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PWR/HTWG/P(88)629(Rev)

# International Agreement Report

# Analysis of Semiscale Test S-LH-1 Using RELAP5/MOD2

Prepared by
P. C. Hall, D. R. Bull

National Power Nuclear
Barnett Way
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United Kingdom

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

**April 1992**

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
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GD/PE-N/725
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CENTRAL ELECTRICITY GENERATING BOARD

GENERATION DEVELOPMENT AND CONSTRUCTION DIVISION

PLANT ENGINEERING DEPARTMENT

NUCLEAR PLANT BRANCH

Title: Analysis of Semiscale Test S-LH-1 Using RELAP5/MOD2

Author: P.C. Hall and D.R. Bull, Safety Technology Section

Approved by: Head of Safety Technology Section

Summary:

The RELAP5/MOD2 code is being used by GDCD for calculating Small Break Loss of Coolant Accidents (SBLOCA) and pressurised transient sequences for the Sizewell 'B' PWR. These calculations are being carried out at the request of the Sizewell 'B' Project Management Team.

To assist in validating RELAP5/MOD2 for the above application, the code is being used by GDCD to model a number of small LOCA and pressurised fault simulation experiments carried out in various integral test facilities. The present report describes a RELAP5/MOD2 analysis of the small LOCA test S-LH-1 which was performed on the Semiscale Mod-2C facility. S-LH-1 simulated a small LOCA caused by a break in the cold leg pipework of an area equal to 5% of the cold leg flow area.

RELAP5/MOD2 gave reasonably accurate predictions of system thermal hydraulic behaviour. In particular, the hydrostatic core level depression resulting from the hold-up of water in the steam generator tubes and pump suction legs was well predicted. A reasonable prediction of core inventory was also obtained in the period of the test in which the core level fell as a result of coolant boil-off.

The code did not give an accurate prediction of the liquid distribution within the core during the uncovering phases. Consequently the fuel temperature excursions due to uncovery were not captured by the code. Failure to calculate the correct void fraction distribution and dryout behaviour is believed to be due to numerical approximations in representing the core by a small number of nodes, rather than due to errors in the physical models and correlations used in the code.

Based on the present study it is suggested that, in reactor analyses in which the potential for core uncovery occurs, the mixture level trajectory and peak fuel temperatures are calculated outside RELAP5 using a code employing a fine axial mesh, using boundary conditions from the RELAP5 analysis.

Date: February 1989

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CONTENTS

## 1. INTRODUCTION

The RELAP5/MOD2 code [1] is being used by GDCD for calculating Small Break Loss of Coolant Accidents (SBLOCA) and pressurised transient sequences for the Sizewell 'B' PWR. These calculations are being carried out at the request of the Sizewell 'B' Project Management Team.

To assist in validating RELAP5/MOD2 for the above application, the code is being used by GDCD to model a number of small LOCA and pressurised fault simulation experiments carried out in various integral test facilities. The present report describes a RELAP5/MOD2 analysis of the small LOCA test S-LH-1 which was performed on the Semiscale Mod-2C facility [2, 3]. S-LH-1 simulated a small LOCA caused by a break in the cold leg pipework of an area equal to 5% of the cold leg flow area.

In addition to a detailed description of the new analysis of S-LH-1, comparisons are also described with earlier calculations with RELAP5/MOD1 and RELAP5/MOD2, described in reference [4].

## 2. CODE VERSION AND INPUT MODEL

The code version used for these calculations was RELAP5/MOD2/cycle 36.05 E03. This code is a version of the standard release of INEL cycle 36.05 containing error corrections (primarily Cray conversion errors) implemented by UKAEA, Winfrith. In addition the horizontal stratification model of Ardron and Bryce [5] is optionally available in version E03. This model was used in the present calculation to model the junction connecting the break line to the cold leg.

The RELAP5/MOD2 model was taken from reference [4]. Discharge coefficients in the break junction were set at 0.9 for both single and two-phase flow. The RELAP5/MOD2 model consisted of 181 volumes, 172 junctions and 256 heat structures : the noding diagram is shown in figure 1.

Microfiche listings of code input and output have been filed under Safety Technology Section in the Microfiche Archive at GDCD, Barnwood. Code input is archived under BBWDQAA, at Barnwood.

## 3. INITIAL AND BOUNDARY CONDITIONS

As stated above, initial and boundary conditions for the present calculations were taken from reference [4]. To establish the required steady state conditions, a steady state calculation was first run for 300s of problem time. Parameters controlled to achieve the desired steady-state were steam and feed flow and the pump speed. A dummy time-dependent volume was connected to the top of the pressuriser to maintain the desired steady primary pressure. After 300s these steady-state conditions were removed, the dummy volumes deleted and the calculations allowed to proceed for 50s before initiating the transient.

Figures 2-4 show the hot leg pressure and pressuriser level, the flows into and out of the intact loop SG separator; and the intact loop steam generator pressure and level during the steady-state run. These figures illustrate that a satisfactory steady-state was achieved. The RELAP5 calculated steady-state conditions are compared with experimental values from reference [4] in Table 1. It can be seen that the steady-state conditions are satisfactorily calculated, except for the intact loop steam generator secondary side level, which had to be set artificially low to allow RELAP5 to calculate stable operation of the steam generator. Use of a reduced inventory is considered acceptable, since in the test S-LH-1 the SG secondary plays only a minor role in the overall primary system energy removal.

The High Pressure Injection System (HPIS) was modelled via a table of flow versus primary pressure. The secondary feed water flow was modelled using a table of flow versus time, with the flow being stopped by the activation of a trip signal. The steam generator steam bypass valves were modelled as set to open when the appropriate steam generator exceeded 7.2MPa. The Semiscale facility makes extensive use of external guard heaters to reduce heat loss from the facility to the surroundings. The time variation of power supplied to these heaters was modelled in the RELAP5 calculation.

## 4. DESCRIPTION OF TEST

The sequence of key events is given in Table 2. The transient is briefly described as follows. The test was initiated by opening a block valve, allowing primary fluid to flow through the break orifice to the break flow condensation system. Reactor trip was simulated by reducing core power to decay heat levels 3.4s after the pressuriser pressure fell to the set point level of 12.6MPa. Loss of offsite power coincident with reactor trip was simulated in the test. Therefore feed water was terminated and MSIV closed upon reactor trip and the primary circulating pump also tripped. High pressure injection was initiated 25s after reactor trip to simulate delay in starting the emergency diesel generators.

In the S-LH-1 transient break flow was initially insufficient to remove decay power. Therefore primary pressure remained above the secondary pressure until the intact loop pump suction pipework cleared of liquid at 171s. A core level depression and dry out occurred prior to pump suction clearance. After clearance a slow core boildown began; dry out of the fuel rod simulators commenced at about 400s and terminated at about 650s, 150s after the initiation of accumulator injection.

## 5. BASE CASE CALCULATION

The calculated timing of key events is compared with data in Table 2.

The measured and calculated primary system pressure histories are shown in Figure 5. The period of subcooled blowdown up to approximately 50s is accurately calculated. The small overestimate of pressure in the period 50-250s probably arises from errors in the calculation of secondary side behaviour. Following loop seal clearance, the calculated depressurisation is too rapid, suggesting overestimation of discharge enthalpy. The accumulator injection pressure set point is reached at 400s in the calculation, approximately 100s earlier than in the experiment. Measured and calculated secondary side pressures are compared in Figure 6. Pressures are systematically overpredicted at all times after closure of the main steam control valves (MSIV), but the errors appear to have only a minor influence in this test. Some sensitivity calculations were performed with an arbitarily specified steam leakage in the MSIV. These indicated that discrepancies between measured and calculated secondary pressures later in this test could be accounted for by assuming a plausible leakage area of less than 0.16% of the full MSIV area.

Figure 7 shows a comparison of measured and calculated discharge mass flow rates. Overall agreement is seen to be good, except in the low quality discharge period of 50-175s. Critical flow rate is strongly sensitive to upstream stagnation enthalpy under these conditions, and the agreement between measured and calculated results in the period 50-175s is therefore considered acceptable. The calculated increase in discharge flow at 140s occurs because of the arrival of lower quality fluid in the broken loop cold leg, as the broken loop pump suction pipework is cleared of liquid. In the period between loop seal clearance and accumulator injection, discharge flow rate is underestimated by about 20% ($0.02 kgs^{-1}$).

Figures 8, 9, 10 and 11 compare the measured and calculated collapsed liquid level in the intact and broken loop SG U-tubes and pump suction legs. Experimental data are derived from differential pressures measurements and are therefore invalid until the termination of forced loop flow at about 50s. It is also suspected that experimental errors are subsequently significant, since some measured values show a large offset late in the transient.

It can be seen in Figures 8 and 9 that RELAP5 predicts considerable liquid hold-up in the up-side of the SG tubes in the period 120-250s. However, the calculated hold-up is generally ~ 1m of water less than the measurements indicate, and is less prolonged. Figure 10 shows that the collapsed liquid levels in the intact loop pump suction are calculated accurately, though with a time shift of about 25s. Agreement between measured and calculated collapsed liquid levels in the broken loop pump suction (Figure 11) is relatively poor. RELAP5 predicts that this loop seal is the first to clear, at 180s, followed by partial refilling as the other loop seal clears. In practice, this loop seal did not clear until ~ 260s, after the broken loop SG U-tube upside had drained. The ability to predict which loop seal clears first is of little practical importance, and the present result is therefore considered to be acceptable.

Figure 12 compares measured and calculated collapsed liquid levels in the reactor vessel downcomer and core. The key features of the experimental data are the deep core level depression which recovered at about 170s and the gradual boildown which occurred between 300s and 530s. The first core level depression, which is caused by hydrostatic pressure due to the build up of liquid in the upsides of the SG tubes and pump suction pipework, is seen to be accurately calculated by RELAP5. The second core level depression, caused by boil-off of water in the core, is less accurately calculated by the code. In addition, the calculation of an over-rapid depressurisation rate leads to the premature activation of the accumulators, which results in the calculated boildown being terminated too early. These errors are discussed further below.

Measured and calculated core void fractions are shown in Figures 13 and 14 respectively. The experimental data of Figure 13 are reproduced from figures given in reference [4]. Figure 14 shows the axial variation of core void fractions calculated by RELAP5. Inspection of Figure 14 shows that in the period of the hydrostatic core uncovery, (150-200s) the calculated void fraction reaches a maximum value of approximately 0.94 in the highest core volume, and 0.86 in the lowest. This is in marked contrast with the test, where the void fraction reaches unity in approximately the upper two thirds of the core, but remains at about 0.1 at the bottom of the core. Thus, even though the calculated core collapsed liquid level was less than the measured value, the void fraction at the top of the core is evidently underestimated by RELAP5/MOD2.

To compare the measured and predicted core axial void fractions in the core boildown phase (350-500s), we examine condition at t = 400s, immediately prior to the calculated time of accumulator injection. At this time the measured and calculated collapsed liquid levels are approximately the same. It is seen by comparing the figures that at t = 400s, a well-defined two-phase mixture level existed at the 250 cm elevation in the test (see Figure 13b). However, in the RELAP5 calculation a near homogeneous two-phase mixture is calculated to exist in the top part of the core. Therefore, although RELAP5 adequately calculated core water inventory at this time, the detailed axial distribution in the core was in error.

Figure 15 compares measured and calculated heater rod temperatures at around the 250cm elevation (the discrepancy prior to trip arises because the RELAP5 value is for the heater rod surface, whereas the experimental value is measured with an embedded thermocouple. Discrepancies due to the thermocouple location become insignificant after trip). It is seen that RELAP5 fails to calculate either of the experimentally observed dryouts. These discrepancies are due primarily to the errors in the calculated core void fraction distribution described above, and are considered further in the next section.

## 6. SENSITIVITY STUDIES

The primary shortcomings of the calculation described above are inaccuracies in the calculated pressure history, core void fraction distribution and the failure to calculate the core dryouts. Numerous sensitivity studies were carried out to investigate the cause of these errors. Results are described in this section.

## 6.1 Modelling of Hydrostatic Core Uncovery

Figure 12 illustrates that the hydrostatic core level depression occurring in the period 170s was well calculated by RELAP5. However, although the core collapsed liquid level was actually underpredicted, dryout was not calculated because RELAP5 predicted significant liquid fractions at the top of core.

