UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 16 1980

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER - 107
RELAP4/MOD7 COMPUTER PROGRAM

1.0 INTRODUCTION

The subject of this Research Information Letter is the RELAP4/MOD7 computer program that was released to the National Energy Software Center in April of 1980 (Ref. 1). RELAP4/MOD7 is a best-estimate computer program designed to calculate thermal-hydraulic phenomena in a nuclear reactor. Although this code was originally designed to address PWR large-break loss-of-coolant accidents (LOCAs), capability exists for analyses of certain small-break LOCAs and non-LOCA transients/accidents in PWRs, together with a limited capability to address accidents and transients in BWR reactor systems. The release of RELAP4/MOD7 computer program represents the completion of the RELAP4 series.

The RELAP4 series, and the RELAP4/MOD7 in particular, was developed in response to a number of requests, including:

NRR: Provide capability for a statistical LOCA study and for sensitivity studies to assess data pertaining to LOCA rule changes (Ref. 3).

ACRS: Improve blowdown and reflood understanding and provide quantitative appraisals of ECCS (Refs. 4 and 5).

Two Research Information Letters have been issued (Refs. 6 and 7), describing the RELAP4/MOD6 code (Ref. 2) and results of its assessment. The major conclusions cited in these letters are:

1. Good results are generally obtained for blowdown regime.
2. Accuracy in the reflood regime is not as good as desired in all cases.
3. Refill is not adequately calculated.
4. A continuous integral LOCA calculation cannot be performed.

The letters also identified certain weaknesses and deficiencies in the RELAP4/MOD6 code, indicating the need to improve accuracy of calculations for the reflood and refill periods of LOCA.

In RELAP4/MOD7, many of these deficiencies have been corrected and further improvements in modeling have been made. This document contains a summary of the more important models and features incorporated in the RELAP4/MOD7 code, the results of the code checkout (developmental assessment) calculations, and recommendations for applying the program to various reactor accidents or transients. It should be noted that predictive capabilities of this code have not been independently assessed.

2.0 DISCUSSION

2.1 MODEL IMPROVEMENTS

2.1.1 Improved Vertical Slip Model

The two major areas of improvement include: (1) a set of flow-regime dependent relative velocity (slip) correlations based on the modified Bennett mass flux-versus-void fraction map and (2) an improved junction void fraction calculation based on the volumetric flux-weighted void fraction rather than the previously used, volume-weighted void fraction. The new vertical slip model should improve calculation of the gravity-dominated vertical two-phase flow and, consequently, prediction of the refill hydraulics in large-break LOCAs and the phase separation in small-break LOCAs. Guidance for the selection of junctions that should be modeled, using the new vertical slip model, will be provided in the user's manual (Ref. 1).

2.1.2 Thermal Nonequilibrium Model

An explicitly formulated nonequilibrium model was incorporated in RELAP4/MOD7 to improve prediction of phenomena associated with ECC injection by allowing subcooled liquid and saturated vapor to coexist within user-specified control volumes (nodes). This model was introduced to facilitate calculation of the refill stage. The energy of subcooled water is tracked in the calculation, and the resulting interphasic heat transfer rate is calculated using the flow-regime dependent constitutive package. A multiplier on the interphasic heat transfer rate is available to allow for scoping and sensitivity studies. Guidance for the selection of the multiplier will be provided in the user's manual (Ref. 1). The nonequilibrium condition is restricted to the liquid only. Saturated and subcooled liquid streams are instantaneously mixed while any superheat in the vapor entering the control volume is assumed to increase the enthalpy of the subcooled liquid.

2.1.3 FRAP-T Fuel Model

The FRAP-T fuel model has been included in the RELAP4/MOD7 code to provide a best estimate capability for fuel rod gap conductance, deformation characteristics, and material properties. The fuel rod temperatures are calculated with the normal RELAP4 conduction and heat transfer models.

2.1.4 Improved Reactor Kinetics and Decay Heat Model

The reactor kinetics model was reprogrammed with some minor errors corrected. In addition, the old ANS decay heat standard was replaced by the new ANS standard. An option is available to calculate the initial decay heat based on reactor operating history.

2.1.5 CHF Correlation

A new best-estimate critical heat flux (CHF) correlation was developed and incorporated in the code. It evolved from a statistical correlation of a large data base, as a function of local conditions.

2.1.6 Liquid Entrainment Correlation

The Steen-Wallis correlation, used in the RELAP4/MOD6, has limitations because it is dependent on the core inlet flow. The modified Heat Transfer Research Institute (HTRI) correlation incorporated in RELAP4/MOD7 removes this limitation. It correlates the entrainment fraction with the local superficial vapor velocity through the Kutateladze number and, therefore, may give significant entrainment even if the core inlet mass flow rate is zero or negative.

The correlation parameters were calibrated against the boiloff portion of the FLECHT-SEASET Test 35557. Using these parameters, RELAP4/MOD7 gave good predictions of the reflood stage of the same experiment (Ref. 8). However, subsequent calculations performed in connection with the International Standard Problem #10 (PKL Test K9A) showed that the modified HTRI correlation gave poor results and the Steen-Wallis correlation provided more accurate predictions (Ref. 9). Hence, benefits of the modified HTRI correlation may be limited to very low reflood velocities and the input parameters may be facility dependent. Reference 1 will provide guidance to the user for selection of input parameters.

2.1.7 Critical Flow Stagnation Pressure Model

The critical flow models in RELAP4 are based on stagnation pressure rather than static pressure. Previous versions of RELAP4 did contain an option for calculation of the stagnation pressure. However, when the flow areas upstream of and at the choking plane were approximately equal, supersonic velocities in the upstream control volumes were sometimes calculated, especially when using the nonequilibrium-based critical flow models, yielding erroneous results and oscillations. To avoid this problem in RELAP4/MOD7, the upstream-volume flow area is updated to values large enough to prevent supersonic velocities while maintaining the correct friction losses. The model breaks down at low pressures, such as 50 psia.

2.1.8 Other Model Improvements

These improvements include: more accurate steam tables and steam-table interpolation methods, minor corrections to the centrifugal pump model, an improved junction specific volume calculation, addition of a fill model where mass flux can be specified as a function of the mixture level in an adjacent volume, heat transfer model improvements, and various minor model improvements and error corrections.

2.2 RELAP4/MOD7 FEATURES

Several new features have been developed for RELAP4/MOD7 to provide more convenience to users, to save computer time, and to improve deficiencies identified in References 6 and 7. A description of the major new features developed for RELAP4/MOD7 is given below:

2.2.1 PWR Self-Initialization

The initial conditions in a RELAP4/MOD7 input model are overspecified in order to maintain the generality and usefulness of the program. However, the overspecification may lead to inconsistencies that could, in turn, lead to erroneous initial perturbations or incorrect values being used. In previous versions of RELAP4, eliminating the input model inconsistencies (balancing) was accomplished through time-consuming iterative computer calculations. The PWR self-initialization feature automates this procedure, balancing the energy by requiring the energy produced in the core and pumps to be equal to the energy transferred out of the steam generators, and balancing the pressure distribution by requiring the volume-to-volume pressure difference to be equal to the connecting junction pressure drop due to friction, momentum flux, elevation effects, and pumps. The restrictions on using the energy balance (which may be applied with or without the pressure balance) are:

1. An active core, pump, and steam generator must be considered,

2. The core inlet temperature must be specified, and

3. The steam generator secondary side must be modeled as a single control volume, with the mixture level and mixture quality specified.

The restrictions on the pressure balance are:

1. At least one flowing loop with an active pump must be specified.

2. The pressure in one control volume in the loop must be specified as a reference.

3. The mass flow rate in any parallel flow path (for example, core and bypass flows) is specified as a reference. Pressure balance is accomplished by adjusting control volume pressures and path friction loss coefficients.

The PWR self-initialization feature does calculate consistent initial conditions and at a very reasonable cost (typically in less than 20 CPU seconds on a CDC Cyber 176 series computer).

