NUREG/IA-0118
TD/SPB/REP/0130

International Agreement Report

Analysis of LOFT Test L5–1 Using RELAP5/MOD2

Prepared by
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Nuclear Electric
Barnett Way
Barnwood, Gloucester, GL4 7RS

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

May 1993

Prepared as part of
The Agreement on Research Participation and Technical Exchange
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and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

Available from

Superintendent of Documents
U.S. Government Printing Office
P.O. Box 37082
Washington, D.C. 20013-7082

and

National Technical Information Service
Springfield, VA 22161

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NOTICE

This report is based on work performed under the sponsorship of the United Kingdom Atomic Energy Authority. The information in this report has been provided to the USNRC under the terms of the International Code Assessment and Application Program (ICAP) between the United States and the United Kingdom (Administrative Agreement - WH 36047 between the United States Nuclear Regulatory Commission and the United Kingdom Atomic Energy Authority Relating to Collaboration in the Field of Modelling of Loss of Coolant Accidents, February 1985). The United Kingdom has consented to the publication of this report as a USNRC document in order to allow the widest possible circulation among the reactor safety community. Neither the United States Government nor the United Kingdom or any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability of responsibility for any third party's use, or the results of such use, or any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

TITLE: Analysis of LOFT Test L5-1 Using RELAP5/MOD2

AUTHOR/AFFILIATION: S. Cooper, Operational Performance (SW) & Analysis Section, Station Performance Branch

ADDRESSEE: HSD/PPG

DATE: January 1991

SUMMARY:

RELAP5/MOD2 is being used by Technology Division for the calculation of certain small break loss-of coolant accidents (SBLOCA) and pressurised transients in the Sizewell 'B' PWR.

To assist in validating RELAP5/MOD2 for the above application, the code is being used to model a number of small LOCA and pressurised fault simulation experiments carried out in integral test facilities. The present report describes a RELAP5/MOD2 analysis of an intermediate break LOCA test in the LOFT facility. This test was designed to simulate the rupture of a single 14 inch diameter accumulator injection line in a commercial PWR with a 25% break in the broken loop cold leg. Early in the transient the pumps were tripped and the HPIS injection initiated; towards the end of the transient, accumulator and LPIS injection began.

RELAP5/MOD2 gave reasonably accurate predictions of the system thermal hydraulic behaviour but failed to accurately calculate the core dryout which occurred due to boil-off prior to accumulator injection. The error is due to the failure to calculate the correct core void distribution during this period of the transient. A separate calculction using the RELPIN code using hydraulic data from the RELAP5 analysis gave significantly improved predictions of the core dryout. However, the peak clad temperature was underpredicted, it is believed that the error is due to the fact that the core liquid inventory in this boildown was overpredicted in the RELAP5/MOD2 calculation.

A sensitivity calculation showed that when the core void distribution and core inventory were well predicted, both RELAP and RELPIN accurately predict fuel clad temperatures.

The work in this report was carried out on behalf of PPG and HSD under Agreement TSPBSW2001, PPG Task G212(22G).

KEYWORDS:

LOFT, RELAP5/MOD2

LIST OF CONTENTS

1. INTRODUCTION

The RELAP5/MOD2 code, Reference 1, is being used by Nuclear Electric for the calculation of Small Break Loss of Coolant Accidents (SBLOCA) and pressurised transient sequences in the Sizewell 'B' PWR. To validate the code for this purpose, it has been used to model experiments of this type of transient carried out in various integral test facilities. A number of these studies have been for experiments carried out in the LOFT experimental reactor, Reference 2, and are described in References 3, 4, 5, 6 and 7.

To assist in assessing the capability of RELAP5/MOD2, the LOFT test L5-1 has been selected for analysis. This test was designed to simulate the rupture of a single 14 inch diameter accumulator injection line in a commercial PWR, equivalent to a 25% area break in the broken loop cold leg. Early in the transient the pumps were tripped and the HPIS injection initiated; towards the end of the transient, accumulator and LPIS injection began. It should be noted that for Sizewell 'B' analyses a 25% break is classified as *large*, whereas in this report, as in the external literature, this break size is referred to as *intermediate*.

The work reported here was performed by Technology Division under ICA TSPBW2001, PPG Task G212, Subtask 22G.

2. TEST DESCRIPTION

The sequence of events in the test L5-1 is given in Table 2. A brief description of the test is given below. A more complete description may be found in Reference 2.

The test was initiated from a steady state condition by operating a quick-opening blowdown valve in the cold leg. The primary pressure fell quickly, with the reactor trip occurring at 0.17s when the hot leg pressure fell below 14.2MPa. Coincident with reactor trip, the main feedwater pump was tripped and the main steam control valve started to close. HPIS injection was initiated when the hot leg pressure reached 10.6MPa, accumulator injection at 1.66MPa and LPIS at 1.08MPa. The primary coolant pumps were manually tripped in the test at 4s and the coastdown completed by 19s when the flywheels were decoupled.

3. DESCRIPTION OF THE CODE INPUT MODEL

The code version used for the calculations reported here was RELAP5/MOD2 cycle 36.05 version E05. The input model was based on that previously used by Technology Division for the analysis of LOFT small break tests LP-SB-01, LP-SB-02 and LP-SB-03, loss of feed test LP-FW-01 and the loss-of-offsite-power anticipated transient without trip test L9-4 (References 3, 4, 5, 6 and 7). The noding diagram is shown in Figure 1. Changes to the basic input deck were as follows.

1. Steady state controls were set for the loop mass flow, SG pressure and SG level. These were deleted before the transient was run.

2. The broken loop was modified with the addition of the quick opening break valve and the deletion of the components associated with the steam generator simulator. This simulator is located in the broken loop and is used for some tests but was detached from the facility for L5-1. Subcooled and two phase discharge coefficients for the break, Cd_1 and Cd_2 were both set to 1.0.

3. Feedwater to the steam generator was ramped down at the appropriate rate commencing at the time of reactor trip. The main steam isolating valve was set to start closing at the prescribed rate at the time of the reactor trip. Components representing the auxiliary feedwater were removed from the deck.

4. The reactor trip was set to occur when the intact loop hot leg pressure fell below 14.2MPa.

5. Because the primary circuit pumps are coupled to the electric motors via fluid drives, the effective moment of inertia is difficult to estimate. For this reason the pump speeds were input from the data up to 67s when the PCP-1 pump was allowed to spin freely and the PCP-2 pump was locked.

6. An accumulator and LPIS components were added to the data. These systems were connected to the HPIS injection flow path which discharges into the intact loop cold leg. Pressure setpoints for the accumulator, LPIS and HPIS injection were checked against the test conditions.

7. Core power up to and following trip was specified from data from the test as in the calculation in Reference 8.

After a steady state had been successfully achieved, the deck was processed by PYGMALION, Reference 9, to provide a full input dataset in which all the initial conditions were set at their converged steady state values. A summary of the calculated steady state is given in Table 1. The calculated steady state is in excellent agreement with the data with the exception of the steam generator feed, and hence steam flow. A calculated heat balance using the measurements suggest that, neglecting heat losses, the steam flow should be 23.3 ± 2.0kg/s.

4. COMPARISON OF RELAP5/MOD2 RESULTS WITH EXPERIMENT

Primary and secondary pressure histories are shown in Figure 2. Primary pressure falls rapidly until the subcooled break flow ends at 10s. The measured pressure then falls more slowly until the loop seal clears at about 50s. Up to this time, the RELAP5 calculated pressure is in good agreement with the data. However, in the calculation the loop seal does not clear until about 64s and the pressure continues to be held up until that time. After the loop seal has cleared, the calculated pressure falls more quickly than in the experiment and at 180s there is again good agreement with the data. The time of initiation of accumulator injection is, therefore well predicted. The accumulator and LPIS flow maintain the pressure until the end of the transient at 300s.

There is good agreement between the calculated and measured steam generator pressure. The slight difference may be attributed to either a small error in the calculated inventory or a slight mismatch in the timing of the closing of the feedwater valve and the steam control valve.

The calculated break mass flow is compared with experiment in Figure 3. The period of subcooled discharge is predicted to end at 13s. There is good agreement in the main, with the flow being slightly overpredicted from 40 to 80s, evidently as a result of the slight overprediction in pressure associated with the error in predicting the timing of the loop seal clearance, noted above. The primary system mass inventory is shown in Figure 4; there is a slight discrepancy in the initial inventory which is probably the result of approximations in the input data but is within the uncertainty of the measured value which was reported as typically ± 300kg in previous tests (Reference 4). After allowance for this offset, the calculated inventory follows the measurements accurately for the first 50s, after which the calculated break flow is evidently too high. From this point onwards, Figure 4 suggests that the break flow is slightly overpredicted until accumulator injection commences. It appears that the largest overprediction in the breakflow occurs during the two-phase discharge period from 50 to 80s.

Figure 5 shows the calculated collapsed liquid level for the loop seal upstream and downstream sides. There are no readily comparable data other than differential pressure measurements which are also shown in Figure 5 and have been arbitrarily scaled. Although the data are noisy, it appears that the loop seal begins to clear at about 25s and is completely clear at about 45s. In contrast, the calculation predicts loop seal clearance late, starting at about 50s and completing at 64s.

The collapsed liquid level in the reactor pressure vessel is shown in Figure 6. Figure 7 shows the collapsed liquid level in the core region. Conductivity probe measurements of the local void fraction in the core are reported in Reference 2. These data have been used to derive the measured collapsed liquid level curves shown in Figure 7. The large uncertainties in the calibration constants for the probes have been used to deduce the uncertainty bands shown in Figure 7. However, comparison of these data with the known elevation of the core dryout, deduced from thermocouple data, suggests that even the lower bound curve may considerably overestimate the collapsed core liquid level, implying that these curves should be considered only indicative of trends (see below). The measurements suggest that RELAP5 underestimates the liquid inventory in the core after loop seal clearing. After loop seal clearing, the data suggest a significant recovery in the core liquid level which is not captured in the RELAP5 simulation. The rate of core boildown appears well predicted prior to accumulator injection after which the rate of refilling of the core is underpredicted.

Figure 8 shows the RELAP5 calculated void fraction in the core. Note that from 10s the void fraction in the top core volume is lower than the volume below it. This reverse profile is accentuated by reverse flow through the core which is most significant from 35 to 60s (see Figure 9). During this period, liquid draining from the hot leg flows down through the core and up the downcomer where it augments the flow arriving at the break from the intact loop cold leg. The void gradient in the core slowly increases and the top most core volume is completely dry at 169s. From 80s onwards the calculated void fraction in the lowest core volume exceeds 0.4. This is because of significant steam generation due to the heat transfer from the metalwork in the lower plenum, and flashing due to depressurisation. According to the RELAP5 analysis a void fraction of 1.0 occurs only in the top half of the core and liquid quickly reappears at these levels when accumulator injection commences at 189s.

In Figures 10 to 13 the calculated fuel clad surface temperatures are compared with the measured values. RELAP5 predicts only a brief dryout of the top half of the core, for a period of about 30s, whereas the measurements indicate dryout extending over the whole core for a period up to 105s. The predicted peak clad temperature is 533K compared to the measured value of 700K.

Figures 14 and 15 compare measured and calculated HHSI, LHSI and accumulator injection flow rates. The HHSI flow rate is accurately modelled. The LHSI flow is calculated to begin 3s later than in the experiment. The flow steadily increases to 2.5kg/s from an initial level of 1.1kg/s: data indicate an initial peak of 1.75kg/s falling to about 1.0kg/s. The error in LHSI flow rate is probably due to the calculated primary system pressure being underpredicted by about 2.0 10^5Pa from 220s onwards. Accumulator injection (Figure 15) is predicted to commence at 189s, compared with 185s seen in the test. Comparison of the calculated accumulator flow rate with that deduced from the accumulator level measurements indicates that the flow rate is slightly underpredicted and the duration of the first period of injection is also underestimated (24s compared to 40s). The accumulator flow is predicted to cycle on and off whereas the measurements indicate continuous injection.

5. CALCULATION OF FUEL TEMPERATURES DURING CORE UNCOVERY

It has been found in previous similar studies (References 10 and 11), that owing to the coarse nodal representation of the core, RELAP5 is generally unable to give an accurate representation of the core void fraction distribution and core liquid level even when the core liquid inventory is accurately calculated. Therefore, the RELPIN code (Reference 12) has been developed. RELPIN extracts core hydraulic data from a RELAP5 calculation, calculates a new void fraction profile for the core using a drift flux type model. Fuel clad temperatures are then calculated assuming single phase steam cooling above the dryout front. The RELPIN calculational route gives a more conservative calculation of fuel pin temperatures in the exposed part of the core than a standalone RELAP5 analysis.

Fuel clad temperatures calculated using RELPIN with core hydraulic data from RELAP5 are compared with the measurements in Figures 10 to 13. Peak fuel clad temperature is now predicted to be 660K, compared with the measured value of 700K. Dryout is predicted to commence at 133s and the quench to be completed at 217s. The predicted heatup rate is in good agreement with the measurements, the slight differences are due to the cell positions not coinciding exactly with the measurement points. The calculated period of dryout is still slightly less than the measurements indicate at all levels in the core, hence peak temperatures are underpredicted. Figure 16 compares the dryout level calculated by RELPIN with that deduced from thermocouple data and shows quite clearly that the mixture level has been overpredicted.

6. SENSITIVITY STUDIES

The RELAP5/MOD2 calculation, discussed above is felt to give a reasonable simulation of the L5-1 test. However, two areas are evident where the predictions may be usefully improved, these being the calculated primary pressure and the calculated dryout level in the core.

Several sensitivity studies were carried out to investigate the significance of uncertainties in key parameters. The base case calculation described above was carried out on the Harwell Cray2 computer. The sensitivity calculations, along with a base case calculation, were carried out on a SUN workstation using a slightly different version of RELAP5/MOD2. It was established that the base case calculations on the workstation and the Cray gave practically identical results.