Detailed investigation of calculated void fraction and flows in the core, upper plenum and hot legs, indicated that during this period of the hydrostatic level depression, a small counterflow of water was predicted to be refluxing from the hot legs into the upper plenum and core. In the core volumes this downflow of water maintained the void fraction below about 0.95; this was sufficient to prevent dryout according to the CHF correlation applied by RELAP5/MOD2 for these condition (modified Zuber correlation). In practice such a downflow would probably run down the wall of the core vessel and would be unlikely to prevent dryout in the rod bundle centre region. Loomis and Streit [4] indeed noted that in the test, whilst some pins dried out, others at the same elevation did not, indicating that falling films of water were present on some rods above the mixture level. This is consistent with the view that a spatially non-uniform liquid distribution exists in the core region. To try to model such liquid distribution effects in RELAP5, the core model was modified as illustrated in Figure 16. The core was split into two channels. One channel represented the outer subchannel, next to the vessel wall. (The vessel heat structures were connected to this channel.) The other channel represented the remaining central subchannels (all heater rod heat structures were connected to this channel). In initial studies crossflow junctions were included between parallel core channels, but recirculating flow patterns arose which inhibited the calculation of dry out. The crossflow junctions were therefore deleted. Finally to ensure that no refluxing water entered the central core zone, the core outlet junction (volume 146 to 161) was defined as a homogeneous ('one velocity') junction.

Figure 17 compares experimental collapsed liquid levels in the core vessel and downcomer for the basecase and the sensitivity calculation. It is seen that the effect of the core noding change is to produce a more prolonged core depression, with earlier clearance of the pump suction. In spite of the increased core liquid inventory in the hydrostatic core uncovery phase (t = 140s), the void fraction in the upper part of the core is now calculated to reach unity (see Figure 18). Subsequently dryout is now calculated to occur as illustrated in Figure 19. The rate of rise of temperatures is well calculated, but because the calculated dryout is too prolonged, the maximum heater rod temperature is over-predicted.

It is concluded that under conditions of core level depression in which reflux condensation is taking place, RELAP5/MOD2 may fail to predict a dryout. Care must therefore be taken in using the code to predict peak fuel clad temperatures in these conditions.

## 6.2 Modelling of Core Boildown Phase

As noted above, RELAP5/MOD2 also failed to calculate dryout during the boildown phase of this transient (350-500s). This appears to be due to errors in the calculated core void distribution, and also to the prediction of early accumulator injection.

Figure 17 shows the collapsed liquid level in the downcomer obtained in the base case and sensitivity calculations. The sensitivity calculation is seen to be more accurate than the base case calculation.

The core void fraction distribution in the sensitivity calculation is shown in Figure 18. Again these results are in much better agreement with the test data (Fig 13b) than results for the base case calculation. However the improvement seems mainly due to the use of the one-velocity junction at the core outlet, which increases the calculated liquid carry-out from the top of the core. The agreement with test data is therefore regarded as somewhat fortuitous.

In spite of the improved agreement with the core collapsed liquid level and void distribution RELAP5/MOD2 still fails to predict a core dry-out during the boildown phase, as can be seen from Figure 19. Modifications to the level sharpener model in the code would probably be necessary to successfully calculate the core dry-out, given the coarse axial mesh used to represent the core in the present analysis.

## 6.3 Calculation of Depressurisation after Loop Seal Clearance

It is seen from Figure 5 that the depressurisation rate after intact loop seal clearance is over-estimated by RELAP5/MOD2. Consequently the onset of accumulator injection which terminated the core boil-down phase is predicted to be too early. Calculations were performed to determine if errors in the calculations of break flow and enthalpy were responsible for the errors in the depressurisation rate.

To investigate the effect of changing the discharge flow multiplier (CD2), a calculation was performed with the value arbitrarily set to 0.65, (as opposed to 0.9 in the base case). The accuracy of the calculated pressure history was greatly improved, but the calculated core water inventory was significantly overestimated in the boildown period. It was therefore concluded that the errors in calculated depressurisation rate cannot be ascribed simply to uncertainties in the break flow multiplier.

A check was then made of the break mass flow rate calculated by RELAP5/MOD2 in the period 250 to 450s. Values were found to be within 10% of prediction of the homogenous thermal equilibrium model of two-phase critical flow, which would be expected to provide a reasonable prediction for the orifice geometry and thermodynamic conditions in the test. Therefore the RELAP5/MOD2 results are considered reasonable.

Finally a check was made on the calculated enthalpy in the broken loop cold leg in the period 250-400s. RELAP5 results indicate void fractions in the range 0.98-1.0 in this period.

Experimental data based on gamma densitometer measurements indicate high void fraction at the vessel end of the broken loop cold leg. However, the bottom densitometer beam at the pump discharge end of the broken cold leg reveals the persistence of a layer of water throughout the transient. This suggests that the error in calculated depressurisation rate results from errors in the calculated rate of entrainment of water from the broken loop pump suction pipework into the cold leg, and break nozzle.

Additional information suggesting that the error in calculated depressurisation rate is related to errors in the calculation of broken loop cold leg conditions comes from detailed inspection of the primary pressure history. The experimental pressure history shows two distinct knees at ~ 180 and 270s as the broken and intact loop pump suctions clear. In contrast, the calculation shows only a single knee as the broken loop pump suction clears.

It was concluded that relatively small errors in the calculated clearing behaviour of the loops seals probably gave rise to the overprediction of the depressurisation rate. However, the data is insufficiently detailed to eliminate errors in calculated primary-to-secondary heat transfer, or metalwork heat transfer as contributors to the errors in calculated pressure [4].

## 7. DISCUSSION AND COMPARISON WITH PREVIOUS ANALYSIS

The present test has been analysed by Loomis and Streit [4] using RELAP5/MOD2/Cycle 36.05. In common with the present study, these authors noted the failure of RELAP5/MOD2 to calculate dryout correctly; they also noted that calculated primary pressure fell too quickly after loop seal clearance.

Loomis and Streit [4] found that by modifying the interphase drag correlations in RELAP5/MOD2 to give a 90% reduction of interphase drag in the core volumes, a reasonable prediction of the liquid level trajectory in the core could be achieved. The present calculations have shown that an accurate prediction of the core axial void fraction profile can also be achieved using the unmodified interphase drag models, providing adjustments are made to the modelling of slip in the core outlet junction. This suggests that errors in the void distributions are more likely to be due to approximations used in numerical implementation of the interphase drag correlation, than to errors in the correlations themselves. It is believed that averaging procedures used to calculate interphase drag in junctions, treatment of inverted void profile and the level sharpener model, all contribute to errors in the core void distribution found in the present base case calculation.

Loomis and Streit also recommended that the critical heat flux (CHF) modelling in RELAP5 be modified to allow calculation of dryout in the hydrostatic uncovering phase. They suggested that the factor $(1 - \alpha_g)$ appearing in the modified Zuber CHF model should be replaced by $(0.94 - \alpha_g)$ to ensure that dryout is calculated when the core void fraction exceeds 0.94.

The present studies suggest that failure to calculate dryout in the S-LH-1 hydrostatic uncovering phase was not in fact due to CHF modelling but was rather due to incorrect calculation of the liquid distribution in the core under conditions of reflux condensation.

It is concluded that considerable care must be taken in modelling the liquid level trajectory and core heat up behaviour in RELAP5/MOD2 simulations in which the core is represented by a small number of nodes. It is recommended that in reactor fault analyses in which the potential for core uncovering occurs, the calculation of the level trajectory and the peak fuel clad temperatures be performed with a separate code using a fine axial mesh, taking thermal-hydraulic boundary conditions (core liquid inventory, pressure, inlet enthalpy, core power) from RELAP5/MOD2.

## 8. GENERAL CODE PERFORMANCE AND CPU TIMES

The present calculations were performed on the Cray-2 computer at AERE, Harwell. 2270s of CPU time was used, giving a CPU:real time ratio of 2.84:1. The CPU time per timestep per mesh cell was 1.32ms. The main limitation to timestep size was the courant limit in the broken loop pump suction pipework. The code was found to be stable and easy to use. However, it was found necessary to reduce the maximum timestep manually during the first 25s to avoid calculation of premature dryout and subsequent code failure.

Using the split core input model, the CPU: real time ratio reduced to 1.75:1, and the CPU time per mesh cell per timestep was 1.20ms.

## 9. CONCLUSIONS

1. RELAP5/MOD2 cycle 36.05 Version E03 has been used to analyse test S-LH-1 (5% cold leg break loss of coolant accident simulation) carried out in the Semiscale PWR test facility.

2. The code gave reasonably accurate predictions of system thermal hydraulic behaviour. In particular, the hydrostatic core level depression resulting from the hold-up of water in the steam generator tubes and pump suction legs was well predicted. A reasonable prediction of core inventory was also obtained in the period of the test in which the core level fell as a result of coolant boil-off.

3. RELAP5/MOD2 did not give an accurate prediction of the liquid distribution within the core during the uncovering phases. Consequently the fuel temperature excursions due to uncovery were not captured by the code. Failure to calculate the correct void fraction distribution and dryout behaviour is believed to be due to numerical approximations in the implementation of interphase drag modelling and in representing the core by a small number of nodes, rather than due to errors in the physical models and correlations used in the code.

4. Based on the present study it is suggested that in reactor analyses in which the potential for core uncovering occurs, the mixture level trajectory and peak fuel temperatures are calculated outside RELAP5 using a code employing a fine axial mesh, using boundary conditions from the RELAP5 analysis.

## 10. REFERENCES


| | | | |
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| 3. | EGG-SEMI-6884 | Quick Look Report for Semiscale Mod-2C Experiments S-LH-1 and S-LH-2 G.G. Loomis, J.E. Streit | May 1985 |
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| 5. | AEEW-R2345 | Assessment of Horizontal Stratification Entrainment Model in RELAP5/MOD2 K.H. Ardron and W.M. Bryce | 1988 |
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TABLE 1

INITIAL CONDITIONS FOR S-LH-1

| | | EXPERIMENT | RELAP5 |
|---|---|---|---|
| Pressuriser pressure | MPa | 15.47 ± 0.14 | 15.47 |
| Core power | kW | 2014.75 ± 0.15 | 2014.75 |
| Core ΔT | K | $37.65\ ^{+1.5}_{-0.6}$ | 37.30 |
| Pressuriser liquid level (collapsed above bottom) | cm | 395 ± 14 | 396.1 |
| Cold leg fluid temperatures | K | | |
| Intact loop | | 562.12 ± 2 | 560.9 |
| Broken loop | | 564.05 ± 2 | 565.68 |
| Primary flow rate | $kgs^{-1}$ | | |
| Intact loop | | 7.13 | 7.13 |
| Broken loop | | 2.35 | 2.35 |
| Initial Bypass flow (% of total core flow) | | 0.9 | 0.92 |
| Leak rate | $kgs^{-1}$ | 0.0002 | 0.0 |
| SG secondary pressure | MPa | | |
| Intact loop | | 5.72 ± 0.07 | 5.8 |
| Broken loop | | 6.08 ± 0.07 | 6.09 |
| SG secondary side mass | kg | | |
| Intact loop | | 191 ± 13 | 150.0* |
| Broken loop | | 43 ± 4.3 | 43.0 |

* Approaching limit of stable operation of steam generator by RELAP5

TABLE 2

TIMING OF EVENTS FOR S-LH-1

| EVENT | TIME AFTER BREAK OPENS (s) EXPERIMENT | RELAP5 (BASE CALCULATION) |
|---|---|---|
| Small break valve opened | 0.0 | 0.0 |
| Pressuriser pressure reaches trip level (12.6MPa) | 14.67 | 16.95 |
| Pump coast-down initiated | | |
| Intact loop | 21.35 | 21.7 |
| Broken loop | 20.76 | 21.35 |
| HPIS initiated | | |
| Intact loop | 41.60 | 43.68 |
| Broken loop | 40.98 | 43.28 |
| Pressurizer empty | 33.9 | 55 |
| Minimum core collapsed liquid level | 172.6 | 182 |
| Pump suction clearing | | |
| Intact loop | 171.4 | 203 |
| Broken loop | 262.3 | 180 |
| Second core dryout | 412.8 | - |
| Accumulator injection | | |
| Intact loop | 503.8 | 406.0 |
| Broken loop | 501.4 | 407.0 |

