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ENCLOSURE

REVISED ECCS ANALYSIS FOR ST LUCIE II......

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September 24, 1976
L-76-340

RECEIVED SEP 28 1976 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Office of Nuclear Reactor Regulation
Attn: Olan D. Parr, Chief
Light Water Reactors Branch 1-3
Division of Project Management
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Parr:

Re: St. Lucie Unit No. 2 ECCS Reanalysis
Docket No. 50-389

Modifications to the Combustion Engineering STRIKIN-II Code to correct certain errors in the code and to preclude a return to nucleate boiling have been completed and submitted to the Commission in the form of Supplement No. 4 to CENPD-135. A reanalysis of the ECCS for St. Lucie Unit No. 2 has been performed in accordance with the revised code and is herewith submitted for your evaluation.

The Preliminary Safety Analysis Report for St. Lucie Unit No. 2 will be updated at a later date to reflect the results of this reanalysis.

Yours very truly,

Robert E. Uhrig
Vice President

9845

REU/LLL/hlc
Attachment

cc: Norman C. Moseley, Region II
Jack R. Newman, Esq.

Revised ECCS Analysis for

St. Lucie - Unit II

I. INTRODUCTION

Due to recent STRIKIN-II modifications[1], which include the prevention of a return to nucleate boiling, a large break spectrum reanalysis has been performed for St. Lucie - Unit II. This revision supercedes the ECCS evaluation which appears in Reference 2.

II. SUMMARY

A four-break spectrum analysis has been performed at a peak linear heat generation rate (PLHGR) of 11.6 kw/ft. The worst break was identified as the 1.0 DEG/PD* with a peak clad temperature of 2120°F.

The results of this analysis demonstrate that the ECCS for St. Lucie - Unit II meets the NRC Acceptance Criteria published in the Federal Register on January 4, 1974. Conformance is summarized as follows:

Criterion (1) - Peak Clad Temperature. "The calculated maximum fuel element cladding temperature shall not exceed 2200°F".

The analysis yielded a peak clad temperature of 2120°F for the 1.0 DEG/PD break.

Criterion (2) - Maximum Cladding Oxidation. "The calculated total oxidation of the cladding shall nowhere exceed 17% of the total cladding thickness before oxidation".

The analysis yielded a local peak clad oxidation percentage of 15.85% for the 1.0 DEG/PD.

Criterion (3) - Maximum Hydrogen Generation. "The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 1% of the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the plenum volume, were to react".

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* 1.0 DEG/PD = 1.0 Double-Ended Guillotine at the Pump Discharge

The analysis yielded a peak core-wide clad oxidation percentage of <0.902% for the 1.0 DEG/PD.

The statements in Reference 2 demonstrating compliance with Criterion 4 (coolable geometry) and Criterion 5 (long term cooling) are unchanged.

III. LARGE BREAK SPECTRUM ANALYSIS

A. Method of Calculation

The only difference between the method used in Reference 2 and that used in the current calculation is the STRIKIN-II version which was used. The description of the current version of STRIKIN-II, which now prevents return to nucleate boiling, is given in Reference 1.

As specified in Reference 3, the reflood heat transfer coefficients used in the Reference 2 analysis were obtained by applying a 0.8 multiplier to the FLECHT-based coefficients. This approach has been retained in the current analysis. Recently, NRC approved(4) a method developed by C-E to apply the FLECHT-based correlation to 16x16(5) fuel such as that used in St. Lucie 2. Use of the reflood heat transfer coefficients obtained with the new method would substantially lower clad temperatures, or, alternately, would allow a PLHGR increase.

B. Emergency Core Cooling System Assumptions

The ECCS assumptions are the same as those stated in Reference 2 except for a change in the flow delivered by the Low Pressure Safety Injection (LPSI) pumps to the vessel. At the time the analysis reported in Reference 2 was performed, the ECCS design included a common header for the two LPSI pumps. With the common header, either LPSI pump could deliver flow to all four Reactor Coolant System cold legs. Subsequently, the header design was modified. In the revised design, each LPSI pump delivers flow to its own header, which in turn provides flow to two cold legs. Since the worst single failure is the failure of one LPSI pump to start, the revised header design results in a LPSI flow to the vessel equal to 50% of that delivered by one pump; the other 50% spills through the cold leg rupture.

C. Core, System, and Containment Parameters

The parameters are the same as those given in Reference 2 with the exception of the parameters which are related to the PLHGR. These parameters, which now reflect a PLHGR of 11.6 kw/ft, are shown in Table III-1.

D. Break Spectrum

The analysis reported in Reference 2 identified the worst break to be a guillotine rupture. In this analysis, a three-break guillotine spectrum was, therefore, performed. In addition, a representative slot break from Reference 2 was also analyzed. The calculations have been performed for breaks at the pump discharge over a range of break sizes varying from 60% to 100% of the double-ended cold leg pipe area.

E. Results

The blowdown hydraulics have not changed from those presented in Reference 2. The reflood results are unchanged from Reference 2 except for slight changes in the downcomer water level and the reflood heat transfer coefficient. The time-dependent downcomer water level and hot spot reflood heat transfer coefficient are shown in Figures III-1 and III-8 respectively. These figures are listed along with all other figures in Table III-2. The times of interest for each of the breaks are the same as those reported in Reference 2 except for the hot rod rupture times. The new rupture times are included in Table III-3, which contains a summary of the peak clad temperatures and oxidation percentages for the break spectrum. Figure III-12 shows peak clad temperature plotted versus break size and type, indicating that the worst break is the 1.0 DEG/PD rupture.

F. Computer Code Version Identification

The following code versions were used in this analysis:

STRIKIN-II: Version 76234*
COMPERC-II: Version 75097

G. Large Break Analysis - Hot and Suction Leg Breaks

Note that the large break analysis spectrum of breaks does not include the hot leg or the pump suction leg breaks. As documented in the St. Lucie Unit 2 PSAR (Appendix 6C, Section 3.0, Rev. 42 of 11/10/76) by reference to docketed submittals, it has been established that analysis of these breaks is not required since they have been shown to result in peak clad temperatures far below those of the limiting breaks. The calculated effects of the modifications to the STRIKIN-II Code

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*Includes modifications of Reference 1.

and the safety injection system piping change, as demonstrated in the present reanalysis, would not alter this conclusion, i.e., the hot and suction leg breaks would not become limiting breaks.

IV. SMALL BREAK SPECTRUM ANALYSIS

The small break spectrum presented in CENPD-137 was reviewed to determine if the recent changes made to STRIKIN-II (CENPD-135, Supplement 4) would influence the results shown therein. The conclusion reached was that the STRIKIN-II changes would have no impact on those results and that the peak clad temperatures for all small breaks will remain as reported in CENPD-137. Those results demonstrate that the small breaks remain much less limiting than large breaks.

