DEMONSTRATION OF THE CONFORMANCE OF PRAIRIE ISLAND UNITS 1 AND 2 TO APPENDIX K AND 10CFR50.46 FOR LARGE BREAK LOCAS

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I. Introduction

This document reports the results of an analysis that was performed to demonstrate that Prairie Island, Units 1 and 2, meet the requirements of Appendix K and 10CFR50.46 for Large Break Loss-of-Coolant-Accidents (LOCA) (Reference 1).

II. Method of Analysis

The analysis was performed using the Westinghouse Large Break LOCA Best-Estimate Methodology (Reference 2). The Westinghouse Best-Estimate Methodology was developed consistent with guidelines set forth in the SECY-83-472 document (Reference 3). These guidelines provide for the use of realistic models and assumptions, with the exception of specific models and assumptions required by Appendix K. The technical basis for the use of this model is discussed in detail in Reference 2.

The Best Estimate Methodology is comprised of the WCOBRA/TRAC and COCO computer codes (References 2 and 4, respectively). The WCOBRA/TRAC code was used to generate the complete transient (blowdown through reflood) system hydraulics as well as the cladding thermal analysis. The COCO code was used to generate the containment pressure response to the mass and energy release from the break. This containment pressure curve was used as an input to the WCOBRA/TRAC code.

The fuel parameters used as input for the LOCA analysis were generated using the Westinghouse fuel performance code (PAD 3.3) (Reference 5). The fuel parameters input to the code were at beginning-of-life (maximum densification) values.

The analysis was performed using the four channel core model developed in Reference 2 for the 0.4 double-ended cold leg guillotine (DECLG) breaks. A break size coefficient (CD) of 0.4 was found to be most limiting as documented in Reference 2. These transients were considered to be terminated if the hot rod cladding temperature began to decline and the injected ECCS flows exceeded the break flow.

III. Results and Conclusions

Table 1 shows the time sequence of events for the Large Break LOCA transients. Table 2 provides a brief summary of the important results of the LOCA analysis. Figures 1 through 8 show important transient results for the limiting 0.4 DECLG break (four channel core model). Note on these figures that the break occurs at time 0.0. Figure 1 shows the core pressure during the transient. Figure 2 shows the vapor and liquid mass flowrate at the top of the hot assembly. Figures 3 and 4 show the collapsed liquid level in the downcomer and core hot assembly channel, respectively, indicating the refilling of the vessel. Figures 5 and 6 show the flow of ECCS water into the cold leg (accumulator and high head safety injection flow) with Figure 7 showing the flow of low head safety injection into the upper plenum (UPI flow). Figure 8 shows the resulting peak cladding temperature for the 0.4 DECLG break as a function of time for each of the five fuel rods modeled. Rod 1 is the hot rod in the hot assembly channel, Rod 2 is the hot assembly average rod, Rods 3 and 4 represent average assemblies in the center of the core and Rod 5 represents the lower power assemblies at the edge of the core. The safety injection (SI) system was assumed to be delivering to the RCS five seconds after the generation of a safety injection signal. This five second delay includes the time required for developing full flow from the SI pumps. No additional delay was required for diesel startup and sequencing since the analysis assumed reactor coolant pumps remain in operation in conjunction with no loss of offsite power. Sensitivity studies (Reference 2) show that this assumption results in the worst peak cladding temperature. Minimum safeguards ECCS capability and operability has also been assumed.

No additional penalties were required for upper plenum injection since the Westinghouse Large Break LOCA Best-Estimate Methodology models the RHR flow to be injected into the upper plenum. This analysis result is below the 2200°F Acceptance Criteria limit established by Appendix K of 10CFR50.46 (Reference 1).

REFERENCES

1. "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Nuclear Power Reactors: 10CFR50.46 and Appendix K of 10CFR50.46," Federal Register, Vol. 39, No. 3, January 4, 1974.

2. Dederer, S. I., et al., Westinghouse Large-Break LOCA Best-Estimate Methodology, Volumes 1 and 2, WCAP-10924-P, (Proprietary Version), April, 1988.

3. NRC Staff Report, "Emergency Core Cooling System Analysis Methods," USNRC-SECY-83-472, November, 1983.

4. Bordelon, F. M., and E. T. Murphy, Containment Pressure Analysis Code (COCO), WCAP-8327 (Proprietary Version), WCAP-8326 (Non-Proprietary Version), June, 1974.

5. Westinghouse Revised PAD Code Thermal Safety Model, WCAP-8720, Addendum 2 (Proprietary), and WCAP-8785 (Non-Proprietary).