6.1 Break Flow

Although a number of factors influence the calculated rate of fall of the primary pressure, the break flow rate is often found to be the key parameter. Frequently measurements of the break flow show large fluctuations and it is difficult to quantify accurately the primary inventory at any time. RELAP5 calculations were carried out with a range of assumed values for Cd_1 and Cd_2 and the results showed that the course of the L5-1 transient was relatively insensitive to this parameter. Adoption of a value of 1.2 for Cd_1 and Cd_2 resulted in the calculated primary pressure falling slightly more rapidly than in the experiment after 70s and also resulted in the time of clearing of the loop seal being advanced from 64s to 60s, a minor improvement. The time of core uncovery was similarly advanced but there was no change in the severity of the predicted uncovery. The more rapid calculated depressurisation also resulted in the predicted time of accumulator injection being brought forward to 158s, in worse agreement with experiment than was achieved in the base case.

6.2 Core Bypass Flows

In the LOFT pressure vessel there are several flow paths that allow flow to bypass the core. The four most significant paths are modelled in the RELAP5 simulation. The bypass path through the filler gap allows the primary fluid to flow from the cold leg nozzle to the hot leg nozzle (Figure 1). Similarly there is a leakage path from the downcomer to the hot leg nozzle. There are several leakage paths from the lower plenum to the upper plenum, which are lumped together as a single core bypass in the RELAP5 model (component 235). Finally, in the broken loop, leakage between the hot leg and the cold leg through the reflood assist bypass valves is represented using junction 375.

In setting up the steady state calculation the flow resistances for the four bypasses were adjusted to give flows agreeing approximately with those quoted in Reference 13.

A sensitivity calculation was carried out in which all of the steam leakage paths, i.e. all except the one designated "core bypass", were closed. This brought the calculated time of loop seal clearing into agreement with experiment. However, there was no improvement in the predicted depressurisation rate after 40s, indicating that in the base case calculations the late clearing of the loop seal was not solely responsible for the errors in the depressurisation rate. Although the minimum elevation of the collapsed liquid level in the RPV during boildown was predicted to be lower by only 50mm in the sensitivity calculation, the peak clad temperature was higher by about 40K. This sensitivity of peak clad temperature to the calculated core collapsed liquid level highlights an inherent uncertainty in the RELAP5 predicted peak clad temperatures in boildown transients of this type.

6.3 Core Filler Gap Inlet Loss Coefficients

In a previous analysis of LOFT test L5-1 using RELAP5/MOD2 carried out at the Korea Nuclear Safety Centre (Reference 14), peak clad temperatures were better predicted than in the present analysis. Examination of the KNSC input deck indicated a number of differences from the deck used in the present analysis. Each difference has been systematically investigated and only one change has been identified which improves the present predictions.

In the base case calculation the loss coefficients at the inlet at the top of the filler gap (volume 223, Figure 1) are set at 52.0 which is the value used by the INEL originators of the deck. The KNSC calculation used a value of 15.0. A sensitivity calculation was carried out in which these loss coefficients were set to zero. Timings of the main events are shown in Table 2. The predicted pressure, break flow and primary inventory were similar to the base case. The collapsed liquid level in the RPV, Figure 17, shows a slightly more severe uncovery than the base case while the core void profile, Figure 18, shows that from 170s until recovery the core is completely empty. Consequently, RELAP predicts a core heat-up and peak clad temperatures which are in much better agreement with the data, Figures 19-22. A RELPIN calculation is also shown which overpredicts peak clad temperatures. This is due to the delay in predicting accumulator injection, Figure 23. This Figure also suggests that the uncovery is overpredicted.

The significant difference between the base case calculation and this sensitivity calculation was an increase in the flow out of the top of the filler gap from 40s onwards. This increase in flow was drawn mainly from the downcomer and reduces the steam flux from the lower plenum into the core, and from 110s to 150s there was a liquid flow out of the bottom of the core (c.f. a steam flow into the core during the same period of the base case). The combined effect of the lower collapsed liquid level and the reduction in the steam flow through the core, resulted in a more severe core dryout.

Although it is likely that the overprediction of core uncovery could be reduced by adjustment of the loss coefficients at the filler gap inlet, this has not been attempted.

7. DISCUSSION

The present base case analysis of the LOFT intermediate break test L5-1 used RELAP5/MOD2 cycle 36.05 version E05. The analysis gave a satisfactory representation of the depressurisation rate and system mass inventory but peak clad temperatures were about 150K lower than measured. Previous analyses using RELAP5/MOD1 (References 8 and 13) also successfully predicted the main features of the transient and gave a better prediction of peak clad temperatures.

The present calculation showed a uniform core void fraction distribution during the boildown period as seen in previous similar analyses with RELAP5/MOD2 (Reference 10). This tends to confirm earlier conclusions that RELAP5/MOD2 cannot be used to reliably calculate the core dryout elevation, and core heatup above the dryout level, for core boildown sequences using the current nodalisation. Failure to calculate the correct void fraction distribution and dryout behaviour is believed to be largely due to numerical approximations in the implementation of interphase drag modelling and as a consequence of representing the core by a small number of nodes (Reference 10). Croxford (Reference 15) showed a significant improvement in the predicted void profile in going from 6 to 24 cells. Such fine noding would be impractical for plant calculations and the RELPIN approach has been developed as an alternative. The RELPIN calculation described above (using 12 cells) provided a better prediction of the dryout and peak clad temperatures. Peak clad temperatures were still underpredicted, but this is due to an overestimate of the liquid inventory in the core during boildown in the RELAP5 calculation.

A sensitivity calculation showed that the core void fraction was very sensitive to the flow in the RPV filler gap. This is a feature unique to the LOFT test facility and its complex geometry and an absence of measurements prevent it being modelled accurately. In the sensitivity calculation, in which the flow resistance of the filler gap was reduced, the modified flow conditions in the filler gap resulted in the core uncovery being slightly overpredicted. Note that in this case the RELPIN predictions for the fuel clad temperatures were very good, the overprediction of peak clad temperatures being due to the late prediction of accumulator injection. In practice, the flow resistance of the filler gap is not known with any confidence. Overestimation of this parameter may well be responsible for the underestimation of the extent of the core uncovery in the base case calculation.

8. CPU TIME

The base case calculation was performed using RELAP5/MOD2 cycle 36.05, UK version E05, on a Cray 2 computer. The calculation used 607s of CPU time for the 300s of problem time. The repeat of the base case calculation on a SUN Sparc workstation required a CPU time of 6640s for 300s problem time.

9. CONCLUSIONS

1. This report has described the results of a RELAP5/MOD2 calculation of LOFT test L5-1, which simulated a 25% cold leg break loss of coolant accident with operation of the high head safety injection (HHSI), low head safety injection (LHSI) and accumulator injection systems.

2. The calculation gives a reasonable simulation of the Loft L5-1 test. Depressurisation rate, break flow, primary coolant inventory and emergency core cooling system injection flow rates were all well predicted.

3. RELAP5/MOD2 did not give a realistic prediction of the liquid distribution within the core during the boildown. Consequently the fuel temperature excursion due to uncovery was not predicted 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 as a consequence of representing the core by a small number of nodes.

4. A supplementary calculation using the RELPIN code using core inventory data from RELAP5/MOD2 gave significantly improved predictions of fuel clad temperatures. Residual underprediction of peak clad temperatures is apparently due to an overprediction of liquid inventory in the core during boildown in the RELAP5/MOD2 calculation.

5. The predicted core uncovery was found to be sensitive to the flow behaviour of the RPV filler gap. Since this feature is unique to the LOFT test facility, it is unlikely that plant calculations will exhibit similar behaviour. Errors in estimating the filler gap resistance may be responsible for the underestimation of the extent of the core uncovery in the RELAP5/MOD2 calculation.

10. ACKNOWLEDGEMENT

The author would like to acknowledge Mr C Harwood who carried out the preliminary dataset preparation for this work.

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Table 1 - Initial Steady State Conditions

Parameter	Measured Value	RELAP
Core power (MW)	45.9 ± 1.2	45.9
Hot leg pressure (MPa)	14.93 ± 0.08	14.92
Hot leg temperature (K)	579.1 ± 0.9	579.4
Cold leg temperature (K)	552.3 ± 0.9	551.5
Mass flow rate (kg/s)	308.2 ± 4.0	308.2
Pressuriser level (m)	1.13 ± 0.03	1.14
SG secondary temperature (K)	537.8 ± 0.8	538.5
SG pressure (MPa)	5.05 ± 0.06	5.11
SG level (m)	3.22 ± 0.02	3.22
SG feed flow (kg/s)	25.3 ± 0.06	23.86

Table 2 - Sequence of Events

Event	Measurement Time (s)	Base case Time (s)	Sensitivity (fill gap) Time (s)
Cold leg QOBV opened	0.0	0.0	0.0
Reactor trip (14.2MPa)	0.17 ± 0.01	0.05	0.10
HPIS trip (10.2MPa)	0.4 ± 0.1	0.5	0.45
Subcooled break flow ended	10.5 ± 0.5	13.0	13.0
Pressuriser indicated empty	15.5 ± 0.5	11.0	11.0
Loop seal cleared	50.0 ± 5	64.0	64.0
Primary pressure below secondary	53.0 ± 1.0	41.3	41.6
Clad temperature excursion started	108.4 ± 1.0	169.0	141.0
Accumulator trip (1.66MPa)	185.8 ± 0.5	189.0	199.0
LPIS flow initiated	201.0 ± 0.5	204.0	212.8
Clad Quench complete	213.0 ± 1.0	200.0	280

