St. Lucie - Unit II Plants
ECCS Performance Results

I. Introduction and Summary

On January 4, 1974, the Atomic Energy Commission issued New Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Reactors(1). The analysis presented herein demonstrates that the St. Lucie-Unit II plant's ECCS design satisfies these new criteria. The analysis has been performed using the Combustion Engineering (C-E) large break evaluation model(4,5) The large break evaluation model results are presented in Section II and cover primary system ruptures larger than 0.5 ft^2. As demonstrated in CENPD-137(2), breaks smaller than 0.5 ft^2 are not limiting. Therefore, a small break spectrum analysis is not presented.

Hot rod temperature calculations were performed for the entire spectrum of break sizes at a peak linear heat generation rate (LHGR) of 12.8 kw/ft. The worst break (that which limits the peak LHGR) was identified as the 0.8 x DEG/PD* which had a local clad oxidation of 16.2%, thus demonstrating that operation at a peak LHGR of 12.8 kw/ft is acceptable. For this analysis, it was found that the local clad oxidation criterion (17%) was more limiting than the temperature criterion (2200°F).

The results of this study supersede those reported in Reference 3 and show that the plant 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 spectrum analysis yielded a peak clad temperature of 2156°F for the 0.8 x DEG/PD break at a peak linear heat generation rate of 12.8 kw/ft.

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

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

The spectrum analysis yielded a local peak clad oxidation percentage of 16.20% for the 0.8 x DEG/PD break.

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 fuel, excluding the cladding surrounding the plenum volume, were to react".

The 0.8 x DEG/PD break produced the highest core-wide oxidation which was 0.886 %.

Criterion (4) Coolable Geometry. "Calculated changes in core geometry shall be such that the core remains amenable to cooling".

The clad swelling and rupture model which is part of the CE Evaluation Model(4) accounts for the effects of changes in core geometry if such changes are predicted to occur. With these core geometry changes, core cooling was enough to lower temperatures. No further rupture can occur since the calculations were carried to the point at which the temperatures were decreasing. Thus, a coolable geometry has been maintained.

Criterion (5) Long Term Cooling. "After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core".

The spectrum analysis presented in this report shows that the rapid insertion of borated water from the ECCS will

suitably limit the peak clad temperature and cool the core within a short period of time. Subsequently, the safety injection pumps would supply cooling water from the refueling water tank to remove decay heat resulting from the long-lived radioactivity remaining in the core. When the refueling water tank is nearly empty, the safety injection pumps would then be lined up to recirculate water from the containment sump. In this manner, the core would be cooled for an indefinite period of time.

II. Large Break Analysis

A. Method of Calculation

The calculations reported in this section were performed using Combustion Engineering's new large break evaluation model which is described in Reference 4. St. Lucie -Unit II has a 16 X 16 array fuel assembly. Thus, in accordance with NRC requirements, a 0.8 factor was applied to the calculated FLECHT reflood heat transfer coefficients.

In addition, the following proposed modifications to the model, as requested in Reference 5, have been included in this calculation:

1. The containment wall noding technique has been revised in order to provide a converged wall temperature solution.

2. Based on a recent review of steam-water mixing data, the resistance across the ECCS injection section during the period after the safety injection tanks have emptied has been revised.

In the C-E model the CEFLASH-4A[6] computer program is used to determine the primary system flow parameters during the blowdown phase, and the COMPERC-II[7] computer program is used to describe the system behavior during the refill and reflood phases. The core flow and thermodynamic parameters from these two codes are used as input to the STRIKIN-II[8] program which is used to calculate the hot rod clad temperature transient. The peak clad temperature and peak local clad oxidation percentage are therefore obtained from the

STRIKIN-II calculation. The core-wide clad oxidation percentage is obtained from the results of both STRIKIN-II and the COMZIRC[7, Suppl. 1] computer programs.

B. Emergency Core Cooling System Assumptions

The Emergency Core Cooling System consists of three high pressure pumps, two low pressure pumps and four safety injection tanks. Automatic operation of the pumps is actuated by either a low-low pressurizer pressure signal or a high containment pressure signal. Flow is initiated from the safety injection tanks when the cold leg pressure drops below 615 psia plus the elevation head. Parameters pertinent to the calculation of the LOCA are presented in Table II-1.

In performing the LOCA calculations, conservative assumptions are made concerning the availability of safety injection flow. It is assumed that two high pressure pumps are operable at the time of the accident. It is assumed that off-site power is lost and all pumps must await diesel startup before they can begin to deliver flow. (It is assumed, however, that off-site power is available for the containment spray system). Also, it is assumed that all safety injection flow delivered to the broken cold leg is lost.

An analysis of the possible single failures that can occur within the ECCS has shown that the worst single failure for the large break results is the failure of one of the low pressure pumps to start[4]. Thus, only one low pressure pump is used in the current LOCA analysis for the St. Lucie-II plant.

The above assumptions lead to the conclusion that the following safety injection flows are available:

75% of the flow from two high pressure pumps

50% of the flow from one low pressure pump (it is assumed that the LPSI pump is connected to the header leading to the loop with the broken leg)

Flow from three safety injection tanks

In the analyses reported in this section, no credit is taken for pump flow until the tanks are empty.

C. Core, System and Containment Parameters

The significant core and system parameters used in the large break calculations are presented in Table II-1. The peak linear heat rate was assumed to occur in the top of the core, the conservative location as identified in Section IV.A.4 of Reference 4. A conservative beginning-of-life moderator temperature coefficient ($+.5 \times 10^{-4}$ $\Delta\rho/^{o}F$) was used for all cases.

Fuel rod conditions, as determined by the FATES[9] computer program, were chosen for this analysis at a burnup of 632 MWd/MTu. A study of the peak local clad oxidation and peak clad temperature vs burnup for the worst break has shown that this burnup produces the most conservative results.

Containment parameters as presented in Table II-2 are chosen to minimize containment pressure such that a conservative determination of core reflood rate is made. Pressure suppression equipment start-up times are selected at their minimum values corresponding to off-site power being available.

D. Break Spectrum

In general, all possible break locations are considered in a LOCA analysis. However, as demonstrated in all past LOCA calculations using both the interim and final evaluation models (References 3 and 4, for example), hot leg

ruptures and cold leg ruptures on the suction side of the pump yield clad temperatures substantially lower than those observed for cold leg ruptures on the discharge side of the pump. Pump discharge leg ruptures are limiting due to the minimization of blowdown core flow and reflood rate for this break location. Thus, only these type breaks need to be considered in order to identify that rupture which results in the highest clad temperature or largest amount of clad oxidation. Since core flow is a function of the break size, calculations have been performed for both guillotine and slot breaks over a range of break sizes from 0.5 ft^2 to twice the flow area of the cold leg.

E. Results

Table II-3 presents a listing of the large break sizes analyzed in this study along with the figure number presenting the pertinent transient data for each break.

As noted in Table II-3, the results for each of the breaks analyzed are displayed graphically in Figures II.1 through II.7. For each break, the nine variables listed in Table II-4 are plotted as a function of time. For the break having the highest local clad oxidation (0.8 x Double-Ended Guillotine) the additional quantities listed in Table II-5 are also presented. Times of interest for the various breaks are shown in Table II-6 while Table II-7 summarizes peak clad temperatures and clad oxidation percentages.

It should be noted that the hot assembly region power in CEFLASH-4A was based on a peak LHGR of 16.0 kw/ft, thus conservatively allowing flexibility during the determination of the allowable peak LHGR based on the STRIKIN-II prediction of the hot rod thermal behavior. This procedure, however, leads to a very conservative core-wide clad oxidation calculation since the CEFLASH-4A hot assembly fuel and clad temperatures are used to initialize COMZIRC at the beginning of the reflood. An evaluation of this conservatism for another plant showed that the core-wide clad oxidation was reduced from 0.933% to 0.776% when the CEFLASH-4A hot assembly reference peak LHGR was reduced from 17.0 to 15.2 kw/ft. Thus, the actual values for core-wide clad oxidation would be less than those reported in Table II-7.

Figure II.8 shows peak clad temperature plotted versus break size and type. It is noticed that the highest clad temperature was calculated for the 0.8 x Double-Ended Guillotine break, which has a peak clad temperature of 2156°F.

Mass and energy release to the containment during blowdown is presented in Table II-8. Also shown in this table is the steam expulsion data during reflood. The ECC water spillage and containment spray flow rates are presented graphically in Figure II.9.

III. Computer Code Version Identification

The following versions of the Combustion Engineering ECCS Evaluation Model computer codes were used for this analysis.

CEFLASH-4A:	Version No. 74329
STRIKIN-II:	Version No. 75066[1]
COMPERC-II:	Version No. 75097
COMZIRC:	Version No. 75055

1 The STRIKIN-II Version 75066 has been modified to prevent occurrence of a negative square root (due to computer round-off error) when in nucleate boiling. Versions 75066 and 75105 predict the same results upon successful computation. Version 75105 was used for the 0.6 x DES/PD and 0.5 ft^2 S/PD break sizes to avoid time step problems.

IV. References

1. Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Nuclear Power Reactors, Federal Register, Vol. 39, No. 3.- Friday January 4, 1974.

2. CENPD-137, "Calculation Methods for the CE Small Break LOCA Evaluation Model", Combustion Engineering Proprietary Report, August, 1974 (proprietary).

3. Florida Power and Light Company, St. Lucie Plant Unit No. 2, Preliminary Safety Analysis Report, Section 6.3.3.6, Rev. 4, dated January 4, 1974.

4. CENPD-132, "Calculative Methods for the CE Large Break LOCA Evaluation Model", August 1974 (proprietary).
   CENPD-132, Supplement 1, December 1974 (proprietary).

5. DP-606, Letter from F. M. Stern (CE) to Victor Stello, Jr. (NRC) dated April 14, 1975, re: Request for Modification of Approved CE ECCS Model of November 27, 1974.

6. CENPD-133, "CEFLASH-4A, A Fortran IV Digital Computer Program for Reactor Blowdown Analysis", April 1974 (proprietary).

   CENPD-133, Supplement 2, "CEFLASH-4A, A Fortran IV Digital Computer Program for Reactor Blowdown Analysis (Modification)", December 1974 (proprietary).

7. CENPD-134, "COMPERC-II, A Program for Emergency Refill-Reflood of the Core", April 1974 (proprietary).

   CENPD-134, Supplement 1, "COMPERC-II, A Program for Emergency Refill-Reflood of the Core (Modification)", December 1974 (proprietary).

8. CENPD-135, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program", April 1974 (proprietary).

   CENPD-135, Supplement 2, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program (Modification), December 1974 (proprietary).

9. CENPD-139, "CE Fuel Evaluation Model", July 1974 (proprietary).

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Table II-1

General System Parameters

Quantity	Value	
Reactor power level (102% of Nominal)	2611	MWt
Average linear heat rate (102% of Nominal)	4.63	kw/ft
Peak linear heat rate	12.8	kw/ft
Gap conductance at peak linear heat rate	1347	BTU/hr-ft^2-^{o}F
Fuel centerline temperature at peak linear heat rate	3223	^{o}F
Fuel average temperature at peak linear heat rate	2081	^{o}F
Hot rod gas pressure	1102	psia
Moderator temperature coefficient at initial density	$+0.5 \times 10^{-4}$	$\Delta\rho/^o$F
System flow rate (total)	139.44×10^6	lbs/hr
Core flow rate	134.56×10^6	lbs/hr
Initial system pressure	2250	psia
Core inlet temperature	548	^{o}F
Core outlet temperature	598.4	^{o}F
Active core height	11.39	ft
Fuel rod OD	0.382	in
Number of cold legs	4	
Number of hot legs	2	
Cold leg diameter	30	
Hot leg diameter	42	in
Safety injection tank pressure	615	psia
Safety injection tank gas/water volume	430/1420	ft^3

Table II-2

Containment Physical Parameters St. Lucie Unit II

1. Net Free Volume	2.506×10^6 ft^3	
2. Initiation Times		
a. Spray Flow	20.0 seconds	
b. Fan Coolers (3 fans)	0.0 seconds	
3. Containment Initial Condition		
a. Temperature (min)	60°F	
b. Pressure (min)	14.7 psia	
c. Relative Humidity (max)	100%	
4. Containment Spray Water		
a. Temperature	40°F	
b. Flow Rate (2 pumps)	3375 gpm	
5. Passive Heat Sink Data :	Surface Area (ft^2)	Thickness (in)
a. Containment Vessel Cylinder	55,900	1.91
Containment Vessel Dome	30,800	0.95
b. Other Steel	310,576	0.375*
c. Concrete Underwater		
Interior Surface Area	26,827	12.0*
Exterior Surface Area	8,209	12.0*
Concrete Exposed to Containment Atmosphere		
Interior Surface Area	30,728	12.0*
Exterior Surface Area	33,093	12.0*
6. Thermal Properties	$K(\frac{BTU}{hr\text{-}ft\text{-}^oF})$	$\rho c_p (\frac{BTU}{ft^3\text{-}^oF})$
Steel	30.0	56.14
Concrete	1.0	31.90
7. Containment External Heat Sink		
a. Surface Heat Transfer Coefficient (h)	13.0 BTU/hr-ft^2-°F	
b. Heat Sink Temperature	38°F	

* Staff values of 3/8" and one foot are used for (b) and (c), respectively.

