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International Agreement Report

Post-Test-Analysis and Nodalization Studies of OECD LOFT Experiment LP–02–6 With RELAP5/MOD2 CY36–02

Prepared by
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Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

August 1992

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
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Abstract

Experiment LP-02-6 was conducted on October 3, 1983. It was the first large-break loss-of-coolant accident (LOCA) simulation and the fourth experiment at all conducted in the Loss-Of-Fluid-Test (LOFT) facility at the Idaho National Engineering Laboratory under the auspicies of the OECD. This experiment, which was designed to meet requirements outlined by the USNRC as specified in the OECD LOFT Project Agreement, simulated a double-ended off-set shear of a commercial pressurized water reactor (PWR) main coolant inlet pipe coincident with loss of offsite power. Experiment LP-02-6 addressed the response of a PWR to conditions closely resembling a USNRC "Design Basis Accident" in that prepressurized fuel rods were installed and minimum US emergency coolant injections were used.

This report presents the results and analysis of nine post-test calculations of the experiment LP-02-6 by using the RELAP5/Mod2 cy36-02 computer code with different nodalizations; these calculations have been performed within the International Code Assessment Program (ICAP). Starting with a "standard nodalization" as more or less used by the code developers at EG&G, we have reduced the number of volumes and junctions (especially in the pressurizer, the steam generator secondary side and the intact loop) as well as the number of radial zones in the fuel rods, for different nodalization studies.

Generally, the code has calculated most of the thermohydraulic parameters of the LOFT-experiment within an accuracy of approximately ±20%. For the cladding temperatures, these deviations are sometimes higher, but the code has never underpredicted the peak cladding temperatures significantly. Except for the cladding temperatures, only small discrepancies have been observed for the other main parameters of the results of runs using different nodalizations but reduced numbers of volumes and junctions usually have lead to a decreased running time for the problem.

The time behaviours of the cladding temperatures have been significantly affected by the choosen nodalizations. The most comparable results with the experimental data have been achieved by using a medium number of nodes.

With respect to high mass-flux, early bottom-up rewetting, one of the key-events of experiment LP-02-6 as well as of most of the other LOFT large break experiments, RELAP5/Mod2 was not able to predict this phenomenon except with a certain manipulation by initiating the reflood option.

Contents

1 Introduction **5**
1.1 Short Description of the LOFT Experiment LP-02-6 5
1.2 The Aim of the Present Investigations 8

2 Nodalization Schemes Used to Analyse Experiment LP-02-6 **10**
2.1 Standard Nodalization 10
2.2 Stripped Nodalisations 14

3 Results **21**
3.1 Experimental Results 22
3.2 Influence of the Nodalization on Computer Time and Mass Error 24
3.3 Discussion of the Code-Predictions of the Main Events 27
3.3.1 Calculation of Mass Flows in the Broken Leg 27
3.3.2 Minimum Collapsed Liquid Level 38
3.3.3 Emptying Points of Pressurizer and Accumulator 39
3.3.4 Peak Cladding Temperatures During the Blowdown Phase 39
3.3.5 Quench Front Positions During the Reflooding Phase 40
3.4 Time Behaviour of Significant Thermo-Hydraulic Parameters 41
3.4.1 Cladding Temperatures 41
3.4.2 Fuel Center Temperature 69
3.4.3 System Pressures 71
3.4.4 Fluid-Temperature in the Downcomer 71
3.4.5 Core Mass Flows 75
3.4.6 Core Average Liquid Fractions 78
3.4.7 Mass-Flow Out of the Broken Loop 82
3.4.8 Intact Loop Mass Flow and Pump Speed 85
3.4.9 ECC System 91
3.5 Investigation on the Prediction of Early Bottom-Up Rewetting 94

4 Conclusions **107**

5 Appendices **110**
5.1 References 110
5.2 Listing of RELAP5/Mod2 - Input Mk. 2-00C 112

List of Figures

1.1 LOFT components showing thermo-fluid instrumentation 6

2.1 Nodalization 2-00 of the LOFT system (most detailed version; 11
2.2 Detail of the nodalization of the LOFT core 13
2.3 nodalization 3-00 (3-005) of the LOFT-system 16
2.4 nodalization 3-02 of the LOFT system (most simplified version; 17

3.1 Measured cladding temperatures in center bundle 5 23
3.2 CPU-time to Real time ratio vs. time 26
3.3 Mass error as defined by RELAP5/Mod2 vs. time 28
3.4 Trip setpoints for experiment LP-02-6 29
3.5 Hot-channel cladding temperatures vs. time at axial level 02 42
3.6 Hot-channel cladding temperatures vs. time at axial level 11 44
3.7 Hot-channel cladding temperatures vs. time at axial level 21 45
3.8 Hot-channel cladding temperatures vs. time at axial level 24 46
3.9 Hot-channel cladding temperatures vs. time at axial level 27 47
3.10 Hot-channel cladding temperatures vs. time at axial level 31 48
3.11 Hot-channel cladding temperatures vs. time at axial level 39 49
3.12 Hot-channel cladd. temperatures vs. time at axial level 43.8 50
3.13 Hot-channel cladding temperatures vs. time at axial level 49 52
3.14 Hot-channel cladding temperatures vs. time at axial level 62 53
3.15 Average channel cladding temperatures vs. time at axial level 11 54
3.16 Averaged channel cladding temperatures vs. time at axial level 21 55
3.17 Averaged channel cladding temperatures vs. time at axial level 28 56
3.18 Averaged channel cladding temperatures vs. time at axial level 39 57
3.19 Axial cladding temperature distribution at time -1.2 s in hot channel 59
3.20 Axial cladding temperature distribution at time 5.3 s in hot channel 60
3.21 Axial cladding temperature distribution at time 40.5 s in hot channel 61
3.22 Calculated void fraction, flow regime and HTC (nodalization 2-00) 62
3.23 Calculated void fraction, flow regime and HTC (nodalization 3-005) 63
3.24 Calculated void fraction, flow regime and HTC (nodalization 3-02) 64
3.25 Calculated void fraction, flow regime and HTC (nodalization 2-00) 65
3.26 Calculated void fraction, flow regime and HTC (nodalization 3-005) 66
3.27 Calculated void fraction, flow regime and HTC (nodalization 3-02) 67

3.28 History of the fuel center temperature in the hot channel compared 70
3.29 System pressures in the cold leg vs. time compared with pressure 72
3.30 Pressures in the pressurizer vs. time compared with pressure 73
3.31 Downcomer fluid temperatures vs. time compared with 74
3.32 Mass fluxes into the hot channel of the core as calculated 76
3.33 Mass fluxes out of the hot channel of the core as calculated 77
3.34 Momentum fluxes into the hot channel of the core as calculated 79
3.35 Momentum fluxes out of the hot channel of the core as calculated 80
3.36 Core averaged liquid fractions vs. time 81
3.37 Calculated mass flows out of the broken cold leg vs. time 83
3.38 Calculated mass flows out of the broken hot leg vs. time 84
3.39 Calculated mass losses out of the double ended break vs. time 86
3.40 Calculated mass flows in the intact hot leg vs. time 88
3.41 Calculated mass flows in the intact cold leg vs. time 89
3.42 Calculated relative pump speed vs. time compared with 90
3.43 Calculated accumulator fluid levels vs. time compared with 92
3.44 Calculated accumulator pressure vs. time compared with 93
3.45 Calculated accumulator mass flows vs. time 95
3.46 Calculated LPIS discharges vs. time compared with the measurement 96
3.47 Comparison of cladding temperatures calculated by RELAP5/Mod2 98
3.47 Comparison of cladding temperatures calculated by RELAP5/Mod2 99
3.47 Comparison of cladding temperatures calculated by RELAP5/Mod2 101
3.47 Comparison of cladding temperatures calculated by RELAP5/Mod2 102
3.47 Comparison of cladding temperatures calculated by RELAP5/Mod2 103
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2 104
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2 105
3.49 Comparison of the fuel center temperatures calculated by RELAP5/Mod2 . . . 106

List of Tables

1.1 Initial Conditions for LOFT-experiment LP-02-6 7

2.1 Numbers of volumes, junctions, heat-structures and fine-meshes as well 18
2.1 ...cont. 20

3.1 RTM values in different intervals of the transient 25
3.2 Comparison of characteristic parameters inferred from experiment 30
3.2 ...cont. 31
3.2 ...cont. 32
3.2 ...cont. 33
3.2 ...cont. 34
3.2 ...cont. 35
3.2 ...cont. 36
3.2 ...cont. 37

Chapter 1

Introduction

1.1 Short Description of the LOFT Experiment LP-02-6

The LOFT facility at Idaho National Engineering Laboratory was designed to simulate the major components and system responses of a commercial PWR during a LOCA for the determination of system transient characteristics and for the assessment of code predictive capabilities for design basis large- and small break LOCAs in pressurized water reactors. The experimental assembly includes five major subsystems which have been instrumented such that system variables can be measured and recorded during LOCA simulation. The subsystems include the reactor vessel, the intact and the broken loop, the blowdown suppression system and the ECC systems; the arrangement of these major components is shown in Fig. 1.1. The entire nuclear core consists of five square and four triangular fuel bundles with a total of 1300 fuel pins each of 1.67m long and an outside diameter of 10.72 mm. A complete system description is given in ref.[1] and a discussion of the LOFT scaling philosophy is provided in ref.[2].

Experiment LP-02-6 was conducted on October 3, 1983, in the Loss-Of-Fluid Test (LOFT) facility at the Idaho National Engineering Laboratory. It was the first large-break loss-of-coolant accident (LOCA) simulation and the fourth experiment at all conducted in the LOFT facility under the auspicies of the OECD. This experiment, which was designed to meet requirements outlined by the USNRC as specified in the OECD LOFT Project Agreement, simulated a double-ended off-set shear of a commercial pressurized water reactor (PWR) main coolant inlet pipe coincident with loss of off-site power. Experiment LP-02-6 addressed the response of a PWR to conditions closely resembling a USNRC "Design Basis Accident" in that prepressurized fuel rods were installed and minimum US emergency coolant injections were used.

The experiment was initiated from conditions representative of those in a commercial PWR; they have been listed in table 1.

The transient was initiated by opening the quick-opening blowdown valves in broken loop hot and cold legs. Pressure decreased rapidly due to the blowdown, with saturated conditions being reached in the upper plenum at 0.05 seconds.

The primary coolant pumps were tripped manually and allowed to coast down, simulating loss of off-site power coincident with the LOCA.

The core flow reversed immediately after the initiation of the transient and fuel rod

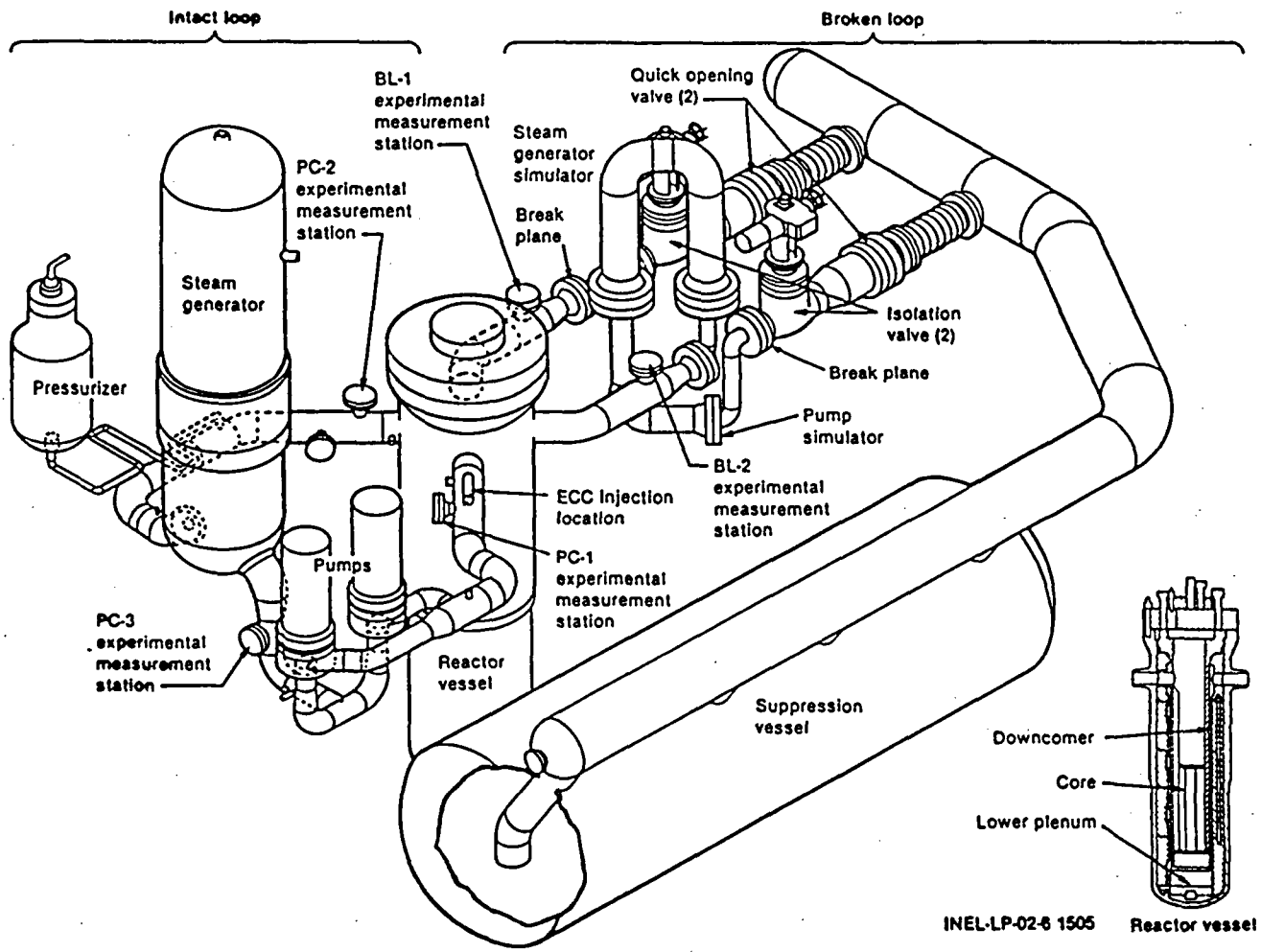


Figure 1.1: LOFT components showing thermo-fluid instrumentation

Initial Conditions for experiment LP-02-6		
parameter	unit	measured value
power	MW	46.0 ± 1.2
maximum linear heat	kW/m	48.8 ± 3.6
ΔT_{core}	K	33.1 ± 1.1
$\text{pressure}_{hot\ leg}$	MPa	15.09 ± 0.08
mass flow rate	kg/s	248.7 ± 2.6
fluid $\text{temperature}_{cold\ leg,intact\ loop}$	K	555.9 ± 1.1
fluid $\text{temperature}_{cold\ leg,broken\ loop}$	K	553.0 ± 6.0
fluid $\text{temperature}_{cold\ leg,broken\ loop}$	K	560.0 ± 6.0
pressurizer :		
liquid level	m	1.04 ± 0.04
pressure	MPa	15.3 ± 0.11
water temperature	K	615.6 ± 5.8
ECC system accumulator :		
liquid level	m	2.10 ± 0.0
standpipe position from bott.	m	1.44 ± 0.03
pressure	MPa	4.11 ± 0.06
liquid temperature	K	302.0 ± 6.1
ECC system HPIS :		
liquid temperature	K	305.0 ± 7.0
flow rate	l/s	1.04 ± 0.04
ECC system LPIS :		
liquid temperature	K	305.0 ± 7.0
flow rate	l/s	depending on pressure difference between LPIS and downcomer

Table 1.1: Initial Conditions for LOFT-experiment LP-02-6

cladding temperatures started to increase. This core-wide temperature increase continued until 4 seconds, when the flow in the broken cold leg saturated and choked with a concomitant decrease in mass flow to below the intact cold leg mass flow. During this period, cladding temperatures reached maximum values less than 1100 K; the maximum temperature has been measured on level 24 in the center bundle (24 inches from bottom, assembly 5) to 1040 K. The decrease in mass flow from the broken leg to below the intact cold leg mass flow reversed the reactor vessel mass loss and caused low quality fluid to flow into the core, causing a partial core bottom-up quench between 5.2 and 9.1 seconds, after which the core flow again reversed and the fuel rod cladding temperatures again increased; during this period maximum temperatures of less than 850 K have been reached. A partial core top-down quench occured starting at 14.8 seconds which extended down to level 39, i.e. 39 inches from the bottom of the core. This quench has been assumed to be caused by liquid fallback from the upper plenum induced by gravity.

The fuel rod cladding again experienced departure from nucleate boiling. There were additional thermal cycles prior to the final core quench, which was complete at 56 seconds. For more details see ref. [3].

One of the major concerns with Experiment LP-02-6 was whether fuel rod damage would occur. Based on the indicated cladding temperatures, the pressure differential across the cladding and the evidence from isotope detection systems, no fuel rod ballooning or cladding rupture occured.

A comparison of results of Experiment LP-02-6 with previous LOFT large break LOCA experiments L2-3 and L2-5 (the first with continous pump operation, the second with pumps disconnected from their flywheels) shows that the loss-of-offsite power-induced pump operation results in a core thermal response that closely matches that resulting from continued pump operation. That is, even though the pump is not powered during the early seconds of the blowdown, a typical pump coastdown results in sufficient pump head to cause a positive core flow and core quench during the early period of the blowdown.

1.2 The Aim of the Present Investigations

Codes like RELAP5/Mod2 and TRAC have been often used for the analysis of LOFT experiments and LOFT results have been extensively used to eliminate insufficiencies both in the codes themselves and the more plant-specific nodalization of the problem by comparing the predictions of the code with the real measurements. Therefore, one has to be aware of the fact that both the code and the LOFT-specific nodalization, normally used for pre- and post-test analyses, are somehow "LOFT-tuned" resulting in quite acceptable predicting capabilities.

To be sure of the code's predicting capability of abnormal situations in real power plants, two main conditions have to be fullfilled :

- the different models of the code have to be adequate for the problem
- the plant has to be nodalized adequately, such that main expected phenomena are simulated

For the verification and possibly also for the optimization of the different models of the code, comparisons of the results of "integral test" like LOFT may be not an appropriate

choice because possible deviations cannot be simply attributed to a specific model. Here, one should prefer the comparison with the results of "separate effect tests".

For the plant to be analysed an "adequate nodalization" is usually unknown and only some very rough criteria can be given to the code user. Consequently, the accuracy of a prediction may be strongly related to the "experience" of the user, a quite unsatisfactory conclusion.

To get a feeling, how the nodalization may influence the prediction of the code, Experiment LP-02-6 has been analysed with respect to the following questions :

- The general predicting capability of the code, i.e. how accurate the sequence of events of Experiment LP-02-6 is calculated by RELAP5/Mod2 cy36-02 in time and value, especially, if the code is able to predict the phenomena of bottom-up quenching during the blow-down phase of the experiment which has an important influence on the peak cladding temperature; in fact it limits the peak cladding temperature to a value of approximately 1000 K i.e. far away from the critical values.

- The influence of the nodalization (number of volumes, junctions and heat structures which describe the whole system) on the calculation, i.e. how the nodalization may influence the accuracy of the results obtained.

Therefore, in what follows, we shall analyse the LP-02-6 experiment by using the best estimate code RELAP5/Mod2 cy36-02 with different nodalizations of the LOFT system. Starting with a nodalization similar to the one used by the code developers at INEL (especially for the analysis of small break LOCAs) we shall reduce the number of volumes, junctions and heat structures in the primary loop of the LOFT system to nearly half whereas the entire vessel stays nearly unchanged to meet the requirements of the given experimental axial positions in the core region, especially for the cladding temperature measurements. We shall further investigate on the influence of the coast down behaviour of the pumps by using both the rapid coast down as used e.g. in the LP-LB-1 experiment and by imposing the pump speed of experiment LP-02-6 , as retrieved from the data tape.

Finally, we shall see, how the reduction of volumes and junctions will influence the computer time, needed to analyse the experiment, a question which is important from the financial point of view. On the other hand, in the framework of this contribution, no attempts will be made to improve models within the code.

Chapter 2

Nodalization Schemes Used to Analyse Experiment LP-02-6

The basis of all schemes of nodalization normally used for LOFT analyses are those developed at INEL for the RELAP5/Mod1 calculations of the small break Experiments LP-SB-1 to LP-SB-3. Similar schemes have been applied for the analyses of Experiement LP-SB-3 by Andreani and Grütter, ref. [4], as well as for all of the other LOFT post-test analyses initiated by the OECD- LOFT- Consortium and using RELAP5/Mod1 or -Mod2 codes.

This basic INEL LOFT nodalization scheme for the RELAP5/Mod1 as well as the -Mod2 code is divided in seven main parts which may be distinguished by their "capital component" numbers :

(1...) Intact Loop
(2...) Reactor Vessel
(3...) Broken Loop
(4...) Pressurizer
(5...) Steam generator, secondary side
(6...) ECC system
(7...) Containment (suppression tank)

Similar to our LP-LB-1 calculations (ref. [7]), the ECC systems, the containment and the reactor vessel remained quite unchanged for the different nodalizations discussed in due course, whereas the steam generator primary and secondary sides, the pressurizer as well as intact and broken loops have been undergone drastic reductions with respect to the initial number of volumes and junctions resulting in reduced computer time and simplification of the problem.

2.1 Standard Nodalization

Let us start with the "standard nodalization" (later on marked by 2-00...) which, compared to the above mentioned INEL-schemes, only has slightly modified to better meet the requirements of the large break experiment LP-02-6 , especially in the core region (Fig. 2.1).

The REACTOR VESSEL constists of the reactor core, of the intact and broken loops downcomer sections (volumes 200 to 210 and 270 to 280 respectively), the lower plenum (220 to 225) and the upper plenum with the vessel dome (240 to 260).

The REACTOR CORE itself has been modeled by three parallel channels, the average channel (230) subdivided into 5 hydrodynamic volumes, the hot channel (231)

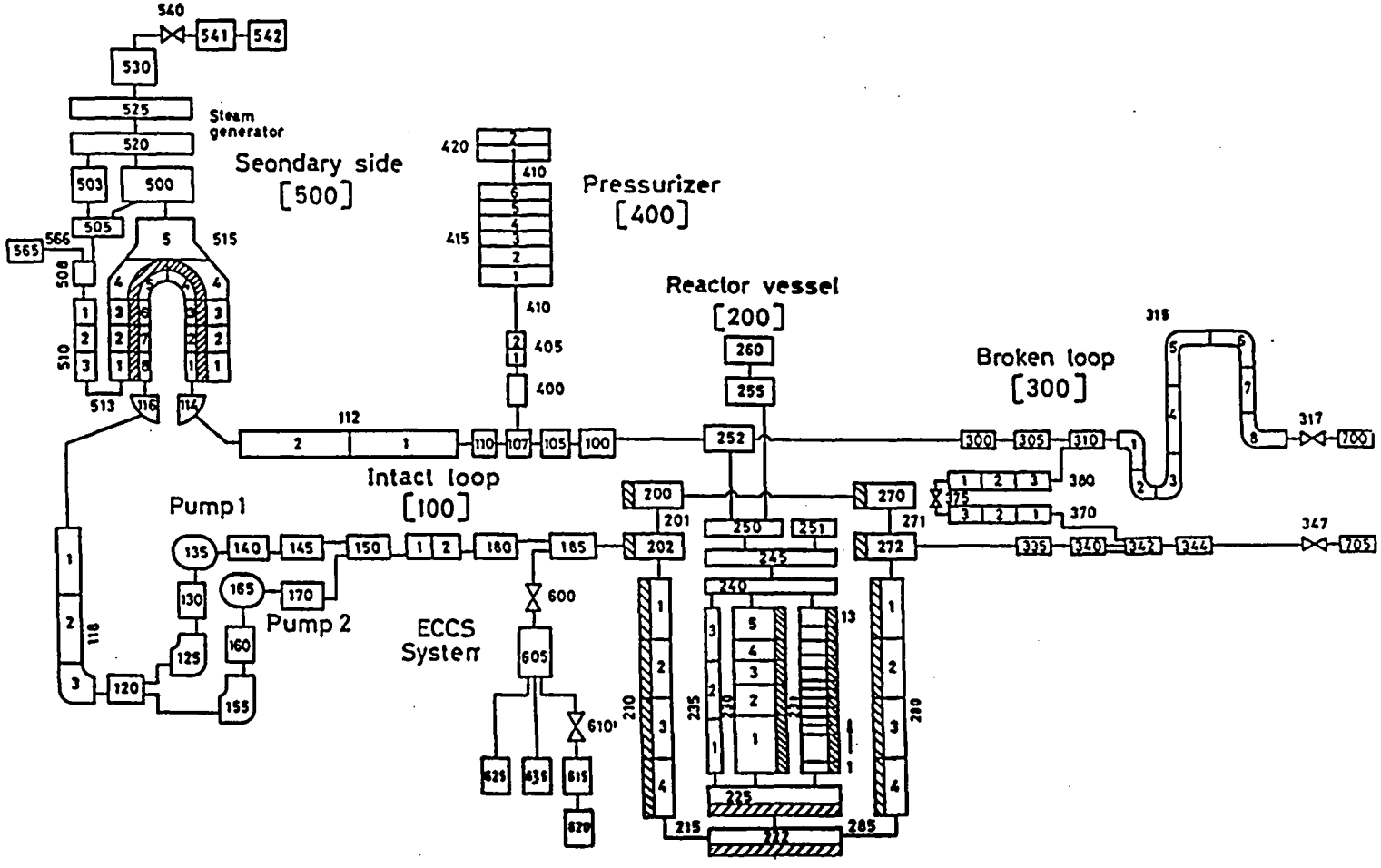


Figure 2.1: Nodalization 2-00 of the LOFT system (most detailed version; similar to EG&G nodalization)

subdivided into 13 volumes and the bypass channel (235) into three equally spaced volumes. In Fig. 2.2, a separate scheme illustrating the nodalization of the active core has been given. Here, the hydrodynamic volumes are not equally sized and they were dimensioned so that the "reference thermocouple location" (cladding temperature measurement indicated by arrows) are always located nearly in the axial center of the requested volume.

The hot channel represents the center part of the core (mainly fuel-assembly 5) and contains 219 pins, the remaining 1081 pins are assigned to the avergage channel. The axial linear heat flux distribution was choosen according to ref. [5].

The total mass-flow through the core is shared approximatly 79% by the average channel, 16% by the hot channel and the remaining 5% by the bypass. Note that the mass-flow distribution in the core region is somehow arbitrary. The choice of these values is based on the relation of the pin numbers associated with each of the channels (arbitrary!) minus the bypass flow which is again an estimated parameter. No crossflow has been assumed between the three channels, because preliminary runs using the crossflow option had shown that the amount of mass exchange in traverse direction remained negligible during the whole transient.

The fuel pins have been modeled by heat structures each radially meshed into 5 (average channel) and 10 nodes (hot channel) respectively. In the "average pin", one zone represents the cladding, one the gap and two the fuel. For the "hot channel", there are 3 cladding zones, one gap and 5 fuel zones. In case of reflooding, the code performs an axial finemeshing for better modelling the advancement of the quench front. The maximum number of allowable fine meshes has to be preset. Because the preliminary investigations using different mesh numbers did not show significant differences between the results of runs using different preset numbers (see ref. [7]), for the sake of saving computer time, we normally have used a low number of fine meshes, namely 4 in the average channel and only 2 in the hot channel for the calculations presented in this report.

The INTACT LOOP consists of 20 volumes with 2 or 3 subvolumes. As in the actual LOFT system, the pumping system is divided into two pump lines with two individual pumps numberd 135 and 165 respectively.
The ECC-injection is connected to the cold leg of the intact loop (volume 185). In addition to the usual ECC line valve (600), an supplementary control valve (610) has been inserted in the accumulator line to close this line when the accumulator is empty. This happens to be necessary in order to continue with the calculation. Probably due to the fact that the version RELAP5/Mod2 cy36-02 used for these calculations was not able to handle noncondensibles, the transient always was terminated by an **execution error** when the accumulator was just emptied and nitrogen was released into the system.

The STEAM GENERATOR consists of 8 volumes on the primary and 5 volumes on the secondary side. A simplified feed, backflow and steam separator modeling as well as a steam flow control valve and condensator unit complete the nodalization of the secondary side. The steam flow valve is controlled by a control logic which allows to keep the secondary side pressure constant. Heat is exchanged from the primary to the secondary side of the steam generator via the wall which is modeled by 8 heat structures each having 7 radial zones (8 nodes).

The PRESSURIZER is composed of the surge line (2 volumes) and the entire pressur-

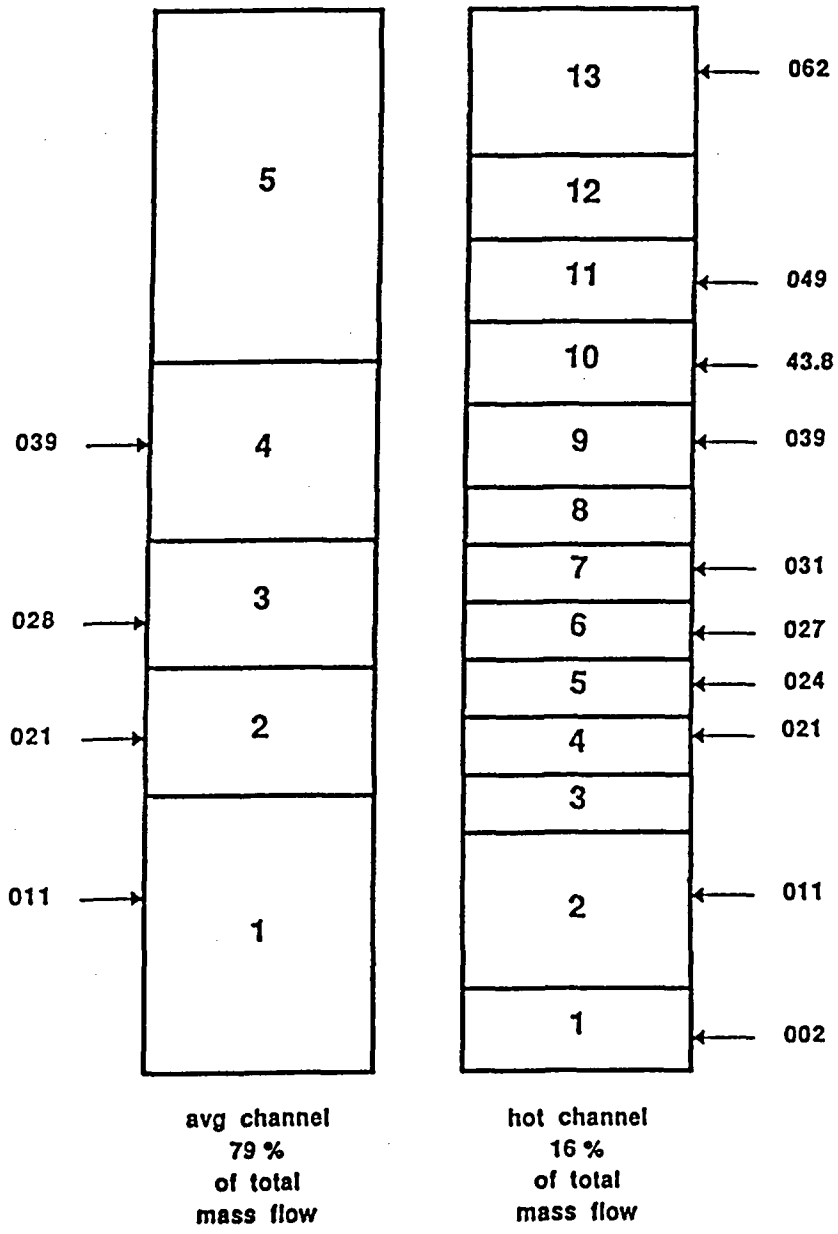


Figure 2.2: Detail of the nodalization of the LOFT core (average and hot channels)

izer. The latter is nodalised by a pipe component (6 subvolumes) which represents the main vessel, and another pipe (2 subvolumes) which describes the pressurizer dome.

The BROKEN LOOP consists of two individual lines. The hot line has been nodalised by 3 volumes (300 to 310) and one pipe component (315), representing the steam generator simulator. The cold line is consisting of 4 volumes (335-344). At the end of each lines, the two break-valves which have to be opened by a trigger signal are placed and connected with the suppression tank, modeled here by two time-dependent volumes (pressure is a function of time).
For preheating the broken loop, a bypass line exists between volumes 310 and 342. This bypass line has been nodalised by two pipe components. In our calculations, the connecting valve (375) remained always closed.

Not included in Fig. 2.1 are some additional control-valves and heat structures, especially for the pressurizer which are only neccessary for steady-state runs to force the system to a stable stationary solution at the desired thermal conditions like circulation mass-flow, core-inlet and core-outlet fluid temperatures, liquid level in the pressurizer, etc.

Because of the rather fast transient of a large break LOCA (the total duration of the transient is about 100 seconds), heat capacity effects of the piping walls, vessel walls and other structures in thermal contact with the coolant, may not play an important role. Consequently, for the sake of saving computer time, in the normal versions of nodalization, heat structures were used only for modeling the heat generation in the reactor core and for the heat transfer from the primary to the secondary side of the steam generator. For some runs, the influence of the heat capacity of the reactor vessel on the transient behaviour of the thermal-hydraulic parameters of interest has been investigated and therefore, some additional heat structures have been inserted in the downcomer and the lower plenum of the reactor vessel (heat-structures 200-210, 220, 222, 225 and 270-280); these runs are marked by an additional "C" to the nodalization number (e.g. 2-00C).

In contrary to LOFT-experiments L2-5 and LP-LB-1 where the main circulation pumps have been disconnected both from power as well as from their flywheels to enable rapid coastdown, in Experiment LP-02-6 the pumps have been switched of only but remained connected to their flywheels. This has led to a much slower coastdown of the pump-speed. To investigate the influence of the pump-speed (and consequently pump-head) on the accuracy of the calculations, in the Mk. 2-00 and 2-00C versions of nodalization we have allowed a rapid coastdown of the pumps similar to the L2-5 and LP-LB-1 experiments whereas for the 2-00PU and 2-00PU,C versions we have superimposed the time-dependent pump-speed curve as measured during the experiment; we have used the average value of the two individual pump speeds.

2.2 Stripped Nodalisations

To investigate the influence of reduced number of volumes and junctions on the accuracy of the analysis as well as on a probable saving of computer time, the number of junctions and volumes of the standard nodalization has been drastically reduced.

A scheme of the first stripped version, the nodalization 3-00, is shown in Fig. 2.3. The main changes have been made in the pressurizer, the intact- as well as in the broken loops and on the secondary side of the steam generator, whereas the reactor vessel and the ECC-system remained nearly unchanged.

With respect to nodalization 2-00, the REACTOR CORE remained nearly unchanged. The nodalization differs only in the maximum number of allowable fine meshes during reflooding; this number has been increased from two to eight in the hot and from four to 16 in the average channels.

The INTACT LOOP now mainly consists of three pipe sections (110, 120 and 150 with four, seven and six subvolumes respectively), only one pump component instead of two (but of course, with the same pump-head) and a steam generator primary side with six instead of the previous 8 subvolumes.

The BROKEN LOOP consists of only two pipe systems (310 and 330) with 11 and 4 subvolumes respectively. Since the bypass-valve (see component 375 in Fig.2.1) is always closed, in this stripped version of nodalization, the whole bypass-line has been omitted. Consequently, possible mass and heat capacity effects in this line are neglected.

The whole PRESSURIZER system (vessel and surge-line) has been reduced to one pipe component with four subvolumes only.

The SECONDARY SIDE of the steam generator and the attributed system has been undergone drastic reductions. In principle, the steam generator has been turned into a simple heat exchanger with single-phase flow on the secondary side. The flow is simply controlled by a time-dependent junction (566) and dumped into an outlet volume (542). To maintain correct primary side inlet and outlet conditions, the mass flow has been adjusted to quite higher values than for the real steam generator conditions where the evaporation of the water is the main heat sink.

The wall between the primary and secondary side of the steam generator has been modeled by six heat structures each radially divided by three zones.

A derivative of nodalization 3-00 is the version 3-005 which differs from it in having a higher number of allowable fine-meshing during reflooding, namely an increase from 4 to 16 for the average and from 2 to 8 for the hot channel. The additional version 3-005T is identical to the version 3-005 except that the reflood option of the code is initiated externally; we shall come to this feature in due course.

The reduced nodalization 3-00 can be stripped even more by simply reducing the subvolumes of each of the pipe components; for the pipe 110 to two, for pipe 120 and 310 to three and for pipe 150 and 330 to only one subvolume each. The nodalization of the steam generator has been reduced to only two on both sides but the radial meshing of the related heat structures remained at three nodes (fig. 2.4).

The maximum number of fine meshes of the heat structures of the core during reflooding has been reduced again to two in the hot and to four in the average channels. This very much reduced nodalization is called 3-02.

Except version 3-005T, the stripped versions have been used with and without heat capacity contribution in the vessel component, as described above. For all stripped down versions of nodalization, the time dependent pump speed has been used.

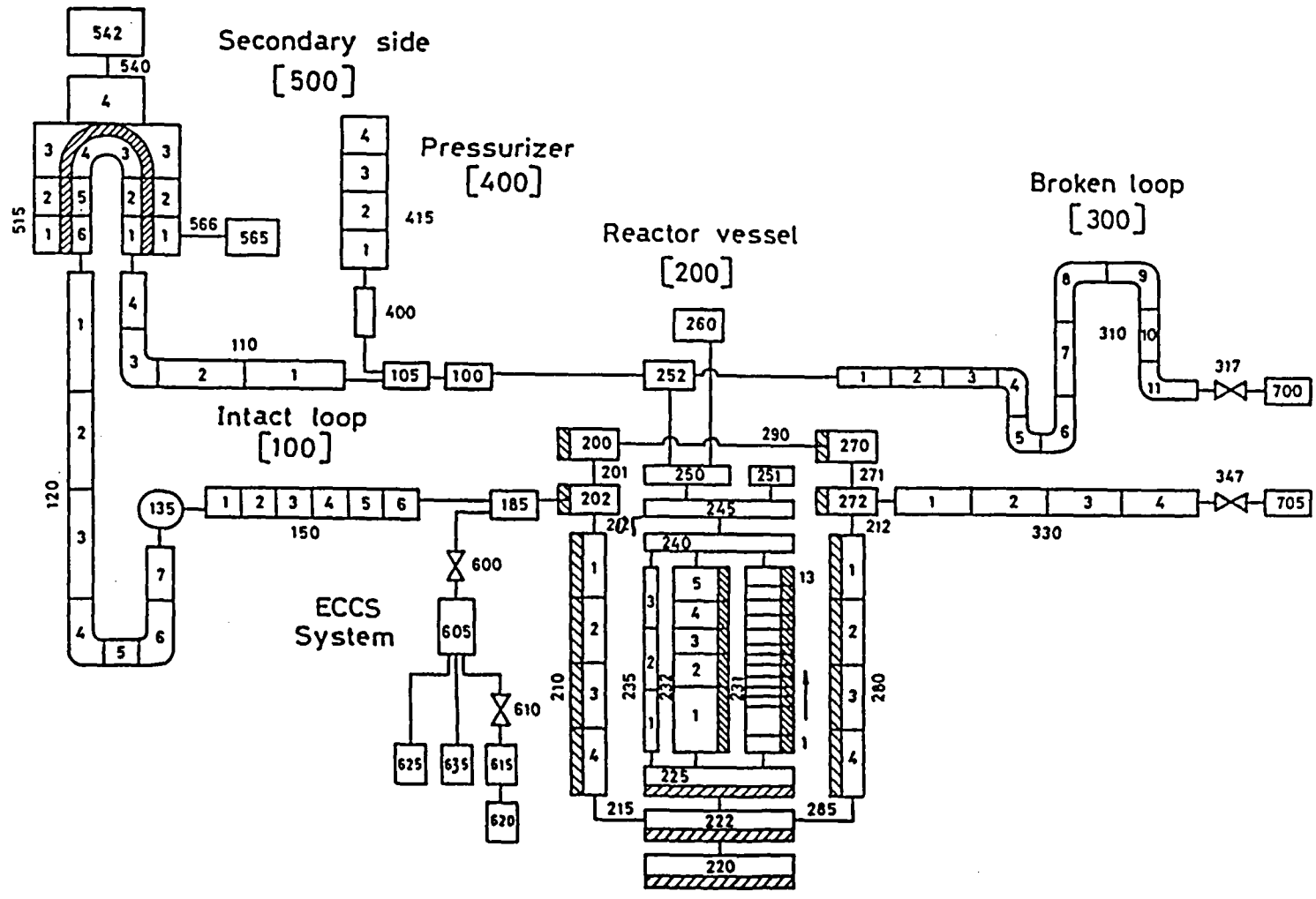


Figure 2.3: nodalization 3-00 (3-005) of the LOFT-system
(simplified nodalization;core remained unchanged)

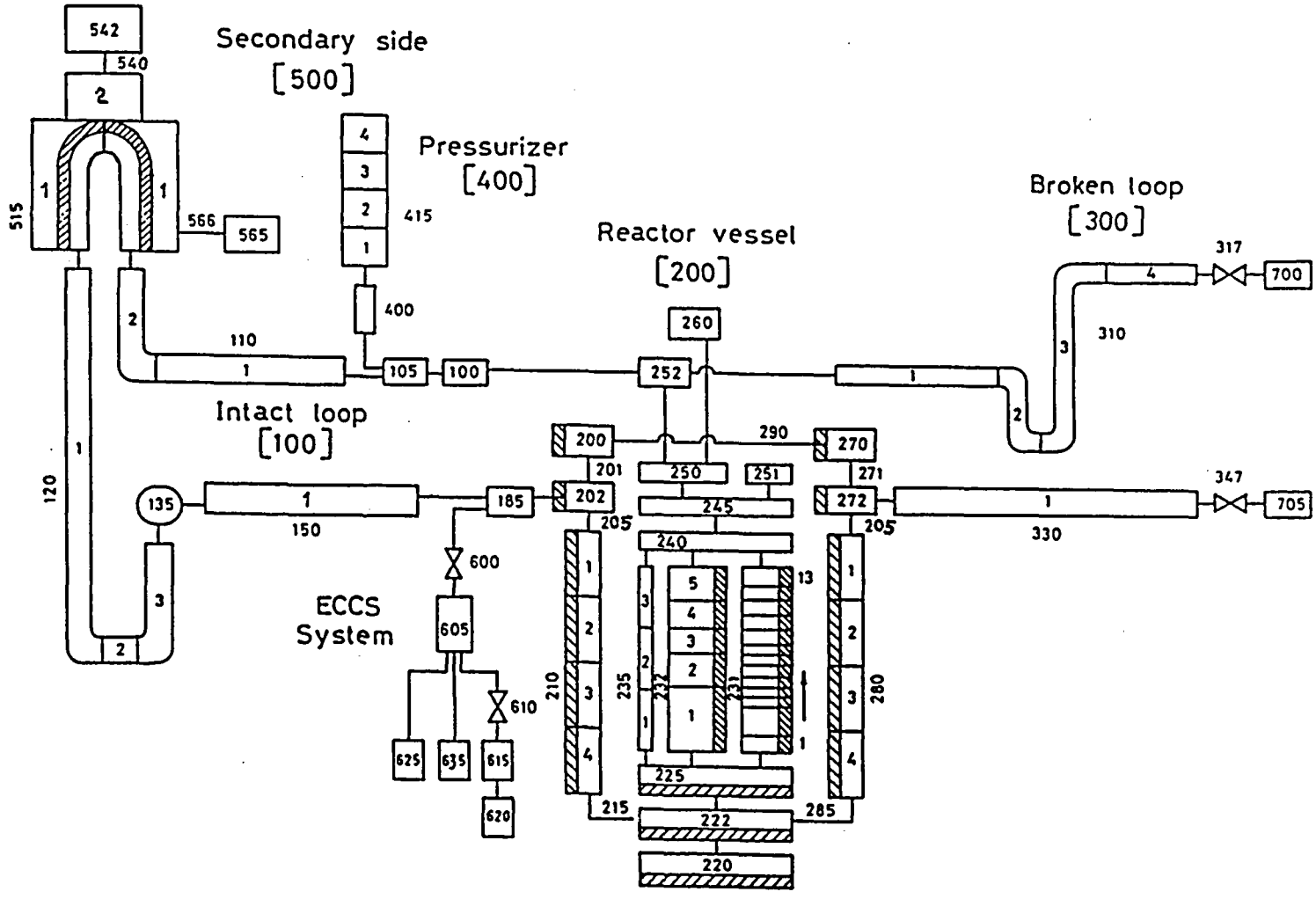


Figure 2.4: nodalization 3-02 of the LOFT system (most simplified version; core remained unchanged)

NAME	HYDRODYNAMICS						HEAT STRUCTURES		RTM0
	number of volum.	number of junct.	primary side mass to	primary side volume m^3	secondary side mass to	secondary side volume m^3	number struct./ meshp.	number finemesh avg/hot	
2-00 [1]	133	139	6.8	9.9	2.3	11.4	26/219	4/2	26.2
2-00C [2]	133	139	6.8	9.9	2.3	11.4	41/296	4/2	27.6
2-00PU [3]	133	139	6.8	9.9	2.3	11.4	26/219	4/2	25.0
2-00PUC [4]	133	139	6.8	9.9	2.3	11.4	41/296	4/2	28.9
3-00 [5]	101	103	6.6	9.6	1.6	1.9	24/173	4/2	(32.3) [6]

Table 2.1: Numbers of volumes, junctions, heat-structures and fine-meshes as well as the resulting Real-Time-Multiplier RTM

[0] $RTM0 = [CPU(t_{end}) - CPU(t_{begin})]/[t_{end} - t_{begin}]$
[1] Rapid pump coastdown similar to experiment LP-LB-1
[2] Rapid pump coastdown similar to experiment LP-LB-1
[3] Pump-speed is controlled by table inferred from LP-02-6 experimental data
[4] Pump-speed is controlled by table inferred from LP-02-6 experimental data
[5] Reduced number of volumes in intact loop, broken loop and pressurizer
[6] Abnormal termination of this calculation at 52.051 s of the transient just before accumulator has been nearly emptied. RTM0 only takes into account 52 seconds of the transient. (results of this calculation only partially have been used in this report)

NAME	HYDRODYNAMICS						HEAT STRUCTURES		RTM0
	number of volum.	number of junct.	primary side mass to	primary side volume m^3	secondary side mass to	secondary side volume m^3	number struct./ meshp.	number finemesh avg/hot	
3-005 [7]	101	103	6.6	9.6	1.6	1.9	24/173	16/8	21.1
3-005T [8]	101	103	6.6	9.6	1.6	1.9	24/173	16/8	21.1
3-00C	101	103	6.6	9.6	1.6	1.9	39/248	4/2	21.8
3-02 [9]	74	76	6.6	9.6	1.6	1.9	20/161	4/2	13.7
3-02C	74	76	6.6	9.6	1.6	1.9	35/236	4/2	(24.5) [10]

Table 2.1: ...cont.

[7]Same as 3-00 but number of fine meshes increased from 2 to 8 (hot) and 4 to 16 (avg.)

[8]Same as 3-005 but with reflooding option tripped by level dependent external trip (fluid level in channel less than 0.1 m)

[9]Same as 3-00 but with even more reduced number of volumes and juctions in the intact and broken loops as well as on the steam generator secondary side

[10]Abnormal termaination after 42 seconds of the transient due to "water property error" (RTM0 only takes into account 42 s)

Finally, in table 2.1, characteristic parameters of the different nodalizations (e.g. number of volumes, junctions and heatstructures, mass inventory of primary and secondary sides as well as the corresponding system volumes) used for this study have been listed. Included in table 2.1 are the average "Real-Time-Multipliers" RTM0 which are the quotient of the CPU time (on a CYBER-855 machine) divided by the duration of the analyzed transient; the RTM0 should illuminate the effect of nodalization from the economical point of view.

Chapter 3

Results

Starting from thermal-hydraulic conditions very close to the ones given in table 2.1, total of ten calculations of the LOFT-experiment LP-02-6 each lasting 120 seconds have been performed using the code RELAP5/Mod2 , cy36-02 with different nodalization schemes described in chapter 2.

In our understanding, with respect to reactor safety one set of "key-parameters" of a large break calculation are mainly the time behaviours of the cladding temperatures at different axial positions (peak temperature, as well as the duration of being over a certain temperature level, which may cause partial zircaloy- water reaction) and with minor importance the peak fuel temperatures. Because the reactor was scrammed after a very short time from the initiation of the experiment, the center fuel temperatures seldom exceed the values of normal operation at full power. Consequentely, we shall focus on the time behaviour of the cladding temperatures. But even a satifactory aggreement between the experimental and the calculated cladding temperatures or between other significant parameters of the experiment like pressures densities or mass-flows should not automatically lead to the conclusion that the code predictions are accurate and RELAP5/Mod2 perfectly has done its job. Because one may argue that the code has given "right answer for the wrong reasons", i.e. a satisfactory calculation of the time behaviour of the cladding temperatures could be the result of an "optimized summation" of individual errors. Therefore, one has to look carefully if the code has accurately described the main phenomena occuring during the experiment. Consequentely, one has to investigate in detail the time traces of the other thermal-hydraulic parameters of importance as well.

In what follows, we would like to start with some words on the updating of the experimental data especially on the averaging process of some temperature traces and of the power (neutron flux data).

The discussion of the results of the calculations we shall start by looking at the influence of the nodalizations on computer time and mass errors.

Second, we shall discuss the capability of RELAP5/Mod2 to predict significant events of the experiment like peak cladding temperatures (value and time of their occurence), the time when pressurizer and accumulator empties as well as the positions of the quench front during the reflood period of the experiment.

Third, we shall analyse additional thermal-hydraulic parameters of the LOFT-plant as given by RELAP5/Mod2 , starting with the time behaviour of our "key parameters"

(cladding and center fuel temperatures) and we shall compare these results with the corresponding data of Experiment LP-02-6 , if available.

Finally, in a separate section, we shall investigate on the question of how the code has modeled the bottom up quench occuring during experiment between five and ten seconds of the transient. This early bottom-up quench has had a very important influence on the time behaviour of the cladding temperatures because it has limited their peak values to temperatures not higher than 1000 K at the hot spot during both the blowdown and the refill phases.

3.1 Experimental Results

The experimental results have been retrieved from the LOFT-transmittal tape. For most of the experimental values only one set of data is available except for the temperature data in the core region, the neutron flux and a few other variables.

The uncertainty of most of the experimental data can be found in table VI of the "Transmittal Tape Description" (ref. [9]). We have used the values listed there for giving the respective transducer uncertainties on each individual plot, if possible.

No problems occur when averaging the four power channels to get the instantaneous power trace of the reactor. But difficulties may occur in using the surface temperature traces at the different core heights of the "hot bundle" 5, only when these values are averaged. In Figs. 3.1a and 3.1b, the temperature traces of all the available thermocouple signals at one specific level have been plotted for level 27 (27 inches from the bottom of the core) and for level 31. We have selected these two examples because at level 27 the highest surface temperatures have been measured during the experiment, whereas the code predicted the highest temperatures at level 31.

In Fig. 3.1a, the traces of 10 thermocouple signals at core level 27 have been plotted. Whereas six of them behave quite similar, the other four have undergone additional heat-up and quench cycles which would lead to a lower "average temperature". When computing the "reference temperature", we have omitted these four signals; the resulting reference temperature is indicated by squares. In addition to their different time behaviour, the thermocouples have indicated different peak cladding temperatures during the blowdown interval of the experiment, the temperatures ranged from about 930 to 1070 K. All thermocouples have quenched for the first time nearly at the same time due to the bottom-up reflooding, nearly 8 seconds after opening of the break valves.

In Fig. 3.1b, the time behaviour of the seven thermocouples at level 31 have been plotted. Again, at least two of these sensors have indicated cyclic heat-ups in the time interval between 10 and 50 seconds. The variation of the different peak cladding temperatures ranges only about 65 K (935 K to 1000 K). All thermocouples at this core height indicated quenching at nearly the same time during the bottom-up reflooding, namely between 7 and 8 seconds. With one exception, also the final quench occured at nearly the same time; the average temperature out of the 5 similar thermocouple signals (the two "cyclic" ones have been omitted) has been indicated by uparrows and is used as reference temperature.

In addition to the problem of averaging, the uncertainty of the temperature measurement itsself is not fully established yet. Because the thermocouples of the LOFT facility were surface mounted ones, there are still some

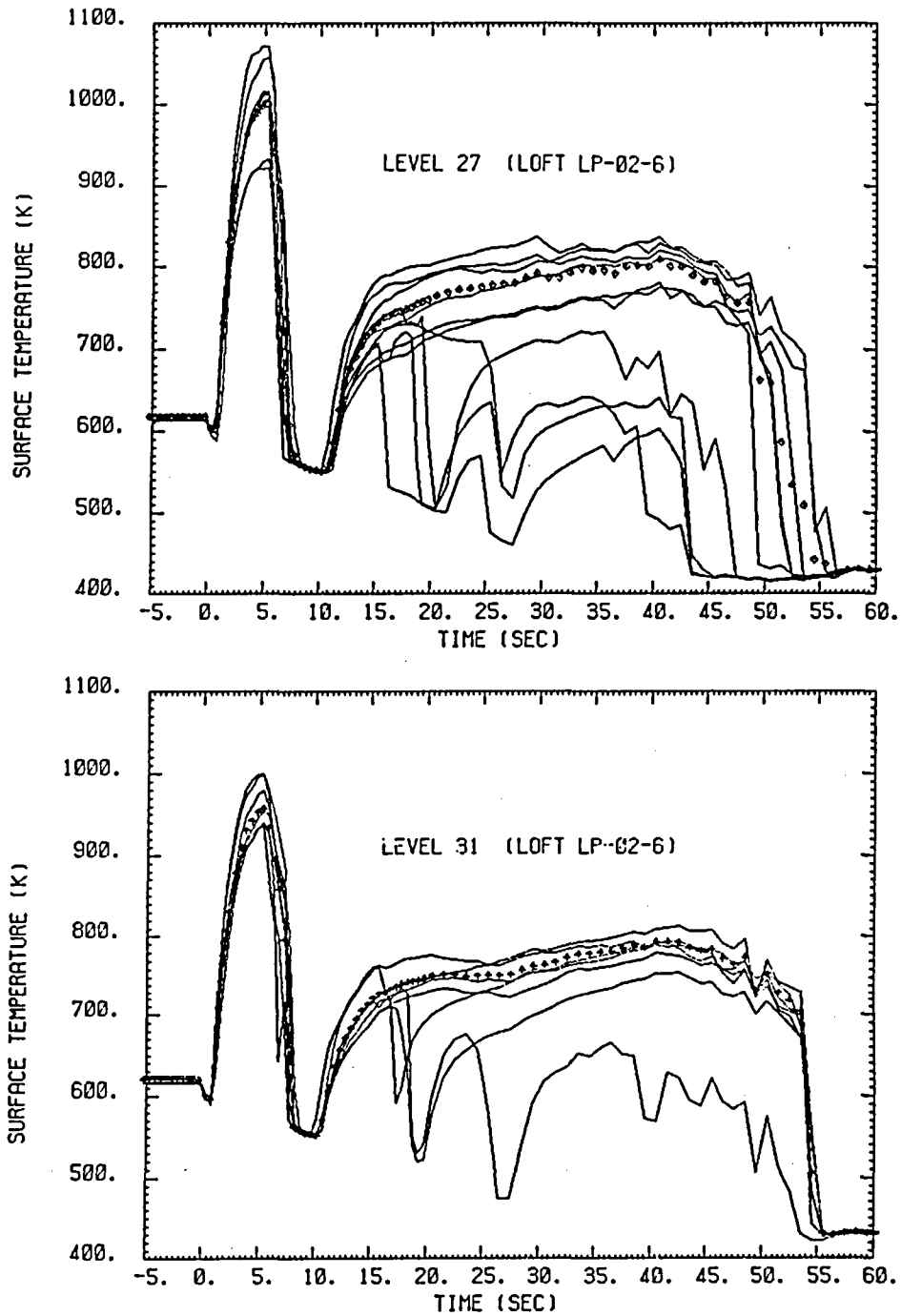


Figure 3.1: Measured cladding temperatures in center bundle 5
(averaged values (symbols) used as reference)
a.) at axial level 27
b.) at axial level 31

doubts whether these thermocouples always measure the temperature of the sourrounding cladding material and are not quenched in advance by impinging water (ref. [10]).

3.2 Influence of the Nodalization on Computer Time and Mass Error

Starting with the influence of the nodalization on the computer time and disregarding the accuracy of the predictions themselves for the present, a first look to the RTM0s in table 2.1 will lead to the conclusion that a severe reduction of the number of volumes and junctions will usually lead to a significant decrease of the computer time consumption, e.g. the comparison between cases 2-00C and 3-02 indicated a reduction of nearly 20%.

A more detailed anlaysis of the computer time needed to analyse the LOFT LP-02-6 experiment is shown in table 3.1. Here, the transient times have been subdivided into nine time intervals, the stationary part from -10 to zero seconds, the initial blowdown part (zero to 1 s) two entire blowdown parts (1 to 5 s) and (5 to 25 s), three reflood intervals (25 to 30 s), (30 to 40 s) and (40 to 60 s) with the starting sequence of the Emergency Core Cooling System (ECCS) during the first of these intervals (i.e. the feed of cold water out of the accumulator, the Low Pressure Injection System (LPIS) and the High Pressure Injection System (HPIS) into the saturated fluid of the intact loop) and finally a more stationary interval (60 to 120 s).

The reduction of the computer time due to a reduction of volumes, junctions and heat structures became mostly significant within the first and the last two time intervals, i.e. in the more or less stationary part of the transient; in addition, also the interval immediately after the opening of the break where the scram of the reactor has taken place is characterized by a rather low consumption of computer time.

The relatively low RTM-values during the more or less stationary parts of the transient have been somehow compensated during the second blowdown (5 to 25s) and the first and second reflood interval (25 to 40 s) where large number of numerical instabilities may occur due to a great degree of thermodynamic non-equilibrium in the intact cold leg and downcomer region mainly caused by the injection of cold water of the ECC system into the saturated fluid inside the intact cold leg.

A visualization of the table 3.1 has been presented in figs. 3.2a and 3.2b where the RTM-values for the different nodalizations have been plotted versus the experimental time.

In Fig. 3.2a, the RTM values are shown for the case of all the nodalizations which are not taking into account heat capacity effects (normal nodalization). One easily recognizes very strong instabilities of all the calculations in the interval 30 to 60 seconds probably due to high non-equilibrium of the two-phase flow i.e. due to cold water injection out of the accumulator into the saturated flow of the intact loop cold leg. High non-equilibrium leads to the above mentioned relatively high RTM-value in this interval of the transient. The overall benifits of the simplified versions of nodalization can well be noticed in the time regions -10 to 30 seconds and 70 to 120 seconds.

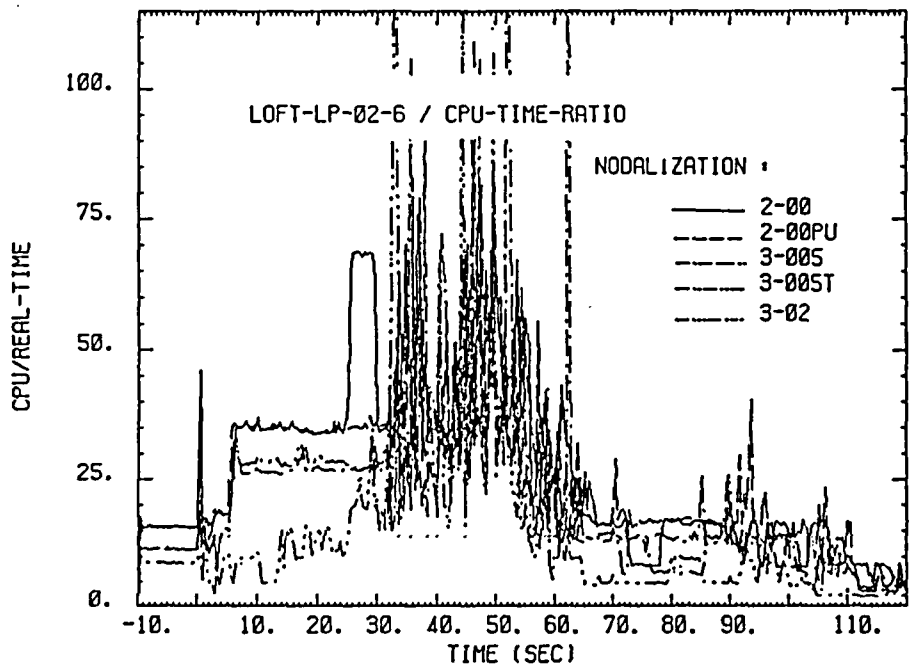
In Fig. 3.2b, the RTM-values for all the C-versions have been plotted (i.e. the versions of nodalization where the heat capacity effects of the wall material of the vessel have been taken into account). Here, compared to

$RTM_{interval} = [CPU(t_2) - CPU(t_1)]/[t_2 - t_1]$ (computer : CYBER-855)

Time interval	Nodalisation									
	2-00	2-00C	2-00Pu	2-00PUC	3-00	3-005	3-005T	3-00C	3-02	3-02C
-10 - 0	17.6	18.1	17.6	18.2	12.7	12.9	12.9	13.1	9.7	10.1
0 - 1	13.8	14.2	13.8	14.0	9.7	10.3	10.5	10.5	8.9	9.3
1 - 5	17.7	21.1	17.9	18.8	19.6	12.8	12.8	13.1	7.1	7.6
5 - 25	34.5	36.9	34.7	36.2	26.9	27.0	28.6	29.4	10.5	12.5
25 - 30	62.4	67.3	34.0	39.0	28.5	26.3	26.1	28.9	21.2	27.6
30 - 40	43.0	43.5	39.4	55.0	33.2	35.2	32.4	31.2	34.4	31.5
40 - 60	43.3	42.2	42.9	47.6	—[1]	40.2	35.9	38.4	32.5	—[2]
75 - 120	12.4	13.7	13.2	15.7	—	10.2	9.6	11.5	5.2	—
-10 - 120	26.2	27.6	25.0	28.9	(32.3)	21.1	19.9	21.8	13.7	(24.5)

[1] Abnormal termination of transient after 52.1 s due to water property error
[2] Abnormal termination of transient after 40.7 s due to water property error

Table 3.1: RTM values in different intervals of the transient



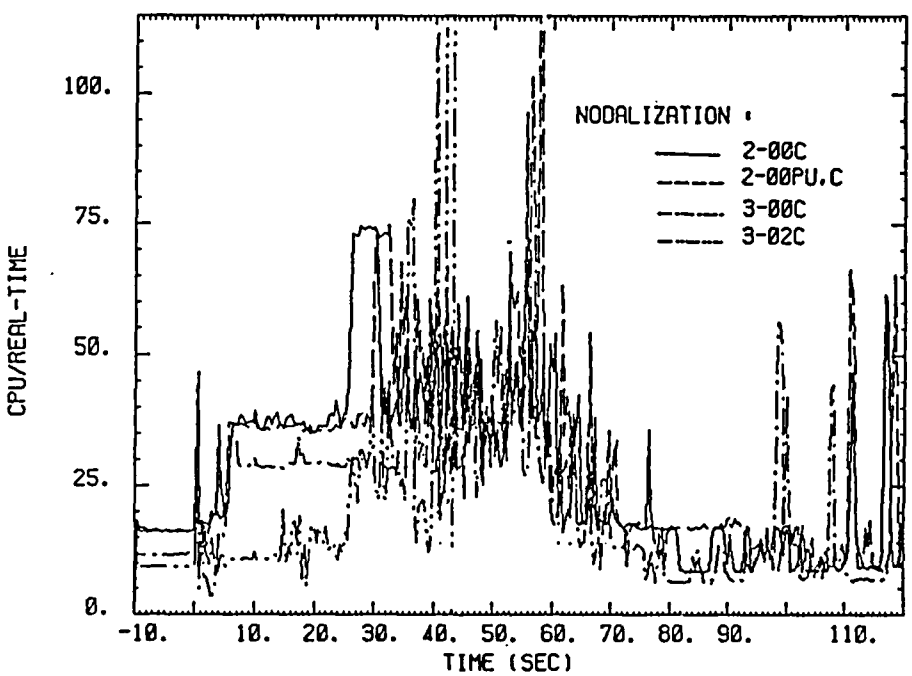


Figure 3.2: CPU-time to Real time ratio vs. time
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

fig. 3.2a, the large number of oscillations in the region of 30 to 60 seconds are somehow slightly dampened.