Semiscale S-LH-1

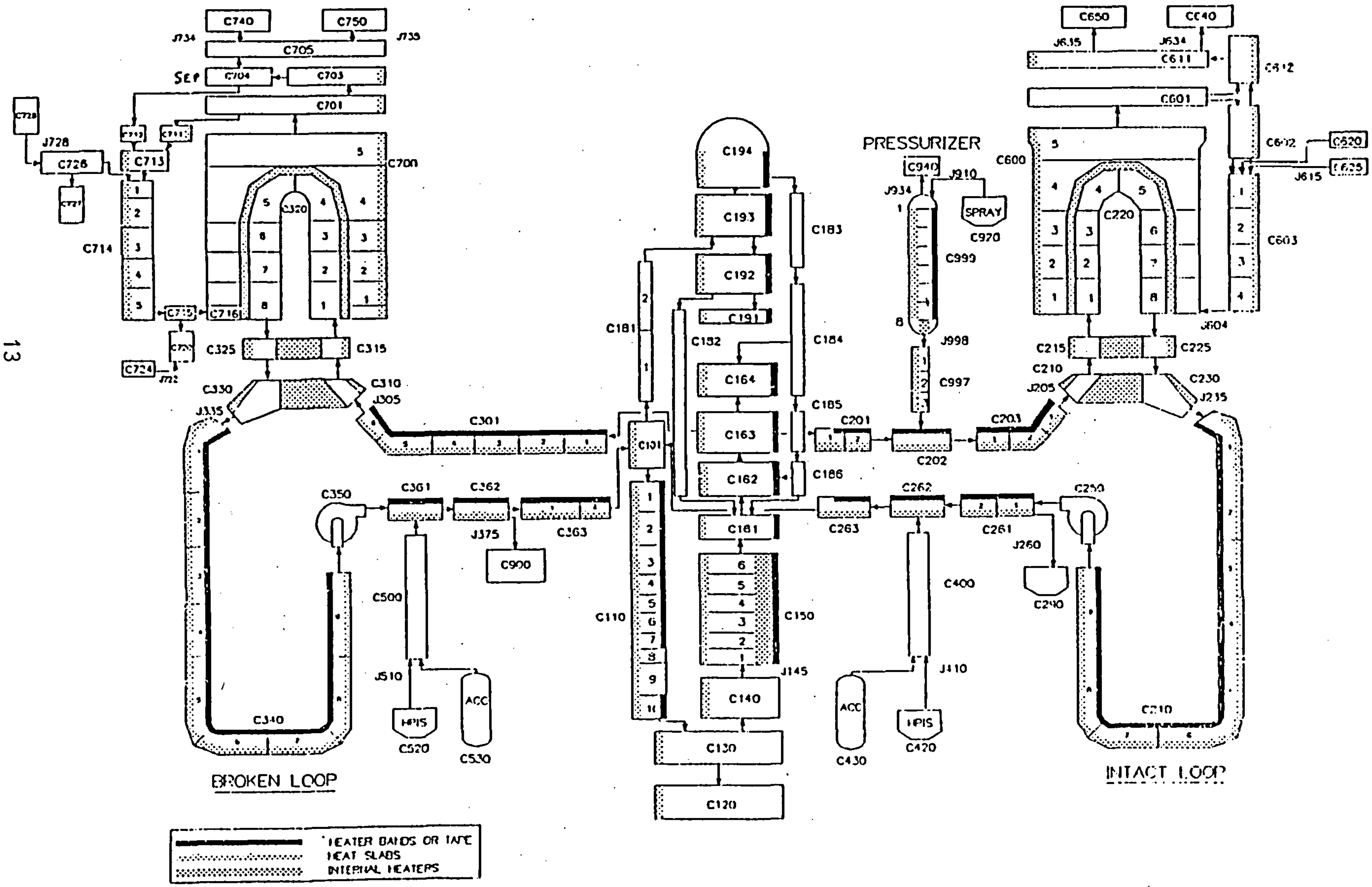


Figure 1 : RELAP5 noding diagram for Semiscale S-LH-1 Calculation ( Base case )

