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RELAP5/MOD3.2 Post Test Analysis and Accuracy Quantification of SPES Test SP-SB-04

Prepared by
F. D'Auria
M. Frogheri*
W. Giannotti

University of Pisa
Via Diotisalvi 2–56100
Pisa, Italy

*University of Genova
DITEC
Via all'Opera Pia 15a
16143 Genova, Italy

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CONTENTS

ABSTRACT

The present document deals with the Relap5/Mod3.2 analysis of the small break LOCA experiment SP-SB-04 performed in SPES facility.

SPES is a PWR simulator (Integral Test Facility) installed at SIET center in Piacenza (IT). Volume scaling and core power scaling factors are 1/427, with respect to the Westinghouse 900 MWe standard reactor.

The experiment is originated by a small break in the cold leg (2» equivalent break area in the plant) without the actuation of the high pressure injection system. The test starts from full power and is the counterpart of the test SP-SB-03, that started at an initial power roughly equal to 10% of nominal power. Low pressure injection system actuation occurs after core dry-out.

The Relap5 code has been extensively used at University of Pisa; the nodalization of SPES facility has been qualified through the application of the version Relap5/Mod2 to the same experiment and another test performed in the same facility.

Sensitivity analyses have been addressed to the influence of several parameters (like discharge break coefficient, time of accumulators start etc.) upon the predicted transient evolution.

Qualitative and quantitative code calculation accuracy evaluation has been performed.

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The authors wish to acknowledge the technical support given to the present research by Dr. P. Marsili by ANPA, who also stimulated the same activity and revisioned the manuscript.

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1. INTRODUCTION

The performance assessment and validation of large thermalhydraulic codes and the accuracy evaluation when calculating the safety margins of Light Water Reactors are among the objectives of international research programs, such as those organized by the Committee on the Safety of Nuclear Installation (CSNI) and the Code Application and Maintenance Program (CAMP).

Solution of these problems would ensure the effectiveness of engineered safety features and, eventually, lead to cost reductions through better design. This activities could also contribute to the determination of a uniform basis on which to assess the consequences of reactor system failures in Nuclear Power Plants, refs [1] and [2].

The execution of the experiments in Integral Test Facilities simulating the behavior of a nuclear plant, plays an important role in this connection, both considering the system code assessment and the possibilities to identify and characterize the relevant phenomena during off-normal conditions.

A special kind of experiments are the so called counterpart tests. These are similar experiments performed in differently scaled facilities. It is well clear that transient scenarios measured in the experimental rigs can not be directly extrapolated to the plant conditions. Nevertheless one of the objectives of a counterpart test is to evaluate the influence of the geometric dimension of the loop upon the evolution of a given accident.

Counterpart tests have been performed in four PWR simulators: LOBI, SPES, BETHSY and LSTF, ref. [3], respectively available at the European Community Joint Research Center of Ispra (I), at SIET in Piacenza (I), at CENG in Grenoble (F) and at JAERI in Tokai-Mura (J). The selected experiment is a small break LOCA originated by a rupture in the cold leg, without actuation of high pressure injection system and with accumulators availability, in particular, starting from low power conditions (about 10% of the nominal period). Both tests have been performed in the smallest facilities, SPES and LOBI, starting from full power conditions, all other conditions being the same.

The activity documented in this report is a part of a multipurpose research aiming at the overall evaluation and exploitation of the counterpart test database. On the one hand the Relap5 system code (Mod2 and, presently, Mod3.2) has been applied to the post test analysis of the four experiments and to the evaluation of plant scenario during the same transient: on the other hand the experimental data base have been evaluated to demonstrate the similarity in the behavior of the facilities, ref. [3]. The two parts of the research have been merged and conclusions have been drawn in relation to the scaling of phenomena and of the accuracy of thermalhydraulic code calculations.

Previous reports dealt with the evaluation of the experimental data base constituted by the four counterpart experiments and with the qualification of Relap5/Mod2 nodalization used for the post test analyses, refs. [4] and [5], as well as with a complete evaluation of the data base leading to the evaluation of uncertainties (e.g. ref. [6]).

The present document deals with the post test analysis performed by Relap5/Mod3.2 of the high power small break LOCA counterpart test carried out in SPES facility (SP-SB-04).

So, the purpose of this report is to evaluate the performance of the Relap5/Mod3.2 also in comparison with the previous application with the version Mod2. In order to achieve this, a systematic qualitative and quantitative accuracy evaluation has been completed. The quantitative analysis has been performed adopting a method (ref. [7]) developed at DCMN, which has capabilities in quantifying the errors in code predictions related to the measured experimental signal; the Fast Fourier Transform (FFT) is used aiming at having an integral representation of the code calculation discrepancies (i.e. error between measured and calculated time trends) in the frequency domain.

The qualitative accuracy evaluation, based on the selection of relevant thermalhydraulic aspects is a prerequisite to the application of the FFT based method.

It can be noted that the main purpose of the high power test (SP-SB-04) was to evaluate the influence of the initial conditions (in particular, high power, high mass flow rate and loss steam generator pressure) upon the evolution of the mentioned small break LOCA transient. The comparison of the two experiments, SP-SB-04 and SP-SB-03 (low power test with properly scaled boundary and initial conditions, see also ref. [8]), led to the conclusion that, apart from the first 200 s of the transient, the key phenomena are the same and occur almost at the same time.

2. DESCRIPTION OF THE EXPERIMENT

2.1 SPES facility

The SPES (Simulatore PWR per Esperienze di Sicurezza) Integral Test Facility, ref. [9], is designed to simulate the whole primary circuit, the relevant parts of the secondary circuit (steam generator secondary sides, main feed water lines up to the isolation valves, main steam lines upstream the turbine valves), and the most significant auxiliary and emergency systems (charging and let-down system, safety injection system, including high pressure and low pressure system, accumulators, emergency feed water system, steam dump and so on) of the Italian Standard Nuclear power plant (PWR-PUN, Westinghouse 312 type, 3 loops, 2775 MWth core power).

The basic design choices of the facility are the following:

- three active loops to simulate a three loops reactor;
- design pressure 20 MPa, design temperature 910 K; this choice allows the execution of tests with primary pressure over the reactor design pressure (17.2 MPa);
- electrical heating of the power channel: 97 electrically heated rods, with uniform flux (local hot spots can be simulated by means of three rods with a peaking factor of 1.19);
- maximum channel power corresponding to about 140% of the reactor nominal power; this choice allows the simulation of reactor power excursions;
- volume scaling factor and power scaling factor (nominal power about 6.5 MW) equal to 1:427;
- the height of all the components is the same as in real plant, except for the pressurizer which is shorter, in order to preserve the volume scaling ratio and to maintain at the same time an acceptable flow area.

A sketch of the primary and secondary loops is reported in Fig. 1, while Fig. 2 shows a simplified flowsheet of the facility.

In the SPES rig 375 measurement points are available, providing a large set of both direct physical quantities (absolute and differential pressure, temperature, voltage, etc.) and derived physical quantities (void fraction, mass velocity, quality, etc.).

Various kinds of transducers are located in the SPES facility (thermocouples, heated thermocouples, pressure transmitters, differential pressure transmitters, densitometers, void fraction probes, Venturi tubes, turbines, catch tank), supplying the following parameters:

- temperature
- pressure
- differential pressure
- liquid level
- density
- void fraction
- velocity
- flow pattern
- fluid mass

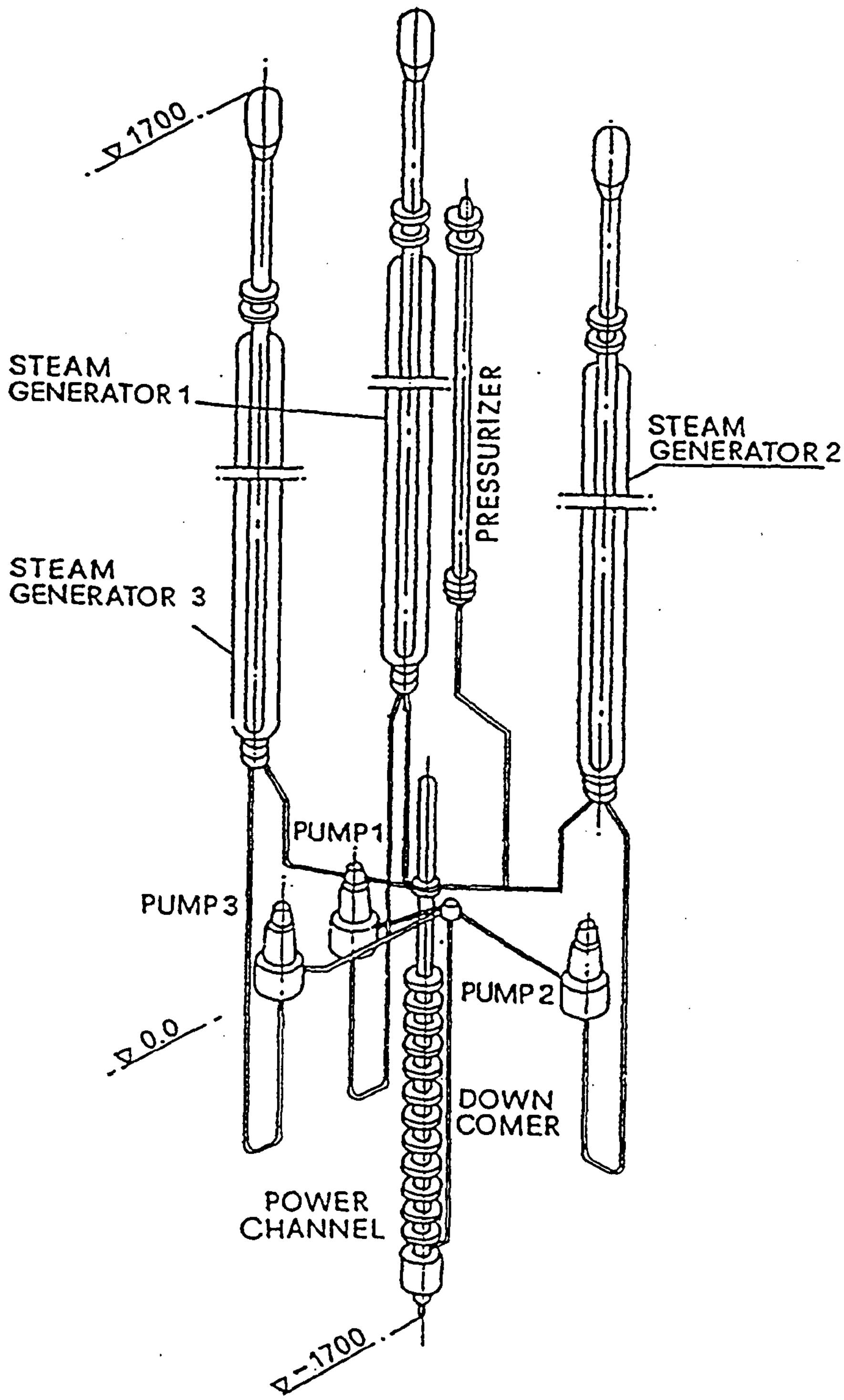

Fig. 1 : SPES facility - sketch of the plant

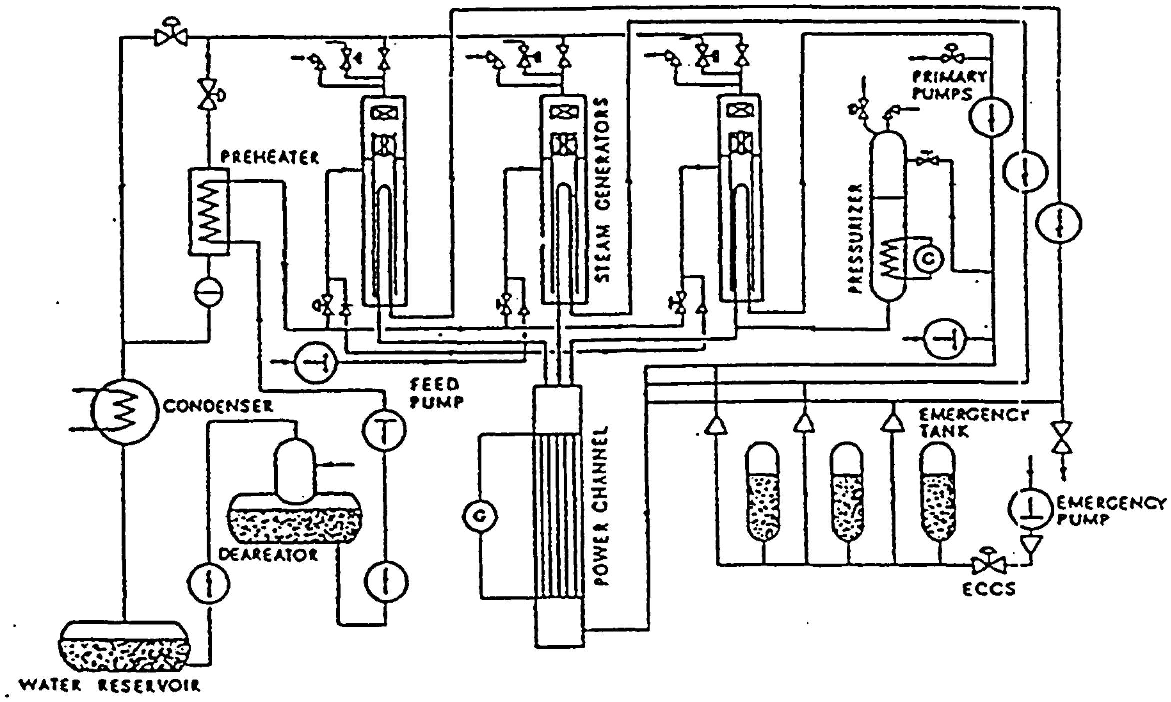

Fig. 2 : SPES facility - flowsheet

2.2 Test SP-SB-04

The experiment SP-SB-04, ref. [9], is a small break LOCA originated by a rupture in the cold leg, without high pressure injection system but with accumulators active and low pressure injection system intervention.

The break is located between the pump and the vessel, it has an area equivalent, roughly, to the 6 % of the area of the main pipe: the reference break diameter in the prototype plant is about 50 mm (2").

The design of the test has been made at University of Pisa, considering the counterpart tests in facilities like BETHSY, LOBI and LSTF, e.g. ref. [3]. The activity is documented in ref. [4].

The sequence of the main imposed and resulting events for SPES test SP-SB-04 are given in Tabs. 1 and 2, respectively. The transient scenario can be also derived from Figs. 3 and 4.

From a phenomenological point of view, the accident can be subdivided into four main periods:

a) subcooled blowdown and first core dry out-rewet (time from 0 to 132 s);
b) saturated blowdown and primary to secondary side pressure decoupling (from 132 s up to accumulators emptying);
c) mass depletion in primary loop (from accumulators emptying to the final core dry out);
d) intervention of low pressure injection system that quenches the core.

Phase a) Following the break the primary system pressure is subjected to an initial fast decrease (0.1 MPa/s) up to the achievement of saturation conditions upstream the break. As a consequence of the depressurization at time t=7.5 s the scam is actuated, the pumps coastdown is initiated, the steam generators are isolated, the MFWIV are stopped with the same signal and with 8 s of delay. The steam generators isolation causes the secondary side pressure increase without reaching the relief valve opening set points. Pressurizer emptying occurs in about 17 seconds.

During the first phase, natural circulation between core and downcomer through the steam generators develops up to the time when U-tubes draining occurs in the primary side: at this time the saturation temperature in primary loop is still few degrees higher than saturation temperature in secondary side.

The stop in natural circulation, essentially due to voiding and mass depletion in the upper zones of the loop, causes manometer type situation in the primary loop piping: the steam produced in the core partly flows directly to the break through the bypass and partly pushes down the level in the core to balance the liquid level present in the loop seals. In this situation a little core dry out occurs. The rod cladding temperature excursion occurs only at the intermediate level and in a rod that is not a hot rod (the radial peak factor is 1.19). The temperature excursion is about 15 K and its time duration is less than 10 s, so we can explain this event as due to a localized effect of fluid stagnation when the core flow rate is very low. The rod temperature excursion ends when loop seals clearing starts (at about 132 s) in the broken loop.

After a more or less complete loop seal clearing in the three loops, a sufficient liquid mass is present in the core to cool the rods.

Following the above events (especially broken loop seal clearing), a large amount of steam is present upstream the break and an important break flow rate decrease takes place.

Phase b) Continuous core boil off and primary-to-secondary side pressure decoupling characterize the first part of phase b). The core boil off causes a second smooth level decrease at a pressure higher than the accumulator pressure (4.22 MPa). In this period the heat transfer from secondary-to-primary side is quite small compared with core power, because of the high void fraction in the U-tubes.

The accumulator intervention at 334.5 s causes the recovery of the liquid level in the core and prevents conditions for a second dry-out.

The isolation of accumulators occurs at about 1000 s: in the period from 334.5 s to 1000 s the primary system mass increases because the liquid flow rate delivered by accumulators is larger than the break flow rate.

Phase c) The stop of second accumulator injection (t = 978 s) causes another mass depletion period, leading to the second dry-out at about 1234 s into the transient, when the pressure is around 1 MPa. No other significant events occur in this period, excluding the core level depression. When the rod surface temperature reaches 697 K the low injection pressure system is actuated (1468.5 s) in the cold leg of the two intact loops.

Phase d) The LPIS flow rate (0.19 kg/s for each intact loops) is quite effective in causing the core quench and in recovering the facility. The quench front velocity is larger than 0.02 m/s and, at about 1450 s, the core is completely recovered. Core refill occurs in this period. The test was terminated at 1637 s with pressure around 0.77 MPa.

EVENT	TIME AND/OR SET POINT VALUES
Break opening	0. s
SCRAM signal	pressurizer pressure < 13 MPa
Pumps coastdown initiation	pressurizer pressure < 13 MPa
SG SS isolated	as above
Normal SG SS FW supply stopped	as above (plus 8 s delay)
Pressurizer internal heaters stop	pressurizer level < 1.18 m
SG SS safety valves opening	SG SS pressure > 7.2 MPa
Safety Injection Signal (HPIS not active)	pressurizer pressure < 11.7 MPa
Accumulators injection start	pressurizer pressure < 4.2 MPa
Accumulators injection stop	accumulator mass < 10 kg
LPIS injection start	pressurizer pressure < 2 MPa and max. rod temperature > 723 K

Tab. 1 : Imposed sequence of main events for SPES test SP-SB-04.

	UNIT	SPES SB-04
Break opening	s	0
Scram power curve enabled	s	7.5
Start of main coolant pumps coast down and its duration	s (s)	(7) 7.5 (9) (10)
Main steam line valve closure	s	7.5
Feedwater valve closure	s	15.5
Upper plenum in saturation condition	s	16
Pressurizer emptied	s	17
Break two phase flow	s	132
First dryout	s	131
Loop seal clearing	s	131.5 loop 1-3 No
Occurrence of minimum primary side mass	s	389 1468
Primary-secondary pressure reversal	s	138
Secondary dryout	s	-
Rewetting due to accumulators	s	-
Accumulators injection start	s	334.5
Accumulators injection stop	s	acc.1 978.5 acc.2 837.5
Final dryout	s	1234
LPIS start	s	1468.5
Final rewetting	s	1515
End of test	s	1637

Tab. 2 : SPES SP-SB-04 experiment: resulting sequence of main events.

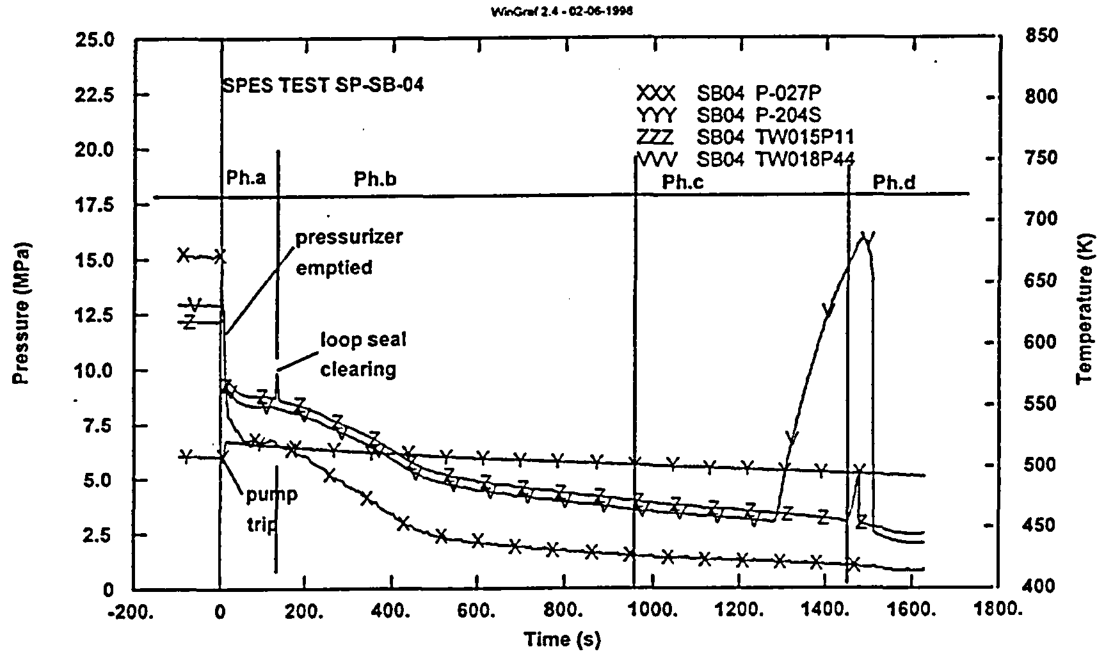

Fig. 3 : SP-SB-04 test - measured trends of primary pressure, secondary pressure and rod surface temperature

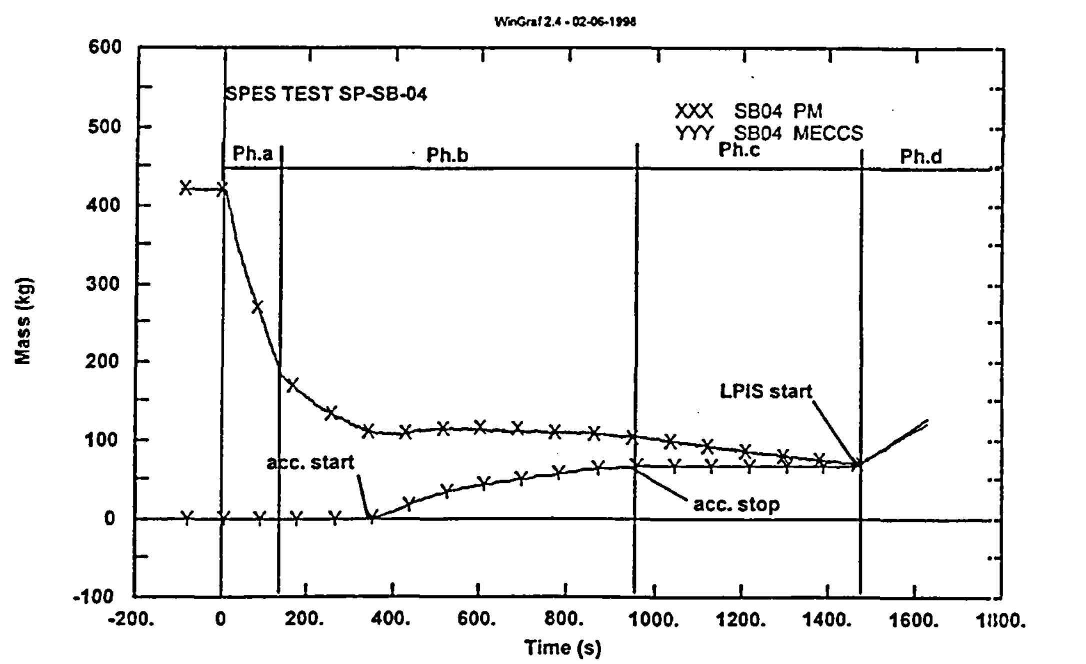

Fig. 4 : SP-SB-04 test - measured trends of primary mass and of ECCS delivered mass

3. ADOPTED CODE AND NODALIZATION

3.1 Relap5/Mod3.2 code

The light water reactor transient analysis code, RELAP5, was developed at the Idaho National Engineering Laboratory (INEL) for the U.S. Nuclear Regulatory Commission (NRC). Specific applications of the code have included simulations of transients in LWR system such as loss of coolant, anticipated transients without Scram (ATWS) and operational transients, such as loss of feed water, loss of offsite power, station blackout and turbine trip.

The Mod3 version of RELAP5 has been still developed by INEL, but a consortium consisted of several countries and domestic Organizations that were members of the International Code Assessment and Application Program (ICAP) and its successor organization, Code Application and Maintenance Program (CAMP), contributed to the development and validation process.

RELAP5/Mod3.2 code, refs. [10] and [11], is based on a non-homogeneous, non-equilibrium set of six partial derivative balance equations for the steam and the liquid phase. A non-condensable component in the steam phase and a non-volatile component (boron) in the liquid phase can be treated by the code. A fast, partially implicit numeric scheme is used to solve the equations inside control volumes connected by junctions.

In particular, the control volume has a direction associated with it that is 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 condition and are viewed as being 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. Control volumes are connected in series using junctions to represents flow paths.

Heat flow paths are also modeled in a one-dimensional sense, using a staggered mesh to calculate temperatures and heat flux vectors. The heat structure is thermally connected to the hydrodynamic control volumes through heat flux that is calculated using a boiling heat transfer formulation. The heat structures are used to simulate pipe walls, heater elements, nuclear fuel pills and heat exchanger surfaces.

Several new models, improvements to existing models and user conveniences have been added. The new models include:

- the Bankoff counter-current flow limiting correlation;
- the ECCMIX component for modeling of the mixing of the subcooled emergency core cooling system liquid and resulting interfacial condensation;
- a zirconium-water reaction model to model the exothermic energy production on the surface of zirconium cladding material at high temperature;
- a surface to surface radiation heat transfer model with multiple radiation enclosures defined through user input;
- a thermal stratification model.

3.2 General criteria adopted for the code models

A detailed nodalization reproducing each geometrical zone of the loop has been developed: in principle it is suitable for different types of transients.

The general methodology followed is described in refs. [11] and [12]. Being used, in this case, the Relap5/Mod3 code, great care is given to the information contained in the specific user manual. Nevertheless, it should be noted that this information alone is generally not exhaustive for the development of an adequate set of input data. So, few supplementary criteria, to those reported in the manual, have been fixed, as result of experience, in the attempt to set up a "homogeneous" nodalization, that is to avoid imbalance in the distribution of hydraulic and thermal meshes. Of course, the achievement of this objective, requires a good user knowledge of the reference facility characteristics. Moreover, the prevision of the phenomena to be simulated in the calculation can also have a role in this context. Compromises apply in the choice of number of nodes: on the one hand there is the need to develop a model adherent to the geometric and material particularities of the physical system, on the other hand computer capabilities (essentially CPU time) limit the maximum number of nodes.

Two limits have been fixed for the linear dimension of nodes: all the volumes should have their flow lengths comprised between 0.5 and 1.0 m (with the exception of core stack, much more detailed, of the descending zone of the SG U-tubes and of the pressurizer and accumulator surge lines, nodalized by 2.0 m length nodes). With regard to conduction heat transfer, the distance between neighboring mesh points inside structures must be less than 5 mm in each case, up to the lower limit of few tenths of mm used for heated rods and steam generator U-tubes. In the subdivision of volumes and slabs the position of instrumentation has been considered.

The following choices have been made with regard to code options:

- thermodynamic non-equilibrium is allowed in all control volumes;
- the smooth area change for all the junctions where it is allowed (i.e. excluding the motor valves);
- the stratification option is used in the junctions of the hot legs and cold legs horizontal parts.

3.3 SPES Nodalization Description

The Relap5/Mod3 nodalization for the SPES facility is shown in Fig. 5. The correspondence between the zones of the facility and the nodes of the code model is presented in Tab.3. In this table the facility is divided in zones, composed by various hydraulic elements. These components are reported in the table according to flow paths in nominal conditions. Number and type of the hydraulic nodes are indicated in the table itself.

The utilized code resources for the SPES nodalization are summarized in Table 4. In particular, the number of hydraulic components and of heat structure are reported.

Hereafter some significant aspects of the developed nodalization are summarized.

The vessel model consists of 45 hydraulic components which are connected through 48 junctions.

The heat structures used in the vessel model are made up of 78 heat slabs subdivided in:

- 24 active structures for the heaters exchanging heat with the pipe component 130 (composed by 12 volumes), where the overall power is dissipated: two stacks of 12 slabs simulate the three hot rods and the remaining 94 rods of the core bundle;
- 4 internal non-active structures simulate the connection zones (in the lower part and in the upper part of the bundle) exchanging heat with the branch components 100-01, 110-01, 120-01 and 140-01, where no power is assumed to be dissipated;
- 50 heat slabs simulate the vessel structures; in 19 over 50 slabs the heat exchange with the environment is imposed;

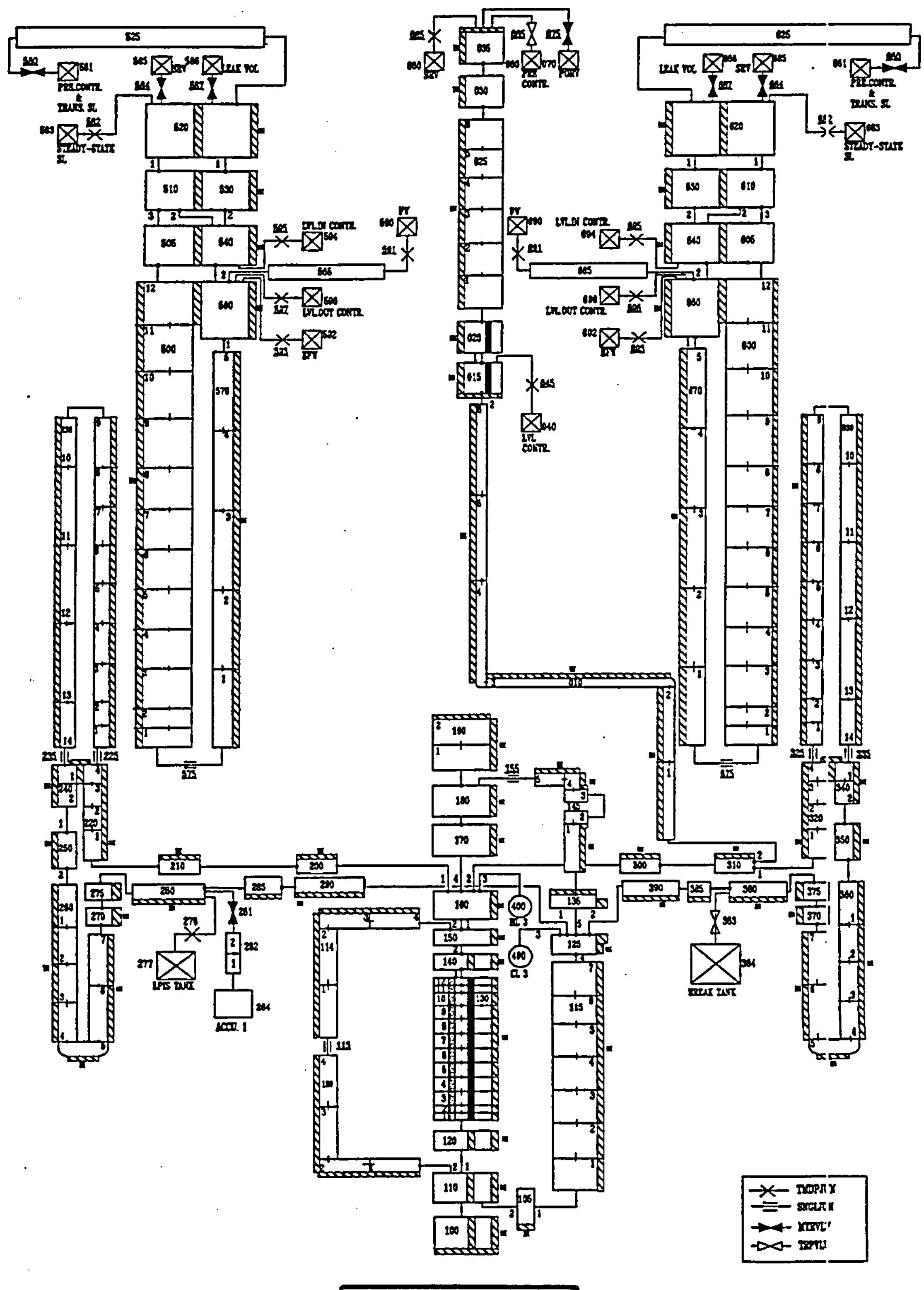

Fig. 5 : Relap5/Mod3 nodalization of SPES facility

GENERAL ZONE	NAME	NUMBER	TYPE
PRESSURE VESSEL	DOWNCOMER REGION	135	BRANCH
		125	BRANCH
		115	PIPE
		105	BRANCH
	LOWER PLENUM	100	BRANCH
		110	BRANCH
		120	BRANCH
	LP-UP BYPASS	112	PIPE
		113	SNGLJUN
		114	PIPE
	CORE REGION	130	PIPE
		140	BRANCH
	UPPER PLENUM	150	BRANCH
		160	BRANCH
	UPPER HEAD	170	BRANCH
		180	BRANCH
		190	PIPE
	DC - UH BYPASS	155	SNGLJUN
		145	PIPE
LOOP 1 (LOOP 2) [LOOP 3] PIPING	VESSEL NOZZLE	200 (300) [400]	BRANCH
	HOT LEG	210 (310) [410]	BRANCH
	SG INLET PIPE	220 (320) [420]	PIPE
	SG INLET JUNCTION	225 (325) [425]	SNGLJUN
	SG OUTLET JUNCTION	235 (335) [435]	SNGLJUN
	SG OUTLET PIPE	240 (340) [440]	PIPE
	LOOP SEAL	250 (350) [450]	BRANCH
		260 (360) [460]	PIPE
	PRIM. COOLANT PUMP	270 (370) [470]	PUMP
	COLD LEG	280 (380) [480]	BRANCH
		290 (390) [490]	BRANCH
PRESSURIZER	SURGE LINE	010	PIPE
	PRESSURIZER VESSEL	015	BRANCH
		020	BRANCH
		025	PIPE
		030	BRANCH
		035	BRANCH
	PRZ LEVEL CONTROLSYSTEM	045	TMDPJUN
		040	TMDPVOL
	PRZ PRESSURE CONTROLSYSTEM	065	TRPVLV
		060	TMDPVOL
	PORV	075	MTRVLV
		070	TMDPVOL
	PRESSURIZER LEAK	085	TMDPJUN
		080	TMDPVOL

Tab. 3 (part 1) : Relap5/Mod3.2 nodalization - correspondence between code nodes and hydraulic zones

GENERAL ZONE	NAME	NUMBER	TYPE
SG1 (2) [3] SECONDARY SIDE	U-TUBE	230 (330) [430]	PIPE
	RISER	500 (600) [700]	PIPE
	UPPER PLENUM	505 (605) [705]	BRANCH
	SEPARATORS	510 (610) [710]	SEPARATR
	STEAM DOME	520 (620) [700]	BRANCH
	DOWNCOMER	530 (630) [730]	BRANCH
		540 (640) [700]	BRANCH
		560 (660) [760]	BRANCH
		570 (670) [770]	PIPE
	DC-RISER CONNECTION	575 (675) [775]	SNGLJUN
	FEEDWATER LINE	590 (690) [790]	TMDPVOL
		591 (691) [791]	TMDPJUN
		565 (665) [765]	PIPE
	EFW SYSTEM	592 (692) [792]	TMDPVOL
		593 (693) [793]	TMDPJUN
	TRANSIENT STEAM LINE (PRE. CONTR. SYSTEM)	581 (681) [781]	TMDPVOL
		580 (680) [780]	MTRVLV
		525 (625) [725]	PIPE
	STEADY - STATE STEAM LINE	582 (682) [782]	TMDPJUN
		583 (683) [783]	TMDPVOL
	LEVEL CONTROL SYSTEM	594 (694) [794]	TMDPVOL
		595 (695) [795]	TMDPJUN
		596 (696) [796]	TMDPVOL
		597 (697) [797]	TMDPJUN
	SAFETY RELIEF VALVE	585 (685) [785]	TMDPVOL
		584 (684) [784]	MTRVLV
	SG LEAK	586 (686) [786]	TMDPVOL
		587 (687) [787]	MTRVLV
BREAK	BREAK VALVE	(383)	TRPVLV
	BREAK VOLUME	(384)	TMDPVOL
LPIS	LPIS JUNCTION	278 [478]	TMDPJUN
	LPIS TANK	277 [477]	TMDPVOL
ACCUMULATOR	ACCUMULATOR VALVE	281 [481]	MTRVLV
	ACCUMULATOR INJ LINE	282 [482]	PIPE
	ACCUMULATOR	284 [484]	ACC

Tab. 3 (part 2): Relap5/Mod3.2 nodalization - correspondence between code nodes and hydraulic zones

PARAMETER	VALUE
1. NUMBER OF NODES	
– primary side	165
– secondary side	99
– total	264
2. NUMBER OF JUNCTIONS	
– primary side	169
– secondary side	102
– total	271
3. NUMBER OF SLABS	
– primary side	224
– secondary side	75
– total	299
4. OVERALL NUMBER OF MESH POINTS	1615
5. NUMBER OF CORE ACTIVE STRUCTURES	24
6. HEAT TRANSFER AREA (m^2)	
– core region	10.596
– steam generator U-tubes	35.417
7. NUMBER OF MESH POINTS	
– core slabs	240
– stem generator slabs	351
8. BYPASS FLOW PATHS	
LOWER PLENUM - UPPER PLENUM	
– area (m^2)	$1.441 \cdot 10^{-3}$
– total energy loss coefficient [ΣK_i (forward)/ΣK_i (reverse)]	82/13.5
DOWNCOMER - UPPER HEAD	
– area (m^2)	$4.638 \cdot 10^{-4}$
– total energy loss coefficient [ΣK_i (forward)/ΣK_i (reverse)]	3.5/3.5
9. OVERALL VOLUME (m^3)	0.622

Tab. 4 : Relap5/Mod3 SPES nodalization - overview of code resources

In the vessel model all the bypass flow paths reported in the facility description have been modeled:

- bypass from lower plenum to upper plenum simulated by the pipe components 112 and 114 connected through the single junction 113;
- bypass from downcomer top to upper head simulated by the pipe component 145 and the single junction 155.

The three loops are almost equal in the nodalization (33 volumes, 32 junctions and 42 slabs) and are differentiated for the pressurizer (placed in loop 2). For simplicity the loop 3 is not shown in Fig. 5; it has the same features of the loop 1.

The steam generator U-tubes are modeled asymmetrically, assuming that the largest portion of the exchanged power between primary and secondary side occurs across the slabs of the rising part of the package.

The pumps in the three loops are considered equal; different working conditions are achieved by changing the shaft velocity. The related input two phase curve differences, which for completeness have been considered in the nodalization, have been set equal to ones related to the LOBI/Mod2 pumps.

Two additional systems can be noted in the pressurizer nodalization:

- a time dependent volume and related trip valve (component 60-01 and 65-01 respectively);
- a time dependent junction and related time dependent volume (components 45-01 and 40-01 respectively).

Both are control systems. The former system allows the primary side pressure to remain constant in the steady-state period. The latter system maintains at an assigned value the liquid level inside the pressurizer. The temperature of the fluid possibly injected by this system corresponds to the saturation conditions inside the pressurizer.

Still, the black structures inside the pressurizer model represent the internal heaters; they simulate in the code model also the external heaters installed in the facility.

The motor valve 75 and the related time dependent volume 70-01, connected to the top of the pressurizer, simulate the PORV system, while the time dependent volume 80 and the time dependent junction 85 simulate the leak detected in the pressurizer in a previous SPES test.

The slabs with an asterisk represent the zones where the heat losses to environment are considered.

Accumulators and related surge lines (with valves) and LPIS simulator are connected with the cold legs of the two intact loops.

The secondary side nodalization of the three steam generators are equal both concerning the hardware of the facility and the control system (33 nodes, 34 junctions and 25 head slabs): in particular the volume identification number can be obtained by changing the first digit in the loop 1 related one (6 in place of 5 for loop 2 and 7 for loop 3). So only one nodalization will be described hereafter.

Five zones can be recognized in each steam generator:

1. the downcomer, consisting of a single stack of nodes (the two external downcomers are gathered in a simple pipe component);
2. the riser zone, essentially including the U-tubes;
3. the top of the vessel, including the separator, the dryer and the steam done regions;
4. the steam line downstream the dome of each SG, simulated with the pipe component 525-01, the motor valve 580 and time dependent volume 581. This last component is also utilized like a pressure control volume imposing constant pressure in the volume itself;
5. the feedwater line connected to the top of the downcomer, simulated with the pipe component 565-01, time dependent junction 591 and the time dependent volume 590.

The degree of detail of the nodalization is commensurate to what considered in the primary loop. In particular, the heights of the riser volumes are the same as the minimum between the heights of the rising and descending corresponding nodes of the primary side U-tubes.

The components 510-01 simulates the separator that is necessary in the code model in order to achieve quality equal to one in the steam dome.

The pre-heaters are not simulated in the code model.

A relatively large number of control volumes are connected with the steam generators; the following functions are accomplished:

- feedwater injection and steam line previously described;
- EFW injection: simulated with the time dependent volume 592 and with the time dependent junction 593 (used only in the steam generator of the loop 1);
- SRV safety system: simulated with the time dependent volume 585 (safety tank) and with the motor valve 584 (safety valve);
- liquid level control system: realized through two time dependent volume components (596 and 594), each one connected with one time dependent junction (597 and 595 respectively). This system assures constant value for steam generator downcomer liquid level during the steady-state period.

3.4 Nodalization qualification

A nodalization representing an actual system (Integral Test Facility or plant) can be considered qualified when:

- it has a geometrical fidelity with the involved system;
- it reproduces the measured nominal steady state condition of the system;
- it shows a satisfactory behavior in time dependent conditions.

Taking into account these statements, a standard procedure to obtain a "qualified nodalization" has been defined, ref. [13].

The qualification process consists of two main phases:

1) **steady state level**: the nodalization is qualified against data available from nominal stationary conditions measured in the simulated system. To this aim:
   a) relevant geometrical parameters of the facility (e.g. volume, heat transfer area, elevations, pressure drops distribution etc.) are compared with the input data and the differences among them must be acceptably small. The adopted acceptability criteria are reported in the first part of Tab. 5 (see also Fig. 6);
   b) the nominal steady state conditions are simulated with a code running (a hundred seconds time interval is considered acceptable to reach correct steady state values); significant parameters are selected and compared with the measured results. A parameter is considered as significant when it is of major relevance in determining the plant behavior and can be reliably measured. The adopted acceptability criteria for this step are reported in the second part of Tab. 5 (see also Fig. 7).
2) **transient level**: the nodalization is tested in time-dependent conditions reproducing the available experimental transients. This phase also includes the procedure for the qualitative and the quantitative (through the application of the FFT based method) evaluation of the code accuracy, necessary to demonstrate the acceptability of the code transient performance. The demonstration of the quality of the nodalization at the transient level, before application to the reference calculation (SP-SB-04 in this case), involves at least one among the following steps:

a) perform a "K_v scaled" calculation aiming at the comparison between the nodalization performance and experimental data in another facility (proper scaling factors must be adopted to fix initial and boundary conditions);
b) compare results of the nodalization with experimental data different than those object of the reference calculations (these can be operational transient data in the case of a Nuclear Power Plant);
c) compare the results of the nodalization with calculations data coming from a previously qualified nodalization.

The idea of the "Kv-scaled" calculation (item a) comes from the objective to comparing calculated data with experimental data before adopting any nodalizations (i.e. including NPP nodalization) for any kind of calculation (code assessment, licensing, etc.). In this frame, adopting proper scaling criteria (time preventing, volume/power scaling) a comparison can be made between predicted and experimental data in the area of PWR and BWR. This must be used to detect nodalization and user choice inadequacies. Correction of errors or deficiencies leads to a "on transient" qualified nodalization ready to be used for other purposes

The acceptability constraints for the FFT (i. e. 0.4 for Average Accuracy and 0.1 for the primary pressure) must be fulfilled in any case.

The qualification process, summarized above, has been applied to the nodalization of SPES facility.

As concerns the first phase (steady state level), the steady state acceptability criteria previously defined (reported in Tab. 5) have been verified; in particular, the comparison between the calculated and the measured volume vs. height curve and the distribution of pressure drops along the length are reported in Figs. 6 and 7, respectively.

The second part of the qualification process (transient level) has been conducted through the steps b) and c) described above: in the first case the International Standard Problem 22, refs. [14] and [15], has been in considered, while in the second case the previous simulation with the version Relap5/Mod2, refs. [5] and [16], has been utilized (see also below).

It is to be mentioned that the application of the FFT based methodology has been exhaustively performed in the Relap5/Mod2 simulation of SP-SB-04. ref. [16], and it was not repeated in a systematic way for the Relap5/Mod3.2 simulation. No important differences related to any of the finding of the Relap5/Mod2 analyses are expected.

	QUANTITY	ACCEPTABLE ERROR (°)
1	Primary circuit volume	1 %
2	Secondary circuit volume	2 %
3	Non-active structures heat transfer area (overall)	10 %
4	Active structures heat transfer area (overall)	0.1 %
5	Non-active structures heat transfer volume (overall)	14 %
6	Active structures heat transfer volume (overall)	0.2 %
7	Volume vs. height curve (i.e. «local» primary and secondary circuit volume)	10 %
8	Component relative elevation	0.01 m
9	Axial and radial power distribution (°°)	1 %
10	Flow area of components like valves, pumps orifices	1 %
11	Generic flow area	10 %
(*)		
12	Primary circuit power balance	2 %
13	Secondary circuit power balance	2 %
14	Absolute pressure (PRZ, SG, ACC)	0.1 %
15	Fluid temperature	0.5 % (**)
16	Rod surface temperature	10 K
17	Pump velocity	1 %
18	Heat losses	10 %
19	Local pressure drops	10 % (^)
20	Mass inventory in primary circuit	2 % (^^)
21	Mass inventory in secondary circuit	5 % (^^)
22	Flow rates (primary and secondary circuit)	2 %
23	Bypass mass flow rates	10 %
24	Pressurizer level (collapsed)	0.05 m
25	Secondary side or downcomer level	0.1 m (^^)

(°) The % error is defined as the ratio $\frac{|\text{reference or measured value - calculated value}|}{|\text{reference or measured value}|}$

The «dimensional error» is the numerator of the above expression

(°°) Additional consideration needed

(*) With reference to each of the quantities below, following a one hundred s «transient-steady-state» calculation, the solution must be stable with an inherent drift < 1% / 100 s.

(**) And consistent with power error

(^) Of the difference between maximum and minimum pressure in the loop.

(^^) And consistent with other errors.

Tab. 5 : Criteria for nodalization qualification at the steady-state level.

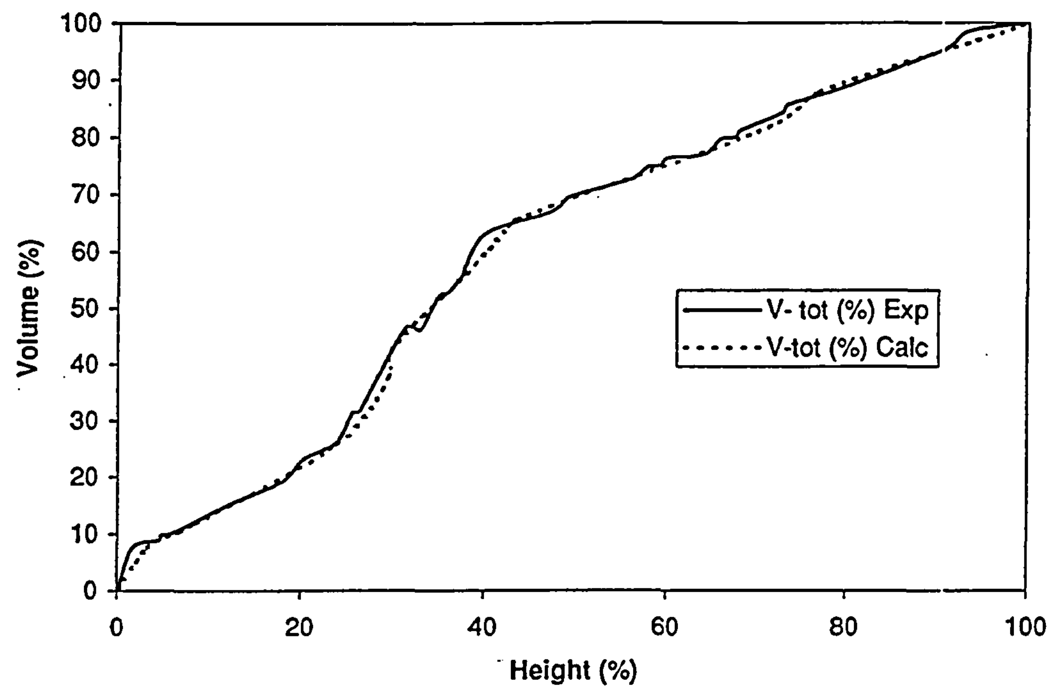

Fig. 6: Comparison between measured and calculated volume vs. height curve

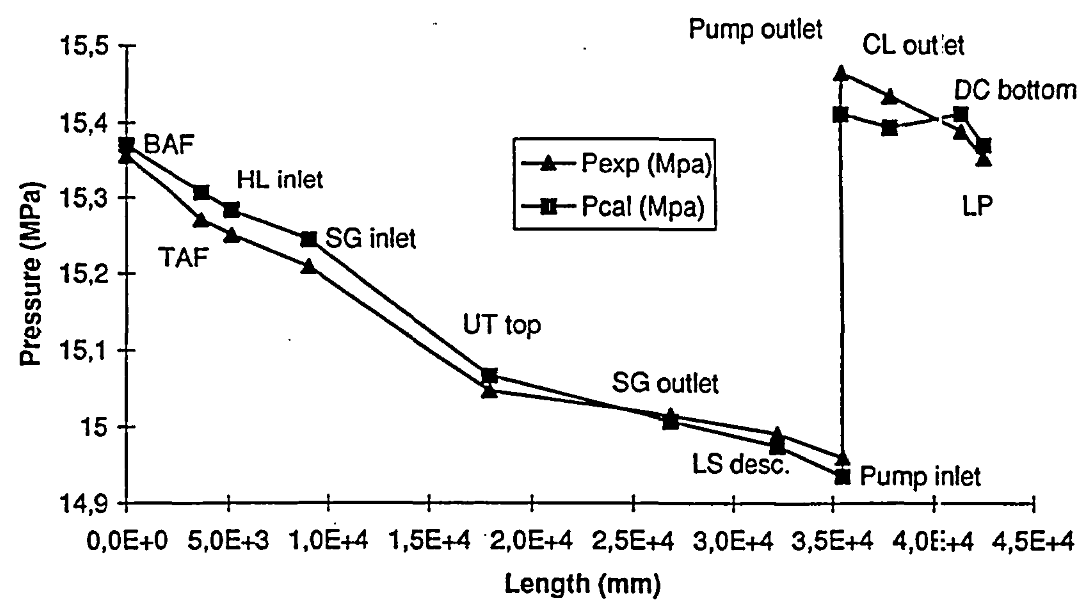

Fig. 7 : Comparison between measured and calculated DP vs. length curve

4. ANALYSIS OF POST TEST CALCULATION RESULTS

Results of code runs are discussed in this chapter. These include:

a) 100 s steady state;

b) reference calculation results;

c) results from sensitivity studies.

It may be noted that item a) constitutes the final part of the nodalization qualification process described in the previous chapter. In addition, qualitative and quantitative accuracy evaluations have been performed and are documented for the 'reference calculation', and only quantitative accuracy is calculated for the 'sensitivity studies'.

When calculating the quantitative accuracy, twenty-three time trends have been selected in relation to which experimental data exist: these are assumed to be the minimum number of measured quantities that fully describe the experimental scenario. The related list is given in the first column of Tabs. 10 and 12.

When calculating qualitative accuracy, including the comparison between time trends, reference is made to the same list (e.g. App.s 2 and 3) of Tab. 12 with the following changes:

* quantities 04 and 03 in Tab. 12 are both reported in Fig. 3; so quantities from 05 to 23 are shown in Figs. 4 to 22, respectively;

* the following quantities have been added to the comparison: pressure drop across DC-UH bypass, pressure drop in the U-tubes ascending leg (also a measure of liquid hold-up in the U-tubes), core inlet flowrate, pressure drop in cold leg, mass flowrate in SG downcomer, hot leg mass flowrate; these are reported in Figures from 23 to 28, respectively. Fig. 29 has been added to give an overall view of the system performance (primary and secondary pressure together).

4.1 Steady State calculations

A steady state calculation, by running the code with the 'TRANSNT' (transient) option for 100 s has been completed. This constitutes the final step of the nodalization qualification process at steady state level.

The related results are shown in Tab. 6 and in App. 2. In both cases, resulting values are compared with experimental data. In the case of Tab. 6, for completeness, the data calculated by Relap5/mod2 are included as taken from ref. [5].

It may be noted that the data in Tab. 6 deal with most of the parameters imposed for the nodalization qualification process (Tab. 5): the values in the table have been taken from the code output at 100. s. The time trends above identified are part of the App. 2, numbering of figures is different owing to the obvious lack of time trends dealing with ECC and break flowrates.

The analysis of data brings to the following conclusions:

- the criteria for nodalization qualification are fulfilled, though the complete comparison between data in Tab. 6 and in App. 2 with acceptability criteria has not been done owing to the lack of experimental data; in addition, some of the criteria can be matched by considering sums or combinations of values from Tab. 6 (e.g. the primary circuit power balance can be obtained by considering data at items 1, 4, 14, 16 and 17); still, the error on bypass flowrate, can be better seen by considering the errors in fluid temperatures owing to the fact that the direct experimental information about bypass flowrate is uncertain (measurement error not available);
- the calculated values are stable as it results from Figs. 1 to 26;
- differences between Relap5/mod2 and Relap5/mod3.2 codes results are negligible;

- discrepancies between measured and calculated values of heater rod temperatures, Figs. 8 to 10 in App. 2, come from the position of thermocouples and from generic experimental error (the calculation result refer to the surface, the experimental data are taken slightly inside the surface, the error almost disappears at low linear rod power, during the transient);
- the discrepancy in Fig. 14 (pressure drop across steam generator) is attributed to the experimental error and to the position of the measurement pressure taps not accounted for by the calculated results;
- the last explanation is also valid in the cases of pressure drops in Figs. 16, 17, 19, 20 and 21; the unknown position of pressure taps is specifically valid in the case of Fig. 20;
- the discrepancy in Fig. 23, related to the recirculation mass flowrate in the steam generator, can also be originated by a measurement error; however, in this case tuning or adjustments of steady state code results was considered unnecessary owing to the low influence that this parameter has in the selected transient (early main coolant pump and feedwater trips occur).

4.2 Reference calculation results

The post-test calculation was performed starting from the input deck suitable for Relap5/mod2. A 'blind' post test was performed by Relap5/mod3.2 constituting the reference calculation for this study (label S4R0); the related time trends and significant single valued parameters are reported, together with experimental data, in App. 3 and in Tab. 7, respectively. The input deck of the reference calculation is reported in App. 5.

A comprehensive comparison between measured and calculated trends or values was performed, including the following steps:

a) comparison between experimental and calculated time trends on the basis of the 29 variables introduced above (App. 3);

b) comparison related to the timing of the resulting events, Tab. 7;

c) qualitative evaluation of calculation accuracy on the basis of the phenomena included in the CSNI matrix, refs. [17] and [18], as given in Tab. 8;

d) qualitative evaluation of calculation accuracy on the basis of the Relevant Thermalhydraulic Aspects (RTA, also used for code uncertainty derivation, e.g. ref. [6]), as given in Tab. 9;

e) quantitative evaluation of calculation accuracy, utilizing the FFT based method, described in refs. [7] and [19], see also App. 1, as given in Tab. 10.

Comments related to items a) and b) are given below, distinguishing groups of homogeneous variables and at the same time some RTA evidence are outlined considering the trend of related parameters; the discussion about items c), d) and e) is given in sect. 4.2.1. An asterisk (*) identifies the items that are subject to sensitivity analyses.

Absolute Pressures

The primary system pressure is well predicted by the code (Fig. 8 below and Fig. 1 in App. 3): the phenomenological phases (e.g. subcooled blowdown, saturated blowdown and steam flow from the break) can be easily recognized from the calculated time trend.

The steam generator pressure is slightly underpredicted as shown in Fig. 2 of App. 3; reasons for this appear connected with the overestimation of heat transfer between primary and secondary sides and, eventually, with overestimation of heat losses from secondary side to the environment; a role could be held in this connection, by minor discrepancies (undetected, so far) between measured and calculated closure times of feedwater and steam lines valves.

The accumulator pressures are well predicted starting from the accumulator injection time that is very well predicted as shown also from the data in Tab. 7 (comparison between experiment and S4R0 results). The final pressure measured during the test for one of the accumulators is lower than the calculated value, as results from Fig. 3 in App. 3. Reason for this cannot be understood from the experimental data base; apparently, the isolation valve closed with some delay.

Fluid temperatures

Measured and calculated fluid temperatures are compared in Figs. 4, 5, 6, and 8 of App. 3, the last one related to the steam generator and the other ones related to the primary circuit.

Good agreement can be observed from Fig. 4 (core inlet fluid temperature) from where the start of saturated blowdown can be identified. The predicted core outlet fluid temperature presents a superheating larger than in the experiment toward the end of the transient. The position of the thermocouple strongly affects this time trend. This is specifically true for the upper head fluid temperature where a very high superheating is measured; in this case, it seems evident that the thermocouple gives a measure of the structural mass temperature starting from about 200 s into the transient, i.e. following the emptying of the upper head.

The underprediction of the fluid temperature in the bottom of the steam generator downcomer (Fig. 8 in App. 3) derives from the same reasons discussed for the pressure.

Mass flowrates

The measured values of break flowrate (Fig. 9 below and Figs. 7 and 9 in App. 3), the ECCS flowrate (Fig. 10 below and Fig. 10 in App. 3), core inlet (Fig. 25 in App. 3), hot leg mass flowrate (Fig. 28 in App. 3) and the steam generator downcomer flowrate (Fig. 27 in App. 3) are compared with the respective calculated trends.

Break flowrate is overpredicted (*); however, the related error can be considered within the uncertainty bands.

ECCS flowrates are clearly overpredicted; the reason for this seems connected with the experimental errors+ (*).

The error in core inlet flowrate appears a consequence of instrumentation inadequacy as also results from observing the good agreement between measured and calculated trends of hot leg flowrates: the "inadequacy of instrumentation" derives from the phenomenon of stream at core inlet (saturation conditions, see also Fig. 4 in App. 3) that causes high volumetric flow not corresponding to high mass flow. Oscillations appear in the calculated trends (mostly one of the loops) of hot leg flowrates, starting from about 400 s into the transient; these could be explained with the 'siphon condensation mechanism', described in ref. [20]: the siphon condensation is a natural circulation mode that appears in the primary side loop of a PWR when mass inventory value is about 70% of the initial mass. In this condition steam coming from the core, condenses in the rising part of U-tubes; however due to CCFL (counter current flow limitation) at U-tubes inlet, the condensate does not drain back to the core, and liquid level formation occurs in the ascending side of U-tubes (in this phase zero flow cold leg occurs). This situation is valid until the liquid level reaches the top of the U-tubes, when the siphon effect occurs, causes liquid

+ A data base for an experiment typically consists of several hundreds time trends (up to 2000s) and hundreds of point values or time functions for boundary and initial conditions, plus indications about status of valves, pumps and of various systems; the data base, as in the present case, is judged as qualified in a global sense, and it is certainly suitable for code assessment purposes. However this does not imply that all the supplied values are unaffected by more or less large errors. Typical examples, in the present data base are constituted by the core mass flowrate that is inconsistent with data for hot legs flowrate, and by accumulators integral mass flowrate that is inconsistent with the supplied data for accumulators injected mass and primary system mass inventory.

draining to cold legs ant to the core. The cycle may repeat several time in a real siphon. Liquid accumulation may be due either to condensation or de-entrainment of droplets carried by the two phases mixture.

Following the steady state misprediction (already discussed), steam generator downcomer flowrates (experimental and calculated values) substantially agree and achieve a value close to zero.

Residual Mass

A good agreement between measured and calculated trends can be observed from Fig. 14 of App. 3; this is at the origin of the conclusions previously drawn, connected with reliability of ECC related instrumentation.

Pressure drops

Pressure drops between different points of the primary circuit are considered in the comparison, e.g. Figs. 17, 19, 20, 22, 23, 24 and 26 in App. 3. All of the comparisons, with different extent, suffer of the limitation already explained in sect. 4.1 (pressure taps not coincident with the center of the volumes of the nodalization).

The transient comparison is acceptable in relation to all the considered trends also having in mind the above limit. Deep studies of local phenomena could be carried out, starting from those trends, to improve the comparison leading to a 'tuned input deck'. This has not been among the purposes of the present activity.

Levels

The pressurizer level (Fig. 11 below and Fig. 21 in App. 3) is very well predicted in the calculation, testifying of the good prediction of the subcooled blowdown flowrate.

Core collapsed level constitutes a critical quantity during this experiment, as the level variations are directly connected with the occurrence of core dryout. The experimental trend (e.g. Fig. 12) is characterized by a lower peak at the transient beginning, when a short duration dryout is also observed; the related PCT (Peak Cladding Temperature) is only 15 K higher than the saturation temperature. A wider core level depression occurs starting from about 1400 s into the transient leading to the final dryout, quenched by LPIS injection. The trend of this variable is strongly affected by the distribution of pressure drops along the loop that also influence the occurrence of threshold phenomena like loop seal clearing.

Core level seems badly predicted (Fig. 12 below and Fig. 15 in App. 3); however, the calculated curve qualitatively reflects the experimental one (*). Reasons for quantitative discrepancies in this case, are connected with the method used to derive the level in the experiment (in other words the definition of experimental collapsed level is different from the quantity calculated by the code) and with the distribution of pressure drops in the entire loop that are not fully 'tuned', as remarked before. Additional reasons are frequently introduced in the literature to explain such discrepancies involving the poor prediction of interfacial drag in the core and the CCFL phenomena in various parts of the loop: clearly these roots of error cannot be excluded here.

Rod Surface Temperatures

When analyzing the rod surface temperature trends, the three-dimensional situation in the core must be considered as described into detail in ref. [8].

Representative experimental data at three core levels have been selected for the present comparison, distinguishing in the axial sense, the core bottom, the core middle and the core top regions (Figs. 11 to 13, respectively in App. 3, and Fig. 13 below related to the top region).

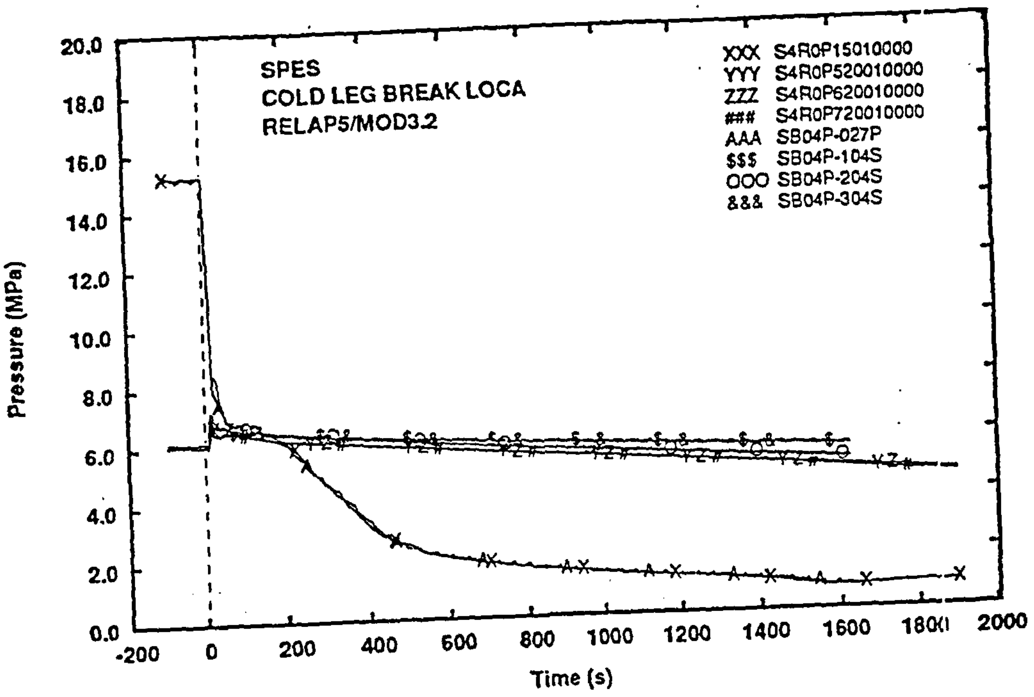

Fig. 8 : SPES post test SP-SB-04 (reference calc.) - primary and secondary pressure

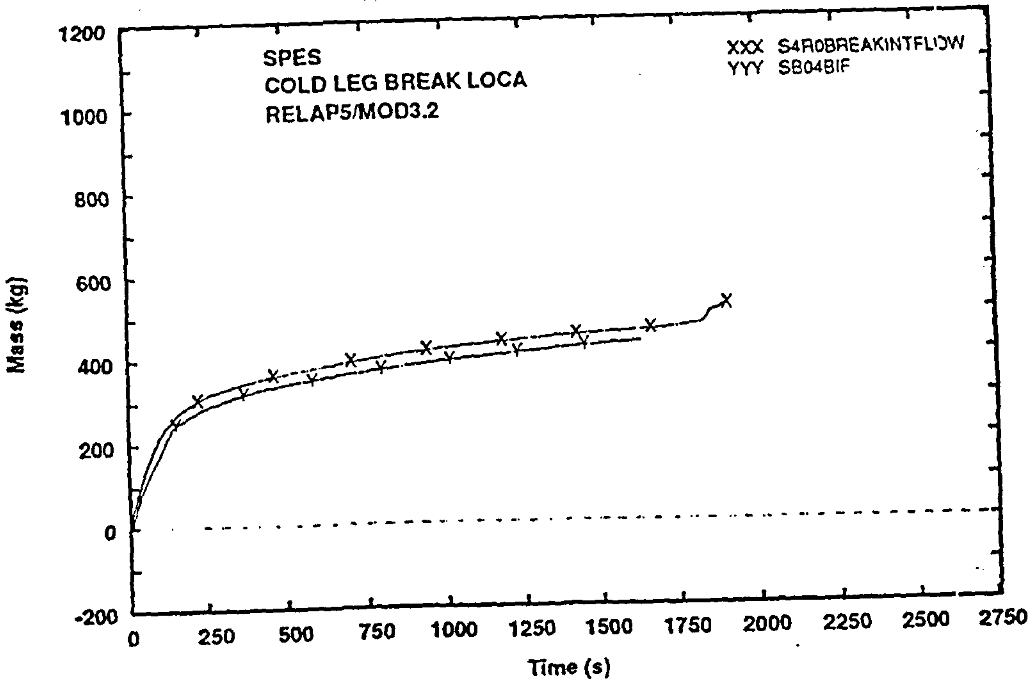

Fig. 9: SPES post test SP-SB-04 (reference calc.) - integral break flow rate

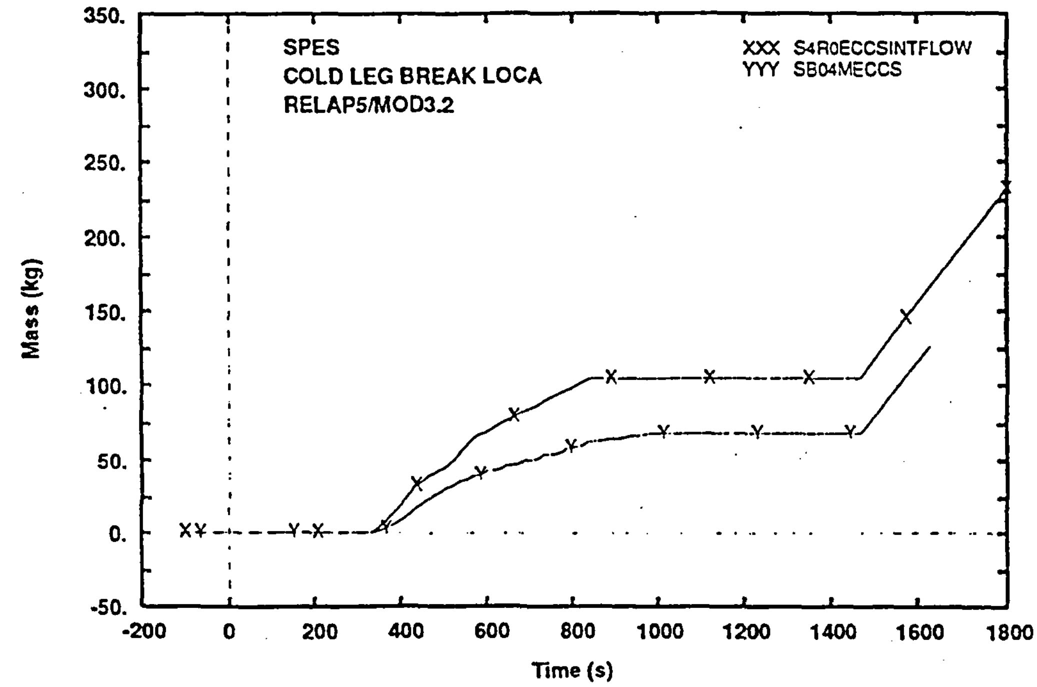

Fig. 10 : SPES post test SP-SB-04 (reference calc.) - ECCS integral flow rate

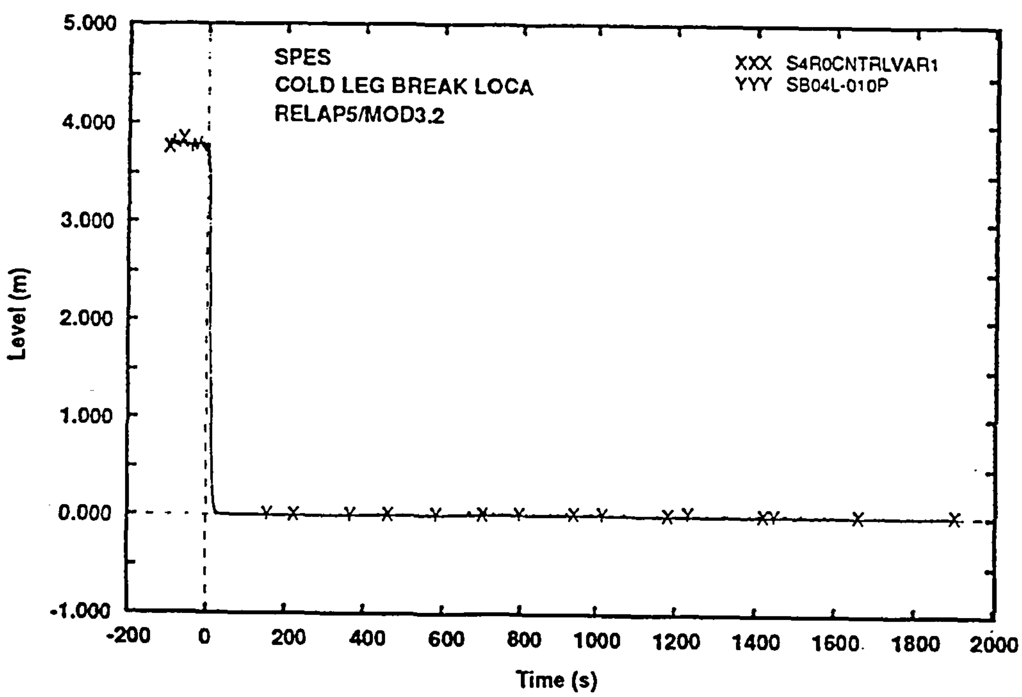

Fig. 11 : SPES post test SP-SB-04 (reference calc.) - pressurizer level

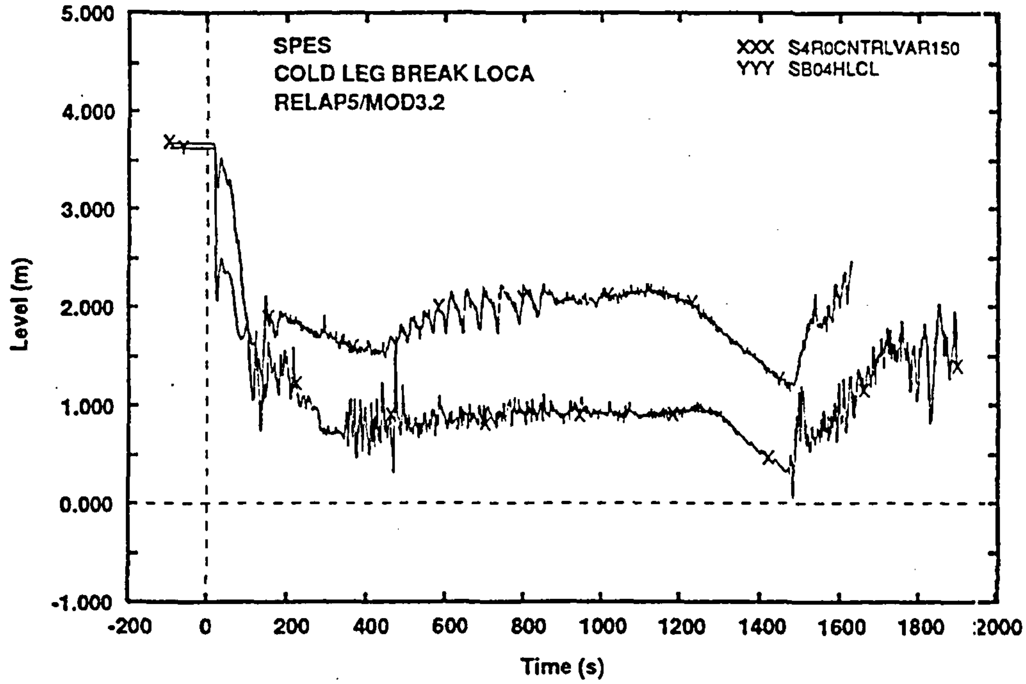

Fig. 12 : SPES post test SP-SB-04 (reference calc.) - core level

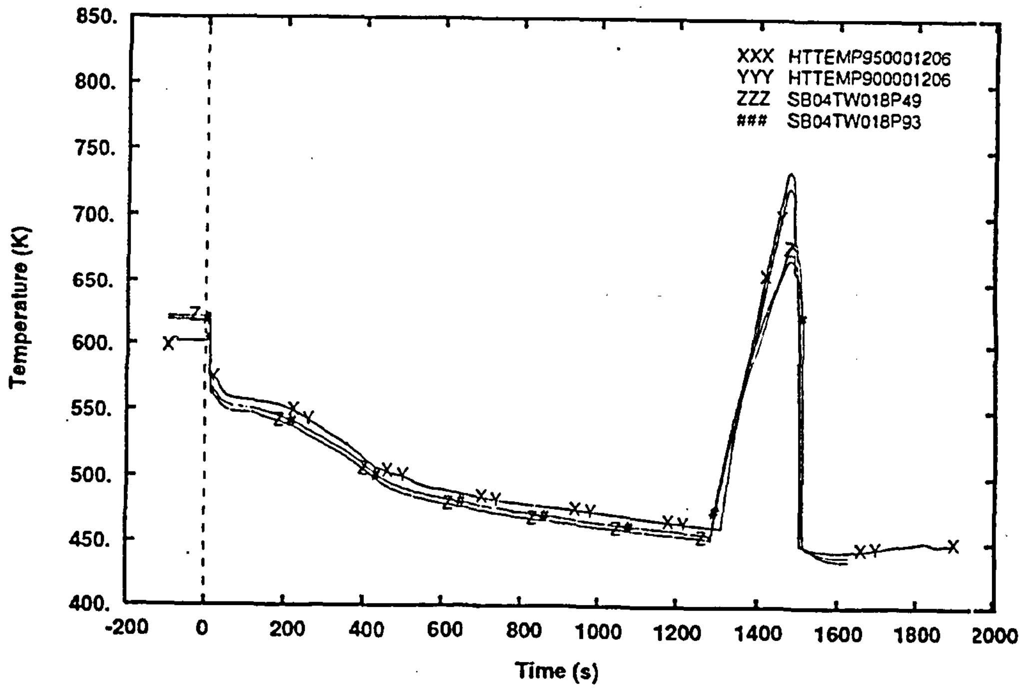

Fig. 13 : SPES post test SP-SB-04 (reference calc.) - rod surface temperature (high level)

QUANTITY	UNIT	EXP	CALC (R5/M2)	CALC (R5/M3.2)
1) Core power	MW	5.715	5.715	5.717
2) Pressurizer pressure	MPa	15.16	15.18	15.18
3) Pressurizer level	m	3.77	3.77	3.77
4) Core mass flow rate	kg/s	30.5	29.2	31
5) Core bypass mass flow rate	kg/s	0.96	1.59	1.6
6) DC-UH bypass mass flow rate	kg/s	0.31	0.56	0.58
7) Primary pumps speed	rad/s	318 325 319	321 321 321	321 321 321
8) Core inlet temperature	K	561	559	559
9) Core outlet temperature	K	594.9	594	592
10) Core ΔT	K	33.9	35	33
11) Upper head temperature	K	555	556	555
12) Primary mass	kg	420	423.5	423.8
13) Acc. liquid temperature	K	322.5 322.7	322.5 322.7	322.5 322.6
14) Secondary pressure SG	MPa	6.15	6.15	6.15
15) SG downcomer level	m	12.5	13	13.0
16) Feedwater temperature	K	431.6 431.1 433.5	431 431 431	431 431 431
17) Feedwater flow rate	kg/s	1.03 0.79 0.86	0.882 0.882 0.882	0.882 0.882 0.882
18) Total primary side heat losses	kW	n.a.	159	158.89
19) Secondary side heat losses	kW	n.a.	74	74.3

Tab. 6 : Comparison between measured and calculated (Relap5/Mod2 and Relap5/Mod3.2) relevant initial and boundary conditions

		EXP.	S4R0	S4R1	S4R2	S431	S332	S433	S4R4	S4R5	S4R6	S4R7	S4R8	S4R9	S4RA
Break opening	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scram time	s	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Start of MCP coast down	s	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
MSIV closure	s	8.5	7.5	7.5	6	5	5	5	5	7	5	6	6	6	6
FW closure	s	15.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Presurizer empty	s	17	23	29	23	23	23	22	29	23	22	23	23	22	22
First dry out occurence/PCT	s/K	131/577	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Loop seal clearing	s	-/131/-	132/108/156	n.a.	n.a.	174/159/191	145/157/192	143/159/189	207/-/207	147/171/190	n.a.	168/130/170	145/122/188	156/179/-	157
Minimum primary system inventory	s	1468	1469	1596	1701	1536	1585	994	1727	1488	1461	1530	1486	1484	319
Primary - secondary pressure reversal	s	160	189	230	190	193	191	191	224	185	185	193	187	185	173
Second dry out occurence/PCT	s/K	-/-	-/-	296/553	-/-	370/556	358/557	360/557	419/710	-/-	339/629	-/-	-/-	-/-	224/717
Rewetting due to accumulators	s	-	-	485	-	385	477	46	522	-	367	-	-	-	423
Accumulators injection start	s	334	332	390	329	331	329	333	395	331	323	339	333	323	304
Accumulators Injection stop	s	978/837	838	1010	981/840	870	930	723	1080	1488	872	870	844	846	754
Final dry out occurrence/PCT	s/K	1234/697	1310/733	1450/729	1532/728	1371/728	1362/728	871/733	1557/728	1318/730	1300/733	1373/728	1329/728	1310/730	634/727
LPIS start	s	1468	1465	1595	1698	1536	1582	994	1727	876	1461	1530	1486	1484	1140
Final rewetting	s	1515	1505	1698	1735	1576	1622	1034	1756	1526	1501	1566	1528	1523	1198
End of test	s	1637	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900

Tab. 7 : Resulting sequence of events, comparison among experimental test and calculated results

Predicted rod surface temperature trends follow qualitatively and quantitatively well the measured values. The first dryout appearing in the middle core region (Fig. 12 in App. 3), only 15 K overheating, is not predicted by the calculation. The last dryout situation is very well predicted by the calculation both in terms of timing and of PCT (Figs. 12 and 13 in App. 3); this dryout does not appear in the bottom core region neither in the experiment nor in the calculated results.