In both plots, the very narrow first peaks at nearly zero seconds are probably due to the thermodynamic non-equilibrium during the subcooled blowdown phase which only lasted some hundreds of milliseconds after the opening of the break valves.

A second basic criteria for the quality of a certain nodalization is the "mass error" which is a measure for the numerical accuracy of the code because it represents a check of the mass balance in all of the system volumes. Therefore, in Figs. 3.3a and 3.3b, the mass errors have been plotted versus the experimental time for all the calculations using different nodalizations, refered to in table 2.1. In general, quantitatively no significant differences have been found between the results with the normal and the "C" nodalizations. The absolute value of the mass error never exeeded values of 1.4 kg and for most of the transient time remained less than 0.6 kg. In any case, because the total mass inventory of the LOFT system is in the order of 7 tons, a "numerical loss" of not more than two kilograms is negligible.

3.3 Discussion of the Code-Predictions of the Main Events

Before starting the discussion of the performance of RELAP5/Mod2 in calculating the main events of the experiment, first, in Fig. 3.4, a graphic representation of the main trip setpoints has been plotted where a value of nearly one indicates that the trip is set. The scheme divides the experiment in several characteristic sections. Shown here are the settings of the break valves, which opened at zero seconds, the power-trip at 0.13 seconds (difficult to distinguish from the break valve line) and the pump-trip at 0.63 seconds. The behaviour of the ECC-system is indicated by the —...— line. For the accumulator, its value is 0.4, for LPIS 0.35 and for HPIS 0.25. The accumulator started injection at 17.5 seconds, followed by HPIS at 21.8 seconds (trip value 0.65). Finally, the LPIS has started at 34.8 seconds (trip value equals 1). The trip curve falls back again to 0.6 when the accumulator has emptied at nearly 58 seconds (the exact time is slightly depending on the nodalization of the problem) and LPIS and HPIS remained functioning.

In Table 3.2, some main events have been listed and their occurence during the experiment (time and value) have been compared to the equivalent code results using the different nodalizations as given in table 2.1. The setpoints of the different trips are again listed in table 3.2. First, one should notice that in contradiction to the experiment where both the reactor power and the accumulator injection have been initiated by an actual pressure- dependent setpoint, for the calculation we have used a time-dependent setpoint retrieved from the experiment thus avoiding a multiplication of errors (if the pressure is predicted wrong, this error will heavily influence the predictions of the other parameters in the following time sequences).

3.3.1 Calculation of Mass Flows in the Broken Leg

We start our comparison with the broken loop and have to look at the peak mass-flow rates as well as at the end of the subcooled break flows in the hot and cold legs.

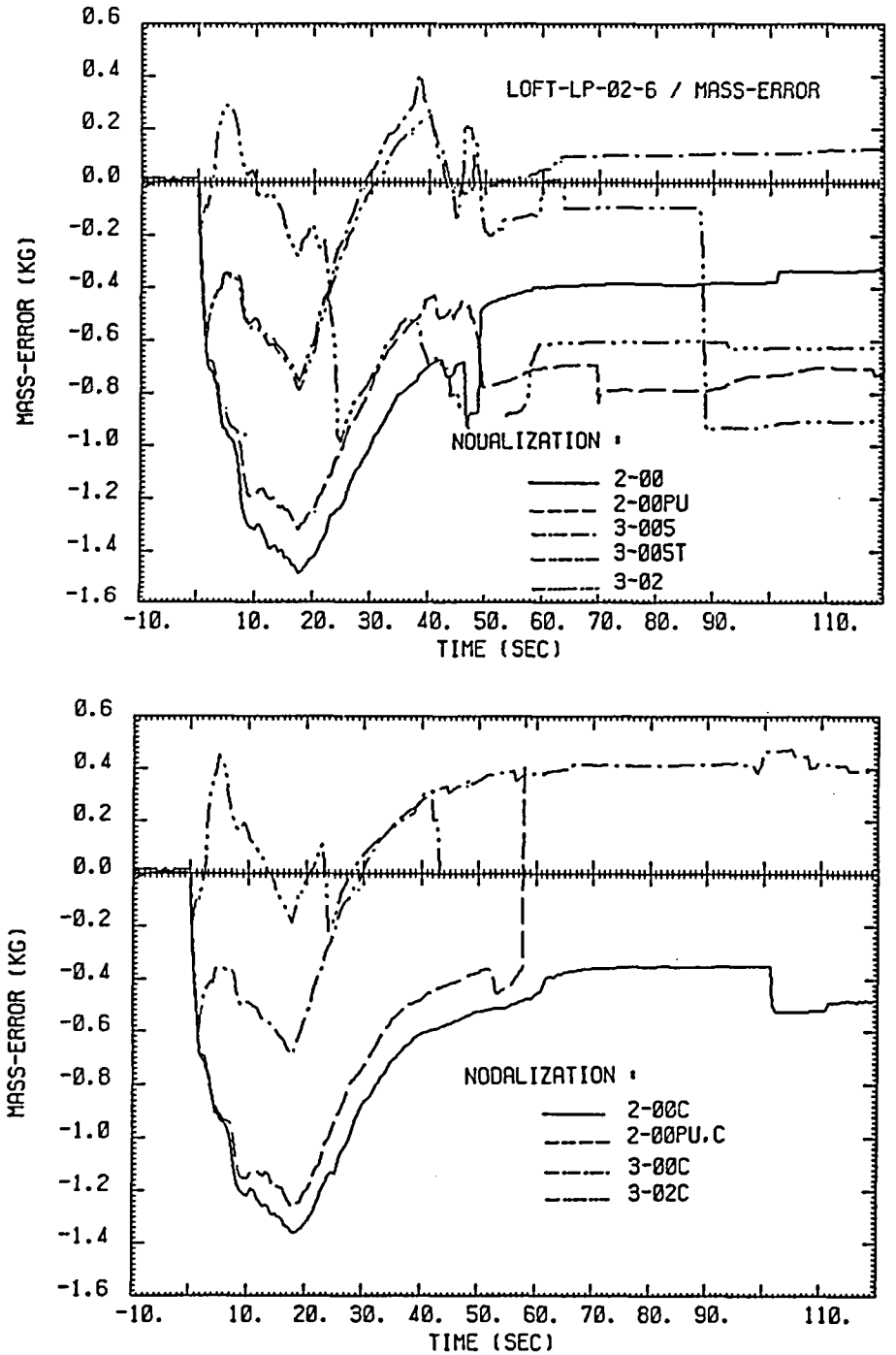


Figure 3.3: Mass error as defined by RELAP5/Mod2 vs. time
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

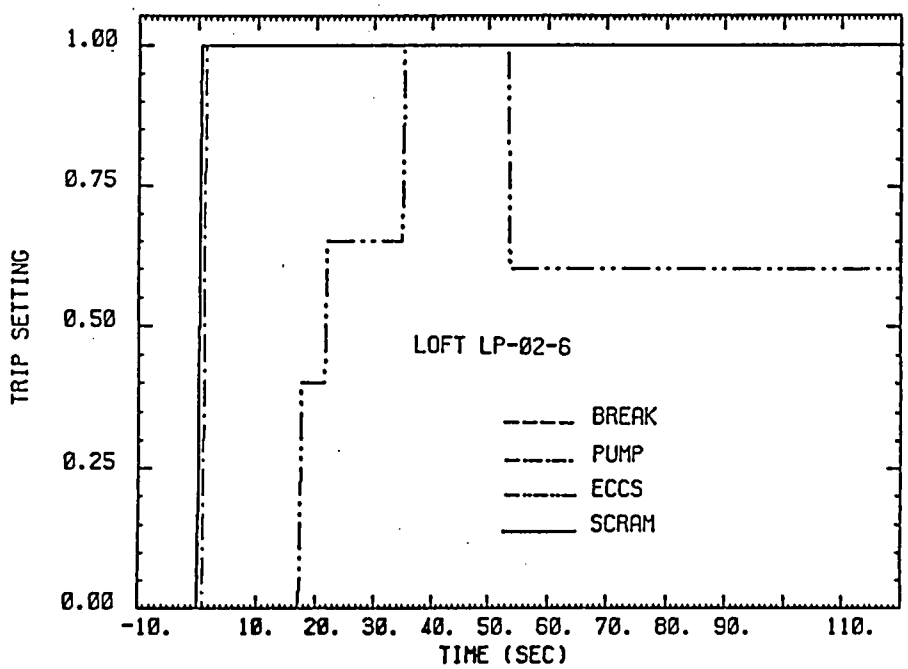


Figure 3.4: Trip setpoints for experiment LP-02-6

For all of the different runs, the end of the subcooled break flow in the hot leg lies between zero and one second. In the cold leg, the end of subcooled break flow occurs between 3.0 and 4.2 seconds, slightly depending on the selected nodalizations; the smallest values have been predicted by the 3-02 nodalizations where the cold leg is represented by only one single volume thus invalidating a correct positioning of the measurement station.

For all the nodalizations, the peak value of the mass-flow has occured at the first printed time step after initiation of the transient (0.4 s) and has to be compared to a reference value measured at 0.25 seconds of the transient. All the nodalizations except 3-02 and 3-02C produce very similar peak values of 562 kg/s from the cold leg and 166 kg/s from the hot leg which are quite close to the measured values of 550 kg/s for the cold leg and 193 kg/s for the hot leg. It should be noted that the most detailed versions 2-00, 2-00C, 2-00PU and 2-00PU,C indicated only 124 kg/s. Even for the nodalizations 3-02 and 3-02C with their strongly simplified piping in the intact and broken loops, the peak values for the cold leg is in quite good aggreement with the experimental data (573 kg/s) whereas this value for the hot leg is about 50% higher than in all the other runs (290 kg/s).

As a general trend, it can be observed that a simplification of the piping of the broken loop tends to give higher predictions of the peak break flows, especially in the hot leg. The most complex 2-00 nodalization underpredicted the peak values about 30% whereas the most simplified 3-02 versions overpredicted it about 50%. On the other hand, one has to keep in mind that two-phase flow mass flow measurements both under stationary and transient conditions are increasingly difficult tasks because the mass

Table 3.2: Comparison of characteristic parameters inferred from experiment with equivalent RELAP5/Mod2 -results of different nodalizations

EVENT	Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS									
				2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
Blowdown valves open	T	s	0.0	set by time trip									
Reactor scrammed [1]	T	s	0.13	set by time trip									
Stop coolant pumps	T	s	0.8	set by time trip									
Start accumul. inject. [2]	T	s	17.5	set by time trip									
Start HPIS	T	s	21.8	set by time trip									
Start LPIS	T	s	34.8	set by time trip									
End of subc. break flow													
cold leg	T	s	3.25	4.2	4.2	4.2	4.2	4.2	3.0	4.2	4.0	4.2	3.0
hot leg	T	s	0.75	0.3	0.3	0.6	0.6	0.6	1.0	0.2	0.2	0.6	1.0
Peak mass flow													
broken $loop_{cold\ leg}$ [3]	T	s	0.25	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	V	kg/s	549.7	561.2	561.2	562.5	562.5	562.5	573.0	561.2	561.2	562.4	573.2
broken $loop_{hot\ leg}$ [3]	T	s	0.25	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	V	kg/s	193.0	124.4	124.4	166.3	166.3	166.3	290.0	124.4	124.4	166.3	289.6

[0]Symbol in the Q-row stands for T=time and V=value
[1]During the experiment tripped by system pressure signal
[2]during the experiment tripped by system pressure signal
[3]Differences may be due to different time steps of the measurement and the calculation

Table 3.2: ...cont.

EVENT	Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS 2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
break mass loss (5 s)	V	ts	2.13	2.35	2.40	2.41	2.41	2.41	2.51	2.35	2.40	2.40	2.53
(10 s)	V	ts	3.15	3.37	3.47	3.43	3.43	3.43	3.53	3.35	3.46	3.42	3.56
(30 s)	V	ts	4.76	5.07	5.12	4.95	4.95	4.96	4.99	5.05	5.16	4.96	5.07
(70 s)	V	ts	5.73	5.20	5.20	—	4.93	4.95	4.93	5.38	5.38	5.13	—[4]
(120 s)	V	ts	6.49	5.14	5.14	—	4.87	4.89	4.87	5.32	5.38	5.14	—
Peak mass loss$_{break}$ [5]	T	s	—	41.6	39.6	—	33.6	35.2	31.2	48.4	46.4	45.0	—
	V	kg	—	5.26	5.26	—	4.98	5.02	5.00	5.41	5.43	5.18	—
Minimum collapsed liq. lvl. reached (hot chann.)	T	s	—[6]	7.2	4.4	4.8	4.8	5.2	4.0	6.8	4.4	4.8	4.0
	V	%	—	3.9	7.3	6.6	6.6	3.2	4.5	3.9	7.4	6.4	5.2
(average chann.)	T	s	—	7.2	4.4	4.8	4.8	5.2	4.0	6.8	4.4	4.8	4.0
	V	%	—	3.6	8.4	6.0	6.0	4.3	6.8	4.0	8.2	6.9	8.0

[4] Abnormal termination after 42.03 seconds of transient due to "water property error"

[5] Calculated integral Break losses reached a defined peak value because flow reversal occured due to negative pressure difference between system pressure and suppression tank pressure

[6] no experimental value available

EVENT	Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS 2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
Pressurizer emptying [7]	T	s	15.5	14.4	14.4	17.6	17.6	17.6	18.4	14.4	14.4	17.6	17.6
-pressure	V	MPa	7.4	7.85	8.29	4.01	4.01	4.01	3.46	7.9	7.9	4.1	3.7
Accumulator emptying	T	s	56.5	55.2	54.4	52.1 [8]	53.2	53.6	52.4	56.8	56.4	54.8	—
Peak cladding temp.[9,10]	T	s	5.25	6.8	4.4	44.4	43.2	4.4	40.0	6.4	4.4	4.8	4.0
	V	K	1074	1054	1026	1066	1066	1026	1050	1047	1026	1034	1017
Blowdown peak cladding temperature [11] in hot channel level-02	T	s	3.3	7.2	4.4	5.2	5.2	4.4	4.0	6.8	4.4	4.8	4.0
	V	K	722	704	746	735	735	714	782	694	743	729	781
level-11	T	s	4.8	7.6	4.4	5.2	5.2	4.8	4.0	7.2	4.4	4.8	4.0
	V	K	914	732	776	742	742	712	845	721	774	731	843
level-21	T	s	4.8	6.8	4.4	5.2	5.2	5.2	4.0	6.4	4.4	5.2	4.0
	V	K	1037	1003	977	815	815	787	959	997	977	829	957

[7] Empty point for the calculation is a pressurizer level less than 0.01 m
[8] Abnormal termination due to "water property error" when accumulator got nearly empty
[9] Experimental value at level-27. Indicated temperature is an average of thermocouples TE-J08-024 and TE-F08-024
[10] All predicted peak cladding temperatures at level-31
[11] Reference value are averages of several temperatures inferred from thermocouple signals at the same axial level but different radial conditions

Table 3.2: ...cont.

Table 3.2: ...cont.

EVENT	Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS									
				2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
level-24	T	s	4.9	6.8	4.4	5.2	5.2	5.6	6.0	6.4	4.4	5.6	5.6
	V	K	1024	1020	994	788	788	765	872	1013	994	625	856
level-27	T	s	5.3	6.8	4.4	5.2	5.2	4.4	4.0	6.4	4.4	4.8	4.0
	V	K	1003	1045	1018	1028	1028	1016	1006	1038	1018	1023	1004
level-31	T	s	5.3	6.8	4.4	5.2	5.2	4.4	4.0	6.4	4.4	4.8	4.0
	V	K	964	1054	1026	1038	1038	1026	1018	1047	1026	1033	1017
level-39	T	s	5.3	6.8	4.0	5.2	5.2	4.4	4.0	6.0	4.0	4.8	4.0
	V	K	965	1002	980	994	994	985	979	996	979	990	979
level-43.8	T	s	5.3	0.8	1.2	4.8	4.8	4.4	6.0	0.8	1.2	4.8	4.0
	V	K	861	740	741	929	929	923	863	787	750	926	857
level-49	T	s	5.3	0.8	1.2	0.8	0.8	0.8	4.8	0.8	0.8	0.8	0.8
	V	K	843	697	602	705	705	705	742	740	697	705	735
level-62	T	s	5.8	—	—	—	—	—	—	0.8	—	—	—
	V	K	719	—	—	—	—	—	—	697	—	—	—
in avg. channel level-11	T	s	4.8	7.2	4.4	5.2	5.2	4.8	4.0	6.8	4.4	4.8	4.0
	V	K	889	636	644	654	654	605	719	632	643	662	717

EVENT		Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS 2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
	level-21	T	s	3.8	7.6	4.4	5.2	5.2	4.0	4.0	7.2	4.4	4.8	4.0
		V	K	728	663	676	691	691	650	711	658	675	668	712
	level-28	T	s	5.3	7.6	—	5.2	5.2	—	4.0	7.2	—	4.8	4.0
		V	K	899	657	—	672	672	—	701	648	—	675	709
	level-39	T	s	5.3	—	—	—	—	—	4.0	—	—	—	4.0
		V	K	849	—	—	—	—	—	695	—	—	—	709
Partial bottom-up quench in hot channel	level-02	T	s	4.8	7.0	5.0	5.0	5.5	5.0	4.0	8.0	4.5	5.0	6.5
		V	K	697	703	745	742	740	700	782	695	740	730	800
	level-11	T	s	4.8	7.0	5.0	5.0	5.5	5.0	—	8.0	4.5	5.0	—
		V	K	914	733	775	742	740	700	—	720	770	730	—
	level-21	T	s	5.3	—	—	5.5	9.0	6.0	—	2.0	—	1.2	—
		V	K	1035	—	—	782	810	785	—	620	—	780	—
	level-24	T	s	5.3	—	—	9.0	6.0	6.0	—	—	—	1.2	—
		V	K	1020	—	—	803	775	763	—	—	—	760	—
	level-27	T	s	5.8	—	—	—	—	8.0	—	—	—	—	—
		V	K	945	—	—	—	—	800	—	—	—	—	—

Table 3.2: ...cont.

Table 3.2: ...cont.

EVENT	Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS									
				2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
level-31	T	s	6.3	—	—	—	—	—	—	—	—	—	—
	V	K	896	—	—	—	—	—	—	—	—	—	—
level-39	T	s	6.8	—	—	—	—	—	—	—	—	—	—
	V	K	890	—	—	—	—	—	—	—	—	—	—
level-43.8	T	s	6.8	—	1.5	—	—	7.0	—	1.0	1.0	—	—
	V	K	780	—	740	—	—	805	—	740	740	—	—
[12]level-49	T	s	15.3	—	1.0	—	1.0	1.0	4.8	1.0	1.0	1.0	7.0
	V	K	762	—	695	—	705	705	740	700	700	705	805
[12]level-62	T	s	14.3	—	—	—	—	—	—	—	—	—	3.5
	V	K	645	—	—	—	—	—	—	—	—	—	640
in avg. channel level-11	T	s	5.3	7.5	4.5	—	5.2	—	4.0	7.0	4.5	4.5	5.0
	V	K	867	630	635	—	655	—	720	630	645	660	620
level-21	T	s	5.3	7.5	4.5	—	5.2	—	4.0	7.0	4.5	4.5	5.0
	V	K	724	660	670	—	690	—	720	650	675	685	655
level-28	T	s	6.0	7.5	—	—	5.5	—	4.0	7.0	—	5.0	—
	V	K	855	655	—	—	670	—	703	645	—	675	—

[12]Top-down rewetting

EVENT		Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS									
					2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
	level-39	T	s	7.0	—	—	—	—	—	4.0	7.0	—	—	—
		V	K	760	—	—	—	—	—	715	645	—	—	—
Quench[13]front during reflooding in hot channel	level-02	T	s	29.5	—	—	36.0	40.0	40.0	—	26.0	—	31.5	24.0
		V	K	585	—	—	570	595	503	—	600	—	615	590
	level-11	T	s	40.5	26.0	—	45.0	43.5	40.0	44.2	29.5	—	41.5	—[14]
		V	K	670	715	—	640	665	580	690	620	—	590	—
	level-21	T	s	46.0	49.0	49.5	54.0	52.0	40.0	52.0	51.5	50.0	52.0	—
		V	K	650	753	780	665	720	580	770	730	745	795	—
	level-24	T	s	50.0	52.2	51.5	55.0	53.5	40.0	53.0	55.0	53.5	53.0	—
		V	K	650	753	810	610	665	582	745	800	785	685	—
	level-27	T	s	48.0	54.5	56.0	—	56.0	50.0	54.5	57.5	57.2	53.5	—
		V	K	620	760	760	—	765	760	785	760	762	810	—

[13]Time and value of "knee temperature"
[14]No values due to abnormal termination of run

Table 3.2: ... cont.

EVENT	Q	unit	MEAS. DATA	RELAP5/Mod2 CALCULATIONS									
				2-00	2-00PU	3-00	3-005	3-005T	3-02	2-00C	2-00PUC	3-00C	3-02C
level-31	T	s	52.0	56.5	57.0	—[15]	60.0	54.5	56.0	60.0	58.5	58.5	—
	V	K	670	765	760	—	755	745	800	750	770	890	—
level-39	T	s	48.5	48.5	51.0	—	60.0	54.0	55.0	55.0	53.5	57.5	—
	V	K	610	895	875	—	735	780	790	800	780	780	—
level-43.8	T	s	53.0	33.5	—	—	54.5	—	50.5	—	—	52.5	—
	V	K	675	625	—	—	790	—	755	—	—	772	—
level-49	T	s	54.0	—	—	—	—	—	—	—	—	—	—
	V	K	605	—	—	—	—	—	—	—	—	—	—
level-62	T	s	54.0	—	—	—	—	—	—	—	—	—	—
	V	K	490	—	—	—	—	—	—	—	—	—	—
in avg. channel level-11	T	s	38.0	—	—	—	—	—	—	—	27.5	28.0	—
	V	K	540	—	—	—	—	—	—	—	550	580	—
level-21	T	s	38.0	—	—	45.0	43.5	—	—	—	27.5	28.0	—
	V	K	510	—	—	560	630	—	—	—	550	582	—
level-28	T	s	43.5	26.5	—	—[15]	48.0	43.5	40.5	—	—	32.0	—
	V	K	530	635	—	—	575	555	570	—	—	525	—
level-39	T	s	39.0	—	—	—	—	44.0	43.0	—	—	—	—
	V	K	580	—	—	—	—	550	570	—	—	—	—

Table 3.2: ...cont.

[15] No values due to abnormal termination of run

flow measurement is the result of a multiplication of two independent measurements which are assumed to produce area averaged quantities. These independent measurements are the momentum flux measurement by drag bodies (or the velocity measurement by miniturbines) and the density measurement by a three beam X-ray densitometer. Both signals are errorneous, especially in high void flow regimes. Furthermore, it is assumed that the product of each of the individual two integrals (i.e. the area-average of the measurements) is equal to the integral of the product of the two variables, an assumption which is fullfilled rather seldom. The quantification of the error of the mass-flow measurements is quite difficult because its dependence of a variety of parameters like flow-regime, void fraction, velocities, etc.

A better picture of what is going on in the broken leg can be achieved by looking at the integral mass losses through the break at different times as listed in table 3.2 where both code predictions and experimental values have been determined by simply summing up the product values of time-step times the instantaneous mass flow at the two breaks. Here, the general trend is that the code calculated higher losses for the first 30 to 40 seconds and then stayed on a certain level (see also figs. 3.39a and b) and finally underpredicted the actual mass losses through the break. In fact, the sign of the flow even changed, indicating a small amount of backflow out of the containment into the primary system due to slightly higher containment pressures (defined as boundary condition using the experimental values) than calculated by RELAP5/Mod2 for the primary system. Because the containment has been modeled as an additional time dependent volume downstream of the break, this backflow is not "unphysical" with respect to the special "LOFT-system" as described by our nodalization schemes. As indicated above, the pressure in this volume has been given as boundary condition according to the experimental recordings of the suppression tank pressure. To indicate the occurence of the flow reversal, the calculated peak mass loss and the time of its occurence have been given in table 3.2.

The code calculated similar mass losses for the different nodalizations. In fact, two groups may be distinguished, the results of the most detailed 2-00 versions which have produced slightly higher mass losses than the more simplified 3-0...versions.

3.3.2 Minimum Collapsed Liquid Level

The next value of interest is the time when the collapsed liquid level in the core region has reached its first minimum, i.e. when the core region was nearly emptied during the blowdown phase of the transient. Unfortunately, for the collapsed liquid level (or equivalent to it, the average liquid fraction in the core region), no experimental data is available. In table 3.2, the collapsed liquid level is given in percents relative to the total heated core height of 1.63 m. The comparison of the results with the different nodalizations indicated no severe discrepancies with respect to the values of the minimum collapsed liquid levels. Their ranges varied between 3.2% and 7.4% in the hot and 3.6% and 8.4% in the average channels. No significant trends have been observed with respect to the sophistication of the nodalizations. The minimum collapsed liquid level has been reached between 4.0 and 5.2 seconds after initiating the transient except for runs 2-00 and 2-00C where it took 7.2 and 6.8 seconds respectively.

3.3.3 Emptying Points of Pressurizer and Accumulator

Two of the significant events during the LOFT-experiment have been found to be the emptying of the pressurizer and the accumulator. The pressurizer emptied during the experiment at about 15.5 seconds after the opening of the break valves; at this moment, pressure in the pressurizer has reached a value of 7.4 MPa.

RELAP5/Mod2 calculated this emptying point between 14.4 seconds for the 2-00, 2-00PU, 2-00C and 2-00PU,C nodalizations and 18.4 seconds for the most simplified 3-02 but not for the equivalent 3-02C nodalization. It is not surprising that the time for emptying the pressurizer strongly depended on the choosen nodalization. Whereas the pressures in the pressurizer as predicted by the code have been found to be quite close to the experimental data for the 2-00 and 2-00PU nodalizations, for the 3-0...series of nodalizations with their crude modelling especially in the pressurizer, the RELAP5/Mod2 - calculations of the pressurizer pressures are rather poor, namely around 4 MPa or even less instead of the measured 7.4 MPa (the 4 MPa is comparable to the system pressure at the time of emptying point).

The accumulator empties at about 56.5 seconds after the initiation of the experiment. In general, the code predictions seem to be sufficiently close to this experimental setpoint. This relatively good aggreement of the code results with the experimental findings is not at all surprising because the emptying time has been tuned once for all for the 6-00 version of nodalization of the post test analysis of the LOFT LP-LB-1 experiment (see ref. [7]) by increasing the forward and reverse flow energy loss coefficients of the accumulator junction from 13, as given in the original EG&G, to about 125.

3.3.4 Peak Cladding Temperatures During the Blowdown Phase

Peak cladding temperatures of 1074 K have been measured by only one of the ten thermocouples in fuel assembly 5 (center of core) on level-27, i.e. 27 inches from the bottom of the core.

The calculated peak cladding temperatures always occured at level-31, i.e. 31 inches from the bottom of the core (by the way, for the original EG&G nodalization of the core which was used for nearly all of the pre- and post-test analyses of the LOFT experiments, core levels-27 and levels-31 fall in the same volume of the nodalization and consequentely indicated the same calculated temperatures). Their values only depend on the choosen nodalization and vary between 1017 K (3-02C) up to 1054 K (2-00). The highest values have been predicted by the 2-00 versions of nodalizations because a rapid coastdown of the pumps has been allowed for this calculation resulting in a longer uncovery period of the hot channel.

The next values of interest are the peak cladding temperatures reached at different core heights during the blowdown period of the experiment which occur in the first 10 seconds after opening the break valves.

With respect to the central core region (hot channel), the blowdown peak cladding temperatures have been slightly overpredicted by the code (not more than 20 K). On the other hand, the code has located the blowdown peak cladding temperatures at axial locations further downstream in the core. Whereas the cladding temperature has been measured at level-21 (1037 K, radially averaged value), the code calculated the highest cladding tem-

peratures (varying from 1017 K (3-02C) to 1054 K (2-00)) at level-31 (32), i.e. 10 inches downstream of the experimentally inferred hot spot.

With respect to the outer core (average channel) for all nodalizations, the blowdown peak cladding temperatures have been underpredicted at least between 10 K (at position 21 inches) and 200 K (at position 27 inches). The lowest underpredictions have been achieved using the most simplified nodalizations 3-02 and 3-02C.

At lower levels of the LOFT core, high flooding rate bottom-up rewetting took place during the blowdown period of the experiment. It enables the quenching of the hot rods between 4.8 and 6.8 seconds of the transient. In table 3.2, times and values of the experimental "knee cladding temperatures" have been listed at which quenching took place at a certain level of the core.

The predicting capabilities of RELAP5/Mod2 have been found to be rather poor with respect to bottom-up rewetting during the blowdown phase. Only with some of the nodalizations some kind of prediction was possible; with respect to early bottom-up quenching, the best results have been obtained with nodalization 3-005T. In chapter 3.4, we shall discuss in more detail the problem of early bottom-up rewetting. The bottom-up rewetting was also observed in the side channels of the LOFT core during the test but again the predictions of RELAP5/Mod2 have been found to be rather poor.

In addition to the early bottom up quenching, the upper parts of the core (level-49 and level-62) have been quenched due to top-down rewetting between 14.3 and 15.3 seconds. RELAP5/Mod2 was also not able to predict this phenomenon, as one can see in table 3.2 for levels-49 and levels-62 (also incorporated in column "partial bottom-up rewetting" of table 3.2.

3.3.5 Quench Front Positions During the Reflooding Phase

The quench front positions during the reflooding phase of the experiment have been found to be one of the most sensitive parameters of the calculations. Therefore, the last values of table 3.2 will show the comparison between the experimental results (time and value at the "knee-point" of the temperature trace of one individual thermocouple at a certain axial core level) and the equivalent code predictions at 10 different core levels where thermocouples have been installed. Because at a certain core height the core-wide radially distributed thermocouples may indicate different quench front positions, we have used an averaged value for time and temperature at one core level.

Different to our findings for the LOFT experiment LP-LB-1 (ref. [7]), where we have found enormous discrepancies between the results of the different nodalizations, for the LP-02-6 calculations the predictions of the quench front positions using the different nodalizations are quite close together. Furthermore, we have not found significant differences between the results of the nodalizations which have taken into account the heat capacity effects of the wall material and which did not; i.e. taking into account the heat capacity of the wall material has not led to negative effects on the predictions of the quench front positions like they have been found for our LP-LB-1 post- test analyses (ref. [7]). For the moment, we can give no reasonable explanations for this observations.

3.4 Time Behaviour of Significant Thermo-Hydraulic Parameters

3.4.1 Cladding Temperatures

Even it can be seen in table 3.2, that the RELAP5/Mod2 only slightly underpredicts the peak-cladding temperatures in the center channel of the core, by looking at the time history of the cladding temperatures at different axial heights of the core, it can be noted that rather significant discrepancies between the predictions and the experimental data exist. Furthermore, it can be observed more clearly that the differences between the results of the different versions of nodalizations occur.

Due to our specific nodalization of the core region which is identical for all of the investigated schemes, RELAP5/Mod2 is able to calculate the cladding temperatures in only two different representative channels, namely the "hot channel" attributed here to the center-box 5 and the "average channel" which can be attributed to one of the side boxes of the LOFT core; for the comparison with experimental data, we have used the side-box 4 (in priciple, any other of the four side-boxes or an average of all of them could be used).

Let us start our discussion of the RELAP5/Mod2 calculations of the cladding temperatures in the "hot channel", i.e. box 5 of the LOFT core.

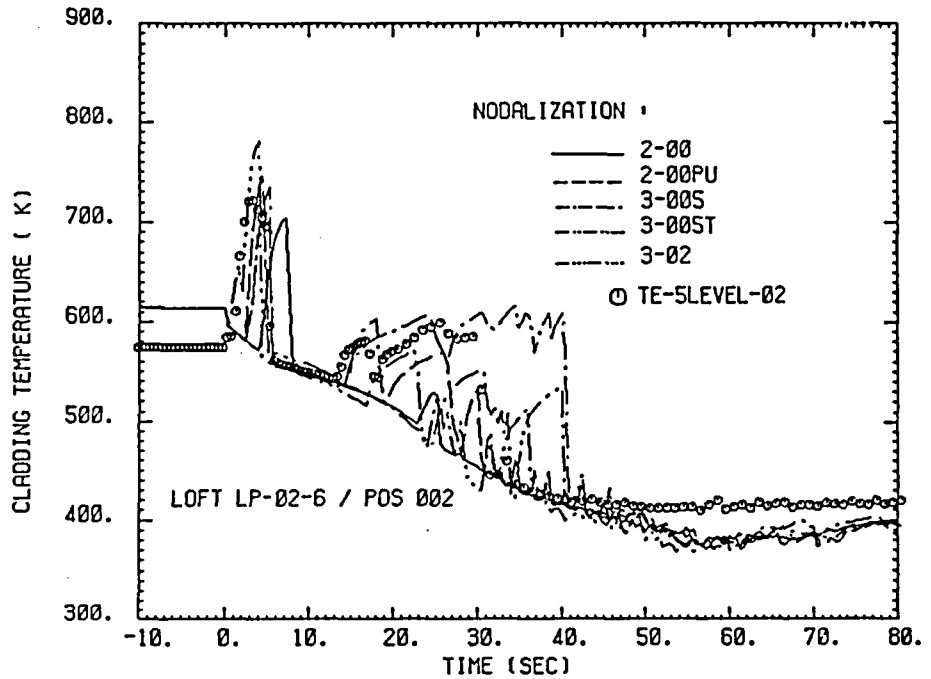
Cladding Temperatures in the Center Box

In Figs. 3.5 to 3.14, the time traces of the cladding temperatures at 10 different core heights in the center box (box 5) as calculated by RELAP5/Mod2 ("hot channel" have been compared to the average temperature (!) at the specific core height (the averaging process has been described in chapter 3.1), using the different nodalizations as listed in table 2.1. For the sake of better readability, for each axial position two figures are given in which it is shown five comparisons of N-type (plot a; versions 2-00, 2-00PU, 3-005, 3-005T and 3-02) and four comparisons of C-type nodalizations (plot b; versions 2-00C, 2-00PU,C, 3-00C and 3-02C), i.e. where the heat capacity effects of the vessel material have been taken into account (C-type) and where these effects have been neglected (N-type).

At axial level 02, i.e. 2 inches from the bottom of the core, the experimental cladding temperatures have undergone a significant temperature increase of approximately 150 degrees mainly during the blowdown phase of the experiment, which the code has overpredicted between 20 K (for the case of rapid coastdown of the pumps, nodalization 2-00 and 2-00C) and 60 K for all the other nodalizations, where the realistic coastdown of the pumps has been imposed (figs. 3.5a and 3.5b). A first quench (bottom-up rewetting) stops this core heat-up at about 8 seconds after the initiation of the experiment. At level-002, this early quenching has been calculated by RELAP5/Mod2 for all types of nodalization.

A second heat-up of the center bundles started at approximately 13 seconds and terminated at nearly 30 seconds. This second heat-up has been "indicated" by all of the runs with quite different accuracy. In addition, for the simplified nodalizations, this core heat-up has been calculated approximately 10 seconds to long,i.e. the time of the final quenching has been overpredicted by at least 10 seconds for the 3-005 and 3-02 nodalizations.

Generally, the final quench during the reflooding phase of the experiment has been



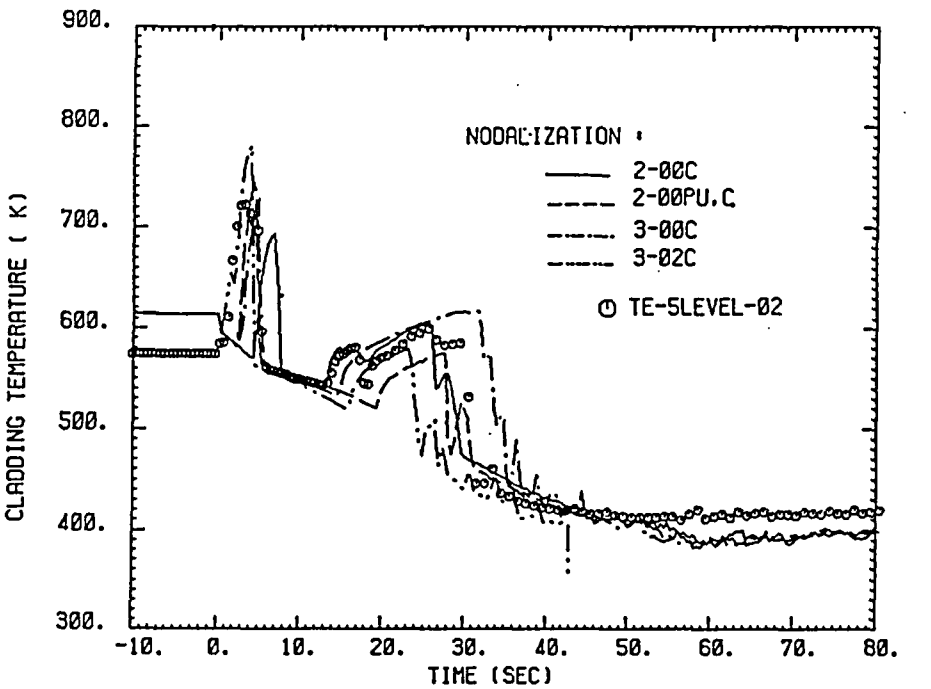


Figure 3.5: Hot-channel cladding temperatures vs. time at axial level 02 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

calculated by RELAP5/Mod2 slightly more accurate by the "C" than by the "N" versions of nodalizations; this finding is in contradiction to our earlier findings when analyzing the LOFT experiment LP-LB-1 (ref.[7]). Whereas the predictions of the different C-versions have been found to be close together, the discrepancies of the "N"-versions are significant. Here the poorest results have been achieved using the 3-005 and 3-02 nodalizations, i.e. the two most simplified ones.

At the following two axial levels (figs. 3.6 and 3.7), the peak surface temperatures generally have been underpredicted at least 50 K and for other nodalization more than 100 K during the blowdown phase. Only for some versions, partial bottom-up quenching, one of the main phenomena of the LP-02-6 experiement, has been calculated.

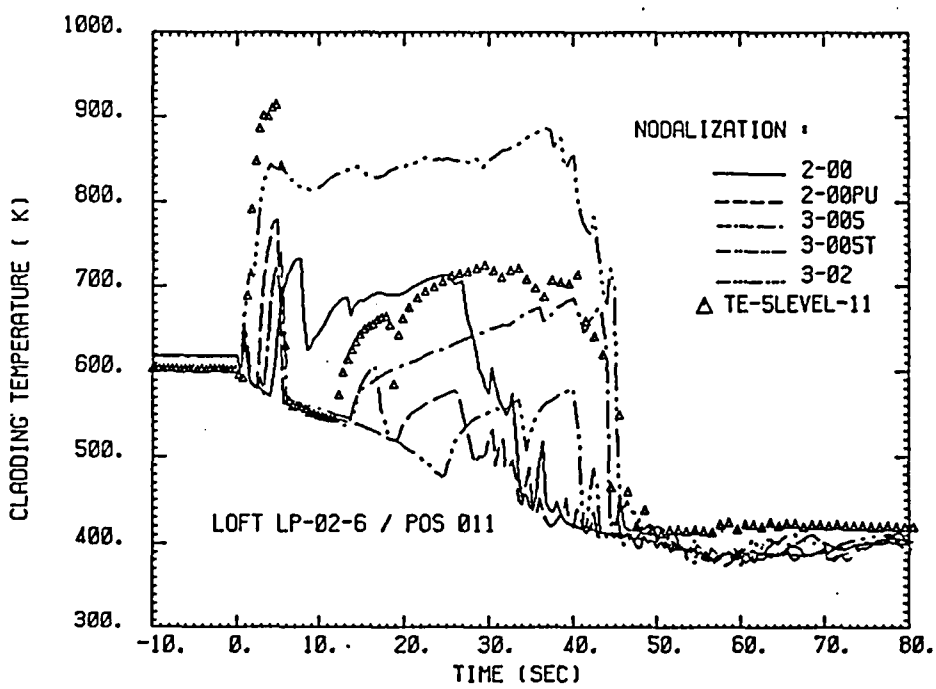
For the next five axial positions, figs. 3.8 to 3.12, a general trend of overpredicting the cladding temperatures both during the blowdown (between 3 and 7 seconds of the transient) and the "refill" of the reflood phase (between 20 and 50 seconds of the transient) has been found but the first higher peak cladding temperature ("blowdown peak") has been overpredicted not more than 50 K whereas during the reflood interval the code has overpredicted the cladding temperatures not less than 150 K. Only the 3-005 and 3-005T versions tend to give certain underpredictions, especially during the reflood interval of the experiment.

For level-27, the calculations of version 3-005T has nearly perfectly reproduced the experimental data. Both the blowdown peak terminated by the bottom-up quenching and the second core heat-up during the refill interval of the experiment have been described perfectly; but we believe that this good agreement is coincidental because it only happened at level-27.

It should be noted that no significant differences have been observed between the predictions of nodalizations 2-00 (rapid coastdown of the pumps) and 2-00PU (given pump speed vs. time curves) with respect to the time behaviour of the cladding temperatures. Only the temperatures at the "blow-down peak" have been always predicted slightly higher (20 to 30 K) by the 2-00 version (rapid coastdown of the pumps).

Whereas in the LOFT LP-LB-1 experiment (see ref. [7]) at the upper levels a top-down quench has been observed within the first 15 seconds (blowdown phase), there is no such strong evidence for the LP-02-6 . Because the experimentally verified momentum fluxes at the exit of the core have been found to be highly positive during the first 15 seconds of the transient (see also fig. 3.33) indicating a coolant flow out of the core; on the other hand, the momentum flux meter (one drag body at a position at the inlet and one at the outlet of the core) only indicated the momentum flux at one specific position at the outlet of bundle 5, so that one cannot exclude reverse flow in some other parts of the flow area. Therefore, we have attributed the first sharp decrease of the cladding temperatures in fig. 3.12 and -less pronounced- in fig. 3.13 to bottom-up reflooding, whereas the second temperature drop (at about 15 seconds) probably is due to top-down quenching.

None of the different RELAP5/Mod2 runs has drawn a sufficiently conclusive picture of what has been going on at these two upper core levels as can be seen from Figs. 3.12 and 3.13. The initial core heat-up has been reproduced quite poorly and the second significant heat-up during the refill interval is



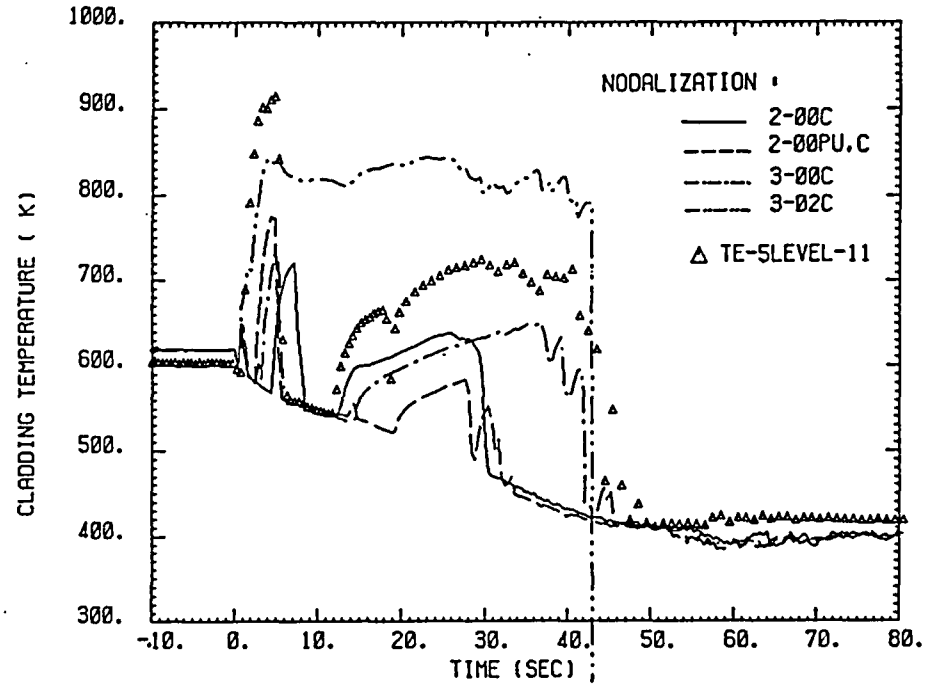
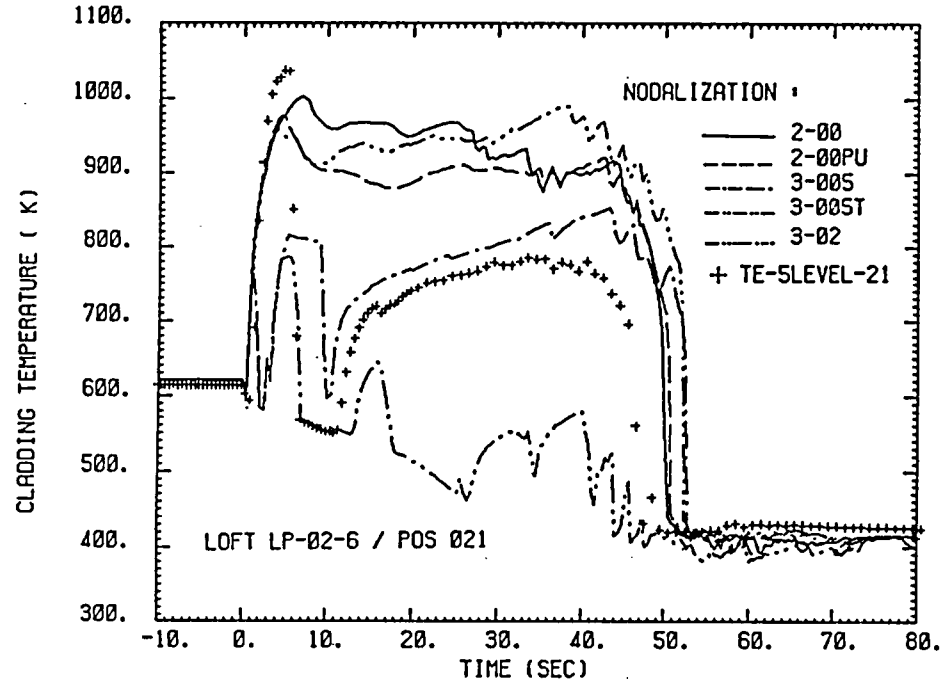


Figure 3.6: Hot-channel cladding temperatures vs. time at axial level 11 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



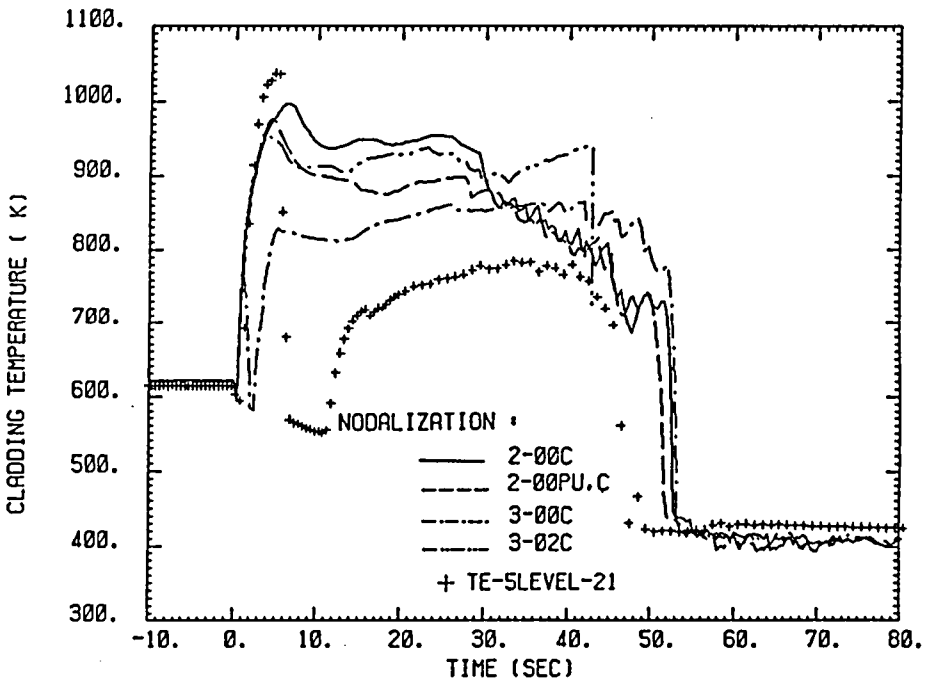
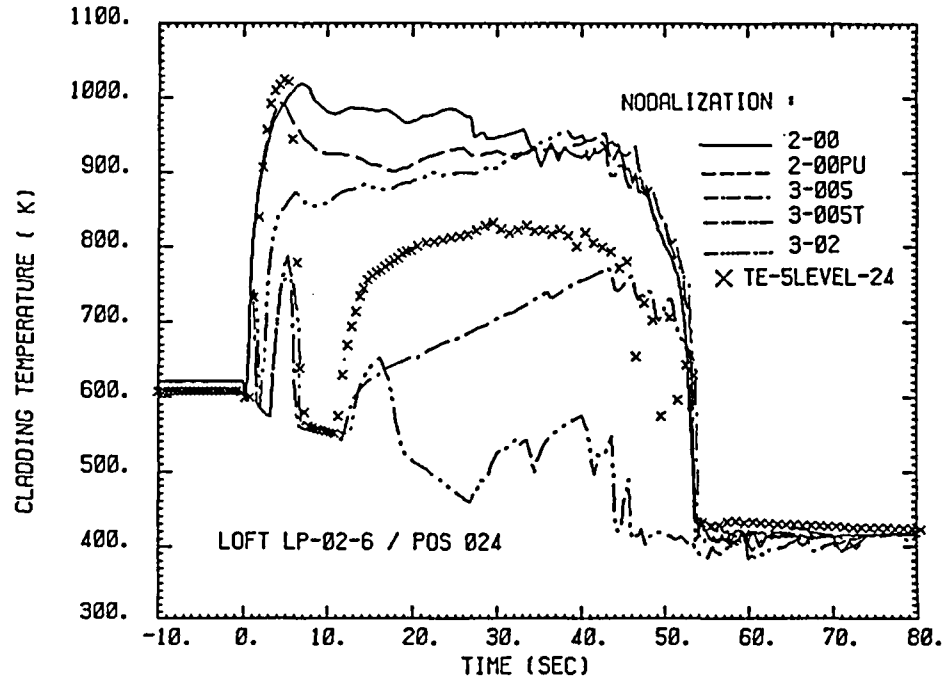


Figure 3.7: Hot-channel cladding temperatures vs. time at axial level 21 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



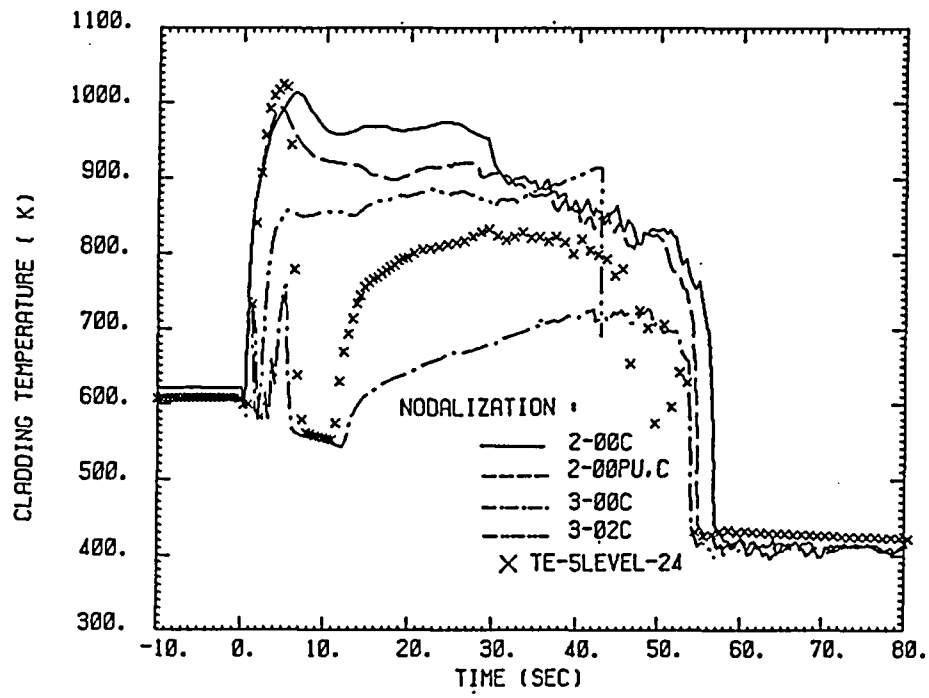


Figure 3.8: Hot-channel cladding temperatures vs. time at axial level 24 compared with the equivalent reference temperature

a) by neglecting wall heat capacity

b) by taking into account wall heat capacity ("C")

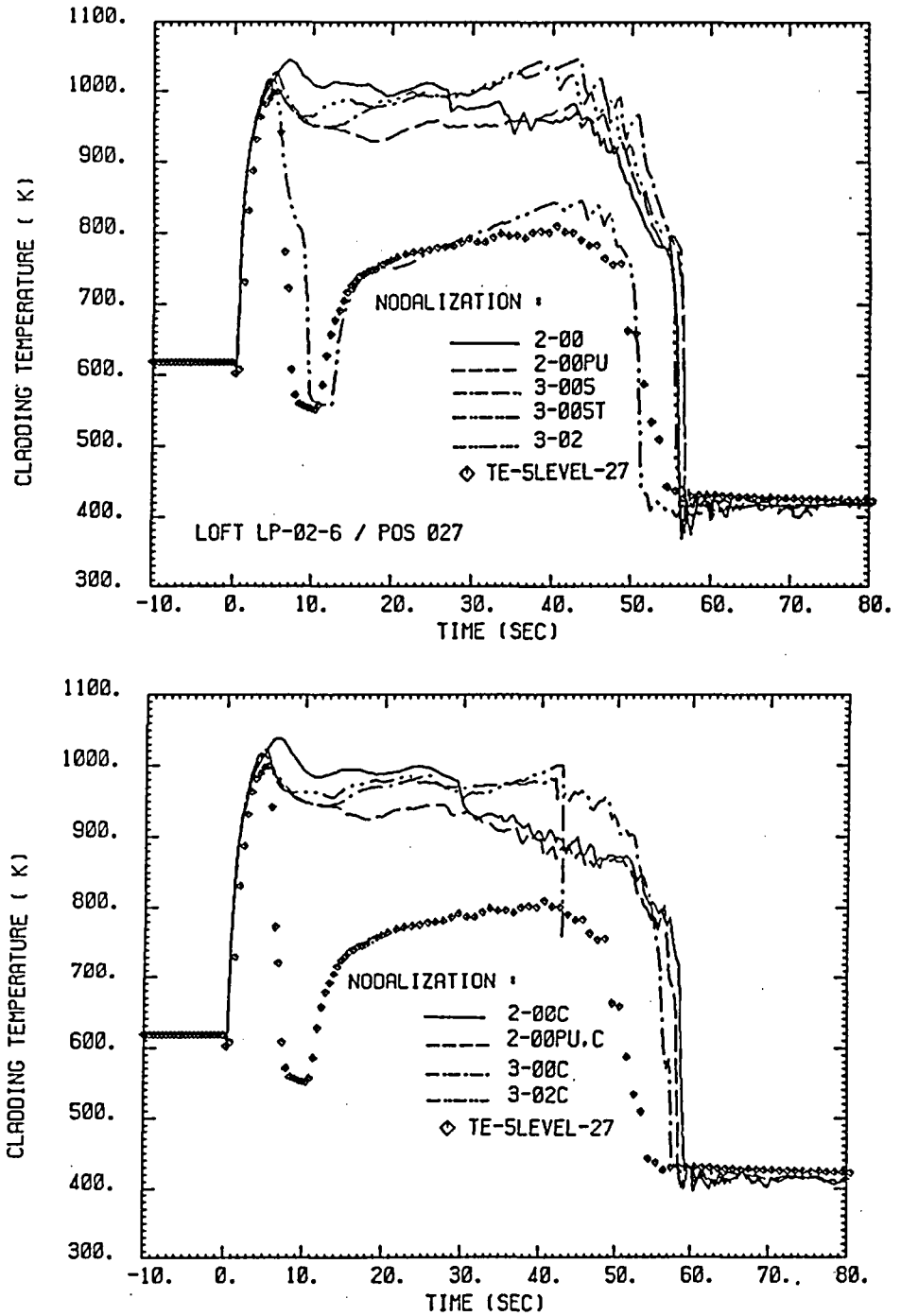
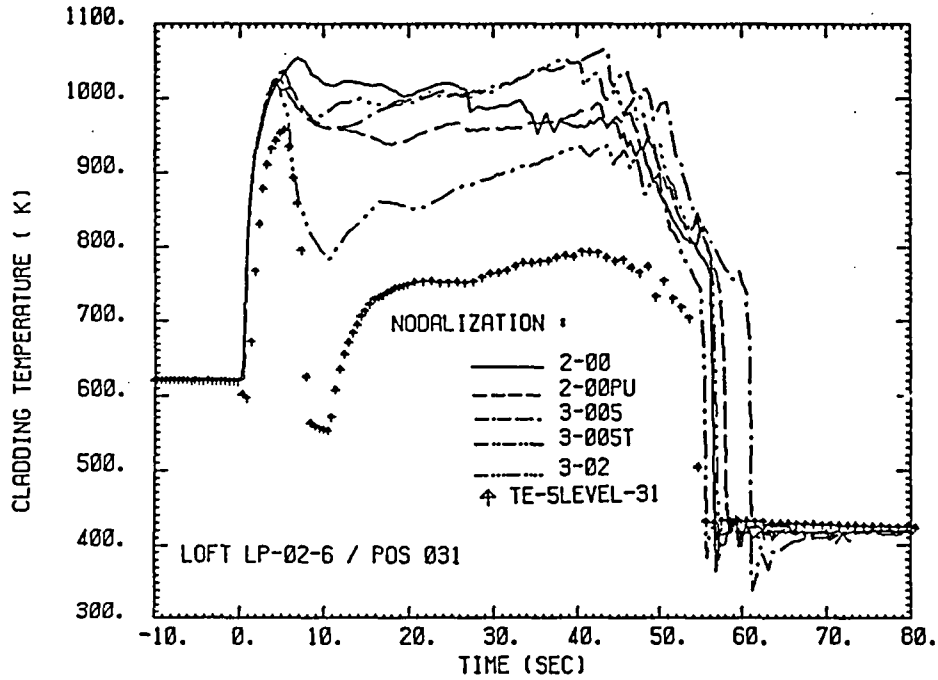


Figure 3.9: Hot-channel cladding temperatures vs. time at axial level 27 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



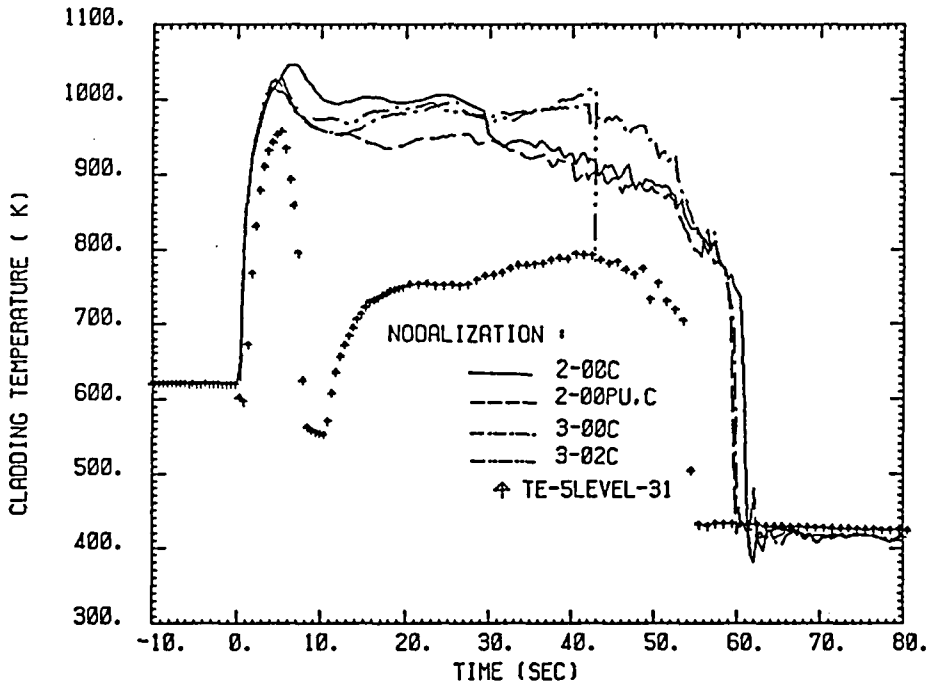


Figure 3.10: Hot-channel cladding temperatures vs. time at axial level 31 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

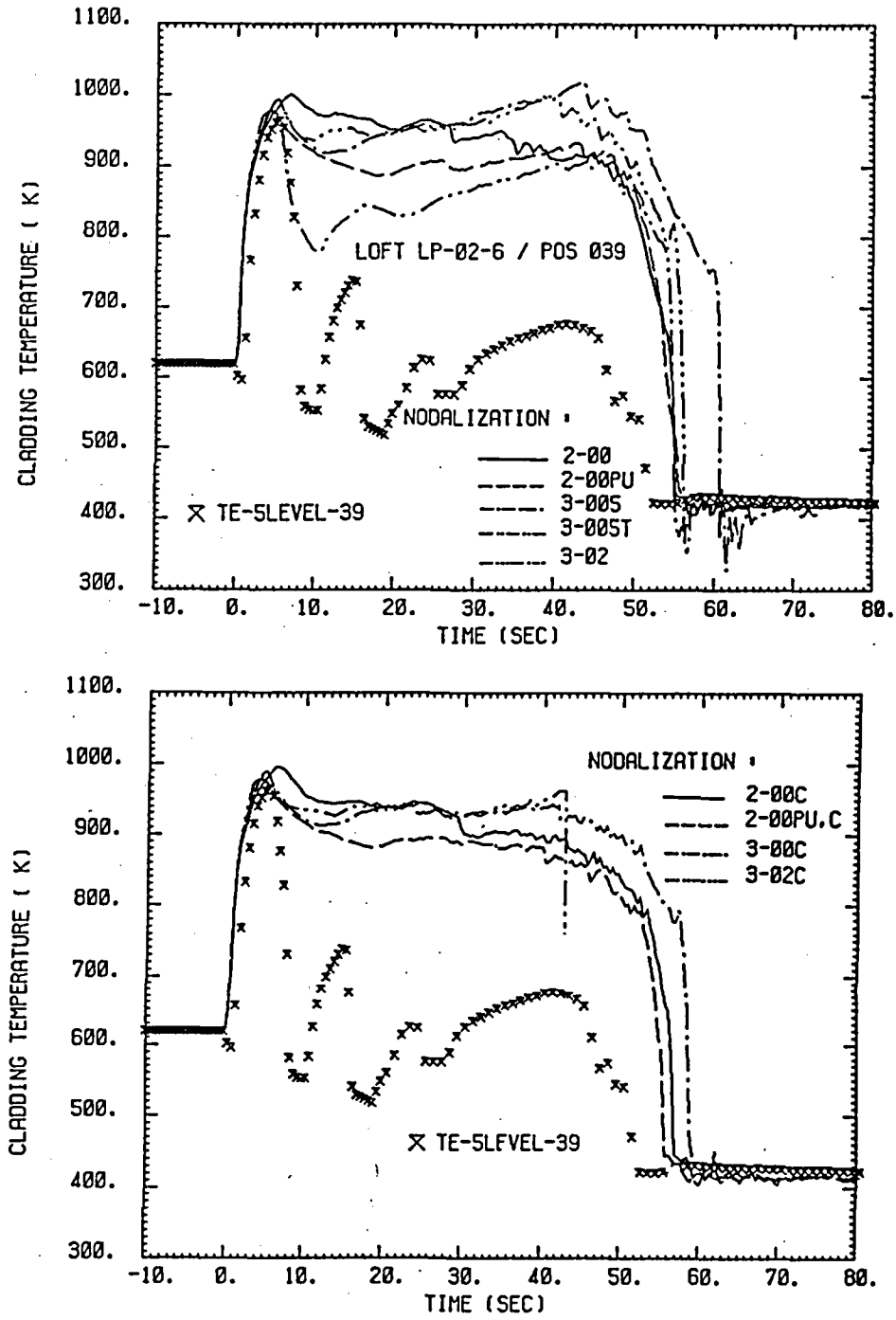
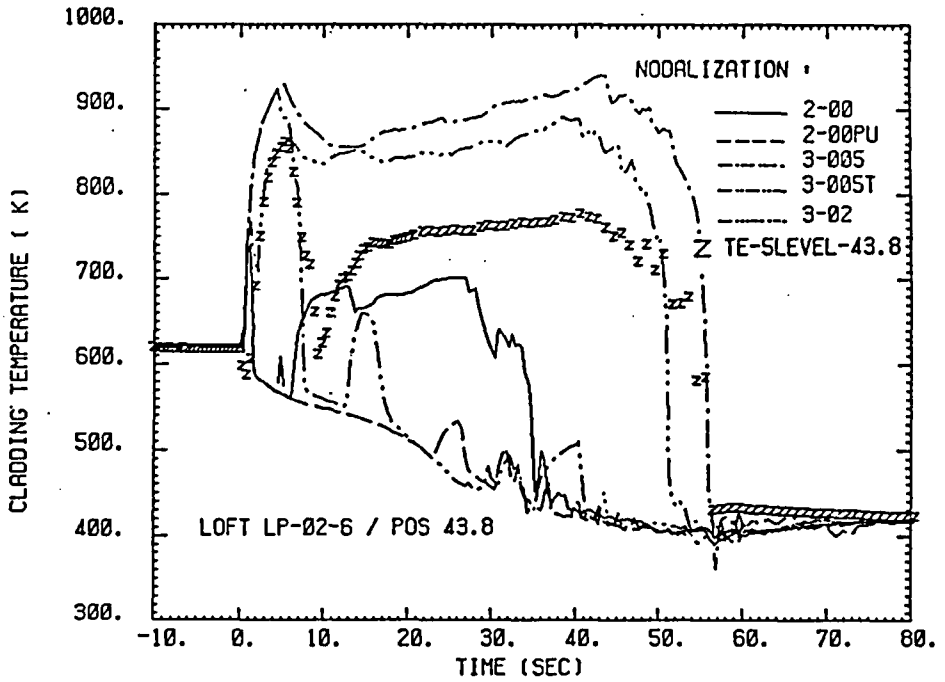


Figure 3.11: Hot-channel cladding temperatures vs. time at axial level 39 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



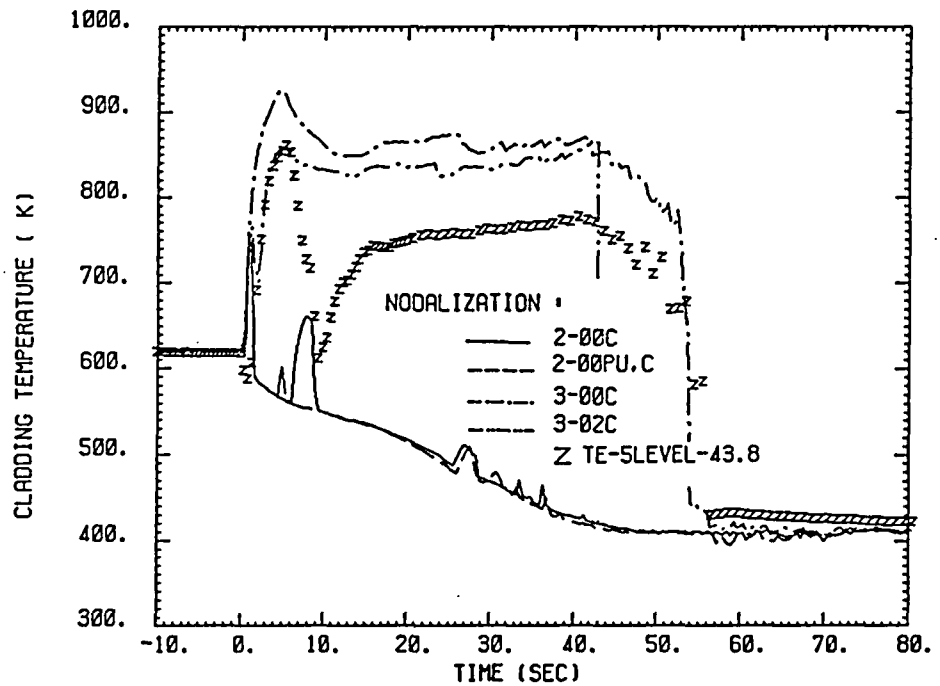


Figure 3.12: Hot-channel cladd. temperatures vs. time at axial level 43.8 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

nearly missing; some vague increase of the surface temperatures cannot be interpreted as a valuable description of the thermohydraulics in this core region.