In addition, the design changes to the safety injection system piping described in III.B. above, do not affect the small break analysis, and the analysis presented in CENPD-137 remains applicable to St. Lucie Unit 2. These piping changes affect only the LPSI pump delivery and have no effect upon the HPSI pump delivery. While the large break analysis is controlled by the LPSI delivery flow, the small break analysis is controlled by the HPSI delivery flow.

REFERENCES

1. CENPD-135, Supplement 4, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program, (August, 1976 Modification)", August, 1976. (Proprietary).

2. Preliminary Safety Analysis Report for St. Lucie - Unit II, Appendix 6C, Section 6.0 "ECCS FAC Analysis", as amended per Revision 42, November 10, 1975.

3. Supplement to the Status Report by the Directorate of Licensing in the Matter of Combustion Engineering, Inc., ECCS Evaluation Model Conformance to 10 CFR 50, Appendix K, November 13, 1974.

4. Letter from Karl Kniel (NRC) to A. E. Scherer (C-E) dated August 2, 1976.

5. CENPD-213, "Application of FLECHT Reflood Heat Transfer Coefficients to C-E's 16x16 Fuel Bundles", J. H. Holderness, January, 1976.

Table III-1

St. Lucie - Unit II Core Parameters

Quantity	Value
Peak Linear Heat Generation Rate (PLHGR)	11.6 kw/ft
Gap Conductance at PLHGR	1199 Btu/hr-ft^2-^{o}F
Fuel Centerline Temperature at PLHGR	2987 ^{o}F
Fuel Average Temperature at PLHGR	1976 ^{o}F

Table III-2

St. Lucie - Unit II

Large Break Spectrum Plots

Break Size, Type, and Location	Plot	Figure Number
All Breaks	Water Level in Down-comer during Reflood	III-1
0.8 x Double-Ended Slot Break in Pump Discharge Leg (0.8 X DES/PD)	Peak Clad Temperature	III-2
1.0 x Double-Ended Guillotine Break in Pump Discharge Leg (1.0 X DEG/PD)	Peak Clad Temperature	III-3
	Local Clad Oxidation	III-4
	Hot Spot Gap Conductance	III-5
	Clad, Fuel Centerline, Fuel Average, and Coolant Temperature for the Hottest Node	III-6
	Hot Spot Heat Transfer Coefficient	III-7
	Hot Spot Heat Transfer Coefficient During Reflood	III-8
	Hot Rod Internal Gas Pressure	III-9
0.8 X Double-Ended Guillotine Break in Pump Discharge Leg (0.8 X DEG/PD)	Peak Clad Temperature	III-10
0.6 X Double-Ended Guillotine Break in Pump Discharge Leg (0.6 x DEG/PD)	Peak Clad Temperature	III-11
All Breaks	Peak Clad Temperature vs. Break Area	III-12

Table III-3

St. Lucie - Unit II

Peak Clad Temperatures and Oxidation Percentages

for the Break Spectrum

Break	Hot Rod Rupture Time (Sec)	Peak Clad Temperature (°F)	Clad Oxidation % Local	Clad Oxidation % Core-Wide
11.6 kw/ft				
0.8 DES/PD	83.20	2111	15.50	<0.894
1.0 DEG/PD	76.79	2120	15.85	<0.902
0.8 DEG/PD	81.05	2114	15.65	<0.897
0.6 DEG/PD	97.01	2089	13.00	<0.839