Table II-2 (continued)

8. Fan Cooling Capacity (per fan)

Vapor Temperature (^{o}F)	Capacity (BTU/sec)
60	0.0
120	220.0
180	4700.0
220	9020.0
264	16666.0

TABLE II-3

Large Break Spectrum

Break Size, Type and Location	Abbreviation	Figure
1.0x Double-Ended Slot Break in Pump Discharge Leg	1.0 x DES/PD	II.1
0.8x Double-Ended Slot Break in Pump Discharge Leg	0.8 x DES/PD	II.2
0.6x Double-Ended Slot Break in Pump Discharge Leg	0.6 x DES/PD	II.3
0.5 ft^2 Slot Break in Pump Discharge Leg	0.5 ft^2 S/PD	II.4
1.0x Double-Ended Guillotine Break in Pump Discharge Leg	1.0 x DEG/PD	II.5
0.8x Double-Ended Guillotine Break in Pump Discharge Leg	0.8 x DEG/PD	II.6
0.6x Double-Ended Guillotine Break in Pump Discharge Leg	0.6 x DEG/PD	II.7

Table II-4

Variables Plotted as a Function of Time for Each Large Break in the Spectrum

Variable	Figure Designation
Core Power	A
Pressure in Center Hot Assembly Node	B
Leak Flow	C
Hot Assembly Flow (below hot spot)	D.1
Hot Assembly Flow (above hot spot)	D.2
Hot Assembly Quality	E
Containment Pressure	F
Mass Added to Core During Reflood	G
Peak Clad Temperature	H*

* For worst case (0.8 X DE Guillotine) the temperature for the ruptured node is also shown.

Table II-5

Additional Variables Plotted as a Function of Time for the Large Break
Having the Highest Clad Temperature
(0.8 X Double-Ended Guillotine)

Variables	Figure Designation
Mid Annulus Flow	I
Qualities Above and Below the Core	J
Core Pressure Drop	K
Safety Injection Flow into Intact Discharge Legs	L
Water Level in Downcomer during Reflood	M
Gap Conductance (Hottest and ruptured nodes)	N
Local Clad Oxidation (Hottest and ruptured nodes)	O
Clad Temperature, Centerline Fuel Temperature, Average Fuel Temperature and Coolant Temperature for Hottest Node	P
Hot Spot Heat Transfer Coefficient	Q
Hot Spot Heat Transfer Coefficient during Reflood	R
Containment Temperature	S
Sump Temperature	T

Table II-6

Times of Interest for Each Large Break (seconds)

Break	Hot Rod Rupture	SI Tanks on	End of Bypass	Start of Reflood	SI Tanks Empty
1.0xDES/PD	63.30	12.90	20.5	35.40	69.35
0.8xDES/PD	61.70	12.80	20.7	35.60	69.44
0.6xDES/PD	71.20	13.70	21.7	36.60	70.70
0.5 ft^2S/PD	259.55	124.0	133.6	149.10	185.95
1.0xDEG/PD	59.25	12.90	20.3	35.20	69.58
0.8xDEG/PD	61.50	12.90	20.7	35.60	69.74
0.6xDEG/PD	71.30	14.40	22.3	37.20	71.27

Table II-7

Peak Clad Temperatures and Oxidation Percentages for the Break Spectrum

Break	Peak Clad Temperature (°F)	Clad Oxidation (%) Local	Clad Oxidation (%) Core-Wide
1.0 X DES/PD	2079	14.8	< 0.76
0.8 X DES/PD	2106	13.3	< 0.75
0.6 X DES/PD	2063	13.9	< 0.71
0.5 ft^2 S/PD	1849	6.9	< 0.27
1.0 X DEG/PD	2087	15.1	< 0.87
0.8 X DEG/PD	2156	16.2	< 0.89
0.6 X DEG/PD	2083	12.5	< 0.70

TABLE II.8

ST. LUCIE II

BLOWDOWN AND REFLOOD MASS AND ENERGY RELEASE DATA

0.8 x DEG/PD

TIME (SEC)	MASS RATE (lb/sec)	ENERGY RATE (BTU/SEC)	INTEGRAL MASS (lb)	INTEGRAL ENERGY (BTU)	PAGE 1
0.0	0.0	0.0	0.0	0.0	
0.1	68039.	3.662 +07	6834.9	3.681 +06	
0.2	68747.	3.6993 +07	13751.1	7.4025 +06	
0.3	67642.	3.6447 +07	20541.	1.10583 +07	
0.4	65933.	3.5564 +07	27191.	1.46436 +07	
0.5	65100.	3.5142 +07	33735.	1.81746 +07	
0.6	64763.	3.4982 +07	40229.	2.16817 +07	
0.7	64666.	3.4951 +07	46704.	2.51806 +07	
0.8	64317.	3.4784 +07	53154.	2.8668 +07	
0.9	64099.	3.4687 +07	59547.	3.2137 +07	
1.0	63977.	3.4642 +07	65948.	3.5602 +07	
1.2	63363.	3.4369 +07	78710.	4.2506 +07	
1.4	61946.	3.3638 +07	91254.	4.9313 +07	
1.6	59296.	3.2233 +07	103407.	5.5917 +07	
1.8	55704.	3.0295 +07	114902.	6.2147 +07	
2.0	52740.	2.8706 +07	125737.	6.8062 +07	
2.2	50340.	2.74195 +07	136026.	7.3444 +07	
2.4	47809.	2.60695 +07	145881.	7.9033 +07	
2.6	46510.	2.53915 +07	155346.	8.4209 +07	
2.8	45478.	2.48535 +07	164555.	8.923 +07	
3.0	44887.	2.45647 +07	173602.	9.4174 +07	
3.2	43777.	2.39892 +07	182475.	9.9034 +07	
3.4	42527.	2.33377 +07	191099.	1.03765 +08	
3.6	41531.	2.2834 +07	199496.	1.08379 +08	
3.8	40686.	2.24276 +07	207724.	1.12907 +08	

TABLE II. 8

ST. LUCIE II

BLOWDOWN AND REFLOOD MASS AND ENERGY RELEASE DATA

0.8 X DEG/PD

TIME (SEC)	MASS RATE (lb/SEC)	ENERGY RATE (BTU/SEC)	INTEGRAL MASS (lb)	INTEGRAL ENERGY (BTU)	PAGE 2
4.0	39566.	2.18739+07	215755.	1.17338+08	
4.5	36677.	2.04909+07	234826.	1.2793 +08	
5.0	33971.	1.93151+07	252544.	1.37911+08	
5.5	31210.	1.81054+07	268794.	1.47247+08	
6.0	29196.	1.71789+07	2.8386+05	1.56057+08	
6.5	27632.	1.63919+07	2.9807+05	1.64449+08	
7.0	26457.	1.57677+07	3.1155+05	1.72475+08	
7.5	25671.	1.52931+07	3.2458+05	1.80237+08	
8.0	24977.	1.48332+07	3.3724+05	1.87771+08	
8.5	24203.	1.43207+07	3.4954+05	1.95056+08	
9.0	23304.	1.37635+07	3.6142+05	2.02094+08	
9.5	22338.	1.31991+07	3.7284+05	2.0882 +08	
10.0	21219.	1.25874+07	3.8373+05	2.15271+08	
11.0	18621.	1.12486+07	4.0367+05	2.27187+08	
12.0	15074.	9.8035+06	4.2073+05	2.37761+08	
13.0	9228.	7.7454+06	4.3287+05	2.46566+08	
14.0	6723.	6.0808+06	4.4075+05	2.53399+08	
15.0	4431.	4.8999+06	4.4587+05	2.58717+08	
16.0	5080.	4.7135+06	4.5054+05	2.6355 +08	
17.0	6035.	4.2791+06	4.5613+05	2.68083+08	
18.0	5699.	3.3112+06	4.6216+05	2.71912+08	
19.0	4100.	2.12571+06	4.6715+05	2.74649+08	
20.0	3462.	1.57725+06	4.7052+05	2.76327+08	
21.0	1731.	9.269+05	4.7265+05	2.77351+08	
22.0	649.	3.2117+05	4.7381+05	2.77909+08	

TABLE II.8
ST. LUCIE II
BLOWDOWN AND REFLOOD MASS AND ENERGY RELEASE DATA
0.8 x DEG/PD

TIME (SEC)	MASS RATE (lb/sec)	ENERGY RATE (BTU/SEC)	INTEGRAL MASS (lb)	INTEGRAL ENERGY (BTU)	PAGE 3
22.5 ← TIME OF ANNULUS DOWNFLOW	3269.	1.0969+06	4.7408+05	2.78059+08	
← START OF REFLOOD (VALUES BELOW ARE FOR STEAM ONLY)					
27.5	0.0	0.0	4.7408+05	2.78059+08	
32.5	0.0	0.0	4.7408+05	2.78059+08	
37.5	0.0	0.0	4.7408+05	2.78059+08	
42.5	0.0	0.0	4.7408+05	2.78059+08	
47.5	0.0	0.0	4.7408+05	2.78059+08	
52.5	0.0	0.0	4.7408+05	2.78059+08	
57.5	203.3	1.3411+06	4.7425+05	2.78285+08	
62.5	192.1	1.3466+06	4.7524+05	2.79568+08	
67.5	185.2	1.33756+06	4.7618+05	2.80792+08	
72.5	180.5	1.33153+06	4.7710+05	2.81977+08	
77.5	203.8	1.36179+06	4.7810+05	2.8329+08	
82.5	201.2	1.35843+06	4.79113+05	2.8460+08	
87.5	201.0	1.3582+06	4.8012+05	2.8591+08	
92.5	198.8	1.3553+06	4.8112+05	2.87208+08	
97.5	198.0	1.35419+06	4.82112+05	2.88499+08	
102.5	196.8	1.35262+06	4.8310+05	2.8978+08	
107.5	203.3	1.36115+06	4.84095+05	2.91062+08	
112.5	196.3	1.35202+06	4.85068+05	2.9234+08	
117.5	195.8	1.35135+06	4.86049+05	2.9362+08	
122.5	195.8	1.35132+06	4.87027+05	2.9489+08	
127.5	195.2	1.3506+06	4.8800+05	2.9616+08	
132.5	194.9	1.35019+06	4.88979+05	2.97424+08	
137.5	195.4	1.35081+06	4.8995+05	2.98691+08	
142.5	195.0	1.35033+06	4.9093+05	2.99956+08	

TABLE II.8
ST. LUCIE II
BLOWDOWN AND MASS AND ENERGY RELEASE DATA
0.8 x DEG/PD)

TIME (SEC)	MASS RATE (lb/SEC)	ENERGY RATE (BTU/SEC)	INTEGRAL MASS (lb)	INTEGRAL ENERGY (BTU)	PAGE 4
147.5	194.2	1.3519 +06	4.9190 +05	3.0122 +08	
152.5	195.3	1.3507 +06	4.9288 +05	3.0249 +08	
157.5	194.7	1.3500 +06	4.9385 +05	3.0376 +08	
162.5	194.7	1.34996 +06	4.9483 +05	3.05021 +08	
167.5	194.1	1.3492 +06	4.9580 +05	3.0629 +08	
172.5	194.7	1.3499 +06	4.9677 +05	3.0755 +08	
177.5	195.5	1.3510 +06	4.9775 +05	3.0882 +08	
182.5	195.7	1.3512 +06	4.9873 +05	3.1009 +08	
187.5	195.0	1.3503 +06	4.9970 +05	3.1136 +08	
192.5	195.8	1.3513 +06	5.0068 +05	3.1263 +08	
197.5	196.4	1.3522 +06	5.0166 +05	3.1390 +08	
202.5	196.2	1.3519 +06	5.0264 +05	3.1518 +08	
207.5	197.1	1.3531 +06	5.0362 +05	3.1645 +08	
212.5	197.1	1.3530 +06	5.0460 +05	3.1773 +08	
217.5	197.5	1.3536 +06	5.0559 +05	3.1901 +08	
225.5	197.2	1.3532 +06	5.0657 +05	3.2029 +08	
235.5	196.1	1.3518 +06	5.0854 +05	3.2285 +08	
245.5	198.3	1.3546 +06	5.1052 +05	3.2542 +08	
255.5	198.0	1.3542 +06	5.1249 +05	3.2798 +08	
265.5	197.8	1.3540 +06	5.1447 +05	3.3056 +08	
275.5	198.9	1.3544 +06	5.1646 +05	3.3314 +08	
285.5	199.3	1.3559 +06	5.1845 +05	3.3573 +08	
295.5	199.0	1.3556 +06	5.2044 +05	3.3832 +08	
305.5	199.8	1.3566 +06	5.2244 +05	3.4091 +08	
315.5	200.3	1.3572 +06	5.2444 +05	3.4351 +08	