2.2.2 Automatic Renodalization

In previous versions of RELAP4, analysis of a complete LOCA required two separate calculations - a blowdown and refill analysis, and a reflood analysis. This was one of the major deficiencies pointed out in References 6 and 7. Data from the blowdown and refill analysis had to be hand-transferred to the reflood analysis, which caused all transient effects to be lost. The automatic renodalization feature has been developed to automate the transfer of data between different nodalizations of the same problem, while maintaining transient effects. This feature requires that two (or more) nodalizations be prepared initially and transfer or mapping functions be constructed for the problem. The primary quantities conserved in mapping are mass and spatial volume, junction flow and then form losses, internal energy of the fluid and the energy stored in heat slabs. The input required with the renodalization is complex and must be checked by running a test case to ensure all data are being correctly transferred and all required input is present. Renodalization may be activated at any time during the transient. For a LOCA analysis, renodalization is usually activated either during the refill period or at the beginning of reflood.

2.2.3 Decoupled Heat Transfer Time Step

The time constant for significant changes in heat transfer conditions is often larger than the time constant for significant changes in hydraulic conditions. For this reason, the heat transfer time advancement has been decoupled from the hydraulic time advancement. A heat transfer time step control, based on temperature changes, calculates a time step bounded by a user-specified maximum time step and the hydraulic time step size. This feature may result in a large saving in computer time as fewer calls to the relatively time-consuming heat transfer routines are made.

2.2.4 SI Units Option

An SI units option has been incorporated. Either British ("Engineering") or SI units may be selected, for either input or output. Internal calculations in the code and the plot-restart tape are still made with the British units.

2.2.5 Other RELAP4/MOD7 Features

Several other features and error corrections have been included. These involve water packing, mass depletion and mixture level crossing models, the generalized input feature which allows nonconsecutive numbering of volumes, junctions and heat slabs, conversion of the RELAP4/MOD7 source to CDC update format to ease updating the program and to maintain better traceability of changes, and the restructuring of subroutines to improve computer efficiency.

3.0 RESULTS

3.1 CHECKOUT (DEVELOPMENTAL ASSESSMENT) CALCULATIONS

Several check problems were analyzed to ensure that the models and features developed for RELAP4/MOD7 were programmed correctly and that the new models and features did not introduce errors in the existing models. The check calculations listed below do not represent a thorough assessment of the program, and no major sensitivity studies were performed.

1. Simulation of Refill-Creare Tests
2. Calculation of the Semiscale Mod-1 System Blowdown Test S-02-9
3. Calculation of the Semiscale Mod-1 System Integral LOCA Test S-06-3
4. Calculation of the LOFT Integral LOCA Test L2-3
5. Best-Estimate Prediction of LOCA in the Zion I Plant

The results of these calculations indicate that incorporation of the new models improved predictions of 1) pressure transient during the blowdown stage and 2) downcomer penetration during the refill stage. The calculations also demonstrate that the code is able to perform an integral, one pass, calculation from blowdown through reflood using two different nodalizations. More details on the results of developmental assessment calculations are presented in Appendix A.

4.0 RECOMMENDATIONS

4.1 APPLICATION TO REGULATORY NEEDS

The RELAP4/MOD7 code has been designed as a best-estimate large-break LOCA analysis tool. The code more accurately calculates the blowdown and refill stages than does the RELAP4/MOD6 code and provides for an improved quantitative appraisal of ECCS which had been requested in References 4 and 5. The calculational capability of the reflood stage is almost the same as in the RELAP4/MOD6 code.

The RELAP4/MOD7 code is user convenient due to its self-initialization and automatic-renodalization features. Running time improvements were made by decoupling the heat transfer time step control. With the self-initialization feature, the user spends less time in preparation of the input decks. Automatic renodalization feature permits integral LOCA calculations, from beginning of blowdown through end of reflood. The code is suitable to perform a statistical LOCA study as requested in Reference 3.

The RELAP4/MOD7 code can be used for the following best-estimate calculations associated with a large-break PWR LOCA:

- BLOWDOWN: In general, good temperature calculations will be obtained in the lower and midcore regions, including the hot spot. As with RELAP4/MOD6, clad temperature predictions will be high in the upper part of the core and low in the lower part of the core. Most other parameters are expected to be calculated reasonably well.

- REFILL: Addition of nonequilibrium and vertical slip models substantially improved the calculational capability of the refill stage. However, this conclusion has been obtained from limited developmental assessment.

- REFLOOD: Acceptable results can be obtained if the user selects appropriate parameters and options. At present, this selection is an art and detailed guidelines will be provided (Ref. 1).

The RELAP4/MOD7 code contains many models important in small-break LOCA analysis. However, the limited number of analyses performed thus far have indicated both successes and failures. For example, the code could not correctly predict the core uncovery; that is, mass inventory in the vessel, in the Semiscale S-SB-P1 test. However, assumptions made to simulate heat losses may play an important role in predicting the inventory distribution. The inventory distribution is also dependent on horizontal flow stratification in the hot legs. In predicting Semiscale S-SB-P1 test data, the flow conditions in the hot legs were assumed to be homogeneous. Scoping studies were performed to assess the existing horizontal flow stratification model. These studies, described in Reference 10, show that the horizontal flow stratification model in the code is not adequate to model physical phenomena, such as reflux boiling and critical discharge through small breaks associated with large horizontal pipes described in Reference 11. The code cannot account for the presence of a noncondensible gas. The control system model considered in the code may be too simplistic in some cases. The reactor point kinetics and reactivity feedback models in RELAP4/MOD7 may be too simplistic for accurate calculation of transients without early reactor scram. These difficulties do not preclude using RELAP4/MOD7 for small-break LOCAs or transients, but they will require greater care when applying the program to areas for which it was not specifically designed.

4.2 FURTHER IMPROVEMENTS AND CHECKOUT, IN PROGRESS

In Reference 12, NRR has requested that additional capabilities be incorporated for analyses of system transients and steam-line-break accidents. These capabilities include:

a. Boron injection and tracking capability and inclusion of boron reactivity effects

b. Self-initialization capability for the secondary side of PWR plants.

c. Self-initialization capability for BWR plants.

Boron injection and tracking capability is incorporated in a new version of the code. The remaining capabilities will be incorporated in a future version.

The RES technical contact for this work is Fuat Odar.

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REFERENCES

1. RELAP4/MOD7 - A Best Estimate Computer Program to Calculate Thermal and Hydraulic Phenomena in a Nuclear Reactor or Related System (to be issued, draft copy available in RES office).

2. RELAP4/MOD6 - A Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems, User's Manual, EG&G Idaho, Inc. Technical Report CDAP-TR-003, January 1978.

3. Case, E. G., "NRR Requirements for Loss-of-Coolant Accident Analysis Computer Programs (RR-NRR-77-5)," NRC Memo to S. Levine, June 23, 1977.

4. Bender, M., "Status of Generic Items Relating to Light-Water Reactors: Report No. 5," Letter from Chairman, ACRS, to M. A. Rowden, Chairman, NRC, Feb. 24, 1977.

5. "NRC Program for the Resolution of Generic Issues Related to Nuclear Power Plants," Report to Congress, NUREG-0410, Jan. 1, 1978.

6. Research Information Letter, 39, RELAP4/MOD6, November 1978.

7. Research Information Letter, 90, RELAP4/MOD6 Assessment, May 22, 1980.

8. D. M. Ogden, Data Comparison of FLECHT-SEASET Boiloff Test 35557 Using RELAP4/MOD7, EGG-CAAP-5152, May 1980.

9. M. Hsu, Posttest Analysis of International Standard Problem 10 Using RELAP4/MOD7, EGG-CAAP-5210, July 1980.

10. C. Tsai, "RELAP4/MOD7 Horizontal Stratification Scoping Study," WR-CD-028 (to be issued, draft copy available in RES office).

11. N. Zuber, "Problem in Modeling of Small Break LOCA," NUREG-0724, August 1980.

12. Memo from Z. R. Rosztoczy to S. Fabic, Subject: RELAP4/MOD7 Modeling Modifications for Licensing Needs, Feb. 22, 1980.

APPENDIX-A

3.1.1 Simulation of Refill-Creare Tests

These calculations involved simulation of the 1/15-scale Creare Countercurrent Flow (CCF) test system. A specified subcooled ($\Delta Tsub=110^{o}F$) liquid injection rate was used in conjunction with the nonequilibrium model for a series of calculations varying the injected steam flow. The flow regime dependent vertical slip model was applied at vertical junctions. The following results were obtained:

1. With a steam injection rate of 0.6 lbm/sec or larger (the nondimensional gas flow, $J^*_g \geq 0.24$) ECC water did not reach the lower plenum.
2. With a steam injection rate of 0.24 lbm/sec or smaller ($J^*_{gc} \leq 0.14$) all of the injected ECC water was delivered to the lower plenum.
3. With an injected steam flow rate between 0.24 lbm/sec and 0.6 lbm/sec ($0.14 < J^*_{gc} < 0.24$) relatively stable flow rates were calculated and partial delivery of the injected ECC water to the lower plenum occurred.