FIGURE III-1

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

WATER LEVEL IN DOWNCOMER DURING REFLOOD

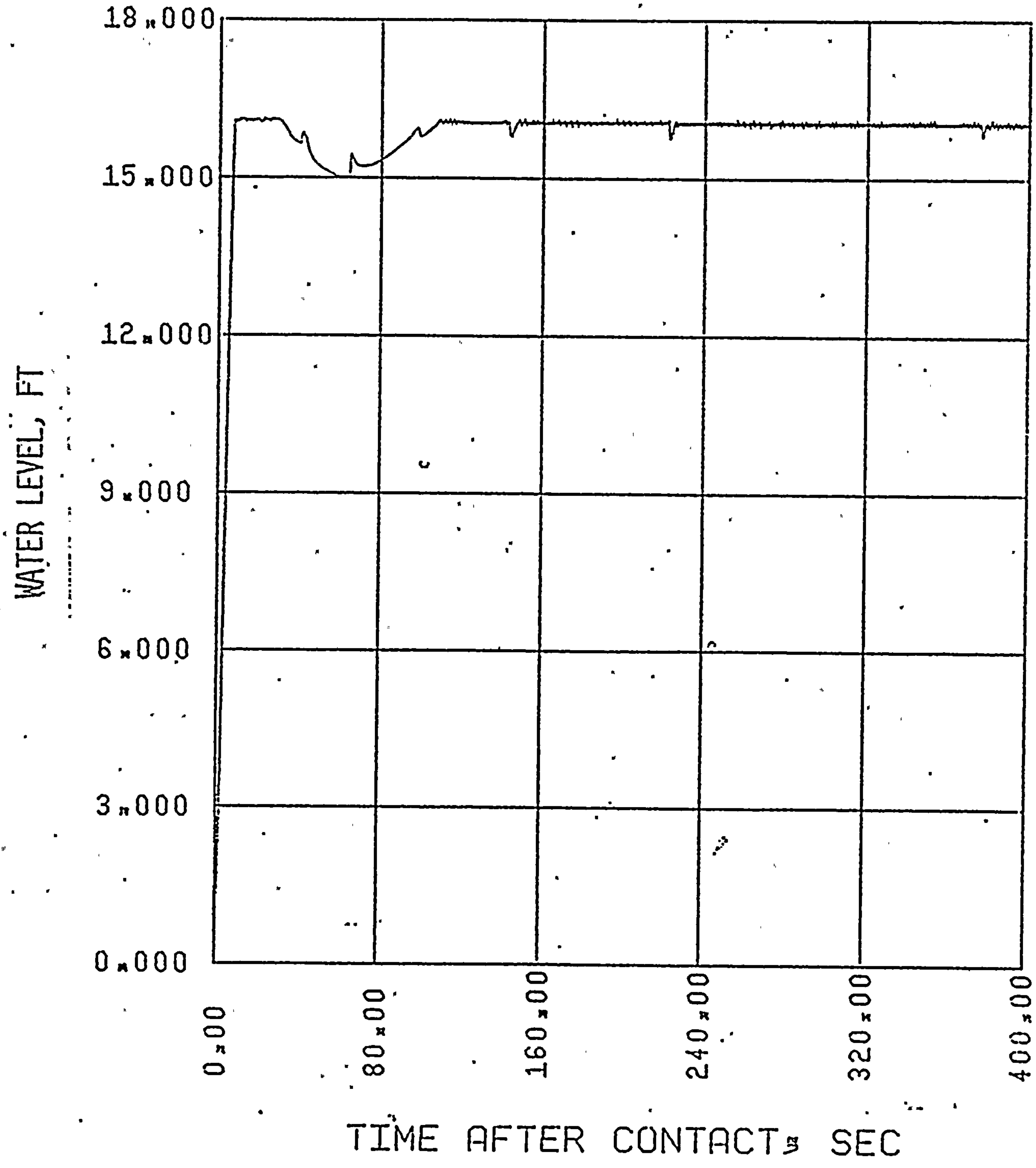
