RELAP4/MOD6 ASSESSMENT RESULTS

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Approximately one year ago, the NRC and various national laboratories and consultants agreed on a method for conducting code assessment. The method involves the development of an assessment matrix specifying various data comparisons and the completion of the comparisons. Ideally, the assessment procedure is applied to released codes. This method has now been applied to the RELAP4/MOD6 code for conducting the base case data comparisons. Because the code was not released and the checkout phase had been limited, additional calculations were made to investigate the application of the code to blowdown and reflood experimental facilities. Most of the data comparisons represent posttest analysis, although six pretest predictions were made and compared with data.

Core component data comparisons utilized Semiscale Test S-06-5 and THTF Test 105. These comparisons revealed that the code heat transfer is capable of predicting the peak cladding temperatures in high powered tests with maximum linear heat generation rates of 39.7 and 55.6 kW/m, respectively, when large cold leg breaks are simulated. The data for both tests reflected the code calculation of early CHF (critical heat flux) at the lower core elevations. However, the data demonstrated mixed early and delayed CHF at the high power step and primarily delayed CHF at elevations above the high power step; the code did not calculate the delayed CHF.

Systems blowdown data comparisons for LOFT Isothermal Test L1-4 and both isothermal and heated Semiscale tests showed that the code provides a good prediction of critical flow at the simulated breaks. The system pressures for the Semiscale heated blowdown tests, however,

were underpredicted. Sensitivity calculations to the critical flow multiplier demonstrated that while the calculated system pressure is sensitive to the saturated critical flow model multiplier, the calculated flow is relatively insensitive to large changes in the multiplier.

Reflood calculations with RELAP4/MOD6 were compared with both forced feed and gravity feed reflood data from FLECHT, FLECHT-SET, Semiscale, and PKL. These comparisons revealed that for tests similar to those used in the checkout phase of the MOD6 code development, the code provides reasonable results. When significantly different tests were considered, however, such as a test with a skewed axial profile, the comparisons were unsatisfactory.

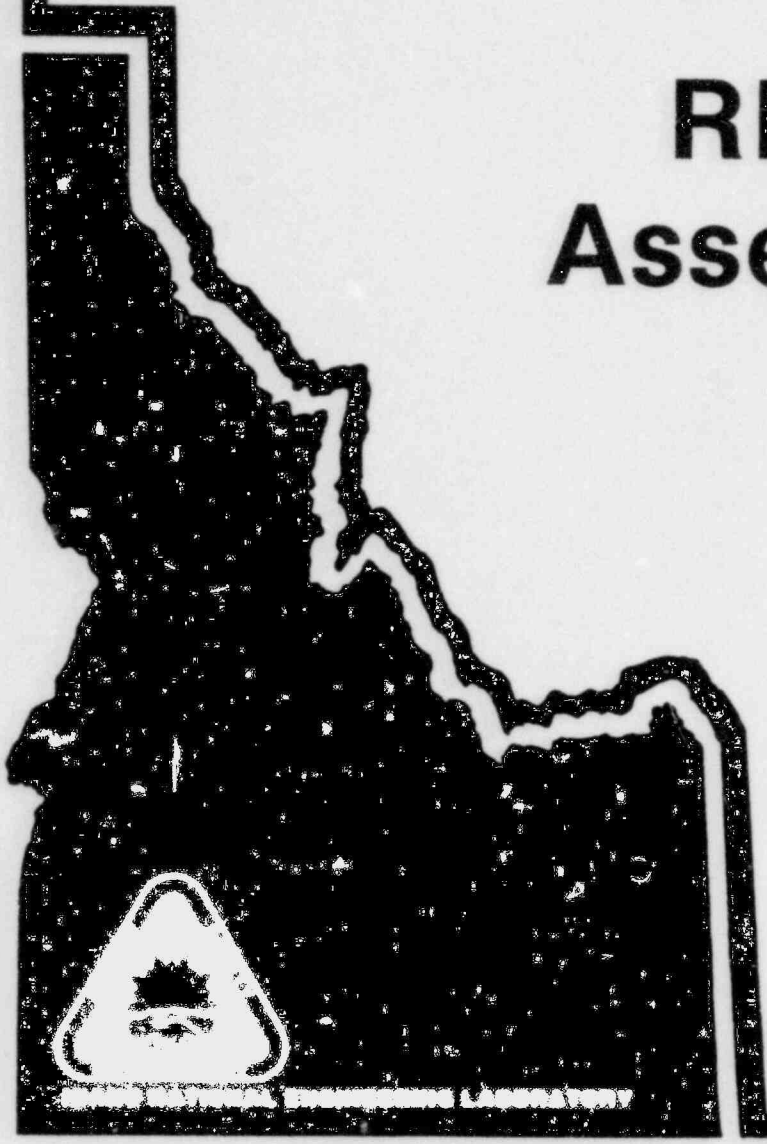
All reflood comparisons with RELAP4/MOD6 were reanalyzed and revised guidelines were developed for selecting reflood heat transfer input options. The new guidelines were applied to the previously analyzed tests and to additional tests. An overall improvement in the cladding temperature comparisons was obtained.

A statistical method has been developed to facilitate investigation of code performance from one test to the next and from one facility to another. The method is based on replication of experiments (or measurements) instead of the response surface methodology requiring large numbers of computer runs for a single experiment. The method has been applied to both blowdown and reflood comparisons, and does provide insight into the ability of the code to represent various phenomena.

The preliminary conclusions from the RELAP4/MOD6 assessment are as follows: (1) a method for assessing large computer codes has been successfully demonstrated; (2) a statistical method for investigating code performance between different facilities has been successfully applied; and (3) areas for additional code development, both in blowdown and in reflood, have been identified.

REFERENCE SOURCES

1. G. E. Wilson, Comparison of RELAP4/MOD6 with Forced-Feed Reflood Data, CVAP-TR-78-007 (May 1978).
2. C. D. Fletcher, Gravity-Feed Reflood Data Comparisons Using RELAP4/MOD6, Update 3, CVAP-TR-78-009, (May 1978).
3. C. B. Davis, Comparisons of RELAP4/MOD6 with Core Blowdown Data, CVAP-TR-78-012 (May 1978).
4. W. S. Haigh, Prediction of KWU PKL Experiments K5A and K7A Using RELAP4/MOD6, CVAP-TR-78-011 (June 1978).
5. M. S. Sahota, Comparisons of RELAP4/MOD6 with Semiscale Blowdown Data, CVAP-TR-78-023 (July 1978).
6. T. H. Chen and C. D. Fletcher, Code Option Guideline Improvement Using Comparisons of RELAP4/MOD6 with Forced and Gravity-Feed Reflood Data, CAAP-TR-78-029 (September 1978).



RELAP4/MOD6 Assessment Results

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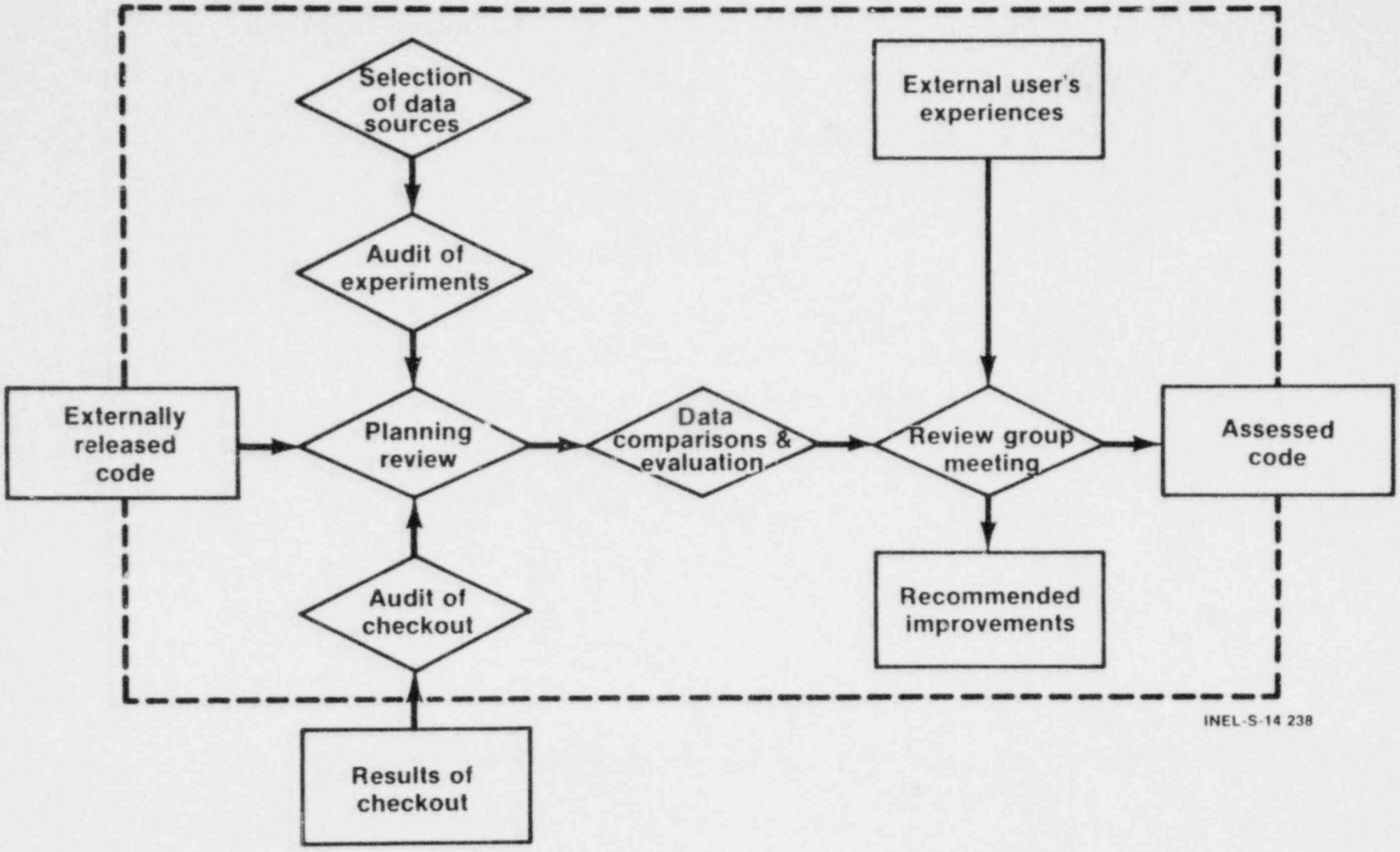
Code Assessment



Assessment Procedure

- Develop matrix
- Data comparisons
  - Component blowdown
  - System blowdown
  - Reflood
  - Integral behavior
- Statistical method for extending results
- Summary documentation

Component Blowdown

- Semiscale
- THTF

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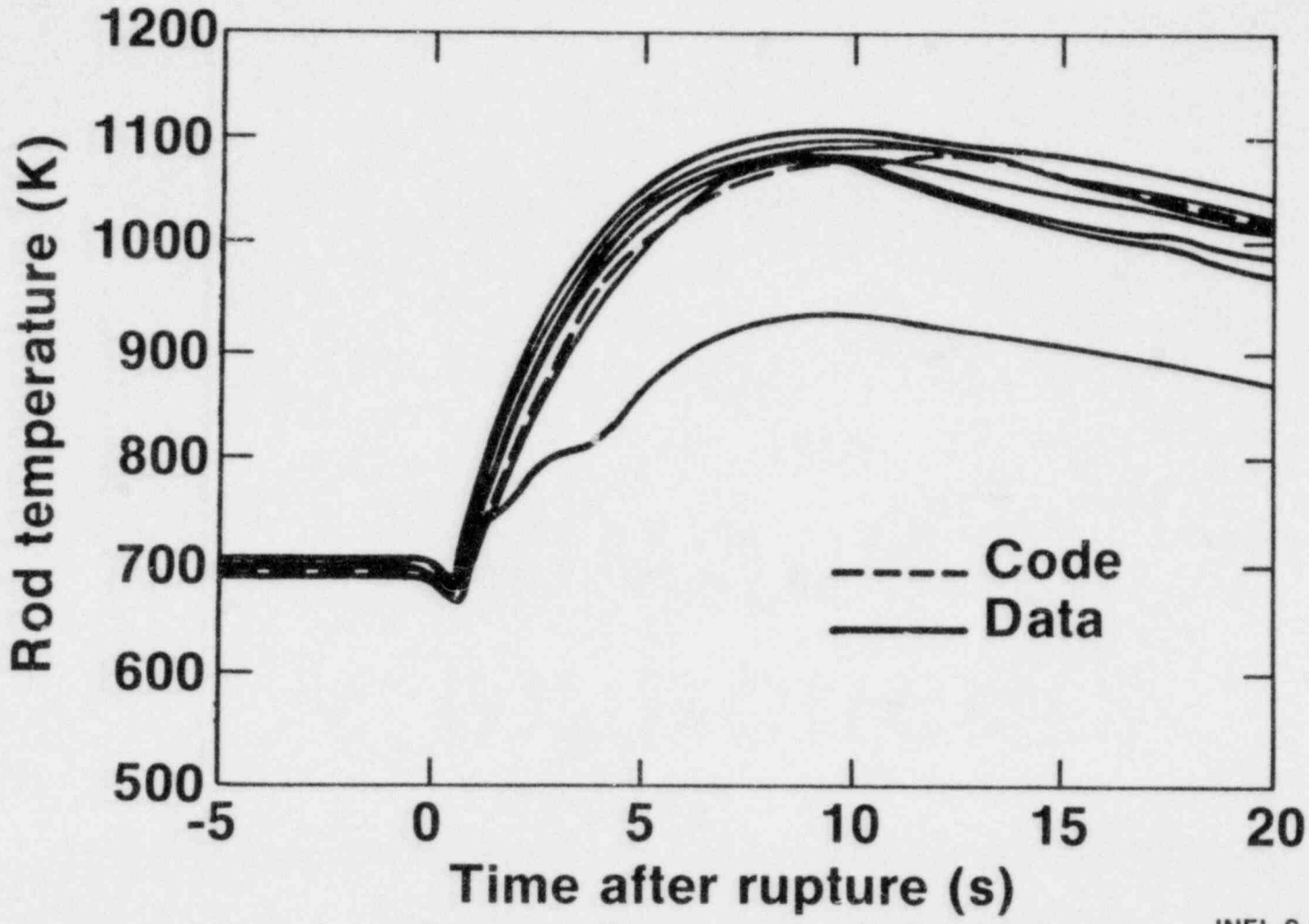
Semiscale Test S-06-5
High Power Step