Cladding Temperatures in Side Box 4 (Average Channel)

In figs. 3.14 to 3.17, the time traces of the cladding temperatures at four different core heights in the side box 4 as calculated by RELAP5/Mod2 for the "average channel" have been compared to an average temperature at the specific core height (if the reference is indicated by the word "level") or to one single thermocouple signal (if a specific number is given as reference, e.g. 4G14). Again, for the four axial positions, located 11, 21, 28 and 39 inches from the bottom of the core, two plots are given showing the comparison of the "N" (plot a) and the "C" type of nodalizations (plot b).

RELAP5/Mod2 was not able to predict the significant heat-up of the fuel cladding in the average channels during the blowdown phase but indicated some temperature increase during the refill phase of the experiment.

For both the blowdown phase of the experiment, surface temperatures have been underpredicted by RELAP5/Mod2 between 20 K (at axial position 21) and 200 K (positions 11 and 28). The highest surface temperatures have been calculated for the 3-02 and 3-02C nodalizations.

During the refill phase, a significant core heat-up has been calculated by RELAP5/Mod2 , the magnitude of which depends on the selected nodalizations. The highest temperatures (overprediction at least 100 K) have been obtained by the 3-005 and 3-02 versions (i.e. the less elaborated ones) whereas the lowest values have been found with the 2-00 version.

Summarizing Remarks on the Cladding Temperature Calculations

Summarizing our findings with respect to RELAP5/Mod2 -calculations of the cladding temperatures in both the hot and the average channels one has to conclude that:

- generally, at most of the core levels, the peak cladding temperatures have been underpredicted not more than 100 K,
- RELAP5/Mod2 has calculated the peak cladding temperature at axial level 31, i.e. 31 inches from the bottom of the core, whereas the experimentally inferred hotspot is located at level-27,
- with respect to the cladding temperatures in the average channel, only small differences have been observed between the results of the "N" and "C" versions of nodalizations, i.e. whether the heat capacity of the wall material of the reactor vessel has been taken into account or not did not make much difference.

The reasons for the deviations are multiple. Concerning the axial shift of the hot spot (second item), one of the reasons may be an incorrect assumption of the axial power distribution in the LOFT core; as mentioned in section 2.1, we have used the one published by [5]. For investigating on this problem, the axial distributions of the cladding temperatures have been compared to the equivalent experimental data for three different time points of the transient, namely at -1.2 seconds (i.e. the stationary part of the transient), at 5.3 seconds (blowdown phase) and at 40.5 seconds, i.e. during the refill phase (Figs. 3.19a,b to 3.21a,b).

In figs. 3.18a,b, the comparison was made for the stationary phase of experiment LP-02-6 . All RELAP5/Mod2 calculations

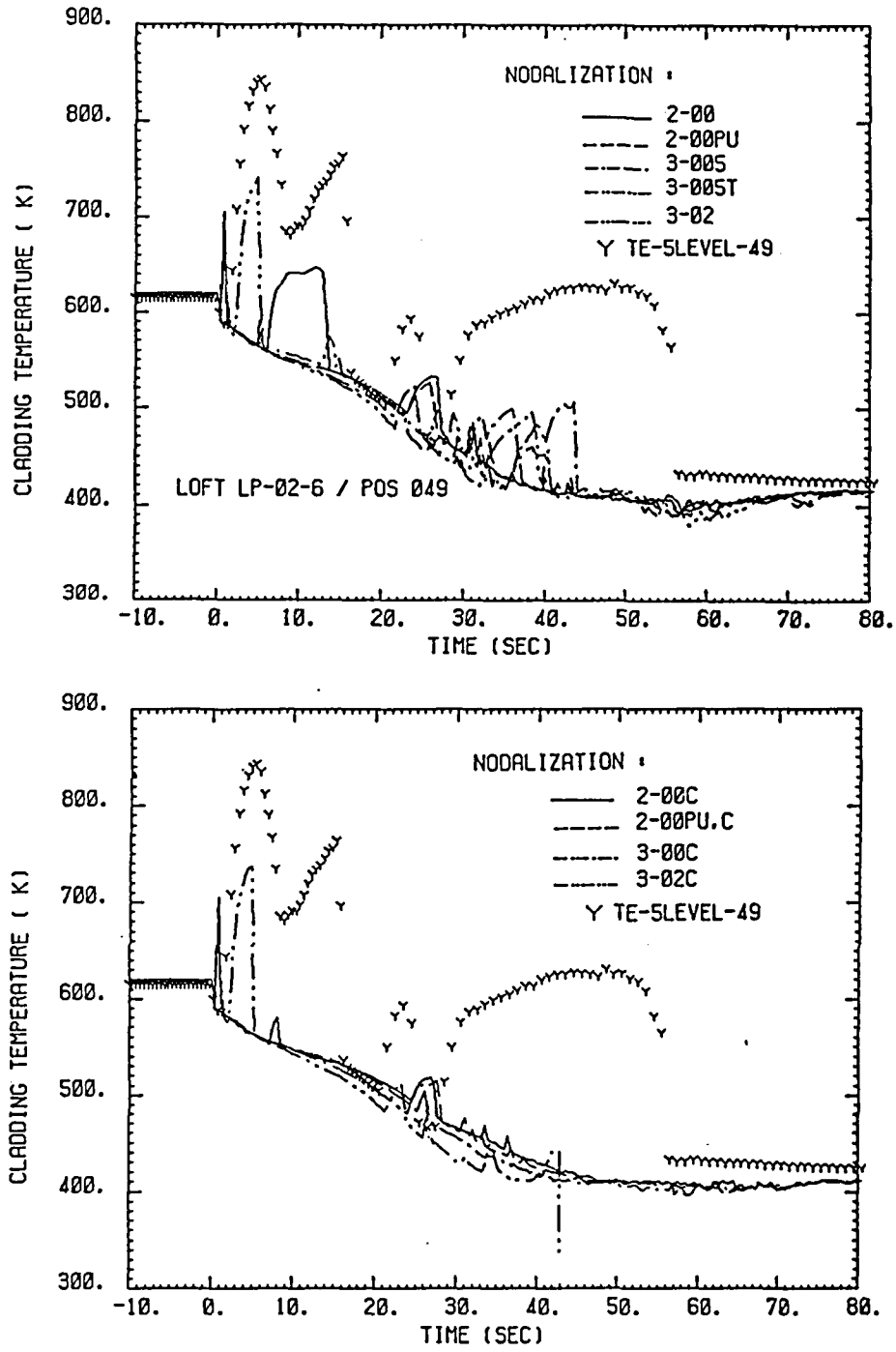
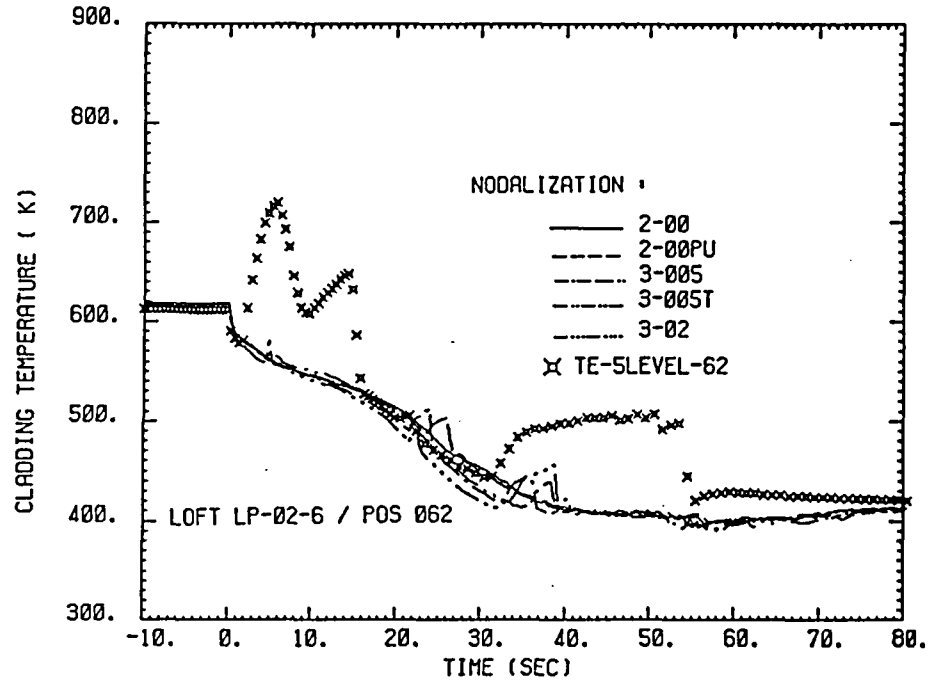


Figure 3.13: Hot-channel cladding temperatures vs. time at axial level 49 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



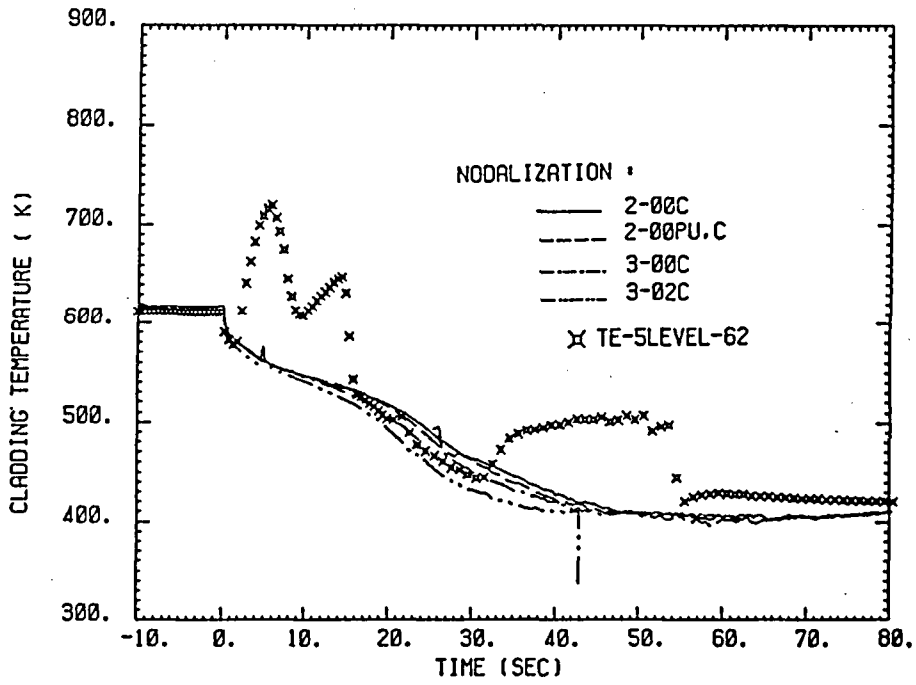
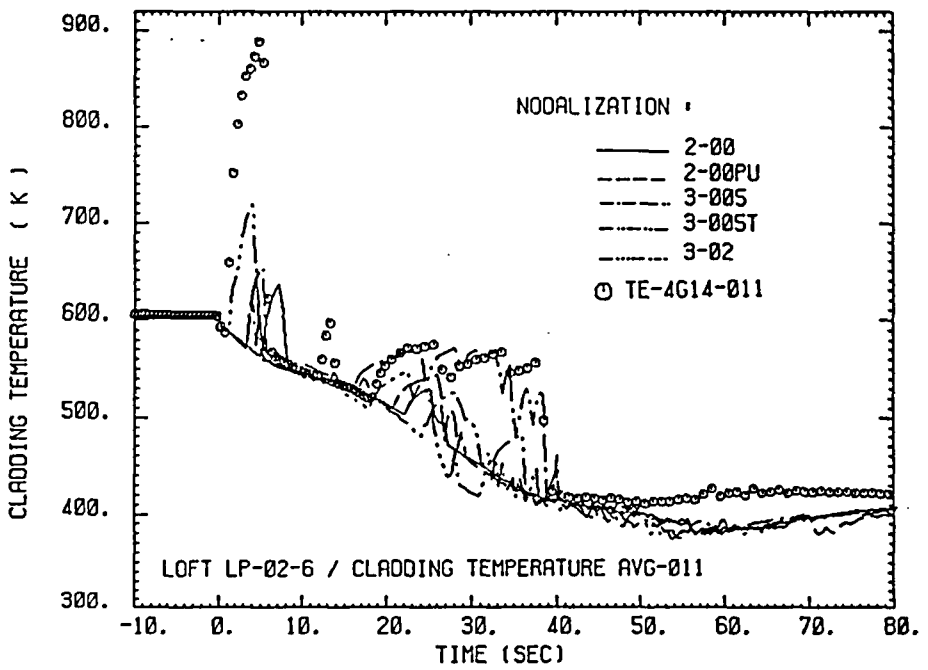


Figure 3.14: Hot-channel cladding temperatures vs. time at axial level 62 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



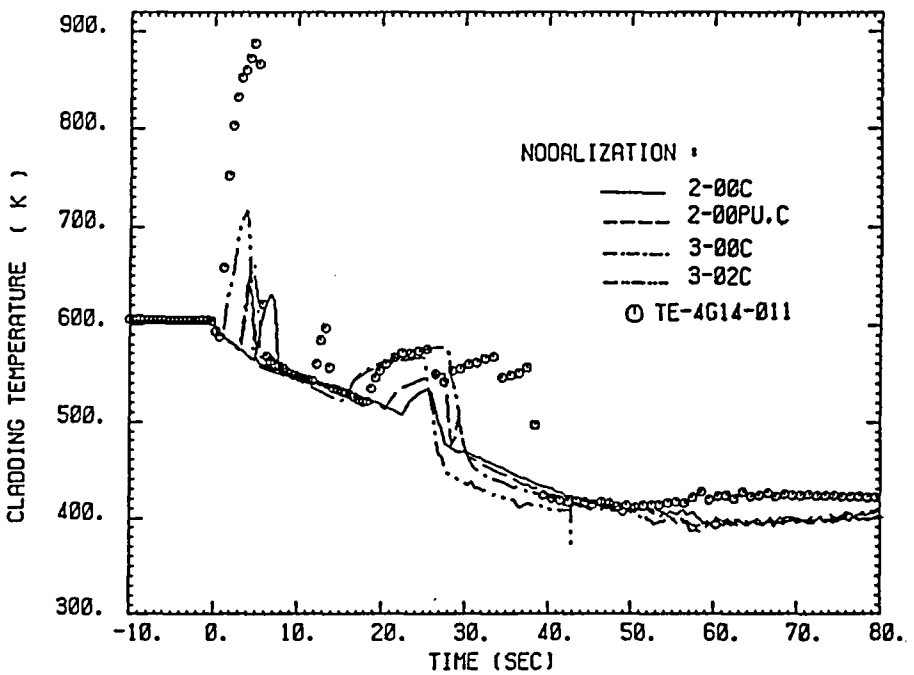
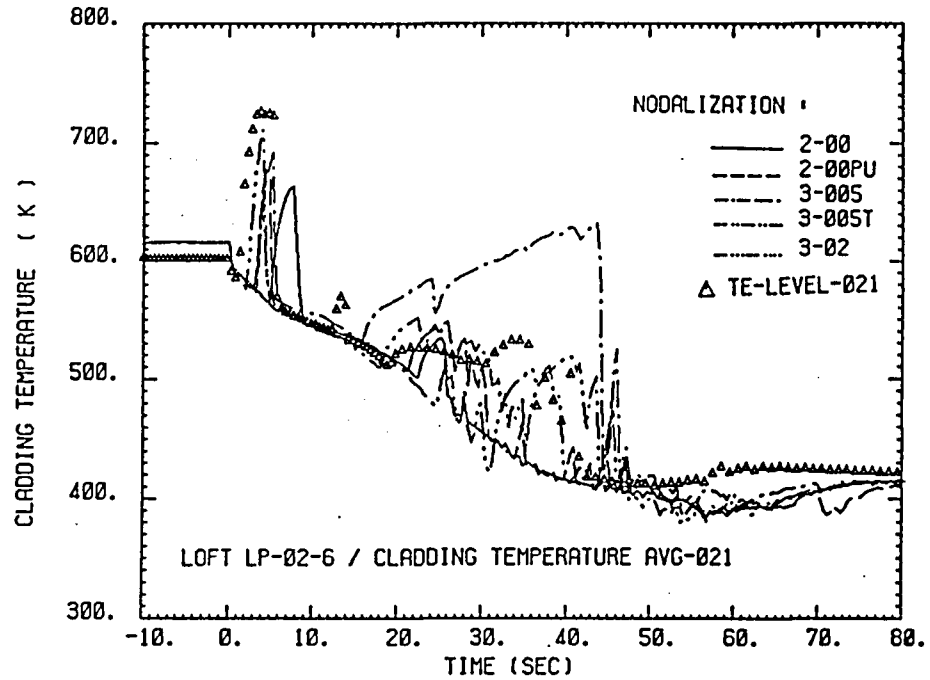


Figure 3.15: Average channel cladding temperatures vs. time at axial level 11 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



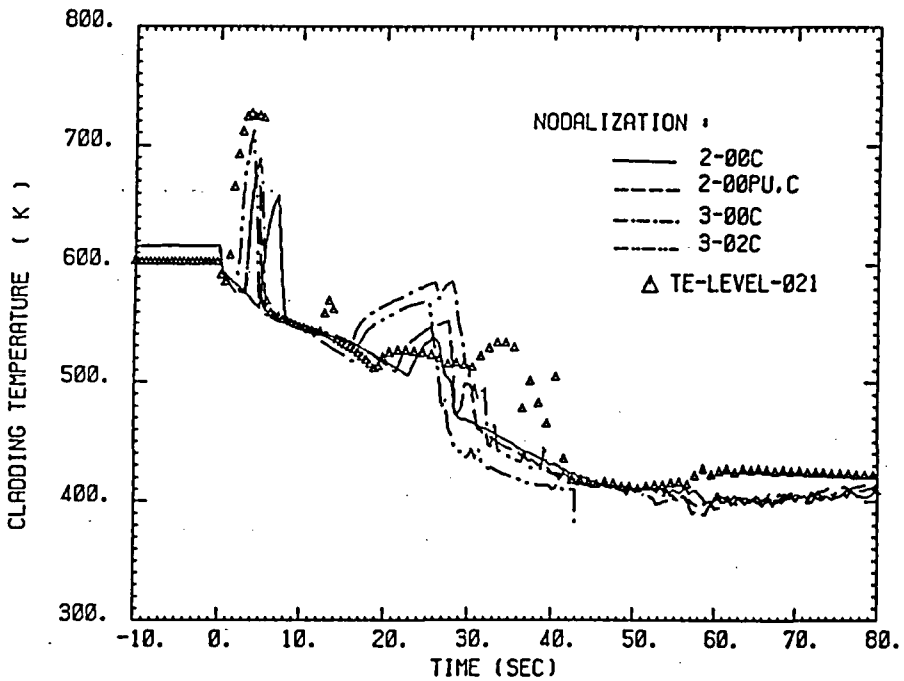
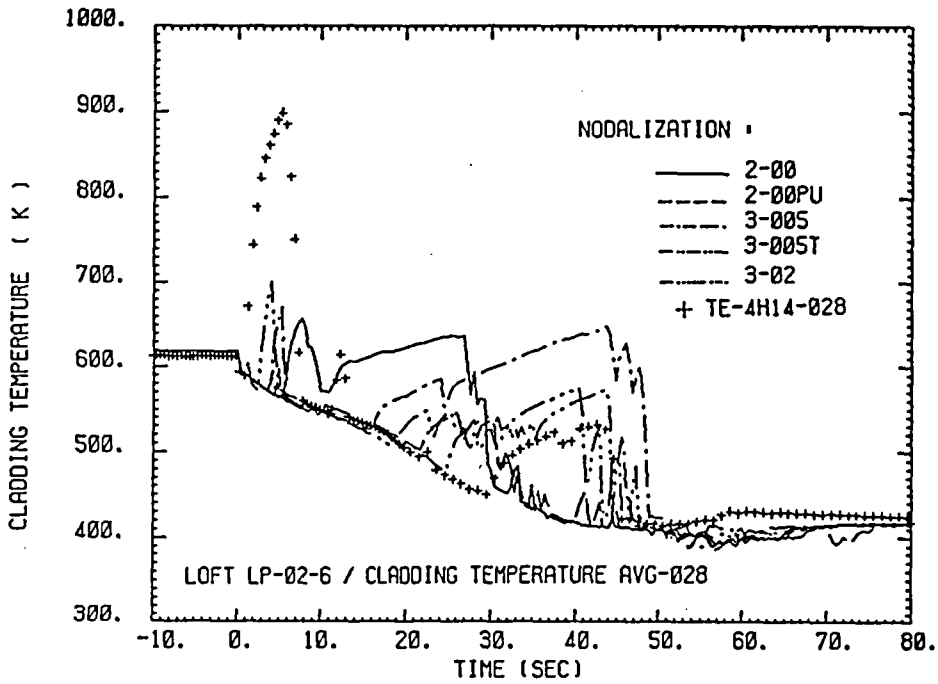


Figure 3.16: Averaged channel cladding temperatures vs. time at axial level 21 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



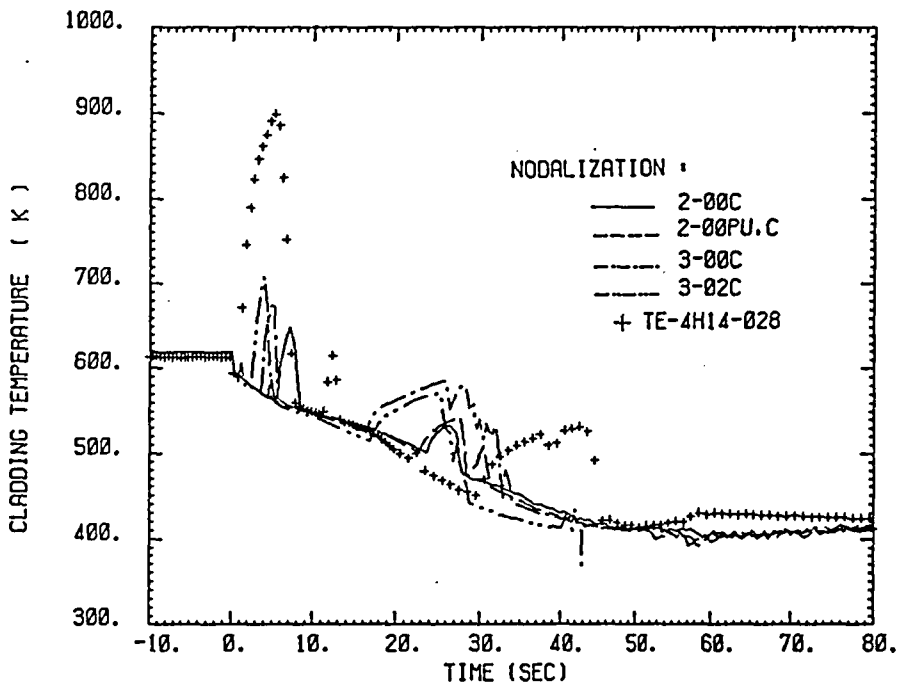
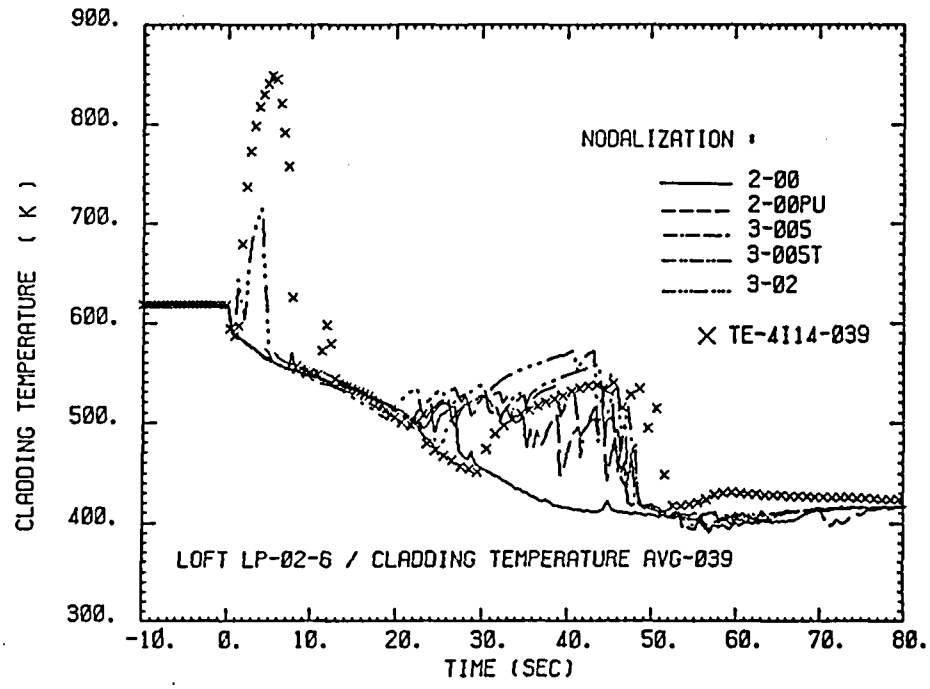


Figure 3.17: Averaged channel cladding temperatures vs. time at axial level 28 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



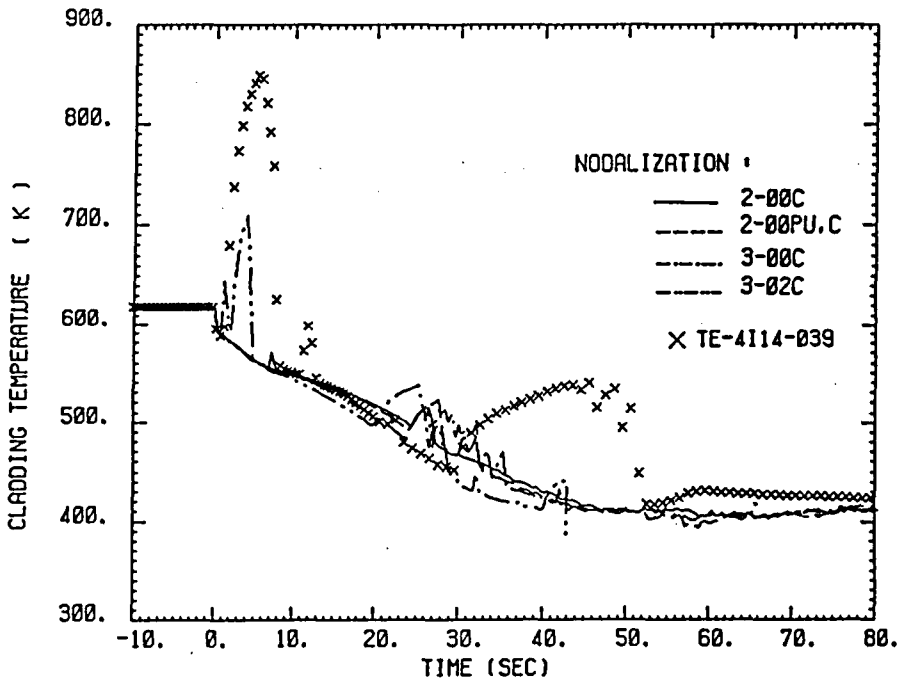


Figure 3.18: Averaged channel cladding temperatures vs. time at axial level 39 compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

indicated very similar axial distributions of the cladding temperatures which only in the middle of the core (core heights .6 to 1.2) are quite close to the experimental data (circles in the plot) whereas they differ at the bottom about 40 K. In fact, the experimentally inferred axial cladding temperature distributions have been found to be much more variing than the one calculated by RELAP5/Mod2 . If a change in the axial power distribution would bring any improvements is an open question and has not been tested yet.

During the blowdown interval, i.e. 5.3 seconds after the initiation of the transient, the RELAP5/Mod2 calculated axial surface temperature distributions of runs with the different nodalization schemes differ quite significantly both to each other as well as in comparison to the experimental findings (figs. 3.20a and 3.20b). The calculated peak cladding temperatures are centered around 0.75 m whereas the corresponding experimental values (triangles) have been found at approximately 0.5 m. On top of this, the RELAP5/Mod2 calculated core heat-ups were rather concentrated in the center region of the core (0.4 to 1.2m) whereas the experimental data indicated a more widened core heat up. One of the reasons may be the fact that RELAP5/Mod2 neglects the axial heat conduction in the cladding as well as in the fuel thus preventing from smoothing out steep axial temperature gradient in the cladding and the fuel (axial conduction is only considered by RELAP5/Mod2 near the quench front when the reflood model is applied).

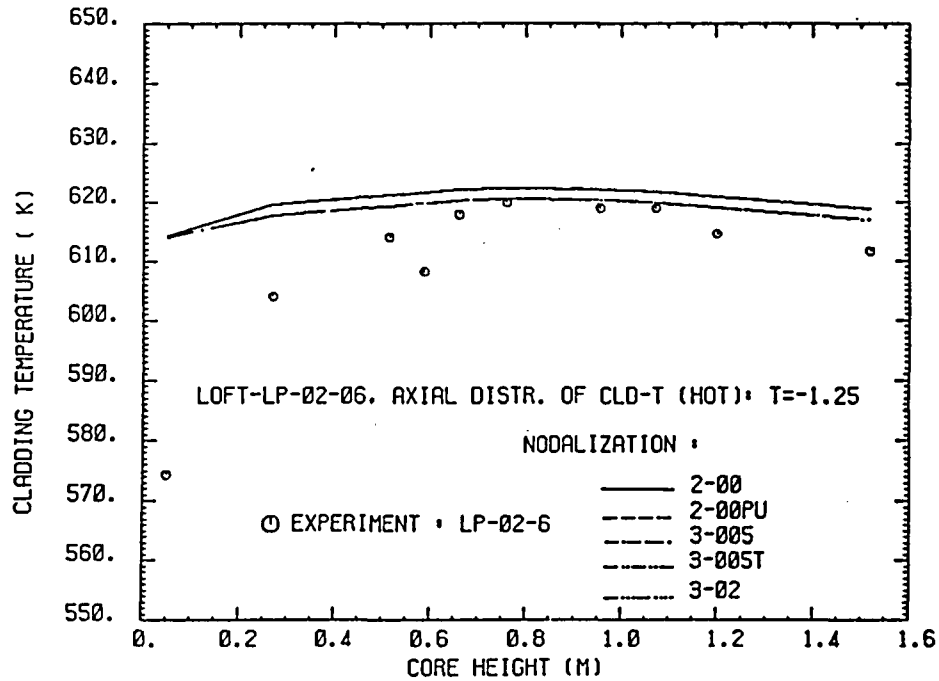
Things do not change significantly for the remaining time point of consideration, namely 40.5 seconds after the initiation of the transient (figs. 3.21a and 3.21b). Compared to the experimental findings of a heat-up of nearly the whole core with the peak value at 0.6 m, except for nodalizations 3-02 and 3-02C, RELAP5/Mod2 still calculated a core heat-up centered to the middle of the core with the peak value at 0.75 m. The 3-02 and 3-02C calculations have indicated a more widened core heat-up but on the other hand have overpredicted the experimental surface temperatures at least 175 K.

Void Fraction, Flow Regime and Heat Transfer Coefficients in the Core Zone

Besides the heat generation in the fuel (source), the other important quantity influencing the cladding temperature is the heat transfer from the cladding to the surrounding fluid (sink). To find some reasons for the deviations of the time traces of the cladding temperatures for different nodalizations, one has to investigate the heat transfer to the fluid at the specific nodes for these different nodalizations even no experimental reference is available.

The heat transfer, expressed by the heat transfer coefficient (HTC), is depending on the mass flow, the local void fraction and the flow-regime "assumed" by RELAP5/Mod2 which itsself mainly refers to the local void fraction as well as to the mass flow and the system pressure. Consequentely, erroneous mass flows and void fraction distributions will lead to wrong heat transfer coefficients and finally to questionable predictions of the cladding temperatures.

In Figs. 3.22 to 3.27 from top to bottom the local void fractions, the flow regimes as choosen by RELAP5/Mod2 and the heat transfer coefficients have been plotted versus time for axial levels 27 inches (figs. 3.22 to 3.24) and 43.8 inches from the bottom of the core. The comparison has been made for three versions of nodalizations, namely 2-00 (most detailed, plots 3.22 and 3.25), 3-005 (medium simplified, plots 3.23 and 3.26) and



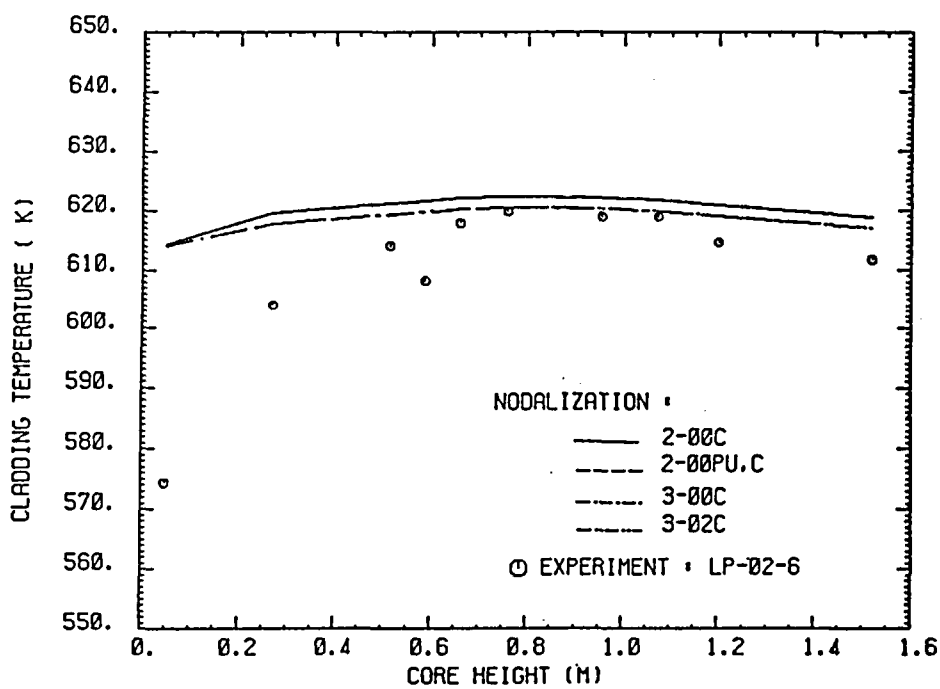
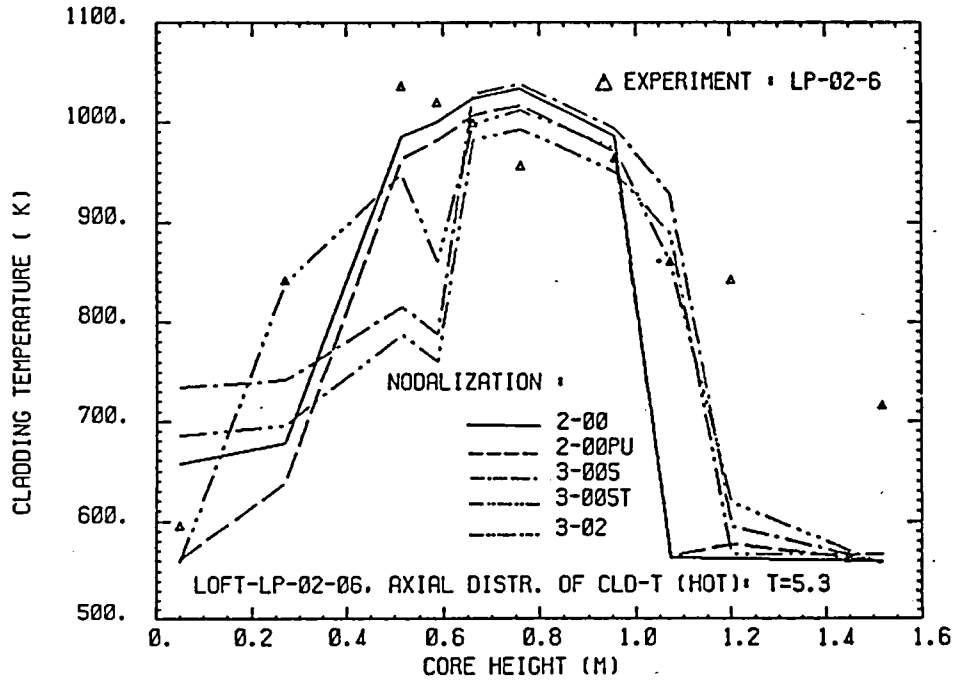


Figure 3.19: Axial cladding temperature distribution at time -1.2 s in hot channel compared with the equivalent averaged reference temperatures in box 5

a) by neglecting wall heat capacity

b) by taking into account wall heat capacity ("C")



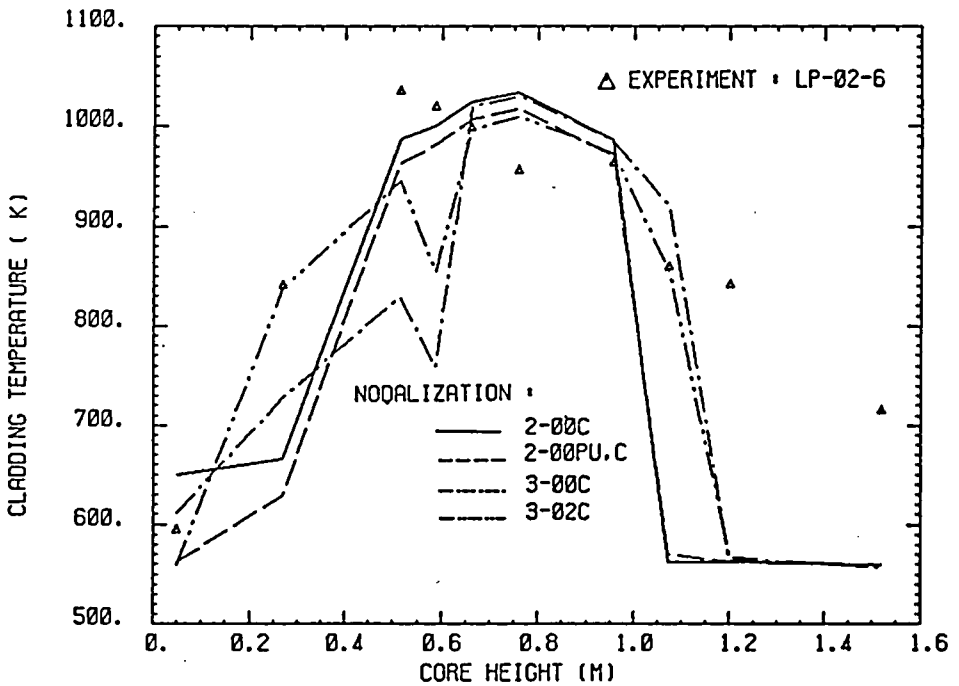
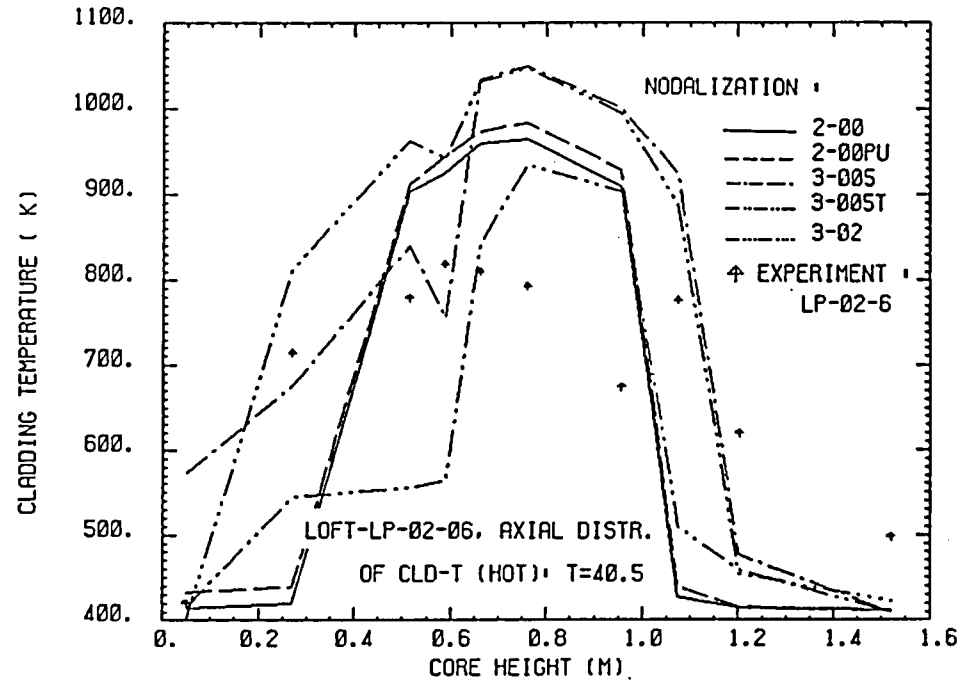


Figure 3.20: Axial cladding temperature distribution at time 5.3 s in hot channel compared with the equivalent averaged reference temperatures in box 5

a) by neglecting wall heat capacity

b) by taking into account wall heat capacity ("C")



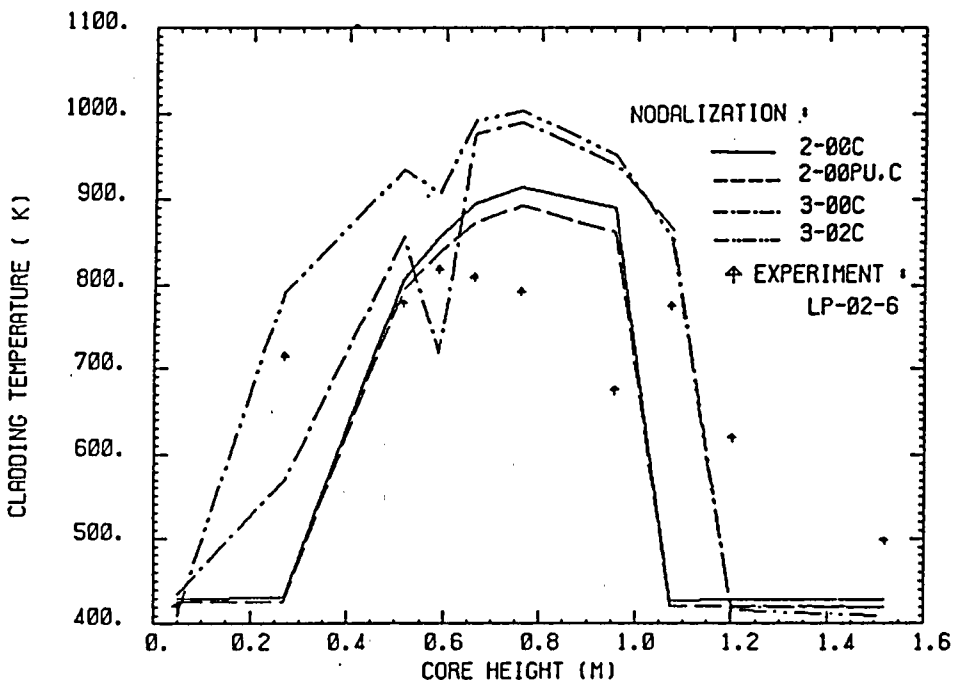


Figure 3.21: Axial cladding temperature distribution at time 40.5 s in hot channel compared with the equivalent averaged reference temperatures in box 5

a) by neglecting wall heat capacity

b) by taking into account wall heat capacity ("C")

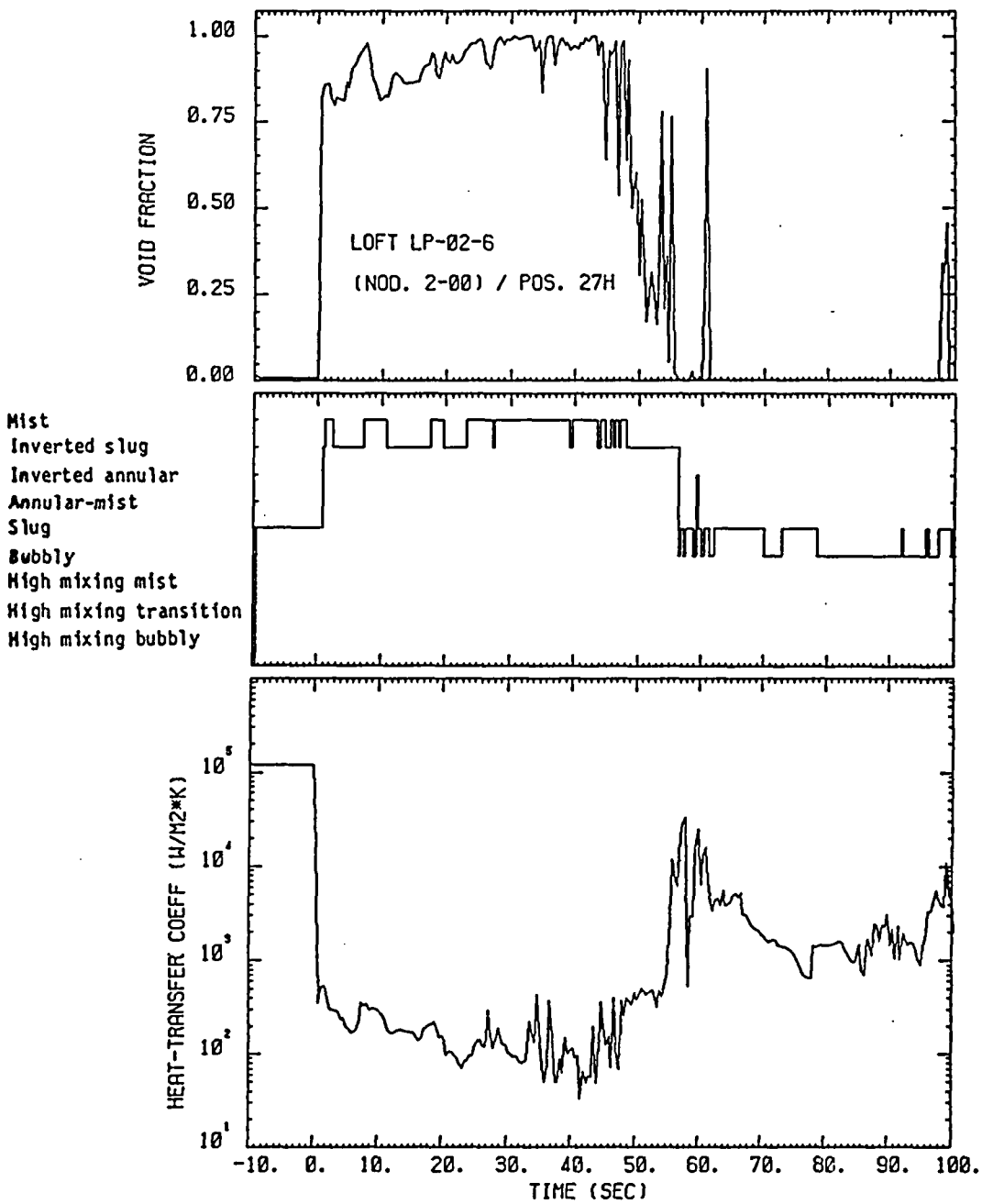


Figure 3.22: Calculated void fraction, flow regime and HTC (nodalization 2-00) for level-27 in the hot channel

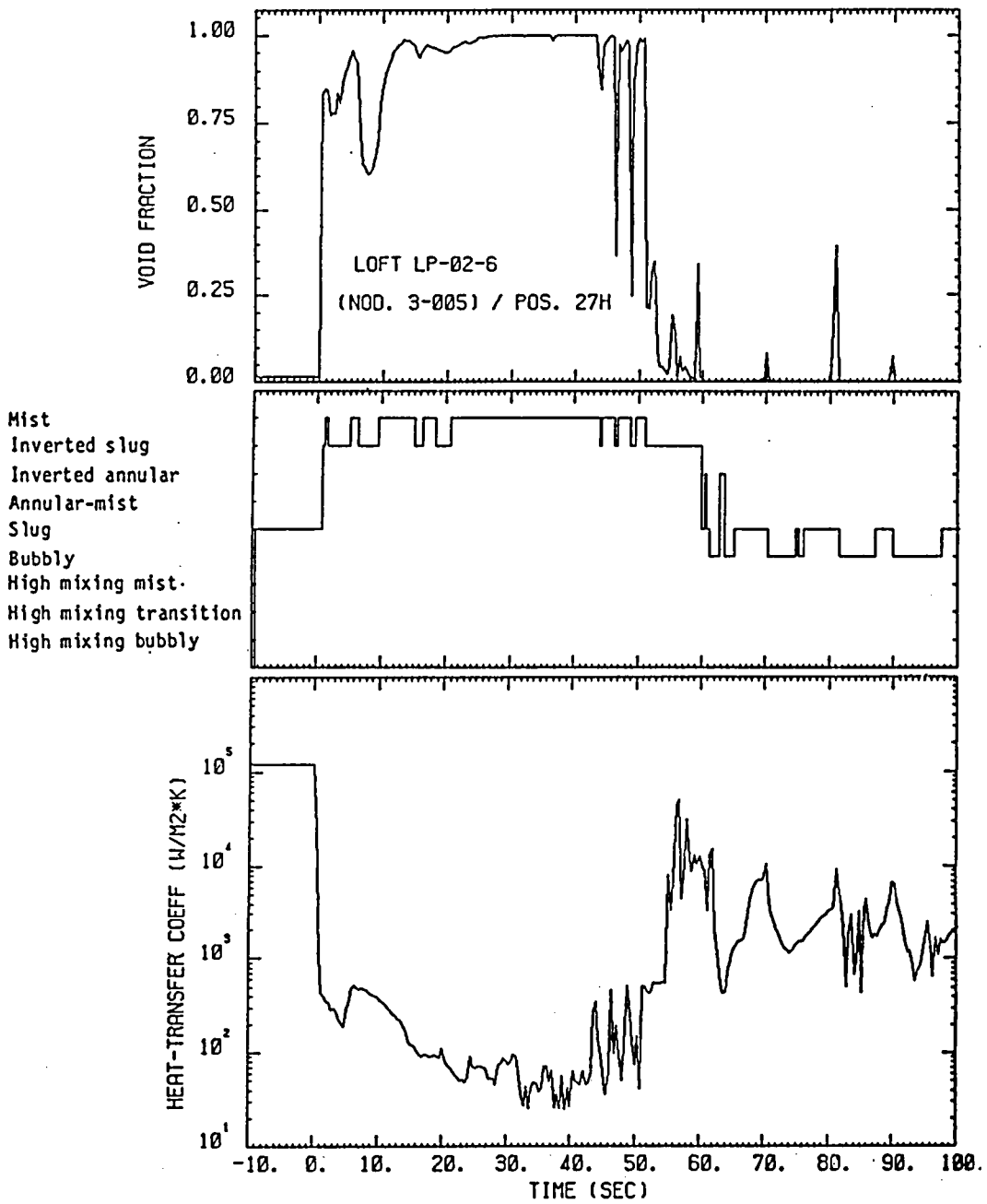


Figure 3.23: Calculated void fraction, flow regime and HTC (nodalization 3-005) for level-27 in the hot channel

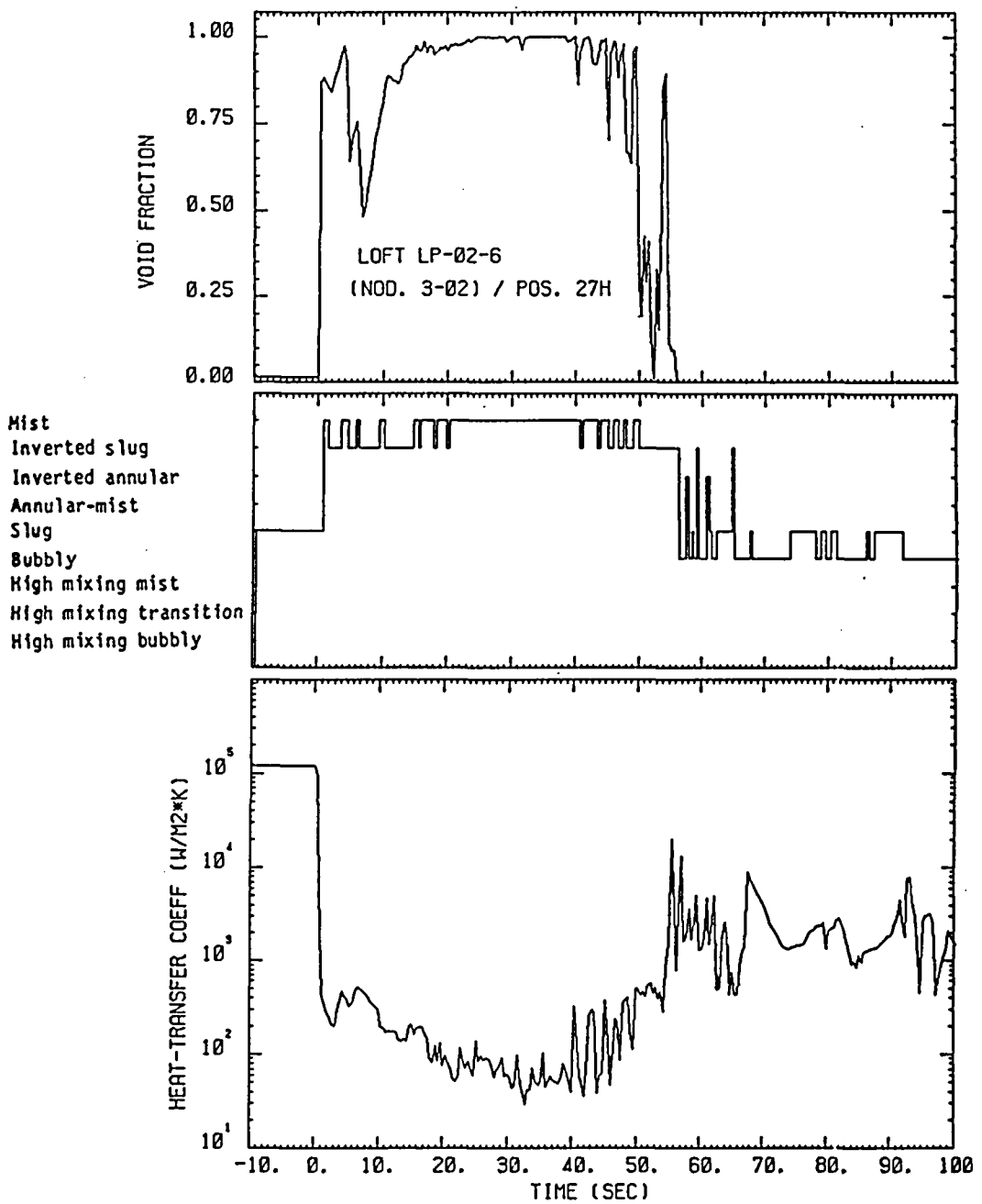


Figure 3.24: Calculated void fraction, flow regime and HTC (*nodalization 3-02*) for level-27 in the hot channel