Evidence of some RTA based on specific parameters trends

Clearly the parameters trends described above are not independent upon each other. Some interactions, identifiable both in the experimental and in the calculate data base, are mentioned hereafter:

- the end of subcooled blowdown can be clearly seen by the decreasing of the rate of change of the primary side pressure and of the break integral mass flowrate (Figs. 8 and 9);
- the first core level depression at about 100 s. into the transient (Fig. 12) brings the system to condition close to the core dryout as it can be seen in Fig. 12 in App. 3; suitable core cooling condition are reestablished after loop seal clearing;
- the second core level depression at about 400 s. into the transient (Fig. 12) is the consequence of primary mass inventory depletion (Fig. 14 in App. 3); accumulators intervention causes the establishment of adequate core cooling conditions;
- the third core level depression at about 1500 s. into the transient (Fig. 12) causes extended core dryout (Fig. 13) that is quenched by LPIS actuation (Fig. 10);
- the emptying of pressurizer (Fig. 11) occurs in the period during a deep negative gradient of primary side pressure;
- steam generator secondary side acts as a heat sink only in the first period of the transient; afterward essentially it acts as a heat source for the primary side fluid as can be seen in Fig.29 in App. 3. However, the thermal power exchanged across the U-tubes is limited by the low value of mass flow rates (Fig. 28).

4.2.1 Qualitative and quantitative accuracy evaluation

Qualitative accuracy

A part of the qualitative accuracy evaluation has already been completed, consisting of the consideration in sect. 4.2, leading to three starred items that are at the basis of the design of sensitivity calculations.

The qualitative accuracy evaluation here discussed is based upon a systematic procedure consisting in the identification of phenomena (CSNI list) and of RTA. In both cases five levels of judgement are introduced (E, R, M, U, and -) whose meaning is detailed in the notes of Tab. 8 and in App. 1. The related results are reported in Tabs. 8 and 9, where for completeness the information related to Relap5/mod2 results, are given.

A positive overall qualitative judgement is achieved if 'U' is not present; in addition, the parameters characterizing the RTA (i.e., SVP = Single Valued Parameter, TSE = parameter belonging to the Time Sequence of Events, IPA= Integral Parameter and NDP = Non Dimensional Parameter) give an idea of the amount of the discrepancy.

In the present case the following conclusions could be reached:

a) no 'U' mark is present;

b) all RTA of the experiment are present in the calculated data base with the exception of the one dealing with the first dryout; in this case, the following considerations apply:
 - very small values characterize the related PCT and duration;

- the Aspect occurs only at one core elevation and at that core elevation it does not occur in all positions;
- the occurrence of the RTA has not any consequence on the remaining part of the test; in other terms it does not trigger any event or system scenario bifurcation.

  As a consequence of the above this RTA has no role in the evaluation of code calculation performance;

c) the accuracy evaluation by adopting RTA and Key Phenomena, supports the conclusion that the calculation is qualitatively correct.

Quantitative Accuracy

The positive conclusion of the qualitative accuracy evaluation, makes it possible addressing the quantitative accuracy evaluation. To this aim a special methodology, developed at University of Pisa, and widely used has been adopted.

The methodology is based upon the use of the Fast Fourier Transform (e.g. ref. [18]); its main features are detailed in App. 1.

The results of the application of the method are given in Tab. 10, where again the information related to Relap5/mod2 calculation is given too. The conclusions from the quantitative accuracy evaluation analysis are as follows:

a) the achieved results are well below the acceptability threshold both in relation to the overall accuracy (AA = 0.24 compared with the acceptability limit of 0.4) and the primary system pressure accuracy (AA = 0.055 compared with the acceptability limit of 0.1);

b) the achieved results appear slightly better than those obtained by Relap5/mod2.

Definitely, the documented reference calculation is acceptable from the code assessment point of view; i.e. the code is positively assessed in relation to its capabilities to predict this kind of transient.

Design of sensitivity calculation

Following the performed qualitative and quantitative accuracy evaluation there is no need to perform additional calculations.

Therefore, the planned sensitivity analyses are carried out with the main purpose of understanding the code behavior (including the robustness of the present solution) rather than following needs from accuracy evaluation. Nevertheless, emphasis is given to the findings of sect. 4.2 and the following objectives for the analyses are established, aiming at addressing the starred (*) items in sect. 4.2:

1) prediction of break flowrate;
2) prediction of ECCS flowrate with main emphasis to the accumulator delivered mass;
3) prediction of the core level.

PHENOMENA	FACILITY	EXPERIMENT	JUDGEMENT OF CALC.	JUDGEMENT OF CALC.
	SPES	SP-SB-04	RELAP5/M2	RELAP5/M3.2
Natural circulation in one-phase flow	o	+	R	R
Natural circulation in two-phase flow	o	+	R	R
Reflux condenser mode and CCFL	+	-	M	M
Asymmetric loop behavior	o	+	M	M
Leak flow	+	o	M	M
Phase separation without mixture level formation	o	-	-	-
Mixture level and entrainment in SG secondary side	+	-	-	-
Mixture level and entrainment in the core	+	+	M	M
Stratification in horizontal pipes	+	+	M	M
Emergency core cooling mixing and condensation	+	+	R	R
Loop seal clearing	o	o	M	M
Pool formation in upper plenum - CCFL	+	-	-	-
Core wide void and flow distribution	-	-	-	-
Heat transfer in covered core	o	o	R	R
Heat transfer in partially uncovered core	+	o	R	R
Heat transfer in SG primary side	o	o	M	M
Heat transfer in SG secondary side	o	-	M/R	M/R
Pressurizer thermalhydraulics	+	+	E	E
Surge line hydraulics (CCFL choking)	+	-	-	-
One and two phase pump behavior	+	+	-	-
Structural heat and heat losses	+	+	R	R
Non condensable gas effect on leak flow	+		-	-
Phase separation in T-junctions	+	+	M	M
Separator behavior	-	-	-	-
Thermalhydraulic nuclear feedback	-	-	-	-
Boron mixing and transport	-	-	-	-

For the test facility vs. phenomenon:
- o suitable for code assessment
- \+ limited suitability
- \- not suitable

For phenomenon vs. test:
- o experimentally well defined
- \+ occurring but not well characterized
- \- not occurring or not measured

For phenomenon vs. calculation:
E = Excellent
R = Reasonable
M = Minimal
U = Unqualified
\- = Not applicable

Tab. 8 : Judgment of code calculation performance on the basis of phenomena included in the CSNI matrix

		UNIT	EXP	CALC (R5/M2)	CALC (R5/M3.2)	Judgment M2/M3.2
Phase a: subcooled blowdown and first core dryout rewet						
Break opening	TSE	S	0	0	0	
Scram power curve enabled	TSE	s (MPa)	7.5 (12.2)	7.5	7.5 (11.5)	
Start of main coolant pumps coast down and its duration	TSE	s (s)	(7) 7.5 (9) (10)	(7) 7.5 (9) (10)	7.5 (11.5)	
Main steam line valve closure	TSE	s (MPa)	8.5	5	7.5 (11.5)	R/R
Feed water valve closure	TSE	s (MPa)	15.5	15.5	7.5	E/R
Upper plenum in sat.conditions	TSE	S	16	14	16	E/E
Pressurizer emptied	TSE	S	17	16	16	E/E
Integrated break flow rate	IPA	Kg	29	63	83.3	M/M
Break two phase flow	TSE	S	132	64	54	M/M
First dry out	TSE	S	131	-	-	M/M
peak cladding temperature	SVP	K	577	-	-	
average linear power	SVP	kW/m	0.67	0.67	-	
maximum linear power	SVP	kW/m	0.80	0.80	-	
core power / primary mass	SVP	kW/kg	1.21	1.64	1.23	R/E
primary mass / initial mass	SVP	%	47	34.5	48	R/E
Loop seal clearing	TSE	s (MPa)	131.5 loop 1-3 no	loop 2 58 loop 1&3 120	132 108 156	M/M
Time when rewet is completed	TSE	S	139	-	-	
Phase b: saturated blowdown and primary to secondary pressure decoupling						
Primary-secondary pressure reverse	TSE	S	160	138	189	E/R
Second dry out	TSE	S	-	-	-	
peak cladding temp.	SVP	K	-	-	-	
average linear power	SVP	kW/m	0.39	0.39	0.39	E/E
core power/primary mass	SVP	kW/kg	1.28	1.65	1.66	R/R
Occurrence of minimum primary side mass	TSE	s (kg)	389 (106) 1468 (69)	349 (84) 1423 (63.3)	356 (87.9) 1469 (78.6)	R/R
Av. linear power at time of min. mass	SVP	kW/m	0.40	0.39	0.37	R/R
Minimum mass/ITF volume	SVP	kg/m^3	170	135	141.3	R/R
Rewetting due to accumulators	TSE	S	-	-	-	
Accumulators injection starts	TSE	s (MPa)	334.5 (4.2)	350	332 (4.21)	R/R
minimum mass/initial mass	SVP	%	25	20	20.8	R/R
Accumulators injection stops	TSE	s (MPa)	978.5(1.44) 837.5 (1.6)	978.5 837.5	838 (1.68)	E/R
primary mass/initial mass	SVP	%	26.4/24.3	21 / 21	28.4	R/
Phase c: mass depletion in primary loop						
Final dry out (range)	TSE	s	1234/1455	1257/1373	1310/1373	R/R
peak cladding temperature	SVP	K	697	725	733	R/R
average linear power	SVP	kW/m	0.28	0.28	0.26	E/E
core power/primary mass	SVP	kW/kg	1.2	1.43	1.17	E/E
primary mass/initial mass	SVP	%	23.8	17	20.5	R/R
Rate of surface temperature increase	SVP	K/s	1.08	1.48	1.6	R/R
Phase d: intervention of Low Pressure Injection System						
LPIS start	TSE	s (MPa)	1468.5	1421	1465 (0.92)	R/E
primary mass/initial mass	SVP	%	16	15	18.6	E/R
Final rewetting	TSE	s	1515	1456	1505	R/R
End of test	TSE	s (MPa)	1637 (0.8)	-	1900 (0.83)	/R

Tab. 9 : Judgment of code calculation on the basis of relevant thermalhydraulic aspects

PARAMETER	R5/M2		R5/M3	
	AA	WF	AA	WF
01 – PRZ pressure	0.08	0.06	0.055	0.066
02 - SG pressure - secondary side	0.19	0.06	0.166	0.056
03 – ACC pressure	0.18	0.06	0.104	0.061
04 – ACC pressure	0.18	0.06	0.067	0.09
05 – Core inlet fluid temperature	0.04	0.05	0.031	0.046
06 – Core outlet fluid temperature	0.07	0.04	0.061	0.035
07 – Upper head fluid temperature	0.37	0.09	0.373	0.071
08 – Integral break flow rate	0.32	0.06	0.064	0.057
09 - SG DC bottom fluid temperature	0.18	0.07	0.199	0.056
10 – Break flow rate	1.09	0.13	0.965	0.133
11 – ECCS integral flow rate	0.37	0.08	0.396	0.043
12 – Heater rod temp. (bottom level)	0.05	0.08	0.046	0.066
13 – Heater rod temp. (middle level)	0.32	0.05	0.373	0.033
14 – Heater rod temp. (high level)	0.45	0.04	0.277	0.058
15 – Primary side total mass	0.18	0.03	0.117	0.039
16 – Core level	0.83	0.06	0.881	0.061
17 - SG DC level	0.69	0.07	0.416	0.072
18 - DP inlet-outlet SG (IL)	0.27	0.11	0.5	0.095
19 – Core power	0.15	0.22	0.165	0.183
20 - DP loop seal BL - ascending side	1.23	0.08	2.63	0.122
21 - DP loop seal BL - descending side	1.09	0.06	0.86	0.081
22 – PRZ level	0.11	0.11	0.048	0.165
23 - DP SG inlet plenum U tubes top IL	0.22	0.06	0.177	0.071
TOTAL	**0.26**	**0.06**	**0.24**	**0.063**

(*) Experimental or calculated variable trend missing from available data

Tab. 10 : Summary of results obtained by application of FFT method to the selected parameters for the reference calculation

4.3 Sensitivity calculations

Considering the reference calculation, a series of sensitivity analyses have been carried out, addressing the items 1) to 3), reported in section 4.2.1 and additional input parameters; these are essentially user's choices that may have some effect in solving discrepancies leading to the same three items.

The characteristics of the performed calculations can be drawn from Tab. 11, together with the results of the FFT methodology application (overall calculation and primary pressure). The summary of the FFT results related to all the parameters for all the performed sensitivity calculations are given in Tab. 12.

One of the sensitivity calculation (R5 in Tab. 11) requested the renoding of the steam generator. The new noding is given in Fig. 14.

The comparison between calculated and measured trends for each sensitivity analysis is reported hereafter and in Appendix 4 related to eight time trends (subensamble of the list of 23 time trends of Tab. 10).

a) Break flow rate

In order to obtain a better prediction of the break mass flow rate, two parameters have been tuned. In the first case (run R1), the discharge coefficient at the break junction has been decreased and set to 0.7: in the first 200 seconds of the transient the flow rate (see Fig. 15) is well predicted, after that the trend is overestimated, although the discrepancy with the experimental data is smaller than in the reference case (about one half). The improvement in the break flow rate prediction corresponds to a worst prediction of the primary pressure trend (see Fig. 16) and of the occurrence of the final dry out that is delayed. From a quantitative point of view, the global accuracy has a worst value.

In the second case (run R6), the value of the form loss coefficient (reverse) for the cold leg has been increased: there is a very little improvement of the break flow rate and the pressure is still well predicted (Figs. 17 and 18). The global result obtained with the FFT application can be explained with a better prediction of the loop seal behavior.

b) ECCS mass flow rate

Several calculations have been performed, aiming at the improvement of the accumulators mass flow rates and are documented in Figs. 19 to 24.

The run R2 is characterized by the delaying of the injection stop of one accumulator respect to the other (see Fig. 19): this did not affect so much the overall transient (the AA_{tot} value is the same of the reference calculation), but the dryout is delayed (Fig. 20) at the high levels in the core, whereas in the other levels (see Tab. 11) the rod temperature is better predicted.

The reduction of the accumulators mass flow rate through the decrease of their discharge area is documented in Figs. 21 and 22, where the results from runs R3/1, R3/2 and R3/3 are reported. In the first two cases the injected mass is the same, but the discharge area is reduced to the 12 % and 6 %, respectively: the slope of the ECCS flow rate curve is better predicted up to about 600 s, after that the trend becomes similar to that of the reference case. As a result, a temperature excursion (more evident in the case R3/2) is predicted after the actuation of the accumulators, and the final dryout is delayed. The run R3/3 is characterized by the reduction of the discharge area and a reduction of the injected mass: in this case, other than the early dryout due to the lower injection rate, an early (about 450 s) dryout is calculated with the anticipated intervention of the LPIS. This fact reflects on the global accuracy evaluation so that the R3/3 results the worst calculation.

The combination of runs R1 and R32 (the simultaneous reduction of the accumulators discharge area and the break discharge coefficient) did not influence very much the accuracy of the calculation (Figs. 23 and 24).

c) Core level

Aiming at the improvement of the core level the following analyses have been performed:

- increase of the number of nodes in the ascending side of U-tubes (run R5), in order to improve the primary to secondary side heat exchange (the modified nodalization is shown in Fig. 14): the effect on the prediction of the core level and the rod temperature is small (Figs. 25 and 26), but the accuracy of the overall calculation is slightly improved (fluid temperatures and loop seal behavior are better predicted);
- the same considerations are valid for the run R9 (Figs. 27 and 28). In this case the increase of the heat exchange is obtained setting the recirculation length (to improve local heat transfer coefficient) equal to 0.05 in the secondary side of the SGs;
- reduction of the form loss coefficients (reverse) in the core by-pass (run R7): small effect on the core level prediction and delay in the dry out occurrence (Figs. 29 and 30), with a small improvement of the overall accuracy;
- activation of the CCFL option at the inlet of hot leg, core outlet and U-tube inlet (run R8): with respect to the previous case, the effect on the addressed parameter is again negligible (Fig. 31) but the time of dryout is better predicted (Fig. 32) and the overall calculation accuracy is the same, as in the reference case;
- the activation of the level tracking option in the core and upper plenum (run RA) strongly influences the core level prediction (Fig. 33): the calculated and measured trends are in agreement in the period 550 - 900 s, but in the initial and final part of the transient, the calculated level presents large discrepancies related to the experimental data, leading to a dryout at about 200 s (Fig. 34) and to the anticipation of the final dryout (about 400 s). As a result, the overall calculation accuracy results very bad. This new capability of the Relap5/Mod3.2 requires specific effort to be qualified. These have not been conducted in the present framework

ID calculation	Variation from reference calculation	FFT application results (Aatot / WF / AAp)	Notes
R0	reference calculation	0.24 / 0.063 / 0.055	-
R1	discharge coefficients in break junction set to 0.7	0.25 / 0.055 / 0.090	Critical flow model not adequate
R2	different time for accumulators injection stop (dt = 141 s)	0.24 / 0.069 / 0.056	Unreliable experimental data related accumulators intervention
R3/1	accumulators discharge area reduced to 12 %	0.24 / 0.061 / 0.054	To reduce mass flow rate from accumulators Unreliable experimental data related accumulators intervention
R3/2	accumulators discharge area reduced to 6 %	0.23 / 0.055 / 0.061	To reduce mass flow rate from accumulators Unreliable experimental data related accumulators intervention
R3/3	accumulators discharge area reduced to 6 % and reduction of acc. injected mass	0.31 / 0.056 / 0.068	To reduce mass flow rate from accumulators Unreliable experimental data related accumulators intervention
R4	R1 + accumulators discharge area reduced to 6 %	0.24 / 0.055 / 0.090	-
R5	more fine nodalization of U-tubes ascending side	0.22 / 0.062 / 0.057	To increase primary to secondary side heat exchanger
R6	$K_{reverse}$ in cold leg 2 (junction 125-02) increased (x 10^2)	0.22 / 0.061 / 0.059	To avoid excessive mass flow rate to break
R7	$K_{reverse}$ in junctions 155-01, 135-01 and 125-05 decreased (x 10^{-2})	0.23 / 0.062 / 0.055	To improve core level prediction
R8	CCFL option activated in HL inlet , core outlet, UT inlet	0.23 / 0.063 / 0.056	To improve core level prediction
R9	Recirculation length set 0.05 in UT secondary side heat structures	0.22 / 0.061 / 0.059	To increase primary to secondary side heat exchanger
RA	Level tracking option activation in core and UP volumes	0.31 / 0.056 / 0.071	To improve core level prediction

Tab. 11 : Sensitivity calculations matrix: varied input parameters and FFT results

PARAMETER	R0 AA/WF	R1 AA/WF	R2 AA/WF	R3/1 AA/WF	R3/2 AA/WF	R3/3 AA/WF	R4 AA/WF	R5 AA/WF	R6 AA/WF	R7 AA/WF	R8 AA/WF	R9 AA/WF	RA AA/WF
01 - PRZ pressure	0.055 0.067	0.09 0.04	0.056 0.066	0.055 0.068	0.062 0.06	0.068 0.056	0.091 0.04	0.057 0.064	0.06 0.062	0.056 0.066	0.057 0.066	0.059 0.062	0.072 0.052
02 - SG pressure - secondary side	0.165 0.056	0.106 0.071	0.165 0.055	0.165 0.056	0.166 0.055	0.17 0.055	0.107 0.071	0.188 0.054	0.185 0.054	0.163 0.056	0.162 0.056	0.186 0.054	0.16 0.057
03 - ACC 1 pressure	0.104 0.061	0.173 0.037	0.057 0.084	0.107 0.058	0.138 0.046	0.252 0.046	0.207 0.031	0.105 0.06	0.108 0.059	0.107 0.059	0.107 0.059	0.109 0.058	0.133 0.049
04 - ACC 2 pressure	0.067 0.09	0.167 0.038	0.067 0.09	0.08 0.076	0.126 0.049	0.213 0.048	0.201 0.031	0.072 0.084	0.078 0.079	0.075 0.081	0.073 0.084	0.078 0.078	0.110 0.057
05 - Core inlet fluid temperature	0.031 0.046	0.038 0.04	0.027 0.047	0.031 0.056	0.033 0.04	0.05 0.035	0.042 0.043	0.031 0.051	0.031 0.045	0.029 0.057	0.034 0.052	0.032 0.05	0.081 0.046
06 - Core outlet fluid temperature	0.061 0.035	0.067 0.04	0.055 0.043	0.056 0.039	0.06 0.036	0.07 0.042	0.071 0.043	0.058 0.036	0.062 0.034	0.056 0.038	0.059 0.037	0.059 0.036	0.063 0.036
07 - Upper head fluid temperature	0.37 0.071	0.363 0.07	0.34 0.071	0.363 0.072	0.349 0.072	0.393 0.067	0.344 0.069	0.374 0.072	0.382 0.072	0.365 0.058	0.367 0.071	0.371 0.072	0.498 0.064
08 - Integral break flow rate	0.064 0.057	0.051 0.054	0.065 0.058	0.063 0.057	0.061 0.048	0.286 0.06	0.046 0.056	0.064 0.056	0.059 0.054	0.062 0.055	0.064 0.058	0.064 0.056	0.170 0.059
09 - SG DC bottom fluid temperature	0.199 0.056	0.134 0.061	0.198 0.055	0.196 0.055	0.19 0.056	0.213 0.055	0.133 0.062	0.192 0.056	0.205 0.055	0.196 0.133	0.198 0.055	0.19 0.056	0.204 0.056
10 - Break flow rate	0.966 0.133	0.898 0.141	0.966 0.133	0.965 0.133	0.968 0.133	1.036 0.127	0.896 0.141	0.969 0.133	0.966 0.133	0.968 0.023	0.971 0.133	0.969 0.133	0.992 0.131
11 - ECCS integral flow rate	0.396 0.043	0.238 0.019	0.285 0.011	0.234 0.021	0.214 0.013	1.535 0.05	0.277 0.032	0.325 0.039	0.394 0.043	0.241 0.067	0.329 0.039	0.335 0.039	1.374 0.05
12 - Heater rod temp. (bottom level)	0.046 0.066	0.068 0.064	0.051 0.076	0.043 0.065	0.052 0.062	0.072 0.065	0.072 0.076	0.046 0.065	0.048 0.064	0.043 0.032	0.045 0.061	0.046 0.063	0.063 0.057
13 - Heater rod temp. (middle level)	0.374 0.033	0.401 0.036	0.132 0.098	0.374 0.037	0.354 0.033	0.364 0.036	0.312 0.041	0.355 0.033	0.35 0.035	0.368 0.033	0.368 0.038	0.368 0.036	0.39 0.037
14 - Heater rod temp. (high level)	0.277 0.058	0.635 0.041	0.563 0.051	0.487 0.03	0.578 0.03	0.568 0.028	0.592 0.044	0.315 0.049	0.297 0.054	0.501 0.049	0.314 0.049	0.261 0.045	0.622 0.025
15 - Primary side total mass	0.117 0.039	0.119 0.05	0.133 0.059	0.105 0.047	0.12 0.048	0.248 0.026	0.131 0.05	0.136 0.038	0.139 0.037	0.099 0.065	0.107 0.04	0.138 0.038	0.335 0.038
16 - Core level	0.881 0.061	0.977 0.056	0.925 0.062	0.908 0.063	0.925 0.062	0.954 0.055	0.934 0.055	0.862 0.069	0.883 0.063	0.987 0.072	0.878 0.064	0.90 0.065	0.892 0.065
17 - SG DC level	0.416 0.072	0.414 0.071	0.416 0.072	0.416 0.072	0.415 0.072	0.42 0.071	0.414 0.071	0.426 0.071	0.418 0.072	0.416 0.095	0.415 0.072	0.425 0.071	0.415 0.072
18 - DP inlet-outlet SG (IL)	0.498 0.095	0.529 0.095	0.507 0.099	0.554 0.155	0.501 0.097	0.525 0.09	0.529. 0.093	0.488 0.096	0.512 0.098	0.512 0.19	0.892 0.124	0.492 0.096	0.518 0.096
19 - Core power	0.165 0.183	0.157 0.189	0.151 0.195	0.36 0.143	0.155 0.192	0.16 0.187	0.167 0.183	0.153 0.192	0.155 0.191	0.156 0.068	0.165 0.185	0.155 0.191	0.156 0.191
20 - DP loop seal BL - ascending side	2.631 0.122	1.126 0.104	2.608 0.123	1.264 0.099	0.211 0.073	0.156 0.072	0.691 0.076	0.867 0.063	0.892 0.077	0.852 0.098	1.392 0.104	0.848 0.067	1.075 0.069
21 - DP loop seal BL - descending side	0.860 0.081	1.026 0.064	0.863 0.081	1.311 0.109	0.744 0.067	0.849 0.073	0.981 0.069	0.731 0.068	0.77 0.069	1.026 0.165	0.873 0.082	0.732 0.068	0.727 0.071
22 - PRZ level	0.048 0.165	0.123 0.071	0.048 0.165	0.048 0.165	0.048 0.165	0.048 0.165	0.123 0.071	0.047 0.169	0.048 0.165	0.048 0.165	0.048 0.185	0.047 0.169	0.048 0.165
23 - DP SG inlet plenum U tubes top IL	0.177 0.071	0.194 0.079	0.177 0.071	0.218 0.087	0.167 0.065	0.221 0.078	0.184 0.074	0.7 0.08	0.216 0.085	0.154 0.075	0.293 0.103	0.703 0.08	0.187 0.068
TOTAL	0.24 0.063	0.25 0.055	0.24 0.069	0.24 0.061	0.23 0.055	0.31 0.056	0.24 0.055	0.22 0.062	0.22 0.061	0.23 0.062	0.23 0.063	0.22 0.061	0.31 0.056

Tab. 12 : Summary of results obtained by application of FFT method to the selected parameters for the sensitivity calculations

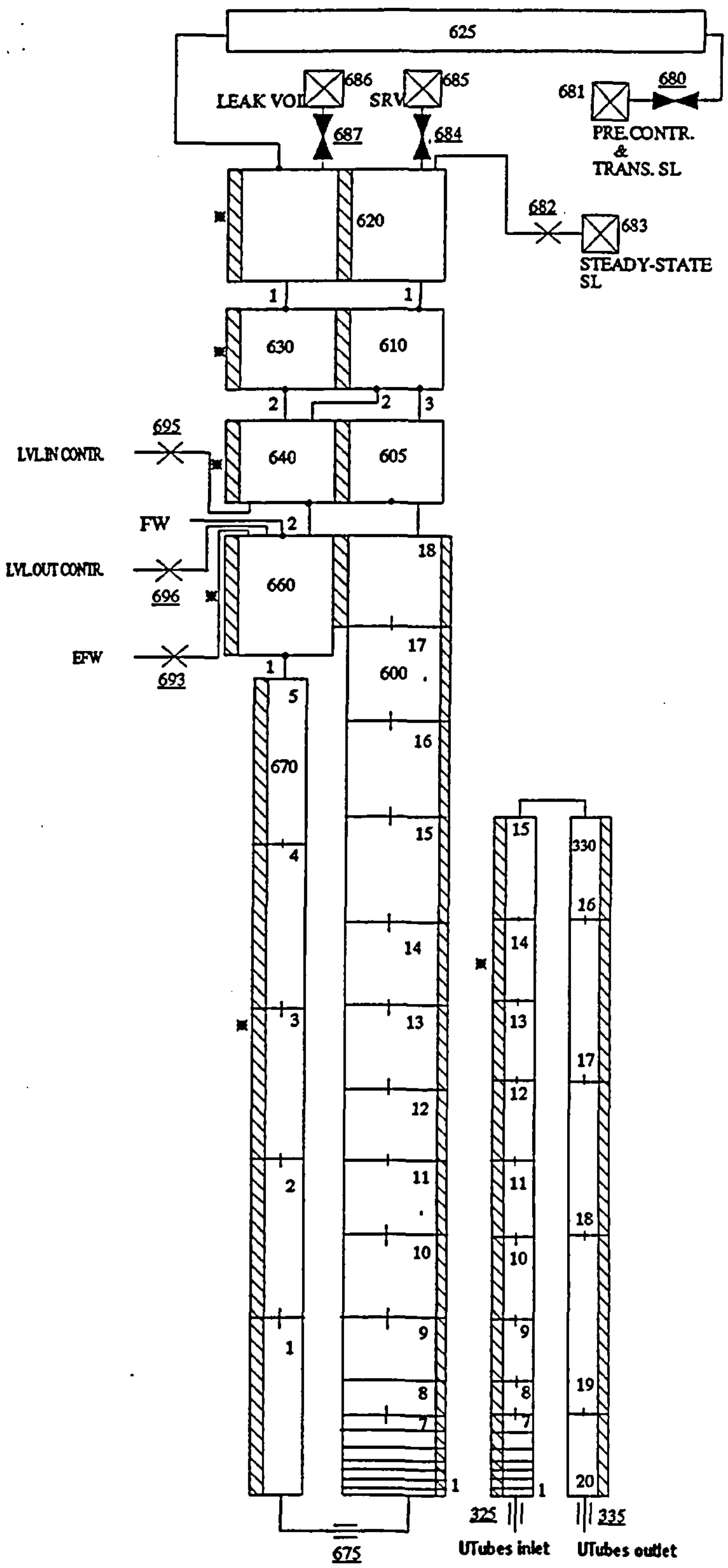

Fig. 14 : Finer nodalization of steam generators U-tubes inlet zone (R5 sensitivity calculation in Tab. 10)

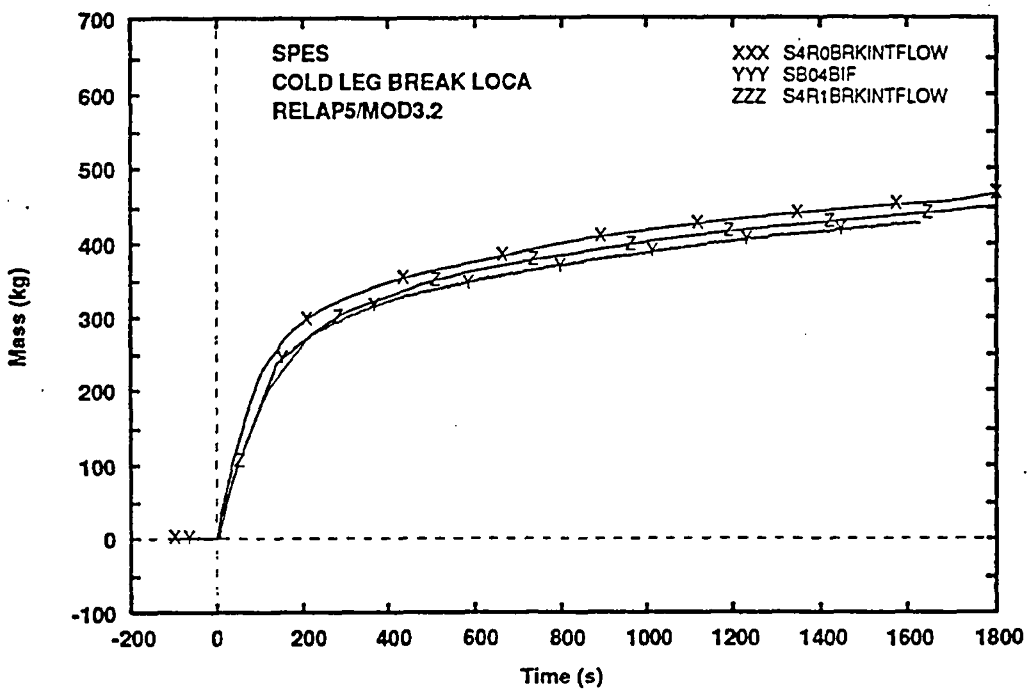

Fig. 15 : SPES post test SP-SB-04 (run R1) - break integral flow rate

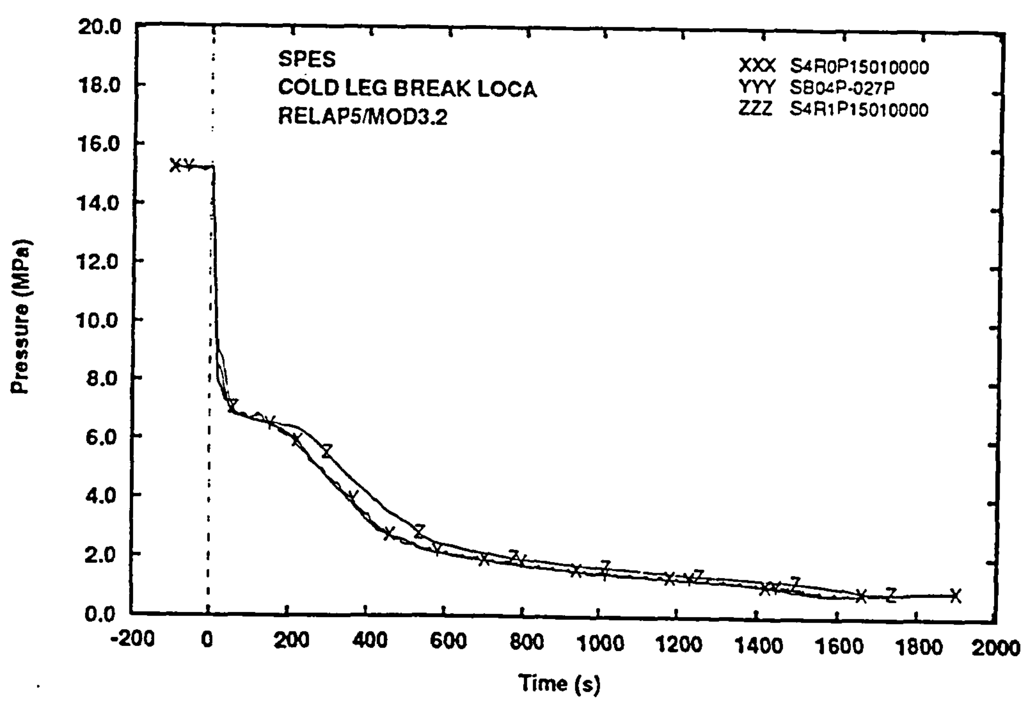

Fig. 16 : SPES post test SP-SB-04 (run R1) - PRZ pressure

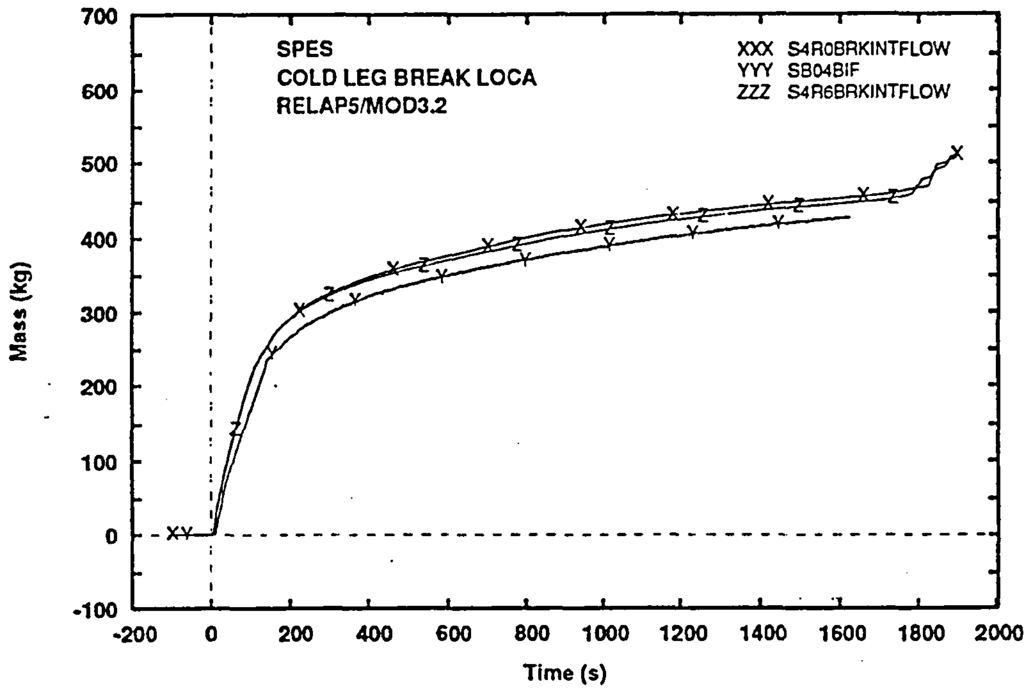

Fig. 17 : SPES post test SP-SB-04 (run R6) - break integral flow rate

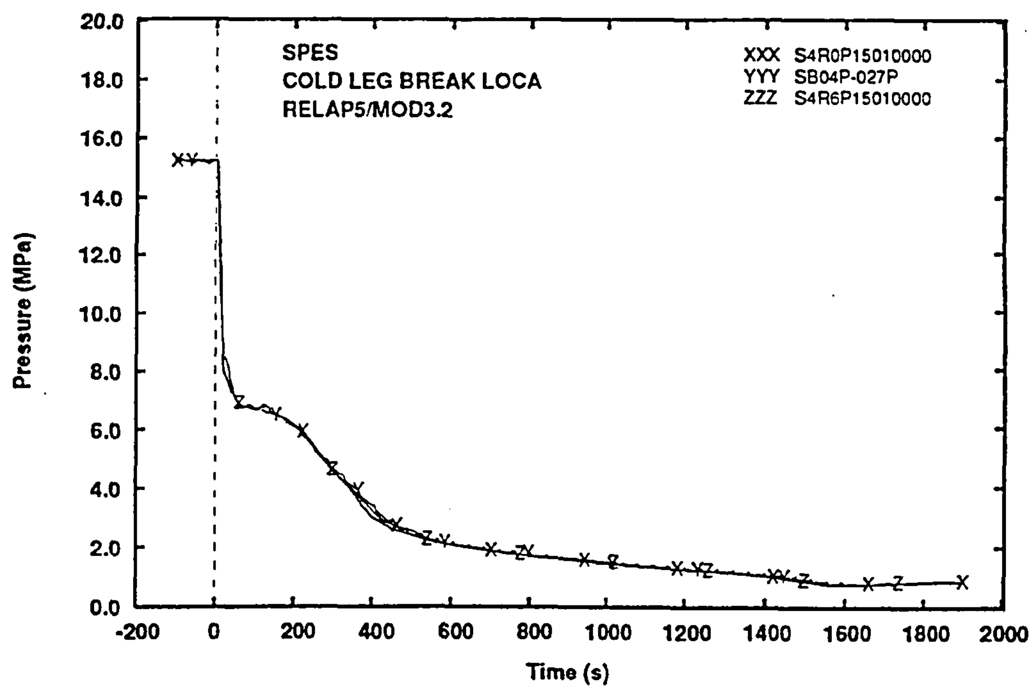

Fig. 18 : SPES post test SP-SB-04 (run R6) - PRZ pressure

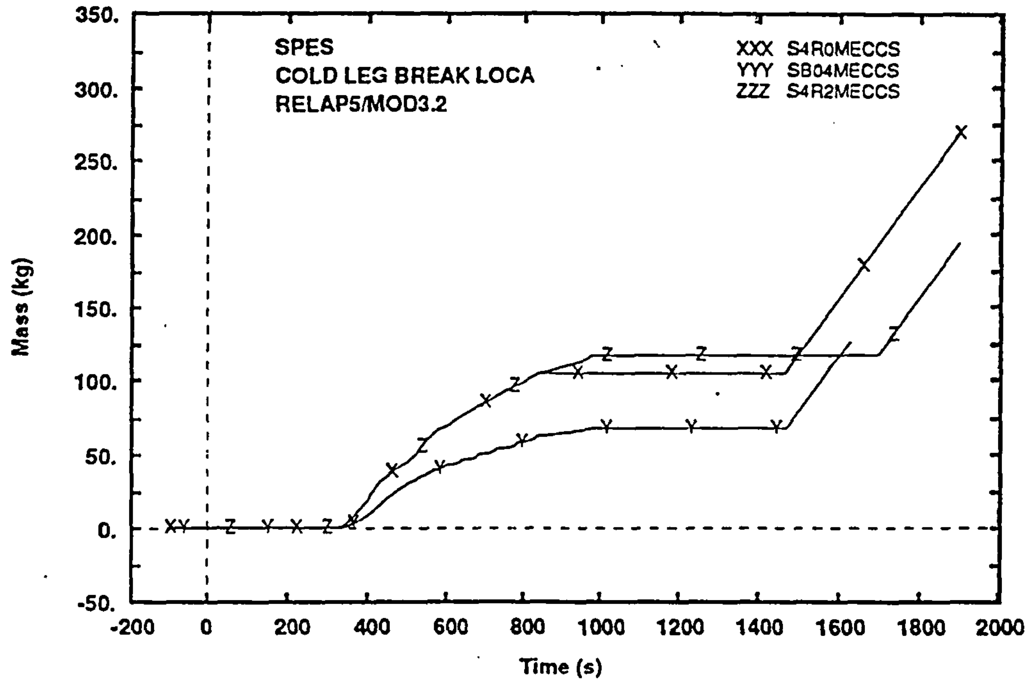

Fig. 19 : SPES post test SP-SB-04 (run R2) - ECCS integral flow rate

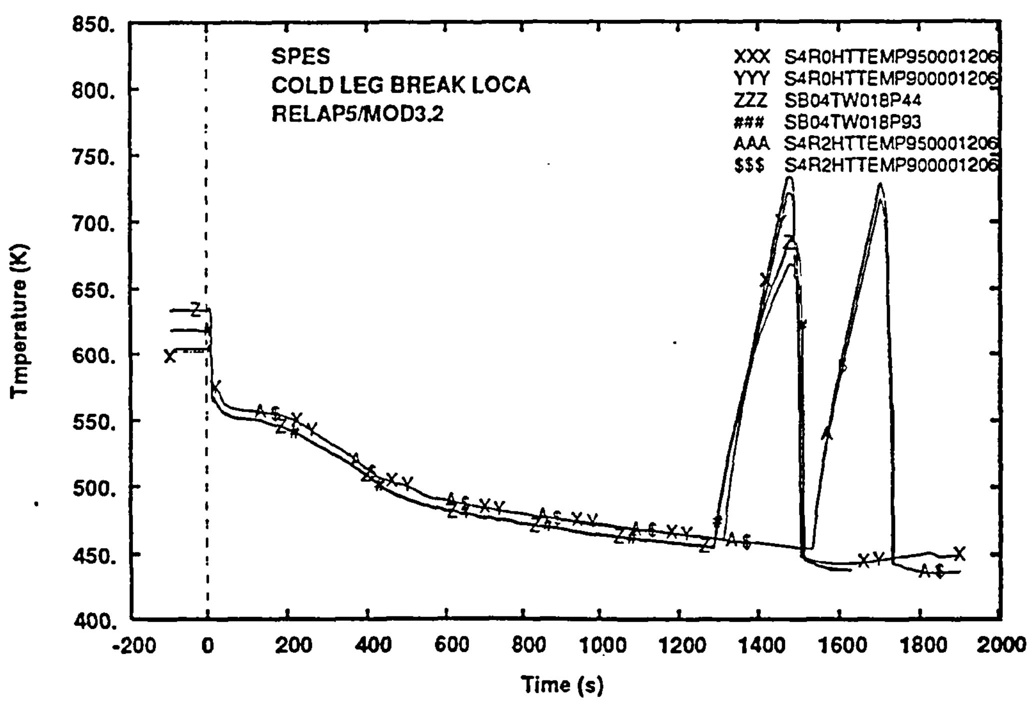

Fig. 20 : SPES post test SP-SB-04 (run R2) - rod surface temperature (high level)

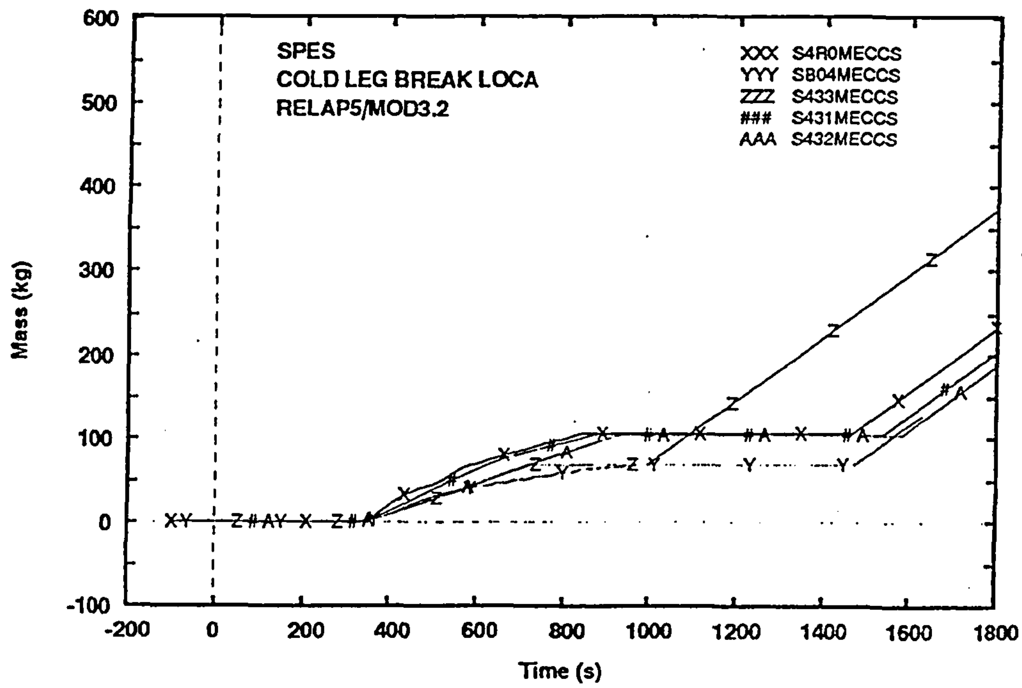

Fig. 21 : SPES post test SP-SB-04 (run R31, R32 and R33) - ECCS integral flow rate

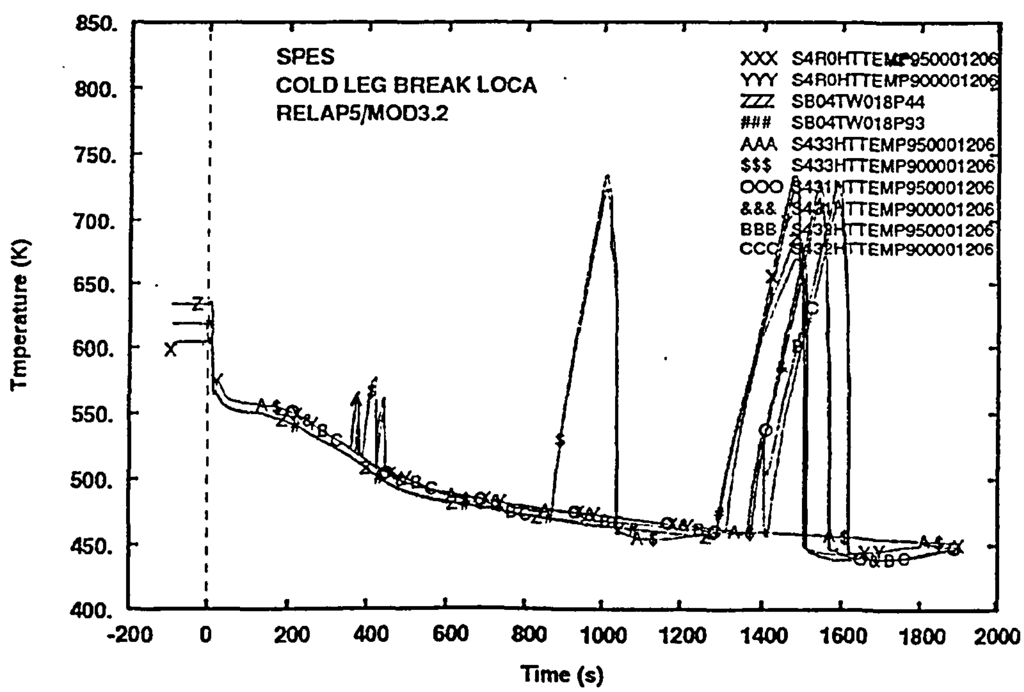

Fig. 22 : SPES post test SP-SB-04 (runs R31, R32 and R33) - rod surface temperature (high level)

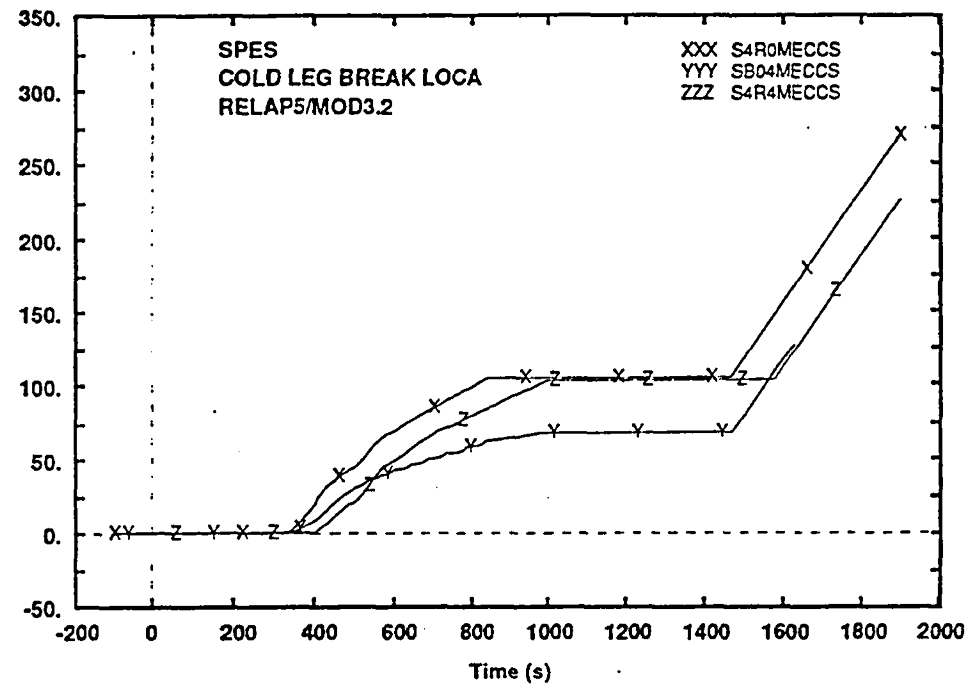

Fig. 23 : SPES post test SP-SB-04 (run R4) - ECCS integral flow rate

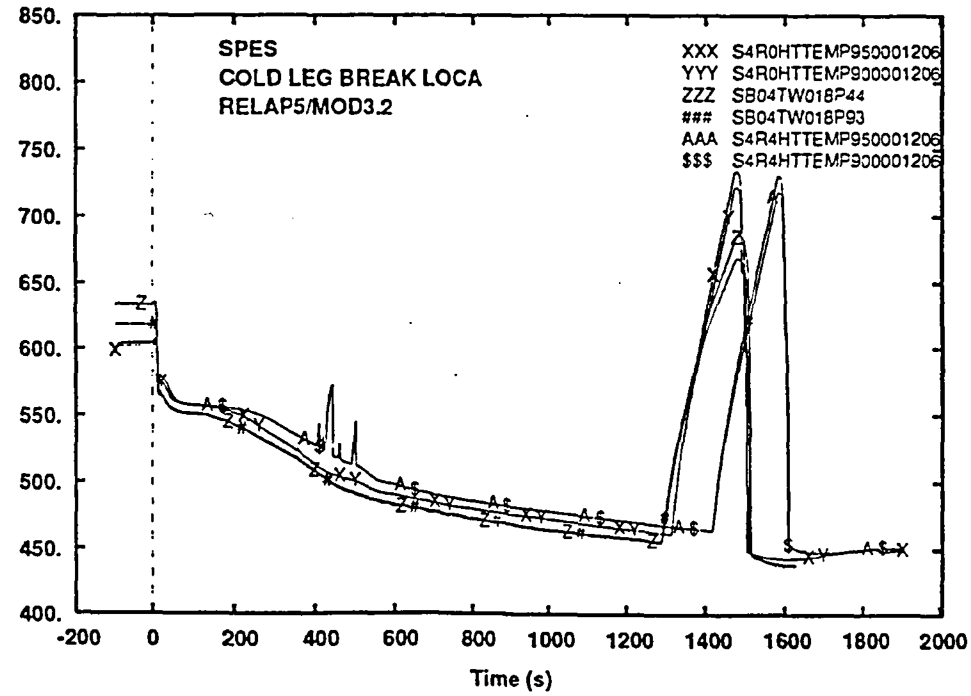

Fig. 24 : SPES post test SP-SB-04 (run R4) - rod surface temperature (high level)

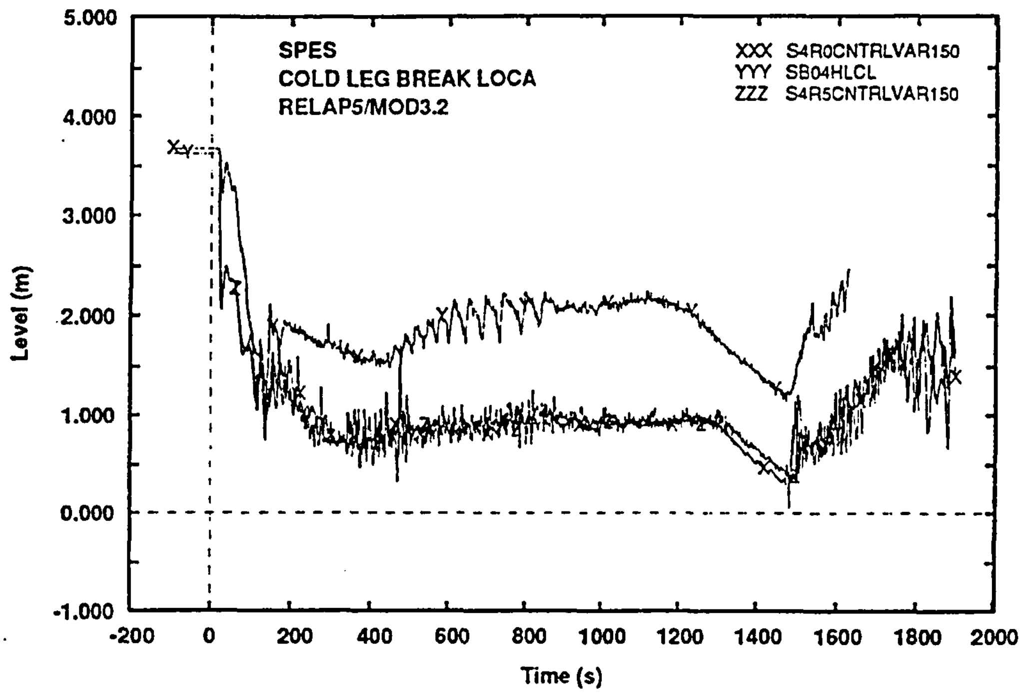

Fig. 25 : SPES post test SP-SB-04 (run R5) - core collapsed level

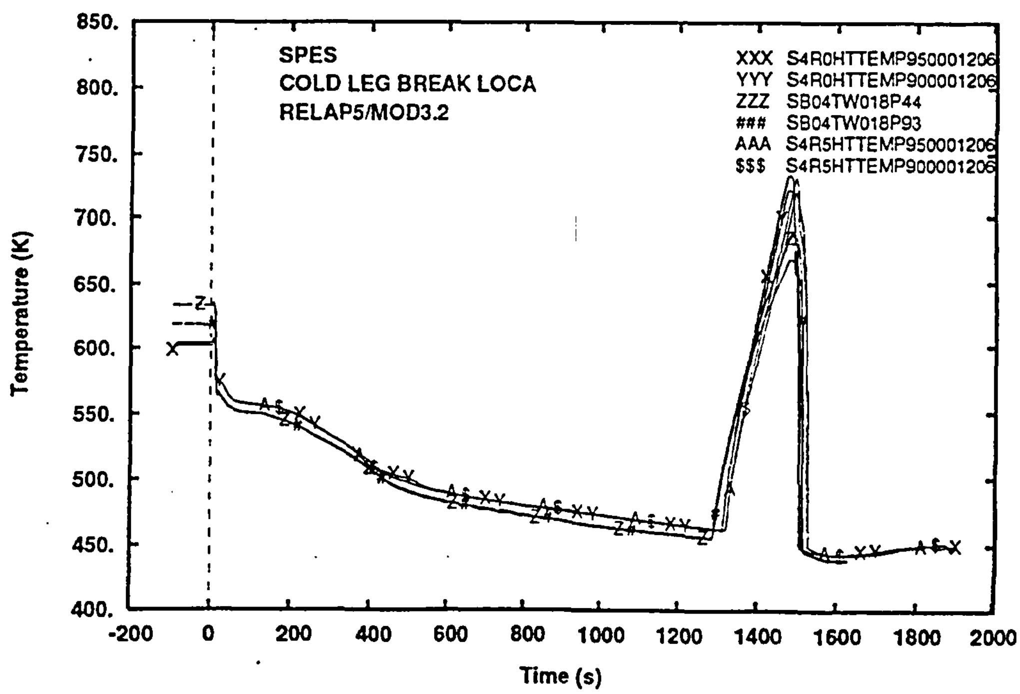

Fig. 26 : SPES post test SP-SB-04 (run R5) - rod surface temperature (high level)

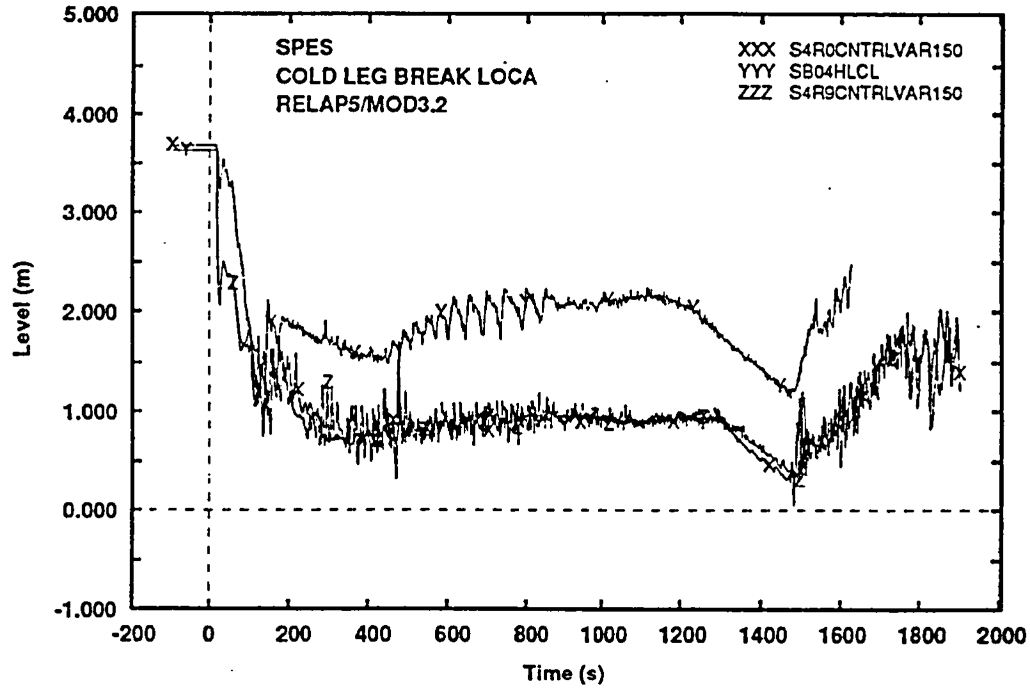

Fig. 27 : SPES post test SP-SB-04 (run R9) - core collapsed level

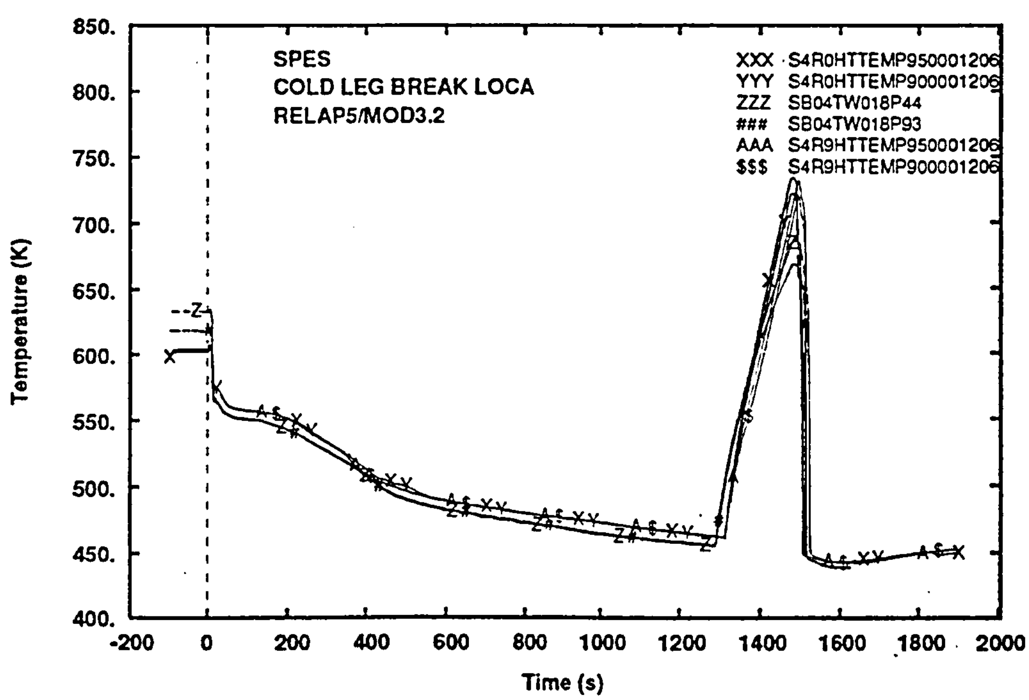

Fig. 28 : SPES post test SP-SB-04 (run R9) - rod surface temperature (high level)

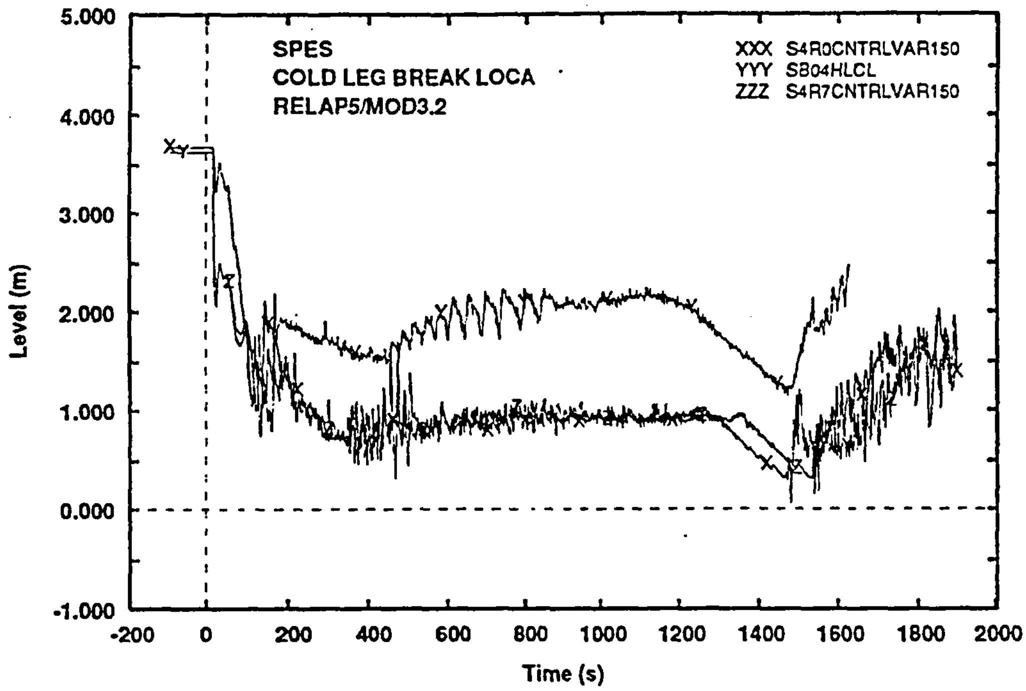

Fig. 29 : SPES post test SP-SB-04 (run R7) - core collapsed level

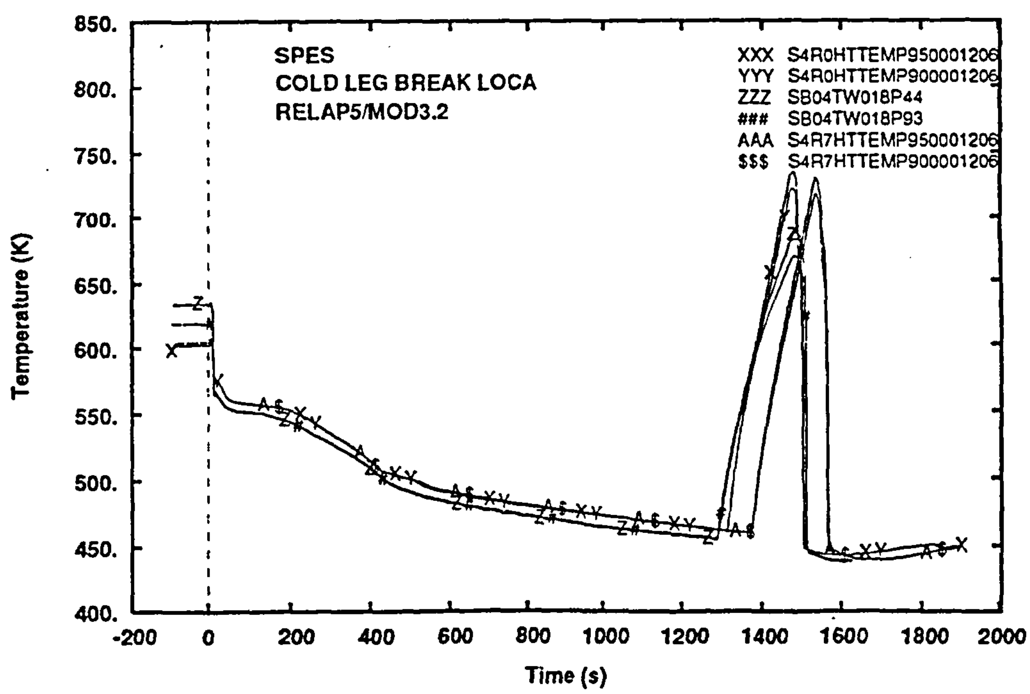

Fig. 30 : SPES post test SP-SB-04 (run R7) - rod surface temperature (high level)

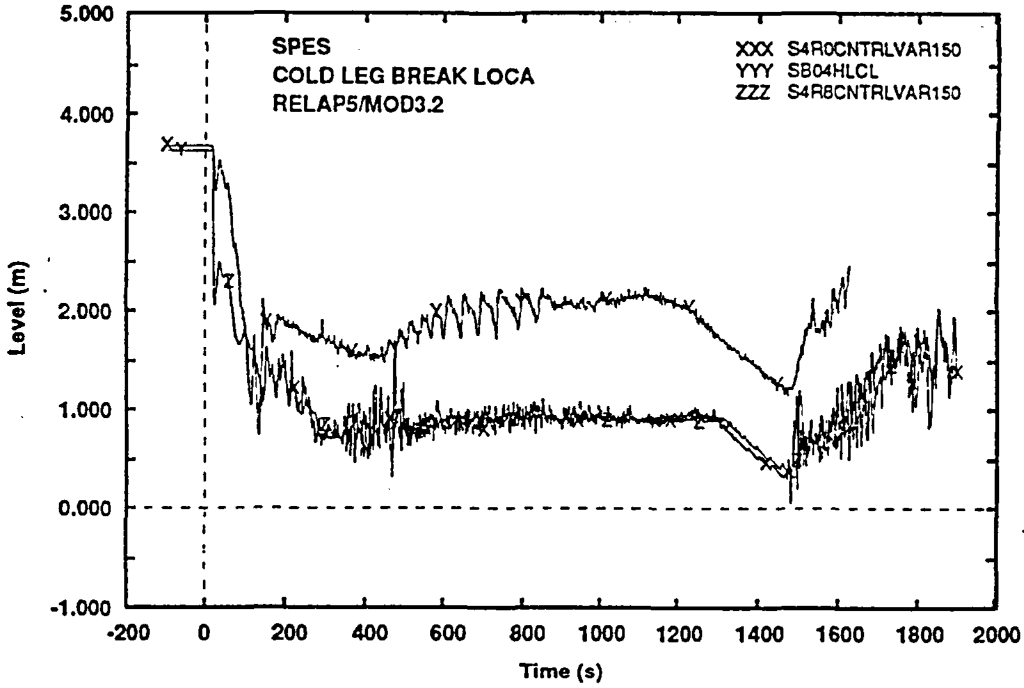

Fig. 31 : SPES post test SP-SB-04 (run R8) - core collapsed level

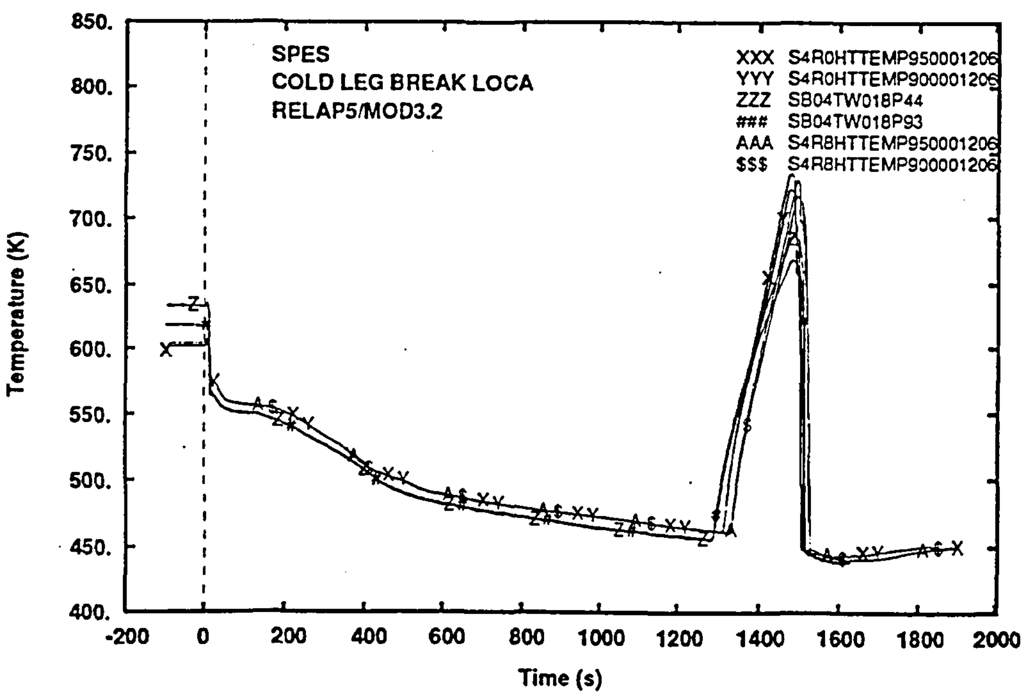

Fig. 32 : SPES post test SP-SB-04 (run R8) - rod surface temperature (high level)

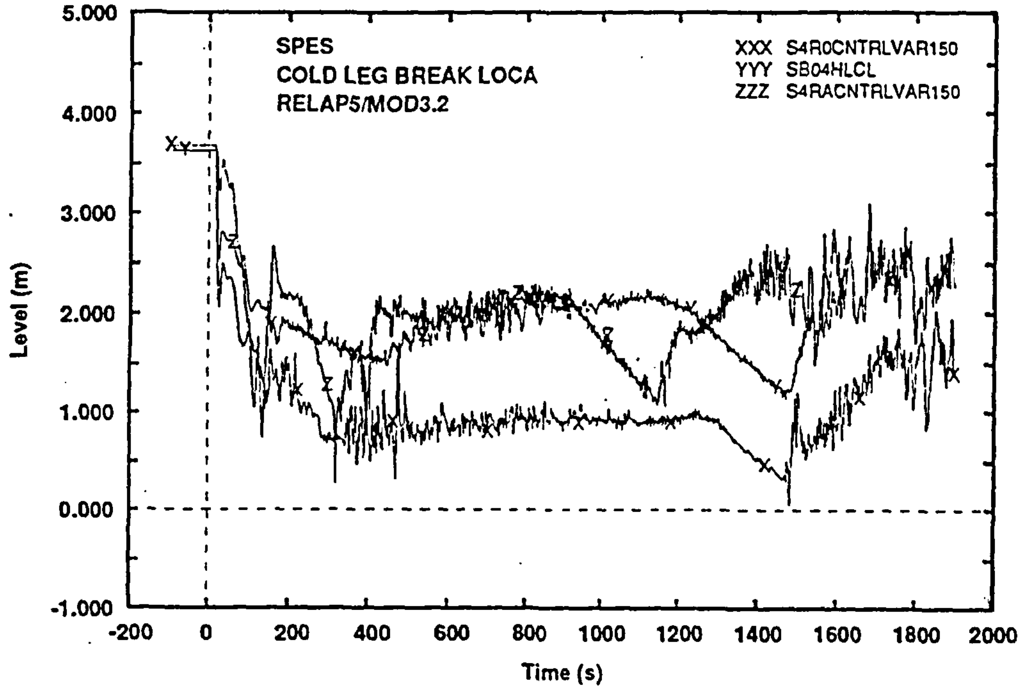

Fig. 33 : SPES post test SP-SB-04 (run RA) - core collapsed level

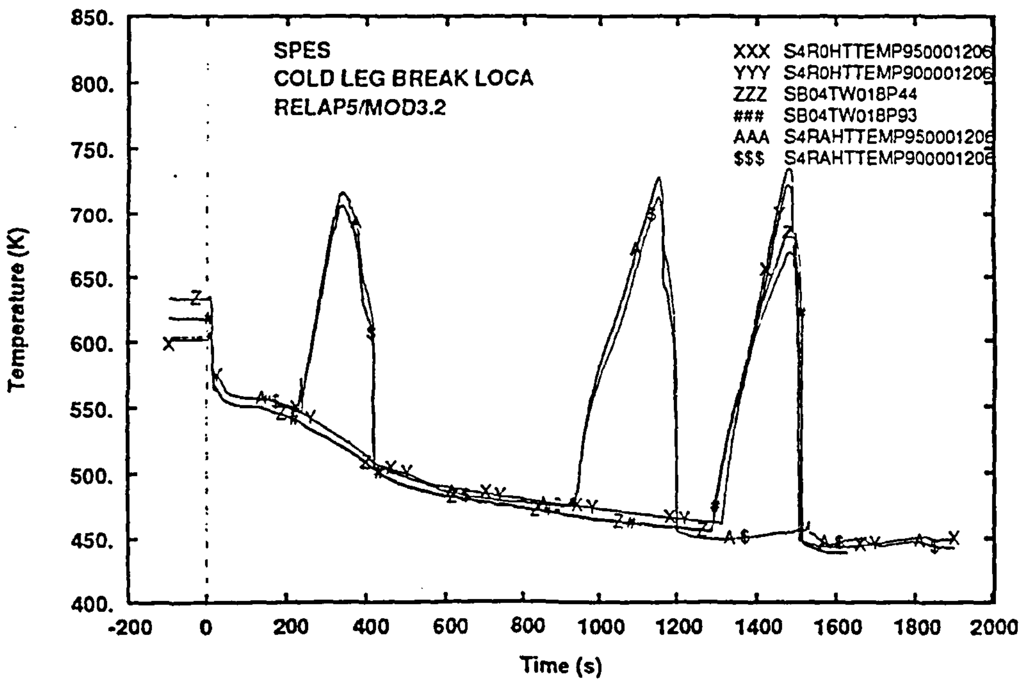

Fig. 34 : SPES post test SP-SB-04 (run RA) - rod surface temperature (high level)

5. CONCLUSIONS

The analyzed transient (SP-SB-04) is a small break LOCA experiment originated by a rupture in the cold leg in one of the three loops of the SPES facility. No high injection system is provided during the test; accumulators intervention prevents unacceptable core rod temperature excursion up to about 1200 s; two dryout situations occur: the first one, at about 130 s into the transient leading to a temperature excursion less then 15 K, is quenched by an intrinsic mechanism like loop seal clearing about 10 s after PCT is reached; the second one is quenched by the intervention of the low pressure injection system.