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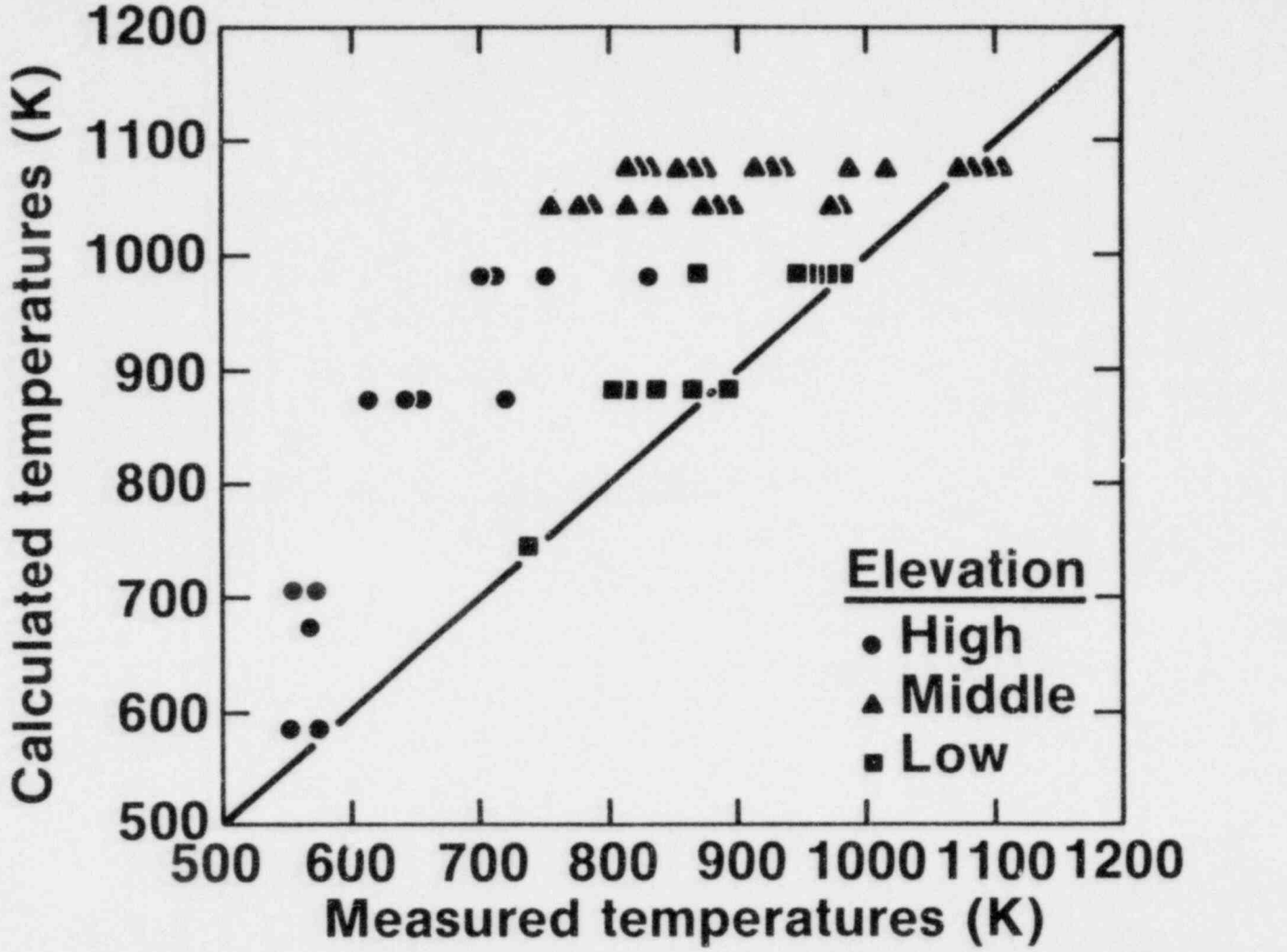
Semiscale Test S-06-5
Maximum Temperatures



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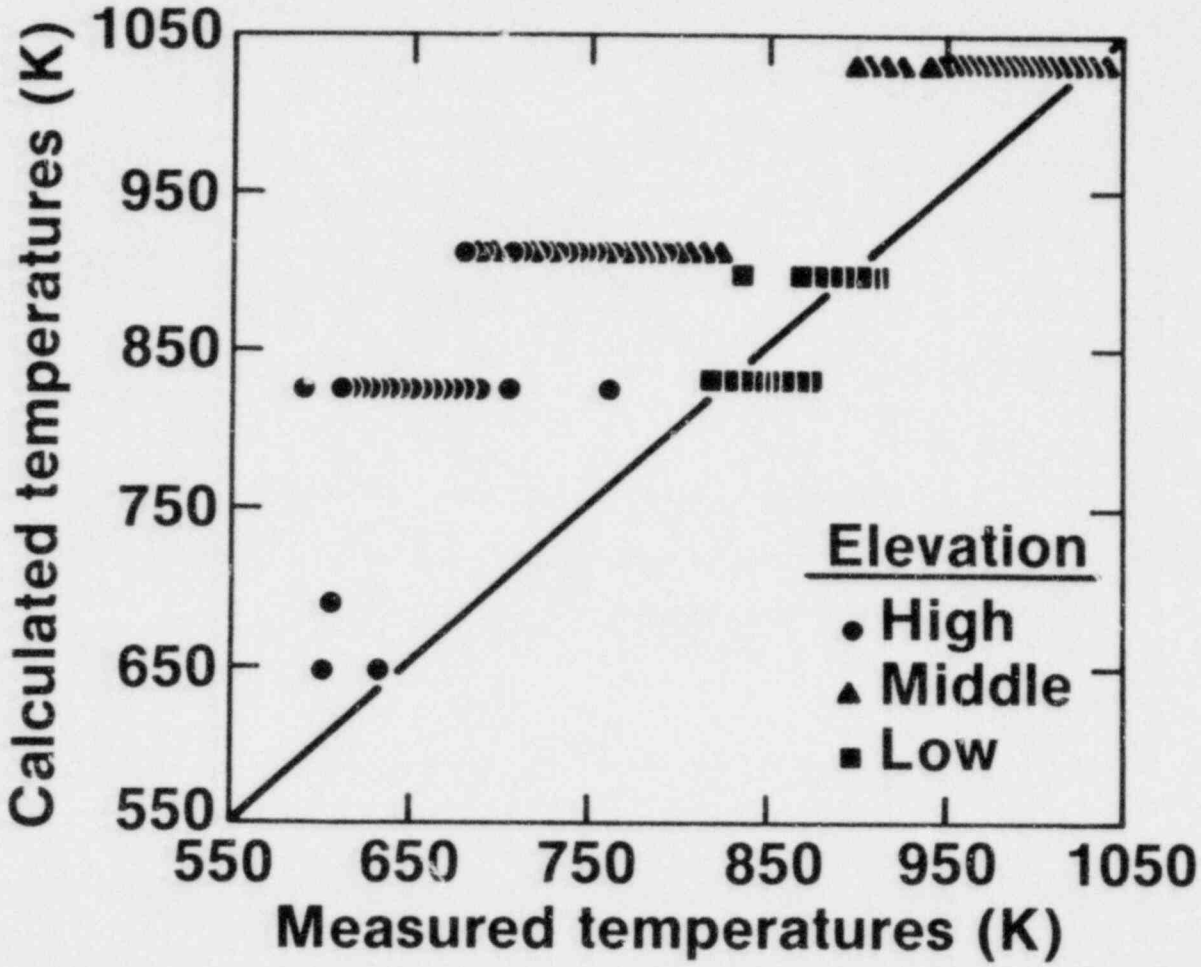
THTF Test 105 Maximum Temperatures



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System Blowdown

- LOFT
- Semiscale

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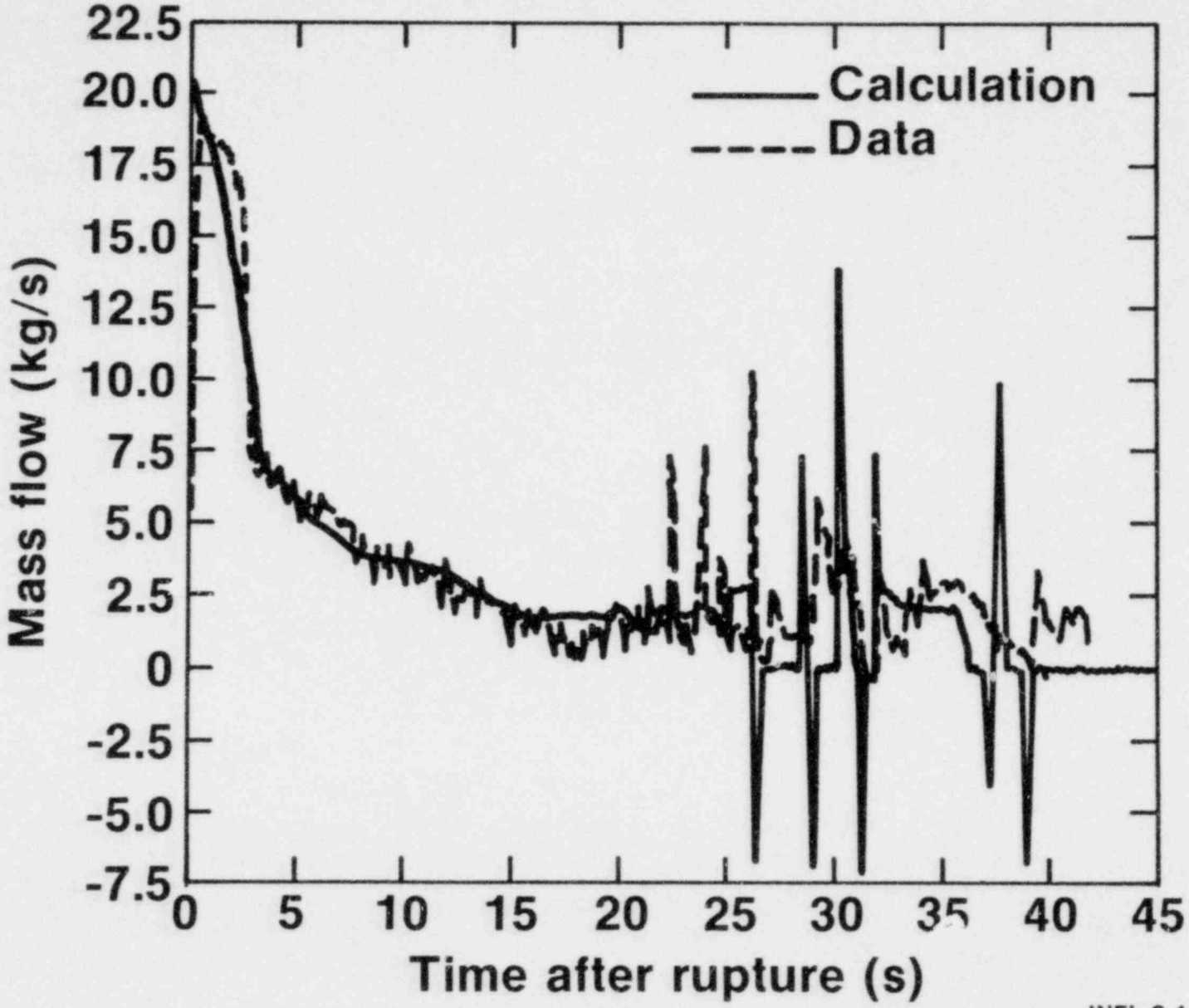
Semiscale Test S-04-6
Broken Cold Leg Mass Flow



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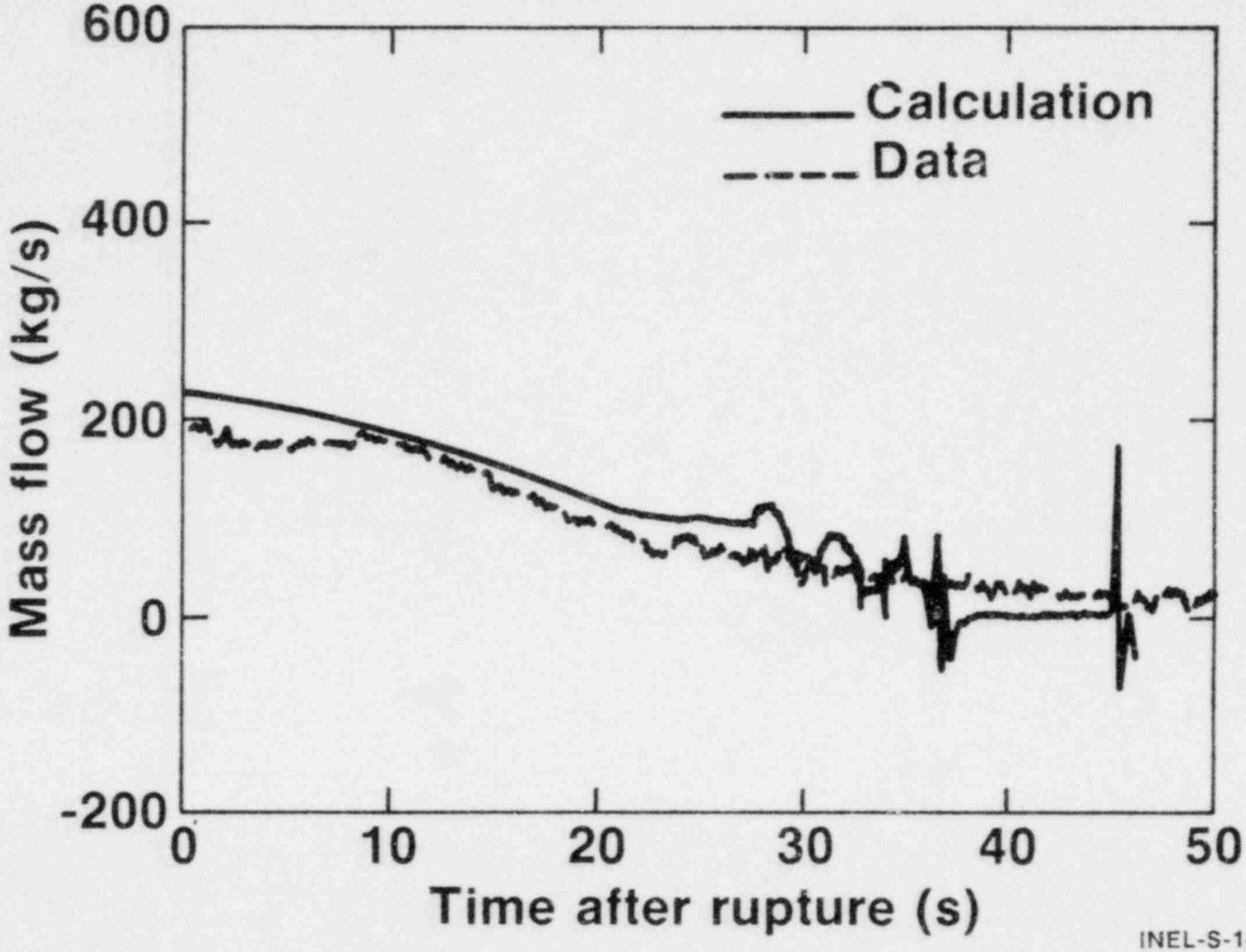
LOFT L1-4 Broken Loop Cold Leg Mass Flow