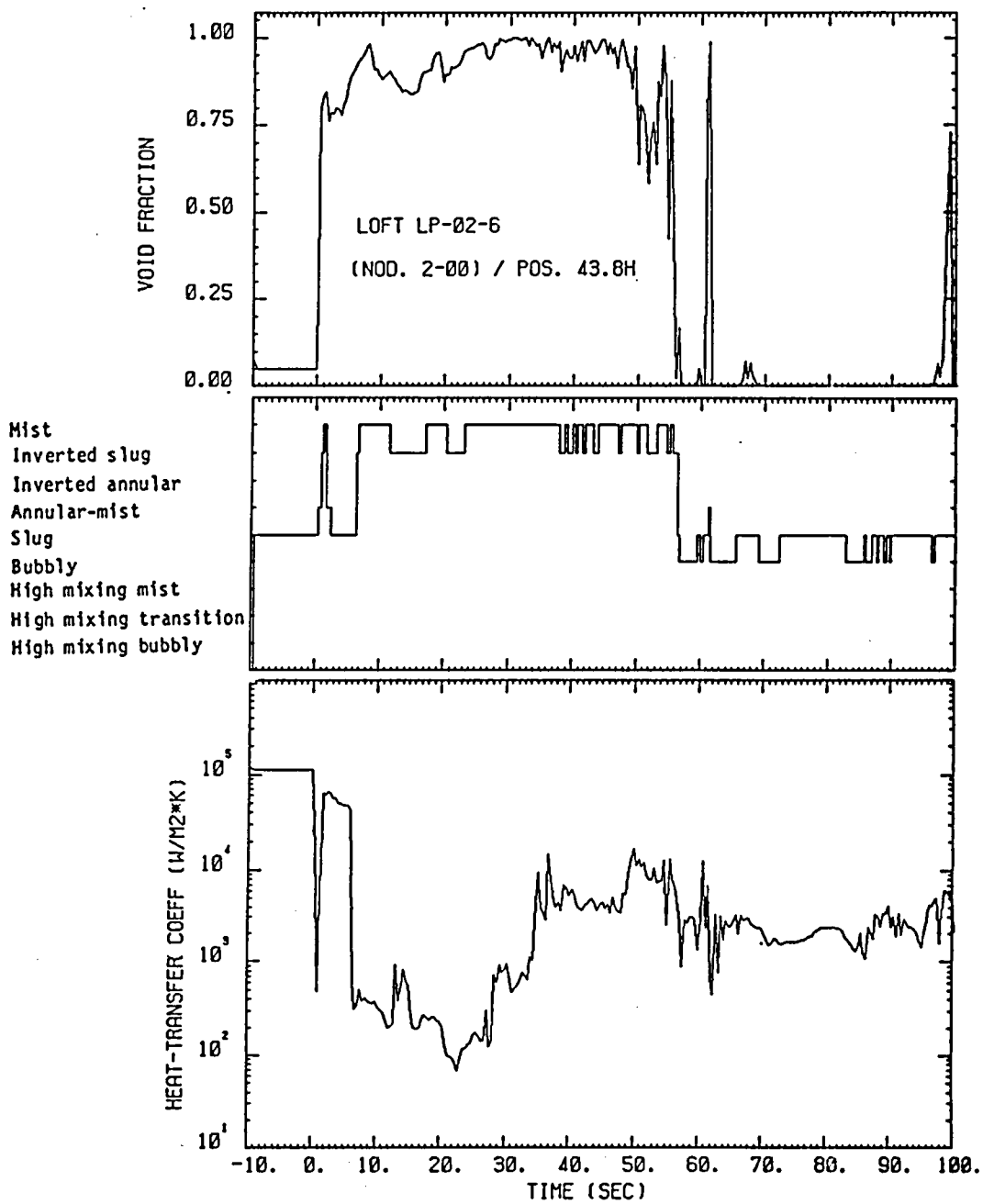


Figure 3.25: Calculated void fraction, flow regime and HTC (nodalization 2-00) for level-43.8 in the hot channel

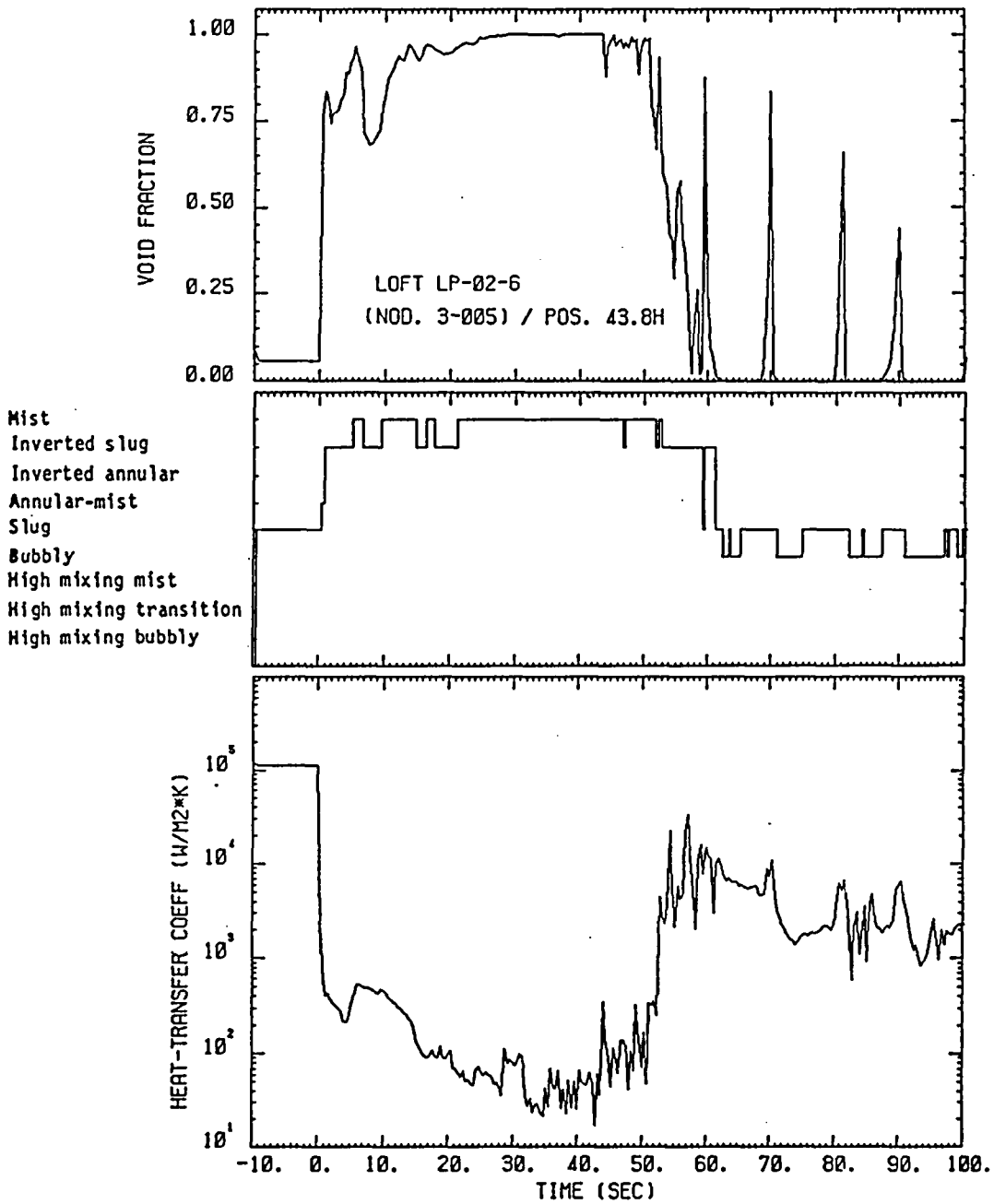


Figure 3.26: Calculated void fraction, flow regime and HTC (nodalization 3-005) for level-43.8 in the hot channel

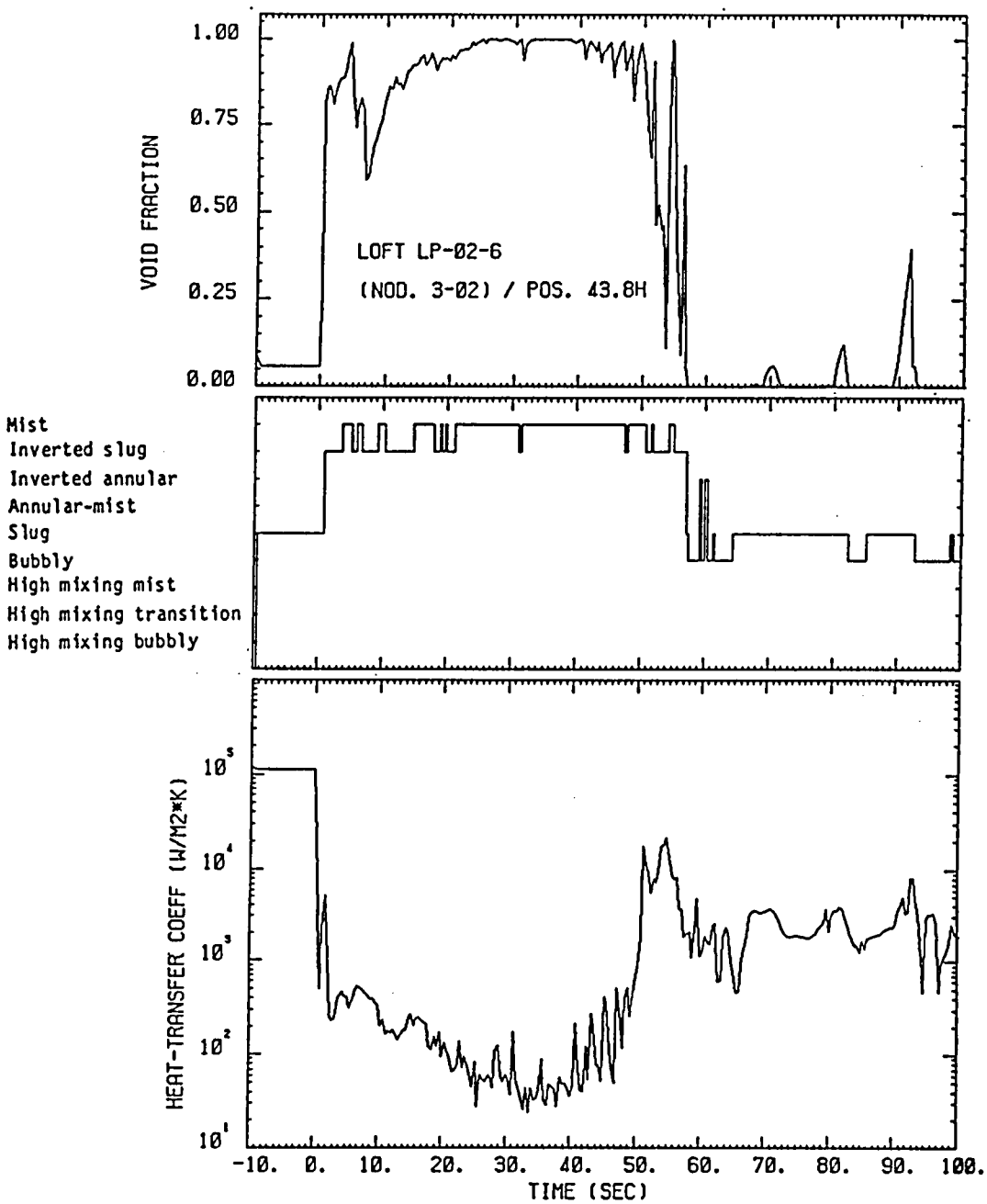


Figure 3.27: Calculated void fraction, flow regime and HTC (nodalization 3-02) for level-43.8 in the hot channel

3-02 (most simplified, plots 3.24 and 3.27).

For all three types of nodalizations, the time behaviour of the local void fraction at the equivalent axial level seem to be comparable, except that there is a "dip" in the time trace of the void fraction at 8 seconds and at the same location for the 3-005 and 3-02 nodalizations, which cannot be found in the results of the 2-00 nodalization. After the initiation of the transient, the void fraction has increased very rapidly from zero to nearly 100%, where it remained until refilling has reached level-27 at about 45 seconds and level 43.8 at 50 seconds. When the quench front has reached axial levels 27 and 43.8 respectively, the void fraction was quite unstable for about 10 to 20 seconds, the oscillations of the void fraction nearly covered half of its range.

The void fraction is one of the main parameters of RELAP5/Mod2 to determine the flow regime which itself is a key information for the evaluation of the interfacial heat transfer as well as of the interfacial shear stress coefficient which, to close the circle, again highly influences the void fraction distribution. Therefore, the graphs in the center of figs. 3.22 to 3.27 show the flow regimes, as defined by the code, as a function of time. In the stationary phase of the experiment, RELAP5/Mod2 decided for slug-flow in the hot zone of the core. After the initiation of the transient, it decided for inverted slug-flow or alternatively mist-flow until the occurence of the quench at this specific position. Then again, slug-flow has been assumed alternatively with annular-mist-flow. Depending on the nodalization used for the claculation, a smaller or even greater number of "switches" between inverted slug and mist-flow on one side and between slug and annular-mist-flow on the other side may occur. The differences of the latter two flow regimes are minor important for the determination of the heat-transfer-coefficient (HTC) from the wall to the liquid but may result in enormous differences when evaluating the interfacial friction factors and the interfacial heat transfer coefficients. Probable oscillations in these two important quantities are then feedbacked, causing instabilities in the void fraction calculation.

The lower graphs on figs. 3.22 to 3.27 show the heat-transfer-coefficients (HTC) as a fuction of time. As expected, heat-transfer-coefficient drops rapidly into the inverted-slug / mist-flow regimes thus resulting in heat-up of the fuel. Occurance of the rewetting is well indicated by the steep increase of the heat-transfer-coefficient between 40 and 60 seconds, depending on the axial location and the type of nodalization.

We would like to focus the attention of the reader on some inconsistencies between the flow regime indicator (middle plot) and the heat-transfer-coefficient (lower plot) more or less pronounced in all of the six calculated cases, namely that the time-traces of the flow regime indicator and of the heat-transfer-coefficient indicate "quench" at different times. We have reported similar inconsistencies in our LP-LB-1 post test analysis. Whereas in fig. 3.22, this discrepancy is only about two seconds (the "quench time" of the heat-transfer-coefficient is comparable to the value given by the steep negative gradient of the cladding temperature, see fig. 3.9), in fig. 3.23 this difference is raised to 24 seconds (again, the heat-transfer-coefficient "quench" is comparable to the cladding temperature "quench" on fig. 3.12). This was a calculation using the 2-00 nodalization. For the other examples, e.g. nodalizations 3-005 and 3-02, these inconsistencies are slightly smaller but still exist. Generally, they were larger at level 43.8 than at level 27. In other

words, the code calculated the heat-transfer-coefficient from the cladding to the coolant assuming completely other flow conditions than the heat-transfer-coefficient between the steam and liquid phases for longer periods.

With regard to the "stabilities" of the void fraction (upper plot), of the flow regime (middle plot) indicator as well as of the heat-transfer-coefficient (lower plot), the most simplified 3-005 and 3-02 nodalizations seem to be more stable than the more detailed version 2-00.

As we have already mentioned above, flow regime and heat transfer coefficients in the core region are stronly depending on the axial void fraction distribution as well as on the mass flows in the core region. Both of them are determined by the thermohydraulic conditions in the primary system of the LOFT reactor like the intact and broken loops, the pressurizer, the heat sink (steam generator secondary side or a more simplified version of it), the primary coolant pumps and the behaviour of the ECC-systems. The predictions of their behaviour during the transient depend on the ability of the code in describing the sequence of thermohyraulic phenomena. Therefore, a realistic description of the main phenomena has to be regarded as a "conditio sine qua non" for the predicting capability of the key parameters like the cladding temperatures.

In what follows, we shall concentrate on the description of these phenomena by considering some other important parameters. But before we start this discussion, we would like to look also at the second key parameters with respect to safety aspects, which in the case of a large break are of less importance because the reactor has been scrammed within parts of a second after the initiation of the transient, thus drastically reducing the heat generation within the fuel.

3.4.2 Fuel Center Temperature

Only at one axial level experimetally inferred fuel center temperatures are available, namely at position 27 (i.e. 27 inches from the bottom of the core, where the "hot-spot" has been found for experiment LP-02-6). The equivalent predictions of RELAP5/Mod2 for the different nodalization schemes have been compared to the experimental data and plotted in fig. 3.28. The experimental data are average values of fuel center temperature data at 10 radially distributed positions on axial level 27 of the center box 5.

Obviously, the highest fuel temperatures have been reached at full power conditions, before the transient has been initiated. For these stationary conditions, the calculated temperatures are quite close to the experimental data, independently of the type of nodalization.

During the transient, the calculated fuel center temperatures have been found to be only in qualitative aggreement with the experimentally inferred reference temperatures. Except the results of the 3-005T nodalization which is surprisingly in good aggreement with the measured temperature distribution (because, as we have already mentioned, also the cladding temperatures have been calculated with excellent accuracy at this axial position; see fig. 3.9a), the fuel center temperatures have been overpredicted by RELAP5/Mod2 between 250 K and 300 K for nearly the whole time period until the rods have been quenched (10 to 55 seconds of the transient). The temperature traces as calculated by RELAP5/Mod2 using different nodalizations are similar. No significant differences have been observed between the

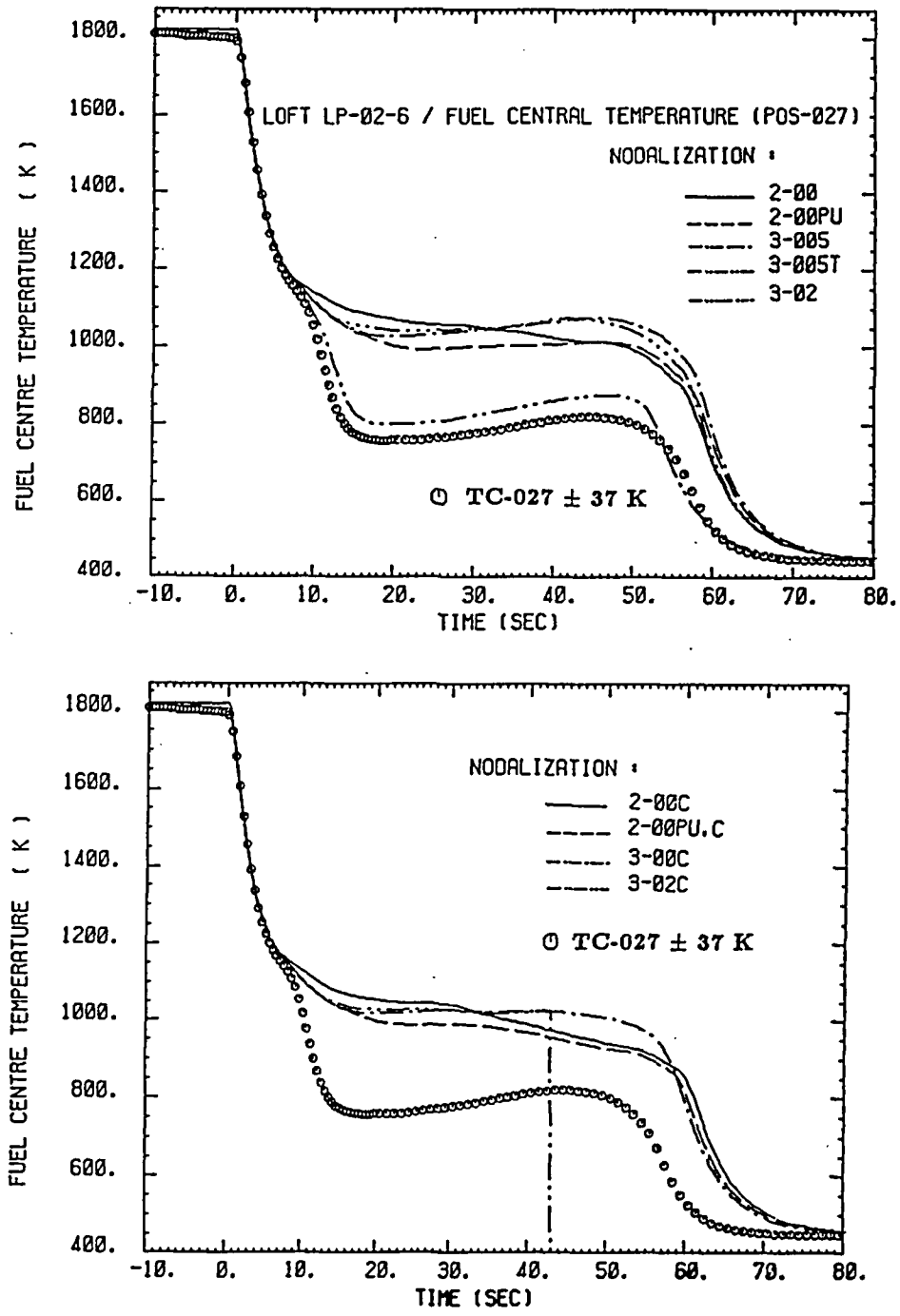


Figure 3.28: History of the fuel center temperature in the hot channel compared with averaged measured fuel temperatures at level-27
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

results of the most elaborated 2-00 and the most simplified 3-02 nodalization. Furthermore, the differences between the normal and the "C" versions (i.e. not taking and taking into account heat capacity effects of the vessel material) are quite small even the overprediction of the "C" versions seems to be by some degrees less.

3.4.3 System Pressures

It is a well-known fact that most of the best-estimate codes do a quite satisfactory job when predicting the system pressures. Our investigation also confirms this common knowledge.

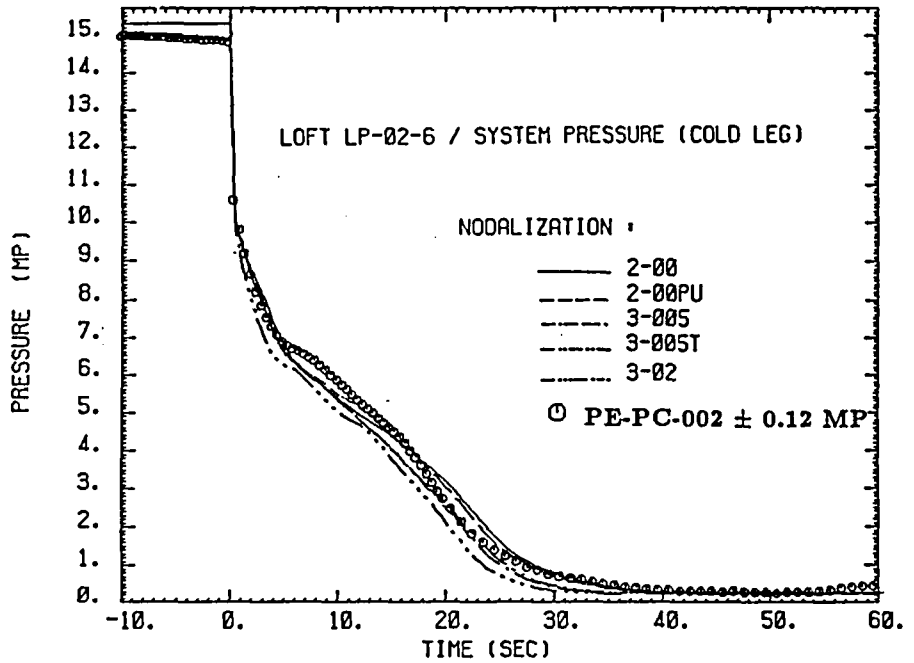
In figs. 3.29a and b, the system pressures as calculated by RELAP5/Mod2 have been compared to the experimental data, i.e. the absolute pressures as measured by the pressure transducer mounted in the cold leg of the intact loop at station 002. As usual in this contribution, we again have separated our results into two plots, the upper showing the results of the predictions using the normal nodalizations and the lower showing the ones using the "C" versions. Obviously, for all the different nodalizations, the RELAP5/Mod2 calculations are fairly good even though smaller discrepancies occur between 5 and 30 seconds of the transient. Closest to the experimental findings seem to be the calculations of versions 3-005 and 3-00C, i.e. the results of calculations using a rather simplified type of nodalizations of the LOFT-system.

Compared to those of the system pressure, the predictions of the pressure in the pressurizer have been found less accurate as one may see in figs. 3.30a and 3.30b. Here, the calculations of the runs with 3-... type of nodalization, i.e. the cases with a reduced modelling of the pressurizer (instead of 11 volumes used for the pressurizer in the standard version 2-00, in the 3-... versions only 5 voulumes have been used), are fairly poorer than those of the standard version 2-... which sufficiently follow the experimental data. Especially between 3 and 15 seconds, the underprediction of RELAP5/Mod2 runs using 3-... nodalizations may exceed 2 MPa. These deviations only occur in the pressurizer and are not to be found at any other location in the system; we therefore believe that these deviations are tolerable for the course of the transient because the predictions of the pressure inside the pressurizer seem to be of secondary importance.

3.4.4 Fluid-Temperature in the Downcomer

Besides the system pressure, the fluid temperatures in the downcomer may be important with respect to the void formation in the core region because these temperatures are more or less identical to those at the entrance of the core, provided a positive flow out of the downcomer into the core region occurs. Therefore, in figs. 3.31a and 3.31b, we would first like to compare the fluid temperatures as predicted by RELAP5/Mod2 using the different nodalizations with equivalent temperature traces as measured in the downcomer at position 005.

The initial values of the fluid temperatures have been predicted fairly well (-10 to zero seconds). This is also the case for the following time interval between zero and approximately 20 seconds where the temperatures follow the saturation line. Because of the rapid drop of the system pressure, the fluid temperature becomes saturated at about 8 seconds after initiation of the transient.



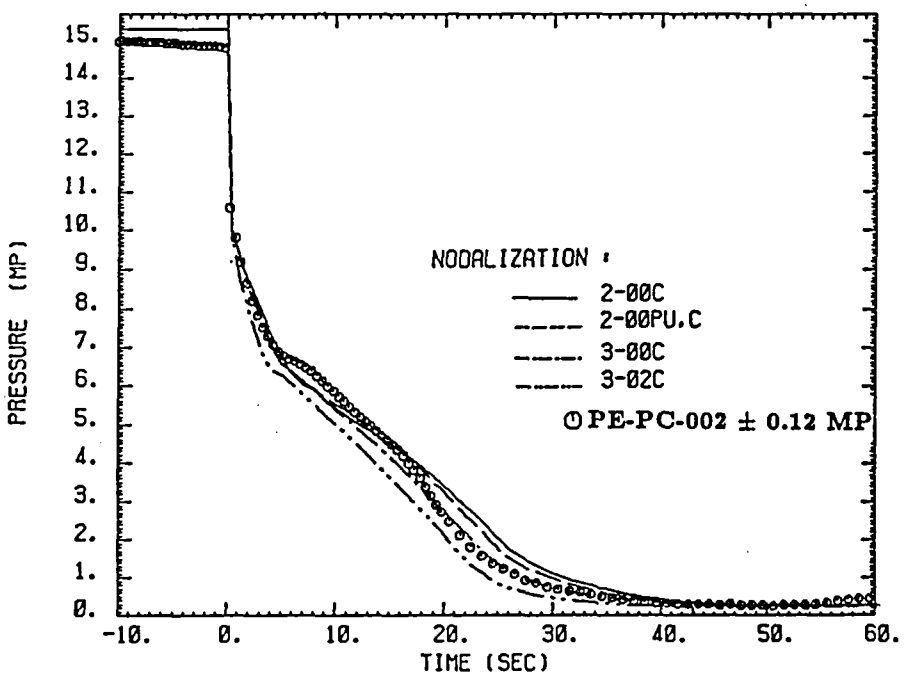
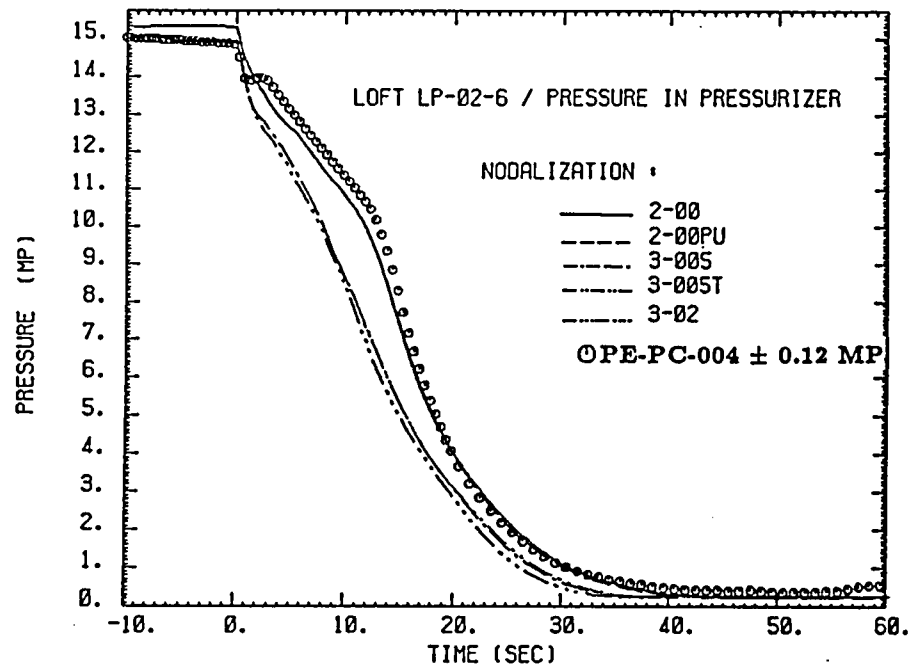


Figure 3.29: System pressures in the cold leg vs. time compared with pressure measured at station PC-002
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



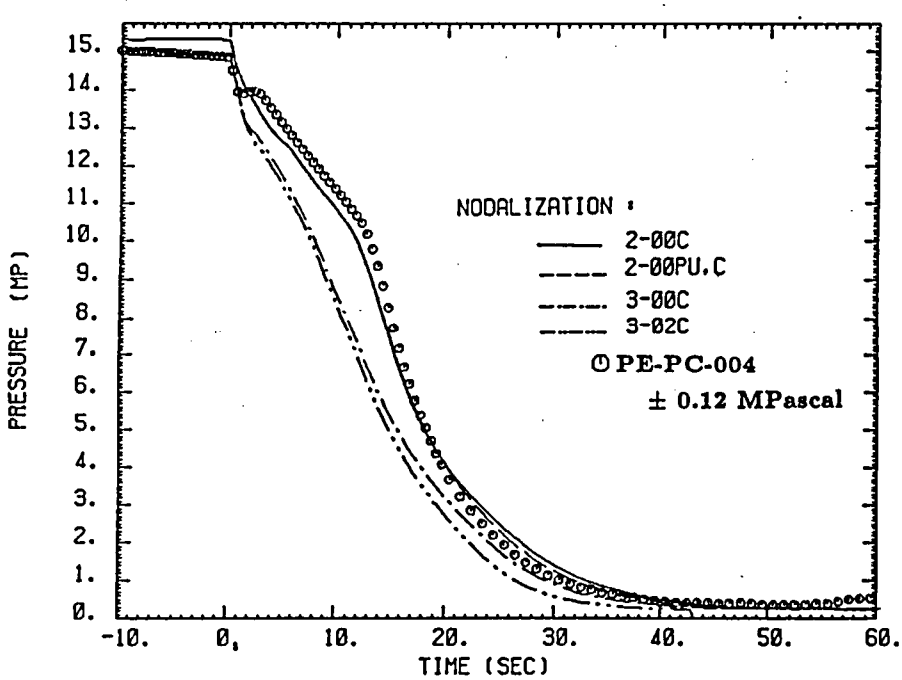
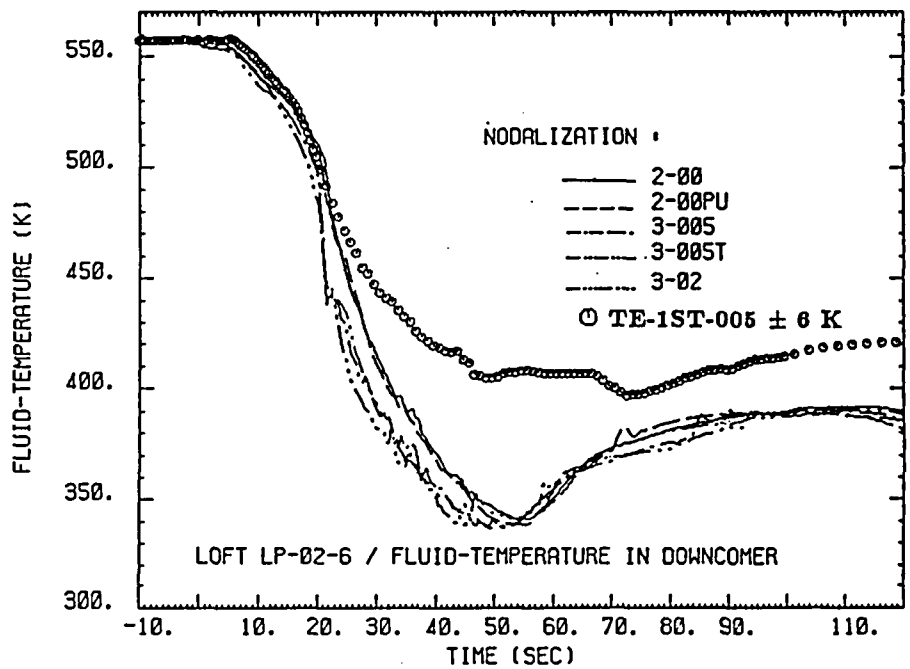


Figure 3.30: Pressures in the pressurizer vs. time compared with pressure measured at station PC-004 of the pressurizer
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



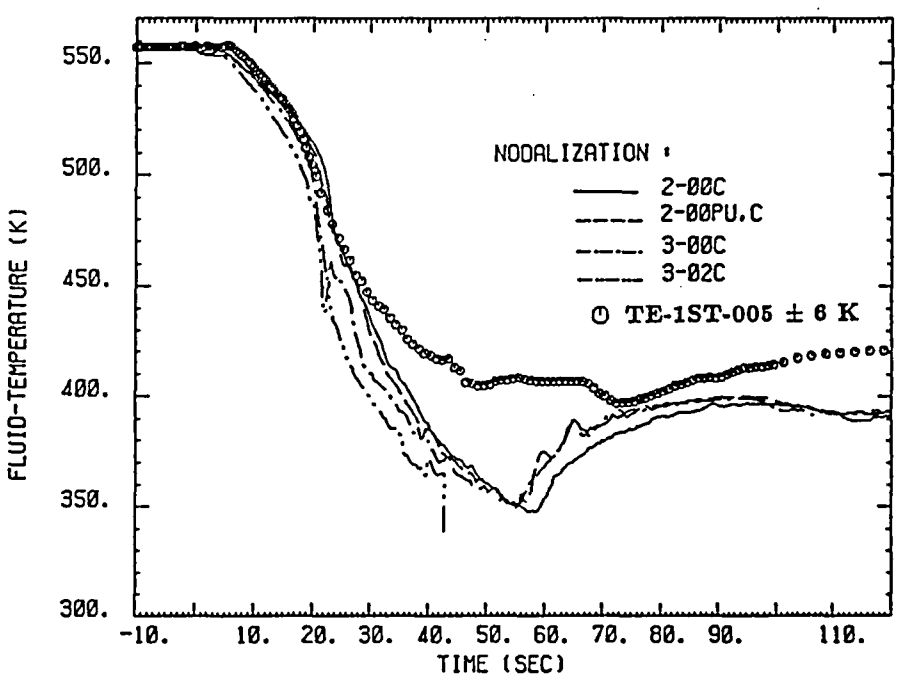


Figure 3.31: Downcomer fluid temperatures vs. time compared with fluid temperatures measured at station 1ST-005
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

For all the versions of nodalizations, the fluid temperatures start to deviate from saturation at approximately 25 seconds and reach the saturation temperature again at about 70 seconds. Beginning at 40 seconds, the system pressure is more or less constant (see figs. 3.29a and 3.29b). The straight line in figs. 3.31a and 3.31b for times higher than 70 seconds can be regarded as the saturation temperature at this pressure, i.e. all temperatures below this line indicate subcooled fluid. Consequentely, RELAP5/Mod2 predicted a certain amount of liquid subcooling in the time interval between 20 and 70 seconds which has reached peak values of up to 70 K for all of the "N" versions of nodalization and minimum peak subcoolings of 55 degrees for most of the "C" versions. On the other hand, the thermocouple signals have indicated a significant "liquid superheat" of nearly 20 K which probably is due to a dry out of the thermocouple tip, measuring something in between saturated steam temperature and thermocouple heat-up due to radiation heat transfer.

3.4.5 Core Mass Flows

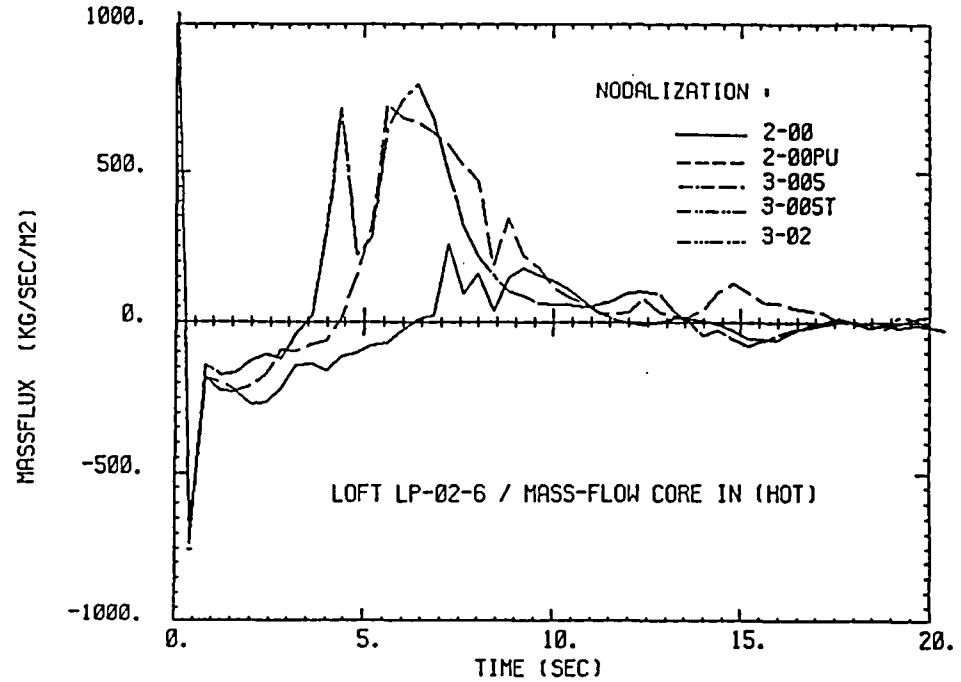
Now, we have to look at mass flows into and out of the core as calculated by RELAP5/Mod2 . In figs. 3.32a and 3.32b, the mass fluxes into the core and in figs. 3.33a and 3.33b, the mass fluxes out of the hot channel have been plotted. Unfortunately, no corresponding experimental reference data are available.

In figs. 3.32a and 3.32b, the inlet mass fluxes into the hot channel as calculated by RELAP5/Mod2 using different nodalizations have been plotted. Generally, depending on the nodalization, the mass fluxes are positive for some seconds between 3.5 and 15 seconds and then remain nearly on the zero line whereas below 3.5 seconds to 6.5 seconds i.e. during the blowdown phase, depending on the nodalization, the flow direction indicates a strong reverse flow.

Obviously, the amount of positive core mass flux during the first 15 seconds of the experiment is strongly depending on the pump behaviour because only the predictions of the 2-00 nodalization (i.e. rapid pump coastdown similar to that of experiment LP-LB-1 (see ref. [7]) have indicated a quite small amount of positive core mass flux whereas all the other runs with imposed pump behaviour, i.e. pump speed has been given as a boundary condition according to the experimental pump behaviour, indicated as significant positive inlet flux.

The mass fluxes out of the core, figs. 3.33a and 3.33b, experienced similar behaviour. Again, for the first 3.5 seconds, the fluxes are negative, i.e. the fluid streams from the upper plenum through the core into the downcomer (broken leg). Then for all the runs except the 2-00 and 2-00C nodalizations, the mass fluxes became highly positive reaching values up to 850 kg $sec^{-1}m^{-2}$ for at least two seconds, indicating a fast liquid flow out of the core. Again, only the RELAP5/Mod2 calculations based on the 2-00 and 2-00C nodalizations (rapid coastdown of the pumps) showed rather low mass fluxes with peak values of not more than 150 kg $sec^{-1}m^{2}$. The highly positive mass fluxes into and out of the core during the first seconds of the transient seem to be a consequence of the pump operation because they only occur when the pumps remained connected to their flywheels; for nodalizations 2-00 and 2-00C where the flywheels have been disconnected, the mass fluxes have been significantly lower.

Based on the RELAP5/Mod2 calculations,



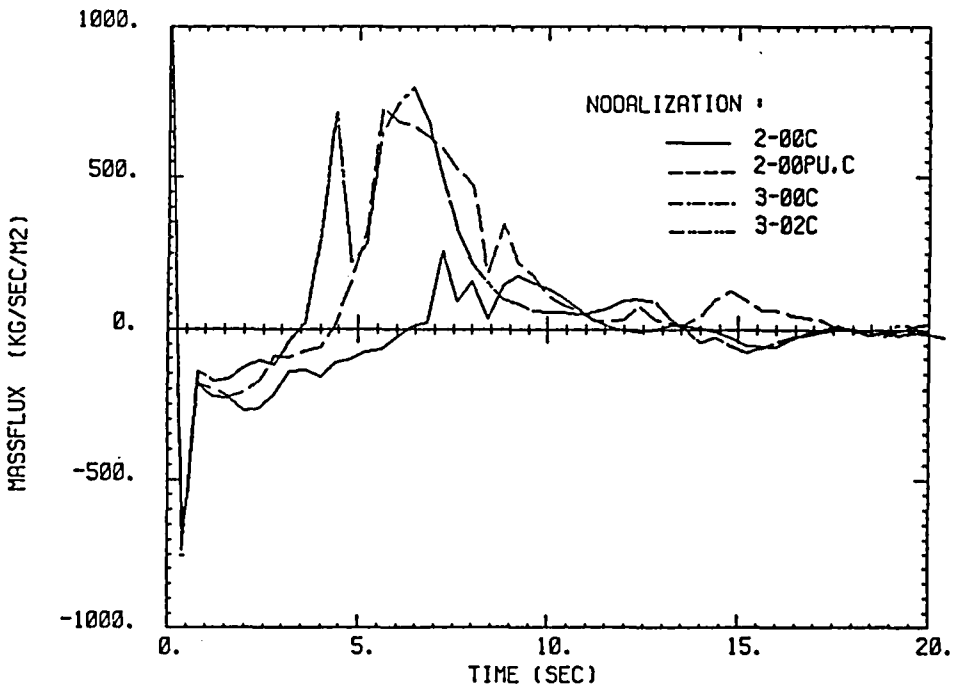
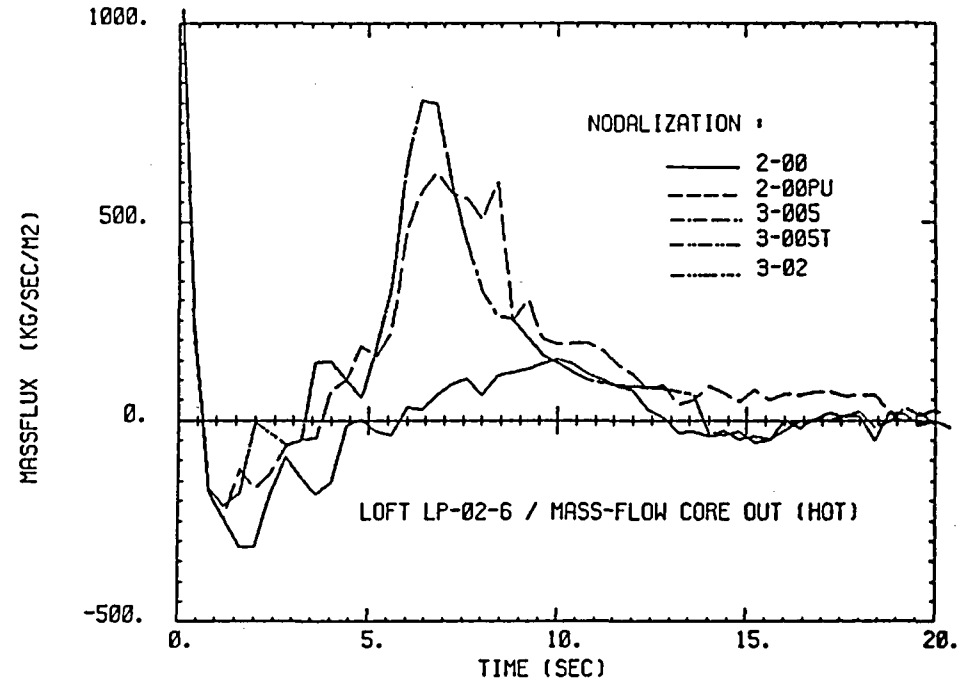


Figure 3.32: Mass fluxes into the hot channel of the core as calculated by RELAP5/Mod2
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



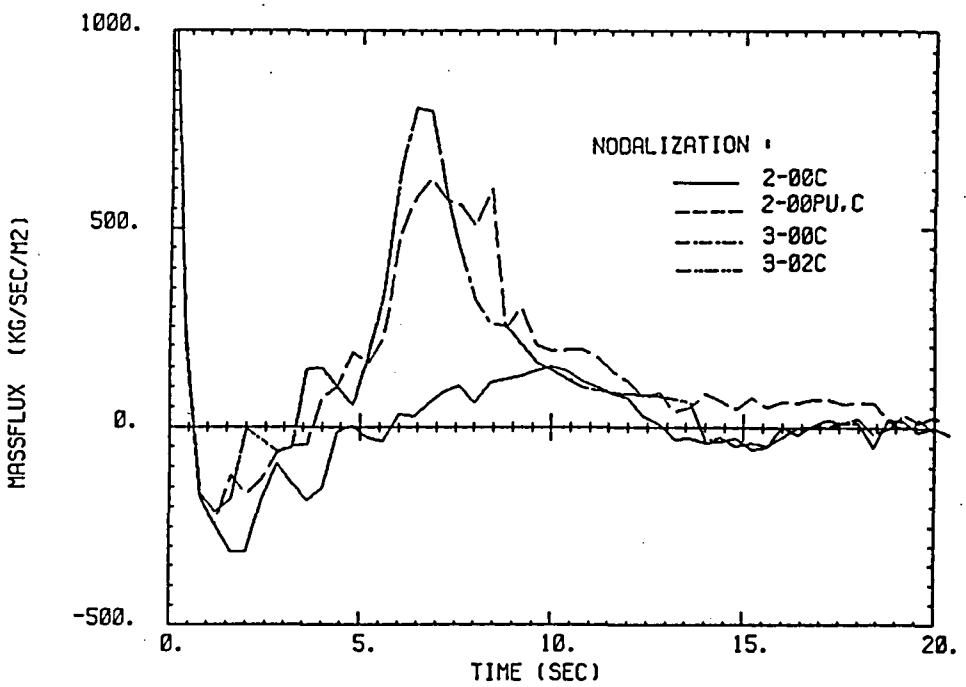


Figure 3.33: Mass fluxes out of the hot channel of the core as calculated by RELAP5/Mod2
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

these high positive mass fluxes into and out of the core during at least three seconds of the blowdown interval of experiment LP-02-6 are a strong indication that bottom-up reflooding could have been taken place. Consequentely, if the code has failed to predict bottom-up rewetting (which on the other hand has been observed experimentally) it has to be attributed to a lack of proper modelling the rewetting phenomena within the RELAP5/Mod2 code. We shall come back to this point in chapter 3.4.

On the other hand, there is no "calculational evidence" for the assumption of a significant top-down quenching during the blowdown phase because the mass fluxes do not reach significant negative values within the first 20 seconds of the experiment. Therefore, top-down reflodding cannot be expected from these calculations.

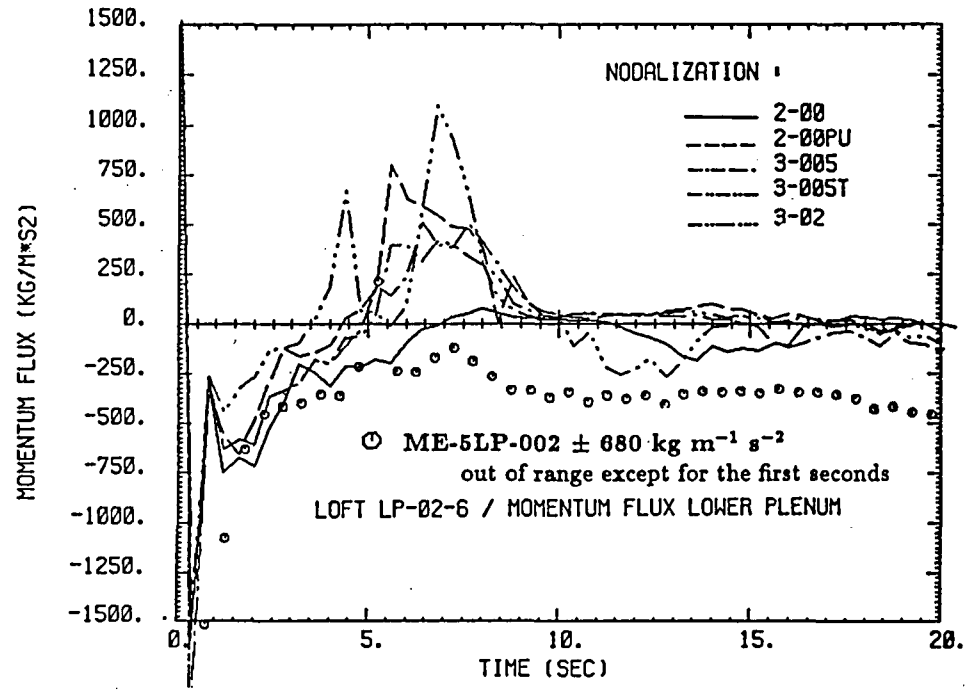
Somehow related to the mass fluxes are the momentum fluxes. Therefore, in addition to the mass fluxes, we shall plot the in- and outflow momentum fluxes in figs 3.34a, 3.34b, 3.35a and 3.35b, because for these parameters experimental references are available. Although these references inferred from very local measurements (small drag bodies) and as indicated in the individual plots observed high transducer uncertainties, they may allow us to see a trend of the time behaviour of the mass flows. Indeed, the time traces of themomentum fluxes and mass fluxes as calculated by RELAP5/Mod2 behave quite similar.

Both the momentum fluxes in the lower plenum (figs. 3.34a and 3.34b) and in the upper plenum (figs. 3.35a and 3.35b) deviated significantly from the measured data points. Whereas the core outlet momentum fluxes have been reproduced by RELAP5/Mod2 within the right magnitude of 2000 kg $m^{-1}s^{-2}$, with the only difference that the measured peak is wider than the calculated one, the core inlet momentum fluxes (figs. 3.34a and 3.34b) indicated even different signs, namely a negative momentum flux of the measured and a positive one of the calculated data; in fact one single data point of the momentum flux at 5.4 seconds of the transient is positive. On the other hand, because the measured momentum fluxes give positive outflows on both sides of the core which implies an impossible fluid source inside the core, at least one of the two local momentum flux measurements is somehow dubious with respect to their applicability to global values.

3.4.6 Core Average Liquid Fractions

Very important for the behaviour of the cladding temperatures are the average liquid fractions in the core region (identical to the relative collapsed liquid levels) because low liquid fractions are essentially neccessary to allow core heat-up whereas increasing liquid fractions are the consequence of a refilling process. Therefore, in figs. 3.36a and 3.36b, the average liquid fractions as calculated by RELAP5/Mod2 for different nodalizations have been plotted. Unfortunately, for this very important quantity again no experimental references have been available.

After a very sharp drop of the liquid fraction during the early blowdown phase (zero to one seconds) bottom-up reflooding is indicated by a very strong "blowdown refill peak" at approximately 8.5 seconds after initiation of the transient; this peak is less pronounced for the 2-00 and 2-00C nodalizations. Then, for all the different nodalizations, RELAP5/Mod2 predicted a minimum liquid level at approximately 30 seconds. Af-



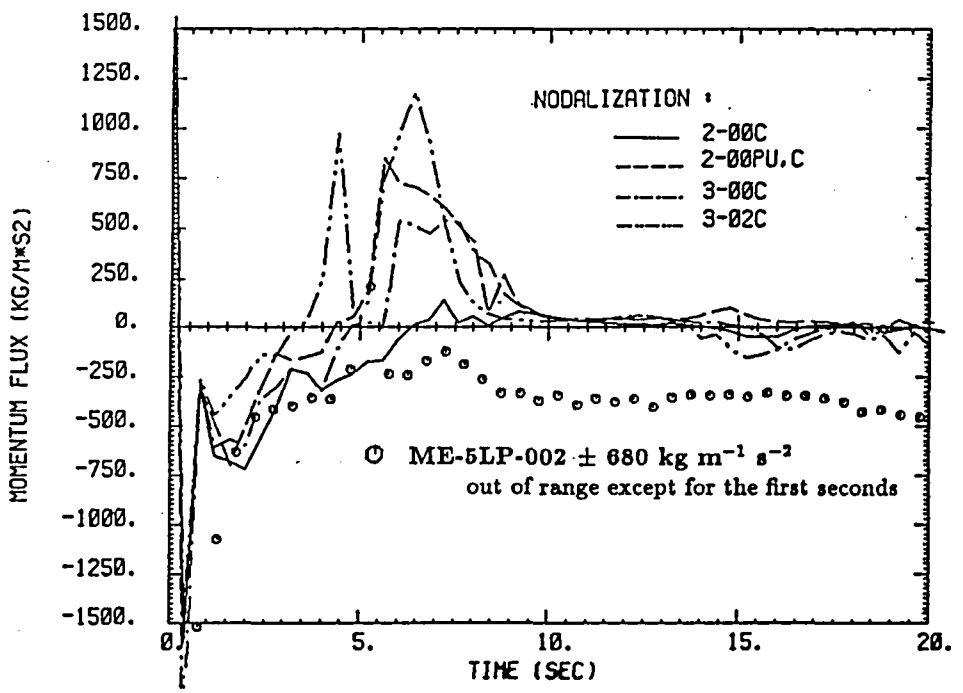
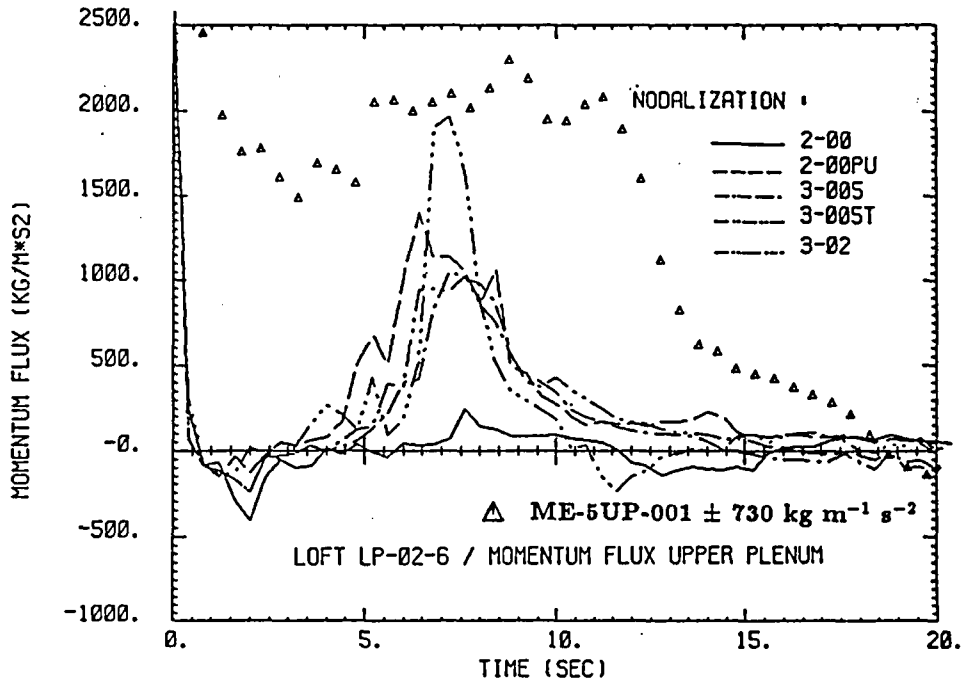


Figure 3.34: Momentum fluxes into the hot channel of the core as calculated by RELAP5/Mod2
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



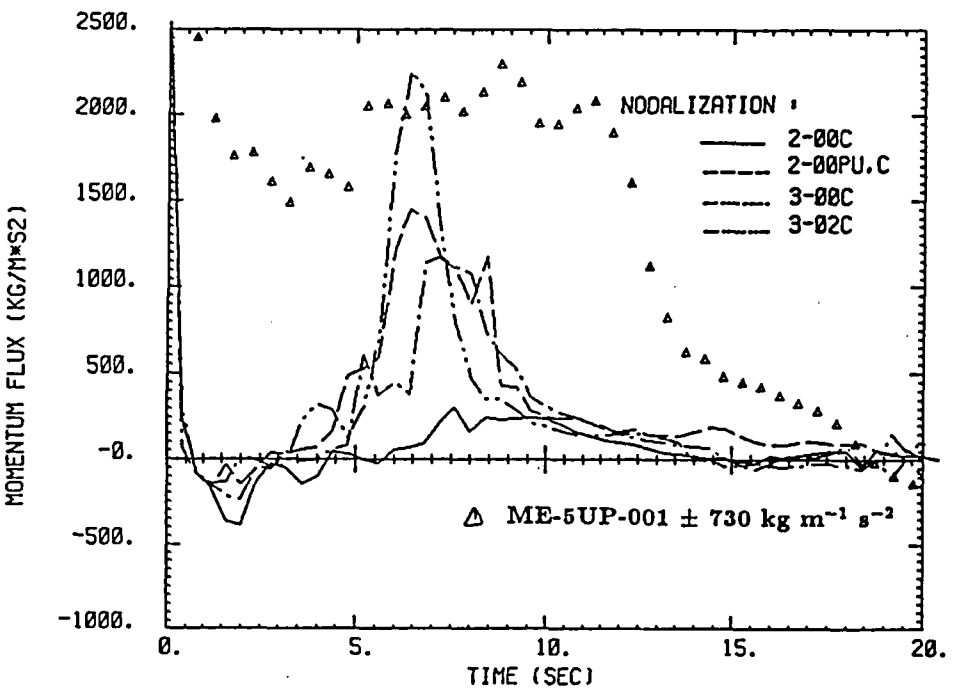
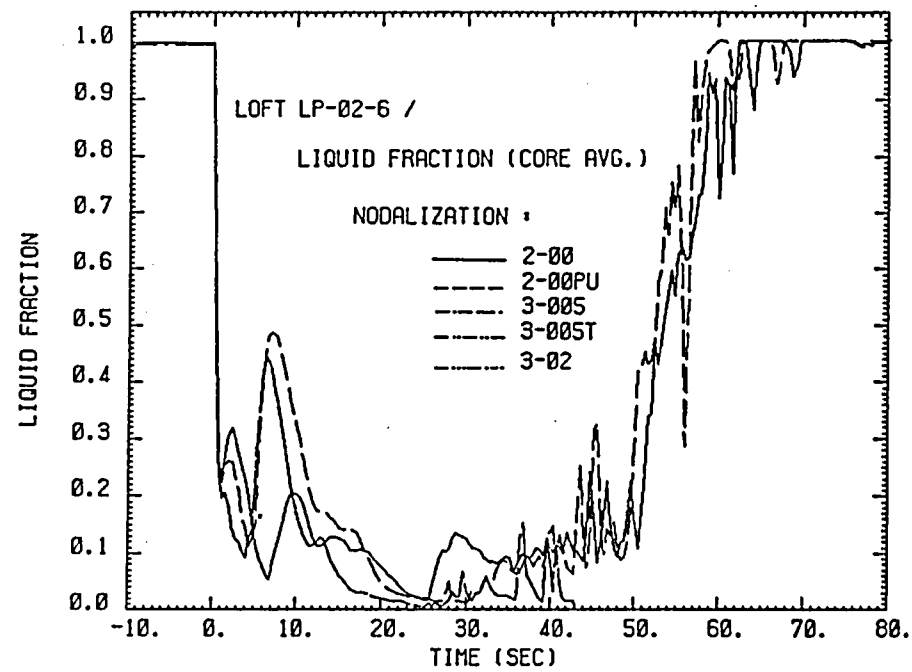


Figure 3.35: Momentum fluxes out of the hot channel of the core as calculated by RELAP5/Mod2
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



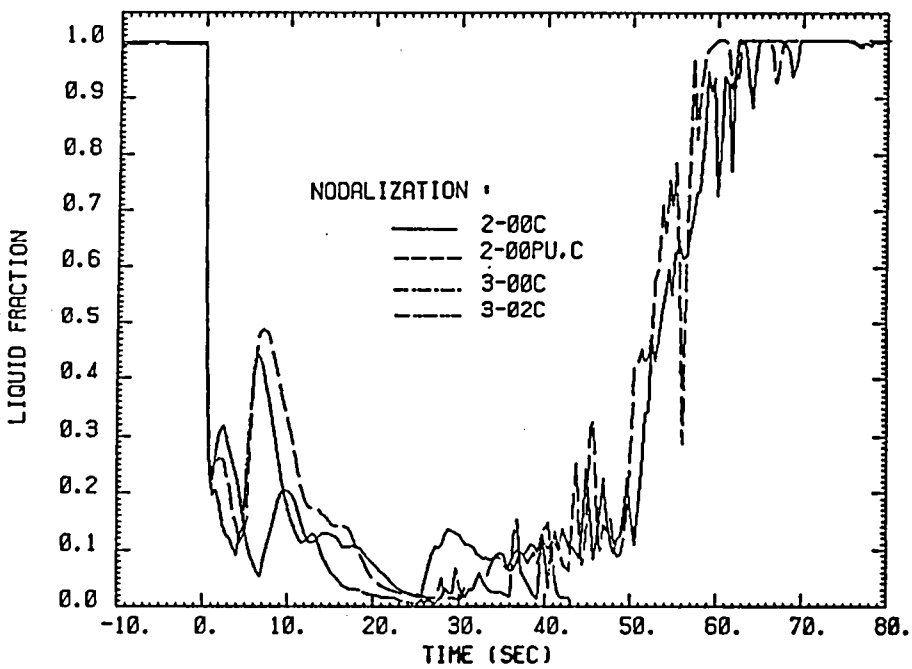


Figure 3.36: Core averaged liquid fractions vs. time
as calculated by RELAP5/Mod2
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

terwards, liquid fractions increased indicating the refill process which has been completed 60 seconds after the experiment has been initiated (liquid fraction nearly one). Allthough no experimental reference is available for the liquid fraction in the core region, figs. 3.36a and 3.36b can give an impression how the code treated the emptying and refilling process during the simulation of the experiment. In general, no large discrepancies have been observed between the different versions of nodalizations except the 2-00 and 2-00C nodalizations where the rapid coastdown of the pumps has dampened the "blowdown refill peak". On top of this, with respect to the time behaviour of the liquid fractions, no significant differences have been found between the "N" and the "C" type of nodalizations.