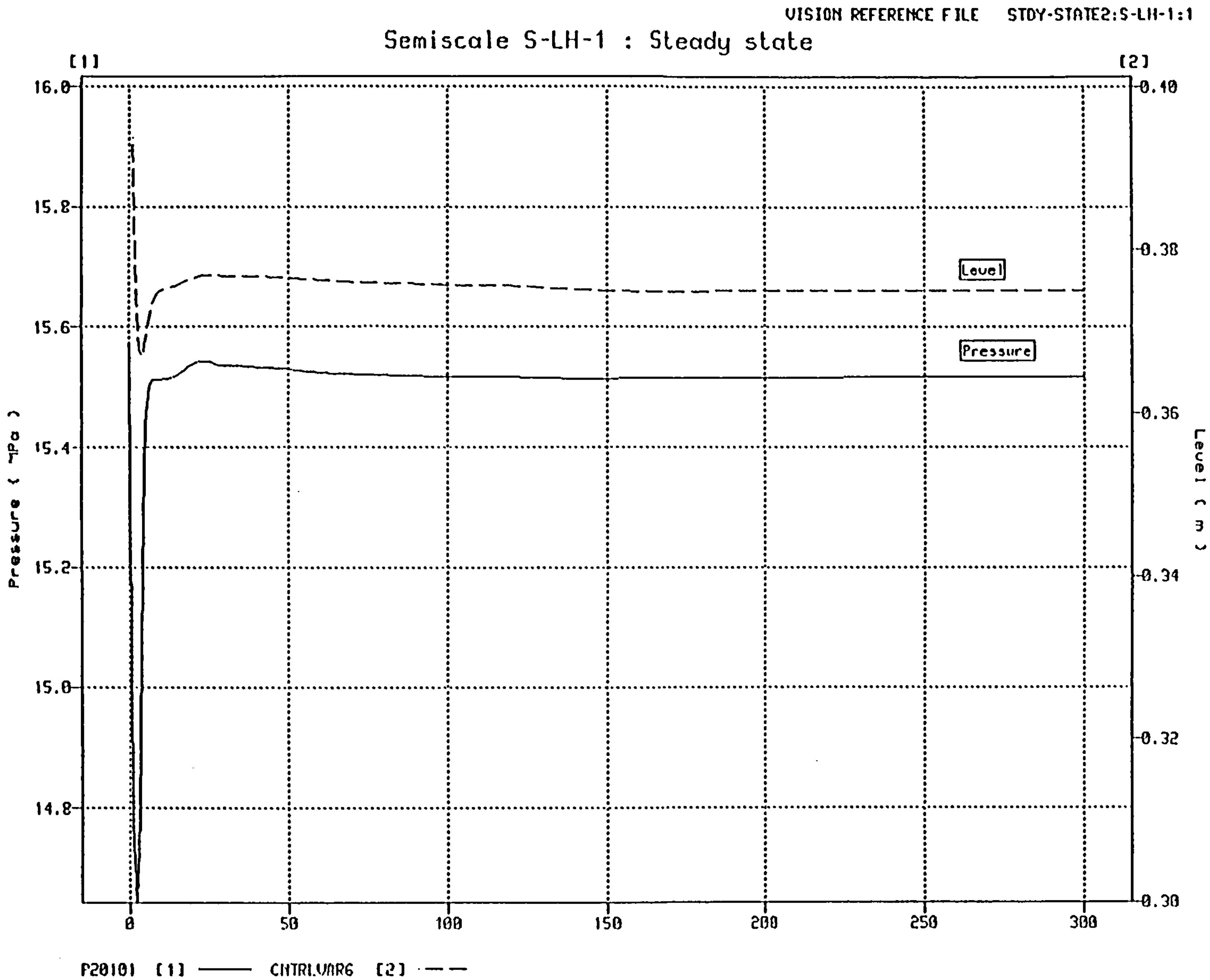


Figure 2 : Hot leg pressure and pressurizer level

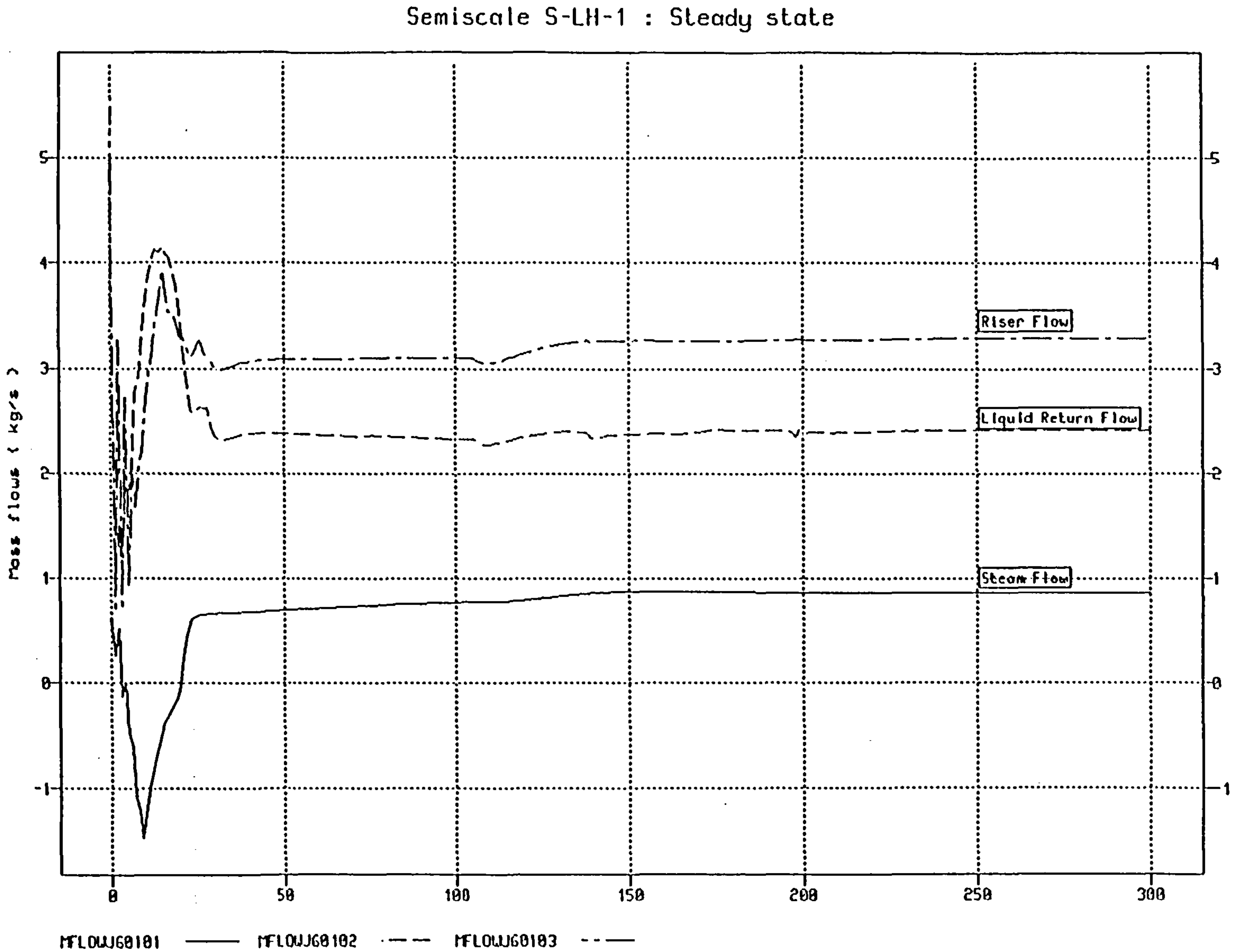


Figure 3 : Intact loop steam generator separator mass flow rates

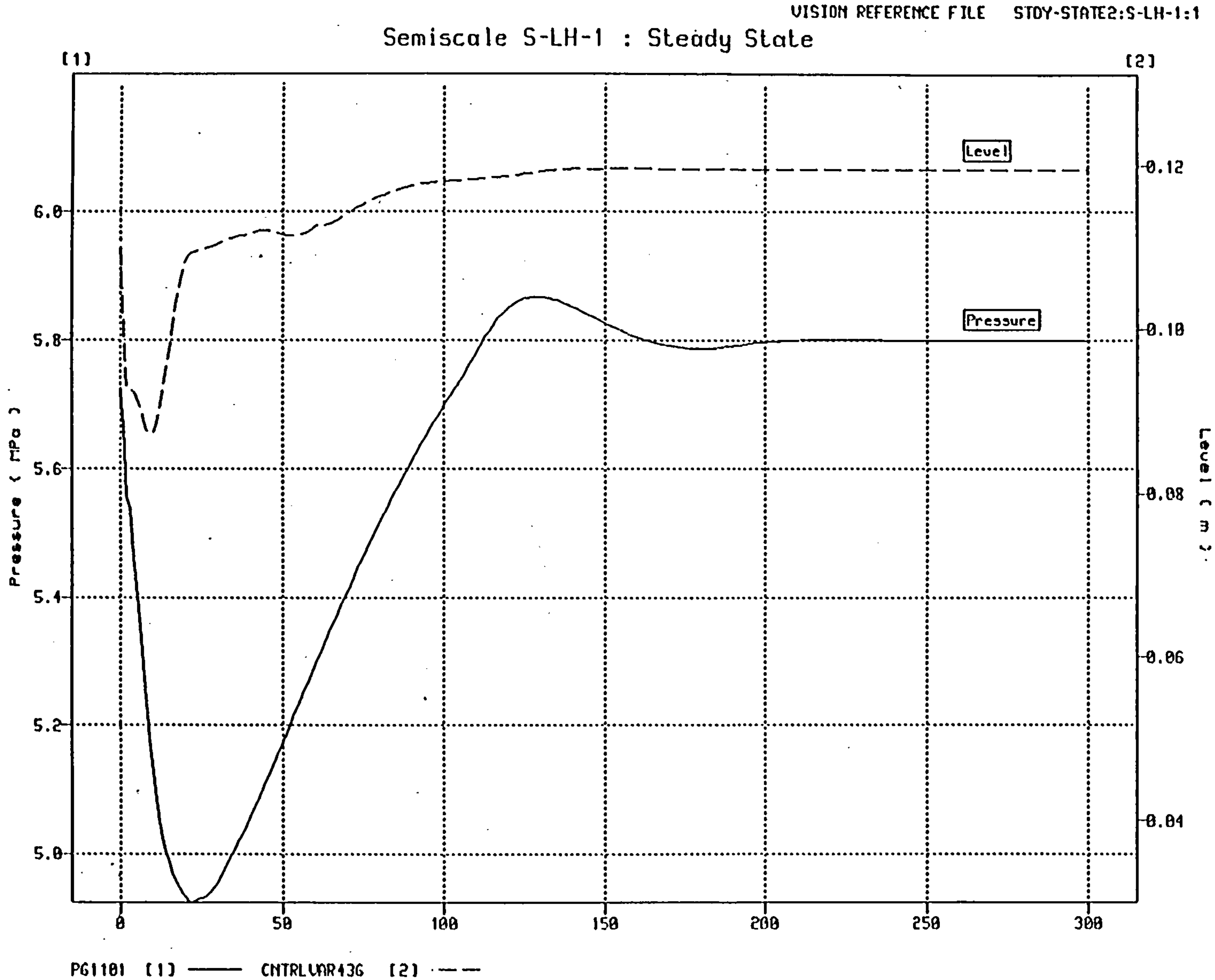


Figure 4 : Intact loop steam generator pressure and collapsed liquid level

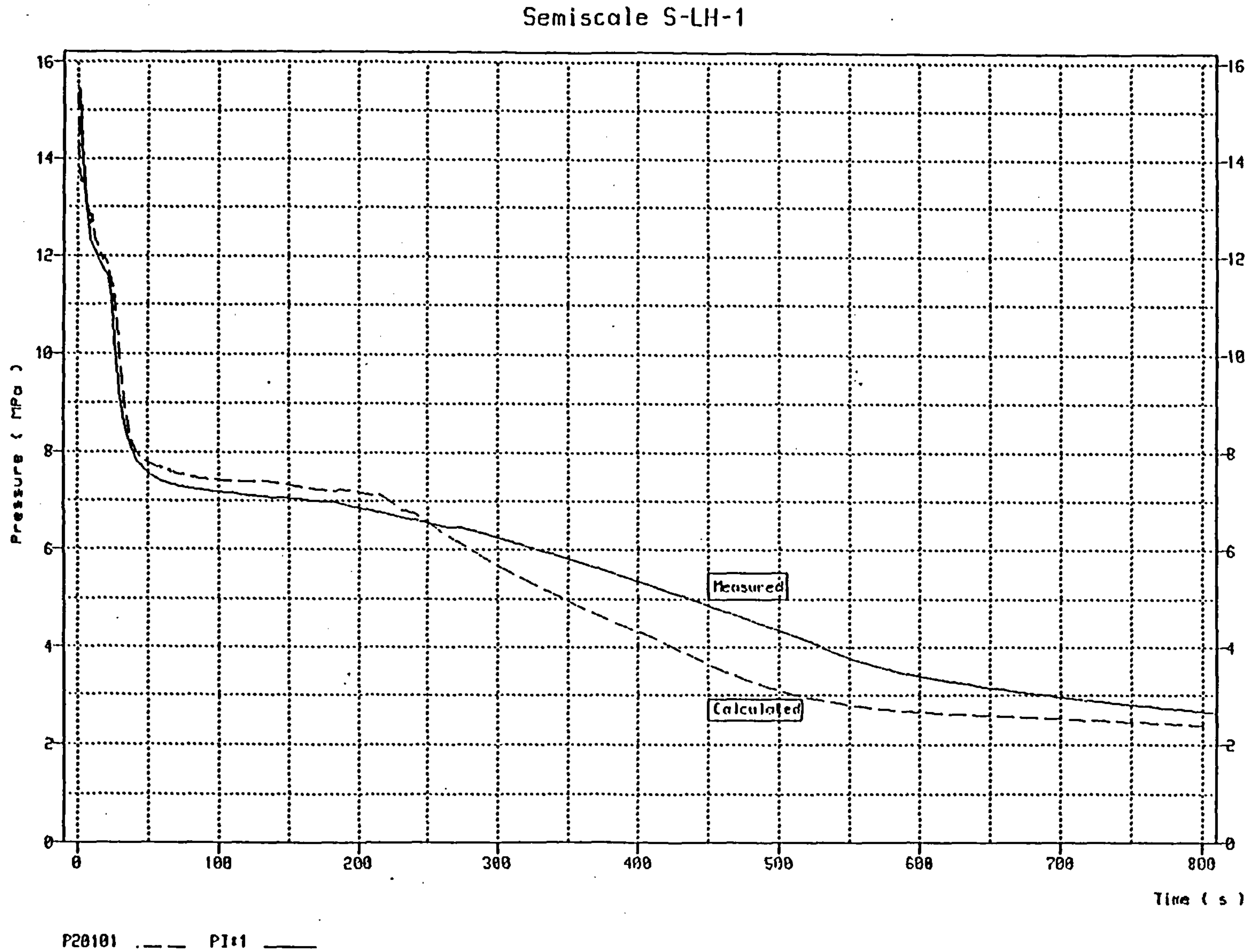


Figure 5 : Measured and calculated primary pressure ( Base case )

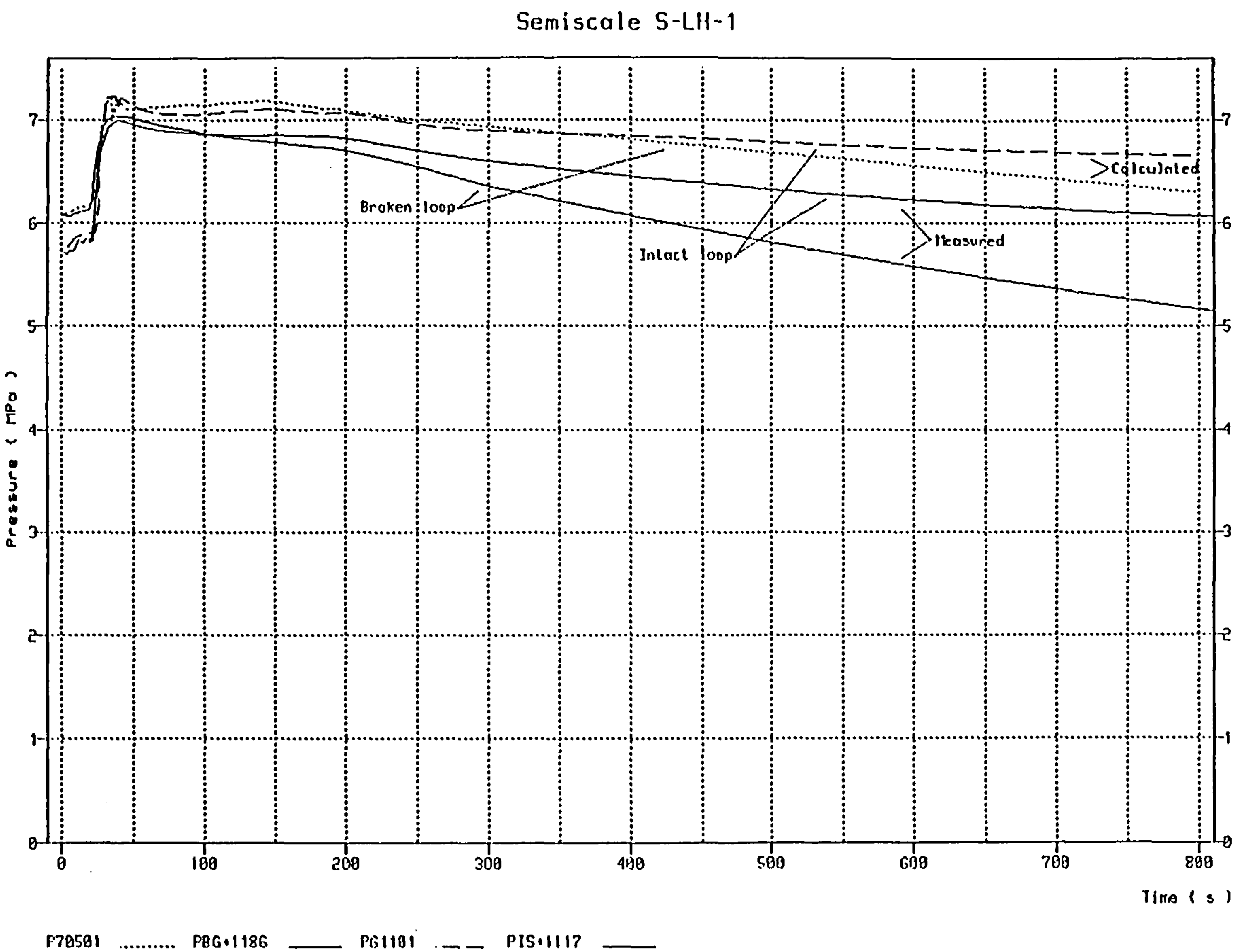


Figure 6 : Measured and calculated secondary pressures ( Base case )