List of Figures

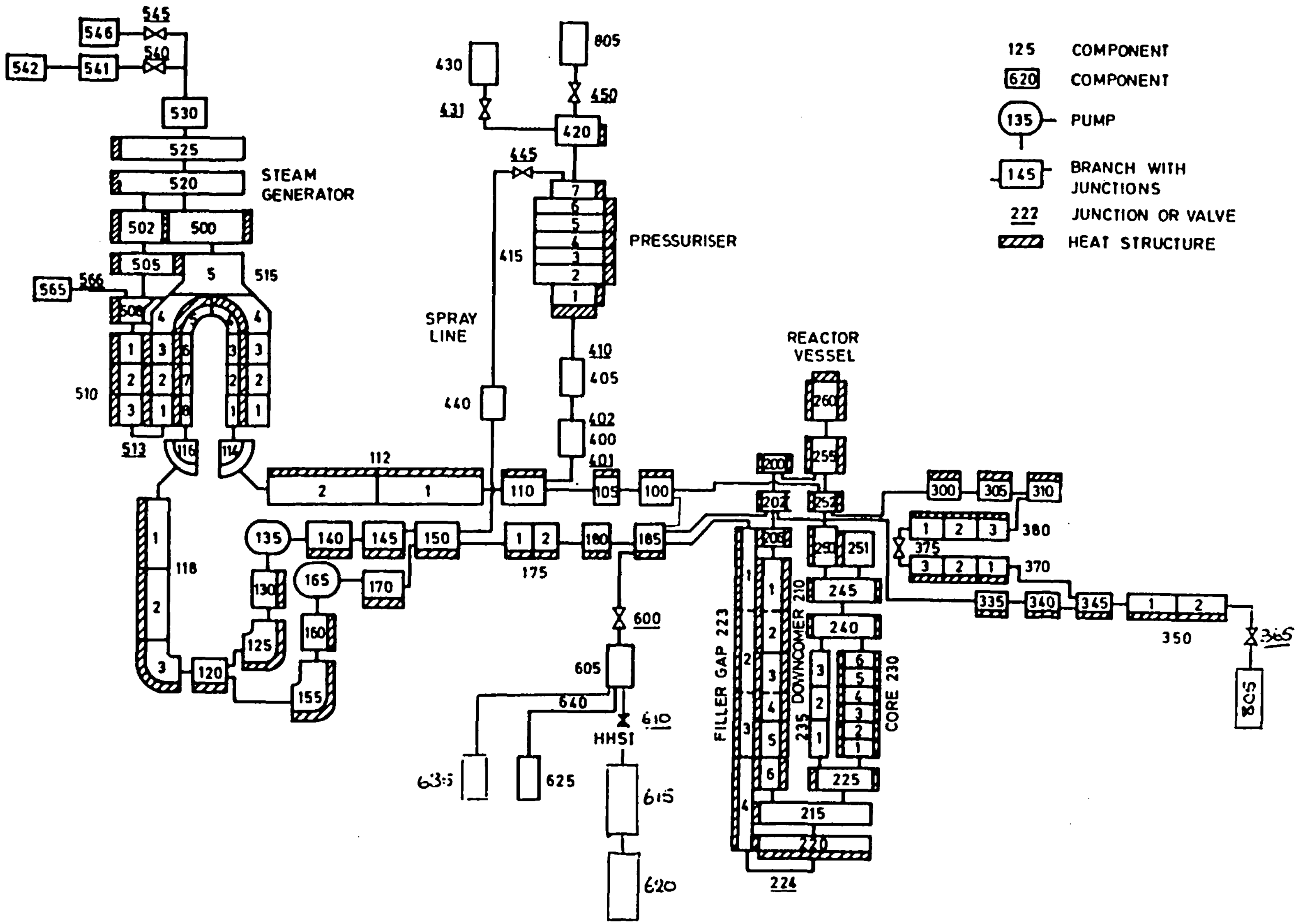

FIGURE 1 RELAP5/MOD2 Noding Diagram for Calculation of LOFT L5-1

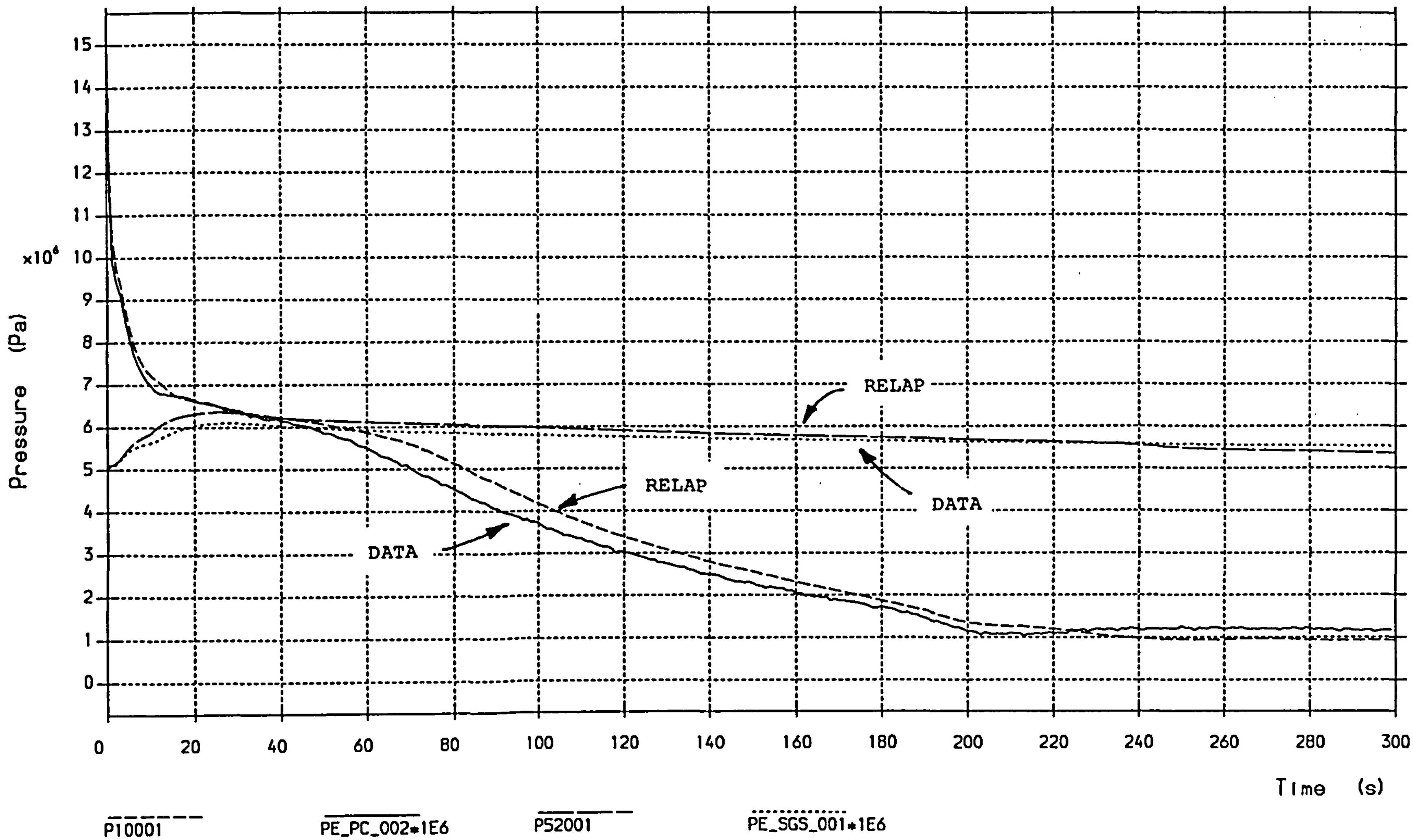

Figure 2. Primary and Secondary Pressure

Nuclear Electric - TOPAS Graphics

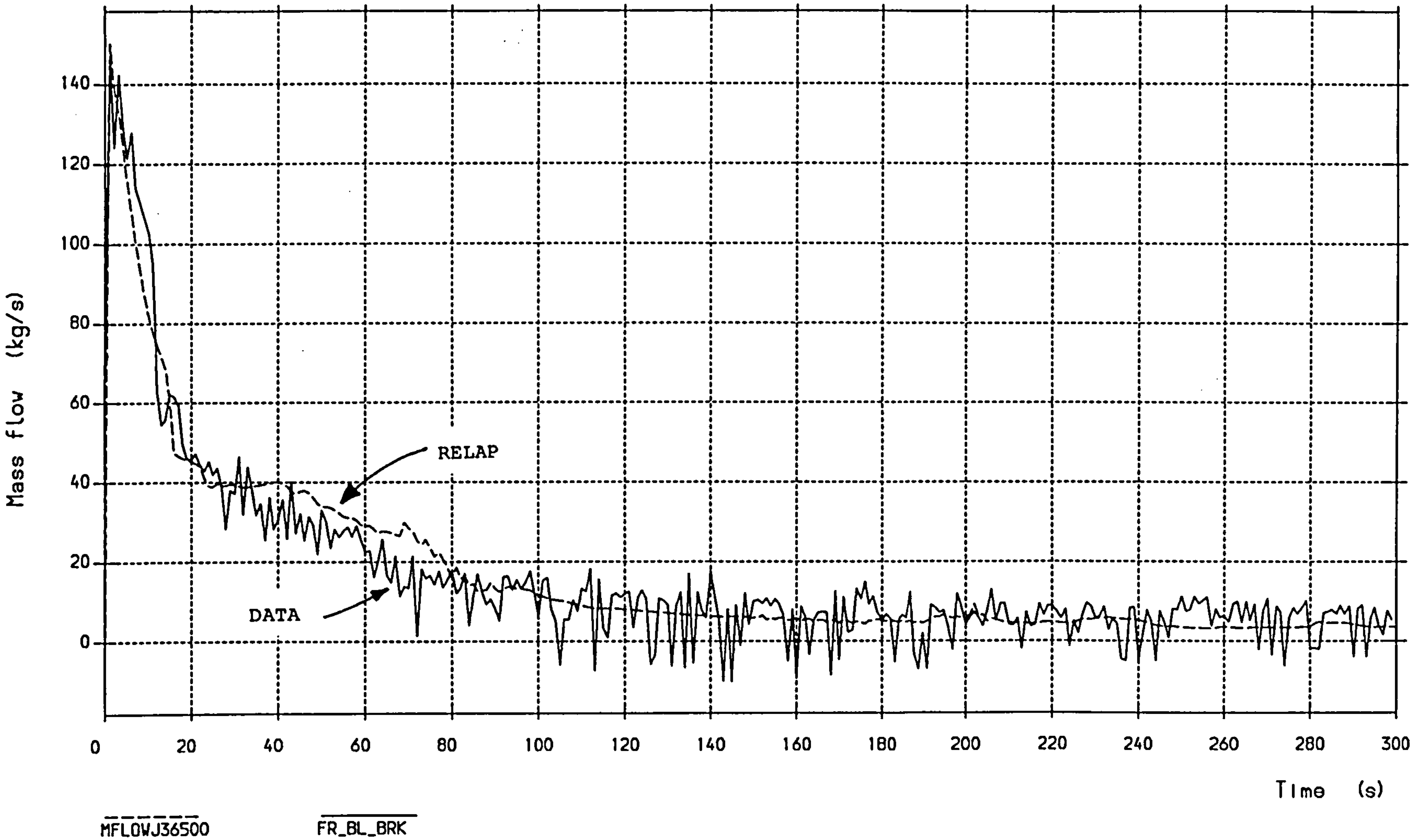

Figure 3. Break flow

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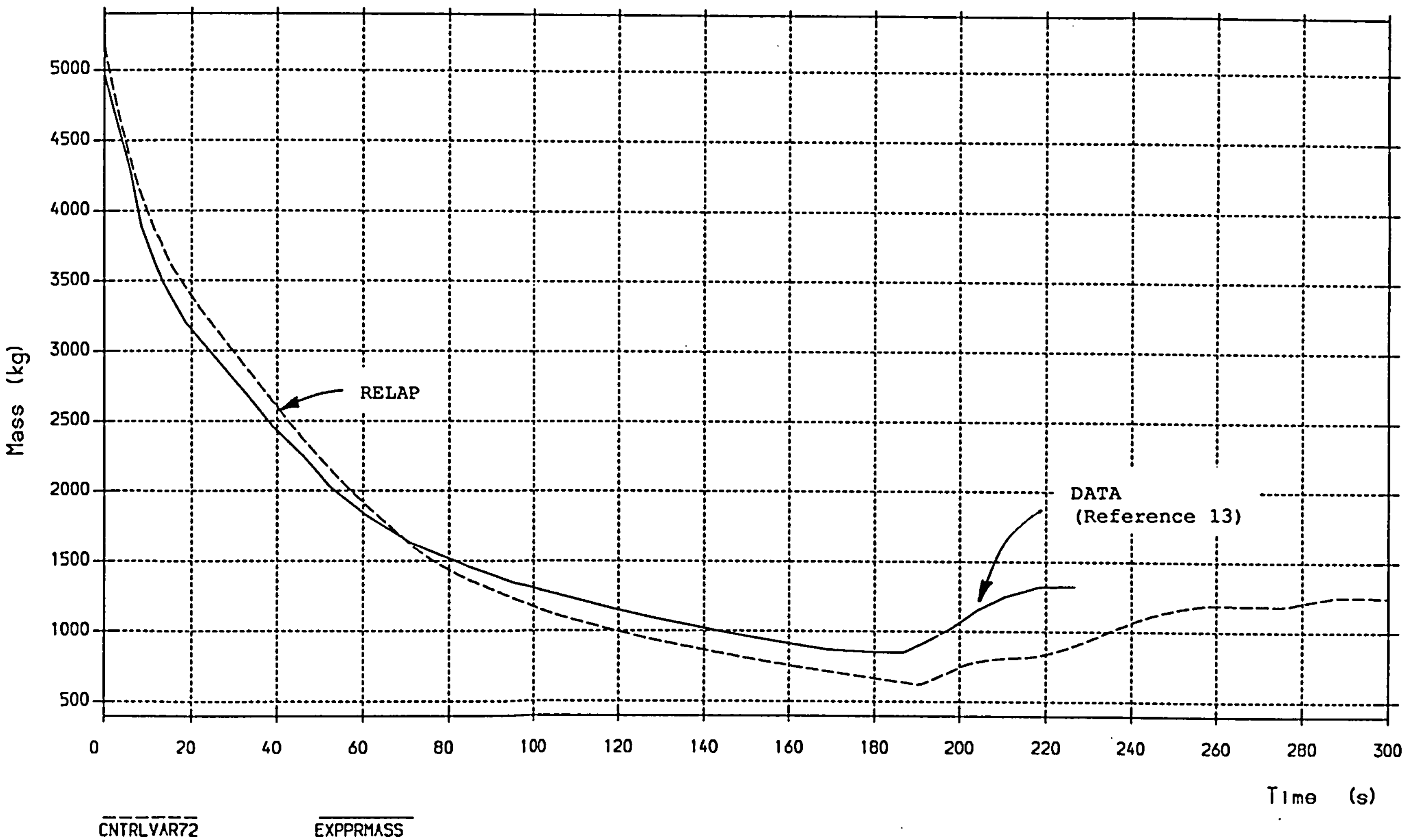