A qualified Relap5/Mod3.2 nodalization has been used for the analysis. The comparison between the code prediction and the experimental data leads to the conclusion that the code is able to predict all the significant aspects of the transient, except for the first dryout occurrence.

Three main discrepancies have been identified, relating to the mass flow rate from the break, the ECCS delivered mass and the core level. Several sensitivity calculations have been performed, addressing these specific aspects.

The following considerations can be pointed out:

1) the variation of parameters considered in the sensitivity calculations, does not affect the phenomena but only the sequence of events;
2) the comparison between experimental and calculated trends shows a good agreement; the adjustments (tuning) of the flowrate delivered by ECCS and, in particular, of the accumulators behavior toward the experimental data, causes a disagreement in the core heat transfer and the worsening of the overall transient prediction;
3) a tuning of the break flow rate is needed: the tuning of about 20 % during all the transient seems to be adequate; this means changing in a reproducible (related to all other small break LOCA analyzed) way the break discharge coefficients of the Relap5 input deck in the range 0.8 - 1.2 (obviously keeping each coefficient constant during the transient);
4) the mixture level tracking option (the digit "1" in the code input deck) has been introduced in the run RA to improve the core level prediction, but it needs the tuning of other parameters (not performed in the present framework), otherwise its results are inconsistent with the other nodalization choices;
5) a small effect of the CCFL parameter, the convection length, the by-pass flow path resistance, the K reverse in the cold leg and the number of nodes has been noted.

The reference calculation can be used for uncertainty evaluation, ref. [6], and specifically, for the development of Code having the capability of Internal Assessment of Uncertainty (CIAU), ref. [21].

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LIST OF ABBREVIATIONS

AA	Average Amplitude
ACC	Accumulator
ATWS	Anticipated Transient Without Scram
BL	Broken Loop
CAMP	Code Assessment and Maintenance Program
CCFL	Counter Current Flow Limitation
CSNI	Committee on the Safety of Nuclear Installations
DC	Downcomer
DCMN	Dipartimento Costruzioni Meccaniche e Nucleari
DP	Differential Pressure
ECCS	Emergency Core Cooling Systems
FFT	Fast Fourier Transform
HPIS	High Pressure Injection System
ICAP	International Code Assessment and Application Program
IL	Intact Loop
INEL	Idaho National Engineering Laboratories
IPA	Integral parameter
ISP	International Standard Problem
ITF	Integral Test Facility
$K_{reverse}$	Reverse form loss coefficient
LOCA	Loss Of Coolant Accident
LPIS	Low Pressure Injection System
MFWIV	Main Feed Water Injection Valve
NA	Not Available
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
PORV	Pressurizer Operated Relief Valve
PRZ	Pressurizer
SG	Steam Generator
SVP	Single Valued Parameter
TSE	Time Sequence of Events
UH	Upper Head
WF	Weighted Frequency

SUBSCRIPTS

A_R	break area
c	core
G_C	overall core inlet flow rate
P_R	break position
RL	recirculation loop
SS.T	mean temperature of secondary side fluid
V	fluid volume
W	core power
WI	total energy supplied by the heater rods

APPENDIX 1

Qualitative and quantitative accuracy evaluation

QUALITATIVE AND QUANTITATIVE ACCURACY EVALUATION

A complete code assessment activity involves a large effort at different levels. Some ideas about various steps that are part of the code assessment process will be given in the following, with particular attention to the independent assessment phase activities (performed by code users) following the developmental ones.

A comprehensive comparison between measured and calculated trends or values should include the following steps:

a) comparison between experimental and calculated time trends;
b) comparison between values of quantities characterizing the sequence of resulting events;
c) qualitative evaluation of calculation accuracy on the basis of the phenomena included in the CSNI matrix, ref. [17];
d) qualitative evaluation of calculation accuracy on the basis of the Relevant Thermalhydraulic Aspects (RTA, also used for code uncertainty derivation, e.g. ref. [6]);
e) quantitative evaluation of calculation accuracy, utilizing the FFT based method (FFTBM).

The considered steps as mentioned above, are part of a wide range code calculating assessment process, where relevant findings from International Community and from previous experiences of the here involved research groups are exploited. An important role is taken, in this contest, by the recently issued OECD/CSNI reports, refs. [17] and [18], both in the area of experimental data qualification and code assessment.

A very high number of selected variables or time trends are recorded during experiments in ITF, typically up to 1000, item a); a much lower number is recorded in each experiment available from ITF, around 100. More than 20 time trends are assumed to realistically characterize an experiment and must be used in the present frame: expertise is needed in the selection that, however, can be made standard having as reference the different types of transient (e.g. identified in ref. [18]). The code user must derive an overall evaluation of calculation performance avoiding a final judgment that should be derived from the following steps: it must be checked that calculation results are qualitatively correct (e.g. a valley or a positive slope for a reasonable time period in any experimental trend should not correspond to a peak or to a negative slope, respectively, in the calculated trend); errors must be tolerated.

Qualitative accuracy evaluation are involved under steps b) to d), that can be completed having in mind the results form step a). Sequence of events must be identified having in mind the experimental data base; actuation or trips of Engineered Safety Features (valves, pumps, scram, ECCS) and dryout/rewet occurrences are part of the "resulting sequence of events".

The list of phenomena classified by CSNI, item 3), concerns with transient types (e.g. Large Break LOCA, Small Break LOCA, etc.): this is used to check the suitability of ITF in simulating that phenomenon, whether that phenomenon is part of the data base and to judge the simulation capabilities of the calculation. Five levels of "subjective" judgments are used as detailed in the next section. It may be noted that the first two sub-steps are part of the qualification of the experimental data base.

Basically the activity under item 4) is the same as before, the only difference being that phenomena are substituted by RTA (Relevant Thermalhydraulic Aspects). RTA characterize a single transient (e.g. a 6 % Small Break LOCA without High Pressure Injection System) and not a class of transients. The same levels of judgment are adopted. A qualitatively acceptable calculation implies that all RTA are evident in the experimental and calculated data base and that no U mark is present (see below). RTA are characterized by values identified as SVP (Single Valued Parameters), NDP (Non Dimensional Parameters), IPA (Integral PArameters) and TSE (parameters belonging to the Time Sequence of Events): more than forty of such values must be used for a complex transient.

The FFTBM, item e), allows a quantitative judgment for a given calculation. Each set of two curves constituted by a calculated and a measured time trend can be processed by FFTBM. The transformation from time to the frequency domain avoids the dependence of the error from the transient duration. Weight factors are attributed to each time trend to make possible the summing up of the error and the achievement of a unique threshold for accepting a calculation. Quantitative accuracy evaluation must be carried out following demonstration that the calculation is qualitatively acceptable. The same time trends selected at item a) above are utilized as input to the FFTBM.

A2.1 Qualitative assessment.

The procedure for the evaluation of the qualitative accuracy includes the following steps:

1 use of the phenomena specified in the CSNI validation matrix that are valid for any kind of transient;

2 subdivision of the considered transient into "phenomenological windows" (i.e. time spans in which a unique relevant physical process mostly occurs, and a limited set of parameters controls the scenario): phenomena consequent to the physical processes characterize each phenomenological windows;

3 for each "phenomenological window":

 3.1 identification of the "relevant thermalhydraulic aspects". These are the events or phenomena consequent to the physical process and are peculiar to each transient;

 3.2 selection of the parameters characterizing the "relevant thermalhydraulic aspects";

4 qualitative analysis of obtained results by evaluating and ranking the comparison between measured and calculated trends.

The qualitative analysis is based on five subjective judgment marks, that are applied both to the matrix of phenomena and to the list of relevant thermalhydraulic aspects: it essentially derives from a visual observation of the experimental and the predicted trends:

a) the code predicts qualitatively and quantitatively the parameter (Excellent - the calculation falls within experimental data uncertainty band);

b) the code predicts qualitatively, but not quantitatively the parameter (Reasonable - the calculation shows only correct behavior and trends);

c) the code does not predict the parameter, but the reason is understood and predictable (Minimal - the calculation does not lie within experimental data uncertainty band and at times does not have correct trends);

d) the code does not predict the parameter and the reason is not understood (Unqualified - calculations does not show correct trend and behavior, reasons are unknown and unpredictable);

e) Not applicable (-).

Through this analysis we can operate a first classification about the calculation quality.

The qualitative step is a necessary prerequisite to the application of the quantitative analysis: it is meaningless performing this last one, if a calculation is not qualitatively correct.

A2.2 FFT based method description

A fundamental property of the Fourier Transform consists in the capability to analyze any relationship between two quantities in the time domain in a different domain without lack of information with respect to the original one. When using functions sampled in digital form, the FFT can be used, i.e. algorithm that computes more rapidly the discrete Fourier Transform.

To apply this algorithm, functions must be identified by a number of values which is a power of 2. Thus, if the number of points defining the function in the time domain is $N=2^{m+1}$, the FFT gives the frequencies $f_n = n/T$, $(n = 0, 1, ..., 2^m)$, in which T is the time duration of the sampled signal.

The accuracy quantification of a code calculation considers the amplitude, in the frequency domain, of the experimental signal $F_{exp}(t)$ and the error function

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

In particular, the method characterizes each calculation through two values:

- **a dimensionless average amplitude**

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

- **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 most significant information is given by AA, which represents the relative magnitude of the discrepancy deriving from the comparison between the addressed calculation and the corresponding experimental trend (AA = 1 means a calculation affected by a 100 % error).

The WF factor characterizes the kind of error, because its value emphasizes if the error has more relevance at low or high frequencies, and depending on transient, high frequency errors can be more acceptable than low frequency ones; in other words, analyzing thermalhydraulic transient, better accuracy is generally represented by low AA values at high WF values [18].

Trying to give an overall picture of the accuracy of a given calculation, average indexes of performance are obtained by defining:

$$(AA)_{tot} = \sum_{i=1}^{N_{var}} (AA)_i \cdot (w_f)_i$$

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

with

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

where N_{var} is the number of the analyzed parameters and $(w_f)_i$ are weighting factors introduced to take into account the different importance of each parameter from the viewpoint of safety analyses. Briefly, each (wf)i takes into account [19]:

- experimental accuracy: experimental trends of thermalhydraulic parameters are characterized by a more or less sensible uncertainty due to:
  - intrinsic characteristic of instruments
  - method of measure
  - different evaluation ways necessary to compare experimental measures and the code calculated results
- safety relevance: particular importance is given to the accuracy evaluation of code calculations concerned with those parameters (such as pressure, peak clad temperature, etc.) which are relevant for safety and design.

Further contribution is given by a factor which normalizes the AA value calculated for the selected parameters with respects to the AA value calculated for the primary pressure. This factor has been introduced in order to consider the physic relations existing between different quantities (i.e. fluid temperature and pressure in case of saturated blowdown must be characterized by the same order of error).

So doing the weighting factor of the j-th parameter is defined as:

$$(wf)_j = \frac{(w_{exp})_j \cdot (w_{saf})_j \cdot (w_{norm})_j}{\sum_{j=1}^{N_{var}} (w_{exp})_j \cdot (w_{saf})_j \cdot (w_{norm})_j}$$

where:

- w_{exp} is the contribution related to the experimental accuracy;
- w_{saf} is the contribution which expresses the safety relevance of the addressed parameter;
- w_{norm} is the component of normalization with reference to the average amplitude evaluated for the primary side pressure.

This introduces a degree of engineering judgment that has been fixed by a proper and unique definition of the weighting factors.

A2.3 Quantitative assessment.

This further level can be managed by means of the application of the FFTBM.

The most suitable factor for the definition of an acceptability criterion is the average amplitude AA. With reference to the accuracy of a given calculation, we can define the following acceptability criterion:

$$(AA)_{tot} < K$$

where K is an acceptability factor valid for the whole transient. As lower is the $(AA)_{tot}$ value, as better is the accuracy of the analyzed calculation (i.e. the code prediction capability and acceptability is higher). On the other hand, $(AA)_{tot}$ should not exceed the unit in any part of the transient (AA = 1 means a calculation affected by a 100% error). Due to this requirement, the accuracy evaluation should be performed at different steps during the transient, to verify if this condition is not satisfied in any phase of it.

With reference to the experience gathered from previous application of this methodology, K = 0.4 has been chosen as reference threshold value identifying good accuracy of a code calculation. In fact, taking into account the previous applications, it has been noted that results in the range:

1. $(AA)_{tot} \leq 0.3$ characterize very good code predictions;
2. $0.3 < (AA)_{tot} \leq 0.5$ characterize good code predictions;
3. $0.5 < (AA)_{tot} \leq 0.7$ characterize poor code predictions;
4. $(AA)_{tot} > 0.7$ characterize very poor code predictions

A similar criterion can be used to evaluate the code capability in the single parameter prediction; clearly, in this case the AA factor is the one evaluated for the addressed parameter.

Recent activities have been aimed at defining upper acceptability limits to the AA values related to safety relevant parameters, like cladding temperature, primary pressure, primary residual mass. As an example, a further requirement to be fulfilled is related to the AA evaluated for the primary side pressure. The accuracy in the prediction of this basic thermalhydraulic parameter, in the various phases of the transient, should satisfy the following criterion:

$$AA_{pr} < 0.1$$

APPENDIX 2:

Steady state calculation

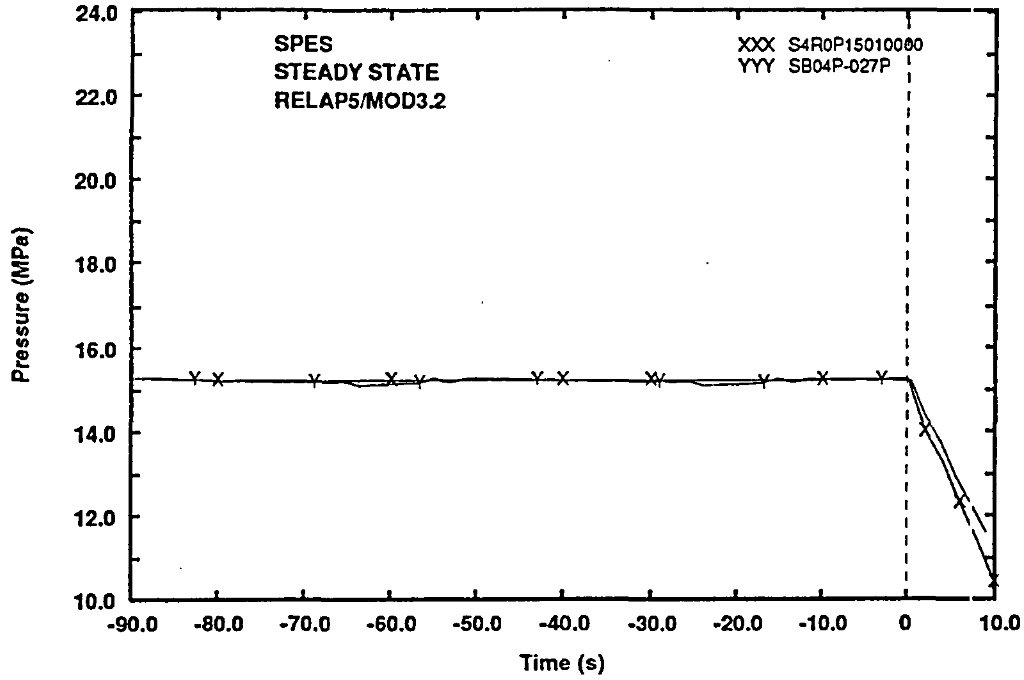

Fig. 1- PRZ pressure

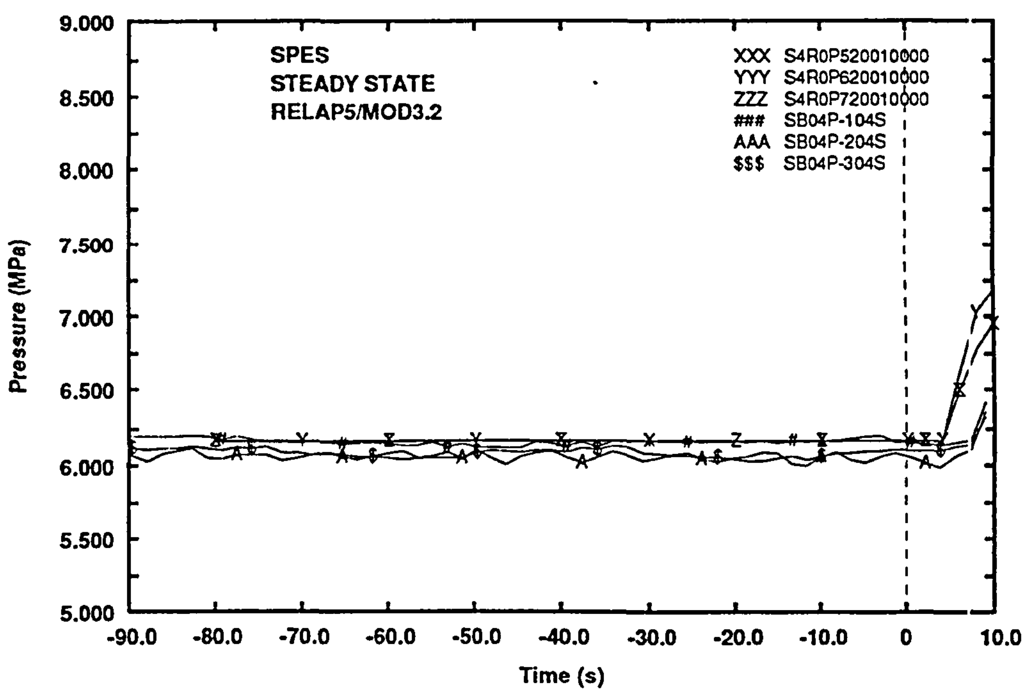

Fig. 2- SGs secondary side pressure

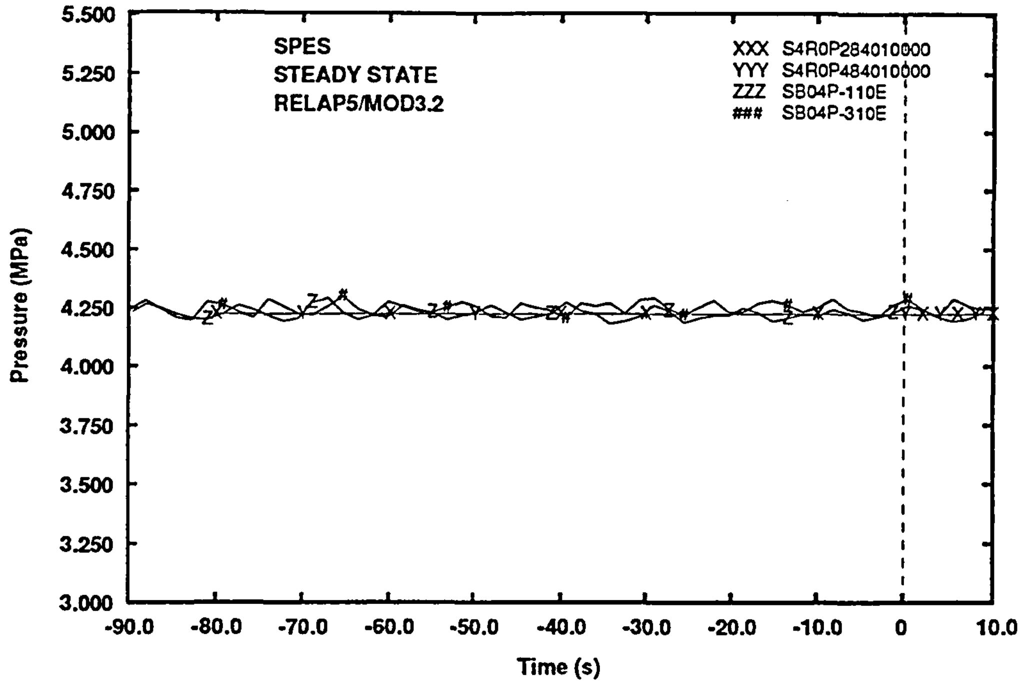

Fig. 3- Accumulator pressure

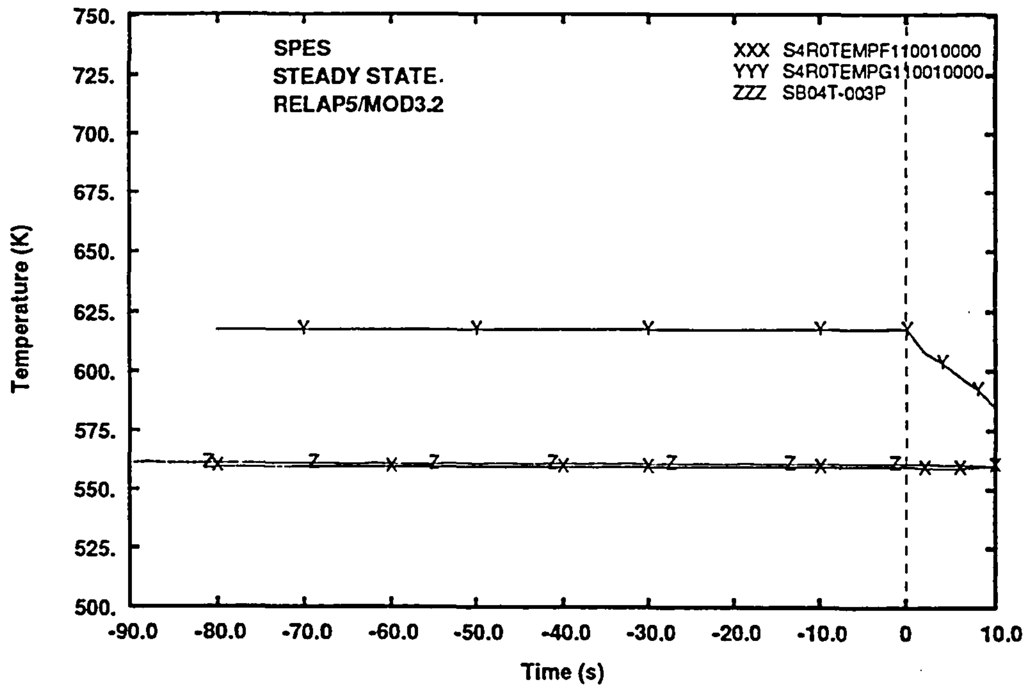

Fig. 4- Core inlet fluid temperature

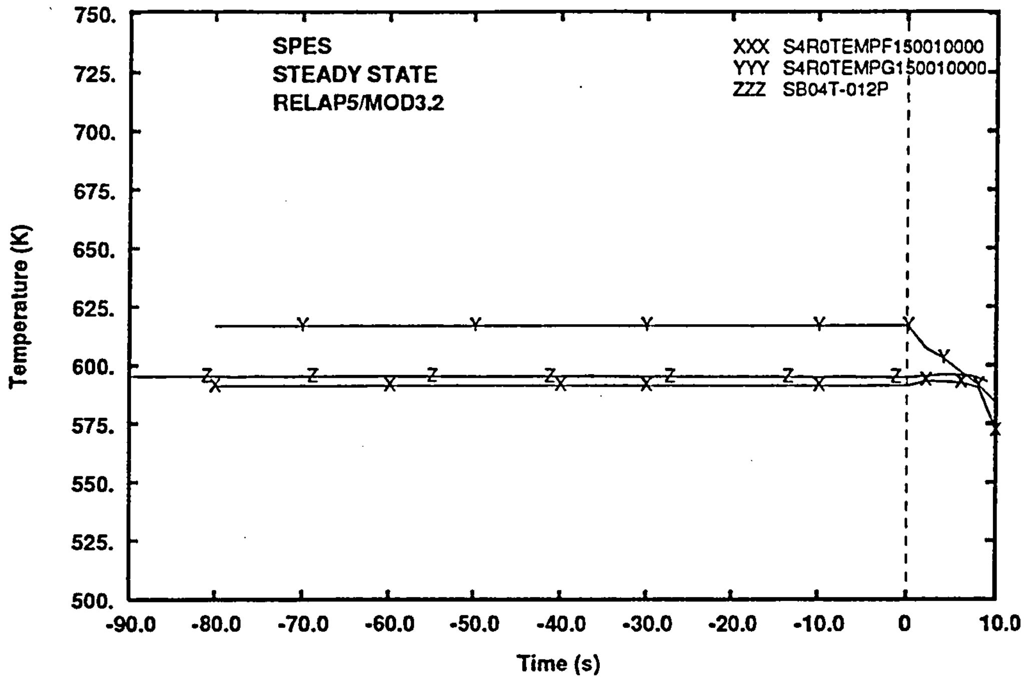

Fig. 5- Core outlet fluid temperature

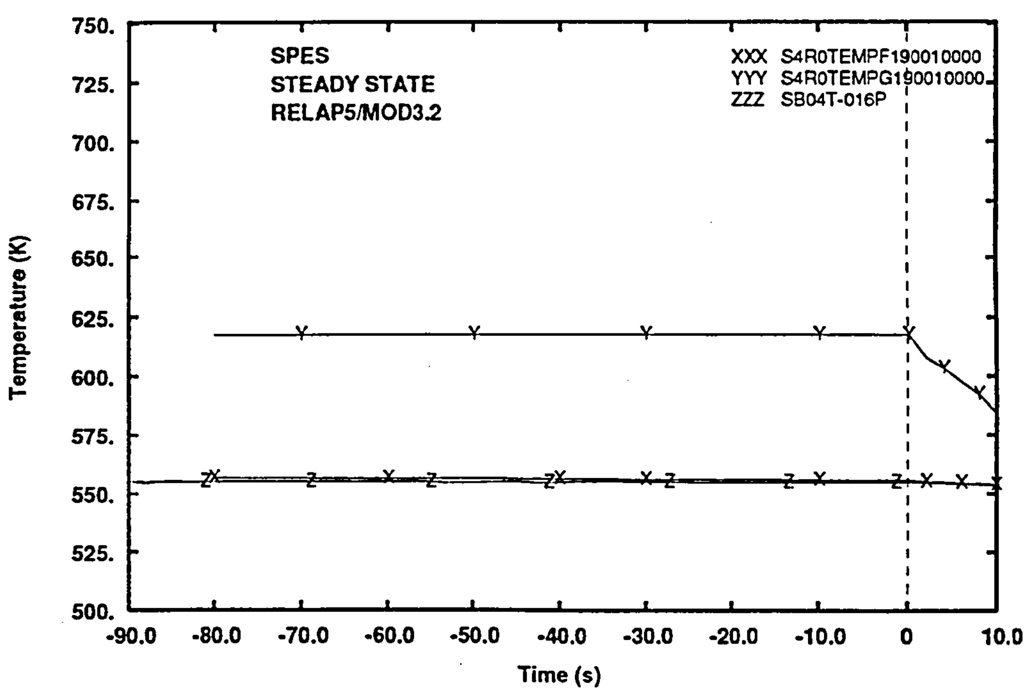

Fig. 6- Upper Head coolant temperature

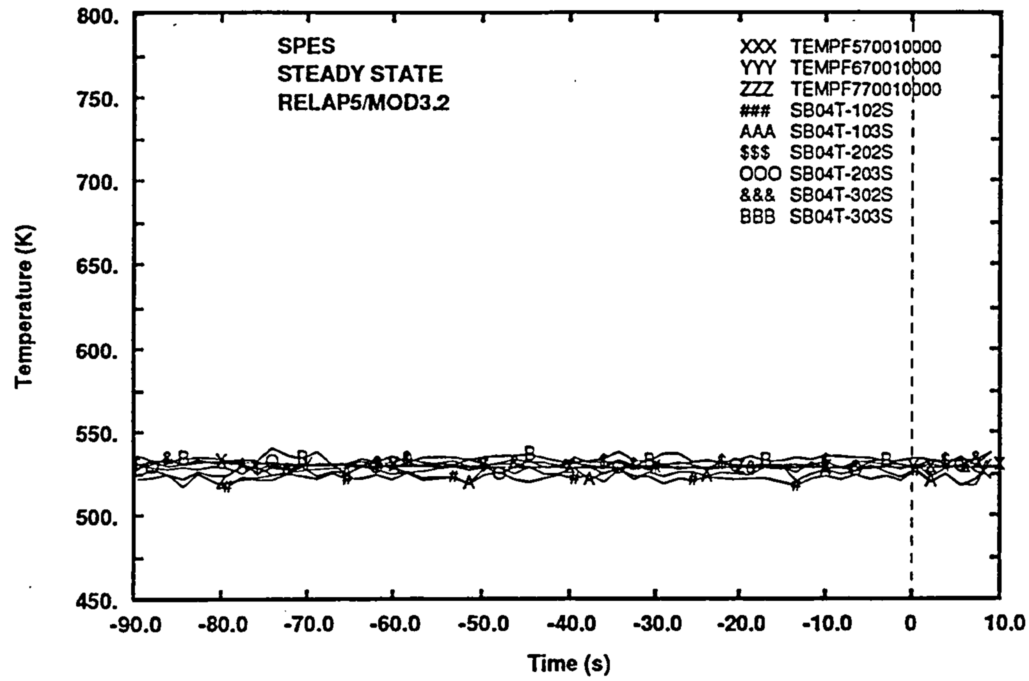

Fig. 7- SG bottom DC fluid temperature

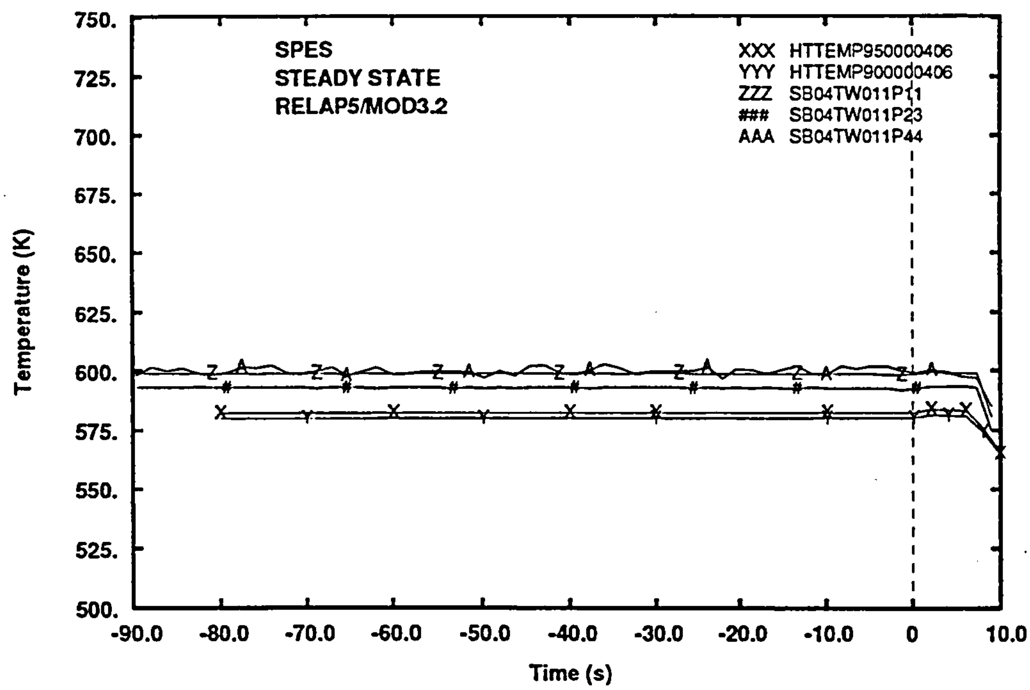

Fig. 8- Heater rod temperature (bottom level)

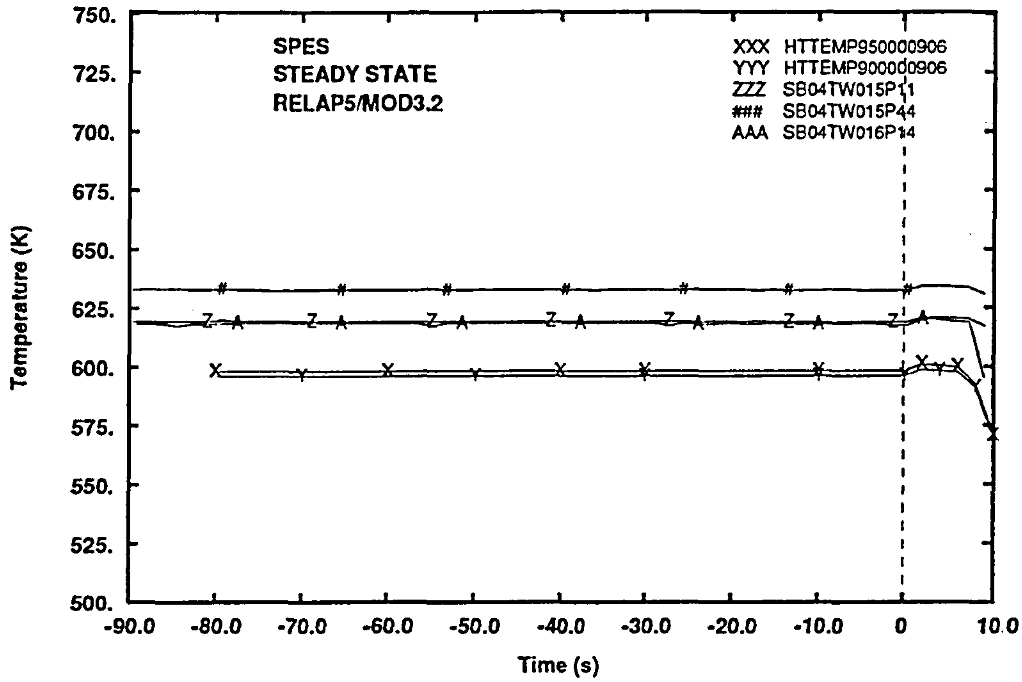

Fig. 9- Heater rod temperature (middle level)

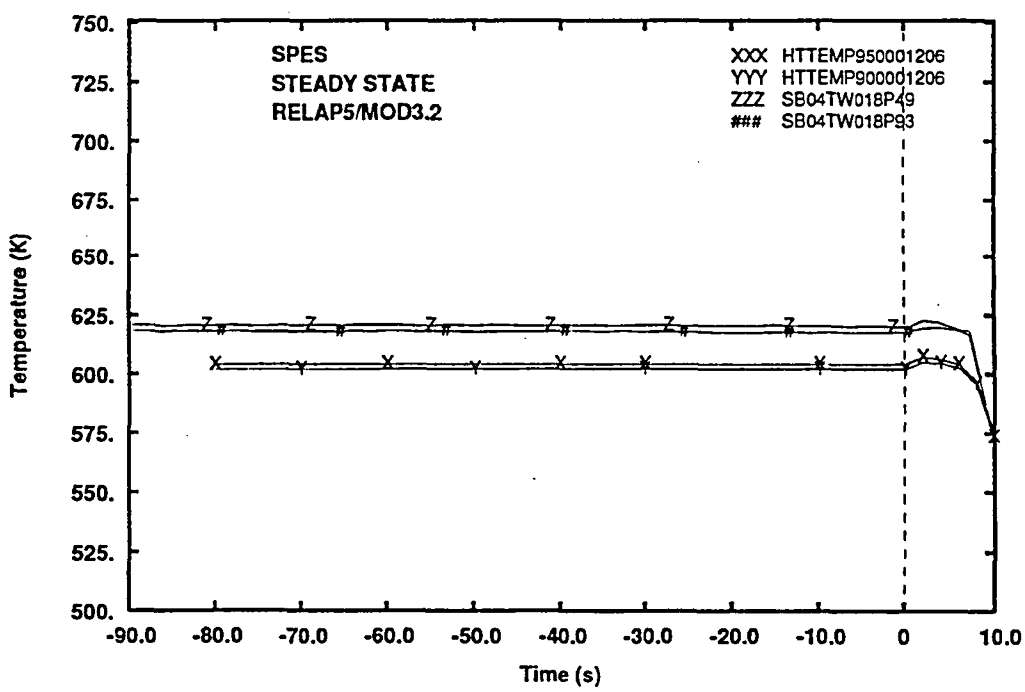

Fig. 10- Heater rod temperature (high level)

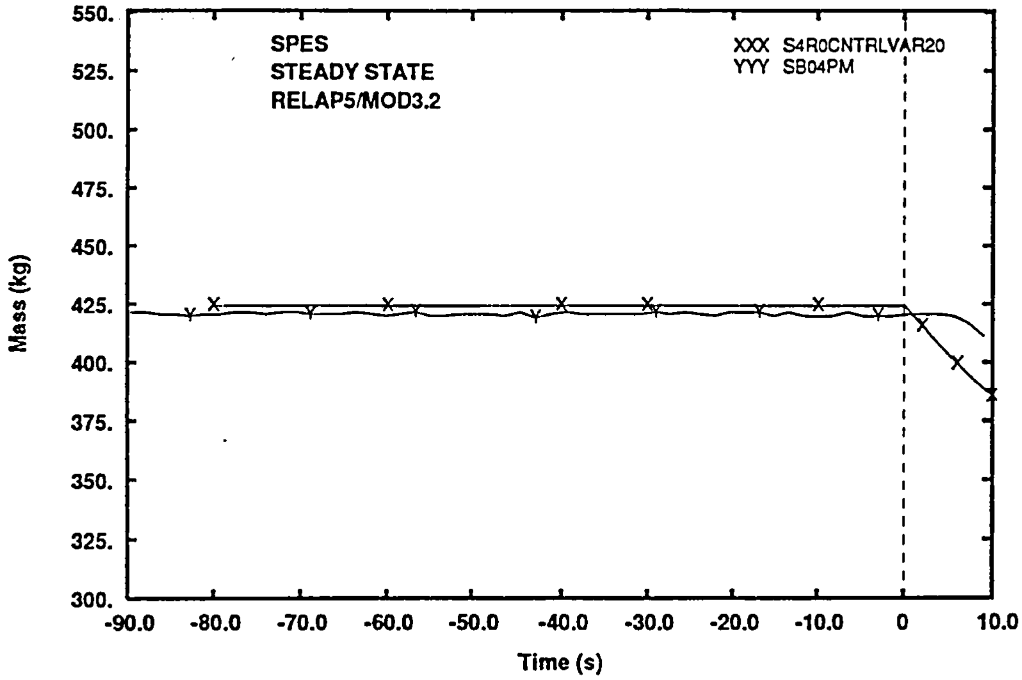

Fig. 11- Primary side total mass

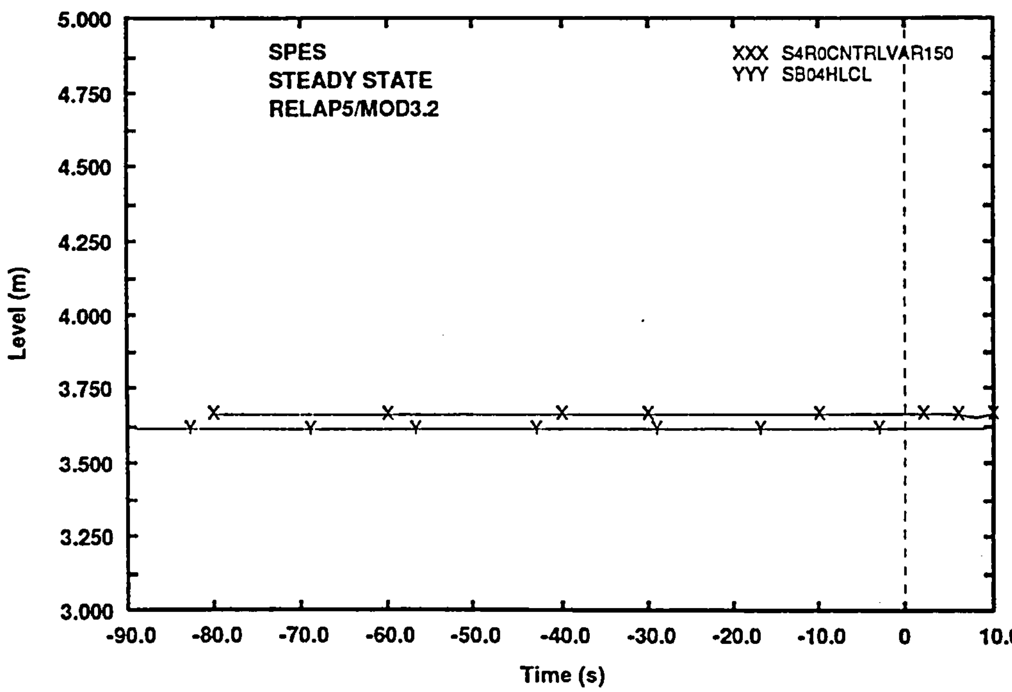

Fig. 12- Core collapsed level

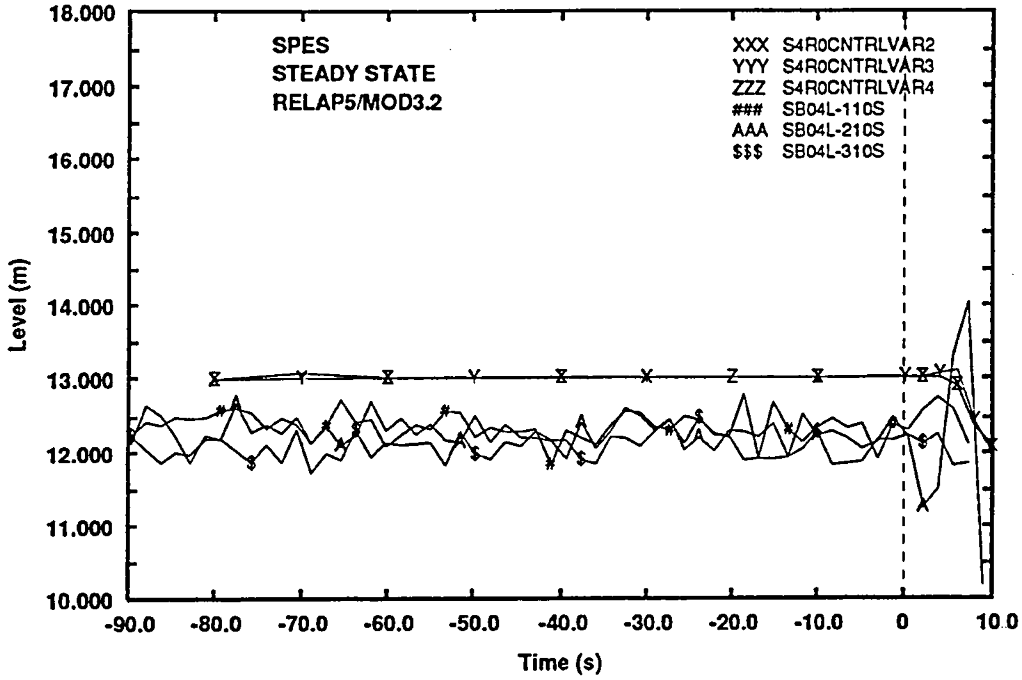

Fig. 13- SG DC level

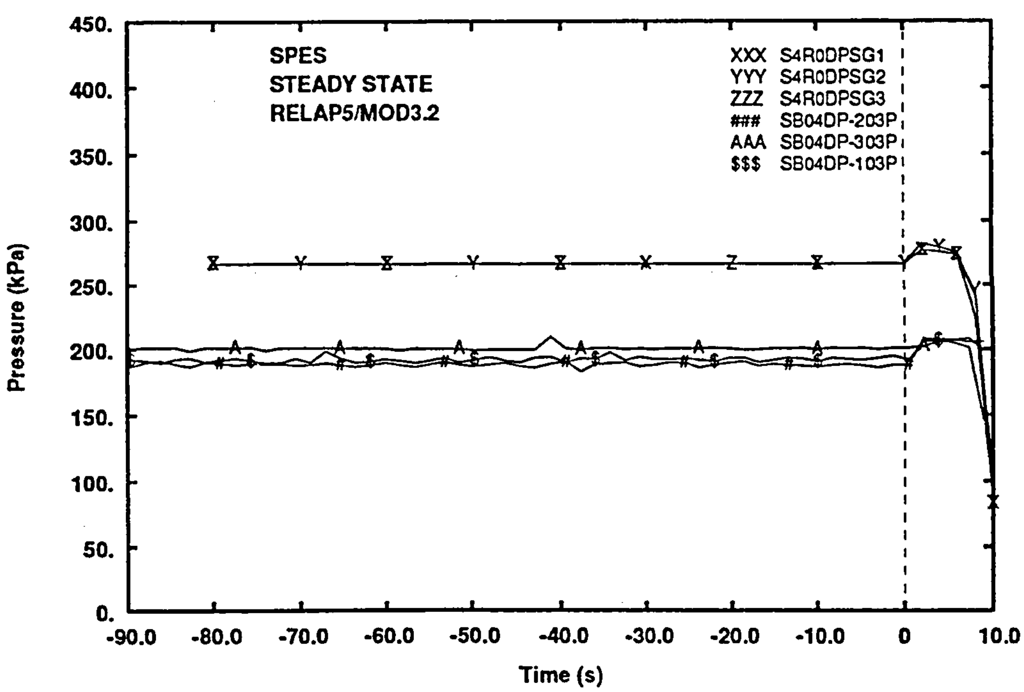

Fig. 14- Pressure drop across inlet-outlet SG

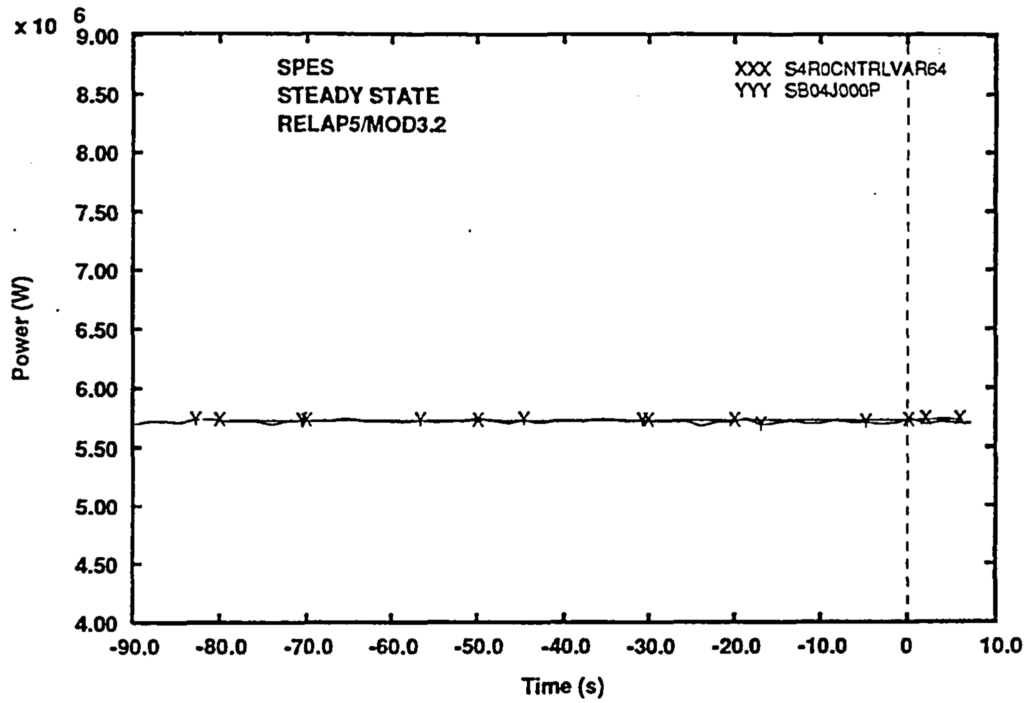

Fig. 15- Core power

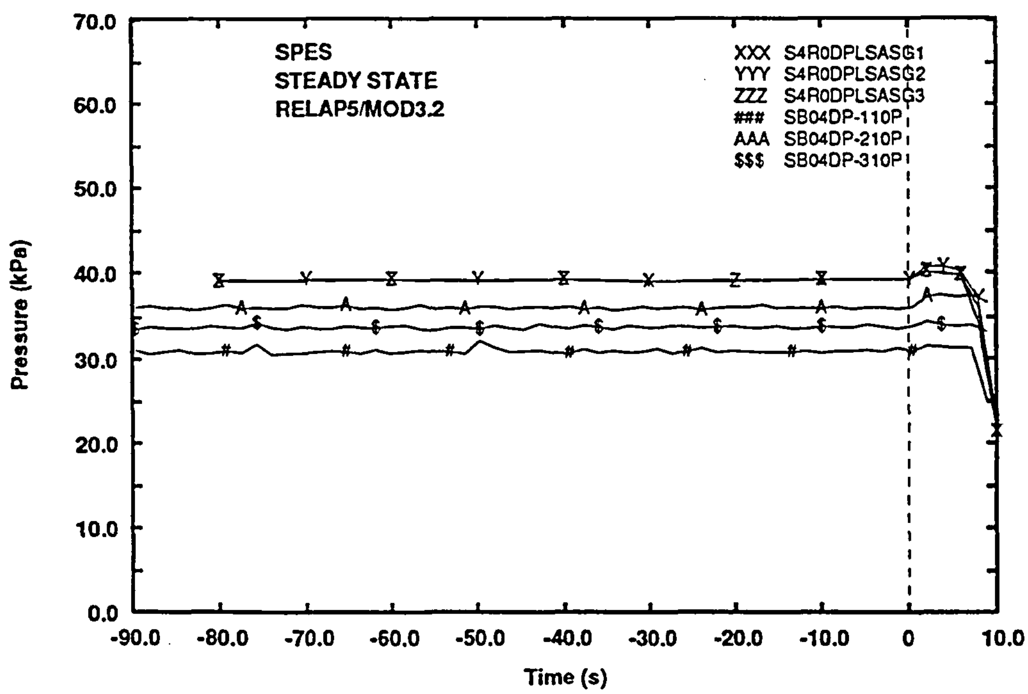

Fig. 16- Pressure drop across loop seal (ascendig side)

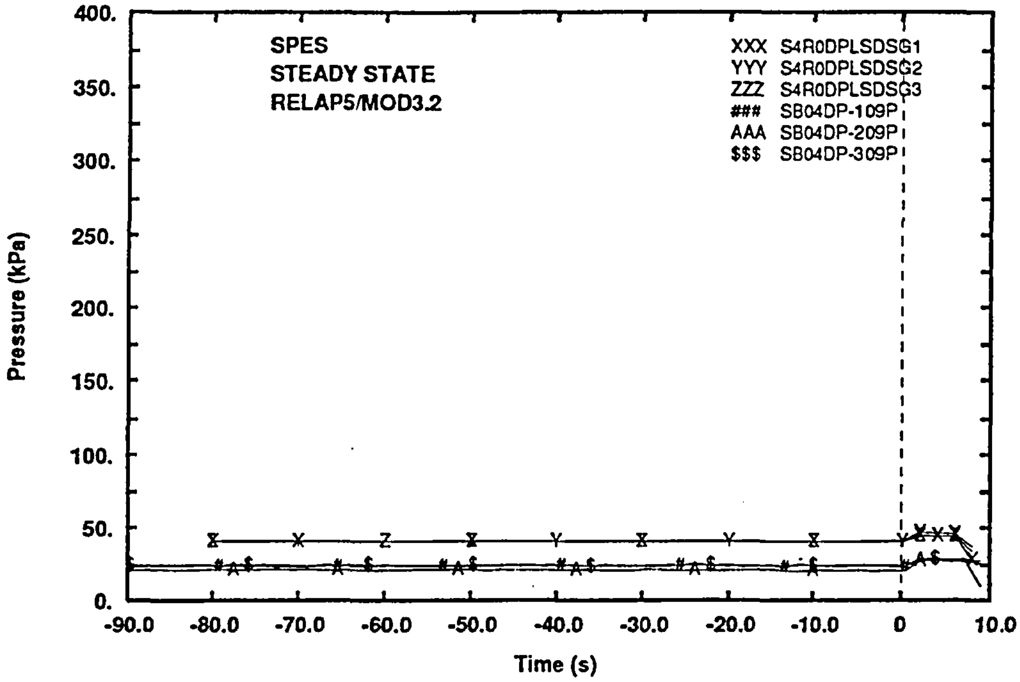

Fig. 17- Pressure drop across loop seal (descendig side)

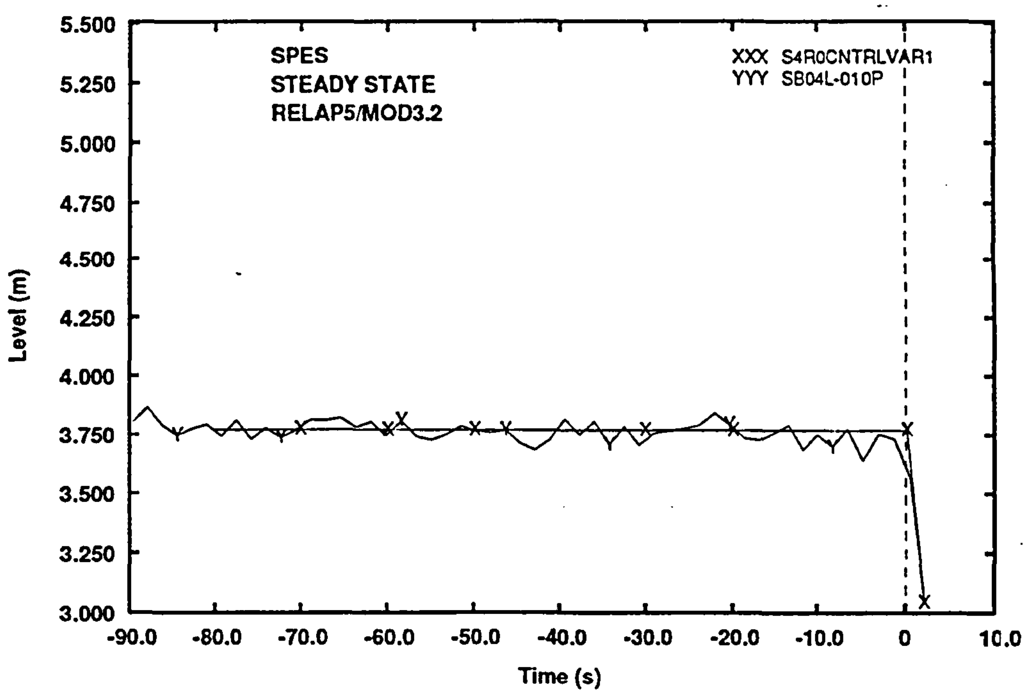

Fig. 18- PRZ level

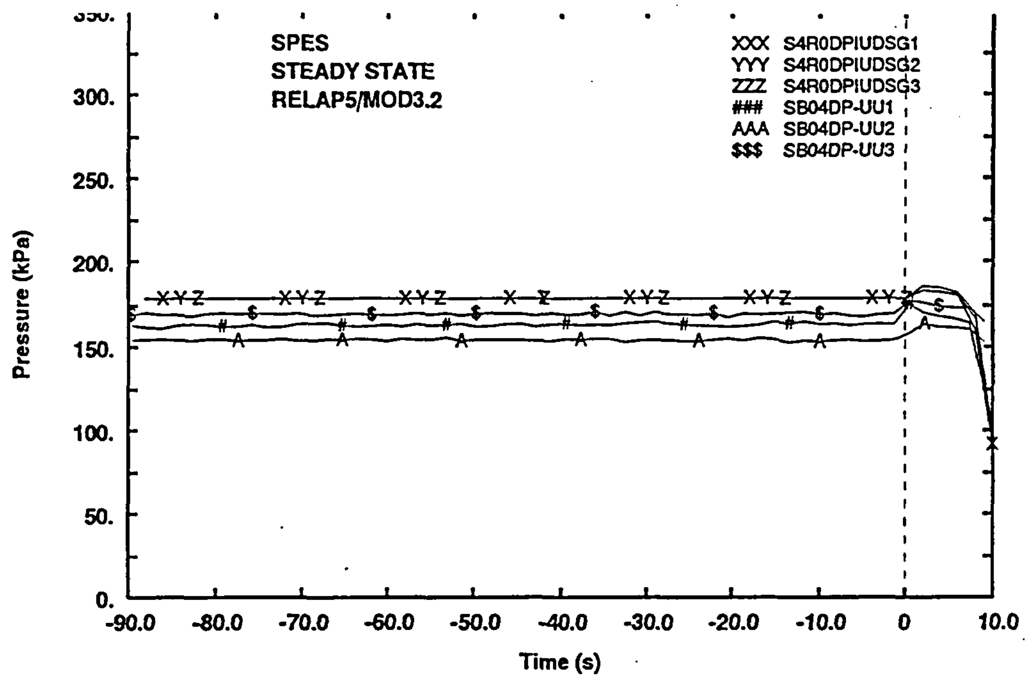

Fig. 19- Pressure drop between SG inlet plenum and Utubes top

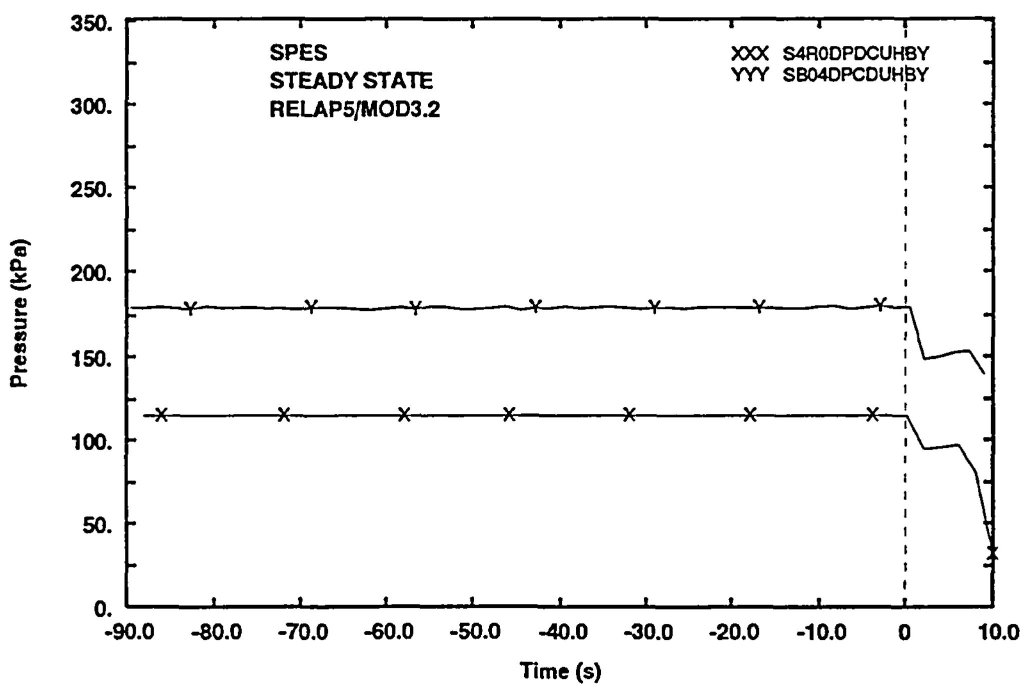

Fig. 20- Pressure drop across DC-UH bypass

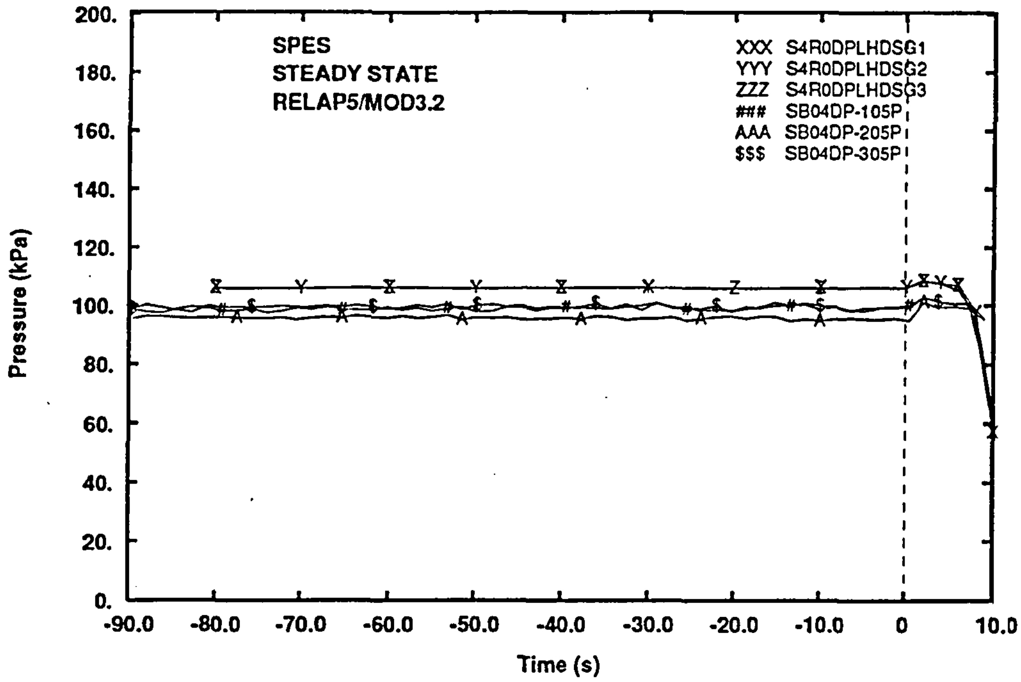

Fig. 21- Liquid hold up in SG (primary side)

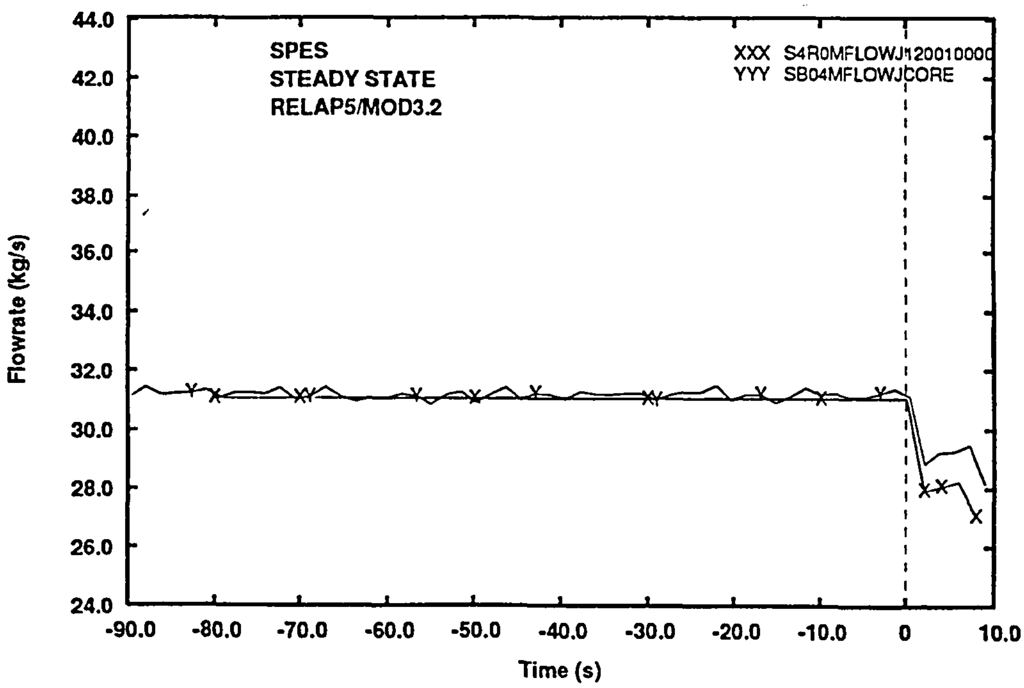

Fig. 22- Core inlet flow rate

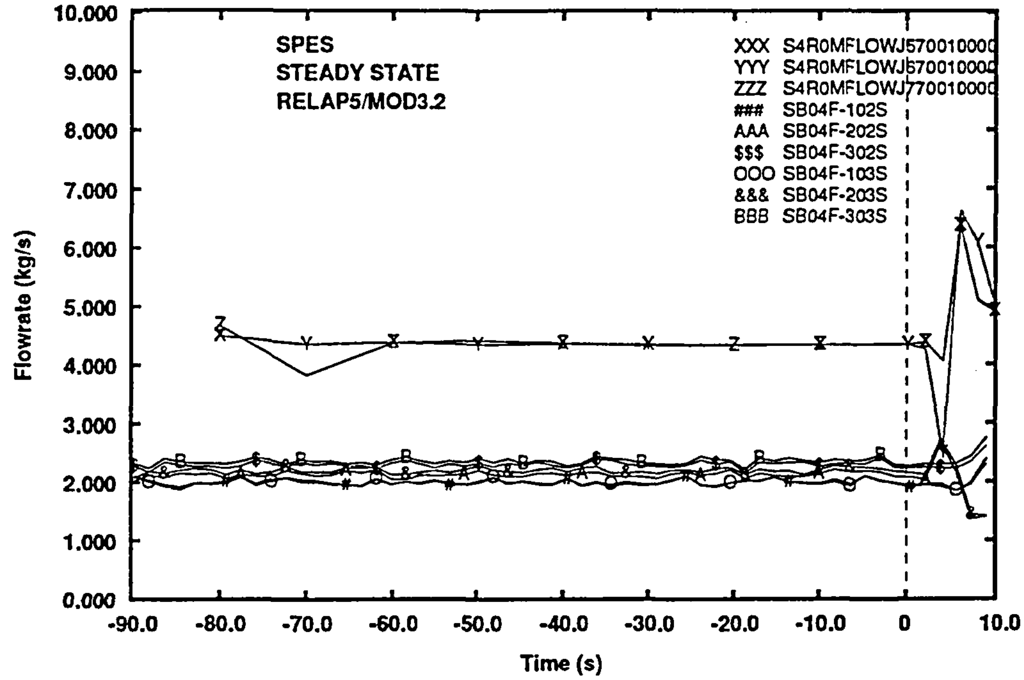

Fig. 23- SG DC flowrate

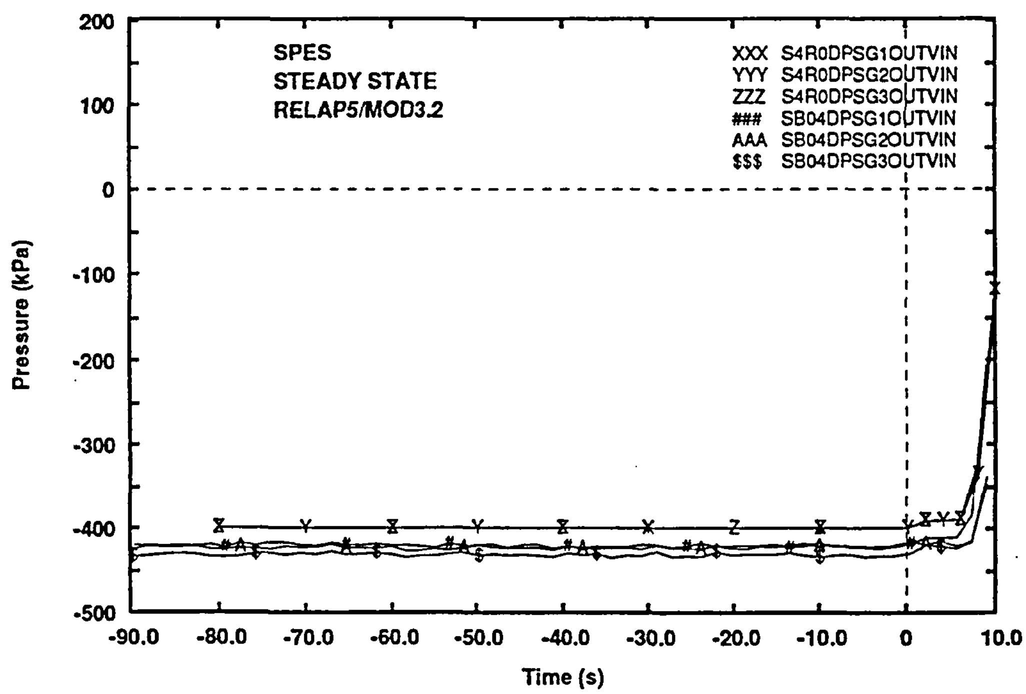

Fig. 24- pressure drop across SG outlet and vessel nozzle.