Two sets of calculations were performed. In the first set, the new vertical slip correlation was used, while in the second set, the old churn-turbulent slip correlation available in previous versions of RELAP4 was employed. All other inputs were identical. Both calculation sets utilized nonequilibrium models in the same volumes involving the cold leg, downcomer, and the lower plenum.

Results of these calculations are compared with the Creare measured data in Figure 1. These results indicate that the flow regime-dependent vertical slip correlations give a better representation of ECC bypass and delivery than the churn-turbulent correlation. Hence, it is expected that the RELAP4/MOD7 code will calculate the downcomer penetration and refill stage more accurately than the RELAP4/MOD6 code. However, since the downcomer penetration involves also other processes (for example, multidimensional flow, detailed nonequilibrium mixing and condensation, turbulence, and flow regimes that are more complex than those the code can consider) the above check calculations do not examine the validity of the slip treatment, per se.

3.1.2 Calculation of Semiscale Mod-1 System Blowdown Test S-02-9

In this case, the focus was on checking the applicability of new models and to ensure that the existing models were not accidentally and erroneously changed.

The results of two comparisons with test data are presented in Figures 2 and 3. Figure 2 is a plot of the RELAP4/MOD7 calculated upper plenum pressure, compared with both the test data and with the RELAP4/MOD6 calculation results. There is an excellent agreement until 25 seconds into the transient. The RELAP4/MOD6 calculation slightly underpredicts the pressure due to nonequilibrium effects after 25 seconds when ECC injection begins. RELAP4/MOD7 accurately predicts the pressure after 25 seconds, indicating the improvements introduced with the nonequilibrium model. Figure 3 shows comparisons of clad surface temperatures at 11 and 16 inch levels. Both the RELAP4/MOD6 and RELAP4/MOD7 calculations are within the measured data spread. The somewhat higher temperature calculated by the RELAP4/MOD7 code is caused by a slightly different system mass distribution that produced a smaller core inlet flow. In general, the RELAP4/MOD7 overpredicts the surface temperatures in the upper part of the core, underpredicts in the lower part of the core and there is a good agreement in the central part of the core. These are the same conclusions reached for the RELAP4/MOD6 code (Refs. 6 and 7).

This very limited information shows that the RELAP4/MOD7 code accurately calculates the blowdown stage of the S-02-9 test. Note that the calculations of the blowdown period have also been quite satisfactory using the RELAP4/MOD6 code. However, it can be seen that the accuracy of calculations of pressure and core inlet flow rate is improved by addition of the new vertical slip correlation and the nonequilibrium model in the RELAP4/MOD7 code. This should lead to more accurate predictions of clad temperatures.

3.1.3 Semiscale Mod-1 System Integral LOCA Test S-06-3

The primary purpose of this checkout was to demonstrate the capability of RELAP4/MOD7 to perform an integral calculation from blowdown through reflood.

The Semiscale S-06-3 Test was a simulated 200 percent double-ended cold leg break with ECC injection in the intact loop. The input model for the calculation described herein was created from two different nodalizations (one for blowdown/refill and one for reflood) used in the previous, RELAP4/MOD6 analysis of the same test. The calculations were switched from the blowdown/refill nodalization to the reflood nodalization during the refill. For reflood calculations the Steen-Wallis correlation was used because the new modified HTRI correlation gave very unrealistic results. Therefore, the Steen-Wallis correlation was used in all developmental assessment calculations.

The RELAP4/MOD7 calculation was run to 111 seconds of transient time, at which time all low power rods were quenched. A comparison of the calculated and the measured upper plenum pressures is shown in Figure 4. The agreement is fairly good during the blowdown period. However, after the onset of ECC injection, at about 18 seconds, the RELAP4/MOD6 code predicted depressurization due to its thermal equilibrium assumption, while the RELAP4/MOD7 calculation, using the nonequilibrium model, showed a much smaller deviation from the data.

Figures 5 and 6 show comparisons of calculated vs. measured low power rod surface temperatures at low and upper-middle elevations of the core, respectively. These low-powered rods (32) are representative of the core average condition. For low elevations, the RELAP4/MOD7 results are, in general, in better agreement with the measured experimental data than the RELAP4/MOD6 results. The calculation of the quench time is also better. At the upper-middle elevation, the RELAP4/MOD7 calculation indicated the heat slab quenched at 110 seconds, while the measured quench time is 160 seconds. For high elevations,(not shown), the predicted quenching times with RELAP4/MOD6, and RELAP4/MOD7 were 260 and 80 seconds, respectively, while the measured quench time was 125 seconds.

For the four high powered rods which were represented by a hot channel, both RELAP4/MOD7 and MOD6 underpredicted the peak clad temperatures in the lower region of the core by about the same amount. In the upper and upper-middle parts of the core, both codes overpredicted the data, the RELAP4/MOD7 predictions of the peak clad temperature being higher in both parts of the core. Hence, the predictions of peak clad temperatures by the RELAP4/MOD7 in the hot channel for this test do not represent any improvement over those predicted by the RELAP4/MOD6.

RELAP4/MOD6 predicted a minor rewet for all elevations at about 10 seconds while RELAP4/MOD7 calculated this type of rewet only at the low elevation. Test data do not indicate a rewet at this time. However, at the lower portion of the hot channel, the data indicate a sudden quench at about 95 seconds which both codes failed to predict.

3.1.4 LOFT Integral LOCA Test L2-3

This case was selected to test incorporation of the FRAP-T fuel model and to check the automatic renodalization feature. The calculation was continued until the final core quench which occurred approximately 55 seconds after experiment initiation.

The nodalizations for the blowdown/refill and reflood periods were originally developed by the LOFT Program for L2-3 experiment pretest predictions and did not contain the modeling of the hot channel. As with the other developmental assessment tests, Steen-Wallis correlation was used for the reflood calculations.

Some comparisons of the calculated vs. measured results are shown in Figures 7 through 9. Figure 7 pertains to the upper plenum pressure where the difference between the calculated and experimental results is traced to the difference in predicted vs. experimental break flows. The fuel rod cladding temperatures for the middle and upper 1/3 of the core are shown in Figures 8 and 9. The calculated temperatures are compared with measurements for the peripheral bundles where the radial power peaking factor was about equal to one. In general, the calculation underpredicts the blowdown peak clad temperatures, although the time for CHF is predicted reasonably well, and does not reproduce the total effect of core-wide rewet at about 8 seconds.

This calculation showed that the new models and features, particularly the automatic renodalization feature, the FRAP-T fuel model, and the nonequilibrium model were successfully incorporated to the code.

3.1.5 Best Estimate Prediction of LOCA in Zion I Plant

The Zion I LOCA (large cold leg break) calculation was performed in the previous BE/EM study (Ref. A-1) using RELAP4/MOD5. The system nodalization developed for that study was maintained, as nearly as possible, for the current investigation; however, RELAP4/MOD7 analytical models and features were selected for this calculation, where appropriate. Steen-Wallis entrainment correlation was used in the calculations of the reflood stage.

The average core rod surface temperatures from both calculations are presented in Figure 10. The large differences between the temperatures are due to the positive core inlet flow prediction by RELAP4/MOD7 between 4 and 11 seconds. This difference in prediction is primarily due to different break flow models and to a lesser extent to new vertical slip and nonequilibrium models. These calculations also indicate that the results are consistent with LOFT large-break loss-of-coolant experiment (LOCE) tests and that the code can perform integral LOCA calculations. Further information on Zion I calculations is presented in Reference A-2.

<u>References</u>

A-1. G. W. Johnsen, F. W. Childs, J. M. Broughton, A Comparison of Best Estimate and Evaluation Model LOCA Calculations: The BE/EM Study, EG&G Idaho, Inc., Technical Report PG-R76-009, December 1976.

A-2 T. L. DeYoung, "RELAP4/MOD7 Developmental Checkout: Zion I" (to be issued, draft copy available in RES office).

