877d-3   rho  510090000
20550011          2.9877d-3   rho  510100000
20550012          2.9877d-3   rho  510110000
20550013          2.9877d-3   rho  510120000
20550014          1.4939d-3   rho  510130000
20550015          1.4939d-3   rho  510140000
20550016          1.4939d-3   rho  510150000
20550017          1.4939d-3   rho  510160000
20550018          1.4939d-3   rho  510170000
20550019          1.4939d-3   rho  510180000
20550020          1.4939d-3   rho  510190000
*
20550200 masssg11  sum      1.0     0.0     1
20550201  0.0     1.4939d-3    rho  510200000
20550202          3.7381d-3   rho  530010000
20550203          3.7381d-3   rho  530020000
20550204          3.7381d-3   rho  530030000
20550205          3.7381d-3   rho  530040000
20550206          3.7381d-3   rho  530050000
20550207          3.7381d-3   rho  530060000
20550208          3.7381d-3   rho  530070000
20550209          3.7381d-3   rho  530080000
20550210          7.4763d-3   rho  530090000
20550211          7.4763d-3   rho  530100000
20550212          7.4763d-3   rho  530110000
20550213          7.4763d-3   rho  530120000
20550214          14.953d-3   rho  530130000
20550215          14.953d-3   rho  530140000
20550216          14.953d-3   rho  530150000
20550217          14.953d-3   rho  530160000
20550218          14.953d-3   rho  530170000
20550219          14.953d-3   rho  530180000
20550220          14.953d-3   rho  530190000
*
20550300 massg12   sum      1.0     0.0     1
20550301  0.0     14.953d-3    rho  530200000
20550302          6.28484d-2   rho  545010000
20550303          3.47660d-2   rho  550010000
20550304          1.856d-1    rho  552010000
20550305          1.17530d-1   rho  555010000
20550306          1.016d-1    rho  560010000
20550307          2.42320d-2   rho  564010000
*
20550400 massg1T  sum       1.0     0.0     1
20550401 0.0  1.0  cntrlvar  500
20550402      1.0  cntrlvar  502
20550403      1.0  cntrlvar  503
**************************************************
****
*  sg2 - seconadry side                          *
**************************************************
****
20560000 masssg2  sum      1.0     0.0     1
20560001 0.0      5.16175d-3    rho  600010000
20560002          3.95840d-3    rho  610010000
20560003          3.95840d-3    rho  610020000
20560004          3.95840d-3    rho  610030000
20560005          3.95840d-3    rho  610040000
20560006          1.97920d-3    rho  610050000
20560007          1.97920d-3    rho  610060000
20560008          0.9896d-3    rho  610070000
20560009          0.9896d-3    rho  610080000
20560010          0.9896d-3    rho  610090000
20560011          0.9896d-3    rho  610100000
20560012          2.3737d-3    rho  630010000
20560013          2.3737d-3    rho  630020000
20560014          2.3737d-3    rho  630030000
20560015          2.3737d-3    rho  630040000
20560016          4.74735d-3    rho  630050000
20560017          4.74735d-3    rho  630060000
20560018          9.49470d-3    rho  630070000
20560019          9.49470d-3    rho  630080000
20560020          9.49470d-3    rho  630090000
*
20560200 masssg21  sum      1.0     0.0     1
20560201 0.0      9.49470d-3    rho  630100000
20560202          2.30638d-2    rho  645010000
20560203          1.23090d-2    rho  650010000
20560204          59.0520d-3    rho  652010000
20560205          3.78000d-2    rho  655010000
20560206          38.991d-3   rho  660010000
20560207          8.46220d-3    rho  664010000
*
20560300  masssg2T  sum     .1.0     0.0     1
20560301  0.0  1.0  cntrlvar   600
20560302       1.0  cntrlvar   602
**************************************************
****
*  sg1 + sg2 :  total secondary side inventory     *
**************************************************
****
20561000 masssgs  sum      1.0     0.0     1
20561001 0.0      1.0       cntrlvar  504
20561002          1.0      cntrlvar  603
20561003          0.009      rho      565010000
**************************************************
****
*  differential pressure values                    *
*  taken between node centres only, not corrected     *
**************************************************
****
20510000 dp1611    sum      1.0     0.0     1
20510001 0.0      1.0      p       145010000
20510002         -1.0      p      100010000
*
20510100 dp1213    sum      1.0     0.0     1
20510101 0.0      1.0      p       110020000
20510102         -1.0      p      130010000
*
20510200 dp1514    sum      1.0     0.0     1
20510201 0.0      1.0      p       137010000
20510202         -1.0      p      133010000
*
20510300 dp9217    sum      1.0     0.0     1
20510301 0.0      1.0      p       120460000
20510302         -1.0      p      130040000
*
20510400 dp1714    sum      1.0     0.0     1
20510401 0.0      1.0      p       130040000
20510402         -1.0      p      133010000
*
20510500 dp90bnx   sum      1.0     0.0     1
```

```
20510501 0.0     1.0     p       120030000
20510502        -1.0     p       120230000
*
20511100 dp9092aa  sum     1.0     0.0     1
20511101 0.0     1.0     p       120010000
20511102        -1.0     p       120460000
*
20520000 dp2621    sum     1.0     0.0     1
20520001 0.0     1.0     p       260010000
20520002        -1.0     p       200010000
*
20520100 dp2223    sum     1.0     0.0     1
20520101 0.0     1.0     p       206030000
20520102        -1.0     p       220010000
*
20520200 dp2524    sum     1.0     0.0     1
20520201 0.0     1.0     p       230010000
20520202        -1.0     p       223010000
*
20520300 dp8227    sum     1.0     0.0     1
20520301 0.0     1.0     p       210260000
20520302        -1.0     p       220040000
*
20520400 dp2724    sum     1.0     0.0     1
20520401 0.0     1.0     p       220040000
20520402        -1.0     p       223010000
*
20520500 dp80bnx   sum     1.0     0.0     1
20520501 0.0     1.0     p       210030000
20520502        -1.0     p       210130000
*
20521300 dp8082aa  sum     1.0     0.0     1
20521301 0.0     1.0     p       210010000
20521302        -1.0     p       210260000
*
20521700 dp3d3rba  sum     1.0     0.0     1
20521701 0.0     1.0     p       305010000
20521702        -1.0     p       350010000
*
20530000 dp1631    sum     1.0     0.0     1
20530001 0.0     1.0     p       145010000
20530002        -1.0     p       305010000
*
20530100 dp2631    sum     1.0     0.0     1
20530101 0.0     1.0     p       260010000
20530102        -1.0     p       305010000
*
20530200 dp3133    sum     1.0     0.0     1
20530201 0.0     1.0     p       305010000
20530202        -1.0     p       310100000
*
20530300 dp3334    sum     1.0     0.0     1
20530301 0.0     1.0     p       310100000
20530302        -1.0     p       315010000
*
20530400 dp3436    sum     1.0     0.0     1
20530401 0.0     1.0     p       315010000
20530402        -1.0     p       325020000
*
20530500 dp3637    sum     1.0     0.0     1
20530501 0.0     1.0     p       325020000
20530502        -1.0     p       345010000
*
20530600 dp3738    sum     1.0     0.0     1
20530601 0.0     1.0     p       345010000
20530602        -1.0     p       350010000
*
20530700 dp3839    sum     1.0     0.0     1
20530701 0.0     1.0     p       350010000
20530702        -1.0     p       370010000
*
20530800 dp3811    sum     1.0     0.0     1
```

```
20530801 0.0     1.0     p       350010000
20530802        -1.0     p       100010000
*
20530900 dp3821    sum     1.0     0.0     1
20530901 0.0     1.0     p       350010000
20530902        -1.0     p       200010000
*
20531000 dp3dbt    sum     1.0     0.0     1
20531001 0.0     1.0     p       305010000
20531002        -1.0     p       310080000
*
20531100 dp3rtk    sum     1.0     0.0     1
20531101 0.0     1.0     p       335010000
20531102        -1.0     p       335060000
*
20531200 dp3rka    sum     1.0     0.0     1
20531201 0.0     1.0     p       335060000
20531202        -1.0     p       350010000
*
20531300 dp3r39a   sum     1.0     0.0     1
20531301 0.0     1.0     p       355010000
20531302        -1.0     p       370010000
*
*************************************************
****
*  collapsed liquid level in pressuriser          *
*************************************************
****
20541000 presslvl  sum     1.0     0.0     1
20541001 0.0     0.898   voidf   409010000
20541002         0.9     voidf   410010000
20541003         0.9     voidf   410020000
20541004         0.9     voidf   410030000
20541005         0.9     voidf   410040000
20541006         0.9     voidf   410050000
20541007         0.9     voidf   410060000
20541008         0.585   voidf   410070000
20541009         0.79    voidf   420010000
*************************************************
****
*                                    *
*  pump speed controller - intact loop            *
*  il mass flow controlled to 21.0 kg/s during st.state  *
*                                    *
*************************************************
****
*                                    *
*  an error term is generated at each time-step, equal  *
*  to the required mass flowrate minus the actual mass  *
*  flowrate. this error, times a constant factor, plus  *
*  the integrated error, times a constant factor, are   *
*  added to the actual (old-time) pump speed to give    *
*  the corrected (new-time) pump speed. in successive   *
*  time-steps, the pump speed is adjusted to give the   *
*  required steady-state mass flowrate in each loop.    *
*  this control remains active during the steady-state. *
*  the end-of-steady-state pump speed is then used      *
*  until pump trip occurs, when the pump-speed curve    *
*  is activated and coastdown occurs.when bl pump speed *
*  is zer0, a bl locked-rotor simulator valve ('penta'  *
*  valve) is activated after a 4 second delay.          *
*  the pump speed function uses unit trips to switch    *
*  control between steady-state & transient operation.  *
*                                    *
*  normalised pump-speed curve is same for both pumps   *
*  referenced in table 135 after homologous curve data  *
*************************************************
****
20512000 p0trip1  tripunit 1.0    1.0     0
20512001 575
*
20512100 flowerl  sum     1.0     0.0     1
```