Figure 4. Primary fluid inventory

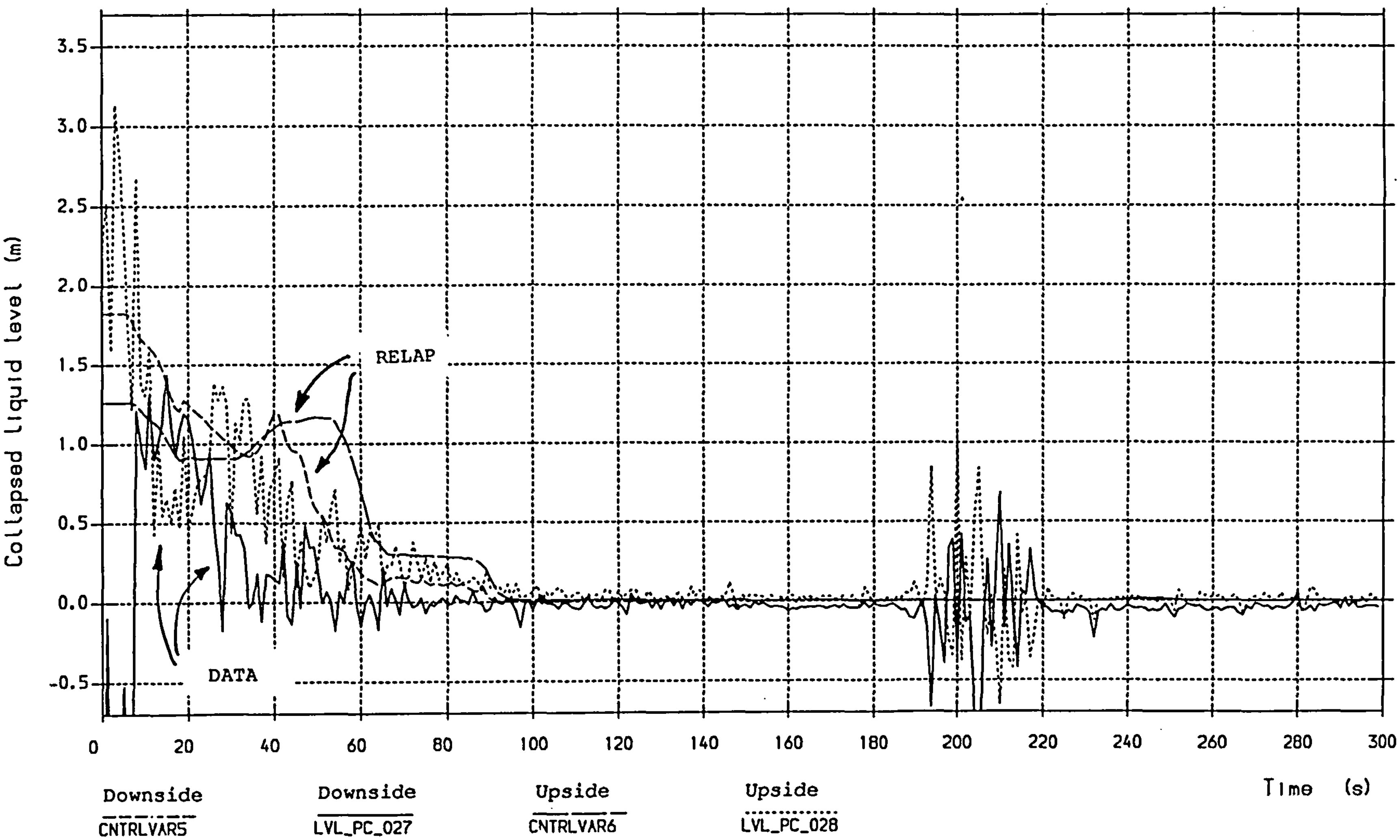

Figure 5. Loop seal collapsed liquid level

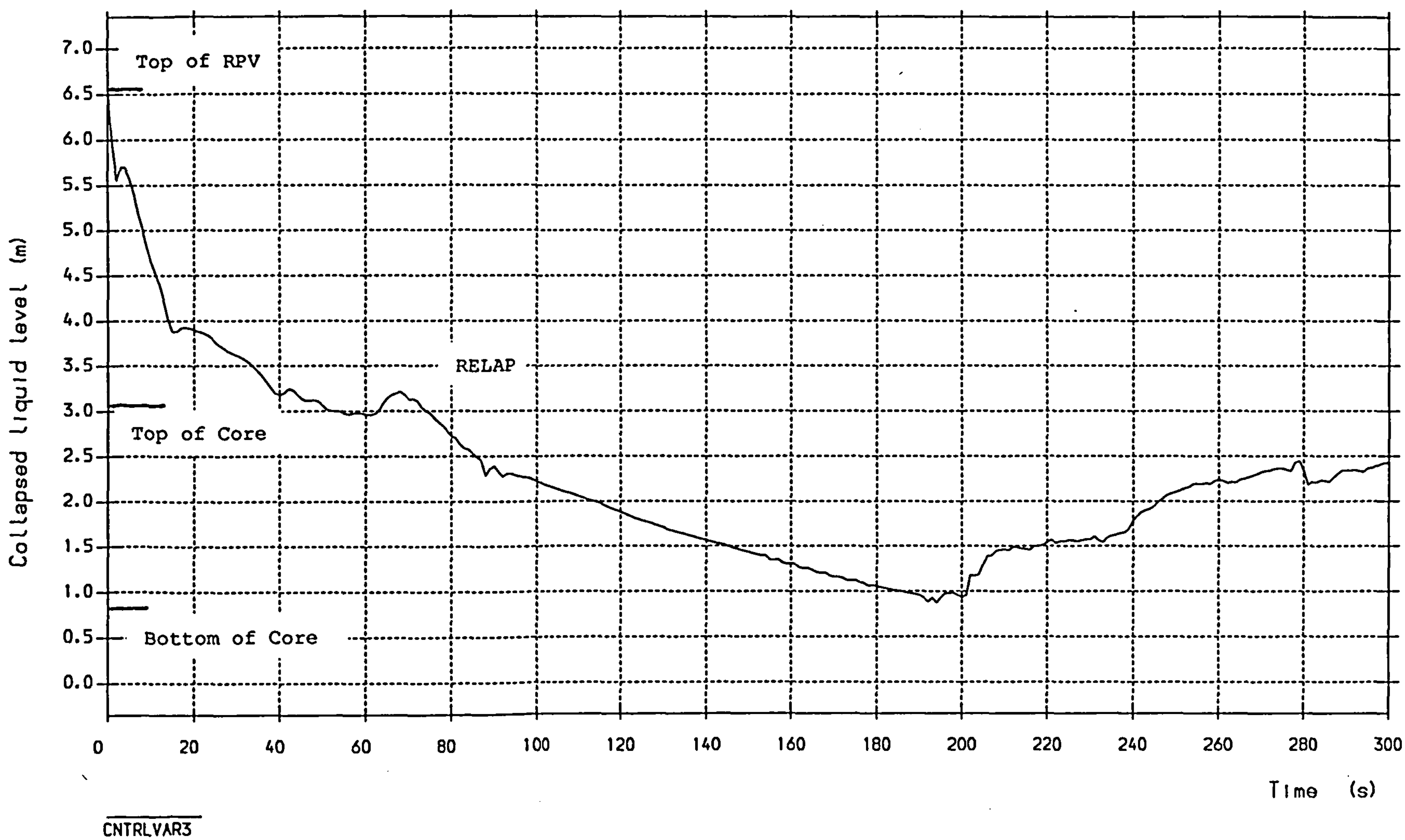

Figure 6. RPV collapsed liquid level

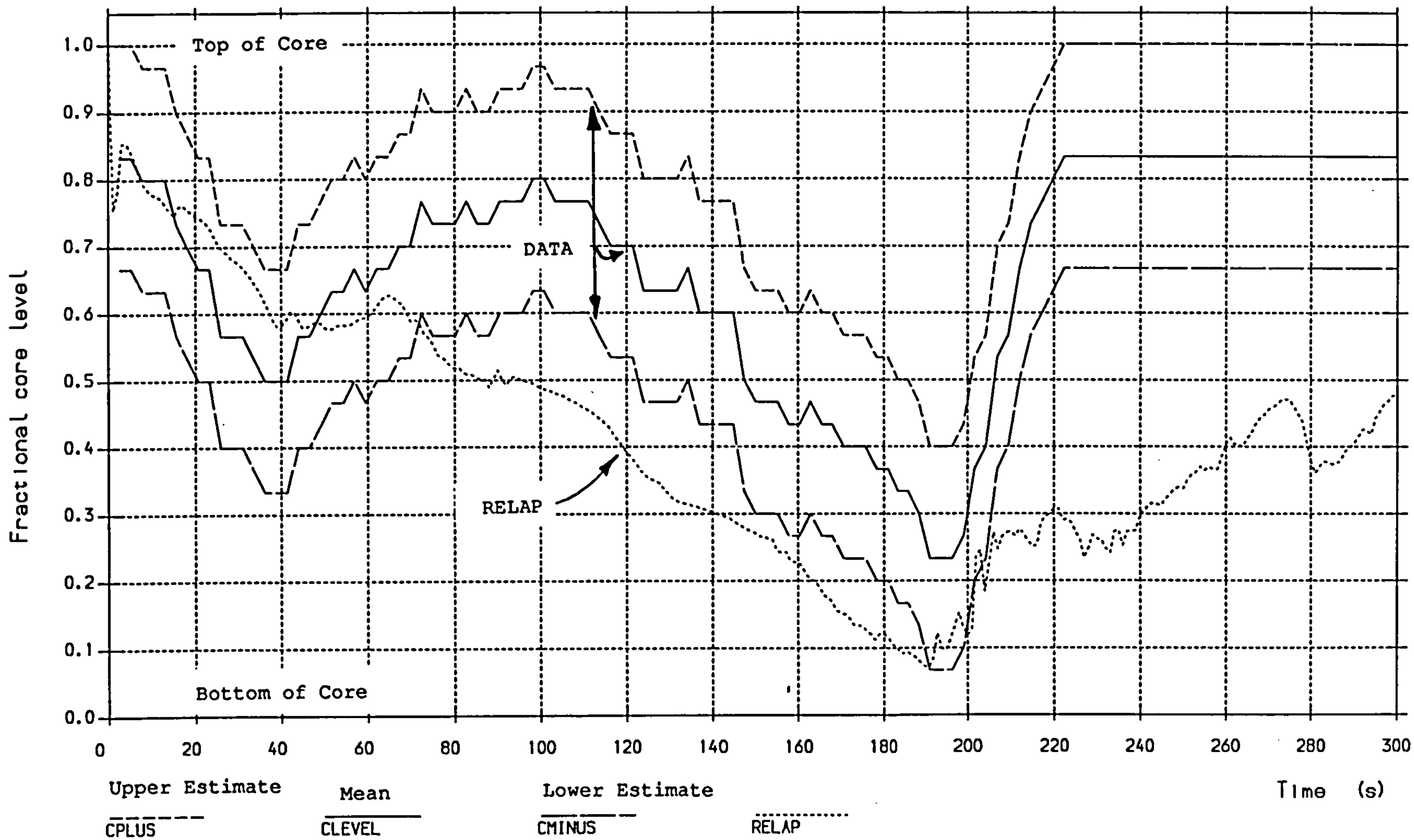

Figure 7. Core collapsed liquid level

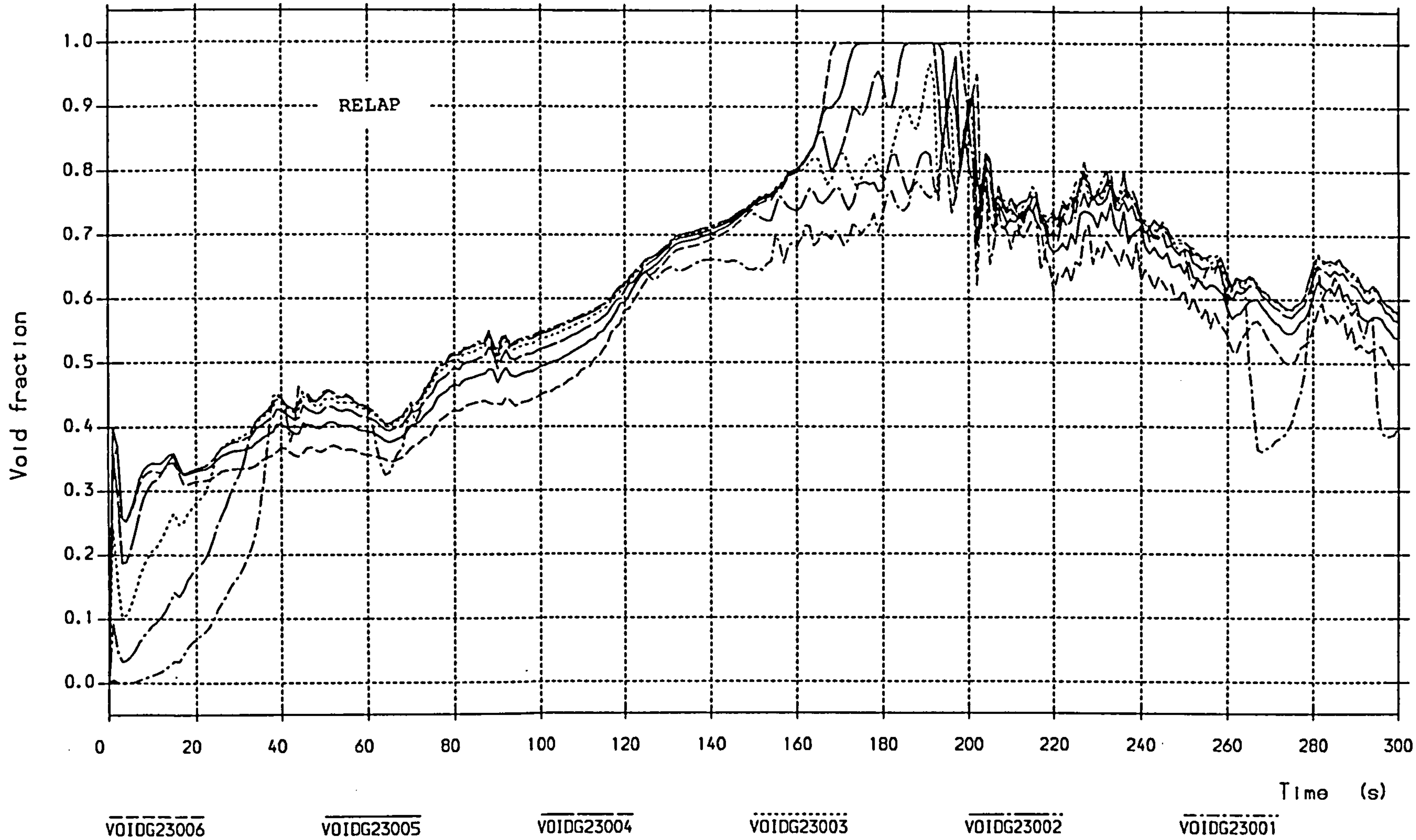

Figure 8. Core Void fractions

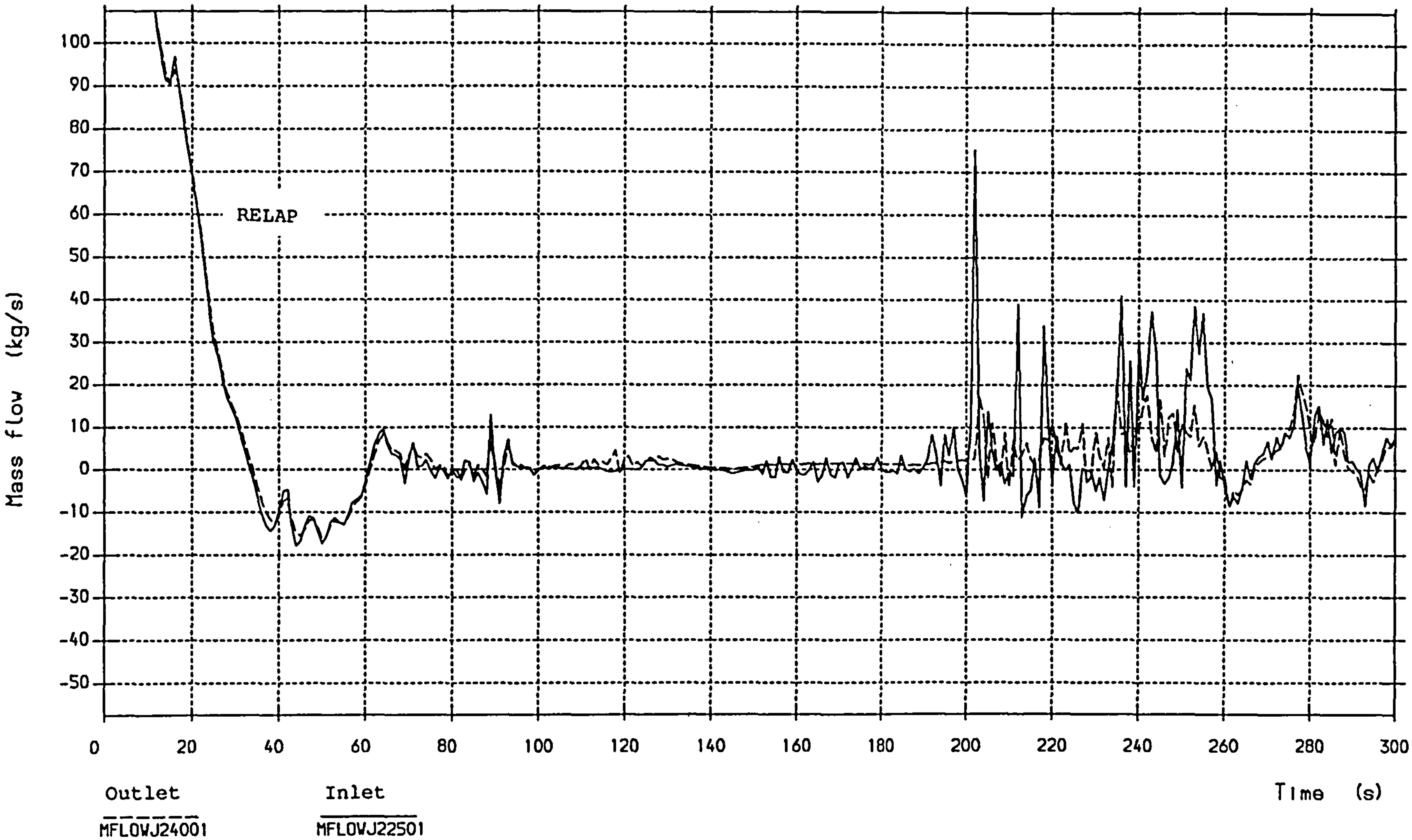