TABLE 1

LARGE BREAK
TIME SEQUENCE OF EVENTS

EVENT	Four Channel Core 0.4 DECLG (seconds)
Start	0.0
Reactor Trip Signal	0.1
Safety Injection (S.I.) Signal	2.0
High Head S.I. Begins	7.0
Blowdown PCT Occurs	7.8
Accumulator Injection	10.0
Low Head S.I. Begins	21.0
End of Bypass	24.2
Bottom of Core Recovery	32.8
Hot Rod Burst	33.8
Hot Assembly Average Rod Burst	42.9
Accumulator Water Empty	45.7
Accumulator Nitrogen Injection Ends	70.0
Reflood PCT Occurs	107.9

TABLE 2

LARGE BREAK RESULTS

EVENT	Four Channel Core 0.4 DECLG (seconds)
Peak Cladding Temp., ^{o}F	2060.
Peak Clad Temp. Location, ft.	7.0
Local Zr/Water Reaction (max), %	1.26
Local Zr/Water Reaction Location ft.	8.0
Total Zr/Water Reaction, %	<0.3
Hot Rod Burst Time, sec.	33.81
Hot Rod Burst Location, ft.	4.60
Hot Assembly Burst Time, sec.	42.9
Hot Assembly Burst Location, ft.	8.00
Hot Assembly % Blockage	35.33

Calculation Input Values:

NSSS Power, Mwt, 102% of	1650.
Peak Linear Power, kw/ft, 102% of	15.789
Peaking Factor (At Design Rating)	2.50
Accumulator Water Volume (Cubic ft. per tank, nominal)	1270.
Accumulator Pressure, psia	754.7
Number of Safety Injection Pumps (Operating (1 RHR + 2 HHSI)	3
Steam Generator Tubes Plugged	10%

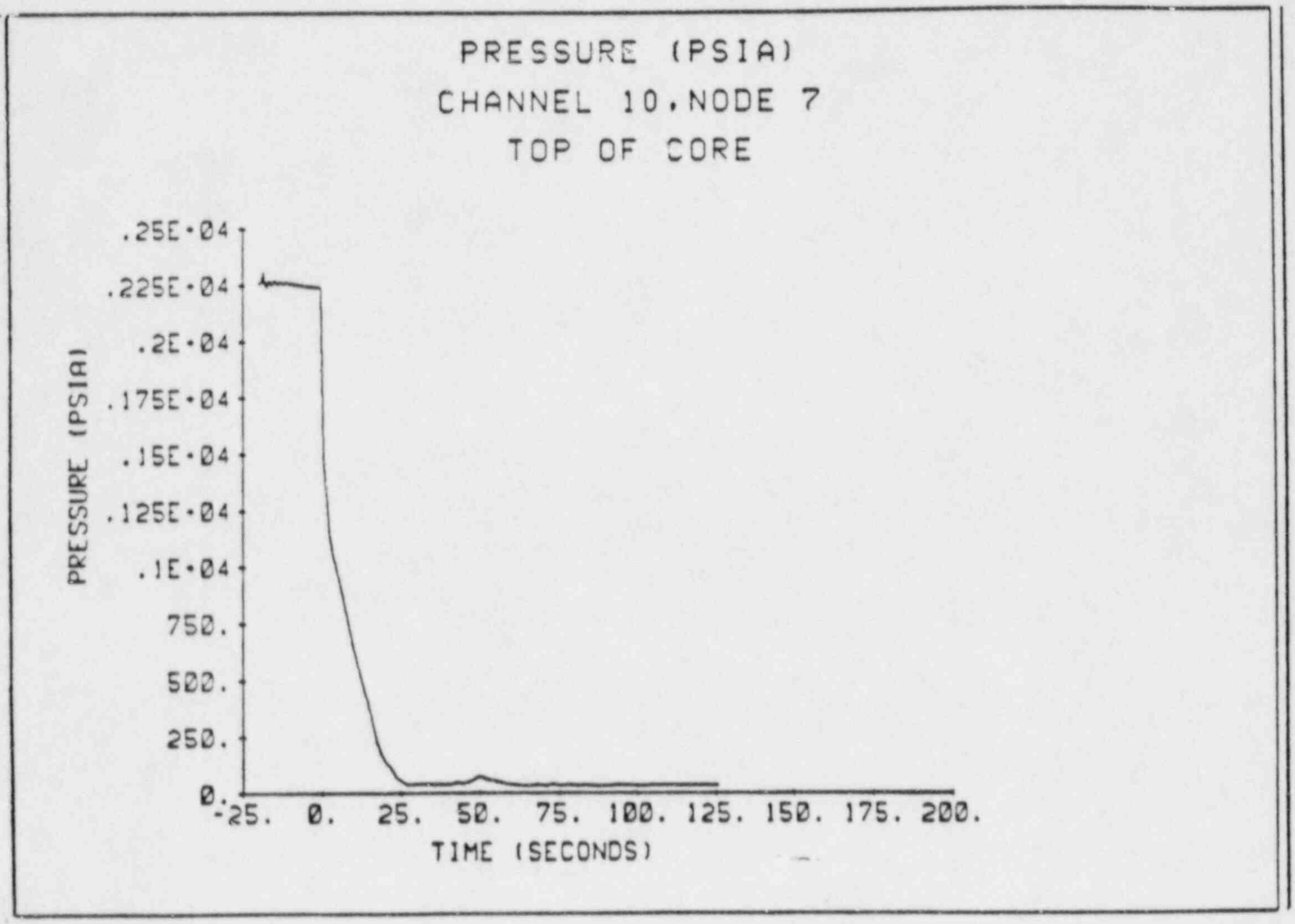

Figure 1: Core Pressure (Four Channel Core Model) (0.4 DECLG)