```
20512101 21.0    -1.0     mflowj    135010000
*
20512200 inter1   integral 1.0     0.0     1
20512201 cntrlvar  121
*
20512400 flower1t  mult     1.0     0.0     1
20512401 cntrlvar  120
20512402 cntrlvar  121
*
20512500 inter1t  mult     1.0     0.0     1
20512501 cntrlvar  120
20512502 cntrlvar  122
*
20512600 pspeed1  sum      1.0     470.0   1
20512601 0.0      1.0      pmpvel   135
20512602          4.0      cntrlvar 124
20512603          0.3      cntrlvar 125
*
************************************************
****
* pump speed table - intact loop pump           *
************************************************
****
*
1356100  522      cntrlvar  140
1356101  0.0      0.0
1356102  1000.0   1000.0
*
20512800 p1trip1  tripunit 1.0     1.0     0
20512801 621
*
20512900 p1trip2  tripunit 1.0     0.0     0
20512901 641
*
20513000 p1trpdly tripdlay 1.0     0.0     1
20513001 641
*
20513100 p1trptim sum      1.0     0.0     1
20513101 0.0      1.0      time    0
20513102          -1.0     cntrlvar 130
*
20513200 speedt1  function 1.0     0.0     1
20513201 cntrlvar 131      135
*
20513300 pspeed11 mult     1.0     0.0     1
20513301 cntrlvar 128
20513302 cntrlvar 126
*
20513400 pspeed12 mult     1.0     0.0     1
20513401 cntrlvar 129
20513402 cntrlvar 144
*
20514000 pspeed1f sum      1.0     0.0     1
20514001 0.0      1.0      cntrlvar 133
20514002          1.0      cntrlvar 134
**
20514100 trantrp1 tripunit 1.0     0.0     0
20514101 661
*
20514200 pmpddf1  mult     1.0     0.0     0
20514201 cntrlvar 141      pmpvel   135
*
20514300 pmpstp1  sum      1.0     0.0     0
20514301 0.0      1.0      cntrlvar 142
20514302          1.0      cntrlvar 143
*
20514400 pmptrn1  mult     1.0     0.0     0
20514401 cntrlvar 143      cntrlvar 132
*
************************************************
****
*                                   *
* pump speed controller - broken loop pump        *
* bl mass flow controlled to 7.00 kg/s during st.state *
*                                    *
************************************************
****
* speed control of bl pump is same as for il pump     *
* referenced in table 135 after homologous curve data  *
************************************************
****
20521100 flower2  sum      1.0     0.0     1
20521101 7.20     -1.0     mflowj   225010000
*
20521200 inter2   integral 1.0     0.0     1
20521201 cntrlvar 211
*
20521400 flower2t mult     1.0     0.0     1
20521401 cntrlvar 120
20521402 cntrlvar 211
*
20521500 inter2t  mult     1.0     0.0     1
20521501 cntrlvar 120
20521502 cntrlvar 212
*
20521600 pspeed2  sum      1.0     335.00  1
20521601 0.0      1.0      pmpvel   225
20521602          12.0     cntrlvar 214
20521603          1.0      cntrlvar 215
*
************************************************
****
* pump speed table - broken loop pump            *
************************************************
***
2256100  522      cntrlvar  240
2256101  0.0      0.0
2256102  1000.0   1000.0
*
20521800 p2trip1  tripunit 1.0     1.0     0
20521801 622
*
20521900 p2trip2  tripunit 1.0     0.0     0
20521901 642
*
20522000 p2trpdly tripdlay 1.0     0.0     1
20522001 642
*
20522100 p2trptim sum      1.0     0.0     1
20522101 0.0      1.0      time    0
20522102          -1.0     cntrlvar 220
*
20522200 speedt2  function 1.0     0.0     1
20522201 cntrlvar 221      135
*
20522300 pspeed21 mult     1.0     0.0     1
20522301 cntrlvar 218
20522302 cntrlvar 216
*
20522400 pspeed22 mult     1.0     0.0     1
20522401 cntrlvar 219
20522402 cntrlvar 244
*
20524000 pspeed2f sum      1.0     0.0     1
20524001 0.0      1.0      cntrlvar 223
20524002          1.0      cntrlvar 224
**
20524200 pmpddf2  mult     1.0     0.0     0
20524201 cntrlvar 141      pmpvel   225
*
20524300 pmpstp1  sum      1.0     0.0     0
20524301 0.0      1.0      cntrlvar 242
20524302          1.0      cntrlvar 243
*
```

```
20524400 pmptrn2  mult     1.0     0.0     0
20524401 cntrlvar 243     cntrlvar 222
*
**************************************************
****
* steam flow control valve/primary temperature controller  *
**************************************************
****
*                                          *
*  the required cold-leg temperature is taken to be the     *
*  weighted mean cl temperature of each loop, so that one   *
*  steam valve may be used to control both il & bl temps.   *
*  an error term is generated at each time-step, equal to   *
*  the required cold-leg temperature (at rpv inlet) minus   *
*  the actual cold-leg temperature. this error, times a     *
*  constant factor, plus the integrated error times a       *
*  constant factor, is used to set the normalised stem      *
*  position of the steam control valve. thus, a cold leg    *
*  temperature which is too high generates a positive error *
*  signal which opens the valve further, drawing more steam
*
*  from the sg & thereby reducing the error & the cold leg  *
*  temperature.                              *
*  the steam valve control function uses unit trips to      *
*  switch between steady-state control & start of transient *
*  and simulates closure of the main steam valve when the
*
*  corresponding trip occurs (eg.low press.131 bar in u.p.) *
*                                          *
*  tables referenced:                              *
*      580   normalised stem position against flow area    *
*      581   deadband, sets temperature control tolerances *
**************************************************
****
20258000 normarea
20258001 0.0      0.0
20258002 1.0      1.0
*
20551000 delta-t1  sum      3.0     0.0     1
20551001 569.15   -1.0     tempf   145010000
*
20551200 delta-t2  sum      1.0     0.0     1
20551201 570.15   -1.0     tempf   260010000
*
20552000 dt-av    sum      0.25    0.0     1
20552001 0.0      1.0     cntrlvar 510
20552002          1.0     cntrlvar 512
*
20552100 prescram  tripunit 1.0     1.0     0
20552101 -603
*
20552200 zero-dt1  mult     1.0     0.0     1
20552201 cntrlvar 521
20552202 cntrlvar 520
*
20552300 deadbnd1  function 1.0     0.0     1
20552301 cntrlvar 522     581
*
20258100 reac-t
20258101 -100.0   -100.0
20258102 -0.10    -0.10
20258103 -0.10     0.0
20258104  0.10     0.0
20258105  0.10     0.10
20258106  100.0    100.0
*
20552400 intdelt1  integral 1.0     0.0     1
20552401 cntrlvar 523
*
20552500 zero-in1  mult     1.0     0.0     1
20552501 cntrlvar 524
20552502 cntrlvar 521
```

```
*
20552600 tcontrl1  sum      1.0     0.2   0 3 0.0 1.0
20552601 0.0      -0.010    cntrlvar 523
20552602          -0.0020   cntrlvar 525
*
**************************************************
****
*  sg1 mass & liquid level controller, intact loop      *
**************************************************
****
*                                          *
*  sg feedwater mass flowrate is continuously adjusted    *
*  during steady-state to match the steam outflow so as   *
*  to stabilise the total water mass inventory and the    *
*  downcomer collapsed liquid level to specified values.  *
*  an error term is generated equal to the required mass  *
*  minus the actual mass, and multiplied by a constant    *
*  factor, plus a similar error term for the collapsed    *
*  level.this is added to the actual steam mass flowrate, *
*  times a constant factor, to set the new feedwater flow.*
*  the mass error term is used to adjust the feed flow    *
*  to obtain a total specified water mass inventory,      *
*  currently set to 208 kg.                     *
*  the level converges to the required level whilst the   *
*  feed flow converges to the steam flow.           *
*  at start of transient, these values for steam & feed   *
*  are maintained until the trip signals for sg isolation *
*  occur. the steam line isolation valves start to close  *
*  at time zero (sudden closure). the feedwater valves    *
*  close at time zero + 0.5sec delay, with a closure time *
*  1.0 sec  isolating each sg and allowing the          *
*  secondary pressure to rise to reach the sg relief     *
*  valve lift pressure. when cooldown trip occurs,       *
*  the transient control system takes over to maintain   *
*  the controlled cooldown rate.                 *
*  this procedure applies to all transients with a       *
*  specified sec-side cooldown. it is switched off for   *
*  transients with no cooldown, but may be supplemented  *
*  by a natural cooldown rate from both steam generators *
*  or by simulated steam leaks from sec-side valves.     *
**************************************************
****
*
20550100 sg1merr  sum      1.0     0.0     1
20550101 236.  -1.     cntrlvar 504
* (or. 208, poi 213, 200, 206
20554900 ilsglvl  sum      1.0     0.0     1
20554901 0.0      1.100    voidf   552010000
20554902          0.593    voidf   560010000
20554903          0.125    voidf   510170000
20554904          0.125    voidf   510180000
20554905          0.125    voidf   510190000
20554906          0.125    voidf   510200000
*
20555000 ilsglvl  sum      1.0     0.0     1
20555001 0.0      1.105    voidf   555010000
20555002          1.402    voidf   500010000
20555003          0.500    voidf   510010000
20555004          0.500    voidf   510020000
20555005          0.500    voidf   510030000
20555006          0.500    voidf   510040000
20555007          0.500    voidf   510050000
20555008          0.500    voidf   510060000
20555009          0.500    voidf   510070000
20555010          0.500    voidf   510080000
20555011          0.250    voidf   510090000
20555012          0.250    voidf   510100000
20555013          0.250    voidf   510110000
20555014          0.250    voidf   510120000
20555015          0.125    voidf   510130000
20555016          0.125    voidf   510140000
20555017          0.125    voidf   510150000
```