Figure 9. Flow through core

Nuclear Electric - TOPAS Graphics

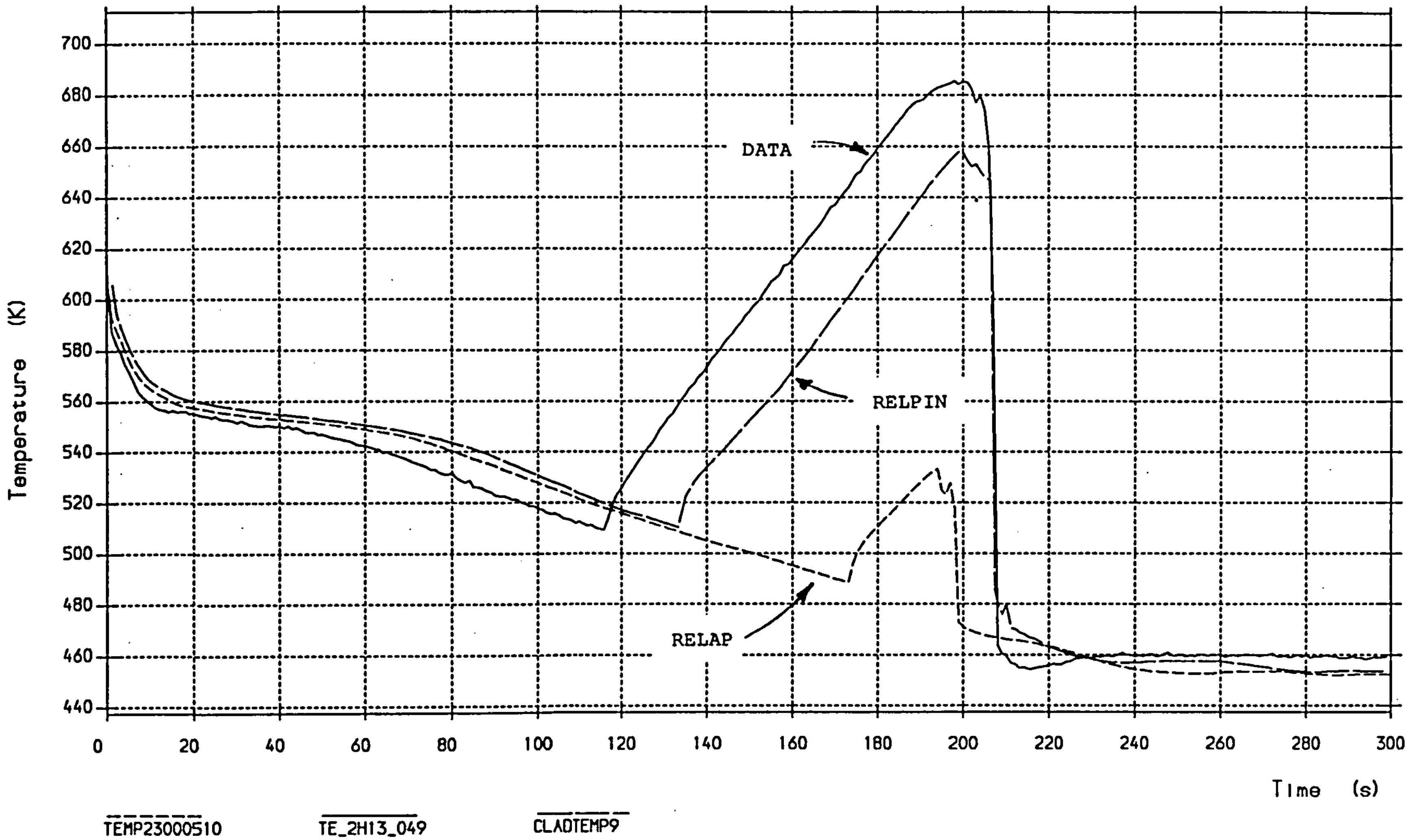

Figure 10. Fuel clad surface temperatures - (Elevation 1.33m)

Nuclear Electric - TOPAS Graphics

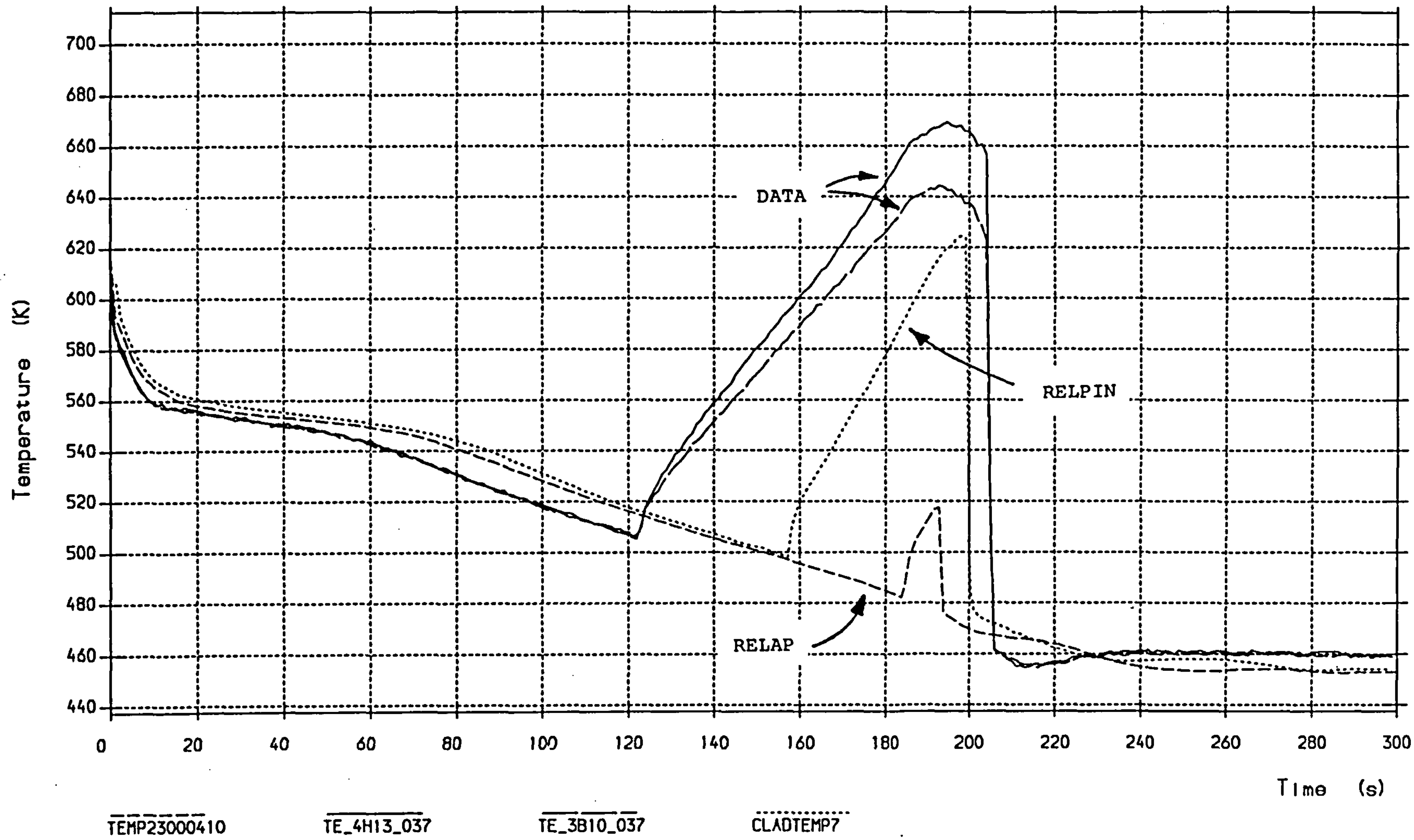

Figure 11. Fuel clad surface temperatures - (Elevation 0.91m)

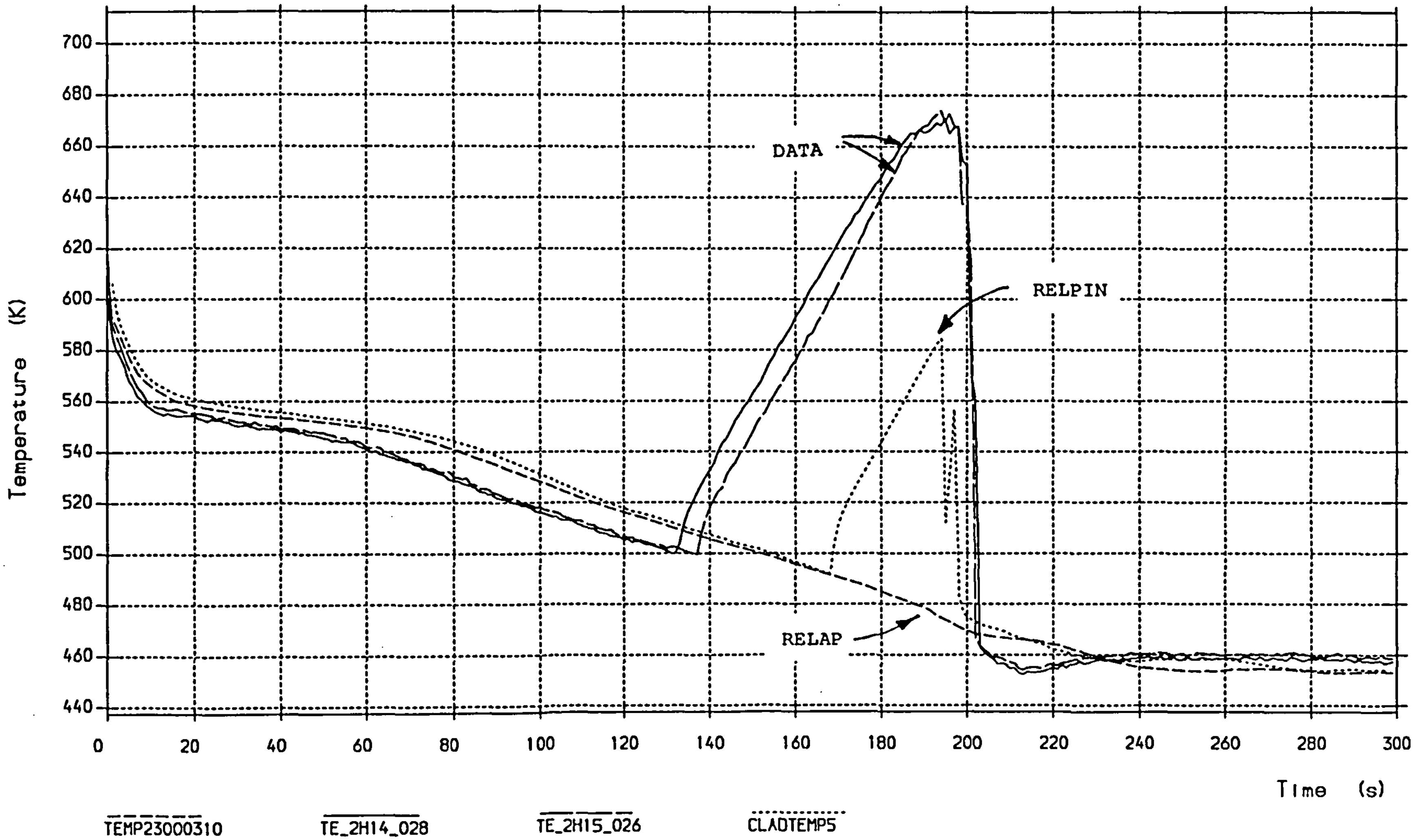

Figure 12. Fuel clad surface temperatures - (Elevation 0.63m)