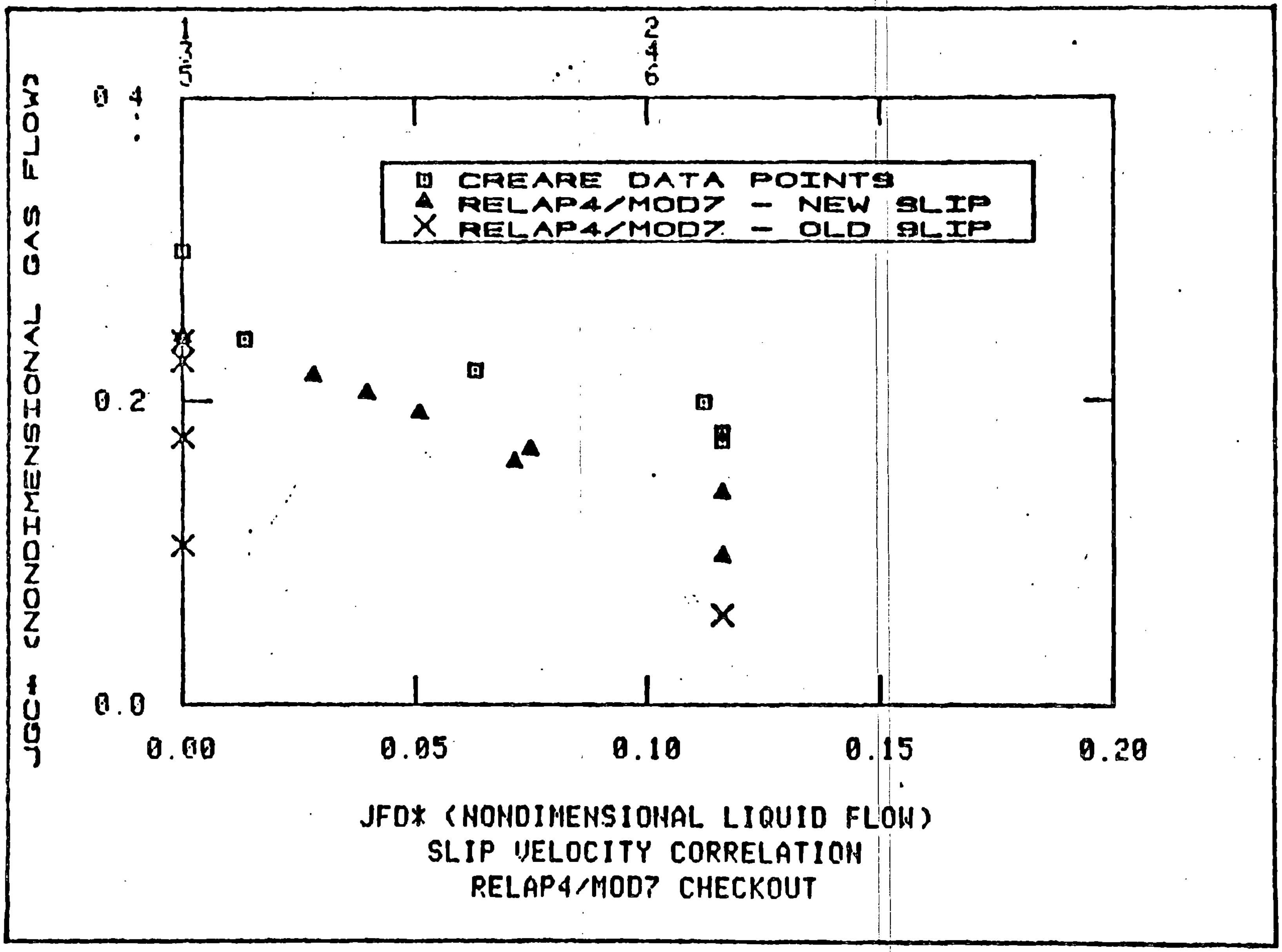
CREARE DATA POINTS
RELAP4/MOD7 - NEW SLIP
RELAP4/MOD7 - OLD SLIP
JGC* (NONDIMENSIONAL GAS FLOW)
0.4
0.2
0.0
0.00
0.05
0.10
0.15
0.20
1
3
5
2
4
6
JFD* (NONDIMENSIONAL LIQUID FLOW)
SLIP VELOCITY CORRELATION
RELAP4/MOD7 CHECKOUT