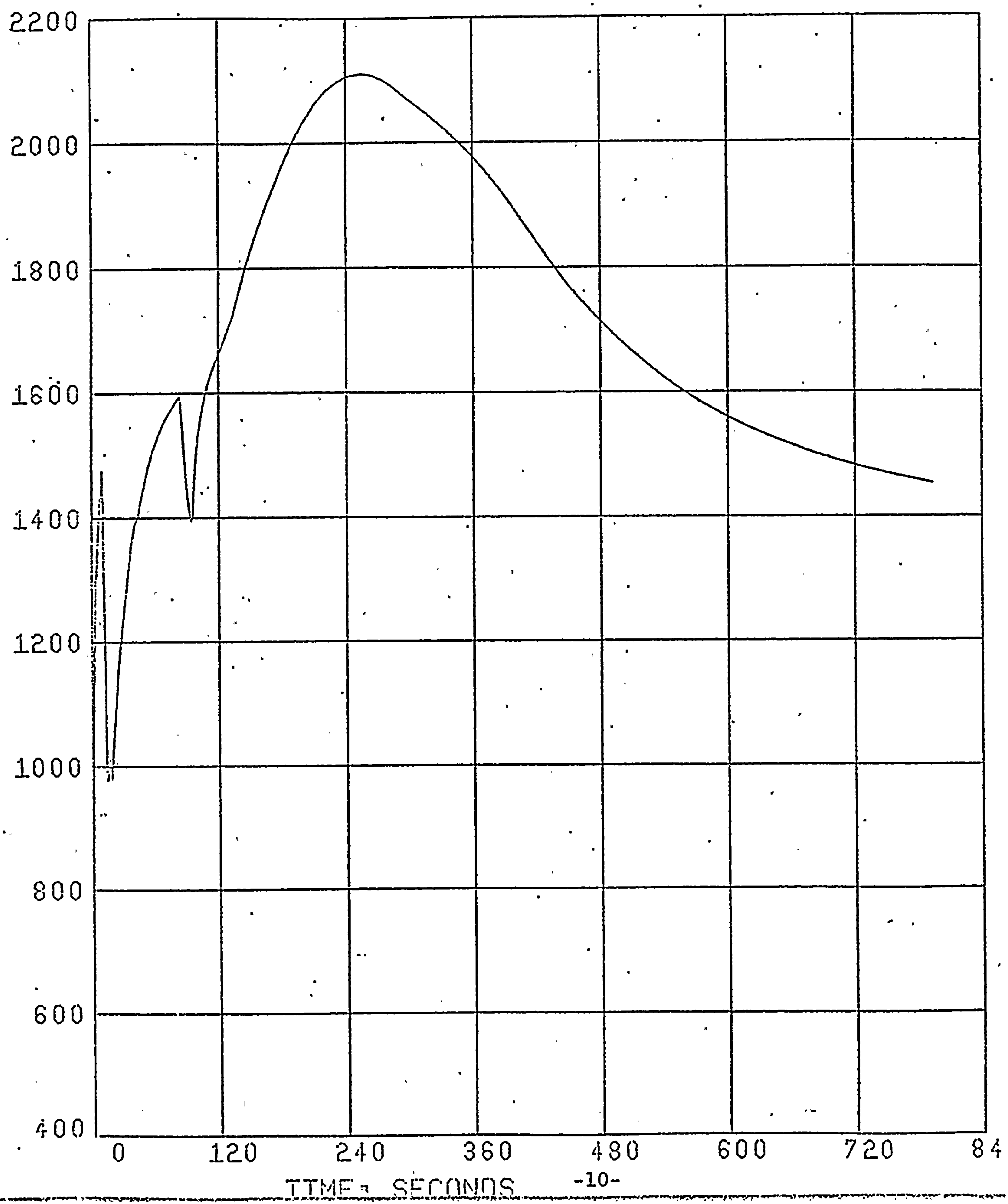


FIGURE III-2

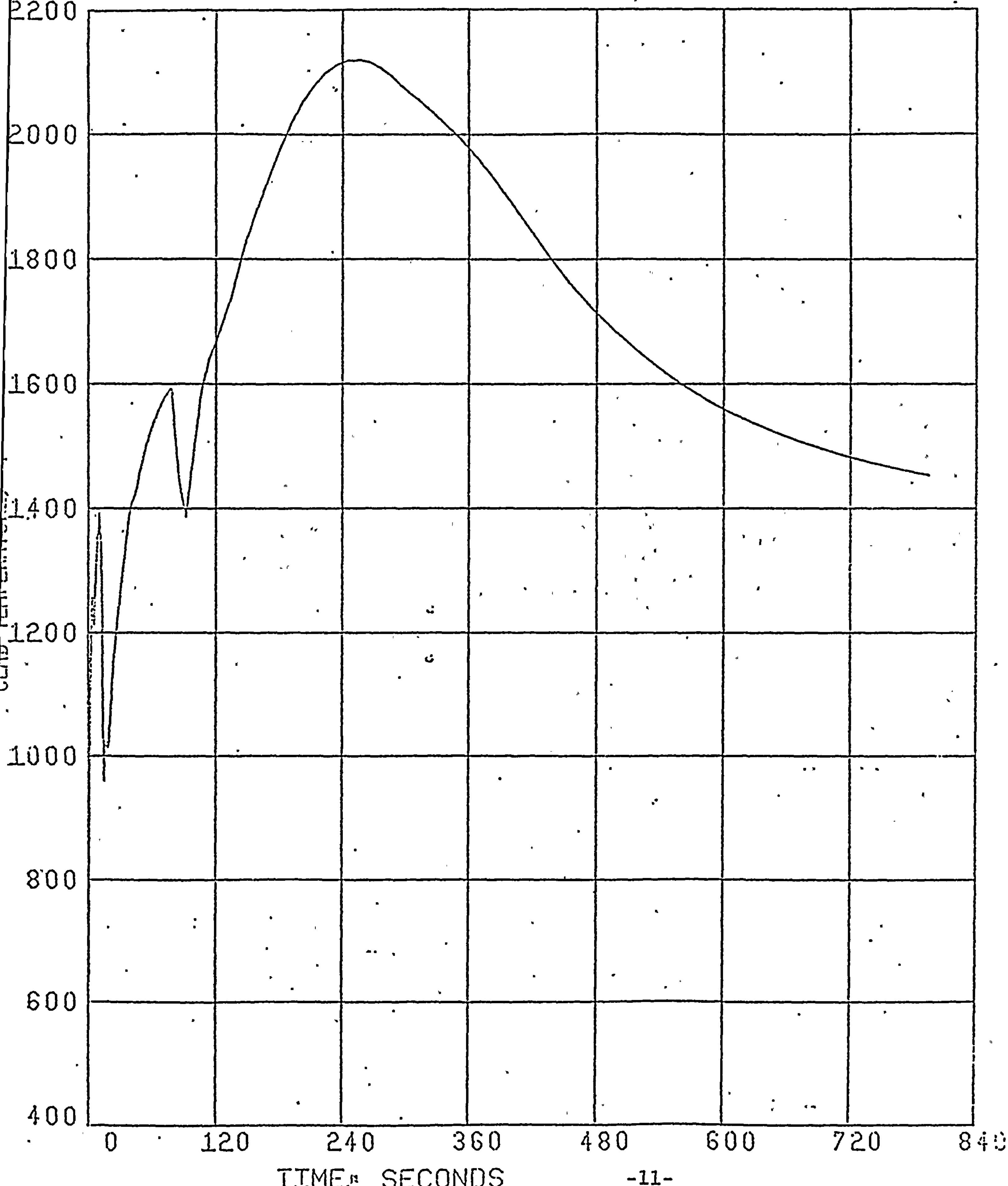
ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE



ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE



ST. LUCIE II
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
LOCAL CLAD OXIDATION

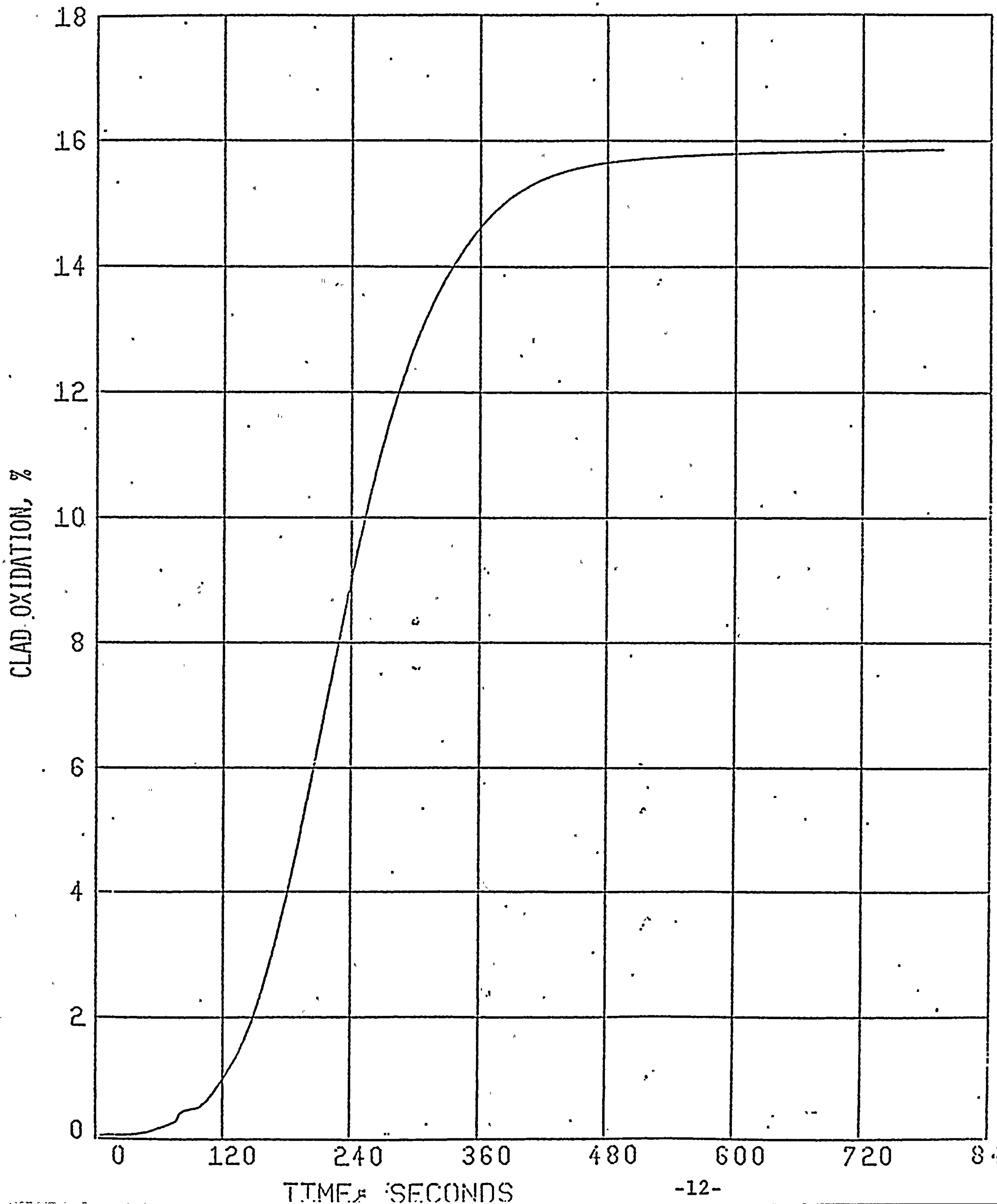
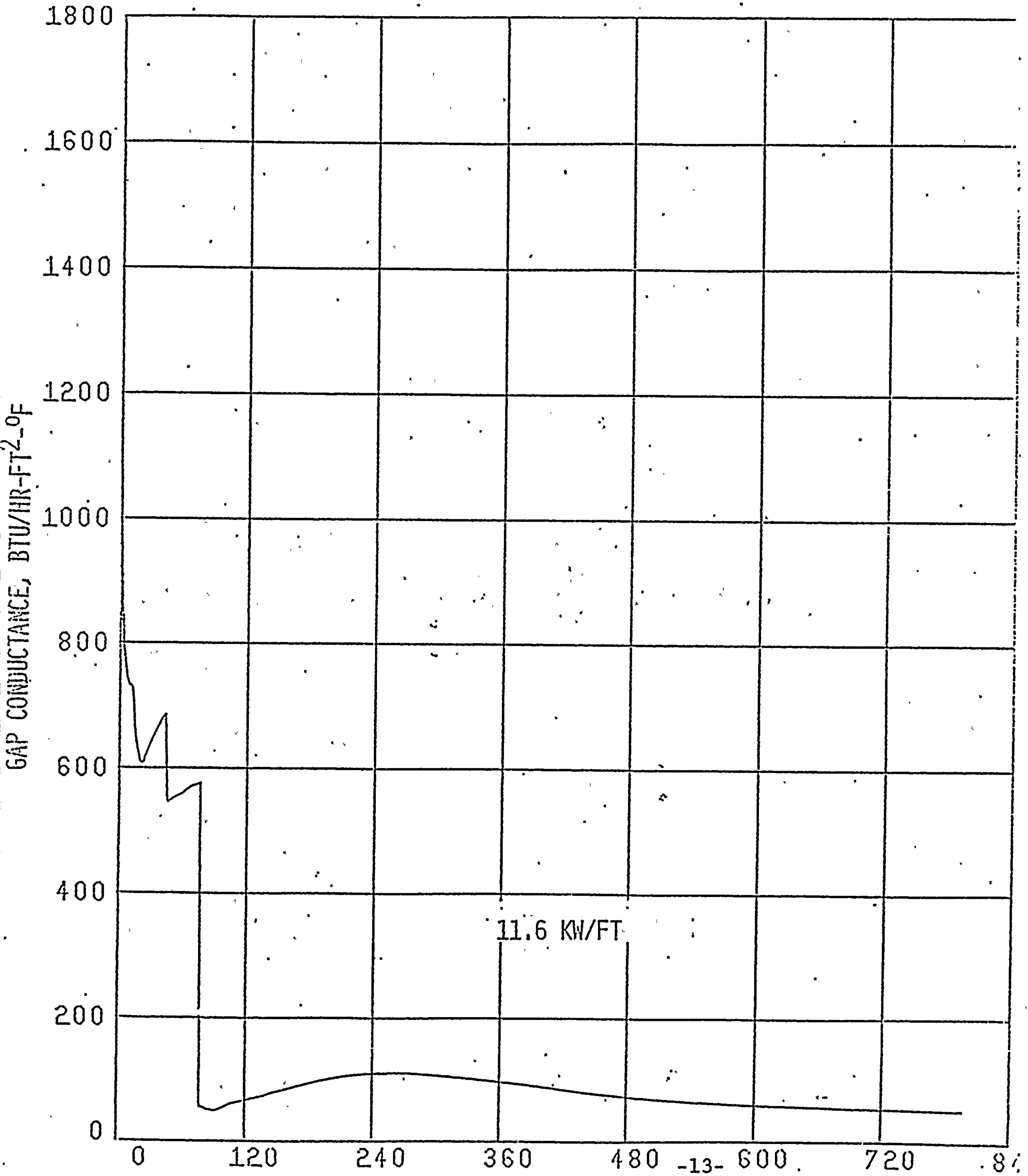