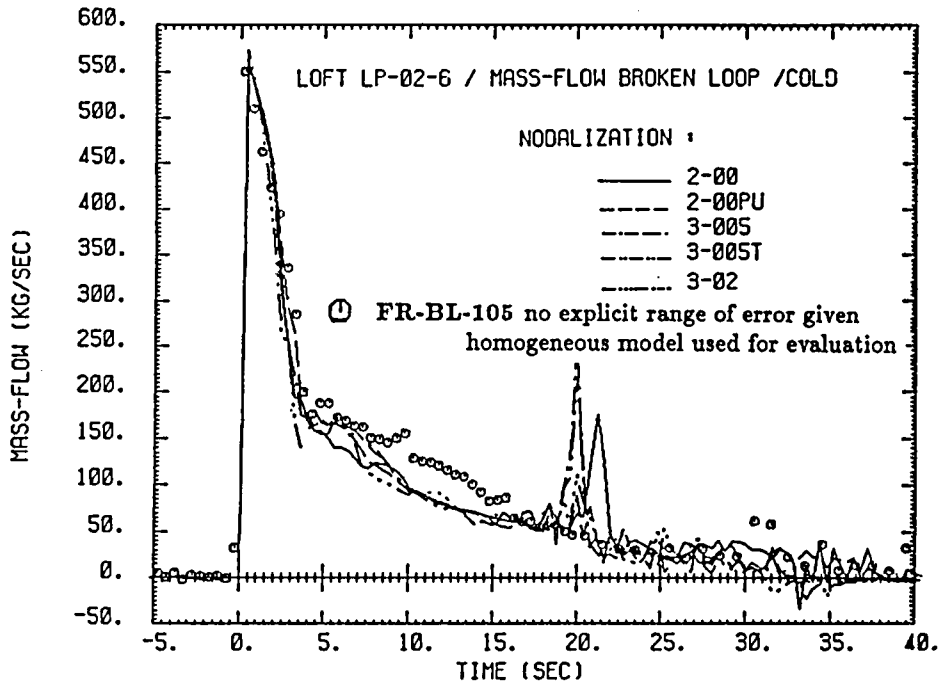
3.4.7 Mass-Flow Out of the Broken Loop

The comparison between predicted and experimental mass flows out of the break of the broken loop allows us to check the capability of RELAP5/Mod2 to describe two-phase flow under critical flow conditions. Therefore, in figs. 3.37 to 3.39, we would like to compare the RELAP5/Mod2 calculations of the mass flows in the cold and in the hot leg of the broken loop as well as the integral mass loss with the equivalent experimental data; the latter gives a clearer picture how calculations and experimetal data deviate. Nevertheless, one has to keep in mind that mass flow measurements in transient two-phase flows are also a rather difficult task, because the data are the result of a multiplication of two independent measurements which are assumed to produce area averaged values.

In figs. 3.37a and 3.37b, let us start with the mass flow in the cold leg of the broken loop. When opening the break valves, for a few hundred milliseconds the fluid is subcooled and the mass flow reaches its maximum value of 550 kg/s which value is slightly overpredicted by all the RELAP5/Mod2 calculations. The following sharp drop of the mass flow (due to fluid saturation and evaporation) has been well described by all types of nodalizations. Between 5 and 15 seconds for all of the different nodalizations, RELAP5/Mod2 has underpredicted the mass flows out of the cold leg break by about 20 to 50 kg/s. During the following time period, some instabilities have occured for some RELAP5/Mod2 -runs which probably are due to numerical instabilities. These instabilities more often have occured in more simplified versions of nodalizations, e.g. the 3-... versions of nodalization. No severe discrepancies have been observed between the RELAP5/Mod2 results using the "N" or the "C" types of nodalization but the "C" versions seem to produce slightly more stable traces of the mass flows.

In figs. 3.38a and 3.38b, the mass flows in the hot leg of the broken loop have been plotted versus time. Except for the most simplified 3-02 and 3-02C versions of nodalization (the break line consists of only 4 volumes instead of 11 for the 2-00 and 3-00 versions), the peak values of the mass flow during the few hundred milliseconds of subcooled liquid flow conditions (measured value 193 kg/s) seemed to be slightly underpredicted whereas the two RELAP5/Mod2 runs (3-02 and 3-02C) overpredicted this peak value at least 50%.

In the intervall 3 seconds up to 20 seconds, we may observe some scatter around the experimental reference which may be attributed to numerical instabilities. Again, these instabilities are slightly more pronounced for the "N" than for the "C" type of nodalizations. It is remarkable that the smoothest curves



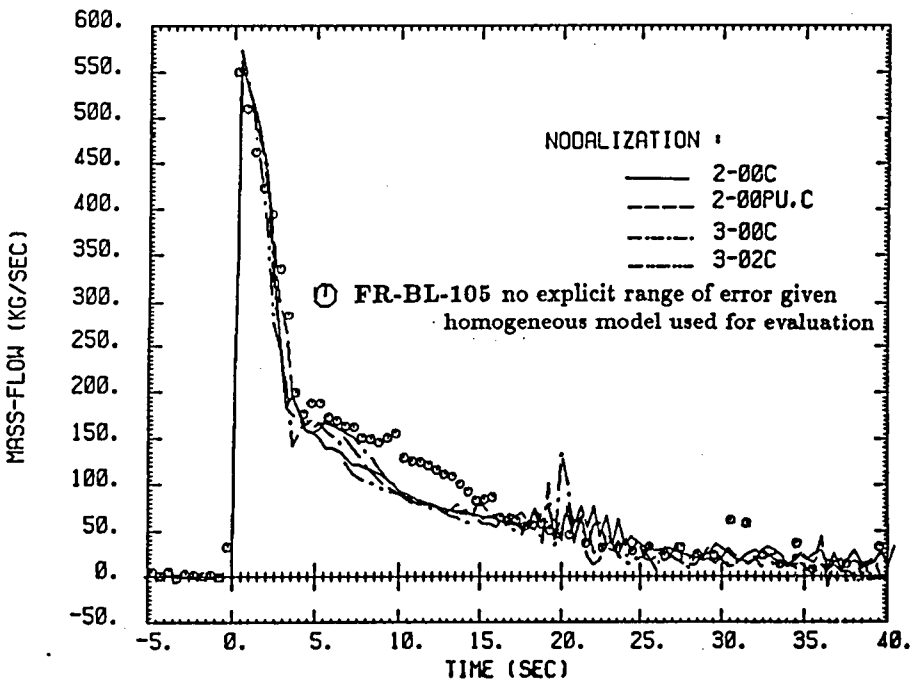
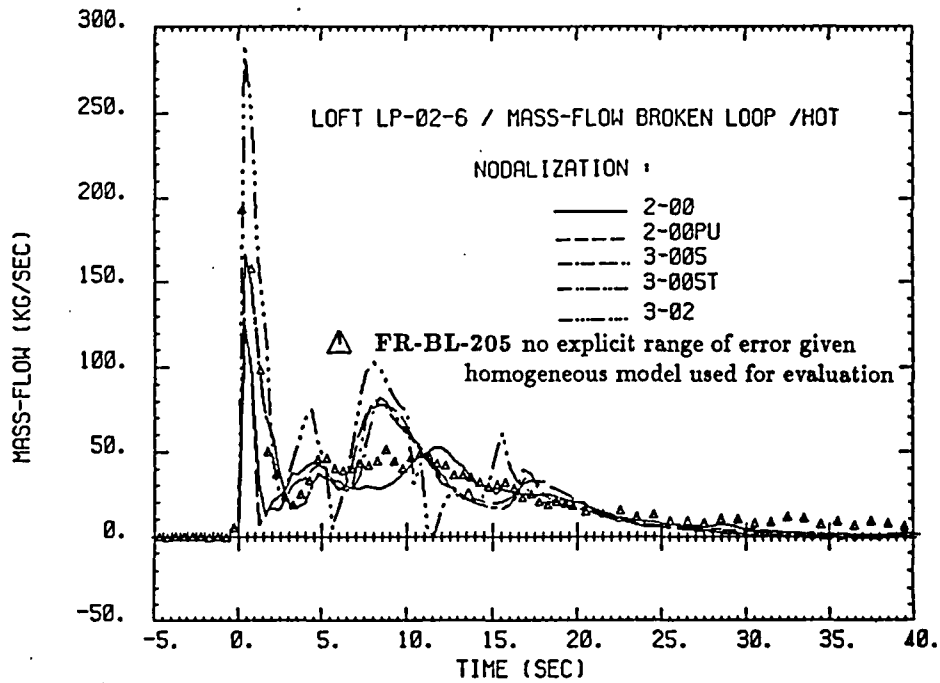


Figure 3.37: Calculated mass flows out of the broken cold leg vs. time compared to the mass flow measured at position BL-105
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



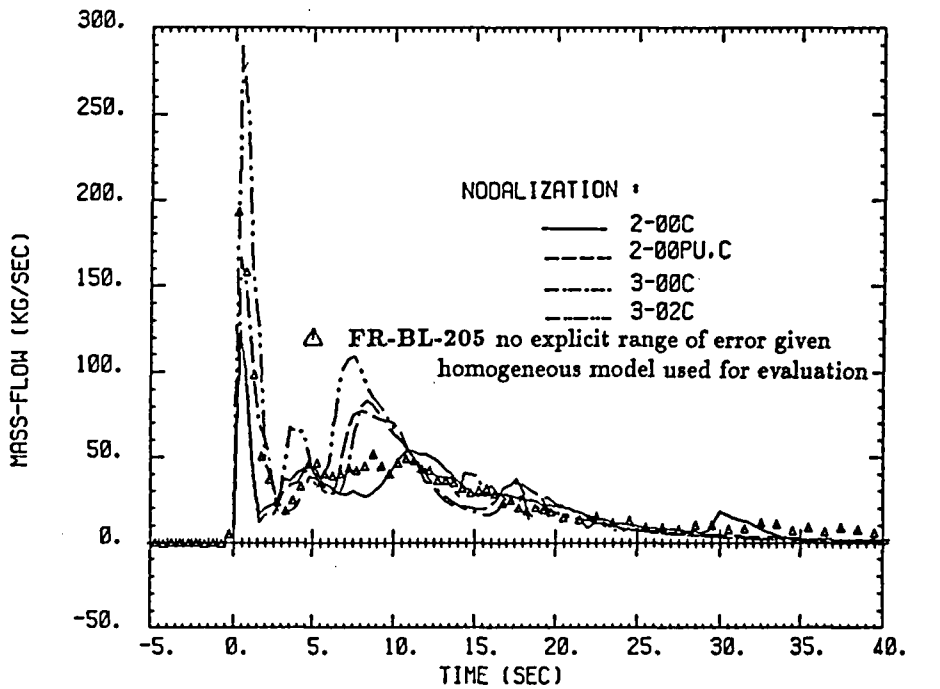


Figure 3.38: Calculated mass flows out of the broken hot leg vs. time compared to the mass flow measured at position BL-205
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

have been calculated by the most detailed 2-00 and 2-00C versions (straight lines) assuming additionally a rapid costdown of the pumps, whereas the equally detailed 2-00PU and 2-00PUC versions (dashed lines) using an imposed pump performance scatter similar to the other runs.

Because of the uncertainties of mass flow measuring techniques in stationary and transient two phase flows it cannot be totally excluded that deviations also are due to errors in the experimental reference values.

Because a plot of the loss of mass focusses more directly on the loss of water inventory rather than the time traces of the individual mass flows through the break, we finally shall compare the instantaneous time integrals of the two mass flows in the cold and hot legs of the broken loop (i.e. the mass losses through the break) as predicted by RELAP5/Mod2 with the equivalent values of the measurement. The integration of the mass flows for both the calculations and the experiment has been performed numerically by simply summing up the products of the two instantaneous values of the mass flows (cold and hot leg of the broken loop) times the actual time step.

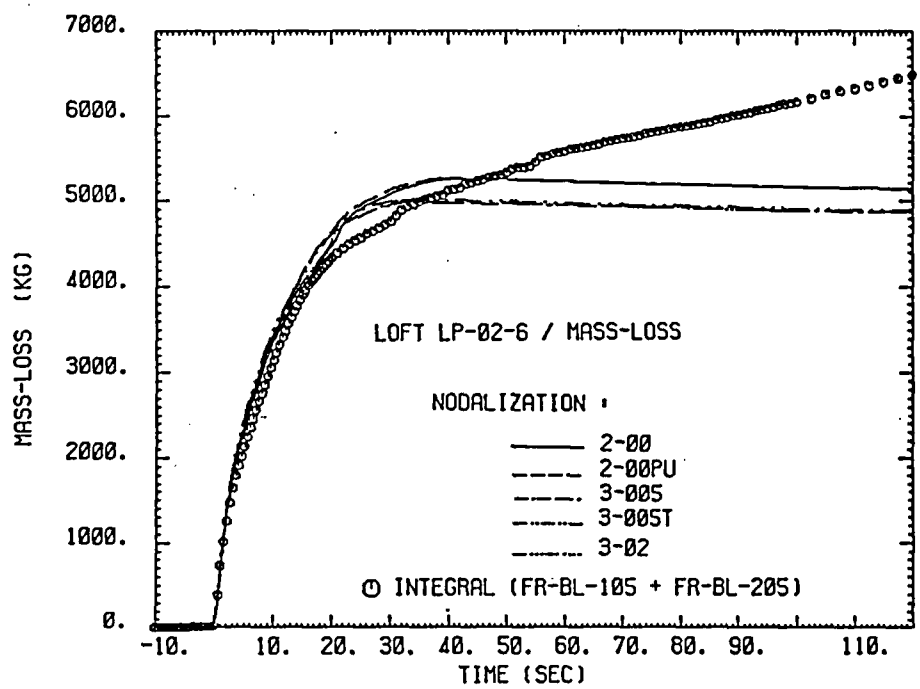
In figs. 3.39a and 3.39b, these mass losses have been plotted as a function of time. Generally, for all types of nodalizations the mass losses have been overpredicted by RELAP5/Mod2 in the time interval between 3 to 60 seconds. This means that RELAP5/Mod2 calculated emptying of the vessel to be more rapidly, which should result in an earlier uncovery of the core.

After the entire blow-down phase, the calculation has been terminated because the system pressure has decreased to the pressure in the suppression tank (for the code, the suppression tank pressure as a function of time is a boundary condition; the pressure history inferred from experiment LP-02-6 has been used). RELAP5/Mod2 calculated no significant increase but a slightly decrease of the mass losses (i.e. a certain amount of fluid is flowing back out of the supression tank into the primary system; in reality an unphysical process), whereas the experimental mass loss data has still increased with a significant gradient. Again, some question marks can be raised with respect to the accuracy of the experimental reference data.

In figs. 3.39a and 3.39b, one may distinguish two different sets of curves, namely, the two 2-... type results and the other three results of the 3-... nodalizations. For the more detailed 2-... nodalizations, the loss of inventory is significantly higher than for the more simplified 3-... versions. On the other hand, no significant differences have been observed between the mass losses of the 3-005 and 3-02 runs even the simplification, especially of the broken loop, has been rather drastic; e.g. the hot leg has been reduced from 11 (3-005) to 4 (3-02) volumes and the cold leg from 4 to 1.

3.4.8 Intact Loop Mass Flow and Pump Speed

In figs. 3.40a, 3.40b, 3.41a and 3.41b, the measured mass flows in the hot and cold legs of the intact loop have been compared with the equivalent quantities as calculated by RELAP5/Mod2 using our different nodalizations. In both cases, the stationary values (-10 to zero seconds) differ significantly from the measured values. Surprisingly, the measured mass flows in this stationary phase (even if all possible leaks are closed) differ from 265 kg/s in the cold leg to 300 kg/s in the hot leg (for the initialization of the



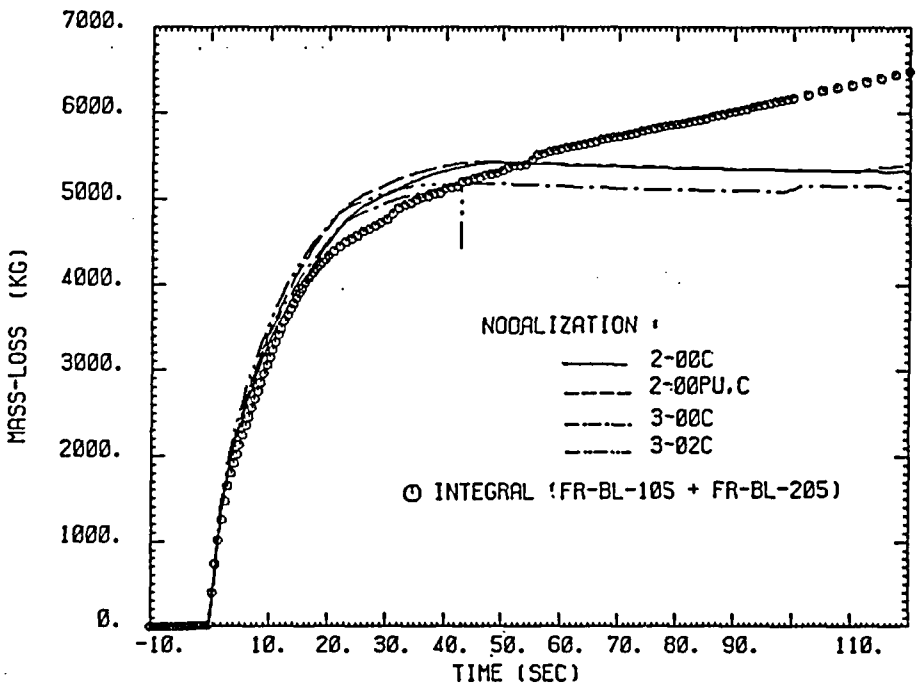


Figure 3.39: Calculated mass losses out of the double ended break vs. time compared to the integrated mass flows measured at position BL-105 and BL-205

a) by neglecting wall heat capacity

b) by taking into account wall heat capacity ("C")

problem, we have used the values given in the quick-look report). With respect to the accuracy of the measurements, the uncertainties of mass flow measurements in two-phase flows as mentioned above, again, have to be taken into account.

In fig. 3.40a and 3.40b, the hot leg mass flows inferred from LOFT experiment LP-02-6 have been compared to the RELAP5/Mod2 calculations. For the first second (highly transient part of the experiment) and after 30 seconds, the discrepancies between the measurement and all of the calculational cases with different nodalizations are remarkably small. Between one and four seconds, all RELAP5/Mod2 cases have predicted a significant "overshoot" of the mass flow which also is observable to a lesser degree in the measured data. Later, between six and 22 seconds of the transient, RELAP5/Mod2 has underpredicted the mass flows; in fact, a flow reversal has been indicated by the calculations which is not significant in the measurement. The calculations of this flow reversal seem to be slightly higher for the "N" than for the "C" versions of nodalization. For the time period after 30 seconds, the calculated mass flows are nearly zero, whereas the measurement still indicated some positive amount of flow. But because the measured flowrate is relatively low, it may be due to uncertainties of the measuring technique.

In figs. 3.41a and 3.41b, the mass flow in the cold leg of the intact loop has been compared to the equivalent RELAP5/Mod2 calculations. Generally, the predictions seem to be more unstable than both the experimental data and the hot leg results. Only the curves of very low mass flow at times greater than 60 seconds seem to be somehow smoother.

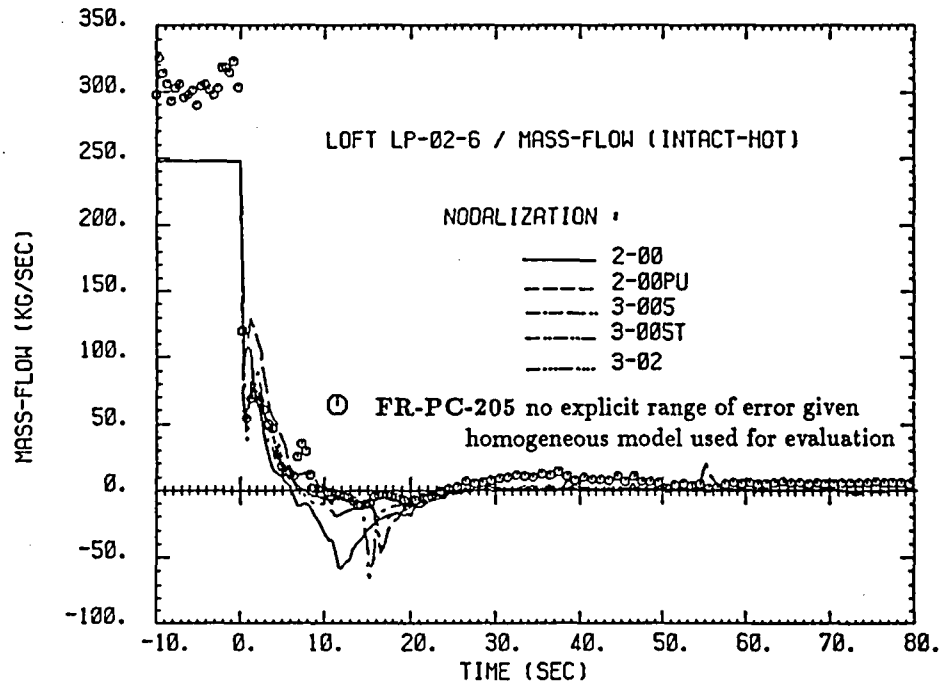
The stepwise increase of the experimentally inferred mass flow during the first 5 seconds of the experiment (260 to 330 kg/s) could not been calculated by any of the RELAP5/Mod2 runs but some smaller hints have been given that such a mass flow increase may exist.

Except the results with nodalizations 2-00 and 2-00C (rapid pump coastdown) the decaying part of the mass flow between 6 and 10 seconds has been reproduced quite satisfactorly by RELAP5/Mod2 ; the abnormal behaviours of the 2-00 and 2-00C predictions are probably due to the "wrong" description of the pump performance.

During the time period between 10 and 20 seconds, RELAP5/Mod2 has slightly overpredicted the mass flows in the cold leg.

Relatively high instabilities occur in the time period between 20 and 55 seconds. Here, the experimental data also exhibits significant oscillations, indicating some strong flow instabilities. Because between 20 and 40 seconds, the accumulator has fed approximately 35 kg/s of highly subcooled ECC water and in addition to this, the instabilities only occur in the cold leg of the intact loop where the ECCs is connected to the loop, we tend to attribute these instabilities to the functioning ECC system.

Because for all the other nodalizations the pump speed has been a boundary condition and consequentely matches perfectly with the measured data, only the results of the 2-00 and 2-00C nodalizations are of some interest. Therefore, in figs. 3.42a and 3.42b, we may concentrate on these two relative pump speeds as calculated by RELAP5/Mod2 which have been compared to the equivalent average experimental data. Here, the relative pump speed is defined as



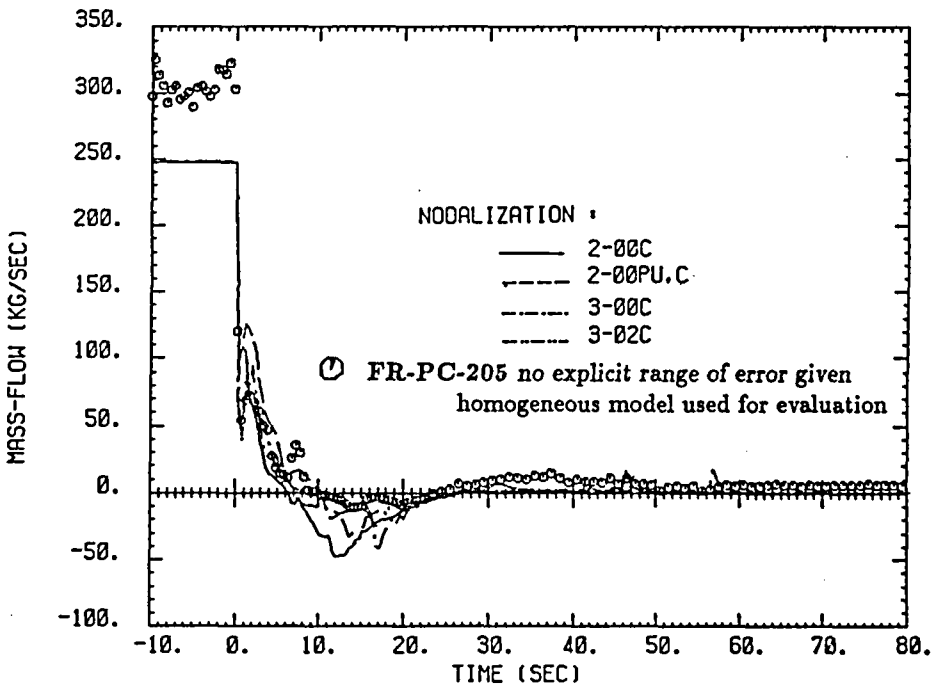
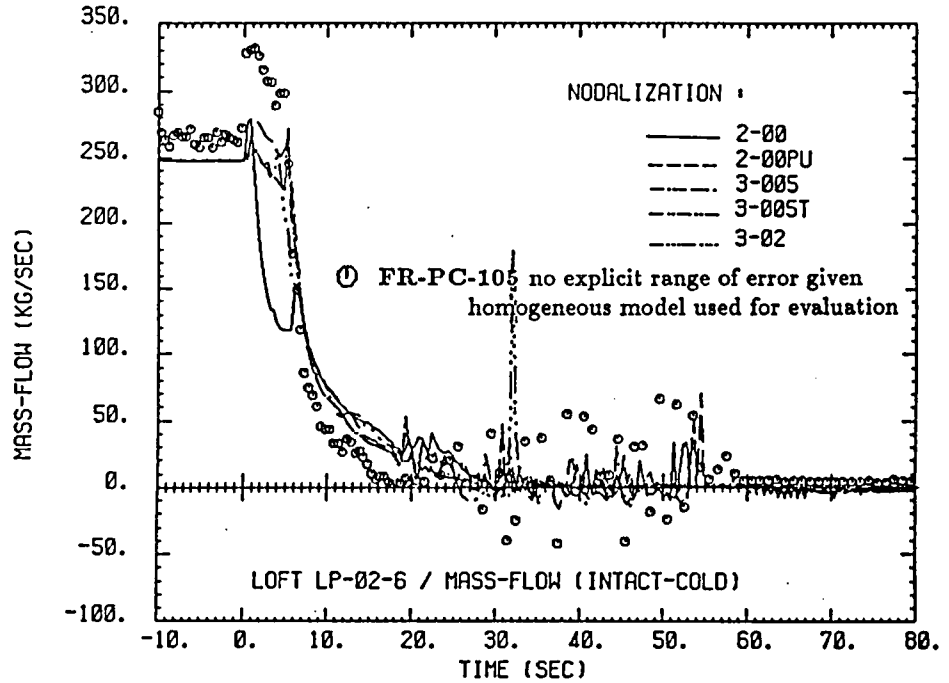


Figure 3.40: Calculated mass flows in the intact hot leg vs. time compared to the mass flow measured at position PC-205
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



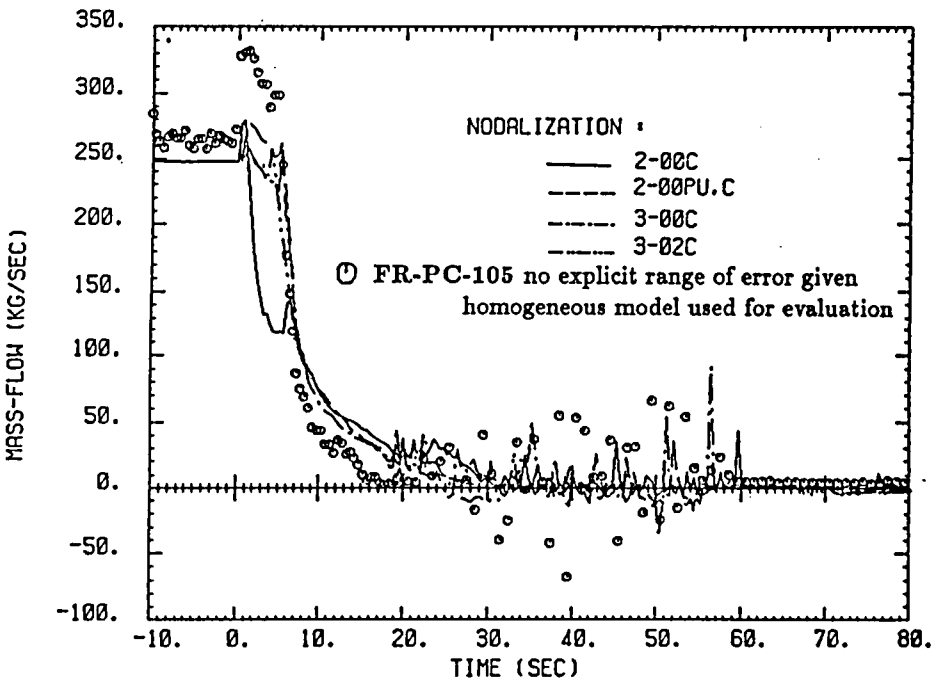
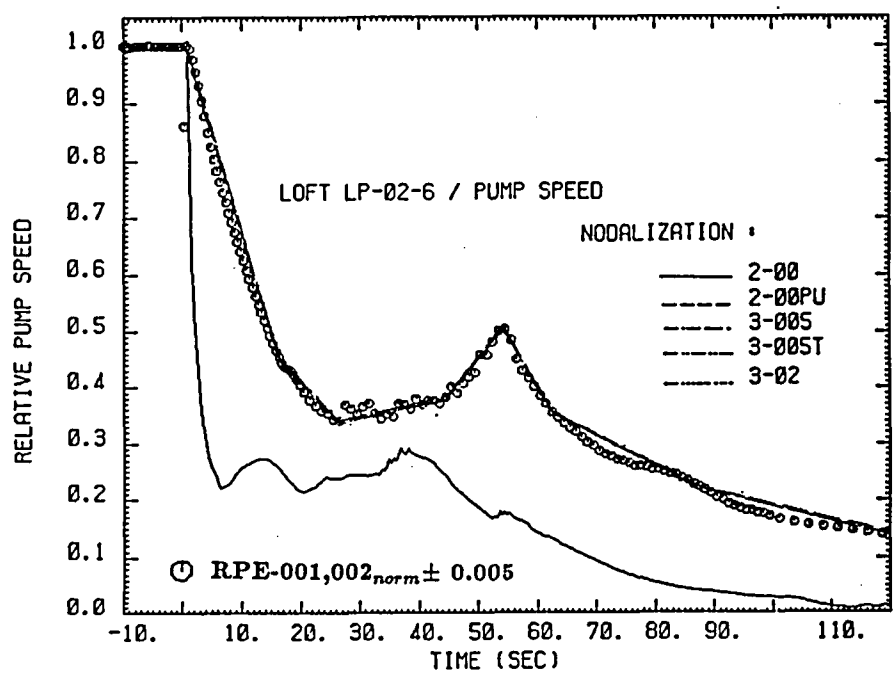


Figure 3.41: Calculated mass flows in the intact cold leg vs. time compared to the mass flow measured at position PC-105
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



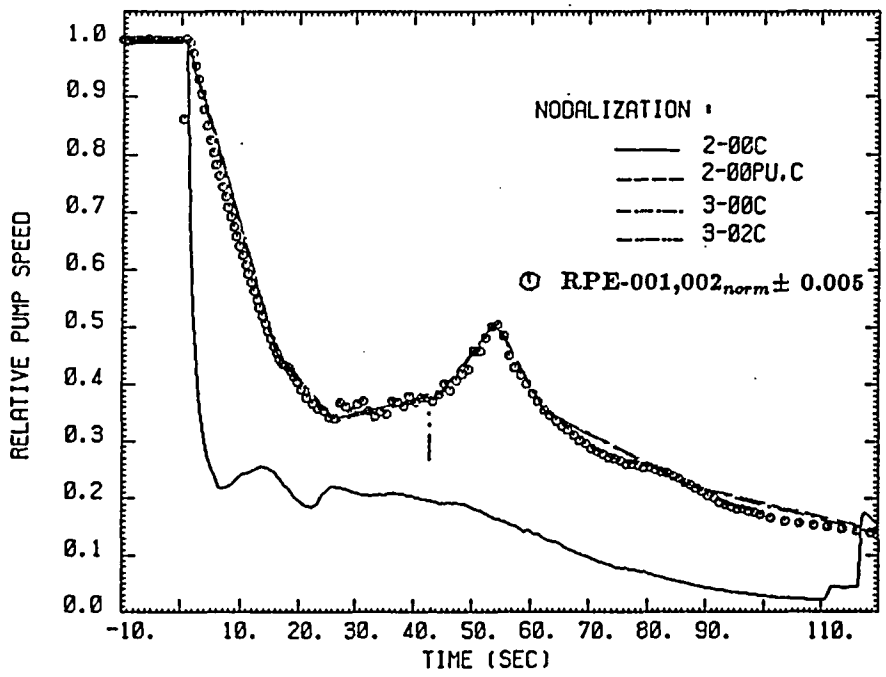


Figure 3.42: Calculated relative pump speed vs. time compared with the measured ones (averaged value of two pumps)
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

the actual value divided by the initial speed under stationary conditions; because the absolute value of the pump speeds has been adjusted so that the intact loop mass flow is equivalent to the experimental one given on table 1.1, only relative values can be compared. Indeed, the coast down of the pumps is much more rapid than for the other cases plotted for reference in the two graphs which may have induced different thermohydraulic conditions inside the whole LOFT system.

3.4.9 ECC System

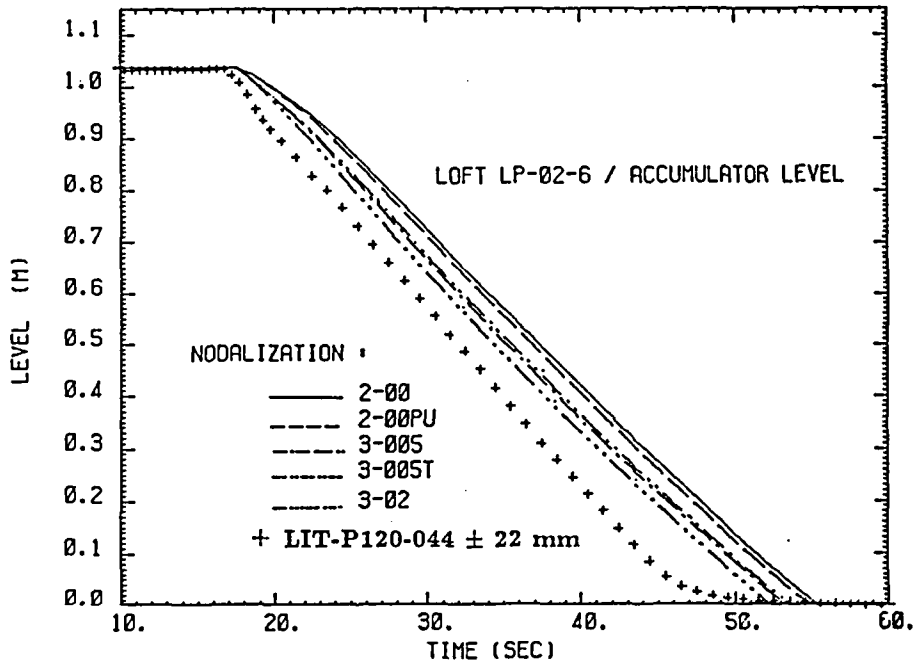
In figs. 3.43 to 3.46, experimentally inferred accumulator liquid level, accumulator pressure, accumulator flowrate as well as the flowrates of the low pressure injection systems (LPIS) have been compared to the equivalent RELAP5/Mod2 calculations. Because the HPIS system has supplied water with a constant flowrate and its value has been a boundary condition, no discrepancies between experimental and RELAP5/Mod2 calculated results are expected; therefore, plots of the HPIS flowrates have been omitted.

The time point of starting the accumulator injection has been defined by a time-trip (boundary condition) instead of a code calculated pressure trip which would model the LOFT system in a more realistic way, but on the other hand would multiply deviations in the RELAP5/Mod2 calculation of the system pressure to other parameters of interest of the whole LOFT system (e.g. a later start of the ECCS would probably influence significantly the shapes of the cladding temperature traces). Furthermore, the empty-point of the accumulator, i.e. the time when the accumulator level approaches zero, has been adjusted once for all for the 6-00 nodalization of the LOFT LP-LB-1 experiment (see ref. [7]) by multiplying the forward and backward energy loss coefficients of the accumulator volume by nearly 3; for all the other types of nodalizations, the same coefficients have been used. In addition, it was necessary to close the valve 610 (see figs. 2.1, 2.3 and 2.4) after the accumulator was emptied to avoid an execution error of RELAP5/Mod2 (message: arithmetic overflow). This error is probably due to an improper modelling of incondensibles (nitrogen) by RELAP5/Mod2 ; nitrogen is released by the accumulator into the system after emptying.

First, in figs. 3.43a and 3.43b, the liquid levels in the accumulator as calculated by RELAP5/Mod2 have been plotted in the time interval the accumulator is activated and compared to the experimental data. The curves are satisfactory close to the experimental points. The longest accumulator times have been achieved by using the most detailed 2-... types of nodalizations whereas the results closest to the measurements are those inferred from the most simplified 3-02 runs, even the discrepancies between the different results are quite low, namely less than 5 second.

In figs. 3.44a and 3.44b, the pressure in the accumulator vessel inferred from the measurement has been compared to the equivalent pressures as calculated by RELAP5/Mod2 . Generally, the code tended to slightly overpredict the real pressures but the difference is less than 0.3 MPa. Because in contrary to the experiment, as already mentioned above, for the RELAP5/Mod2 predictions a valve has to be closed for numerical reasons, the predicted pressure remained constant after this valve has been closed.

Closest to the measurements we have found the results of the 3-02 nodalizations, i.e. of the most simplified versions of the LOFT system. The poorest results on the other hand



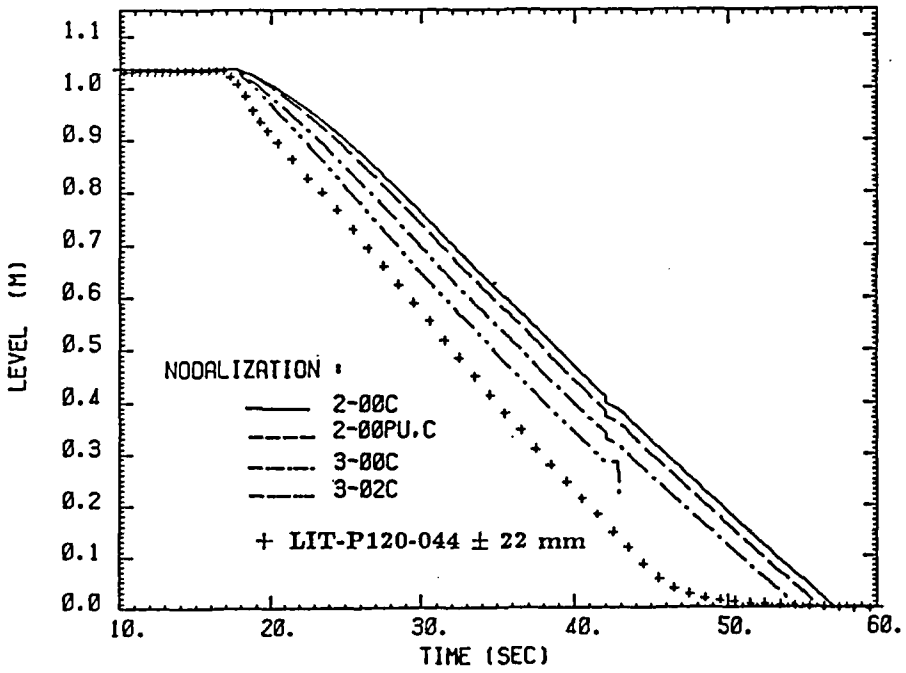
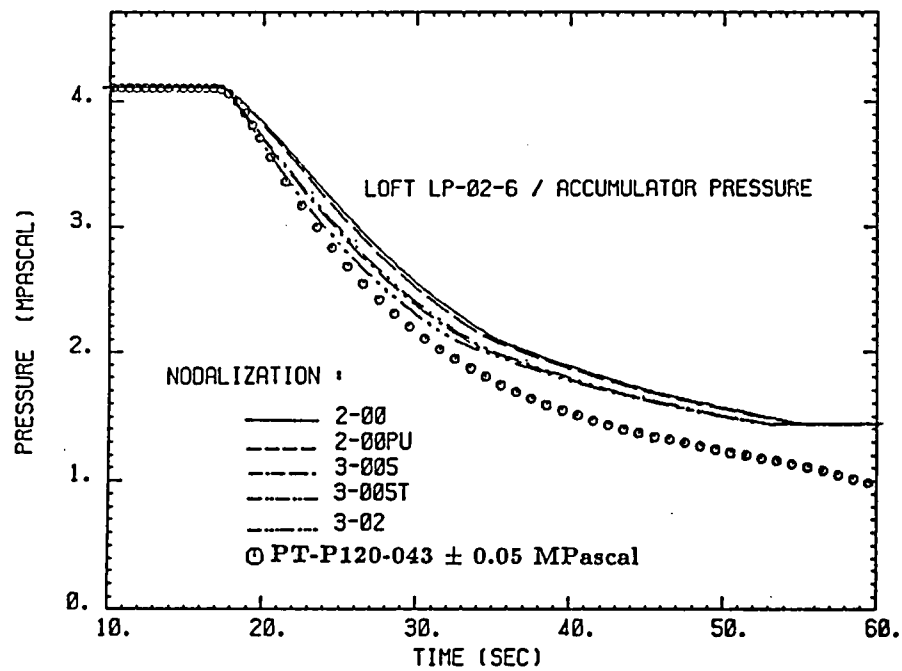


Figure 3.43: Calculated accumulator fluid levels vs. time compared with the measured level
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



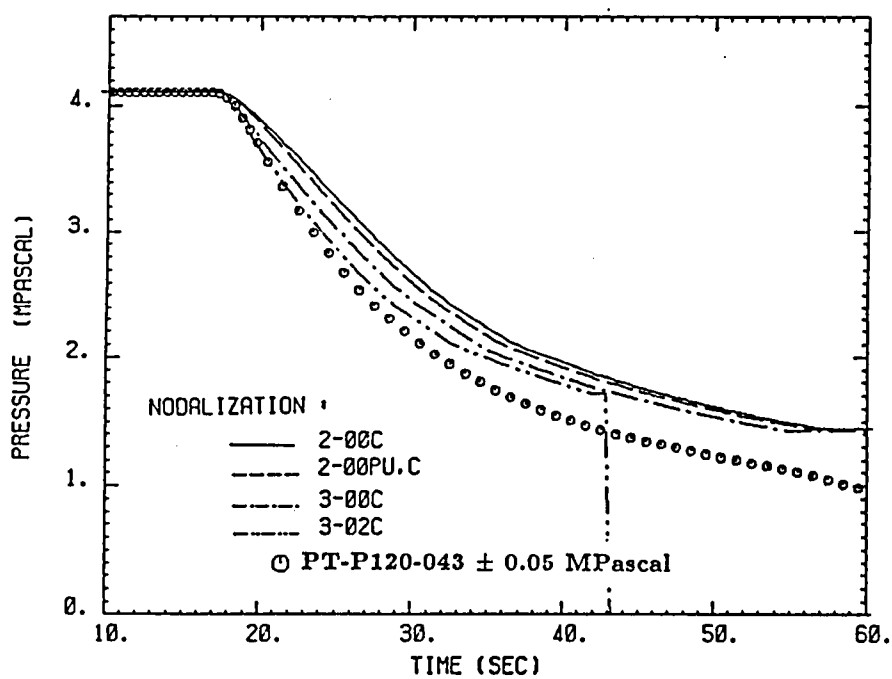


Figure 3.44: Calculated accumulator pressure vs. time compared with the measured pressure
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

have been found to be the 2-00 and 2-00C calculations.

In figs. 3.45a and 3.45b, the flowrates out of the accumulator as calculated by RELAP5/Mod2 using our different nodalizations have been plotted but unfortunately, no experimental data has been available. The highest flowrates have been calculated using the most simplified 3-02 and 3-02C types of nodalization whereas the lowest values have been calculated with the 2-00 and 2-00C cases.

Finally, in figs. 3.46a and 3.46b, the flowrates of the Low Pressure Injection System (LPIS) have been compared to the equivalent RELAP5/Mod2 results. For all the different nodalizations, the calculated results have been found to be rather poor although with respect to the qualitative aspect of the total mass injected, the predictions are acceptable.

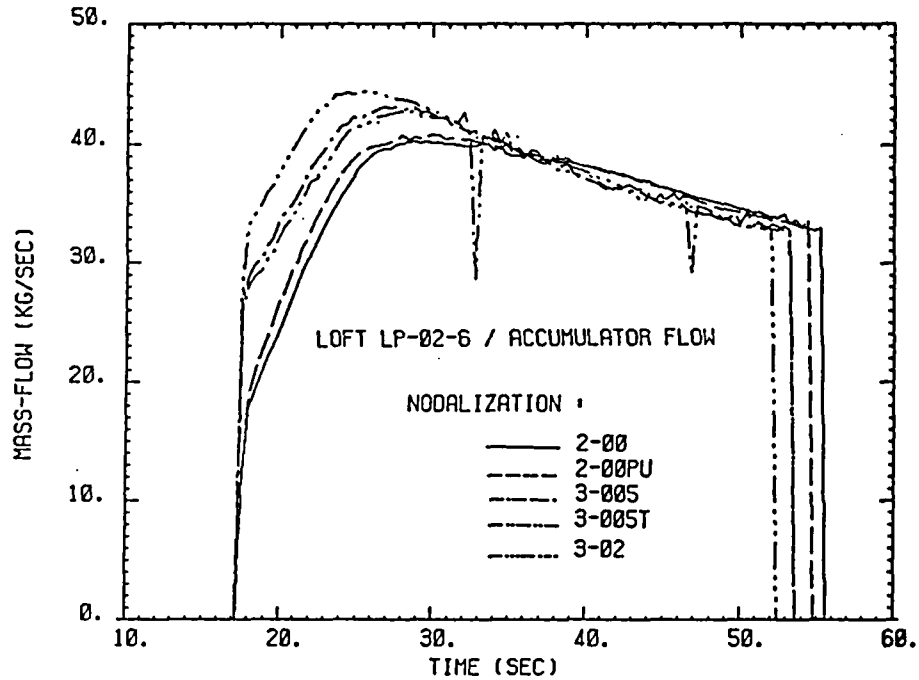
At the beginning of the LPIS action, a sudden decrease from 6 to 4.5 kg/s followed by an increase from 4.5 to 7 kg/s can be observed in the experimental data which has not at all been calculated by RELAP5/Mod2 . This strange behaviour of the LPIS mass flow is believed to be due to a short high pressure nitrogen release out of the accumulator into the system at the moment when it has been emptied completely. This nitrogen release for some seconds caused a small increase of the system pressure (which can be observed in the system pressure data of figs. 3.29a and 3.29b at around 60 s) and even a larger increase directly in the ECCS-piping thus reducing the LPIS flow-rate which is governed by the pressure difference between ECCS-piping pressure and the constant LPIS pressure. After some seconds, this increase in the ECCS-piping pressure diminishes and the LPIS flowrate recovered. Because the "nitrogen injection" has not been taken into account by the RELAP5/Mod2 calculations, the code has calculated a more or less smooth curve which is close to the experimental data after the experimentally observed flow instability has been dampened and which more or less represents the time-average of the experimentally inferred LPIS mass flow between 40 and 65 seconds.

3.5 Investigation on the Prediction of Early Bottom-Up Rewetting

The occurence of a high flowrate, early bottom up quench front has been regarded as one of the "key events" of LOFT large break experiments and also of experiment LP-02-6 . This early bottom-up quench rewetted the whole core between approximately 4.5 and 8 seconds after the initiation of the transient thus reducing drastically the general core heat-up during this experiment. As we have already mentioned, RELAP5/Mod2 was not able to predict this early bottom-up quench.

One of the features of RELAP5/Mod2 code is the fact that it uses different sets of heat-transfer correlations under non-reflood and reflood conditions (e.g. correlations for nucleate boiling, transition boiling and film boiling). On top of this, the calculation of the temperature distribution of the fuel rod is enhanced by subdividing the axial length (corresponding to the length of the connected hydrodynamic volume) into several "fine meshes" to better model the occurence of steep temperature gradients inside the cladding during reflooding. The "switching" from normal operation to reflooding can be achieved by three different methods :

1. external trip (to be set by user defined



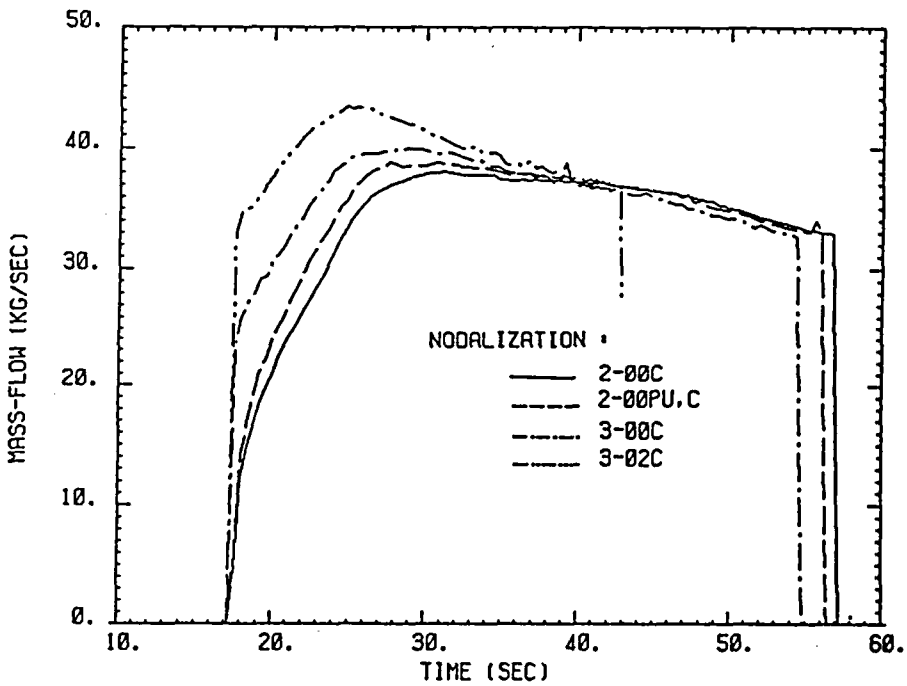
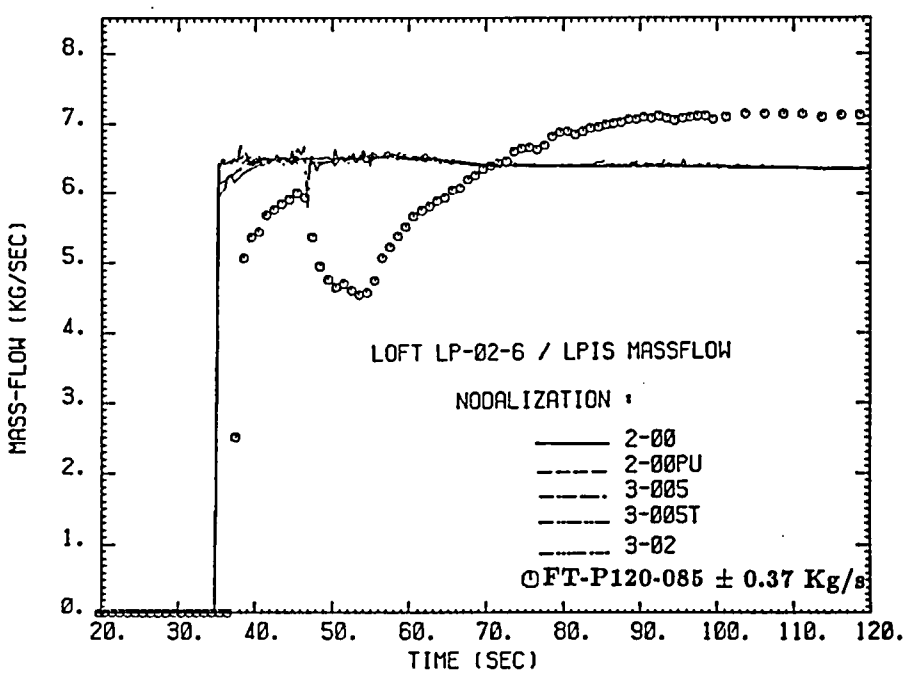


Figure 3.45: Calculated accumulator mass flows vs. time
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")



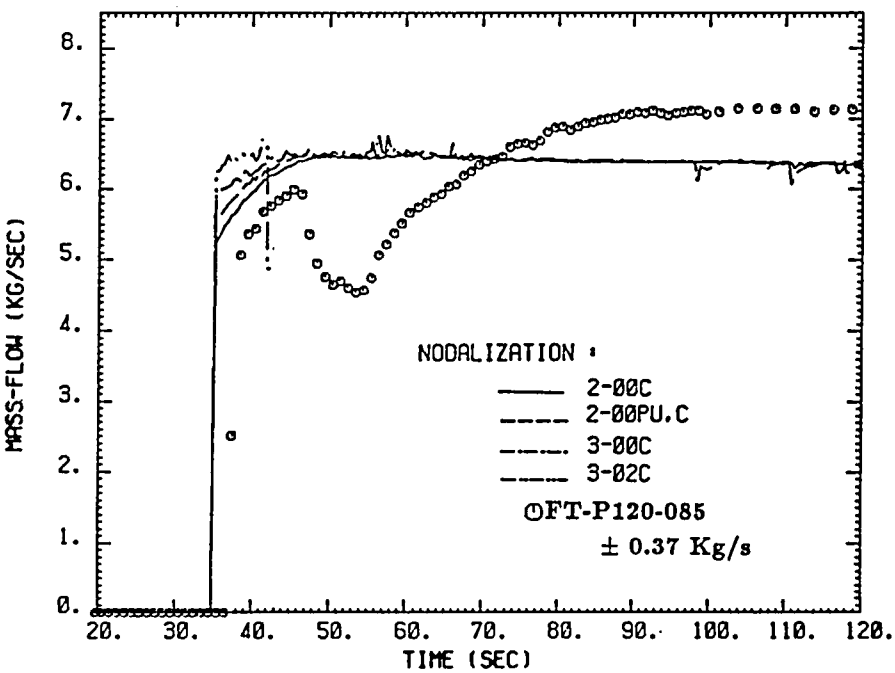


Figure 3.46: Calculated LPIS discharges vs. time compared with the measurement
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

options)

2. internally set by the code when the connected hydrodynamic volumes are nearly empty

3. internally set by the code when dryout begins in the connected hydrodynamic volumes

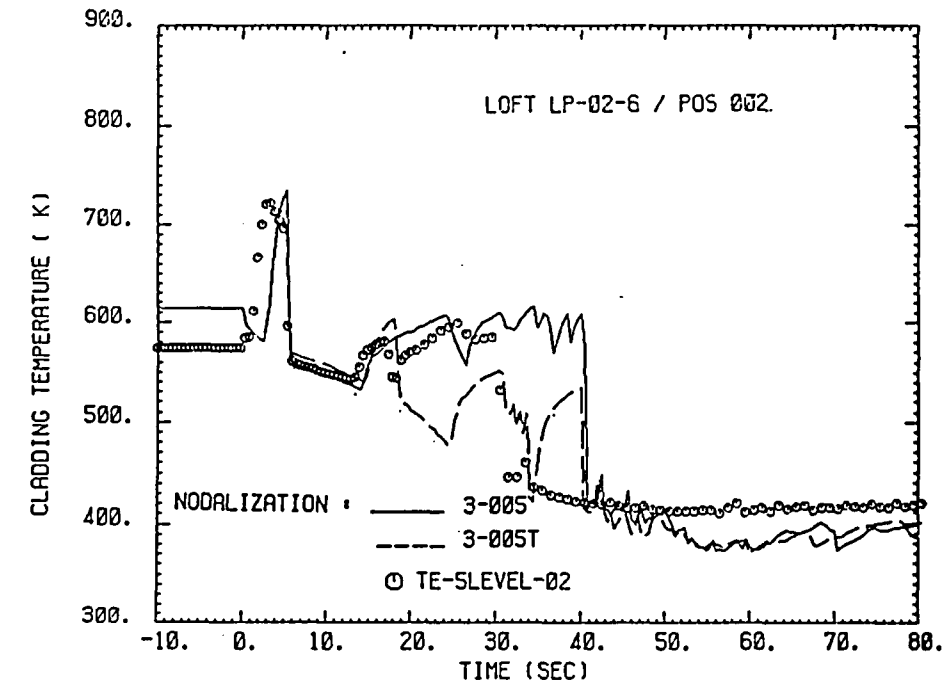
In addition, the last two cases are limited to system pressures less than 10 bars. Once the reflood calculation has been initiated, it remains activated until the end of the calculation.

Obviously, the choice of a slightly different heat transfer correlations combined with as a better tracing of the axial cladding temperature distribution by "fine meshing" will have an important influence on the prediction of cladding temperatures. Consequently, the time of the reflood initiation, i.e. the "switch" between both the different sets of correlations and the numerical solution schemes may have a very important result. Therefore, one may argue that the calculation of the early bottom-up quench by RELAP5/Mod2 in experiment LP-02-6 only failed because the reflood option has not been initiated early enough.

For investigation of this problem, we have performed two different RELAP5/Mod2 calculation, using first nodalization 3-005 with reflood initiation option one (3-005T). Because we have observed earlier (see ref. [7]) that the last two options produce equivalent results, we have not calculated the problem using option number two. For version 3-005, the reflood option usually has been initiated automatically by the code between 30 and 40 seconds after opening of the break valves when the system pressure has fallen below 10 bars and the collapsed liquid level in the core has reached its minimum (see figs. 3.29 and 3.36). For version 3-005T, the reflood option initiation trip has been set externally when the average collapsed liquid level in the core-region reached a value of less than 10%. According to fig. 3.36, this happened for the first time approximately 4 seconds after the initiation of the experiment; this external initiation of the reflood option is independent of the system pressure.

In figs. 3.47 a to k, the cladding temperatures measured at 10 axial positions in the center box 5 (hot channel) have been compared to the equivalent two RELAP5/Mod2 calculations; figs. 3.47 have to be regarded as an extract out of the figs. 3.5 to 3.14, which have been discussed above. From a general point of view, for all the ten levels, the deviations between the two predictions are quite considerable. On the other hand, with respect to early bottom-up rewetting during the first 10 seconds of the experiment, no significant differences have been observed for the first four levels, namely levels-02, -11, -21 and -24 (figs. 3.47 a to d).

Significant deviations start at level-27 (fig. 3.47e). Here, the 3-005T calculation (i.e. the run with external triggering of the reflood option) has done a nearly perfect job in predicting the time trace of the cladding temperature both during early bottom-up rewetting as well as the during final refill, whereas the 3-005 calculation failed totally in predicting bottom-up rewetting. This optimistic picture has already been changed at the next position, level-31 and again at level-39, even the 3-005T calculations still have been closer to the experimentally inferred reference data (figs 3.47f and g). At level-43.8 (fig. 3.47h), for the 3-005T calculation RELAP5/Mod2 did an acceptable job concerning the prediction of early bottom-up rewet-



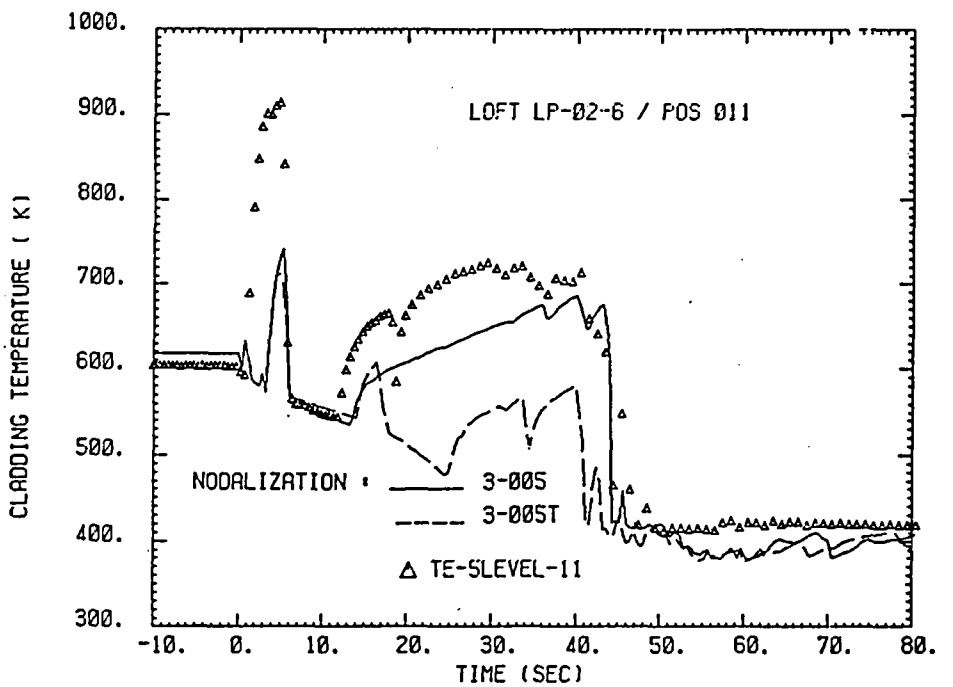
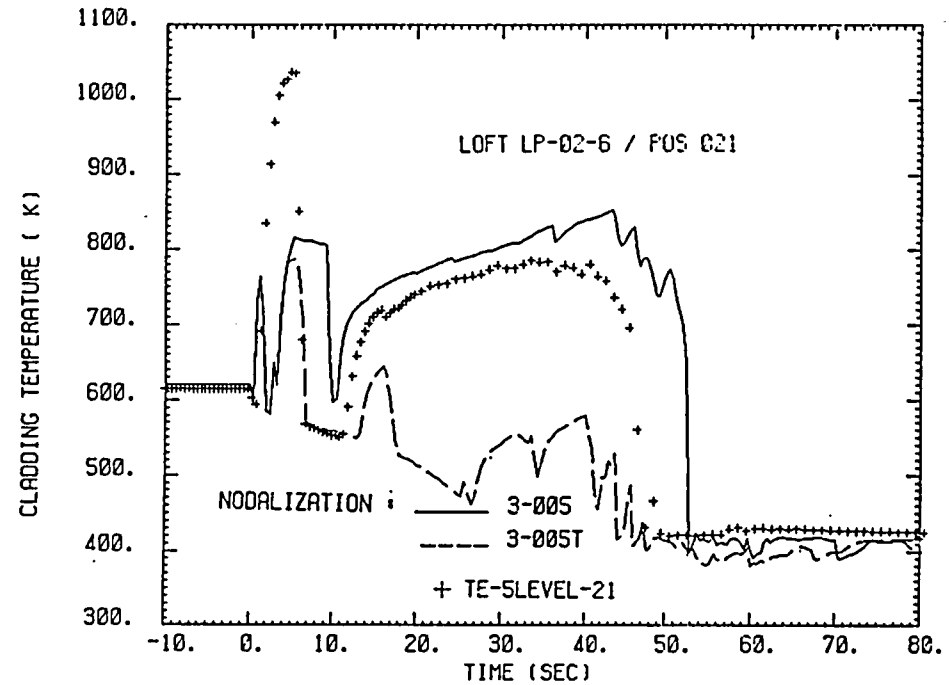


Figure 3.47: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

a) at level-02

b) at level-11



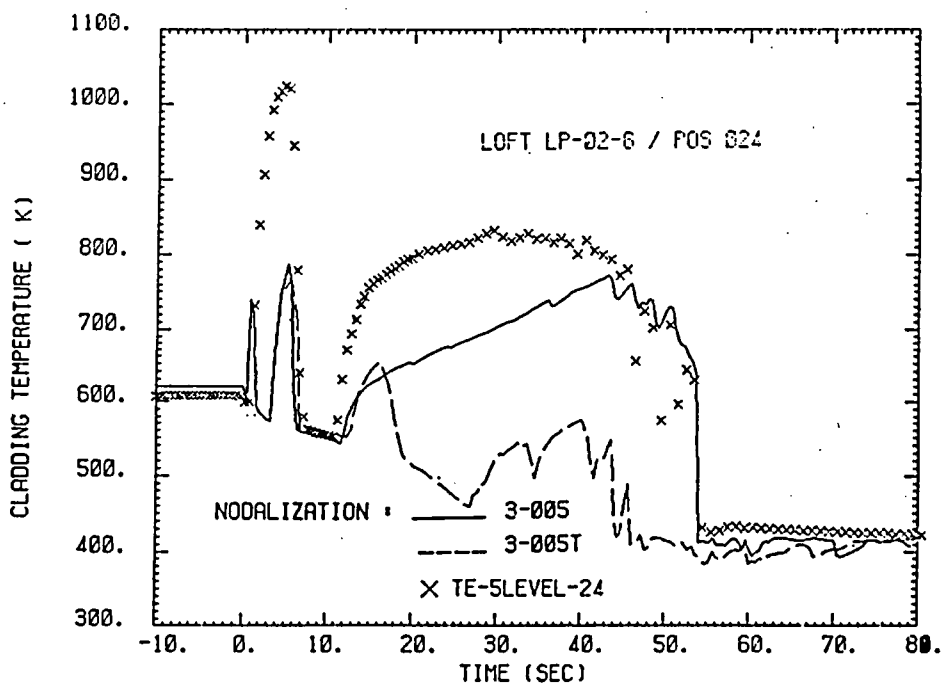


Figure 3.47: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

c) at level-21

d) at level-24

ting but failed in calculating the second core heat-up during the refill phase of the experiment whereas the calculation 3-005 totally has missed the early bottom-up rewetting.