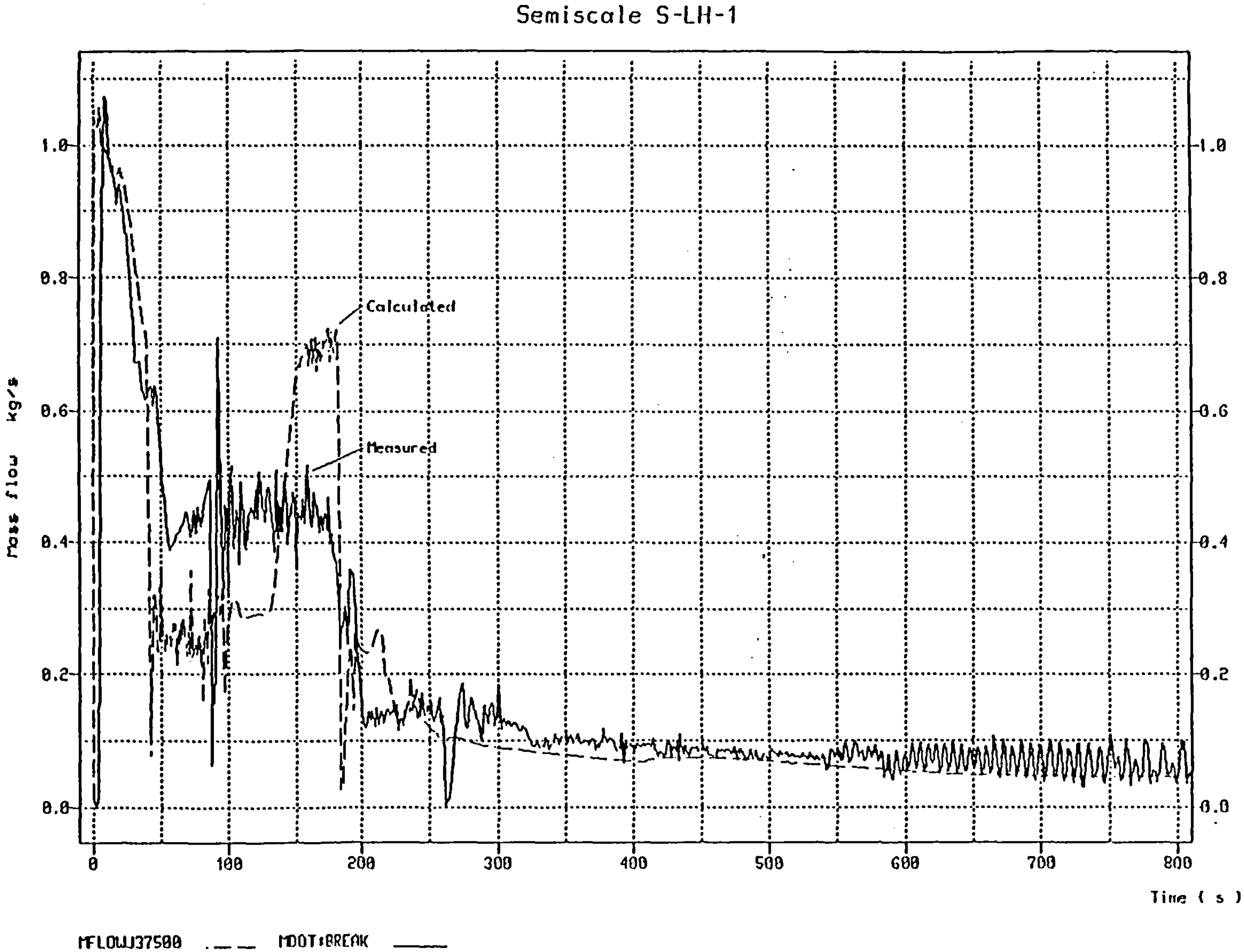


Figure 7 : Measured and calculated break flow ( Base case )