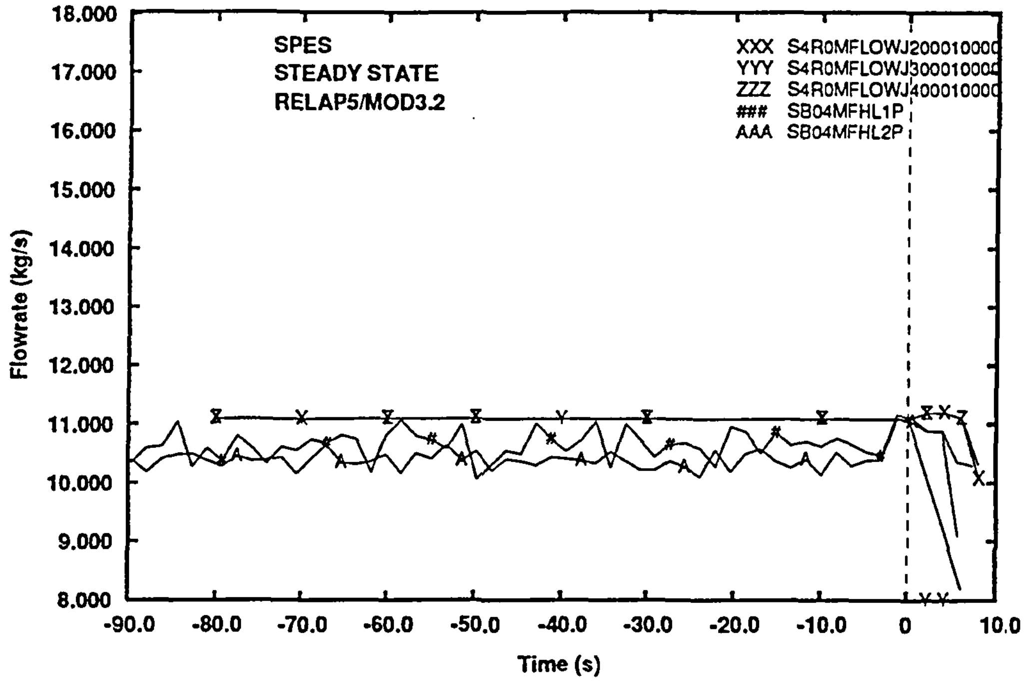

Fig. 25- Hot leg mass flowrate

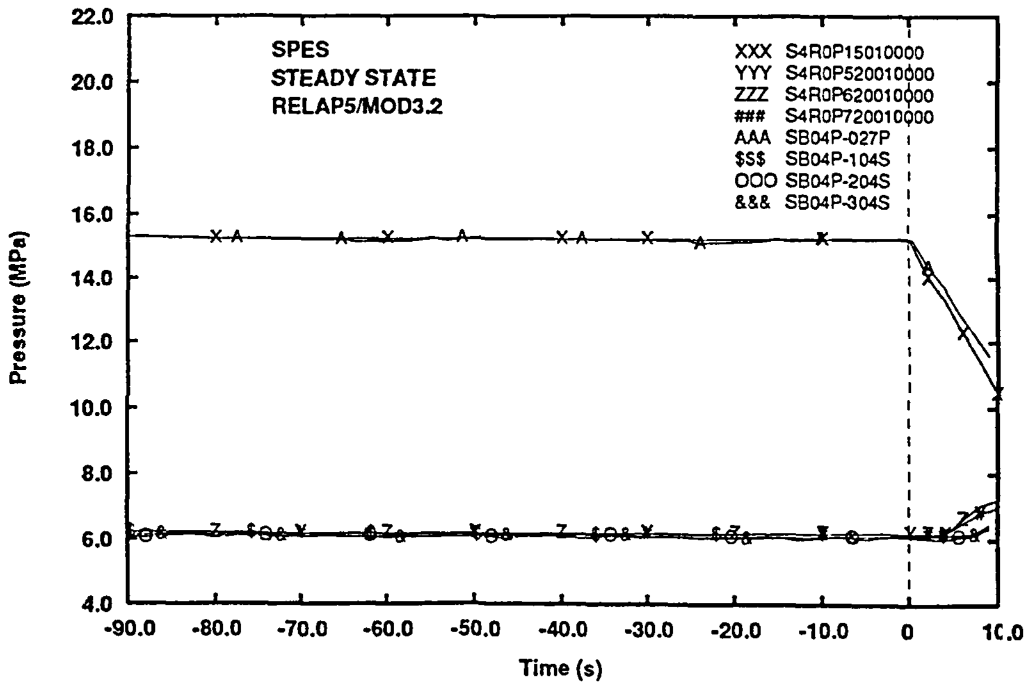

Fig. 26- Primary and secondary pressure

APPENDIX 3:

Results of the reference calculation (run R0)

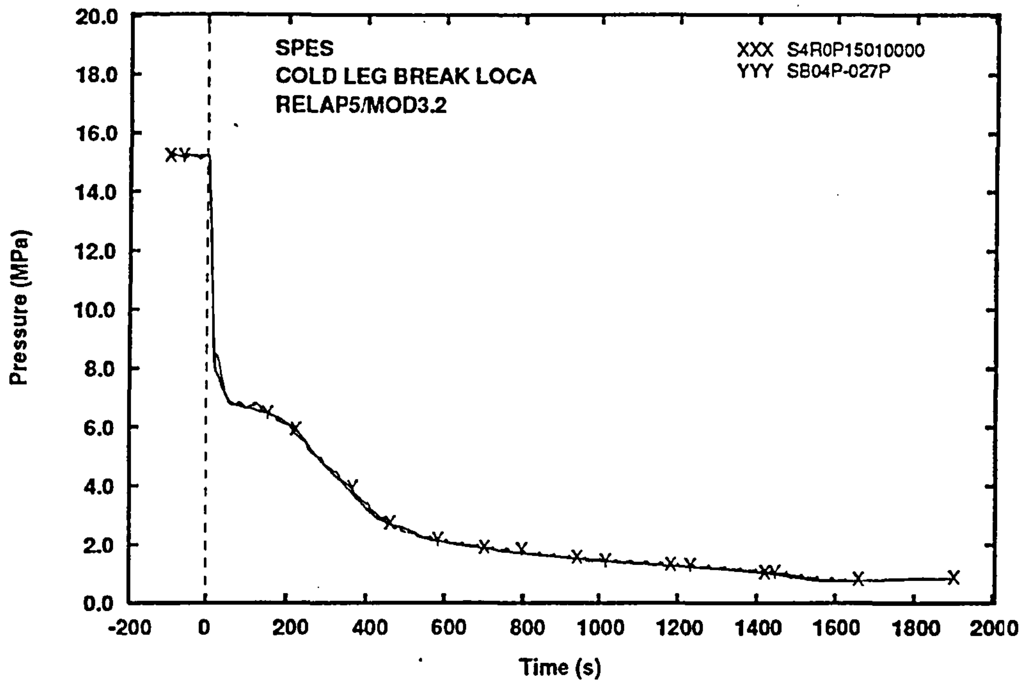

Fig. 1- PRZ pressure

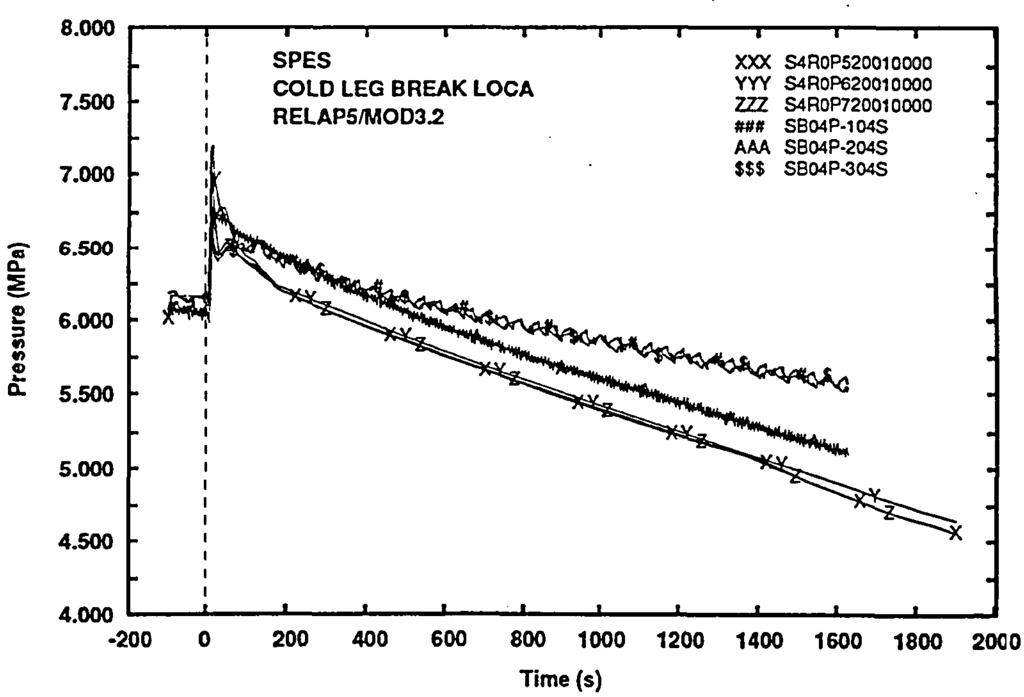

Fig. 2- SGs secondary side pressure

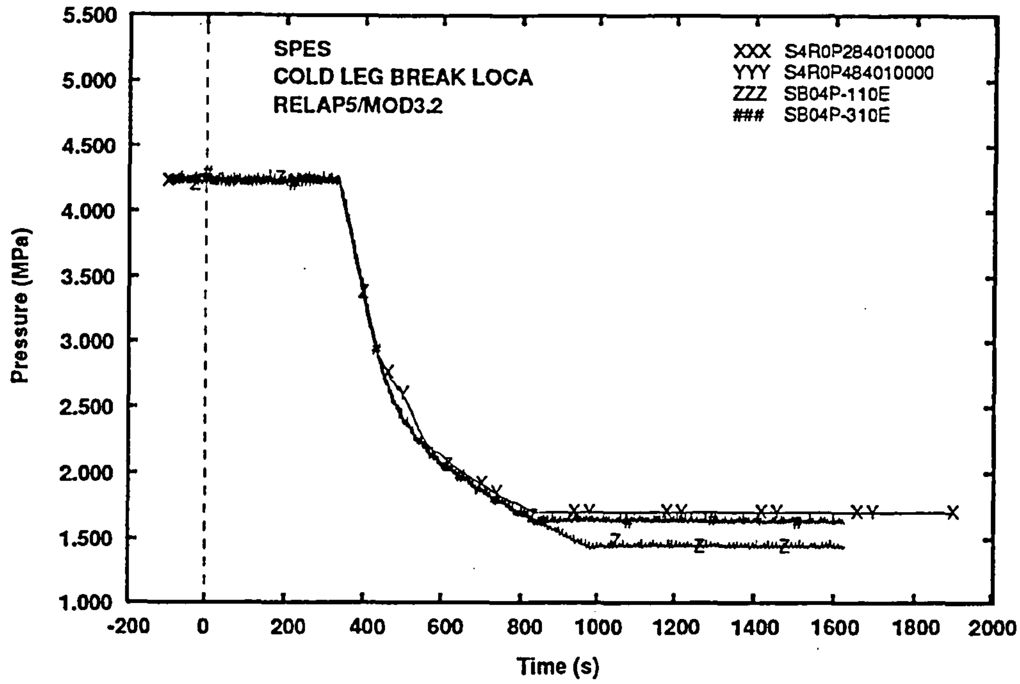

Fig. 3- Accumulator pressure

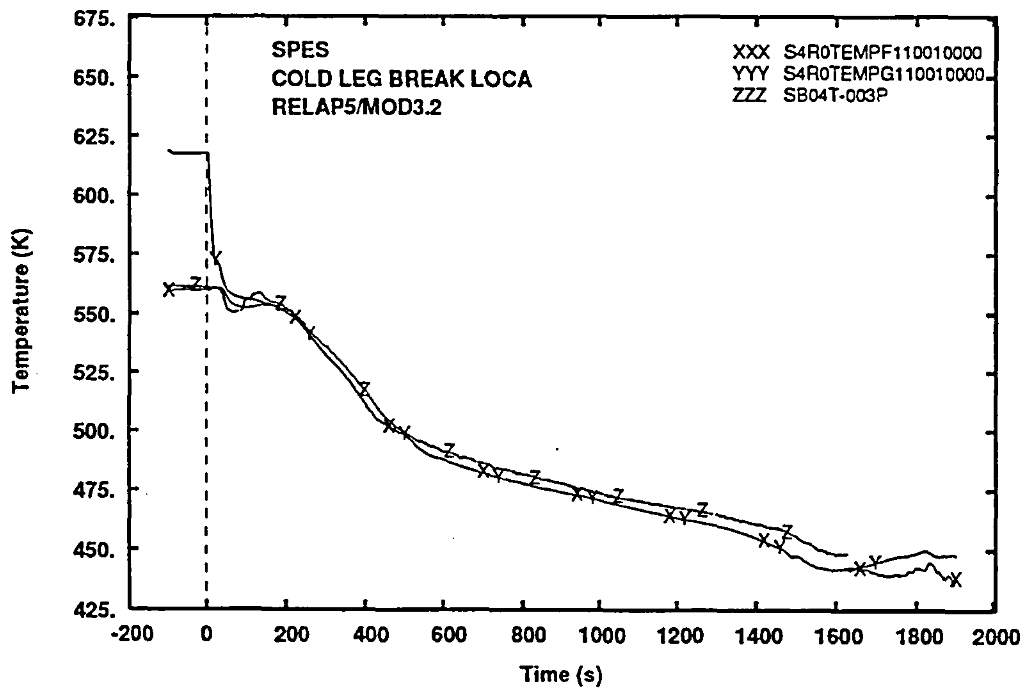

Fig. 4- Core inlet fluid temperature

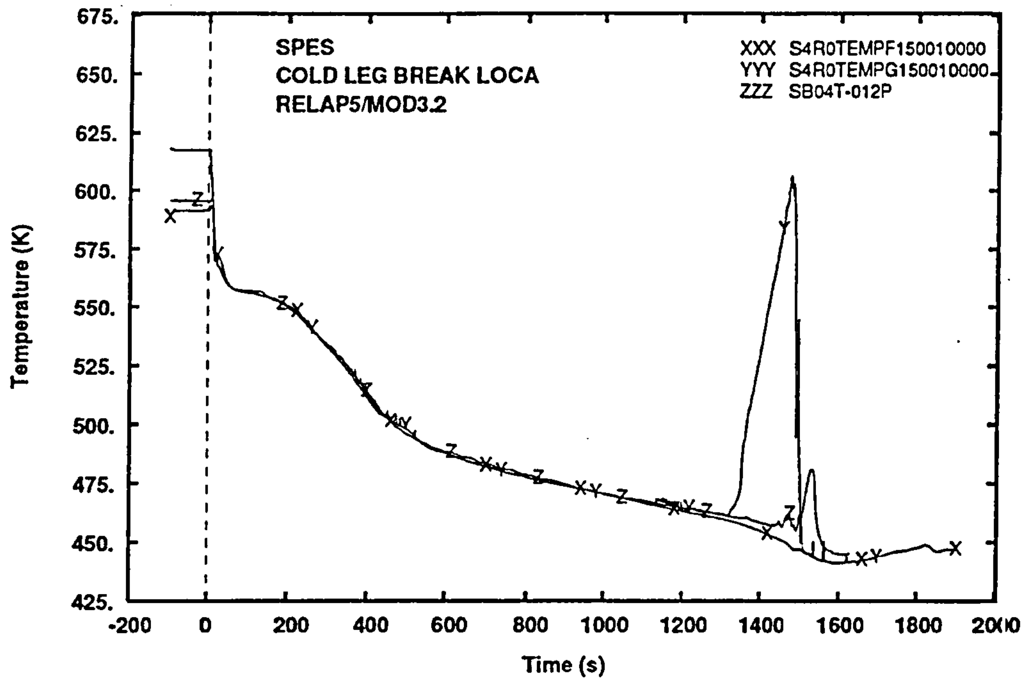

Fig. 5- Core outlet fluid temperature

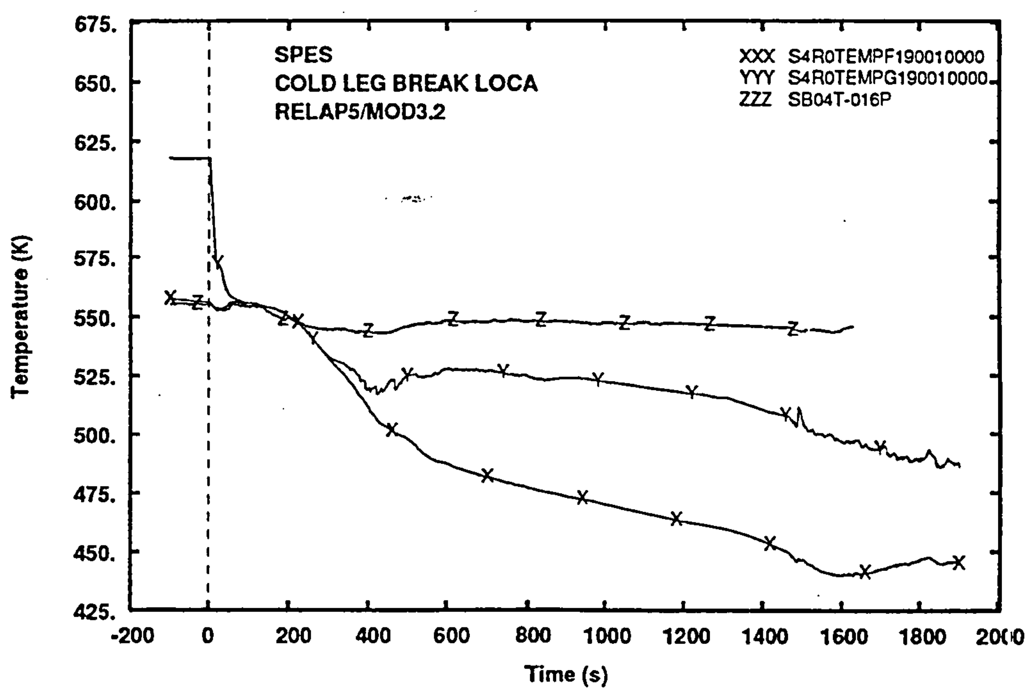

Fig. 6- Upper Head coolant temperature

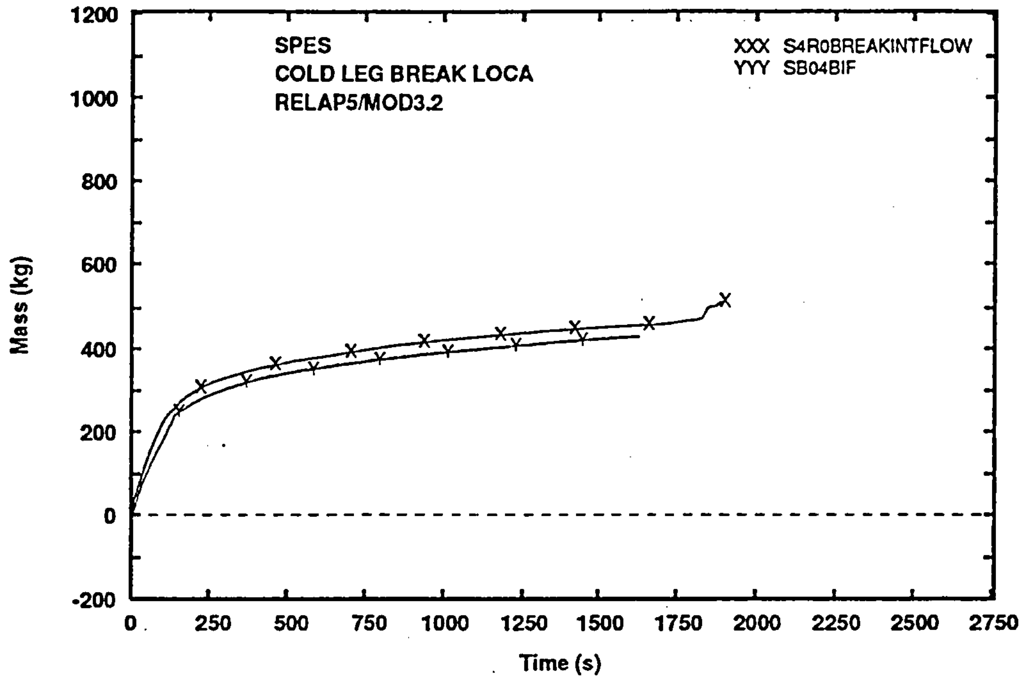

Fig. 7- Integral break flowrate

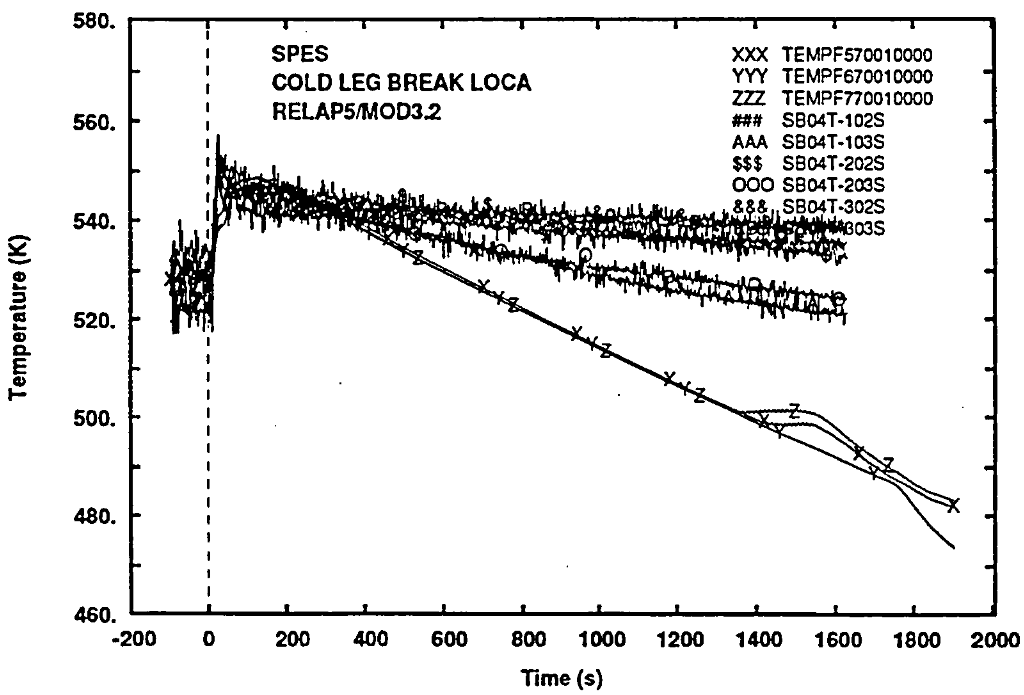

Fig. 8- SG bottom DC fluid temperature

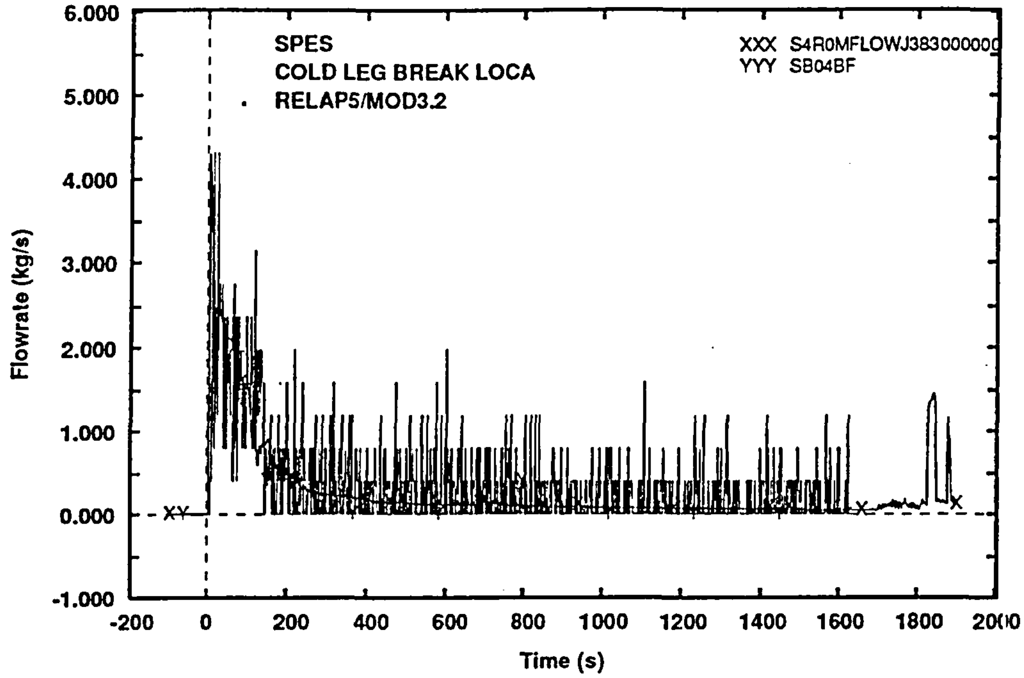

Fig. 9- Break flowrate

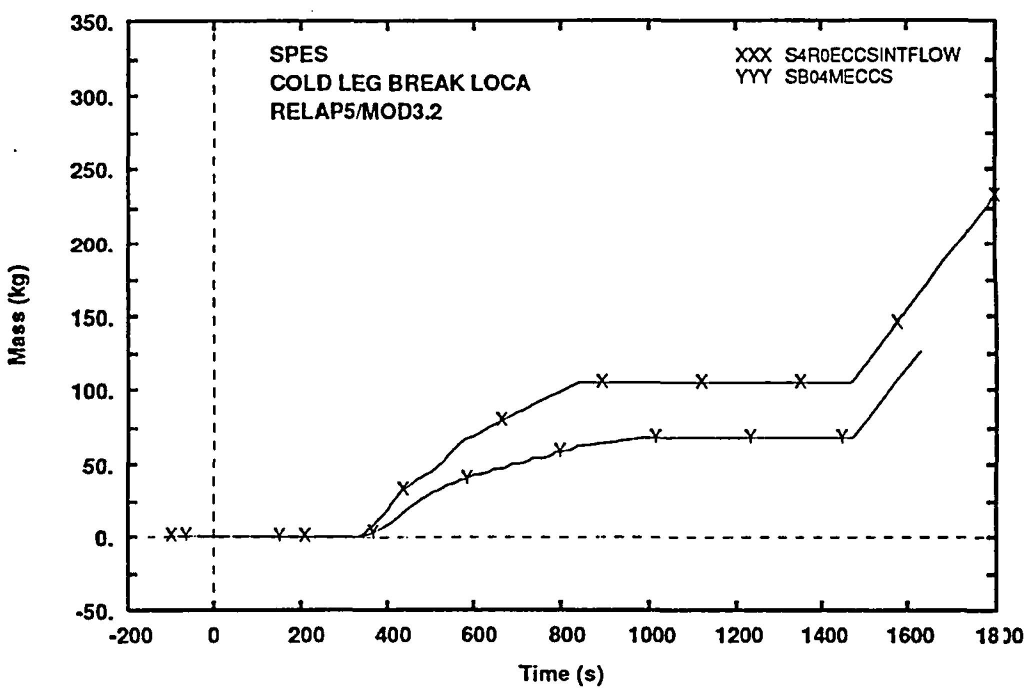

Fig. 10- ECCS integral flowrate

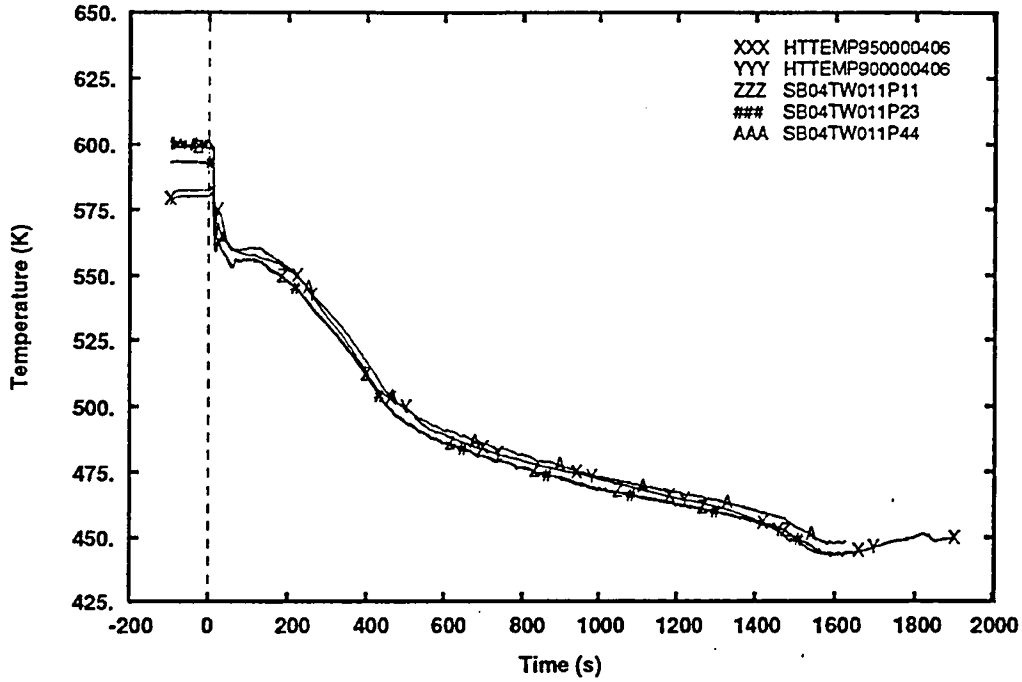

Fig. 11- Heater rod temperature (bottom level)

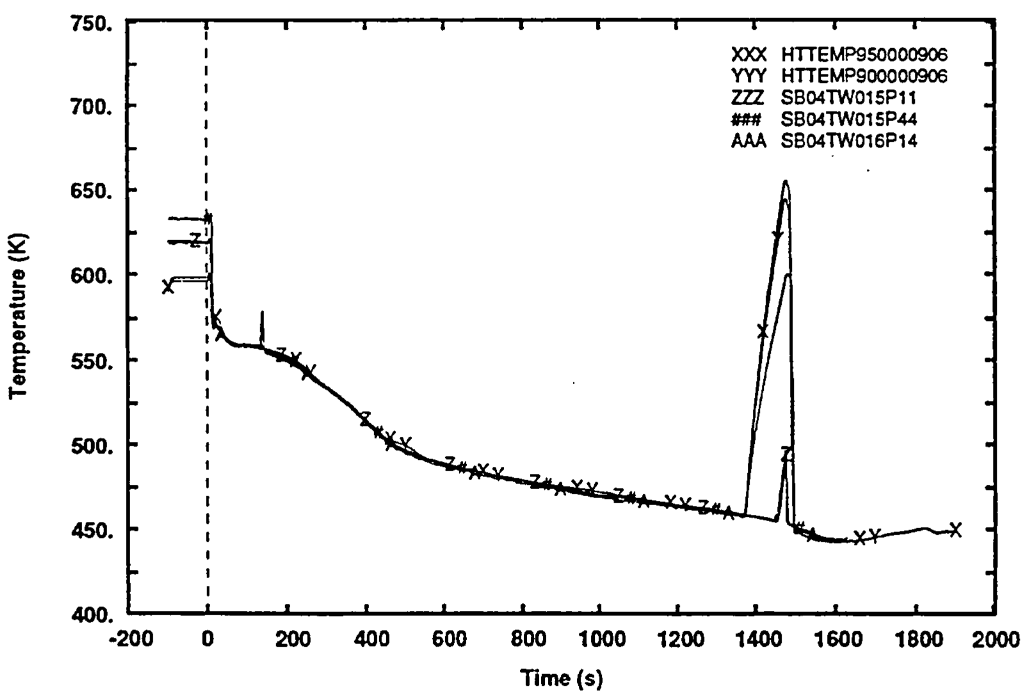

Fig. 12- Heater rod temperature (middle level)

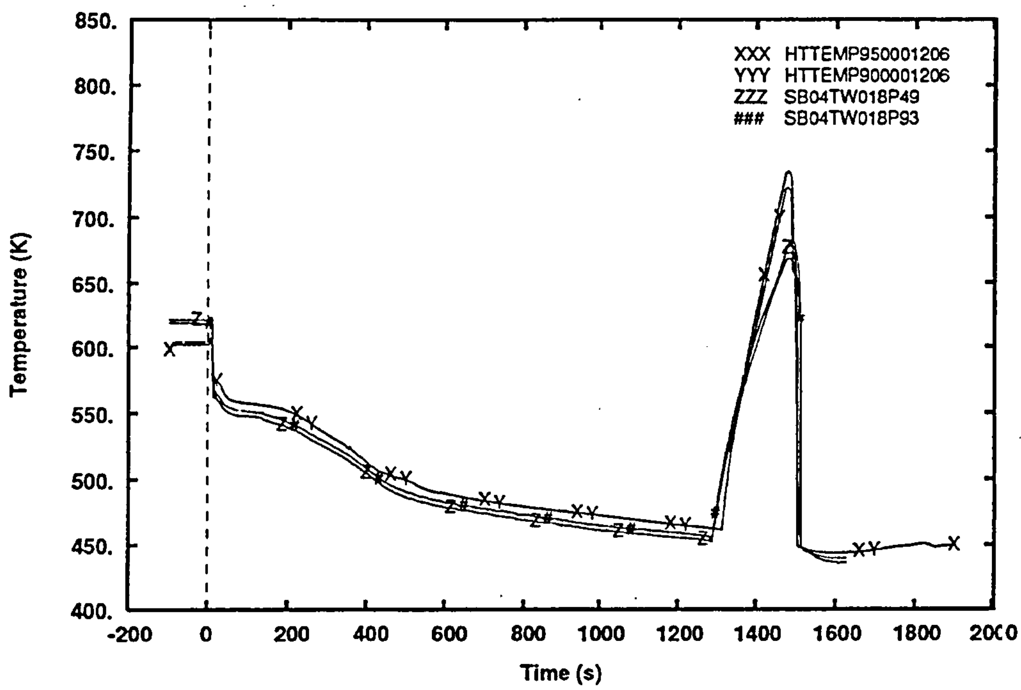

Fig. 13- Heater rod temperature (high level)

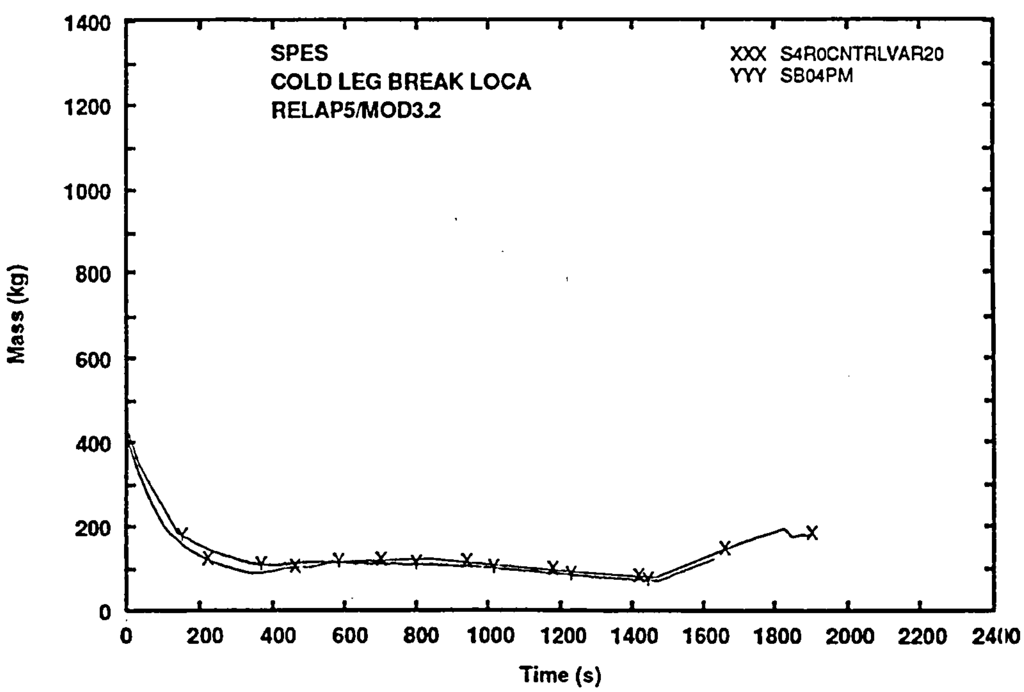

Fig. 14- Primary side total mass

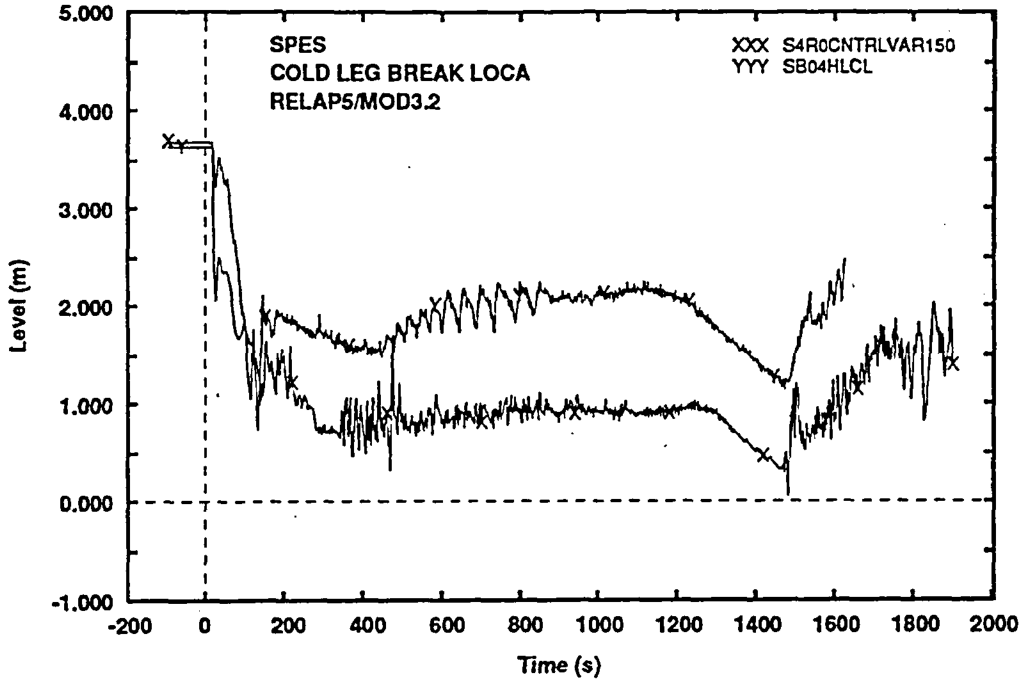

Fig. 15- Core collapsed level

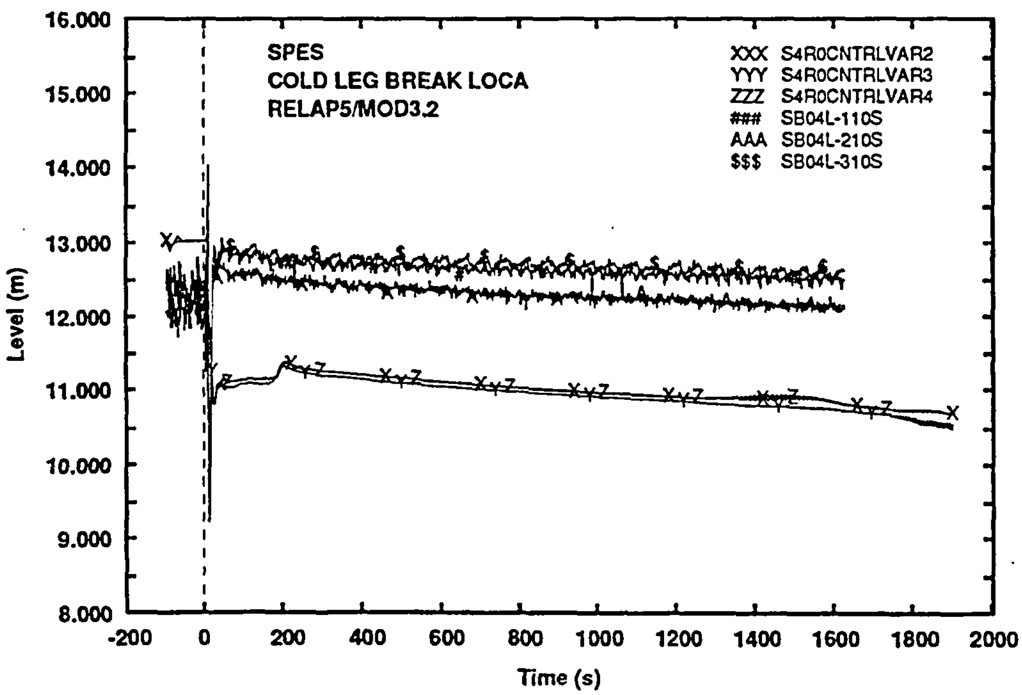

Fig. 16- SG DC level

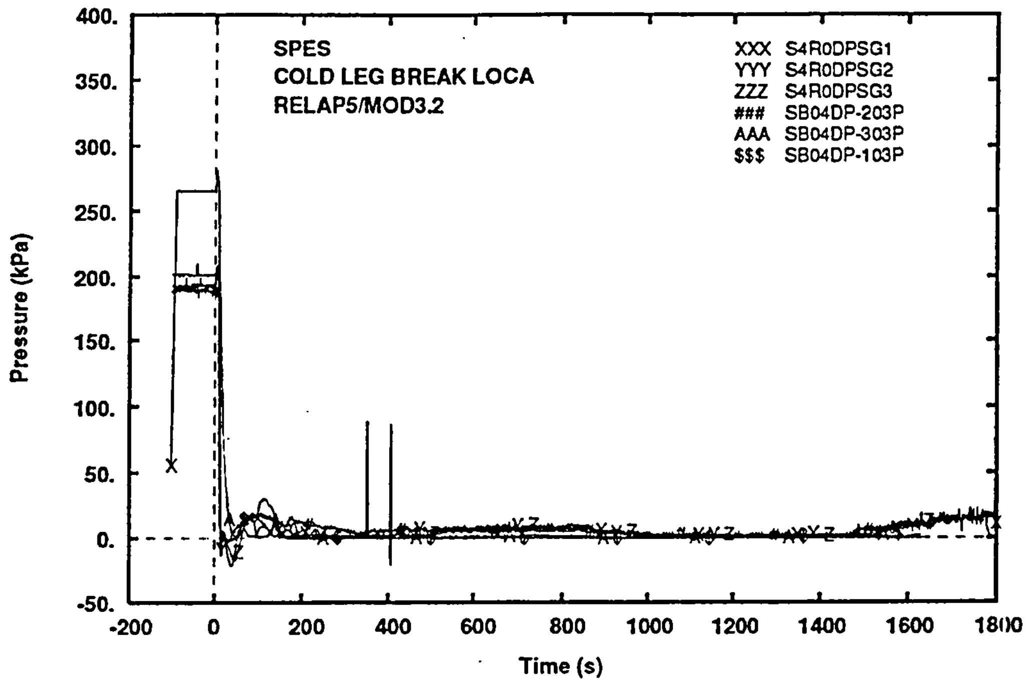

Fig. 17- Pressure drop across inlet-outlet SG

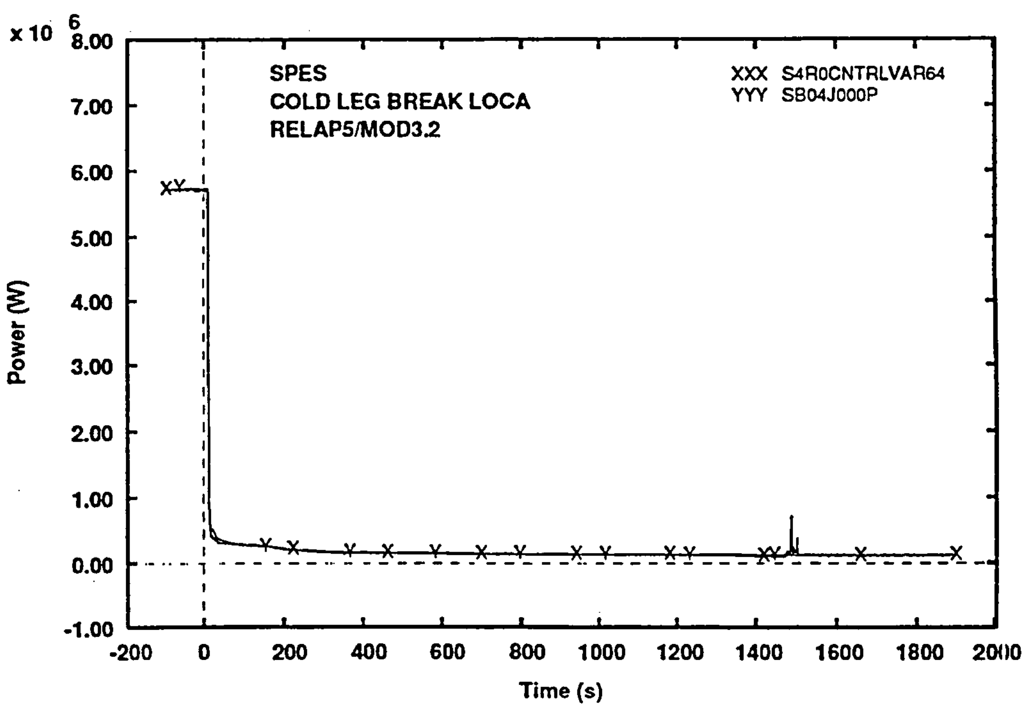

Fig. 18- Core power

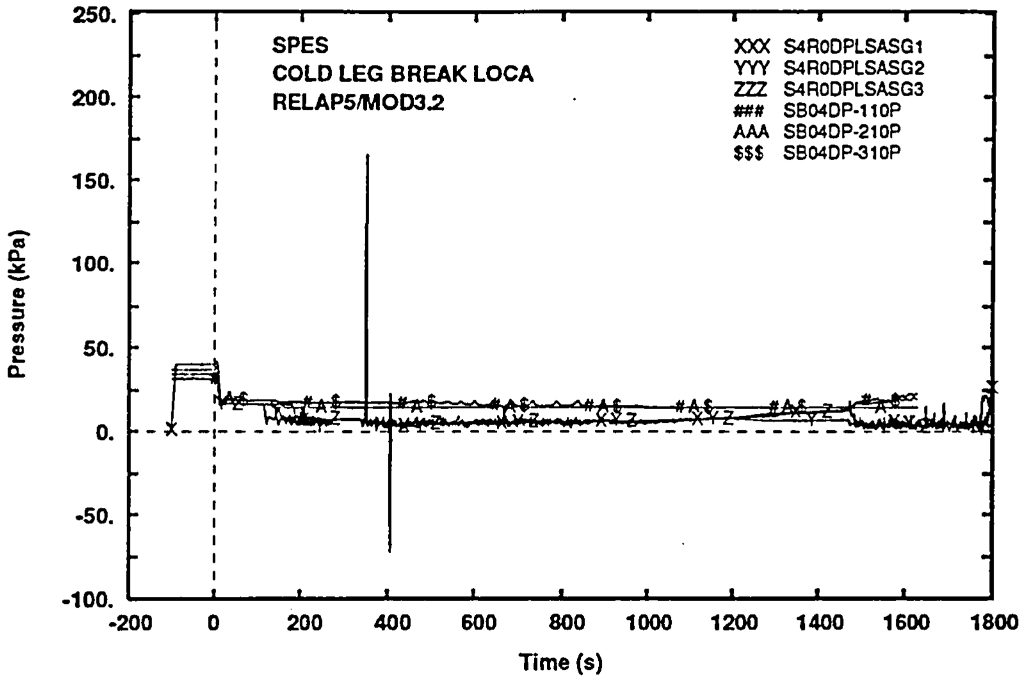

Fig. 19- Pressure drop across loop seal (ascendig side)

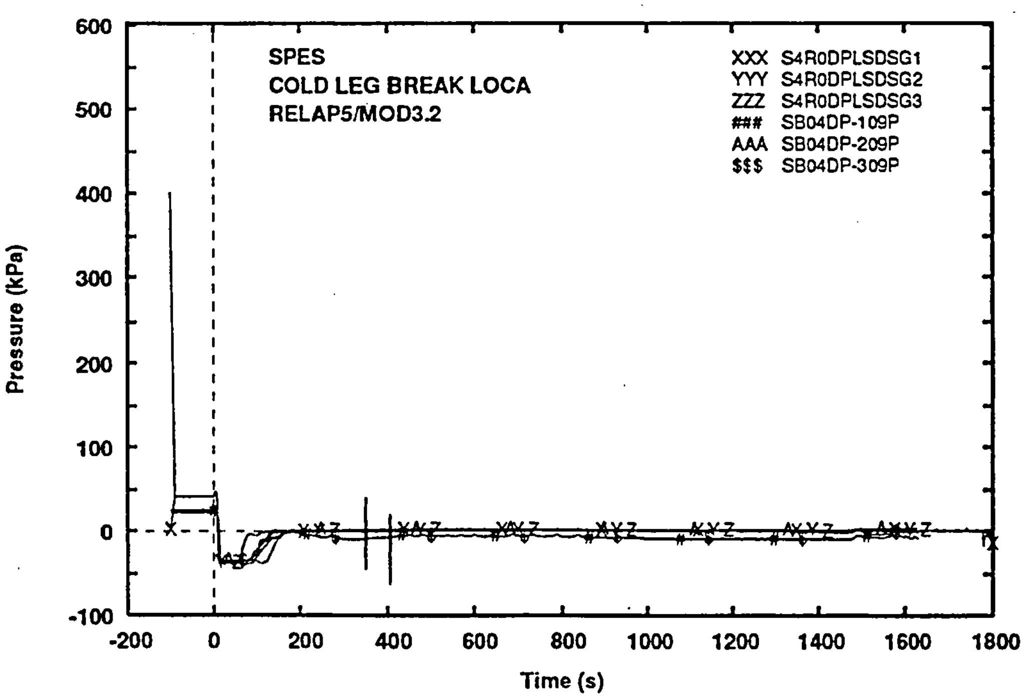

Fig. 20- Pressure drop across loop seal (descendig side)

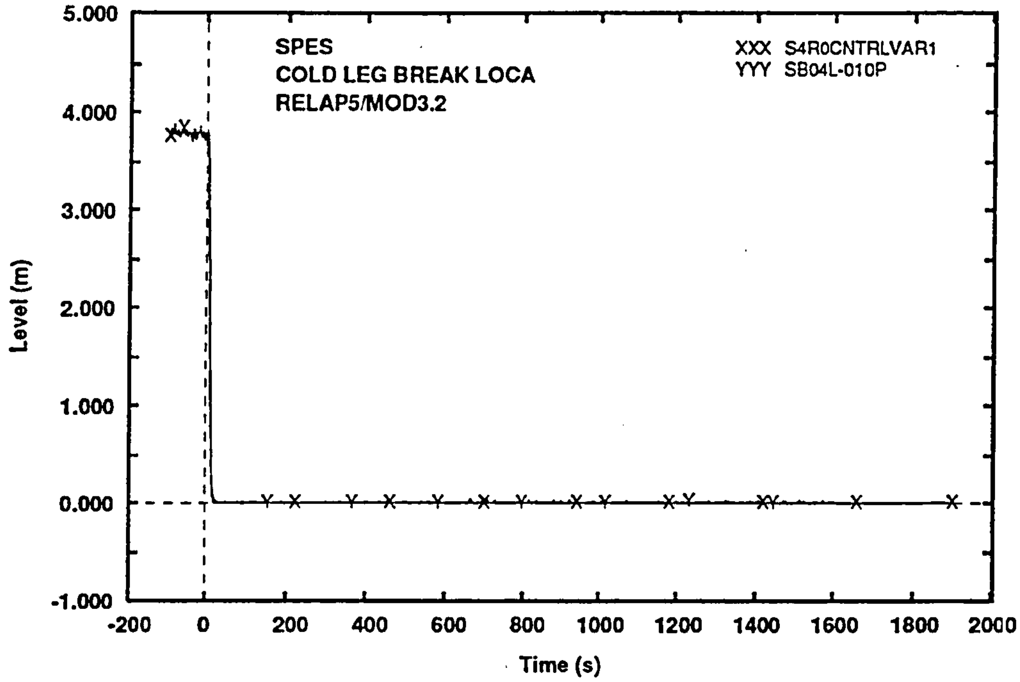

Fig. 21- PRZ level

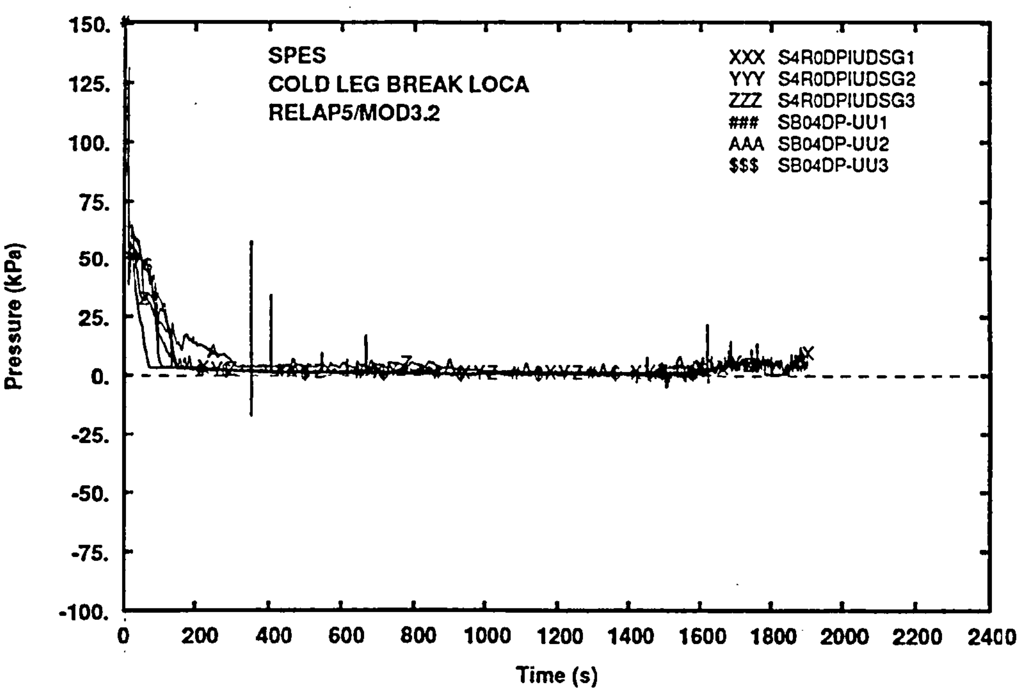

Fig. 22- Pressure drop between SG inlet plenum and Utubes top

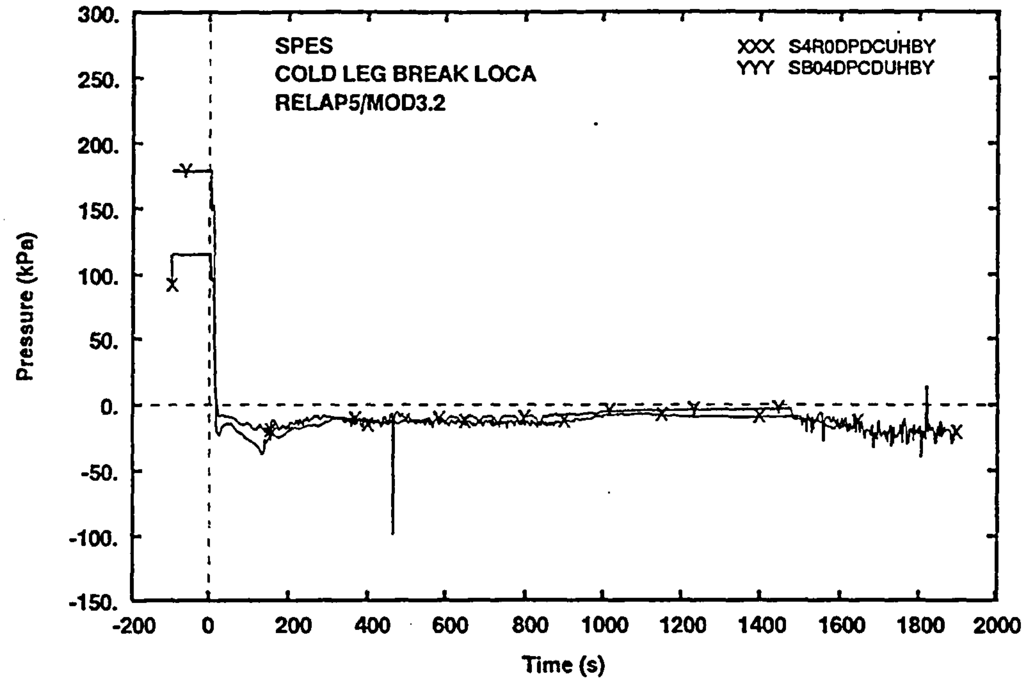

Fig. 23- Pressure drop across DC-UH bypass

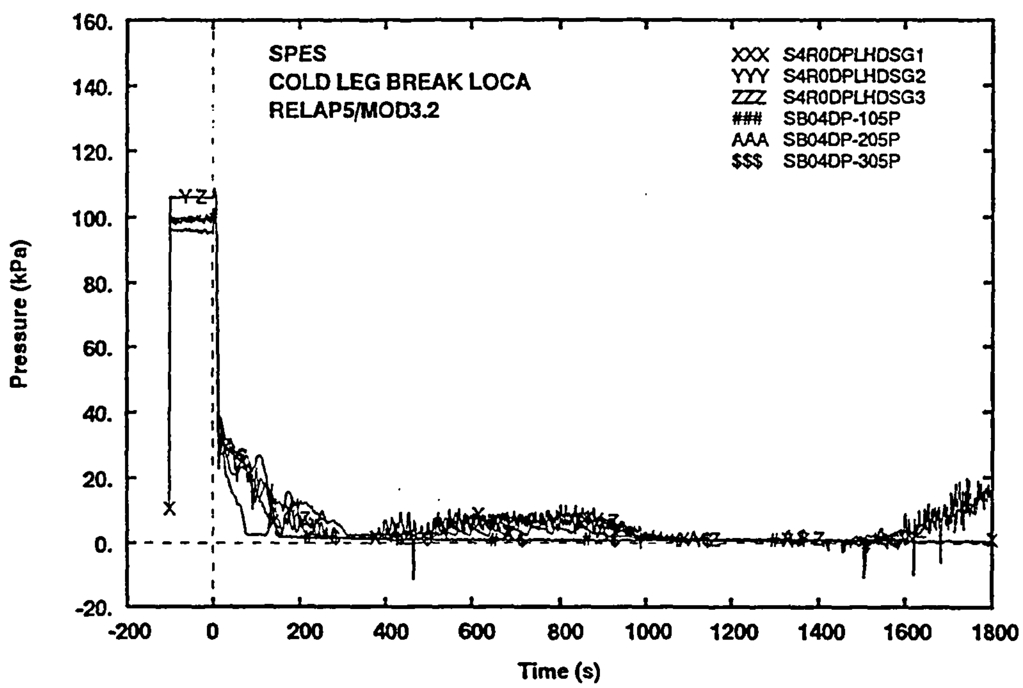

Fig. 24- Liquid hold up in SG (primary side)

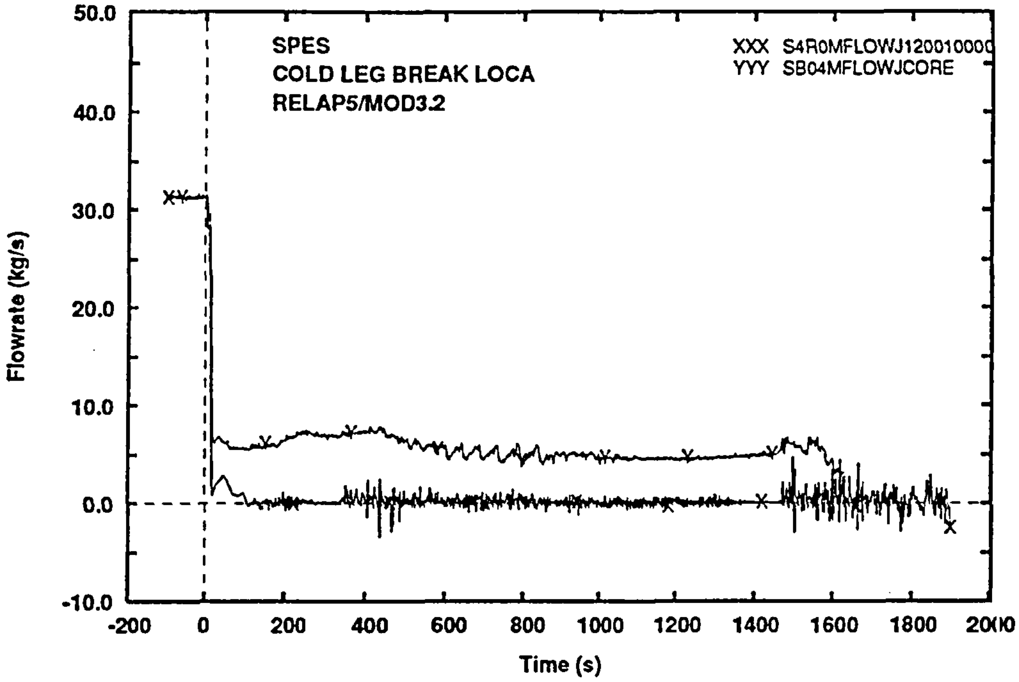

Fig. 25- Core inlet flow rate

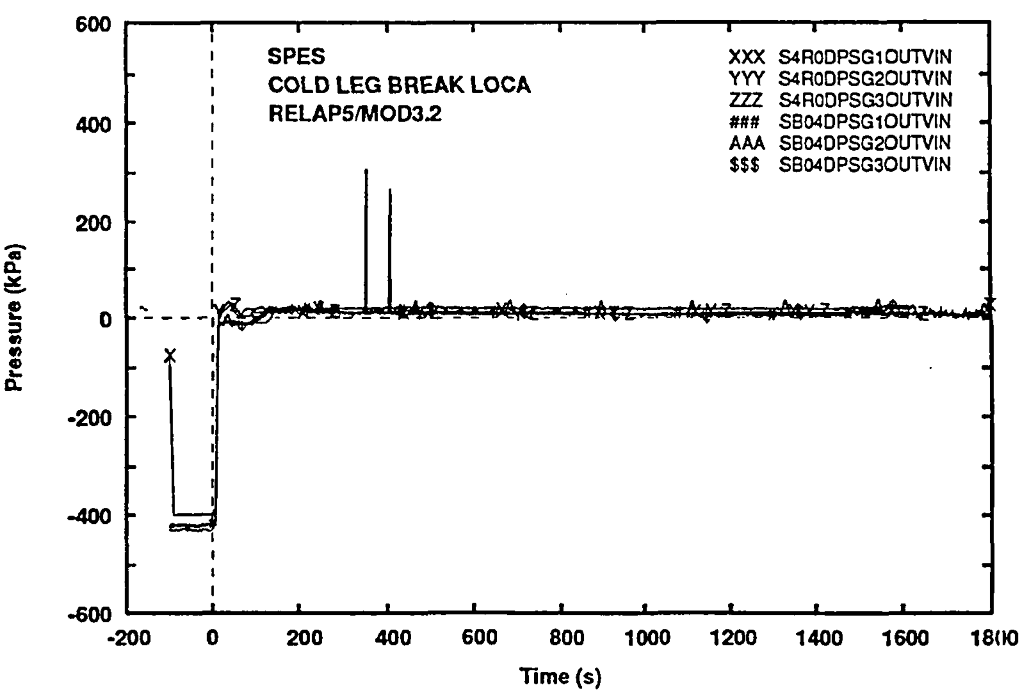

Fig. 26- pressure drop across SG outlet and vessel nozzle.

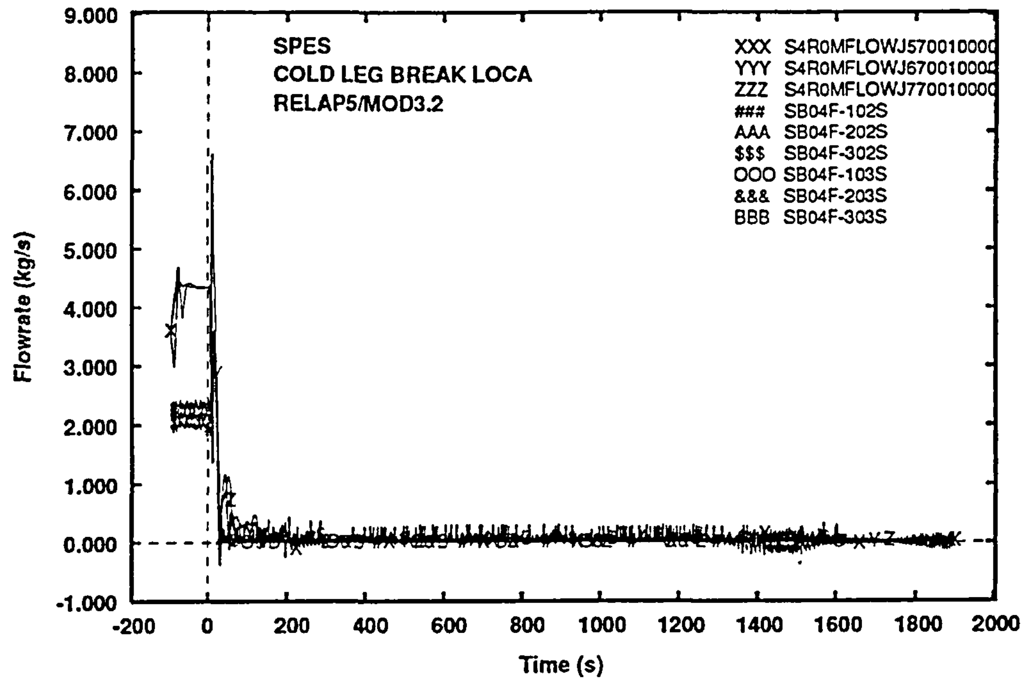

Fig. 27- SG DC flowrate

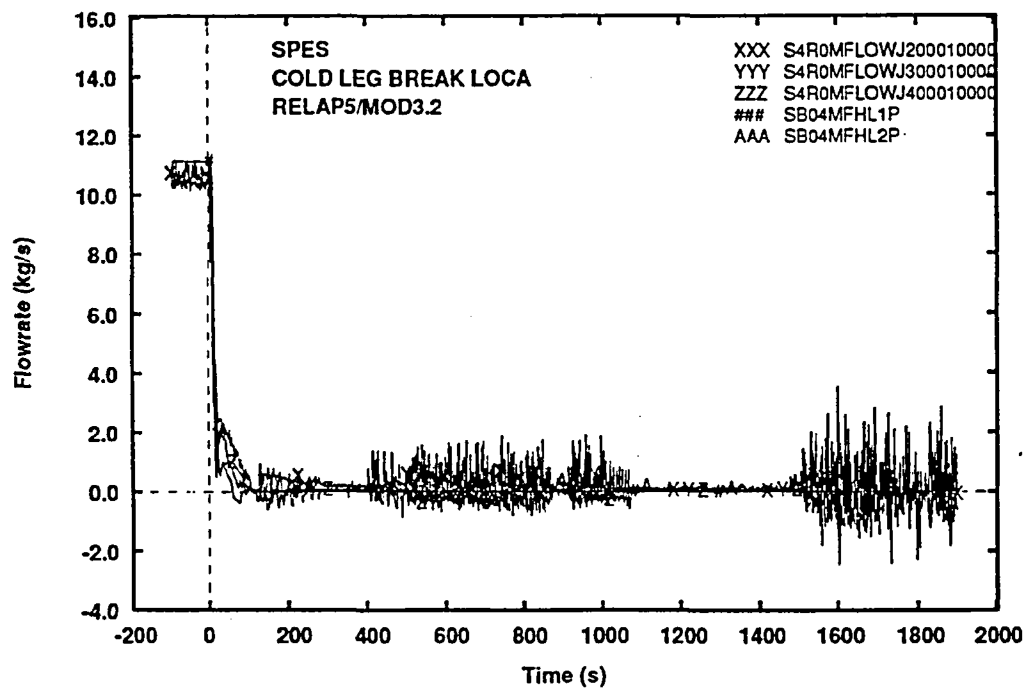

Fig. 28- Hot leg mass flowrate

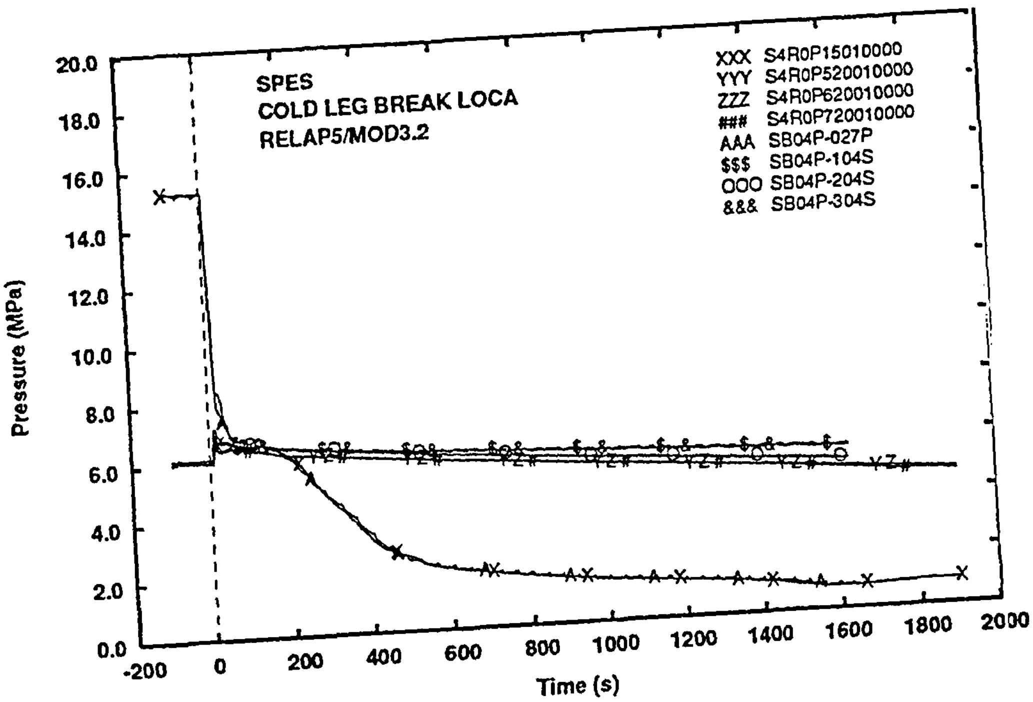

Fig. 29- Primary and secondary pressure

APPENDIX 4:

Results of the sensitivity analysis
(run R1, R2, R31, R32, R33, R4, R5, R6, R7, R8, R9, RA)

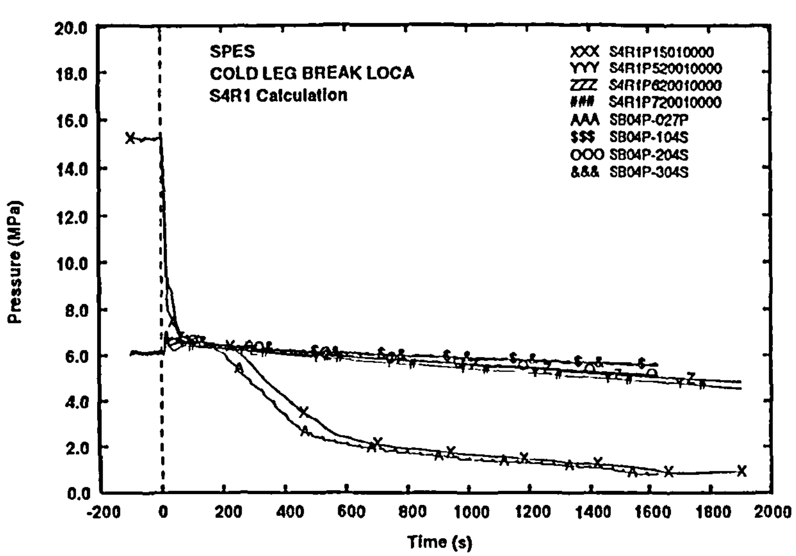

Fig. 1- S4R1 Case - Primary and secondary pressure

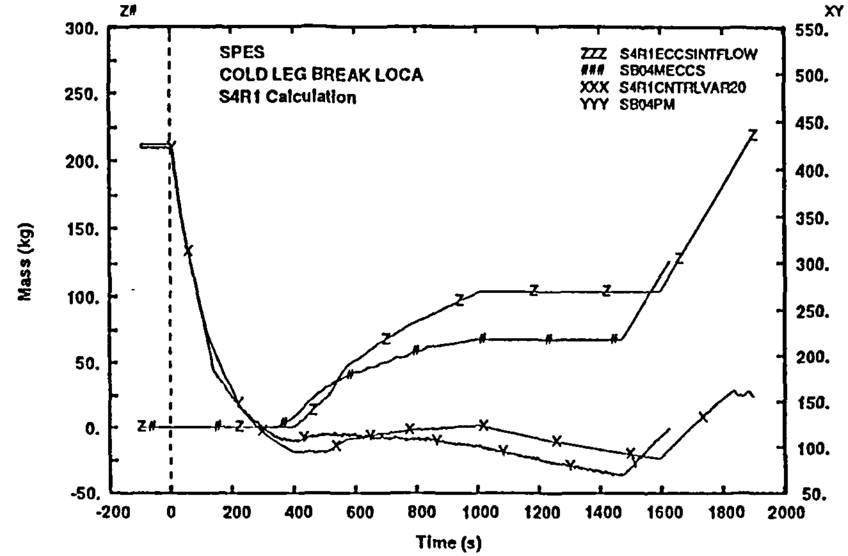

Fig. 2- S4R1 Case - ECCS integral flowrate and primary side total mass

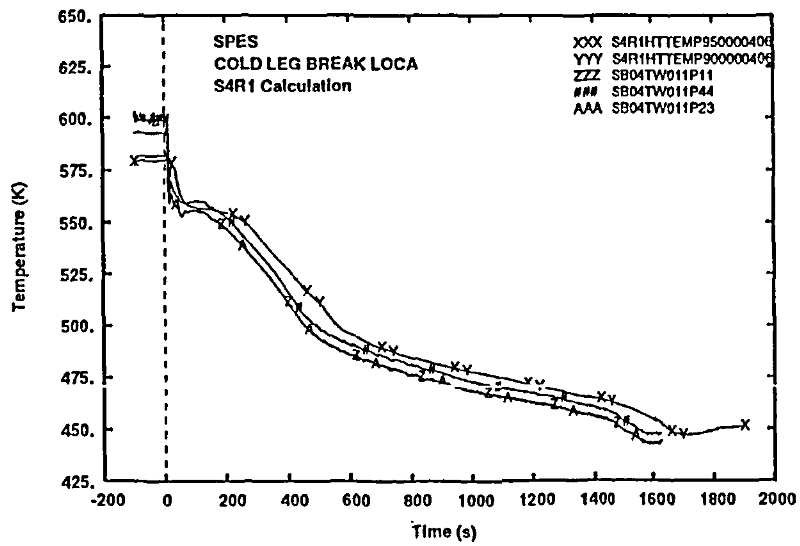

Fig. 3- S4R1 Case - Heater rod temperature (bottom level)

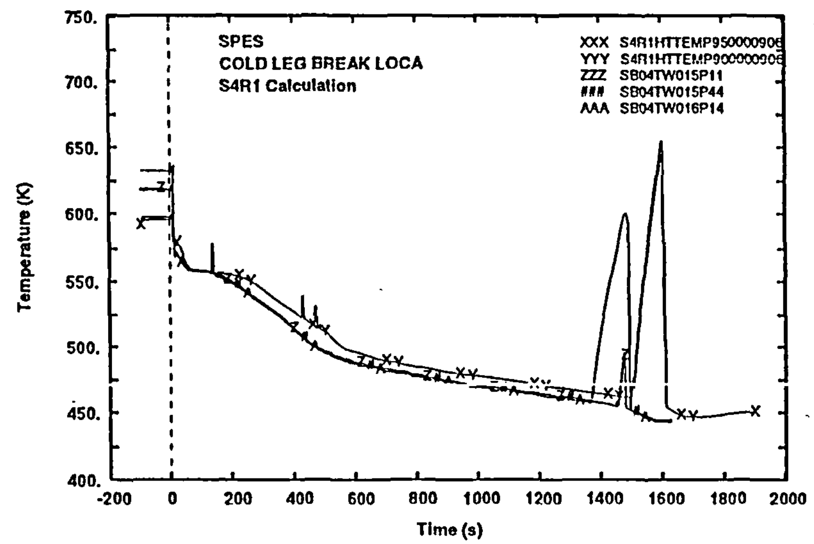

Fig. 4- S4R1 Case - Heater rod temperature (middle level)

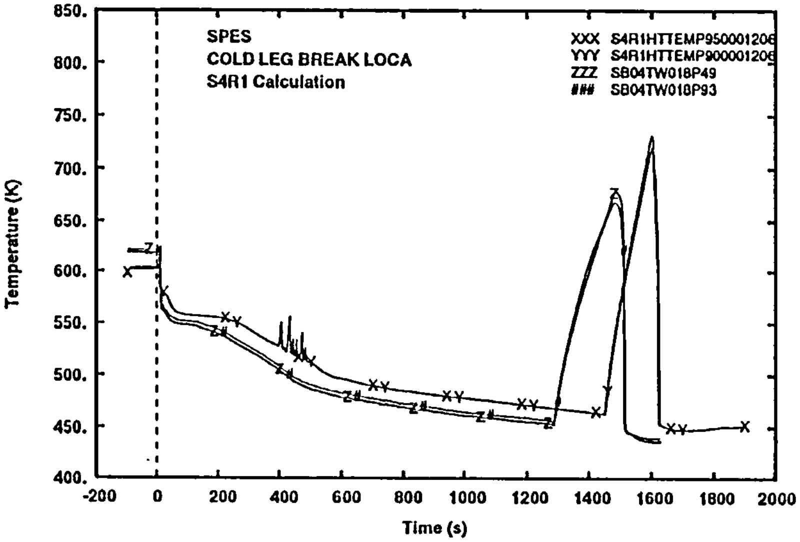

Fig. 5- S4R1 Case - Heater rod temperature (high level)

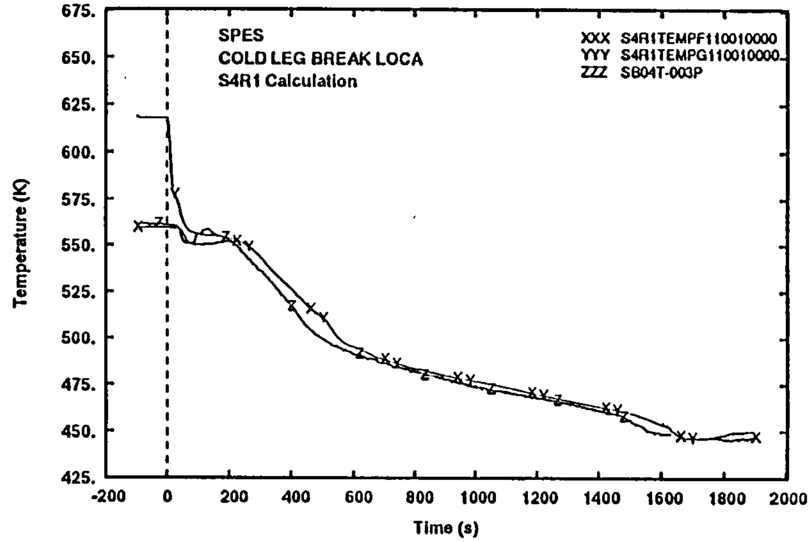

Fig. 6- S4R1 Case - Core inlet fluid temperature

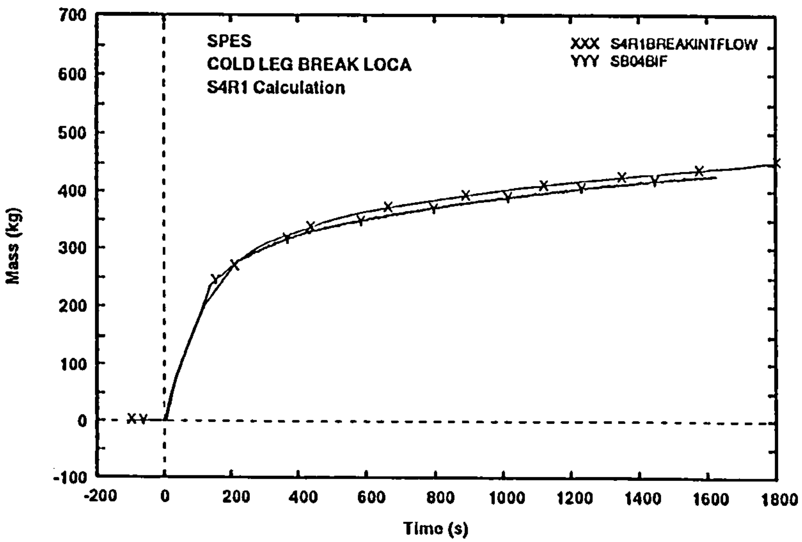

Fig. 7- S4R1 Case - Integral break flowrate

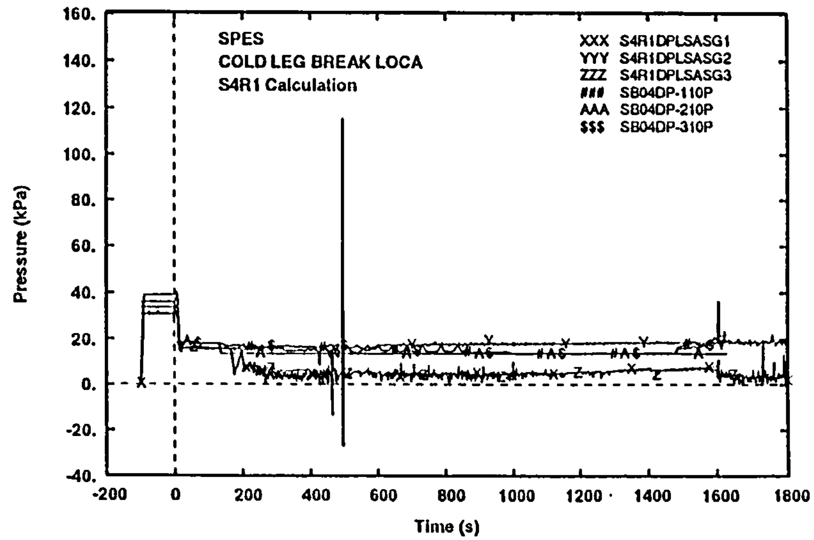

Fig. 8- S4R1 Case - Pressure drop across loop seal (ascendig side)

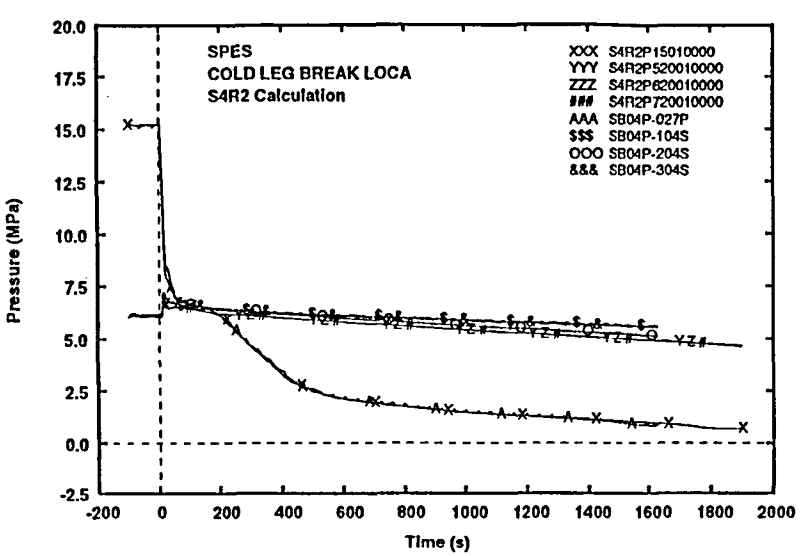

Fig. 1- S4R2 Case - Primary and secondary pressure

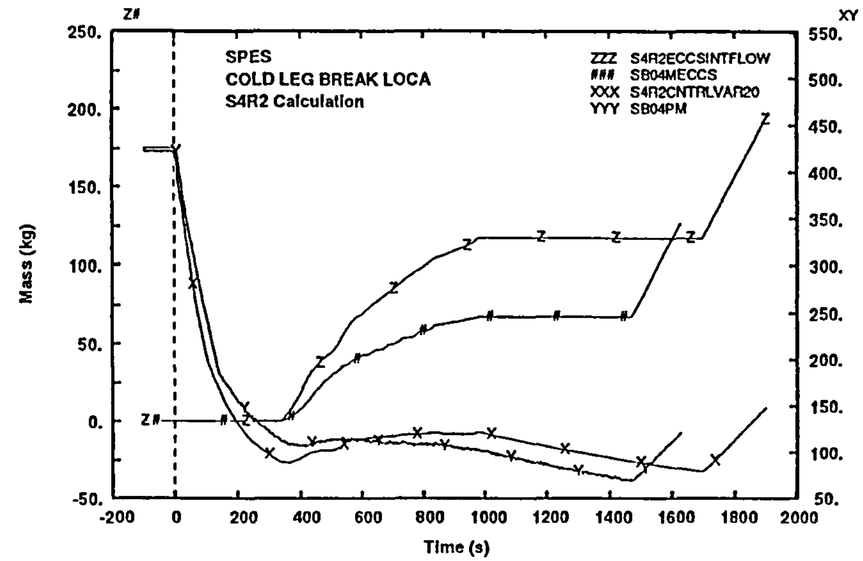

Fig. 2- S4R2 Case - ECCS integral flowrate and primary side total mass

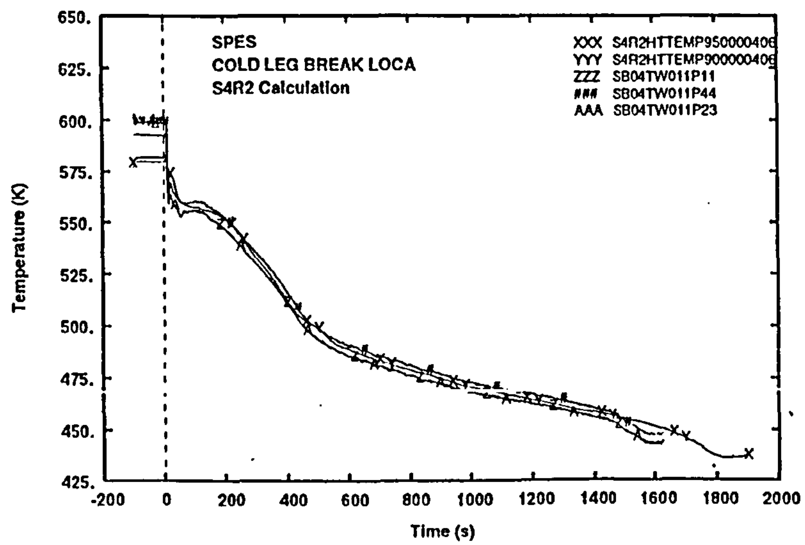

Fig. 3- S4R2 Case - Heater rod temperature (bottom level)