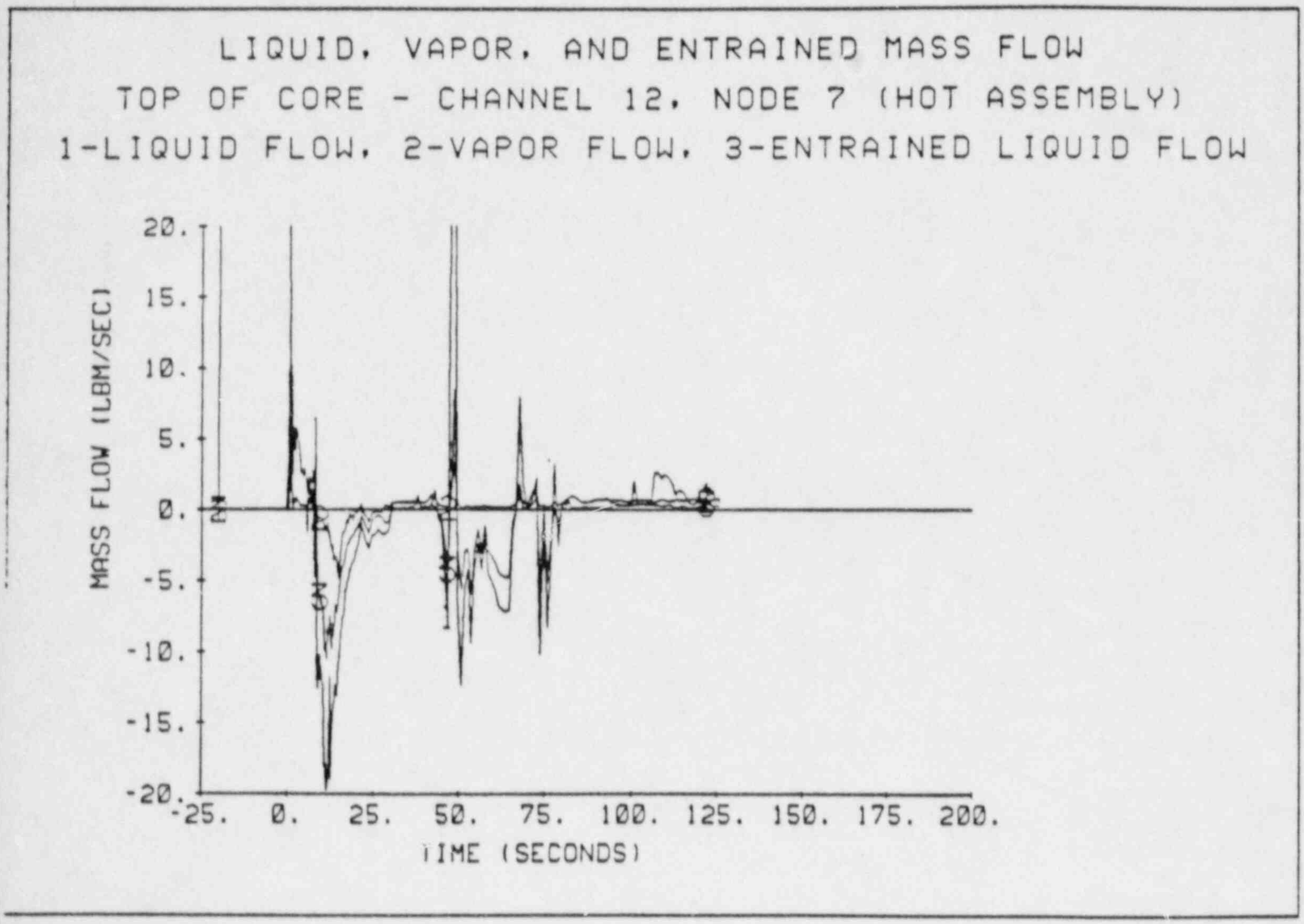

Figure 2: Core Flow at Top of Hot Assembly (Four Channel Core Model) (0.4 DECLG)