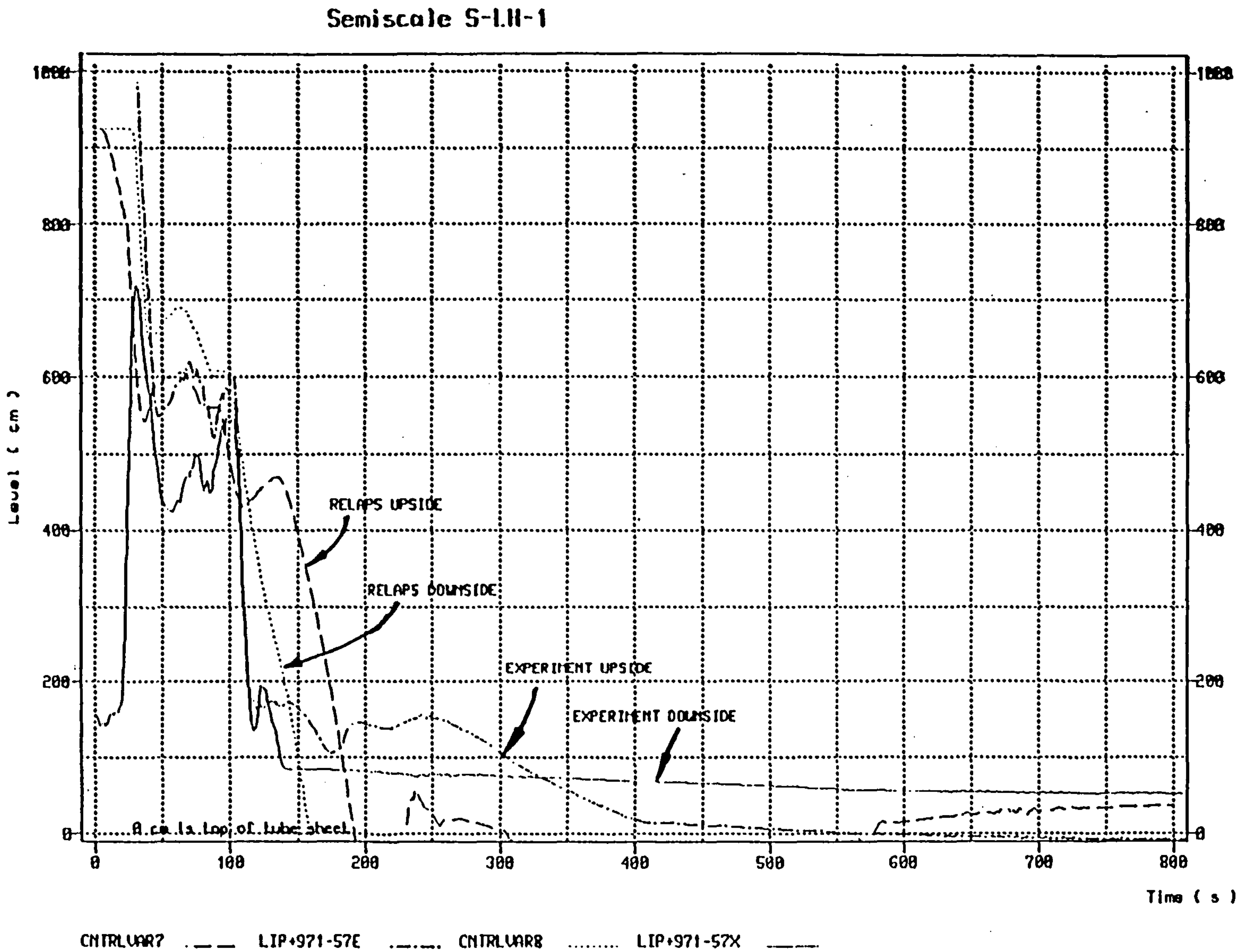


Figure 8. Collapsed Liquid Levels in Intact Loop U-tubes

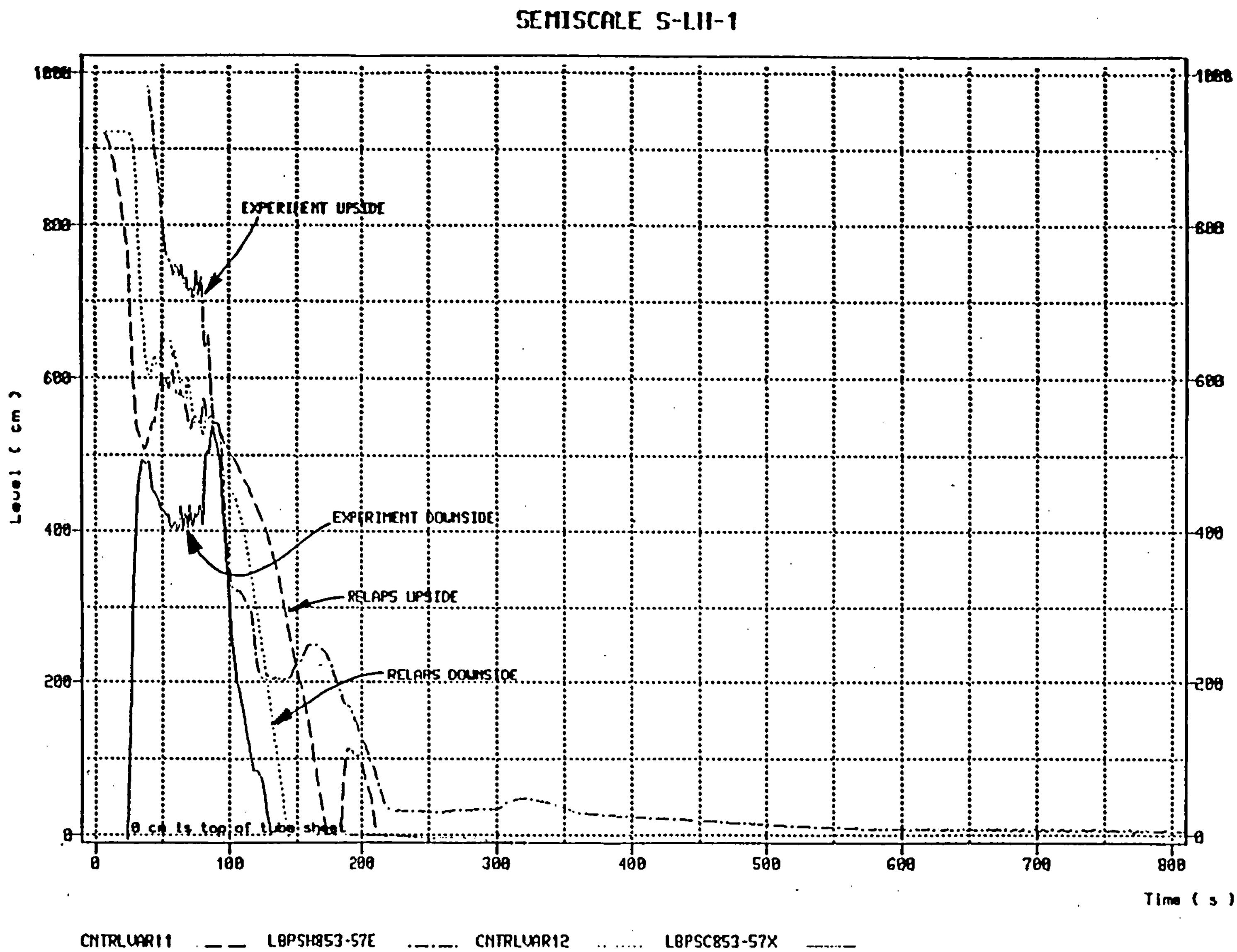


Figure 9. Collapsed Liquid Levels in Broken Loop U-tube

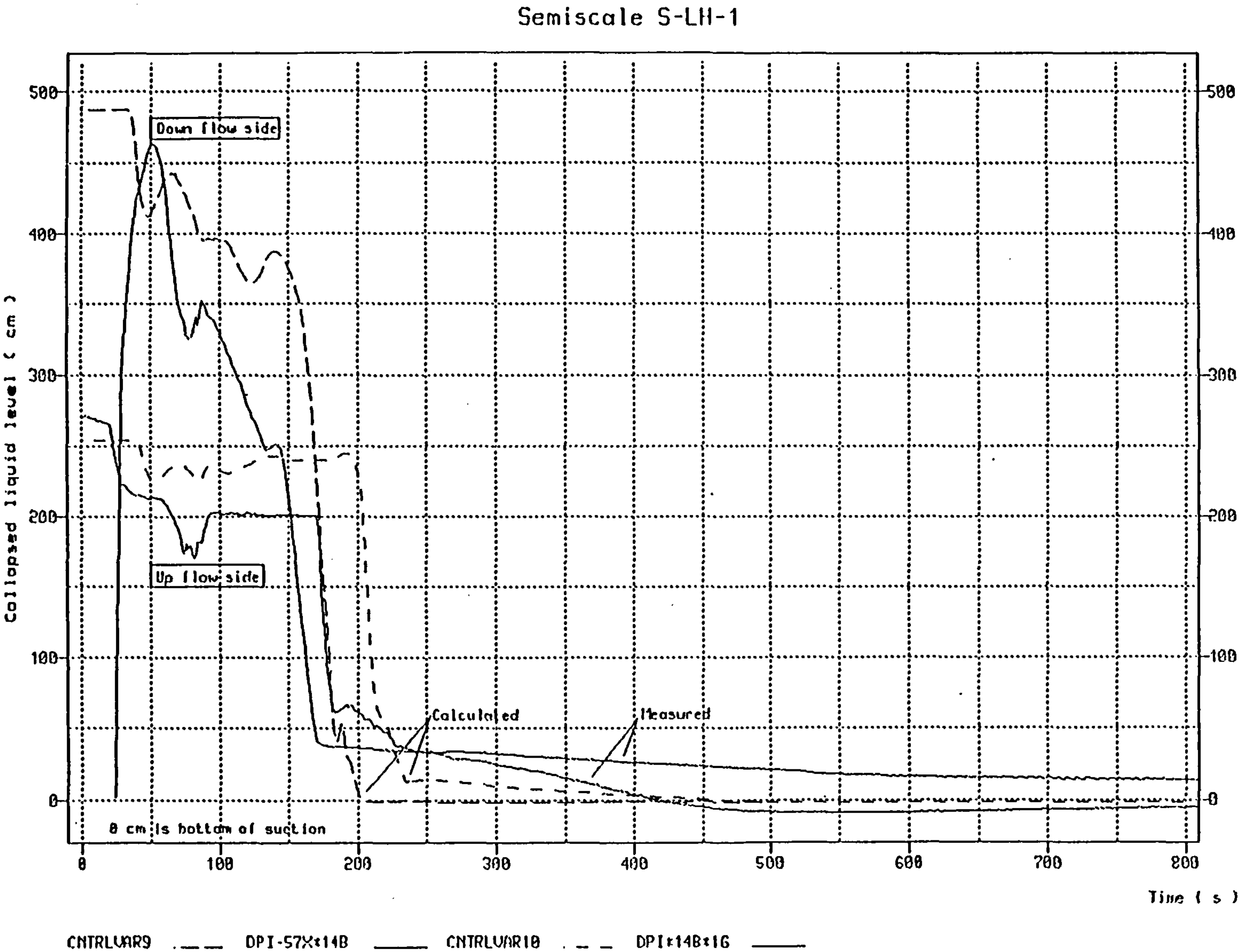


Figure 10: Measured and calculated IL pump suction collapsed liquid level

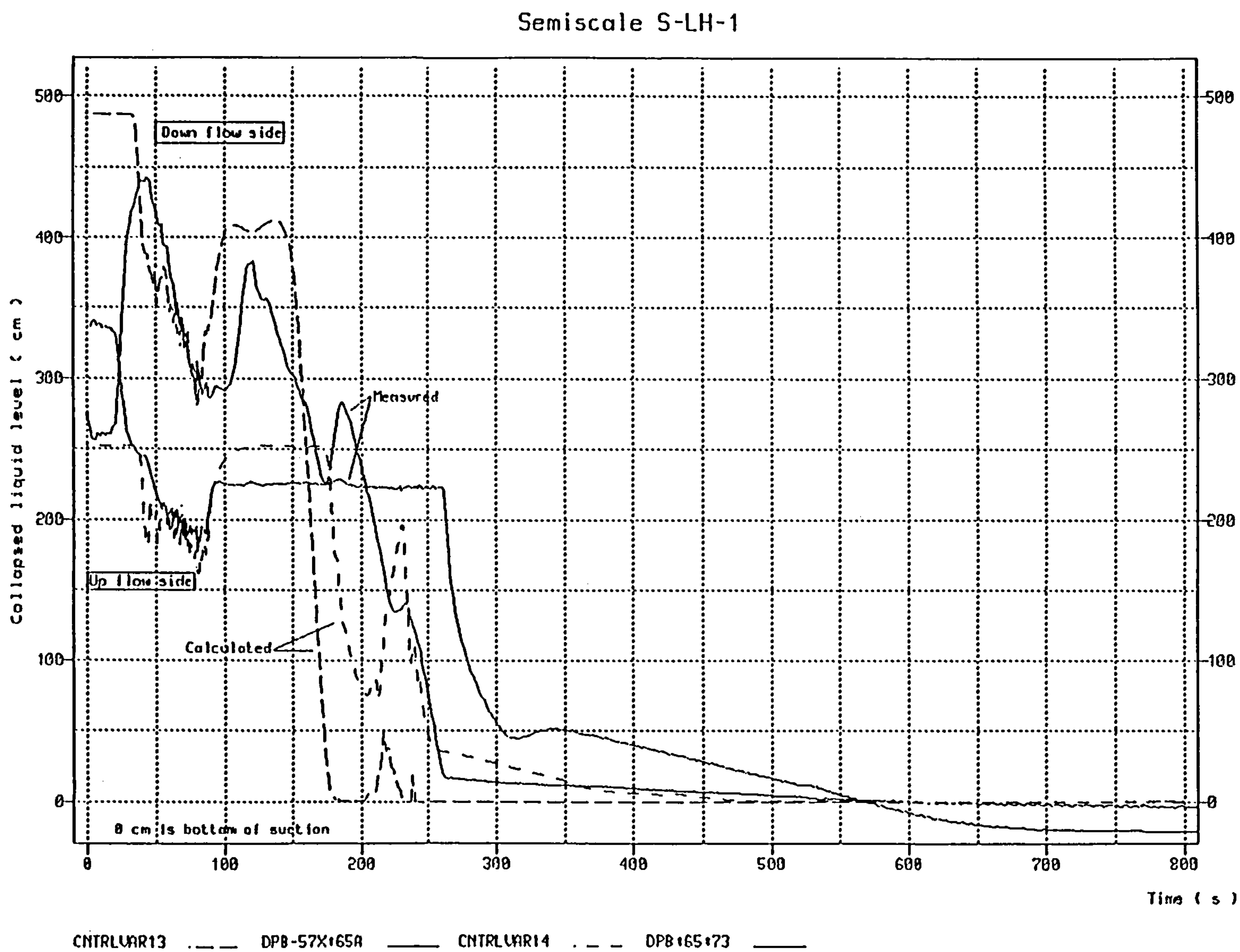


Figure 11: Measured and calculated BL pump suction collapsed liquid level

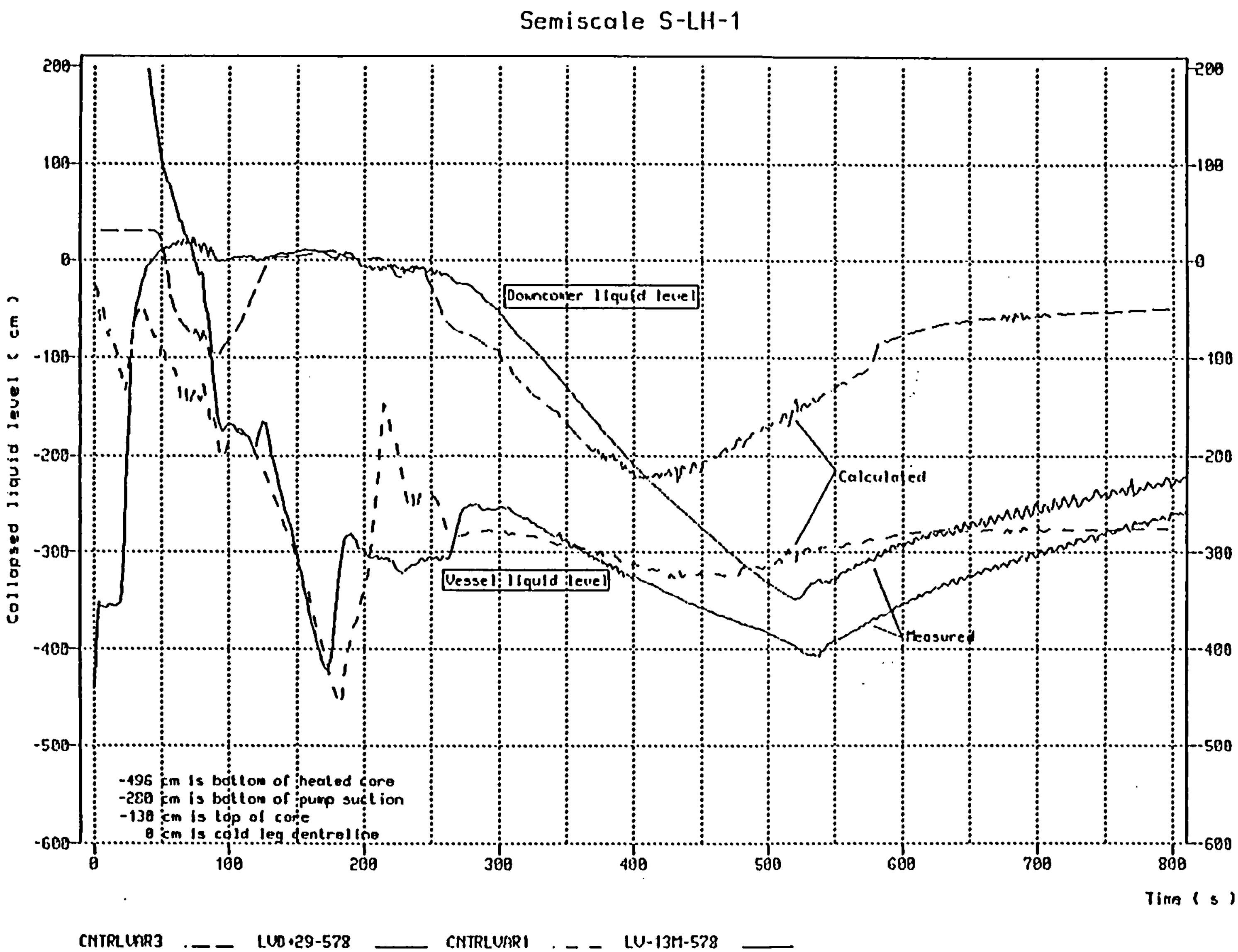


Figure 12 : Vessel and downcomer collapsed liquid levels ( Base case )

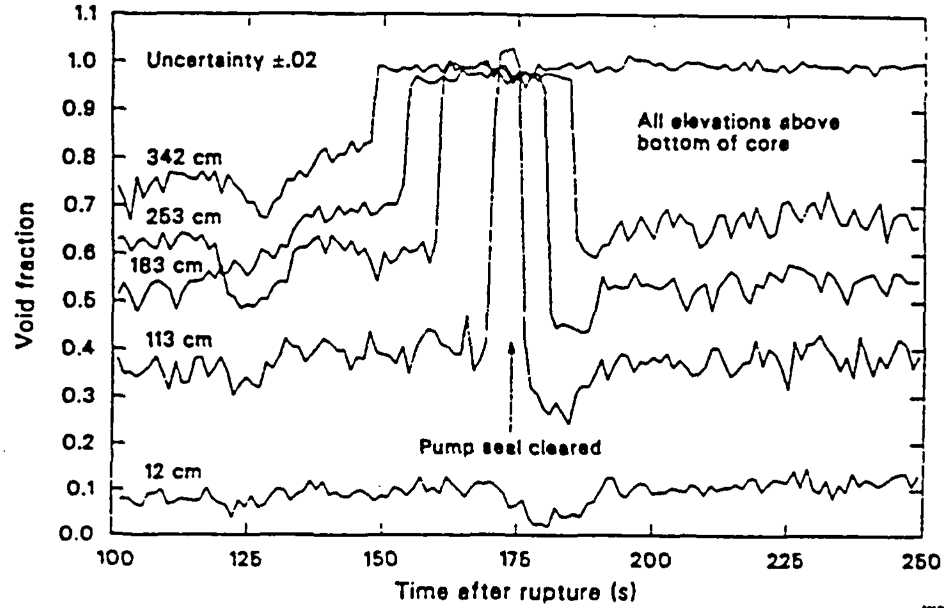


Figure 13 a : Measured vessel axial void fraction distribution during the manometric depression

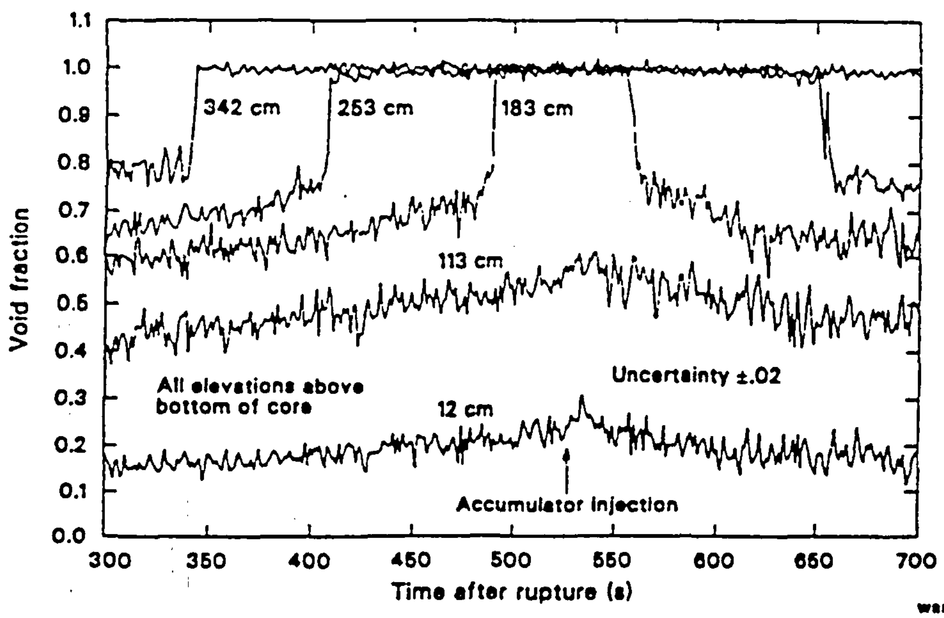


Figure 13b : Measured vessel axial void fraction distribution during core boildown