```
20555018       0.125   voidf   510160000
20555019      1.0     cntrlvar 549
*
20555100 sg1lverr sum     1.0     0.0     1
20555101 8.25    -1.0    cntrlvar 550
*
20555200 feedflo1 sum     1.0     2.07    0
20555201 0.0     0.75    mflowj   580000000
20555202         1.2     cntrlvar 551
20555203         0.1     cntrlvar 501
*
* feedwater flowrate vs time curve, i.l.sg
*
20555300 feedtrp1 tripunit 1.0    1.0     0
20555301 664
*
20555400 feedtrp2 tripunit 1.0    0.0     0
20555401 503
*
20214000 reac-t
20214001 0.0     2.0
20214002 1.5     0.0
20214003 10000.0 0.0
*
20555500 fltrpdly tripdlay 1.0    0.0     1
20555501 503
*
20555600 fltrptim sum     1.0     0.0     1
20555601 0.0     1.0     time    0
20555602        -1.0     cntrlvar 555
*
20555700 feed1tr  function 1.0    2.07    0
20555701 cntrlvar 556    140
*
20555800 fflow1ss mult    1.0     2.07    0
20555801 cntrlvar 553
20555802 cntrlvar 552
*
20555900 fflow1tr mult    1.0     0.0     0
20555901 cntrlvar 554
20555902 cntrlvar 557
*
20556000 fflowsg1 sum     1.0     2.07  0 3 0.0 3.0
20556001 0.0     1.0     cntrlvar 558
20556002         1.0     cntrlvar 559
*
20556100 trsglv1  tripunit 1.0    0.0     0
20556101 665
*
20556200 lvldif1  mult    1.0     0.0     0
20556201 cntrlvar 561    cntrlvar 550
*
20556300 lvlstp1  sum     1.0     0.0     0
20556301 0.0     1.0     cntrlvar 562
20556302         1.0     cntrlvar 563
**************************************************
****
* sg2 level controller, broken loop              *
**************************************************
****
*
20560100 sg2merr  sum     1.0     0.0     1
20560101 81.9    -1.0    cntrlvar 603
20565000 blsglvl  sum     1.0     0.0     1
20565001 0.0     1.128   voidf    655010000
20565002         1.304   voidf    600010000
20565003         1.000   voidf    610010000
20565004         1.000   voidf    610020000
20565005         1.000   voidf    610030000
20565006         1.000   voidf    610040000
20565007         0.500   voidf    610050000
20565008         0.500   voidf    610060000
```

```
20565009       0.250   voidf   610070000
20565010       0.250   voidf   610080000
20565011       0.250   voidf   610090000
20565012       0.250   voidf   610100000
20565013       1.100   voidf   652010000
20565014       0.681   voidf   660010000
*
20565100 sg2lverr sum     1.0     0.0     1
20565101 7.96    -1.0    cntrlvar 650
*
20565200 feedflo2 sum     1.0     0.69    0
20565201 0.0     0.25    mflowj   580000000
20565202         0.4     cntrlvar 651
20565203         0.1     cntrlvar 601
*
* feedwater flowrate vs time curve, b.l.sg
*
20224000 reac-t
20224001 0.0     0.68
20224002 1.5     0.0
20224003 10000.0 0.0
*
20565700 feed2tr  function 1.0    0.69    0
20565701 cntrlvar 556    240
*
20565800 fflow2ss mult    1.0     0.69    0
20565801 cntrlvar 553
20565802 cntrlvar 652
*
20565900 fflow2tr mult    1.0     0.0     0
20565901 cntrlvar 554
20565902 cntrlvar 657
*
20566000 fflowsg2 sum     1.0     0.69  0 3 0.0 1.0
20566001 0.0     1.0     cntrlvar 658
20566002         1.0     cntrlvar 659
*
20566100 trsglv2  tripunit 1.0    0.0     0
20566101 665
*
20566200 lvldif2  mult    1.0     0.0     0
20566201 cntrlvar 661    cntrlvar 650
*
20566300 lvlstp2  sum     1.0     0.0     0
20566301 0.0     1.0     cntrlvar 662
20566302         1.0     cntrlvar 663
**************************************************
****
* il sg adjustable throttle valve controller         *
* recirculation ratio set to 6.2    MOD 6.4           *
**************************************************
****
*
* the sg downcomer flow is continuously adjusted during
* steady-state by control of the throttle valve between
* downcomer & riser, modelled as a servo-valve and is
* regulated to give the correct recirculation ratio.
* this is defined here as downcomer flowrate divided
* by main feedwater flowrate. an error term is generated
* at each time-step equal to the controlled feedwater
* massflow times the required recirculation ratio, minus
* the actual downcomer flow. this error term, times a
* constant factor, plus the integrated error times a
* constant factor, are summed and 0.5 added to set the
* normalised stem position of the throttle valve. this
* is varied during steady-state to control the flow
* in the downcomer and thereby the recirculation ratio.
*
20553000 rr1diflo sum     1.0     0.0     0
20553001 0.0     6.4     mflowj  570000000
20553002        -1.0     mflowj  510020000
*
```

```
20553100 pos1stst  mult     0.33   0.0     0
20553101 cntrlvar  120
20553102 cntrlvar  530
*
20553200 interr1   integral  1.0   -46.63    0
20553201 cntrlvar  531
*
20553500 slv1pos   sum   1.0  0.27    0  3    0.0  1.0
20553501 0.5      0.005    cntrlvar   532
20553502          0.05     cntrlvar   531
*
****************************************************
****
*  bl sg adjustable throttle valve controller          *
*  recirculation ratio set to 4.2 MOD 4.3              *
****************************************************
****
20563000 rr2diflo  sum       1.0    0.0     0
20563001 0.0       4.3      mflowj  670000000
20563002          -1.0      mflowj  610020000
*
20563100 pos2stst  mult      1.0    0.0     0
20563101 cntrlvar  120
20563102 cntrlvar  630
*
20563200 interr2   integral  1.0   -24.46    0
20563201 cntrlvar  631
*
20563500 slv2pos   sum   1.0  0.30    0  3    0.0  1.0
20563501 0.5      0.008    cntrlvar   632
20563502          0.05     cntrlvar   631
*
****************************************************
****
*  collapsed liquid level on riser side, intact loop sg1  *
****************************************************
****
20557400 riserlv1  sum       1.0      0.0      1
20557401 0.0       0.5    voidf     530180000
20557402           0.5    voidf     530190000
20557403           0.5    voidf     530200000
*
20557500 riserlv1  sum       1.0      0.0      1
20557501 0.0       1.105    voidf    550010000
20557502           1.402    voidf    545010000
20557503           0.125    voidf    530010000
20557504           0.125    voidf    530020000
20557505           0.125    voidf    530030000
20557506           0.125    voidf    530040000
20557507           0.125    voidf    530050000
20557508           0.125    voidf    530060000
20557509           0.125    voidf    530070000
20557510           0.125    voidf    530080000
20557511           0.25    voidf     530090000
20557512           0.25    voidf     530100000
20557513           0.25    voidf     530110000
20557514           0.25    voidf     530120000
20557515           0.5    voidf     530130000
20557516           0.5    voidf     530140000
20557517           0.5    voidf     530150000
20557518           0.5    voidf     530160000
20557519           0.5    voidf     530170000
20557520           1.0    cntrlvar   574
****************************************************
****
*  level difference in sg1                    *
****************************************************
****
20557600 lvldiff1  sum       1.0      0.0      1
20557601 0.0       1.0      cntrlvar  550
20557602          -1.0      cntrlvar  575
```