CLW 4/29/75

TABLE II.8
ST. LUCIE II
BLOWDOWN AND REFLOOD MASS AND ENERGY RELEASE DATA
0.8 x DEG/PD

TIME (sec)	MASS RATE (lb/sec)	ENERGY RATE (BTU/SEC)	INTEGRAL MASS (lb)	INTEGRAL ENERGY (BTU)	PAGES
325.5	201.1	1.3583 +06	5.2644 +05	3.4611 +08	
335.5	200.9	1.3580 +06	5.2845 +05	3.4872 +08	
345.5	200.8	1.3579 +06	5.3046 +05	3.5133 +08	
355.5	201.4	1.3587 +06	5.3247 +05	3.5395 +08	
365.5	201.3	1.3586 +06	5.3448 +05	3.5656 +08	
375.5	201.9	1.3593 +06	5.3649 +05	3.5917 +08	
385.5	202.0	1.3595 +06	5.3850 +05	3.6179 +08	
395.5	202.0	1.3594 +06	5.4051 +05	3.6440 +08	
405.5	201.8	1.3591 +06	5.4253 +05	3.6702 +08	
415.5	201.2	1.3584 +06	5.4455 +05	3.6965 +08	
425.5	201.5	1.3588 +06	5.4657 +05	3.7227 +08	