Figure 1

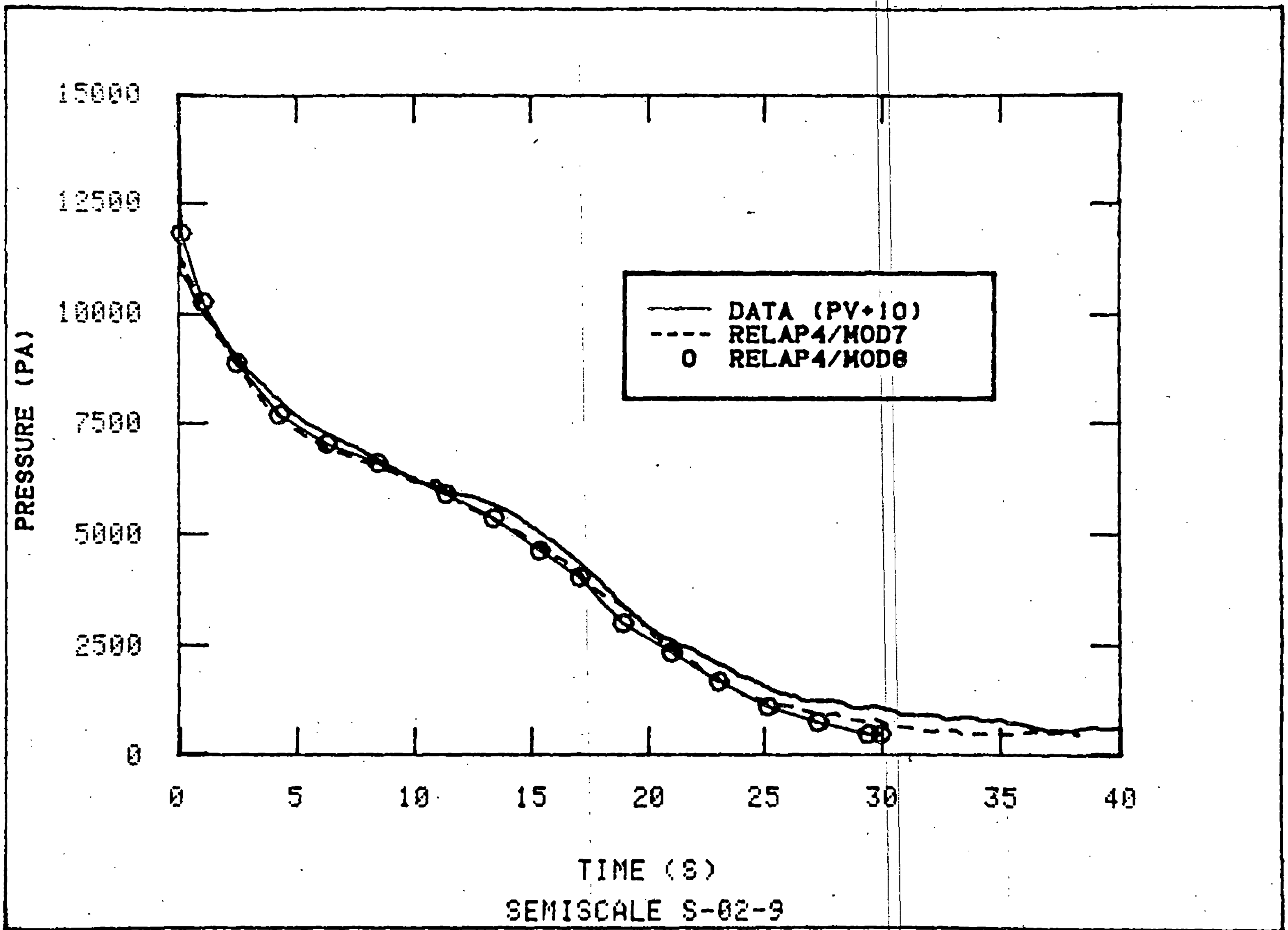

Figure 2 - Upper Plenum Pressure

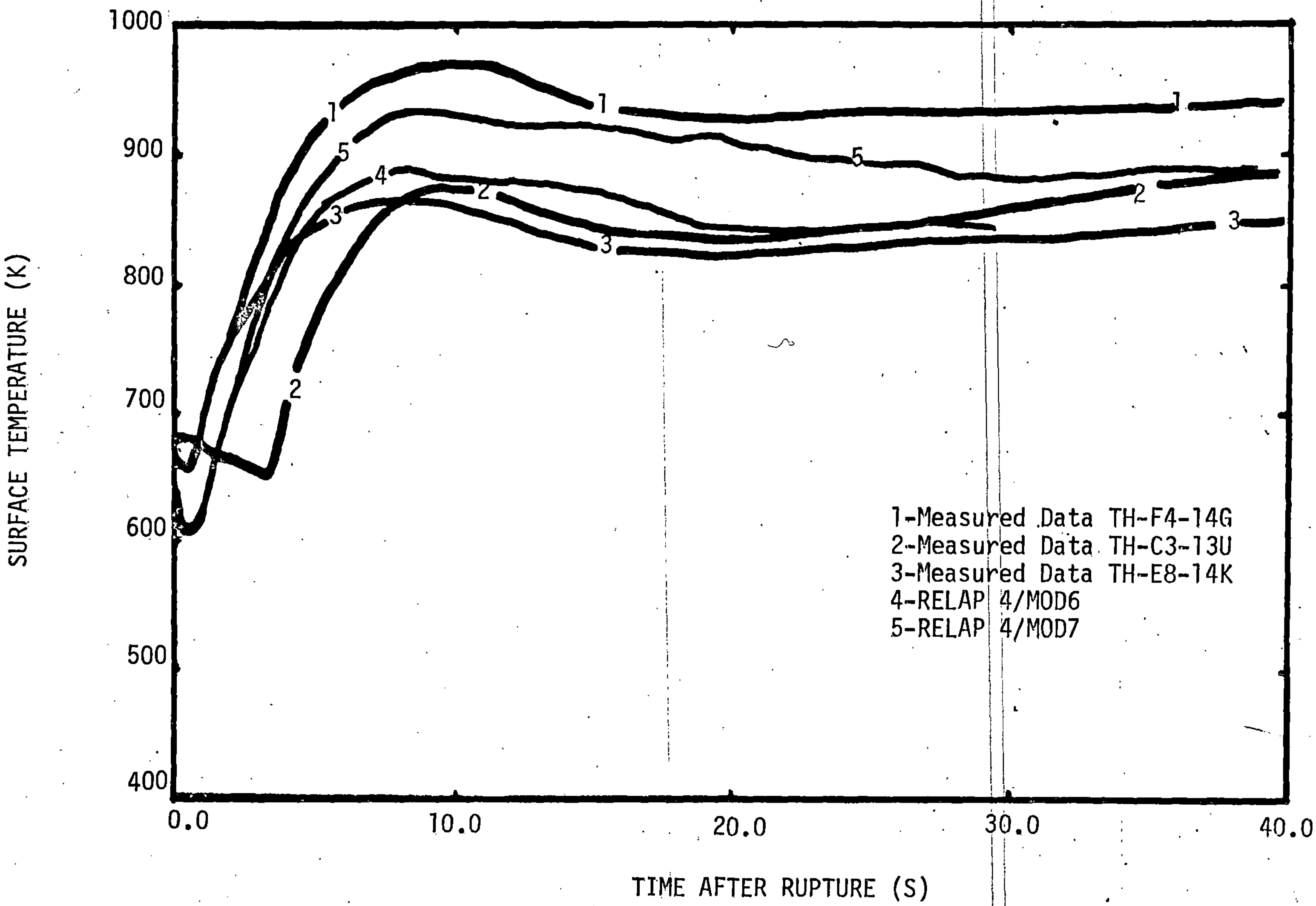

Figure 3. Average Channel Clad Temperature, 11-16 inch level

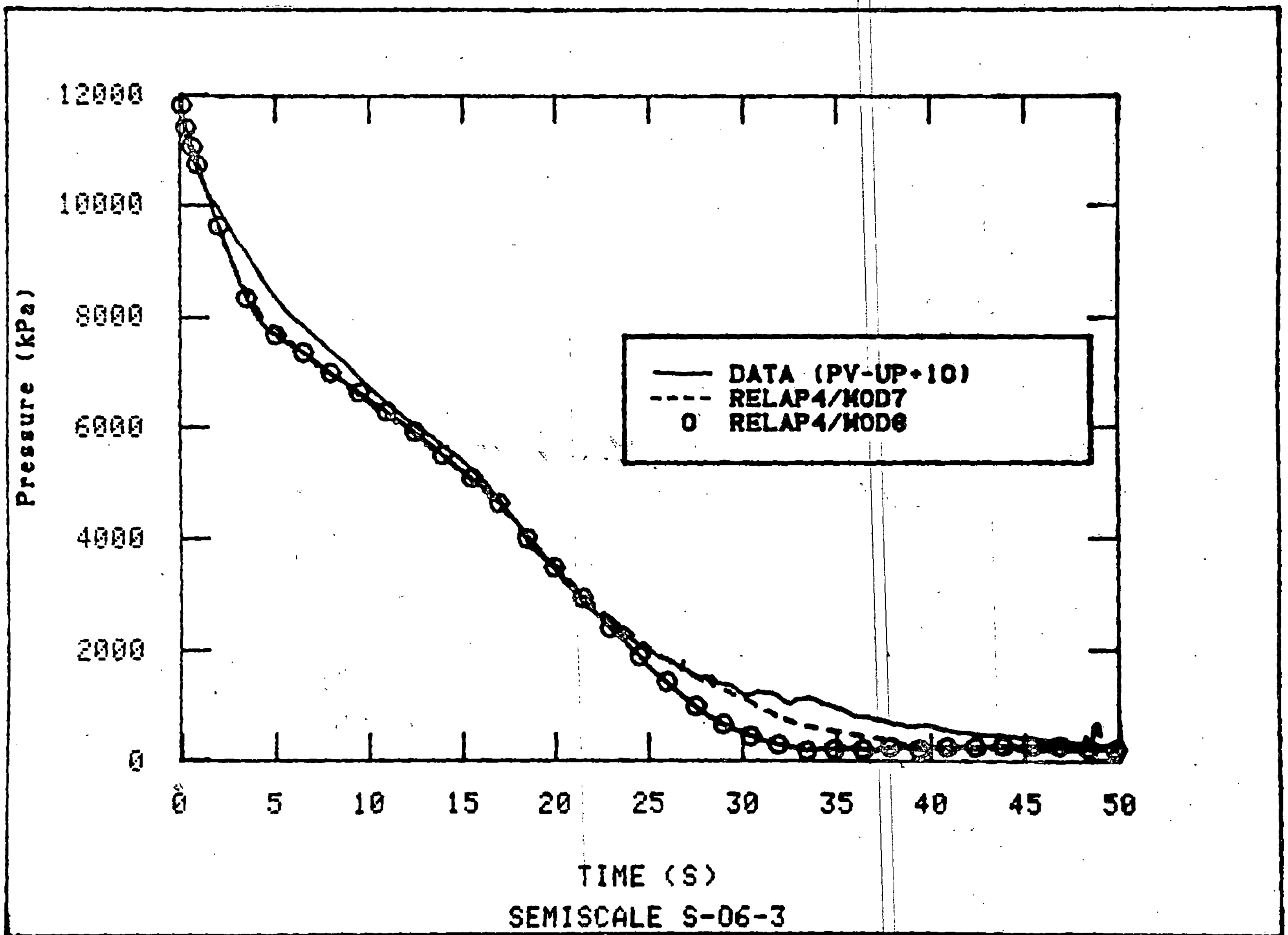

Figure 4 - Upper Plenum Pressure

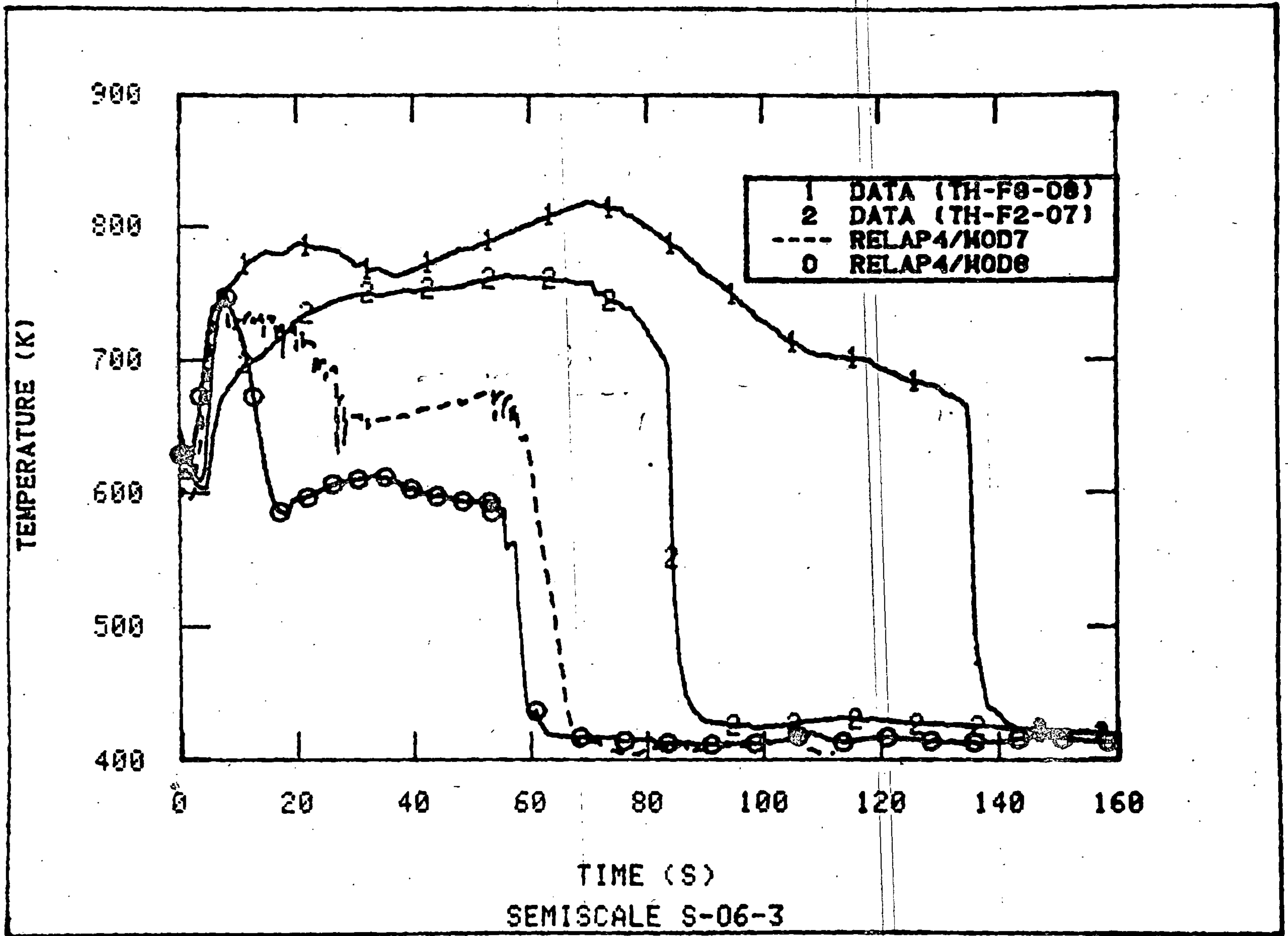

Figure 5 - Low Power Rod Surface Temperature, 6-11 in. Elevation

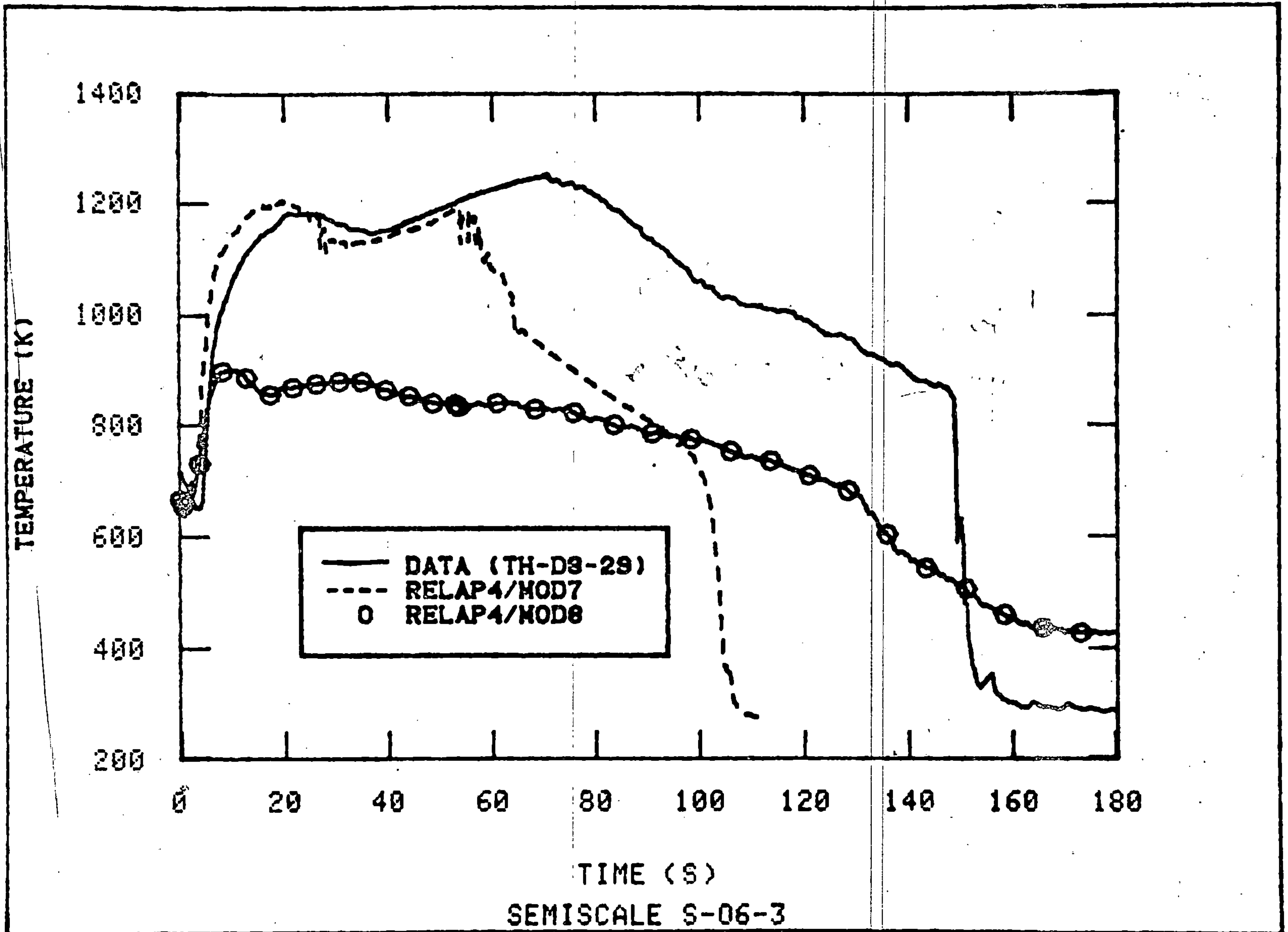

Figure 6 - Low Power Rod Surface Temperature, 24-30 in. Elevation

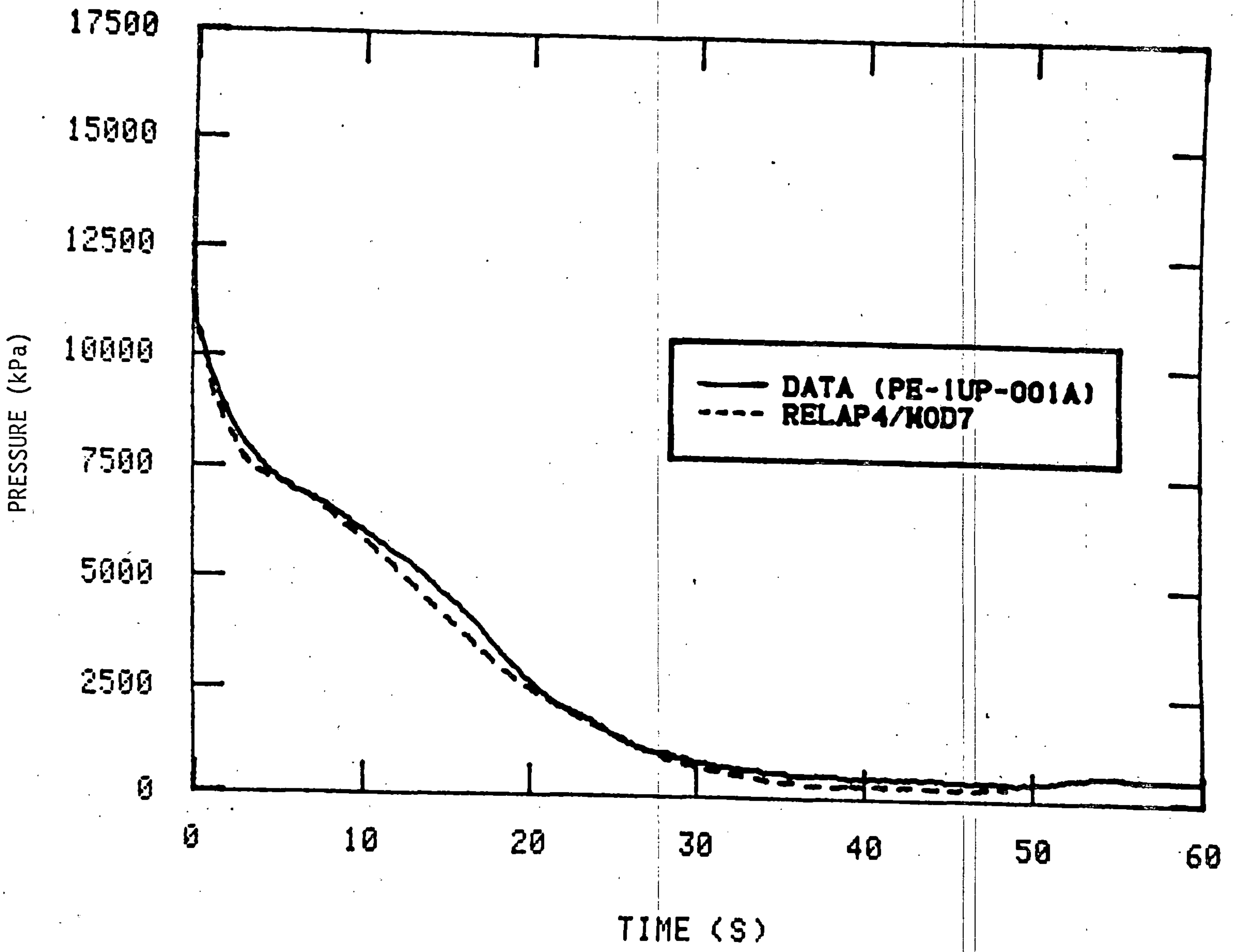

Figure 7 - Calculated and Experimental
Upper Plenum Pressures

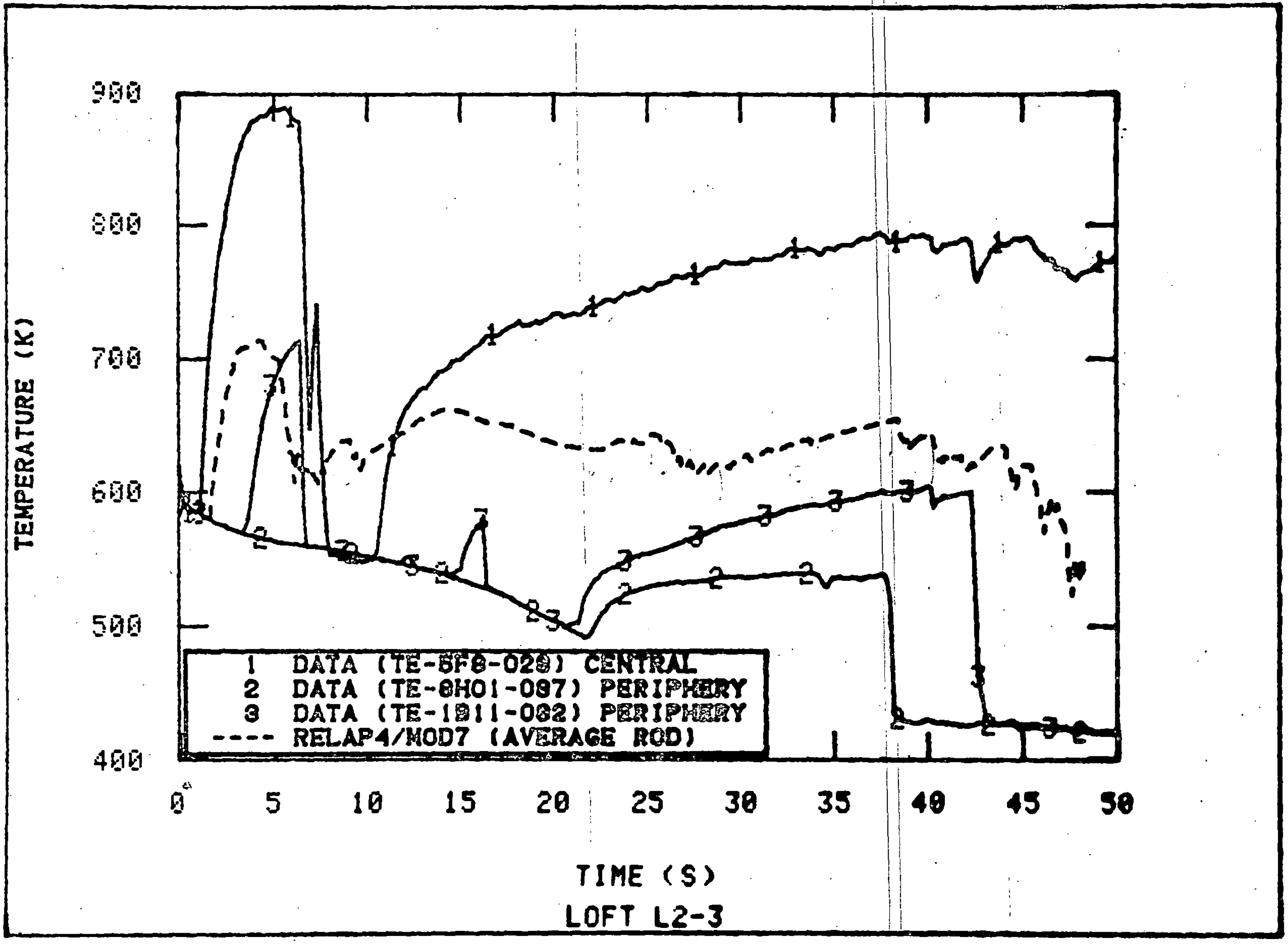

Figure 8 - Calculated and Experimental Cladding Temperatures in Middle of Core