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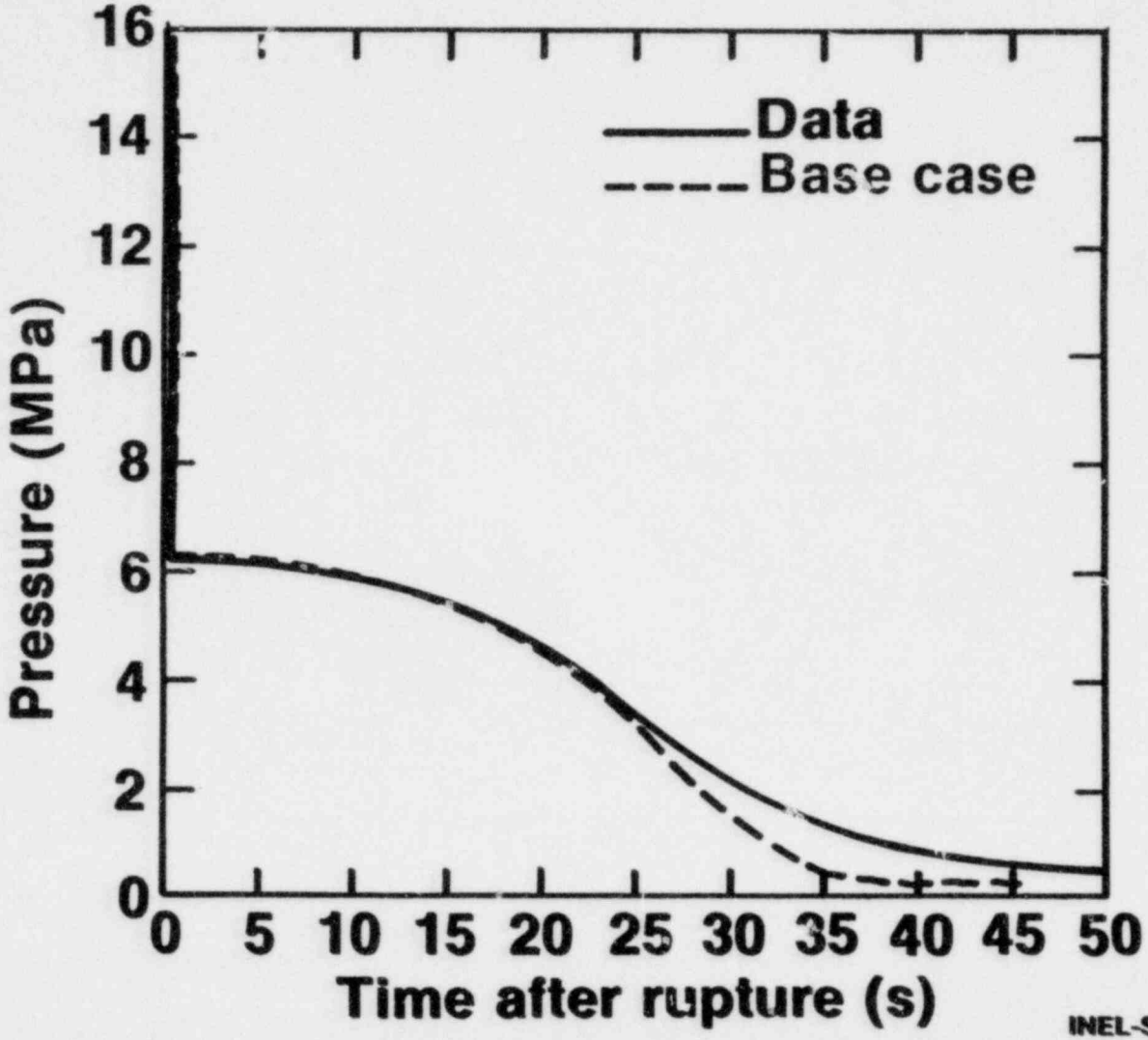
LOFT L1-4 System Pressure



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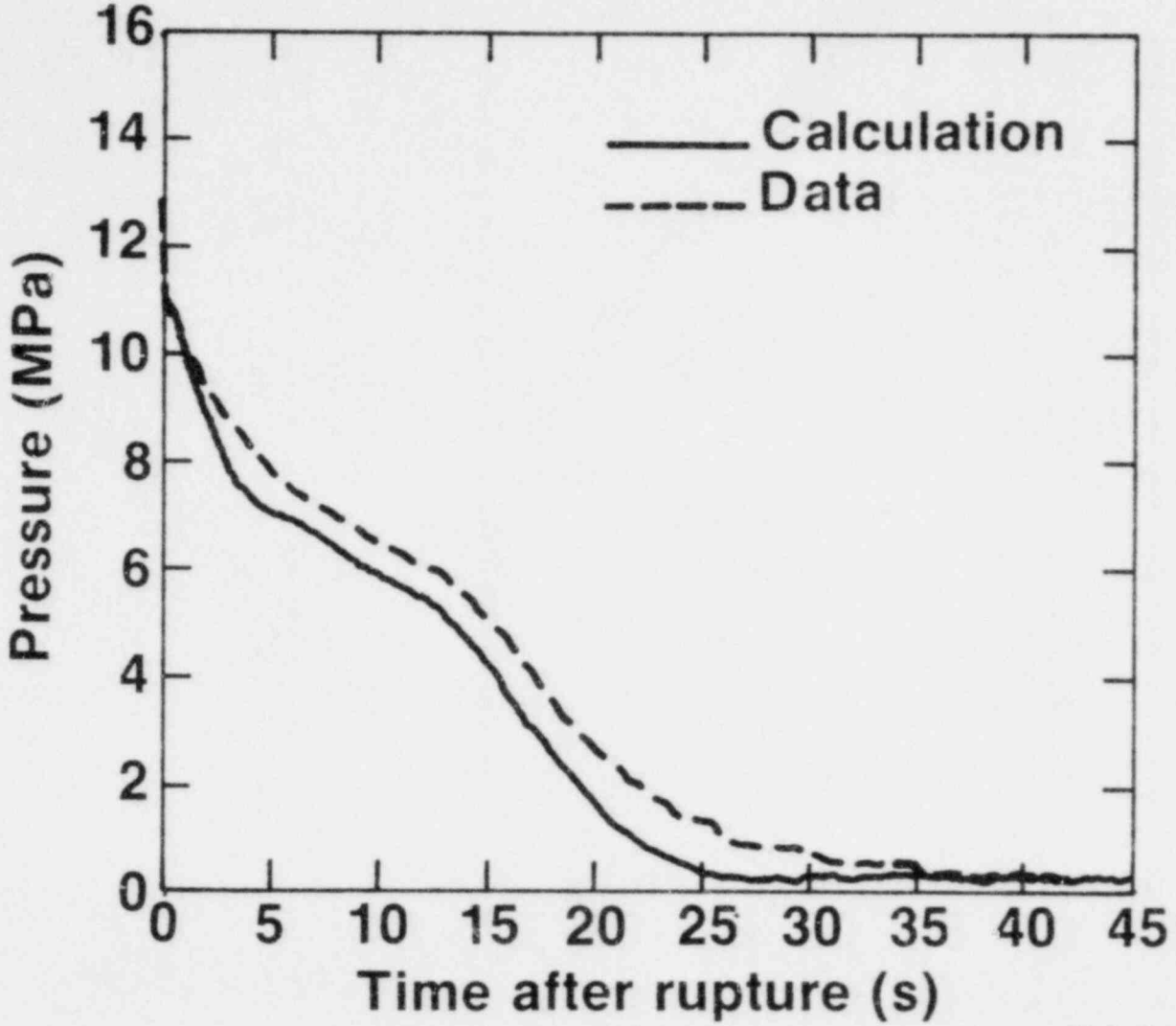
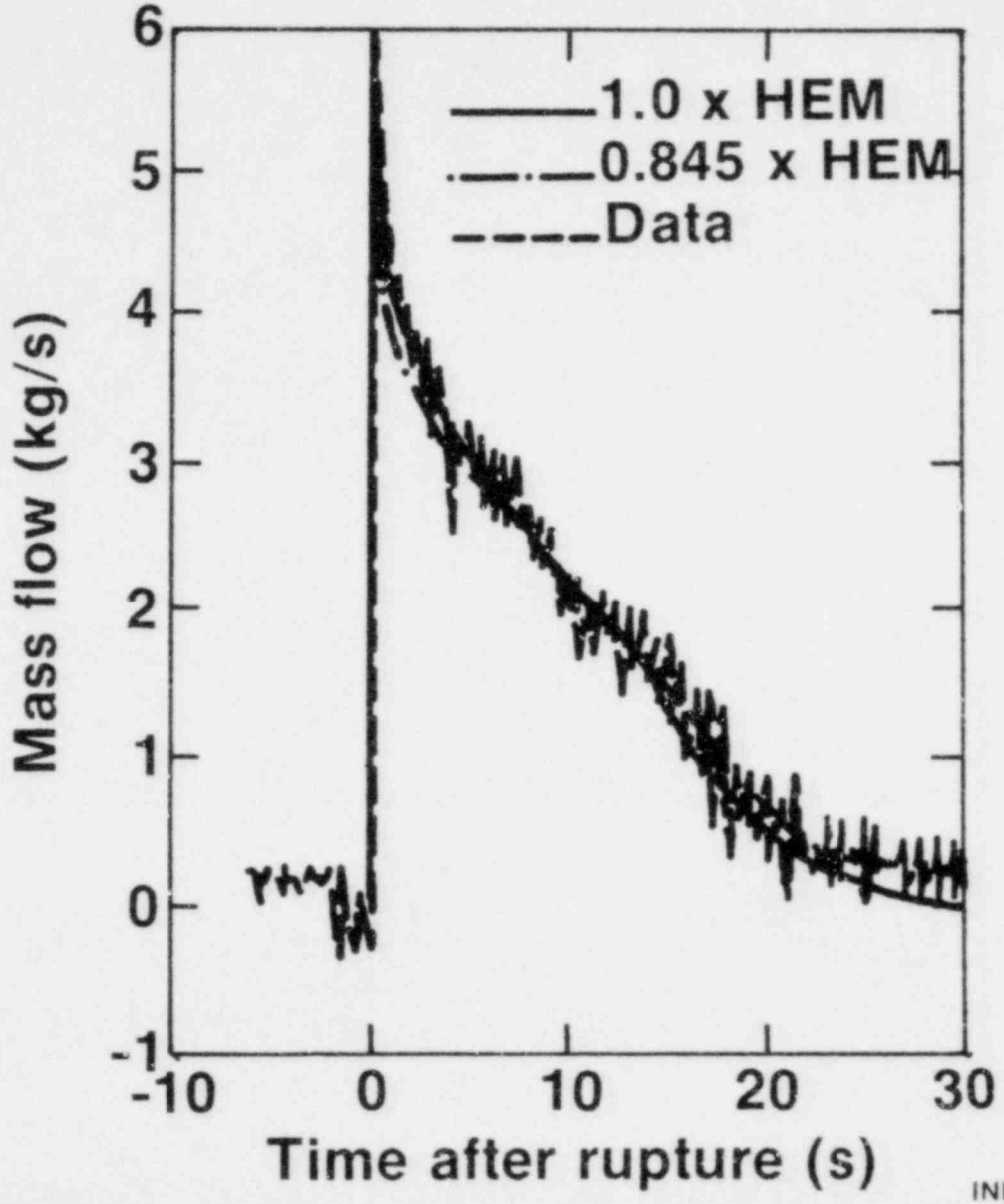
Semiscale Test S-04-6
Upper Plenum Pressure



INEL-S-14 247

HEM Break Flow Dial Sensitivity for Test S-06-1 (Hot Leg Break Flow)



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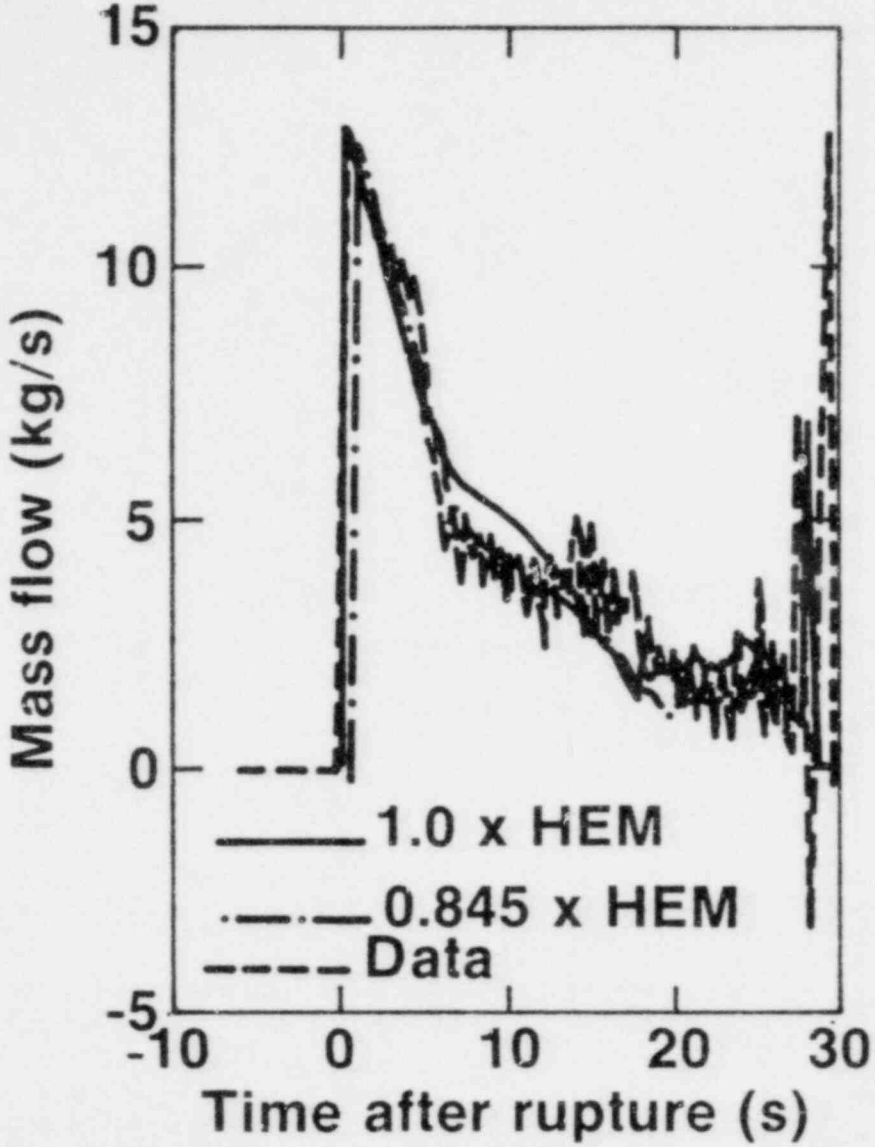
HEM Break Flow Dial Sensitivity for Test S-06-1 (Cold Leg Break Flow)



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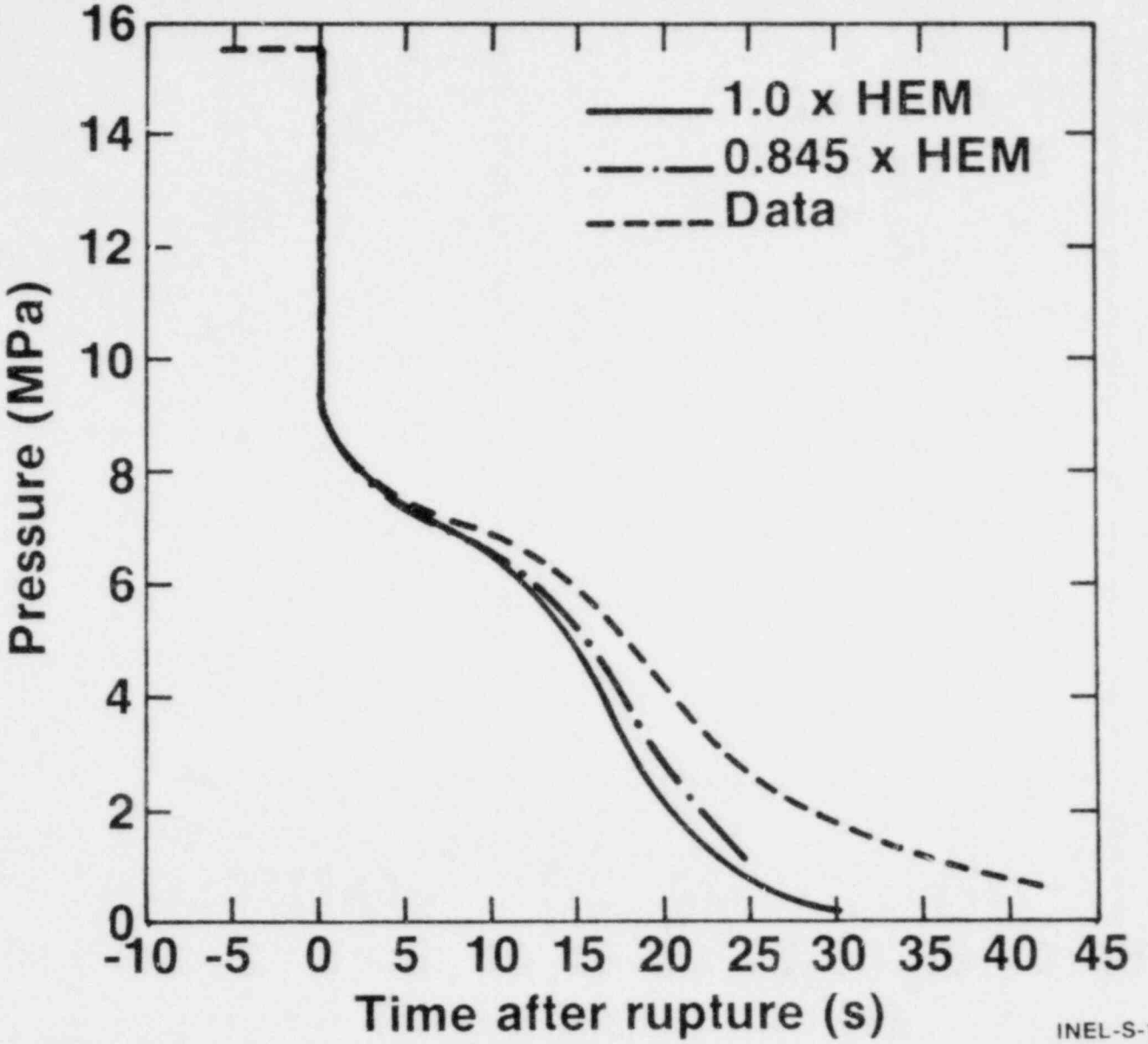
HEM Break Flow Dial Sensitivity for Test S-06-1 (Upper Plenum Pressure)