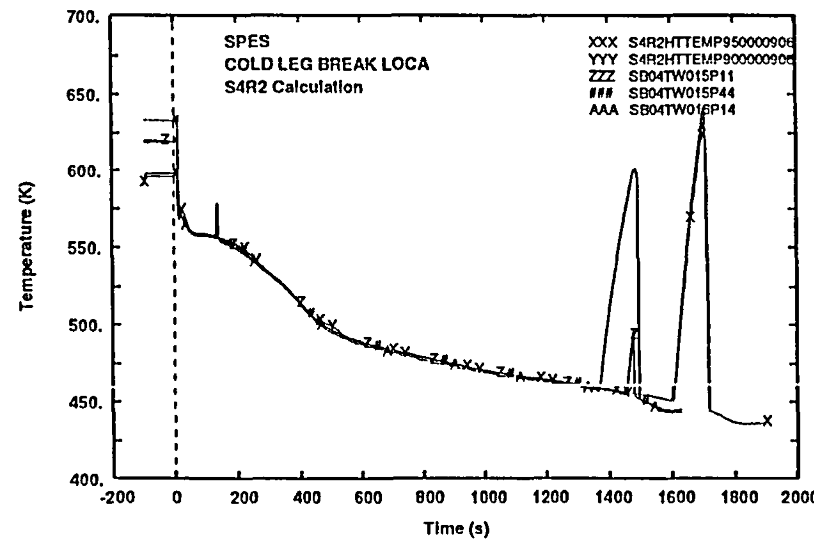

Fig. 4- S4R2 Case - Heater rod temperature (middle level)

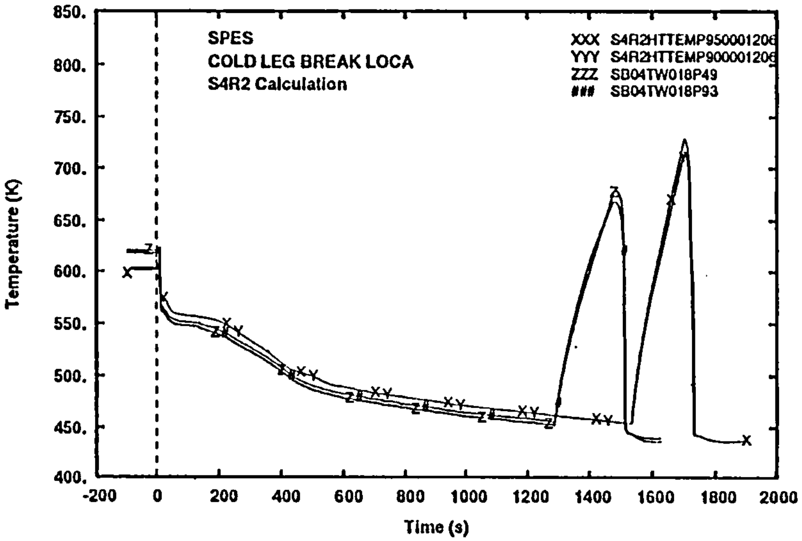

Fig. 5- S4R2 Case - Heater rod temperature (high level)

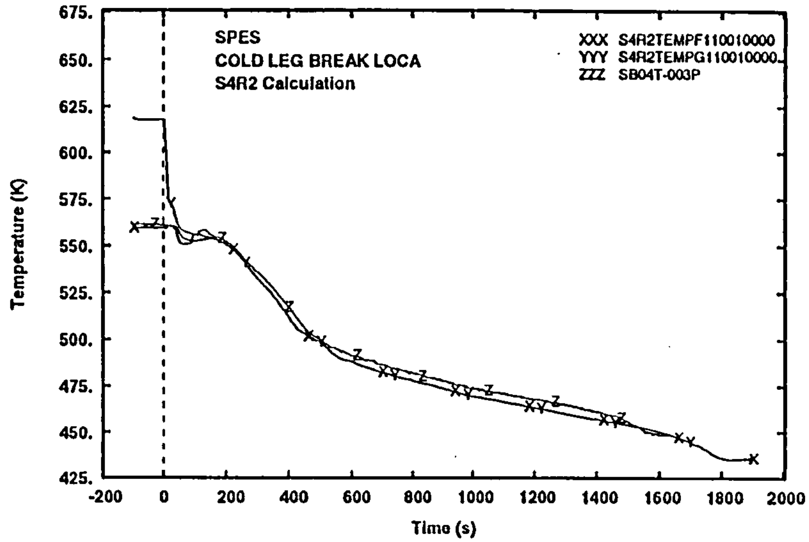

Fig. 6- S4R2 Case - Core inlet fluid temperature

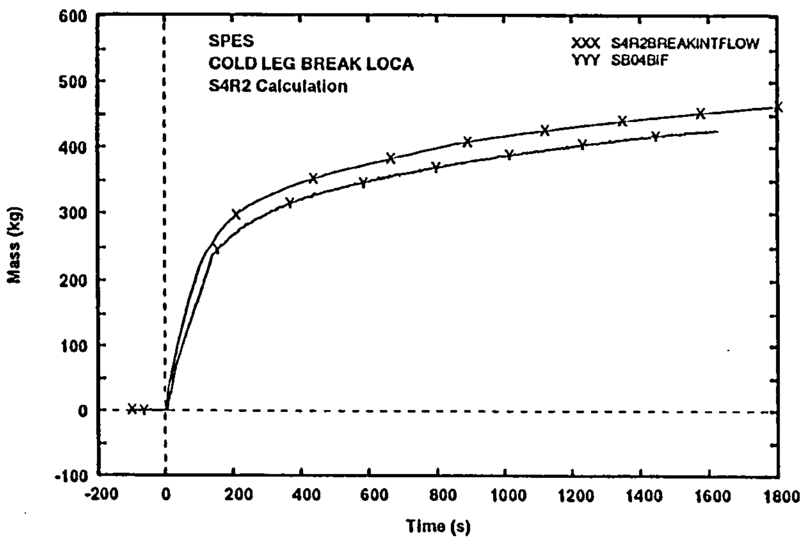

Fig. 7- S4R2 Case - Integral break flowrate

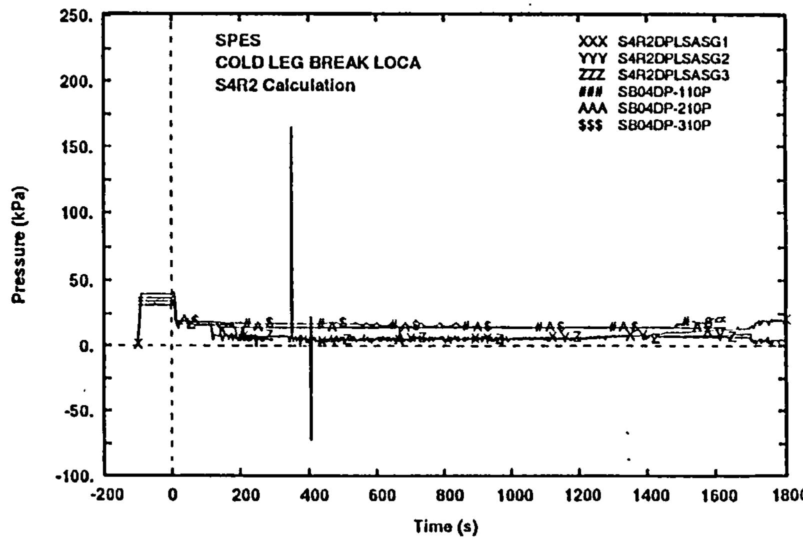

Fig. 8- S4R2 Case - Pressure drop across loop seal (ascendig side)

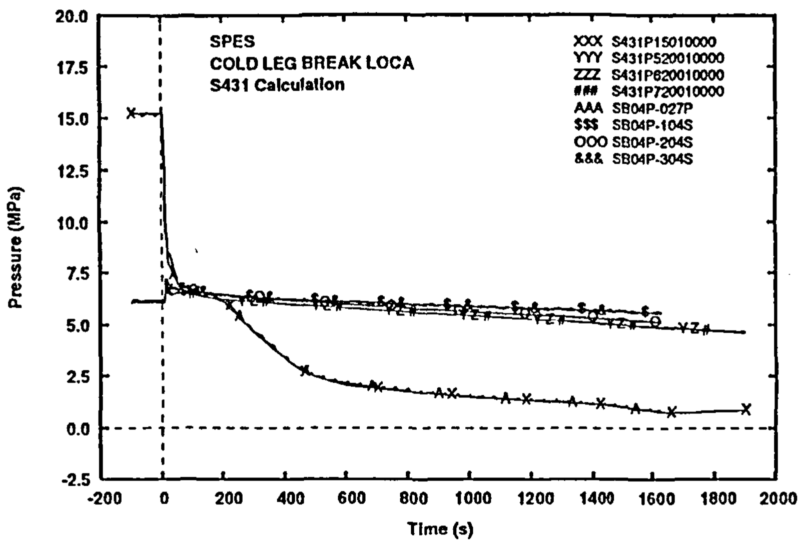

Fig. 1- S431 Case - Primary and secondary pressure

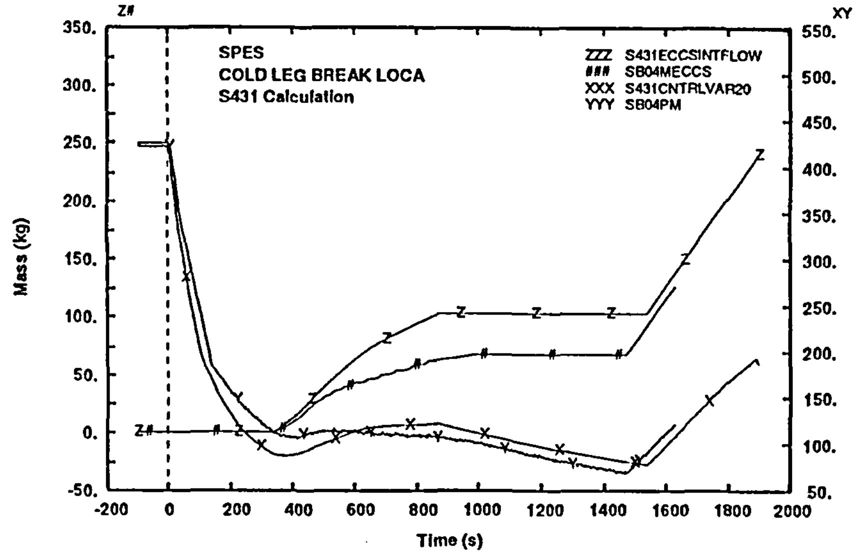

Fig. 2- S431 Case - ECCS integral flowrate and primary side total mass

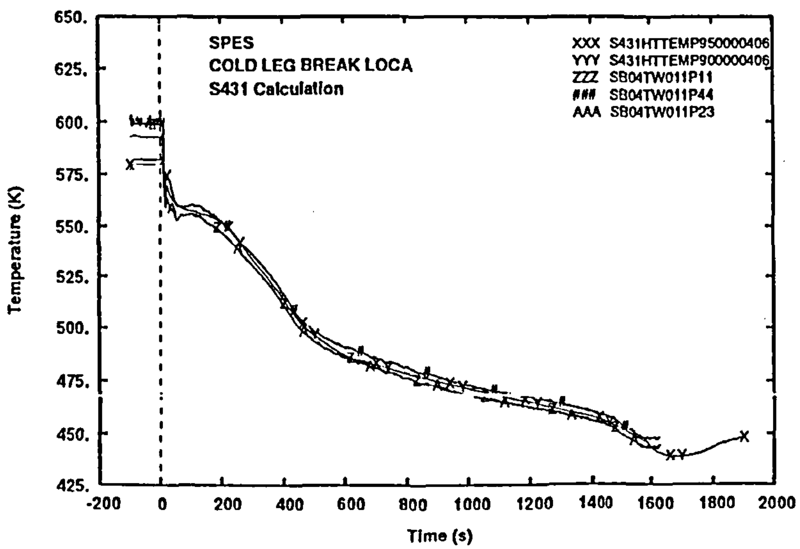

Fig. 3- S431 Case - Heater rod temperature (bottom level)

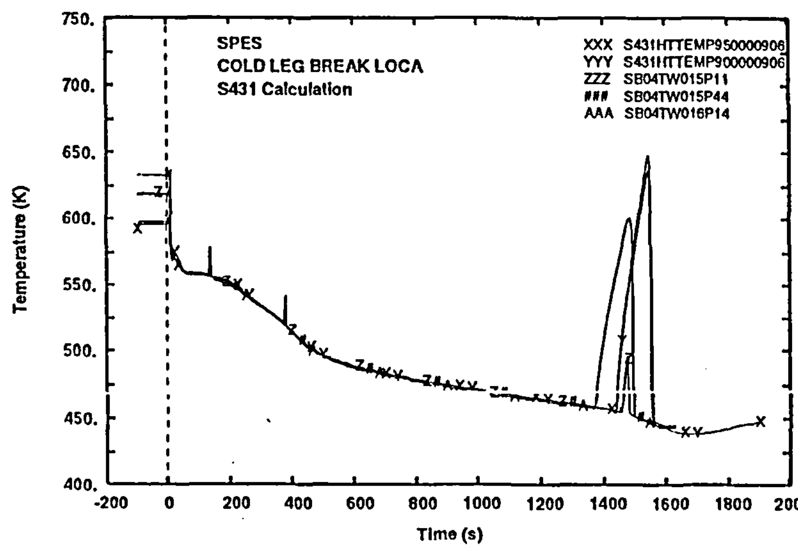

Fig. 4- S431 Case - Heater rod temperature (middle level)

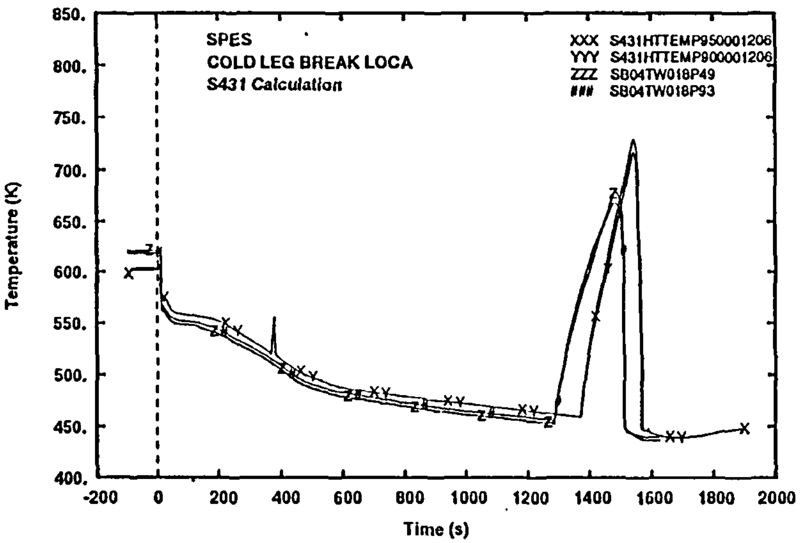

Fig. 5- S431 Case - Heater rod temperature (high level)

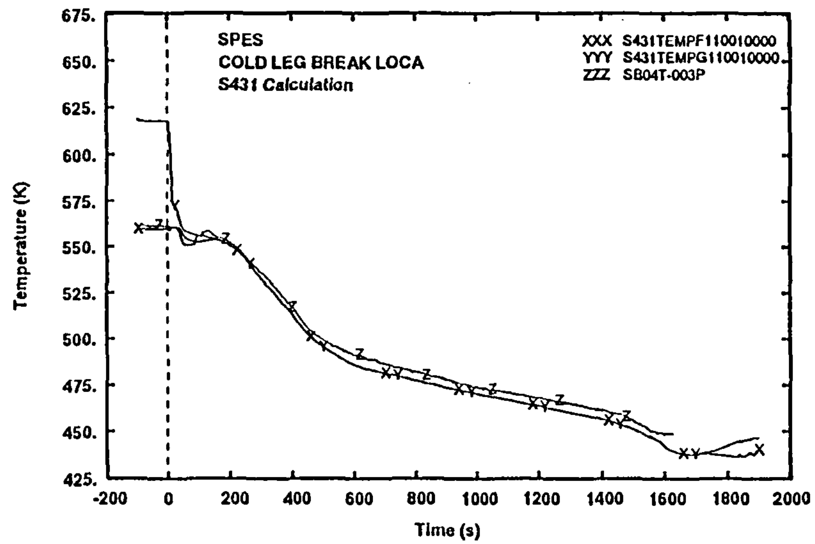

Fig. 6- S431 Case - Core inlet fluid temperature

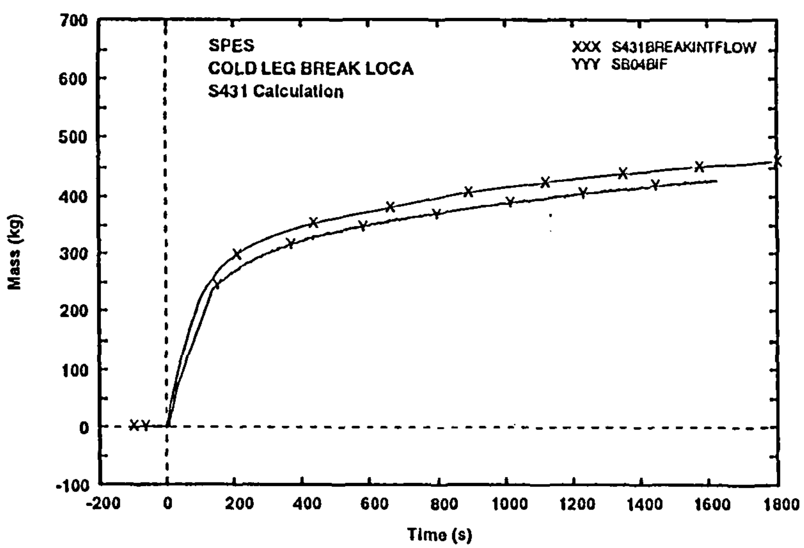

Fig. 7- S431 Case - Integral break flowrate

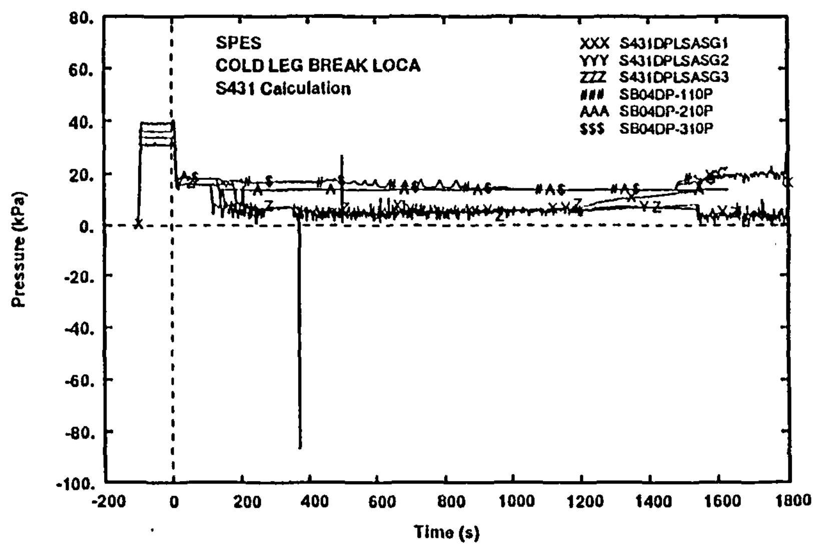

Fig. 8- S431 Case - Pressure drop across loop seal (ascendig side)

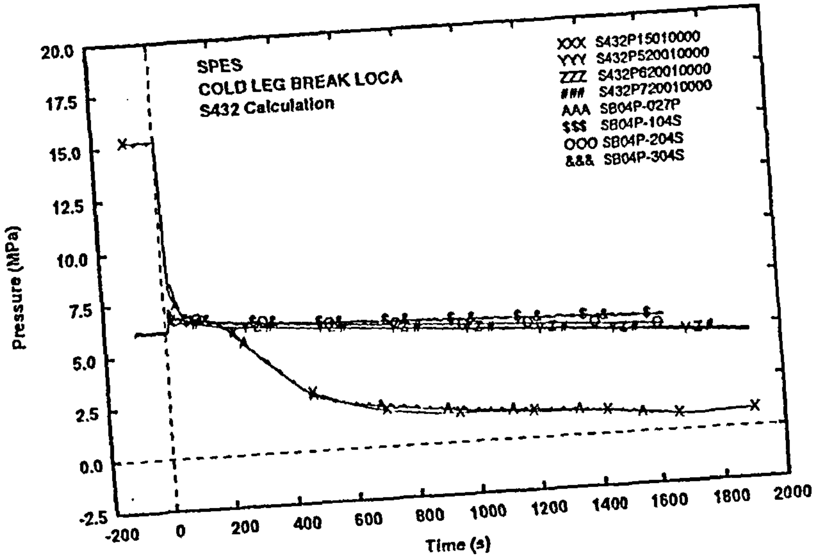

Fig. 1- S432 Case - Primary and secondary pressure

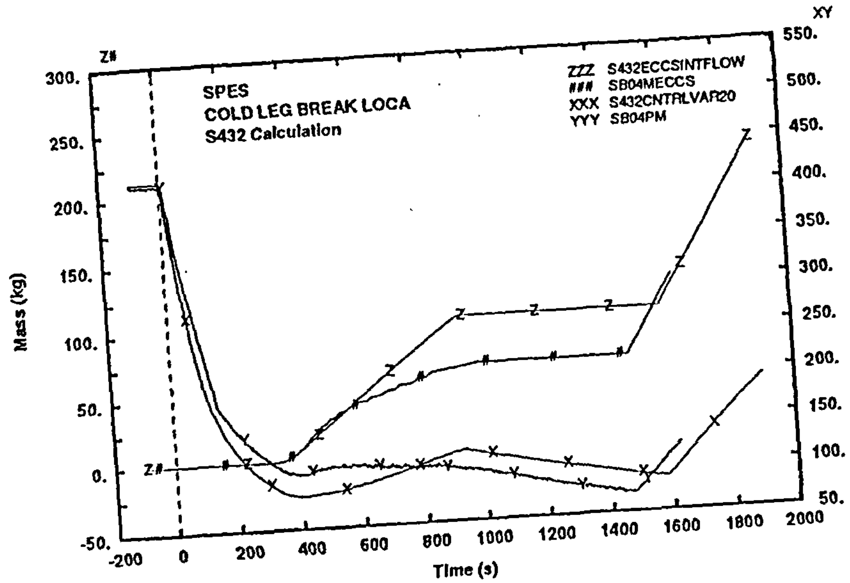

Fig. 2- S432 Case - ECCS integral flowrate and primary side total mass

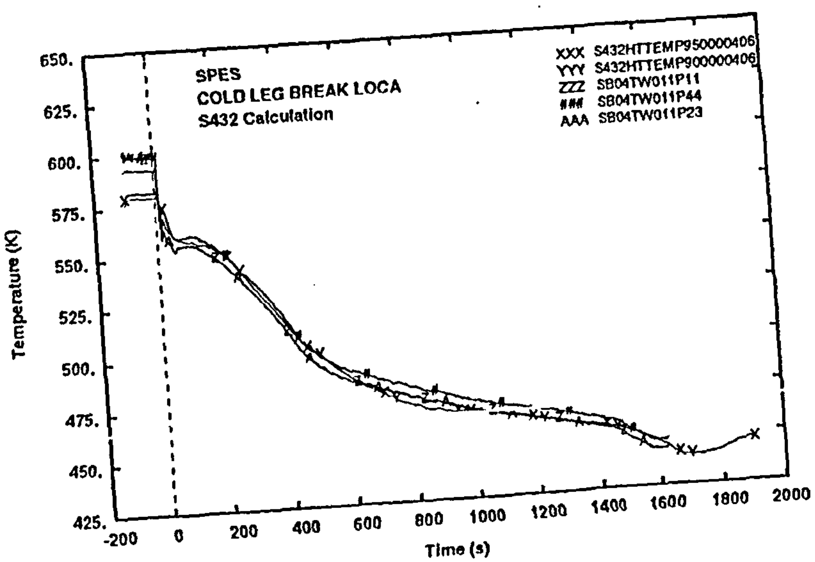

Fig. 3- S432 Case - Heater rod temperature (bottom level)

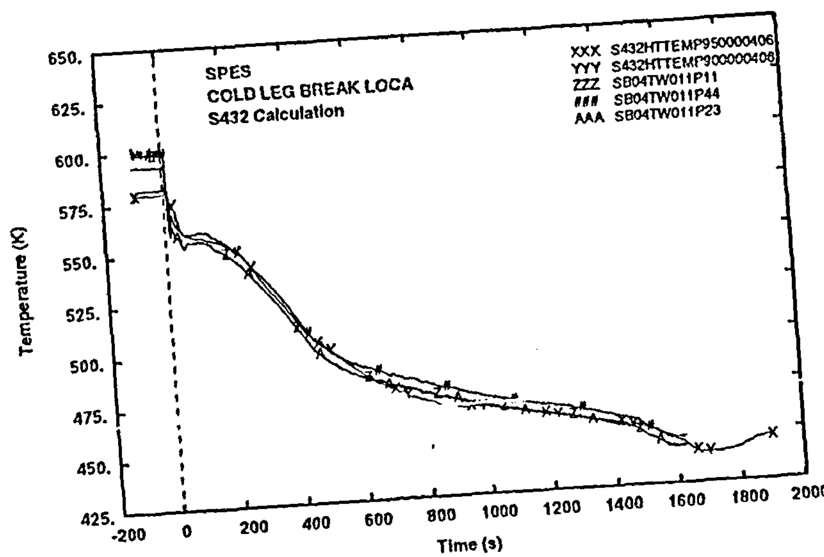

Fig. 3- S432 Case - Heater rod temperature (bottom level)

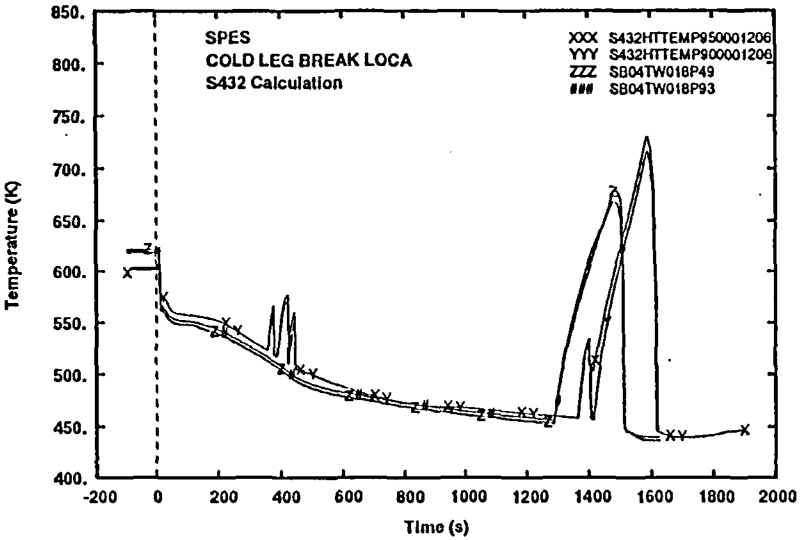

Fig. 5- S432 Case - Heater rod temperature (high level)

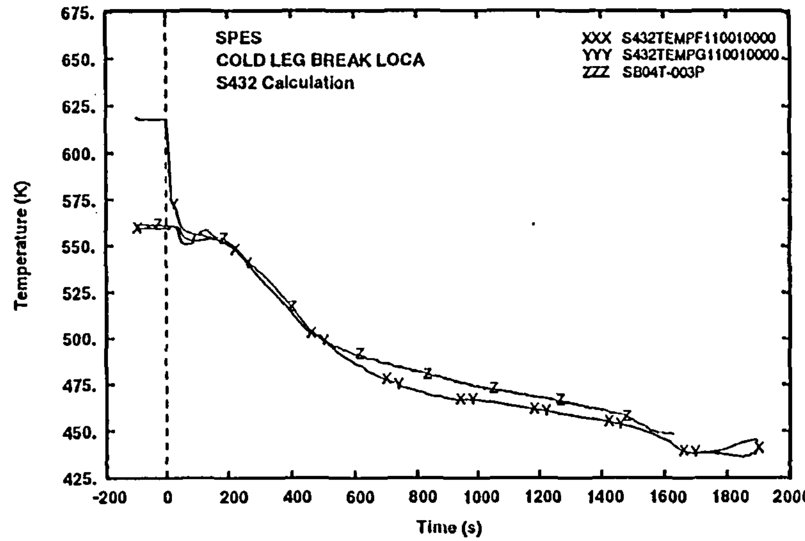

Fig. 6- S432 Case - Core inlet fluid temperature

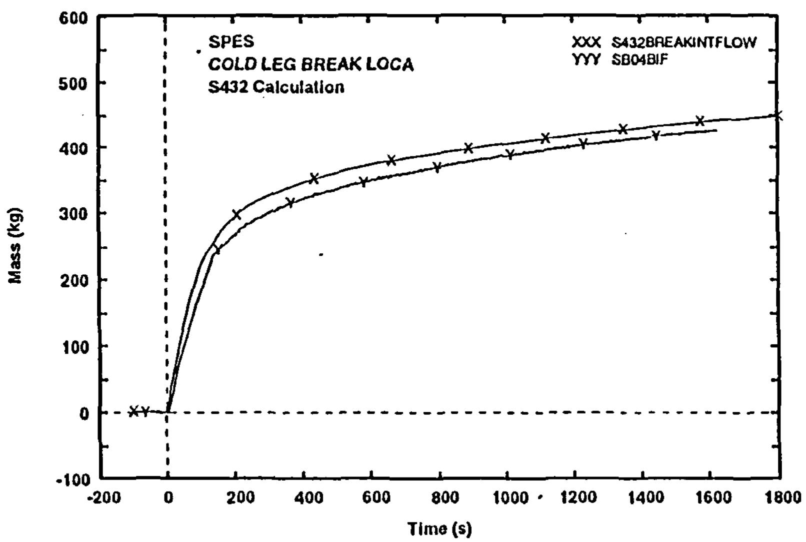

Fig. 7- S432 Case - Integral break flowrate

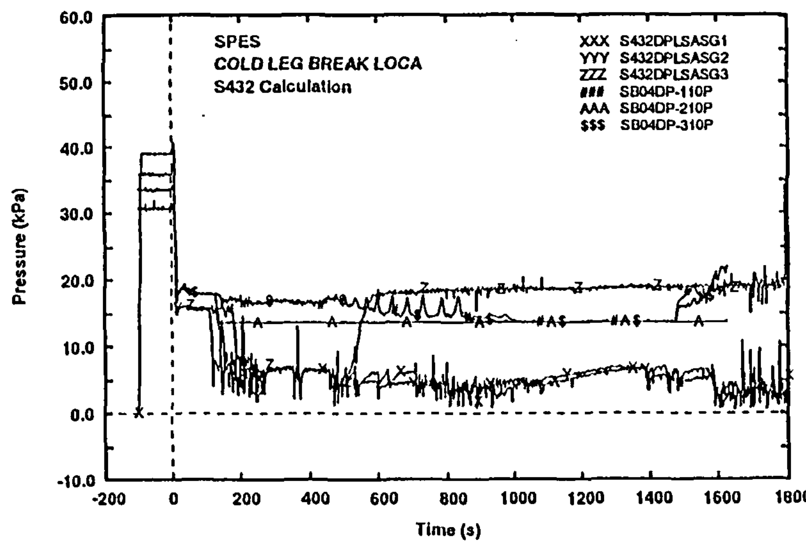

Fig. 8- S432 Case - Pressure drop across loop seal (ascendig side)

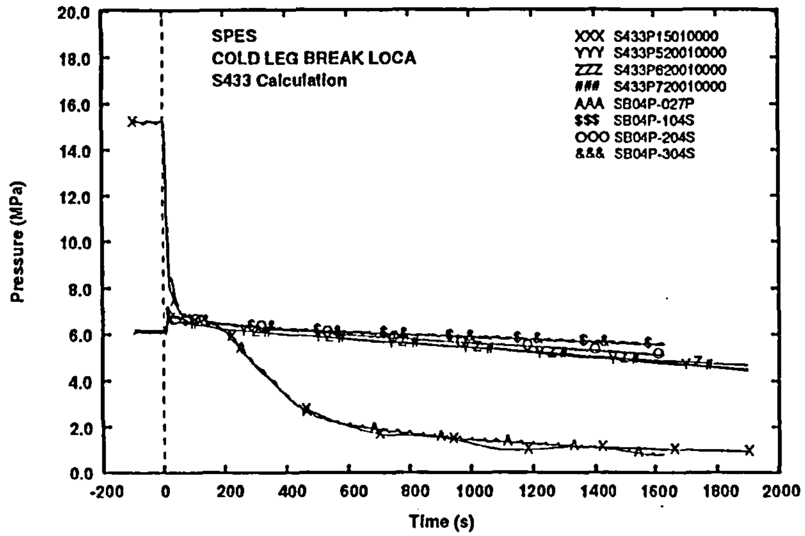

Fig. 1- S433 Case - Primary and secondary pressure

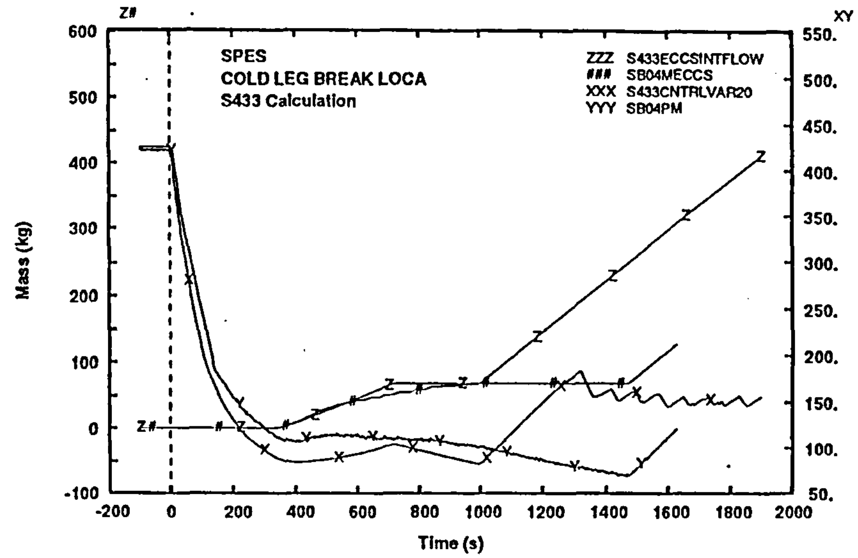

Fig. 2- S433 Case - ECCS integral flowrate and primary side total mass

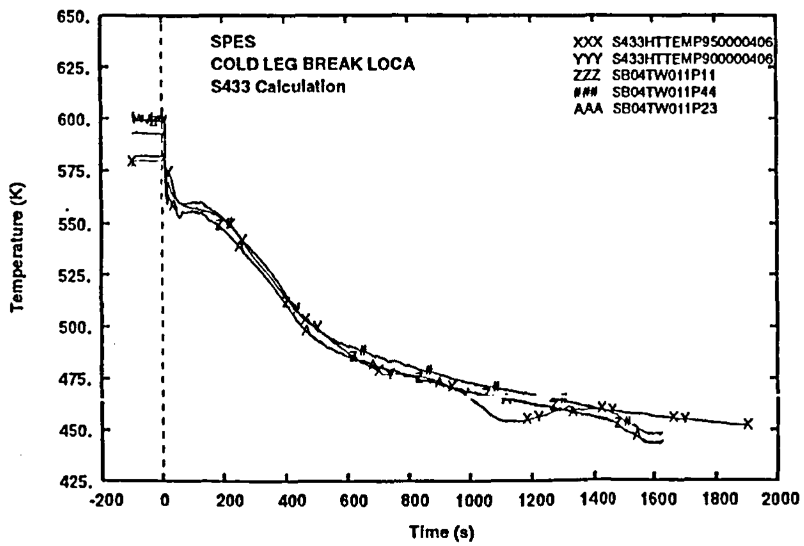

Fig. 3- S433 Case - Heater rod temperature (bottom level)

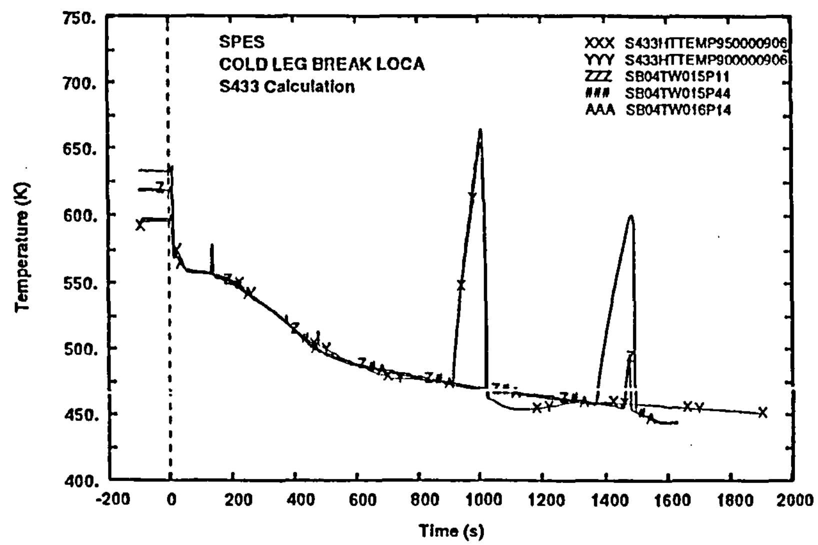

Fig. 4- S433 Case - Heater rod temperature (middle level)

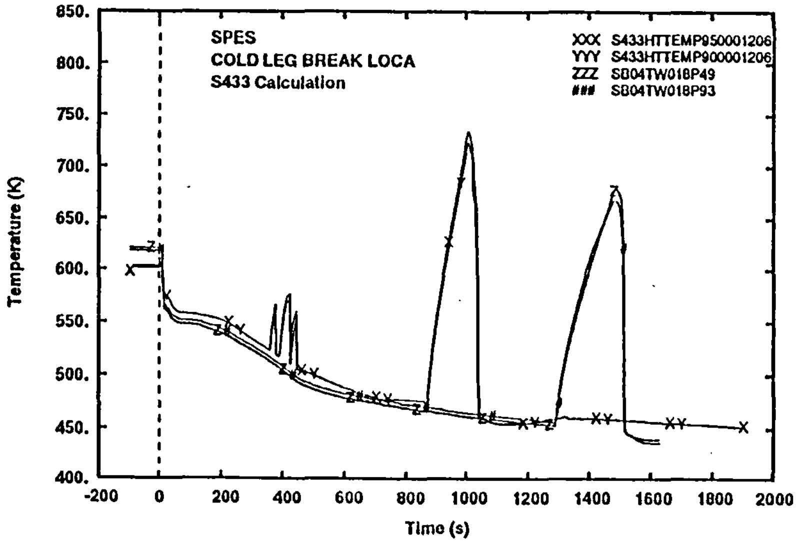

Fig. 5 - S433 Case - Heater rod temperature (high level)

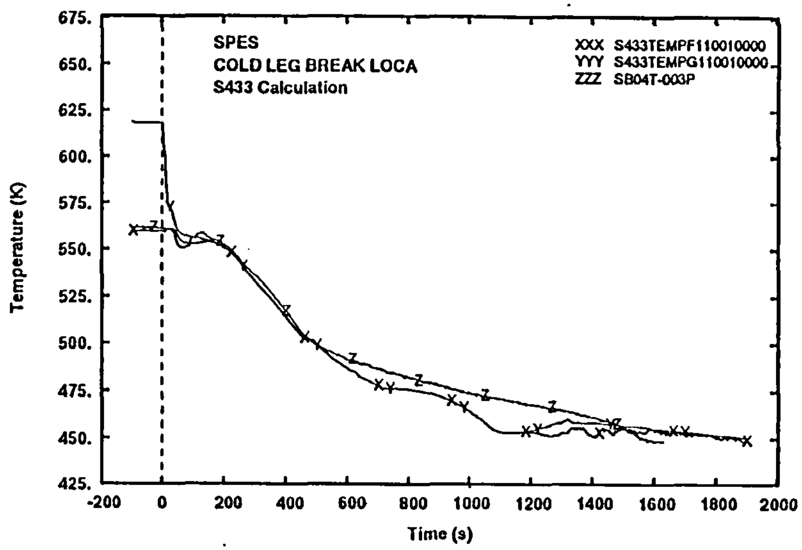

Fig. 6 - S433 Case - Core inlet fluid temperature

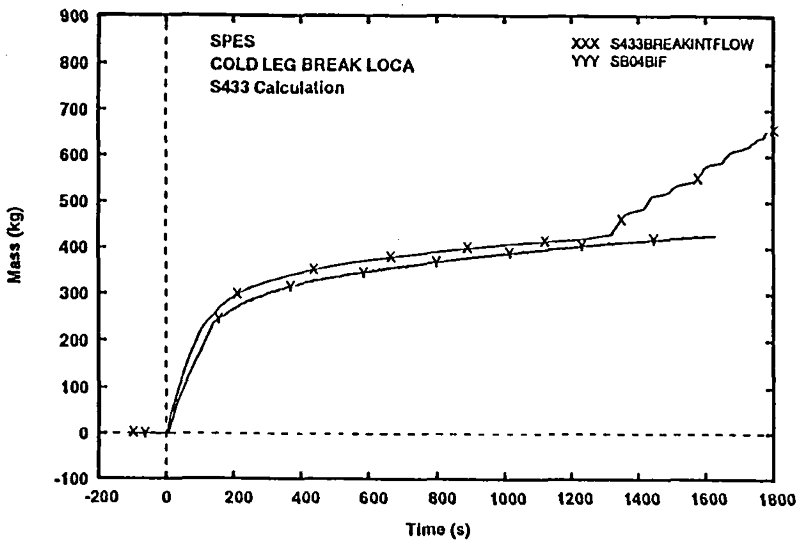

Fig. 7 - S433 Case - Integral break flowrate

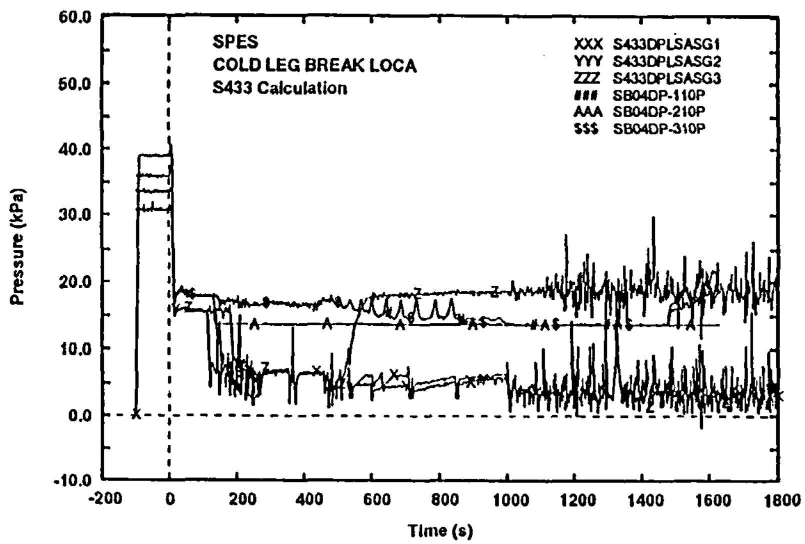

Fig. 8 - S433 Case - Pressure drop across loop seal (ascendig side)

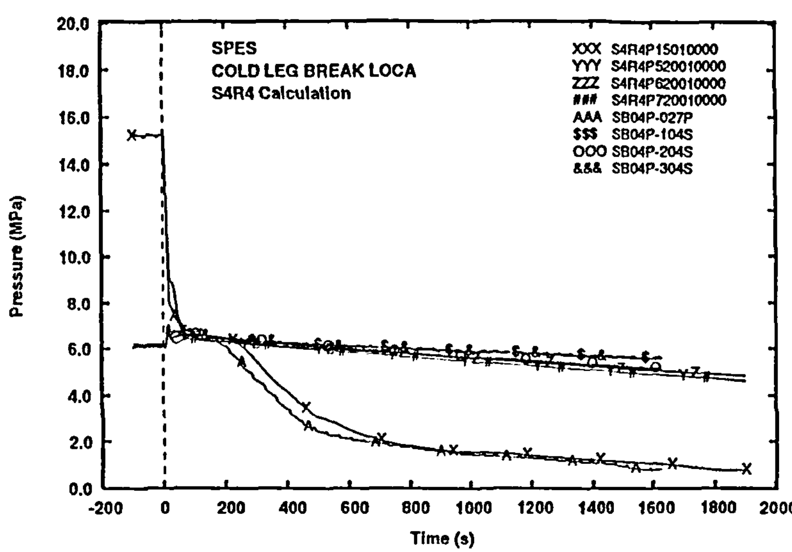

Fig. 1- S4R4 Case - Primary and secondary pressure

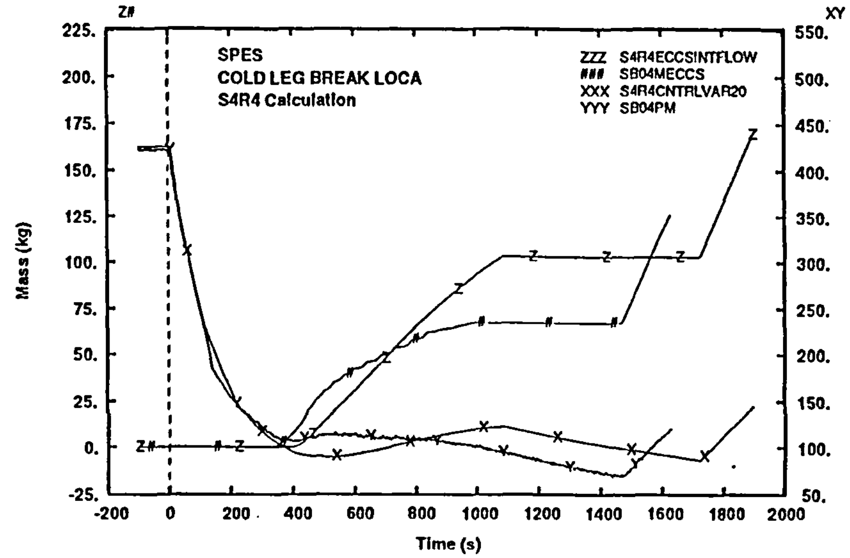

Fig. 2- S4R4 Case - ECCS integral flowrate and primary side total mass

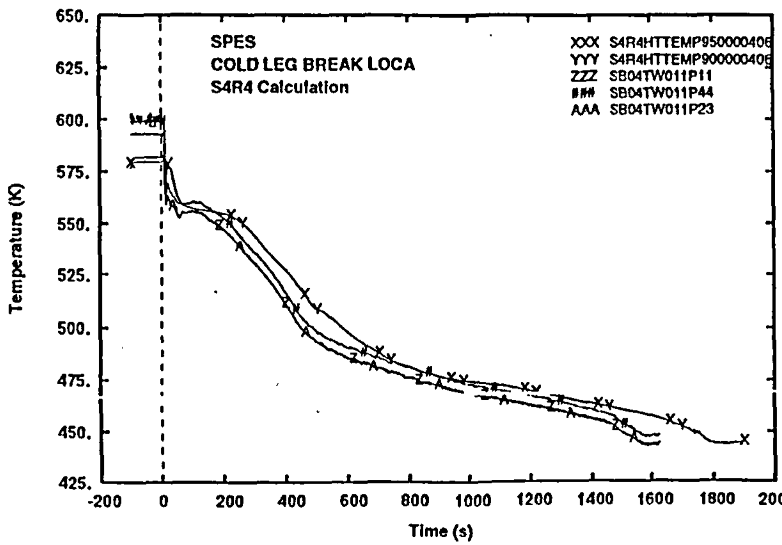

Fig. 3- S4R4 Case - Heater rod temperature (bottom level)

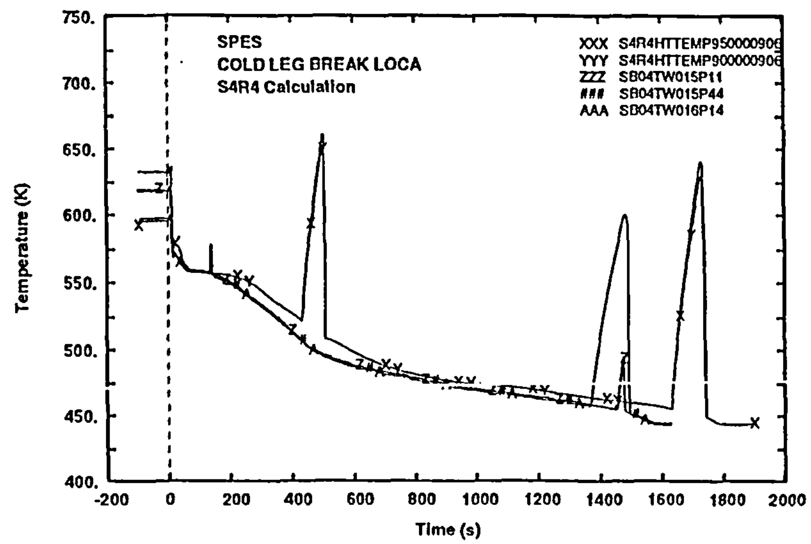

Fig. 4- S4R4 Case - Heater rod temperature (middle level)

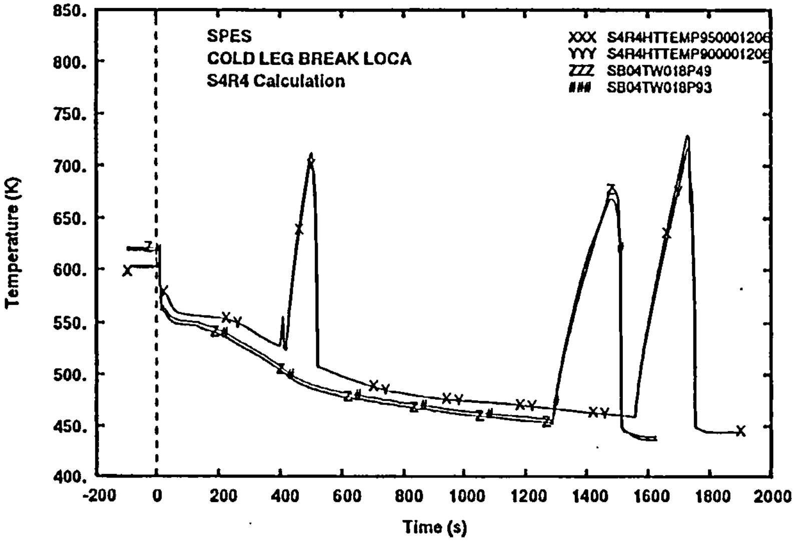

Fig. 5- S4R4 Case - Heater rod temperature (high level)

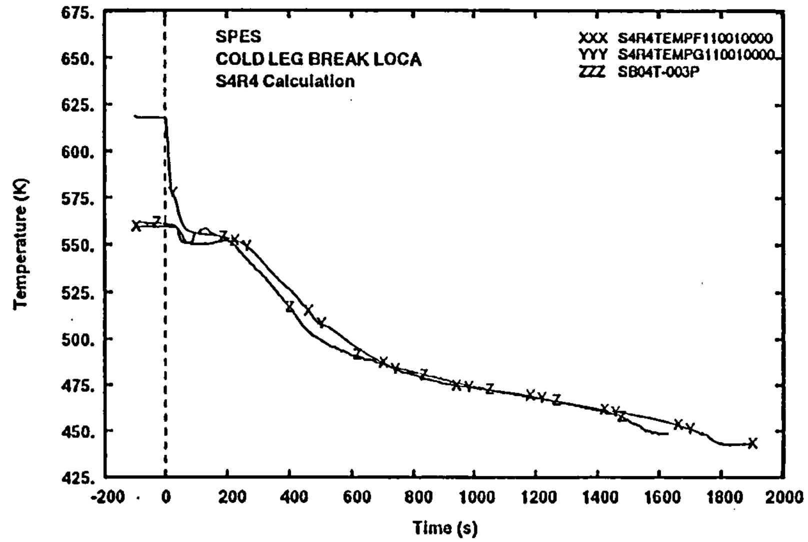

Fig. 6- S4R4 Case - Core inlet fluid temperature

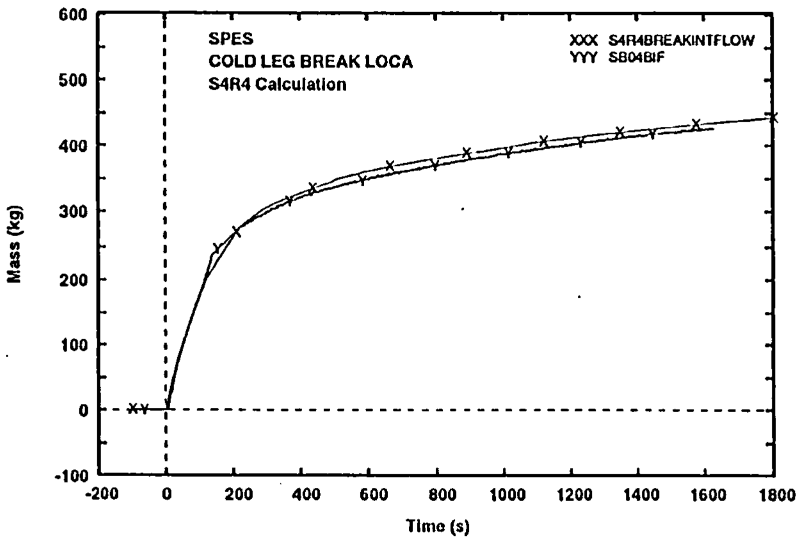

Fig. 7- S4R4 Case - Integral break flowrate

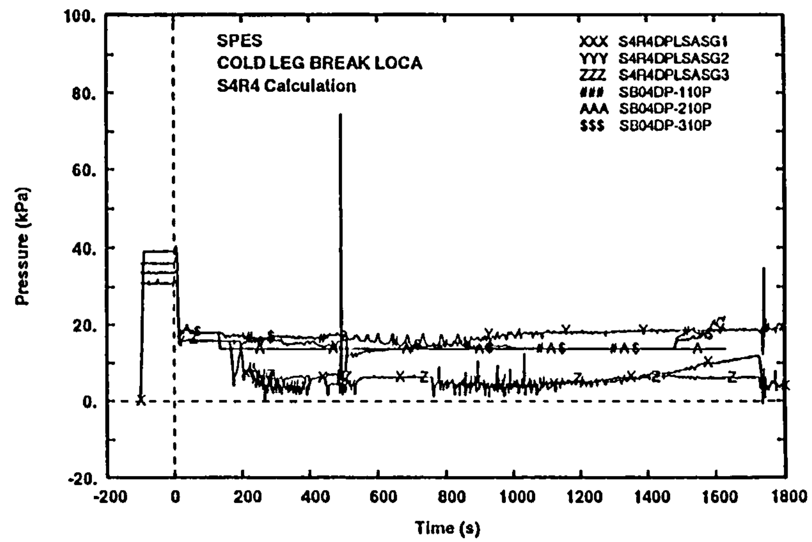

Fig. 8- S4R4 Case - Pressure drop across loop seal (ascendig side)

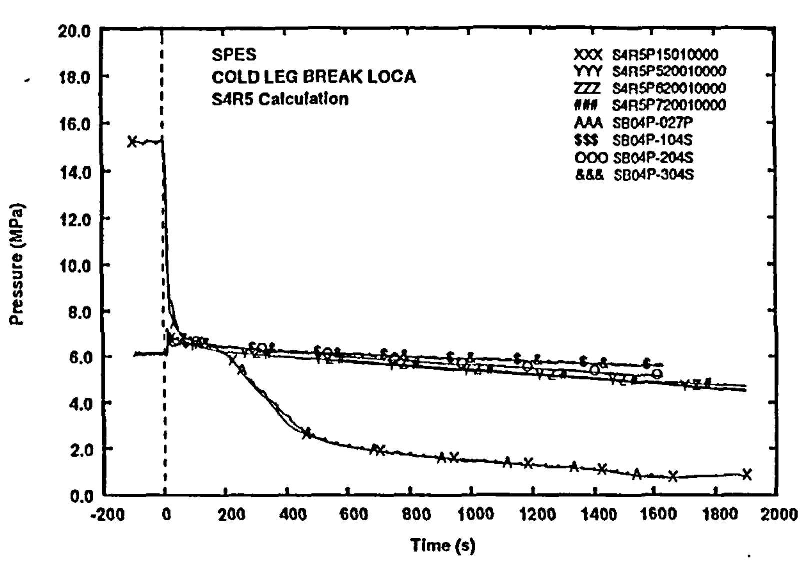

Fig. 1- S4R5 Case - Primary and secondary pressure

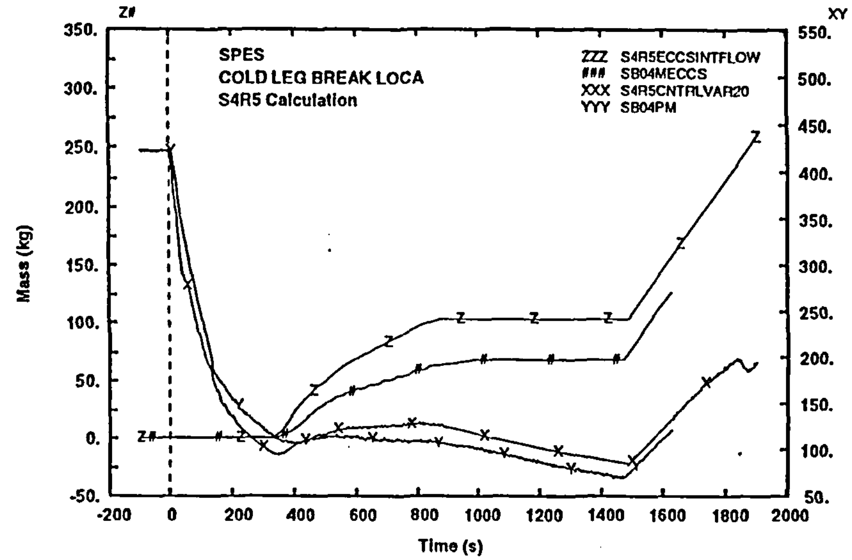

Fig. 2- S4R5 Case - ECCS integral flowrate and primary side total mass

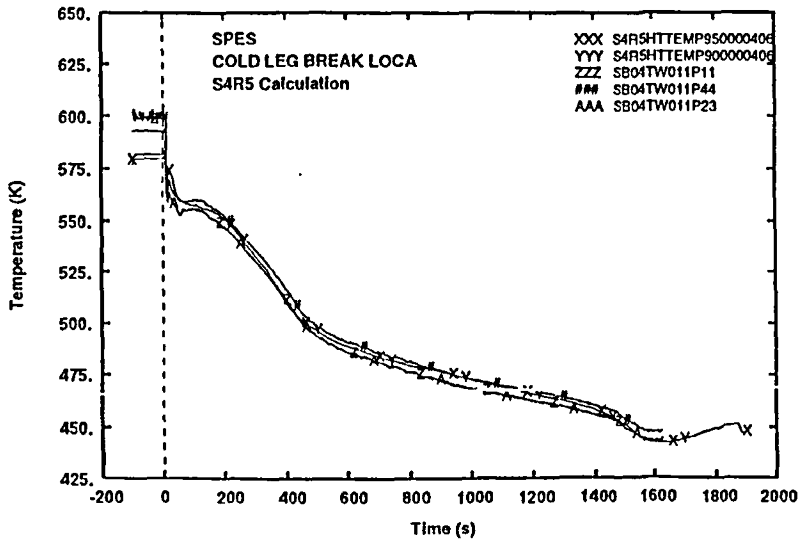

Fig. 3- S4R5 Case - Heater rod temperature (bottom level)

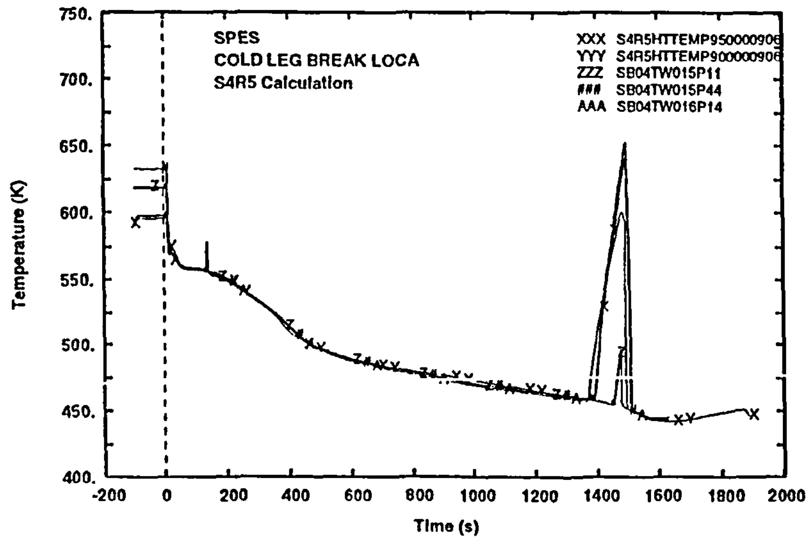

Fig. 4- S4R5 Case - Heater rod temperature (middle level)

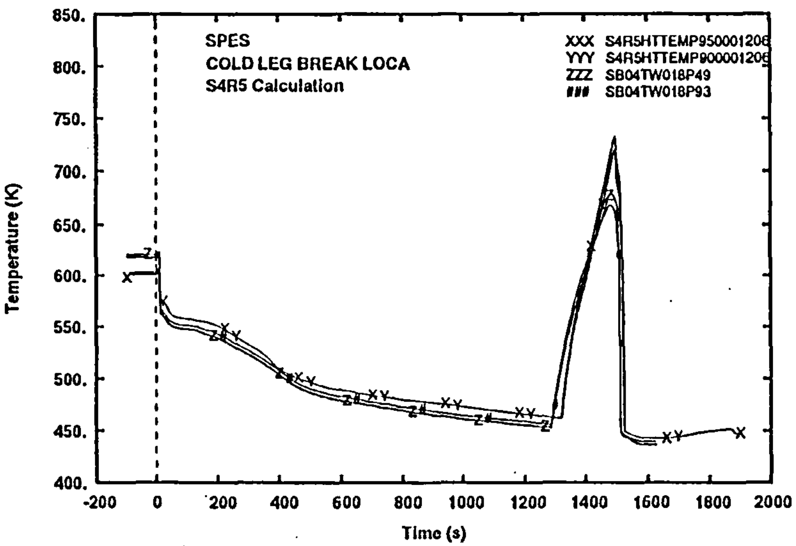

Fig. 5 - S4R5 Case - Heater rod temperature (high level)

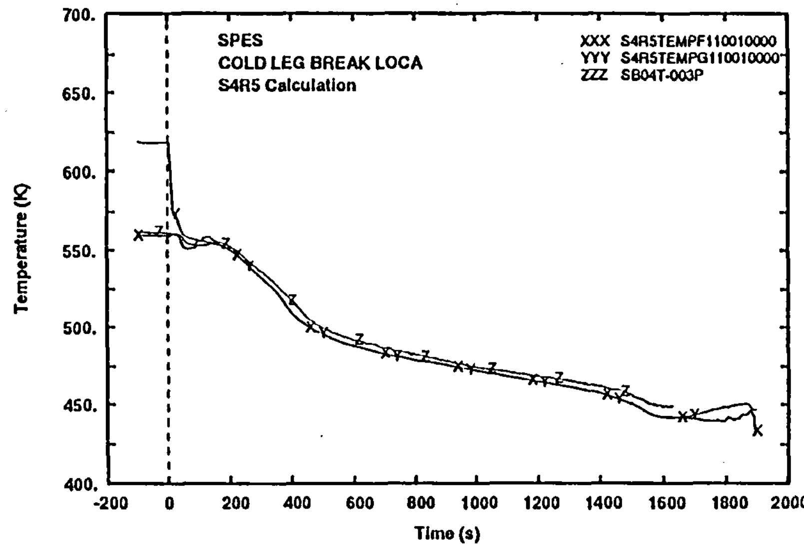

Fig. 6 - S4R5 Case - Core inlet fluid temperature

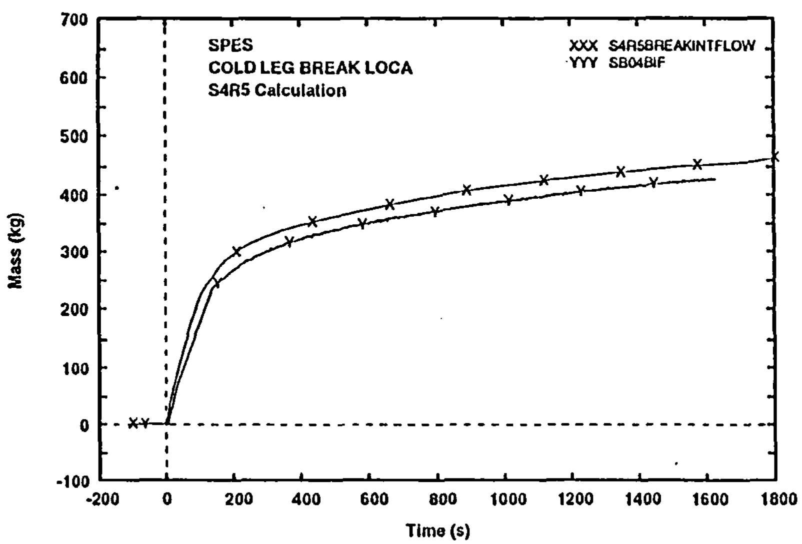

Fig. 7 - S4R5 Case - Integral break flowrate

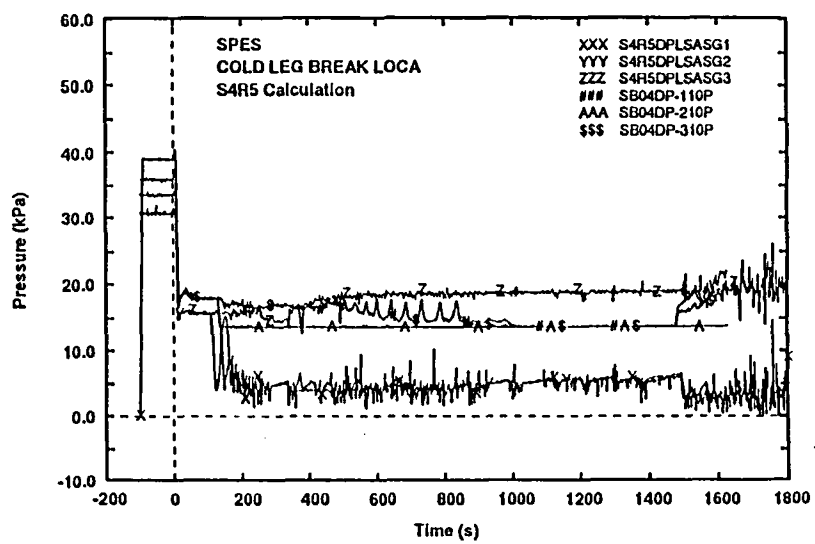

Fig. 8 - S4R5 Case - Pressure drop across loop seal (ascendig side)

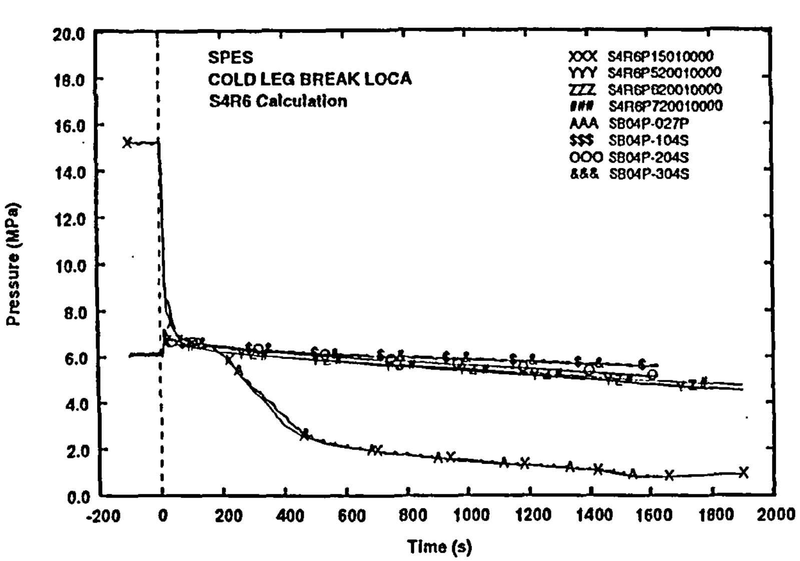

Fig. 1- S4R6 Case - Primary and secondary pressure

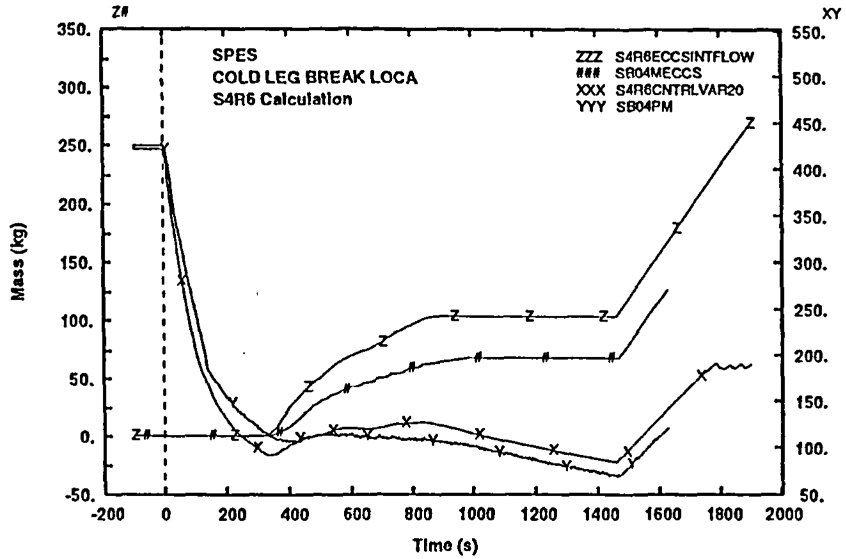

Fig. 2- S4R6 Case - ECCS integral flowrate and primary side total mass

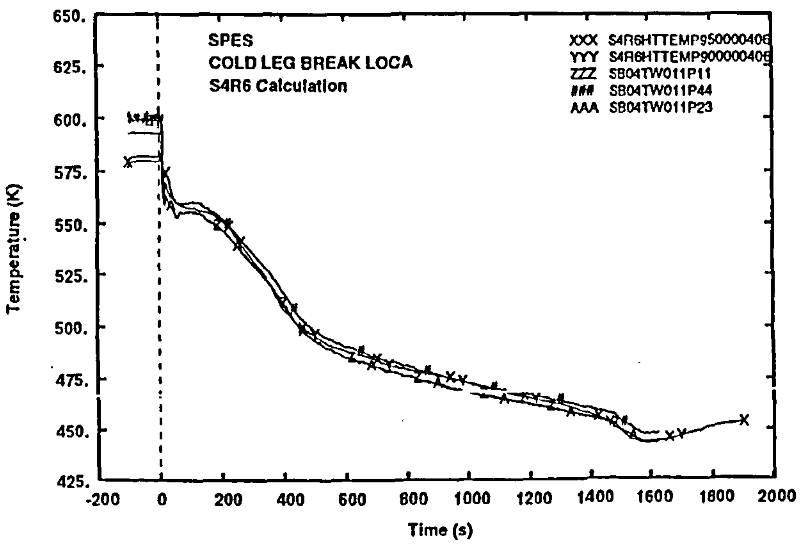

Fig. 3- S4R6 Case - Heater rod temperature (bottom level)

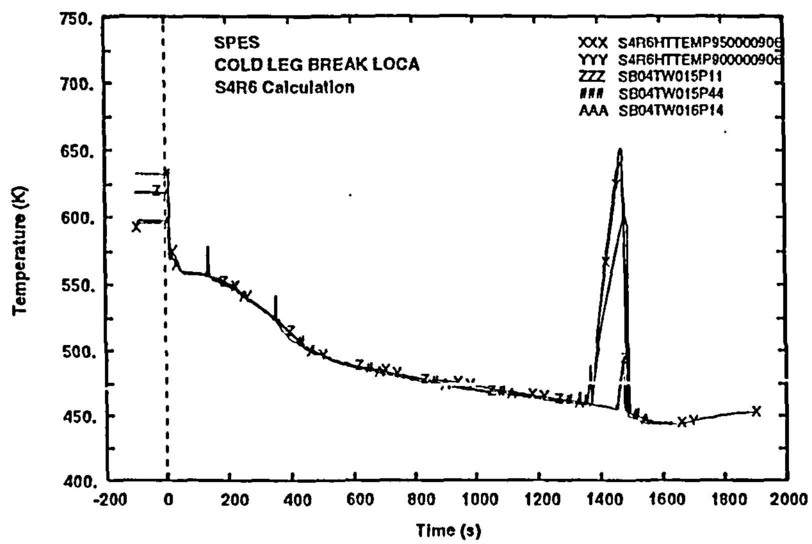

Fig. 4- S4R6 Case - Heater rod temperature (middle level)

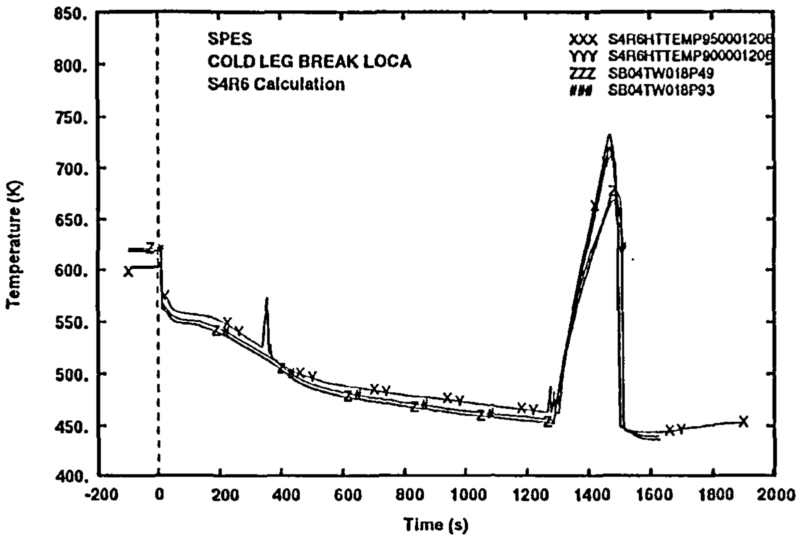

Fig. 5- S4R6 Case - Heater rod temperature (high level)