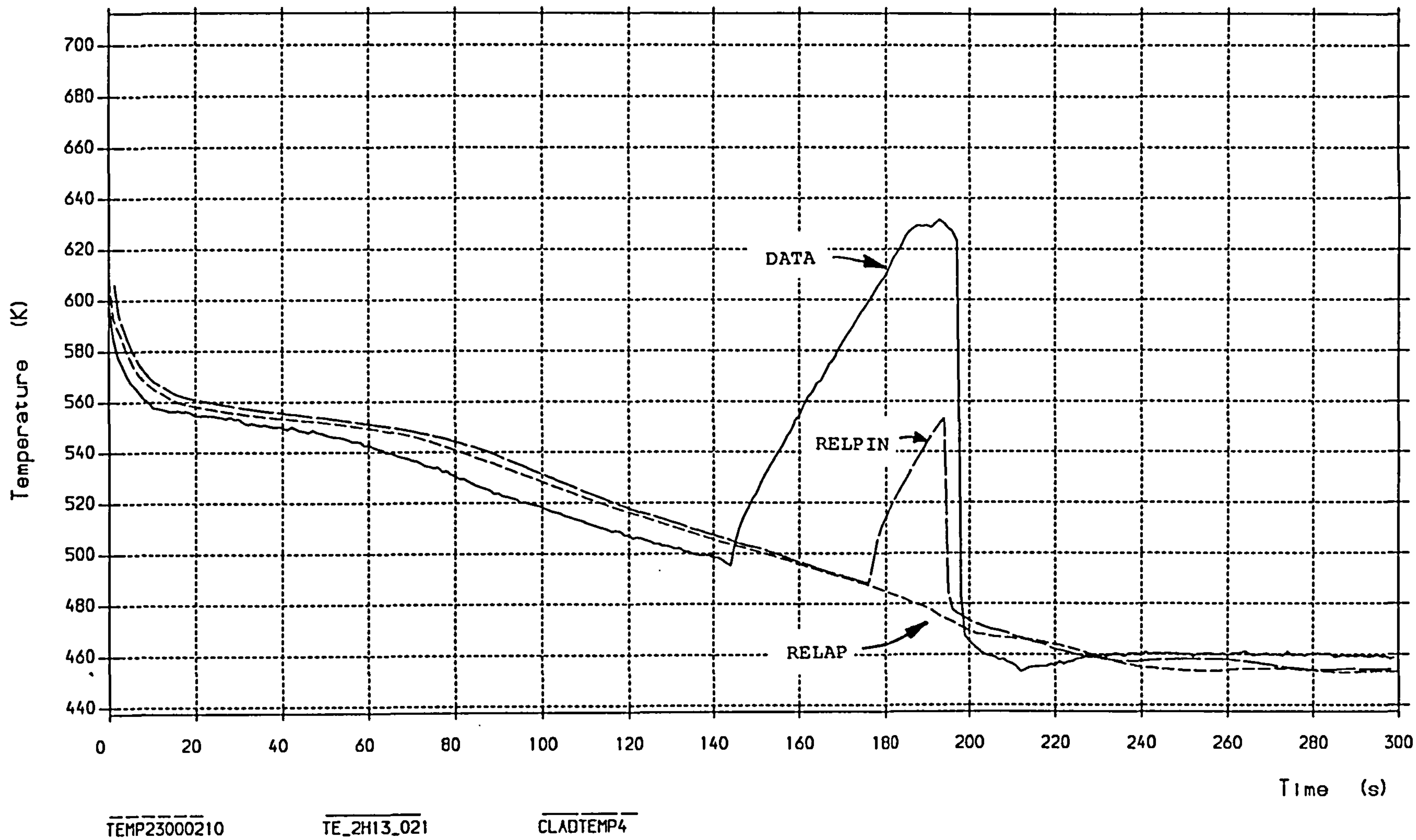

Figure 13. Fuel clad surface temperatures - (Elevation 0.49m)

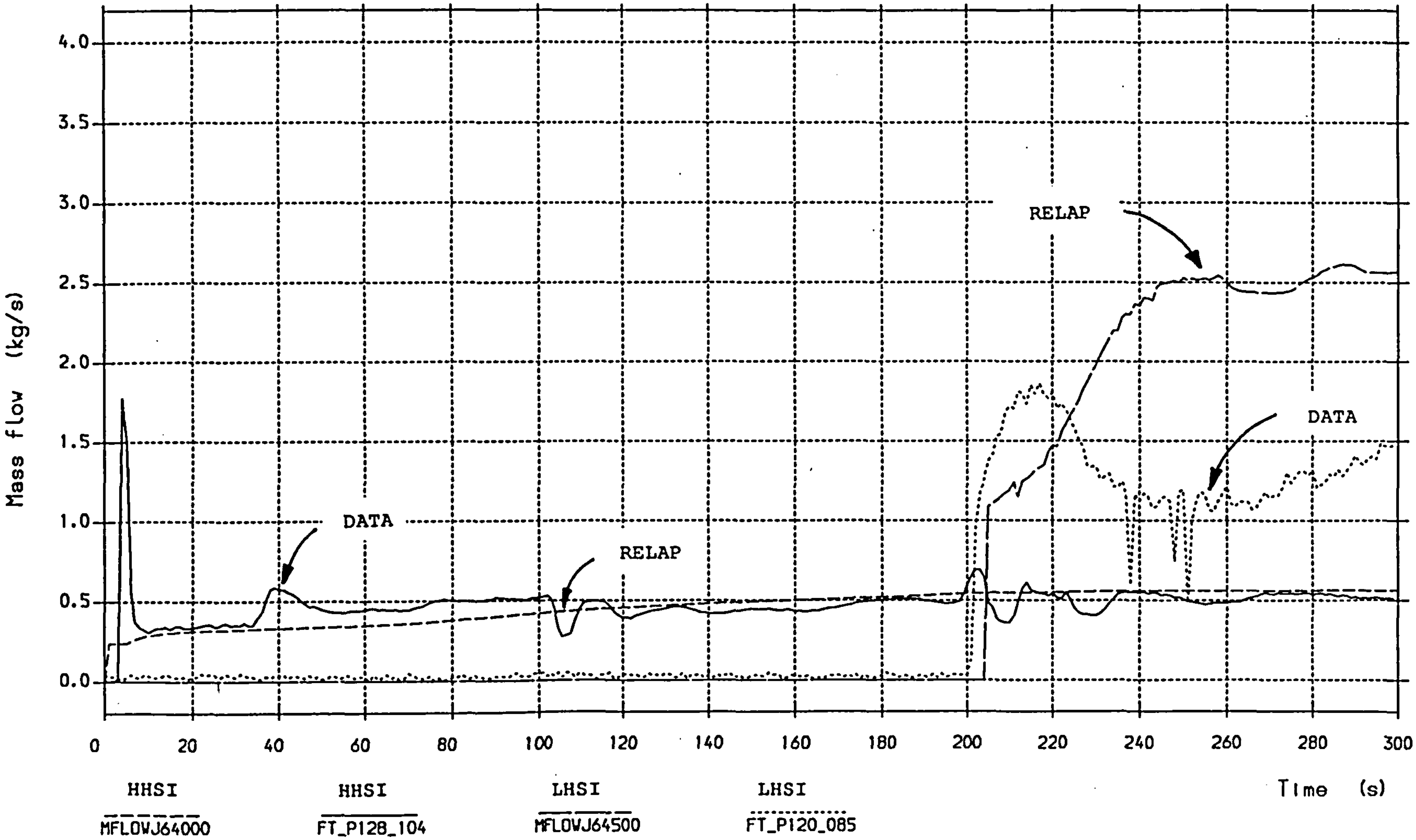

Figure 14. HHSI and LHSI flows

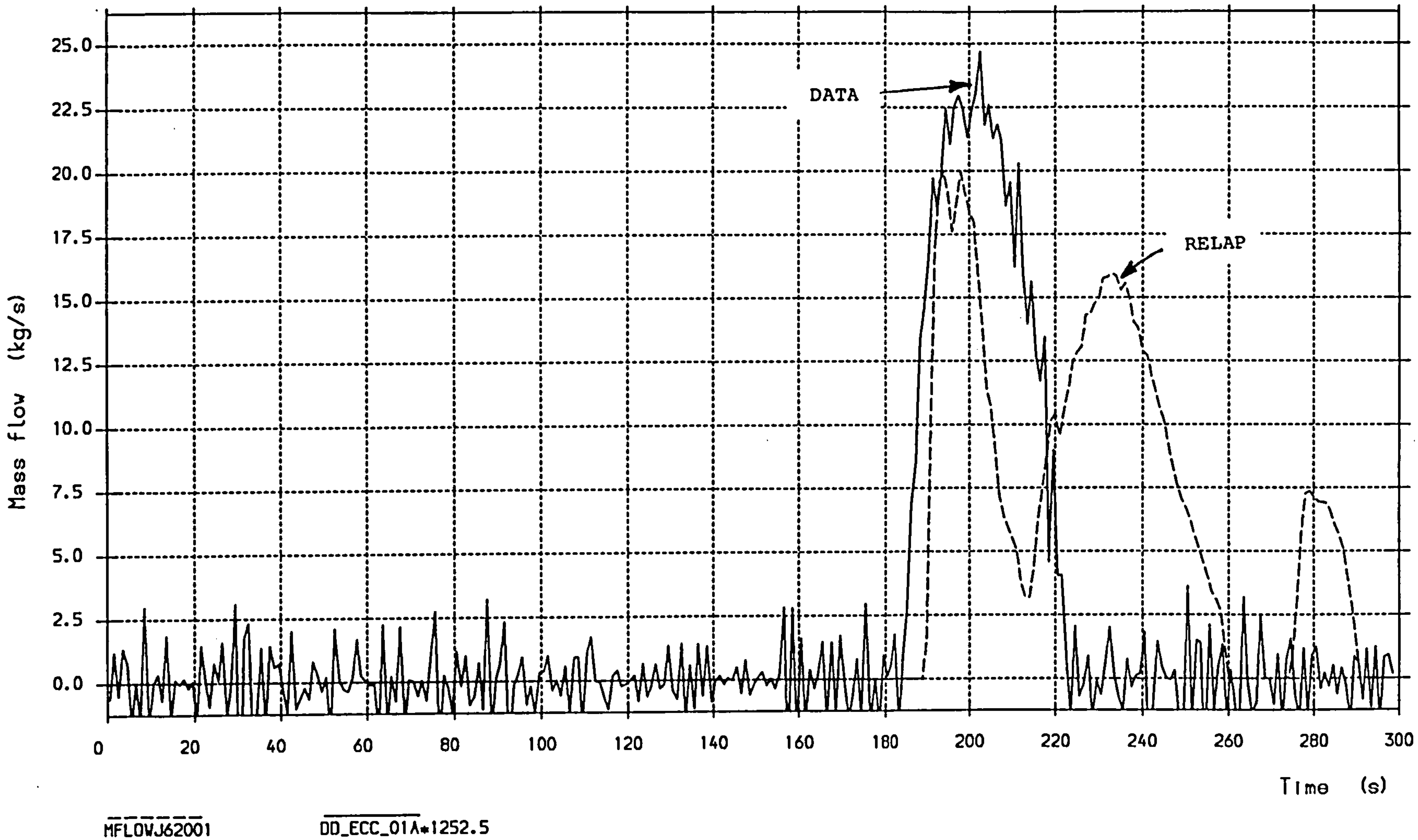

Figure 15. Accumulator Flow

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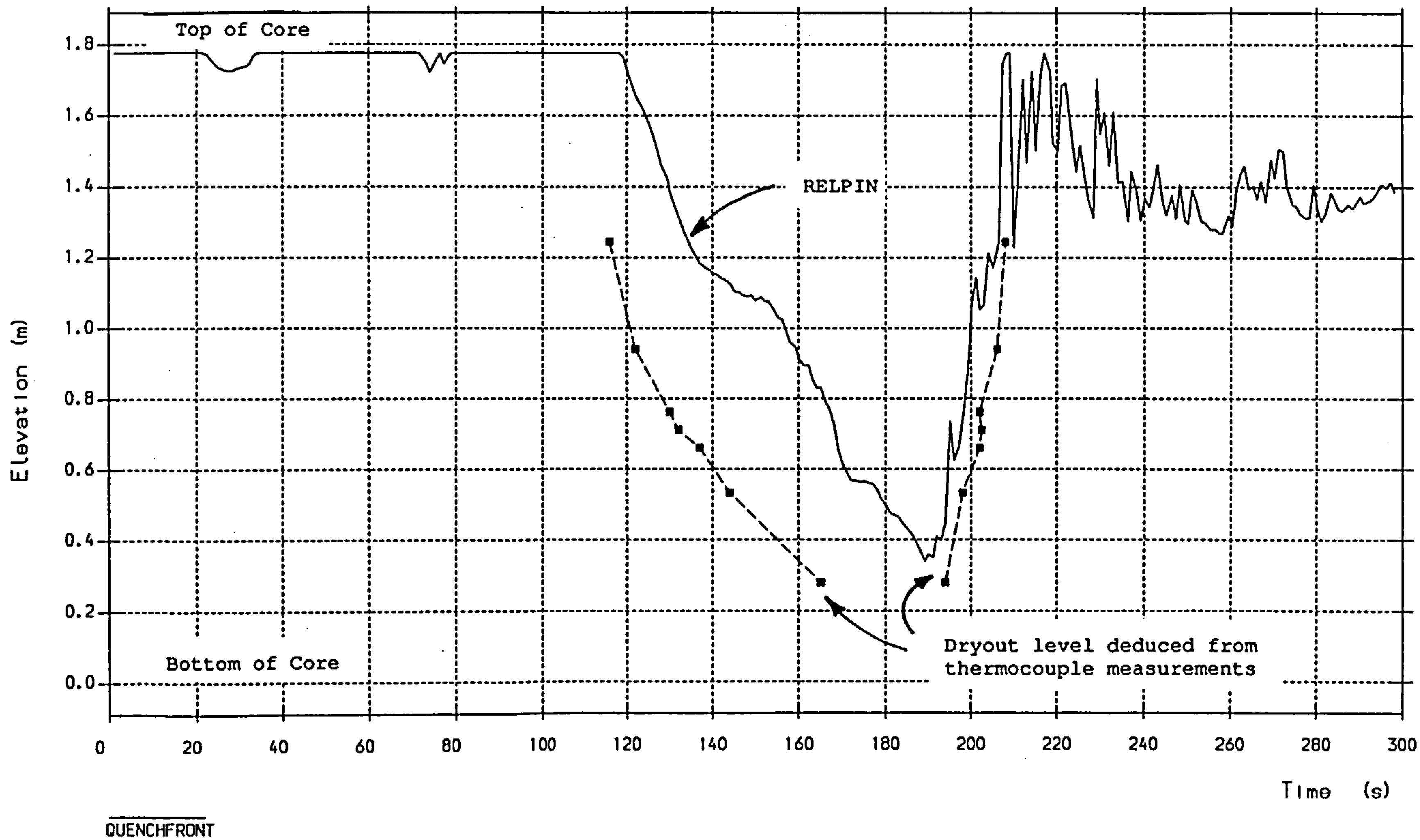