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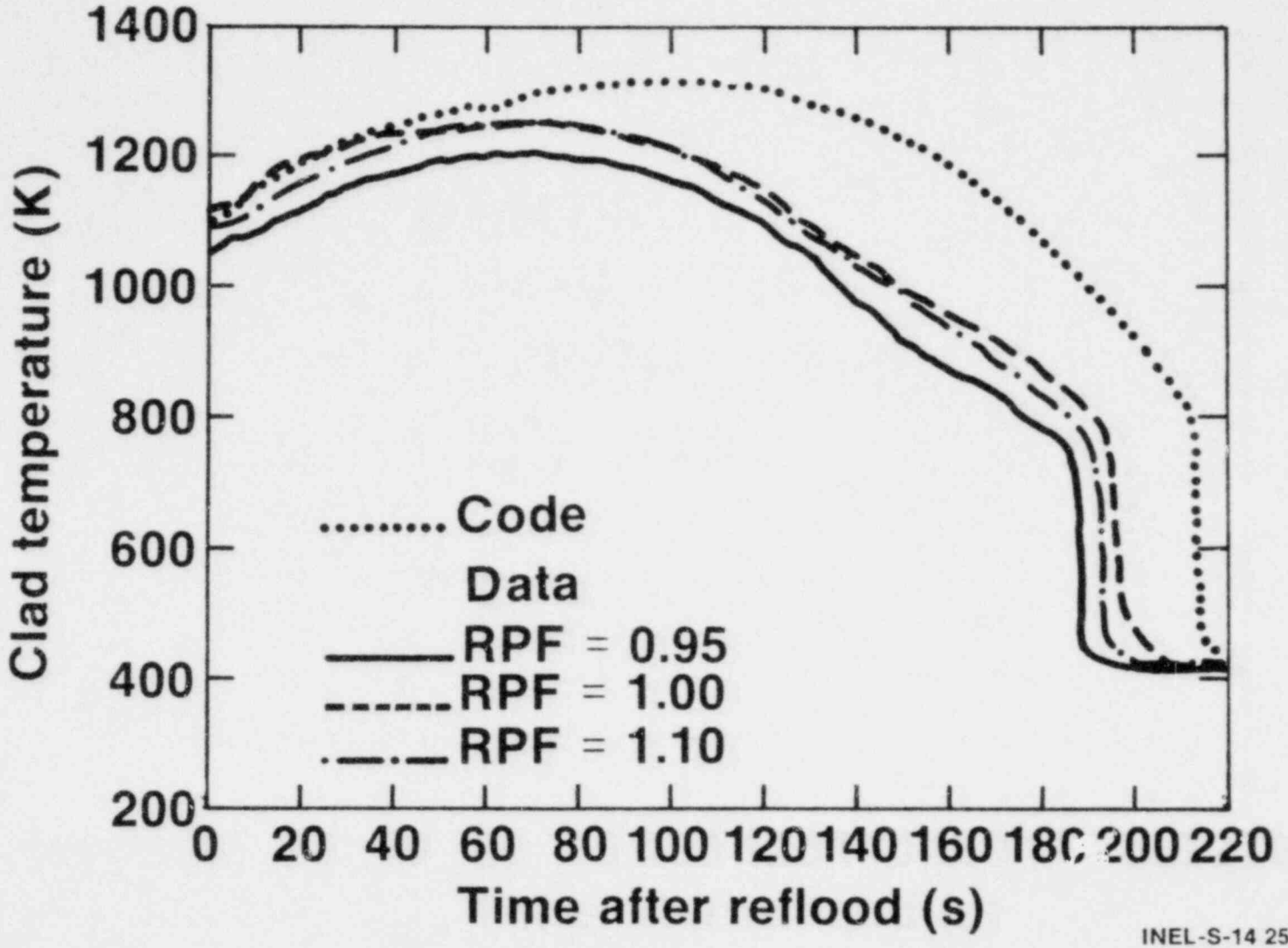
Reflood

- FLECHT
- FLECHT-SET
- Semiscale
- PKL

FLECHT Test 4019 Base Run (Hot Spot)



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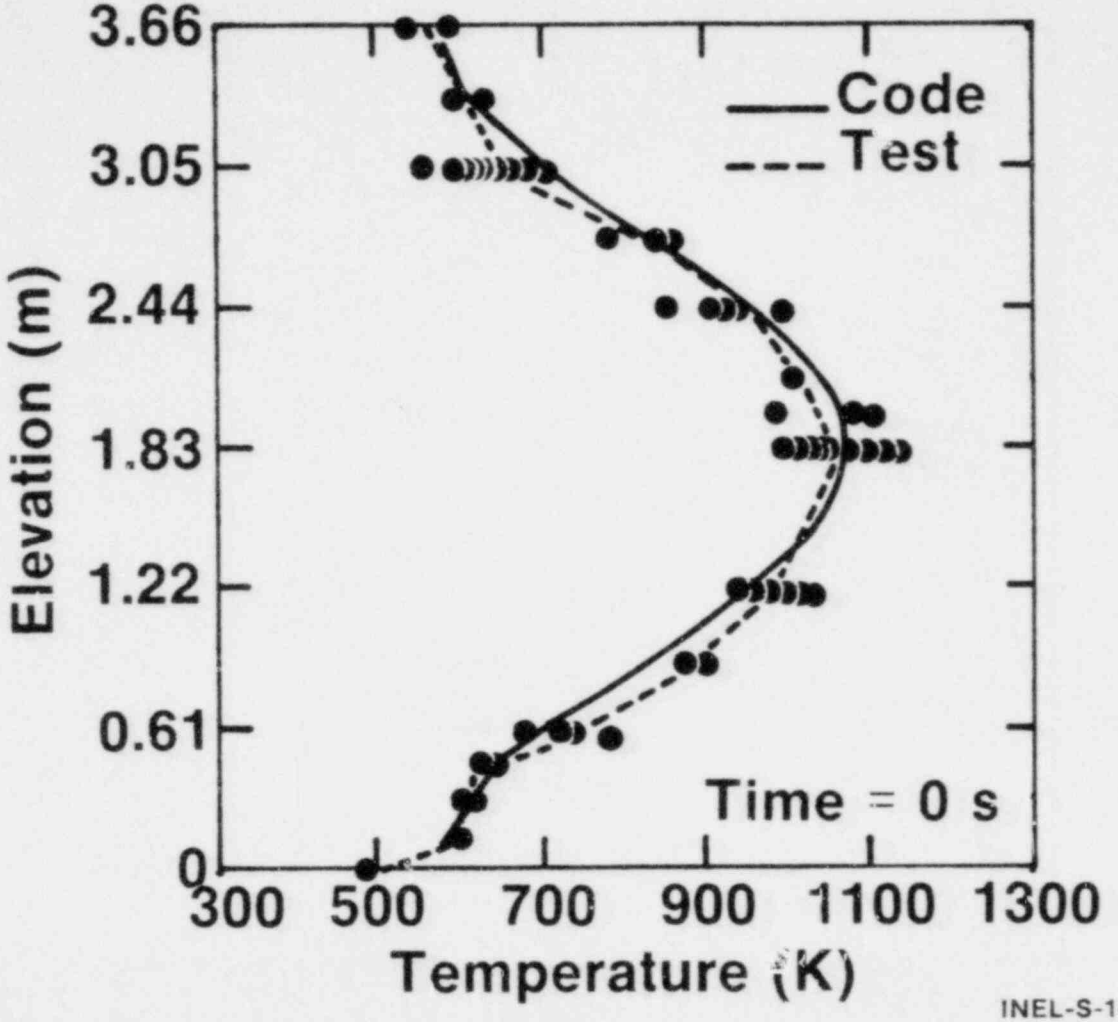
FLECHT LFR Test 4019



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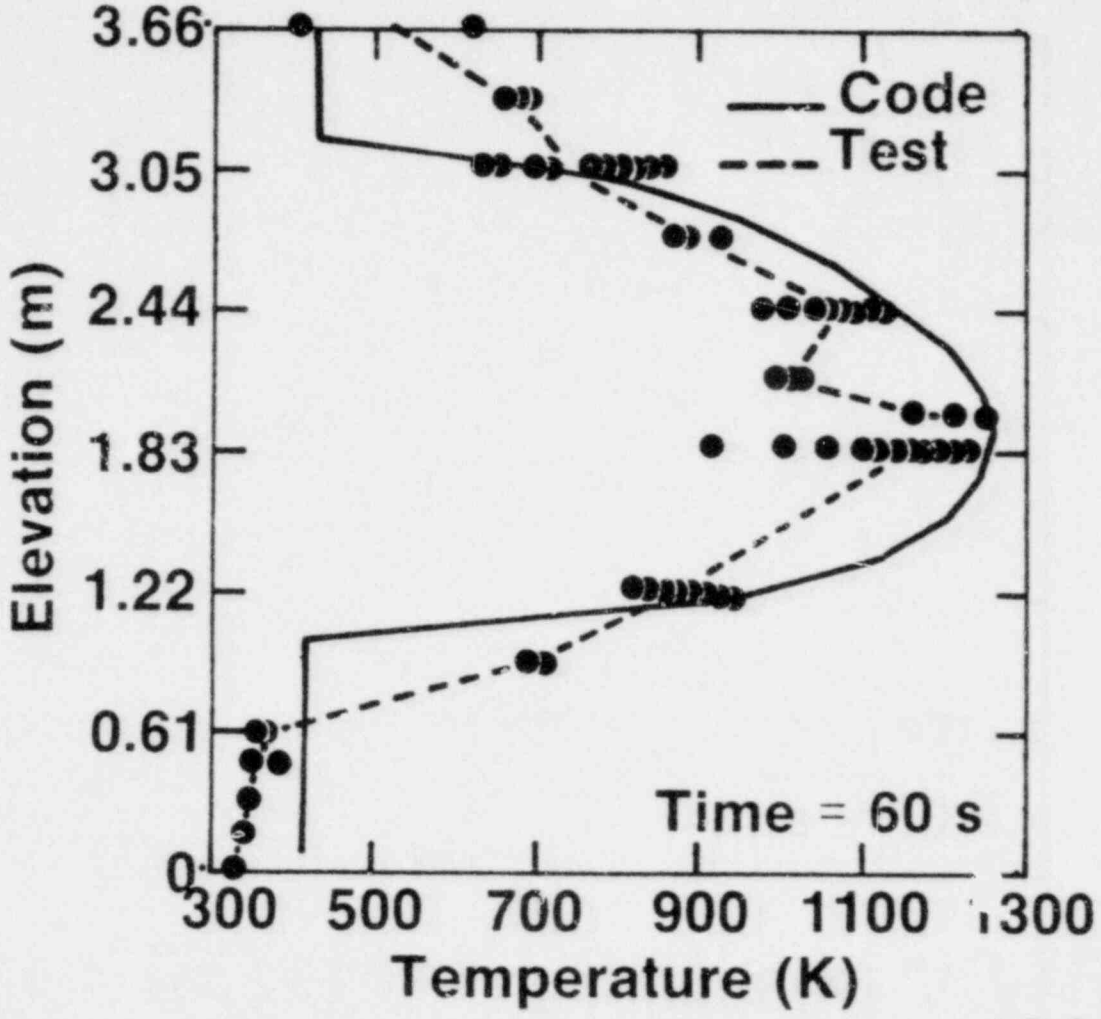

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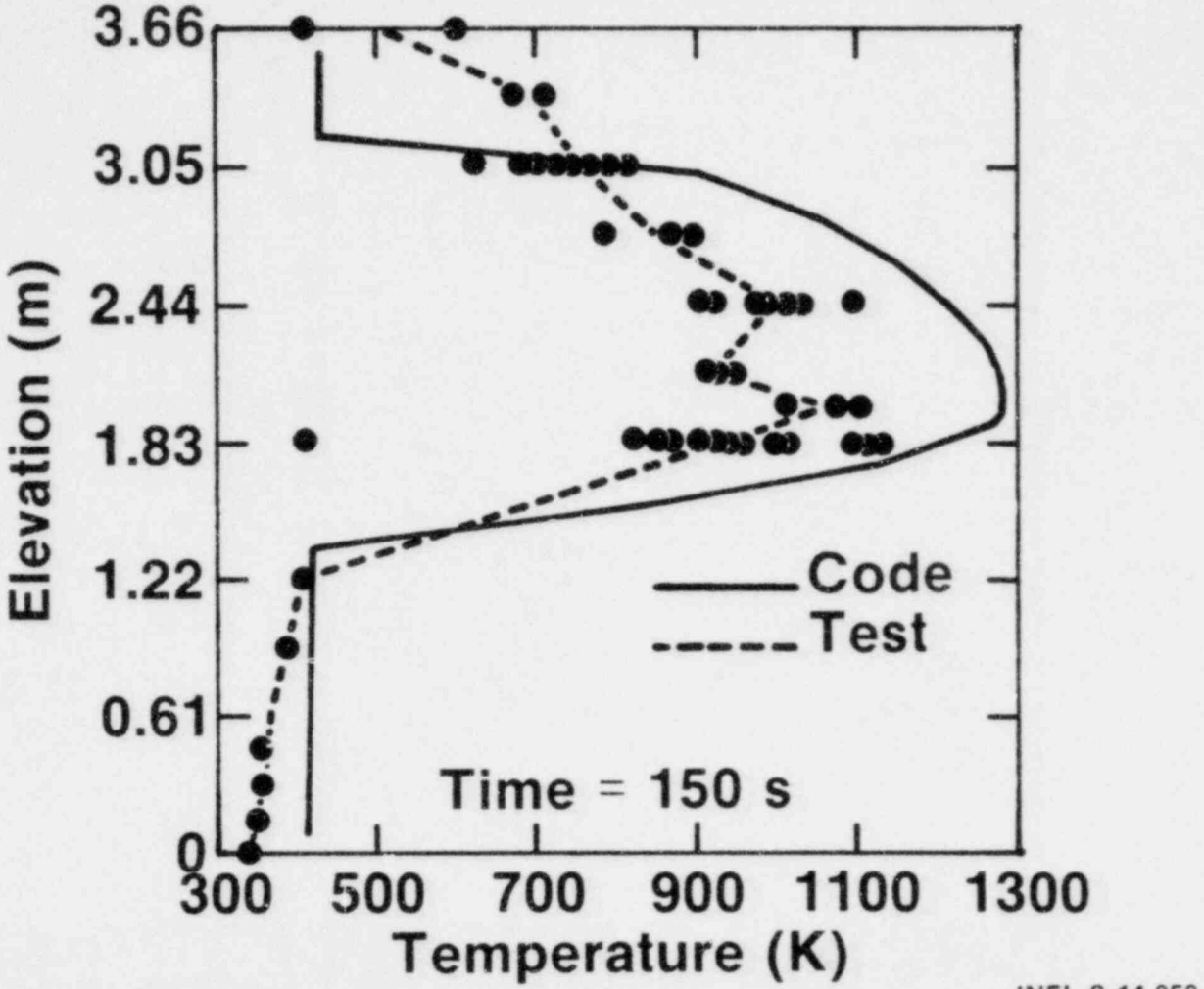