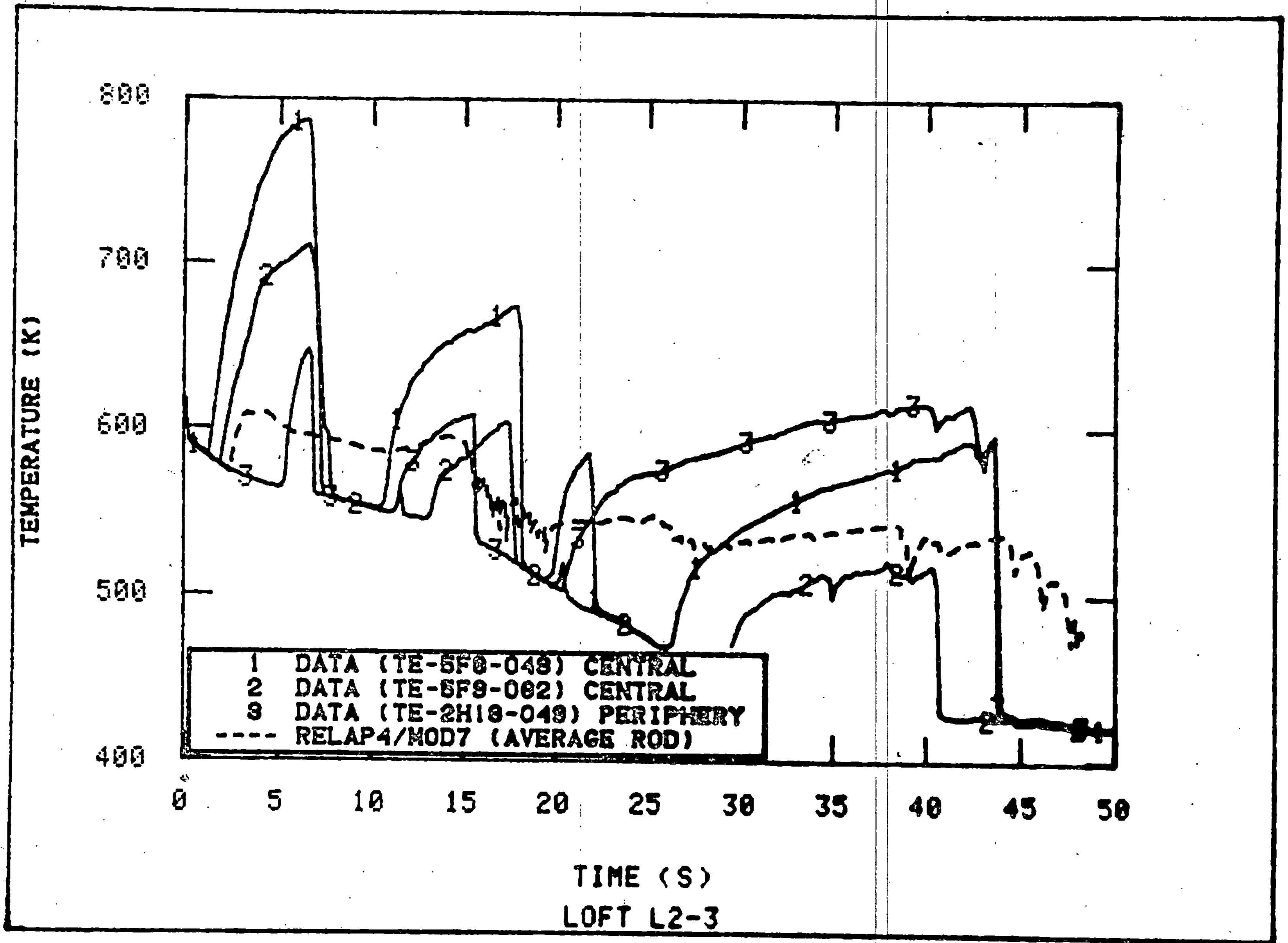

Figure 9 - Calculated and Experimental Clad Temperatures in Upper 1/3 of Core

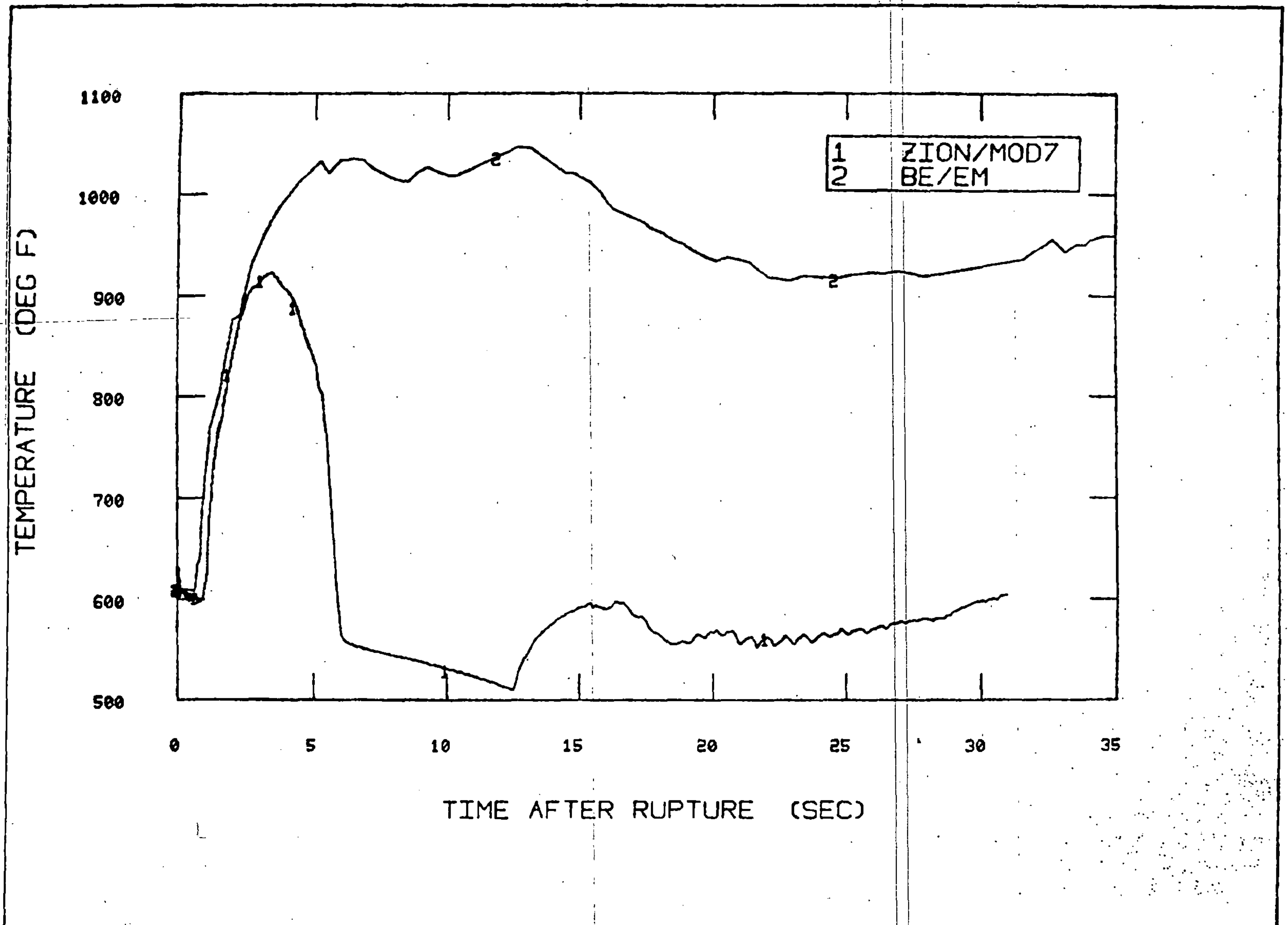

Figure 10 - Average-core-rod surface temperatures - center of core.

horizontal flow stratification model. These studies, described in Reference 10, show that the horizontal flow stratification model in the code is not adequate to model physical phenomena, such as reflux boiling and critical discharge through small breaks associated with large horizontal pipes described in Reference 11. The code cannot account for the presence of a noncondensible gas. The control system model considered in the code