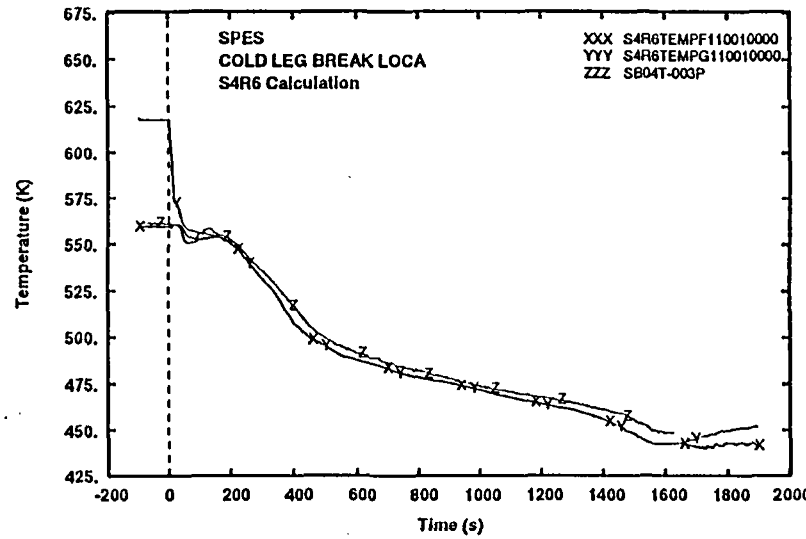

Fig. 6- S4R6 Case - Core inlet fluid temperature

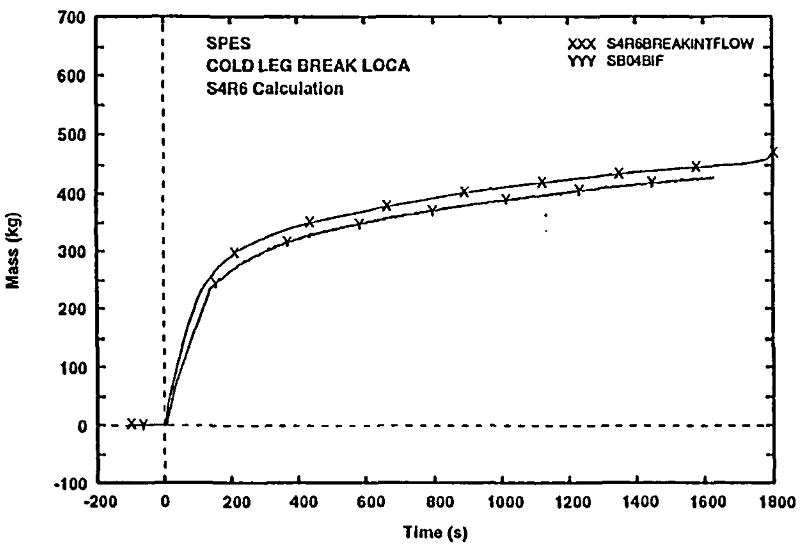

Fig. 7- S4R6 Case - Integral break flowrate

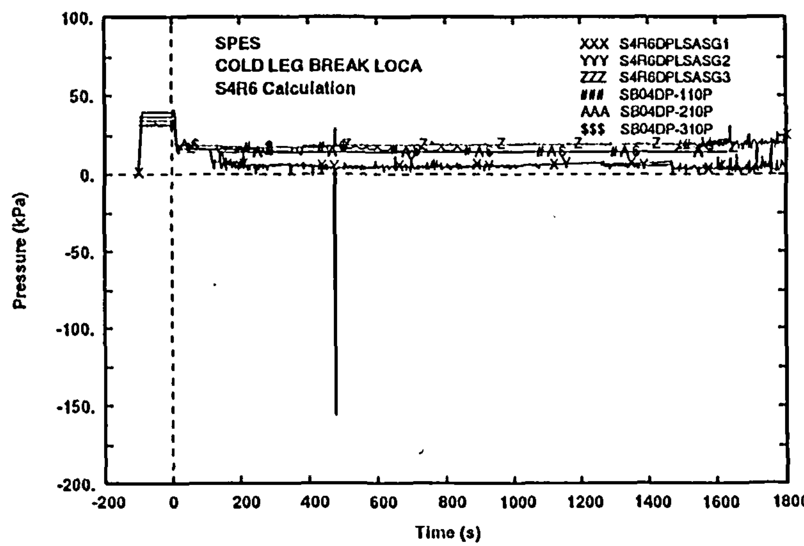

Fig. 8- S4R6 Case - Pressure drop across loop seal (ascendig side)

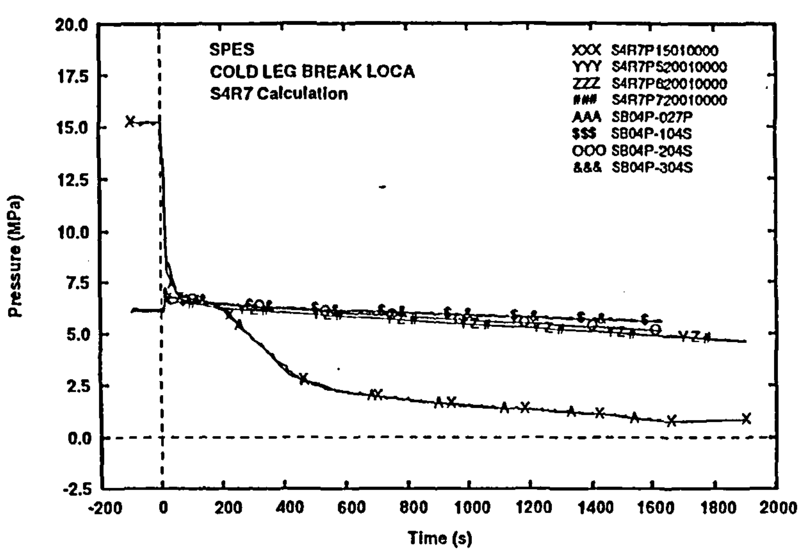

Fig. 1- S4R7 Case - Primary and secondary pressure

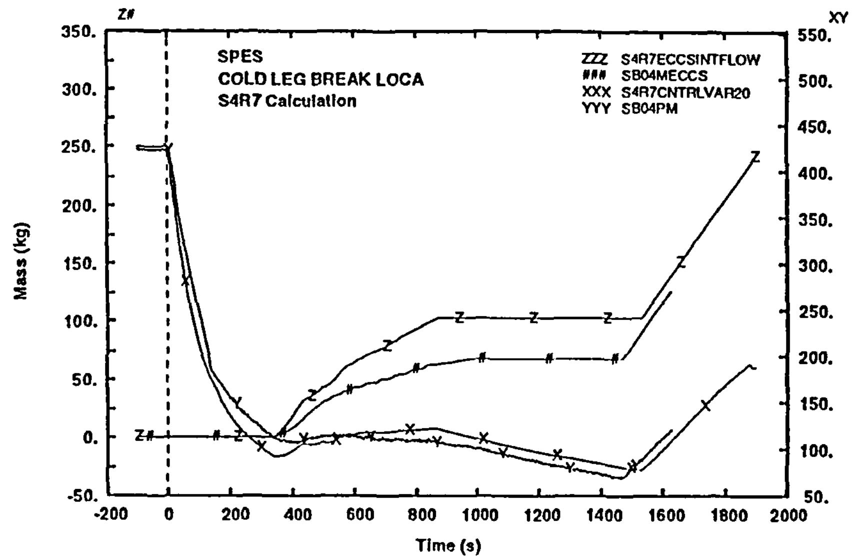

Fig. 2- S4R7 Case - ECCS integral flowrate and primary side total mass

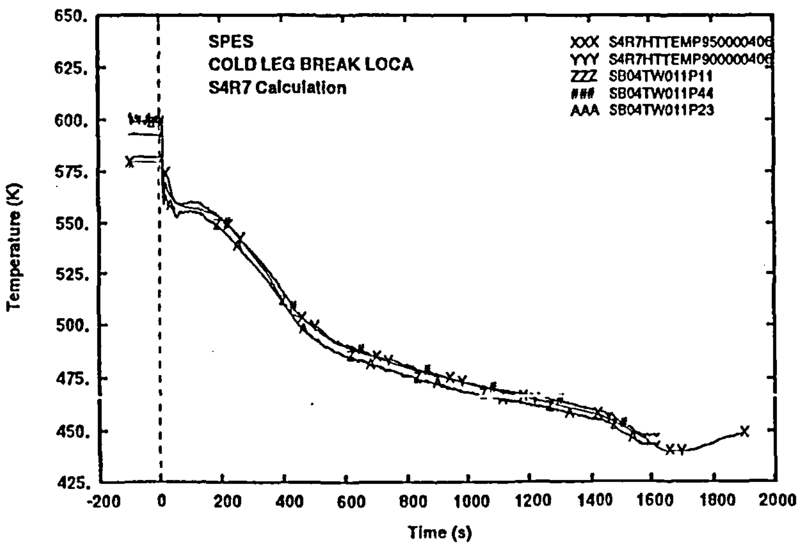

Fig. 3- S4R7 Case - Heater rod temperature (bottom level)

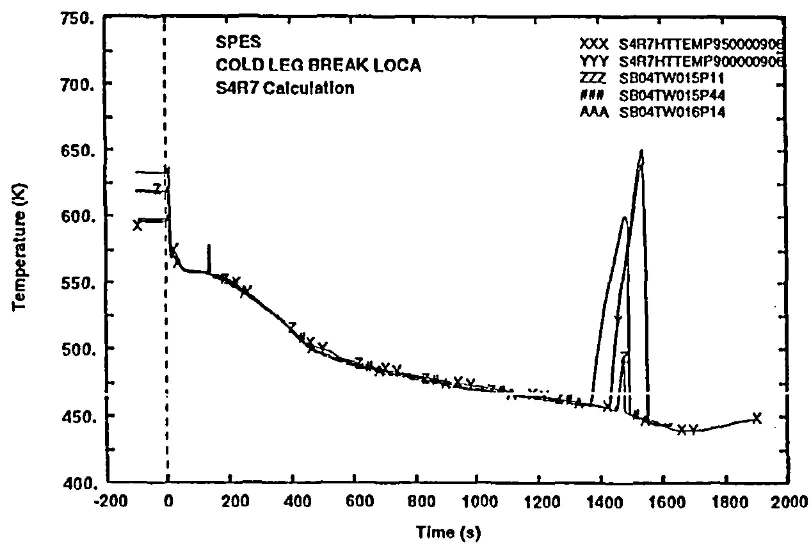

Fig. 4- S4R7 Case - Heater rod temperature (middle level)

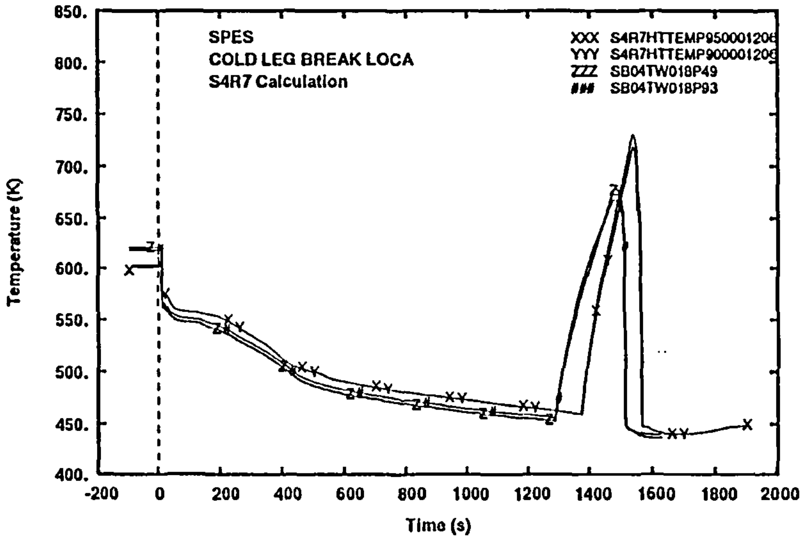

Fig. 5- S4R7 Case - Heater rod temperature (high level)

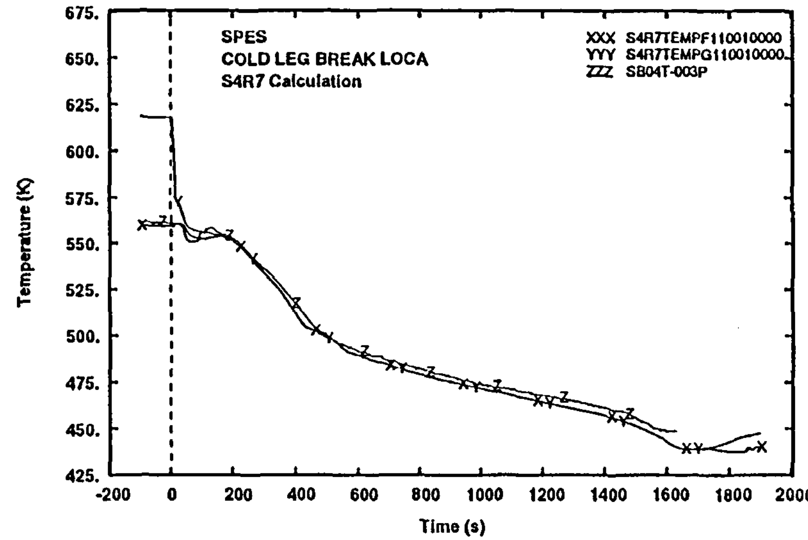

Fig. 6- S4R7 Case - Core inlet fluid temperature

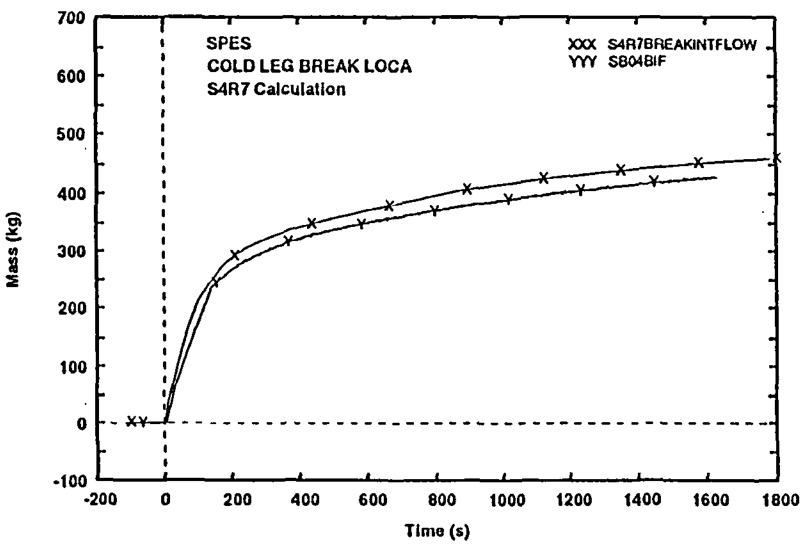

Fig. 7- S4R7 Case - Integral break flowrate

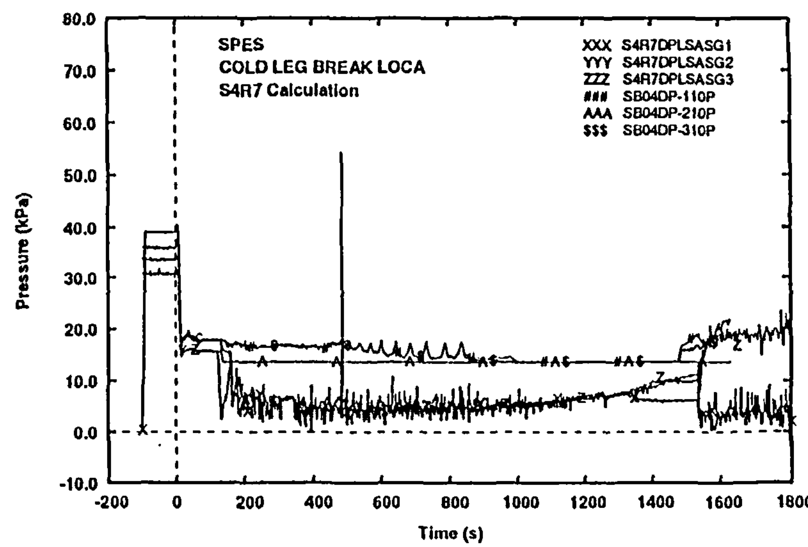

Fig. 8- S4R7 Case - Pressure drop across loop seal (ascendig side)

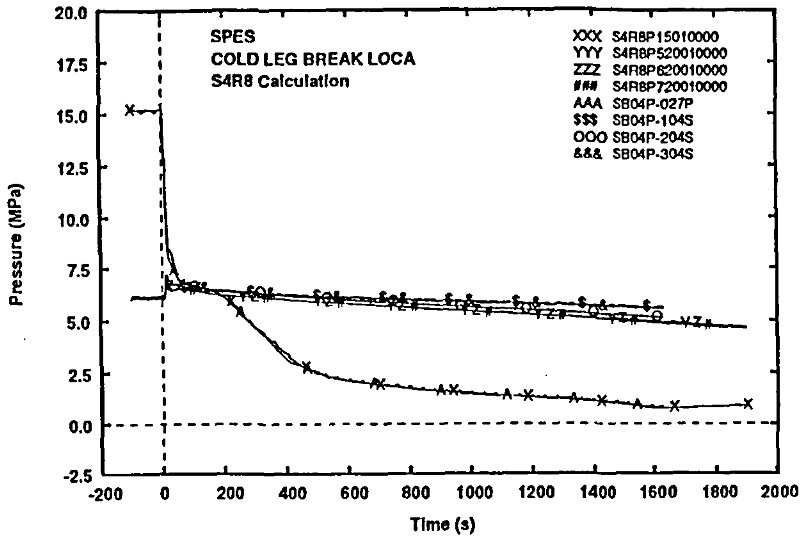

Fig. 1- S4R8 Case - Primary and secondary pressure

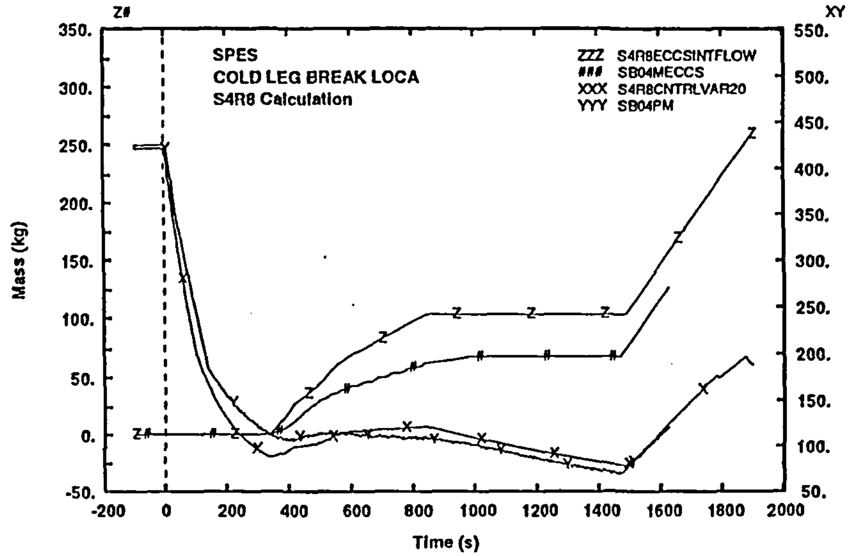

Fig. 2- S4R8 Case - ECCS integral flowrate and primary side total mass

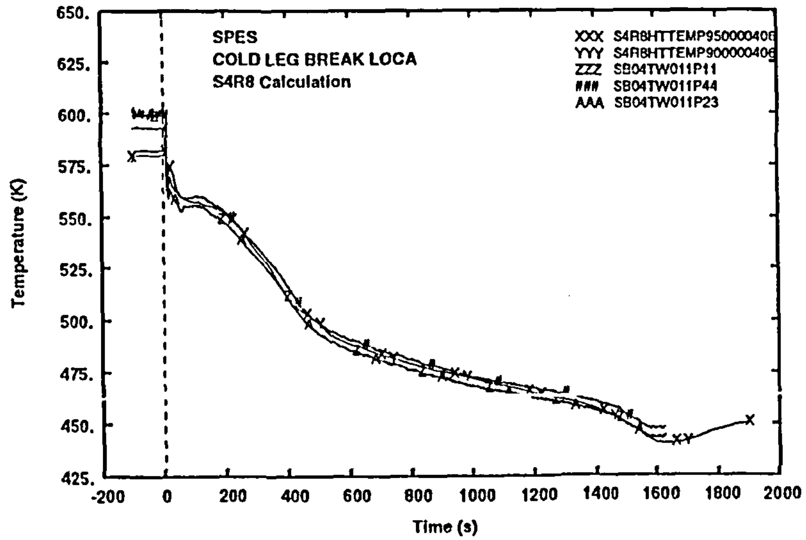

Fig. 3- S4R8 Case - Heater rod temperature (bottom level)

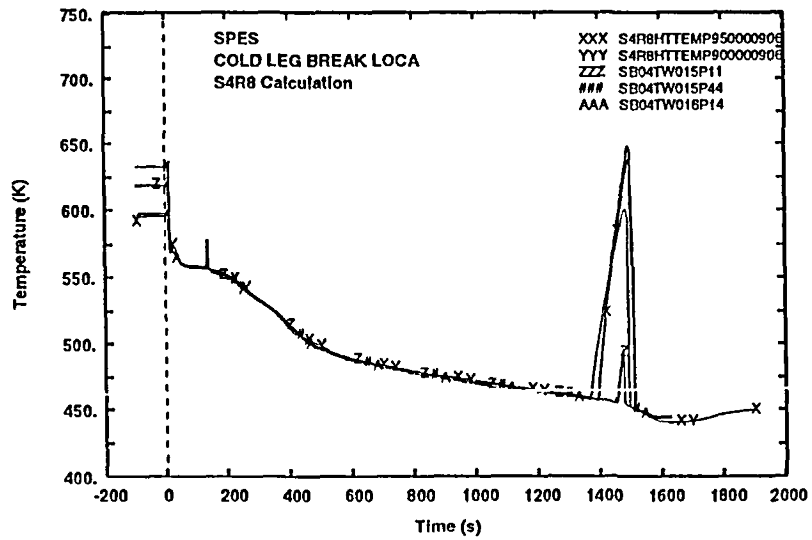

Fig. 4- S4R8 Case - Heater rod temperature (middle level)

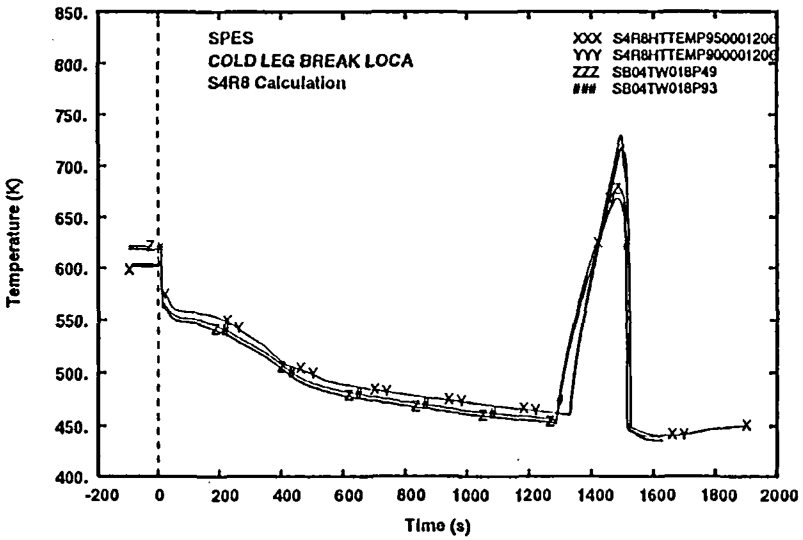

Fig. 5- S4R8 Case - Heater rod temperature (high level)

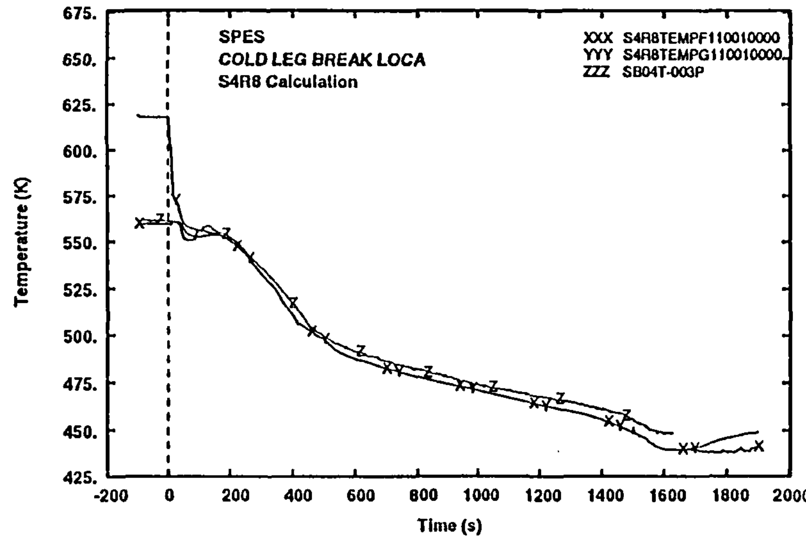

Fig. 6- S4R8 Case - Core inlet fluid temperature

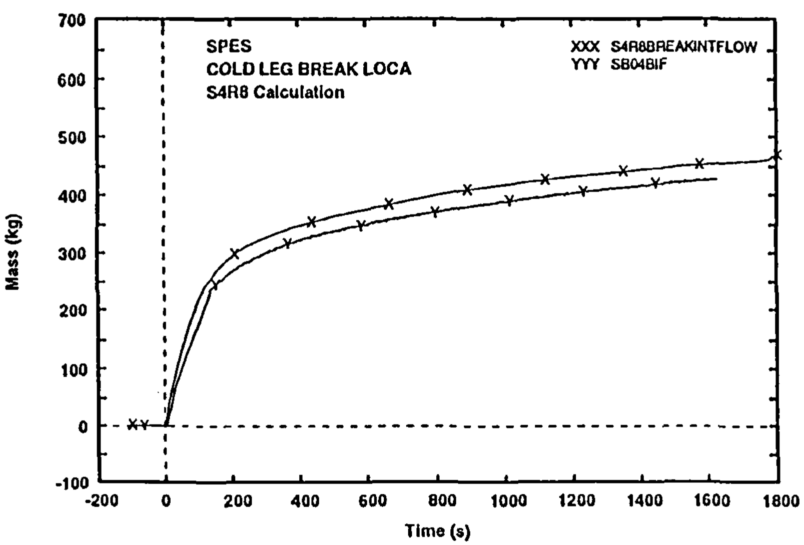

Fig. 7- S4R8 Case - Integral break flowrate

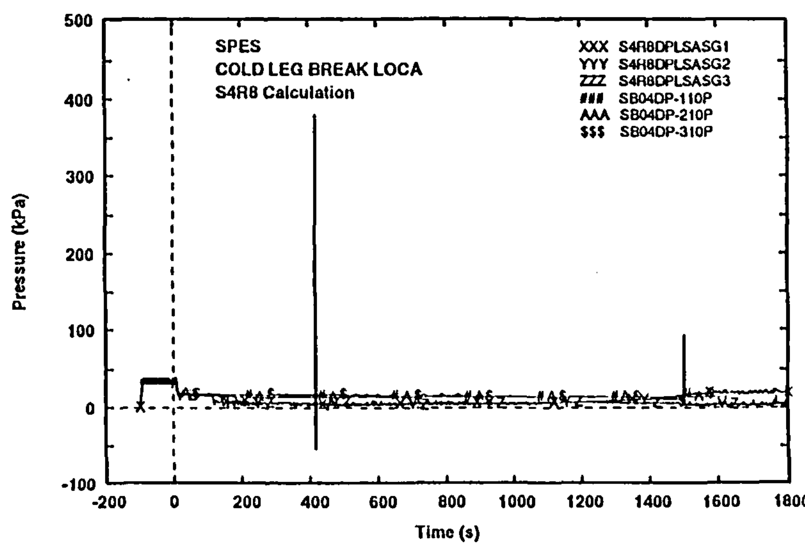

Fig. 8- S4R8 Case - Pressure drop across loop seal (ascendig side)

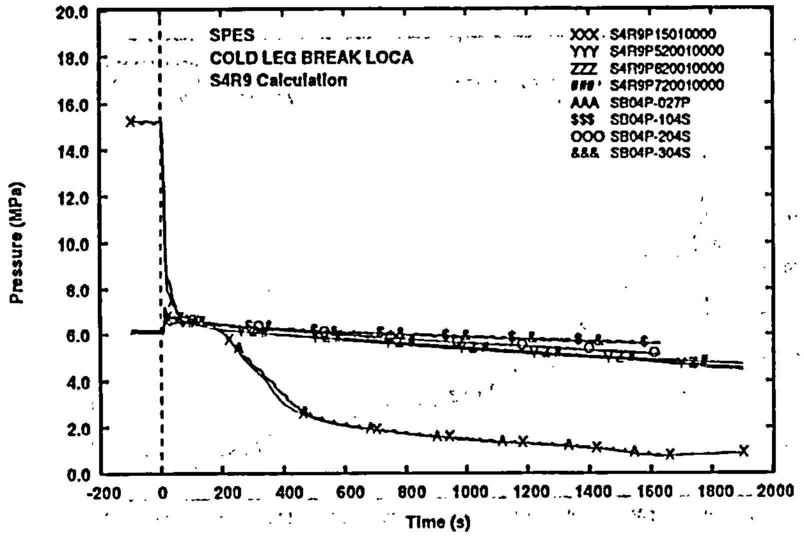

Fig. 1- S4R9 Case - Primary and secondary pressure

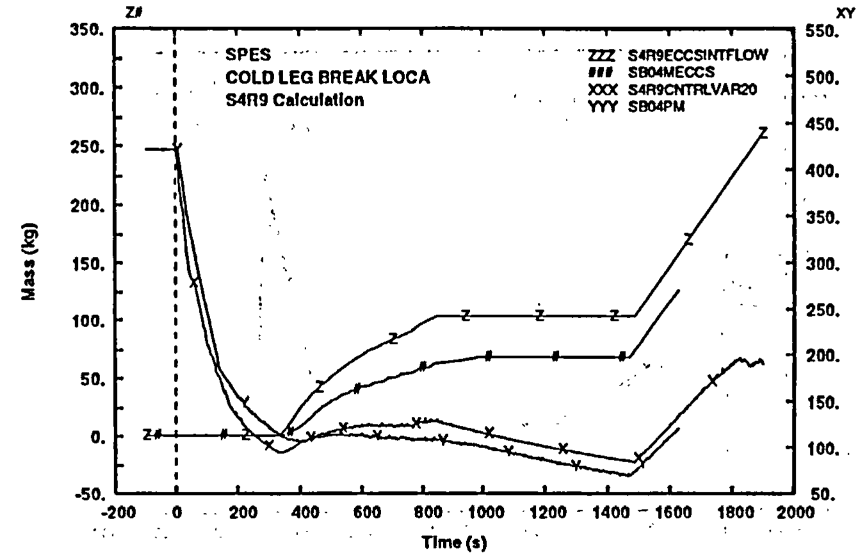

Fig. 2- S4R9 Case - ECCS integral flowrate and primary side total mass

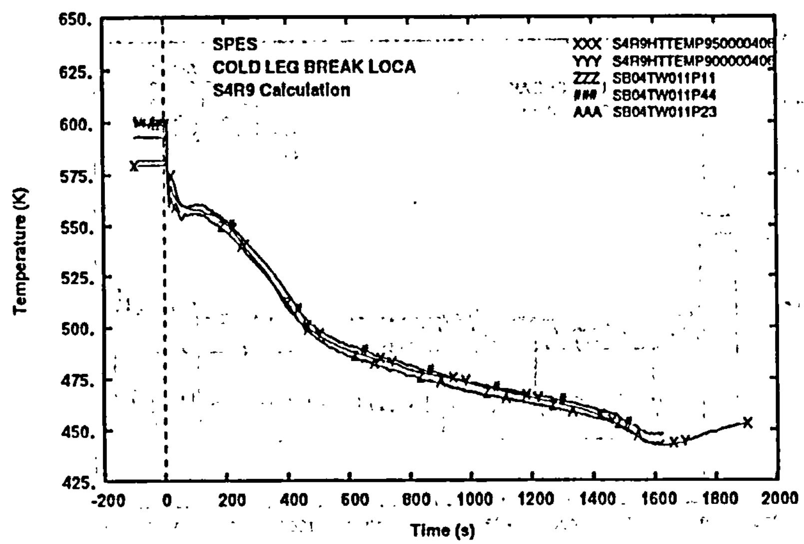

Fig. 3- S4R9 Case - Heater rod temperature (bottom level)

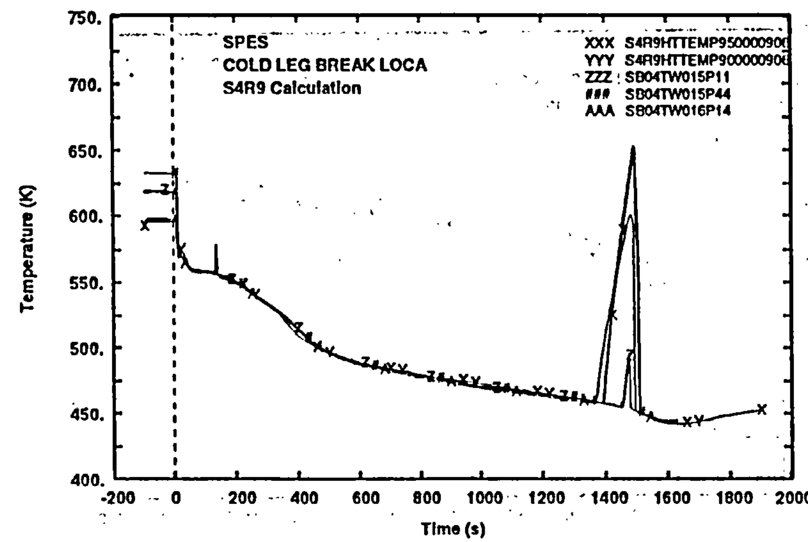

Fig. 4- S4R9 Case - Heater rod temperature (middle level)

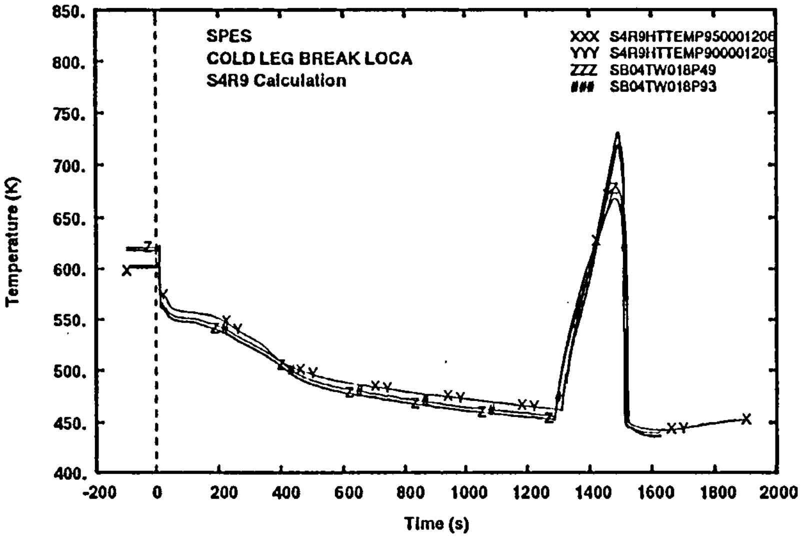

Fig. 5 - S4R9 Case - Heater rod temperature (high level)

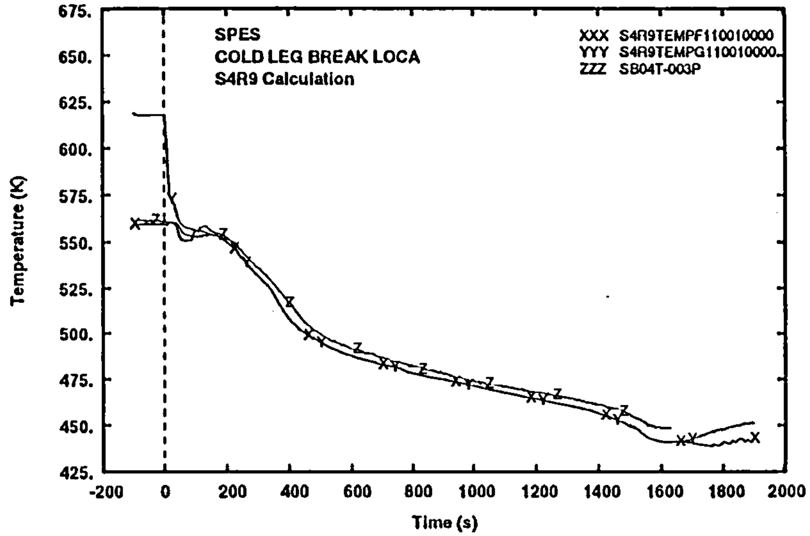

Fig. 6 - S4R9 Case - Core inlet fluid temperature

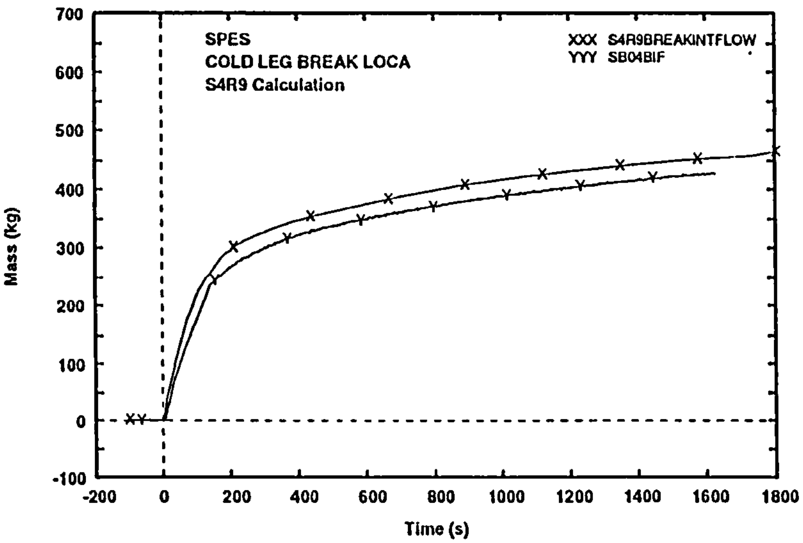

Fig. 7 - S4R9 Case - Integral break flowrate

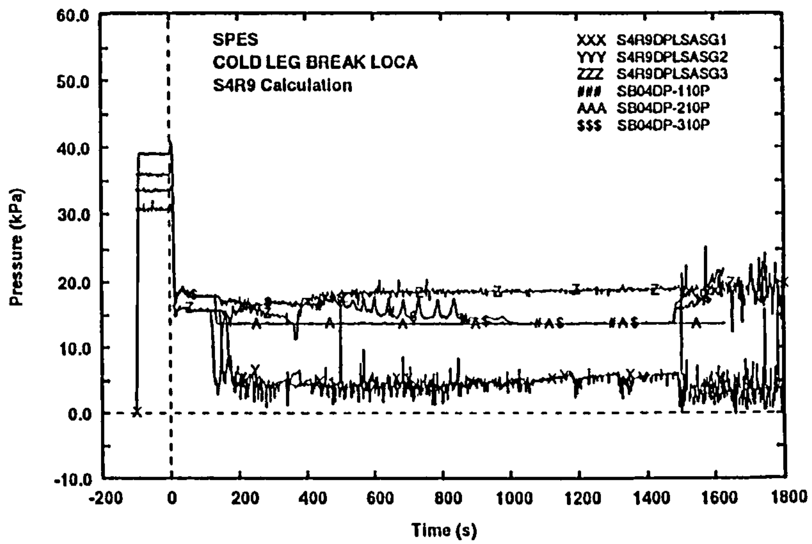

Fig. 8 - S4R9 Case - Pressure drop across loop seal (ascendig side)

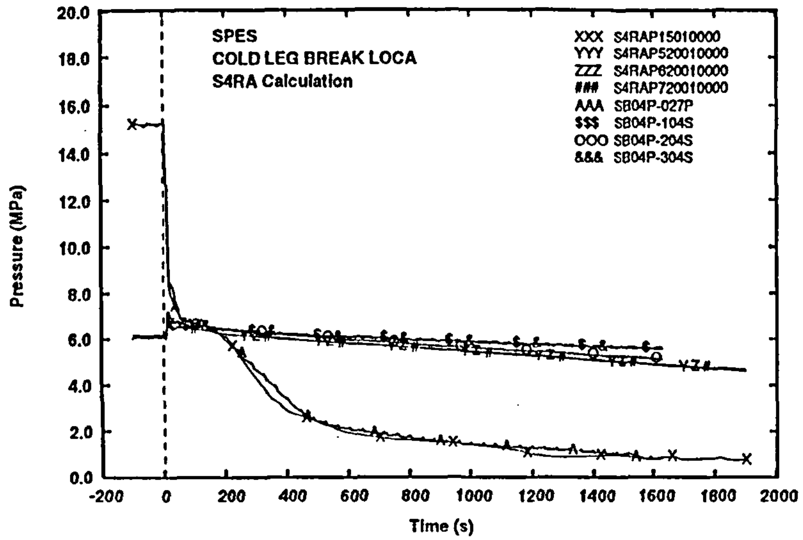

Fig. 1- S4RA Case - Primary and secondary pressure

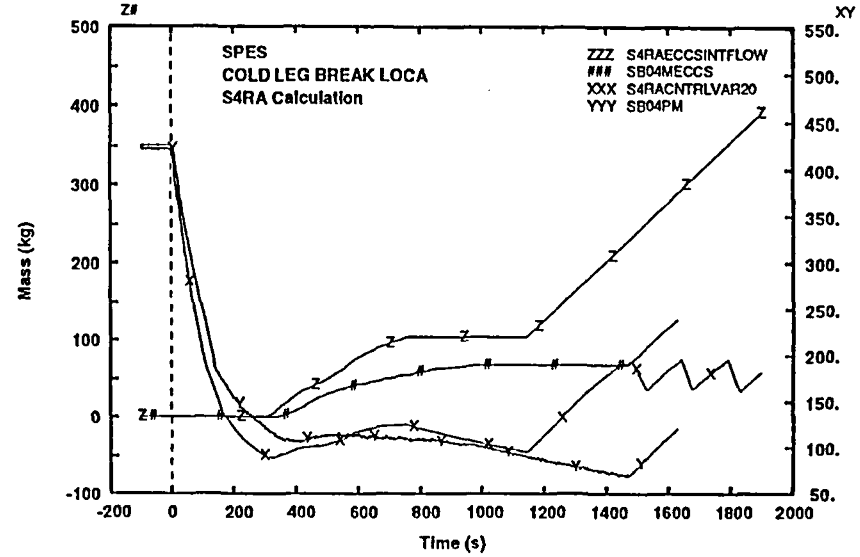

Fig. 2- S4RA Case - ECCS integral flowrate and primary side total mass

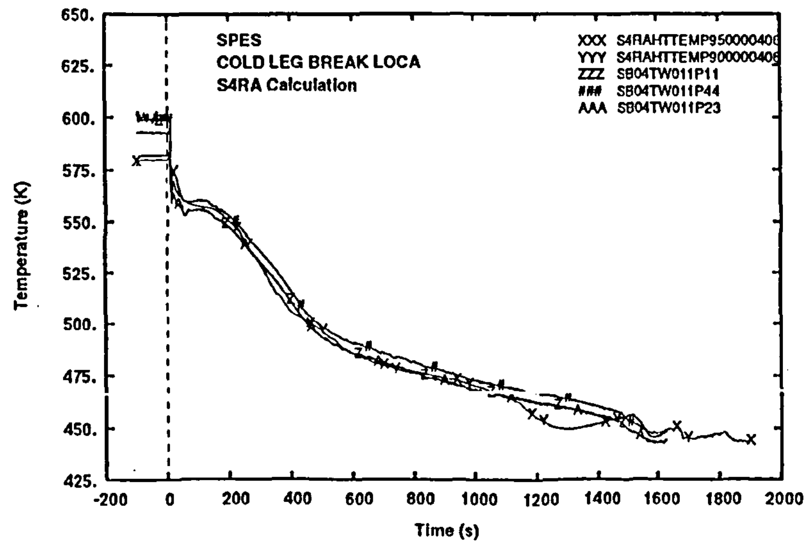

Fig. 3- S4RA Case - Heater rod temperature (bottom level)

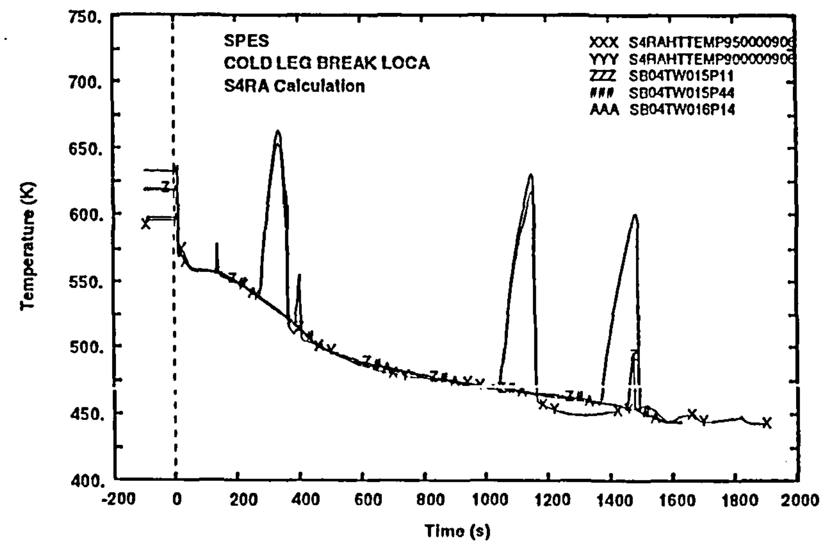

Fig. 4- S4RA Case - Heater rod temperature (middle level)

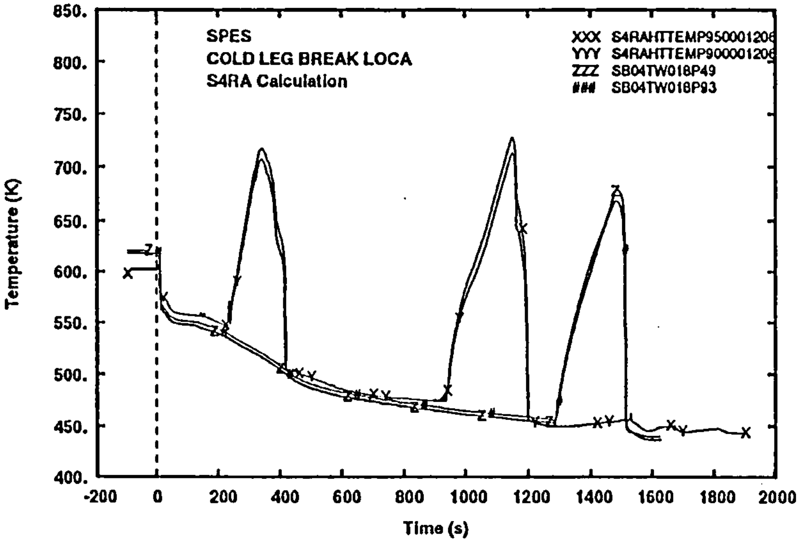

Fig. 5- S4RA Case - Heater rod temperature (high level)

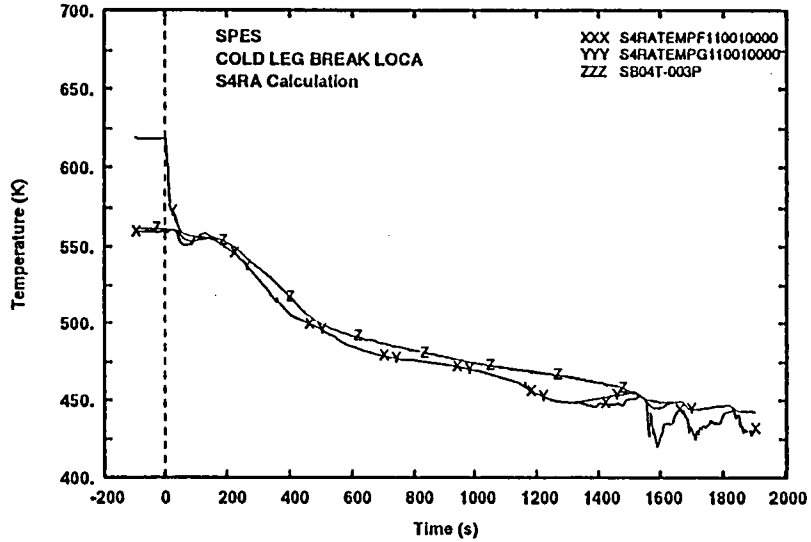

Fig. 6- S4RA Case - Core inlet fluid temperature

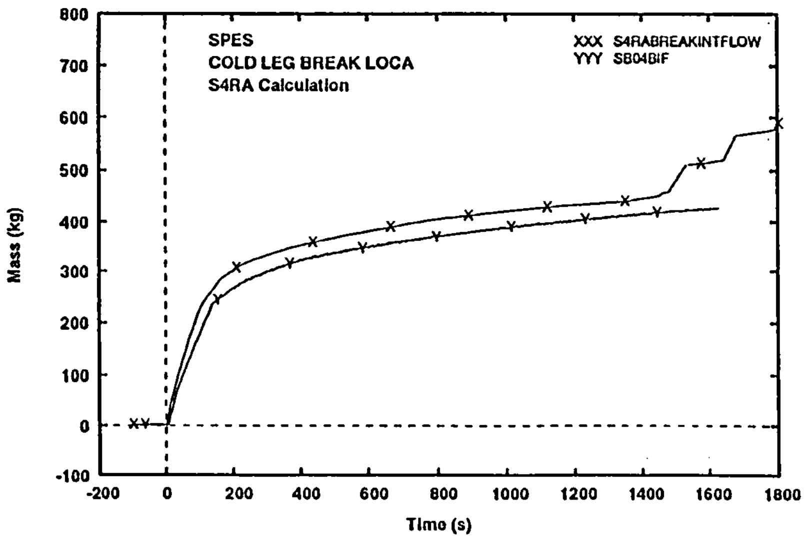

Fig. 7- S4RA Case - Integral break flowrate

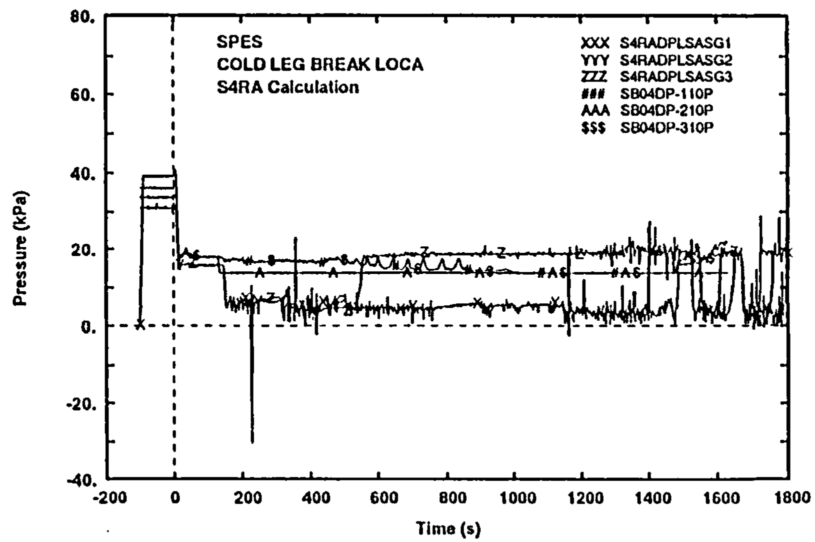

Fig. 8- S4RA Case - Pressure drop across loop seal (ascendig side)

APPENDIX 5:

Reference calculation input deck

```
=spes4
*
100 new transnt
*
105 5. 6.
*
110 nitrogen
*
* time steps              min mj  re
0000201  100.  .5e-7  0.5  07003  20  100  100
0000202  400.  .5e-7  0.1  07003  20 1000 1000
0000203  600.  .5e-7  0.05 07003  40 2000 2000
0000204  900.  .5e-7  0.01 07003 200 4000 4000
0000205 2200.  .5e-7  0.01 07003 200 4000 4000
0000206 3200.  .5e-7  0.05 07003  40 4000 4000
0000207 1.e6  .5e-7  0.1  07003 100 4000 4000
*
*------------------------------------------------------------------
* minor edits
*------------------------------------------------------------------
* pressures & varies
301  p      015010000     * prz pre
302  p      520010000     * sg1 ss pre.
303  p      620010000     * sg2 ss pre.
304  p      720010000     * sg3 ss pre.
305 voidg     570050000     * sg1 ss dc void
306 voidg     670050000     * sg2 ss dc void
307 voidg     770050000     * sg3 ss dc void
308 cntrlvar   150        * core lvl
309 cntrlvar   151        * rpv  lvl
*
* energy balance
310   cntrlvar 064      * core power
311   cntrlvar 021      * sg1 heat transfer
312   cntrlvar 022      * sg2 heat transfer
313   cntrlvar 023      * sg3 heat transfer
314   cntrlvar 056      * struct. heat transfer
315   cntrlvar 060      * prz int. heaters
316   cntrlvar 061      * core mean rod
317   cntrlvar 090      * heat losses ps total
318   cntrlvar 091      * heat losses ss total
*
* liquid levels & masses
319   cntrlvar 001      * prz level
320   cntrlvar 002      * sg1 dc lvl
321   cntrlvar 003      * sg2 dc lvl
322   cntrlvar 004      * sg3 dc lvl
323   cntrlvar 020      * ps total mass
324   cntrlvar 036      * sg1 total mass
325   cntrlvar 037      * sg2 total mass
326   cntrlvar 038      * sg3 total mass
*327   cntrlvar 200      * ps power imb.
*
* fluid temperatures
328   tempg   120010000     * core inlet
329   tempf   120010000     * core inlet
330   tempf   140010000     * core outlet
331   tempg   140010000     * core outlet
332   tempg   015010000     * prz bot
333   tempf   015010000     * prz bot
334   tempg   180010000     * upper head
335   tempf   180010000     * upper head
336   tempf   010030000     * surge line
*
* fluid temperatures
337   tempf   290010000     * l1 cl temp
338   tempf   390010000     * l2 cl temp
339   tempf   490010000     * l3 cl temp
340   tempf   570010000     * sg1 dc t.
341   tempf   670010000     * sg2 dc t.
342   tempf   770010000     * sg3 dc t.
343   tempg   520010000     * sg1 sd t.
344   tempg   620010000     * sg2 sd t.
345   tempg   720010000     * sg3 sd t.
*
* fluid flowrates
346   mflowj    591000000     *feed water 1
347   mflowj    691000000     *feed water 2
348   mflowj    791000000     *feed water 3
349   mflowj    580000000     *steam line 1
350   mflowj    680000000     *steam line 2
351   mflowj    780000000     *steam line 3
*352   rho     510000000     *
*353   rho     610000000     *
*354   rho     710000000     *
*
* mass flowrates
355   mflowj   105010000     * rpv dc
356   mflowj   120010000     * core inlet
357   mflowj   113000000     * core bypass
358   mflowj   135010000     * dc-uh bypassin
359   mflowj   160040000     * dc-uh bypass ou
360   mflowj   010010000     * surge line
361   mflowj   200010000     * hl1
362   mflowj   300010000     * hl2
363   mflowj   400010000     * hl3
*
* mass flowrates
364   mflowj   595000000     * sg1 lvl con -
365   mflowj   695000000     * sg2 lvl con -
366   mflowj   795000000     * sg3 lvl con -
367   mflowj   045000000     * prz lvl contr.
368   mflowj   065000000     * prz pre contr.
369   mflowj   580000000     * sg1 pre contr.
370   mflowj   680000000     * sg2 pre contr.
371   mflowj   780000000     * sg3 pre contr.
372   mflowj   575000000     * sg1 dc
*
* mass flowrates
373   mflowj   281000000     * loop1 acc
374   mflowj   481000000     * loop3 acc
375   mflowj   383000000     * break
376   mflowj   510020000     * sg1 sep liq
377   mflowj   610020000     * sg2 sep liq
378   mflowj   710020000     * sg3 sep liq
379   mflowj   597000000     * sg1 lvl con --
380   mflowj   697000000     * sg2 lvl con --
381   mflowj   797000000     * sg3 lvl con --
*
* rod surface temperatures
382   httemp   950001205     * hot rod
383   httemp   950001105     * hot rod
384   httemp   950001005     * hot rod
385   httemp   900001205     * average rod
386   httemp   900001105     * average rod
387   httemp   900000405     * average rod
388   httemp   910000101     * average rod in lp
389   httemp   920000101     * average rod in up
390   httemp   020100102     * prz  int. heater
*
* pressure differentials
391   cntrlvar 106        * l1 hl dp
392   cntrlvar 100        * sg1 ps
393   cntrlvar 107        * l1 loop seal desc leg dp
394   cntrlvar 108        * l1 loop seal asc leg dp
395   cntrlvar 109        * l1 pu dp
396   cntrlvar 110        * l1 cl dp
397   cntrlvar 101        * sg2 dp
398   cntrlvar 102        * sg3 dp
399   cntrlvar 103        * l1 tot dp
*
*------------------------------------------------------------------
* trips
*------------------------------------------------------------------
*
*  heat lossses temperature table in.
501 time 0 ge null 0  0. l              *
*
*  prz pressure control
503 time 0 ge null 0  0. l              *
504 time 0 ge null 0  99. l             * closure
602  503 xor  504       n               * opening
*
* pump1 trip
```

```
505 time 0 lt null 0 -1.   l            * pump1 trip
506 time 0 ge null 0 107.5               l * pump1 decay
*
* pump2 trip
508 time 0 lt null 0 -1.   l            * pump2 trip
509 time 0 ge null 0 107.5               l * pump2 decay
*
* pump3 trip
511 time 0 lt null 0 -1.  l             * pump3 trip
512 time 0 ge null 0 107.5               l * pump3 decay
*
* sg1 pressure control
515 time 0 ge null 0 -1.                l * sg1
516 p 030010000 lt null 0  13.0e6         l * trip for vlv sl clo
610 515 xor 516                        n * opening
*
* sg2 pressure control
517 time 0 ge null 0 -1.                l * sg2
518 p 030010000 lt null 0  13.0e6         l * trip for vlv sl clo
611 517 xor 518                        n * opening
*
* sg3 pressure control
519 time 0 ge null 0 -1.                l * sg3
520 p 030010000 lt null 0  13.0e6         l * trip for vlv sl clo
612 519 xor 520                        n * opening
*
* prz level control
522 time 0 ge null 0 0.          l      * lvl control prez
523 time 0 ge null 0   99.9       l      * lvl control sto
606 522 xor 523                 n      * lvl control prez.
*
* sg1 ss level control (steady state)
524 time 0 ge null 0  0.         l      * sg1
525 time 0 ge null 0 90.         l      * sg1 lvl cont stop
607 524 xor 525                 n      * sg1 lvl cont in.
*
* sg2 ss level control (steady state)
526 time 0 ge null 0  0.         l      * sg2
527 time 0 ge null 0 90.         l      * sg2 lvl cont stop
608 526 xor 527                 n      * sg2 lvl cont in.
*
* sg3 ss level control (steady state)
528 time 0 ge null 0  0.         l      * sg3
529 time 0 ge null 0 90.         l      * sg3 lvl cont stop
609 528 xor 529                 n      * sg3 lvl cont in.
*
* end programm
540 time 0 ge null 0    2000.      l    * end
600  540                             * end program
*
* sg1 safety valve
550   p  520010000 ge null 0  7.20e6  n    *
551   p  520010000 ge null 0 30.24e6  l    *
552   p  520010000 lt null 0  7.00e6  n    * sg1 sa. clo.
630   550 xor 551              n     * sg1 sa. op.
*
* sg2 safety valve
553   p  620010000 ge null 0  7.20e6  n    *
554   p  620010000 ge null 0 30.24e6  l    *
555   p  620010000 lt null 0  7.00e6  n    * sg2 sa. clo.
631   553 xor 554              n     * sg2 sa. op.
*
* sg3 safety valve
556   p  720010000 ge null 0  7.20e6  n    *
557   p  720010000 ge null 0 30.24e6  l    *
558   p  720010000 lt null 0  7.00e6  n    * sg3 sa. clo.
632   556 xor 557              n     * sg3 sa. op.
*
* sg1 fw closure
560 time 0 ge null 0 107.5              l * trip for vlv clo
*
* sg2 fw closure
561 time 0 ge null 0 107.5              l * trip for vlv clo
*
* sg3 fw closure
562 time 0 ge null 0 107.5              l * trip for vlv clo
*
* sp-sb-03 break opening
563 time 0 ge null 0    100.        l     *
*
* sg1-sg2 vlv connection opening
568 time 0 ge null 0     1.e6       l     * sg1-sg2 conn. op.
*
* sg1-sg3 vlv connection opening
569 time 0 ge null 0     1.e6       l     * sg1-sg3 conn. op.
*
* prz internal heaters stop
570 cntrlvar 001 lt null 0   1.18     n      * prz heat. shut-off 150
*
* scram
575  time 0 ge null 0  107.5              l * scram
*
* si signal trip (not utilized)
*576 p 030010000 lt null 0  11.70e6         l * si trip
*
* lpis actuation in loop 1 & 3
580 p 030010000 le null 0   2.50e6        l * lpis
581 httemp 950001205  gt null 0   723.     l * lpis
582 httemp 950001105  gt null 0   723.     l * lpis
583 httemp 950001005  gt null 0   723.     l * lpis
645  581  or 582                       n *
646  645  or 583                       n *
647  646 and 580                       n * tj op.
*
* acc vlv loop 1 actuation
585 p 280010000 lt null 0    4.22e6       l *
586 acvliq 284      lt null 0 0.0106       l * vlv clo.
650  585 xor 586                       n * vlv op.
*
* acc vlv loop 2 actuation  & closure
587 p 480010000 lt null 0    4.22e6       l *
588 acvliq 484      lt null 0 0.0106       l * vlv clo.
651  587 xor 588                       n * vlv op.

*
*
*-------------------------------------------------------------
*
* hydraulic components
*
*-------------------------------------------------------------
*
*
* surge line
0100000 su.li.hl pipe
0100001 6
0100101 4.64e-4 6
0100301 1.804   1
0100302 1.863   2
0100303 2.600   3
0100304 2.000   5
0100305 2.062   6
0100401 0.     6
0100601 90.    2
0100602  0.    3
0100603 90.    6
0100701  1.804   1
0100702  1.863   2
0100703  0.      3
0100704  2.000   5
0100705  2.062   6
0100801 4.e-5 0.0243  6
0100901  1.e-6 1.e-6 1
0100902 0.5   0.5   2
0100903 0.5   0.5   3
0100904  1.e-6 1.e-6 5
0101001 0000000  6
0101101 0000000  5
0101201 000 15.4200e6 1.4000e6  2.4549e6 0. 0. 1
0101202 000 15.4200e6 1.4224e6  2.4549e6 0. 0. 2
0101203 000 15.4200e6 1.4424e6  2.4549e6 0. 0. 3
0101204 000 15.4200e6 1.5124e6  2.4549e6 0. 0. 4
0101205 000 15.4200e6 1.6000e6  2.4549e6 0. 0. 5
0101206 000 15.4200e6 1.6000e6  2.4549e6 0. 0. 6
```

```
0101300 1
0101301 0. 0. 0.   5
*
* prez bot1
0150000 pre.bot. branch
0150001 2 1
0150101 0. 0.679 0.008504 0. 90. 0.679 4.e-5 0.06970 0000000
0150200 000 15.1600e6 1.6000e6 2.4549e6 0.
0151101 015010000 020000000 0. 1.e-6 1.e-6 0000000
0152101 010010000 015000000 0. 0.5  0.5  0000000
0151201 0. 0. 0.
0152201 0. 0. 0.
*
* prez bot2
0200000 pre.b.up branch
0200001 1 1
0200101 0. 0.679 0.009532 0. 90. 0.679 4.e-5 0. 0000000
0200200 000 15.1600e6 1.6000e6 2.4549e6 0.
0201101 020010000 025000000 0. 0. 0. 0000000
0201201 0. 0. 0.
*
* prz vessel
0250000 pre.vsl pipe
0250001 6
0250101 0.014208  6
0250301 0.679    6
0250401 0.      6
0250601 90.     6
0250701 0.679    6
0250801 4.e-5 0.1345 6
0250901 1.e-6 1.e-6  5
0251001 0000000 6
0251101 0000000 5
0251201 000 15.1600e6 1.6000e6 2.4490e6 0.  0. 3
0251202 000 15.1600e6 1.6000e6 2.4490e6 0.5  0. 4
0251203 000 15.1600e6 1.6000e6 2.4490e6 1.  0. 6
0251300 1
0251301 0. 0. 0.   5
*
* prez top1
0300000 pre.top. branch
0300001 1 1
0300101 0.014208 0.679 0. 0. 90. 0.679 4.e-5 0. 0000000
0300200 000 15.1600e6 1.6000e6 2.4490e6 1.
0301101 025010000 030000000 0. 1.e-6 1.e-6 0000000
0301201 0. 0. 0.
*
* prez top2
0350000 pre.t.up branch
0350001 1 1
0350101 0.014208 0.679 0. 0. 90. 0.679 4.e-5 0. 0000000
0350200 000 15.1600e6 1.6000e6 2.4490e6 1.
0351101 030010000 035000000 0. 1.e-6 1.e-6 0000000
0351201 0. 0. 0.
*
* prez lvl control vol
0400000 prz.cvvo  tmdpvol
0400101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
0400200 2
0400201 0. 16.00e6 0.
*
* prez level control j
0450000 prz.lec  tmdpjun
0450101 040000000 015010000 0.
0450200 1 606 cntrlvar 001
0450201 -1.    0.  0.  0.
0450202  1.   4.5  0.  0.
0450203  3.0   3.2  0.  0.
0450204  3.77  0.0  0.  0.
0450205  4.2   0.  0.  0.
0450206  5.2  -1.  0.  0.
0450207  10.  -3.  0.  0.
*
* steady state pressure control
0600000 pre.sts  tmdpvol
0600101 0.0121 2. 0. 0. 0.  0. 4.e-5 0. 0000000
0600200 2
0600201 0. 15.16e6 1.0
*
* tmdp conn valve to prez
0650000 pr.tmv  valve
0650101 035010000 060000000 0.01  1.e-6 1.e-6 0000000
0650201 1 0. 0. 0.
0650300 trpvlv
0650301 602
*
* lower plenum 1
1000000 lo.pl1 branch
1000001 1 1
1000101 0.  0.798 0.04734 0. 90. 0.798 4.e-5 0.013367 0000000
1000200 000 15.580e6 1.2420e6 2.4799e6 0.
1001101 100010000 110000000 .01127 0.5 0.5 0000000
1001201 0.   0.  0.
*
* lower downcomer hor.
1050000 ldc.hor  branch
1050001 2 1
1050101 0.006656 0.344 0. 0.  0. 0.  4.e-5 0.09206  0000000
1050200 000 15.560e6 1.2420e6 2.4799e6 0.
1051101 115010000 105000000 0.   0.5 0.5 0000000
1052101 105010000 110000000 .006656 1.5 1.5 0000000
1051201 32.0  0. 0.
1052201 32.0  0. 0.
*
* lower plenum 2
1100000 lo.pl2 branch
1100001 2 1
1100101 0.01127 0.753 0. 0. 90. 0.753 4.e-5 0.013367 0000000
1100200 000 15.560e6 1.2420e6 2.4799e6 0.
1101101 110010000 120000000 .009197 0.1 0.1 0000000
1102101 110010000 112000000 .001441 26. 36. 0000000
1101201 31.  0. 0.
1102201 0.96  0. 0.
*
* core bypass lower part
1120000 co.by.lo pipe
1120001 4
1120101 0.001441 4
1120301 1.015   2
1120302 1.374   4
1120401 0.     4
1120601 0.     2
1120602 90.    4
1120701 0.     2
1120702 1.374   4
1120801 4.e-5 0.0428 4
1120901 1.e-6 1.e-6 1
1120902 0.5  0.5  2
1120903 1.e-6 1.e-6 3
1121001 0000000  4
1121101 0000000 3
1121201 000 15.4800e6 1.2420e6 2.4799e6 0. 0. 4
1121300 1
1121301 0.96  0. 0. 3
*
* core bypass conn. jun (valve)
1130000 by.by.j sngljun
1130101 112010000 114000000 0. 1.e-6 1.e-6 0000000
1130201 1 0.96  0. 0.
*
* core bypass upper part
1140000 co.by.up pipe
1140001 4
1140101 0.001441 4
1140301 1.081   2
1140302 1.015   4
1140401 0.     4
1140601 90.    2
1140602 0.     4
1140701 1.081   2
1140702 0.     4
1140801 4.e-5 0.0428 4
1140901 1.e-6 1.e-6 1
1140902 0.5  0.5  2
```

```
1140903 1.e-6 1.e-6 3
1141001 0000000 4
1141101 0000000 3
1141201 0 15.4600e6 1.2420e6 2.4799e6 0. 0. 4
1141300 1
1141301 0.96 0. 0. 3
*
* downcomer pipe
1150000 downcom. pipe
1150001 7
1150101 0.006656 7
1150301 0.823 7
1150401 0. 7
1150601 -90. 7
1150701 -0.823 7
1150801 4.e-5 0.09206 7
1150901 1.e-6 1.e-6 6
1151001 0000000 7
1151101 0000000 6
1151201 000 15.5000e6 1.2457e6 2.4799e6 0. 0. 7
1151300 1
1151301 32. 0. 0. 6
*
* lower plenum 3
1200000 lo.pl1 branch
1200001 1 1
1200101 0.01127 0.486 0. 0. 90. 0.486 4.e-5 0.013367 0000000
1200200 000 15.480e6 1.2420e6 2.4799e6 0.
1201101 120010000 130000000 .009197 0.1 0.1 0000000
1201201 31. 0. 0.
*
* upper downcomer - cl connection
1250000 udc.clc branch
1250001 5 1
1250101 0. 0.49 0.0032614 0. -90. -0.49 4.e-5 0.125 0000000
1250200 000 15.480e6 1.2420e6 2.4799e6 0.
1251101 290010000 125000000 .002734 0.5 0.5 0000000
1252101 390010000 125000000 .002734 0.5 0.5 0000000
1253101 490010000 125000000 .002734 0.5 0.5 0000000
1254101 125010000 115000000 .006656 0.1 0.1 0000000
1255101 125000000 135000000 0. 0.1 0.1 0000000
1251201 10.65 0. 0.
1252201 10.65 0. 0.
1253201 10.65 0. 0.
1254201 32.0 0. 0.
1255201 0.31 0. 0.
*
* core active length
1300000 core pipe
1300001 12
1300101 .009648 12
1300301 .183 2
1300302 .366 10
1300303 .183 12
1300401 0. 12
1300601 90. 12
1300801 1.27e-7 0.011476 12
1300901 0.05 0.05 1
1300902 0.17 0.17 2
1300903 0.05 0.05 3
1300904 0.17 0.17 4
1300905 0.05 0.05 5
1300906 0.17 0.17 6
1300907 0.05 0.05 7
1300908 0.17 0.17 8
1300909 0.05 0.05 9
1300910 0.17 0.17 10
1300911 0.05 0.05 11
1301001 0000100 12
1301101 0000000 11
1301201 000 15.5624e6 1.2500e6 2.5164e6 0. 0. 1
1301202 000 15.5255e6 1.2677e6 2.5164e6 0. 0. 2
1301203 000 15.5087e6 1.2799e6 2.5164e6 0. 0. 3
1301204 000 15.4919e6 1.2820e6 2.5164e6 0. 0. 4
1301205 000 15.4851e6 1.2942e6 2.5164e6 0. 0. 5
1301206 000 15.4882e6 1.3163e6 2.5164e6 0. 0. 6
1301207 000 15.4714e6 1.3285e6 2.5164e6 0. 0. 7
1301208 000 15.4705e6 1.3300e6 2.5164e6 0. 0. 8
1301209 000 15.4645e6 1.3526e6 2.5164e6 0. 0. 9
1301210 000 15.4445e6 1.3776e6 2.5164e6 0. 0. 10
1301211 000 15.4345e6 1.3826e6 2.5164e6 0. 0. 11
1301212 000 15.4245e6 1.3900e6 2.5164e6 0. 0. 12
1301300 1
1301301 31. 0. 0. 11
*
* downcomer top
1350000 dc.top1 branch
1350001 1 1
1350101 0. 0.356 0.003261 0. 90. 0.356 4.e-5 0.114 0000000
1350200 000 15.430e6 1.23300e6 2.4799e6 0.
1351101 135010000 145000000 .0002360 0.5 0.5 0000000
1351201 0.31 0. 0.
*
* core top
1400000 core.top branch
1400001 2 1
1400101 0. 0.382 .00362 0. 90. .382 4.e-5 0.011476 0000000
1400200 000 15.4677e6 1.4000e6 2.5164e6 0.
1401101 130010000 140000000 0.007571 0.5 0.5 0000000
1402101 140010000 150000000 0.007571 0.5 0.5 0000000
1401201 31.0 0. 0.
1402201 31.0 0. 0.
*
* dc-uh bypass
1450000 dc.uh.by pipe
1450001 5
1450101 0.0004638 5
1450301 1.201 1
1450302 0.463 3
1450303 0.415 4
1450304 0.582 5
1450401 0. 5
1450601 90. 1
1450602 0. 3
1450603 90. 4
1450604 0. 5
1450701 1.201 1
1450702 0. 3
1450703 0.415 4
1450704 0. 5
1450801 4.e-5 0.0243 5
1450901 0.5 0.5 1
1450902 .02 .02 2
1450903 0.5 0.5 4
1451001 0000000 5
1451101 0000000 4
1451201 000 15.4040e6 1.2580e6 2.4799e6 0. 0. 5
1451300 1
1451301 0.31 0. 0. 4
*
* core-bypass connection
1500000 co.by.co branch
1500001 2 1
1500101 0.019607 0.382 0. 0. 90. .382 4.e-5 0.158 0000000
1500200 000 15.4007e6 1.4000e6 2.5212e6 0.
1501101 150010000 160000000 0. 1.e-6 1.e-6 0000000
1502101 114010000 150010000 0.001441 50. 100. 0000000
1501201 31.0 0. 0.
1502201 0.96 0. 0.
*
* dc-uh by. conn. jun (valve)
1550000 dc.uh.j sngljun
1550101 145010000 180000000 0. 1. 1. 0000000
1550201 1 0.31 0. 0.
*
* upper plenum - hl connections
1600000 up.hl.co branch
1600001 4 1
1600101 0.019607 0.688 0. 0. 90. .688 4.e-5 0.158 0000000
1600200 000 15.4007e6 1.4000e6 2.5212e6 0.
1601101 160010000 200000000 0.003489 1. 1. 0000000
1602101 160010000 300000000 0.003489 1. 1. 0000000
1603101 160010000 400000000 0.003489 1. 1. 0000000
1604101 170010000 160010000 0. 1.e-6 1.e-6 0000000
```

```
1601201 10.65  0. 0.
1602201 10.65  0. 0.
1603201 10.65  0. 0.
1604201 0.31   0. 0.
*
* upper head 1
1700000 uh.1    branch
1700001 1 1
1700101 0.019607 0.936  0. 0. -90. -.936  4.e-5 0.158  0000000
1700200 000 15.3897e6 1.2330e6  2.5312e6 0.
1701101 180010000 170000000 0.1400e-4  0.1    0.1    0000000
1701201 0.31    0. 0.
*
* upper head 2
1800000 uh.2    branch
1800001 1 1
1800101 0. 0.936 0.022281  0. -90. -.936  4.e-5 0.158  0000000
1800200 000 15.3897e6 1.2330e6  2.4799e6 0.
1801101 190010000 180000000 0.    0.1    0.1    0000000
1801201 0.    0. 0.
*
* upper head 3
1900000 uh.3    pipe
1900001 2
1900101 0.027465  2
1900301 0.642    2
1900401 0.       2
1900601 -90.     2
1900701 -0.642   2
1900801 4.e-5 0.187  2
1900901 1.e-6  1.e-6 1
1901001 0000000    2
1901101 0000000  1
1901201 000 15.4000e6 1.2330e6  2.4799e6 0. 0. 2
1901300 1
1901301 0. 0. 0. 1
*
* loop 1 rpv-hl conn
2000000 l1.hlpv  branch
2000001 1 1
2000101 0.003489 0.782  0. 0.  0. 0.  4.e-5 0.0666  0000000
2000200 000 15.4597e6 1.4000e6  2.5212e6 0.
2001101 200010000 210000000 0.    1.e-6   1.e-6  0000000
2001201 10.65  0. 0.
*
* loop 1 rpv-hl conn
2100000 l1.hlho  branch
2100001 1 1
2100101 0.003489 0.781  0. 0.  0. 0.  4.e-5 0.0666  0000000
2100200 000 15.4597e6 1.4000e6  2.5212e6 0.
2101101 210010000 220000000 0.    0.5    0.5    0000000
2101201 10.65  0. 0.
*
* loop 1 hl-sg conn. pipe
2200000 l1.hl.sg pipe
2200001 4
2200101 0.003489  3
2200102 0.       4
2200301 0.8785    2
2200302 0.569    3
2200303 0.474    4
2200401 0.       3
2200402 0.00269   4
2200601 90.      4
2200701 0.8785    2
2200702 0.417    3
2200703 0.474    4
2200801 4.e-5 0.06666 3
2200802 4.e-5 0.01542 4
2200901 1.e-6  1.e-6  2
2200902 0.1    0.1    3
2201001 0000000    4
2201101 0000000  3
2201201 000 15.4540e6 1.4000e6   2.5212e6 0. 0. 4
2201300 1
2201301 10.65  0. 0.   3
*
* loop 1 hl-ut conn. jun.
2250000 l1.hl.ut  sngljun
2250101 220010000 230000000 0.    0.2 0.2   0000000
2250201 1 10.65  0. 0.
*
* loop 1 ps sg u-tubes
2300000 l1.sg.ut pipe
2300001 14
2300101 0.0024277 14
2300301 0.5000    2
2300302 1.0000    8
2300303 1.2780    10
2300304 2.0000    13
2300305 1.0000    14
2300401 0.        14
2300601 90.       9
2300602 -90.      14
2300701 0.5       2
2300702 1.0       8
2300703 1.278     9
2300704 -1.278    10
2300705 -2.0      13
2300706 -1.0      14
2300801 3.e-6 0.01542 14
2300901 0.    0.    8
2300902 0.01   0.01  9
2300903 0.    0.    13
2301001 0000000    14
2301101 0000000 13
2301201 000 15.4440e6 1.3950e6   2.5212e6 0. 0. 1
2301202 000 15.4440e6 1.3883e6   2.5212e6 0. 0. 2
2301203 000 15.4440e6 1.3783e6   2.5212e6 0. 0. 3
2301204 000 15.4440e6 1.3683e6   2.5212e6 0. 0. 4
2301205 000 15.4440e6 1.3583e6   2.5212e6 0. 0. 5
2301206 000 15.4440e6 1.3483e6   2.5212e6 0. 0. 6
2301207 000 15.4440e6 1.3383e6   2.5212e6 0. 0. 7
2301208 000 15.4440e6 1.3283e6   2.5212e6 0. 0. 8
2301209 000 15.4440e6 1.3183e6   2.5212e6 0. 0. 9
2301210 000 15.4440e6 1.3083e6   2.5212e6 0. 0. 10
2301211 000 15.4440e6 1.2983e6   2.5212e6 0. 0. 11
2301212 000 15.4440e6 1.2883e6   2.5212e6 0. 0. 12
2301213 000 15.4440e6 1.2703e6   2.5212e6 0. 0. 13
2301214 000 15.4440e6 1.2500e6   2.5212e6 0. 0. 14
2301300 1
2301301 10.65 0. 0.   13
*
* loop 1 cl-ut conn. jun.
2350000 l1.cl.ut  sngljun
2350101 230010000 240000000 0.  0.01 0.2    0000000
2350201 1 10.65 0. 0.
*
* loop 1 cl-sg conn. pipe
2400000 l1.cl.sg pipe
2400001 2
2400101 0.       1
2400102 0.       2
2400301 0.474    1
2400302 0.569    2
2400401 0.00269   1
2400402 0.00162   2
2400601 -90.     2
2400701 -0.474    1
2400702 -0.417    2
2400801 4.e-5 0.01542 1
2400802 4.e-5 0.04924 2
2400901 0.1    0.1    1
2401001 0000000    2
2401101 0000000  1
2401201 000 15.4000e6 1.2420e6   2.5212e6 0. 0. 2
2401300 1
2401301 10.65 0. 0.    1
*
* loop 1 loop seal branch
2500000 l1.lsbr  branch
2500001 2 1
2500101 0.001904 0.898  0. 0. -90. -0.898 4.e-5 0.04924  0000000
2500200 000 15.4000e6 1.2420e6   2.5212e6 0.
```

```
2501101 240010000 250000000 0.  1.e-6  1.e-6  0000000
2502101 250010000 260000000 0.  1.e-6  1.e-6  0000000
2501201 10.65 0. 0.
2502201 10.65 0. 0.
*
* loop 1 loop seal pipe
2600000 l1.ls.pi pipe
2600001 7
2600101 0.001904 7
2600201 0.    2
2600202 0.000929 3
2600203 0.    6
2600301 0.859   1
2600302 1.021   4
2600303 0.727   5
2600304 1.503   6
2600305 1.2    7
2600401 0.     7
2600601 -90.   4
2600602 0.     5
2600603 90.    7
2600701 -0.859  1
2600702 -1.021  4
2600703 0.     5
2600704 1.503   6
2600705 1.200   7
2600801 4.e-5 0.04924 7
2600901 1.e-6 1.e-6 2
2600902 0.1  0.1  3
2600903 0.1  0.1  4
2600904 0.1  0.1  5
2600905 1.e-6 1.e-6 6
2601001 0000000   7
2601101 0000000 6
2601201 000 15.4000e6 1.2420e6  2.5212e6 0. 0. 7
2601300 1
2601301 10.65 0. 0.  6
*
* loop 1 pump
2700000 l1-pump pump
2700101 0. 0.26 4.340e-3 0. 90. 0.26 0000000
2700108 260010000 .0019 0.01 0.01 0000000
2700109 275000000 .0019 0.01 0.01 0000000
2700200 000 15.4500e6 1.2420e6  2.4749e6 0.
2700201 1 10.65 0. 0.
2700202 1 10.65 0. 0.
2700301 0 0 0 -1 0 505 1
2700302 335.0 0.96030 0.0106  77.0 59.7  3.5
2700303 747.3 0. 0. 0. 0. 0.
*
*** head curves ***
2701100 1 1
2701101 0.   1.1
2701102 0.1  1.12
2701103 0.2  1.12
2701104 0.3  1.11
2701105 0.4  1.1
2701106 0.5  1.09
2701107 0.6  1.08
2701108 0.7  1.07
2701109 0.8  1.06
2701110 0.9  1.04
2701111 1.0  1.
*
2701200 1 2
2701201 0.   -1.9
2701202 0.2  -1.2
2701203 0.3  -.5
2701204 0.4  -.2
2701205 0.6  .29
2701206 0.7  .45
2701207 0.8  .64
2701208 0.9  .8
2701209 0.95 .9
2701210 1.   1.
*
2701300 1 3
2701301 -1.  1.65
2701302 -.9  1.53
2701303 -.8  1.4
2701304 -.7  1.32
2701305 -.6  1.25
2701306 -.5  1.18
2701307 -.4  1.13
2701308 -.3  1.12
2701309 -.2  1.11
2701310 -.1  1.11
2701311 0.   1.1
*
2701400 1 4
2701401 -1.  1.65
2701402 -.9  1.42
2701403 -.8  1.19
2701404 -.7  1.03
2701405 -.6  0.87
2701406 -.5  0.74
2701407 -.4  0.64
2701408 -.3  0.58
2701409 -.2  0.51
2701410 -.1  0.45
2701411 0.   0.39
*
2701500 1 5
2701501 0.  .39
2701502 .1  .43
2701503 .2  .48
2701504 .3  .52
2701505 .4  .56
2701506 .5  .6
2701507 .6  .64
2701508 .7  .68
2701509 .8  .71
2701510 .9  .72
2701511 1.  .73
*
2701600 1 6
2701601 0.  .39
2701602 .1  .35
2701603 .2  .33
2701604 .3  .34
2701605 .4  .36
2701606 .5  .39
2701607 .6  .42
2701608 .7  .47
2701609 .8  .53
2701610 .9  .63
2701611 1.  .73
*
2701700 1 7
2701701 -1.  -1.9
2701702 -.9  -1.2
2701703 -.8  -.8
2701704 -.7  -.5
2701705 -.6  -.25
2701706 -.5  0.
2701707 -.4   .1
2701708 -.3   .19
2701709 -.2   .27
2701710 -.1   .34
2701711 0.    .39
*
2701800 1 8      * non riportata
2701801 -1. -1.11
2701802 -.7 -1.4
2701803 -.5 -1.34
2701804 -.3 -1.17
2701805 -.1 -0.91
2701806 0. -0.78
*
*** torque curves ***
2701900 2 1
2701901 0.  .75
2701902 .1  .78
2701903 .2  .78
```

```
2701904 .3  .79
2701905 .4  .81
2701906 .5  .82
2701907 .6  .85
2701908 .7  .86
2701909 .8  .88
2701910 .9  .91
2701911 1.  1.
*
2702000 2 2
2702001 0.  -.5
2702002 .1  -.35
2702003 .3  .2
2702004 .4  .15
2702005 .6  .4
2702006 .8  .67
2702007 .9  .84
2702008 1.  1.
*
2702100 2 3
2702101 -1.  1.2
2702102 -.9  1.
2702103 -.8  .9
2702104 -.7  .87
2702105 -.5  .83
2702106 -.3  .79
2702107 0.  .75
*
2702200 2 4
2702201 -1.  1.2
2702202 -.9  1.12
2702203 -.8  1.1
2702204 -.7  1.1
2702205 -.6  1.2
2702206 -.5  1.3
2702207 -.4  1.3
2702208 -.3  1.25
2702209 -.2  1.2
2702210 -.1  1.
2702211 0.  0.99
*
2702300 2 5
2702301 0.  -.56
2702302 .1  -.4
2702303 .2  -.32
2702304 .3  -.2
2702305 .4  -.1
2702306 .5  .069
2702307 .6  .2
2702308 .7  .28
2702309 .8  .4
2702310 .9  .55
2702311 1.  .63
*
2702400 2 6
2702401 0.  .99
2702402 .1  .95
2702403 .2  .91
2702404 .3  .9
2702405 .4  .87
2702406 .5  .83
2702407 .6  .8
2702408 .7  .75
2702409 .8  .72
2702410 .9  .68
2702411 1.  .6
*
2702500 2 7
2702501 -.6  -1.6
2702502 -.5  -1.4
2702503 -.45  -1.3
2702504 -.38  -1.2
2702505 -.3  -1.
2702506 -.25  -.95
2702507 -.2  -.88
2702508 -.15  -.8
2702509 -.1  -.7
2702510 -.05  -.64
2702511 0.  -.5
*
2702600 2 8       * non riportata
2702601 -1. -0.518
2702602 0.  -0.518
*
*** two-phase curves multipliers ***
2703000 0
2703001 0.  0.
2703002 .2  0.
2703003 .43  1.
2703004 .95  1.
2703005 1.  0.
*
2703100 0
2703101 0. 0.
2703102 1. 0.
*
*** two-phase curves differences ***
2704100 1 1
2704101 0.  .165
2704102 .05  .774
2704103 .1  .81
2704104 .3  .773
2704105 .5  .804
2704106 .7  .828
2704107 1.  .816
*
2704200 1 2
2704201 0.  .22
2704202 .1  .2285
2704203 .3  .248
2704204 .5  .329
2704205 .7  .477
2704206 1.  .816
*
2704300 1 3
2704301 -1.  -.82
2704302 -.8  -11.71
2704303 -.7  -1.6695
2704304 -.5  -1.78
2704305 -.3  -1.5
2704306 -.2  -1.137
2704307 -.1  -.5895
2704308 0.  0.165
*
2704400 1 4
2704401 -1.  -.82
2704402 -.90  -.538
2704403 -.8  -.33
2704404 -.6  -.098
2704405 -.4  -.045
2704406 -.2  -.039
2704407 0.  -.039
*
2704500 1 5
2704501 0.  -.046
2704502 .2  -.366
2704503 .4  -.58
2704504 .6  -.6805
2704505 .7  -.693
2704506 .8  -.676
2704507 1.  -.482
*
2704600 1 6
2704601 0.  -.039
2704602 .2  -.066
2704603 .3  -.095
2704604 .4  -.097
2704605 .6  -.173
2704606 .8  -.331
2704607 1.  -.482
*
2704700 1 7
2704701 -1.  .89
2704702 -.7  .87
```

```
2704703 -.5  .653
2704704 -.3  .366
2704705 -.1  .1
2704706 0.  -.046
*
2704800 1 8
2704801 -1.  .89
2704802 -.7  .37
2704803 -.5  .03
2704804 -.3  .2
2704805 -.1  .22
2704806 0.  .22
*
*** two-phase torque curve differences *** (loft l2-5)
2704900 2 1
2704901 0. 1.
2704902 1. 1.
*
2705000 2 2
2705001 0. 1.
2705002 1. 1.
*
2705100 2 3
2705101 -1.  1.9843
2705102 -.80096 1.394
2705103 -.60638 1.0975
2705104 -.40686 0.82
2705105 -.19928 0.6648
2705106 0.  0.6032
*
2705200 2 4
2705201 -1.0000 1.9843
2705202 -.82234 1.8308
2705203 -.63371 1.6824
2705204 -.45853 1.557
2705205 -.26702 1.436
2705206 -.17610 1.3879
2705207 -.0893 1.3481
2705208 0.  1.2336
*
2705300 2 5
2705301 0. -.45
2705302 .4 -.25
2705303 .5 0.
2705304 1. .3569
*
2705400 2 6
2705401 0.  1.2336
2705402 .09  1.1965
2705403 .1885  1.1096
2705404 .2734  1.0416
2705405 .4586  0.8958
2705406 .5744  .7807
2705407 .7381  .6134
2705408 .7685  .5849
2705409 .87  .4877
2705410 1.  .357
*
2705500 2 7
2705501 -1. -1.
2705502 -.3 -.9
2705503 -.1 -.5
2705504 0. -.45
*
2705600 2 8
2705601 -1. -1.
2705602 -.25 -.9
2705603 -.08 -.8
2705604 0. -.67
*
*** loop 1 pump decay velocity ***
2706100  506
2706101  0.  321.7
2706102  2.  202.
2706103  3.7  103.
2706104  5.  30.
2706105  7.  0.
2706106  1.e6  0.
*
* loop 1 cold leg pump outlet p1
2750000 l1.cl.p1 branch
2750001 1 1
2750101 0.002734 0.706 0. 0. 0. 0. 4.e-5 0.05900 0000000
2750200 000 15.5200e6 1.2420e6 2.5212e6 0.
2751101 275010000 280000000 0. 1.e-6 1.e-6 0000000
2751201 10.65 0. 0.
*
* loop1 lpis tank
2770000 l1.lp.ta tmdpvol
2770101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
2770200 0 0
2770201 0. 30.00e5 1.950e5 2.582e6 0.
*
* loop1 lpis j.
2780000 l1.lpij tmdpjun
2780101 277000000 280010000 0.
2780200 1 647
2780201 -1.  0. 0. 0.
2780202 0.  0. 0. 0.
2780203 1.  0.19 0. 0.
2780204 1.e6 0.19 0. 0.
*
* loop 1 cold leg pump outlet p2
2800000 l1.cl.p2 branch
2800001 1 1
2800101 0.002734 0.706 0. 0. 0. 0. 4.e-5 0.05900 0000000
2800200 000 15.5200e6 1.2420e6 2.5212e6 0.
2801101 280010000 285000000 0. 1.e-6 1.e-6 0000000
2801201 10.65 0. 0.
*
* loop 1 acc vlv
2810000 l1.sgvp  valve
2810101 282000000 280000000 0.08e-3 300. 1.e6 0000100 1. 1.
2810201 1 0. 0. 0.
2810300 mtrvlv
2810301 650 586 1.5  0.
*
* loop 1 acc injection line
2820000 l1.accli pipe
2820001 16
2820101 0.45e-3  16
2820301 0.520  1
2820302 0.400  3
2820303 0.429  4
2820304 0.366  13
2820305 0.375  14
2820306 0.420  15
2820307 0.452  16
2820401 0.  16
2820601 45.  1
2820602 0.  3
2820603 0.  4
2820604 -90.  13
2820605 -90.  14
2820606 0.  15
2820607 90.  16
2820801 4.e-5 0.0  16
2821001 0000000  16
2821101 0000000 15
2821201 000 4.19000e6 1.9960e5 2.4400e6 0. 0. 16
2821300 1
2821301 0. 0. 0. 15
*
* loop 1 accumulator
2840000 l1.acc accum
2840101 0. 2.073 0.096  0. 90. 2.073
2840102 4.0e-5 0. 0011000
2840200 4.22e6 322.5 0.
2841101 282010000 0.24e-3  10. 10. 0000000
2842200 0.061 0.0 6.290 -3.301 0.0125 0 0. 0.
*
* loop 1 cold leg pump outlet p3
2850000 l1.cl.p3 branch
2850001 1 1
```

```
2850101 0.002734 0.706 0. 0. 0. 0. 4.e-5 0.05900 0000000
2850200 000 15.5200e6 1.2420e6 2.5212e6 0.
2851101 285010000 290000000 0. 1.e-6 1.e-6 0000000
2851201 10.65 0. 0.
*
* loop 1 cold leg rpv conn. branch p4
2900000 l1.cl.p4 branch
2900001 0
2900101 0.002734 0.706 0. 0. 0. 0. 4.e-5 0.05900 0000000
2900200 000 15.5000e6 1.2420e6 2.5212e6 0.
*
* loop 2 rpv-hl conn
3000000 l2.hlpv branch
3000001 1 1
3000101 0.003489 0.782 0. 0. 0. 0. 4.e-5 0.0666 0000000
3000200 000 15.4507e6 1.4000e6 2.5212e6 0.
3001101 300010000 310000000 0. 1.e-6 1.e-6 0000000
3001201 10.65 0. 0.
*
* loop 2 rpv-hl conn
3100000 l2.hlho branch
3100001 2 1
3100101 0.003489 0.781 0. 0. 0. 0. 4.e-5 0.0666 0000000
3100200 000 15.4597e6 1.4000e6 2.5212e6 0.
3101101 310010000 320000000 0. 0.5 0.5 0000000
3102101 310010000 010000000 0. 1.0 1.0 0000000
3101201 10.65 0. 0.
3102201 0. 0. 0.
*
* loop 2 hl-sg conn. pipe
3200000 l2.hl.sg pipe
3200001 4
3200101 0.003489 3
3200102 0. 4
3200301 0.8785 2
3200302 0.569 3
3200303 0.474 4
3200401 0. 3
3200402 0.00269 4
3200601 90. 4
3200701 0.8785 2
3200702 0.417 3
3200703 0.474 4
3200801 4.e-5 0.06666 3
3200802 4.e-5 0.01542 4
3200901 1.e-6 1.e-6 2
3200902 0.1 0.1 3
3201001 0000000 4
3201101 0000000 3
3201201 000 15.4540e6 1.4000e6 2.5212e6 0. 0. 4
3201300 1
3201301 10.65 0. 0. 3
*
* loop 2 hl-ut conn. jun.
3250000 l2.hl.ut sngljun
3250101 320010000 330000000 0. 0.2 0.2 0000000
3250201 1 10.65 0. 0.
*
* loop 2 ps sg u-tubes
3300000 l2.sg.ut pipe
3300001 14
3300101 0.0024277 14
3300301 0.5000 2
3300302 1.0000 8
3300303 1.2780 10
3300304 2.0000 13
3300305 1.0000 14
3300401 0. 14
3300601 90. 9
3300602 -90. 14
3300701 0.5 2
3300702 1.0 8
3300703 1.278 9
3300704 -1.278 10
3300705 -2.0 13
3300706 -1.0 14
3300801 3.e-6 0.01542 14
3300901 0. 0. 8
3300902 0.01 0.01 9
3300903 0. 0. 13
3301001 0000000 14
3301101 0000000 13
3301201 000 15.4440e6 1.3950e6 2.5212e6 0. 0. 1
3301202 000 15.4440e6 1.3883e6 2.5212e6 0. 0. 2
3301203 000 15.4440e6 1.3783e6 2.5212e6 0. 0. 3
3301204 000 15.4440e6 1.3683e6 2.5212e6 0. 0. 4
3301205 000 15.4440e6 1.3583e6 2.5212e6 0. 0. 5
3301206 000 15.4440e6 1.3483e6 2.5212e6 0. 0. 6
3301207 000 15.4440e6 1.3383e6 2.5212e6 0. 0. 7
3301208 000 15.4440e6 1.3283e6 2.5212e6 0. 0. 8
3301209 000 15.4440e6 1.3183e6 2.5212e6 0. 0. 9
3301210 000 15.4440e6 1.3083e6 2.5212e6 0. 0. 10
3301211 000 15.4440e6 1.2983e6 2.5212e6 0. 0. 11
3301212 000 15.4440e6 1.2883e6 2.5212e6 0. 0. 12
3301213 000 15.4440e6 1.2703e6 2.5212e6 0. 0. 13
3301214 000 15.4440e6 1.2500e6 2.5212e6 0. 0. 14
3301300 1
3301301 10.65 0. 0. 13
*
* loop 2 cl-ut conn. jun.
3350000 l2.cl.ut sngljun
3350101 330010000 340000000 0. 0.01 0.2 0000000
3350201 1 10.65 0. 0.
*
* loop 2 cl-sg conn. pipe
3400000 l2.cl.sg pipe
3400001 2
3400101 0. 1
3400102 0. 2
3400301 0.474 1
3400302 0.569 2
3400401 0.00269 1
3400402 0.00162 2
3400601 -90. 2
3400701 -0.474 1
3400702 -0.417 2
3400801 4.e-5 0.01542 1
3400802 4.e-5 0.04924 2
3400901 0.1 0.1 1
3401001 0000000 2
3401101 0000000 1
3401201 000 15.4000e6 1.2420e6 2.5212e6 0. 0. 2
3401300 1
3401301 10.65 0. 0. 1
*
* loop 2 loop seal branch
3500000 l2.lsbr branch
3500001 2 1
3500101 0.001904 0.898 0. 0. -90. -0.898 4.e-5 0.04924 0000000
3500200 000 15.4000e6 1.2420e6 2.5212e6 0.
3501101 340010000 350000000 0. 1.e-6 1.e-6 0000000
3502101 350010000 360000000 0. 1.e-6 1.e-6 0000000
3501201 10.65 0. 0.
3502201 10.65 0. 0.
*
* loop 2 loop seal pipe
3600000 l2.ls.pi pipe
3600001 7
3600101 0.001904 7
3600201 0. 2
3600202 0.000929 3
3600203 0. 6
3600301 0.859 1
3600302 1.021 4
3600303 0.727 5
3600304 1.503 6
3600305 1.2 7
3600401 0. 7
3600601 -90. 4
3600602 0. 5
3600603 90. 7
3600701 -0.859 1
3600702 -1.021 4
3600703 0. 5
```

```
3600704 1.503    6
3600705 1.200    7
3600801 4.e-5 0.04924 7
3600901 1.e-6  1.e-6  2
3600902 0.1    0.1   3
3600903 0.1    0.1   4
3600904 0.1    0.1   5
3600905 1.e-6  1.e-6  6
3601001 0000000    7
3601101 0000000  6
3601201 000 15.0000e6 1.2420e6   2.5212e6 0. 0. 7
3601300 1
3601301 10.65   0. 0.  6
*
* loop 2 pump
3700000 l2-pump pump
3700101 0. 0.26 4.340e-3 0. 90. 0.26  0000000
3700108 360010000 .0019 0.01 0.01 0000000
3700109 375000000 .0019 0.01 0.01 0000000
3700200 000 15.1500e6 1.2420e6   2.4749e6 0.
3700201 1 10.65 0. 0.
3700202 1 10.65 0. 0.
3700301 270 270 270 -1 0 508 1
3700302 335.0 0.96030 0.0106   77.0 59.7   3.5
3700303 747.3 0. 0. 0. 0. 0.
*
*** loop 2 pump decay velocity ***
3706100    509
3706101    0.     321.7
3706102    1.     281.
3706103    2.7    174.
3706104    4.4    92.
3706105    6.1    18.
3706106    8.     0.
3706107    1.e6    0.
*
* loop 2 cold leg pump outlet  p1
3750000 l2.cl.p1 branch
3750001 1 1
3750101 0.002734 0.706  0. 0.   0.  0.   4.e-5 0.05900  0000000
3750200 000 15.5200e6 1.2420e6   2.5212e6 0.
3751101 375010000 380000000 0.   1.e-6   1.e-6    0000000
3751201 10.65  0. 0.
*
* loop 2 cold leg pump outlet p2
3800000 l2.cl.p2 branch
3800001 1 1
3800101 0.002734 0.706  0. 0.   0.  0.   4.e-5 0.05900  0000000
3800200 000 15.5200e6 1.2420e6   2.5212e6 0.
3801101 380010000 385000000 0.   1.e-6   1.e-6    0000000
3801201 10.65  0. 0.
*
* loop2 break area sim
3830000 l2.break    valve
3830101 380010000 384000000 4.07150e-5  1. 1. 0000100 1.00 0.80
0.80 *era 0.85 nell'sb04n2
3830201 1 0. 0. 0.             ** rottura esatta 4.0715000e-5
3830300 trpvlv
3830301 563
*
* loop2 break volume
3840000 l2.br.ta   tmdpvol
3840101 0. 10. 10. 0. 0. 0. 4.e-5  0. 0000000
3840200 0 0
3840201 0.  1.40e5  1.862e5 2.582e6  0.
*
* loop 2 cold leg pump outlet  p3
3850000 l2.cl.p3 branch
3850001 1 1
3850101 0.002734 0.706  0. 0.   0.  0.   4.e-5 0.05900  0000000
3850200 000 15.5200e6 1.2420e6   2.5212e6 0.
3851101 385010000 390000000 0.   1.e-6   1.e-6    0000000
3851201 10.65  0. 0.
*
* loop 2 cold leg rpv conn. branch  p4
3900000 l2.cl.p4 branch
3900001 0
3900101 0.002734 0.706  0. 0.   0.  0.   4.e-5 0.05900  0000000
3900200 000 15.5000e6 1.2420e6   2.5212e6 0.
*
* loop 3 rpv-hl conn
4000000 l3.hlpv  branch
4000001 1 1
4000101 0.003489 0.782  0. 0.   0.  0.   4.e-5 0.0666 0000000
4000200 000 15.4597e6 1.4000e6  2.5212e6 0.
4001101 400010000 410000000 0.    1.e-6   1.e-6  0000000
4001201 10.65 0. 0.
*
* loop 3 rpv-hl conn
4100000 l3.hlho  branch
4100001 1 1
4100101 0.003489 0.781  0. 0.   0.  0.   4.e-5 0.0666 0000000
4100200 000 15.4597e6 1.4000e6  2.5212e6 0.
4101101 410010000 420000000 0.    0.5    0.5    0000000
4101201 10.65  0. 0.
*
* loop 3 hl-sg conn. pipe
4200000 l3.hl.sg pipe
4200001 4
4200101 0.003489  3
4200102 0.       4
4200301 0.8785    2
4200302 0.569     3
4200303 0.474     4
4200401 0.       3
4200402 0.00269   4
4200601 90.      4
4200701 0.8785    2
4200702 0.417     3
4200703 0.474     4
4200801 4.e-5 0.06666 3
4200802 4.e-5 0.01542 4
4200901 1.e-6  1.e-6  2
4200902 0.1    0.1   3
4201001 0000000     4
4201101 0000000  3
4201201 000 15.4540e6 1.4000e6   2.5212e6 0. 0. 4
4201300 1
4201301 10.65 0. 0.    3
*
* loop 3 hl-ut conn. jun.
4250000 l3.hl.ut  sngljun
4250101 420010000 430000000 0.  0.2 0.2    0000000
4250201 1  10.65 0. 0.
*
* loop 3 ps sg u-tubes
4300000 l3.sg.ut pipe
4300001 14
4300101 0.0024277 14
4300301 0.5000    2
4300302 1.0000    8
4300303 1.2780    10
4300304 2.0000    13
4300305 1.0000    14
4300401 0.       14
4300601 90.      9
4300602 -90.     14
4300701 0.5      2
4300702 1.0      8
4300703 1.278    9
4300704 -1.278   10
4300705 -2.0     13
4300706 -1.0     14
4300801 3.e-6 0.01542 14
4300901 0.    0.    8
4300902 0.01   0.01   9
4300903 0.    0.    13
4301001 0000000    14
4301101 0000000 13
4301201 000 15.4440e6 1.3950e6   2.5212e6 0. 0. 1
4301202 000 15.4440e6 1.3883e6   2.5212e6 0. 0. 2
4301203 000 15.4440e6 1.3783e6   2.5212e6 0. 0. 3
4301204 000 15.4440e6 1.3683e6   2.5212e6 0. 0. 4
4301205 000 15.4440e6 1.3583e6   2.5212e6 0. 0. 5
```

```
4301206 000 15.4440e6 1.3483e6  2.5212e6 0. 0. 6
4301207 000 15.4440e6 1.3383e6  2.5212e6 0. 0. 7
4301208 000 15.4440e6 1.3283e6  2.5212e6 0. 0. 8
4301209 000 15.4440e6 1.3183e6  2.5212e6 0. 0. 9
4301210 000 15.4440e6 1.3083e6  2.5212e6 0. 0. 10
4301211 000 15.4440e6 1.2983e6  2.5212e6 0. 0. 11
4301212 000 15.4440e6 1.2883e6  2.5212e6 0. 0. 12
4301213 000 15.4440e6 1.2703e6  2.5212e6 0. 0. 13
4301214 000 15.4440e6 1.2500e6  2.5212e6 0. 0. 14
4301300 1
4301301 10.65 0. 0.   13
*
* loop 3 cl-ut conn. jun.
4350000 l3.cl.ut  sngljun
4350101 430010000 440000000 0.  0.01 0.2   0000000
4350201 1 10.65 0. 0.
*
* loop 3 cl-sg conn. pipe
4400000 l3.cl.sg pipe
4400001 2
4400101 0.      1
4400102 0.      2
4400301 0.474    1
4400302 0.569    2
4400401 0.00269   1
4400402 0.00162   2
4400601 -90.    2
4400701 -0.474    1
4400702 -0.417    2
4400801 4.e-5 0.01542 1
4400802 4.e-5 0.04924 2
4400901 0.1   0.1   1
4401001 0000000    2
4401101 0000000  1
4401201 000 15.4000e6 1.2420e6  2.5212e6 0. 0. 2
4401300 1
4401301 10.65 0. 0.   1
*
* loop 3 loop seal branch
4500000 l3.lsbr  branch
4500001 2 1
4500101 0.001904 0.898  0. 0. -90. -0.898 4.e-5 0.04924  0000000
4500200 000 15.4000e6 1.2420e6  2.5212e6 0.
4501101 440010000 450000000 0.  1.e-6  1.e-6   0000000
4502101 450010000 460000000 0.  1.e-6  1.e-6   0000000
4501201 10.65  0. 0.
4502201 10.65  0. 0.
*
* loop 3 loop seal pipe
4600000 l3.ls.pi pipe
4600001 7
4600101 0.001904  7
4600201 0.      2
4600202 0.000929  3
4600203 0.      6
4600301 0.859    1
4600302 1.021    4
4600303 0.727    5
4600304 1.503    6
4600305 1.2      7
4600401 0.       7
4600601 -90.     4
4600602 0.       5
4600603 90.      7
4600701 -0.859   1
4600702 -1.021   4
4600703 0.       5
4600704 1.503    6
4600705 1.200    7
4600801 4.e-5 0.04924 7
4600901 1.e-6  1.e-6  2
4600902 0.1    0.1   3
4600903 0.1    0.1   4
4600904 0.1    0.1   5
4600905 1.e-6  1.e-6  6
4601001 0000000    7
4601101 0000000  6
4601201 000 15.4000e6 1.2420e6  2.5212e6 0. 0. 7
4601300 1
4601301 10.65 0. 0.   6
*
* loop 3 pump
4700000 l3-pump pump
4700101 0. 0.26 4.340e-3 0. 90. 0.26  0000000
4700108 460010000 .0019 0.01 0.01 0000000
4700109 475000000 .0019 0.01 0.01 0000000
4700200 000 15.1500e6 1.2420e6  2.4749e6 0.
4700201 1 10.65  0. 0.
4700202 1 10.65  0. 0.
4700301 270 270 270 -1 0 511 1
4700302 335.0 0.96030 0.0106   77.0 59.7  3.5
4700303 747.3 0. 0. 0. 0. 0.
*
*** loop 3 pump decay velocity ***
4706100    512
4706101    0.     321.7
4706102    1.     280.
4706103    2.7    178.
4706104    4.4    93.
4706105    6.1    16.
4706106    10.    0.
4706107    1.e6    0.
*
* loop 3 cold leg pump outlet  p1
4750000 l3.cl.p1 branch
4750001 1 1
4750101 0.002734 0.706  0. 0.  0.  0.   4.e-5 0 05900  0000000
4750200 000 15.5200e6 1.2420e6  2.5212e6 0.
4751101 475010000 480000000 0.  1.e-6  1.e-6   0000000
4751201 10.65  0. 0.
*
* loop3 lpis  tank
4770000 l3.lp.ta   tmdpvol
4770101 0. 10. 10. 0. 0. 0. 4.e-5  0. 0000000
4770200 0 0
4770201 0. 30.00e5  1.950e5 2.582e6  0.
*
* loop1 lpis j.
4780000 l1.lpij   tmdpjun
4780101 477000000 480010000 0.
4780200 1  647
4780201  -1.    0.  0.  0.
4780202  0.     0.  0.  0.
4780203  1.     0.19  0.  0.
4780204  1.e6   0.19  0.  0.
*
* loop 3 cold leg pump outlet p2
4800000 l3.cl.p2 branch
4800001 1 1
4800101 0.002734 0.706  0. 0.  0.  0.   4.e-5 0 05900  0000000
4800200 000 15.5200e6 1.2420e6  2.5212e6 0.
4801101 480010000 485000000 0.  1.e-6  1.e-6   0000000
4801201 10.65  0. 0.
*
* loop 3 acc vlv
4810000 l3.sgvp    valve
4810101 482000000 480000000 0.08e-3 300. 1.e6 0000100  1. 1.
4810201 1 0. 0. 0.
4810300 mtrvlv
4810301 651 588 1.5    0.
*
* loop 3 acc injection line
4820000 l3.accli pipe
4820001 16
4820101 0.45e-3   16
4820301 0.520     1
4820302 0.445     3
4820303 0.449     4
4820304 0.366     13
4820305 0.370     14
4820306 0.440     15
4820307 0.512     16
4820401 0.        16
4820601 45.       1
```

```
4820602 0.    3
4820603 0.    4
4820604 -90.   13
4820605 -90.   14
4820606 0.    15
4820607 90.    16
4820801 4.e-5 0.0   16
4821001 0000000   16
4821101 0000000  15
4821201 000 4.19000e6 1.9960e5  2.4400e6 0. 0. 16
4821300 1
4821301 0. 0. 0. 15
*
* loop 3 accumulator
4840000 l3.acc  accum
4840101 0.  2.073 0.096   0.  90.  2.073
4840102 4.0e-5 0. 0000000
4840200 4.22e6  322.7  0.
4841101 482010000 0.24e-3   10.  10. 0000000
4842200 0.061 0.0 6.435 -3.296 0.0125 0  0.  0.
*
* loop 3 cold leg pump outlet  p3
4850000 l3.cl.p3 branch
4850001 1 1
4850101 0.002734 0.706  0. 0.   0.  0.   4.e-5 0.05900  0000000
4850200 000 15.5200e6 1.2420e6   2.5212e6 0.
4851101 485010000 490000000 0.   1.e-6   1.e-6    0000000
4851201 10.65  0. 0.
*
* loop 3 cold leg rpv conn. branch  p4
4900000 l3.cl.p4 branch
4900001 0
4900101 0.002734 0.706  0. 0.   0.  0.   4.e-5 0.05900  0000000
4900200 000 15.5000e6 1.2420e6   2.5212e6 0.
*
*---------------------------------------------------------------------
*          secondary sides
*---------------------------------------------------------------------
*
* loop1 sg ss riser
5000000 l1.sg.ri   pipe
5000001 12
5000101 0.01764  4    * x 1.515  .
5000102 0.01164  9
5000103 0.      11
5000104 0.007088 12
5000301 0.5    2
5000302 1.    8
5000303 1.278  9
5000304 1.1645 11
5000305 1.097  12
5000401 0.     9
5000402 0.022962 11
5000403 0.     12
5000601 90. 12
5000701 0.5    2
5000702 1.0    8
5000703 1.278   9
5000704 1.1645  11
5000705 1.097   12
5000801 4.e-5 .0111    9
5000802 4.e-5 .0800    12
5000901 0.001 0.001 8
5000902 0.01  0.01  11
5001001 0000000    12
5001101 0000000  11
5001201 000     6.0840e6  1.1338e6  2.5890e6  .014  0.   1
5001202 000     6.0850e6  1.1626e6  2.5890e6  .042  0.   2
5001203 000     6.0700e6  1.1981e6  2.5890e6  .211  0.   3
5001204 000     6.0700e6  1.2076e6  2.5890e6  .441  0.   4
5001205 000     6.0600e6  1.2091e6  2.5890e6  .584  0.   5
5001206 000     6.0500e6  1.2091e6  2.5890e6  .662  0.   6
5001207 000     6.0500e6  1.2089e6  2.5890e6  .715  0.   7
5001208 000     6.0400e6  1.2089e6  2.5890e6  .750  0.   8
5001209 000     6.0400e6  1.2064e6  2.5890e6  .773  0.   9
5001210 000     6.0400e6  1.2068e6  2.5890e6  .773  0.   10
5001211 000     6.0400e6  1.2061e6  2.5890e6  .789  0.   11
5001212 000     6.0385e6  1.2068e6  2.5890e6  .789  0.   12
5001300 1
5001301 4.59   .0   0. 3
5001302 4.57   .02  0. 5
5001303 4.50   .07  0. 7
5001304 4.30   .29   0. 11
*
* loop1 sg riser exit
5050000 l1.sg.re  branch
5050001 1 1
5050101 .007088 1.000 0. 0. 90. 1.000 4.e-5 .011  0000000
5050200 000 6.000e6 1.2068e6   2.5900e6 0.830
5051101 500010000 505000000 0.  1.  1. 0000000
5051201 3.473 0.097 0.
*
* loop1 sg ss separator
5100000 l1.sg.se  separatr
5100001 3 1
5100101 .007088 0.961 0. 0. 90. 0.961 4.e-5 .010  0000000
5100200 000 6.000e6 1.2060e6   2.5900e6 0.8102
5101101 510010000 520000000 0. 0.1 0.1 0000000 0.5
5102101 510000000 540010000 0. 1.  1.  0000000 0.15
5103101 505010000 510000000 0. 18. 18. 0000000
5101201 0.   0.097  0.
5102201 3.473 0.    0.
5103201 3.473 .097  0.
*
* loop1 sg ss steam dome
5200000 l1.sg.sd branch
5200001 1 1
5200101 0.  1.355 0.137 0. 90.  1.355    4.e-5 0.0      0000000
5200200 000 6.000e6 1.2060e6   2.5900e6 0.99
5201101 520010000 525000000 0.0    0.1    0.1    0000000
5201201 0. 0.097 0.
*
* loop1 sg ss sl
5250000 l1.sg.sl  pipe
5250001 1
5250101 0.004260  1
5250301 8.028  1
5250401 0.       1
5250601 0.   1
5250701 0.       1
5250801 4.e-5 0.07  1
5251001 0000000 1
5251201 000 6.000e6  1.2060e6  2.5900e6  0.99  0.  1
*
* loop1 sg ss dc-sd connection zone
5300000 l1.dc.sd  branch
5300001 2 1
5300101 .018371 0.961 0. 0. 90. 0.961 4.e-5 .051  0000000
5300200 000 6.000e6 1.2060e6   2.5900e6 0.692
5301101 530010000 520000000 0.0018 500.   500.  0000000
5302101 540010000 530000000 0.      1.e-6  1.e-6 0000000
5301201 0. 0. 0.
5302201 0. 0. 0.
*
* loop1 sg ss dc top
5400000 l1.dc.to  branch
5400001 1 1
5400101 .018371 1.000 0. 0. 90. 1.000 4.e-5 .051  0000000
5400200 000 6.000e6 1.2060e6   2.5900e6   0.
5401101 560010000 540000000 0.0    1.e-6  1.e-6 0000000
5401201 -3.473 0. 0.
*
* loop1 sg ss dc upper part
5600000 l1.dc.up  branch
5600001 2 1
5600101 0. 1.042 0.019143 0. 90. 1.042 4.e-5 .051  0000000
5600200 000 6.000e6 1.102e6   2.5900e6    0.
5601101 560000000 570010000 0.0    1.e-6  1.e-6 0000000
5602101 560010000 565010000 0.0    0.5    0.5   0000000
5601201 3.57  0. 0.
5602201 0.097  0. 0.
*
* loop1 sg ss fwl
5650000 l1.sg.fl  pipe
```

```
5650001 1
5650101 0.002268 1
5650301 5.145 1
5650401 0.    1
5650601 0. 1
5650701 0.    1
5650801 4.e-5 0.04 1
5651001 0000000 1
5651201 000 6.100e6 653.e3  2.7000e6 0.  0. 1
*
* loop1 sg ss dc
5700000 l1.sg.dc pipe
5700001 5
5700101 0.  1
5700102 0.0029 4
5700103 0.  5
5700301 2.1324 5
5700401 0.007412 1
5700402 0.    4
5700403 0.007412 5
5700601 90. 5
5700701 2.1324  5
5700801 4.e-5 0.04 5
5700901 1.e-6 1.e-6 4
5701001 0000000 5
5701101 0000000 4
5701201 000 6.000e6 1.1010e6 2.5900e6 0. 0. 1
5701202 000 6.000e6 1.1010e6 2.5900e6 0. 0. 5
5701300 1
5701301 -3.57 0.  0. 4
*
* loop1 sg ss dc-riser connection junction
5750000 l1.ri.dc sngljun
5750101 570000000 500000000 0.   8.  8. 0000000
5750201 1 3.57 0.  0.
*
* loop1 vlv conn. to tmdpvol (p=const.)
5800000 l1.sgvp   valve
5800101 525010000 581000000 0.0040 1.e-6 1.e-6 0000100 1. 1.
5800201 1 0. 0.882 0.
5800300 mtrvlv
5800301 610 516 2.  1.
*
* loop1 p=const. vol.
5810000 l1.sgtv   tmdpvol
5810101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
5810200 0 0
5810201 0. 61.50e5 1.206e6 2.5900e6 1.
*
* loop1 sg safety vlv
5840000 l1.saju   valve
5840101 520010000 585000000 2.1237e-5 1. 1. 0000100 1. 1. *
d=5.2 mm
5840201 1 0. 0. 0.
5840300 mtrvlv
5840301 630 552 1.5  0.
*
* loop1 sg safety tank
5850000 l1.satv   tmdpvol
5850101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
5850200 2 0
5850201 0. 5.4e5      0.9999
*
* loop1 sg fw tank
5900000 l1.fw.ta  tmdpvol
5900101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
5900200 0 0
5900201 0. 80.40e5 664.3e3 2.7e6 0.
*
* loop1 sg fw
5910000 l1.fwj  tmdpjun
5910101 590000000 565000000 0.
5910200 1 560
5910201 -1.0  0.882 0.  0.
5910202  8.0  0.882 0.  0.
5910203  9.  0.   0.  0.
5910204  1.e6  0.  0.  0.
*
* loop1 sg lvl control tank
5940000 l1.lv.cv  tmdpvol
5940101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
5940200 0 0
5940201 0. 80.40e5 1.250e6 2.70e6 0.
*
* loop1 sg lvl control jun.
5950000 l1.lv.cj tmdpjun
5950101 594000000 560010000 0.
5950200 1 607 cntrlvar 002
5950201 -1.0  0.  0.  0.
5950202  1.0  6.0  0.  0.
5950203  8.6  5.5  0.  0.
5950204  12.80 4.  0.  0.
5950205  13.00 0.  0.  0.
5950206  15.00 0.  0.  0.
*
* loop1 sg lvl control tank
5960000 l1.lv.cl  tmdpvol
5960101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
5960200 0 0
5960201 0. 70.40e5 1.067e6 2.70e6 0.
*
* loop1 sg lvl control jun.
5970000 l1.lv.lj tmdpjun
5970101 560010000 596000000 0.
5970200 1 607 cntrlvar 002
5970201 -1.0  0.  0.  0.
5970202  1.0  0.  0.  0.
5970203  13.00 0.  0.  0.
5970204  13.20 4.  0.  0.
5970205  16.00 6.  0.  0.
*
* loop2 sg ss riser
6000000 l2.sg.ri  pipe
6000001 12
6000101 0.01764 4
6000102 0.01164 9
6000103 0.    11
6000104 0.007088 12
6000301 0.5  2
6000302 1.   8
6000303 1.278 9
6000304 1.1645 11
6000305 1.097 12
6000401 0.    9
6000402 0.022962 11
6000403 0.    12
6000601 90. 12
6000701 0.5   2
6000702 1.0   8
6000703 1.278  9
6000704 1.1645 11
6000705 1.097  12
6000801 4.e-5 .0111   9
6000802 4.e-5 .0800   12
6000901 0.001 0.001 8
6000902 0.01  0.01 11
6001001 0000000   12
6001101 0000000  11
6001201 000   6.0840e6  1.1338e6  2.5890e6  .014  0.  1
6001202 000   6.0850e6  1.1626e6  2.5890e6  .042  0.  2
6001203 000   6.0700e6  1.1981e6  2.5890e6  .211  0.  3
6001204 000   6.0700e6  1.2076e6  2.5890e6  .441  0.  4
6001205 000   6.0600e6  1.2091e6  2.5890e6  .584  0.  5
6001206 000   6.0500e6  1.2091e6  2.5890e6  .662  0.  6
6001207 000   6.0500e6  1.2089e6  2.5890e6  .715  0.  7
6001208 000   6.0400e6  1.2089e6  2.5890e6  .750  0.  8
6001209 000   6.0400e6  1.2064e6  2.5890e6  .773  0.  9
6001210 000   6.0400e6  1.2068e6  2.5890e6  .773  0.  10
6001211 000   6.0400e6  1.2061e6  2.5890e6  .789  0.  11
6001212 000   6.0385e6  1.2068e6  2.5890e6  .789  0.  12
6001300 1
6001301 4.59  .0  0. 3
6001302 4.57  .02  0. 5
6001303 4.50  .07  0. 7
```

```
6001304 4.30 .29 0.11
*
* loop2 sg riser exit
6050000 l2.sg.re branch
6050001 1 1
6050101 .007088 1.000 0. 0. 90. 1.000 4.e-5 .011 0000000
6050200 000 6.000e6 1.2068e6 2.5900e6 0.830
6051101 600010000 605000000 0. 1. 1. 0000000
6051201 3.473 0.097 0.
*
* loop2 sg ss separator
6100000 l2.sg.se separatr
6100001 3 1
6100101 .007088 0.961 0. 0. 90. 0.961 4.e-5 .010 0000000
6100200 000 6.000e6 1.2060e6 2.5900e6 0.8102
6101101 610010000 620000000 0. 0.1 0.1 0000000 0.5
6102101 610000000 640010000 0. 1. 1. 0000000 0.15
6103101 605010000 610000000 0. 18. 18. 0000000
6101201 0. 0.097 0.
6102201 3.473 0. 0.
6103201 3.473 0.097 0.
*
* loop2 sg ss steam dome
6200000 l2.sg.sd branch
6200001 1 1
6200101 0. 1.355 0.137 0. 90. 1.355 4.e-5 0.0 0000000
6200200 000 6.000e6 1.2060e6 2.5900e6 0.99
6201101 620010000 625000000 0.0 0.1 0.1 0000000
6201201 0. 0.097 0.
*
* loop2 sg ss sl
6250000 l2.sg.sl pipe
6250001 1
6250101 0.004260 1
6250301 8.028 1
6250401 0. 1
6250601 0. 1
6250701 0. 1
6250801 4.e-5 0.07 1
6251001 0000000 1
6251201 000 6.000e6 1.2060e6 2.5900e6 0.99 0. 1
*
* loop2 sg ss dc-sd connection zone
6300000 l2.dc.sd branch
6300001 2 1
6300101 .018371 0.961 0. 0. 90. 0.961 4.e-5 .051 0000000
6300200 000 6.000e6 1.2060e6 2.5900e6 0.692
6301101 630010000 620000000 0.0018 500. 500. 0000000
6302101 640010000 630000000 0. 1.e-6 1.e-6 0000000
6301201 0. 0. 0.
6302201 0. 0. 0.
*
* loop2 sg ss dc top
6400000 l2.dc.to branch
6400001 1 1
6400101 .018371 1.000 0. 0. 90. 1.000 4.e-5 .051 0000000
6400200 000 6.000e6 1.2060e6 2.5900e6 0.
6401101 660010000 640000000 0.0 1.e-6 1.e-6 0000000
6401201 -3.473 0. 0.
*
* loop2 sg ss dc upper part
6600000 l2.dc.up branch
6600001 2 1
6600101 0. 1.042 0.019143 0. 90. 1.042 4.e-5 .051 0000000
6600200 000 6.000e6 1.102e6 2.5900e6 0.
6601101 660000000 670010000 0.0 1.e-6 1.e-6 0000000
6602101 660010000 665010000 0.0 0.5 0.5 0000000
6601201 3.57 0. 0.
6602201 0.097 0. 0.
*
* loop2 sg ss fwl
6650000 l2.sg.fl pipe
6650001 1
6650101 0.002268 1
6650301 5.145 1
6650401 0. 1
6650601 0. 1
6650701 0. 1
6650801 4.e-5 0.04 1
6651001 0000000 1
6651201 000 6.100e6 653.e3 2.7000e6 0. 0. 1
*
* loop2 sg ss dc
6700000 l2.sg.dc pipe
6700001 5
6700101 0. 1
6700102 0.0029 4
6700103 0. 5
6700301 2.1324 5
6700401 0.007412 1
6700402 0. 4
6700403 0.007412 5
6700601 90. 5
6700701 2.1324 5
6700801 4.e-5 0.04 5
6700901 1.e-6 1.e-6 4
6701001 0000000 5
6701101 0000000 4
6701201 000 6.000e6 1.1010e6 2.5900e6 0. 0. 1
6701202 000 6.000e6 1.1010e6 2.5900e6 0. 0. 5
6701300 1
6701301 -3.57 0.000 0. 4
*
* loop2 sg ss dc-riser connection junction
6750000 l2.ri.dc sngljun
6750101 670000000 600000000 0. 8. 8. 0000000
6750201 1 3.57 0. 0.
*
* loop2 vlv conn. to tmdpvol (p=const.)
6800000 l2.sgvp valve
6800101 625010000 681000000 0.00400 1.e-6 1.e-6 0000100 1. 1.
6800201 1 0. 0.882 0.
6800300 mtrvlv
6800301 611 518 2. 1.
*
* loop2 p=const. vol.
6810000 l2.sgtv tmdpvol
6810101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
6810200 0 0
6810201 0. 61.50e5 1.206e6 2.5900e6 1.
*
* loop2 sg safety vlv
6840000 l2.saju valve
6840101 620010000 685000000 2.1237e-5 1. 1. 0000100 1. 1.
6840201 1 0. 0. 0.
6840300 mtrvlv
6840301 631 555 1.5 0.
*
* loop2 sg safety tank
6850000 l2.satv tmdpvol
6850101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
6850200 2 0
6850201 0. 5.4e5 0.9999
*
* loop2 sg fw tank
6900000 l2.fw.ta tmdpvol
6900101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
6900200 0 0
6900201 0. 80.40e5 664.3e3 2.7e6 0.
*
* loop2 sg fw
6910000 l2.fwj tmdpjun
6910101 690000000 665000000 0.
6910200 1 561
6910201 -1.0 0.882 0. 0.
6910202 8.0 0.882 0. 0.
6910203 9. 0. 0. 0.
6910204 1.e6 0. 0. 0.
*
* loop2 sg lvl control tank
6940000 l2.lv.cv tmdpvol
6940101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
6940200 0 0
6940201 0. 80.40e5 1250.0e3 2.70e6 0.
```

```
*
* loop2 sg lvl control jun.
6950000 l2.lv.cj tmdpjun
6950101 694000000 660010000 0.
6950200 1 608 cntrlvar 003
6950201 -1.0 0. 0. 0.
6950202 1.0 6.0 0. 0.
6950203 8.6 5.5 0. 0.
6950204 12.80 4.00 0. 0.
6950205 13.00 0. 0. 0.
6950206 14.0 0. 0. 0.
*
* loop2 sg lvl control tank
6960000 l2.lv.cl tmdpvol
6960101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
6960200 0 0
6960201 0. 70.40e5 1.067e6 2.70e6 0.
*
* loop2 sg lvl control jun.
6970000 l2.lv.lj tmdpjun
6970101 660010000 696000000 0.
6970200 1 608 cntrlvar 003
6970201 -1.0 0. 0. 0.
6970202 1.0 0.0 0. 0.
6970203 13.00 0.0 0. 0.
6970204 13.20 4.00 0. 0.
6970205 16.00 6. 0. 0.
*
* loop3 sg ss riser
7000000 l3.sg.ri pipe
7000001 12
7000101 0.01764 4
7000102 0.01164 9
7000103 0. 11
7000104 0.007088 12
7000301 0.5 2
7000302 1. 8
7000303 1.278 9
7000304 1.1645 11
7000305 1.097 12
7000401 0. 9
7000402 0.022962 11
7000403 0. 12
7000601 90. 12
7000701 0.5 2
7000702 1.0 8
7000703 1.278 9
7000704 1.1645 11
7000705 1.097 12
7000801 4.e-5 .0111 9
7000802 4.e-5 .0800 12
7000901 0.001 0.001 8
7000902 0.01 0.01 11
7001001 0000000 12
7001101 0000000 11
7001201 000 6.0840e6 1.1338e6 2.5890e6 .014 0. 1
7001202 000 6.0850e6 1.1626e6 2.5890e6 .042 0. 2
7001203 000 6.0700e6 1.1981e6 2.5890e6 .211 0. 3
7001204 000 6.0700e6 1.2076e6 2.5890e6 .441 0. 4
7001205 000 6.0600e6 1.2091e6 2.5890e6 .584 0. 5
7001206 000 6.0500e6 1.2091e6 2.5890e6 .662 0. 6
7001207 000 6.0500e6 1.2089e6 2.5890e6 .715 0. 7
7001208 000 6.0400e6 1.2089e6 2.5890e6 .750 0. 8
7001209 000 6.0400e6 1.2064e6 2.5890e6 .773 0. 9
7001210 000 6.0400e6 1.2068e6 2.5890e6 .773 0. 10
7001211 000 6.0400e6 1.2061e6 2.5890e6 .789 0. 11
7001212 000 6.0385e6 1.2068e6 2.5890e6 .789 0. 12
7001300 1
7001301 4.59 .0 0.3
7001302 4.57 .02 0.5
7001303 4.50 .07 0.7
7001304 4.30 .29 0.11
*
* loop3 sg riser exit
7050000 l3.sg.re branch
7050001 1 1
7050101 .007088 1.000 0. 0. 90. 1.000 4.e-5 .011 0000000
7050200 000 6.000e6 1.2068e6 2.5900e6 0.830
7051101 700010000 705000000 0. 1. 1. 0000000
7051201 3.473 0.097 0.
*
* loop3 sg ss separator
7100000 l3.sg.se separatr
7100001 3 1
7100101 .007088 0.961 0. 0. 90. 0.961 4.e-5 .010 0000000
7100200 000 6.000e6 1.2060e6 2.5900e6 0.8102
7101101 710010000 720000000 0. 0.1 0.1 0000000 0.5
7102101 710000000 740010000 0. 1. 1. 0000000 0.15
7103101 705010000 710000000 0. 18. 18. 0000000
7101201 0. 0.097 0.
7102201 3.473 0. 0.
7103201 3.473 0.097 0.
*
* loop3 sg ss steam dome
7200000 l3.sg.sd branch
7200001 1 1
7200101 0. 1.355 0.137 0. 90. 1.355 4.e-5 0.0 0000000
7200200 000 6.000e6 1.2060e6 2.5900e6 0.99
7201101 720010000 725000000 0.0 0.1 0.1 0000000
7201201 0. 0.097 0.
*
* loop3 sg ss sl
7250000 l3.sg.sl pipe
7250001 1
7250101 0.004260 1
7250301 8.028 1
7250401 0. 1
7250601 0. 1
7250701 0. 1
7250801 4.e-5 0.07 1
7251001 0000000 1
7251201 000 6.000e6 1.2060e6 2.5900e6 0.99 0. 1
*
* loop3 sg ss dc-sd connection zone
7300000 l3.dc.sd branch
7300001 2 1
7300101 .018371 0.961 0. 0. 90. 0.961 4.e-5 .051 0000000
7300200 000 6.000e6 1.2060e6 2.5900e6 0.6920
7301101 730010000 720000000 0.0018 500. 500. 0000000
7302101 740010000 730000000 0. 1.e-6 1.e-6 0000000
7301201 0. 0. 0.
7302201 0. 0. 0.
*
* loop3 sg ss dc top
7400000 l3.dc.to branch
7400001 1 1
7400101 .018371 1.000 0. 0. 90. 1.000 4.e-5 .051 0000000
7400200 000 6.000e6 1.2060e6 2.5900e6 0.
7401101 760010000 740000000 0.0 1.e-6 1.e-6 0000000
7401201 -3.473 0. 0.
*
* loop3 sg ss dc upper part
7600000 l3.dc.up branch
7600001 2 1
7600101 0. 1.042 0.019143 0. 90. 1.042 4.e-5 .051 0000000
7600200 000 6.000e6 1.102e6 2.5900e6 0.
7601101 760000000 770010000 0.0 1.e-6 1.e-6 0000000
7602101 760010000 765010000 0.0 0.5 0.5 0000000
7601201 3.57 0. 0.
7602201 0.097 0. 0.
*
* loop3 sg ss fwl
7650000 l3.sg.fl pipe
7650001 1
7650101 0.002268 1
7650301 5.145 1
7650401 0. 1
7650601 0. 1
7650701 0. 1
7650801 4.e-5 0.04 1
7651001 0000000 1
7651201 000 6.100e6 653.e3 2.7000e6 0. 0. 1
*
* loop3 sg ss dc
```

```
7700000 l3.sg.dc pipe
7700001 5
7700101 0.   1
7700102 0.0029 4
7700103 0.   5
7700301 2.1324 5
7700401 0.007412 1
7700402 0.      4
7700403 0.007412 5
7700601 90. 5
7700701 2.1324  5
7700801 4.e-5 0.04 5
7700901 1.e-6 1.e-6 4
7701001 0000000 5
7701101 0000000 4
7701201 000 6.000e6 1.1010e6 2.5820e6 0. 0. 1
7701202 000 6.000e6 1.1010e6 2.5820e6 0. 0. 5
7701300 1
7701301 -3.57 0.  0. 4
*
* loop3 sg ss dc-riser connection junction
7750000 l3.ri.dc sngljun
7750101 770000000 700000000 0.    8.  8. 0000000
7750201 1 3.57 0.  0.
*
* loop3 vlv conn. to tmdpvol (p=const.)
7800000 l3.sgvp    valve
7800101 725010000 781000000 0.00400 1.e-6 1.e-6 0000100 1. 1.
7800201 1 0. 0.882 0.
7800300 mtrvlv
7800301 612 520 2.  1.
*
* loop3 p=const. vol.
7810000 l3.sgtv    tmdpvol
7810101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
7810200 0 0
7810201 0. 61.50e5 1.257e6 2.5900e6 1.
*
* loop3 sg safety vlv
7840000 l3.saju    valve
7840101 720010000 785000000 2.1237e-5 1. 1. 0000100 1. 1.
7840201 1 0. 0. 0.
7840300 mtrvlv
7840301 632 558 1.5   0.
*
* loop3 sg safety tank
7850000 l3.satv    tmdpvol
7850101 0. 10. 10. 0. 90. 10. 4.e-5 0. 0000000
7850200 2 0
7850201 0. 5.4e5       0.9999
*
* loop3 sg fw tank
7900000 l3.fw.ta  tmdpvol
7900101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
7900200 0 0
7900201 0. 80.40e5 664.3e3 2.7e6 0.
*
* loop3 sg fw
7910000 l3.fwj   tmdpjun
7910101 790000000 765000000 0.
7910200 1 562
7910201 -1.0  0.882 0. 0.
7910202 8.0  0.882 0. 0.
7910203 9.   0.0  0.  0.
7910204 1.e6  0.0 0.  0.
*
* loop3 sg lvl control tank
7940000 l3.lv.cv  tmdpvol
7940101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
7940200 0 0
7940201 0. 80.40e5 1067.6e3 2.70e6 0.
*
* loop3 sg lvl control jun.
7950000 l3.lv.cj tmdpjun
7950101 794000000 760010000 0.
7950200 1 609 cntrlvar 004
7950201 -1.0  0.  0.  0.
7950202  1.0  6.0  0.  0.
7950203  8.6  5.5  0.  0.
7950204  12.80 4.00 0.  0.
7950205  13.00 0.  0.  0.
7950206  14.0  0.  0.  0.
*
* loop3 sg lvl control tank
7960000 l3.lv.cl  tmdpvol
7960101 0. 10. 10. 0. 0. 0. 4.e-5 0. 0000000
7960200 0 0
7960201 0. 70.40e5 1.067e6 2.70e6 0.
*
* loop3 sg lvl control jun.
7970000 l3.lv.cj tmdpjun
7970101 760010000 796000000 0.
7970200 1 609 cntrlvar 004
7970201 -1.0  0.  0.  0.
7970202  1.0  0.0  0.  0.
7970203  13.00 0.0  0.  0.
7970204  13.20 4.00 0.  0.
7970205  16.00 6.00 0.  0.
*
*-----------------------------------------------------------------
*
*     structures
*
*-----------------------------------------------------------------
*
* surge line walls
10101000 6 5  2 1 0.01215
10101100 0 1
10101101 4 0.0167
10101201 1  4
10101301 0. 4
10101400 0
10101401 567. 5
10101501 010010000 0 1 1 1.804 1
10101502 010020000 0 1 1 1.863 2
10101503 010030000 0 1 1 2.600 3
10101504 010040000 0 1 1 2.000 4
10101505 010050000 0 1 1 2.000 5
10101506 010060000 0 1 1 2.062 6
10101601 -999     0 3101 1 1.804 1
10101602 -999     0 3101 1 1.863 2
10101603 -999     0 3101 1 2.600 3
10101604 -999     0 3101 1 2.000 4
10101605 -999     0 3101 1 2.000 5
10101606 -999     0 3101 1 2.062 6
10101701 0 0. 0. 0. 6
10101801 0. 10. 10. 0. 0. 0. 0. 1. 6
*
* prz vessel walls
10151000 10 5  2 1 0.06725
10151100 0 1
10151101 4 0.08005
10151201 1  4
10151301 0. 4
10151400 0
10151401 567. 5
10151501 015010000 0       1 1 0.679 1
10151502 020010000 0       1 1 0.679 2
10151503 025010000 10000    1 1 0.679 8
10151504 030010000 0       1 1 0.679 9
10151505 035010000 0       1 1 0.679 10
10151601 000000000 0 0 1 0.679 10
10151701 0 0. 0. 0. 10
10151801 0. 10. 10. 0. 0. 0. 0. 1. 10
*
* prz bottom end
10152000 1 5  1 1 0.
10152100 0 1
10152101 4 0.150
10152201 1  4
10152301 0. 4
10152400 0
10152401 560. 5
10152501 015010000 0 1 1 0.0142 1
```

```
10152601 000000000 0 0 1 0.0142 1
10152701 0 0. 0. 0. 1
10152801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* prz top end wall
10153000 1 5 1 1 0.
10153100 0 1
10153101 4 0.120
10153201 1 4
10153301 0. 4
10153400 0
10153401 560. 5
10153501 035010000 0 1 1 0.0142 1
10153601 000000000 0 0 1 0.0142 1
10153701 0 0. 0. 0. 1
10153801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* prz internal heaters
10201000 2   10 2 1 0.0
10201100 0   1
10201101 3   0.0040
10201102 1   0.0050
10201103 1   0.0070
10201104 1   0.0086
10201105 1   0.0100
10201106 2   0.0110
10201201 3   3
10201202 2   4
10201203 5   5
10201204 5   6
10201205 2   7
10201206 2   9
10201301 0.04 3
10201302 0.0 6
10201303 0.96 7
10201304 0.0 9
10201401 561.0  10
10201501 000000000 0    0    1    2.37  1
10201502 000000000 0    0    1    0.303 2
10201601 015010000 0    1    1    2.37  1
10201602 020010000 0    1    1    0.303 2
10201701 910         0.87   0.0    0.0  1
10201702 910         0.13   0.0    0.0  2
10201901 0.01223 10. 10. 0. 0. 0. 0. 1. 1
10201902 0.01223 10. 10. 0. 0. 0. 0. 1. 2
*
* lower plenum bottom
11001000 1 5 1 1 0.
11001100 0 1
11001101 4 0.0700
11001201 1 4
11001301 0. 4
11001400 0
11001401 560. 5
11001501 100010000 0 1 1 0.2318 1
11001601 000000000 0 0 1 0.2318 1
11001701 0 0. 0. 0. 1
11001801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* lower plenum walls
11002000 1 5 2 1 0.183
11002100 0 1
11002101 4 0.2400
11002201 1 4
11002301 0. 4
11002400 0
11002401 567. 5
11002501 100010000 0 1 1 0.798 1
11002601 000000000 0 0 1 0.798 1
11002701 0 0. 0. 0. 1
11002801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* dc walls incl. lower hor. part
11051000 9 5 2 1 0.04603
11051100 0 1
11051101 4 0.092
11051201 1 4
11051301 0. 4
11051400 0
11051401 567. 5
11051501 105010000 0       1 1 0.344  1
11051502 115010000 10000    1 1 0.823  8
11051503 125010000 0       1 1 0.359  9
11051601 -999    0     3100 1 0.344  1
11051602 -999    0     3100 1 0.823  8
11051603 -999    0     3100 1 0.359  9
11051701 0 0. 0. 0.   9
11051801 0. 10. 10. 0. 0. 0. 0. 1. 1
11051802 0. 10. 10. 0. 0. 0. 0. 1. 8
11051803 0. 10. 10. 0. 0. 0. 0. 1. 9
11051901 0. 10. 10. 0. 0. 0. 0. 1. 1
11051902 0. 10. 10. 0. 0. 0. 0. 1. 8
11051903 0. 10. 10. 0. 0. 0. 0. 1. 9
*
* lower plenum walls part ii
11101000 3 5 2 1 0.076
11101100 0 1
11101101 4 0.090
11101201 1 4
11101301 0. 4
11101400 0
11101401 567. 5
11101501 100010000 0 1 1 0.264 1
11101502 110010000 0 1 1 0.753 2
11101503 120010000 0 1 1 0.486 3
11101601 -999    0      3200  1 0.264 1
11101602 -999    0      3200  1 0.753 2
11101603 -999    0      3200  1 0.486 3
11101701 0 0. 0. 0. 3
11101801 0. 10. 10. 0. 0. 0. 0. 1. 3
*
* core bypass walls
11121000 8 5 2 1 0.04284
11121100 0 1
11121101 4 0.06032
11121201 1 4
11121301 0. 4
11121400 0
11121401 567. 5
11121501 112010000 10000    1 1 1.015 2
11121502 112030000 10000    1 1 1.374 4
11121503 114010000 10000    1 1 1.081 6
11121504 114030000 10000    1 1 1.015 8
11121601 000000000 0       0 1 1.015 2
11121602 000000000 0       0 1 1.374 4
11121603 000000000 0       0 1 1.081 6
11121604 000000000 0       0 1 1.015 8
11121701 0 0. 0. 0. 8
11121801 0. 10. 10. 0. 0. 0. 0. 1. 8
*
* dc walls top (larger part)
11251000 2 5 2 1 0.0625
11251100 0 1
11251101 4 0.0925
11251201 1 4
11251301 0. 4
11251400 0
11251401 567. 5
11251501 125010000 0       1 1 0.131  1
11251502 135010000 0       1 1 0.132  2
11251601 000000000 0       0 1 0.131  1
11251602 000000000 0       0 1 0.132  2
11251701 0 0. 0. 0.   2
11251801 0. 10. 10. 0. 0. 0. 0. 1. 1
11251802 0. 10. 10. 0. 0. 0. 0. 1. 2
11251901 0. 10. 10. 0. 0. 0. 0. 1. 1
11251902 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* rpv walls - core region
11301000 13 5 2 1 0.07448
11301100 0 1
11301101 4 0.125
11301201 1 4
11301301 0. 4
```

```
11301400 0
11301401 567.5
11301501 130010000 10000    1 1 0.183 2
11301502 130030000 10000    1 1 0.366 10
11301503 130110000 10000    1 1 0.183 12
11301504 140010000 0        1 1 0.382 13
11301601 -999    0     3210 1 0.183 2
11301602 -999    0     3210 1 0.366 10
11301603 -999    0     3210 1 0.183 12
11301604 -999    0     3210 1 0.382 13
11301701 0 0. 0. 0.   13
11301801 0. 10. 10. 0. 0. 0. 0. 1. 2
11301802 0. 10. 10. 0. 0. 0. 0. 1. 10
11301803 0. 10. 10. 0. 0. 0. 0. 1. 12
11301804 0. 10. 10. 0. 0. 0. 0. 1. 13
11301901 0. 10. 10. 0. 0. 0. 0. 1. 2
11301902 0. 10. 10. 0. 0. 0. 0. 1. 10
11301903 0. 10. 10. 0. 0. 0. 0. 1. 12
11301904 0. 10. 10. 0. 0. 0. 0. 1. 13
*
* dc top plate
11351000 1 5  1 1 0.
11351100 0 1
11351101 4 0.0500
11351201 1  4
11351301 0. 4
11351400 0
11351401 560. 5
11351501 135010000 0 1 1 0.0122 1
11351601 000000000 0 0 1 0.0122 1
11351701 0 0. 0. 0. 1
11351801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* dc-up bypass walls
11451000 5  5  2 1 0.01215
11451100 0 1
11451101 4 0.0167
11451201 1  4
11451301 0. 4
11451400 0
11451401 567. 5
11451501 145010000 0        1 1 1.201  1
11451502 145020000 10000    1 1 0.463  3
11451503 145040000 0        1 1 0.415  4
11451504 145050000 0        1 1 0.582  5
11451601 -999    0     3225 1 1.201  1
11451602 -999    0     3225 1 0.463  3
11451603 -999    0     3225 1 0.415  4
11451604 -999    0     3225 1 0.582  5
11451701 0 0. 0. 0.   5
11451801 0. 10. 10. 0. 0. 0. 0. 1. 1
11451802 0. 10. 10. 0. 0. 0. 0. 1. 3
11451803 0. 10. 10. 0. 0. 0. 0. 1. 4
11451804 0. 10. 10. 0. 0. 0. 0. 1. 5
11451901 0. 10. 10. 0. 0. 0. 0. 1. 1
11451902 0. 10. 10. 0. 0. 0. 0. 1. 3
11451903 0. 10. 10. 0. 0. 0. 0. 1. 4
11451904 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* rpv walls - upper plenum region
11501000 3  5  2 1 0.079
11501100 0 1
11501101 4 0.1025
11501201 1  4
11501301 0. 4
11501400 0
11501401 567. 5
11501501 150010000 0        1 1 0.382  1
11501502 160010000 0        1 1 0.688  2
11501503 170010000 0        1 1 0.936  3
11501601 -999    0     3220 1 0.382  1
11501602 -999    0     3220 1 0.688  2
11501603 -999    0     3220 1 0.936  3
11501701 0 0. 0. 0.   3
11501801 0. 10. 10. 0. 0. 0. 0. 1. 1
11501802 0. 10. 10. 0. 0. 0. 0. 1. 2
11501803 0. 10. 10. 0. 0. 0. 0. 1. 3
11501901 0. 10. 10. 0. 0. 0. 0. 1. 1
11501902 0. 10. 10. 0. 0. 0. 0. 1. 2
11501903 0. 10. 10. 0. 0. 0. 0. 1. 3
*
* rpv walls - upper head region
11801000 3  5  2 1 0.0935
11801100 0 1
11801101 4 0.1225
11801201 1  4
11801301 0. 4
11801400 0
11801401 567. 5
11801501 180010000 0        1 1 0.936  1
11801502 190010000 10000    1 1 0.642  3
11801601 -999    0     3230 1 0.936  1
11801602 -999    0     3230 1 0.642  3
11801701 0 0. 0. 0.   3
11801801 0. 10. 10. 0. 0. 0. 0. 1. 1
11801802 0. 10. 10. 0. 0. 0. 0. 1. 3
11801901 0. 10. 10. 0. 0. 0. 0. 1. 1
11801902 0. 10. 10. 0. 0. 0. 0. 1. 3
*
* upper head top plate
11901000 1 5  1 1 0.
11901100 0 1
11901101 4 0.0700
11901201 1  4
11901301 0. 4
11901400 0
11901401 560. 5
11901501 190010000 0 1 1 0.0275 1
11901601 000000000 0 0 1 0.0275 1
11901701 0 0. 0. 0. 1
11901801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 1 hot leg pipe walls
12001000 5  5  2 1 0.0333
12001100 0 1
12001101 4 0.0445
12001201 1  4
12001301 0. 4
12001400 0
12001401 567. 5
12001501 200010000 0        1 1 0.782  1
12001502 210010000 0        1 1 0.781  2
12001503 220010000 10000    1 1 0.8785 4
12001504 220030000 0        1 1 0.569  5
12001601 -999    0     3300 1 0.782  1
12001602 -999    0     3300 1 0.781  2
12001603 -999    0     3300 1 0.8785 4
12001604 -999    0     3300 1 0.569  5
12001701 0 0. 0. 0.   5
12001801 0. 10. 10. 0. 0. 0. 0. 1. 1
12001802 0. 10. 10. 0. 0. 0. 0. 1. 2
12001803 0. 10. 10. 0. 0. 0. 0. 1. 4
12001804 0. 10. 10. 0. 0. 0. 0. 1. 5
12001901 0. 10. 10. 0. 0. 0. 0. 1. 1
12001902 0. 10. 10. 0. 0. 0. 0. 1. 2
12001903 0. 10. 10. 0. 0. 0. 0. 1. 4
12001904 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* loop 1 sg inlet & outlet plena small pipe walls
12201000 2  5  2 1 0.031
12201100 0 1
12201101 4 0.036
12201201 1  4
12201301 0. 4
12201400 0
12201401 567. 5
12201501 220040000 0        1 1 0.166  1
12201502 240010000 0        1 1 0.166  2
12201601 000000000 0        0 1 0.166  2
12201701 0 0. 0. 0.   2
12201801 0. 10. 10. 0. 0. 0. 0. 1. 2
12201901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 1 sg inlet & outlet plena large pipe walls
```

```
12202000 2 5 2 1 0.054
12202100 0 1
12202101 4 0.064
12202201 1 4
12202301 0. 4
12202400 0
12202401 567. 5
12202501 220040000 0      1 1 0.110 1
12202502 240010000 0      1 1 0.110 2
12202601 000000000 0      0 1 0.110 2
12202701 0 0. 0. 0.   2
12202801 0. 10. 10. 0. 0. 0. 0. 1. 2
12202901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 1 sep. wall between inlet and outlet plena
12203000 1 3 1 1 0.
12203100 0 1
12203101 2 0.010
12203201 1 2
12203301 0. 2
12203400 0
12203401 560. 3
12203501 220040000 0 1 1 0.0477 1
12203601 240010000 0 1 1 0.0477 1
12203701 0 0. 0. 0. 1
12203801 0. 10. 10. 0. 0. 0. 0. 1. 1
12203901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 1 sg plate (conn. with ss - assumed isolated, 1/2 thickn.)
12204000 2 5 1 1 0.
12204100 0 1
12204101 4 0.045
12204201 1 4
12204301 0. 4
12204400 0
12204401 560. 5
12204501 220040000 0 1 1 0.0710 1
12204502 240010000 0 1 1 0.0710 2
12204601 000000000 0 0 1 0.0710 2
12204701 0 0. 0. 0. 2
12204801 0. 10. 10. 0. 0. 0. 0. 1. 2
12204901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 1 sg u-tubes walls
12301000 18 5 2 1 0.00771
12301100 0 1
12301101 4 0.00873
12301201 2 4
12301301 0. 4
12301400 0
12301401 567. 5
12301501 230010000 10000     1 1 6.500 2
12301502 230030000 10000     1 1 13.00 8
12301503 230090000 10000     1 1 16.614 10
12301504 230110000 0      1 1 13.00 12
12301505 230120000 0      1 1 13.00 14
12301506 230130000 0      1 1 13.00 16
12301507 230140000 0      1 1 6.500 18
12301601 500010000 10000     1 1 6.500 2
12301602 500030000 10000     1 1 13.00 8
12301603 500090000 0      1 1 16.614 10
12301604 500080000 -10000     1 1 13.00 16
12301605 500020000 -10000     1 1 6.500 18
12301701 0 0. 0. 0.   18
12301801 0. 10. 10. 0. 0. 0. 0. 1. 18
12301901 0. 10. 10. 0. 0. 0. 0. 1. 18
*
* loop 1 cold leg pipe walls (sg to pump)
12401000 9 5 2 1 0.0246
12401100 0 1
12401101 4 0.0302
12401201 1 4
12401301 0. 4
12401400 0
12401401 567. 5
12401501 240020000 0      1 1 0.569 1
12401502 250010000 0      1 1 0.898 2
12401503 260010000 0      1 1 0.859 3
12401504 260020000 10000     1 1 1.021 6
12401505 260050000 0      1 1 0.727 7
12401506 260060000 0      1 1 1.503 8
12401507 260070000 0      1 1 1.200 9
12401601 -999   0    3310 1 0.569 1
12401602 -999   0    3310 1 0.898 2
12401603 -999   0    3310 1 0.859 3
12401604 -999   0    3310 1 1.021 6
12401605 -999   0    3310 1 0.727 7
12401606 -999   0    3310 1 1.503 8
12401607 -999   0    3310 1 1.200 9
12401701 0 0. 0. 0.   9
12401801 0. 10. 10. 0. 0. 0. 0. 1. 9
12401901 0. 10. 10. 0. 0. 0. 0. 1. 9
*
* loop 1 pump wall
12701000 1 5 2 1 0.033
12701100 0 1
12701101 4 0.083
12701201 1 4
12701301 0. 4
12701400 0
12701401 567. 5
12701501 270010000 0      1 1 0.520 1
12701601 -999   0    3320 1 0.520 1 * -999     3320
12701701 0 0. 0. 0.   1
12701801 0. 10. 10. 0. 0. 0. 0. 1. 1
12701901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 1 cold leg pipe wall (pump to rpv)
12801000 4 5 2 1 0.0295
12801100 0 1
12801101 4 0.0365
12801201 1 4
12801301 0. 4
12801400 0
12801401 567. 5
12801501 275010000 0      1 1 0.723 1
12801502 280010000 0      1 1 0.723 2
12801503 285010000 0      1 1 0.723 3
12801504 290010000 0      1 1 0.723 4
12801601 -999   0    3330 1 0.723 1
12801602 -999   0    3330 1 0.723 2
12801603 -999   0    3330 1 0.723 3
12801604 -999   0    3330 1 0.723 4
12801701 0 0. 0. 0.   4
12801801 0. 10. 10. 0. 0. 0. 0. 1. 4
12801901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
* loop 2 hot leg pipe walls
13001000 5 5 2 1 0.0333
13001100 0 1
13001101 4 0.0445
13001201 1 4
13001301 0. 4
13001400 0
13001401 567. 5
13001501 300010000 0      1 1 0.782 1
13001502 310010000 0      1 1 0.781 2
13001503 320010000 10000     1 1 0.8785 4
13001504 320030000 0      1 1 0.569 5
13001601 -999   0    3300 1 0.782 1
13001602 -999   0    3300 1 0.781 2
13001603 -999   0    3300 1 0.8785 4
13001604 -999   0    3300 1 0.569 5
13001701 0 0. 0. 0.   5
13001801 0. 10. 10. 0. 0. 0. 0. 1. 5
13001901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* loop 2 sg inlet & outlet plena small pipe walls
13201000 2 5 2 1 0.031
13201100 0 1
13201101 4 0.036
13201201 1 4
13201301 0. 4
13201400 0
```

```
13201401 567.5
13201501 320040000 0        1 1 0.166  1
13201502 340010000 0        1 1 0.166  2
13201601 000000000 0        0 1 0.166  2
13201701 0 0. 0. 0.   2
13201801 0. 10. 10. 0. 0. 0. 0. 1. 2
13201901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 2 sg inlet & outlet plena large pipe walls
13202000 2 5  2 1 0.054
13202100 0 1
13202101 4 0.064
13202201 1  4
13202301 0. 4
13202400 0
13202401 567.5
13202501 320040000 0        1 1 0.110  1
13202502 340010000 0        1 1 0.110  2
13202601 000000000 0        0 1 0.110  2
13202701 0 0. 0. 0.   2
13202801 0. 10. 10. 0. 0. 0. 0. 1. 2
13202901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 2 sep. wall between inlet and outlet plena
13203000 1 3  1 1 0.
13203100 0 1
13203101 2 0.010
13203201 1  2
13203301 0. 2
13203400 0
13203401 560.3
13203501 320040000 0 1 1 0.0477 1
13203601 340010000 0 1 1 0.0477 1
13203701 0 0. 0. 0. 1
13203801 0. 10. 10. 0. 0. 0. 0. 1. 1
13203901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 2 sg plate (conn. with ss - assumed isolated. 1/2 thickn.)
13204000 2 5  1 1 0.
13204100 0 1
13204101 4 0.045
13204201 1  4
13204301 0. 4
13204400 0
13204401 560.5
13204501 320040000 0 1 1 0.0710 1
13204502 340010000 0 1 1 0.0710 2
13204601 000000000 0 0 1 0.0710 2
13204701 0 0. 0. 0. 2
13204801 0. 10. 10. 0. 0. 0. 0. 1. 2
13204901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 2 sg u-tubes walls
13301000 18 5  2 1 0.00771
13301100 0 1
13301101 4 0.00873
13301201 2  4
13301301 0. 4
13301400 0
13301401 567.5
13301501 330010000 10000      1 1 6.500  2
13301502 330030000 10000      1 1 13.00  8
13301503 330090000 10000      1 1 16.614 10
13301504 330110000 0        1 1 13.00  12
13301505 330120000 0        1 1 13.00  14
13301506 330130000 0        1 1 13.00  16
13301507 330140000 0        1 1 6.500  18
13301601 600010000 10000      1 1 6.500  2
13301602 600030000 10000      1 1 13.00  8
13301603 600090000 0        1 1 16.614 10
13301604 600080000 -10000     1 1 13.00  16
13301605 600020000 -10000     1 1 6.500  18
13301701 0 0. 0. 0.   18
13301801 0. 10. 10. 0. 0. 0. 0. 1. 18
13301901 0. 10. 10. 0. 0. 0. 0. 1. 18
*
* loop 2 cold leg pipe walls (sg to pump)
13401000 9  5  2 1 0.0246
13401100 0 1
13401101 4 0.0302
13401201 1  4
13401301 0. 4
13401400 0
13401401 567.5
13401501 340020000 0        1 1 0.569  1
13401502 350010000 0        1 1 0.898  2
13401503 360010000 0        1 1 0.859  3
13401504 360020000 10000      1 1 1.021  6
13401505 360050000 0        1 1 0.727  7
13401506 360060000 0        1 1 1.503  8
13401507 360070000 0        1 1 1.200  9
13401601 -999    0      3310 1 0.569  1
13401602 -999    0      3310 1 0.898  2
13401603 -999    0      3310 1 0.859  3
13401604 -999    0      3310 1 1.021  6
13401605 -999    0      3310 1 0.727  7
13401606 -999    0      3310 1 1.503  8
13401607 -999    0      3310 1 1.200  9
13401701 0 0. 0. 0.   9
13401801 0. 10. 10. 0. 0. 0. 0. 1. 9
13401901 0. 10. 10. 0. 0. 0. 0. 1. 9
*
* loop 2 pump wall
13701000 1  5  2 1 0.033
13701100 0 1
13701101 4 0.083
13701201 1  4
13701301 0. 4
13701400 0
13701401 567.5
13701501 370010000 0        1 1 0.520  1
13701601 -999    0      3320 1 0.520  1 * -999     3320
13701701 0 0. 0. 0.   1
13701801 0. 10. 10. 0. 0. 0. 0. 1. 1
13701901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 2 cold leg pipe wall (pump to rpv)
13801000 4  5  2 1 0.0295
13801100 0 1
13801101 4 0.0365
13801201 1  4
13801301 0. 4
13801400 0
13801401 567.5
13801501 375010000 0        1 1 0.723  1
13801502 380010000 0        1 1 0.723  2
13801503 385010000 0        1 1 0.723  3
13801504 390010000 0        1 1 0.723  4
13801601 -999    0      3330 1 0.723  1
13801602 -999    0      3330 1 0.723  2
13801603 -999    0      3330 1 0.723  3
13801604 -999    0      3330 1 0.723  4
13801701 0 0. 0. 0.   4
13801801 0. 10. 10. 0. 0. 0. 0. 1. 4
13801901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
* loop 3 hot leg pipe walls
14001000 5  5  2 1 0.0333
14001100 0 1
14001101 4 0.0445
14001201 1  4
14001301 0. 4
14001400 0
14001401 567.5
14001501 400010000 0        1 1 0.782  1
14001502 410010000 0        1 1 0.781  2
14001503 420010000 10000      1 1 0.8785 4
14001504 420030000 0        1 1 0.569  5
14001601 -999    0      3300 1 0.782  1
14001602 -999    0      3300 1 0.781  2
14001603 -999    0      3300 1 0.8785 4
14001604 -999    0      3300 1 0.569  5
14001701 0 0. 0. 0.   5
14001801 0. 10. 10. 0. 0. 0. 0. 1. 5
```

```
14001901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* loop 3 sg inlet & outlet plena small pipe walls
14201000 2 5 2 1 0.031
14201100 0 1
14201101 4 0.036
14201201 1 4
14201301 0. 4
14201400 0
14201401 567. 5
14201501 420040000 0      1 1 0.166 1
14201502 440010000 0      1 1 0.166 2
14201601 000000000 0      0 1 0.166 2
14201701 0 0. 0. 0.   2
14201801 0. 10. 10. 0. 0. 0. 0. 1. 2
14201901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 3 sg inlet & outlet plena large pipe walls
14202000 2 5 2 1 0.054
14202100 0 1
14202101 4 0.064
14202201 1 4
14202301 0. 4
14202400 0
14202401 567. 5
14202501 420040000 0      1 1 0.110 1
14202502 440010000 0      1 1 0.110 2
14202601 000000000 0      0 1 0.110 2
14202701 0 0. 0. 0.   2
14202801 0. 10. 10. 0. 0. 0. 0. 1. 2
14202901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 3 sep. wall between inlet and outlet plena
14203000 1 3 1 1 0.
14203100 0 1
14203101 2 0.010
14203201 1 2
14203301 0. 2
14203400 0
14203401 560. 3
14203501 420040000 0 1 1 0.0477 1
14203601 440010000 0 1 1 0.0477 1
14203701 0 0. 0. 0. 1
14203801 0. 10. 10. 0. 0. 0. 0. 1. 1
14203901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 3 sg plate (conn. with ss - assumed isolated, 1/2 thickn.)
14204000 2 5 1 1 0.
14204100 0 1
14204101 4 0.045
14204201 1 4
14204301 0. 4
14204400 0
14204401 560. 5
14204501 420040000 0 1 1 0.0710 1
14204502 440010000 0 1 1 0.0710 2
14204601 000000000 0 0 1 0.0710 2
14204701 0 0. 0. 0. 2
14204801 0. 10. 10. 0. 0. 0. 0. 1. 2
14204901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
* loop 3 sg u-tubes walls
14301000 18 5 2 1 0.00771
14301100 0 1
14301101 4 0.00873
14301201 2 4
14301301 0. 4
14301400 0
14301401 567. 5
14301501 430010000 10000     1 1 6.500 2
14301502 430030000 10000     1 1 13.00 8
14301503 430090000 10000     1 1 16.614 10
14301504 430110000 0      1 1 13.00 12
14301505 430120000 0      1 1 13.00 14
14301506 430130000 0      1 1 13.00 16
14301507 430140000 0      1 1 6.500 18
14301601 700010000 10000     1 1 6.500 2
14301602 700030000 10000     1 1 13.00 8
14301603 700090000 0       1 1 16.614 10
14301604 700080000 -10000    1 1 13.00 16
14301605 700020000 -10000    1 1 6.500 18
14301701 0 0. 0. 0.   18
14301801 0. 10. 10. 0. 0. 0. 0. 1. 18
14301901 0. 10. 10. 0. 0. 0. 0. 1. 18
*
* loop 3 cold leg pipe walls (sg to pump)
14401000 9 5 2 1 0.0246
14401100 0 1
14401101 4 0.0302
14401201 1 4
14401301 0. 4
14401400 0
14401401 567. 5
14401501 440020000 0      1 1 0.569 1
14401502 450010000 0      1 1 0.898 2
14401503 460010000 0      1 1 0.859 3
14401504 460020000 10000    1 1 1.021 6
14401505 460050000 0      1 1 0.727 7
14401506 460060000 0      1 1 1.503 8
14401507 460070000 0      1 1 1.200 9
14401601 -999   0    3310 1 0.569 1
14401602 -999   0    3310 1 0.898 2
14401603 -999   0    3310 1 0.859 3
14401604 -999   0    3310 1 1.021 6
14401605 -999   0    3310 1 0.727 7
14401606 -999   0    3310 1 1.503 8
14401607 -999   0    3310 1 1.200 9
14401701 0 0. 0. 0.   9
14401801 0. 10. 10. 0. 0. 0. 0. 1. 9
14401901 0. 10. 10. 0. 0. 0. 0. 1. 9
*
* loop 3 pump wall
14701000 1 5 2 1 0.033
14701100 0 1
14701101 4 0.083
14701201 1 4
14701301 0. 4
14701400 0
14701401 567. 5
14701501 470010000 0      1 1 0.520 1
14701601 -999   0    3320 1 0.520 1 * -999    3320
14701701 0 0. 0. 0.   1
14701801 0. 10. 10. 0. 0. 0. 0. 1. 1
14701901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 3 cold leg pipe wall (pump to rpv)
14801000 4 5 2 1 0.0295
14801100 0 1
14801101 4 0.0365
14801201 1 4
14801301 0. 4
14801400 0
14801401 567. 5
14801501 475010000 0      1 1 0.723 1
14801502 480010000 0      1 1 0.723 2
14801503 485010000 0      1 1 0.723 3
14801504 490010000 0      1 1 0.723 4
14801601 -999   0    3330 1 0.723 1
14801602 -999   0    3330 1 0.723 2
14801603 -999   0    3330 1 0.723 3
14801604 -999   0    3330 1 0.723 4
14801701 0 0. 0. 0.   4
14801801 0. 10. 10. 0. 0. 0. 0. 1. 4
14801901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
* loop 1sg ss riser walls (equivalent struct.)
15001000 12 5 2 1 0.086
15001100 0 1
15001101 4 0.112
15001201 1 4
15001301 0. 4
15001400 0
15001401 567. 5 .
15001501 500010000 10000    1 1 0.500 2
```

```
15001502 500030000 10000    1 1 1.000  8
15001503 500090000 0      1 1 1.278  9
15001504 500100000 10000    1 1 1.1645 11
15001505 500120000 0      1 1 1.097  12
15001601 -999    0    3400 1 0.500  2
15001602 -999    0    3400 1 1.000  8
15001603 -999    0    3400 1 1.278  9
15001604 -999    0    3400 1 1.1645 11
15001605 -999    0    3400 1 1.097  12
15001701 0 0. 0. 0.   12
15001801 0. 10. 10. 0. 0. 0. 0. 1. 12
15001901 0. 10. 10. 0. 0. 0. 0. 1. 12
*
* loop 1sg ss separator internal walls (equiv. struct.)
15101000 4  3  2 1 0.050
15101100 0 1
15101101 2 0.053
15101201 1  2
15101301 0. 2
15101400 0
15101401 567. 3
15101501 510010000 0      1 1 1.000  1
15101502 510010000 0      1 1 1.261  2
15101503 520010000 0      1 1 9.000  3
15101504 500120000 0      1 1 1.042  4
15101601 540010000 0      1 1 1.000  1
15101602 530010000 0      1 1 1.261  2
15101603 000000000 0      0 1 9.000  3
15101604 560010000 0      1 1 1.042  4
15101701 0 0. 0. 0.   4
15101801 0. 10. 10. 0. 0. 0. 0. 1. 4
15101901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
* loop 1sg steam dome external walls
15201000 1  5  2 1 0.254
15201100 0 1
15201101 4 0.294
15201201 1  4
15201301 0. 4
15201400 0
15201401 567. 5
15201501 520010000 0      1 1 1.355  1
15201601 -999    0    3410 1 1.355  1
15201701 0 0. 0. 0.   1
15201801 0. 10. 10. 0. 0. 0. 0. 1. 1
15201901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 1sg downcomer annular part walls
15301000 3  5  2 1 0.094
15301100 0 1
15301101 4 0.111
15301201 1  4
15301301 0. 4
15301400 0
15301401 567. 5
15301501 530010000 0      1 1 0.961  1
15301502 540010000 0      1 1 1.000  2
15301503 560010000 0      1 1 1.042  3
15301601 -999    0    3420 1 0.961  1
15301602 -999    0    3420 1 1.000  2
15301603 -999    0    3420 1 1.042  3
15301701 0 0. 0. 0.   3
15301801 0. 10. 10. 0. 0. 0. 0. 1. 3
15301901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
* loop 1sg downcomer tubular part walls
15701000 5  5  2 1 0.0215
15701100 0 1
15701101 4 0.02425
15701201 1  4
15701301 0. 4
15701400 0
15701401 567. 5
15701501 570010000 10000    1 1 4.4008 5
15701601 -999    0    3430 1 4.4008 5
15701701 0 0. 0. 0.   5
15701801 0. 10. 10. 0. 0. 0. 0. 1. 5
15701901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* loop 2sg ss riser walls (equivalent struct.)
16001000 12 5  2 1 0.086
16001100 0 1
16001101 4 0.112
16001201 1  4
16001301 0. 4
16001400 0
16001401 567. 5
16001501 600010000 10000    1 1 0.500  2
16001502 600030000 10000    1 1 1.000  8
16001503 600090000 0      1 1 1.278  9
16001504 600100000 10000    1 1 1.1645 11
16001505 600120000 0      1 1 1.097  12
16001601 -999    0    3400 1 0.500  2
16001602 -999    0    3400 1 1.000  8
16001603 -999    0    3400 1 1.278  9
16001604 -999    0    3400 1 1.1645 11
16001605 -999    0    3400 1 1.097  12
16001701 0 0. 0. 0.   12
16001801 0. 10. 10. 0. 0. 0. 0. 1. 12
16001901 0. 10. 10. 0. 0. 0. 0. 1. 12
*
* loop 2sg ss separator internal walls (equiv. struct.)
16101000 4  3  2 1 0.050
16101100 0 1
16101101 2 0.053
16101201 1  2
16101301 0. 2
16101400 0
16101401 567. 3
16101501 610010000 0      1 1 1.000  1
16101502 610010000 0      1 1 1.261  2
16101503 620010000 0      1 1 9.000  3
16101504 600120000 0      1 1 1.042  4
16101601 640010000 0      1 1 1.000  1
16101602 630010000 0      1 1 1.261  2
16101603 000000000 0      0 1 9.000  3
16101604 660010000 0      1 1 1.042  4
16101701 0 0. 0. 0.   4
16101801 0. 10. 10. 0. 0. 0. 0. 1. 4
16101901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
* loop 2sg steam dome external walls
16201000 1  5  2 1 0.254
16201100 0 1
16201101 4 0.294
16201201 1  4
16201301 0. 4
16201400 0
16201401 567. 5
16201501 620010000 0      1 1 1.355  1
16201601 -999    0    3410 1 1.355  1
16201701 0 0. 0. 0.   1
16201801 0. 10. 10. 0. 0. 0. 0. 1. 1
16201901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 2sg downcomer annular part walls
16301000 3  5  2 1 0.094
16301100 0 1
16301101 4 0.111
16301201 1  4
16301301 0. 4
16301400 0
16301401 567. 5
16301501 630010000 0      1 1 0.961  1
16301502 640010000 0      1 1 1.000  2
16301503 660010000 0      1 1 1.042  3
16301601 -999    0    3420 1 0.961  1
16301602 -999    0    3420 1 1.000  2
16301603 -999    0    3420 1 1.042  3
16301701 0 0. 0. 0.   3
16301801 0. 10. 10. 0. 0. 0. 0. 1. 3
16301901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
* loop 3sg downcomer tubular part walls
```

```
16701000 5 5 2 1 0.0215
16701100 0 1
16701101 4 0.02425
16701201 1 4
16701301 0. 4
16701400 0
16701401 567. 5
16701501 670010000 10000    1 1 4.4008 5
16701601 -999    0    3430 1 4.4008 5
16701701 0 0. 0. 0.   5
16701801 0. 10. 10. 0. 0. 0. 0. 1. 5
16701901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* loop 3sg ss riser walls (equivalent struct.)
17001000 12 5 2 1 0.086
17001100 0 1
17001101 4 0.112
17001201 1 4
17001301 0. 4
17001400 0
17001401 567. 5
17001501 700010000 10000    1 1 0.500 2
17001502 700030000 10000    1 1 1.000 8
17001503 700090000 0        1 1 1.278 9
17001504 700100000 10000    1 1 1.1645 11
17001505 700120000 0        1 1 1.097 12
17001601 -999    0    3400 1 0.500 2
17001602 -999    0    3400 1 1.000 8
17001603 -999    0    3400 1 1.278 9
17001604 -999    0    3400 1 1.1645 11
17001605 -999    0    3400 1 1.097 12
17001701 0 0. 0. 0.   12
17001801 0. 10. 10. 0. 0. 0. 0. 1. 12
17001901 0. 10. 10. 0. 0. 0. 0. 1. 12
*
* loop 3sg ss separator internal walls (equiv. struct.)
17101000 4 3 2 1 0.050
17101100 0 1
17101101 2 0.053
17101201 1 2
17101301 0. 2
17101400 0
17101401 567. 3
17101501 710010000 0        1 1 1.000 1
17101502 710010000 0        1 1 1.261 2
17101503 720010000 0        1 1 9.000 3
17101504 700120000 0        1 1 1.042 4
17101601 740010000 0        1 1 1.000 1
17101602 730010000 0        1 1 1.261 2
17101603 000000000 0        0 1 9.000 3
17101604 760010000 0        1 1 1.042 4
17101701 0 0. 0. 0.   4
17101801 0. 10. 10. 0. 0. 0. 0. 1. 4
17101901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
* loop 3sg steam dome external walls
17201000 1 5 2 1 0.254
17201100 0 1
17201101 4 0.294
17201201 1 4
17201301 0. 4
17201400 0
17201401 567. 5
17201501 720010000 0        1 1 1.355 1
17201601 -999    0    3410 1 1.355 1
17201701 0 0. 0. 0.   1
17201801 0. 10. 10. 0. 0. 0. 0. 1. 1
17201901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* loop 3sg downcomer annular part walls
17301000 3 5 2 1 0.094
17301100 0 1
17301101 4 0.111
17301201 1 4
17301301 0. 4
17301400 0
17301401 567. 5
17301501 730010000 0        1 1 0.961 1
17301502 740010000 0        1 1 1.000 2
17301503 760010000 0        1 1 1.042 3
17301601 -999    0    3420 1 0.961 1
17301602 -999    0    3420 1 1.000 2
17301603 -999    0    3420 1 1.042 3
17301701 0 0. 0. 0.   3
17301801 0. 10. 10. 0. 0. 0. 0. 1. 3
17301901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
* loop 3sg downcomer tubular part walls
17701000 5 5 2 1 0.0215
17701100 0 1
17701101 4 0.02425
17701201 1 4
17701301 0. 4
17701400 0
17701401 567. 5
17701501 770010000 10000    1 1 4.4008 5
17701601 -999    0    3430 1 4.4008 5
17701701 0 0. 0. 0.   5
17701801 0. 10. 10. 0. 0. 0. 0. 1. 5
17701901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
* core active zone (94 rods - low power)
19000000 12 6 2 1 0.00395
19000100 0 1
19000101 5 0.00475
19000201 2 5
19000301 1. 5
19000400 0
19000401 587. 6
19000501 0          0     0 1  17.202  2
19000502 0          0     0 1  34.404  10
19000503 0          0     0 1  17.202  12
19000601 130010000  10000     111 1  17.202  2
19000602 130030000  10000     111 1  34.404  10
19000603 130110000  10000     111 1  17.202  12
19000701 900 0.048125 0. 0. 2
19000702 900 0.096250 0. 0. 10
19000703 900 0.048125 0. 0. 12
19000900 1
19000901 0. 0.0915 0.0915 0.2325 0.1375 0.5 0.5  1. 3.66 1.326 1.3
1
19000902 0. 0.0915 0.0915 0.0495 0.3205 0.5 0.5  1. 3.66 1.326 1.3
2
19000903 0. 0.183  0.183  0.275  0.225  0.5 0.5  1. 3.66 1.326 1.3 3
19000904 0. 0.183  0.183  0.409  0.091  0.5 0.5  1. 3.66 1.326 1.3 4
19000905 0. 0.183  0.183  0.043  0.475  0.5 0.5  1. 3.66 1.326 1.3 5
19000906 0. 0.183  0.183  0.177  0.323  0.5 0.5  1. 3.66 1.326 1.3 6
19000907 0. 0.183  0.183  0.311  0.189  0.5 0.5  1. 3.66 1.326 1.3 7
19000908 0. 0.183  0.183  0.445  0.055  0.5 0.5  1. 3.66 1.326 1.3 8
19000909 0. 0.183  0.183  0.079  0.421  0.5 0.5  1. 3.66 1.326 1.3 9
19000910 0. 0.183  0.183  0.213  0.287  0.5 0.5  1. 3.66 1.326 1.3 10
19000911 0. 0.0915 0.0915 0.4385 0.0615 0.5 0.5  1. 3.66 1.326 1.3
11
19000912 0. 0.0915 0.0915 0.2555 0.2445 0.5 0.5  1. 3.66 1.326 1.3
12
*
* core rods (97 rods - zero power - lower plenum)
19100000 3 3 2 1 0.00200
19100100 0 1
19100101 2 0.00475
19100201 3 2
19100301 0. 2
19100400 0
19100401 587. 3
19100501 0          0     0 1  77.406  1
19100502 0          0     0 1  73.041  2
19100503 0          0     0 1  47.142  3
19100601 100010000     0     1 1  77.406  1
19100602 110010000     0     1 1  73.041  2
19100603 120010000     0     1 1  47.142  3
19100701 0 0.    0. 0.  3
19100901 0. 10. 10. 0. 0. 0. 0. 1. 1
19100902 0. 10. 10. 0. 0. 0. 0. 1. 2
19100903 0. 10. 10. 0. 0. 0. 0. 1. 3
```

```
*
* core rods (97 rods - zero power - upper plenum)
19200000 1 3 2 1 0.
19200100 0 1
19200101 2 0.00335
19200201 4 2
19200301 0. 2
19200400 0
19200401 587. 3
19200501 0          0   0 1  37.054  1
19200601 140010000  0   1 1  37.054  1
19200701 0 0.   0. 0.  1
19200901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
* core active zone (3 rods - high power)
19500000 12 6 2 1 0.00375
19500100 0 1
19500101 5 0.00475
19500201 2 5
19500301 1. 5
19500400 0
19500401 587. 6
19500501 0          0   0 1   0.549  2
19500502 0          0   0 1   1.098  10
19500503 0          0   0 1   0.549  12
19500601 130010000  10000  111 1  0.549  2
19500602 130030000  10000  111 1  1.098  10
19500603 130110000  10000  111 1  0.549  12
19500701 900 0.001875 0. 0. 2
19500702 900 0.003750 0. 0. 10
19500703 900 0.001875 0. 0. 12
19500900 1
19500901 0. 0.0915 0.0915 0.2325 0.1375 0.5 0.5 1. 3.66 1.326 1.3
1
19500902 0. 0.0915 0.0915 0.0495 0.3205 0.5 0.5 1. 3.66 1.326 1.3
2
19500903 0. 0.183 0.183 0.275 0.225 0.5 0.5 1. 3.66 1.326 1.3 3
19500904 0. 0.183 0.183 0.409 0.091 0.5 0.5 1. 3.66 1.326 1.3 4
19500905 0. 0.183 0.183 0.043 0.475 0.5 0.5 1. 3.66 1.326 1.3 5
19500906 0. 0.183 0.183 0.177 0.323 0.5 0.5 1. 3.66 1.326 1.3 6
19500907 0. 0.183 0.183 0.311 0.189 0.5 0.5 1. 3.66 1.326 1.3 7
19500908 0. 0.183 0.183 0.445 0.055 0.5 0.5 1. 3.66 1.326 1.3 8
19500909 0. 0.183 0.183 0.079 0.421 0.5 0.5 1. 3.66 1.326 1.3 9
19500910 0. 0.183 0.183 0.213 0.287 0.5 0.5 1. 3.66 1.326 1.3 10
19500911 0. 0.0915 0.0915 0.4385 0.0615 0.5 0.5 1. 3.66 1.326 1.3
11
19500912 0. 0.0915 0.0915 0.2555 0.2445 0.5 0.5 1. 3.66 1.326 1.3
12
*
*------------------------------------------------------------
* materials tables
*------------------------------------------------------------
*
20100100 tbl/fctn 1 1
20100200 tbl/fctn 1 1
20100300 tbl/fctn 1 1
20100400 tbl/fctn 1 1
20100500 tbl/fctn 1 1
*
* piping steel conductivity (w/m/k)
20100101 93. 14.700
20100102 2073. 18.60
*
*  "   heat capacity (j/m3/kg)
20100151 93. 3.62e6
20100152 2073. 4.21e6
*
* inc 600 (vessel) conductivity (w/m/k)
20100201 13.   12.
20100202 473.  15.5
20100203 573.  18.1
20100204 700.  20.4
20100205 922.  24.9
20100206 1033. 26.9
20100207 1144. 29.4
20100208 1477. 36.1
20100209 2477. 36.1
*
*  "   heat capacity (j/m3/kg)
20100251 13.  3.46e6
20100252 373. 3.67e6
20100253 473. 3.87e6
20100254 573. 4.05e6
20100255 673. 4.26e6
20100256 2073. 4.36e6
*
* copper connectors conductivity (w/m/k)
20100301 93.  390.2
20100302 533. 374.9
20100303 813. 373.0
20100304 1088. 364.8
20100305 2800. 355.0
*
*  "   heat capacity (j/m3/kg)
20100351 93.  3.75e6
20100352 1000. 4.05e6
20100353 2073. 4.05e6
*
* ni-200 conductivity (w/m/k)
20100401 93.  79.2
20100402 533. 61.9
20100403 813. 59.0
20100404 1088. 64.8
20100405 2800. 67.0
*
*  "   heat capacity (j/m3/kg)
20100451 93.  4.05e6
20100452 2073. 4.05e6
*
* boron nitride
20100501 293. 33.9
20100502 300. 34.9
20100503 400. 32.3
20100504 500. 29.9
20100505 600. 27.7
20100506 700. 26.4
20100507 800. 25.4
20100508 900. 24.5
20100509 1000. 23.7
20100510 1050. 23.3
20100511 1500. 22.9
*
*    "   heat capacity (j/m3/kg)
20100551 293. 1.55e6
20100552 300. 1.55e6
20100553 400. 2.14e6
20100554 500. 2.53e6
20100555 600. 2.84e6
20100556 700. 3.09e6
20100557 800. 3.31e6
20100558 900. 3.48e6
20100559 1000. 3.64e6
20100560 1050. 3.77e6
20100561 1500. 3.95e6
*
*------------------------------------------------------------
*  general tables
*------------------------------------------------------------
*
* dc wall heat losses
20210000  htc-t
20210001  -1.0  0.0
20210002  0.    14.
20210003  1.e6  14.
*
* surge line heat losses
20210100  htc-t
20210101  -1.0  0.0
20210102  0.    7.
20210103  1.e6  7.
*
* lower plenum vessel walls heat losses
20220000  htc-t
20220001  0.    27.
```

```
20220002   1.e6   27.
*
* core region vessel walls  heat losses
20221000   htc-t
20221001   0.     16.
20221002   1.e6   16.
*
* upper plenum vessel walls heat losses
20222000   htc-t
20222001   0.     35.
20222002   1.e6   35.
*
* dc-up bypass walls heat losses
20222500   htc-t
20222501   0.     40.
20222502   1.e6   40.
*
* upper head   vessel walls heat losses
20223000   htc-t
20223001   0.     12.
20223002   1.e6   12.
*
* hot legs 1&2&3  walls heat losses
20230000   htc-t
20230001   0.     9.
20230002   1.e6   9.
*
* loop seals 1&2&3  walls heat losses
20231000   htc-t
20231001   0.     23.
20231002   1.e6   23.
*
* pumps  1&2&3  walls heat losses
20232000   htc-t
20232001   0.      400.
20232002   1000.   400.
20232003   3200.   400.
20232004   1.e6    400.
*
* cold legs 1&2&3  walls heat losses
20233000   htc-t
20233001   0.    115. * 89 corrisp. a 43+26 kw
20233002   1.e6  115.
*
* sg ss 1&2&3  riser walls heat losses
20240000   htc-t
20240001   0.     4.
20240002   1.e6   4.
*
* sg ss 1&2&3  steam dome walls heat losses
20241000   htc-t
20241001   0.     6.3
20241002   1.e6   6.3
*
* sg ss 1&2&3  u-dc walls heat losses
20242000   htc-t
20242001   0.     15.
20242002   1.e6   15.
*
* sg ss 1&2&3  l-dc walls heat losses
20243000   htc-t
20243001   0.     10.
20243002   1.e6   10.
*
* core power table
20290000   power  575  1.0  1.0000e6
20290001   -1.    5.715
20290002   0.     5.692
20290003   .5     2.348
20290004   1.     1.001
20290005   4.5    0.580
20290006   22.5   0.332
20290007   67.5   0.267
20290008   142.5  0.235
20290009   192.5  0.190
20290010   300.   0.150
20290011   309.   0.147
20290012   400.   0.137
20290013   600.   0.123
20290014   800.   0.113
20290015   1000.  0.108
20290016   1200.  0.103
20290017   1400.  0.099
20290018   1637.  0.096
20290019   1.e6   0.096
*
* prez heater power decay table
20291000 power  570  1.0  10.57e3
20291001   0.   1.
20291002   1.   0.
20291003   1.e6  0.
*
* environment temperature table  (for heat-loss)
20299900   temp  501
20299901 -1.    320.
20299902 0.     320.
20299903 1.e6   320.
*
*----------------------------------------------------------------------
* control variables
*----------------------------------------------------------------------
*
*  pressurizer level
20500100   przlvl      sum    1.   0.   1
20500101   0.     0.679    voidf    015010000
20500102          0.679    voidf    020010000
20500103          0.679    voidf    025010000
20500104          0.679    voidf    025020000
20500105          0.679    voidf    025030000
20500106          0.679    voidf    025040000
20500107          0.679    voidf    025050000
20500108          0.679    voidf    025060000
20500109          0.679    voidf    030010000
20500110          0.679    voidf    035010000
*
*  downcomer level s.g.1
20500200   dclsg1      sum    1.   0.   1
20500201   0.     0.961    voidf    530010000
20500202          1.000    voidf    540010000
20500203          1.042    voidf    560010000
20500204          2.1324   voidf    570010000
20500205          2.1324   voidf    570020000
20500206          2.1324   voidf    570030000
20500207          2.1324   voidf    570040000
20500208          2.1324   voidf    570050000
*
* downcomer level s.g.2
20500300   dclsg2      sum    1.   0.   1
20500301   0.     0.961    voidf    630010000
20500302          1.000    voidf    640010000
20500303          1.042    voidf    660010000
20500304          2.1324   voidf    670010000
20500305          2.1324   voidf    670020000
20500306          2.1324   voidf    670030000
20500307          2.1324   voidf    670040000
20500308          2.1324   voidf    670050000
*
* downcomer level s.g.3
20500400   dclsg3      sum    1.   0.   1
20500401   0.     0.961    voidf    730010000
20500402          1.000    voidf    740010000
20500403          1.042    voidf    760010000
20500404          2.1324   voidf    770010000
20500405          2.1324   voidf    770020000
20500406          2.1324   voidf    770030000
20500407          2.1324   voidf    770040000
20500408          2.1324   voidf    770050000
*
*    total mass (primary side)
*
20501000 tml           sum    1. 0. 1
20501001 0.  8.370560e-4   rho    010010000
20501002     8.644320e-4   rho    010020000
20501003     12.064000e-4  rho    010030000
```