CLW 4/25/78

FIGURE II.1-A

ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

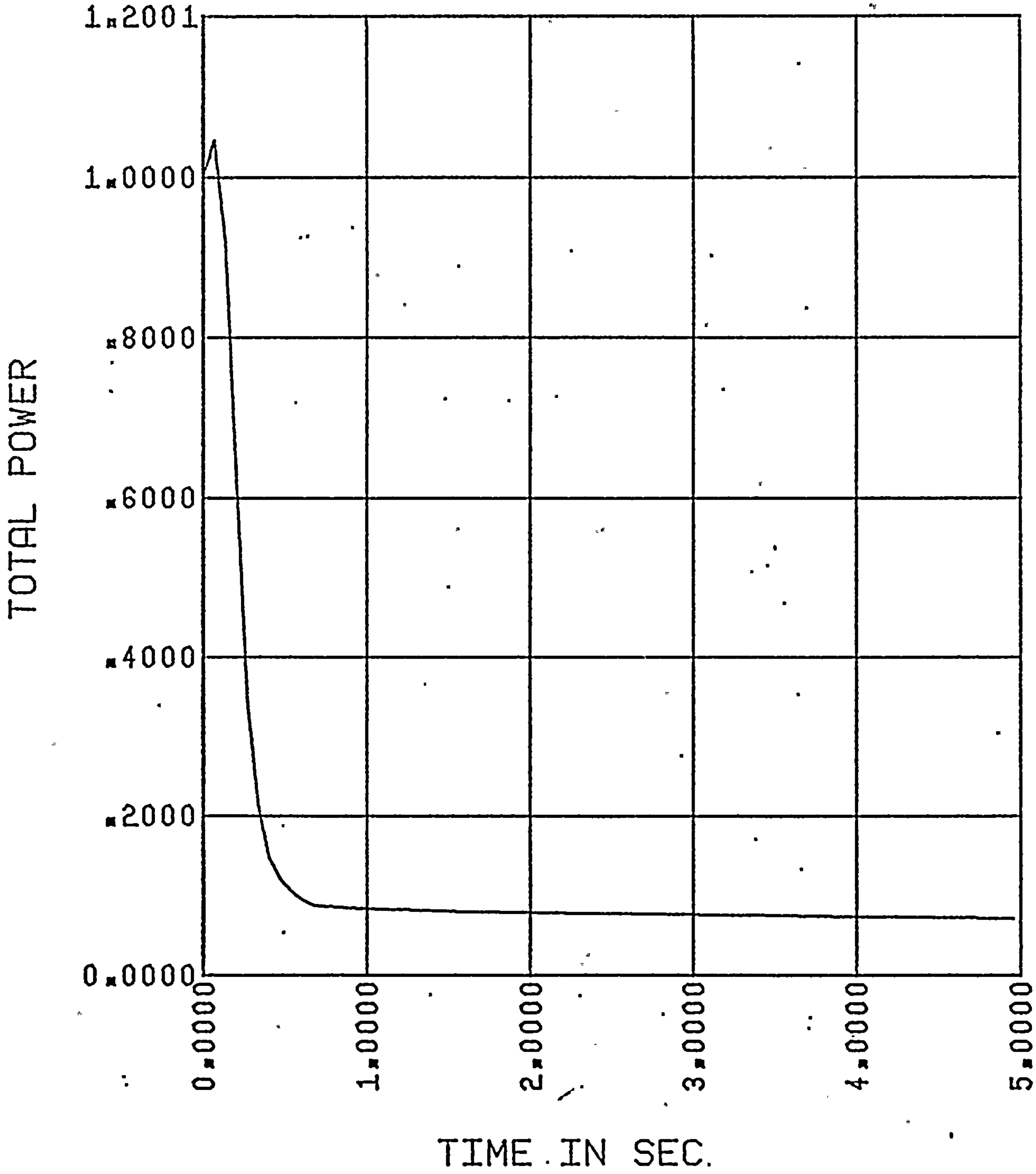


FIGURE II.1-B

ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

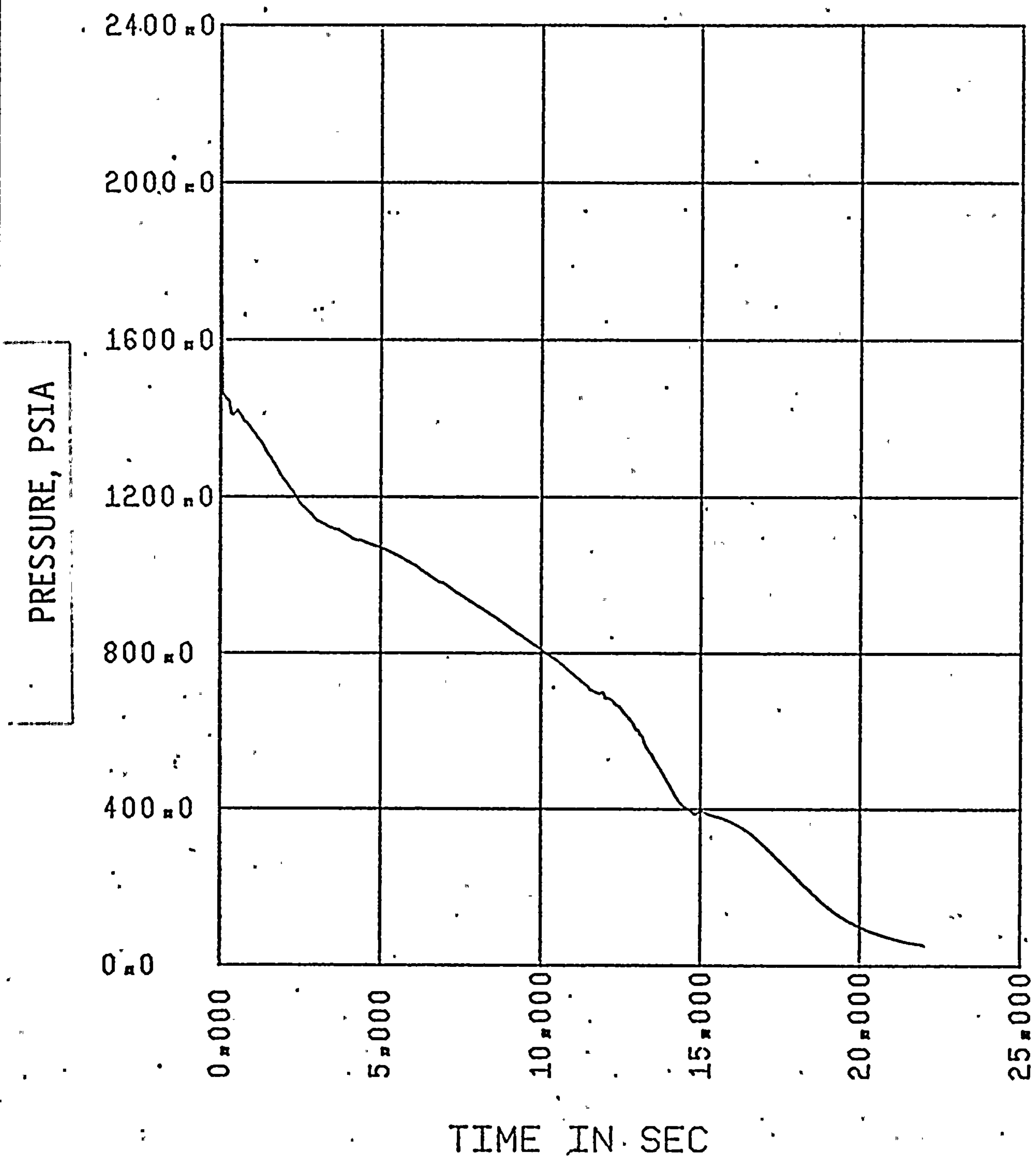


FIGURE II.1-C

ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

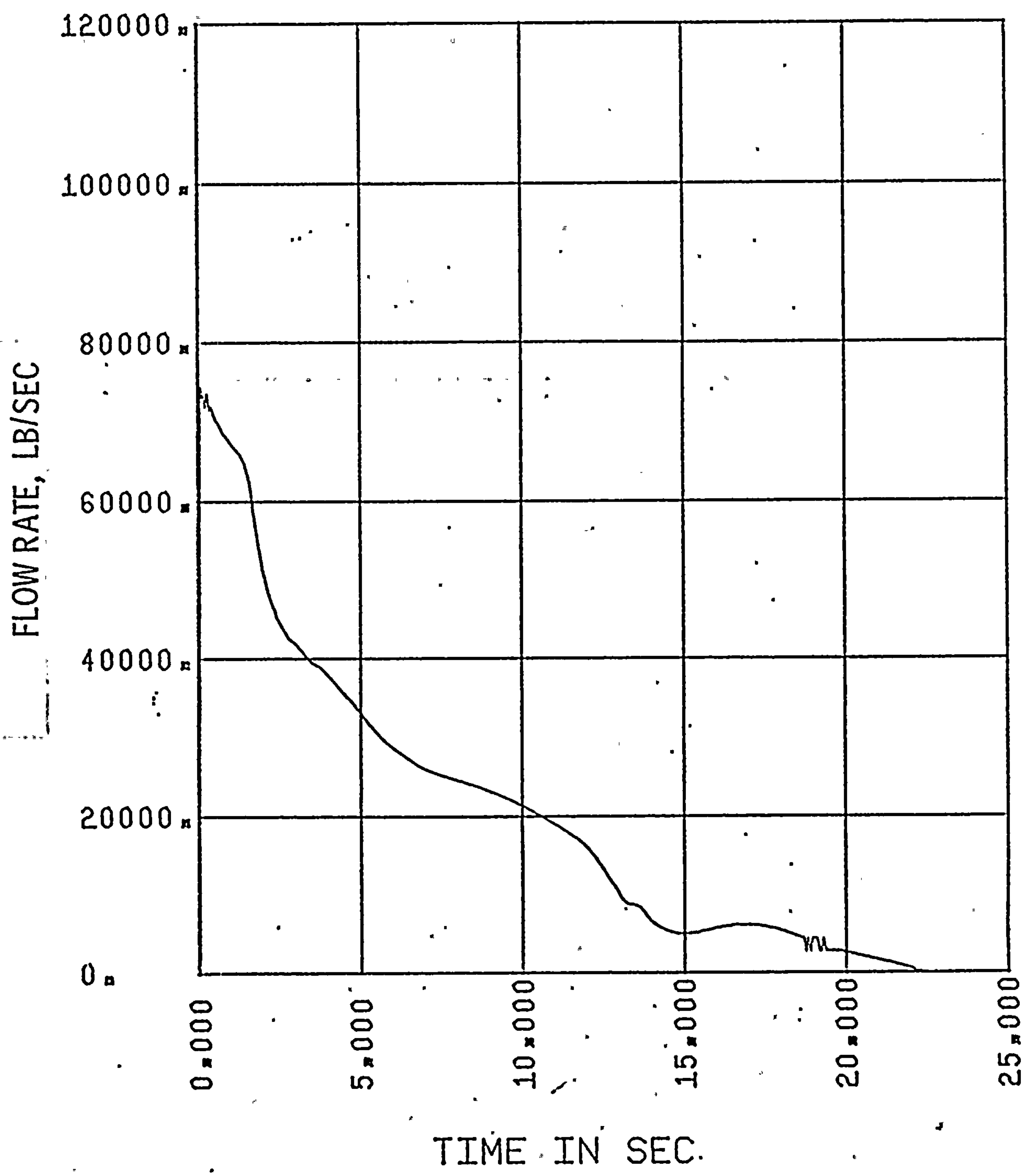


FIGURE II.1-D.1

ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

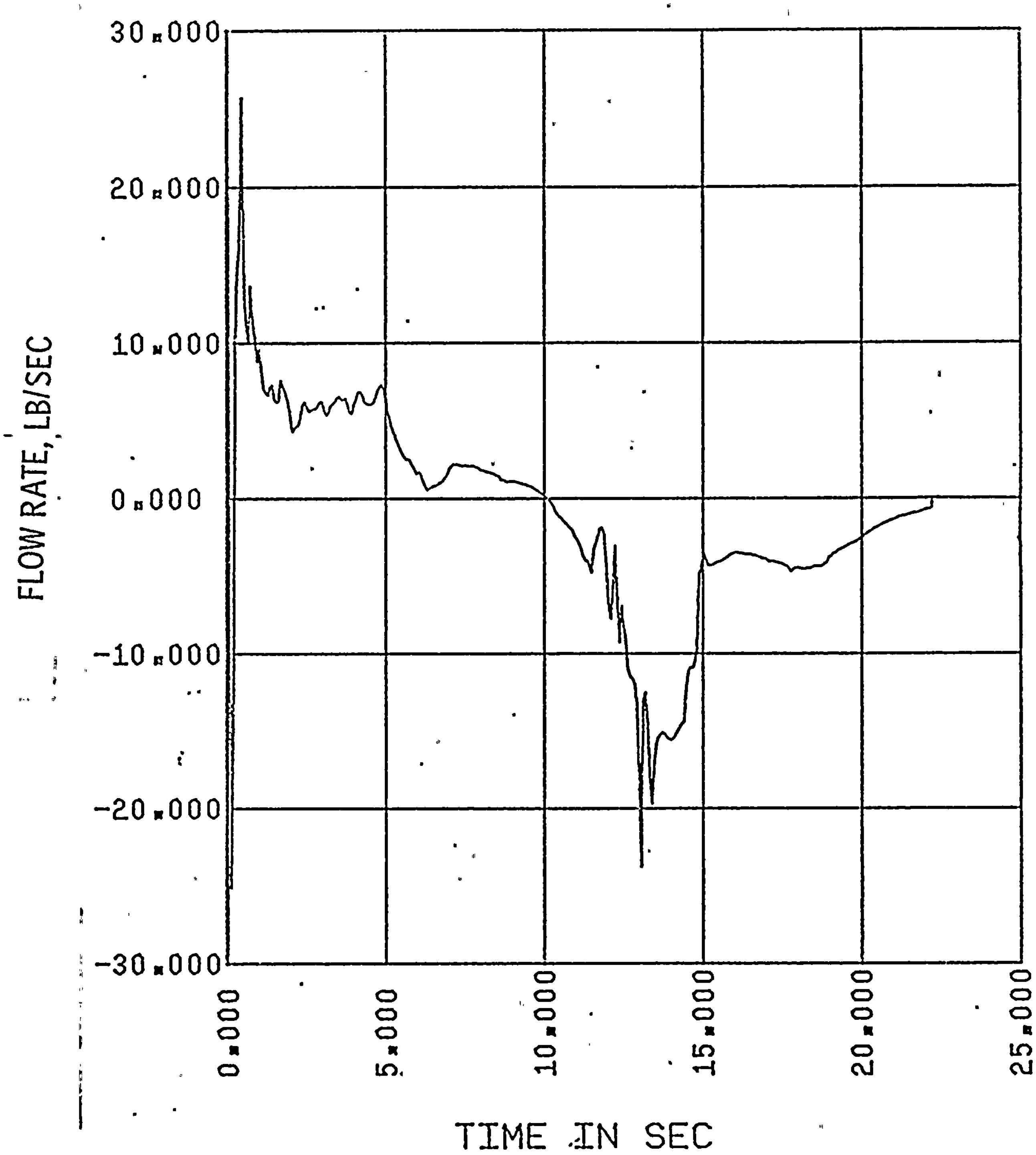


FIGURE II.1-D.2

ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

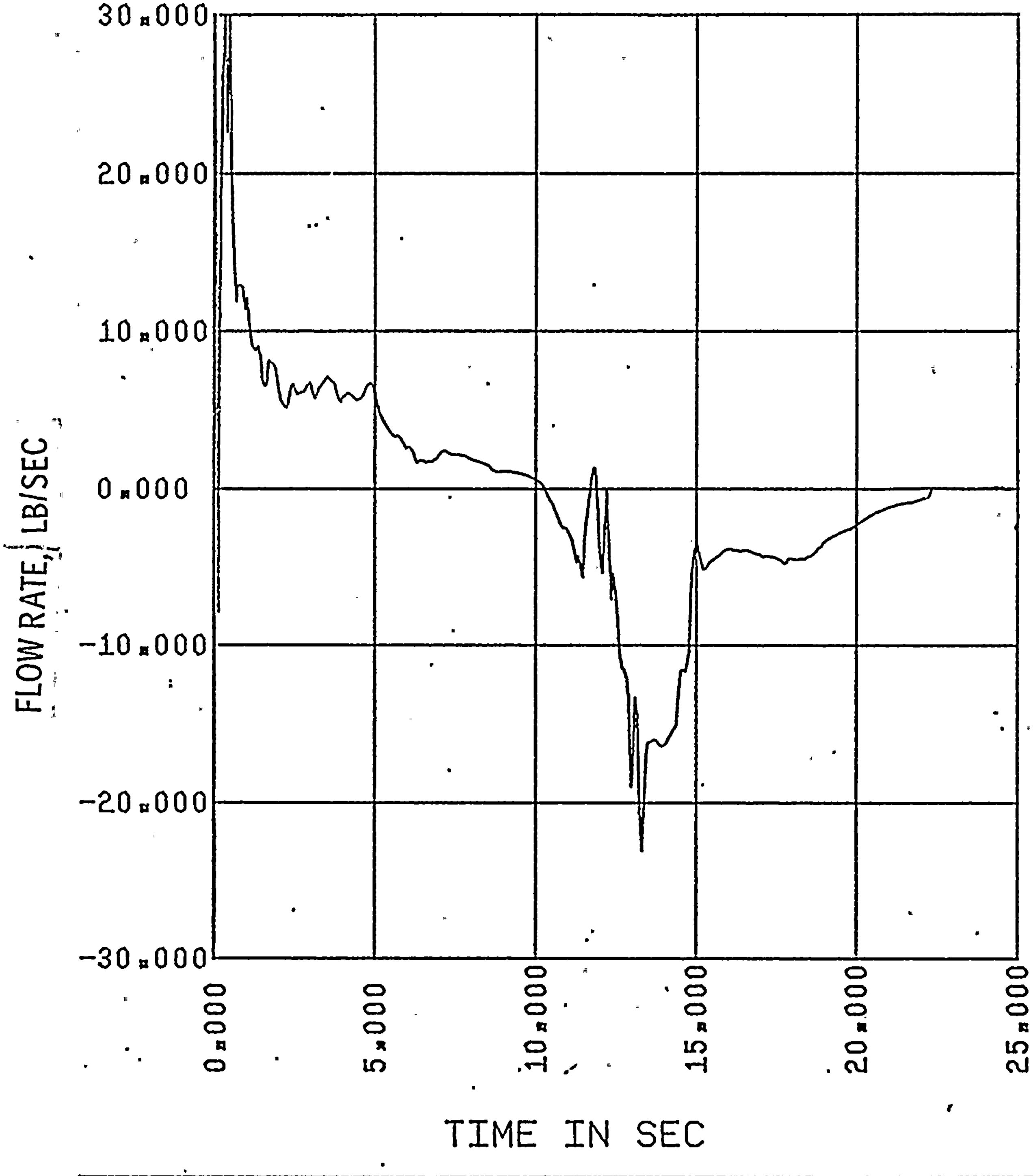


FIGURE II.1-F