```
****************************************************
****
*  collapsed liquid level on riser side, broken loop sg2  *
****************************************************
****
20567500 riserlv2  sum       1.0      0.0      1
20567501 0.0       1.128    voidf    650010000
20567502           1.304    voidf    645010000
20567503           0.250    voidf    630010000
20567504           0.250    voidf    630020000
20567505           0.250    voidf    630030000
20567506           0.250    voidf    630040000
20567507           0.500    voidf    630050000
20567508           0.500    voidf    630060000
20567509           1.000    voidf    630070000
20567510           1.000    voidf    630080000
20567511           1.000    voidf    630090000
20567512           1.000    voidf    630100000
****************************************************
****
*  level difference in sg2                          *
****************************************************
****
20567600 lvldiff2  sum       1.0      0.0      1
20567601 0.0       1.0      cntrlvar  650
20567602          -1.0      cntrlvar  675
****************************************************
****
*  collapsed level over core heated length           *
****************************************************
****
20533500 corelev   sum       1.0      0      1
20533501 0.0       0.612    voidf    335010000
20533502           0.663    voidf    335020000
20533503           0.875    voidf    335030000
20533504           0.875    voidf    335040000
20533505           0.663    voidf    335050000
20533506           0.740    voidf    335060000
****************************************************
****
*  collapsed liquid level over downcomer region        *
*  lower plenum to d.c.upper annulus                   *
****************************************************
****
20531500 dclevel   sum       1.0      0.0      1
20531501 0.0       0.315    voidf    300010000
20531502           0.487    voidf    305010000
20531503           0.600    voidf    310010000
20531504           0.600    voidf    310020000
20531505           0.740    voidf    310030000
20531506           0.663    voidf    310040000
20531507           0.875    voidf    310050000
20531508           0.875    voidf    310060000
20531509           0.663    voidf    310070000
20531510           0.612    voidf    310080000
20531511           0.390    voidf    310090000
20531512           0.616    voidf    310100000
20531513           0.175    voidf    315010000
20531514           0.175    voidf    320010000
****************************************************
****
*  collapsed liquid level over core region             *
*  lower plenum to upper plenum                        *
****************************************************
****
20533600 tcorelvl  sum       1.0      0      1
20533601 0.0       1.0      cntrlvar  335
20533602           0.175    voidf    320010000
20533603           0.175    voidf    315010000
20533604           0.616    voidf    325010000
20533605           0.390    voidf    325020000
20533606           0.600    voidf    345010000
```

```
20533607        0.600   voidf   345020000
20533608        0.487   voidf   350010000
20533609        0.315   voidf   355010000
****************************************************
****
*  intact loop seal                          *
*  collapsed level in descending section          *
****************************************************
****
20515000 ilseald   sum     1.0     0     1
20515001 0.0     0.769    voidf    130020000
20515002         1.545    voidf    130030000
****************************************************
****
*  collapsed level in rising section               *
****************************************************
****
20515100 ilsealr   sum     1.     0     1
20515101 0.0     1.545    voidf    130050000
20515102         0.769    voidf    133010000
****************************************************
****
*  broken loop seal                          *
*  collapsed level in descending section          *
****************************************************
****
20525000 blseald   sum     1.0     0     1
20525001 0.0     1.153    voidf    220020000
20525002         0.622    voidf    220030000
****************************************************
****
*  collapsed level in rising section               *
****************************************************
****
20525100 blsealr   sum     1.0     0     1
20525101 0.0     0.622    voidf    220050000
20525102         1.153    voidf    223010000
****************************************************
****
*                                          *
*          heat fluxes                        *
*          --------                          *
*     - electrical heater rod bundle -             *
****************************************************
****
20502000 qbundle   sum     1.0     0.0     1
20502001 0.0      0.35396   htrnr    325100101
20502002          0.43228   htrnr    334100101
20502003          0.89050   htrnr    335100101
20502004          1.43300   htrnr    335200101
20502005          1.8912    htrnr    335300101
20502006          1.8912    htrnr    335300201
20502007          1.4330    htrnr    335500101
20502008          0.89050   htrnr    335600101
20502009          0.70894   htrnr    336600101
20502010          1.2968    htrnr    345100101
20502011          1.2968    htrnr    345100201
20502012          1.0526    htrnr    345100301
20502013          0.68085   htrnr    345100401
20502014          0.031362  htrnr    355000100
****************************************************
****
*  heat transfer sg intact loop                    *
****************************************************
****
20501800 qsgil    sum     1.0     0.0     1
20501801 0.0      0.18472565 htrnr    120300100
20501802        0.18472565 htrnr    120300200
20501803        0.18472565 htrnr    120300300
20501804        0.18472565 htrnr    120300400
20501805        0.18472565 htrnr    120300500
20501806        0.18472565 htrnr    120300600
20501807        0.18472565 htrnr    120300700
20501808        0.18472565 htrnr    120300800
20501809        0.3694513  htrnr    120300900
20501810        0.3694513  htrnr    120301000
20501811        0.3694513  htrnr    120301100
20501812        0.3694513  htrnr    120301200
20501813         0.7389026  htrnr    120301300
20501814         0.7389026  htrnr    120301400
20501815         0.7389026  htrnr    120301500
20501816         0.7389026  htrnr    120301600
20501817         0.7389026  htrnr    120301700
20501818         0.7389026  htrnr    120301800
20501819         0.7389026  htrnr    120301900
20501820         0.7389026  htrnr    120302000
*
20502100 qsgil    sum     1.0     0.0     1
20502101 0.0      0.18472565 htrnr 120304200
20502102         0.18472565 htrnr 120304100
20502103         0.18472565 htrnr 120304000
20502104         0.18472565 htrnr 120303900
20502105         0.18472565 htrnr 120303800
20502106         0.18472565 htrnr 120303700
20502107         0.18472565 htrnr 120303600
20502108         0.18472565 htrnr 120303500
*
20502200 qsgil    sum     1.0     0.0     1
20502201 0.0      1.4997240  htrnr    120302100
20502202         1.4997240  htrnr    120302200
20502203         0.7389026   htrnr    120302300
20502204         0.7389026   htrnr    120302400
20502205         0.7389026   htrnr    120302500
20502206         0.7389026   htrnr    120302600
20502207         0.7389026   htrnr    120302700
20502208         0.7389026   htrnr    120302800
20502209         0.7389026   htrnr    120302900
20502210         0.7389026   htrnr    120303000
20502211         0.3694513   htrnr    120303100
20502212         0.3694513   htrnr    120303200
20502213         0.3694513   htrnr    120303300
20502214         0.3694513   htrnr    120303400
20502215         1.0        cntrlvar 021
20502216         1.0        cntrlvar 018
****************************************************
****
*  heat transfer sg broken loop                    *
****************************************************
****
20502300 qsgbl    sum     1.0     0.0     1
20502301 0.0  0.12315045 htrnr    210300100
20502302     0.12315045 htrnr    210300200
20502303     0.12315045 htrnr    210300300
20502304     0.12315045 htrnr    210300400
20502305     0.2463009  htrnr    210300500
20502306     0.2463009  htrnr    210300600
20502307     0.49260175 htrnr    210300700
20502308     0.49260175 htrnr    210300800
20502309     0.49260175 htrnr    210300900
20502310     0.49260175 htrnr    210301000
20502311     0.4986716  htrnr    210301100
20502312     0.4986716  htrnr    210301200
20502313     0.49260175 htrnr    210301300
20502314     0.49260175 htrnr    210301400
20502315     0.49260175 htrnr    210301500
20502316     0.49260175 htrnr    210301600
20502317    0.2463009  htrnr    210301700
20502318    0.2463009  htrnr    210301800
20502319    0.12315045 htrnr    210301900
*
20502400 qsgbl    sum     1.0     0.0     1
20502401 0.0      0.12315045   htrnr    210302000
20502402         0.12315045   htrnr    210302100
20502403         0.12315045   htrnr    210302200
```