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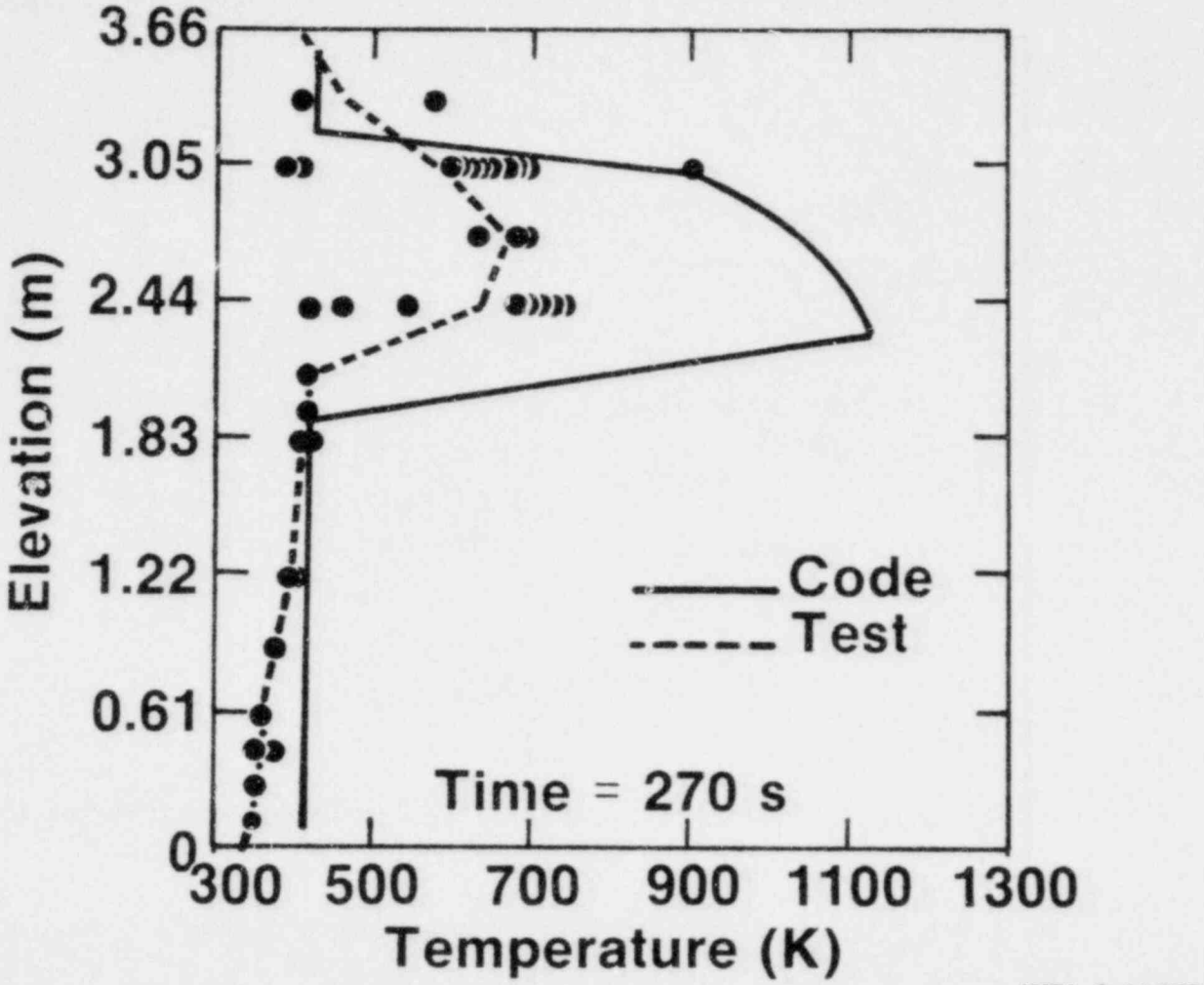

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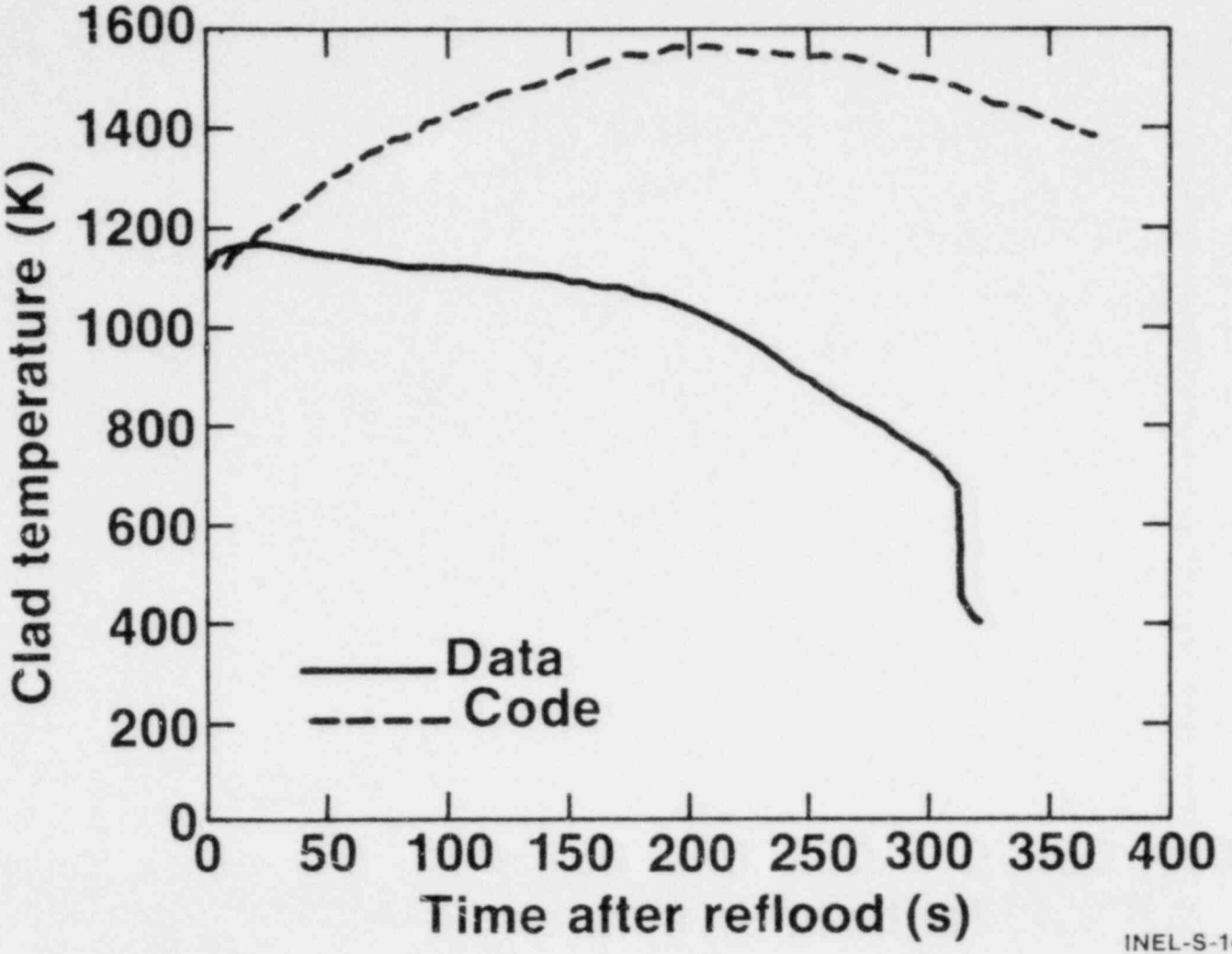
FLECHT Test 11003 Skewed Axial Profile (Hot Spot)



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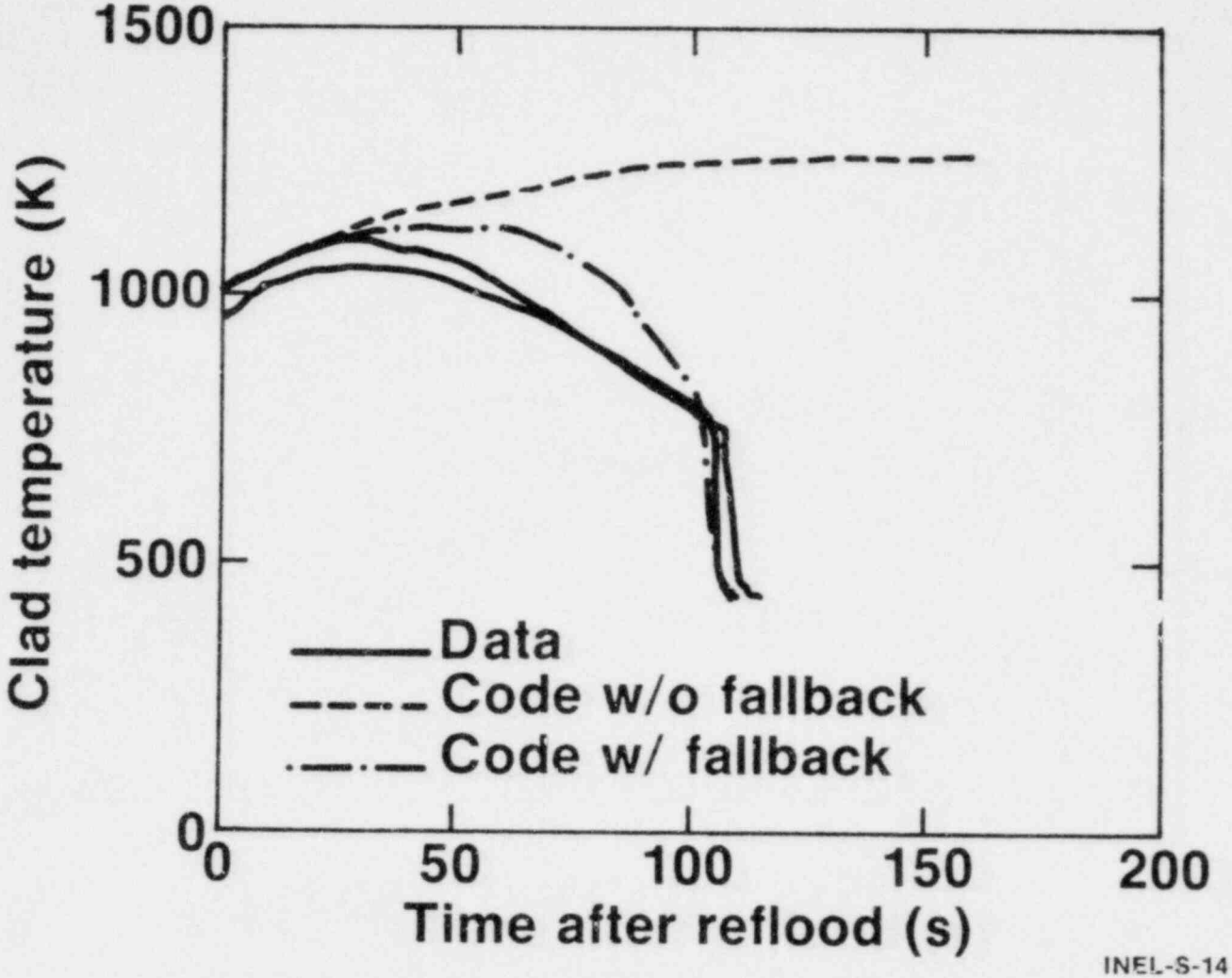
Semiscale Test S-03-D



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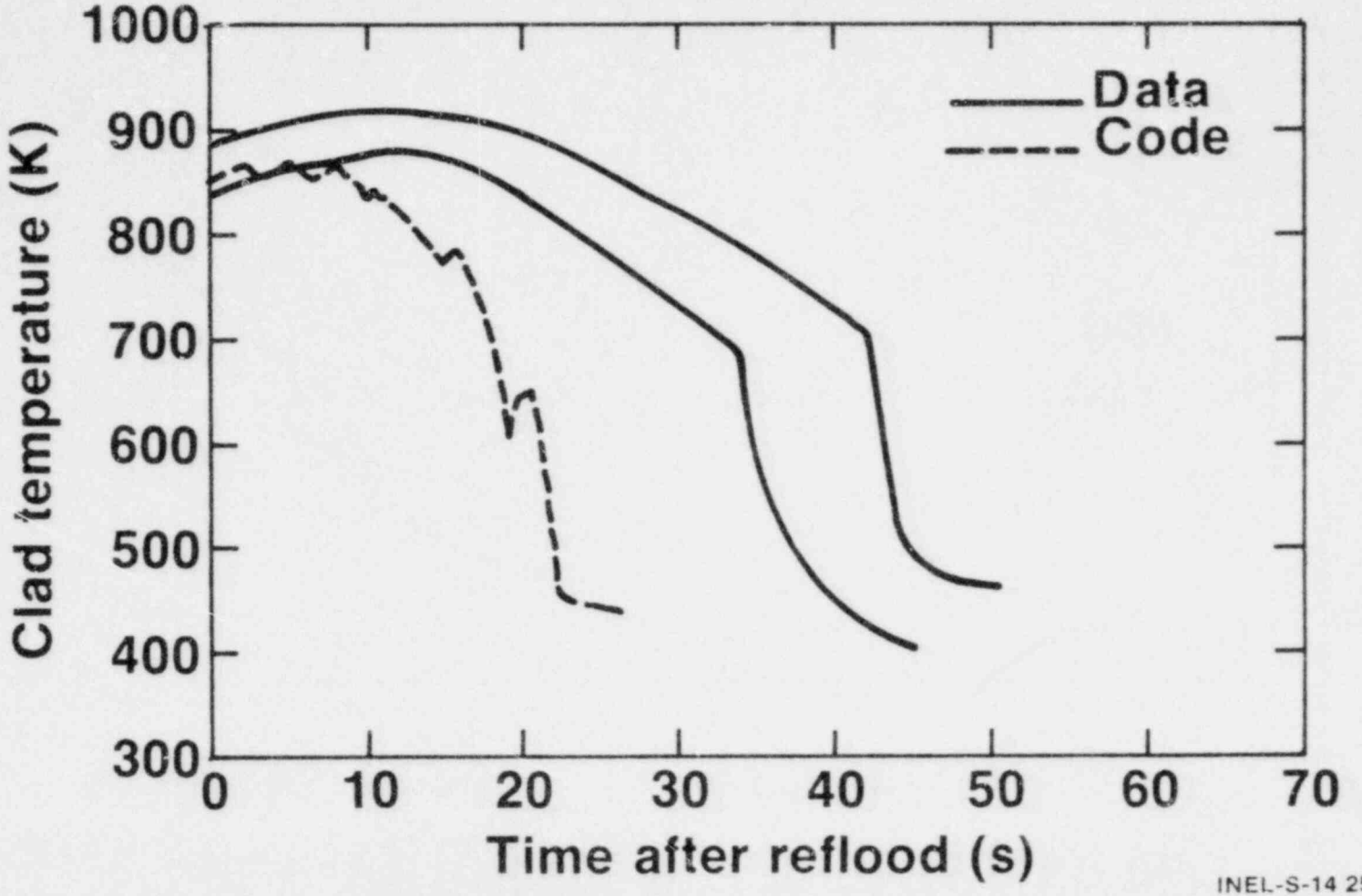
Semiscale Test S-03-5
Hot Spot Temperature