ST. LUCIE II

1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

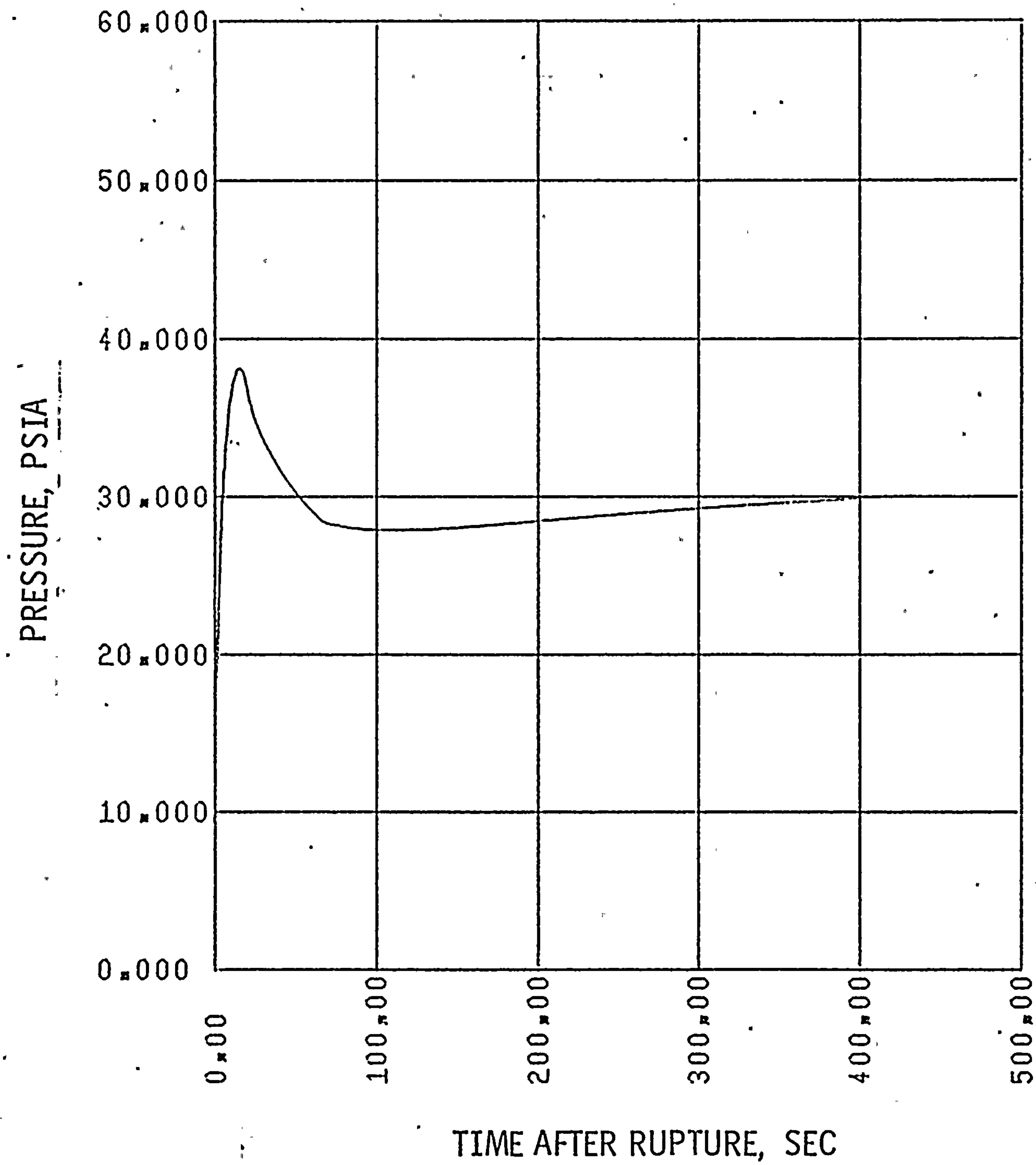


FIGURE II.1-E

ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

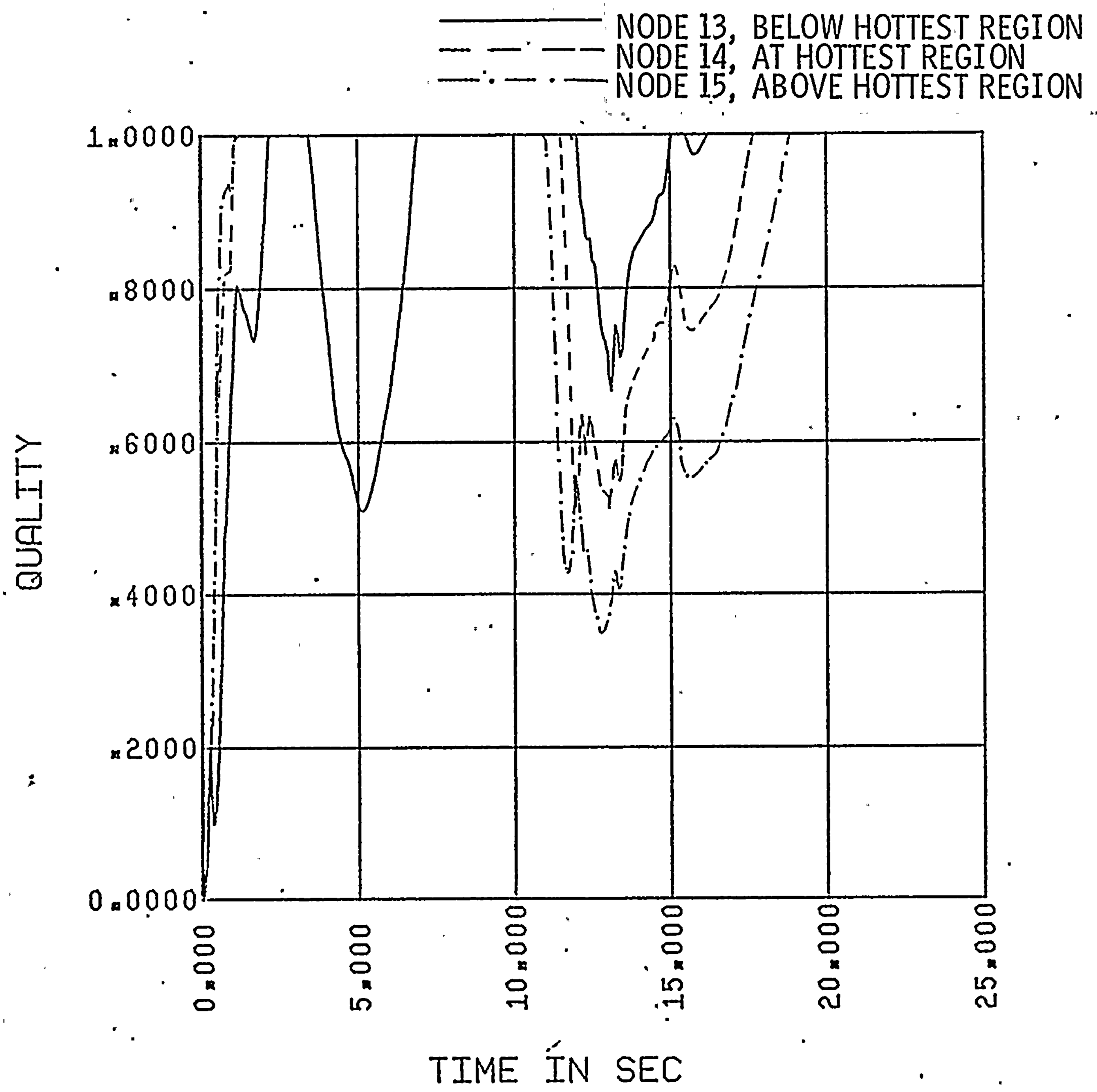
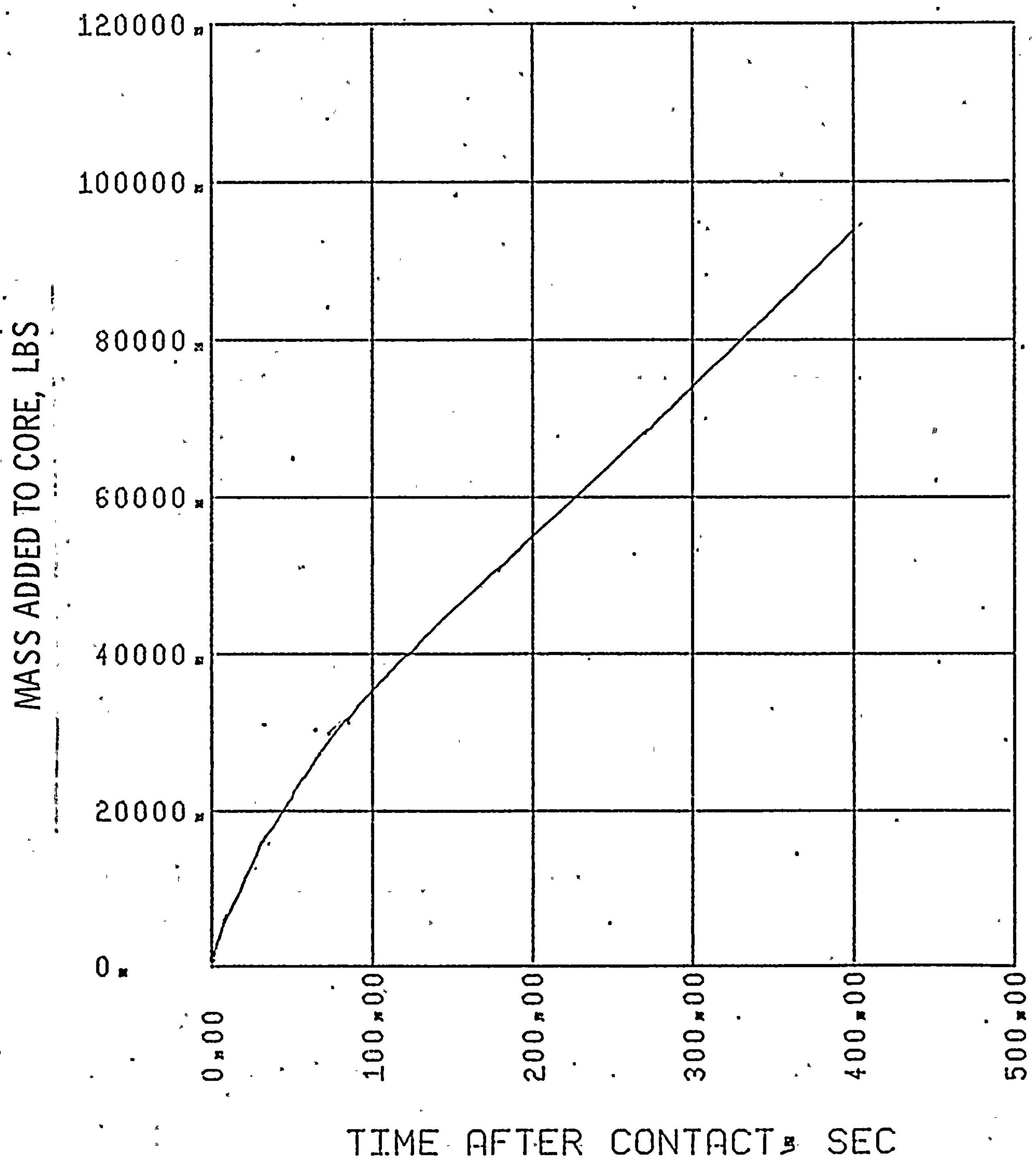


FIGURE II.1-G

ST. LUCIE II

1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD



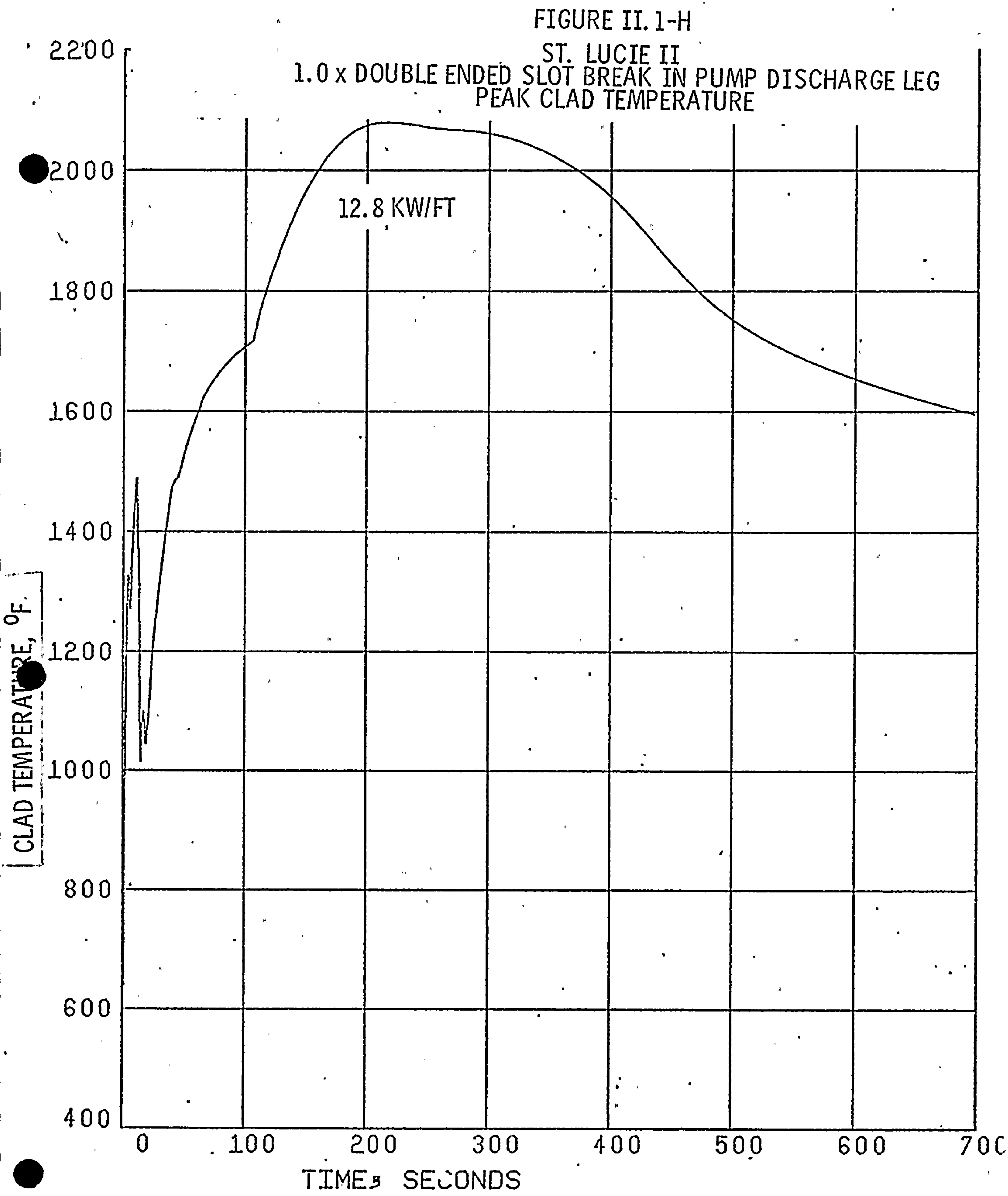


FIGURE II.1-H
ST. LUCIE II
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE
12.8 KW/FT
CLAD TEMPERATURE, °F
2200
2000
1800
1600
1400
1200
1000
800
600
400
0
100
200
300
400
500
600
700
TIME, SECONDS