```
20502404        1.0     cntrlvar  023
*************************************************
****
*
*   this section sums the heat fluxes from each heat
*   structure in the various parts of the loop and
*   assigns these values to control variables. this
*   allows the exchange of heat between the structures
*   and the fluid to be examined.
*
*
*   intact loop hot leg
*   ---------------
*
20516100 fluxinhl   sum      1.0     0.0    1
20516101    0.0   1.579d-1    htmr    100000100
20516102          4.214d-2    htmr    101000100
20516103          3.936d-2    htmr    101100100
20516104          1.579d-1    htmr    100100100
20516105          3.705d-1    htmr    100100200
20516106          1.449d-1    htmr    100000200
20516107          2.894d-2    htmr    101000200
20516108          6.412d-1    htmr    120000100
20516109          1.676d-1    htmr    120200100
20516110          4.020d-2    htmr    120400100
20516111          9.630d-2    htmr    120500100
*
*   intact loop seal
*   ------------
*
20516200 fluxinls   sum      1.0     0.0    1
20516201    0.0   1.449d-1    htmr    100000300
20516202          1.776d-1    htmr    100000400
20516203          2.711d-1    htmr    100100300
20516204          3.730d-1    htmr    100100400
20516205          1.447d-1    htmr    100100500
20516206          3.728d-1    htmr    100100600
20516207          2.894d-2    htmr    101000300
20516208          7.317d-2    htmr    101000400
20516209          3.936d-2    htmr    101100200
20516210          6.412d-1    htmr    120000200
20516211          1.676d-1    htmr    120200200
20516212          4.020d-2    htmr    120400200
20516213          9.630d-2    htmr    120500101
*
*   intact loop cold leg
*   ---------------
*
20516300 fluxincl   sum      1.0     0.0    1
20516301    0.0   1.706d-1    htmr    100000500
20516302          1.591d-1    htmr    100000600
20516303          2.689d-1    htmr    100100700
20516304          3.033d-1    htmr    100100800
20516305          5.580d-2    htmr    101000500
20516306          2.454d-2    htmr    101000600
20516307          2.936d-2    htmr    101100300
20516308          1.257d-1    htmr    137000100
*
*   total flux for intact loop
*   ------------------
*
20517000 fluxint    sum      1.0     0.0    1
20517001    0.0   1.0       cntrlvar 161
20517002          1.0       cntrlvar 162
20517003          1.0       cntrlvar 163
*
*
*   broken loop hot leg
*   --------------
*
20526100 fluxbrhl   sum      1.0     0.0    1
20526101    0.0   9.037d-2    htmr    200000100
20526102          9.906d-2    htmr    200000200
20526103          1.282d-1    htmr    200100100
20526104          9.935d-2    htmr    200100200
20526105          9.935d-2    htmr    200100300
20526106          5.923d-2    htmr    201000100
20526107          1.854d-2    htmr    201000200
20526108          2.462d-2    htmr    201100100
20526109          4.096d-1    htmr    210000100
20526110          6.857d-1    htmr    210200100
20526111          1.940d-2    htmr    210400100
20526112          3.920d-2    htmr    210500100
*
*   broken loop seal
*   ------------
*
20526200 fluxbrls   sum      1.0     0.0    1
20526201    0.0   9.906d-2    htmr    200000300
20526202          1.681d-1    htmr    200000400
20526203          2.175d-1    htmr    200100400
20526204          1.073d-1    htmr    200100500
20526205          1.060d-1    htmr    200100600
20526206          1.073d-1    htmr    200100700
20526207          3.288d-2    htmr    201000300
20526208          5.503d-2    htmr    201000400
20526209          2.462d-2    htmr    201100200
20526210          4.096d-1    htmr    210000200
20526211          6.857d-1    htmr    210200200
20526212          1.940d-2    htmr    210400200
20526213          3.920d-2    htmr    210500101
*
*   broken loop cold leg
*   ----------------
*
20526300 fluxbrcl   sum      1.0     0.0    1
20526301    0.0   1.242d-1    htmr    200000500
20526302          9.037d-2    htmr    200000600
20526303          1.829d-1    htmr    200100800
20526304          1.431d-1    htmr    200100900
20526305          6.082d-2    htmr    201000500
20526306          3.172d-2    htmr    201000600
20526307          2.462d-2    htmr    201100300
20526308          2.463d-2    htmr    201100400
20526309          1.257d-1    htmr    230000100
*
*   total flux for broken loop
*   ---------------------
*
20526500 fluxbrt    sum      1.0     0.0    1
20526501    0.0   1.0       cntrlvar 261
20526502          1.0       cntrlvar 262
20526503          1.0       cntrlvar 263
*
*
*   vessel downcomer above loop piping
*   ---------------------------
*
20536100 fluxdoto   sum      1.0     0.0    1
20536101    0.0   3.088d-1    htmr    310000100
20536102          4.773d-1    htmr    310000200
20536103          4.406d-1    htmr    310200401
20536104          1.900d-1    htmr    310200501
20536105          9.500d-2    htmr    310300201
20536106          6.861d-2    htmr    310700100
20536107          3.619d-2    htmr    310500100
20536108          3.619d-2    htmr    310500200
*
*   downcomer top half
*   -------------
*
20536200 fluxdomi   sum      1.0     0.0    1
20536201    0.0   1.666d-1    htmr    310000300
20536202          5.881d-1    htmr    310000400
```

```
20536203        7.253d-1   htmr   310000500
20536204        6.498d-1   htmr   310000600
20536205        8.576d-1   htmr   310000700
20536206        7.017d-1   htmr   310100401
20536207        5.998d-1   htmr   310100501
20536208        6.695d-1   htmr   310100601
20536209        5.428d-1   htmr   310200201
20536210        5.428d-1   htmr   310200301
20536211        4.215d-1   htmr   310600100
20536212        3.619d-2   htmr   310500300
20536213        3.619d-2   htmr   310500400
20536214        7.238d-2   htmr   310500500
20536215        7.238d-2   htmr   310500600
20536216        7.238d-2   htmr   310500700
*
*   downcomer bottom half
*   ----------------
*
20536300 fluxdobo   sum      1.0    0.0   1
20536301    0.0   8.576d-1   htmr   310000800
20536302        6.498d-1   htmr   310000900
20536303        2.764d-1   htmr   310001000
20536304        3.822d-1   htmr   310001100
20536305        6.038d-1   htmr   310001200
20536306        5.537d-1   htmr   310100101
20536307        5.999d-1   htmr   310100201
20536308        7.917d-1   htmr   310100301
20536309        3.800d-1   htmr   310200101
20536310        3.854d-1   htmr   310300101
20536311        1.448d-1   htmr   310400101
20536312        3.234d-1   htmr   310600200
20536313        1.960d-1   htmr   310700200
20536314        7.238d-2   htmr   310500800
20536315        3.619d-2   htmr   310500900
20536316        3.619d-2   htmr   310501000
20536317        3.619d-2   htmr   310501100
20536318        3.619d-2   htmr   310501200
*
*   complete downcomer
*   -------------
*
20536400 fluxdown   sum      1.0    0.0   1
20536401    0.0   1.0      cntrlvar 361
20536402        1.0      cntrlvar 362
20536403        1.0      cntrlvar 363
*
*
*   lower plenum and core entry
*   --------------------
*
20536500 fluxcobo   sum      1.0    0.0   1
20536501    0.0   1.715d-1   htmr   310001300
20536502        2.794d-1   htmr   310001400
20536503        2.613d-1   htmr   310200100
20536504        2.650d-1   htmr   310300100
20536505        6.535d-2   htmr   310400100
*
*   core centre region
*   -------------
*
20536600 fluxcomi   sum      1.0    0.0   1
20536601    0.0   2.600d-1   htmr   310100100
20536602        2.773d-1   htmr   310100200
20536603        3.660d-1   htmr   310100300
20536604        3.660d-1   htmr   310100400
20536605        2.773d-1   htmr   310100500
20536606        3.095d-1   htmr   310100600
*
*   core top region
*   -----------
*
20536700 fluxcoto   sum      1.0    0.0   1
```