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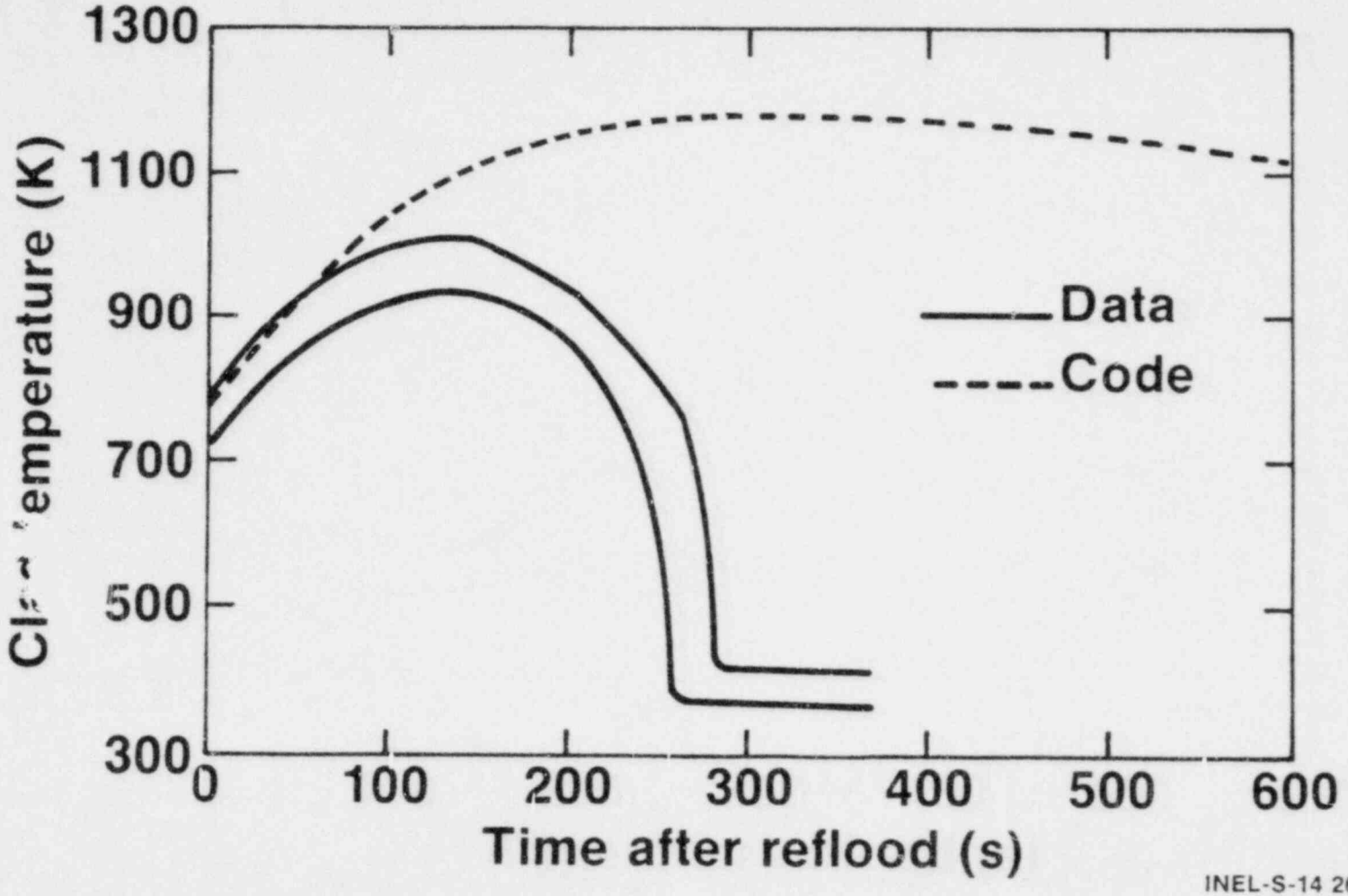
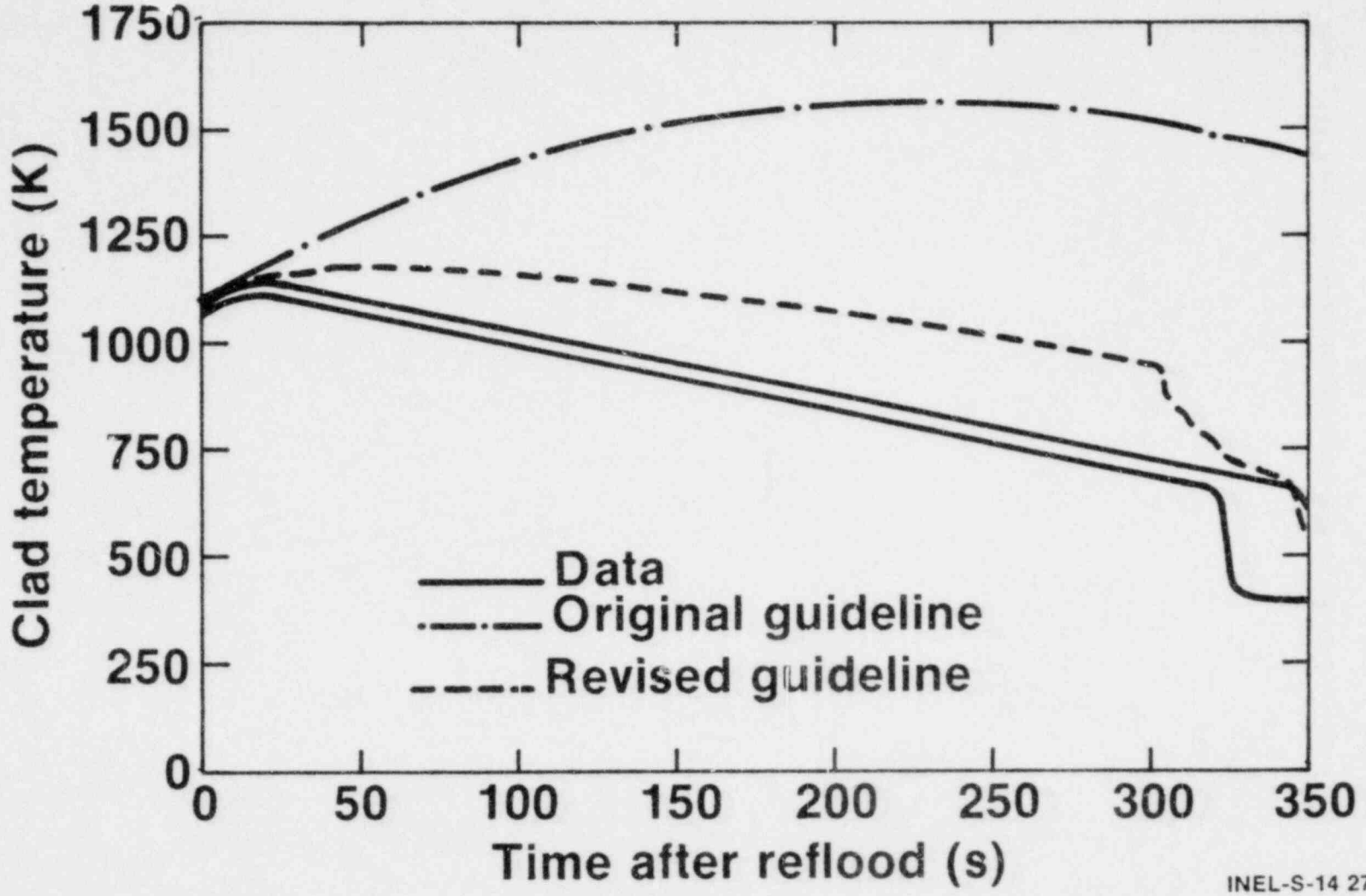
FLECHT-SET Test 2714B
Hot Spot Temperature



Reflood Guideline Improvement
FLECHT 11003



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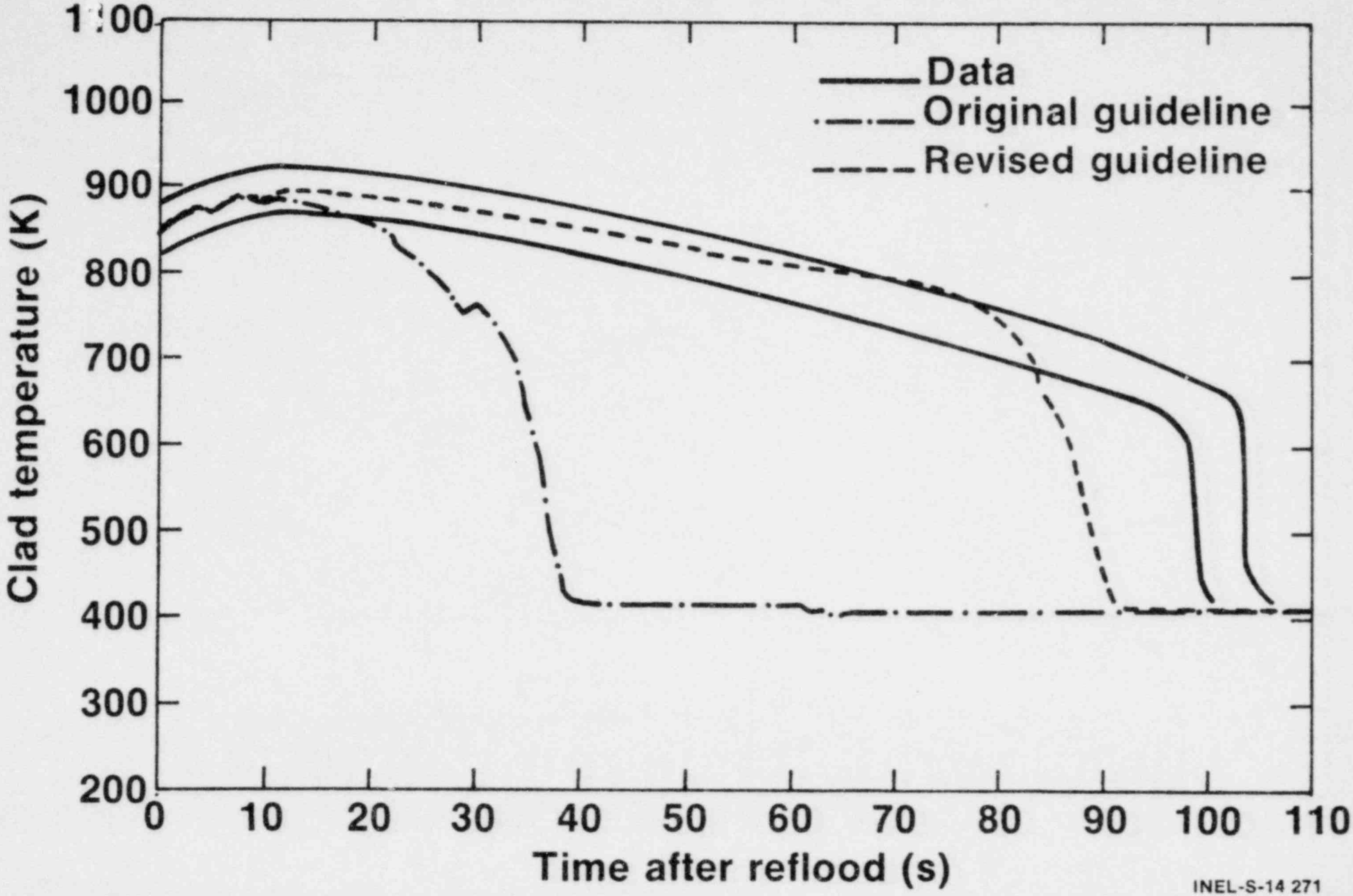
Reflood Guideline Improvement
Semiscale S-03-8



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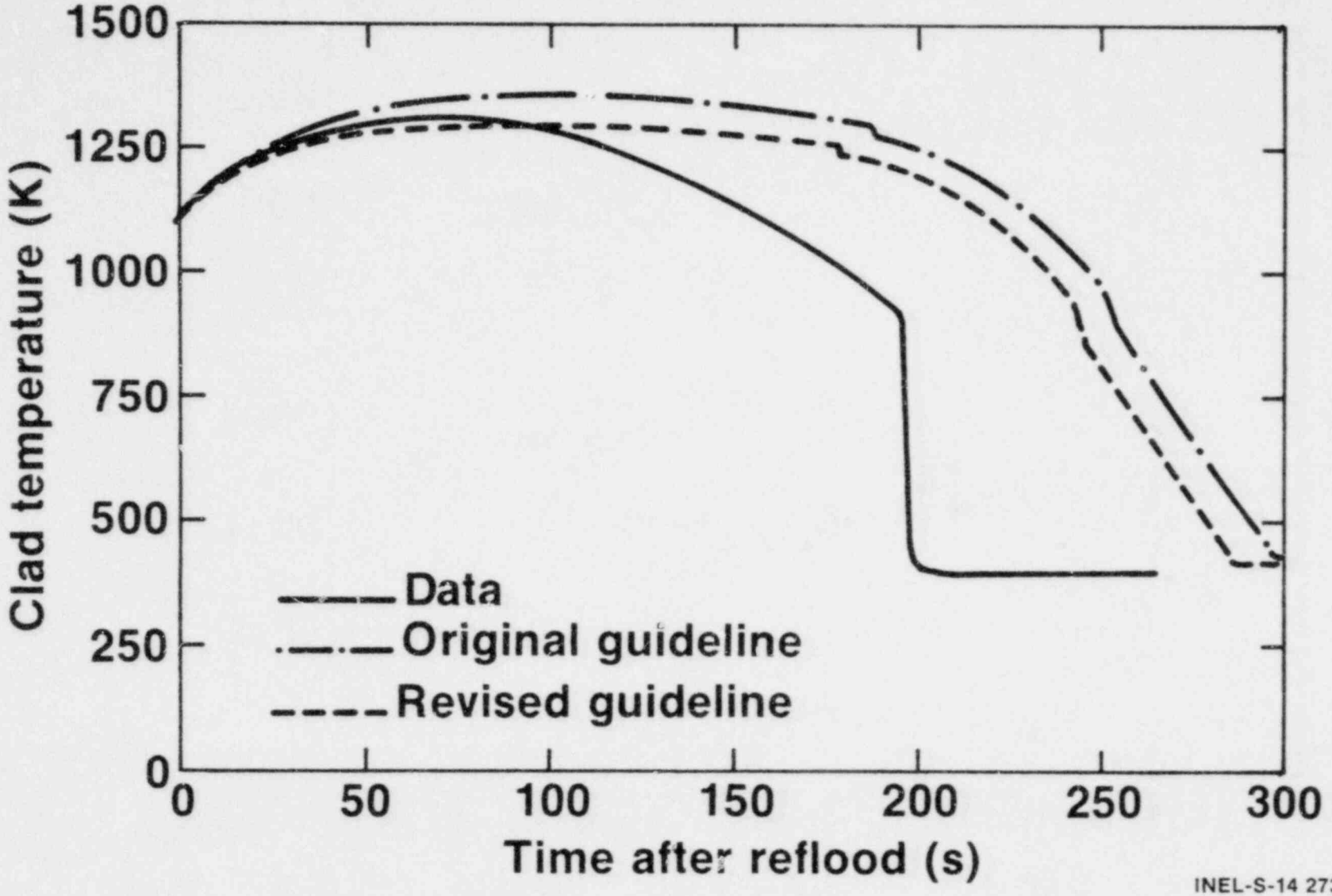
Reflood Guideline Improvement
FLECHT 4831