For the last two levels -49 and -62 (figs. 3.47 i and k), again no dramatic differences between the RELAP5/Mod2 results of the two nodalizations have been observed; in fact, both calculations have missed what was really happened during the experimental transient at these core levels.

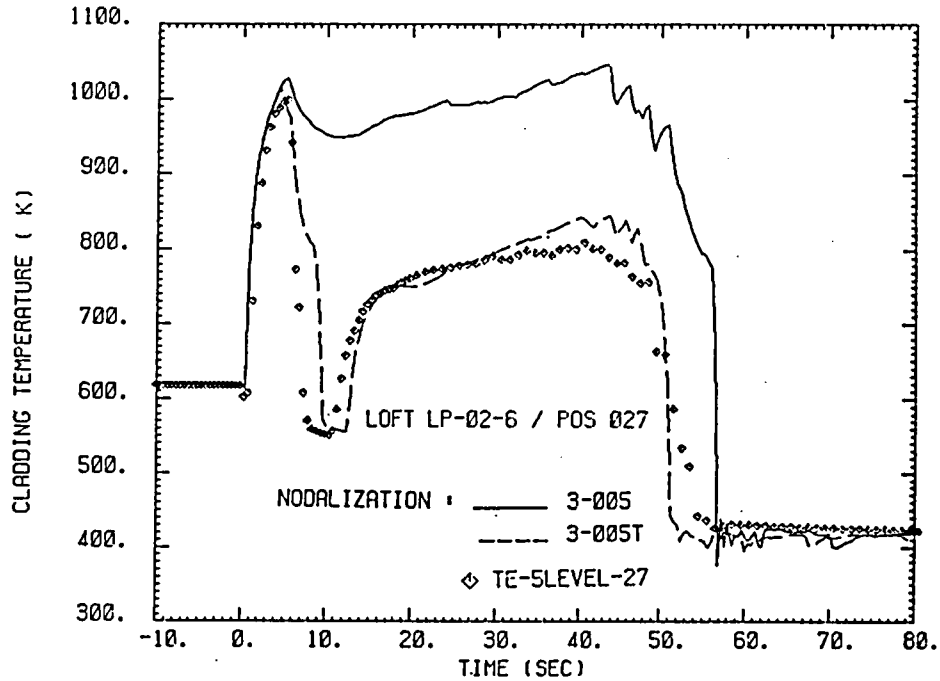
In figs. 3.48a to d, the comparison has been made for the predictions of the average channel at the four available core levels of side box 4. Here, for both of the RELAP5/Mod2 calculations, the results are rather poor. With respect to the prediction of early bottom-up rewetting, none of them was able even to describe the core heat-up from which the cladding can be cooled down by bottom-up rewetting. Some exceptions to this statement we may identify at level-21 (fig. 3.48b) where the standard nodalization 3-005 indicated some short temperature rise between 4 and 6 seconds which is still 40 K lower than the temperatures inferred from the experiment.

On the other hand, the core heat-up during the refill phase has been calculated by the two RELAP5/Mod2 -runs but it is hard to decide which one of the two versions made a better calculation because at some levels, the 3-005 results are more "on the line" (e.g. figs 3.48a and 3.48d) whereas at the two other levels the 3-005T calculations seemed to be slightly better (figs. 3.48b and 3.48c).

Finally, in fig. 3.49, we would like to look again at the time behaviour of the center fuel temperature where reference temperatures are available only for level-27. In this graph, the prediction of the 3-005T RELAP5/Mod2 calculation seems to be nearly perfect. This is not at all surprising because we have already found the cladding temperature trace at this core level to be in excellent agreement with the measurement. On the other hand, we have seen this good agreement with the reference cladding temperatures only at level 27 which may lead us to the conclusion that the center fuel temperatures also might deviate at the other core levels where no reference data is available.

Summarizing our observations with respect to early bottom-up rewetting, one has to conclude that RELAP5/Mod2 generally has not been able to predict this phenomenon. A change in the logic of initiating the reflood option (which forces RELAP5/Mod2 both to use a slightly modified heat transfer package and to subdivide the axial meshing of the cladding as predetermined by the length of the adjacent hydrodynamic volume in order to keep better track of the axial temperature distribution in the vicinity of the quench front) resulted only partially in better pedictions without explaining the physical phenomena but on the other hand created worse results in other phases of the transient. E.g. compared to the ones of the standard 3-005-RELAP5/Mod2 calculations, the results of the 3-005T RELAP5/Mod2 prediction have been found to be always lower.

In a recent work, Analytis and Lübbesmeyer (ref. [8]) investigated the failure of RELAP5/Mod2 in descibing the early bottom-up phenomenon by looking at the differences in the heat transfer packages under rewetting and non-rewetting conditions. It has been found, that these differences are negligible small. There is only one statement which prevents RELAP5/Mod2 from describing the early bottom up phenomena and this state-



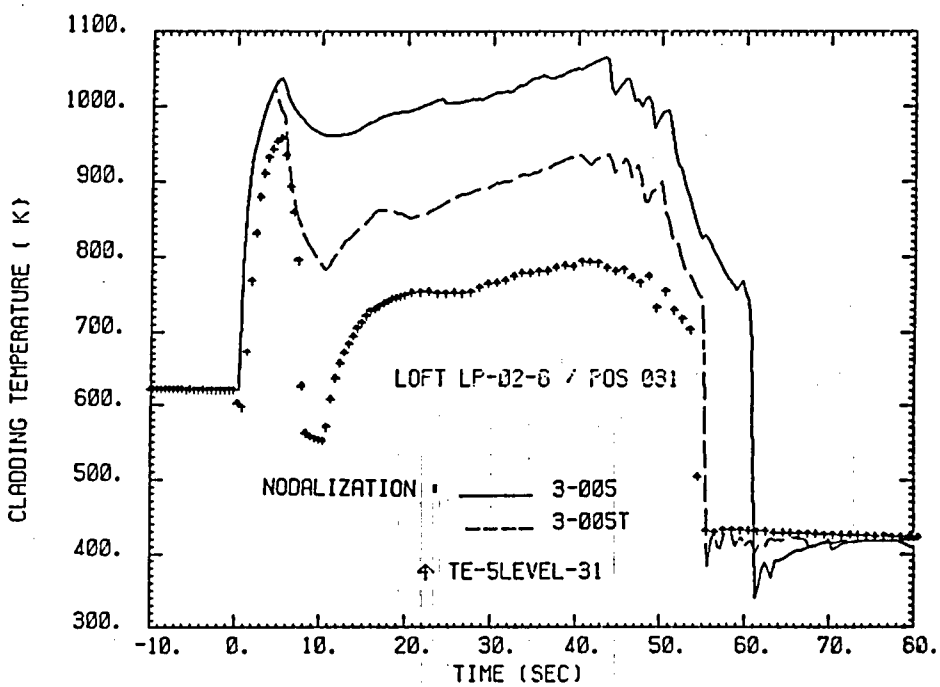
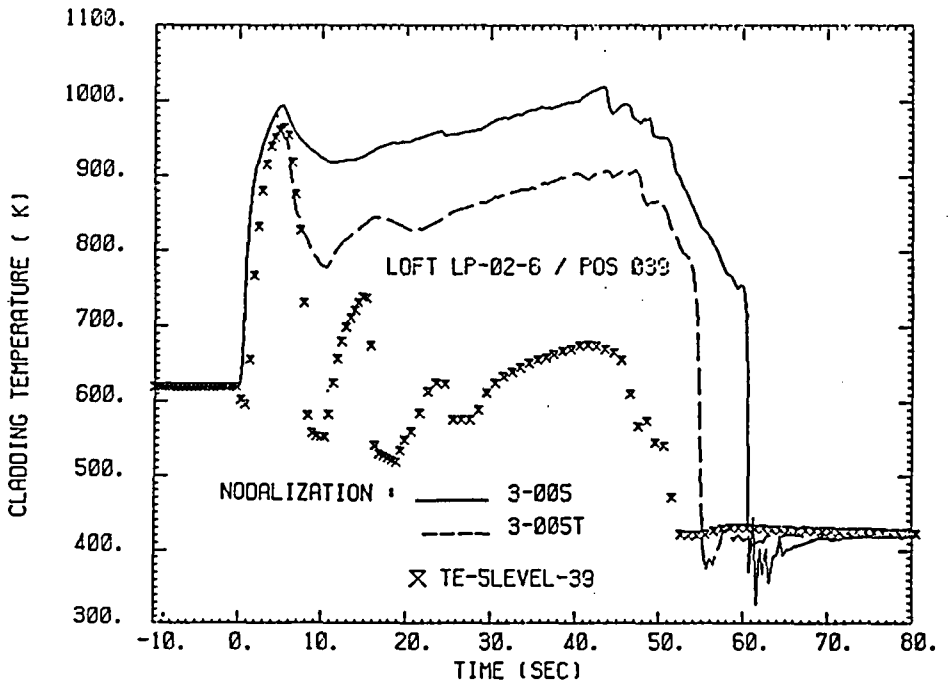


Figure 3.47: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

e) at level-27

f) at level-32



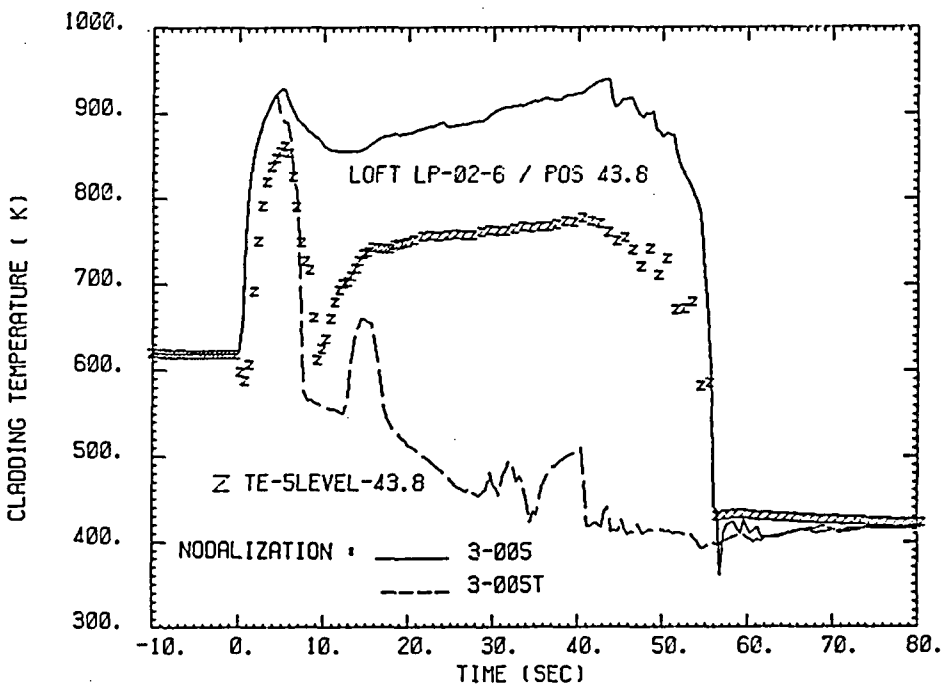


Figure 3.47: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

g) at level-39

h) at level-43.8

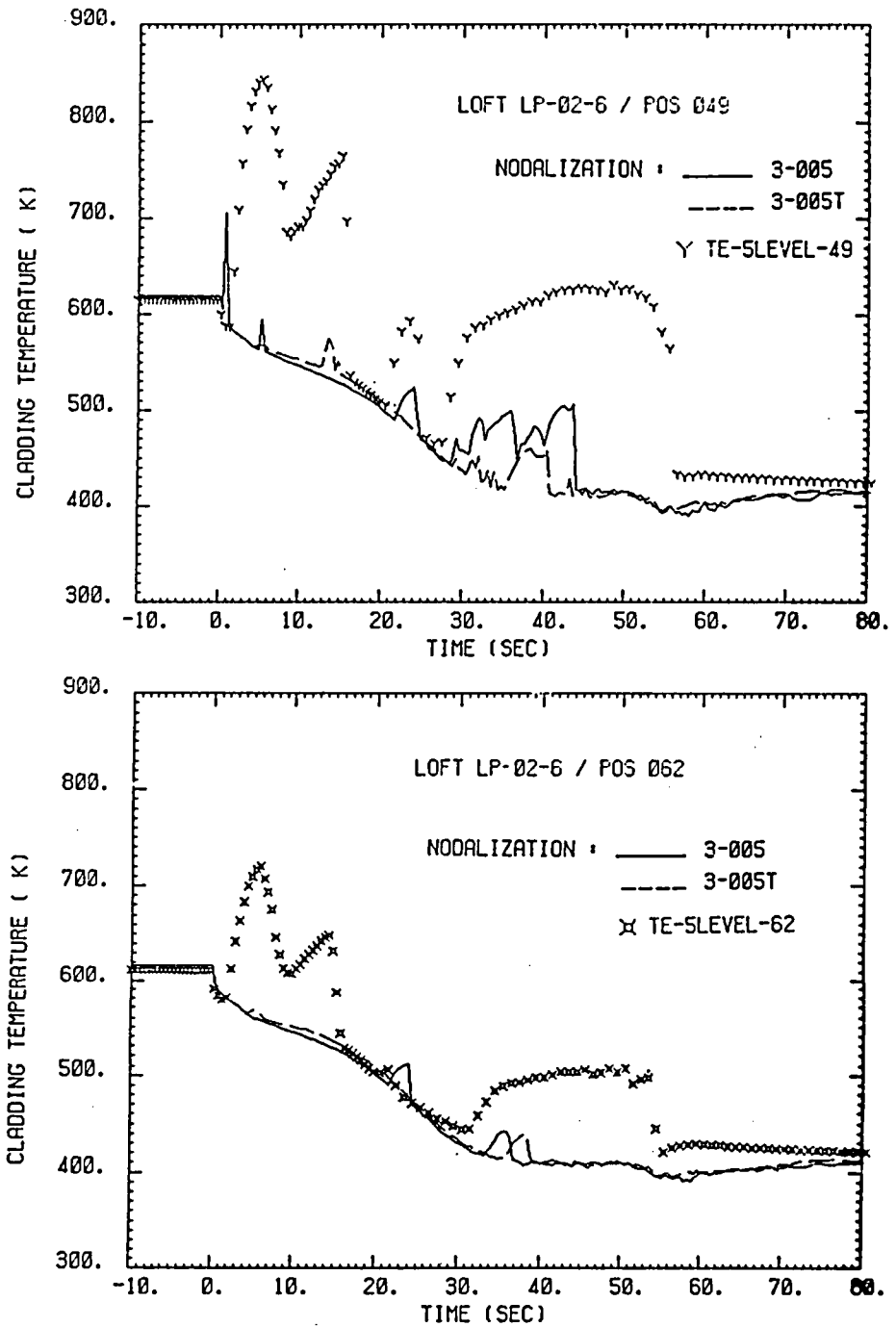


Figure 3.47: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

i) at level-49

k) at level-62

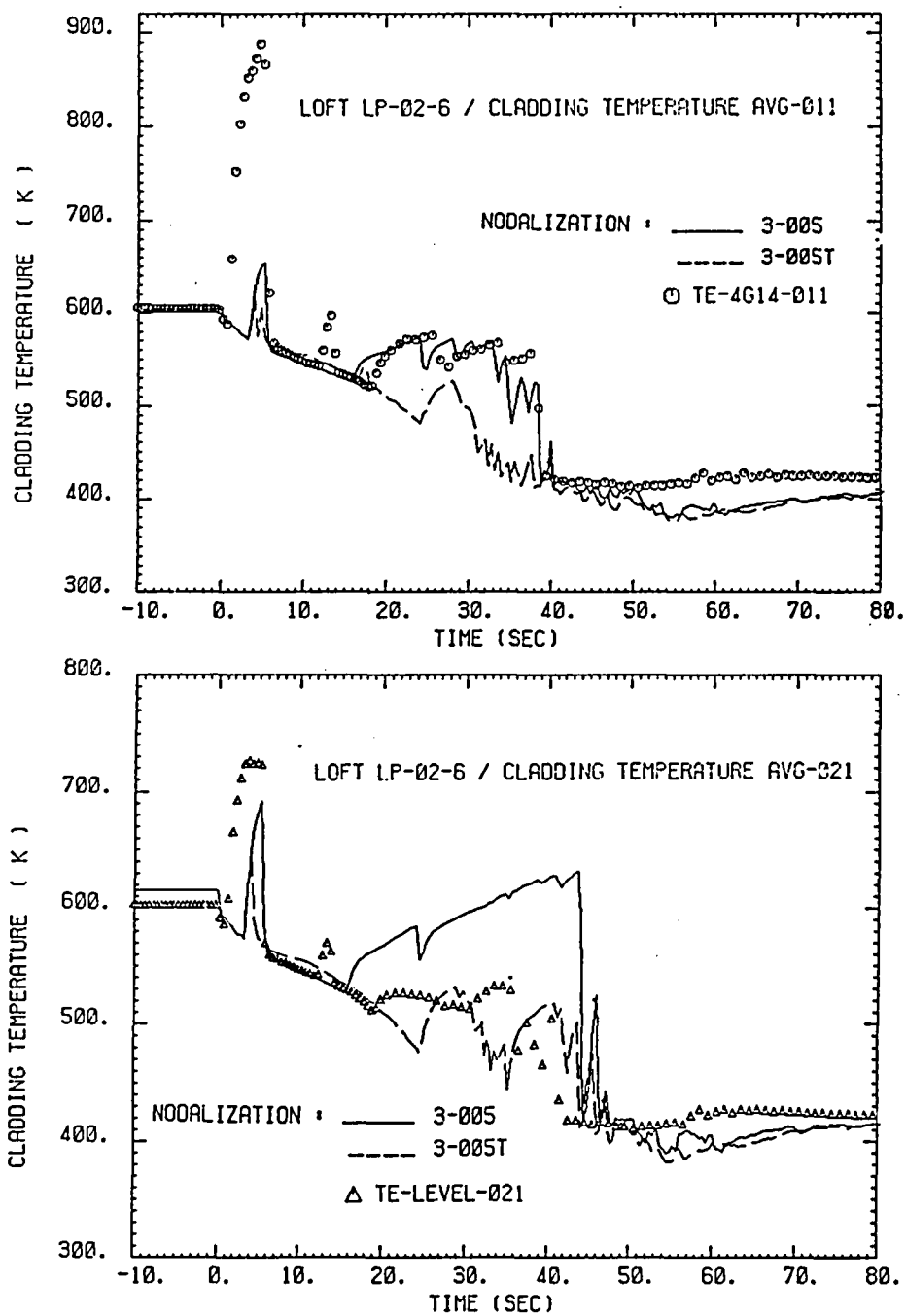
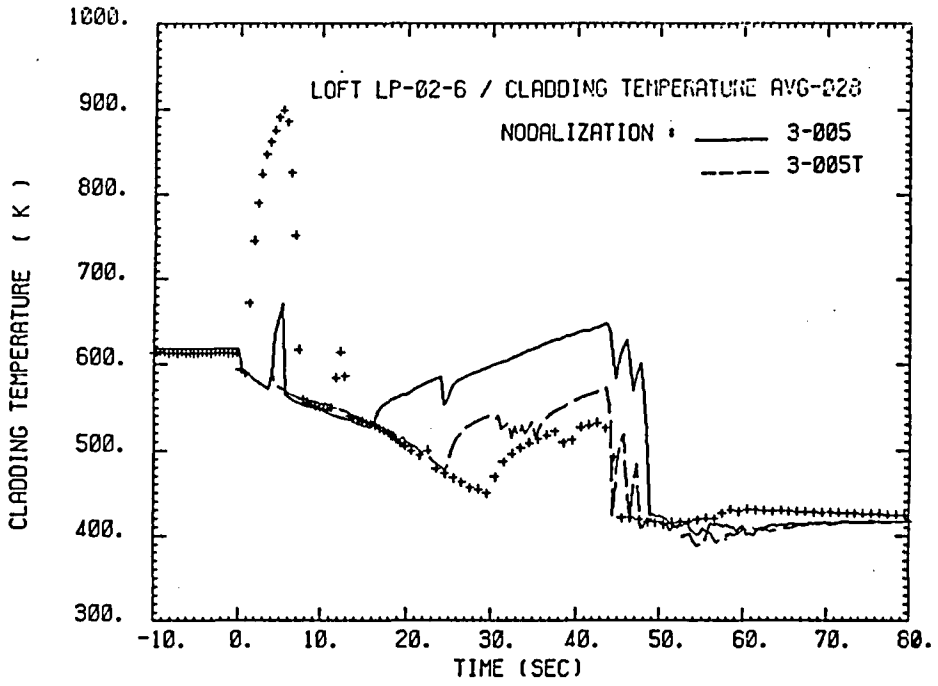


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

a) at level-11 (average channel)

b) at level-21 (average channel)



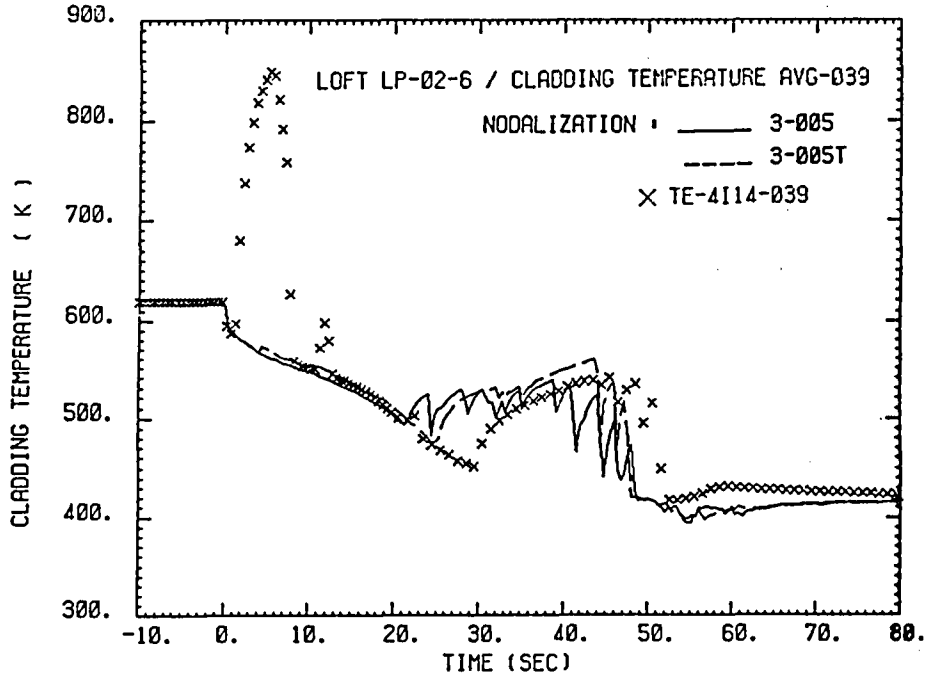


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option

c) at level-28 (average channel)

d) at level-39 (average channel)

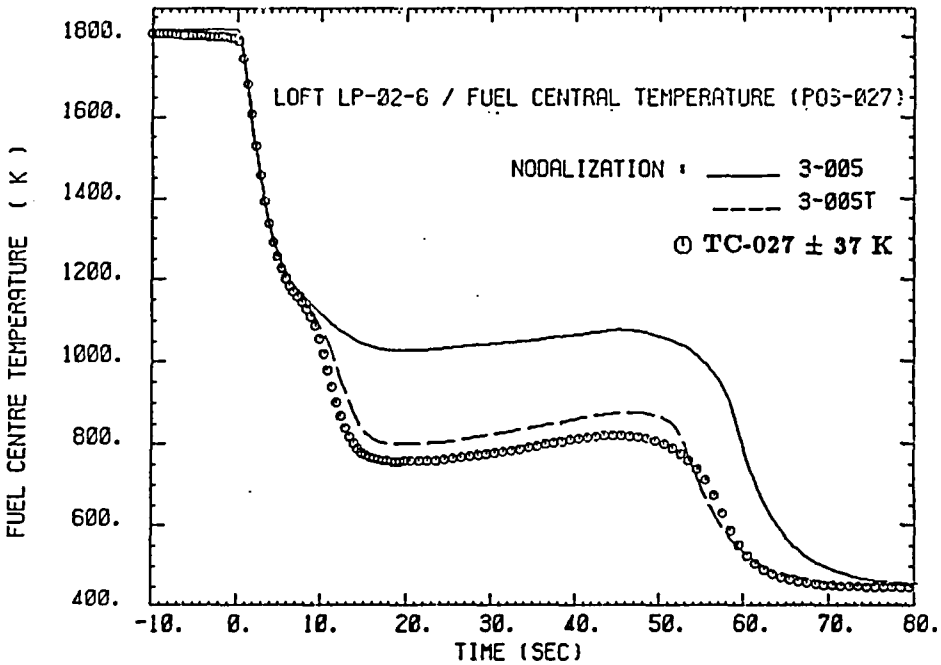


Figure 3.49: Comparison of the fuel center temperatures calculated by RELAP5/Mod2 without (3-005) and with (3-005T) external triggering of the reflood option at level 27

ment is independent of the status of the reflooding option of the RELAP5/Mod2 code. In the frozen version of RELAP5, the heat transfer logic forces the code to stay in film boiling and does not allow it for any reason to return to transition boiling if the cladding temperature is higher than 1350 K minus $T_{saturation}$. The same restriction is valid in the Post and Pre-dryout flow regimes where the code is prevented from returning to nucleate boiling, if the above temperature criterion is valid. By removing these two restrictions, one was able to calculate the early bottom up rewetting using the 3-005 nodalization (e.g. without "artificial initialization of the reflood option) much more accurate at nearly all core level than the results shown in this report.

Chapter 4

Conclusions

Experiment LP-02-6 was conducted in the Loss-Of-Fluid Test (LOFT) facility at the Idaho National Engineering Laboratory. It was the first large break loss-of-coolant accident simulation and the fourth experiment overall conducted on the LOFT test facility under the auspices of the OECD.

During this experiment, the cladding temperatures remained at temperatures lower than 1060 K which mainly was due to fact that high mass flow, early bottom-up rewetting took place during the blowdown phase of the experiment, approximately 4.5 to 8 seconds after opening of the break valves. In addition, in the upper part of the core, heat-up might have been delayed due to partial top-down quenching between 15 and 18 seconds of the experiment.

For the plant to be analysed, the "adequate nodalization" is usually unknown and only some very rough criteria can be given to the code user. Consequentely, the accuracy of a prediction may be strongly related to the "experience" of the code user, a quite unsatisfactory conclusion. Therefore, we have analysed the LP-02-6 experiment by using the best estimate code RELAP5/Mod2 cy36-02 with different nodalizations of the loft system. Starting with a nodalization similar to the one used by the code developers at INEL (specially developed for small break LOCAs), we have reduced the numbers of volumes, junctions and heat structures in the primary Loop of the LOFT system to nearly half whereas the entire vessel stayed unchanged to meet the requirements of the given experimental axial positions, especially for the cladding temperature measurements. We further have investigated on the influence of fine meshing in the core zone during reflooding on quench time and -temperature and on the influence of the time of initialization of the reflood option with respect to RELAP5/Mod2 's predicting capabilities of the quench phenomena.

- RELAP5/Mod2 , cy36-02 has calculated the general thermo-hydraulic behaviour of experiment LP-02-6 satisfactorly although it failed in describing the early bottom-up rewetting which happened between 4 and 8 seconds of the transient (blowdown phase) quenching the whole core. Independently of the choosen nodalization, most of the investigated parameters like pressures, mass flows in the broken and intact loops, pump speed and ECC systems have error bounds less than ±20%. The cladding temperatures have been both over- and underpredicted (depending on the investigated core level) but not more than 150 K. For all nodalizations, the hot spot has been calculated at a position more downstream

of the core; instead at the experimentally inferred position 27 inches from the bottom of the core, RELAP5/Mod2 always calculated the hot spot at axial level 31. We believe that the, generally spoken, relatively good agreement of most of the RELAP5/Mod2 results with the measured LOFT data is not really surprising because codes like RELAP5/Mod2 have been extensively used for analysing LOFT experiments and LOFT results have been extensively used to eliminate insufficiencies both in the codes themselves as well as in the more plant specific nodalization of the problem. Therefore, even if these "adjustements" have been mainly made for small break LOCAs, one has to be aware of the fact that both the code and the LOFT specific nodalization (also used here as the basic nodalization scheme), are somehow "LOFT tuned" which resulted in these quite acceptable results.

- With respect to the computation time, the degree of specification of the nodalization, i.e. the numbers of volumes and junctions, is of course an important parameter. But not always a lower number of junctions and volumes automatically has lead to a faster calculation. Sometimes, with respect to computing time, the profit of a much reduced nodalization is rather small.

- For large break LOCAs, the nodalization seems to be important only for the cladding temperatures, where significant differences can be observed for the different nodalizations under investigation. But, opposite to our findings when analysing the LP-LB-1 experiment (see ref. [7]), the differences in the times of final quenching are usually rather small and within a band of less than ten seconds. Also for the other parameters, the deviations between the results of the calculations with the different nodalizations under investigation remain relatively small.

- The time point of initiating the reflood option determines the "quench behaviour" of the code because it starts the fine-meshing in the core-zone thus enabling a more correct tracing of the axial cladding temperature distribution and consequentely a better reflood modeling. Therefore, the comparison of two of three possible methods of initiating the reflood option have manifested a strong dependence of the results on this settings. An external trip based on the fluid level in the core alone has lead to much lower values of the cladding temperatures at nearly all axial levels of the LOFT core but still was not able to correctly calculate the early bottom-up rewetting which has quenched the whole core within the first 4.5 to 8 seconds of the experiment and therefore has had a very important influence on the behaviour of the whole system.
  Early bottom-up rewetting probably is a consequence of the coast-down behaviour of the primary pumps. RELAP5/Mod2 has been able to give an indication for this dependence. Looking at the different mass fluxes as calculated by the code using different assumptions about the pump coast-down behaviour, one easily will observe the strong relationship between coast-down behaviour and mass flux; e.g. rapid pump coast down lead to much lower core -in and out mass fluxes than normal coast-down (see figs. 3.32 and 3.33).

- Finally, a remarkable inconsistency has been observed concerning the heat transfer and flow regime logics of RELAP5/Mod2 . During the refill phase of the calculation, at the same time RELAP5/Mod2 assumed different flow regimes on one side for its calculation of the interfacial shear stresses and interfacial heat transfers and on the other side for the determination of the heat transfer from the wall to the fluid (liquid). This unphysical modeling of the thermo-hydraulic conditions in the core region of the LOFT reactor may invalidate even results which have been proved as to be satisfactory by a pure comparison with the experimental data, e.g. at the same axial position and at the same time, RELAP5/Mod2 assumed both wet and dry surface by defining mist flow and slug flow for the same volume.

Chapter 5

Appendices

5.1 References

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on OECD LOFT-Experiment LP-02-6
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[4] **Andreani, M and Grütter, H.P** : Post-Test Analysis of
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[9] **Anonymous :** OECD LOFT Experiment LP-02-6 : Tape Descriptions and Supplementary Information

[10] **Brittain, I. and Aksan, S.N. :** OECD-LOFT Large Break LOCA Experiments : Phenomenology and Computer Code Analyses
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5.2 Listing of RELAP5/Mod2 - Input Mk. 2-00C

Finally, as an example, the RELAP5/Mod2 - inputdeck Mk. 2-00C will be listed (for the "Normal Version", lines **LP2-1742** to **LP2-1889** and lines **LP2-2256** to **LP2-2292** have to be deleted) :

```
*                                                                    LP2-   1
= LOFT LP-02-6   [post test analysis] / mk 2-00 C   ( 1.4.87 )      *LP2-   2
*                                                                    LP2-   3
*     LP-02-6    initial conditions                                 LP2-   4
*                                                                    LP2-   5
*                       power =  46.0 MW                             LP2-   6
*                    pcs flow = 248.7 kg/s                           LP2-   7
*                       t hot = 589.1 K                              LP2-   8
*                       tcold = 556.0 K                              LP2-   9
*                pcs pressure = 15.09 MPa                            LP2-  10
*                                                                    LP2-  11
*                pzr pressure = 15.3  MPa                            LP2-  12
*                pzr    level = 1.04 m (41 in)                       LP2-  13
*                                                                    LP2-  14
*                                                                    LP2-  15
*                                                                    LP2-  16
* nodalisation                                                       LP2-  17
* ------------                                                       LP2-  18
*                                                                    LP2-  19
00000100   new       transnt                                        *LP2-  20
00000101   run                                                      *LP2-  21
00000105   5.0       10.0      850.                                 *LP2-  22
00000110   nitrogen                                                 *LP2-  23
*                                                                    LP2-  24
*     time step control cards                     * required         LP2-  25
*         end time  min dt   max dt   optn   mnr   mjr  rst         LP2-  26
00000201   10.       1.0-6    .2      15003   10   1000 1000        *LP2-  27
00000202   12.       1.0-12   .01     15003   1    1000 1000        *LP2-  28
00000203   1.+5      1.0-12   .1      15003   1    1000 1000        *LP2-  29
*                                                                    LP2-  30
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-  31
*                                                                    LP2-  32
*   minor edit variables                                             LP2-  33
*                                                                    LP2-  34
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-  35
*                                                                    LP2-  36
*                                                                    LP2-  37
```

```
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-  38
* transient plot requests                                             LP2-  39
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-  40
00000301  cputime   0                                                *LP2-  41
00000302  emass     0                                                *LP2-  42
00000303  p         340010000                                        *LP2-  43
00000304  rho       340010000                                        *LP2-  44
00000305  mflowj    340010000                                        *LP2-  45
00000306  cntrlvar  404                                              *LP2-  46
00000307  tempf     340010000                                        *LP2-  47
00000308  tempg     340010000                                        *LP2-  48
00000309  p         342010000                                        *LP2-  49
00000310  p         344010000                                        *LP2-  50
*                                                                     LP2-  51
00000311  p         305010000                                        *LP2-  52
00000312  rho       305010000                                        *LP2-  53
00000313  mflowj    305010000                                        *LP2-  54
00000314  cntrlvar  414                                              *LP2-  55
00000315  tempf     305010000                                        *LP2-  56
00000316  tempg     305010000                                        *LP2-  57
00000317  p         315070000                                        *LP2-  58
*                                                                     LP2-  59
00000318  rho       180010000                                        *LP2-  60
00000319  mflowj    185020000                                        *LP2-  61
00000320  cntrlvar  424                                              *LP2-  62
00000321  velf      180010000                                        *LP2-  63
00000322  tempf     180010000                                        *LP2-  64
00000323  tempg     180010000                                        *LP2-  65
00000324  cntrlvar  80                                               *LP2-  66
*                                                                     LP2-  67
00000325  rho       100010000                                        *LP2-  68
00000326  mflowj    100020000                                        *LP2-  69
00000327  cntrlvar  434                                              *LP2-  70
00000328  tempf     100010000                                        *LP2-  71
00000329  tempg     100010000                                        *LP2-  72
00000330  p         100010000                                        *LP2-  73
00000331  p         420010000                                        *LP2-  74
*                                                                     LP2-  75
00000332  cntrlvar  460                                              *LP2-  76
00000333  cntrlvar  461                                              *LP2-  77
00000334  cntrlvar  462                                              *LP2-  78
00000335  cntrlvar  463                                              *LP2-  79
00000336  cntrlvar  464                                              *LP2-  80
```

```
*                                                                  LP2-  81
00000337  mflowj    610000000                                     *LP2-  82
00000338  cntrlvar  4                                             *LP2-  83
00000339  p         620010000                                     *LP2-  84
00000340  mflowj    630000000                                     *LP2-  85
00000341  mflowj    640000000                                     *LP2-  86
*                                                                  LP2-  87
00000342  p         240010000                                     *LP2-  88
00000343  voidf     240010000                                     *LP2-  89
00000344  cntrlvar  240                                           *LP2-  90
00000345  voidf     225010000                                     *LP2-  91
00000346  voidf     210020000                                     *LP2-  92
00000347  velfj     225020000                                     *LP2-  93
00000348  cntrlvar  444                                           *LP2-  94
00000349  cntrlvar  454                                           *LP2-  95
00000350  cntrlvar  90                                            *LP2-  96
00000351  cntrlvar  91                                            *LP2-  97
00000352  cntrlvar  93                                            *LP2-  98
00000353  cntrlvar  98                                            *LP2-  99
00000354  voidg     231010000                                     *LP2- 100
00000355  voidg     231020000                                     *LP2- 101
00000356  voidg     231040000                                     *LP2- 102
00000357  voidg     231050000                                     *LP2- 103
00000358  voidg     231060000                                     *LP2- 104
00000359  voidg     231070000                                     *LP2- 105
00000360  voidg     231090000                                     *LP2- 106
00000361  voidg     231100000                                     *LP2- 107
00000362  voidg     231110000                                     *LP2- 108
00000363  voidg     231130000                                     *LP2- 109
00000364  cntrlvar  470                                           *LP2- 110
*                                                                  LP2- 111
00000365  tempf     202010000                                     *LP2- 112
00000366  tempf     210020000                                     *LP2- 113
00000367  tempf     210030000                                     *LP2- 114
00000368  tempf     210040000                                     *LP2- 115
00000369  tempf     220010000                                     *LP2- 116
00000370  httemp    231000110                                     *LP2- 117
00000371  httemp    231000210                                     *LP2- 118
00000372  httemp    231000410                                     *LP2- 119
00000373  httemp    231000510                                     *LP2- 120
00000374  httemp    231000610                                     *LP2- 121
00000375  httemp    231000710                                     *LP2- 122
00000376  httemp    231000910                                     *LP2- 123
```

```
00000377  httemp    231001010                                          *LP2- 124
00000378  httemp    231001110                                          *LP2- 125
00000379  httemp    231001310                                          *LP2- 126
*                                                                       LP2- 127
00000380  httemp    231000601                                          *LP2- 128
00000381  httemp    231001001                                          *LP2- 129
*                                                                       LP2- 130
00000382  httemp    230000105                                          *LP2- 131
00000383  httemp    230000205                                          *LP2- 132
00000384  httemp    230000305                                          *LP2- 133
00000385  httemp    230000405                                          *LP2- 134
*                                                                       LP2- 135
00000386  cntrlvar  2                                                  *LP2- 136
00000387  cntrlvar  230                                                *LP2- 137
00000388  cntrlvar  231                                                *LP2- 138
00000389  cntrlvar  250                                                *LP2- 139
00000390  cntrlvar  76                                                 *LP2- 140
*                                                                       LP2- 141
00000391  mflowj    245020000                                          *LP2- 142
00000392  mflowj    201000000                                          *LP2- 143
00000393  mflowj    205000000                                          *LP2- 144
00000394  mflowj    271000000                                          *LP2- 145
00000395  mflowj    275000000                                          *LP2- 146
*                                                                       LP2- 147
*                                                                       LP2- 148
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*    LP2- 149
*                                                                       LP2- 150
*     trips                                                             LP2- 151
*                                                                       LP2- 152
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*    LP2- 153
*                                                                       LP2- 154
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 155
*  [t-500]   end of job trip                                            LP2- 156
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 157
00000500  time      0         ge   null    0      130.      1          *LP2- 158
00000600  500                                                          *LP2- 159
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 160
*                                                                       LP2- 161
*                                                                       LP2- 162
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 163
*     510-516  test specific trips                                      LP2- 164
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 165
*     break opens                                                       LP2- 166
```

```
00000510   time      0          ge   null      0          10.0     l   *LP2- 167
*                                                                       LP2- 168
*                                                                       LP2- 169
*     scram                                                             LP2- 170
00000511   time      0          ge   timeof    510        0.13     l   *LP2- 171
*     pcp trip                                                          LP2- 172
00000512   time      0          ge   timeof    510        0.8      l   *LP2- 173
*     lpis on                                                           LP2- 174
00000513   time      0          ge   timeof    510        34.8     l   *LP2- 175
*     hpis on                                                           LP2- 176
00000514   time      0          ge   timeof    510        21.8     l   *LP2- 177
*     accumulator valve                                                 LP2- 178
00000515   time      0          ge   timeof    510        17.5     l   *LP2- 179
*  broken leg bypass                                                    LP2- 180
00000516   time      0          ge   null      0          1.0+9    l   *LP2- 181
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 182
*                                                                       LP2- 183
*    different related trips                                            LP2- 184
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 185
* lt  681  ecc check valve          card 6000301                       LP2- 186
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 187
00000577   mflowj    600000000 ge   null      0          0.0      n   *LP2- 188
00000578   p         605010000 gt   p         185010000 0.        n   *LP2- 189
00000681   577       and       578       n                             *LP2- 190
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 191
* lt 682 accumulator valve  card 6100301                                LP2- 192
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 193
00000582   cntrlvar  4         lt   null      0          1.0-4    l   *LP2- 194
00000682   -582      and       515       n                             *LP2- 195
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 196
* lt  685-686  steam valve          card 5400301                       LP2- 197
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 198
* open trip                                                             LP2- 199
00000589   p         530010000 gt   null      0          5.55+6   n   *LP2- 200
00000590   p         530010000 lt   null      0          5.50+6   n   *LP2- 201
00000670   685       or        589       n                             *LP2- 202
00000671   -590      and       -686      n                             *LP2- 203
00000685   671       and       670       n                             *LP2- 204
* close trip                                                            LP2- 205
00000591   p         530010000 gt   null      0          5.10+6   n   *LP2- 206
00000592   p         530010000 lt   null      0          5.05+6   n   *LP2- 207
00000672   686       or        592       n                             *LP2- 208
00000673   -591      and       672       n                             *LP2- 209
```

```
00000674   -685      and       511       n                                  *LP2- 210
00000686   673       and       674       n                                  *LP2- 211
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 212
* job termination valve trips                                               LP2- 213
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 214
* open                                                                      LP2- 215
00000687   685       or        685       n                                  *LP2- 216
* close                                                                     LP2- 217
00000688   686       or        686       n                                  *LP2- 218
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 219
*                                                                           LP2- 220
*                                                                           LP2- 221
*                                                                           LP2- 222
*                                                                           LP2- 223
*                                                                           LP2- 224
*                                                                           LP2- 225
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*    LP2- 226
*                                                                           LP2- 227
*   intact loop   [ 100 ]                                                   LP2- 228
*                                                                           LP2- 229
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*    LP2- 230
*                                                                           LP2- 231
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 232
* reactor vessel nozzle - intact loop hot leg                               LP2- 233
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 234
1000000   "rvn ilhl"          branch                                       *LP2- 235
1000001   2         0                                                       *LP2- 236
1000101   0.0       1.58878   0.102752  0.0       0.0       0.0            *LP2- 237
1000102   4.0e-5    0.0       00                                            *LP2- 238
1000200   0         1.52896+7 1410741.  2452898.  0.                        *LP2- 239
1001101   252010000 100000000 0.0634    0.1       0.1       0002           *LP2- 240
1002101   100010000 105000000 0.0       0.1       0.1       0000           *LP2- 241
1001201   5.6727028 5.7111053 0.      * (M = 247.55 kg/s)                   LP2- 242
1002201   5.6688271 5.6727905 0.      * (M = 247.55 kg/s)                   LP2- 243
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 244
* pressurizer connection tee reactor vessel side                            LP2- 245
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----            LP2- 246
1050000   "pzr t rv"          branch                                       *LP2- 247
1050001   1         0                                                       *LP2- 248
1050101   0.0634444 1.0531192 0.0       0.0       0.0       0.0            *LP2- 249
1050102   4.0e-5    0.0       00                                            *LP2- 250
1050200   0         1.52874+7 1410744.  2452952.  0.                        *LP2- 251
1051101   105010000 107000000 0.0       0.12      0.12      0000           *LP2- 252
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1051201   5.7985497 5.8006973 0.      * (M = 247.55 kg/s)              LP2- 253
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 254
* pressurizer connection tee                                           LP2- 255
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 256
1070000   "pzr t   "          branch                                  *LP2- 257
1070001   1         0                                                  *LP2- 258
1070101   0.0620253 0.2810215 0.0       0.0       0.0       0.0       *LP2- 259
1070102   4.0e-5    0.0       00                                      *LP2- 260
1070200   0         1.52852+7 1410746.  2453006.  0.                  *LP2- 261
1071101   107010000 110000000 0.0       0.135     0.135     0000      *LP2- 262
1071201   5.9346313 5.9351082 0.      * (M = 247.57 kg/s)              LP2- 263
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 264
* pressurizer connection tee steam generator side                      LP2- 265
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 266
1100000   "pzr t sg"          branch                                  *LP2- 267
1100001   1         0                                                  *LP2- 268
1100101   0.0606063 0.9207292 0.0       0.0       0.0       0.0       *LP2- 269
1100102   4.0e-5    0.0       00                                      *LP2- 270
1100200   0         1.52827+7 1410749.  2453066.  0.                  *LP2- 271
1101101   110010000 112000000 0.0       0.15      0.15      0000      *LP2- 272
1101201   6.2683144 6.2684364 0.      * (M = 247.57 kg/s)              LP2- 273
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 274
* hot leg piping                                                       LP2- 275
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 276
1120000   "hot leg "          pipe                                    *LP2- 277
1120001   2                                                            *LP2- 278
1120101   0.0       2                                                  *LP2- 279
1120201   0.0       1                                                  *LP2- 280
1120301   1.38893   1                                                  *LP2- 281
1120302   0.707687  2                                                  *LP2- 282
1120401   0.0796973 1                                                  *LP2- 283
1120402   0.0579614 2                                                  *LP2- 284
1120501   0.0       2                                                  *LP2- 285
1120601   0.0       1                                                  *LP2- 286
1120602   90.0      2                                                  *LP2- 287
1120701   0.0       1                                                  *LP2- 288
1120702   0.246447  2                                                  *LP2- 289
1120801   4.0e-5    0.0       2                                        *LP2- 290
1120901   0.20      0.20      1                                        *LP2- 291
1121001   00        2                                                  *LP2- 292
1121101   0000      1                                                  *LP2- 293
1121201   0         1.52785+7 1410752.  2453166.  0.        0.     1  *LP2- 294
1121202   0         1.52814+7 1410754.  2453098.  0.        0.     2  *LP2- 295
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1121300   0                                                          *LP2- 296
1121301   6.2683678 6.2683411 0.         1   * (M = 247.57 kg/s)      LP2- 297
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 298
* sg inlet plenum                                                     LP2- 299
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 300
1140000   "sg in pl"          branch                                 *LP2- 301
1140001   2         0                                                 *LP2- 302
1140101   0.0       0.629795  0.33532   0.0       90.0      0.512756 *LP2- 303
1140102   4.e-5     0.0102    00                                      *LP2- 304
1140200   0         1.52560+7 1410762.  2453710.  0.                  *LP2- 305
1141101   112010000 114000000 0.0512    0.0       0.0       0100     *LP2- 306
1142101   114010000 115000000 0.0       0.0       0.0       0100     *LP2- 307
1141201   4.391552  4.3915901 0.      * (M = 247.57 kg/s)             LP2- 308
1142201   2.3794098 2.3794098 0.      * (M = 247.56 kg/s)             LP2- 309
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 310
* sg u-tubes                                                          LP2- 311
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 312
1150000   "sg tubes"          pipe                                   *LP2- 313
1150001   8                                                           *LP2- 314
1150101   0.0       8                                                 *LP2- 315
1150201   0.151171  7                                                 *LP2- 316
1150301   0.902     1                                                 *LP2- 317
1150302   0.6096    3                                                 *LP2- 318
1150303   0.462908  5                                                 *LP2- 319
1150304   0.6096    7                                                 *LP2- 320
1150305   0.902     8                                                 *LP2- 321
1150401   0.136356  1                                                 *LP2- 322
1150402   0.0921538 3                                                 *LP2- 323
1150403   0.0699783 5                                                 *LP2- 324
1150404   0.0921538 7                                                 *LP2- 325
1150405   0.136356  8                                                 *LP2- 326
1150501   0.0       8                                                 *LP2- 327
1150601   90.0      4                                                 *LP2- 328
1150602   -90.0     8                                                 *LP2- 329
1150701   0.902     1                                                 *LP2- 330
1150702   0.6096    3                                                 *LP2- 331
1150703   0.299572  4                                                 *LP2- 332
1150704   -0.299572 5                                                 *LP2- 333
1150705   -0.6096   7                                                 *LP2- 334
1150706   -0.902    8                                                 *LP2- 335
1150801   1.27-7    0.01022   8                                       *LP2- 336
1150901   0.0       0.0       7                                       *LP2- 337
1151001   00        8                                                 *LP2- 338
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1151101   0000      7                                                  *LP2- 339
1151201   0         1.52468+7 1367802.  2453930.  0.        0.    1  *LP2- 340
1151202   0         1.52390+7 1333644.  2454120.  0.        0.    2  *LP2- 341
1151203   0         1.52326+7 1306228.  2454274.  0.        0.    3  *LP2- 342
1151204   0         1.52275+7 1288303.  2454396.  0.        0.    4  *LP2- 343
1151205   0         1.52260+7 1272624.  2454434.  0.        0.    5  *LP2- 344
1151206   0         1.52275+7 1255106.  2454396.  0.        0.    6  *LP2- 345
1151207   0         1.52300+7 1239987.  2454336.  0.        0.    7  *LP2- 346
1151208   0         1.52331+7 1226804.  2454260.  0.        0.    8  *LP2- 347
1151300   0                                                          *LP2- 348
1151301   2.3187809 2.3187809 0.         1   * (M = 247.56 kg/s)      LP2- 349
1151302   2.274889  2.274889  0.         2   * (M = 247.56 kg/s)      LP2- 350
1151303   2.242157  2.242157  0.         3   * (M = 247.56 kg/s)      LP2- 351
1151304   2.2215405 2.2215405 0.         4   * (M = 247.56 kg/s)      LP2- 352
1151305   2.2040806 2.2040806 0.         5   * (M = 247.56 kg/s)      LP2- 353
1151306   2.1854172 2.1854172 0.         6   * (M = 247.56 kg/s)      LP2- 354
1151307   2.1697006 2.1697006 0.         7   * (M = 247.56 kg/s)      LP2- 355
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 356
* sg outlet plenum                                                     LP2- 357
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 358
1160000   "sg out p"          branch                                  *LP2- 359
1160001   2         0                                                  *LP2- 360
1160101   0.0       0.629795  0.33532   0.0       -90.0     -0.512756 *P2- 361
1160102   4.e-5     0.0102    00                                       *LP2- 362
1160200   0         1.52375+7 1226810.  2454156.  0.                   *LP2- 363
1161101   115010000 116000000 0.0       0.0       0.0       0100     *LP2- 364
1162101   116010000 118000000 0.0512    0.0       0.0       0100     *LP2- 365
1161201   2.1562672 2.1562672 0.      * (M = 247.56 kg/s)              LP2- 366
1162201   3.9985161 3.9985161 0.      * (M = 247.56 kg/s)              LP2- 367
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 368
* pump suction piping                                                  LP2- 369
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 370
1180000   "pmp suc "          pipe                                    *LP2- 371
1180001   3                                                            *LP2- 372
1180101   0.0       3                                                  *LP2- 373
1180201   0.0       2                                                  *LP2- 374
1180301   0.546638  1                                                  *LP2- 375
1180302   0.688596  2                                                  *LP2- 376
1180303   0.558577  3                                                  *LP2- 377
1180401   0.0445625 1                                                  *LP2- 378
1180402   0.0445137 2                                                  *LP2- 379
1180403   0.0354278 3                                                  *LP2- 380
1180501   0.0       3                                                  *LP2- 381
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1180601   -90.0     3                                                  *LP2- 382
1180701   -0.498052 1                                                  *LP2- 383
1180702   -0.688596 2                                                  *LP2- 384
1180703   -0.355604 3                                                  *LP2- 385
1180801   4.e-5     0.0       3                                        *LP2- 386
1180901   0.083     0.083     1                                        *LP2- 387
1180902   0.104     0.104     2                                        *LP2- 388
1181001   00        3                                                  *LP2- 389
1181101   0000      2                                                  *LP2- 390
1181201   0         1.52202+7 1226811.  2454574.  0.        0.    1   *LP2- 391
1181202   0         1.52200+7 1226812.  2454578.  0.        0.    2   *LP2- 392
1181203   0         1.52222+7 1226814.  2454524.  0.        0.    3   *LP2- 393
1181300   0                                                            *LP2- 394
1181301   5.0425262 5.0425262 0.         1   * (M = 247.56 kg/s)       LP2- 395
1181302   5.1394501 5.1394501 0.         2   * (M = 247.56 kg/s)       LP2- 396
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 397
* pump suction tee                                                     LP2- 398
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 399
1200000   "pmp sct "          branch                                  *LP2- 400
1200001   3         0                                                  *LP2- 401
1200101   0.0       0.759614  0.0487901 0.0       0.0       0.0        *LP2- 402
1200102   4.0e-5    0.0       00                                       *LP2- 403
1200200   0         1.52235+7 1226815.  2454494.  0.                   *LP2- 404
1201101   118010000 120000000 0.063427  0.0       0.0       0000       *LP2- 405
1202101   120010000 125000000 0.063427  1.075     1.25      0000       *LP2- 406
1203101   120010000 155000000 0.063427  1.075     1.25      0000       *LP2- 407
1201201   5.1392822 5.1392822 0.      * (M = 247.56 kg/s)               LP2- 408
1202201   2.4195442 2.4195442 0.      * (M = 116.55 kg/s)               LP2- 409
1203201   2.7197304 2.7197304 0.      * (M = 131.01 kg/s)               LP2- 410
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 411
* pump1 suction tee outlet                                             LP2- 412
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 413
1250000   "pmp1 sct"          branch                                  *LP2- 414
1250001   1         0                                                  *LP2- 415
1250101   0.0       1.00308   0.0640548 0.0       90.   0.520704       *LP2- 416
1250102   4.0e-5    0.0       00                                       *LP2- 417
1250200   0         1.52266+7 1226819.  2454418.  0.                   *LP2- 418
1251101   125010000 130000000 0.0       0.13      0.13      0000       *LP2- 419
1251201   3.9541416 3.9541416 0.      * (M = 116.55 kg/s)               LP2- 420
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 421
* pump 1 inlet                                                         LP2- 422
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 423
1300000   "pmp1 inl"          snglvol                                 *LP2- 424
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1300101   0.0       0.457201  0.0177444 0.0       90.0  0.457201     *LP2- 425
1300102   4.0e-5    0.0       00                                     *LP2- 426
1300200   0         1.52183+7 1226821.  2454620.  0.                 *LP2- 427
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 428
* primary coolant pump 1                                              LP2- 429
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 430
1350000   "pcpump1"          pump                                   *LP2- 431
1350101   .0366     0.0       0.0991    0.0       90.   0.317900     *LP2- 432
1350102   0                                                          *LP2- 433
1350108   130010000 0.0       0.017     0.017     0000               *LP2- 434
1350109   140000000 0.0       0.05      0.05      0000               *LP2- 435
1350200   0         1.52814+7 1226902.  2453096.  0.                 *LP2- 436
1350201   0         4.1930466 4.1930466 0.      * (M = 116.55 kg/s)   LP2- 437
1350202   0         4.1928749 4.1928749 0.      * (M = 116.55 kg/s)   LP2- 438
1350301   0    0    0         -1        -1        512         0      *LP2- 439
1350302   369.      0.448699  .3155     96.       500.6     1.431    *LP2- 440
*                      ^^     (pump speed = 165.56995 rev/s)         LP2- 441
1350303   613.6     0.        207.433   .0444     19.5987   0.       *LP2- 442
1350310   0.0       0.0       0.0                                    *LP2- 443
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 444
* pump 1 outlet pump side                                             LP2- 445
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 446
1400000   "pmp1 out"         snglvol                                *LP2- 447
1400101   0.0       0.502185  0.0183849 0.0       0.0       0.0      *LP2- 448
1400102   4.0e-5    0.0       00                                     *LP2- 449
1400200   0         1.53468+7 1226905.  2451526.  0.                 *LP2- 450
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 451
* pump1 outlet pipe tee side                                          LP2- 452
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 453
1450000   "pmp1 out"         branch                                 *LP2- 454
1450001   2         0                                                *LP2- 455
1450101   0.0       1.40843   0.0633861 0.0       0.0       0.0      *LP2- 456
1450102   4.0e-5    0.0       00                                     *LP2- 457
1450200   0         1.53488+7 1226911.  2451478.  0.                 *LP2- 458
1451101   140010000 145000000 0.0       0.0       0.0       0000     *LP2- 459
1452101   145010000 150000000 0.0       0.57456   0.050347  0000     *LP2- 460
1451201   4.191433  4.191433  0.      * (M = 116.55 kg/s)             LP2- 461
1452201   3.4095764 3.4095764 0.      * (M = 116.55 kg/s)             LP2- 462
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 463
* pump outlet tee                                                     LP2- 464
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 465
1500000   "pmp out"          branch                                 *LP2- 466
1500001   1         0                                                *LP2- 467
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1500101   0.0        0.496511  0.0316011 0.0       0.0       0.0      *LP2- 468
1500102   4.0e-5     0.0       00                                     *LP2- 469
1500200   0          1.53404+7 1226911.  2451678.  0.                 *LP2- 470
1501101   150010000  175000000 0.063427  0.0       0.0       0000     *LP2- 471
1501201   5.1387558  5.1387558 0.      * (M = 247.56 kg/s)             LP2- 472
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 473
* pump 2 suction tee outlet                                             LP2- 474
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 475
1550000   "pmp2 sct"           branch                                 *LP2- 476
1550001   1          0                                                  *LP2- 477
1550101   0.0        1.00308   0.0640548 0.0       90.   0.520704     *LP2- 478
1550102   4.0e-5     0.0       00                                     *LP2- 479
1550200   0          1.52253+7 1226819.  2454448.  0.                 *LP2- 480
1551101   155010000  160000000 0.0       0.13      0.13      0000     *LP2- 481
1551201   4.4447289  4.4447289 0.      * (M = 131.01 kg/s)             LP2- 482
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 483
* pump 2 inlet pipe                                                    LP2- 484
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 485
1600000   "pmp2 inl"           snglvol                                *LP2- 486
1600101   0.0        0.457201  0.0177444 0.0       90.   0.457201     *LP2- 487
1600102   4.0e-5     0.0       00                                     *LP2- 488
1600200   0          1.52158+7 1226820.  2454678.  0.                 *LP2- 489
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 490
* primary coolant pump 2                                               LP2- 491
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 492
1650000   "pcpump2"           pump                                   *LP2- 493
1650101   .0366      0.0       0.0991    0.0       90.   0.317900     *LP2- 494
1650102   0                                                            *LP2- 495
1650108   160010000 0.0       0.017     0.017     0000               *LP2- 496
1650109   170000000 0.0       0.1       0.1       0000               *LP2- 497
1650200   0          1.52797+7 1226905.  2453138.  0.                 *LP2- 498
1650201   0          4.7132797 4.7132797 0.      * (M = 131.01 kg/s)   LP2- 499
1650202   0          4.7130966 4.7130966 0.      * (M = 131.01 kg/s)   LP2- 500
1650301   135  135   135       -1        -1        512         0      *LP2- 501
1650302   369.       0.4724932 .3155     96.       500.6     1.431    *LP2- 502
*                                (pump speed = 174.34998 rev/s)       LP2- 503
1650303   613.6      0.        207.433   .0444     19.5987   0.       *LP2- 504
1650310   0.0        0.0       0.0                                    *LP2- 505
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 506
* pump 2 outlet                                                        LP2- 507
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 508
1700000   "pmp2 out"           branch                                 *LP2- 509
1700001   1          0                                                  *LP2- 510
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1700101   0.0       0.514071  0.0192958 0.0       0.0       0.      *LP2- 511
1700102   4.0e-5    0.0       00                                    *LP2- 512
1700200   0         1.53458+7 1226908.  2451548.  0.                *LP2- 513
1701101   170010000 150000000 0.036611  0.3847    0.6316    0000    *LP2- 514
1701201   4.7113152 4.7113152 0.      * (M = 131.01 kg/s)            LP2- 515
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2- 516
* intact loop cold leg pipe                                          LP2- 517
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2- 518
1750000   "ilcl pip"          pipe                                  *LP2- 519
1750001   2                                                          *LP2- 520
1750101   0.0       2                                                 *LP2- 521
1750201   0.0       1                                                 *LP2- 522
1750301   0.558577  1                                                 *LP2- 523
1750302   0.613244  2                                                 *LP2- 524
1750401   0.035428  1                                                 *LP2- 525
1750402   0.038895  2                                                 *LP2- 526
1750501   0.0       2                                                 *LP2- 527
1750601   0.0       2                                                 *LP2- 528
1750701   0.0       2                                                 *LP2- 529
1750801   4.0e-5    0.0       2                                       *LP2- 530
1750901   0.0       0.0       1                                       *LP2- 531
1751001   00        2                                                 *LP2- 532
1751101   0000      1                                                 *LP2- 533
1751201   0         1.53401+7 1226913.  2451686.  0.        0.    1  *LP2- 534
1751202   0         1.53399+7 1226914.  2451692.  0.        0.    2  *LP2- 535
1751300   0                                                          *LP2- 536
1751301   5.1389198 5.1389198 0.         1   * (M = 247.56 kg/s)     LP2- 537
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2- 538
* ecc connection tee                                                 LP2- 539
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2- 540
1800000   "ecc t  "          branch                                *LP2- 541
1800001   1         0                                                *LP2- 542
1800101   0.0       1.15189   0.0730598 0.0       0.0       0.      *LP2- 543
1800102   4.0e-5    0.0       00                                    *LP2- 544
1800200   0         1.53395+7 1226918.  2451702.  0.                *LP2- 545
1801101   175010000 180000000 0.0       0.0       0.0       0000    *LP2- 546
1801201   5.1389236 5.1389236 0.      * (M = 247.56 kg/s)            LP2- 547
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2- 548
* reactor vessel nozzle - intact loop cold leg                       LP2- 549
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2- 550
1850000   "rvn ilcl"          branch                                *LP2- 551
1850001   2         0                                                *LP2- 552
1850101   0.0       1.00965   0.0644920 0.0       0.0       0.      *LP2- 553
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1850102   4.0e-5    0.0       00                                        *LP2- 554
1850200   0         1.53395+7 1226921.  2451700.  0.                    *LP2- 555
1851101   185010000 202000000 0.0634    2.8       2.8       0001       *LP2- 556
1852101   180010000 185000000 0.0       0.0       0.0       0000       *LP2- 557
1851201   5.1409569 5.1409569 0.      * (M = 247.56 kg/s)               LP2- 558
1852201   5.1388474 5.1388474 0.      * (M = 247.56 kg/s)               LP2- 559
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 560
*                                                                       LP2- 561
*                                                                       LP2- 562
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2- 563
*                                                                       LP2- 564
*   reactor vessel   [ 200 ]                                            LP2- 565
*                                                                       LP2- 566
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2- 567
*                                                                       LP2- 568
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 569
* inlet annulus upper volume intact side                                LP2- 570
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 571
2000000   "inanuprt"          annulus                                  *LP2- 572
2000001   1                                                            *LP2- 573
2000101   0.1308530 1                                                  *LP2- 574
2000301   0.1876129 1                                                  *LP2- 575
2000401   0.0       1                                                  *LP2- 576
2000501   0.0       1                                                  *LP2- 577
2000601   90.0      1                                                  *LP2- 578
2000801   3.81-6    0.172     1                                        *LP2- 579
2001001   00        1                                                  *LP2- 580
2001201   0         1.53186+7 1226927.  2452202.  0.        0.    1    *LP2- 581
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 582
* junction - upper to lower inlet annulus intact side                   LP2- 583
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 584
2010000   "inanmuit"          sngljun                                  *LP2- 585
2010101   202000000 200000000 0.129467  0.0000    0.0000    0100       *LP2- 586
2010201   0         0.7271485 0.7271485 0.      * (M = 72.268 kg/s)     LP2- 587
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 588
* inlet annulus middle volume intact side                               LP2- 589
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 590
2020000   "inanmidt"          annulus                                  *LP2- 591
2020001   1                                                            *LP2- 592
2020101   0.1308530 1                                                  *LP2- 593
2020301   0.2851823 1                                                  *LP2- 594
2020401   0.0       1                                                  *LP2- 595
2020501   0.0       1                                                  *LP2- 596
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2020601   -90.0     1                                                  *LP2- 597
2020801   3.81-6    0.172     1                                        *LP2- 598
2021001   00        1                                                  *LP2- 599
2021201   0         1.53206+7 1226923.  2452154.  0.        0.    1   *LP2- 600
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 601
* junction - middle to lower inlet annulus intact side                 LP2- 602
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 603
2050000   "inanmlit"          sngljun                                  *LP2- 604
2050101   202010000 210000000 0.0709408 0.0       0.0       0100      *LP2- 605
2050201   0         1.7637691 1.7637691 0.      * (M = 175.29 kg/s)    LP2- 606
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 607
* inlet annulus lower volume intact side                               LP2- 608
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 609
2100000   "int dowc"          annulus                                  *LP2- 610
2100001   4                                                            *LP2- 611
2100101   0.1464354 1                                                  *LP2- 612
2100102   0.0       4                                                  *LP2- 613
2100201   0.0709408 3                                                  *LP2- 614
2100301   0.2525361 1                                                  *LP2- 615
2100302   1.5200561 2                                                  *LP2- 616
2100303   1.2616333 3                                                  *LP2- 617
2100304   1.0792591 4                                                  *LP2- 618
2100401   0.0       1                                                  *LP2- 619
2100402   0.1581866 2                                                  *LP2- 620
2100403   0.1217000 3                                                  *LP2- 621
2100404   0.0986806 4                                                  *LP2- 622
2100501   0.0       4                                                  *LP2- 623
2100601   -90.      4                                                  *LP2- 624
2100801   3.81-6     0.172   4                                        *LP2- 625
2100901   0.0        0.0     3                                        *LP2- 626
2101001   00        04                                                 *LP2- 627
2101101   00000     03                                                 *LP2- 628
2101201   0         1.53177+7 1226925.  2452224.  0.        0.    1   *LP2- 629
2101202   0         1.53233+7 1226937.  2452090.  0.        0.    2   *LP2- 630
2101203   0         1.53331+7 1226945.  2451854.  0.        0.    3   *LP2- 631
2101204   0         1.53414+7 1226952.  2451654.  0.        0.    4   *LP2- 632
2101300   0                                                            *LP2- 633
2101301   3.2533512 3.2533512 0.         1   * (M = 175.29 kg/s)      LP2- 634
2101302   3.253336  3.253336  0.         2   * (M = 175.29 kg/s)      LP2- 635
2101303   3.2533035 3.2533035 0.         3   * (M = 175.29 kg/s)      LP2- 636
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 637
* junction - lower downcomer to lower plenum intact side               LP2- 638
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2- 639
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2150000   "inanmuit"          sngljun                                  *LP2- 640
2150101   210010000 222000000 0.0709408 0.0000    0.0000    0100     *LP2- 641
2150201   0         2.5241261 2.5241261 0.      * (M = 175.29 kg/s)   LP2- 642
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 643
* lower plenum bottom volume                                          LP2- 644
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 645
2200000   "lwr pl b"          snglvol                                 *LP2- 646
2200101   0.0       0.3741720 0.29656   0.0   90.   0.3741720        *LP2- 647
2200102   4.0e-5    0.0       00                                      *LP2- 648
2200200   0         1.53399+7 1227769.  2451692.  0.                  *LP2- 649
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 650
* lower plenum top volume                                             LP2- 651
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 652
2220000   "lwr pl t"          branch                                  *LP2- 653
2220001   2         0                                                  *LP2- 654
2220101   0.0       0.3533183 0.2592277 0.0   90.   0.3533183        *LP2- 655
2220102   3.81-6    0.0       00                                      *LP2- 656
2220200   0         1.53426+7 1226974.  2451628.  0.                  *LP2- 657
2221101   222010000 220000000 0.0       0.005     0.005     0000     *LP2- 658
2222101   222000000 225000000 0.1499    1.5       1.5       0000     *LP2- 659
2221201   0.        0.        0.      * (M =-1.556-4 kg/s)            LP2- 660
2222201   2.1743755 2.1743755 0.      * (M = 247.56 kg/s)             LP2- 661
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 662
* lower core support structure                                        LP2- 663
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 664
2250000   "l core s"          branch                                  *LP2- 665
2250001   3         0                                                  *LP2- 666
2250101   0.2832456 0.5709989 0.0       0.0       90.0  0.5709989    *LP2- 667
2250102   3.81-6    0.095     00                                      *LP2- 668
2250200   0         1.53385+7 1226979.  2451724.  0.                  *LP2- 669
2251101   225010000 230000000 0.0       1.5       1.5       00100    *LP2- 670
2252101   225010000 231000000 0.0       1.5       1.5       00100    *LP2- 671
2253101   225010000 235000000 0.0       12.       12.       00100    *LP2- 672
2251201   1.7612839 1.7612839 0.      * (M = 197.33 kg/s)             LP2- 673
2252201   1.661684  1.661684  0.      * (M = 38.994 kg/s)             LP2- 674
2253201   0.706759  0.706759  0.      * (M = 11.235 kg/s)             LP2- 675
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 676
* active core : average channels  (75!)                               LP2- 677
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 678
2300000   "core avg"          pipe                                    *LP2- 679
2300001   5                                                            *LP2- 680
2300101   0.147510  1                                                  *LP2- 681
2300102   0.137871  2                                                  *LP2- 682
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2300103   0.139239  3                                                  *LP2- 683
2300104   0.138031  4                                                  *LP2- 684
2300105   0.140191  5                                                  *LP2- 685
2300201   0.142384  1                                                  *LP2- 686
2300202   0.120254  2                                                  *LP2- 687
2300203   0.142384  3                                                  *LP2- 688
2300204   0.120254  4                                                  *LP2- 689
2300301   0.432000  1                                                  *LP2- 690
2300302   0.195000  3                                                  *LP2- 691
2300303   0.280000  4                                                  *LP2- 692
2300304   0.5744204 5                                                  *LP2- 693
2300401   0.0       5                                                  *LP2- 694
2300501   0.0       5                                                  *LP2- 695
2300601   90.0      5                                                  *LP2- 696
2300801   1.27-7    0.0124    5                                        *LP2- 697
2300901   0.0       0.0       1                                        *LP2- 698
2300902   0.66      0.66      2                                        *LP2- 699
2300903   0.0       0.0       4                                        *LP2- 700
2301001   00        5                                                  *LP2- 701
2301101   0000      4                                                  *LP2- 702
2301201   0         1.53318+7 1273867.  2451886.  0.        0.    1   *LP2- 703
2301202   0         1.53287+7 1300012.  2451960.  0.        0.    2   *LP2- 704
2301203   0         1.53257+7 1328641.  2452032.  0.0010644 0.    3   *LP2- 705
2301204   0         1.53234+7 1365651.  2452078.  0.        0.    4   *LP2- 706
2301205   0         1.53196+7 1405308.  2452158.  0.        0.    5   *LP2- 707
2301300   0                                                            *LP2- 708
2301301   1.8661213 1.8661213 0.         1   * (M = 197.33 kg/s)       LP2- 709
2301302   2.2392406 2.4544048 0.         2   * (M = 197.33 kg/s)       LP2- 710
2301303   1.9214153 2.0573864 0.         3   * (M = 197.33 kg/s)       LP2- 711
2301304   2.321682  2.4601345 0.         4   * (M = 197.33 kg/s)       LP2- 712
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 713
* active core   hot channels (14 prozent)                               LP2- 714
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2- 715
2310000   "core hot"          pipe                                     *LP2- 716
2310001   13                                                           *LP2- 717
2310101   3.0897-2  1                                                  *LP2- 718
2310102   2.98875-2 2                                                  *LP2- 719
2310103   2.90272-2 8                                                  *LP2- 720
2310104   2.89101-2 12                                                 *LP2- 721
2310105   2.9881-2  13                                                 *LP2- 722
2310201   3.1031-2  3                                                  *LP2- 723
2310202   2.6208-2  4                                                  *LP2- 724
2310203   3.1031-2  9                                                  *LP2- 725
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2310204   2.6208-2  10                                                  *LP2- 726
2310205   3.1031-2  12                                                  *LP2- 727
2310301   0.1397017 1                                                   *LP2- 728
2310302   0.265     2                                                   *LP2- 729
2310303   0.08833   8                                                   *LP2- 730
2310304   0.1325    12                                                  *LP2- 731
2310305   0.2117387 13                                                  *LP2- 732
2310501   0.0       13                                                  *LP2- 733
2310601   90.0      13                                                  *LP2- 734
2310801   1.27-7    0.0124    13                                        *LP2- 735
2310901   0.0       0.0       3                                         *LP2- 736
2310902   0.66      0.66      4                                         *LP2- 737
2310903   0.0       0.0       9                                         *LP2- 738
2310904   0.66      0.66      10                                        *LP2- 739
2310905   0.0       0.0       12                                        *LP2- 740
2311001   00        13                                                  *LP2- 741
2311101   0000      12                                                  *LP2- 742
2311201   0         1.53335+7 1247369.  2451844.  0.        0.    1    *LP2- 743
2311202   0         1.53316+7 1290795.  2451890.  0.        0.    2    *LP2- 744
2311203   0         1.53299+7 1307016.  2451926.  0.0020526 0.    3    *LP2- 745
2311204   0         1.53291+7 1324140.  2451946.  0.003501  0.    4    *LP2- 746
2311205   0         1.53272+7 1341869.  2451982.  0.0060557 0.    5    *LP2- 747
2311206   0         1.53264+7 1359890.  2452004.  0.0109216 0.    6    *LP2- 748
2311207   0         1.53256+7 1377786.  2452022.  0.0177716 0.    7    *LP2- 749
2311208   0         1.53248+7 1395020.  2452036.  0.0260033 0.    8    *LP2- 750
2311209   0         1.53238+7 1418119.  2452058.  0.0393193 0.    9    *LP2- 751
2311210   0         1.53226+7 1437675.  2452076.  0.0492094 0.   10    *LP2- 752
2311211   0         1.53203+7 1453285.  2452106.  0.0578185 0.   11    *LP2- 753
2311212   0         1.53191+7 1465710.  2452132.  0.0571978 0.   12    *LP2- 754
2311213   0         1.53178+7 1479893.  2452164.  0.047818  0.   13    *LP2- 755
2311300   0                                                             *LP2- 756
2311301   1.6706018 1.8061981 0.         1   * (M = 38.994 kg/s)        LP2- 757
2311302   1.7080393 1.8510113 0.         2   * (M = 38.994 kg/s)        LP2- 758
2311303   1.7239475 1.8758583 0.         3   * (M = 38.994 kg/s)        LP2- 759
2311304   2.062048  2.3587456 0.         4   * (M = 38.994 kg/s)        LP2- 760
2311305   1.7623568 1.9251204 0.         5   * (M = 38.994 kg/s)        LP2- 761
2311306   1.7877073 1.9422255 0.         6   * (M = 38.994 kg/s)        LP2- 762
2311307   1.8165417 1.9692841 0.         7   * (M = 38.994 kg/s)        LP2- 763
2311308   1.8482618 2.0023212 0.         8   * (M = 38.994 kg/s)        LP2- 764
2311309   1.8967094 2.0517426 0.         9   * (M = 38.994 kg/s)        LP2- 765
2311310   2.2930279 2.5529308 0.        10   * (M = 38.994 kg/s)        LP2- 766
2311311   1.971818  2.1296444 0.        11   * (M = 38.994 kg/s)        LP2- 767
2311312   1.9859562 2.294836  0.        12   * (M = 38.994 kg/s)        LP2- 768
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 769
* core bypass volume  (7!)                                            LP2- 770
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 771
2350000   "core byp"          pipe                                   *LP2- 772
2350001   3                                                          *LP2- 773
2350101   2.0930-2  3                                                *LP2- 774
2350201   0.0       2                                                *LP2- 775
2350301   0.5588068 3                                                *LP2- 776
2350401   0.0       3                                                *LP2- 777
2350501   0.0       3                                                *LP2- 778
2350601   90.0      3                                                *LP2- 779
2350801   3.81-6    0.003     3                                      *LP2- 780
2350901   0.0       0.0       2                                      *LP2- 781
2351001   00        3                                                *LP2- 782
2351101   0000      2                                                *LP2- 783
2351201   0         1.53317+7 1226988.  2451888.  0.        0.    1  *LP2- 784
2351202   0         1.53263+7 1226996.  2452016.  0.        0.    2  *LP2- 785
2351203   0         1.53210+7 1227005.  2452146.  0.        0.    3  *LP2- 786
2351300   0                                                          *LP2- 787
2351301   0.7067657 0.7067657 0.         1   * (M = 11.235 kg/s)     LP2- 788
2351302   0.7067709 0.7067709 0.         2   * (M = 11.235 kg/s)     LP2- 789
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 790
* upper end boxes and support structure                               LP2- 791
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 792
2400000   "upr end"           branch                                 *LP2- 793
2400001   3         0                                                *LP2- 794
2400101   0.2423341 0.5867979 0.0       0.0       90.0  0.5867979   *LP2- 795
2400102   3.81-6    0.145     00                                     *LP2- 796
2400200   0         1.53134+7 1410433.  2452314.  0.0016037         *LP2- 797
2401101   230010000 240000000 0.0       1.5       1.5       00100   *LP2- 798
2402101   231010000 240000000 0.0       1.5       1.5       00100   *LP2- 799
2403101   235010000 240000000 0.0       12.       12.       00100   *LP2- 800
2401201   2.0379944 2.1104431 0.      * (M = 197.33 kg/s)            LP2- 801
2402201   2.0633316 2.7305183 0.      * (M = 38.994 kg/s)            LP2- 802
2403201   0.7067766 0.7620459 0.      * (M = 11.235 kg/s)            LP2- 803
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 804
* upper core support structure - cross flow region                    LP2- 805
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 806
2450000   "upr cr s"          branch                                 *LP2- 807
2450001   2         0                                                *LP2- 808
2450101   0.0       0.4933248 0.1280806 0.0       90.0  0.4933248   *LP2- 809
2450102   3.81-6    0.145     00                                     *LP2- 810
2450200   0         1.53098+7 1410683.  2452392.  0.                 *LP2- 811
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2451101   240010000 245000000 0.0       0.0       0.0       0000     *LP2- 812
2452101   245010000 251000000 0.0       0.0       0.0       0000     *LP2- 813
2451201   1.4857721 1.6411304 0.      * (M = 247.55 kg/s)             LP2- 814
2452201   0.        0.0901192 0.      * (M =-3.466-4 kg/s)            LP2- 815
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 816
* upper flow skirt region                                             LP2- 817
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 818
2500000   "u flw sk"          branch                                 *LP2- 819
2500001   1         0                                                 *LP2- 820
2500101   0.1547532 0.7850547 0.0       0.0       90.   0.7850547    *LP2- 821
2500102   3.81-6    0.131     00                                     *LP2- 822
2500200   0         1.53042+7 1410729.  2452526.  0.                 *LP2- 823
2501101   245010000 250000000 0.0       0.0       0.0       0000     *LP2- 824
2501201   2.3244343 2.4370956 0.      * (M = 247.55 kg/s)             LP2- 825
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 826
* dead end of fuel modules                                            LP2- 827
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 828
2510000   "de fl m"           snglvol                                *LP2- 829
2510101   0.0       0.7844123 0.1154214 0.0       90.0  0.7844123    *LP2- 830
2510102   3.81-6    0.214     00                                     *LP2- 831
2510200   0         1.53062+7 1391389.  2452502.  0.                 *LP2- 832
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 833
* upper head                                                          LP2- 834
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 835
2520000   "upr head"          branch                                 *LP2- 836
2520001   1         0                                                 *LP2- 837
2520101   0.2622585 0.2869580 0.0       0.0       90.0  0.2869580    *LP2- 838
2520102   3.81-6    0.0       00                                     *LP2- 839
2520200   0         1.53017+7 1410736.  2452600.  0.                 *LP2- 840
2521101   250010000 252000000 0.0       0.006     0.006     0000     *LP2- 841
2521201   2.3240528 2.3864136 0.      * (M = 247.55 kg/s)             LP2- 842
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 843
* upper plenum bottom volume                                          LP2- 844
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 845
2550000   "upr pl b"          branch                                 *LP2- 846
2550001   2         0                                                 *LP2- 847
2550101   0.2622585 0.6312304 0.0       0.0       90.0  0.6312304    *LP2- 848
2550102   3.81-6    0.0       00                                     *LP2- 849
2550200   0         1.53013+7 1387737.  2452618.  0.                 *LP2- 850
2551101   250010000 255000000 0.0       0.006     0.006     0000     *LP2- 851
2552101   255010000 260000000 0.0       0.03      0.03      0000     *LP2- 852
2551201   0.        0.0596712 0.      * (M =-2.917-4 kg/s)            LP2- 853
2552201   0.        0.0020278 0.      * (M =-1.428-4 kg/s)            LP2- 854
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 855
* upper plenum top volume                                             LP2- 856
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 857
2600000   "upr pl t"          snglvol                                *LP2- 858
2600101   0.0       0.7747094 0.1914909 0.0       90.0  0.7747094    *LP2- 859
2600102   3.81-6    0.0       00                                     *LP2- 860
2600200   0         1.52965+7 1391188.  2452734.  0.                 *LP2- 861
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 862
* inlet annulus upper volume broken side                              LP2- 863
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 864
2700000   "inanuprb"          annulus                                *LP2- 865
2700001   1                                                          *LP2- 866
2700101   0.1308530 1                                                *LP2- 867
2700301   0.1876129 1                                                *LP2- 868
2700401   0.0       1                                                *LP2- 869
2700501   0.0       1                                                *LP2- 870
2700601   90.0      1                                                *LP2- 871
2700801   3.81-6    0.172     1                                      *LP2- 872
2701001   00        1                                                *LP2- 873
2701201   0         1.53114+7 1226931.  2452374.  0.        0.    1  *LP2- 874
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 875
* junction - middle to upper inlet annulus broken side                LP2- 876
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 877
2710000   "inanmub"           sngljun                                *LP2- 878
2710101   272000000 270000000 0.129467  0.0000    0.0000    0100     *LP2- 879
2710201   0         -0.727157 -0.727157 0.      * (M =-72.267 kg/s)   LP2- 880
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 881
* inlet annulus middle volume broken side                             LP2- 882
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 883
2720000   "inanmidb"          annulus                                *LP2- 884
2720001   1                                                          *LP2- 885
2720101   0.1308530 1                                                *LP2- 886
2720301   0.2851823 1                                                *LP2- 887
2720401   0.0       1                                                *LP2- 888
2720501   0.0       1                                                *LP2- 889
2720601   -90.0     1                                                *LP2- 890
2720801   3.81-6    0.172     1                                      *LP2- 891
2721001   00        1                                                *LP2- 892
2721201   0         1.53130+7 1226938.  2452336.  0.        0.    1  *LP2- 893
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 894
* junction - middle to lower inlet annulus broken side                LP2- 895
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 896
2750000   "inanmlbk"          sngljun                                *LP2- 897
```