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20501004    9.280000e-4  rho   010040000
20501005    9.280000e-4  rho   010050000
20501006    9.567680e-4  rho   010060000
20501007    8.504000e-3  rho   015010000
20501008    9.532000e-3  rho   020010000
20501009    9.647232e-3  rho   025010000
20501010    9.647232e-3  rho   025020000
20501011    9.647232e-3  rho   025030000
20501012    9.647232e-3  rho   025040000
20501013    9.647232e-3  rho   025050000
20501014    9.647232e-3  rho   025060000
20501015    9.647232e-3  rho   030010000
20501016    9.647232e-3  rho   035010000
20501017    4.734000e-2  rho   100010000
20501018    2.289664e-3  rho   105010000
20501019    8.486310e-3  rho   110010000
*
20501100 tm2          sum   1. 0. 1
20501101 0.  1.462615e-3  rho   112010000
20501102    1.462615e-3  rho   112020000
20501103    1.979934e-3  rho   112030000
20501104    1.979934e-3  rho   112040000
20501105    1.557721e-3  rho   114010000
20501106    1.557721e-3  rho   114020000
20501107    1.462615e-3  rho   114030000
20501108    1.462615e-3  rho   114040000
20501109    5.477888e-3  rho   115010000
20501110    5.477888e-3  rho   115020000
20501111    5.477888e-3  rho   115030000
20501112    5.477888e-3  rho   115040000
20501113    5.477888e-3  rho   115050000
20501114    5.477888e-3  rho   115060000
20501115    5.477888e-3  rho   115070000
20501116    5.477220e-3  rho   120010000
20501117    3.261400e-3  rho   125010000
*
20501200 tm3          sum   1. 0. 1
20501201 0.  1.765584e-3  rho   130010000
20501202    1.765584e-3  rho   130020000
20501203    3.531168e-3  rho   130030000
20501204    3.531168e-3  rho   130040000
20501205    3.531168e-3  rho   130050000
20501206    3.531168e-3  rho   130060000
20501207    3.531168e-3  rho   130070000
20501208    3.531168e-3  rho   130080000
20501209    3.531168e-3  rho   130090000
20501210    3.531168e-3  rho   130100000
20501211    1.765584e-3  rho   130110000
20501212    1.765584e-3  rho   130120000
20501213    3.261000e-3  rho   135010000
20501214    3.620000e-3  rho   140010000
20501215    5.570238e-4  rho   145010000
20501216    2.147394e-4  rho   145020000
20501217    2.147394e-4  rho   145030000
20501218    1.924770e-4  rho   145040000
20501219    2.699316e-4  rho   145050000
20501220    7.489874e-3  rho   150010000
*
20501300 tm4          sum   1. 0. 1
20501301 0.  1.348962e-2  rho   160010000
20501302    1.835215e-2  rho   170010000
20501303    2.228100e-2  rho   180010000
20501304    1.763253e-2  rho   190010000
20501305    1.763253e-2  rho   190020000
20501306    2.728398e-3  rho   200010000
20501307    2.724909e-3  rho   210010000
20501308    3.065086e-3  rho   220010000
20501309    3.065086e-3  rho   220020000
20501310    1.985241e-3  rho   220030000
20501311    2.690000e-3  rho   220040000
*
20501400 tm5          sum   1. 0. 1
20501401 0.  1.213850e-3  rho   230010000
20501402    1.213850e-3  rho   230020000
20501403    2.427700e-3  rho   230030000
20501404    2.427700e-3  rho   230040000
20501405    2.427700e-3  rho   230050000
20501406    2.427700e-3  rho   230060000
20501407    2.427700e-3  rho   230070000
20501408    2.427700e-3  rho   230080000
20501409    3.102601e-3  rho   230090000
20501410    3.102601e-3  rho   230100000
20501411    4.855400e-3  rho   230110000
20501412    4.855400e-3  rho   230120000
20501413    4.855400e-3  rho   230130000
20501414    2.427700e-3  rho   230140000
20501415    2.690000e-3  rho   240010000
20501416    1.620000e-3  rho   240020000
20501417    1.709792e-3  rho   250010000
*
20501500 tm6          sum   1. 0. 1
20501501 0.  1.635536e-3  rho   260010000
20501502    1.943984e-3  rho   260020000
20501503    0.929000e-3  rho   260030000
20501504    1.943984e-3  rho   260040000
20501505    1.384208e-3  rho   260050000
20501506    2.861712e-3  rho   260060000
20501507    2.284800e-3  rho   260070000
20501508    4.340000e-3  rho   270010000
20501509    1.978098e-3  rho   280010000
20501510    1.978098e-3  rho   290010000
20501511    2.728398e-3  rho   300010000
20501512    2.724909e-3  rho   310010000
20501513    3.065086e-3  rho   320010000
20501514    3.065086e-3  rho   320020000
20501515    1.982541e-3  rho   320030000
20501516    2.690000e-3  rho   320040000
20501517    1.978000e-3  rho   275010000
20501518    1.978000e-3  rho   285010000
*
20501600 tm7          sum   1. 0. 1
20501601 0.  1.213850e-3  rho   330010000
20501602    1.213850e-3  rho   330020000
20501603    2.427700e-3  rho   330030000
20501604    2.427700e-3  rho   330040000
20501605    2.427700e-3  rho   330050000
20501606    2.427700e-3  rho   330060000
20501607    2.427700e-3  rho   330070000
20501608    2.427700e-3  rho   330080000
20501609    3.102601e-3  rho   330090000
20501610    3.102601e-3  rho   330100000
20501611    4.855400e-3  rho   330110000
20501612    4.855400e-3  rho   330120000
20501613    4.855400e-3  rho   330130000
20501614    2.427700e-3  rho   330140000
20501615    2.690000e-3  rho   340010000
20501616    1.620000e-3  rho   340020000
20501617    1.709792e-3  rho   350010000
*
20501700 tm8          sum   1. 0. 1
20501701 0.  1.635536e-3  rho   360010000
20501702    1.943984e-3  rho   360020000
20501703    0.929000e-3  rho   360030000
20501704    1.943984e-3  rho   360040000
20501705    1.384208e-3  rho   360050000
20501706    2.861712e-3  rho   360060000
20501707    2.284800e-3  rho   360070000
20501708    4.340000e-3  rho   370010000
20501709    1.978408e-3  rho   380010000
20501710    1.978408e-3  rho   390010000
20501711    2.728398e-3  rho   400010000
20501712    2.724909e-3  rho   410010000
20501713    3.065086e-3  rho   420010000
20501714    3.065086e-3  rho   420020000
20501715    1.982541e-3  rho   420030000
20501716    2.690000e-3  rho   420040000
20501717    1.978000e-3  rho   375010000
20501718    1.978000e-3  rho   385010000
*
20501800 tm9          sum   1. 0. 1
20501801 0.  1.213850e-3  rho   430010000
20501802    1.213850e-3  rho   430020000
20501803    2.427700e-3  rho   430030000
20501804    2.427700e-3  rho   430040000
```

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20501805    2.427700e-3  rho   430050000
20501806    2.427700e-3  rho   430060000
20501807    2.427700e-3  rho   430070000
20501808    2.427700e-3  rho   430080000
20501809    3.102601e-3  rho   430090000
20501810    3.102601e-3  rho   430100000
20501811    4.855400e-3  rho   430110000
20501812    4.855400e-3  rho   430120000
20501813    4.855400e-3  rho   430130000
20501814    2.427700e-3  rho   430140000
20501815    2.690000e-3  rho   440010000
20501816    1.620000e-3  rho   440020000
20501817    1.709792e-3  rho   450010000
*
20501900 tm10          sum    1. 0. 1
20501901 0.  1.635536e-3  rho   460010000
20501902    1.943984e-3  rho   460020000
20501903    0.929000e-3  rho   460030000
20501904    1.943984e-3  rho   460040000
20501905    1.384208e-3  rho   460050000
20501906    2.861712e-3  rho   460060000
20501907    2.284800e-3  rho   460070000
20501908    4.340000e-3  rho   470010000
20501909    1.978098e-3  rho   480010000
20501910    1.978098e-3  rho   490010000
20501911    1.978098e-3  rho   475010000
20501912    1.978098e-3  rho   485010000
*
* total mass primary side
20502000 tmass.p       sum    1. 0. 1
20502001 0.  1.      cntrlvar  010
20502002    1.      cntrlvar  011
20502003    1.      cntrlvar  012
20502004    1.      cntrlvar  013
20502005    1.      cntrlvar  014
20502006    1.      cntrlvar  015
20502007    1.      cntrlvar  016
20502008    1.      cntrlvar  017
20502009    1.      cntrlvar  018
20502010    1.      cntrlvar  019
*
* heat transfer  s.g.1
20502100 htsg1         sum    1. 0. 1
20502101 0.  1.       q      230010000
20502102    1.       q      230020000
20502103    1.       q      230030000
20502104    1.       q      230040000
20502105    1.       q      230050000
20502106    1.       q      230060000
20502107    1.       q      230070000
20502108    1.       q      230080000
20502109    1.       q      230090000
20502110    1.       q      230100000
20502111    1.       q      230110000
20502112    1.       q      230120000
20502113    1.       q      230130000
20502114    1.       q      230140000
*
* heat transfert s.g.2
20502200 htsg2         sum    1. 0. 1
20502201 0.  1.       q      330010000
20502202    1.       q      330020000
20502203    1.       q      330030000
20502204    1.       q      330040000
20502205    1.       q      330050000
20502206    1.       q      330060000
20502207    1.       q      330070000
20502208    1.       q      330080000
20502209    1.       q      330090000
20502210    1.       q      330100000
20502211    1.       q      330110000
20502212    1.       q      330120000
20502213    1.       q      330130000
20502214    1.       q      330140000
*
* heat transfert s.g.3
20502300 htsg3         sum    1. 0. 1
```

```
20502301 0.  1.       q      430010000
20502302    1.       q      430020000
20502303    1.       q      430030000
20502304    1.       q      430040000
20502305    1.       q      430050000
20502306    1.       q      430060000
20502307    1.       q      430070000
20502308    1.       q      430080000
20502309    1.       q      430090000
20502310    1.       q      430100000
20502311    1.       q      430110000
20502312    1.       q      430120000
20502313    1.       q      430130000
20502314    1.       q      430140000
*
* total mass (secondary side)
20503000 tms1          sum    1. 0. 1
20503001 0.  8.820000e-3  rho   500010000
20503002    8.820000e-3  rho   500020000
20503003    1.764000e-2  rho   500030000
20503004    1.764000e-2  rho   500040000
20503005    1.164000e-2  rho   500050000
20503006    1.164000e-2  rho   500060000
20503007    1.164000e-2  rho   500070000
20503008    1.164000e-2  rho   500080000
20503009    1.487592e-2  rho   500090000
20503010    2.296200e-2  rho   500100000
20503011    2.296200e-2  rho   500110000
20503012    7.775536e-3  rho   500120000
20503013    6.811000e-3  rho   510010000
20503014    1.370000e-1  rho   520010000
20503015    1.765453e-2  rho   530010000
20503016    1.837100e-2  rho   540010000
20503017    1.914300e-2  rho   560010000
20503018    7.088000e-3  rho   505010000
*
20503100 tms2          sum    1. 0. 1
20503101 0.  7.412000e-3  rho   570010000
20503102    6.183960e-3  rho   570020000
20503103    6.183960e-3  rho   570030000
20503104    6.183960e-3  rho   570040000
20503105    7.412000e-3  rho   570050000
20503106    3.415400e-2  rho   525010000
20503107    1.166000e-2  rho   565010000
*
20503200 tms3          sum    1. 0. 1
20503201 0.  8.820000e-3  rho   600010000
20503202    8.820000e-3  rho   600020000
20503203    1.764000e-2  rho   600030000
20503204    1.764000e-2  rho   600040000
20503205    1.164000e-2  rho   600050000
20503206    1.164000e-2  rho   600060000
20503207    1.164000e-2  rho   600070000
20503208    1.164000e-2  rho   600080000
20503209    1.487592e-2  rho   600090000
20503210    2.296200e-2  rho   600100000
20503211    2.296200e-2  rho   600110000
20503212    7.775536e-3  rho   600120000
20503213    6.811000e-3  rho   610010000
20503214    1.370000e-1  rho   620010000
20503215    1.765453e-2  rho   630010000
20503216    1.837100e-2  rho   640010000
20503217    1.914300e-2  rho   660010000
20503218    7.088000e-3  rho   605010000
*
20503300 tms4          sum    1. 0. 1
20503301 0.  7.412000e-3  rho   670010000
20503302    6.183960e-3  rho   670020000
20503303    6.183960e-3  rho   670030000
20503304    6.183960e-3  rho   670040000
20503305    7.412000e-3  rho   670050000
20503306    8.028000e-2  rho   625010000
20503307    1.166000e-2  rho   665010000
*
20503400 tms5          sum    1. 0. 1
20503401 0.  8.820000e-3  rho   700010000
20503402    8.820000e-3  rho   700020000
```

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20503403     1.764000e-2  rho   700030000
20503404     1.764000e-2  rho   700040000
20503405     1.164000e-2  rho   700050000
20503406     1.164000e-2  rho   700060000
20503407     1.164000e-2  rho   700070000
20503408     1.164000e-2  rho   700080000
20503409     1.487592e-2  rho   700090000
20503410     2.296200e-2  rho   700100000
20503411     2.296200e-2  rho   700110000
20503412     7.775536e-3  rho   700120000
20503413     6.811000e-3  rho   710010000
20503414     1.370000e-1  rho   720010000
20503415     1.765453e-2  rho   730010000
20503416     1.837100e-2  rho   740010000
20503417     1.914300e-2  rho   760010000
20503418     7.088000e-3  rho   705010000
*
20503500 tms6         sum   1. 0. 1
20503501 0.  7.412000e-3  rho   770010000
20503502     6.183960e-3  rho   770020000
20503503     6.183960e-3  rho   770030000
20503504     6.183960e-3  rho   770040000
20503505     7.412000e-3  rho   770050000
20503506     3.415400e-2  rho   725010000
20503507     1.166000e-2  rho   765010000
*
* total mass ss sg1
20503600 tmsg1        sum   1. 0. 1
20503601 0.  1.     cntrlvar  030
20503602     1.     cntrlvar  031
*
* total mass ss sg2
20503700 tmsg2        sum   1. 0. 1
20503701 0.  1.     cntrlvar  032
20503702     1.     cntrlvar  033
*
* total mass ss sg3
20503800 tmsg3        sum   1. 0. 1
20503801 0.  1.     cntrlvar  034
20503802     1.     cntrlvar  035
*
* struct. heat transfer
20504000 htexc01  sum  1. 0. 1
20504001 0.  0.1377186   htmr  010100100
20504002     0.1422227   htmr  010100200
20504003     0.1984858   htmr  010100300
20504004     0.1526814   htmr  010100400
20504005     0.1526814   htmr  010100500
20504006     0.1574145   htmr  010100600
20504007     0.2869075   htmr  015100100
20504008     0.2869075   htmr  015100200
20504009     0.2869075   htmr  015100300
20504010     0.2869075   htmr  015100400
20504011     0.2869075   htmr  015100500
20504012     0.2869075   htmr  015100600
20504013     0.2869075   htmr  015100700
20504014     0.2869075   htmr  015100800
20504015     0.2869075   htmr  015100900
20504016     0.2869075   htmr  015101000
*
20504100 htexc02  sum  1. 0. 1
20504101 0.  0.0142000   htmr  015200100
20504102     0.0142000   htmr  015300100
20504103     0.2318000   htmr  100100100
20504104     0.9175587   htmr  100200100
20504105     9.948997e-2 htmr  105100100
20504106     0.2380240   htmr  105100200
20504107     0.2380240   htmr  105100300
20504108     0.2380240   htmr  105100400
20504109     0.2380240   htmr  105100500
20504110     0.2380240   htmr  105100600
20504111     0.2380240   htmr  105100700
*
20504200 htexc03  sum  1. 0. 1
20504201 0.  0.2380240   htmr  105100800
20504202     9.948997e-2 htmr  105100900
20504203     0.1260658   htmr  110100100
20504204     0.3595741   htmr  110100200
20504205     0.2320757   htmr  110100300
20504206     0.2732092   htmr  112100100
20504207     0.2732092   htmr  112100200
20504208     0.3698418   htmr  112100300
20504209     0.3698418   htmr  112100400
20504210     0.2909746   htmr  112100500
20504211     0.2909746   htmr  112100600
20504212     0.2732092   htmr  112100700
20504213     0.2732092   htmr  112100800
20504214     5.144358e-2 htmr  125100100
20504215     5.183628e-2 htmr  125100200
*
20504300 htexc04  sum  1. 0. 1
20504301 0.  8.563881e-2 htmr  130100100
20504302     8.563881e-2 htmr  130100200
20504303     0.1712776   htmr  130100300
20504304     0.1712776   htmr  130100400
20504305     0.1712776   htmr  130100500
20504306     0.1712776   htmr  130100600
20504307     0.1712776   htmr  130100700
20504308     0.1712776   htmr  130100800
20504309     0.1712776   htmr  130100900
20504310     0.1712776   htmr  130101000
20504311     8.563881e-2 htmr  130101100
20504312     8.563881e-2 htmr  130101200
20504313     0.1787652   htmr  130101300
20504314     0.0122000   htmr  135100100
20504315     9.168518e-2 htmr  145100100
20504316     3.534574e-2 htmr  145100200
20504317     3.534574e-2 htmr  145100300
20504318     3.168139e-2 htmr  145100400
20504319     4.443029e-2 htmr  145100500
*
20504400 htexc05  sum  1. 0. 1
20504401 0.  0.1896140   htmr  150100100
20504402     0.3415037   htmr  150100200
20504403     0.4646039   htmr  150100300
20504404     0.5498793   htmr  180100100
20504405     0.3771608   htmr  180100200
20504406     0.3771608   htmr  180100300
20504407     0.1636179   htmr  200100100
20504408     0.1634087   htmr  200100200
20504409     0.1838086   htmr  200100300
20504410     0.1838086   htmr  200100400
20504411     0.1190519   htmr  200100500
20504412     3.233327e-2 htmr  220100100
20504413     3.233327e-2 htmr  220100200
20504414     3.732212e-2 htmr  220200100
20504415     3.732212e-2 htmr  220200200
20504416     0.047700    htmr  220300100
20504417     0.071000    htmr  220400100
20504418     0.071000    htmr  220400200
*
20504500 htexc06  sum  1. 0. 1
20504501 0.  0.3148818   htmr  230100100
20504502     0.3148818   htmr  230100200
20504503     0.6297637   htmr  230100300
20504504     0.6297637   htmr  230100400
20504505     0.6297637   htmr  230100500
20504506     0.6297637   htmr  230100600
20504507     0.6297637   htmr  230100700
20504508     0.6297637   htmr  230100800
20504509     0.8048380   htmr  230100900
20504510     0.8048380   htmr  230101000
20504511     0.6297637   htmr  230101100
20504512     0.6297637   htmr  230101200
20504513     0.6297637   htmr  230101300
20504514     0.6297637   htmr  230101400
20504515     0.6297637   htmr  230101500
20504516     0.6297637   htmr  230101600
20504517     0.3148818   htmr  230101700
20504518     0.3148818   htmr  230101800
*
20504600 htexc07  sum  1. 0. 1
20504601 0.  0.3148818   htmr  230100101
20504602     0.3148818   htmr  230100201
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20504603    0.6297637   htmr  230100301
20504604    0.6297637   htmr  230100401
20504605    0.6297637   htmr  230100501
20504606    0.6297637   htmr  230100601
20504607    0.6297637   htmr  230100701
20504608    0.6297637   htmr  230100801
20504609    0.8048380   htmr  230100901
20504610    0.8048380   htmr  230101001
20504611    0.6297637   htmr  230101101
20504612    0.6297637   htmr  230101201
20504613    0.6297637   htmr  230101301
20504614    0.6297637   htmr  230101401
20504615    0.6297637   htmr  230101501
20504616    0.6297637   htmr  230101601
20504617    0.3148818   htmr  230101701
20504618    0.3148818   htmr  230101801
*
20504700  htexc08  sum  1.  0.  1
20504701  0.   8.794826e-2 htmr  240100100
20504702    0.1388006   htmr  240100200
20504703    0.13277225  htmr  240100300
20504704    0.1578123   htmr  240100400
20504705    0.1578123   htmr  240100500
20504706    0.1578123   htmr  240100600
20504707    0.1123697   htmr  240100700
20504708    0.2323132   htmr  240100800
20504709    0.1854796   htmr  240100900
20504710    0.1078195   htmr  270100100
20504711    0.2682072   htmr  280100100
20504712    0.2682072   htmr  280100200
*
20504800  htexc09  sum  1.  0.  1
20504807  0.   0.1636179   htmr  300100100
20504808    0.1634087   htmr  300100200
20504809    0.1838086   htmr  300100300
20504810    0.1838086   htmr  300100400
20504811    0.1190519   htmr  300100500
20504812    3.233327e-2 htmr  320100100
20504813    3.233327e-2 htmr  320100200
20504814    3.732212e-2 htmr  320200100
20504815    3.732212e-2 htmr  320200200
20504816    0.047700    htmr  320300100
20504817    0.071000    htmr  320400100
20504818    0.071000    htmr  320400200
*
20504900  htexc10  sum  1.  0.  1
20504901  0.   0.3148818   htmr  330100100
20504902    0.3148818   htmr  330100200
20504903    0.6297637   htmr  330100300
20504904    0.6297637   htmr  330100400
20504905    0.6297637   htmr  330100500
20504906    0.6297637   htmr  330100600
20504907    0.6297637   htmr  330100700
20504908    0.6297637   htmr  330100800
20504909    0.8048380   htmr  330100900
20504910    0.8048380   htmr  330101000
20504911    0.6297637   htmr  330101100
20504912    0.6297637   htmr  330101200
20504913    0.6297637   htmr  330101300
20504914    0.6297637   htmr  330101400
20504915    0.6297637   htmr  330101500
20504916    0.6297637   htmr  330101600
20504917    0.3148818   htmr  330101700
20504918    0.3148818   htmr  330101800
*
20505000  htexc11  sum  1.  0.  1
20505001  0.   0.3148818   htmr  330100101
20505002    0.3148818   htmr  330100201
20505003    0.6297637   htmr  330100301
20505004    0.6297637   htmr  330100401
20505005    0.6297637   htmr  330100501
20505006    0.6297637   htmr  330100601
20505007    0.6297637   htmr  330100701
20505008    0.6297637   htmr  330100801
20505009    0.8048380   htmr  330100901
20505010    0.8048380   htmr  330101001
20505011    0.6297637   htmr  330101101
20505012    0.6297637   htmr  330101201
20505013    0.6297637   htmr  330101301
20505014    0.6297637   htmr  330101401
20505015    0.6297637   htmr  330101501
20505016    0.6297637   htmr  330101601
20505017    0.3148818   htmr  330101701
20505018    0.3148818   htmr  330101801
*
20505100  htexc12  sum  1.  0.  1
20505101  0.   8.794826e-2 htmr  340100100
20505102    0.1388006   htmr  340100200
20505103    0.13277252  htmr  340100300
20505104    0.1578123   htmr  340100400
20505105    0.1578123   htmr  340100500
20505106    0.1578123   htmr  340100600
20505107    0.1123697   htmr  340100700
20505108    0.2323132   htmr  340100800
20505109    0.1854796   htmr  340100900
20505110    0.1078195   htmr  370100100
20505111    0.2617198   htmr  380100100
20505112    0.2617198   htmr  380100200
*
20505200  htexc13  sum  1.  0.  1
20505207  0.   0.1636179   htmr  400100100
20505208    0.1634087   htmr  400100200
20505209    0.1838086   htmr  400100300
20505210    0.1838086   htmr  400100400
20505211    0.1190519   htmr  400100500
20505212    3.233327e-2 htmr  420100100
20505213    3.233327e-2 htmr  420100200
20505214    3.732212e-2 htmr  420200100
20505215    3.732212e-2 htmr  420200200
20505216    0.047700    htmr  420300100
20505217    0.071000    htmr  420400100
20505218    0.071000    htmr  420400200
*
20505300  htexc14  sum  1.  0.  1
20505301  0.   0.3148818   htmr  430100100
20505302    0.3148818   htmr  430100200
20505303    0.6297637   htmr  430100300
20505304    0.6297637   htmr  430100400
20505305    0.6297637   htmr  430100500
20505306    0.6297637   htmr  430100600
20505307    0.6297637   htmr  430100700
20505308    0.6297637   htmr  430100800
20505309    0.8048380   htmr  430100900
20505310    0.8048380   htmr  430101000
20505311    0.6297637   htmr  430101100
20505312    0.6297637   htmr  430101200
20505313    0.6297637   htmr  430101300
20505314    0.6297637   htmr  430101400
20505315    0.6297637   htmr  430101500
20505316    0.6297637   htmr  430101600
20505317    0.3148818   htmr  430101700
20505318    0.3148818   htmr  430101800
*
20505400  htexc15  sum  1.  0.  1
20505401  0.   0.3148818   htmr  430100101
20505402    0.3148818   htmr  430100201
20505403    0.6297637   htmr  430100301
20505404    0.6297637   htmr  430100401
20505405    0.6297637   htmr  430100501
20505406    0.6297637   htmr  430100601
20505407    0.6297637   htmr  430100701
20505408    0.6297637   htmr  430100801
20505409    0.8048380   htmr  430100901
20505410    0.8048380   htmr  430101001
20505411    0.6297637   htmr  430101101
20505412    0.6297637   htmr  430101201
20505413    0.6297637   htmr  430101301
20505414    0.6297637   htmr  430101401
20505415    0.6297637   htmr  430101501
20505416    0.6297637   htmr  430101601
20505417    0.3148818   htmr  430101701
20505418    0.3148818   htmr  430101801
*
20505500  htexc16  sum  1.  0.  1
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0. 8.794826e-2 htmr 440100100
2 0.1388006 htmr 440100200
503 0.13277252 htmr 440100300
505504 0.1578123 htmr 440100400
20505505 0.1578123 htmr 440100500
20505506 0.1578123 htmr 440100600
20505507 0.1123697 htmr 440100700
20505508 0.2323132 htmr 440100800
20505509 0.1854796 htmr 440100900
20505510 0.1078195 htmr 470100100
20505511 0.2682072 htmr 480100100
20505512 0.2682072 htmr 480100200
*
* overall heat transfer fluid-to-struct.
20505600 htfluid sum 1. 0. 1
20505601 0. 1. cntrlvar 040
20505602 1. cntrlvar 041
20505603 1. cntrlvar 042
20505604 1. cntrlvar 043
20505605 1. cntrlvar 044
20505606 1. cntrlvar 047
20505607 1. cntrlvar 048
20505608 1. cntrlvar 051
20505609 1. cntrlvar 052
20505610 1. cntrlvar 055
*
* prz internal heaters
20506000 przihea sum 1. 0. 1
20506001 0. 0.1638026 htmr 020100101
20506002 2.094186e-2 htmr 020100201
*
* core power
20506100 co.pow1 sum 1. 0. 1
20506101 0. 0.5133959 htmr 900000101
20506102 0.5133959 htmr 900000201
20506103 1.0267920 htmr 900000301
20506104 1.0267920 htmr 900000401
20506105 1.0267920 htmr 900000501
20506106 1.0267920 htmr 900000601
20506107 1.0267920 htmr 900000701
20506108 1.0267920 htmr 900000801
20506109 1.0267920 htmr 900000901
20506110 1.0267920 htmr 900001001
20506111 0.5133959 htmr 900001101
20506112 0.5133959 htmr 900001201
*
20506300 co.pow3 sum 1. 0. 1
20506301 0. 1.638498e-2 htmr 950000101
20506302 1.638498e-2 htmr 950000201
20506303 3.276996e-2 htmr 950000301
20506304 3.276996e-2 htmr 950000401
20506305 3.276996e-2 htmr 950000501
20506306 3.276996e-2 htmr 950000601
20506307 3.276996e-2 htmr 950000701
20506308 3.276996e-2 htmr 950000801
20506309 3.276996e-2 htmr 950000901
20506310 3.276996e-2 htmr 950001001
20506311 1.638498e-2 htmr 950001101
20506312 1.638498e-2 htmr 950001201
*
* overall core power
20506400 co.powt sum 1. 0. 1
20506401 0. 1. cntrlvar 061
20506402 1. cntrlvar 063
*
* subcooling at pump1 inlet
20506700 sbc.pu1 sum 1. 0. 1
20506701 0. 1. sattemp 260070000
20506702 -1. tempf 260070000
*
* subcooling at pump2 inlet
20506800 sbc.pu2 sum 1. 0. 1
20506801 0. 1. sattemp 360070000
20506802 -1. tempf 360070000
*
* subcooling at pump3 inlet
20506900 sbc.pu3 sum 1. 0. 1
20506901 0. 1. sattemp 460070000
20506902 -1. tempf 460070000
*
* heat losses to environment
20507000 htlrpv1 sum 1. 0. 1
20507001 0. 0.1988503 htmr 105100101
20507002 0.4757377 htmr 105100201
20507003 0.4757377 htmr 105100301
20507004 0.4757377 htmr 105100401
20507005 0.4757377 htmr 105100501
20507006 0.4757377 htmr 105100601
20507007 0.4757377 htmr 105100701
20507008 0.4757377 htmr 105100801
20507009 0.1988503 htmr 105100901
20507010 0.1492885 htmr 110100101
20507011 0.4258115 htmr 110100201
20507012 0.2748266 htmr 110100301
*
* heat losses rpv
20507100 htlrpv2 sum 1. 0. 1
20507101 0. 0.1437279 htmr 130100101
20507102 0.1437279 htmr 130100201
20507103 0.2874557 htmr 130100301
20507104 0.2874557 htmr 130100401
20507105 0.2874557 htmr 130100501
20507106 0.2874557 htmr 130100601
20507107 0.2874557 htmr 130100701
20507108 0.2874557 htmr 130100801
20507109 0.2874557 htmr 130100901
20507110 0.2874557 htmr 130101001
20507111 0.1437279 htmr 130101101
20507112 0.1437279 htmr 130101201
20507113 0.3000022 htmr 130101301
20507114 0.2460181 htmr 150100101
20507115 0.4430903 htmr 150100201
20507116 0.6028088 htmr 150100301
20507117 0.7204301 htmr 180100101
20507118 0.4941412 htmr 180100201
20507119 0.4941412 htmr 180100301
*
* vessel heat losses
20507200 hlrpvt sum 1. 0. 1
20507201 0. 1.0 cntrlvar 070
20507202 1.0 cntrlvar 071
20507203 1.0 cntrlvar 073
*
* up-dc bypass heat losses
20507300 up-dchl sum 1. 0. 1
20507301 0. 0.125 htmr 145100101
20507302 0.048 htmr 145100201
20507303 0.048 htmr 145100301
20507304 0.043 htmr 145100401
20507305 0.061 htmr 145100501
*
* hls heat losses
20507400 hlholeg sum 1. 0. 1
20507401 0. 0.2186486 htmr 200100101
20507402 0.2183690 htmr 200100201
20507403 0.2456301 htmr 200100301
20507404 0.2456301 htmr 200100401
20507405 0.1590934 htmr 200100501
20507406 0.2186486 htmr 300100101
20507407 0.2183690 htmr 300100201
20507408 0.2456301 htmr 300100301
20507409 0.2456301 htmr 300100401
20507410 0.1590934 htmr 300100501
20507411 0.2186486 htmr 400100101
20507412 0.2183690 htmr 400100201
20507413 0.2456301 htmr 400100301
20507414 0.2456301 htmr 400100401
20507415 0.1590934 htmr 400100501
*
* loop seal1&2 heat losses
20507500 hllose12 sum 1. 0. 1
20507501 0. 0.1079690 htmr 240100101
20507502 0.1703975 htmr 240100201
20507503 0.1629972 htmr 240100301
```

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20507504      0.1937370   htmr  240100401
20507505      0.1937370   htmr  240100501
20507506      0.1937370   htmr  240100601
20507507      0.1379499   htmr  240100701
20507508      0.2851976   htmr  240100801
20507509      0.2277027   htmr  240100901
20507510      0.1079690   htmr  340100101
20507511      0.1703975   htmr  340100201
20507512      0.1629972   htmr  340100301
20507513      0.1937370   htmr  340100401
20507514      0.1937370   htmr  340100501
20507515      0.1937370   htmr  340100601
20507516      0.1379499   htmr  340100701
20507517      0.2851976   htmr  340100801
20507518      0.2277027   htmr  340100901
*
* loop seal3 heat losses
20507600  hllosc2  sum  1.  0.  1
20507601  0.   0.1079690   htmr  440100101
20507602       0.1703975   htmr  440100201
20507603       0.1629972   htmr  440100301
20507604       0.1937370   htmr  440100401
20507605       0.1937370   htmr  440100501
20507606       0.1937370   htmr  440100601
20507607       0.1379499   htmr  440100701
20507608       0.2851976   htmr  440100801
20507609       0.2277027   htmr  440100901
*
* overall loop seal heat losses
20507700  hllosea  sum  1.  0.  1
20507701  0.   1.0    cntrlvar  075
20507702       1.0    cntrlvar  076
*
* pumps heat losses
20507800  hlspump  sum  1.  0.  1
20507801  0.   0.2711823   htmr  270100101
20507802       0.2711823   htmr  370100101
20507803       0.2711823   htmr  470100101
*
* cls heat losses
20507900  hlcoleg  sum  1.  0.  1
20507901  0.   0.3318496   htmr  280100101
20507902       0.3318496   htmr  280100201
20507903       0.3238228   htmr  380100101
20507904       0.3238228   htmr  380100201
20507905       0.3318496   htmr  480100101
20507906       0.3318496   htmr  480100201
*
* sg1 ss heat losses
20508000  hlsg1ss  sum  1.  0.  1
20508001  0.   0.3518584   htmr  500100101
20508002       0.3518584   htmr  500100201
20508003       0.7037167   htmr  500100301
20508004       0.7037167   htmr  500100401
20508005       0.7037167   htmr  500100501
20508006       0.7037167   htmr  500100601
20508007       0.7037167   htmr  500100701
20508008       0.7037167   htmr  500100801
20508009       0.8993500   htmr  500100901
20508010       0.8194782   htmr  500101001
20508011       0.8194782   htmr  500101101
20508012       0.7719773   htmr  500101201
20508013       2.5030325   htmr  520100101
*
* sg1 ss heat losses
20508100  hlsg1ss  sum  1.  0.  1
20508101  0.   0.6702337   htmr  530100101
20508102       0.6974336   htmr  530100201
20508103       0.7267258   htmr  530100301
20508104       0.6705378   htmr  570100101
20508105       0.6705378   htmr  570100201
20508106       0.6705378   htmr  570100301
20508107       0.6705378   htmr  570100401
20508108       0.6705378   htmr  570100501
*
* sg2 ss heat losses
20508200  hlsg2ss  sum  1.  0.  1
20508201  0.   0.3518584   htmr  600100101
20508202       0.3518584   htmr  600100201
20508203       0.7037167   htmr  600100301
20508204       0.7037167   htmr  600100401
20508205       0.7037167   htmr  600100501
20508206       0.7037167   htmr  600100601
20508207       0.7037167   htmr  600100701
20508208       0.7037167   htmr  600100801
20508209       0.8993500   htmr  600100901
20508210       0.8194782   htmr  600101001
20508211       0.8194782   htmr  600101101
20508212       0.7719773   htmr  600101201
20508213       2.5030325   htmr  620100101
*
* sg2 ss heat losses
20508300  hlsg2ss  sum  1.  0.  1
20508301  0.   0.6702337   htmr  630100101
20508302       0.6974336   htmr  630100201
20508303       0.7267258   htmr  630100301
20508304       0.6705378   htmr  670100101
20508305       0.6705378   htmr  670100201
20508306       0.6705378   htmr  670100301
20508307       0.6705378   htmr  670100401
20508308       0.6705378   htmr  670100501
*
* sg3 ss heat losses
20508400  hlsg3ss  sum  1.  0.  1
20508401  0.   0.3518584   htmr  700100101
20508402       0.3518584   htmr  700100201
20508403       0.7037167   htmr  700100301
20508404       0.7037167   htmr  700100401
20508405       0.7037167   htmr  700100501
20508406       0.7037167   htmr  700100601
20508407       0.7037167   htmr  700100701
20508408       0.7037167   htmr  700100801
20508409       0.8993500   htmr  700100901
20508410       0.8194782   htmr  700101001
20508411       0.8194782   htmr  700101101
20508412       0.7719773   htmr  700101201
20508413       2.5030325   htmr  720100101
*
* sg3 ss heat losses
20508500  hlsesi6  sum  1.  0.  1
20508501  0.   0.6702337   htmr  730100101
20508502       0.6974336   htmr  730100201
20508503       0.7267258   htmr  730100301
20508504       0.6705378   htmr  770100101
20508505       0.6705378   htmr  770100201
20508506       0.6705378   htmr  770100301
20508507       0.6705378   htmr  770100401
20508508       0.6705378   htmr  770100501
*
* overall ps heat losses
20509000  hlpst   sum  1.  0.  1
20509001  0.   1.0    cntrlvar  072
20509002       1.0    cntrlvar  074
20509003       1.0    cntrlvar  077
20509004       1.0    cntrlvar  078
20509005       1.0    cntrlvar  079
*
* loop 1&2&3 sg ss heat losses
20509100  hlsgsst  sum  1.  0.  1
20509101  0.   1.0    cntrlvar  080
20509102       1.0    cntrlvar  081
20509103       1.0    cntrlvar  082
20509104       1.0    cntrlvar  083
20509105       1.0    cntrlvar  084
20509106       1.0    cntrlvar  085
*
* sg1 ps total dp
20510000  sg1dpt  sum  1.  0.  1
20510001  0.   1.0    p    220040000
20510002       -1.0   p    240010000
*
* sg2 ps total dp
20510100  sg2dpt  sum  1.  0.  1
20510101  0.   1.0    p    320040000
```

```
20510102     -1.0    p     340010000
*
* sg3 ps total dp
20510200  sg3dpt   sum  1.  0.  1
20510201  0.  1.0    p     420040000
20510202     -1.0    p     440010000
*
* loop1 total dp
20510300  l1dpt    sum  1.  0.  1
20510301  0.  1.0    p     290010000
20510302     -1.0    p     200010000
*
* loop2 total dp
20510400  l2dpt    sum  1.  0.  1
20510401  0.  1.0    p     390010000
20510402     -1.0    p     300010000
*
* loop3 total dp
20510500  l3dpt    sum  1.  0.  1
20510501  0.  1.0    p     490010000
20510502     -1.0    p     400010000
*
* loop1 hl  dp
20510600  l1hldp   sum  1.  0.  1
20510601  0.  1.0    p     200010000
20510602     -1.0    p     220040000
*
* loop1 loop seal desc leg dp
20510700  l1lsddp  sum  1.  0.  1
20510701  0.  1.0    p     240010000
20510702     -1.0    p     260050000
*
* loop1 loop seal asc leg dp
20510800  l1lsadp  sum  1.  0.  1
20510801  0.  1.0    p     260050000
20510802     -1.0    p     260070000
*
* loop1 pump dp
20510900  l1pudp   sum  1.  0.  1
20510901  0.  1.0    p     260070000
20510902     -1.0    p     280010000
*
* loop1 cl  dp
20511000  l1cldp   sum  1.  0.  1
20511001  0.  1.0    p     280010000
20511002     -1.0    p     290010000
*
* rpv dc1 dp001
20511100  rpvdc1   sum  1.  0.  1
20511101  0.  1.0    p     115070000
20511102     -1.0    p     115040000
*
* rpv dc2 dp002
20511200  rpvdc2   sum  1.  0.  1
20511201  0.  1.0    p     115040000
20511202     -1.0    p     105010000
*
* rpv dclp dp003
20511300  rpvdclp  sum  1.  0.  1
20511301  0.  1.0    p     105010000
20511302     -1.0    p     120010000
*
* rpv core inlet dp005
20511400  rpvcoin  sum  1.  0.  1
20511401  0.  1.0    p     120010000
20511402     -1.0    p     130020000
*
* rpv core bot dp011
20511500  rpvcobo  sum  1.  0.  1
20511501  0.  1.0    p     130020000
20511502     -1.0    p     130050000
*
* rpv core middle dp012
20511600  rpvcome  sum  1.  0.  1
20511601  0.  1.0    p     130050000
20511602     -1.0    p     130080000
*
* rpv core top dp013
20511700  rpvcoto  sum  1.  0.  1
20511701  0.  1.0    p     130080000
20511702     -1.0    p     140010000
*
* rpv core outlet - upper plenum dp015
20511800  rpvcoup  sum  1.  0.  1
20511801  0.  1.0    p     140010000
20511802     -1.0    p     160010000
*
* sg1 ss riser lower part dp101s
20512100  sg1rilo  sum  1.  0.  1
20512101  0.  1.0    p     500010000
20512102     -1.0    p     500040000
*
* sg1 ss riser upper part dp102s
20512200  sg1riup  sum  1.  0.  1
20512201  0.  1.0    p     500040000
20512202     -1.0    p     500110000
*
* sg1 ss riser to dome dp103s + dp104s
20512300  sg1riup  sum  1.  0.  1
20512301  0.  1.0    p     500110000
20512302     -1.0    p     520010000
*
* core level
20515000  corelvl  sum  1.  0.  1
20515001  0.  .183    voidf  130010000
20515002      .183    voidf  130020000
20515003      .366    voidf  130030000
20515004      .366    voidf  130040000
20515005      .366    voidf  130050000
20515006      .366    voidf  130060000
20515007      .366    voidf  130070000
20515008      .366    voidf  130080000
20515009      .366    voidf  130090000
20515010      .366    voidf  130100000
20515011      .183    voidf  130110000
20515012      .183    voidf  130120000
*
* rpv collapsed level
20515100  rpvlvl   sum  1.  0.  1
20515101  0.  .798    voidf  100010000
20515102      .753    voidf  110010000
20515103      .486    voidf  120010000
20515104      .382    voidf  140010000
20515105      .382    voidf  150010000
20515106      .688    voidf  160010000
20515107      .936    voidf  170010000
20515108      .936    voidf  180010000
20515109      .642    voidf  190010000
20515110      .642    voidf  190020000
20515111      1.  cntrlvar  150
*
.
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Pisa, Italy

*University of Genova
DITEC
Via all'Opera Pia 15a
16143 Genova, Italy

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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

The present document deals with the RELAP5/MOD3.2 analysis of the small break LOCA experiment SP-SB-04 performed in SPES facility. SPES is a PWR simulator (Integral Test Facility) installed at SIET center in Piacenza (IT). Volume scaling and core power scaling factors are 1/427, with respect to the Westinghouse 900 MWe standard reactor. The experiment is originated by a small break in the cold leg (2" equivalent break area in the plant) without the actuation of the high pressure injection system. The test starts from full power and is the counterpart of the test SP-SB-03, that started at an initial power roughly equal to 10% of nominal power. Low pressure injection system actuation occurs after core dry-out. The RELAP5 code has been extensively used at University of Pisa; the nodaliztion of SPES facility has been qualified through the application of the version RELAP5/MOD2 to the same experiment and another test performed in the same facility. Sensitivity analyses have been addressed to the influence of several parameters (like discharge break coefficient, time of accumulators start, etc.) upon the predicted transient evolution. Qualitative and quantitative code calculation accuracy evaluation has been performed.

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

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