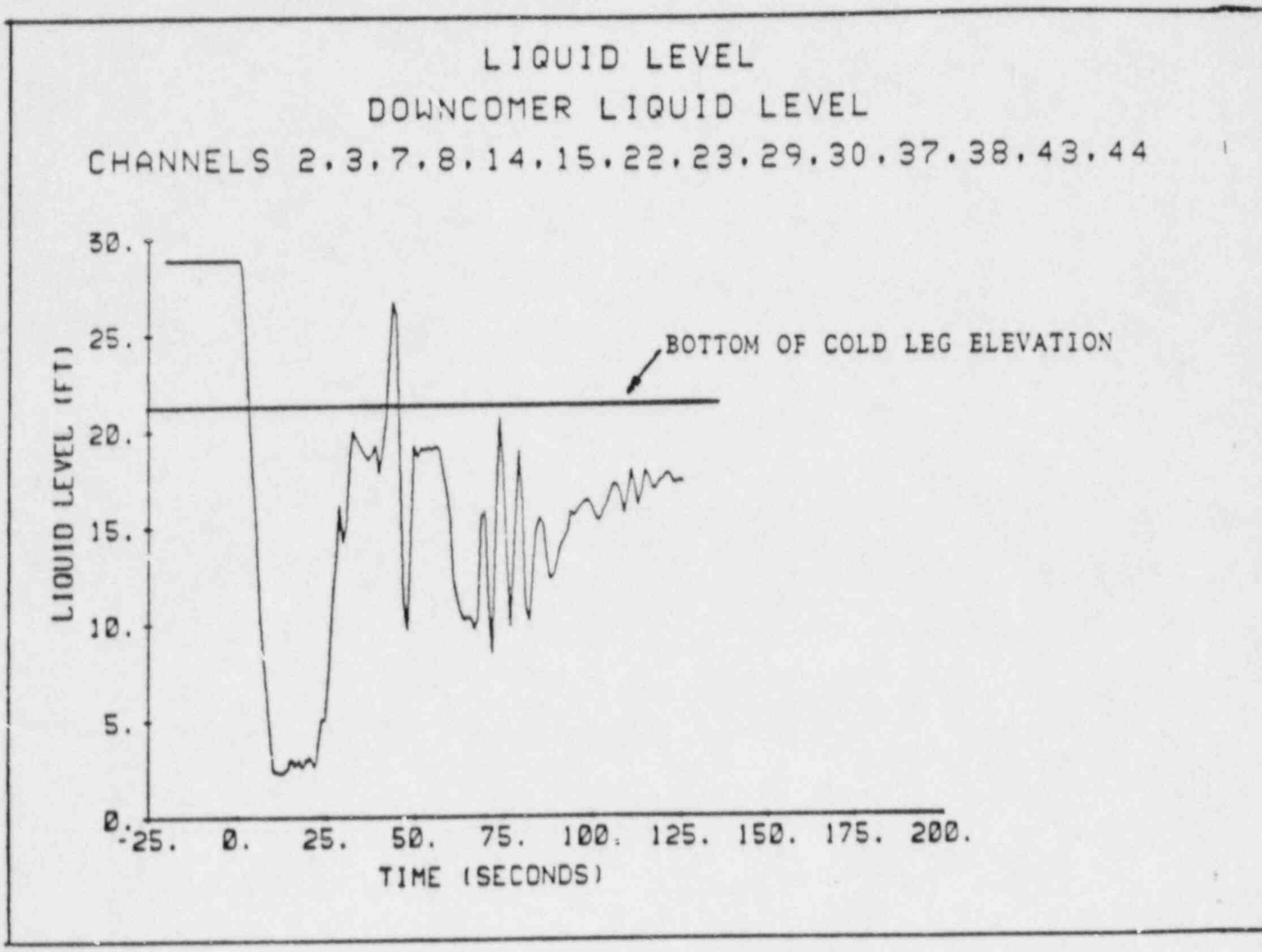

Figure 3: Downcomer Collapsed Liquid Level (Four Channel Core Model) (0.4 DECLG)