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2750101   272010000 280000000 0.0709408 0.0       0.0       0100     *LP2- 898
2750201   0         0.7271585 0.7271585 0.      * (M = 72.267 kg/s)   LP2- 899
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 900
* inlet annulus lower volume broken side                              LP2- 901
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 902
2800000   "brok dow"          annulus                                *LP2- 903
2800001   4                                                          *LP2- 904
2800101   0.1464354 1                                                *LP2- 905
2800102   0.0       4                                                *LP2- 906
2800201   0.0709408 3                                                *LP2- 907
2800301   0.2525361 1                                                *LP2- 908
2800302   1.5200561 2                                                *LP2- 909
2800303   1.2616333 3                                                *LP2- 910
2800304   1.0792591 4                                                *LP2- 911
2800401   0.0       1                                                *LP2- 912
2800402   0.1581866 2                                                *LP2- 913
2800403   0.1217000 3                                                *LP2- 914
2800404   0.0986806 4                                                *LP2- 915
2800501   0.0       4                                                *LP2- 916
2800601   -90.      4                                                *LP2- 917
2800801   3.81-6    0.172     4                                      *LP2- 918
2800901   0.0       0.0       3                                      *LP2- 919
2801001   00        04                                               *LP2- 920
2801101   0000      03                                               *LP2- 921
2801201   0         1.53144+7 1226943.  2452304.  0.        0.    1 *LP2- 922
2801202   0         1.53208+7 1226966.  2452150.  0.        0.    2 *LP2- 923
2801203   0         1.53311+7 1226985.  2451904.  0.        0.    3 *LP2- 924
2801204   0         1.53397+7 1226999.  2451696.  0.        0.    4 *LP2- 925
2801300   0                                                          *LP2- 926
2801301   1.3412704 1.3412704 0.         1   * (M = 72.267 kg/s)     LP2- 927
2801302   1.3412666 1.3412666 0.         2   * (M = 72.267 kg/s)     LP2- 928
2801303   1.3412552 1.3412552 0.         3   * (M = 72.267 kg/s)     LP2- 929
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 930
2850000   "lrdc2lpb"          sngljun                                *LP2- 931
2850101   280010000 222000000 0.0709408 0.0000    0.0000    0100     *LP2- 932
2850201   0         1.0406351 1.0406351 0.      * (M = 72.266 kg/s)   LP2- 933
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 934
2900000   "lwrinan"            sngljun                               *LP2- 935
2900101   200000000 270000000 0.0296780 1.8341    1.8341    0003     *LP2- 936
2900201   0         3.2060738 3.2060738 0.      * (M = 72.268 kg/s)   LP2- 937
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2- 938
*                                                                     LP2- 939
*                                                                     LP2- 940
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*$*$*$
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3150000   "sg+pmp s"          pipe                                  *LP2- 984
3150001   8                                                         *LP2- 985
3150101   0.0        8                                              *LP2- 986
3150201   8.3647-3   1                                              *LP2- 987
3150202   1.12-2     2                                              *LP2- 988
3150203   0.105626   3                                              *LP2- 989
3150204   1.12-2     4                                              *LP2- 990
3150205   8.3647-3   7                                              *LP2- 991
3150301   0.919969   1                                              *LP2- 992
3150302   1.987956   2                                              *LP2- 993
3150303   0.849744   4                                              *LP2- 994
3150304   1.987956   5                                              *LP2- 995
3150305   1.371350   6                                              *LP2- 996
3150306   1.365029   7                                              *LP2- 997
3150307   1.674812   8                                              *LP2- 998
3150401   7.75291-3  1                                              *LP2- 999
3150402   0.1721108  2                                              *LP2-1000
3150403   8.97552-2  4                                              *LP2-1001
3150404   0.1721108  5                                              *LP2-1002
3150405   1.82303-2  6                                              *LP2-1003
3150406   5.46687-2  7                                              *LP2-1004
3150407   1.82489-2  8                                              *LP2-1005
3150601   90.0       3                                              *LP2-1006
3150602   -90.0      7                                              *LP2-1007
3150603   90.0       8                                              *LP2-1008
3150701   0.679201   1                                              *LP2-1009
3150702   1.987956   2                                              *LP2-1010
3150703   0.457202   3                                              *LP2-1011
3150704   -0.457202  4                                              *LP2-1012
3150705   -1.987956  5                                              *LP2-1013
3150707   -1.371350  6                                              *LP2-1014
3150708   -0.520701  7                                              *LP2-1015
3150709   1.212851   8                                              *LP2-1016
3150801   4.0e-5     0.0        8                                  *LP2-1017
3150901   0.93596    0.93596    1                                  *LP2-1018
3150902   2.0        2.0        2                                  *LP2-1019
3150903   0.5        0.5        3                                  *LP2-1020
3150904   2.0        2.0        4                                  *LP2-1021
3150905   0.23025    0.23025    5                                  *LP2-1022
3150906   2.534      2.534      6                                  *LP2-1023
3150907   5.069      5.069      7                                  *LP2-1024
3151001   00         8                                              *LP2-1025
3151101   0000       7                                              *LP2-1026
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3151201   0         1.52994+7 1368077.  2452664.  0.        0.    1  *LP2-1027
3151202   0         1.52900+7 1333628.  2452890.  0.        0.    2  *LP2-1028
3151203   0         1.52814+7 1306323.  2453098.  0.        0.    3  *LP2-1029
3151204   0         1.52814+7 1288477.  2453098.  0.        0.    4  *LP2-1030
3151205   0         1.52903+7 1272854.  2452884.  0.        0.    5  *LP2-1031
3151206   0         1.53026+7 1255389.  2452588.  0.        0.    6  *LP2-1032
3151207   0         1.53095+7 1240304.  2452420.  0.        0.    7  *LP2-1033
3151208   0         1.53069+7 1227222.  2452482.  0.        0.    8  *LP2-1034
3151300   0                                                          *LP2-1035
3151301   0.        0.        0.         7   * (M =-3.560-4 kg/s)     LP2-1036
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1037
* hot leg break valve                                                 LP2-1038
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1039
3170000   "hl break"          valve                                  *LP2-1040
3170101   315010000 700000000 8.3647-3  1.10813   1.06560   0100     *LP2-1041
3170102   0.93      0.84                                              *LP2-1042
3170201   0         0.        0.         0.      * (M = 0.0000 kg/s)  LP2-1043
3170300   trpvlv                                                     *LP2-1044
3170301   510                                                        *LP2-1045
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1046
* reactor vessel nozzle - broken loop cold leg                        LP2-1047
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1048
3350000   "rvn blcl"          branch                                 *LP2-1049
3350001   2         0                                                 *LP2-1050
3350101   0.0       0.749305  0.047979  0.0       0.0       0.0      *LP2-1051
3350102   4.0e-5    0.0       00                                      *LP2-1052
3350200   0         1.53130+7 1227348.  2452336.  0.                 *LP2-1053
3351101   272000000 335000000 0.064130  1.455594  0.812933  0002     *LP2-1054
3352101   335010000 340000000 0.063426  0.1005    0.1005    0000     *LP2-1055
3351201   0.        0.        0.      * (M =-1.935-4 kg/s)            LP2-1056
3352201   0.        0.        0.      * (M =-1.687-4 kg/s)            LP2-1057
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1058
* cold leg pipe to reflood assist bypass tee                          LP2-1059
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1060
3400000   "clp-rabs"          branch                                 *LP2-1061
3400001   1         0                                                 *LP2-1062
3400101   0.0       0.698336  0.0443927 0.0       0.0       0.0      *LP2-1063
3400102   4.0e-5    0.0       00                                      *LP2-1064
3400200   0         1.53130+7 1227348.  2452336.  0.                 *LP2-1065
3401101   340010000 342000000 0.063426  0.1005    0.1005    0000     *LP2-1066
3401201   0.        0.        0.      * (M =-1.457-4 kg/s)            LP2-1067
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1068
* broken loop cold leg rabs to dtt                                    LP2-1069
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1070
3420000   "blcl 2dt"          branch                                 *LP2-1071
3420001   1         0                                                 *LP2-1072
3420101   0.0       0.5715069 0.0362484 0.0       0.0       0.0      *LP2-1073
3420102   4.0e-5    0.0       00                                      *LP2-1074
3420200   0         1.53130+7 1227338.  2452336.  0.                 *LP2-1075
3421101   342000000 370000000 0.0388    0.84      0.84      0000     *LP2-1076
3421201   0.        0.        0.      * (M =-1.109-4 kg/s)            LP2-1077
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1078
* broken loop cold leg dtt to break plane                             LP2-1079
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1080
3440000   "blcl 2br"          branch                                 *LP2-1081
3440001   1         0                                                 *LP2-1082
3440101   0.0       0.9286231 0.0310679 0.0       0.0       0.0      *LP2-1083
3440102   4.0e-5    0.0       00                                      *LP2-1084
3440200   0         1.53130+7 1227241.  2452336.  0.                 *LP2-1085
3441101   342010000 344000000 0.0540157 6.545     14.05     0000     *LP2-1086
3441201   0.        0.        0.      * (M =-1.607-5 kg/s)            LP2-1087
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1088
* cold leg break valve                                                LP2-1089
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1090
3470000   "cl break"         valve                                  *LP2-1091
3470101   344010000 705000000 8.3647-3  0.81969   0.96836   0100     *LP2-1092
3470102   0.93      0.84                                              *LP2-1093
3470201   0         0.        0.        0.      * (M = 0.0000 kg/s)   LP2-1094
3470300   trpvlv                                                      *LP2-1095
3470301   510                                                         *LP2-1096
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1097
* reflood assist bypass piping - cold leg side                        LP2-1098
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1099
3700000   "rabs c l"         pipe                                   *LP2-1100
3700001   3                                                           *LP2-1101
3700101   0.0388    2                                                 *LP2-1102
3700102   0.0776    3                                                 *LP2-1103
3700201   0.0388    2                                                 *LP2-1104
3700301   0.0       3                                                 *LP2-1105
3700401   0.0279    1                                                 *LP2-1106
3700402   0.070     2                                                 *LP2-1107
3700403   0.1165    3                                                 *LP2-1108
3700601   90.0      1                                                 *LP2-1109
3700602   0.0       3                                                 *LP2-1110
3700701   0.64      1                                                 *LP2-1111
3700702   0.0       3                                                 *LP2-1112
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3700801   4.0-5     0.0       3                                          *LP2-1113
3700901   0.28      0.28      1                                          *LP2-1114
3700902   0.84      0.84      2                                          *LP2-1115
3701001   00        3                                                    *LP2-1116
3701101   0000      2                                                    *LP2-1117
3701201   0         1.53106+7 1227348.  2452394.  0.        0.    1    *LP2-1118
3701202   0         1.53082+7 1227348.  2452452.  0.        0.    2    *LP2-1119
3701203   0         1.53082+7 1227348.  2452452.  0.        0.    3    *LP2-1120
3701300   0                                                            *LP2-1121
3701301   0.        0.        0.         2   * (M =-9.649-5 kg/s)      LP2-1122
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-1123
* reflood assist bypass valves                                          LP2-1124
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-1125
3750000   "rabs val"          valve                                    *LP2-1126
3750101   370010000 380000000 0.0       0.90+4    0.90+4    0000       *LP2-1127
3750201   0         0.        0.        0.      * (M = 0.0000 kg/s)    LP2-1128
3750300   trpvlv                                                       *LP2-1129
3750301   516                                                          *LP2-1130
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-1131
* reflood assist bypass piping - hot leg side                           LP2-1132
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-1133
3800000   "rabs h l"          pipe                                     *LP2-1134
3800001   3                                                            *LP2-1135
3800101   0.0776    1                                                  *LP2-1136
3800102   0.0388    3                                                  *LP2-1137
3800201   0.0388    2                                                  *LP2-1138
3800301   0.0       3                                                  *LP2-1139
3800401   0.0915    1                                                  *LP2-1140
3800402   0.048     2                                                  *LP2-1141
3800403   0.0489    3                                                  *LP2-1142
3800601   0.0       1                                                  *LP2-1143
3800602   -90.0     2                                                  *LP2-1144
3800603   0.0       3                                                  *LP2-1145
3800701   0.0       1                                                  *LP2-1146
3800702   -0.64     2                                                  *LP2-1147
3800703   0.0       3                                                  *LP2-1148
3800801   4.0-5     0.0       3                                        *LP2-1149
3800901   0.84      0.84      1                                        *LP2-1150
3800902   0.28      0.28      2                                        *LP2-1151
3801001   00        3                                                  *LP2-1152
3801101   0000      2                                                  *LP2-1153
3801201   0         1.52974+7 1410329.  2452712.  0.        0.    1    *LP2-1154
3801202   0         1.52996+7 1410329.  2452660.  0.        0.    2    *LP2-1155
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3801203   0         1.53017+7 1410329.  2452608.  0.        0.    3  *LP2-1156
3801300   0                                                          *LP2-1157
3801301   0.        0.        0.         2   * (M = 7.006-5 kg/s)     LP2-1158
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1159
*                                                                     LP2-1160
*                                                                     LP2-1161
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*     LP2-1162
*                                                                     LP2-1163
*   pressurizer  [ 400 ]                                              LP2-1164
*                                                                     LP2-1165
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*     LP2-1166
*                                                                     LP2-1167
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1168
* surge line pcs side                                                 LP2-1169
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1170
4000000   "srg ln p"        branch                                  *LP2-1171
4000001   2         0                                                 *LP2-1172
4000101   1.44561-3 2.30      0.0       0.0       90.0      0.54     *LP2-1173
4000102   2.3622-5  0.0       00                                      *LP2-1174
4000200   0         1.52834+7 1454066.  2453048.  0.                 *LP2-1175
4001101   107000000 400000000 1.44561-3 3.9       3.9       0002     *LP2-1176
4002101   400010000 405000000 1.44561-3 2.85      2.85      1000     *LP2-1177
4001201   -0.012242 -0.012187 0.      * (M =-0.0118 kg/s)              LP2-1178
4002201   -0.012243 -0.012243 0.      * (M =-0.0117 kg/s)              LP2-1179
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1180
* pressurizer surge line                                              LP2-1181
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1182
4050000   "srg ln p"        pipe                                    *LP2-1183
4050001   2                                                           *LP2-1184
4050101   1.44561-3 2                                                 *LP2-1185
4050201   1.44561-3 1                                                 *LP2-1186
4050301   2.30      2                                                 *LP2-1187
4050401   0.0       2                                                 *LP2-1188
4050601   90.0      2                                                 *LP2-1189
4050701   0.30      2                                                 *LP2-1190
4050801   2.3622-5  0.0       2                                       *LP2-1191
4050901   2.85      2.85      1                                       *LP2-1192
4051001   00        2                                                 *LP2-1193
4051101   1000      1                                                 *LP2-1194
4051201   0         1.52807+7 1470594.  2453114.  0.        0.    1  *LP2-1195
4051202   0         1.52787+7 1476693.  2453160.  0.        0.    2  *LP2-1196
4051300   0                                                           *LP2-1197
4051301   -0.01224  -0.01224  0.         1   * (M =-0.0117 kg/s)      LP2-1198
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1199
* pressurizer surge line                                              LP2-1200
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1201
4100000   "srg line"          sngljun                                *LP2-1202
4100101   405010000 415000000 1.44561-3 0.42      1.00      1000     *LP2-1203
4100201   0         -0.012236 -0.012236 0.      * (M =-0.0116 kg/s)   LP2-1204
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1205
* pressurizer vessel                                                  LP2-1206
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1207
4150000   "pzr vess"          pipe                                   *LP2-1208
4150001   6                                                           *LP2-1209
4150101   0.0       2                                                 *LP2-1210
4150102   0.5653    5                                                 *LP2-1211
4150103   0.0       6                                                 *LP2-1212
4150201   0.0       5                                                 *LP2-1213
4150301   0.1815    1                                                 *LP2-1214
4150302   0.1524    2                                                 *LP2-1215
4150303   0.3967    3                                                 *LP2-1216
4150304   0.5289    4                                                 *LP2-1217
4150305   0.3967    5                                                 *LP2-1218
4150306   0.1943    6                                                 *LP2-1219
4150401   0.0684    1                                                 *LP2-1220
4150402   0.0838    2                                                 *LP2-1221
4150403   0.0       5                                                 *LP2-1222
4150404   0.0732    6                                                 *LP2-1223
4150501   0.0       6                                                 *LP2-1224
4150601   90.0      6                                                 *LP2-1225
4150801   4.0e-5    0.0       6                                       *LP2-1226
4151001   00        6                                                 *LP2-1227
4151101   0000      5                                                 *LP2-1228
4151201   0         1.52772+7 1479974.  2453198.  0.        0.    1  *LP2-1229
4151202   0         1.52761+7 1517248.  2453224.  0.        0.    2  *LP2-1230
4151203   0         1.52744+7 1553270.  2453264.  0.        0.    3  *LP2-1231
4151204   0         1.52722+7 1584998.  2464230.  0.4156959 0.    4  *LP2-1232
4151205   0         1.52710+7 1596344.  2466824.  1.        0.    5  *LP2-1233
4151206   0         1.52707+7 1596333.  2472040.  1.        0.    6  *LP2-1234
4151300   0                                                           *LP2-1235
4151301   0.        0.        0.         2   * (M =-0.0109 kg/s)     LP2-1236
4151302   0.        0.8685241 0.         3   * (M =-0.0103 kg/s)     LP2-1237
4151303   -0.672544 0.        0.         4   * (M =-0.0012 kg/s)     LP2-1238
4151304   0.        0.        0.         5   * (M =-3.527-4 kg/s)    LP2-1239
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1240
* pressurizer vessel to top hat                                       LP2-1241
```

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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1242
4170000   "vssl-tph"          sngljun                                *LP2-1243
4170101   415010000 420000000 0.0       0.0       0.0       0000     *LP2-1244
4170201   0         0.        0.        0.      * (M =-8.968-5 kg/s)  LP2-1245
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1246
* pressurizer top hat and relief connection                            LP2-1247
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1248
4200000   "pzr toph"          pipe                                   *LP2-1249
4200001   2                                                          *LP2-1250
4200101   0.0       2                                                *LP2-1251
4200201   0.0       1                                                *LP2-1252
4200301   0.1104915 2                                                *LP2-1253
4200401   0.0139870 2                                                *LP2-1254
4200601   90.0      2                                                *LP2-1255
4200801   4.e-5     0.346066  2                                      *LP2-1256
4201001   00        2                                                *LP2-1257
4201101   0000      1                                                *LP2-1258
4201201   0         1.52706+7 1596328.  2486248.  1.        0.    1  *LP2-1259
4201202   0         1.52705+7 1596324.  2488128.  1.        0.    2  *LP2-1260
4201300   0                                                          *LP2-1261
4201301   0.        0.        0.         1   * (M =-4.567-5 kg/s)    LP2-1262
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1263
*                                                                     LP2-1264
*                                                                     LP2-1265
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-1266
*                                                                     LP2-1267
*   steam generator secondary side  [ 500 ]                           LP2-1268
*                                                                     LP2-1269
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-1270
*                                                                     LP2-1271
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1272
* primary separator                                                   LP2-1273
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1274
5000000   "separatr"          separatr                               *LP2-1275
5000001   3         0                                                *LP2-1276
5000101   0.0       0.4445    0.2425    0.0       90.0      0.4445   *LP2-1277
5000102   4.e-5     0.2840    00                                     *LP2-1278
5000200   0         5404120.  1172242.  2594424.  0.8999395          *LP2-1279
5001101   500010000 520000000 0.087745  0.0       0.0       0100     *LP2-1280
5002101   500000000 505000000 0.087745  0.0       0.0       0100     *LP2-1281
5003101   515010000 500000000 0.29187   0.4       0.4       0100     *LP2-1282
5001201   1.4813786 1.5054722 0.      * (M = 22.624 kg/s)             LP2-1283
5002201   0.3410316 0.3109779 0.      * (M = 97.089 kg/s)             LP2-1284
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5003201   2.6684513 3.3779411 0.      * (M = 119.69 kg/s)            LP2-1285
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1286
* separator bypass                                                   LP2-1287
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1288
5030000   "sepbypas"          branch                                *LP2-1289
5030001   2         0                                                *LP2-1290
5030101   0.0       0.4445    0.4384    0.0       90.0      0.4445   *LP2-1291
5030102   4.e-5     0.3678    00                                     *LP2-1292
5030200   0         5401448.  1170419.  2594416.  0.7823005          *LP2-1293
5031101   505000000 503000000 0.98627   0.0       0.0       0100     *LP2-1294
5032101   503010000 520000000 0.98627   0.8       0.0       0100     *LP2-1295
5031201   0.        0.362268  0.      * (M = 1.3335 kg/s)             LP2-1296
5032201   -3.233191 0.0685197 0.      * (M = 1.4555 kg/s)             LP2-1297
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1298
* separator outlet region                                            LP2-1299
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1300
5050000   "lwr sepr"          branch                                *LP2-1301
5050001   1         0                                                *LP2-1302
5050101   0.0       1.2131    1.4850    0.0       -90.0     -1.2131  *LP2-1303
5050102   4.e-5     1.9048    00                                     *LP2-1304
5050200   0         5405752.  1172323.  2594434.  0.1483094          *LP2-1305
5051101   505010000 508000000 0.0       0.0       0.0       0100     *LP2-1306
5051201   0.4016726 0.0678293 0.      * (M = 95.591 kg/s)             LP2-1307
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1308
* feed inlet volume                                                  LP2-1309
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1310
5080000   "upr dwnc"          branch                                *LP2-1311
5080001   1         0                                                *LP2-1312
5080101   0.0       0.6096    0.22107   0.0       -90.0     -0.6096  *LP2-1313
5080102   4.e-5     0.163697  00                                     *LP2-1314
5080200   0         5411968.  1113044.  2594394.  0.001081          *LP2-1315
5081101   508010000 510000000 0.0       0.0       0.0       0100     *LP2-1316
5081201   0.6533933 0.4960883 0.      * (M = 119.60 kg/s)             LP2-1317
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1318
* steam generator downcomer                                          LP2-1319
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1320
5100000   "dwncmr  "          annulus                               *LP2-1321
5100001   3                                                          *LP2-1322
5100101   0.232     3                                                *LP2-1323
5100201   0.0       2                                                *LP2-1324
5100301   0.6096    3                                                *LP2-1325
5100401   0.0       3                                                *LP2-1326
5100601   -90.0     3                                                *LP2-1327
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5100701   -0.6096   3                                                  *LP2-1328
5100801   4.e-5     0.10793   3                                        *LP2-1329
5100901   0.0       0.0       2                                        *LP2-1330
5101001   00        3                                                  *LP2-1331
5101101   0000      2                                                  *LP2-1332
5101201   0         5416568.  1113115.  2594358.  0.        0.    1  *LP2-1333
5101202   0         5421272.  1113138.  2594324.  0.        0.    2  *LP2-1334
5101203   0         5425976.  1113145.  2594290.  0.        0.    3  *LP2-1335
5101300   0                                                          *LP2-1336
5101301   0.6527472 0.5822005 0.         1   * (M = 119.60 kg/s)      LP2-1337
5101302   0.6527133 0.6326365 0.         2   * (M = 119.60 kg/s)      LP2-1338
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1339
* junction - downcomer to boiler                                       LP2-1340
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1341
5130000   "dncmr-bl"          sngljun                                 *LP2-1342
5130101   510010000 515000000 0.0       17.5      17.5      0100      *LP2-1343
5130201   0         0.6527085 0.9282889 0.      * (M = 119.60 kg/s)    LP2-1344
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1345
* steam generator boiler                                               LP2-1346
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1347
5150000   "boiler "           pipe                                    *LP2-1348
5150001   5                                                            *LP2-1349
5150101   0.2776    4                                                  *LP2-1350
5150102   0.306294  5                                                  *LP2-1351
5150201   0.0       4                                                  *LP2-1352
5150301   1.8288    4                                                  *LP2-1353
5150302   1.2131    5                                                  *LP2-1354
5150401   0.0       5                                                  *LP2-1355
5150601   60.0      4                                                  *LP2-1356
5150602   90.0      5                                                  *LP2-1357
5150701   0.6096    4                                                  *LP2-1358
5150702   1.2131    5                                                  *LP2-1359
5150801   4.e-5     0.0234    4                                        *LP2-1360
5150802   4.e-5     0.5962    5                                        *LP2-1361
5150901   4.05      4.05      4                                        *LP2-1362
5151001   00        5                                                  *LP2-1363
5151101   0100      4                                                  *LP2-1364
5151201   0         5423840.  1165477.  2594306.  0.4626362 0.    1  *LP2-1365
5151202   0         5419924.  1172424.  2594332.  0.6820841 0.    2  *LP2-1366
5151203   0         5415480.  1172881.  2594364.  0.7778749 0.    3  *LP2-1367
5151204   0         5410208.  1172598.  2594400.  0.8280373 0.    4  *LP2-1368
5151205   0         5405076.  1172299.  2594416.  0.8481822 0.    5  *LP2-1369
5151300   0                                                          *LP2-1370
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5151301   0.9967246 1.3567104 0.          1   * (M = 119.61 kg/s)      LP2-1371
5151302   1.5849476 2.2897224 0.          2   * (M = 119.64 kg/s)      LP2-1372
5151303   2.1229439 3.1752205 0.          3   * (M = 119.66 kg/s)      LP2-1373
5151304   2.5998421 3.8117561 0.          4   * (M = 119.68 kg/s)      LP2-1374
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1375
* lower portion of steam dome                                           LP2-1376
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1377
5200000   "lwr stm "          branch                                  *LP2-1378
5200001   1         0                                                  *LP2-1379
5200101   0.0       0.46956   0.705312  0.0       90.0      0.46956   *LP2-1380
5200102   4.e-5     1.383     00                                       *LP2-1381
5200200   0         5401000.  1172058.  2594344.  0.9999995           *LP2-1382
5201101   520010000 525000000 0.0       0.0       0.0       0000      *LP2-1383
5201201   0.4609571 0.5822439 0.      * (M = 24.079 kg/s)              LP2-1384
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1385
* upper portion of steam dome                                           LP2-1386
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1387
5250000   "upr stm "          branch                                  *LP2-1388
5250001   1         0                                                  *LP2-1389
5250101   0.0       0.46956   0.705312  0.0       90.0      0.46956   *LP2-1390
5250102   4.e-5     1.383     00                                       *LP2-1391
5250200   0         5400872.  1172051.  2594390.  0.9999971           *LP2-1392
5251101   525010000 530000000 0.0       0.8       0.8       0100      *LP2-1393
5251201   11.321671 18.869934 0.      * (M = 24.080 kg/s)              LP2-1394
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1395
* steam pipe from generator to control valve                            LP2-1396
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1397
5300000   "steam pi"          snglvol                                 *LP2-1398
5300101   0.04635   25.074    0.0       0.0       0.0       0.0       *LP2-1399
5300102   4.e-5     0.0       00                                       *LP2-1400
5300200   0         5386864.  1171229.  2594480.  0.9999866           *LP2-1401
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1402
* steam flow control valve                                              LP2-1403
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1404
5400000   "cv-p4-10"         valve                                   *LP2-1405
5400101   530010000 541000000 0.0047772 0.0       0.0       1100      *LP2-1406
5400201   0         15.548279 18.917633 0.      * (M = 24.080 kg/s)    LP2-1407
5400300   mtrvlv                                                      *LP2-1408
5400301   687       688       0.20      0.58774   540                 *LP2-1409
20254000  normarea                                                    *LP2-1410
20254001  0.0       0.0                                               *LP2-1411
20254002  9.25-4    9.25-4                                            *LP2-1412
20254003  1.0       1.0                                               *LP2-1413
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1414
* pipe downstream of steam control valve                              LP2-1415
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1416
5410000   "cond inl"          branch                                 *LP2-1417
5410001   1         0                                                 *LP2-1418
5410101   0.06557   54.44     0.0       0.0       0.0       0.0      *LP2-1419
5410102   4.e-5     0.0       00                                      *LP2-1420
5410200   0         2077408.  915023.   2598362.  0.9981079          *LP2-1421
5411101   541010000 542000000 0.0       0.0       0.0       0100     *LP2-1422
5411201   15.508499 32.88266  0.      * (M = 24.080 kg/s)             LP2-1423
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1424
* air cooled condenser                                                LP2-1425
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1426
5420000   "condens"           tmdpvol                                *LP2-1427
5420101   0.21677   17.67     0.0       0.0       0.0       0.0      *LP2-1428
5420102   4.e-5     0.02      00                                      *LP2-1429
5420200   2                                                           *LP2-1430
5420201   0.0       2.069+6   1.0                                     *LP2-1431
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1432
* simplified feed system                                              LP2-1433
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1434
* feed storage tank                                                   LP2-1435
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1436
5650000   "feed tnk"          tmdpvol                                *LP2-1437
5650101   29.81     3.048     0.0       0.0       0.0       0.0      *LP2-1438
5650102   4.e-5     0.0       00                                      *LP2-1439
5650200   3         0                                                 *LP2-1440
5650201   0.0       2.15323+6 477.6                                   *LP2-1441
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1442
* feed water                                                          LP2-1443
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1444
5660000   "feed"              tmdpjun                                *LP2-1445
5660101   565000000 508000000 0.05                                    *LP2-1446
5660200   1         511                                               *LP2-1447
5660201   -100.0    24.012    0.0       0.0       *lp-02-6           LP2-1448
5660202   0.0       24.012    0.0       0.0       *lp-02-6           LP2-1449
5660203   0.5       15.35     0.0       0.0       *lp-02-6           LP2-1450
5660204   1.0       3.88      0.0       0.0       *lp-02-6           LP2-1451
5660205   1.5       1.39      0.0       0.0       *lp-02-6           LP2-1452
5660206   2.0       0.424     0.0       0.0       *lp-02-6           LP2-1453
5660207   2.5       0.105     0.0       0.0       *lp-02-6           LP2-1454
5660208   3.0       0.0       0.0       0.0       *lp-02-6           LP2-1455
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1456
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*                                                                        LP2-1457
*                                                                        LP2-1458
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-1459
*                                                                        LP2-1460
*   ecc system  [ 600 ]                                                  LP2-1461
*                                                                        LP2-1462
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-1463
*                                                                        LP2-1464
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1465
* ecc check valve                                                        LP2-1466
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1467
6000000   "ecc chk"          valve                                      *LP2-1468
6000101   605010000 185000000 5.9896-3  0.935     0.935     1120        *LP2-1469
6000201   0         0.        0.        0.      * (M = 0.0000 kg/s)     LP2-1470
6000300   trpvlv                                                        *LP2-1471
6000301   681                                                            *LP2-1472
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1473
* eccs header to pcs                                                     LP2-1474
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1475
6050000   "eccs hdr"         snglvol                                    *LP2-1476
6050101   5.9896-3  5.0148    0.0       0.0  90.  3.3071202             *LP2-1477
6050102   4.0-5     0.0       00                                         *LP2-1478
6050200   0         4500000.  172410.   2599486.  0.                    *LP2-1479
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1480
* accumulator valve                                                      LP2-1481
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1482
6100000   "accum v"          valve                                      *LP2-1483
6100101   615010000 605000000 5.9896-3  6.278     6.278     1000        *LP2-1484
6100201   0         0.        0.        0.      * (M = 0.0000 kg/s)     LP2-1485
6100300   trpvlv                                                        *LP2-1486
6100301   682                                                            *LP2-1487
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1488
* accumulator pipe                                                       LP2-1489
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1490
6150000   "acc pipe"         snglvol                                    *LP2-1491
6150101   0.0       25.997165 0.4074774 0.0       0.0       0.0         *LP2-1492
6150102   4.0-5     0.0       00                                         *LP2-1493
6150200   0         4225000.  112409.   2600518.  0.                    *LP2-1494
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1495
* accumulator vessel                                                     LP2-1496
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1497
6200000   "accumul"         accum                                      *LP2-1498
6200101   1.2938    1.806     0.0       0.0       90.0      1.806       *LP2-1499
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6200102   4.0-5     0.0       00                                        *LP2-1500
6200200   4.11+6    302.00    0.0                                       *LP2-1501
6201101   615000000 8.2132-3  125.      125.      00000                 *LP2-1502
6202200   0.0       1.03795   3.3266    0.8       0.04445   1           *LP2-1503
+         0.0       0.0                                                 *LP2-1504
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1505
* bwst lpis                                                             LP2-1506
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1507
6250000   "bwst lps"        tmdpvol                                     *LP2-1508
6250101   20.44     5.0       0.0       0.0       90.0      5.0         *LP2-1509
6250102   4.0e-5    0.0       00                                        *LP2-1510
6250200   3                                                             *LP2-1511
6250201   0.0       1.0+5     300.0                                     *LP2-1512
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1513
* low pressure injection system                                         LP2-1514
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1515
6300000   "lpis"             tmdpjun                                     *LP2-1516
6300101   625000000 605000000 5.9896-3                                   *LP2-1517
6300200   1         513       p         605010000                       *LP2-1518
6300201   -1.0      0.0       0.0       0.0                             *LP2-1519
6300202   0.0       0.0       0.0       0.0                             *LP2-1520
6300203   8.483+4   7.045     0.0       0.0                             *LP2-1521
6300204   4.297+5   6.091     0.0       0.0                             *LP2-1522
6300205   7.745+5   5.045     0.0       0.0                             *LP2-1523
6300206   9.448+5   4.313     0.0       0.0                             *LP2-1524
6300207   1.119+6   3.454     0.0       0.0                             *LP2-1525
6300208   1.186+6   3.173     0.0       0.0                             *LP2-1526
6300209   1.257+6   2.673     0.0       0.0                             *LP2-1527
6300210   1.326+6   2.159     0.0       0.0                             *LP2-1528
6300211   1.395+6   1.536     0.0       0.0                             *LP2-1529
6300212   1.464+6   0.7182    0.0       0.0                             *LP2-1530
6300213   1.517+6   0.0       0.0       0.0                             *LP2-1531
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1532
* bwst hpis                                                             LP2-1533
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1534
6350000   "bwst hps"        tmdpvol                                     *LP2-1535
6350101   20.44     5.0       0.0       0.0       90.0      5.0         *LP2-1536
6350102   4.0-5     0.0       00                                        *LP2-1537
6350200   3                                                             *LP2-1538
6350201   0.0       1.0+5     305.0                                     *LP2-1539
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1540
* high pressure injection system                                        LP2-1541
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----         LP2-1542
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6400000   "hpis"              tmdpjun                                  *LP2-1543
6400101   635000000 185000000 5.9896-3                                 *LP2-1544
6400200   1         514       p         185010000                      *LP2-1545
6400201   -1.0      0.0       0.0       0.0                            *LP2-1546
6400202   0.0       1.035     0.0       0.0                            *LP2-1547
6400203   7.72514+6 1.035     0.0       0.0                            *LP2-1548
6400204   8.35970+6 .315      0.0       0.0                            *LP2-1549
6400205   1.72436+7 .315      0.0       0.0                            *LP2-1550
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1551
*                                                                      LP2-1552
*                                                                      LP2-1553
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-1554
*                                                                      LP2-1555
*   containment   [ 700 ]                                              LP2-1556
*                                                                      LP2-1557
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*  LP2-1558
*                                                                      LP2-1559
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1560
* containment broken loop hot leg                                      LP2-1561
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1562
7000000   "cont bhl"          tmdpvol                                  *LP2-1563
7000101   5.1956-2  0.0       104.68    0.0       0.0       0.0       *LP2-1564
7000102   0.0       0.0       00                                       *LP2-1565
7000200   2         511                                                *LP2-1566
7000201   -1.0      106681.   1.0  * containment-pressure lp-02-6     LP2-1567
7000202   0.0       106681.   1.0                                      *LP2-1568
7000203   0.25      118070.   1.0                                      *LP2-1569
7000204   0.75      197780.   1.0                                      *LP2-1570
7000205   2.25      188490.   1.0                                      *LP2-1571
7000206   5.25      205010.   1.0                                      *LP2-1572
7000207   20.       309910.   1.0                                      *LP2-1573
7000208   45.       259190.   1.0                                      *LP2-1574
7000209   70.       307540.   1.0                                      *LP2-1575
7000210   120.      314600.   1.0                                      *LP2-1576
7000211   1.+5      100000.   1.0                                      *LP2-1577
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1578
* containment broken loop cold leg                                     LP2-1579
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1580
7050000   "cont bcl"          tmdpvol                                  *LP2-1581
7050101   2.35203-2 0.0       104.703   0.0       0.0       0.0       *LP2-1582
7050102   0.0       0.0       00                                       *LP2-1583
7050200   2         511                                                *LP2-1584
7050201   -1.0      106681.   1.0  * containment-pressure lp-02-6     LP2-1585
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7050202   0.0       106681.   1.0                                    *LP2-1586
7050203   0.25      118070.   1.0                                    *LP2-1587
7050204   0.75      197780.   1.0                                    *LP2-1588
7050205   2.25      188490.   1.0                                    *LP2-1589
7050206   5.25      205010.   1.0                                    *LP2-1590
7050207   20.       309910.   1.0                                    *LP2-1591
7050208   45.       259190.   1.0                                    *LP2-1592
7050209   70.       307540.   1.0                                    *LP2-1593
7050210   120.      314600.   1.0                                    *LP2-1594
7050211   1.+5      100000.   1.0                                    *LP2-1595
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1596
*                                                                     LP2-1597
*                                                                     LP2-1598
*""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""    LP2-1599
*""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""    LP2-1600
*                                                                     LP2-1601
*            ----   heat structures  -------                         LP2-1602
*                                                                     LP2-1603
*""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""    LP2-1604
*""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""    LP2-1605
*                                                                     LP2-1606
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1607
*   steam generator heat structures                                   LP2-1608
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1609
11150000  8         8         2         0         0.0051054         *LP2-1610
11150100  0         1                                                 *LP2-1611
11150101  7         0.006348984                                       *LP2-1612
11150201  6         7                                                 *LP2-1613
11150301  0.0       7                                                 *LP2-1614
11150400  -1                                                          *LP2-1615
11150401  567.10 564.39 561.68 558.98 556.27 553.56 550.85 548.15     *LP2-1616
11150402  563.90 561.75 559.60 557.44 555.29 553.14 550.98 548.83     *LP2-1617
11150403  561.20 559.47 557.74 556.01 554.28 552.55 550.83 549.10     *LP2-1618
11150404  559.10 557.60 556.10 554.60 553.10 551.61 550.11 548.61     *LP2-1619
11150405  557.16 555.85 554.54 553.22 551.91 550.60 549.28 547.97     *LP2-1620
11150406  554.98 553.87 552.77 551.66 550.55 549.44 548.33 547.22     *LP2-1621
11150407  552.91 551.95 550.99 550.03 549.07 548.11 547.15 546.20     *LP2-1622
11150408  551.00 550.16 549.33 548.49 547.65 546.82 545.98 545.14     *LP2-1623
11150501  115010000 10000     1         1         1124.71   3        *LP2-1624
11150502  115040000 10000     1         1         849.063   5        *LP2-1625
11150503  115060000 10000     1         1         1124.71   8        *LP2-1626
11150601  515010000 10000     1         1         1124.71   3        *LP2-1627
11150602  515040000 0         1         1         849.063   4        *LP2-1628
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11150603  515040000 0         1         1         849.063   5         *LP2-1629
11150604  515030000 -10000    1         1         1124.71   8         *LP2-1630
11150701  0         0         0         0         8                   *LP2-1631
11150801  0         0         0         0         8                   *LP2-1632
11150901  0         0         0         0         8                   *LP2-1633
*                                                                      LP2-1634
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1635
* active core                                                          LP2-1636
*                                                                      LP2-1637
* peripheral fuel modules                                              LP2-1638
*---- ----1---- ----1---- ----1----                                    LP2-1639
12300000  5         10        2         0         0.0  2    1    32   *LP2-1640
12300001  7.869e+6  230050000                                          *LP2-1641
12300011  1.0e-6    2.0e-6    0.0       0.0       5                   *LP2-1642
12300100  0         1                                                  *LP2-1643
12300101  5         4.647-3                                            *LP2-1644
12300102  1         4.742-3                                            *LP2-1645
12300103  3         5.359-3                                            *LP2-1646
12300201  1         5                                                  *LP2-1647
12300202  -2        6                                                  *LP2-1648
12300203  -3        9                                                  *LP2-1649
12300301  1.00      5                                                  *LP2-1650
12300302  0.0       9                                                  *LP2-1651
12300400  -1                                                           *LP2-1652
12300401  1147.01 1124.54 1059.17 957.45 830.77 693.34 626.88 619.18 *LP2-1653
+         611.69 604.48                                                *LP2-1654
12300402  1310.59 1281.81 1198.11 1067.83 905.60 729.61 644.50 634.63 *P2-1655
+         625.05 615.81                                                *LP2-1656
12300403  1394.25 1362.15 1268.77 1123.46 942.49 746.17 651.23 640.23 *P2-1657
+         629.53 619.22                                                *LP2-1658
12300404  1185.14 1161.65 1093.33 987.00 854.59 710.94 641.47 633.42 *LP2-1659
+         625.60 618.05                                                *LP2-1660
12300405  781.08 773.68 752.13 718.60 676.84 631.55 609.64 607.10    *LP2-1661
+         604.63 602.25                                                *LP2-1662
12300501  0         0         0         1         466.992   1         *LP2-1663
12300502  0         0         0         1         210.795   3         *LP2-1664
12300503  0         0         0         1         356.730   4         *LP2-1665
12300504  0         0         0         1         1064.091  5         *LP2-1666
12300601  230010000 0         1         1         466.991   1         *LP2-1667
12300602  230020000 10000     1         1         210.795   3         *LP2-1668
12300603  230040000 0         1         1         356.730   4         *LP2-1669
12300604  230050000 0         1         1         1064.091  5         *LP2-1670
12300701  900       .20308197 0.0       0.0       1                   *LP2-1671
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12300702  900        .11333616 0.0       0.0       2                    *LP2-1672
12300703  900        .12500311 0.0       0.0       3                    *LP2-1673
12300704  900        .16034587 0.0       0.0       4                    *LP2-1674
12300705  900        .17183945 0.0       0.0       5                    *LP2-1675
12300901  0          0.013633  0.0       0.0       5                    *LP2-1676
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-1677
* center fuel module                                                    LP2-1678
*---- ----1---- ----1---- ----1----                                     LP2-1679
12310000  13         10        2         0         0.0  2    1  8      *LP2-1680
12310001  7.869e+6   231130000                                          *LP2-1681
12310011  1.0e-6     2.0e-6    0.0       0.0       13                   *LP2-1682
12310100  0          1                                                  *LP2-1683
12310101  5          4.647-3                                            *LP2-1684
12310102  1          4.742-3                                            *LP2-1685
12310103  3          5.359-3                                            *LP2-1686
12310201  1          5                                                  *LP2-1687
12310202  -2         6                                                  *LP2-1688
12310203  -3         9                                                  *LP2-1689
12310301  1.00       5                                                  *LP2-1690
12310302  0.0        9                                                  *LP2-1691
12310400  -1                                                            *LP2-1692
12310401  1355.56 1323.34 1228.12 1079.33 897.49 711.34 641.95 632.46 *P2-1693
+         623.12 614.22                                                 *LP2-1694
12310402  1483.20 1445.66 1334.71 1161.35 949.47 732.57 651.72 640.67 *P2-1695
+         629.78 619.42                                                 *LP2-1696
12310403  1627.48 1583.71 1454.36 1252.24 1005.21 752.33 658.07 645.1 *P2-1697
+         632.49 620.40                                                 *LP2-1698
12310404  1703.81 1656.76 1517.68 1300.36 1034.75 762.86 661.52 647.6 *P2-1699
+         634.01 621.02                                                 *LP2-1700
12310405  1761.50 1711.96 1565.53 1336.73 1057.08 770.83 664.12 649.5 *P2-1701
+         635.16 621.48                                                 *LP2-1702
12310406  1819.83 1767.77 1613.91 1373.49 1079.64 778.84 666.72 651.3 *P2-1703
+         636.29 621.91                                                 *LP2-1704
12310407  1839.48 1786.57 1630.22 1385.91 1087.30 781.64 667.70 652.1 *P2-1705
+         636.78 622.17                                                 *LP2-1706
12310408  1810.66 1759.01 1606.37 1367.86 1076.34 777.93 666.70 651.4 *P2-1707
+         636.51 622.25                                                 *LP2-1708
12310409  1682.56 1636.47 1500.26 1287.42 1027.29 761.00 661.73 648.1 *P2-1709
+         634.80 622.07                                                 *LP2-1710
12310410  1486.85 1449.25 1338.11 1164.45 952.20 734.93 653.94 642.86 *P2-1711
+         631.96 621.58                                                 *LP2-1712
12310411  1267.83 1239.71 1156.60 1026.74 868.01 705.54 644.97 636.69 *P2-1713
+         628.53 620.77                                                 *LP2-1714
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12310412  1096.11 1075.41 1014.25 918.68 801.88 682.31 637.74 631.64 *LP2-1715
+         625.64 619.93                                              *LP2-1716
12310413  911.85 899.10 861.45 802.61 730.69 657.07 629.63 625.88    *LP2-1717
+         622.19 618.67                                              *LP2-1718
12310501  0         0         0         1         30.5947   1        *LP2-1719
12310502  0         0         0         1         58.035052 2        *LP2-1720
12310503  0         0         0         1         19.344287 8        *LP2-1721
12310504  0         0         0         1         29.017526 12       *LP2-1722
12310505  0         0         0         1         46.370817 13       *LP2-1723
12310601  231010000 0         1         1         30.5947   1        *LP2-1724
12310602  231020000 0         1         1         58.035052 2        *LP2-1725
12310603  231030000 10000     1         1         19.344287 8        *LP2-1726
12310604  231090000 10000     1         1         29.017526 12       *LP2-1727
12310605  231130000 0         1         1         46.370817 13       *LP2-1728
12310701  900       1.74501-2 0.0       0.0       1                  *LP2-1729
12310702  900       3.7340-2  0.0       0.0       2                  *LP2-1730
12310703  900       1.4071-2  0.0       0.0       3                  *LP2-1731
12310704  900       1.4937-2  0.0       0.0       4                  *LP2-1732
12310705  900       1.5587-2  0.0       0.0       5                  *LP2-1733
12310706  900       1.6235-2  0.0       0.0       6                  *LP2-1734
12310707  900       1.6452-2  0.0       0.0       7                  *LP2-1735
12310708  900       1.6127-2  0.0       0.0       8                  *LP2-1736
12310709  900       2.2017-2  0.0       0.0       9                  *LP2-1737
12310710  900       1.8672-2  0.0       0.0       10                 *LP2-1738
12310711  900       1.4612-2  0.0       0.0       11                 *LP2-1739
12310712  900       1.1203-2  0.0       0.0       12                 *LP2-1740
12310713  900       1.1675-2  0.0       0.0       13                 *LP2-1741
12310901  0         0.013633  0.0       0.0       13                 *LP2-1742
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1743
*                                                                     LP2-1744
* wall heat structures (core)                                         LP2-1745
*                                                                     LP2-1746
* volume 200                                                          LP2-1747
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1748
12000000  1         5         2         0         0.508              *LP2-1749
12000100  0         1                                                 *LP2-1750
12000101  4         0.7264                                            *LP2-1751
12000201  4         4                                                 *LP2-1752
12000301  0.0       4                                                 *LP2-1753
12000400  -1                                                          *LP2-1754
12000401  555.98 555.99 556.01 556.03 556.05                          *LP2-1755
12000501  200010000 0         1         1         .093810   1        *LP2-1756
12000601  0         0         0         1         .09381    1        *LP2-1757
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12000701  0         0.0       0.0       0.0       1                 *LP2-1758
12000801  0         0.1524    0.0       0.0       1                 *LP2-1759
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1760
* volume 202                                                         LP2-1761
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1762
12020000  1         5         2         0         0.508             *LP2-1763
12020100  0         1                                                 *LP2-1764
12020101  4         0.7264                                            *LP2-1765
12020201  4         4                                                 *LP2-1766
12020301  0.0       4                                                 *LP2-1767
12020400  -1                                                          *LP2-1768
12020401  556.02 556.02 556.03 556.04 556.05                          *LP2-1769
12020501  202010000 0         1         1         .1426     1        *LP2-1770
12020601  0         0         0         1         .1426     1        *LP2-1771
12020701  0         0.0       0.0       0.0       1                 *LP2-1772
12020801  0         0.1524    0.0       0.0       1                 *LP2-1773
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1774
* volume 210                                                         LP2-1775
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1776
12100000  4         5         2         0         0.47              *LP2-1777
12100100  0         1                                                 *LP2-1778
12100101  4         0.7264                                            *LP2-1779
12100201  1         4                                                 *LP2-1780
12100301  0.0       4                                                 *LP2-1781
12100400  -1                                                          *LP2-1782
12100401  555.94 555.97 555.99 556.02 556.05                          *LP2-1783
12100402  555.94 555.97 555.99 556.02 556.05                          *LP2-1784
12100403  555.94 555.97 556.00 556.02 556.05                          *LP2-1785
12100404  555.95 555.97 556.00 556.03 556.05                          *LP2-1786
12100501  210010000 0         1         1         0.1267    1        *LP2-1787
12100502  210020000 0         1         1         0.7603    2        *LP2-1788
12100503  210030000 0         1         1         0.6308    3        *LP2-1789
12100504  210040000 0         1         1         0.5396    4        *LP2-1790
12100601  0         0         0         1         0.1267    1        *LP2-1791
12100602  0         0         0         1         0.7603    2        *LP2-1792
12100603  0         0         0         1         0.6308    3        *LP2-1793
12100604  0         0         0         1         0.5396    4        *LP2-1794
12100701  0         0.0       0.0       0.0       4                 *LP2-1795
12100801  0         0.1016    0.0       0.0       4                 *LP2-1796
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1797
* volume 220                                                         LP2-1798
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1799
12200000  1         5         2         0         0.47              *LP2-1800
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12200100  0         1                                                  *LP2-1801
12200101  4         0.7264                                             *LP2-1802
12200201  4         4                                                  *LP2-1803
12200301  0.0       4                                                  *LP2-1804
12200400  -1                                                           *LP2-1805
12200401  556.10 556.11 556.11 556.11 556.11                           *LP2-1806
12200501  220010000 0         1         1         0.479     1         *LP2-1807
12200601  0         0         0         1         0.479     1         *LP2-1808
12200701  0         0.0       0.0       0.0       1                   *LP2-1809
12200801  0         0.1016    0.0       0.0       1                   *LP2-1810
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1811
* volume 222                                                            LP2-1812
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1813
12220000  1         5         2         0         0.47                *LP2-1814
12220100  0         1                                                  *LP2-1815
12220101  4         0.7264                                             *LP2-1816
12220201  4         4                                                  *LP2-1817
12220301  0.0       4                                                  *LP2-1818
12220400  -1                                                           *LP2-1819
12220401  556.05 556.05 556.05 556.05 556.05                           *LP2-1820
12220501  222010000 0         1         1         0.36      1         *LP2-1821
12220601  0         0         0         1         0.36      1         *LP2-1822
12220701  0         0.0       0.0       0.0       1                   *LP2-1823
12220801  0         0.1016    0.0       0.0       1                   *LP2-1824
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1825
* core support structure (v225)                                         LP2-1826
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1827
12250000  1         5         2         0         0.282               *LP2-1828
12250100  0         1                                                  *LP2-1829
12250101  4         0.3                                                *LP2-1830
12250201  4         4                                                  *LP2-1831
12250301  0.0       4                                                  *LP2-1832
12250400  -1                                                           *LP2-1833
12250401  555.95 555.97 555.99 556.00 556.02                           *LP2-1834
12250501  225010000 0         1         1         0.4269792 1       *LP2-1835
12250601  0         0         0         1         0.4269792 1       *LP2-1836
12250701  0         0.0       0.0       0.0       1                   *LP2-1837
12250801  0         0.095     0.0       0.0       1                   *LP2-1838
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1839
* volume 270                                                            LP2-1840
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1841
12700000  1         5         2         0         0.508               *LP2-1842
12700100  0         1                                                  *LP2-1843
```