may be too simplistic in some cases. The reactor point kinetics and reactivity feedback models in RELAP4/MOD7 may be too simplistic for accurate calculation of transients without early reactor scram. These difficulties do not preclude using RELAP4/MOD7 for small-break LOCAs or transients, but they will require greater care when applying the program to areas for which it was not specifically designed.

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a. Boron injection and tracking capability and inclusion of boron reactivity effects

b. Self-initialization capability for the secondary side of PWR plants.

c. Self-initialization capability for BWR plants.

Boron injection and tracking capability is incorporated in a new version of the code. The remaining capabilities will be incorporated in a future version.

The RES technical contact for this work is Fuat Odar.

Robert B. Minogue

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Office of Nuclear Regulatory Research

* SEE PREVIOUS CONCURRENCES

CRESS*	WRSR:ADB *	WRSR:ADB*	WRSR:AD*	WRSR:AD*	RES *
Odar 1/a	FOdar:mw	SFabic	CJohnson	LSTong	TEMurley
12/9/80	12/ /80	12/ /80	12/ 80	12/ /80	12/ /80

RES	RES	RES
JLarkins	SBassett	RMinogue
12/11 /80	12/ /80	12/ /80

OZB
12/15/80

Distribution:
Subj
Circ
Chron
FOdar
SFabic
CJohnson/Sullivan/Tong
TMurley/LShao
JLarkins
SBassett
RMinogue
FOdar R/F
Branch R/F