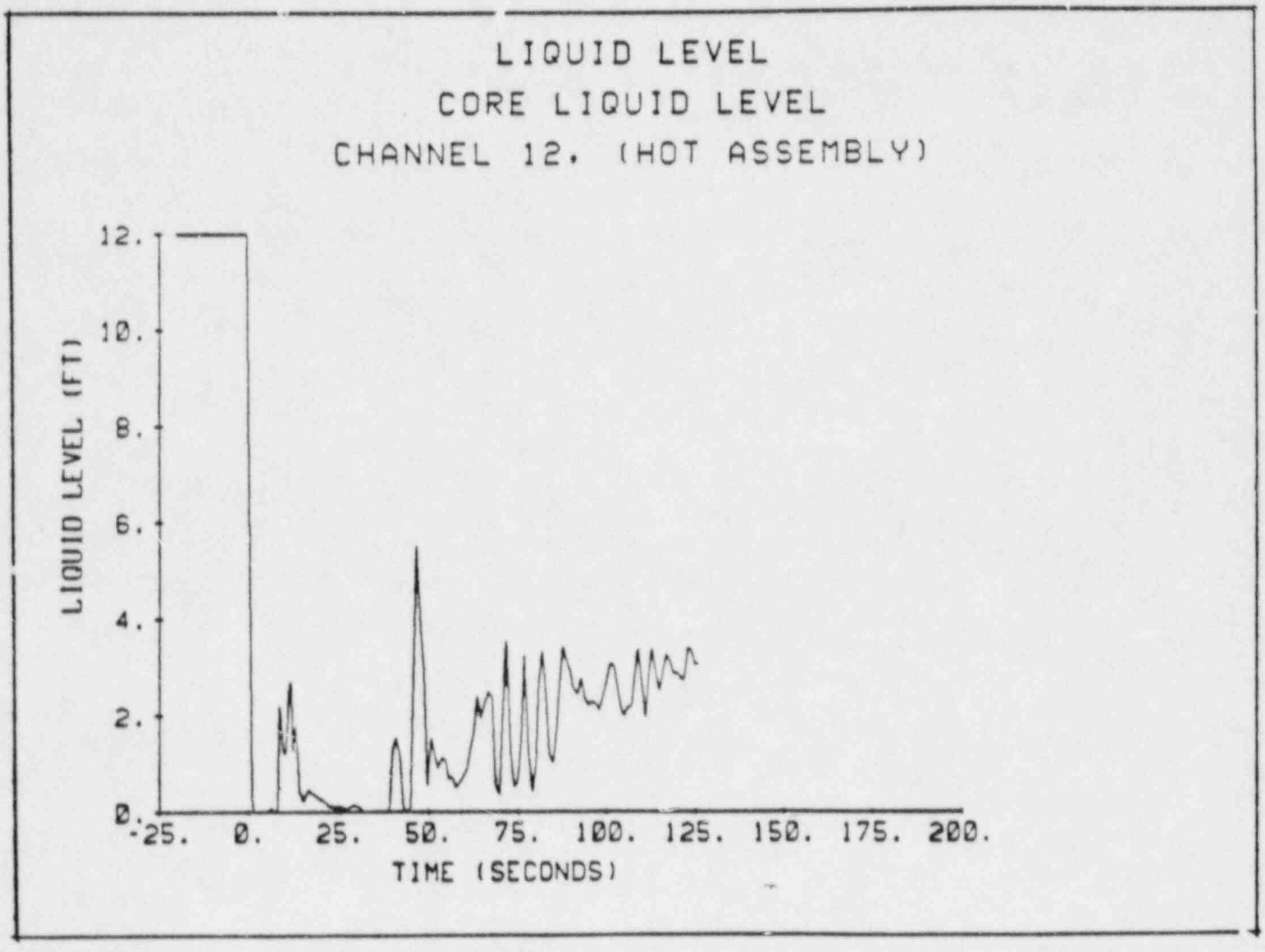

Figure 4: Collapsed Liquid Level in Hot Assembly (Four Channel Core Model) (0.4 DECLG)