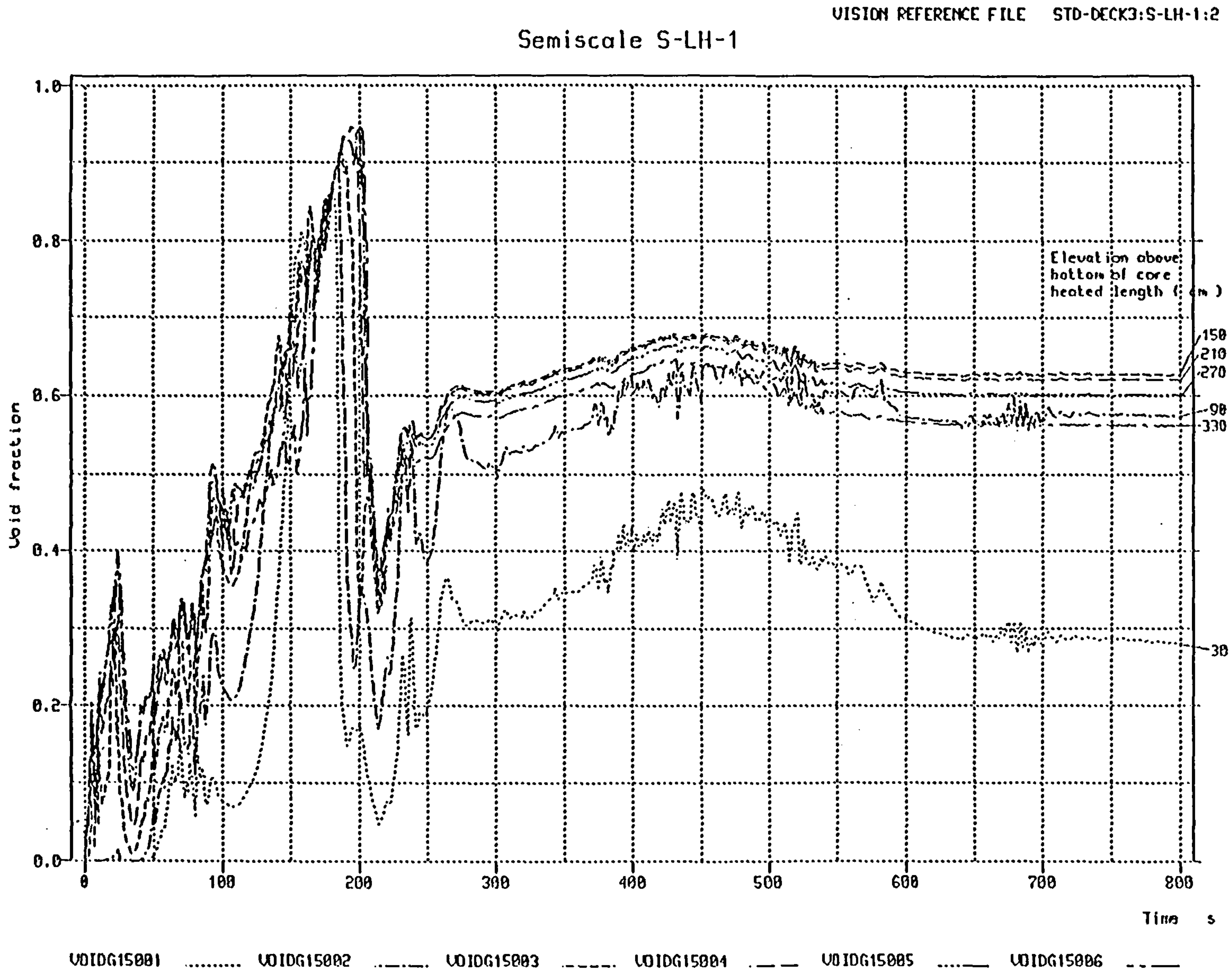


Figure 14 : Calculated core void fractions

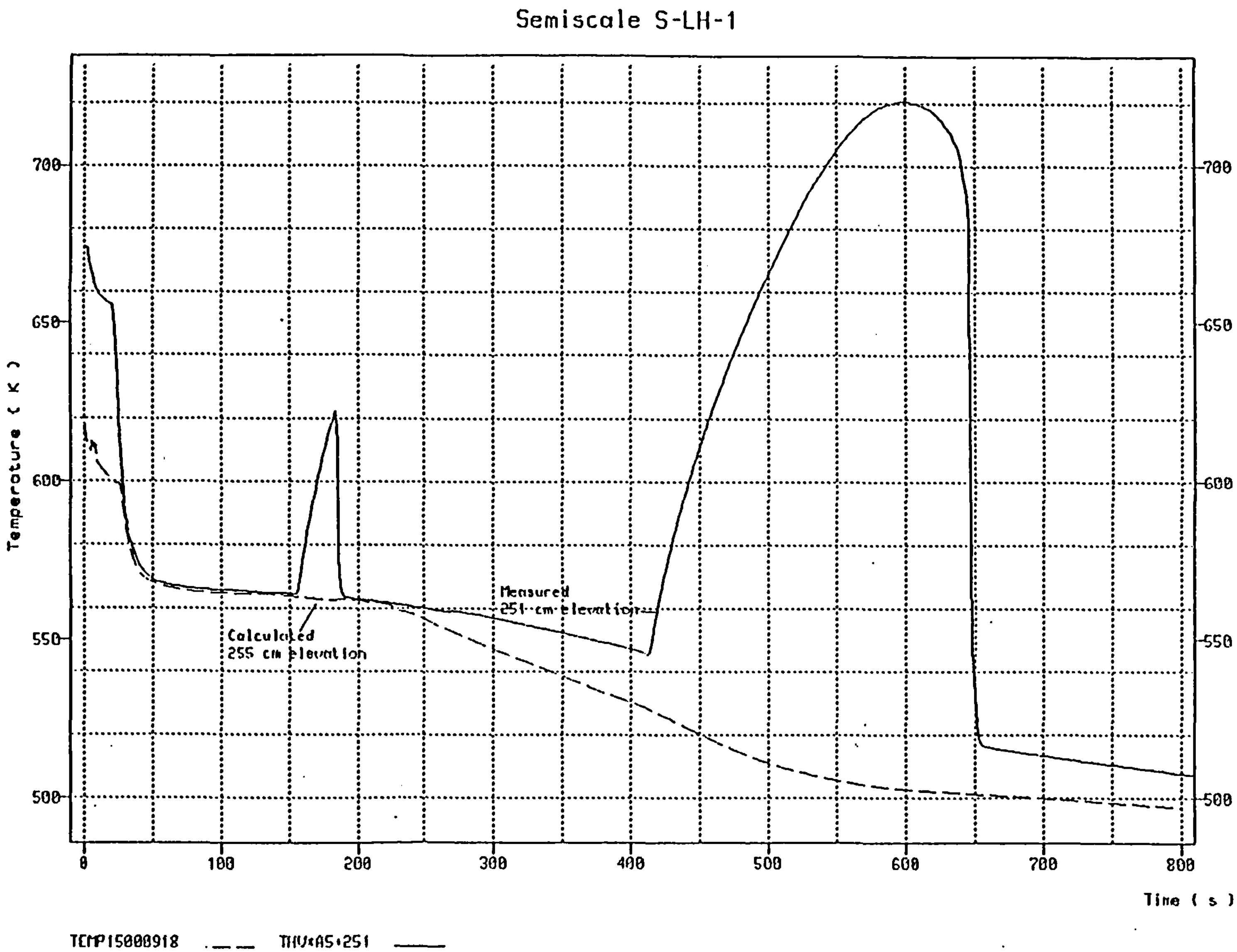


Figure 15 : Measured and calculated heater rod temperatures ( Base case )