FIGURE III-5

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

HOT SPOT GAP CONDUCTANCE



ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CLAD TEMPERATURE, CENTERLINE FUEL TEMPERATURE, AVERAGE FUEL TEMPERATURE AND COOLANT TEMPERATURE FOR HOTTEST NODE

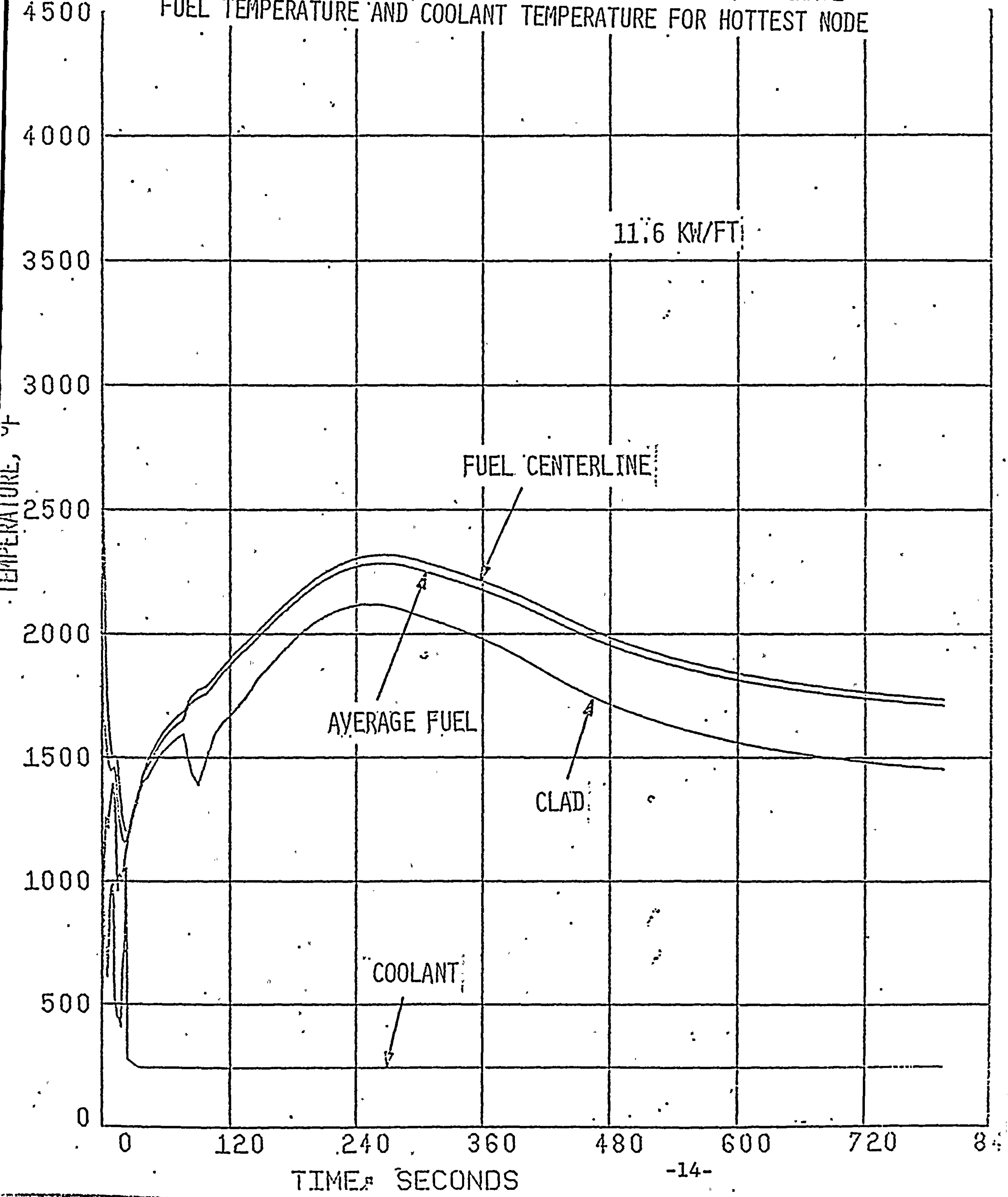


FIGURE III-7