FIGURE II.2-A

ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

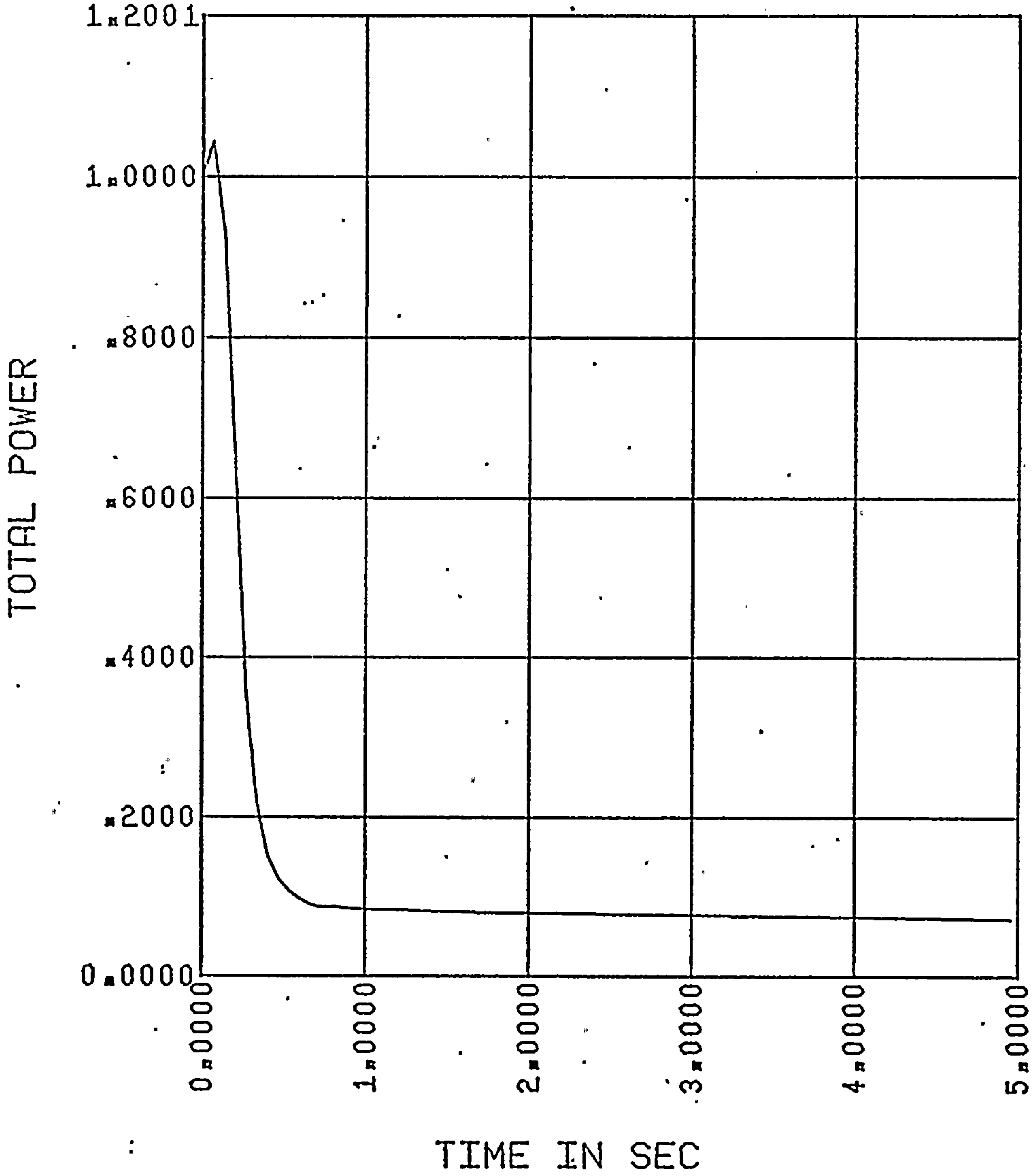


FIGURE II.2-B

ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

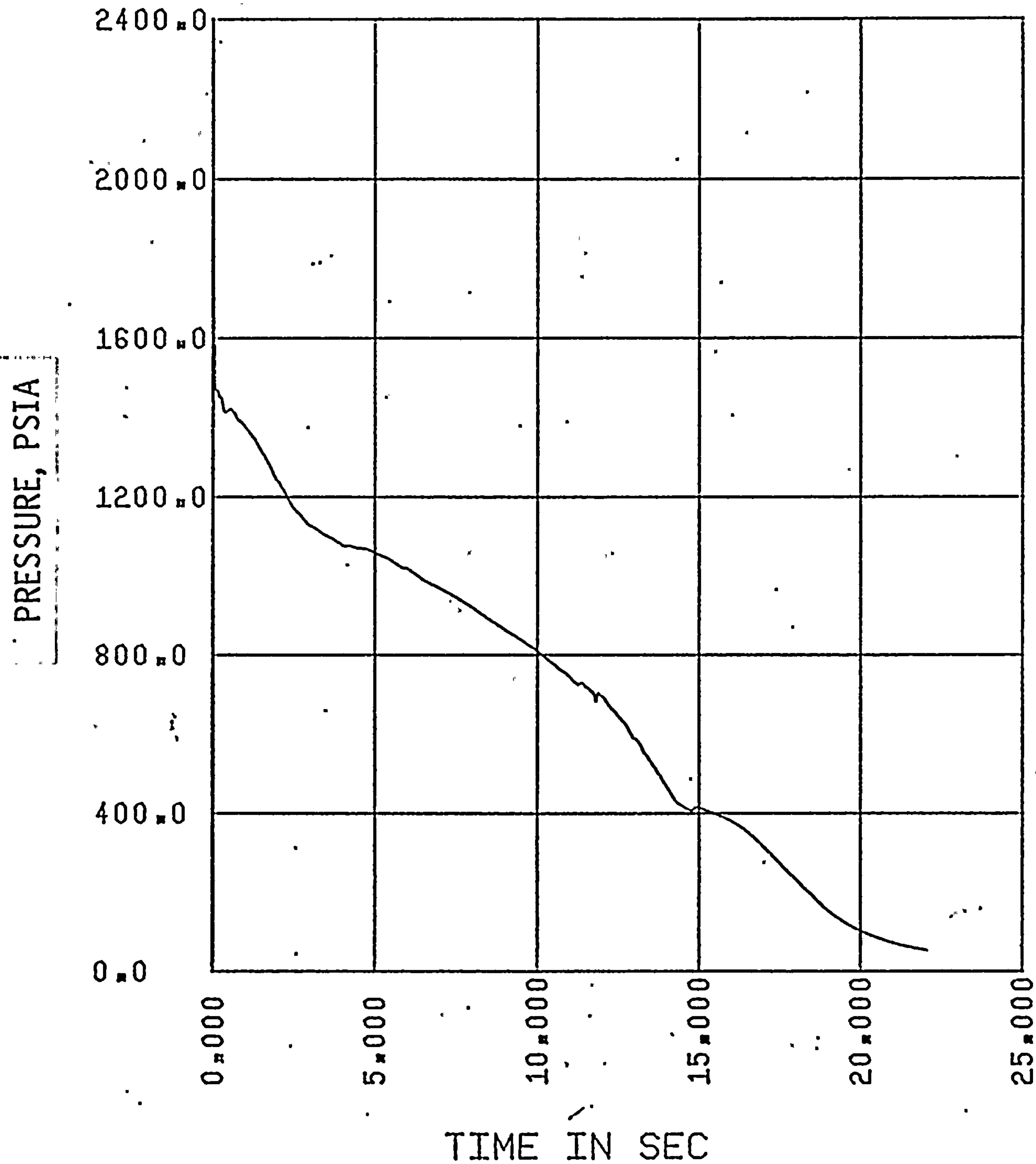


FIGURE II.2-C

ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

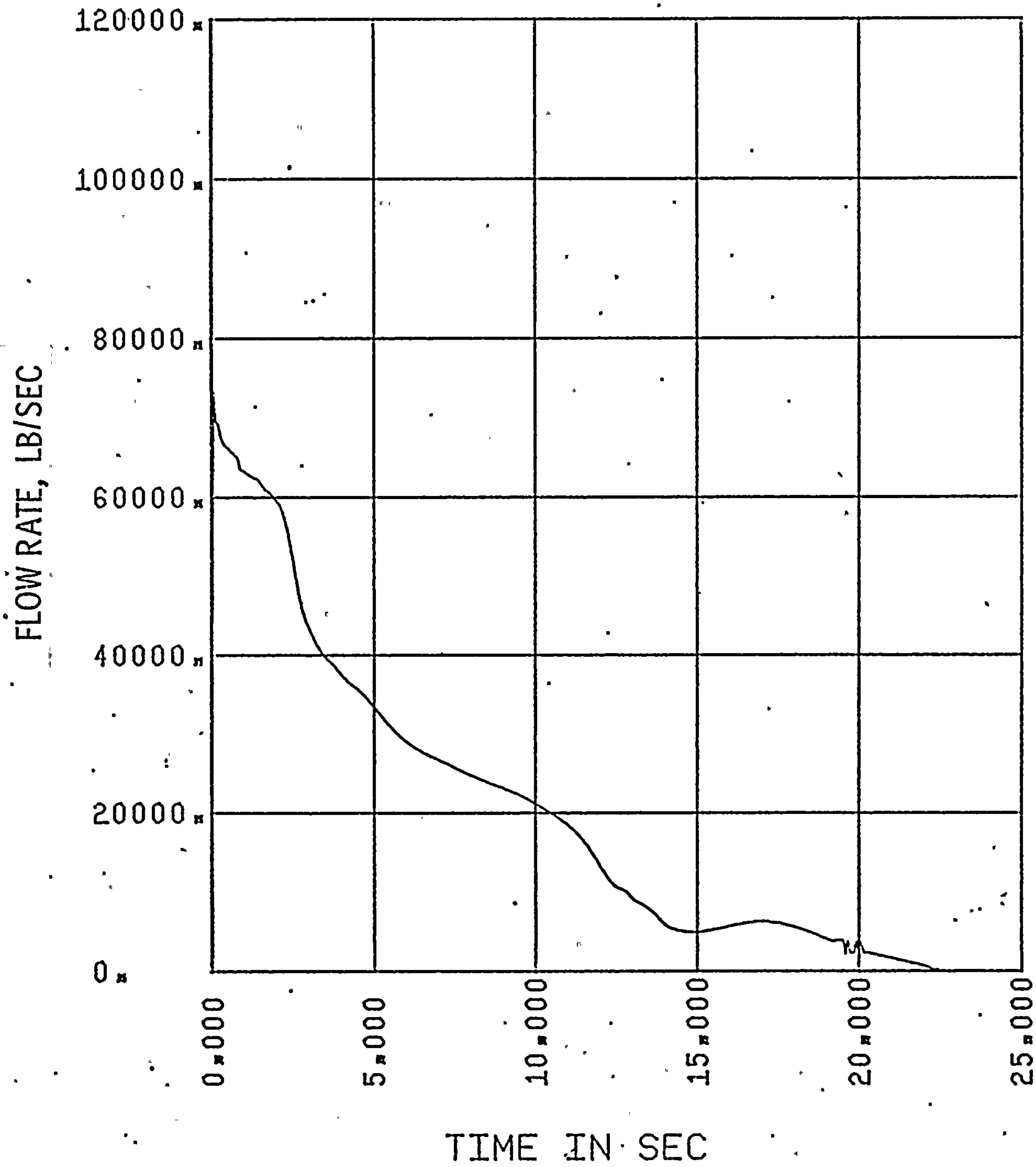


FIGURE II.2-D.1

ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

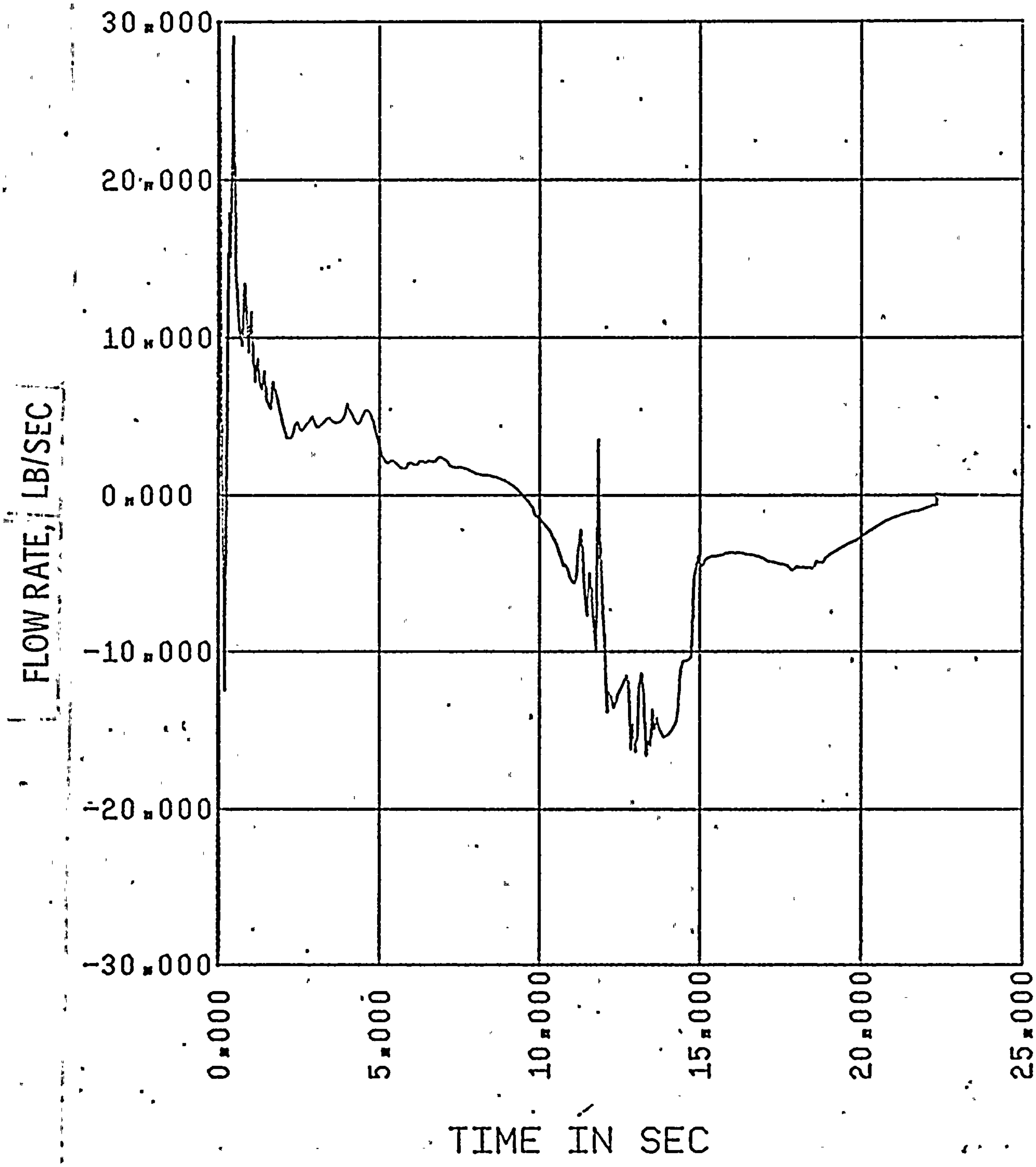


FIGURE II.2-D.2

ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

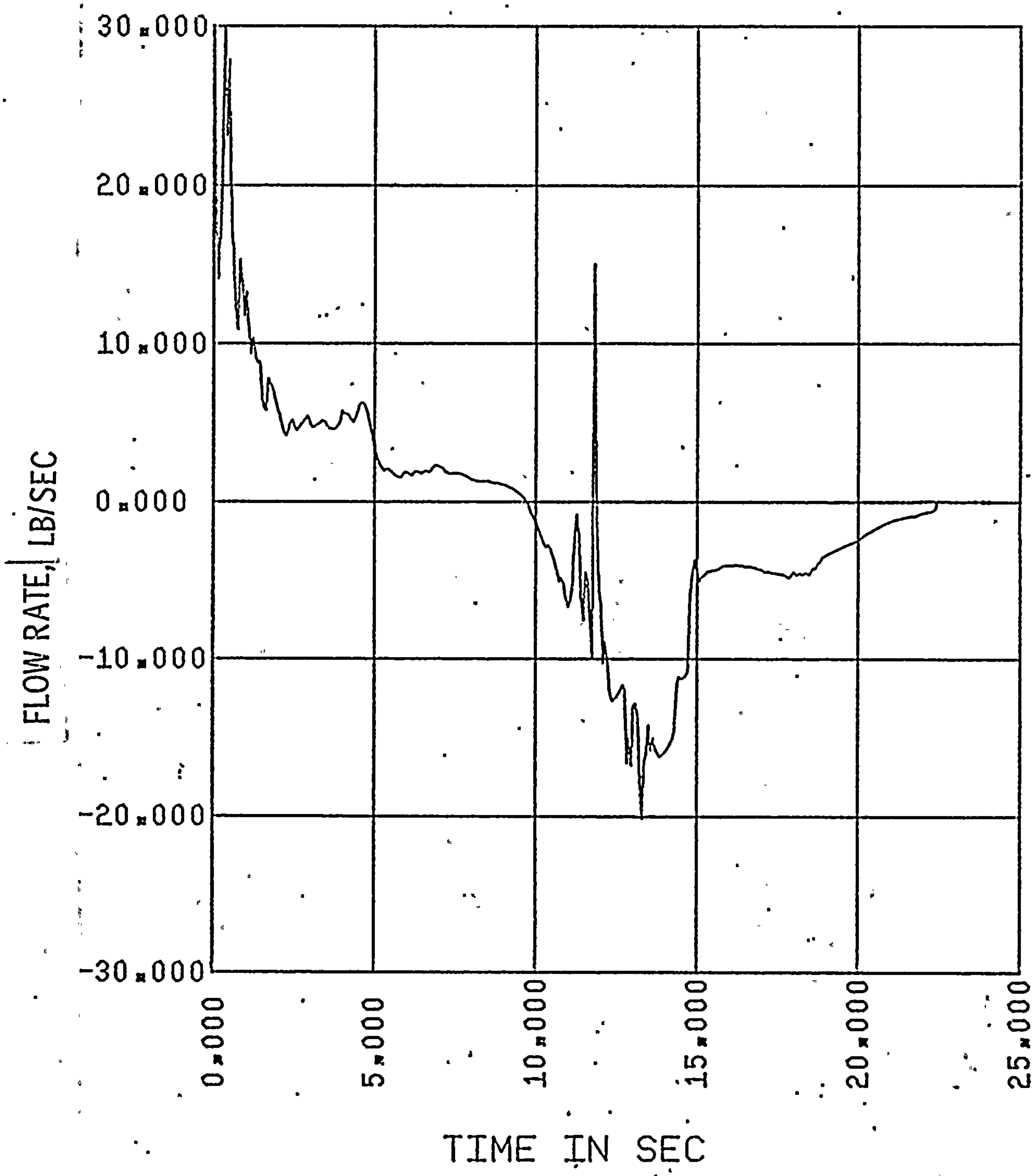


FIGURE II.2-E

ST. LUCIE II
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

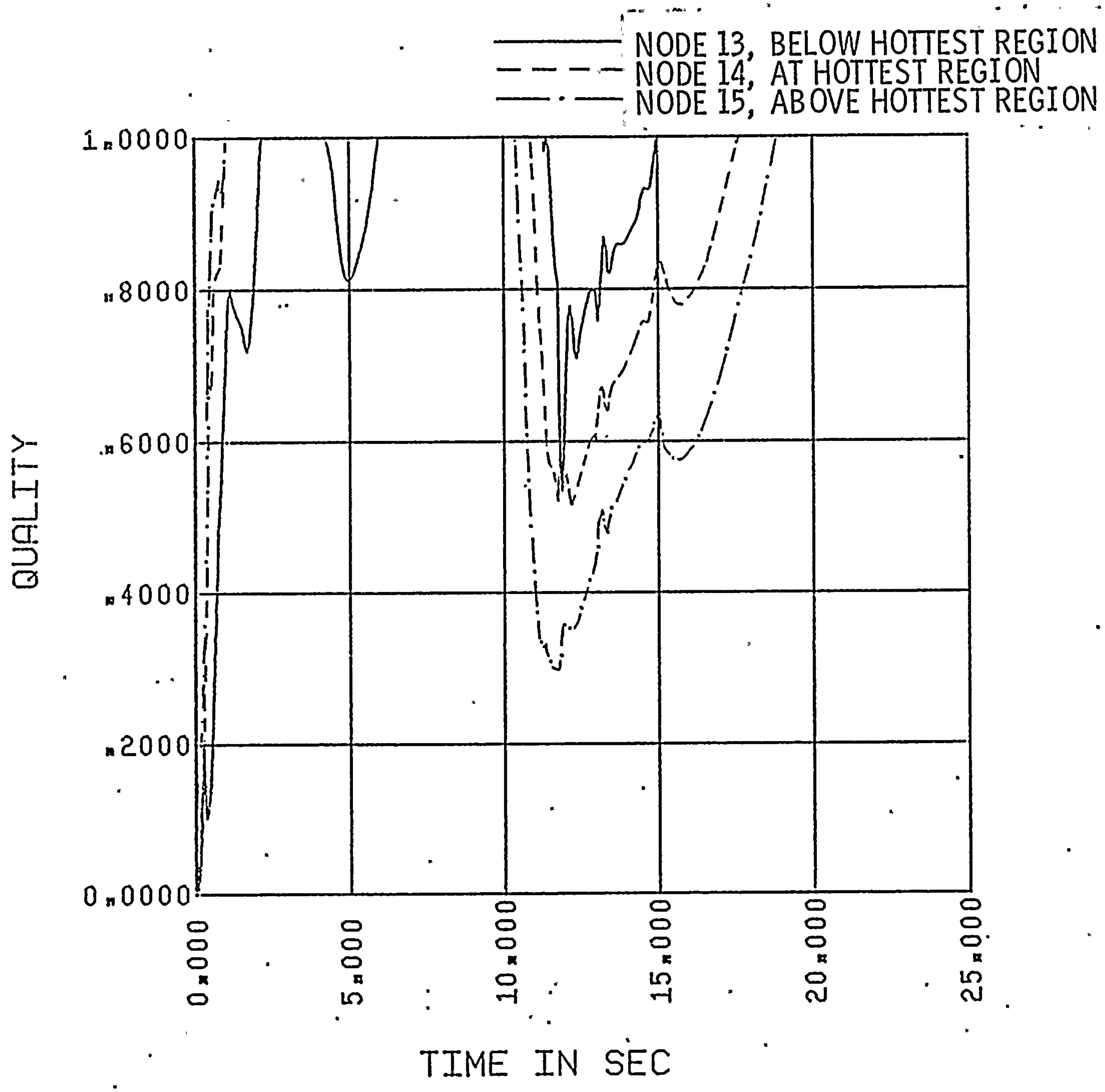


FIGURE II.2-F

ST. LUCIE II

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

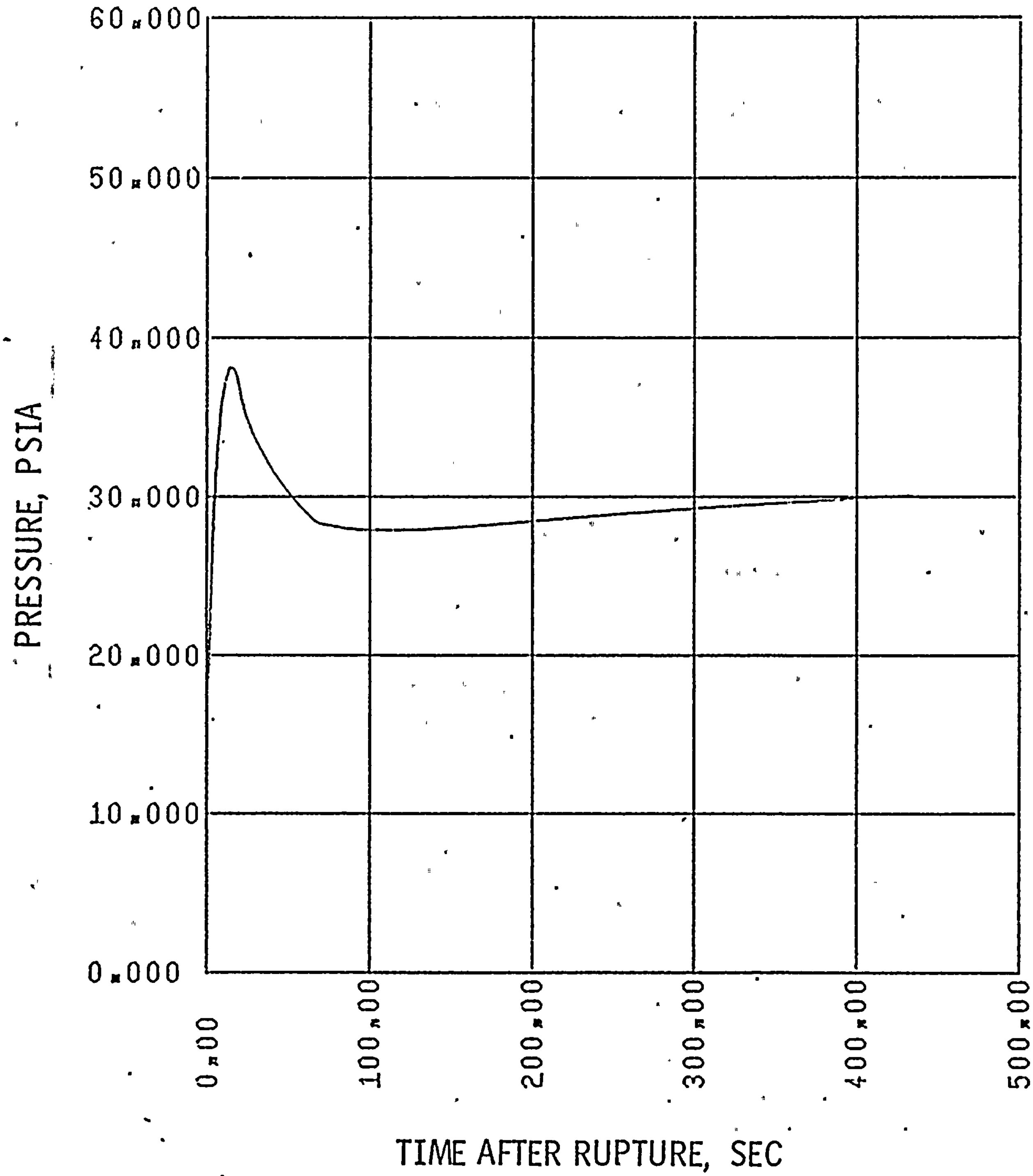


FIGURE II.2-G

ST. LUCIE II

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

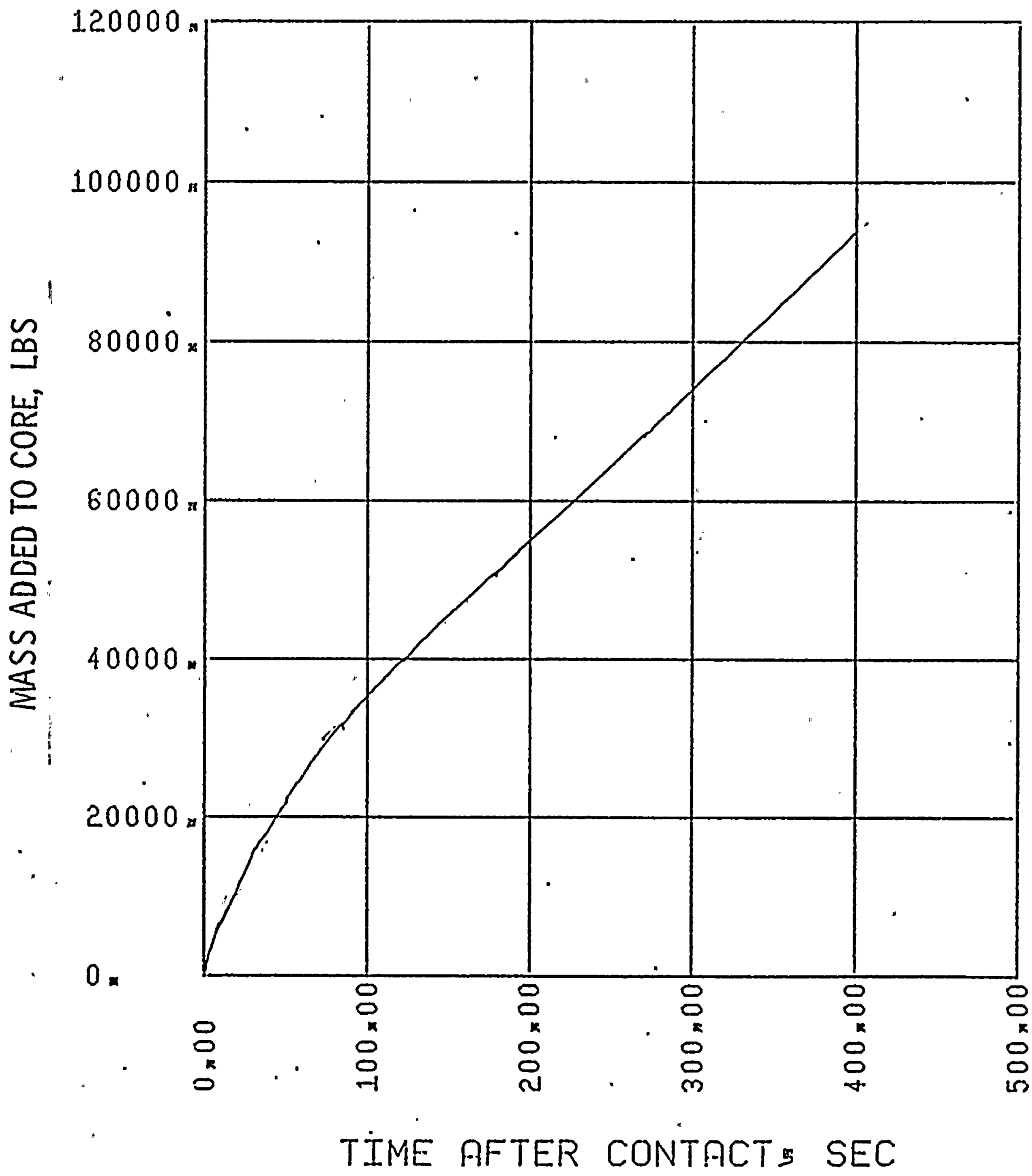