```
20536701    0.0   3.732d-1   htmr   310200200
20536702        3.732d-1   htmr   310200300
20536703        3.029d-1   htmr   310200400
20536704        1.306d-1   htmr   310200500
20536705        6.531d-2   htmr   310300200
*
*   vessel upper head
*   --------------
*
20536800 fluxuphe   sum      1.0    0.0   1
20536801    0.0   3.480d-1   htmr   370000100
20536802        3.223d-1   htmr   370000200
20536803        3.480d-1   htmr   370000300
20536804        8.897d-2   htmr   365000100
20536805        1.991d-1   htmr   365000200
20536806        1.512d-1   htmr   380000100
*
*   complete vessel
*   -------------
*
20537000 fluxvess   sum      1.0    0.0   1
20537001    0.0   1.0      cntrlvar 364
20537002        1.0      cntrlvar 365
20537003        1.0      cntrlvar 366
20537004        1.0      cntrlvar 367
20537005        1.0      cntrlvar 368
*
*   pressurizer
*   ---------
*
20547000 fluxpres   sum      1.0    0.0   1
20547001    0.0   3.029d-1   htmr   410000100
20547002        3.517d-1   htmr   410000200
20547003        3.517d-1   htmr   410000300
20547004        3.517d-1   htmr   410000400
20547005        3.517d-1   htmr   410000500
20547006        3.517d-1   htmr   410000600
20547007        3.517d-1   htmr   410000700
20547008        2.286d-1   htmr   410000800
20547009        2.697d-1   htmr   410000900
20547010        5.226d-2   htmr   410100100
*20547011        7.174d-2   htmr   400000100
*20547012        1.078d-1   htmr   400000200
*20547013        1.161d-1   htmr   400000300
*
*   intact loop steam generator
*   ---------------------
*  total secondary side metal-to-fluid heat flow
*
20585000 fluxsg11   sum      1.0    0.0   1
20585001 0.0      3.3175219  htmr   120300101
20585002          3.3175219  htmr   120300201
20585003          3.3175219  htmr   120300301
20585004          1.6833637  htmr   120300401
20585005          1.6833637  htmr   120300501
20585006          3.3175219  htmr   120300601
20585007          3.3175219  htmr   120300701
20585008          3.3175219  htmr   120300801
*
20584800 fluxdum1   sum      1.0    0.0   1
20584801 0.0      0.15504    htmr   510000100
20584802          0.28208    htmr   555000100
20584803          0.21648    htmr   560200100
*
20585100 fluxsg12   sum      1.0    0.0   1
20585101 0.0      0.00402    htmr   120400101
20585102          0.00402    htmr   120400201
20585103          1.8912388  htmr   530100100
20585104          1.8912388  htmr   530100200
20585105          1.8912388  htmr   530100300
20585106          1.3257584  htmr   530100400
20585107          0.561459   htmr   530100500
```

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20585108        1.9163715  htmr   530100101
20585109        1.9163715  htmr   530100201
20585110        1.9163715  htmr   530100301
20585111        1.3433764  htmr   530100401
20585112        0.568921   htmr   530100501
20585113        2.0671680  htmr   510100100
20585114        2.0671680  htmr   510100200
20585115        2.0671680  htmr   510100300
20585116        1.4490847  htmr   510100400
20585117        1.17599    htmr   555100100
20585118        1.38350    htmr   560100100
20585119        1.10034    htmr   560100200
20585120        1.0     cntrlvar 848
*
20585200 fluxsg13   sum      1.0     0.0    1
20585201 0.0       0.9569291  htmr   530200101
20585202           0.9569291  htmr   530200201
20585203           0.9569291  htmr   530200301
20585204           0.3373175  htmr   530200401
20585205           0.022246   htmr   530300101
*
*
*  broken loop steam generator
*  ___________________
*  total secondary side metal-to-fluid heat flow
*
20585300 fluxsg21   sum      1.0     0.0    1
20585301 0.0       1.1058406  htmr   210300101
20585302           1.1058406  htmr   210300201
20585303           1.1058406  htmr   210300301
20585304           0.5597334  htmr   210300401
20585305           0.5597334  htmr   210300501
20585306           1.1058406  htmr   210300601
20585307           1.1058406  htmr   210300701
20585308           1.1058406  htmr   210300801
*
20584900 fluxdum2   sum      1.0     0.0    1
20584901 0.0       0.054287   htmr   610000100
20584902           0.15017    htmr   655000100
20584903           0.07258    htmr   660200100
*
20585400 fluxsg22   sum      1.0     0.0    1
20585401 0.0       0.00194    htmr   210400101
20585402           0.00194    htmr   210400201
20585403           1.2629203  htmr   630100100
20585404           1.2629203  htmr   630100200
20585405           1.2629203  htmr   630100300
20585406           0.823424   htmr   630100400
20585407           0.328621   htmr   630100500
20585408           1.2817698  htmr   630100101
20585409           1.2817698  htmr   630100201
20585410           1.2817698  htmr   630100301
20585411           0.8357139  htmr   630100401
20585412           0.333526   htmr   630100501
20585413           1.35717    htmr   610100100
20585414           1.35717    htmr   610100200
20585415           1.35717    htmr   610100300
20585416           0.88487    htmr   610100400
20585417           0.95807    htmr   655100100
20585418           0.874525   htmr   660100100
20585419           0.636173   htmr   660100200
20585420           1.0     cntrlvar 849
*
20585500 fluxsg23   sum      1.0     0.0    1
20585501 0.0       0.7904247  htmr   630200101
20585502           0.7904247  htmr   630200201
20585503           0.7904247  htmr   630200301
20585504           0.2806008  htmr   630200401
20585505           0.015394   htmr   630300101
*
*
*  total flux for intact loop secondary side
```

```
*
20585600 fluxsg1    sum      1.0     0.0    1
20585601 0.0      1.0      cntrlvar 850
20585602          1.0      cntrlvar 851
20585603          1.0      cntrlvar 852
*
*  total flux for broken loop secondary side
*
20585700 fluxsg2    sum      1.0     0.0    1
20585701 0.0      1.0      cntrlvar 853
20585702          1.0      cntrlvar 854
20585703          1.0      cntrlvar 855
*
*  flusso termico scambiato tra pimario e secondario
*
20500300 fluxsg41   sum      1.0     0.0    1
20500301 0.0      0.2054601754  htmr   120300101
20500302          0.2054601754  htmr   120300201
20500303          0.2054601754  htmr   120300301
20500304          0.2054601754  htmr   120300401
20500305          0.2054601754  htmr   120300501
20500306          0.2054601754  htmr   120300601
20500307          0.2054601754  htmr   120300701
20500308          0.2054601754  htmr   120300801
20500309          0.410920325   htmr   120300901
20500310          0.410920325   htmr   120301001
20500311          0.410920325   htmr   120301101
20500312          0.410920325   htmr   120301201
20500313          0.82184065    htmr   120301301
20500314          0.82184065    htmr   120301401
20500315          0.82184065    htmr   120301501
20500316          0.82184065    htmr   120301601
20500317          0.82184065    htmr   120301701
20500318          0.82184065    htmr   120301801
20500319          0.82184065    htmr   120301901
20500320          0.82184065    htmr   120302001
*
20500400 fluxsg51   sum      1.0     0.0    1
20500401 0.0      1.6680604     htmr   120302101
20500402          1.6680604     htmr   120302201
20500403          0.82184065    htmr   120302301
20500404          0.82184065    htmr   120302401
20500405          0.82184065    htmr   120302501
20500406          0.82184065    htmr   120302601
20500407          0.82184065    htmr   120302701
20500408          0.82184065    htmr   120302801
20500409          0.82184065    htmr   120302901
20500410          0.82184065    htmr   120303001
20500411          0.410920325   htmr   120303101
20500412          0.410920325   htmr   120303201
20500413          0.410920325   htmr   120303301
20500414          0.410920325   htmr   120303401
20500415          0.2054601754  htmr   120303501
20500416          0.2054601754  htmr   120303601
20500417          0.2054601754  htmr   120303701
20500418          0.2054601754  htmr   120303801
20500419          0.2054601754  htmr   120303901
20500420          0.2054601754  htmr   120304001
*
20500500 fluxsg81   sum      1.0     0.0    1
20500501 0.0      0.2054601754  htmr   120304101
20500502          0.2054601754  htmr   120304201
**
20501100 fluxsg61  sum     1.0     0.0     1
20501101 0.0     1.0     cntrlvar  003
20501102         1.0     cntrlvar  004
20501103         1.0     cntrlvar  005
*
20500600 fluxsg71   sum      1.0     0.0    1
20500601 0.0      0.18472565    htmr   120300100
20500602          0.18472565    htmr   120300200
20500603          0.18472565    htmr   120300300
```

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20500604        0.18472565   htmr   120300400
20500605        0.18472565   htmr   120300500
20500606        0.18472565   htmr   120300600
20500607        0.18472565   htmr   120300700
20500608        0.18472565   htmr   120300800
20500609        0.3694513   htmr   120300900
20500610        0.3694513   htmr   120301000
20500611        0.3694513   htmr   120301100
20500612        0.3694513   htmr   120301200
20500613        0.7389026   htmr   120301300
20500614        0.7389026   htmr   120301400
20500615        0.7389026   htmr   120301500
20500616        0.7389026   htmr   120301600
20500617        0.7389026   htmr   120301700
20500618        0.7389026   htmr   120301800
20500619        0.7389026   htmr   120301900
20500620        0.7389026   htmr   120302000
*
20500700 fluxsg81   sum      1.0     0.0    1
20500701 0.0      1.4997240   htmr   120302100
20500702        1.4997240   htmr   120302200
20500703        0.7389026   htmr   120302300
20500704        0.7389026   htmr   120302400
20500705        0.7389026   htmr   120302500
20500706        0.7389026   htmr   120302600
20500707        0.7389026   htmr   120302700
20500708        0.7389026   htmr   120302800
20500709        0.7389026   htmr   120302900
20500710        0.7389026   htmr   120303000
20500711        0.3694513   htmr   120303100
20500712        0.3694513   htmr   120303200
20500713        0.3694513   htmr   120303300
20500714        0.3694513   htmr   120303400
20500715        0.18472565   htmr   120303500
20500716        0.18472565   htmr   120303600
20500717        0.18472565   htmr   120303700
20500718        0.18472565   htmr   120303800
20500719        0.18472565   htmr   120303900
20500720        0.18472565   htmr   120304000
*
20500800 fluxsg81   sum      1.0     0.0    1
20500801 0.0        0.18472565   htmr   120304100
20500802        0.18472565   htmr   120304200
**
20500900 fluxsg91  sum     1.0      0.0      1
20500901 0.0     1.0      cntrlvar  006
20500902      1.0      cntrlvar  007
20500903      1.0      cntrlvar  008
*
20501300 fluxsg41   sum      1.0     0.0    1
20501301 0.0       0.13697345   htmr   210300101
20501302        0.13697345   htmr   210300201
20501303        0.13697345   htmr   210300301
20501304        0.13697345   htmr   210300401
20501305        0.2739469   htmr   210300501
20501306        0.2739469   htmr   210300601
20501307        0.547893754   htmr   210300701
20501308        0.547893754   htmr   210300801
20501309        0.54789375   htmr   210300901
20501310        0.54789375   htmr   210301001
20501311        0.5546449   htmr   210301101
20501312        0.5546449   htmr   210301201
20501313        0.54789375   htmr   210301301
20501314        0.54789375   htmr   210301401
20501315        0.54789375   htmr   210301501
20501316        0.54789375   htmr   210301601
20501317        0.2739469   htmr   210301701
20501318        0.2739469   htmr   210301801
20501319        0.13697345   htmr   210301901
20501320        0.13697345   htmr   210302001
*
20501400 fluxsg51   sum      1.0     0.0    1
20501401 0.0      0.13697345   htmr   210302101
20501402       0.13697345   htmr   210302201
*
20501500 fluxsg61  sum     1.0     0.0     1
20501501 0.0     1.0     cntrlvar  013
20501502       1.0     cntrlvar  014
*
20501600 fluxsg71   sum      1.0     0.0    1
20501601 0.0      0.12315045   htmr   210300100
20501602         0.12315045   htmr   210300200
20501603         0.12315045   htmr   210300300
20501604         0.12315045   htmr   210300400
20501605         0.2463009   htmr   210300500
20501606         0.2463009   htmr   210300600
20501607         0.492601755   htmr   210300700
20501608         0.492601755   htmr   210300800
20501609         0.49260175   htmr   210300900
20501610         0.49260175   htmr   210301000
20501611         0.4986716   htmr   210301100
20501612         0.4986716   htmr   210301200
20501613         0.49260175   htmr   210301300
20501614         0.49260175   htmr   210301400
20501615         0.49260175   htmr   210301500
20501616         0.49260175   htmr   210301600
20501617         0.2463009   htmr   210301700
20501618         0.2463009   htmr   210301800
20501619         0.12315045   htmr   210301900
20501620         0.12315045   htmr   210302000
*
20501700 fluxsg81   sum      1.0     0.0    1
20501701 0.0      0.12315045   htmr   210302100
20501702         0.12315045   htmr   210302200
*
20501900 fluxsg91  sum     1.0     0.0     1
20501901 0.0     1.0     cntrlvar  016
20501902       1.0     cntrlvar  017
*
*
*
*   total flux for complete primary loop
*   ==========================================
*
20597000 fluxloop   sum      1.0     0.0    1
20597001     0.0   1.0      cntrlvar 170
20597002          1.0      cntrlvar 265
20597003          1.0      cntrlvar 370
20597004          1.0      cntrlvar 470
20597005          1.0      cntrlvar 420   * przr.power
*
*   integrated total flux for complete primary loop
*   ------------------------------------------
*
20597100 fluxtotl   integral  1.0    0.0    0
20597101                     cntrlvar 970
*
*   total flux for complete secondary side
*
20597200 fluxsgs    sum      1.0     0.0    1
20597201 0.0       1.0      cntrlvar 856
20597202          1.0      cntrlvar 857
*
*************************************************
***
*  pump seal bleed flow from upper plenum varied to     *
*  maintain steady-state level of 5.1 m in pressuriser *
*************************************************
*
20575000 preslerr  sum     1.0     0.0      1
20575001 -4.8    1.0     cntrlvar  410
*
20575500 upbleedf sum     1.0 0.0 1 3 0.0 0.1
20575501 0.0      1.0     cntrlvar  750
```