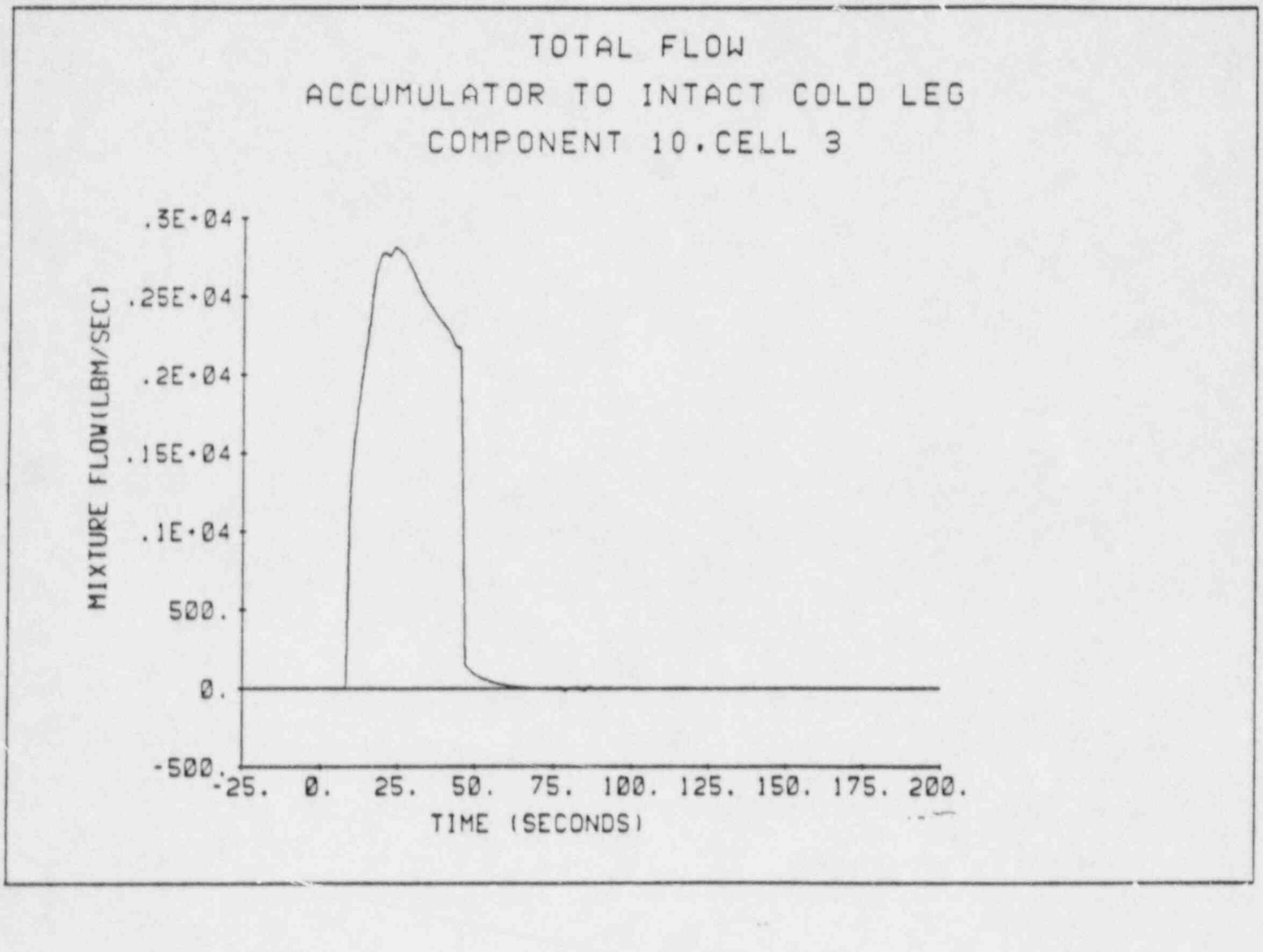

Figure 5: Accumulator Mixture Flow (Four Channel Core Model) (0.4 DECLG)