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

HOT SPOT HEAT TRANSFER COEFFICIENT

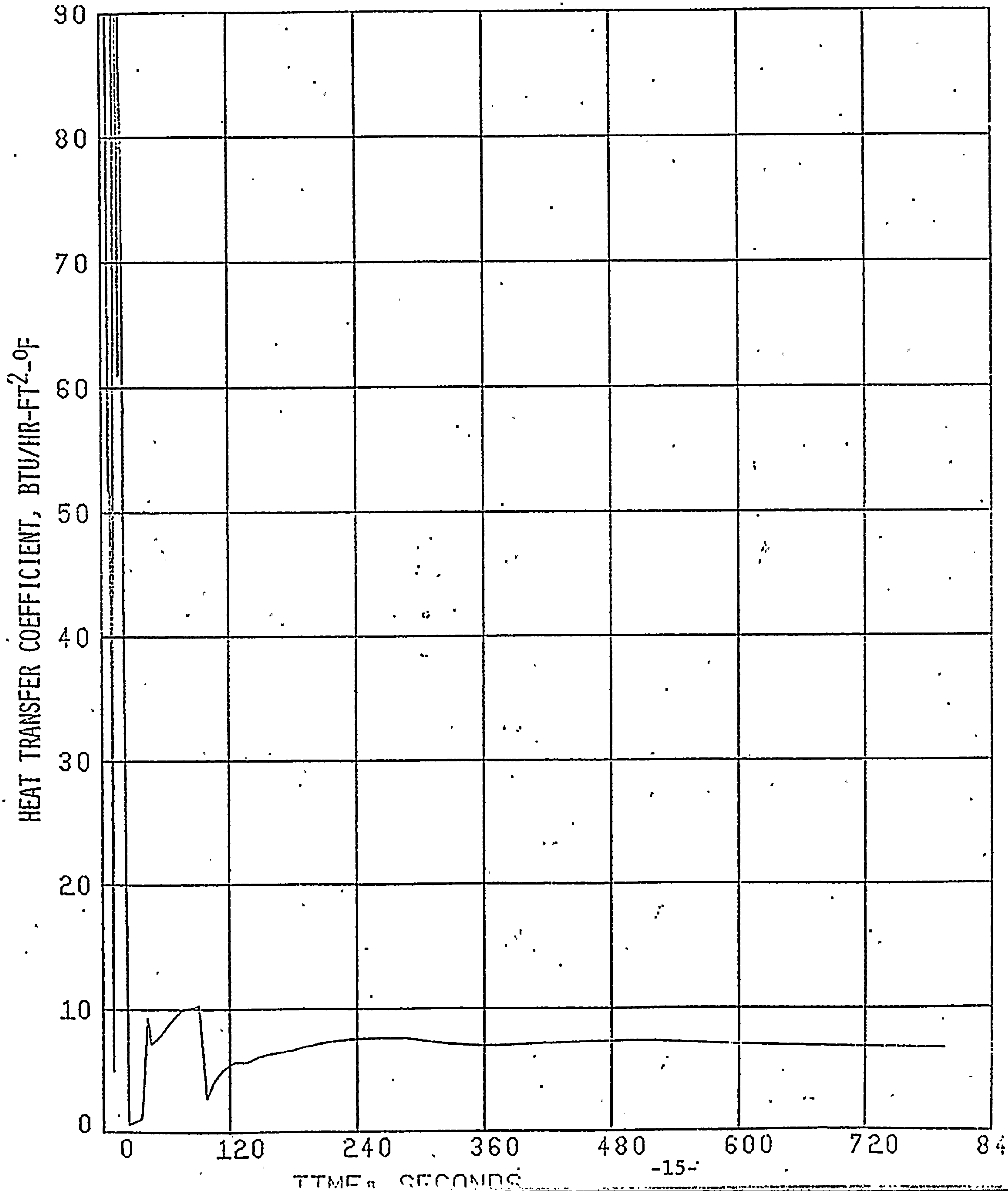


FIGURE III-8

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
HOT SPOT HEAT TRANSFER COEFFICIENT DURING REFLOOD

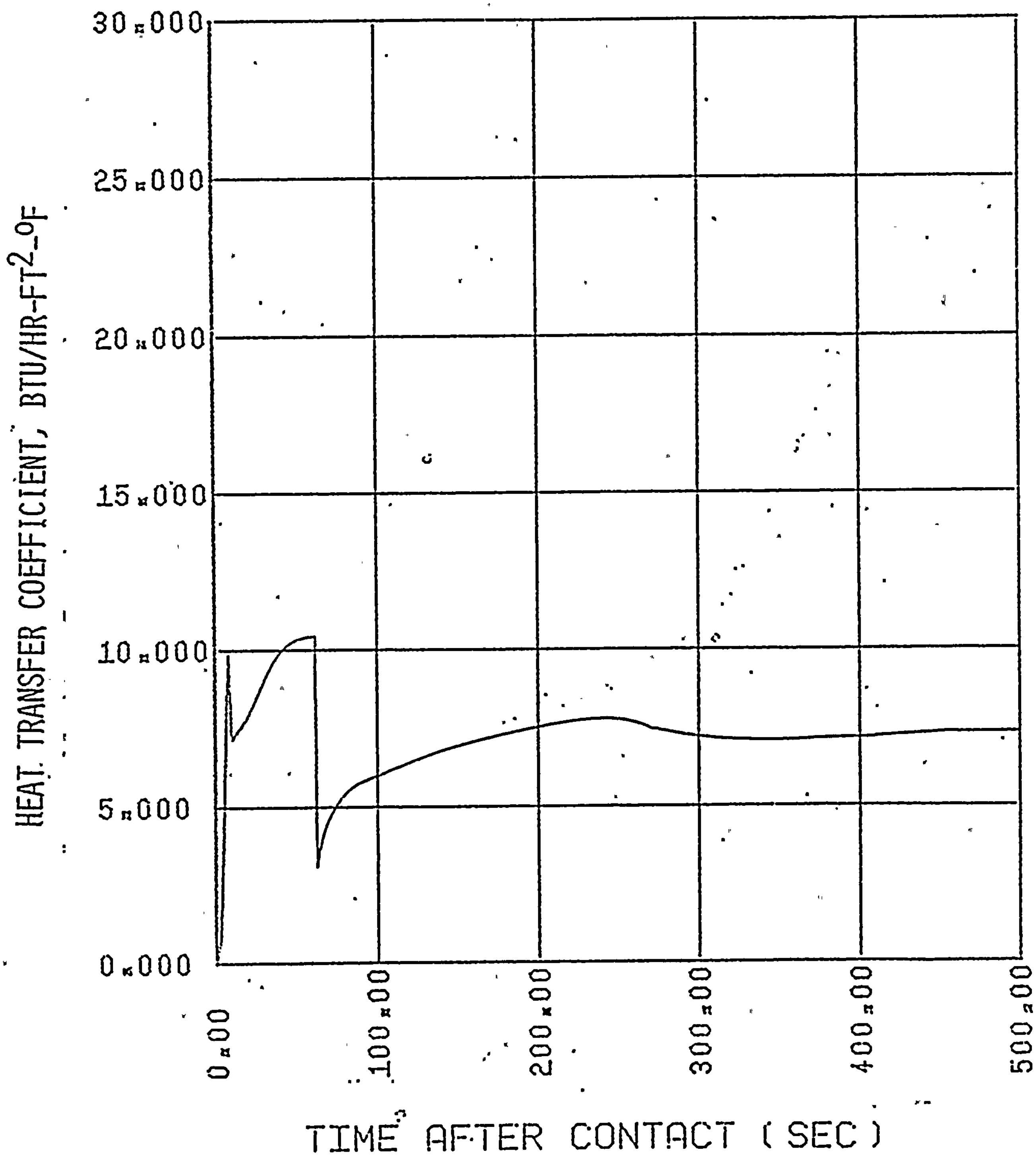
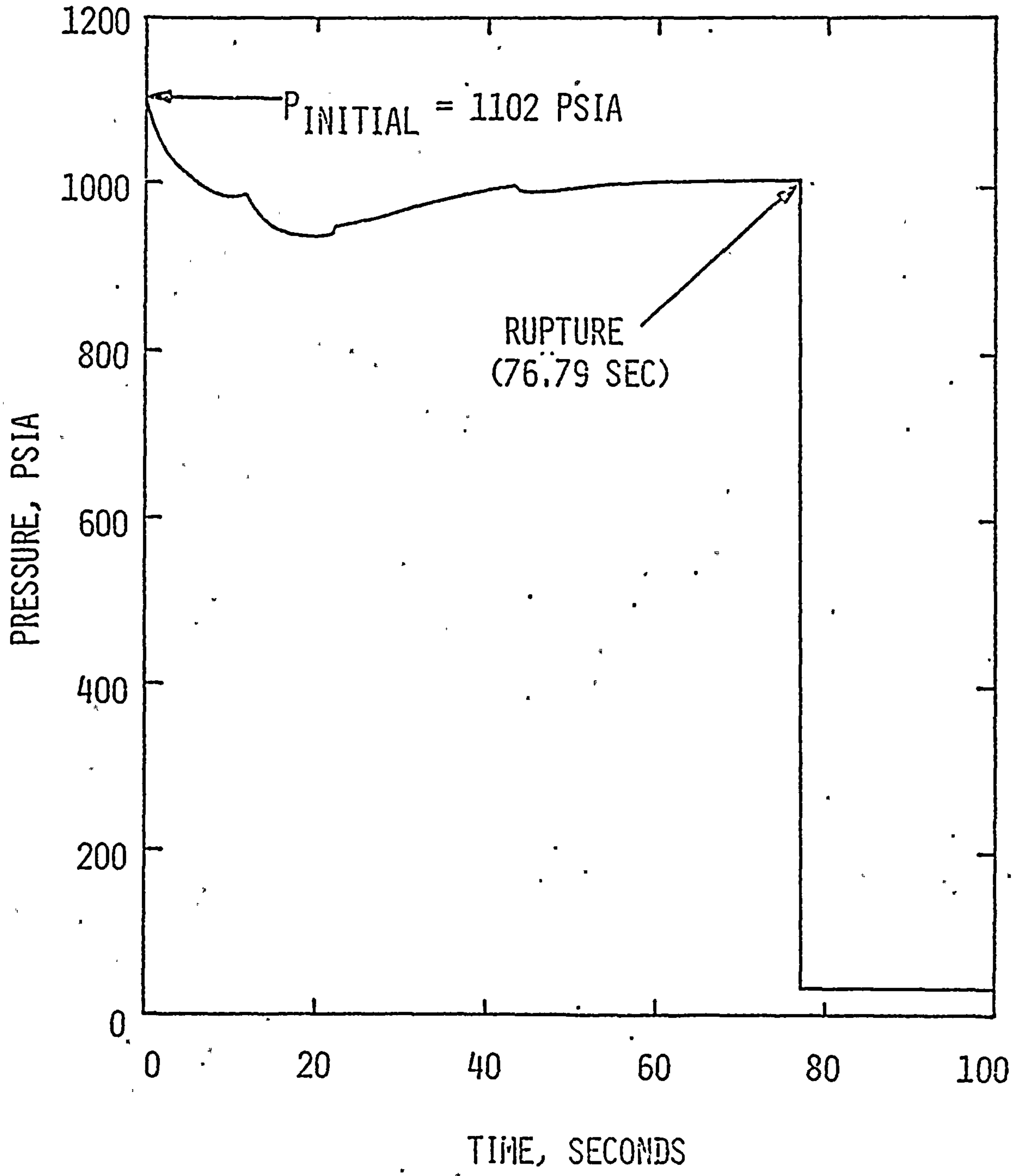