```
*
**************************************************
****
*  lower  pressure injection system
**************************************************
****
*
*
20580000 hpis-dp   sum      1.0      0.0      1
20580001 -1.0d5   1.0      p       145010000
*
20580500 hpisflow  function  1.0      0.0      0
20580501 cntrlvar  800      810
*
*  table of dp(bar) against flowrate(kg/s)
*  ------------------------------
*      bar     kg/s
20281000 reac-t
20281001 0.0      0.4
20281002 19.00d5   0.4
20281003 79.00d5   0.4
20281004 119.0d5   0.4
20281005 174.0d5   0.4
*
**************************************************
****
*  this section calculates the heat losses from the primary
*  system to the environment & an overall heat balance.
**************************************************
****
*
*  heat loss from instrumented spool pieces, intact loop
*  ----------------------------------------
20505000 htlsilsp  sum      1.0      0.0      1
20505001 0.0      2.3075d-1 htrnr    100000101
20505002          2.1181d-1 htrnr    100000201
20505003          2.1181d-1 htrnr    100000301
20505004          2.5951d-1 htrnr    100000401
20505005          2.4936d-1 htrnr    100000501
20505006          2.3245d-1 htrnr    100000601
*
*  ht.loss from il pump casing
*  -------------------
20505100 htlsilp  sum      1.0      0.0      1
20505101 0.0      3.217d-1  htrnr    137000101
*
*  total ht.loss from il spool pieces + pump casing
*  ----------------------------------
20505200 htlsil   sum      1.0      0.0      1
20505201 0.0      1.0      cntrlvar  050
20505202          1.0      cntrlvar  051
*
*  ht.loss from instrumented spool pieces, broken loop
*  ------------------------------------
20505300 htlsblsp  sum      1.0      0.0      1
20505301 0.0      1.5702d-1 htrnr    200000101
20505302          1.7212d-1 htrnr    200000201
20505303          1.7212d-1 htrnr    200000301
20505304          2.9216d-1 htrnr    200000401
20505305          2.1591d-1 htrnr    200000501
20505306          1.5702d-1 htrnr    200000601
*
*  ht.loss from bl pump casing
*  -------------------
20505400 htlsblp  sum      1.0      0.0      1
20505401 0.0      3.217d-1  htrnr    230000101
*
*  total ht.loss from bl spool pieces + pump casing
*  ----------------------------------
20505500 htlsbl   sum      1.0      0.0      1
20505501 0.0      1.0      cntrlvar  053
20505502          1.0      cntrlvar  054
```

```
*
*  ht.loss from rpv downcomer walls and supports
*  ----------------------------------
20505600 htlsrpvw  sum      1.0      0.0      1
20505601 0.0      3.4003d-1 htrnr    310000101
20505602          5.2569d-1 htrnr    310000201
20505603          1.8351d-1 htrnr    310000301
20505604          6.4767d-1 htrnr    310000401
20505605          7.9879d-1 htrnr    310000501
20505606          7.1568d-1 htrnr    310000601
20505607          9.4452d-1 htrnr    310000701
20505608          9.4452d-1 htrnr    310000801
20505609          7.1568d-1 htrnr    310000901
20505610          3.0441d-1 htrnr    310001001
20505611          4.2099d-1 htrnr    310001101
20505612          6.6494d-1 htrnr    310001201
20505613          1.8890d-1 htrnr    310001301
20505614          3.0764d-1 htrnr    310001401
20505615          5.0685d-1 htrnr    310600101
20505616          3.8898d-1 htrnr    310600201
*
*  ht.loss from rpv downcomer stubpipes & instn.
*  ----------------------------------
20505700 htlsrpvi  sum      1.0      0.0      1
20505701 0.0      1.1038d-1 htrnr    310500101
20505702          1.1038d-1 htrnr    310500201
20505703          1.1038d-1 htrnr    310500301
20505704          1.1038d-1 htrnr    310500401
20505705          2.2077d-1 htrnr    310500501
20505706          2.2077d-1 htrnr    310500601
20505707          2.2077d-1 htrnr    310500701
20505708          2.2077d-1 htrnr    310500801
20505709          1.1038d-1 htrnr    310500901
20505710          1.1038d-1 htrnr    310501001
20505711          1.1038d-1 htrnr    310501101
20505712          1.1038d-1 htrnr    310501201
*
*  ht.loss from rpv flange & power connector
*  ----------------------------
20505800 htlsrpvf  sum      1.0      0.0      1
20505801 0.0      1.2315d-1 htrnr    310700101
20505802          3.5186d-1 htrnr    310700201
*
*  ht.loss from rpv upper mounting plate
*  --------------------------
20505900 htlsrpvp  sum      1.0      0.0      1
20505901 0.0      0.0731296 htrnr    355000101
*
*  total ht.loss from rpv d.c.walls, support structures,
*  flanges, power connector (lower) & upper mtg.plate
*  ----------------------------------------
20506000 htlsrpv  sum      1.0      0.0      1
20506001 0.0      1.0      cntrlvar  056
20506002          1.0      cntrlvar  057
20506003          1.0      cntrlvar  058
20506004          1.0      cntrlvar  059
*
*  ht.loss from pump seal flow from u.p. & l.p.
*  ----------------------------
*  based on  enthalpy
* valid only in liquid cond's
20504000 swdup.pv  div      1.0      0.0      1
20504001 rho      355010000 p        355010000
*
20504100 swdup.h  sum      1.0      0.0      1
20504101 0.0      1.0      cntrlvar  040
20504102          1.0      uf       355010000
*
20504200 hl.swdup  mult     1.0      0.0      1
20504201 cntrlvar  041      mflowj   358000000
*
20504300 swdlp.pv  div      1.0      0.0      1
```

```
20504301 rho     320010000 p      320010000
*
20504400 swdlp.h  sum     1.0    0.0    1
20504401 0.0     1.0     cntrlvar 043
20504402         1.0     uf       320010000
*
20504500 hl.swdlp  mult    1.0    0.0    1
20504501 cntrlvar 044     mflowj  359000000
*
20506300 totalbf  sum     1.0    0.0    1
20506301 0.0     1.0     cntrlvar 045
20506302         1.0     cntrlvar 042
*
*  ht.input due to il pump seal flow
*  ------------------------------
*     valid only in liq. cond's
20506400 ilpmp.pv  div     1.0    0.0    1
20506401 rho     136010000 p      136010000
*
20506500 ilpmp.h  sum     1.0    0.0    1
20506501 0.0     1.0     cntrlvar 064
20506502         1.0     uf       136010000
*
20506600 hl.ilpmp  mult    1.0    0.0    1
20506601 cntrlvar 065     mflowj  134000000
*
*  ht.input due to bl pump seal flow
*  ------------------------------
20506700 blpmp.pv  div     1.0    0.0    1
20506701 rho     226010000 p      226010000
*
20506800 blpmp.h  sum     1.0    0.0    1
20506801 0.0     1.0     cntrlvar 067
20506802         1.0     uf       226010000
*
20506900 hl.blpmp  mult    1.0    0.0    1
20506901 cntrlvar 068     mflowj  224000000
*
*  nett ht.loss due to sealwater flow into both pumps &
*  draining of pump sealwater from upper & lower plena
*  ---------------------------------------------
20507000 hl.up-2p  sum     1.0    0.0    1
20507001 0.0     1.0     cntrlvar 063
20507002        -1.0     cntrlvar 066
20507003        -1.0     cntrlvar 069
*
*  ht.loss from pressurizer
*  ---------------------
20507100 hllspriz  sum     1.0    0.0    1
20507101 0.0     0.38956  htmr    410000101
20507102         0.45239  htmr    410000201
20507103         0.45239  htmr    410000301
20507104         0.45239  htmr    410000401
20507105         0.45239  htmr    410000501
20507106         0.45239  htmr    410000601
20507107         0.45239  htmr    410000701
20507108         0.29405  htmr    410000801
20507109         0.34683  htmr    410000901
20507110         0.15018  htmr    410100101
*
*  nett ht.loss to environment (excl.sg's & przr.)
*  ---------------------------------------
20507500 ht.loss1  sum     1.0    0.0    1
20507501 0.0     1.0     cntrlvar 052
20507502         1.0     cntrlvar 055
20507503         1.0     cntrlvar 060
20507504         1.0     cntrlvar 070
*
* il pump work, torque * velocity * -1.0
* ------------------------------
20507700 il.pmp.w  mult    -1.0   0.0    1
20507701 pmptrq   135      pmpvel  135
```