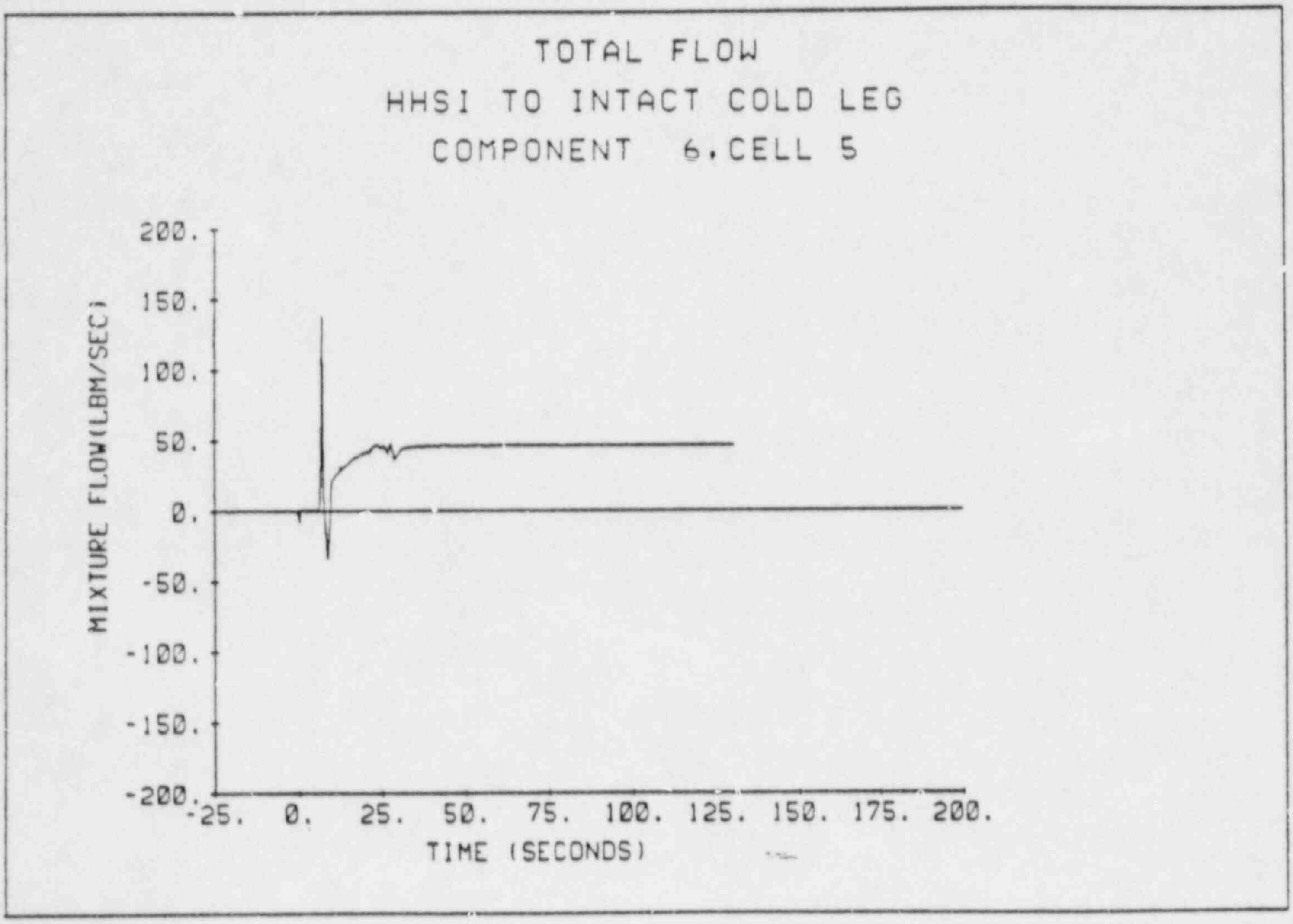

Figure 6: HHSI Flow to Intact Cold Leg (Four Channel Core Model) (0.4 DECLG)