FIGURE III-9

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

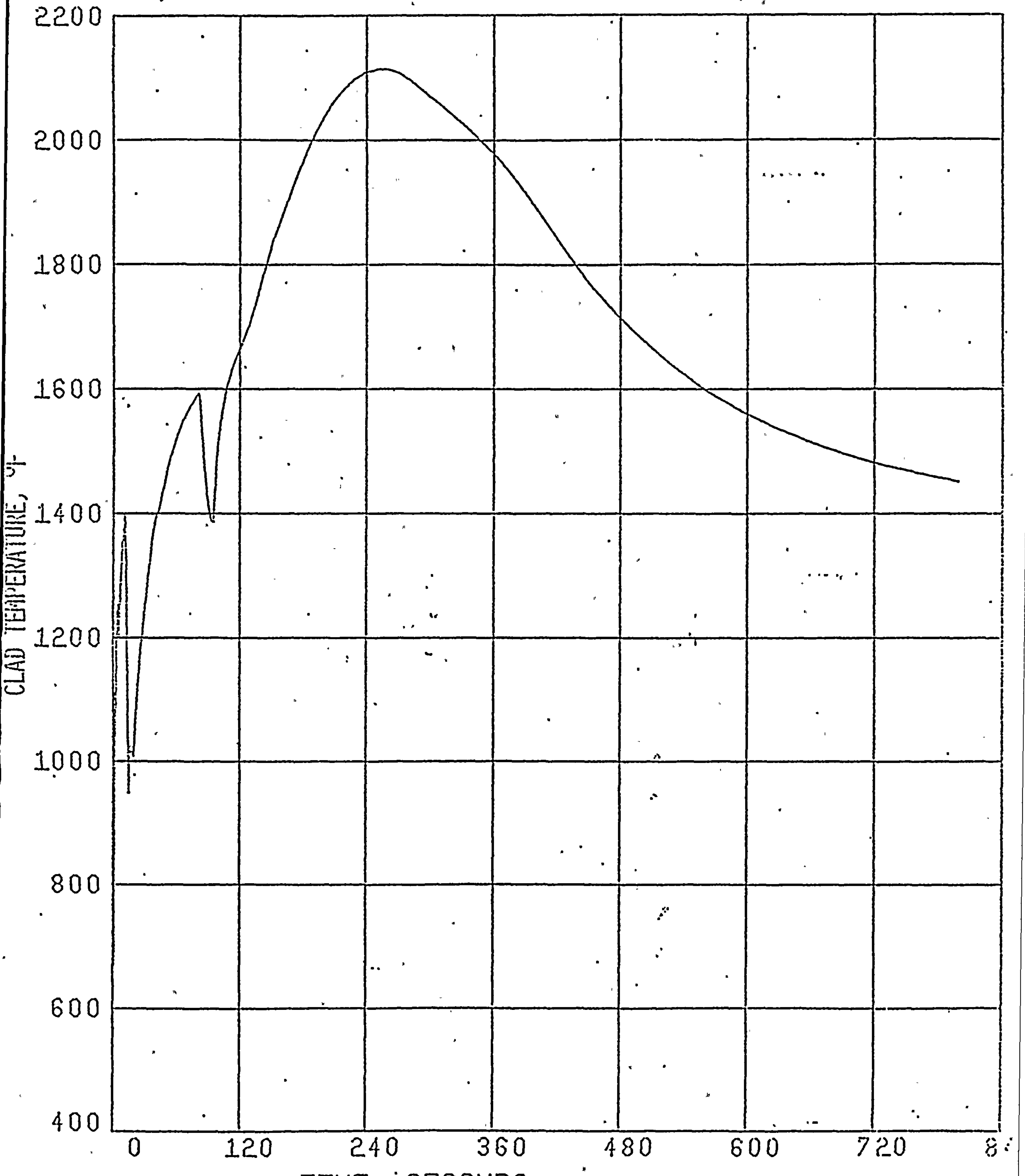
HOT ROD INTERNAL GAS PRESSURE



ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE



ST. LUCIE II

0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

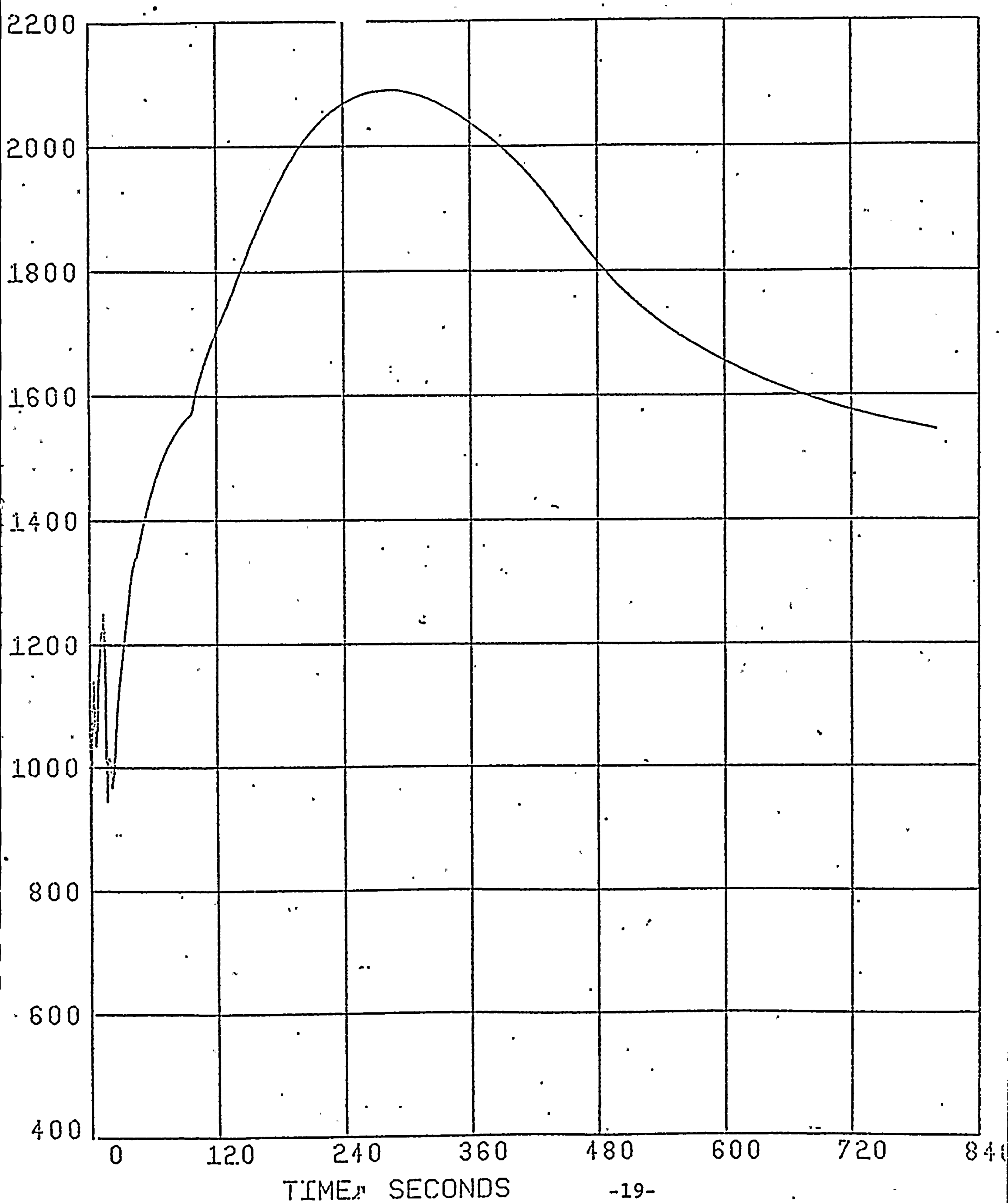


FIGURE III-12
ST. LUCIE II
PEAK CLAD TEMPERATURE vs BREAK AREA