Figure 16. Core Dryout Level

Nuclear Electric - TOPAS Graphics

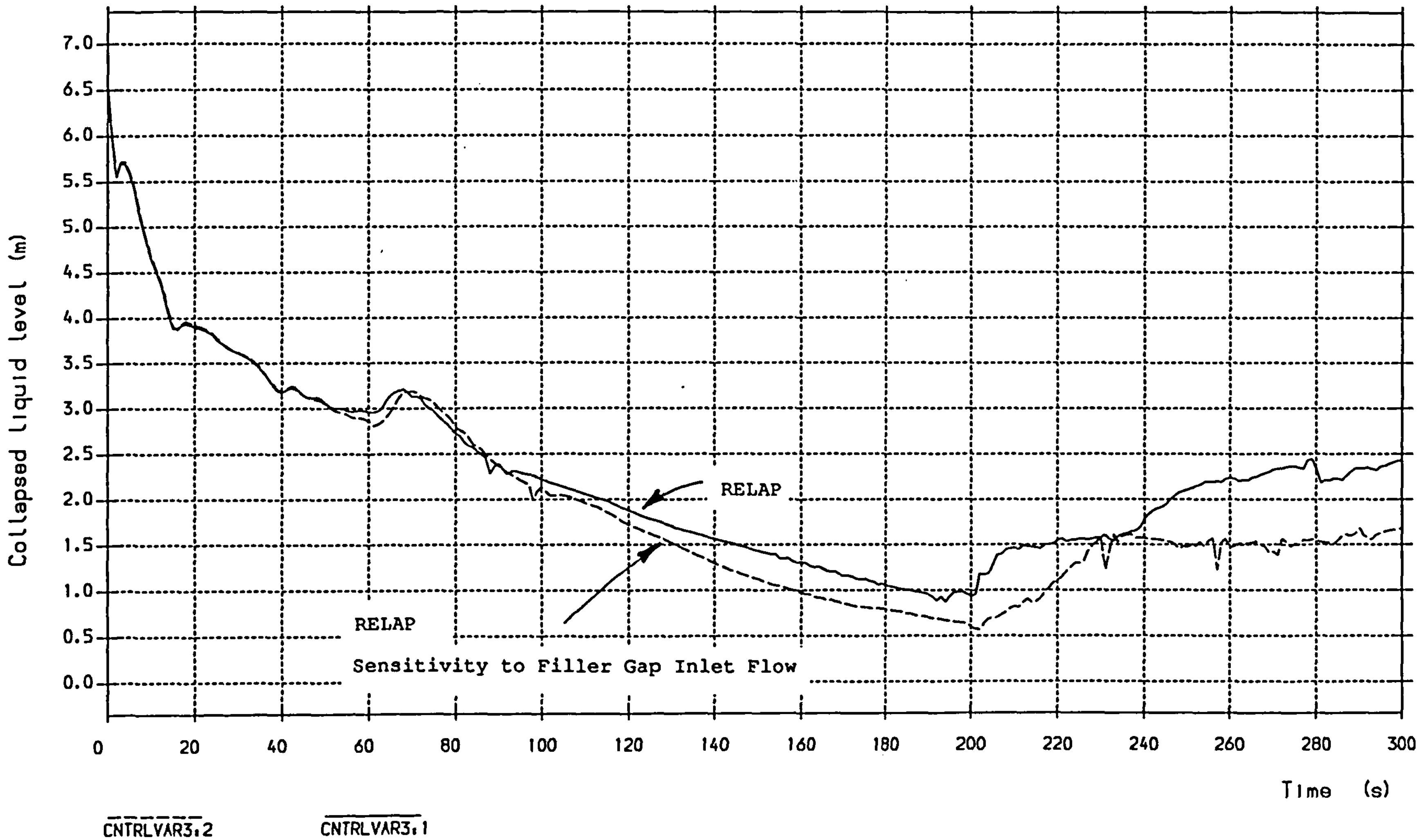

Figure 17. RPV collapsed liquid level

Nuclear Electric - TOPAS Graphics

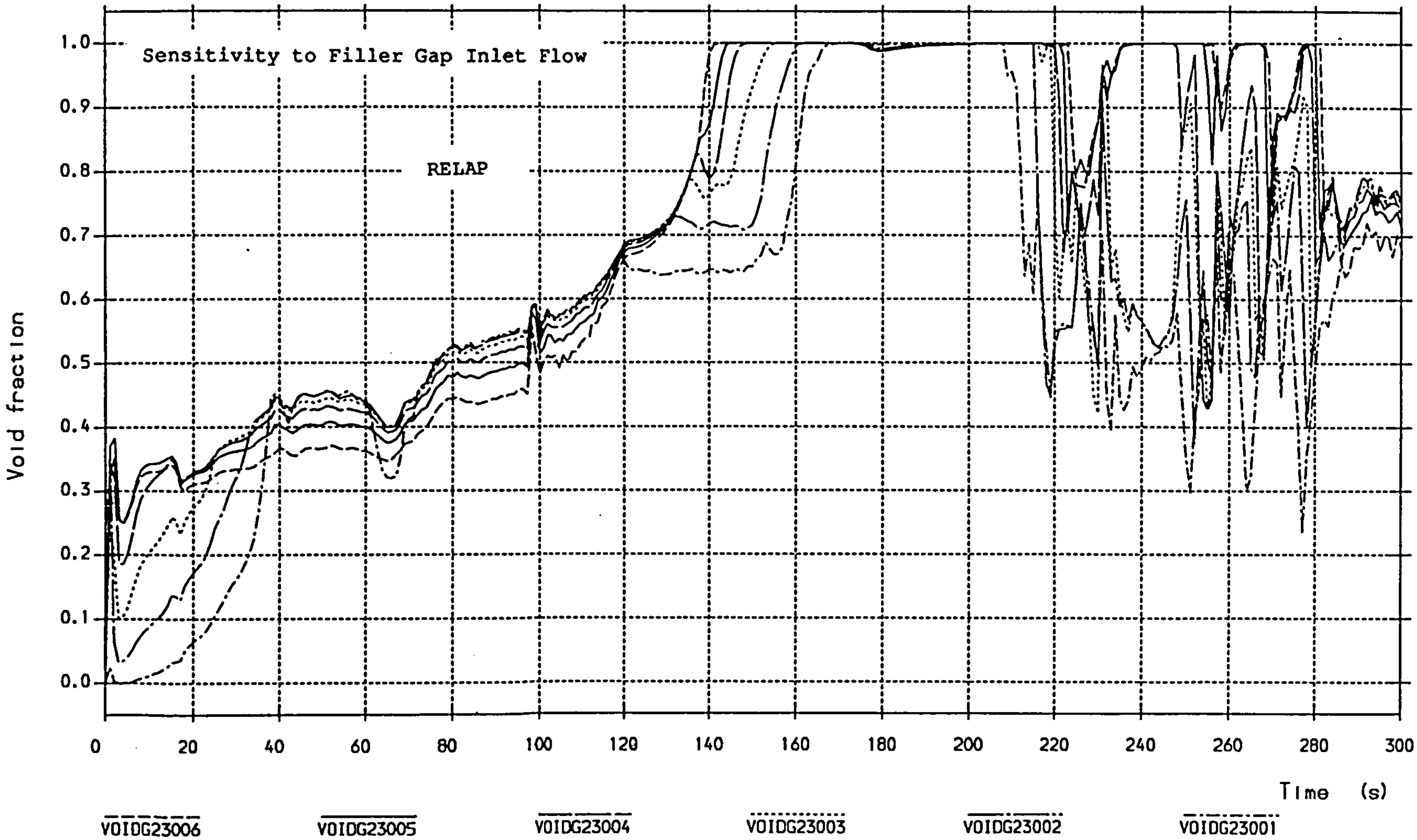

Figure 18. Core Void fractions

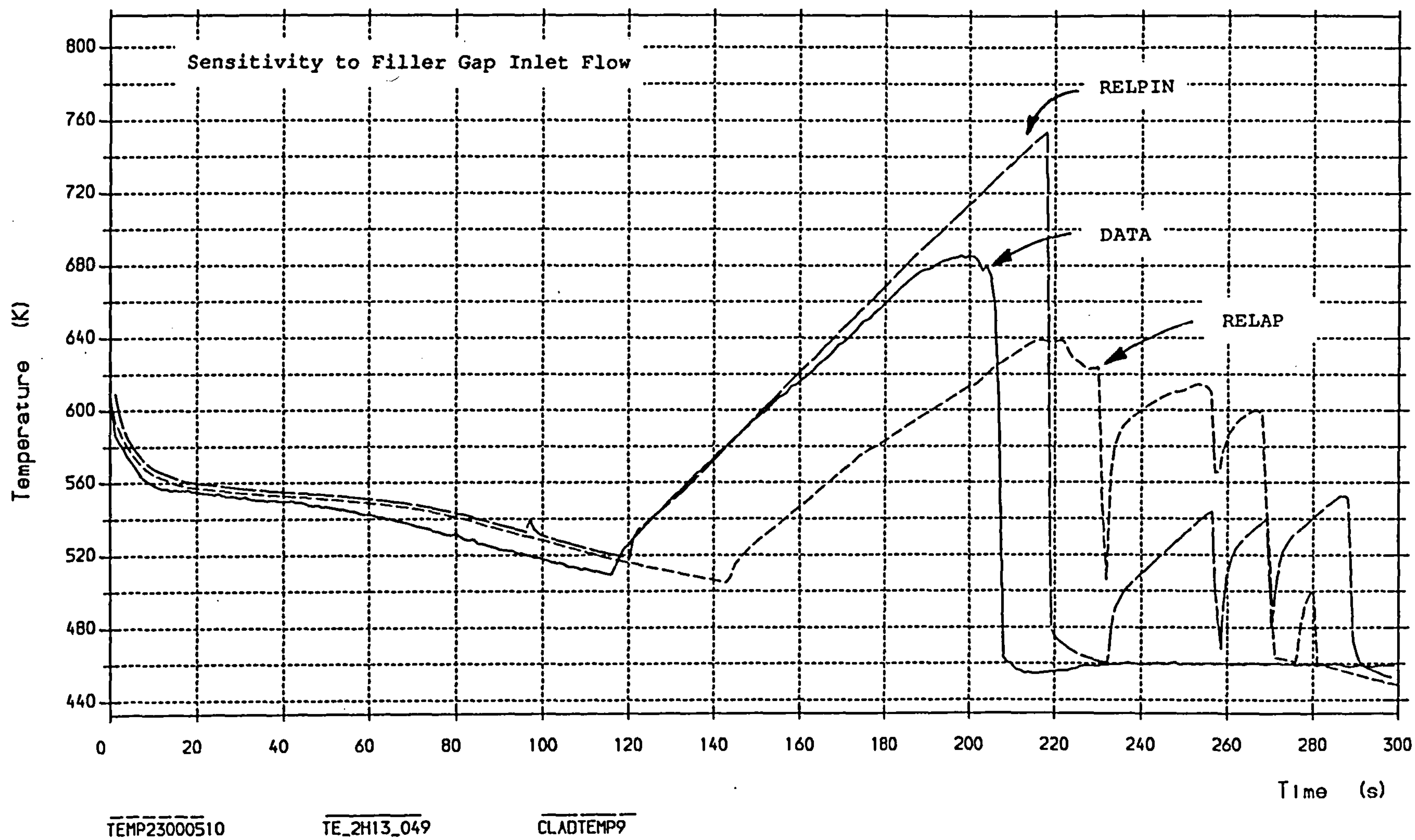

Figure 19. Fuel clad surface temperatures - (Elevation 1.33m)

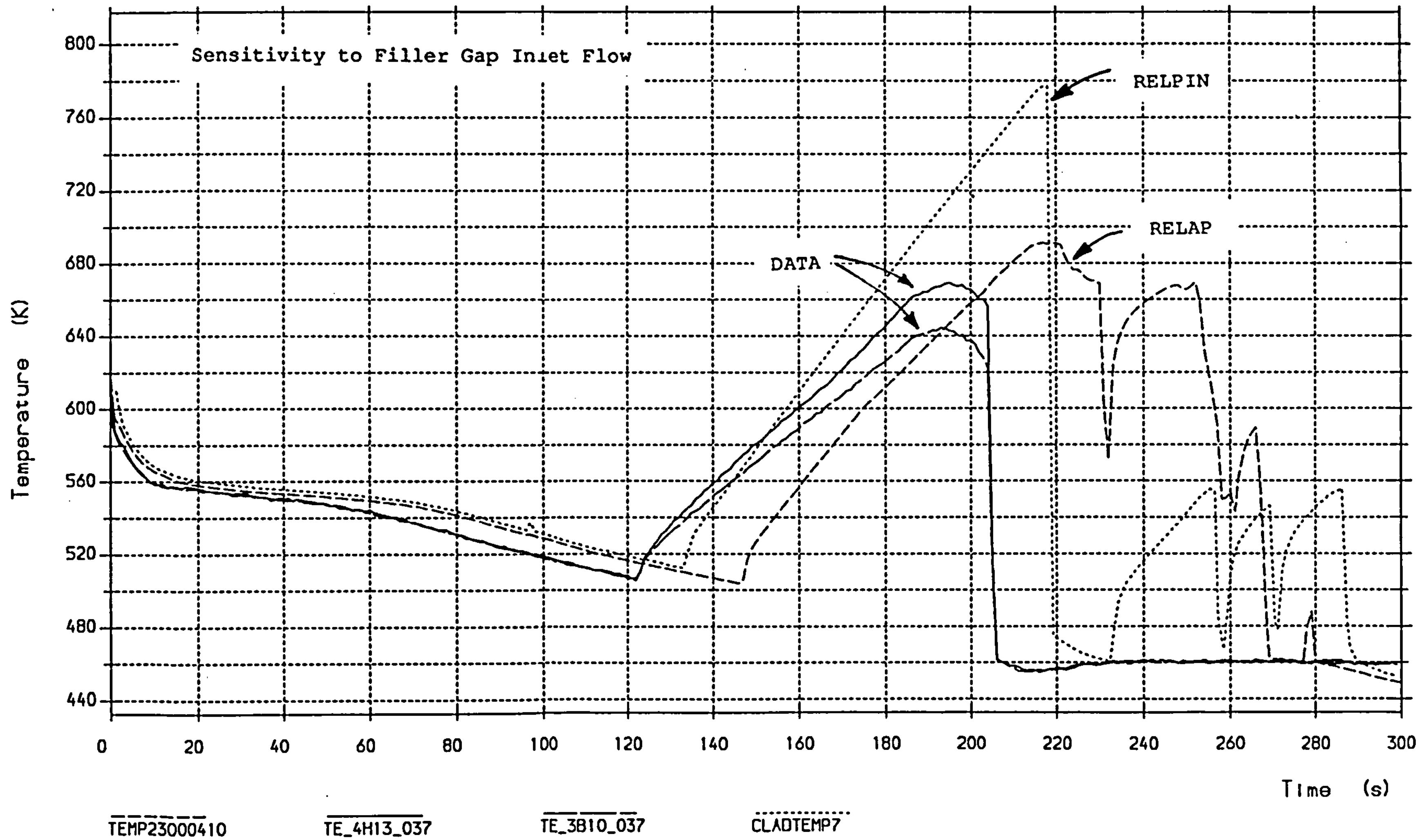

Figure 20. Fuel clad surface temperatures - (Elevation 0.91m)