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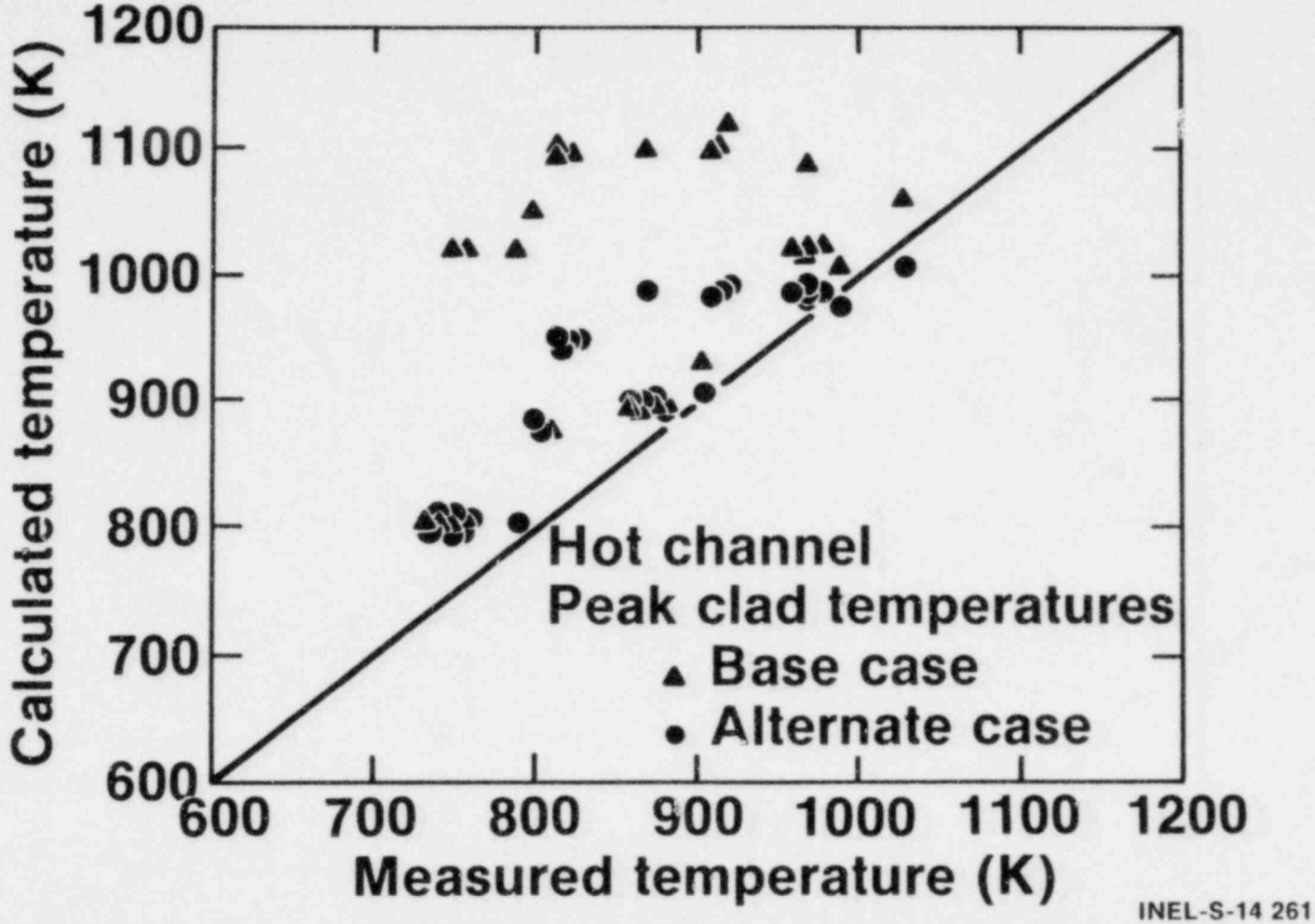
PKL K5A Reflood Experiment
200% Cold Leg Break



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Indicated Code/Guideline Weaknesses

- Thermal equilibrium assumption
- Nodalization/running time
- Early calculated DNB
- Break flow
- Fallback behavior
- Dispersed flow heat transfer
- Reflood constants not universal

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Guideline Improvement

- Nodalization
- Option selection
- Input constants

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Statistical Method

Replication, not response

- Reflood
- Blowdown

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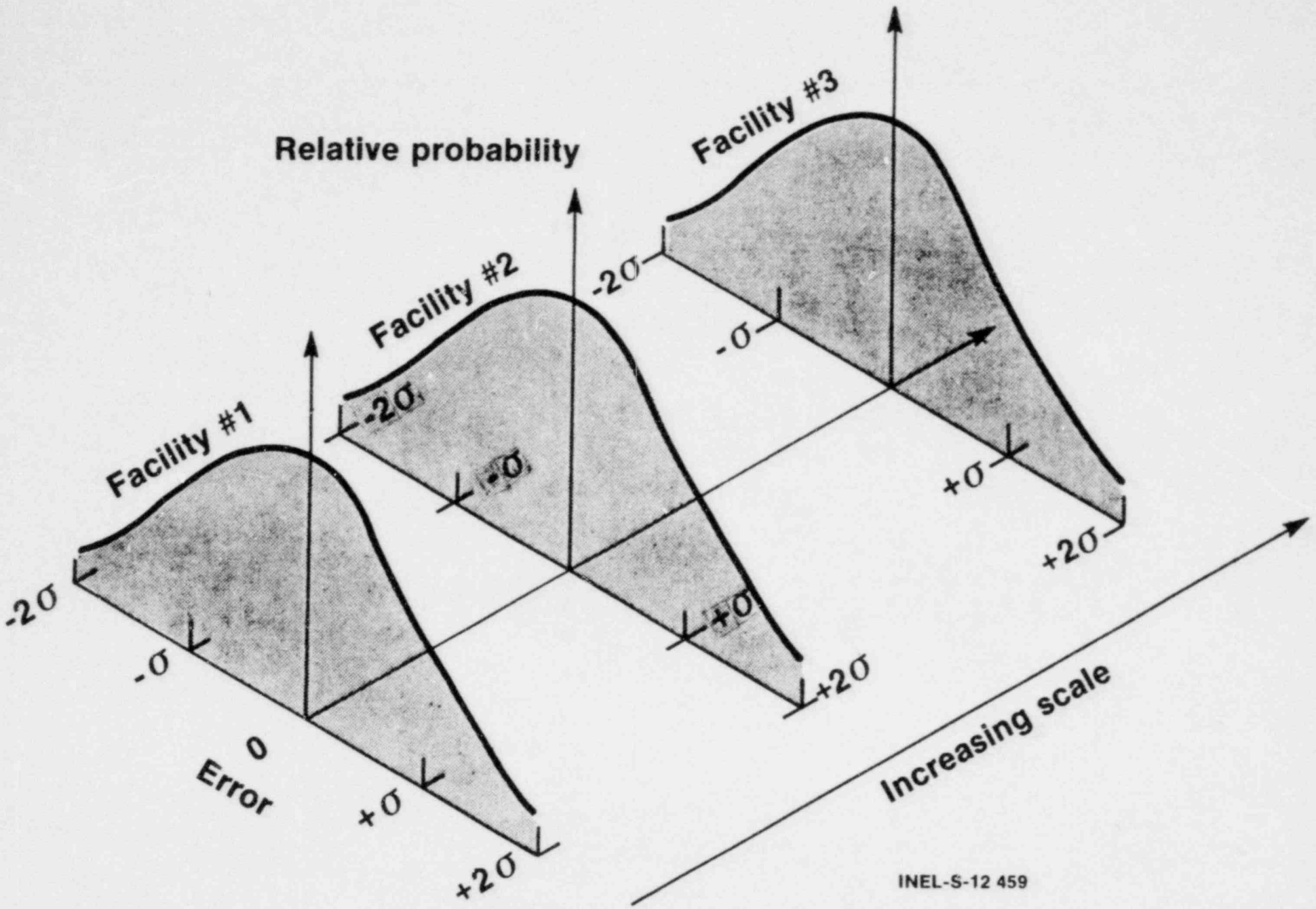
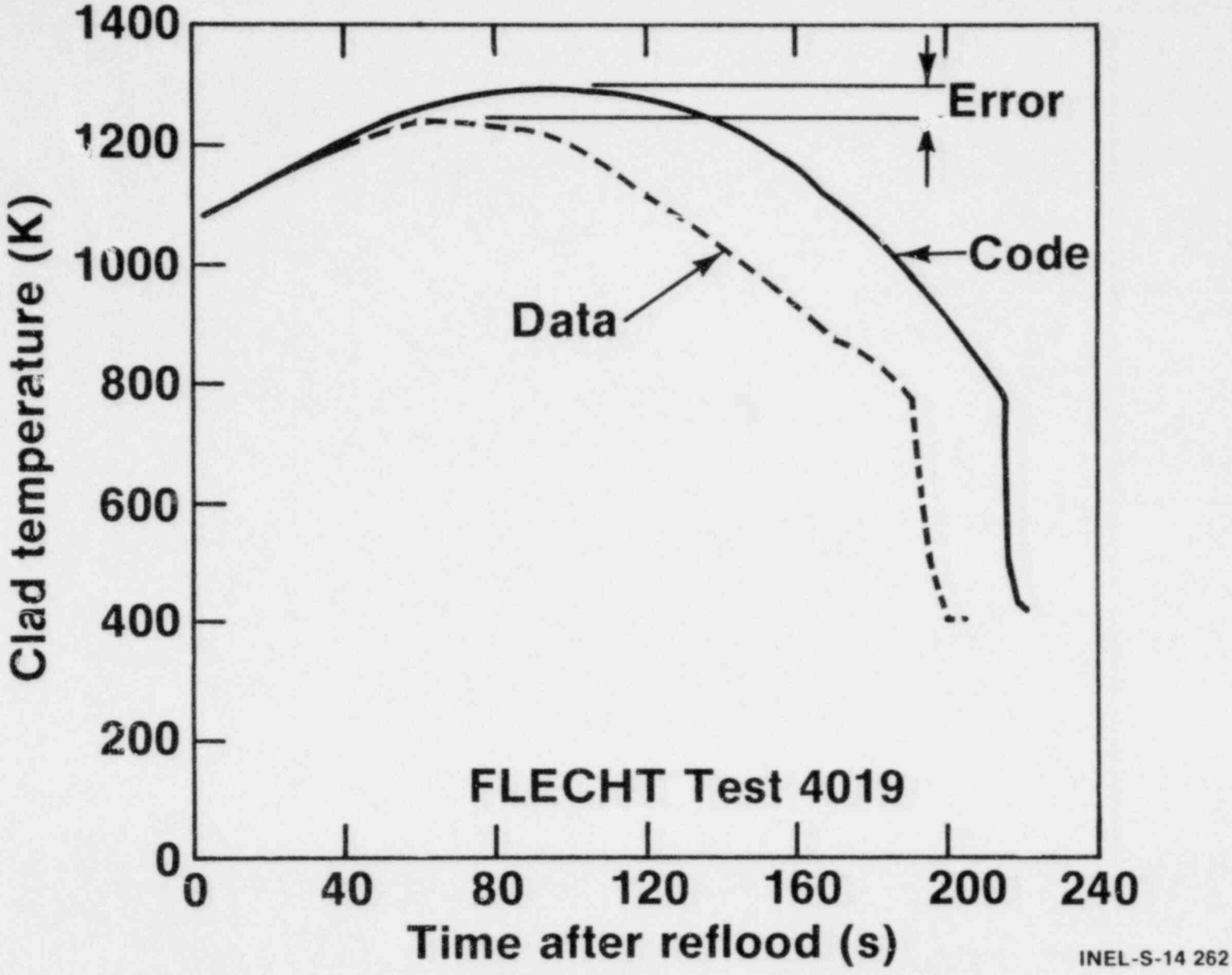

Relative probability
Facility #1
Facility #2
Facility #3
-2σ
-σ
0
Error
+σ
+2σ
Increasing scale
INEL-S-12 459

Typical Results - Initial Data Set



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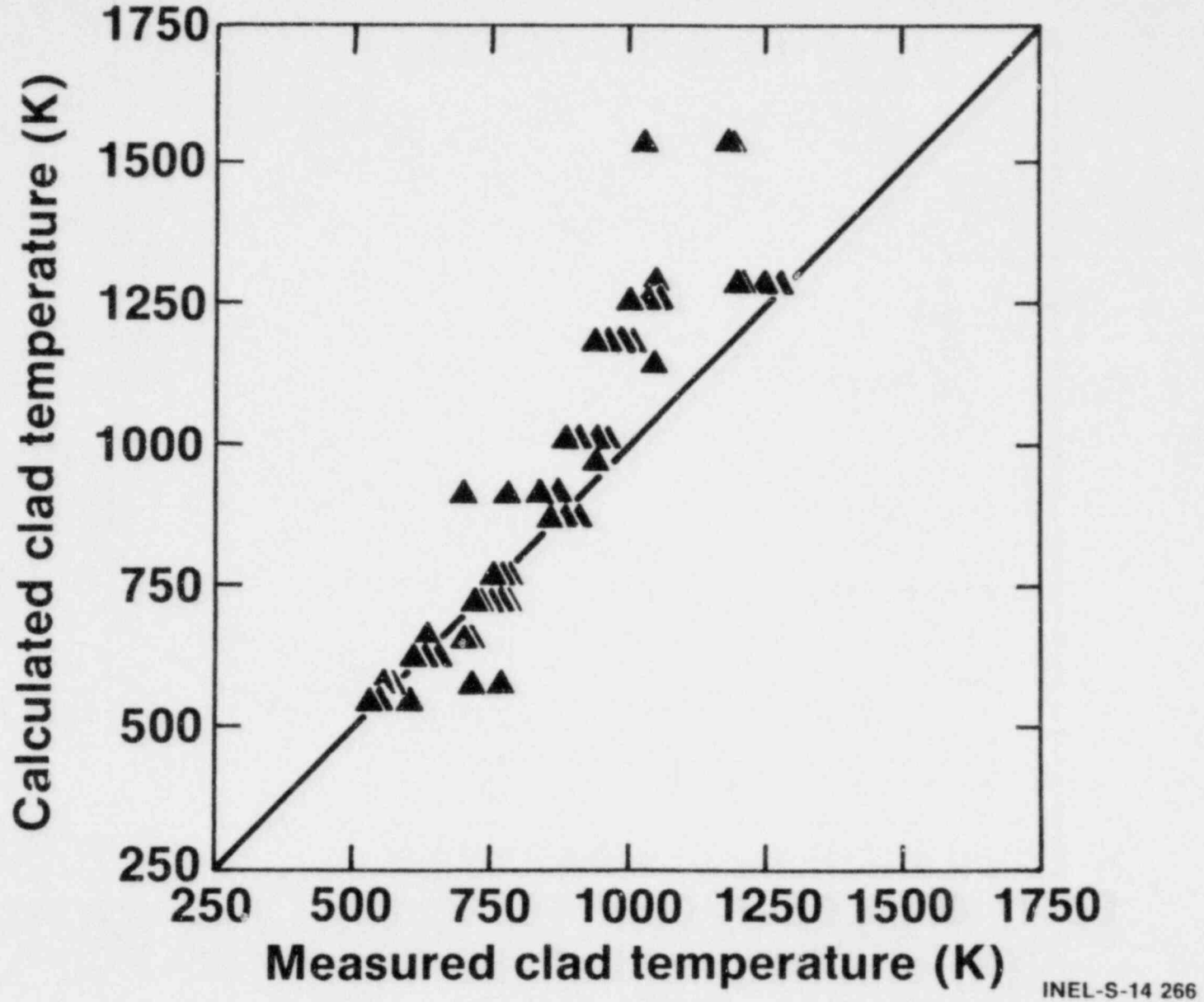
Summary of Peak Clad Temperatures - Initial Data Set