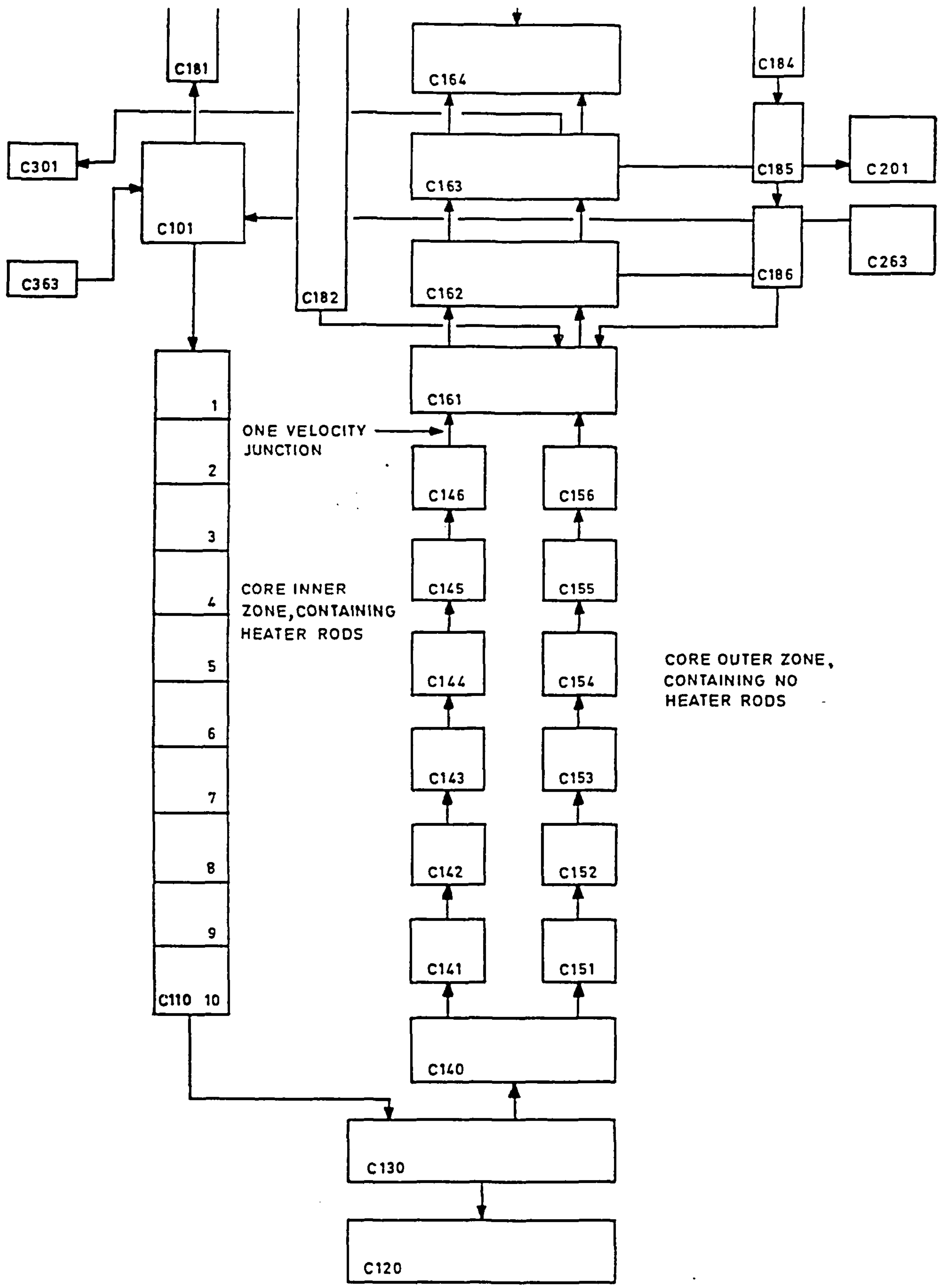


FIG.16 RENODALISATION OF THE CORE

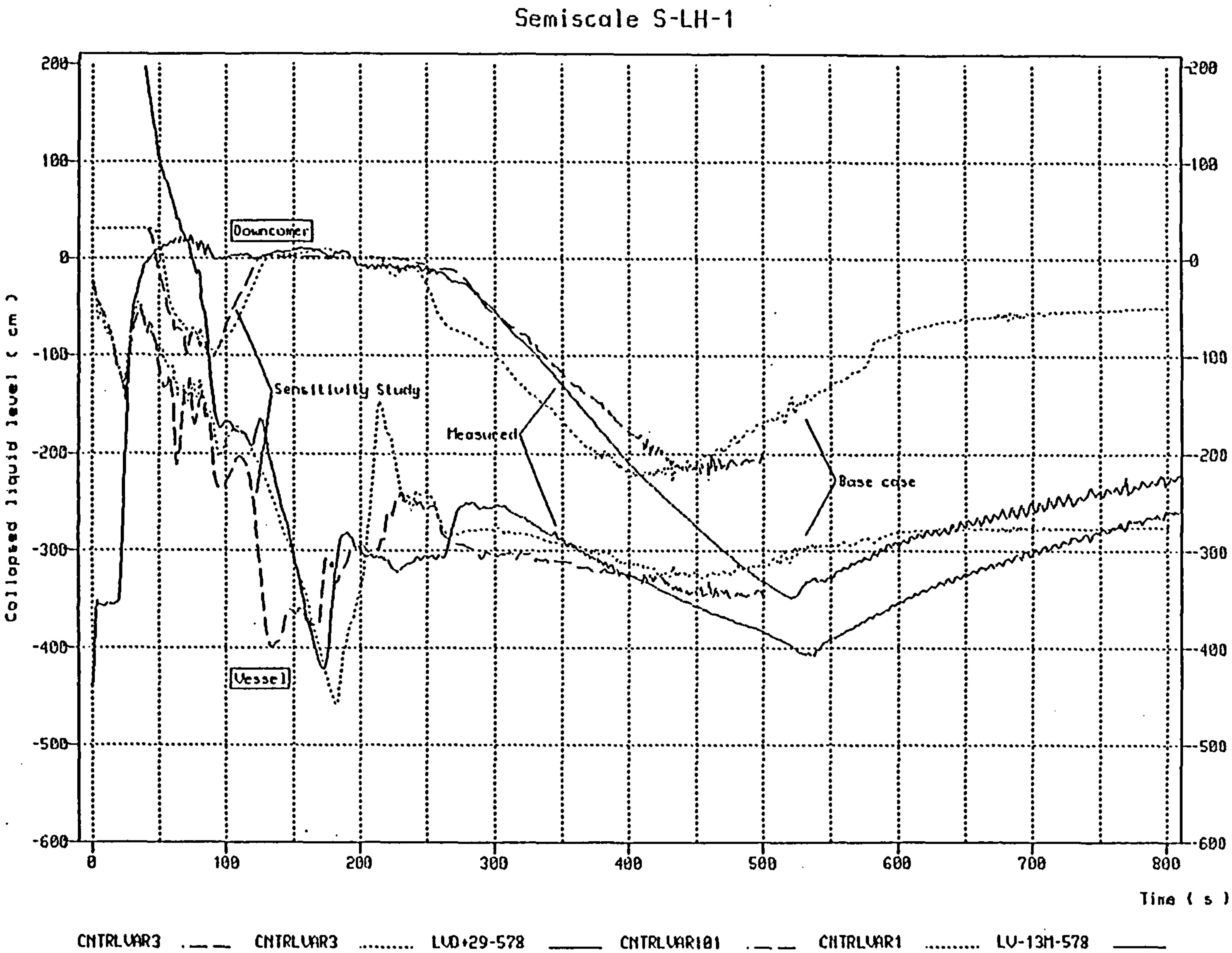


Figure 17 : Comparison of vessel and downcomer collapsed liquid levels

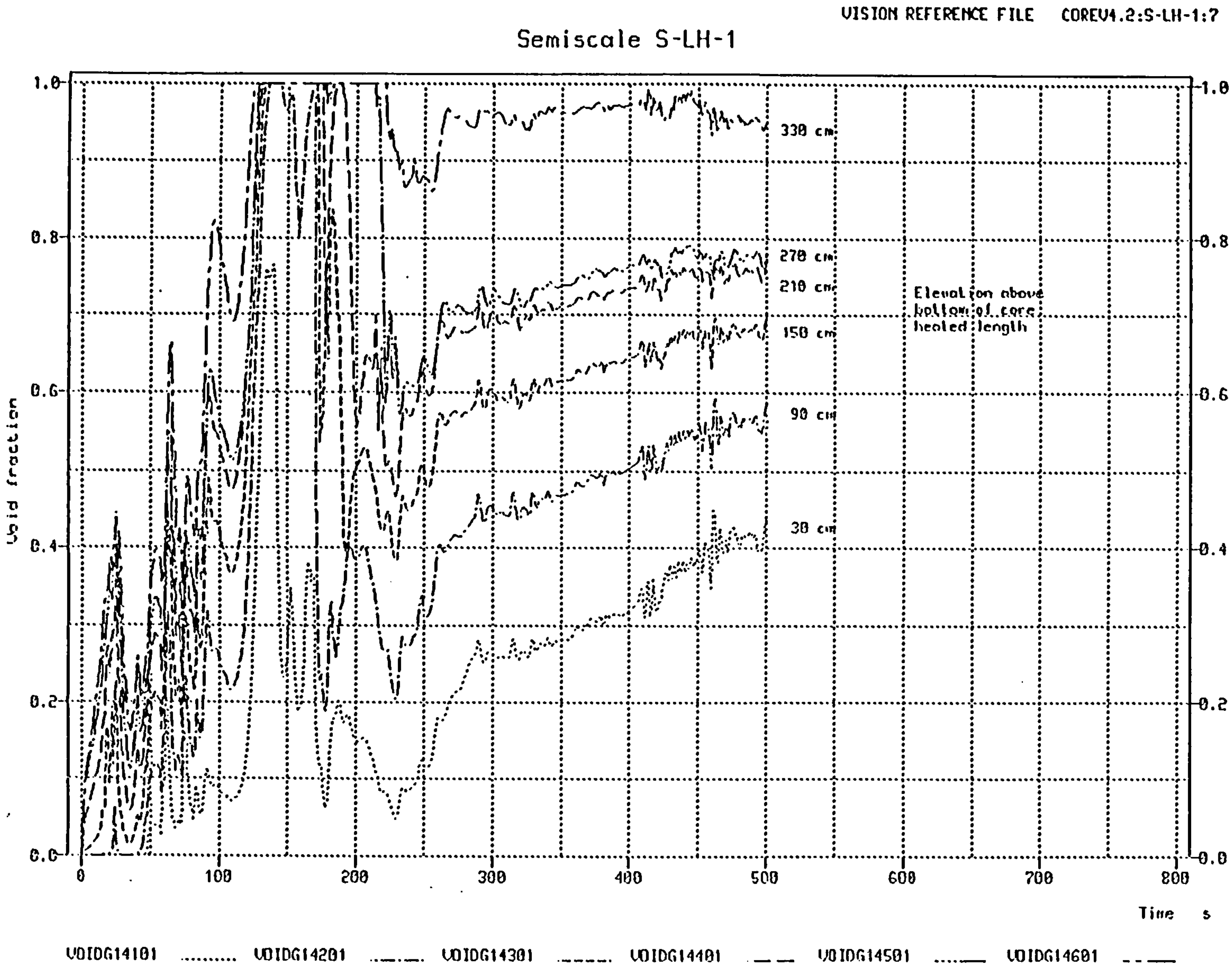


Figure 18 : Calculated core void fraction ( Sensitivity study )

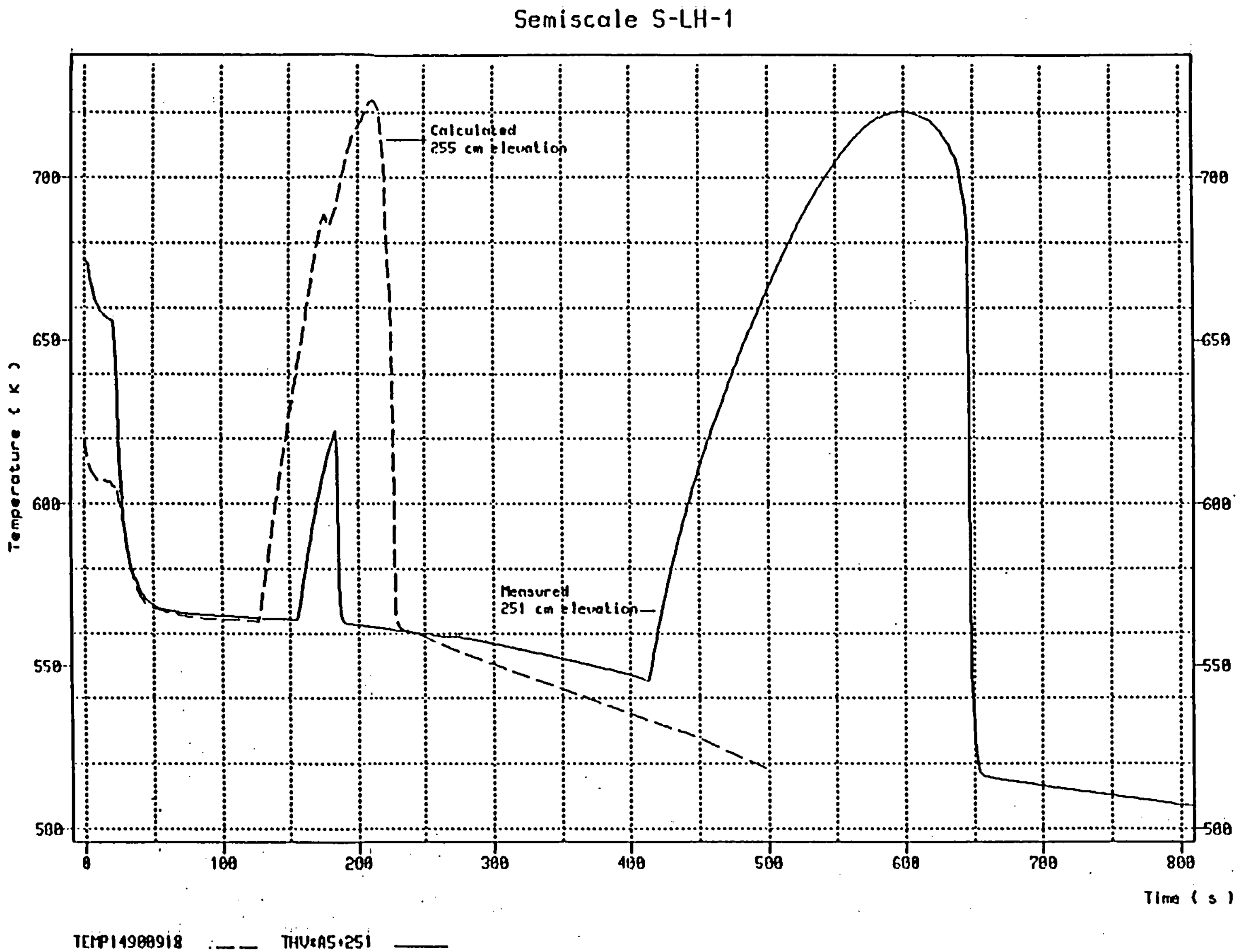


Figure 19 : Measured and calculated heater rod temperatures

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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

The RELAP5/MOD2 code is being used by GDCD for calculating Small Break Loss of Coolant Accidents (SBLOCA) and pressurized transient sequences for the Sizewell 'B' PWR. These calculations are being carried out at the request of Sizewell 'B' Project Management Team. To assist in validating RELAP5/MOD2 for the above application, the code is being used by GDCD to model a number of small LOCA and pressurized fault simulation experiments carried out in various integral test facilities. The present report describes a RELAP5/MOD2 analysis of the small LOCA test S-LH-1 which was performed on the Semiscale Mod-2C facility. S-LH-1 simulated a small LOCA caused by a break in the cold leg pipework of an area equal to 5% of the cold leg flow area.

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

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