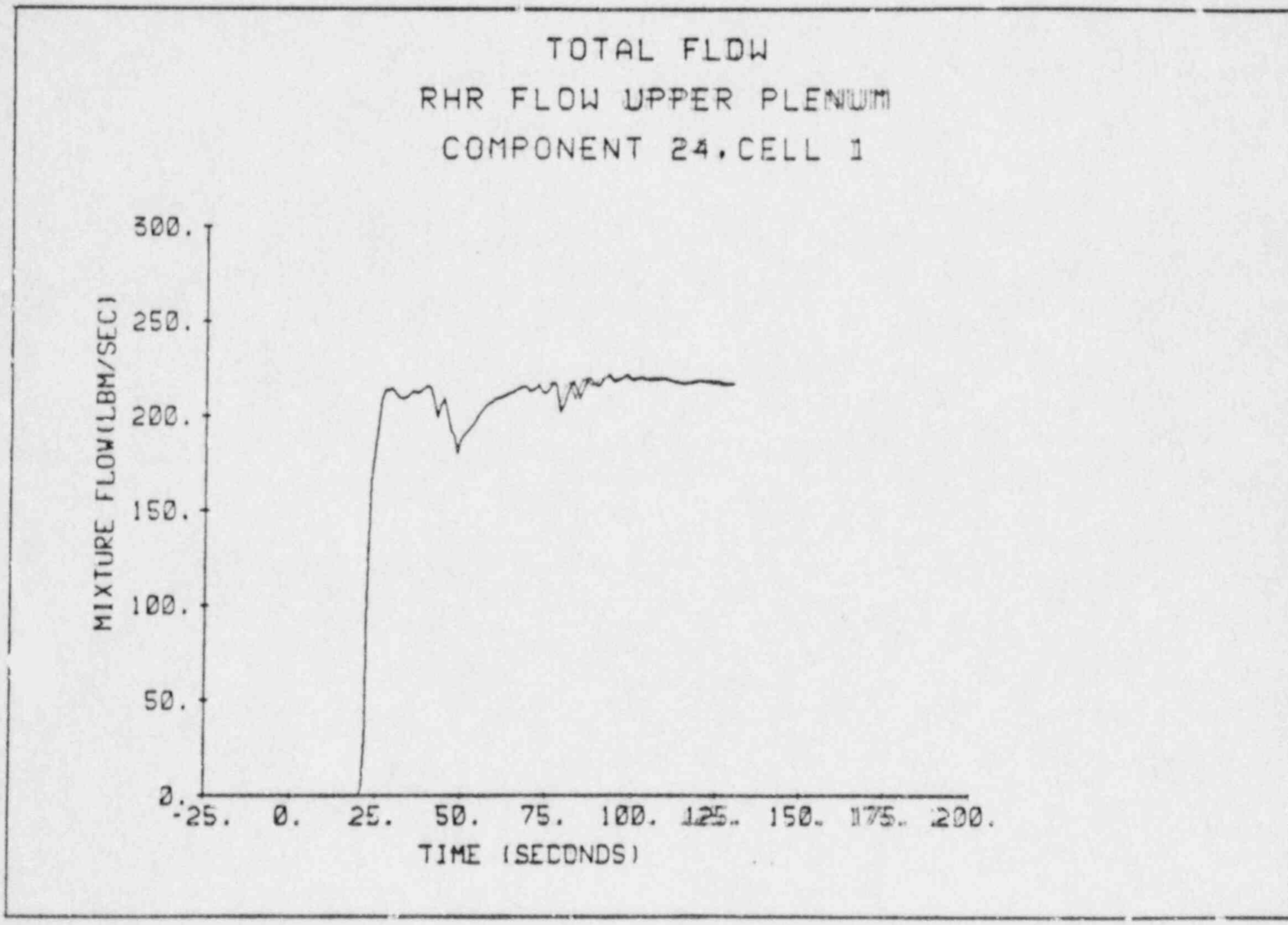

Figure 7: RHR Flow to Upper Plenum (Four Channel Core Model) (0.4 DECLG)

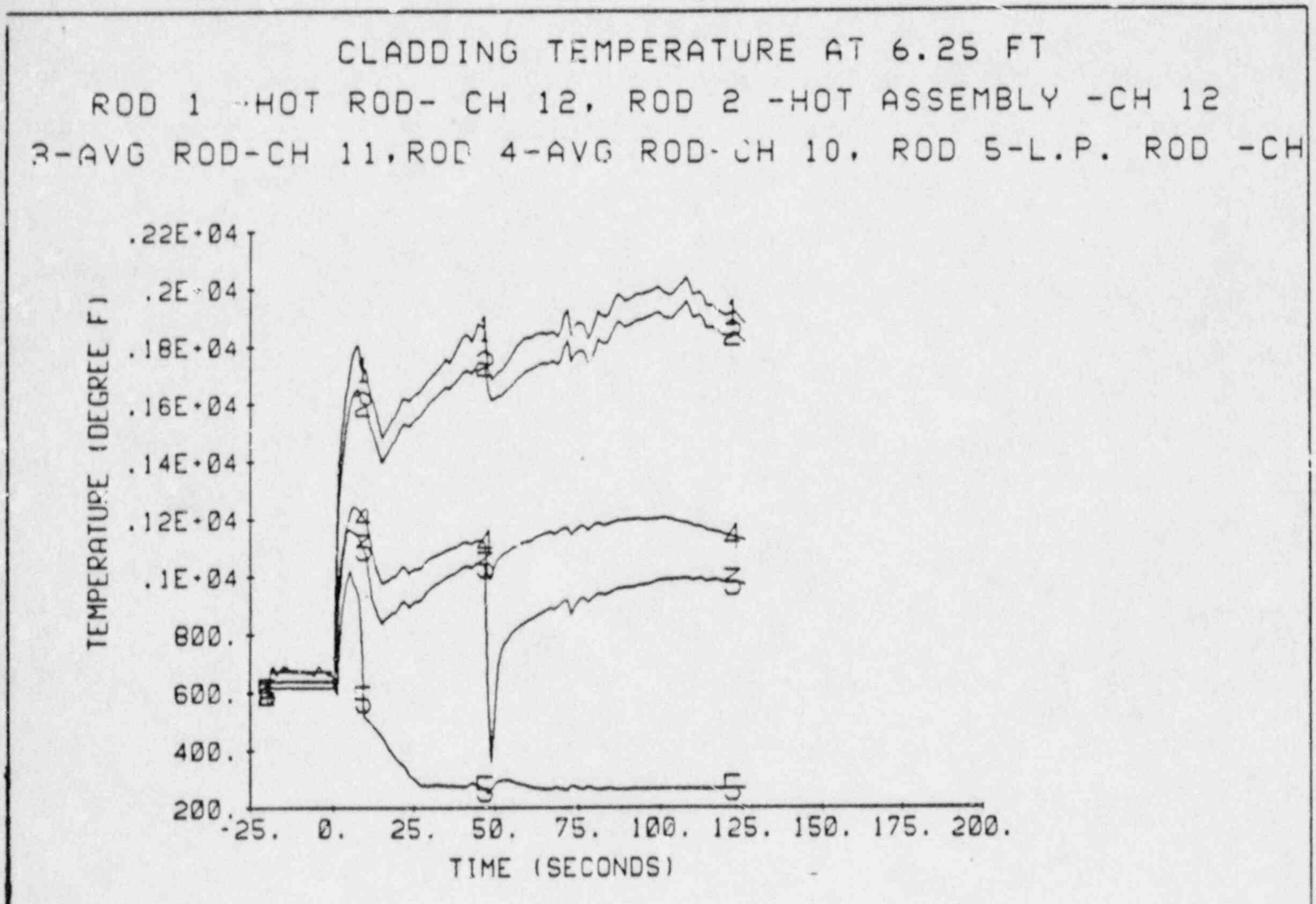

Figure 8: Cladding Temperature (Four Channel Core Model) (0.4 DECLG)