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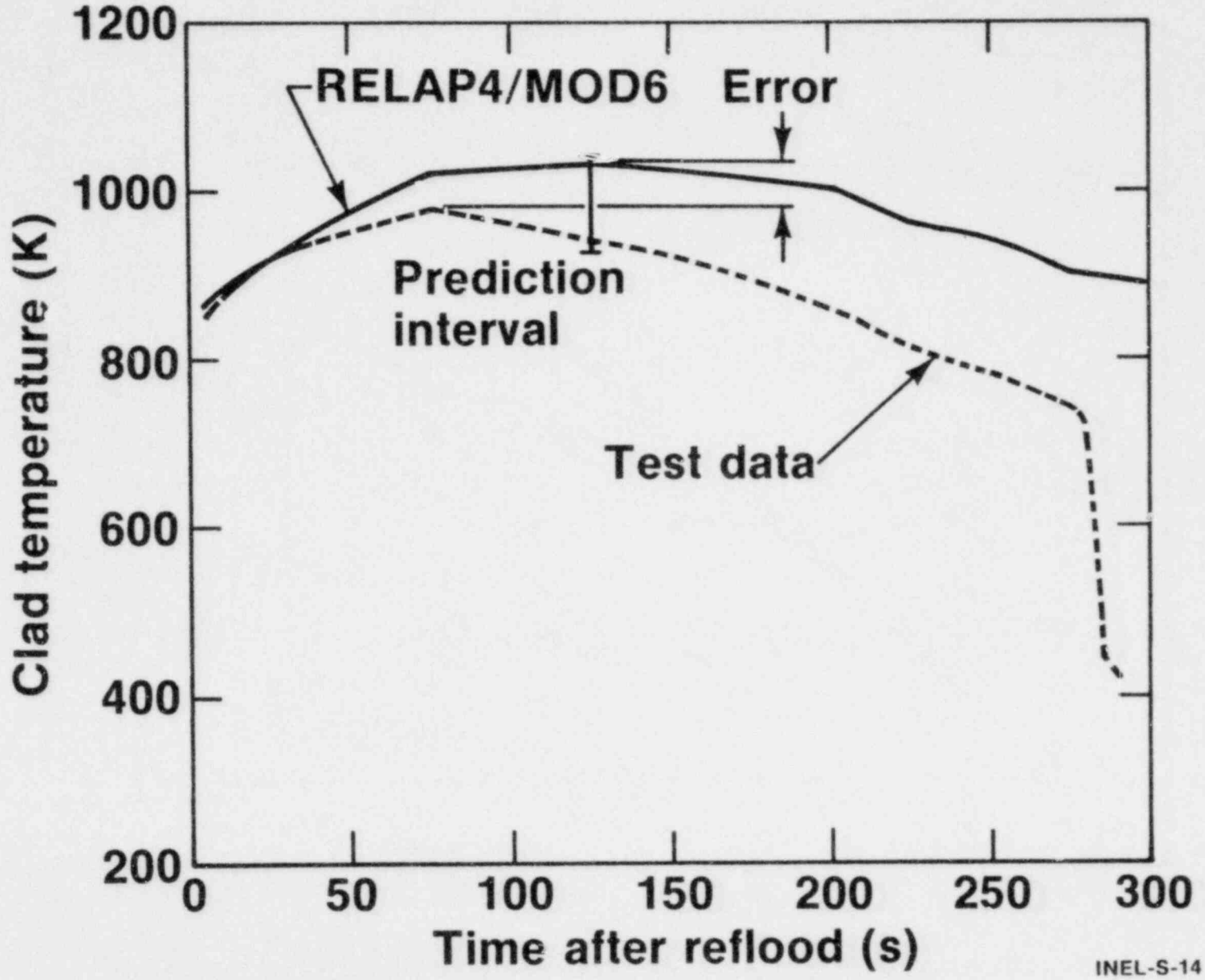
Typical Results - PKL Facility



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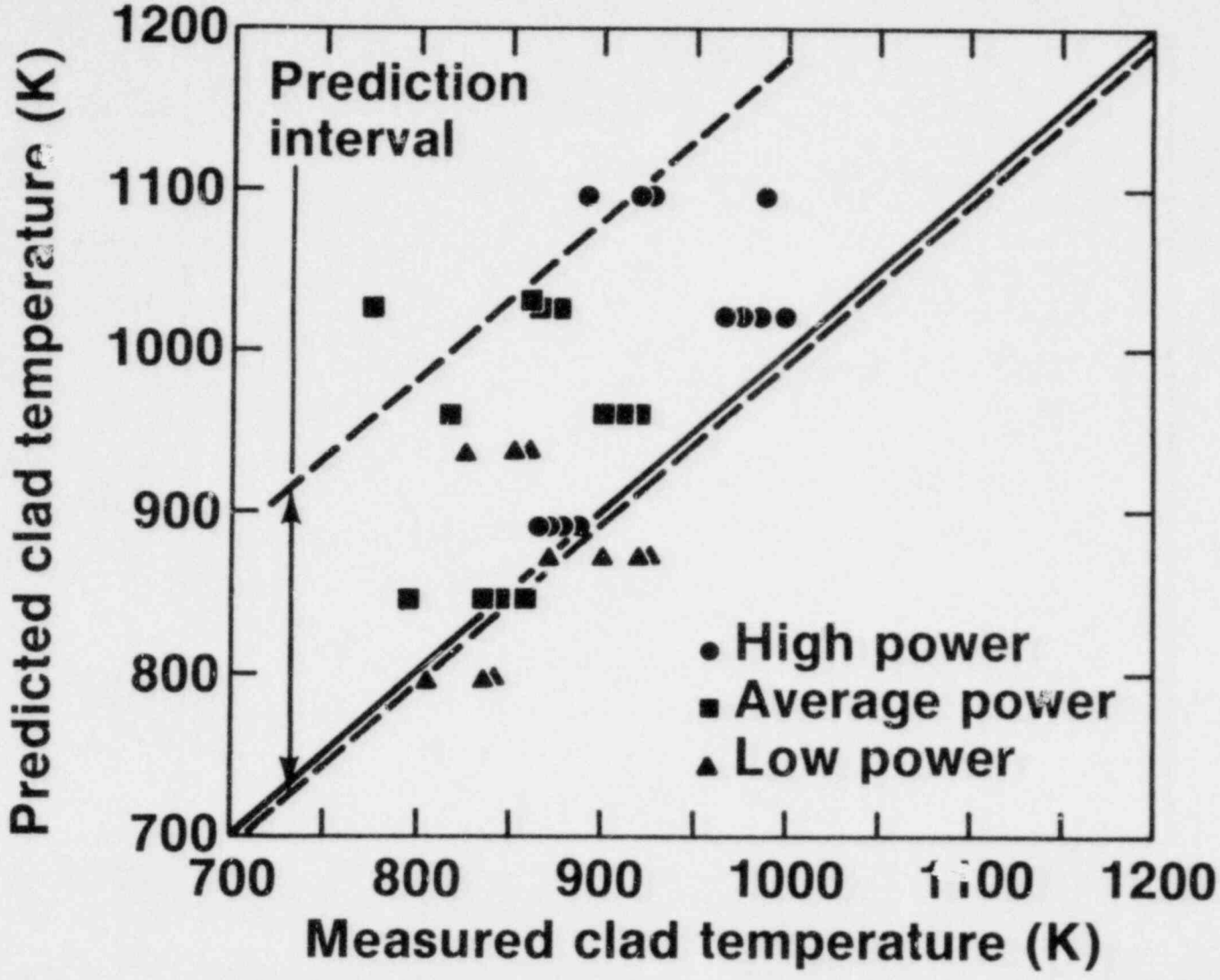
Summary of Clad Temperatures - PKL Data Set



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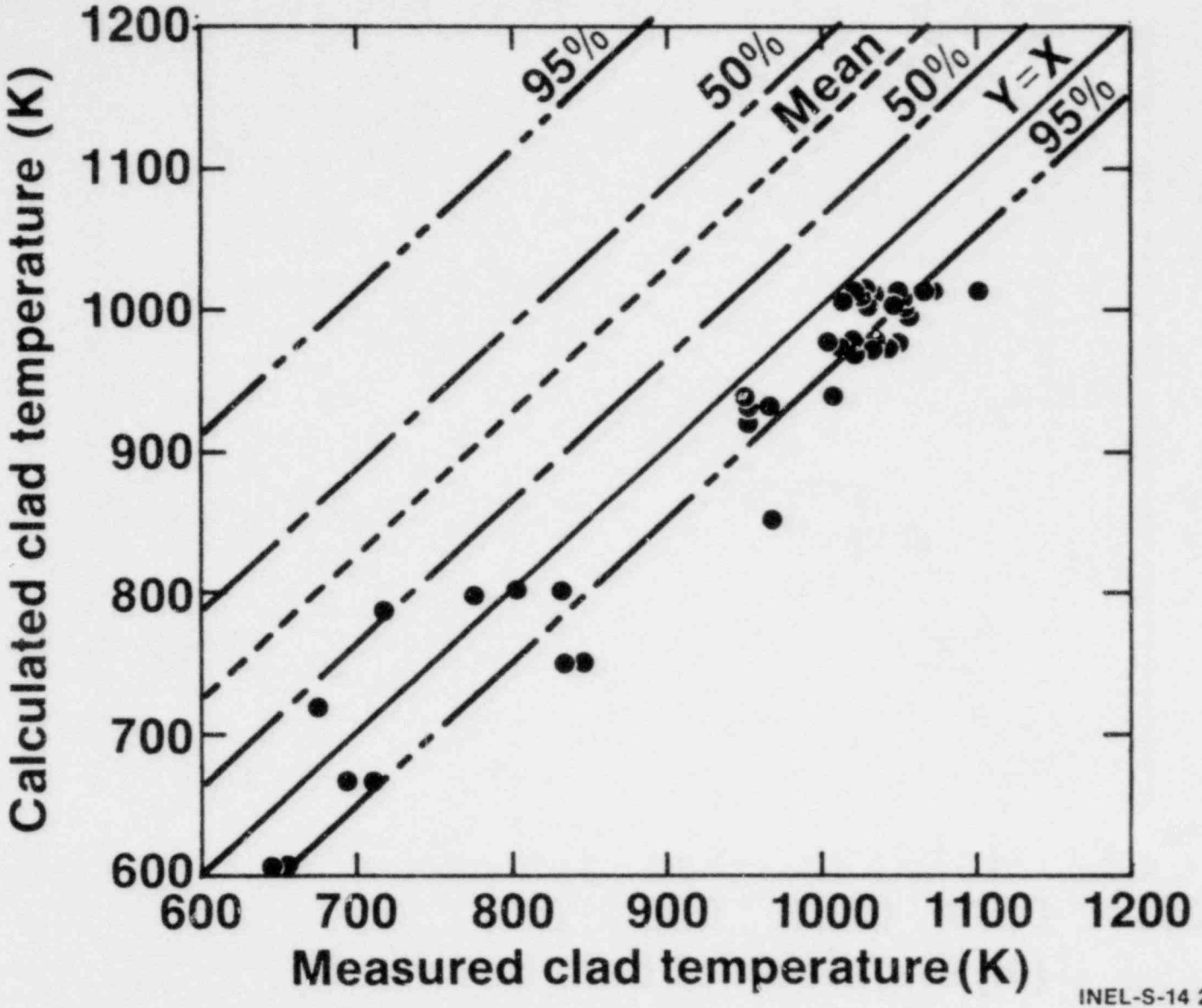
Prediction of S-07-1 PCT Based on All S-04-6 Data



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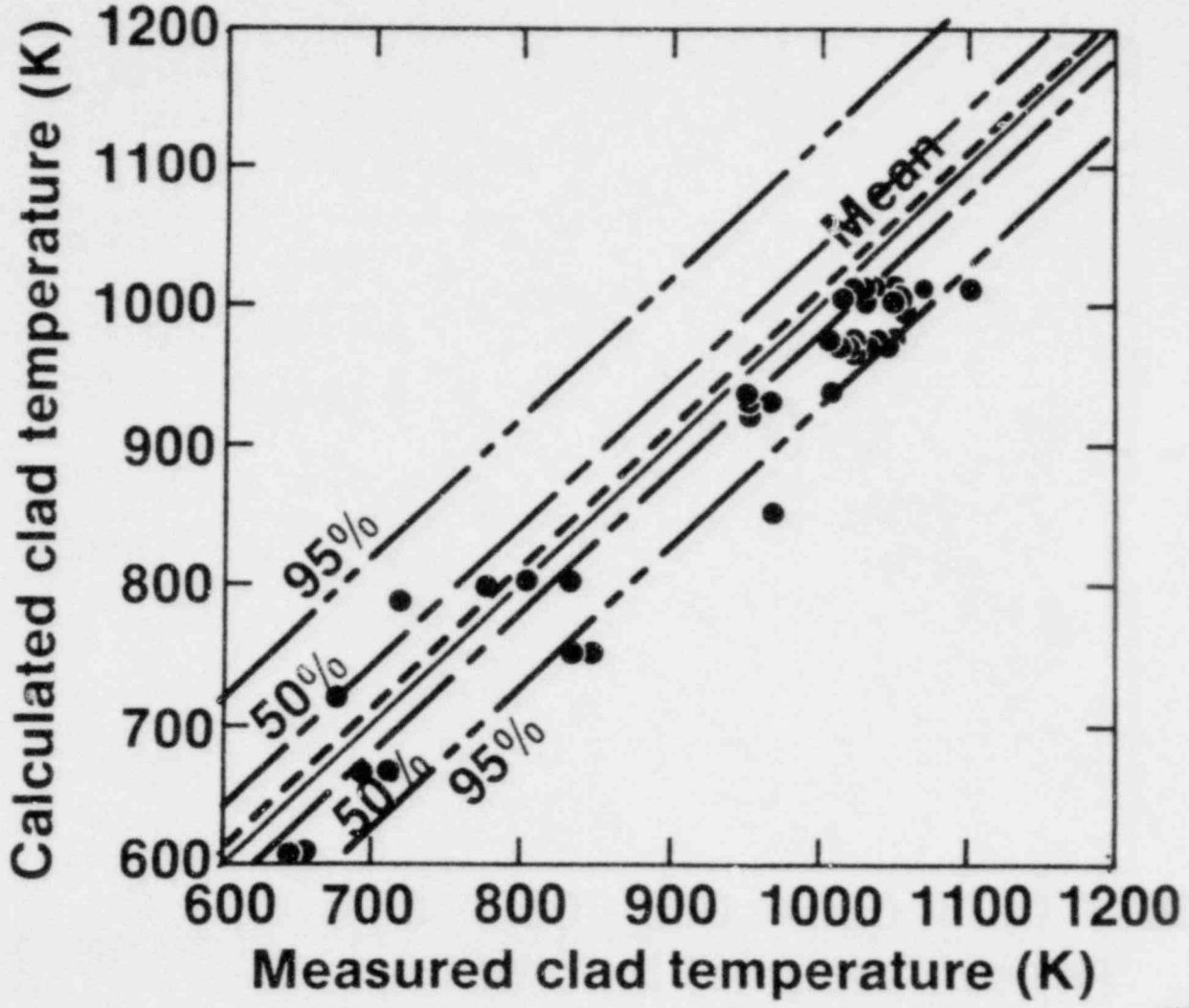
Prediction of S-07-1 PCT Based on Early CHF S-04-6 Data



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Conclusions

- Method for assessing large code
- Method for extrapolating between facilities
- Blowdown comparisons reasonable
- Reflood comparisons indicate need for additional code development