```
*
* bl pump work, torque * velocity * -1.0
* ------------------------------
20507800 bl.pmp.w  mult    -1.0   0.0    1
20507801 pmptrq   225      pmpvel  225
*
*  total input power to primary fluid, core power + pump
work
*  -----------------------------------------------
20508000 enrgy.in  sum     1.0    0.0    1
20508001 0.0     1.0     cntrlvar 010
20508002         1.0     cntrlvar 077
20508003         1.0     cntrlvar 078
*
*  total heat removed, ht.losses to environment + both sg's
*  -----------------------------------------------
20509000 engy.out  sum     1.0    0.0    1
20509001 0.0     1.0     cntrlvar 075
20509002        -1.0     cntrlvar 022
20509003        -1.0     cntrlvar 024
*
*
*  secondary side heat losses
*  ==========================
*
*  ht.loss from intact loop steam generator
*  --------------------------------
20508200 hllsg1  sum      1.0    0.0    1
20508201 0.0     0.102533725  htmr    510100101
20508202         0.102533725  htmr    510100201
20508203         0.102533725  htmr    510100301
20508204         0.102533725  htmr    510100401
20508205         0.14647675   htmr    510100501
20508206         0.14647675   htmr    510100601
20508207         0.14647675   htmr    510100701
20508208         0.14647675   htmr    510100801
20508209         0.292953525  htmr    510100901
20508210         0.292953525  htmr    510101001
20508211         0.292953525  htmr    510101101
20508212         0.292953525  htmr    510101201
20508213         0.585907025  htmr    510101301
20508214         0.585907025  htmr    510101401
20508215         0.585907025  htmr    510101501
20508216         0.585907025  htmr    510101601
20508217         0.585907025  htmr    510101701
*
*
*
20508100 hllsg1  sum      1.0    0.0    1
20508101 0.0     1.00292   htmr    555100101
20508102         0.97806   htmr    560100101
20508103         1.81427   htmr    560100201
20508104         0.06185   htmr    510000101
20508105         0.06185   htmr    510000201
20508106         0.06185   htmr    510000301
20508107         0.06185   htmr    510000401
20508108         0.55041   htmr    555000101
20508109         0.21648   htmr    560200101
20508110         0.585907025  htmr    510101801
20508111         0.585907025  htmr    510101901
20508112         0.585907025  htmr    510102001
20508113         1.6428833    htmr    510102101
*
20509200 hllsssg1  sum     1.0    0.0    1
20509201 0.0     1.0     cntrlvar 081
20509202         1.0     cntrlvar 082
*
*
*  ht.loss from broken loop steam generato2
*  --------------------------------
20509400 hllsssg2  sum     1.0    0.0    1
20509401 0.0     0.1609752  htmr    610100101
```

```
20509402      0.1609752  htmr   610100201
20509403      0.1916375  htmr   610100301
20509404      0.1916375  htmr   610100401
20509405      0.383275  htmr   610100501
20509406      0.383275  htmr   610100601
20509407      0.76655  htmr   610100701
20509408      0.76655  htmr   610100801
20509409      0.76655  htmr   610100901
20509410      0.76655  htmr   610101001
20509411      0.99958  htmr   610101101
20509412      0.90932  htmr   655100101
20509413      0.65039  htmr   660100101
20509414      1.05055  htmr   660100201
20509415      0.0446105 htmr   610000101
20509416      0.0446105 htmr   610000201
20509417      0.31416  htmr   655000101
20509418      0.07258  htmr   660200101
*
* ht.loss from steam line up to manifold
* ---------------------------------
20509600 steamlne sum    1.0    0.0    1
20509601 0.0    1.5540   htmr   564100101
20509602        0.8801   htmr   664100101
*
* calculated stratified water levels at horizontal
* measurement inserts, locations 11,16,21,25,26
*
=====================================================
====
* table 123: (theta-sin.theta)/2pi .vs. h/d
* table input is liquid void fraction in volume
* table output is normalised stratified level
*
20212300 reac-t
20212301 0.0      0.0
20212302 0.0004743 0.004278
20212303 0.0037559 0.017037
20212304 0.0124605 0.038060
20212305 0.0288344 0.066987
20212306 0.0908451 0.146447
20212307 0.1955011 0.25
20212308 0.3370892 0.370590
20212309 0.5      0.5
20212310 0.6629108 0.629410
20212311 0.8044989 0.75
20212312 0.9091549 0.853553
20212313 0.9711656 0.933013
20212314 0.9875395 0.961940
20212315 0.9962441 0.982963
20212316 0.9995257 0.995722
20212317 1.0      1.0
*
* table of dp/dt,sat as a function of pressure
* ----------------------------------------
20258200   reac-t   0      1.0d5   1.0d5
20258201   1.0      0.0
20258202   1.0133    0.0362
20258203   1.4327    0.04815
20258204   1.9854    0.06295
20258205   2.7013    0.0808
20258206   3.614    0.102
20258207   4.76    0.1275
20258208   6.188    0.157
20258209   7.92    0.1915
20258210   10.027    0.2305
20258211   12.551    0.2755
20258212   15.549    0.3255
20258213   19.077    0.3815
20258214   23.198    0.4435
20258215   27.976    0.513
20258216   33.478    0.589
20258217   39.776    0.672
20258218  46.943   0.763
20258219  55.058   0.861
20258220  64.202   0.9685
20258221  74.461   1.0845
20258222  85.927   1.2105
20258223  98.7    1.3445
20258224  112.89   1.495
*
*
* table of tsat (k) as a function of p (pa)
* ------------------------------------------
20255000  reac-t   0      1.0d5   1.0
20255001  4.0     416.77
20255002  5.0     424.99
20255003  6.0     431.99
20255004  7.0     438.11
20255005  8.0     443.56
20255006  9.0     448.51
20255007  10.0    453.03
20255008  12.0    461.11
20255009  14.0    468.19
20255010  16.0    474.52
20255011  18.0    480.26
20255012  20.0    485.52
20255013  25.0    497.09
20255014  30.0    506.99
20255015  35.0    515.69
20255016  40.0    523.48
20255017  45.0    530.56
20255018  50.0    537.06
20255019  55.0    543.08
20255020  60.0    548.70
20255021  65.0    553.97
20255022  70.0    558.94
20255023  75.0    563.65
20255024  80.0    568.12
20255025  85.0    572.38
20255026  90.0    576.46
20255027  95.0    580.36
20255028  100.0   584.11
20255029  110.0   591.20
20255030  120.0   597.80
20255031  130.0   603.98
20255032  140.0   609.79
20255033  150.0   615.28
20255034  160.0   620.48
20255035  170.0   625.41
20255036  180.0   630.11
20255037  190.0   634.58
20255038  200.0   638.85
20255039  210.0   642.93
20255040  220.0   646.84
20255041  221.2   647.30
*
*
* ans decay function (100%)
* --------------------
20211000  reac-t
20211001  0.0    0.0699
20211002  0.1    0.0675
20211003  1.0    0.0625
20211004  2.0    0.059
20211005  4.0    0.0552
20211006  6.0    0.0533
20211007  8.0    0.0512
20211008  10.0    0.05
20211009  20.0    0.045
20211010  40.0    0.0396
20211011  60.0    0.0365
20211012  80.0    0.0346
20211013  100.0   0.0331
20211014  200.0   0.0275
```

```
20211015  400.0      0.0235
20211016  600.0      0.0211
20211017  800.0      0.0196
20211018  1000.0     0.0185
20211019  2000.0     0.0157
20211020  4000.0     0.0128
20211021  6000.0     0.0112
20211022  8000.0     0.0105
20211023  10000.0    0.00965
20211024  20000.0    0.00795
20211025  40000.0    0.00625
20211026  60000.0    0.00566
20211027  80000.0    0.00505
20211028  100000.0   0.00475
*
20515800  acmail  integral 1. 0. 0
20515801      mflowj  732000000
*
20515900  acmail  integral 1. 0. 0
20515901      mflowj  950000000
*
.end of input deck - thank god !
```

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10. SUPPLEMENTARY NOTES

G. Rhee, NRC Project Manager

11. ABSTRACT *(200 words or less)*

This report deals with the results of the "post-test analysis" of the test BL-06 performed in the LOBI/MOD2 test facility. LOBI/MOD2 is an integral test facility that represents, at approximately 1:712 scale, a four loop (KWU design, 1300 MWe) PWR. The test BL-06 simulates a 1% cold leg break LOCA, with the main coolant pumps switched off very late in the transient. The calculations have been realized with the code RELAP5/MOD3.2.1. The uncertainty evaluation of the calculation result has been performed using a specific method developed by Pisa University.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

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