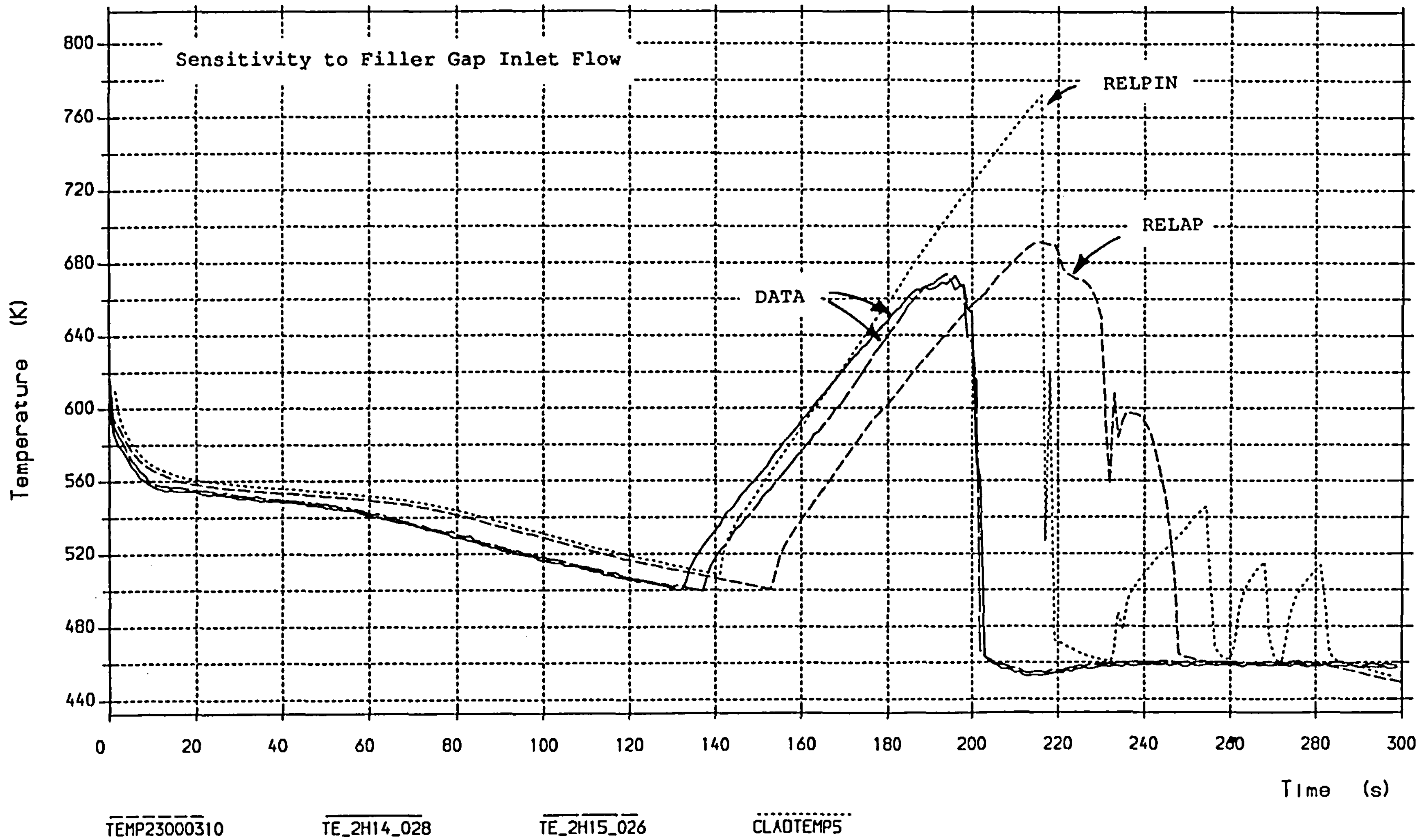

Figure 21. Fuel clad surface temperatures - (Elevation 0.63m)

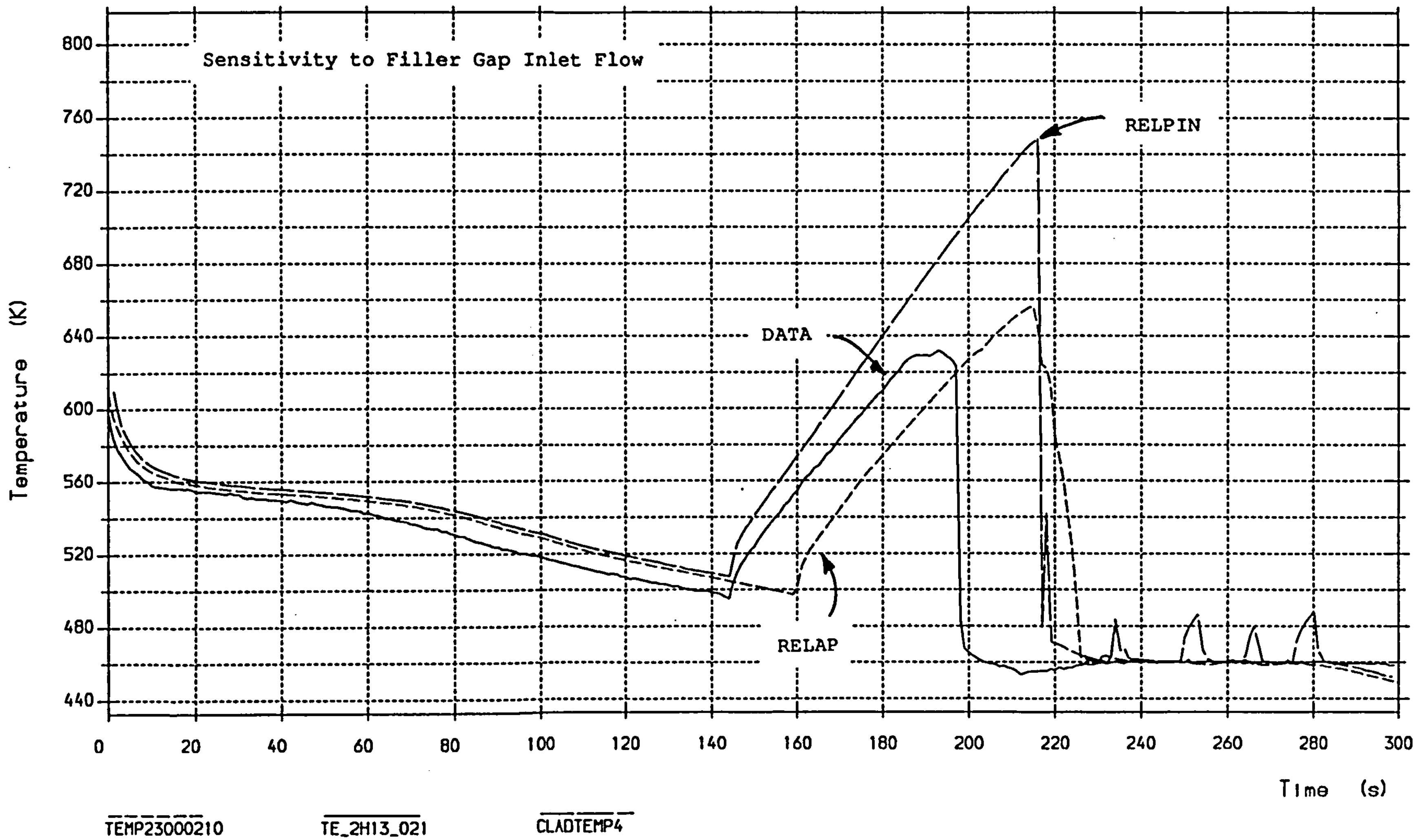

Figure 22. Fuel clad surface temperatures - (Elevation 0.49m)

Nuclear Electric - TOPAS Graphics

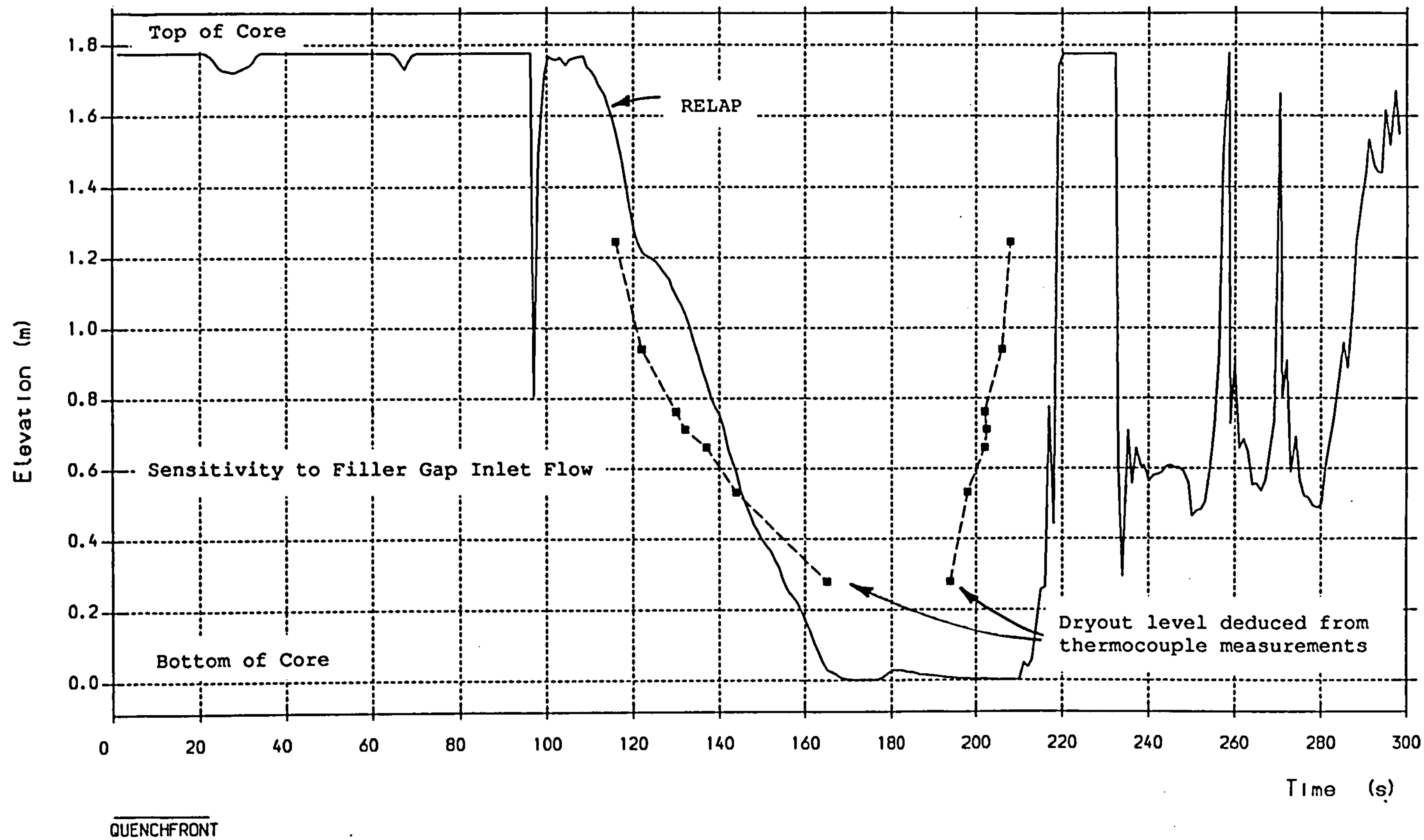

Figure 23. Core Dryout Level

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC. Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG/IA-0118
TD/SPB/REP/0130

2. TITLE AND SUBTITLE
Analysis of LOFT Test L5-1 Using RELAP5/MOD2

3. DATE REPORT PUBLISHED
MONTH: May | YEAR: 1993

4. FIN OR GRANT NUMBER
L2245

5. AUTHOR(S)
S. Cooper

6. TYPE OF REPORT
Technical Report

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION — NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)
Nuclear Electric
Barnett Way
Barnwood, Gloucester, GL4 7RS

9. SPONSORING ORGANIZATION — NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

The RELAP5/MOD2 code, Reference 1, is being used by Nuclear Electric for the calculation of Small Break Loss of Coolant Accidents (SBLOCA) and pressurized transient sequences in the Sizewell "B" PWR. To validate the code for this purpose, it has been used to model experiments of this type of transient carried out in various integral test facilities. A number of these studies have been for experiments carried out in the LOFT experimental reactor, Reference 2, and are described in References 3, 4, 5, 6, and 7.

To assist in assessing the capability of RELAP5/MOD2, the LOFT test L5-1 has been selected for analysis. This test was designed to simulate the rupture of a single 14 inch diameter accumulator injection line in a commercial PWR, equivalent to a 25% area break in the broken loop cold leg. Early in the transient the pumps were tripped and the HPIS injection initiated; towards the end of the transient, accumulator and LPIS injection began. It should be noted that for Sizewell "B" analyses a 25% break is classified as *large*, whereas in this report, as in the external literature, this break size is referred to as *intermediate*.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)
LOFT
RELAP5/MOD2
ICAP Program

13. AVAILABILITY STATEMENT
Unlimited

14. SECURITY CLASSIFICATION
(This Page) Unclassified
(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE

NRC FORM 335 (2-89)

Printed on recycled paper

Federal Recycling Program