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12700101  4         0.7264                                          *LP2-1844
12700201  4         4                                               *LP2-1845
12700301  0.0       4                                               *LP2-1846
12700400  -1                                                        *LP2-1847
12700401  555.97 555.99 556.01 556.03 556.04                        *LP2-1848
12700501  270010000 0         1         1         0.09381   1      *LP2-1849
12700601  0         0         0         1         0.09381   1      *LP2-1850
12700701  0         0.0       0.0       0.0       1                *LP2-1851
12700801  0         0.1524    0.0       0.0       1                *LP2-1852
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2-1853
* volume 272                                                        LP2-1854
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2-1855
12720000  1         5         2         0         0.508            *LP2-1856
12720100  0         1                                               *LP2-1857
12720101  4         0.7264                                          *LP2-1858
12720201  4         4                                               *LP2-1859
12720301  0.0       4                                               *LP2-1860
12720400  -1                                                        *LP2-1861
12720401  555.97 555.99 556.01 556.03 556.04                        *LP2-1862
12720501  272010000 0         1         1         0.1426    1      *LP2-1863
12720601  0         0         0         1         0.1426    1      *LP2-1864
12720701  0         0.0       0.0       0.0       1                *LP2-1865
12720801  0         0.1524    0.0       0.0       1                *LP2-1866
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2-1867
* volume 280                                                        LP2-1868
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----    LP2-1869
12800000  4         5         2         0         0.47             *LP2-1870
12800100  0         1                                               *LP2-1871
12800101  4         0.7264                                          *LP2-1872
12800201  1         4                                               *LP2-1873
12800301  0.0       4                                               *LP2-1874
12800400  -1                                                        *LP2-1875
12800401  555.97 555.99 556.00 556.02 556.04                        *LP2-1876
12800402  555.96 555.98 556.00 556.02 556.04                        *LP2-1877
12800403  555.97 555.99 556.01 556.03 556.05                        *LP2-1878
12800404  555.97 555.99 556.01 556.03 556.05                        *LP2-1879
12800501  280010000 0         1         1         0.1267    1      *LP2-1880
12800502  280020000 0         1         1         0.7603    2      *LP2-1881
12800503  280030000 0         1         1         0.6308    3      *LP2-1882
12800504  280040000 0         1         1         0.5396    4      *LP2-1883
12800601  0         0         0         1         0.1267    1      *LP2-1884
12800602  0         0         0         1         0.7603    2      *LP2-1885
12800603  0         0         0         1         0.6308    3      *LP2-1886
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12800604  0         0         0         1         0.5396    4        *LP2-1887
12800701  0         0.0       0.0       0.0       4                  *LP2-1888
12800801  0         0.1016    0.0       0.0       4                  *LP2-1889
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1890
*                                                                     LP2-1891
*                                                                     LP2-1892
*                                                                     LP2-1893
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*     LP2-1894
*                                                                     LP2-1895
*   general table and heat structure thermal property data            LP2-1896
*                                                                     LP2-1897
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*     LP2-1898
*                                                                     LP2-1899
*                                                                     LP2-1900
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1901
*       900         reactor power vs time after scram                 LP2-1902
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1903
20290000  power     511       1.0       46.0+6                        *LP2-1904
20290001  -1.0      1.0        *  lp-lp-02 (trac post-test)           LP2-1905
20290002  0.0       1.0                                              *LP2-1906
20290003  0.1       0.913489                                         *LP2-1907
20290004  0.2       0.278195                                         *LP2-1908
20290005  0.3       0.155347                                         *LP2-1909
20290006  0.4       0.112396                                         *LP2-1910
20290007  0.5       0.092927                                         *LP2-1911
20290008  0.6       0.084394                                         *LP2-1912
20290009  0.8       0.074600                                         *LP2-1913
20290010  1.0       0.066306                                         *LP2-1914
20290011  1.5       0.064594                                         *LP2-1915
20290012  2.0       0.061312                                         *LP2-1916
20290013  3.0       0.058698                                         *LP2-1917
20290014  4.0       0.056596                                         *LP2-1918
20290015  6.0       0.053434                                         *LP2-1919
20290016  8.0       0.051091                                         *LP2-1920
20290017  10.0      0.049237                                         *LP2-1921
20290018  60.0      0.032621                                         *LP2-1922
20290019  200.      0.024929                                         *LP2-1923
*                                                                     LP2-1924
*                                                                     LP2-1925
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1926
*   heat structure thermal property data                              LP2-1927
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-1928
20100100  tbl/fctn  1         1         * uo2                         LP2-1929
```

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20100200  tbl/fctn  3         1         * gap                          LP2-1930
20100300  tbl/fctn  1         1         * zr                           LP2-1931
20100400  tbl/fctn  1         1         * s-steel                      LP2-1932
20100500  c-steel                                                      *LP2-1933
20100600  tbl/fctn  1         1         * inconel 600                  LP2-1934
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1935
* uo2 - thermal conductivity                                            LP2-1936
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1937
20100101  2.7315e2  8.44                                               *LP2-1938
20100102  4.1667e2  6.46                                               *LP2-1939
20100103  5.3315e2  5.782385                                           *LP2-1940
20100104  6.99817e2 4.633177                                           *LP2-1941
20100105  8.66483e2 3.880307                                           *LP2-1942
20100106  1.03315e3 3.357625                                           *LP2-1943
20100107  1.08871e3 3.155129                                           *LP2-1944
20100108  1.19982e3 2.983787                                           *LP2-1945
20100109  1.28315e3 2.836674                                           *LP2-1946
20100110  1.36648e3 2.713792                                           *LP2-1947
20100111  1.53315e3 2.521680                                           *LP2-1948
20100112  1.61648e3 2.448990                                           *LP2-1949
20100113  1.69982e3 2.391875                                           *LP2-1950
20100114  1.97759e3 2.289762                                           *LP2-1951
20100115  2.25537e3 2.307069                                           *LP2-1952
20100116  2.53315e3 2.433413                                           *LP2-1953
20100117  2.81093e3 2.661870                                           *LP2-1954
20100118  3.08871e3 2.994171                                           *LP2-1955
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1956
* uo2 - volumetric heat capacity                                        LP2-1957
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-1958
20100151  2.73150e2 2.310427e6                                         *LP2-1959
20100152  3.23150e2 2.571985e6                                         *LP2-1960
20100153  3.73150e2 2.746357e6                                         *LP2-1961
20100154  6.7315e2  3.138694e6                                         *LP2-1962
20100155  1.37315e3 3.443844e6                                         *LP2-1963
20100156  1.77315e3 3.531030e6                                         *LP2-1964
20100157  1.97315e3 3.792588e6                                         *LP2-1965
20100158  2.17315e3 4.228518e6                                         *LP2-1966
20100159  2.37315e3 4.882412e6                                         *LP2-1967
20100160  2.67315e3 6.015829e6                                         *LP2-1968
20100161  2.77315e3 6.320980e6                                         *LP2-1969
20100162  2.87315e3 6.582538e6                                         *LP2-1970
20100163  2.97315e3 6.713317e6                                         *LP2-1971
20100164  3.11315e3 6.800503e6                                         *LP2-1972
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20100165  4.69982e3 6.800503e6                                          *LP2-1973
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1974
* helium(gap) - thermal conductivity                                     LP2-1975
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1976
20100201  helium    1.00                                                *LP2-1977
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1978
* helium(gap) - volumetric heat capacity                                 LP2-1979
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1980
20100251  273.15    5.4                                                 *LP2-1981
20100252  5000.0    5.4                                                 *LP2-1982
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1983
* zircaloy-4 - thermal conductivity          from matpro                 LP2-1984
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-1985
20100301  380.4     13.6                                                *LP2-1986
20100302  469.3     14.6                                                *LP2-1987
20100303  577.6     15.8                                                *LP2-1988
20100304  685.9     17.3                                                *LP2-1989
20100305  774.8     18.4                                                *LP2-1990
20100306  872.0     19.8                                                *LP2-1991
20100307  973.2     21.8                                                *LP2-1992
20100308  1073.2    23.2                                                *LP2-1993
20100309  1123.2    25.4                                                *LP2-1994
20100310  1152.3    24.2                                                *LP2-1995
20100311  1232.2    25.5                                                *LP2-1996
20100312  1331.2    26.6                                                *LP2-1997
20100313  1404.2    28.2                                                *LP2-1998
20100314  1576.2    33.0                                                *LP2-1999
20100315  1625.2    36.7                                                *LP2-2000
20100316  1755.2    41.2                                                *LP2-2001
20100317  2273.2    55.0                                                *LP2-2002
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2003
* zircaloy-4 - volumetric heat capacity      from matpro                 LP2-2004
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2005
20100351  300.0     1.841e6                                             *LP2-2006
20100352  400.0     1.978e6                                             *LP2-2007
20100353  640.0     2.168e6                                             *LP2-2008
20100354  1090.0    2.456e6                                             *LP2-2009
20100355  1093.0    3.288e6                                             *LP2-2010
20100356  1113.0    3.865e6                                             *LP2-2011
20100357  1133.0    4.028e6                                             *LP2-2012
20100358  1153.0    4.709e6                                             *LP2-2013
20100359  1173.0    5.345e6                                             *LP2-2014
20100360  1193.0    5.044e6                                             *LP2-2015
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20100361  1213.0    4.054e6                                          *LP2-2016
20100362  1233.0    3.072e6                                          *LP2-2017
20100363  1243.0    2.332e6                                          *LP2-2018
20100364  1477.0    2.332e6                                          *LP2-2019
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2020
* s-steel - thermal conductivity                                     LP2-2021
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2022
20100401  273.15    12.98                                            *LP2-2023
20100402  1199.82   25.1                                             *LP2-2024
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2025
* s-steel - volumetric heat capacity                                 LP2-2026
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2027
20100451  273.15    3.83e6                                           *LP2-2028
20100452  366.5     3.83e6                                           *LP2-2029
20100453  477.59    4.190e6                                          *LP2-2030
20100454  588.59    4.336e6                                          *LP2-2031
20100455  699.82    4.504e6                                          *LP2-2032
20100456  810.93    4.639e6                                          *LP2-2033
20100457  922.04    4.773e6                                          *LP2-2034
20100458  1144.26   5.076e6                                          *LP2-2035
20100459  1366.5    5.376e6                                          *LP2-2036
20100460  1477.59   5.546e6                                          *LP2-2037
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2038
* inconel-600 - thermal conductivity                                 LP2-2039
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2040
20100601  366.5     13.85                                            *LP2-2041
20100602  477.6     15.92                                            *LP2-2042
20100603  588.7     18.17                                            *LP2-2043
20100604  700.0     20.42                                            *LP2-2044
20100605  810.9     22.50                                            *LP2-2045
20100606  922.0     24.92                                            *LP2-2046
20100607  1033.2    26.83                                            *LP2-2047
20100608  1144.3    29.42                                            *LP2-2048
20100609  1477.6    36.06                                            *LP2-2049
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2050
* inconel-600 - volumetric heat capacity                             LP2-2051
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2052
20100651  366.5     3.908+6                                          *LP2-2053
20100652  477.6     4.084+6                                          *LP2-2054
20100653  588.7     4.260+6                                          *LP2-2055
20100654  700.0     4.436+6                                          *LP2-2056
20100656  810.9     4.665+6                                          *LP2-2057
20100657  922.0     4.929+6                                          *LP2-2058
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20100658  1033.2    5.105+6                                          *LP2-2059
20100659  1477.6    5.727+6                                          *LP2-2060
*                                                                     LP2-2061
*                                                                     LP2-2062
*""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""    LP2-2063
*""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""    LP2-2064
*                                                                     LP2-2065
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*    LP2-2066
*                                                                     LP2-2067
*         control variables                                           LP2-2068
*                                                                     LP2-2069
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*    LP2-2070
*                                                                     LP2-2071
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2072
*                                                                     LP2-2073
*  001-008 and 230-235  level calculators                             LP2-2074
*                                                                     LP2-2075
* 001 steam generator level                                           LP2-2076
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2077
20500100  sglvl               sum       1.        3.5676594 0        *LP2-2078
20500101  0.0       0.4445    voidf     503010000                    *LP2-2079
20500102            1.2131    voidf     505010000                    *LP2-2080
20500103            0.6096    voidf     508010000                    *LP2-2081
20500104            0.6096    voidf     510010000                    *LP2-2082
20500105            0.6096    voidf     510020000                    *LP2-2083
20500106            0.6096    voidf     510030000                    *LP2-2084
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2085
* 002 pressurizer level                                               LP2-2086
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2087
20500200  pzrlvl              sum       1.        1.0396376 0        *LP2-2088
20500201  0.0       0.1815    voidf     415010000                    *LP2-2089
20500202            0.1524    voidf     415020000                    *LP2-2090
20500203            0.3967    voidf     415030000                    *LP2-2091
20500204            0.5289    voidf     415040000                    *LP2-2092
20500205            0.3967    voidf     415050000                    *LP2-2093
20500206            0.1943    voidf     415060000                    *LP2-2094
20500207            0.1029    voidf     420010000                    *LP2-2095
20500208            0.1029    voidf     420020000                    *LP2-2096
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2097
* 004 accumulator level                                               LP2-2098
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2099
20500400  accmlvl             integral  -0.006348 1.0379496 0        *LP2-2100
20500401  velfj     620010000                                         *LP2-2101
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2102
* 007 reactor vessel downcomer level intact side                      LP2-2103
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2104
20500700  rvdclvn             sum       1.        5.3137665 0       *LP2-2105
20500701  0.0       0.1876129 voidf     200010000                   *LP2-2106
20500702            0.2851823 voidf     202010000                   *LP2-2107
20500703            0.2525361 voidf     210010000                   *LP2-2108
20500704            1.5200561 voidf     210020000                   *LP2-2109
20500705            1.2616333 voidf     210030000                   *LP2-2110
20500706            1.0792591 voidf     210040000                   *LP2-2111
20500707            0.3533183 voidf     222010000                   *LP2-2112
20500708            0.3741720 voidf     220010000                   *LP2-2113
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2114
* 008 reactor vessel downcomer level broken side                      LP2-2115
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2116
20500800  rvdclbk             sum       1.        5.3137665 0       *LP2-2117
20500801  0.0       0.1876129 voidf     270010000                   *LP2-2118
20500802            0.2851823 voidf     272010000                   *LP2-2119
20500803            0.2525361 voidf     280010000                   *LP2-2120
20500804            1.5200561 voidf     280020000                   *LP2-2121
20500805            1.2616333 voidf     280030000                   *LP2-2122
20500806            1.0792591 voidf     280040000                   *LP2-2123
20500807            0.3533183 voidf     222010000                   *LP2-2124
20500808            0.3741720 voidf     220010000                   *LP2-2125
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2126
* 230 level average channel                                           LP2-2127
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2128
20523000  "lvl avg"           sum       1.        1.6842699 0       *LP2-2129
20523001  0.0       .432      voidf     230010000                   *LP2-2130
20523002            .195      voidf     230020000                   *LP2-2131
20523003            .195      voidf     230030000                   *LP2-2132
20523004            .28833    voidf     230040000                   *LP2-2133
20523005            .5744204  voidf     230050000                   *LP2-2134
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2135
* 231 level hot channel                                               LP2-2136
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2137
20523100  "lvl hot"           sum       1.        1.6332083 0       *LP2-2138
20523101  0.0       .1397017  voidf     231010000                   *LP2-2139
20523102            .265      voidf     231020000                   *LP2-2140
20523103            .08833    voidf     231030000                   *LP2-2141
20523104            .08833    voidf     231040000                   *LP2-2142
20523105            .08833    voidf     231050000                   *LP2-2143
20523106            .08833    voidf     231060000                   *LP2-2144
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20523107            .08833    voidf     231070000                    *LP2-2145
20523108            .08833    voidf     231080000                    *LP2-2146
20523109            .1325     voidf     231090000                    *LP2-2147
20523110            .1325     voidf     231100000                    *LP2-2148
20523111            .1325     voidf     231110000                    *LP2-2149
20523112            .1325     voidf     231120000                    *LP2-2150
20523113            .2117387  voidf     231130000                    *LP2-2151
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2152
* 235 level bypass channel                                            LP2-2153
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2154
20523500  "lvl byps"          sum       0.5588068 1.6764202 0        *LP2-2155
20523501  0.0       1.0       voidf     235010000                    *LP2-2156
20523502            1.0       voidf     235020000                    *LP2-2157
20523503            1.0       voidf     235030000                    *LP2-2158
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2159
* 240  average voidfraction coreliquid void fraction                  LP2-2160
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2161
20524000  "void avg"          sum       2.9926155 0.9995193 0        *LP2-2162
20524001  0.0       .14751    cntrlvar  230                          *LP2-2163
20524002            3.0897-2  cntrlvar  231                          *LP2-2164
20524003            2.093-2   cntrlvar  235                          *LP2-2165
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2166
* 250 reactor vessel level                                            LP2-2167
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2168
20525000  rvlvl               sum       1.        6.5309792 0        *LP2-2169
20525001  0.0       0.7747094 voidf     260010000                    *LP2-2170
20525002            0.6312304 voidf     255010000                    *LP2-2171
20525003            0.286958  voidf     252010000                    *LP2-2172
20525004            0.7850547 voidf     250010000                    *LP2-2173
20525005            0.4933248 voidf     245010000                    *LP2-2174
20525006            0.5867979 voidf     240010000                    *LP2-2175
20525007            0.74      cntrlvar  230                          *LP2-2176
20525008            0.155     cntrlvar  231                          *LP2-2177
20525009            0.105     cntrlvar  235                          *LP2-2178
20525010            0.5709989 voidf     225010000                    *LP2-2179
20525011            0.3533183 voidf     222010000                    *LP2-2180
20525012            0.3741720 voidf     220010000                    *LP2-2181
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2182
*                                                                     LP2-2183
* 075-076  mass loss calculator                                       LP2-2184
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2185
20507500  losssum             sum       1.        0.        0        *LP2-2186
20507501  0.0       1.0       mflowj    317000000                    *LP2-2187
```

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20507502            1.0       mflowj    347000000                    *LP2-2188
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2189
20507600  lossmas             integral  1.        0.        0       *LP2-2190
20507601  cntrlvar  75                                               *LP2-2191
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2192
*                                                                     LP2-2193
*                                                                     LP2-2194
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2195
* 080-081  average values of pumps                                    LP2-2196
*                                                                     LP2-2197
* 080  average pump speed                                             LP2-2198
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2199
20508000  avgpmps             sum       1.        169.95996 0       *LP2-2200
20508001  0.0       0.5       pmpvel    135                         *LP2-2201
20508002            0.5       pmpvel    165                         *LP2-2202
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2203
* 081  average pump head                                              LP2-2204
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2205
20508100  avgpmph             sum       1.        134888.12 0       *LP2-2206
20508101  0.0       0.5       pmphead   135                         *LP2-2207
20508102            0.5       pmphead   165                         *LP2-2208
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2209
*                                                                     LP2-2210
* 090-098  power to fluid calculation                                 LP2-2211
*                                                                     LP2-2212
* 090 power average channel                                           LP2-2213
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2214
20509000  "power a"           sum       1.        3.55872+7 0       *LP2-2215
20509001  0.0       1.0       q         230010000                   *LP2-2216
20509002            1.0       q         230020000                   *LP2-2217
20509003            1.0       q         230030000                   *LP2-2218
20509004            1.0       q         230040000                   *LP2-2219
20509005            1.0       q         230050000                   *LP2-2220
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2221
* 091  power hot channel                                              LP2-2222
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2223
20509100  "power h"           sum       1.        1.04137+7 0       *LP2-2224
20509101  0.0       1.0       q         231010000                   *LP2-2225
20509102            1.0       q         231020000                   *LP2-2226
20509103            1.0       q         231030000                   *LP2-2227
20509104            1.0       q         231040000                   *LP2-2228
20509105            1.0       q         231050000                   *LP2-2229
20509106            1.0       q         231060000                   *LP2-2230
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20509107            1.0       q         231070000                    *LP2-2231
20509108            1.0       q         231080000                    *LP2-2232
20509109            1.0       q         231090000                    *LP2-2233
20509110            1.0       q         231100000                    *LP2-2234
20509111            1.0       q         231110000                    *LP2-2235
20509112            1.0       q         231120000                    *LP2-2236
20509113            1.0       q         231130000                    *LP2-2237
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2238
* 092  total power                                                   LP2-2239
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2240
20509200  power               sum       1.        4.60009+7 0       *LP2-2241
20509201  0.0       1.0       cntrlvar  90                          *LP2-2242
20509202            1.0       cntrlvar  91                          *LP2-2243
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2244
* 093  heat sink  (steam generator)                                  LP2-2245
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2246
20509300  "heat sk"           sum       -1.       4.60636+7 0       *LP2-2247
20509301  0.0       1.0       q         115010000                    *LP2-2248
20509302            1.0       q         115020000                    *LP2-2249
20509303            1.0       q         115030000                    *LP2-2250
20509304            1.0       q         115040000                    *LP2-2251
20509305            1.0       q         115050000                    *LP2-2252
20509306            1.0       q         115060000                    *LP2-2253
20509307            1.0       q         115070000                    *LP2-2254
20509308            1.0       q         115080000                    *LP2-2255
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2256
*                                                                    LP2-2257
* 095 - 098 power of structure heat capacity                         LP2-2258
*                                                                    LP2-2259
* 095 structures downcomer intact loop                               LP2-2260
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2261
20509500  "hc intl"           sum       1.        1511.0059 0       *LP2-2262
20509501  0.0       1.0       q         200010000                    *LP2-2263
20509502            1.0       q         202010000                    *LP2-2264
20509503            1.0       q         210010000                    *LP2-2265
20509504            1.0       q         210020000                    *LP2-2266
20509505            1.0       q         210030000                    *LP2-2267
20509506            1.0       q         210040000                    *LP2-2268
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2269
*  096 structures downcommer broken loop                             LP2-2270
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2271
20509600  "hc brkl"           sum       1.        1591.3711 0       *LP2-2272
20509601  0.0       1.0       q         270010000                    *LP2-2273
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20509602            1.0       q         272010000                    *LP2-2274
20509603            1.0       q         280010000                    *LP2-2275
20509604            1.0       q         280020000                    *LP2-2276
20509605            1.0       q         280030000                    *LP2-2277
20509606            1.0       q         280040000                    *LP2-2278
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2279
*  097 structures core barrel                                         LP2-2280
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2281
20509700  "hc core"           sum       1.        150.18909 0        *LP2-2282
20509701  0.0       1.0       q         220010000                    *LP2-2283
20509702            1.0       q         222010000                    *LP2-2284
20509703            1.0       q         225010000                    *LP2-2285
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2286
*  098 structures total                                               LP2-2287
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2288
20509800  heatcap             sum       1.        3252.5664 0        *LP2-2289
20509801  0.0       1.0       cntrlvar  95                           *LP2-2290
20509802            1.0       cntrlvar  96                           *LP2-2291
20509803            1.0       cntrlvar  97                           *LP2-2292
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2293
*                                                                    LP2-2294
*  510 - 520  trip-sets                                              LP2-2295
*                                                                    LP2-2296
*  510 blow-down valves                                              LP2-2297
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2298
20551000  blowdown            tripunit  1.        0.        0        *LP2-2299
20551001  510                                                        *LP2-2300
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2301
*  511 power scram                                                   LP2-2302
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2303
20551100  powerscr            tripunit  1.        0.        0        *LP2-2304
20551101  511                                                        *LP2-2305
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2306
*  512 pump trip                                                     LP2-2307
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2308
20551200  pumptrip            tripunit  1.        0.        0        *LP2-2309
20551201  512                                                        *LP2-2310
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2311
*  523 lpis trip                                                     LP2-2312
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2313
20552300  lpistrip            tripunit  1.        0.        0        *LP2-2314
20552301  513                                                        *LP2-2315
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2316
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*  524 hpis trip                                                        LP2-2317
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2318
20552400  hpistrip            tripunit  1.        0.        0          *LP2-2319
20552401  514                                                           *LP2-2320
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2321
*  525 accumulator valve                                                LP2-2322
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2323
20552500  accumulv            tripunit  1.        0.        0          *LP2-2324
20552501  682                                                           *LP2-2325
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2326
*  514 eccs                                                             LP2-2327
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2328
20551400  eccs                sum       1.        0.        0          *LP2-2329
20551401  0.0       .35       cntrlvar  523                             *LP2-2330
20551402            .25       cntrlvar  524                             *LP2-2331
20551403            .40       cntrlvar  525                             *LP2-2332
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2333
*  516 steam valve                                                      LP2-2334
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2335
20552600  steamvop            tripunit  1.        0.        0          *LP2-2336
20552601  685                                                           *LP2-2337
20552700  steamvcl            tripunit  -1.       0.        0          *LP2-2338
20552701  686                                                           *LP2-2339
20551600  steamvlv            sum       1.        0.        0          *LP2-2340
20551601  0.0       1.0       cntrlvar  526                             *LP2-2341
20551602            1.0       cntrlvar  527                             *LP2-2342
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2343
*                                                                       LP2-2344
* 400-454  calculation of fluid-momentum flux                           LP2-2345
*                                                                       LP2-2346
* 404 momentum flux of junction 34001                                   LP2-2347
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----        LP2-2348
20540000  "abs vf"            stdfnctn  1.        3.02597-6 0          *LP2-2349
20540001            abs       velfj     340010000                       *LP2-2350
20540100  "abs vg"            stdfnctn  1.        3.02597-6 0          *LP2-2351
20540101            abs       velgj     340010000                       *LP2-2352
*                                                                       LP2-2353
20540200  "momflux1"          mult      1.        -6.9531-9 0          *LP2-2354
20540201  voidfj    340010000 rhofj     340010000                       *LP2-2355
20540202  velfj     340010000 cntrlvar  400                             *LP2-2356
20540300  "momflux2"          mult      1.        0.        0          *LP2-2357
20540301  voidgj    340010000 rhogj     340010000                       *LP2-2358
20540302  velgj     340010000 cntrlvar  401                             *LP2-2359
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*                                                                       LP2-2360
20540400  "mf3401"            sum       1.        -6.9531-9 0          *LP2-2361
20540401          0.0         1.0       cntrlvar  402                  *LP2-2362
20540402                      1.0       cntrlvar  403                  *LP2-2363
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2364
*                                                                       LP2-2365
* 414 momentum flux of junction 31001                                  LP2-2366
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2367
20541000  "abs vf"            stdfnctn  1.        5.39944-6 0          *LP2-2368
20541001            abs       velfj     310010000                      *LP2-2369
20541100  "abs vg"            stdfnctn  1.        5.39944-6 0          *LP2-2370
20541101            abs       velgj     310010000                      *LP2-2371
*                                                                       LP2-2372
20541200  "momflux1"          mult      1.        2.00727-8 0          *LP2-2373
20541201  voidfj   310010000  rhofj     310010000                      *LP2-2374
20541202  velfj    310010000  cntrlvar  410                            *LP2-2375
20541300  "momflux2"          mult      1.        0.        0          *LP2-2376
20541301  voidgj   310010000  rhogj     310010000                      *LP2-2377
20541302  velgj    310010000  cntrlvar  411                            *LP2-2378
*                                                                       LP2-2379
20541400  "mf3401"            sum       1.        2.00727-8 0          *LP2-2380
20541401          0.0         1.0       cntrlvar  412                  *LP2-2381
20541402                      1.0       cntrlvar  413                  *LP2-2382
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2383
*                                                                       LP2-2384
* 424 momentum flux of junction 18502                                  LP2-2385
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2386
20542000  "abs vf"            stdfnctn  1.        5.1388474 0          *LP2-2387
20542001            abs       velfj     185020000                      *LP2-2388
20542100  "abs vg"            stdfnctn  1.        5.1388474 0          *LP2-2389
20542101            abs       velgj     185020000                      *LP2-2390
*                                                                       LP2-2391
20542200  "momflux1"          mult      1.        20057.594 0          *LP2-2392
20542201  voidfj   185020000  rhofj     185020000                      *LP2-2393
20542202  velfj    185020000  cntrlvar  420                            *LP2-2394
20542300  "momflux2"          mult      1.        0.        0          *LP2-2395
20542301  voidgj   185020000  rhogj     185020000                      *LP2-2396
20542302  velgj    185020000  cntrlvar  421                            *LP2-2397
*                                                                       LP2-2398
20542400  "mf3401"            sum       1.        20057.594 0          *LP2-2399
20542401          0.0         1.0       cntrlvar  422                  *LP2-2400
20542402                      1.0       cntrlvar  423                  *LP2-2401
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2402
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*                                                                       LP2-2403
* 434 momentum flux of junction 10002                                   LP2-2404
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2405
20543000  "abs vf"            stdfnctn  1.        5.6688271 0          *LP2-2406
20543001            abs       velfj     100020000                      *LP2-2407
20543100  "abs vg"            stdfnctn  1.        5.6727905 0          *LP2-2408
20543101            abs       velgj     100020000                      *LP2-2409
*                                                                       LP2-2410
20543200  "momflux1"          mult      1.        22119.25  0          *LP2-2411
20543201  voidfj   100020000  rhofj     100020000                      *LP2-2412
20543202  velfj    100020000  cntrlvar  430                            *LP2-2413
20543300  "momflux2"          mult      1.        0.0038276 0          *LP2-2414
20543301  voidgj   100020000  rhogj     100020000                      *LP2-2415
20543302  velgj    100020000  cntrlvar  431                            *LP2-2416
*                                                                       LP2-2417
20543400  "mf3401"            sum       1.        22119.266 0          *LP2-2418
20543401          0.0         1.0       cntrlvar  432                  *LP2-2419
20543402                      1.0       cntrlvar  433                  *LP2-2420
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2421
*                                                                       LP2-2422
* 444 momentum flux of junction 22502                                   LP2-2423
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2424
20544000  "abs vf"            stdfnctn  1.        1.661684  0          *LP2-2425
20544001            abs       velfj     225020000                      *LP2-2426
20544100  "abs vg"            stdfnctn  1.        1.661684  0          *LP2-2427
20544101            abs       velgj     225020000                      *LP2-2428
*                                                                       LP2-2429
20544200  "momflux1"          mult      1.        2097.1621 0          *LP2-2430
20544201  voidfj   225020000  rhofj     225020000                      *LP2-2431
20544202  velfj    225020000  cntrlvar  440                            *LP2-2432
20544300  "momflux2"          mult      1.        0.        0          *LP2-2433
20544301  voidgj   225020000  rhogj     225020000                      *LP2-2434
20544302  velgj    225020000  cntrlvar  441                            *LP2-2435
*                                                                       LP2-2436
20544400  "mf3401"            sum       1.        2097.1621 0          *LP2-2437
20544401          0.0         1.0       cntrlvar  442                  *LP2-2438
20544402                      1.0       cntrlvar  443                  *LP2-2439
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2440
*                                                                       LP2-2441
* 454 momentum flux of junction 24002                                   LP2-2442
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2443
20545000  "abs vf"            stdfnctn  1.        2.0633316 0          *LP2-2444
20545001            abs       velfj     240020000                      *LP2-2445
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20545100  "abs vg"            stdfnctn  1.        2.7305183 0        *LP2-2446
20545101            abs       velgj     240020000                    *LP2-2447
*                                                                     LP2-2448
20545200  "momflux1"          mult      1.        2665.6641 0        *LP2-2449
20545201  voidfj   240020000  rhofj     240020000                    *LP2-2450
20545202  velfj    240020000  cntrlvar  450                          *LP2-2451
20545300  "momflux2"          mult      1.        35.657471 0        *LP2-2452
20545301  voidgj   240020000  rhogj     240020000                    *LP2-2453
20545302  velgj    240020000  cntrlvar  451                          *LP2-2454
*                                                                     LP2-2455
20545400  "mf3401"            sum       1.        2701.3223 0        *LP2-2456
20545401           0.0        1.0       cntrlvar  452                *LP2-2457
20545402                      1.0       cntrlvar  453                *LP2-2458
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2459
*                                                                     LP2-2460
*  460 - 464  pressure differences                                    LP2-2461
*                                                                     LP2-2462
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2463
*                                                                     LP2-2464
20546000  "pde001"            sum       1.        116991.5  0        *LP2-2465
20546001           0.0        -1.0      p         120010000          *LP2-2466
20546002                      1.0       p         150010000          *LP2-2467
*                                                                     LP2-2468
20546100  "pde002"            sum       1.        -57892.87 0        *LP2-2469
20546101           0.0        -1.0      p         112020000          *LP2-2470
20546102                      1.0       p         120010000          *LP2-2471
*                                                                     LP2-2472
20546200  "pde003"            sum       1.        -8259.594 0        *LP2-2473
20546201           0.0        -1.0      p         100010000          *LP2-2474
20546202                      1.0       p         112020000          *LP2-2475
*                                                                     LP2-2476
20546300  "pde005"            sum       1.        -972.8379 0        *LP2-2477
20546301           0.0        -1.0      p         150010000          *LP2-2478
20546302                      1.0       p         180010000          *LP2-2479
*                                                                     LP2-2480
20546400  "pde006"            sum       1.        -49866.19 0        *LP2-2481
20546401           0.0        -1.0      p         180010000          *LP2-2482
20546402                      1.0       p         100010000          *LP2-2483
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2484
*                                                                     LP2-2485
* 470  reactor-power                                                  LP2-2486
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2487
20547000  "reac.pow"          function  1.        4.60000+7 0        *LP2-2488
```

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20547001                        time      0         900                 *LP2-2489
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2490
*                                                                      LP2-2491
*                                                                      LP2-2492
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*      LP2-2493
*                                                                      LP2-2494
*   pump data                                                          LP2-2495
*                                                                      LP2-2496
*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*$*      LP2-2497
*                                                                      LP2-2498
*""""""""" pump 1                                                      LP2-2499
*                                                                      LP2-2500
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2501
* single phase head curves                                             LP2-2502
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2503
* head curve no. 1                                                     LP2-2504
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2505
1351100   1                   1                                       *LP2-2506
1351101   0.000000e+00        1.403600e+00                            *LP2-2507
1351102   1.906100e-01        1.363600e+00                            *LP2-2508
1351103   3.896300e-01        1.318600e+00                            *LP2-2509
1351104   5.939600e-01        1.232800e+00                            *LP2-2510
1351105   7.902000e-01        1.133600e+00                            *LP2-2511
1351106   1.000000e+00        1.000000e+00                            *LP2-2512
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2513
* head curve no. 2                                                     LP2-2514
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2515
1351200   1                   2                                       *LP2-2516
1351201   0.000000e+00        -6.700000e-01                           *LP2-2517
1351202   2.000000e-01        -5.000000e-01                           *LP2-2518
1351203   4.000000e-01        -2.500000e-01                           *LP2-2519
1351204   5.755400e-01        0.000000e+00                            *LP2-2520
1351205   7.443200e-01        2.583000e-01                            *LP2-2521
1351206   7.734800e-01        3.778000e-01                            *LP2-2522
1351207   8.631300e-01        6.326000e-01                            *LP2-2523
1351208   1.000000e+00        1.000000e+00                            *LP2-2524
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2525
* head curve no. 3                                                     LP2-2526
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----      LP2-2527
1351300   1                   3                                       *LP2-2528
1351301   -1.000000e+00       2.472200e+00                            *LP2-2529
1351302   -8.057400e-01       2.047400e+00                            *LP2-2530
1351303   -6.069000e-01       1.831000e+00                            *LP2-2531
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1351304   -4.068300e-01       1.624000e+00                          *LP2-2532
1351305   -2.001710e-01       1.470500e+00                          *LP2-2533
1351306   0.000000e+00        1.403600e+00                          *LP2-2534
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2535
* head curve no. 4                                                   LP2-2536
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2537
1351400   1                   4                                     *LP2-2538
1351401   -1.000000e+00       2.472200e+00                          *LP2-2539
1351402   -8.229700e-01       1.996800e+00                          *LP2-2540
1351403   -6.333200e-01       1.589700e+00                          *LP2-2541
1351404   -4.553400e-01       1.327900e+00                          *LP2-2542
1351405   -2.710900e-01       1.194900e+00                          *LP2-2543
1351406   -1.771600e-01       1.060500e+00                          *LP2-2544
1351407   -9.073000e-02       1.015600e+00                          *LP2-2545
1351408   0.000000e+00        9.342790e-01                          *LP2-2546
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2547
* head curve no. 5                                                   LP2-2548
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2549
1351500   1                   5                                     *LP2-2550
1351501   0.000000e+00        2.500000e-01                          *LP2-2551
1351502   2.000000e-01        2.800000e-01                          *LP2-2552
1351503   4.000000e-01        3.400000e-01                          *LP2-2553
1351504   4.118000e-01        2.768000e-01                          *LP2-2554
1351505   5.976300e-01        4.584000e-01                          *LP2-2555
1351506   7.934670e-01        6.992000e-01                          *LP2-2556
1351507   1.000000e+00        1.000000e+00                          *LP2-2557
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2558
* head curve no. 6                                                   LP2-2559
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2560
1351600   1                   6                                     *LP2-2561
1351601   0.000000e+00        9.342790e-01                          *LP2-2562
1351602   9.109900e-02        9.229000e-01                          *LP2-2563
1351603   1.865090e-01        8.963000e-01                          *LP2-2564
1351604   2.717620e-01        8.750000e-01                          *LP2-2565
1351605   4.558720e-01        8.433000e-01                          *LP2-2566
1351606   5.744060e-01        8.355000e-01                          *LP2-2567
1351607   7.405760e-01        8.466000e-01                          *LP2-2568
1351608   7.666190e-01        8.469000e-01                          *LP2-2569
1351609   8.714710e-01        8.838000e-01                          *LP2-2570
1351610   1.000000e+00        1.000000e+00                          *LP2-2571
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2572
* head curve no. 7                                                   LP2-2573
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2574
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1351700   1                   7                                   *LP2-2575
1351701   -1.000000e+00       -1.000000e+00                       *LP2-2576
1351702   -8.000000e-01       -6.300000e-01                       *LP2-2577
1351703   -6.000000e-01       -3.000000e-01                       *LP2-2578
1351704   -4.000000e-01       -5.000000e-02                       *LP2-2579
1351705   -2.000000e-01       1.500000e-01                        *LP2-2580
1351706   0.000000e+00        2.500000e-01                        *LP2-2581
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2582
* head curve no. 8                                                 LP2-2583
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2584
1351800   1                   8                                   *LP2-2585
1351801   -1.000000e+00       -1.000000e+00                       *LP2-2586
1351802   -8.000000e-01       -9.700000e-01                       *LP2-2587
1351803   -6.000000e-01       -9.500000e-01                       *LP2-2588
1351804   -4.000000e-01       -8.800000e-01                       *LP2-2589
1351805   -2.000000e-01       -8.000000e-01                       *LP2-2590
1351806   0.000000e+00        -6.700000e-01                       *LP2-2591
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2592
* single phase torque data                                         LP2-2593
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2594
* torque curve no. 1                                               LP2-2595
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2596
1351900   2                   1                                   *LP2-2597
1351901   0.000000e+00        6.032000e-01                        *LP2-2598
1351902   1.930000e-01        6.325000e-01                        *LP2-2599
1351903   3.930000e-01        7.369000e-01                        *LP2-2600
1351904   5.955200e-01        8.331000e-01                        *LP2-2601
1351905   7.978200e-01        9.229000e-01                        *LP2-2602
1351906   1.000000e+00        1.000000e+00                        *LP2-2603
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2604
* torque curve no. 2                                               LP2-2605
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2606
1352000   2                   2                                   *LP2-2607
1352001   0.000000e+00        -6.700000e-01                       *LP2-2608
1352002   4.000000e-01        -2.500000e-01                       *LP2-2609
1352003   5.000000e-01        1.500000e-01                        *LP2-2610
1352004   7.372550e-01        5.265860e-01                        *LP2-2611
1352005   7.680490e-01        6.065940e-01                        *LP2-2612
1352006   8.672300e-01        7.436600e-01                        *LP2-2613
1352007   1.000000e+00        1.000000e+00                        *LP2-2614
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2615
* torque curve no. 3                                               LP2-2616
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2617
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1352100   2                   3                                   *LP2-2618
1352101   -1.000000e+00       1.984300e+00                        *LP2-2619
1352102   -8.009600e-01       1.394000e+00                        *LP2-2620
1352103   -6.063800e-01       1.097500e+00                        *LP2-2621
1352104   -4.068600e-01       8.220000e-01                        *LP2-2622
1352105   -1.992800e-01       6.648000e-01                        *LP2-2623
1352106   0.000000e+00        6.032000e-01                        *LP2-2624
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2625
* torque curve no. 4                                               LP2-2626
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2627
1352200   2                   4                                   *LP2-2628
1352201   -1.000000e+00       1.984300e+00                        *LP2-2629
1352202   -8.223400e-01       1.830800e+00                        *LP2-2630
1352203   -6.337100e-01       1.682400e+00                        *LP2-2631
1352204   -4.585300e-01       1.557000e+00                        *LP2-2632
1352205   -2.670230e-01       1.436200e+00                        *LP2-2633
1352206   -1.761070e-01       1.387900e+00                        *LP2-2634
1352207   -8.931000e-02       1.348100e+00                        *LP2-2635
1352208   0.000000e+00        1.233610e+00                        *LP2-2636
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2637
* torque curve no. 5                                               LP2-2638
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2639
1352300   2                   5                                   *LP2-2640
1352301   0.000000e+00        -4.500000e-01                       *LP2-2641
1352302   4.000000e-01        -2.500000e-01                       *LP2-2642
1352303   5.000000e-01        0.000000e+00                        *LP2-2643
1352304   1.000000e+00        3.569000e-01                        *LP2-2644
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2645
* torque curve no. 6                                               LP2-2646
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2647
1352400   2                   6                                   *LP2-2648
1352401   0.000000e+00        1.233610e+00                        *LP2-2649
1352402   9.064300e-02        1.196500e+00                        *LP2-2650
1352403   1.885690e-01        1.109600e+00                        *LP2-2651
1352404   2.734700e-01        1.041600e+00                        *LP2-2652
1352405   4.586690e-01        8.958000e-01                        *LP2-2653
1352406   5.744800e-01        7.807000e-01                        *LP2-2654
1352407   7.381600e-01        6.134000e-01                        *LP2-2655
1352408   7.685200e-01        5.849000e-01                        *LP2-2656
1352409   8.700570e-01        4.877000e-01                        *LP2-2657
1352410   1.000000e+00        3.569000e-01                        *LP2-2658
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----   LP2-2659
* torque curve no. 7                                               LP2-2660
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*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2661
1352500   2                   7                                      *LP2-2662
1352501   -1.000000e+00       -1.000000e+00                          *LP2-2663
1352502   -3.000000e-01       -9.000000e-01                          *LP2-2664
1352503   -1.000000e-01       -5.000000e-01                          *LP2-2665
1352504   0.000000e+00        -4.500000e-01                          *LP2-2666
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2667
* torque curve no. 8                                                 LP2-2668
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2669
1352600   2                   8                                      *LP2-2670
1352601   -1.000000e+00       -1.000000e+00                          *LP2-2671
1352602   -2.500000e-01       -9.000000e-01                          *LP2-2672
1352603   -8.000000e-02       -8.000000e-01                          *LP2-2673
1352604   0.000000e+00        -6.700000e-01                          *LP2-2674
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2675
* two - phase multiplier data from 13-6 test data                    LP2-2676
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2677
* head curve                                                         LP2-2678
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2679
1353000   0                                                          *LP2-2680
1353001   0.000000e+00        0.000000e+00                           *LP2-2681
1353002   1.000000e-01        0.000000e+00                           *LP2-2682
1353003   2.000000e-01        1.000000e-01                           *LP2-2683
1353004   3.000000e-01        2.000000e-01                           *LP2-2684
1353005   3.500000e-01        3.000000e-01                           *LP2-2685
1353006   4.000000e-01        6.000000e-01                           *LP2-2686
1353007   5.000000e-01        6.000000e-01                           *LP2-2687
1353008   6.000000e-01        6.000000e-01                           *LP2-2688
1353009   7.000000e-01        6.000000e-01                           *LP2-2689
1353010   8.000000e-01        5.000000e-01                           *LP2-2690
1353011   9.000000e-01        3.000000e-01                           *LP2-2691
1353012   1.000000e+00        0.000000e+00                           *LP2-2692
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2693
* torque curve                                                       LP2-2694
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2695
1353100   0                                                          *LP2-2696
1353101   0.000000e+00        0.000000e+00                           *LP2-2697
1353102   1.000000e-01        0.000000e+00                           *LP2-2698
1353103   2.000000e-01        1.000000e-01                           *LP2-2699
1353104   3.000000e-01        3.000000e-01                           *LP2-2700
1353105   3.500000e-01        5.000000e-01                           *LP2-2701
1353106   4.000000e-01        7.500000e-01                           *LP2-2702
1353107   5.000000e-01        7.500000e-01                           *LP2-2703
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1353108   6.000000e-01        7.500000e-01                          *LP2-2704
1353109   7.000000e-01        7.500000e-01                          *LP2-2705
1353110   8.000000e-01        7.500000e-01                          *LP2-2706
1353111   9.000000e-01        5.000000e-01                          *LP2-2707
1353112   1.000000e+00        0.000000e+00                          *LP2-2708
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2709
* pump 2-phase difference data                                        LP2-2710
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2711
* head curve no. 1                                                   LP2-2712
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2713
1354100   1                   1                                     *LP2-2714
1354101   0.000000e+00        1.000000e+00                          *LP2-2715
1354102   1.000000e+00        1.000000e+00                          *LP2-2716
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2717
* head curve no. 2                                                   LP2-2718
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2719
1354200   1                   2                                     *LP2-2720
1354201   0.000000e+00        1.000000e+00                          *LP2-2721
1354202   1.000000e+00        1.000000e+00                          *LP2-2722
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2723
* head curve no. 3                                                   LP2-2724
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2725
1354300   1                   3                                     *LP2-2726
1354301   -1.000000e+00       -1.160000e+00                         *LP2-2727
1354302   -9.000000e-01       -1.240000e+00                         *LP2-2728
1354303   -8.000000e-01       -1.770000e+00                         *LP2-2729
1354304   -7.000000e-01       -2.360000e+00                         *LP2-2730
1354305   -6.000000e-01       -2.790000e+00                         *LP2-2731
1354306   -5.000000e-01       -2.910000e+00                         *LP2-2732
1354307   -4.000000e-01       -2.670000e+00                         *LP2-2733
1354308   -2.500000e-01       -1.690000e+00                         *LP2-2734
1354309   -1.000000e-01       -5.000000e-01                         *LP2-2735
1354310   0.000000e+00        0.000000e+00                          *LP2-2736
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2737
* head curve no. 4                                                   LP2-2738
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2739
1354400   1                   4                                     *LP2-2740
1354401   -1.000000e+00       -1.160000e+00                         *LP2-2741
1354402   -9.000000e-01       -7.800000e-01                         *LP2-2742
1354403   -8.000000e-01       -5.000000e-01                         *LP2-2743
1354404   -7.000000e-01       -3.100000e-01                         *LP2-2744
1354405   -6.000000e-01       -1.700000e-01                         *LP2-2745
1354406   -5.000000e-01       -8.000000e-02                         *LP2-2746
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1354407   -3.500000e-01       0.000000e+00                          *LP2-2747
1354408   -2.000000e-01       5.000000e-02                          *LP2-2748
1354409   -1.000000e-01       8.000000e-02                          *LP2-2749
1354410   0.000000e+00        1.100000e-01                          *LP2-2750
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2751
* head curve no. 5                                                   LP2-2752
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2753
1354500   1                     5                                   *LP2-2754
1354501   0.000000e+00        0.000000e+00                          *LP2-2755
1354502   2.000000e-01        -3.400000e-01                         *LP2-2756
1354503   4.000000e-01        -6.500000e-01                         *LP2-2757
1354504   6.000000e-01        -9.300000e-01                         *LP2-2758
1354505   8.000000e-01        -1.190000e+00                         *LP2-2759
1354506   1.000000e+00        -1.470000e+00                         *LP2-2760
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2761
* head curve no. 6                                                   LP2-2762
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2763
1354600   1                     6                                   *LP2-2764
1354601   0.000000e+00        1.100000e-01                          *LP2-2765
1354602   1.000000e-01        1.300000e-01                          *LP2-2766
1354603   2.500000e-01        1.500000e-01                          *LP2-2767
1354604   4.000000e-01        1.300000e-01                          *LP2-2768
1354605   5.000000e-01        7.000000e-02                          *LP2-2769
1354606   6.000000e-01        -4.000000e-02                         *LP2-2770
1354607   7.000000e-01        -2.300000e-01                         *LP2-2771
1354608   8.000000e-01        -5.100000e-01                         *LP2-2772
1354609   9.000000e-01        -9.100000e-01                         *LP2-2773
1354610   1.000000e+00        -1.470000e+00                         *LP2-2774
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2775
* head curve no. 7                                                   LP2-2776
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2777
1354700   1                     7                                   *LP2-2778
1354701   -1.000000e+00        0.000000e+00                          *LP2-2779
1354702   0.000000e+00        0.000000e+00                          *LP2-2780
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2781
* head curve no. 8                                                   LP2-2782
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2783
1354800   1                     8                                   *LP2-2784
1354801   -1.000000e+00        0.000000e+00                          *LP2-2785
1354802   0.000000e+00        0.000000e+00                          *LP2-2786
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2787
* torque curve no. 1                                                 LP2-2788
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2789
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1354900   2                   1                                        *LP2-2790
1354901   0.000000e+00        1.000000e+00                             *LP2-2791
1354906   1.000000e+00        1.000000e+00                             *LP2-2792
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2793
* torque curve no. 2                                                   LP2-2794
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2795
1355000   2                   2                                        *LP2-2796
1355001   0.000000e+00        1.000000e+00                             *LP2-2797
1355007   1.000000e+00        1.000000e+00                             *LP2-2798
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2799
* torque curve no. 3                                                   LP2-2800
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2801
1355100   2                   3                                        *LP2-2802
1355101   -1.000000e+00       1.984300e+00                             *LP2-2803
1355102   -8.009600e-01       1.394000e+00                             *LP2-2804
1355103   -6.063800e-01       1.097500e+00                             *LP2-2805
1355104   -4.068600e-01       8.220000e-01                             *LP2-2806
1355105   -1.992800e-01       6.648000e-01                             *LP2-2807
1355106   0.000000e+00        6.032000e-01                             *LP2-2808
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2809
* torque curve no. 4                                                   LP2-2810
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2811
1355200   2                   4                                        *LP2-2812
1355201   -1.000000e+00       1.984300e+00                             *LP2-2813
1355202   -8.223400e-01       1.830800e+00                             *LP2-2814
1355203   -6.337100e-01       1.682400e+00                             *LP2-2815
1355204   -4.585300e-01       1.557000e+00                             *LP2-2816
1355205   -2.670230e-01       1.436200e+00                             *LP2-2817
1355206   -1.761070e-01       1.387900e+00                             *LP2-2818
1355207   -8.931000e-02       1.348100e+00                             *LP2-2819
1355208   0.000000e+00        1.233610e+00                             *LP2-2820
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2821
* torque curve no. 5                                                   LP2-2822
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2823
1355300   2                   5                                        *LP2-2824
1355301   0.000000e+00        -4.500000e-01                            *LP2-2825
1355302   4.000000e-01        -2.500000e-01                            *LP2-2826
1355303   5.000000e-01        0.000000e+00                             *LP2-2827
1355304   1.000000e+00        3.569000e-01                             *LP2-2828
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2829
* torque curve no. 6                                                   LP2-2830
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----       LP2-2831
1355400   2                   6                                        *LP2-2832
```

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1355401   0.000000e+00        1.233610e+00                          *LP2-2833
1355402   9.064300e-02        1.196500e+00                          *LP2-2834
1355403   1.885690e-01        1.109600e+00                          *LP2-2835
1355404   2.734700e-01        1.041600e+00                          *LP2-2836
1355405   4.586690e-01        8.958000e-01                          *LP2-2837
1355406   5.744800e-01        7.807000e-01                          *LP2-2838
1355407   7.381600e-01        6.134000e-01                          *LP2-2839
1355408   7.685200e-01        5.849000e-01                          *LP2-2840
1355409   8.700570e-01        4.877000e-01                          *LP2-2841
1355410   1.000000e+00        3.569000e-01                          *LP2-2842
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2843
* torque curve no. 7                                                 LP2-2844
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2845
1355500   2                     7                                   *LP2-2846
1355501   -1.000000e+00        -1.000000e+00                         *LP2-2847
1355502   -3.000000e-01        -9.000000e-01                         *LP2-2848
1355503   -1.000000e-01        -5.000000e-01                         *LP2-2849
1355504   0.000000e+00         -4.500000e-01                         *LP2-2850
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2851
* torque curve no. 8                                                 LP2-2852
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2853
1355600   2                     8                                   *LP2-2854
1355601   -1.000000e+00        -1.000000e+00                         *LP2-2855
1355602   -2.500000e-01        -9.000000e-01                         *LP2-2856
1355603   -8.000000e-02        -8.000000e-01                         *LP2-2857
1355604   0.000000e+00         -6.700000e-01                         *LP2-2858
*---- ----1---- ----1---- ----1---- ----1---- ----1---- ----1----     LP2-2859
*                                                                    LP2-2860
.......  RELAP5/MOD2  (LP-02-6 / Mk.2-00C)                           *LP2-2861
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11. ABSTRACT (200 words or less)

This report presents the results and analysis of nine post-test calculations of the Experiment LP-02-6 by using RELAP5/MOD2 CY36-02 computer code with different nodalizations. Starting with a "standard nodalization" we have reduced the number of volumes and junctions as well as the number of radial zones in the fuel rods, for different nodalization studies. Except for the cladding temperatures, only small discrepancies have been observed for the other main parameters of the results of runs using different nodalizations but reduced number of volumes and junctions usually have lead to a decreased running time for the problem. The time behaviors of the cladding temperatures have been significantly affected by the chosen nodalizations. The most comparable results with the experimental data have been achieved by using medium number of nodes. With respect to high mass-flux, early bottom-up rewetting, one of the key-events of Experiment LP-02-6 as well as of most of the other LOFT large break experiments ,RELAP5/MOD2 was not able to predict this phenomenon except with a certain manipulation by initiating the reflood option.

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