FIGURE II.2-H

ST. LUCIE II

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

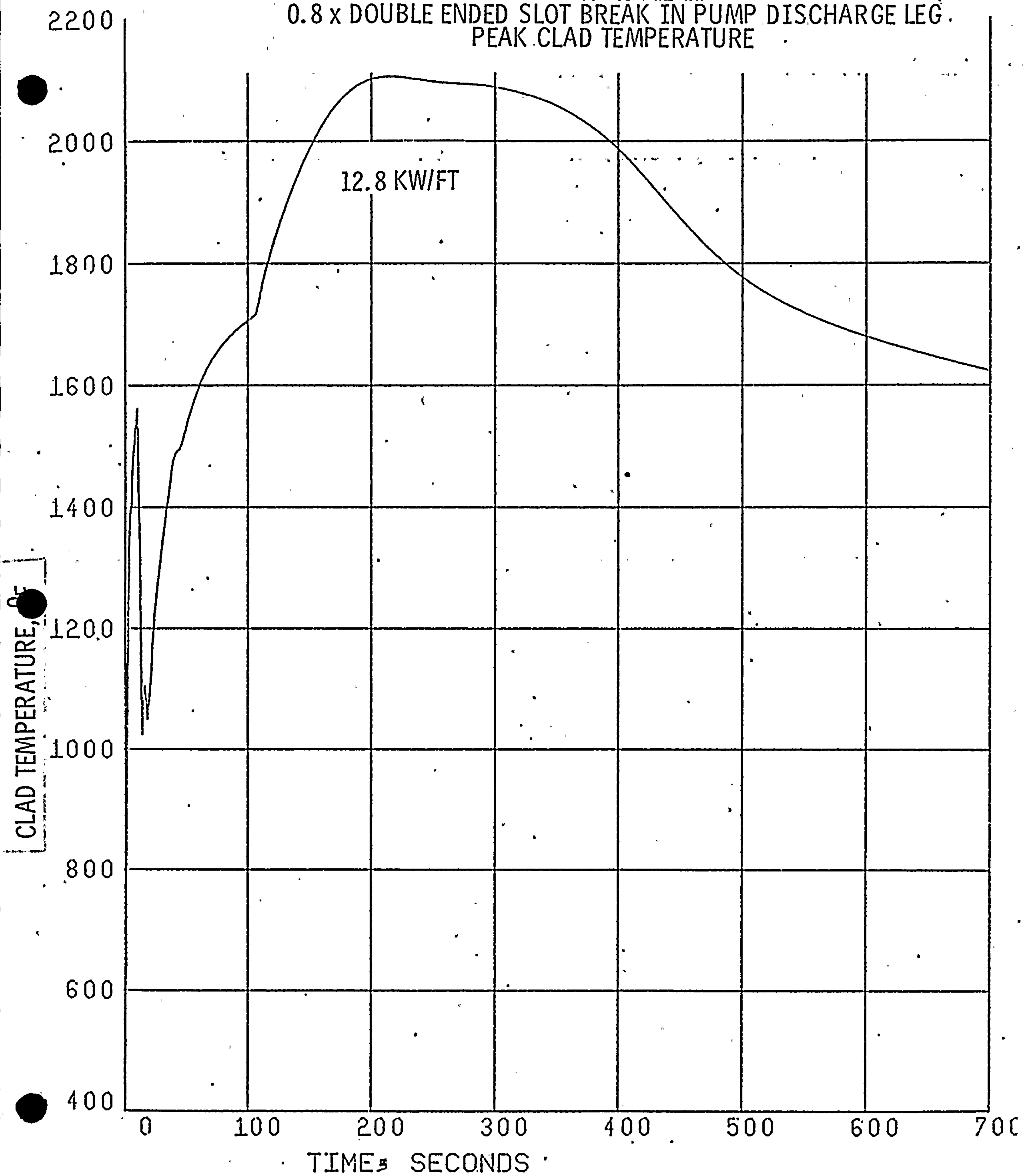


FIGURE II.3-A

ST. LUCIE II
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

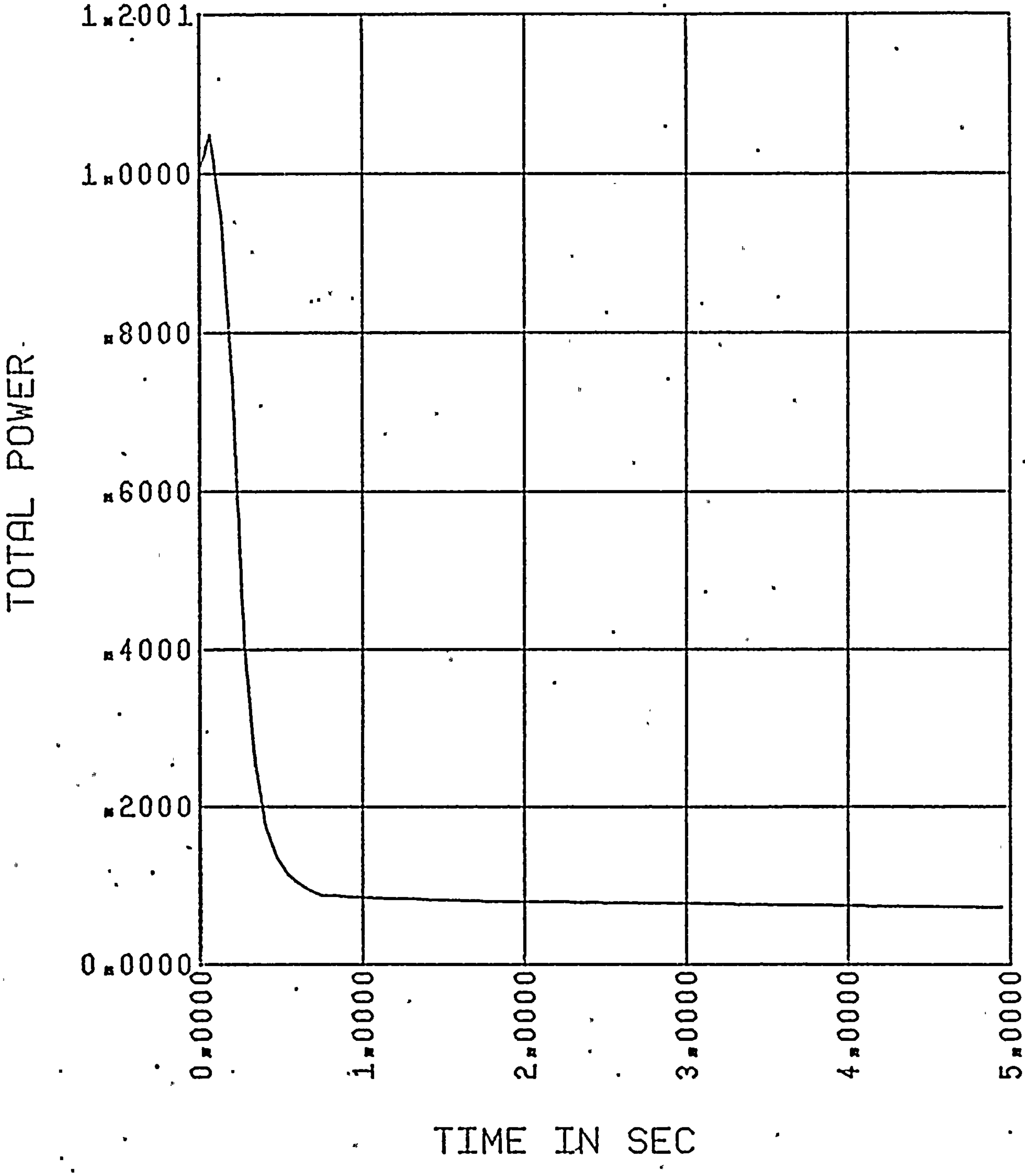


FIGURE II.3-B

ST. LUCIE II
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

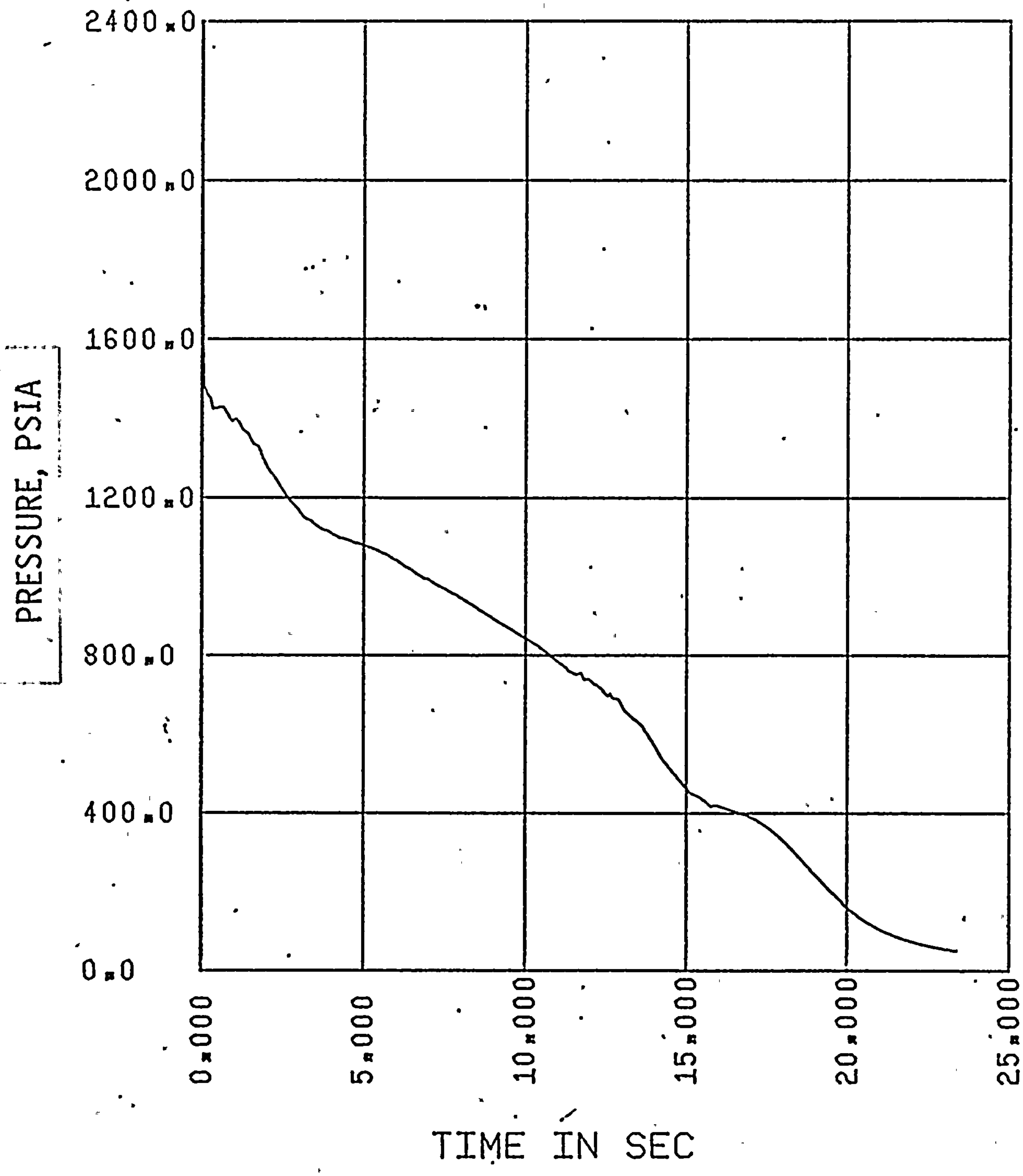


FIGURE II.3-C

ST. LUCIE II

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

LEAK FLOW

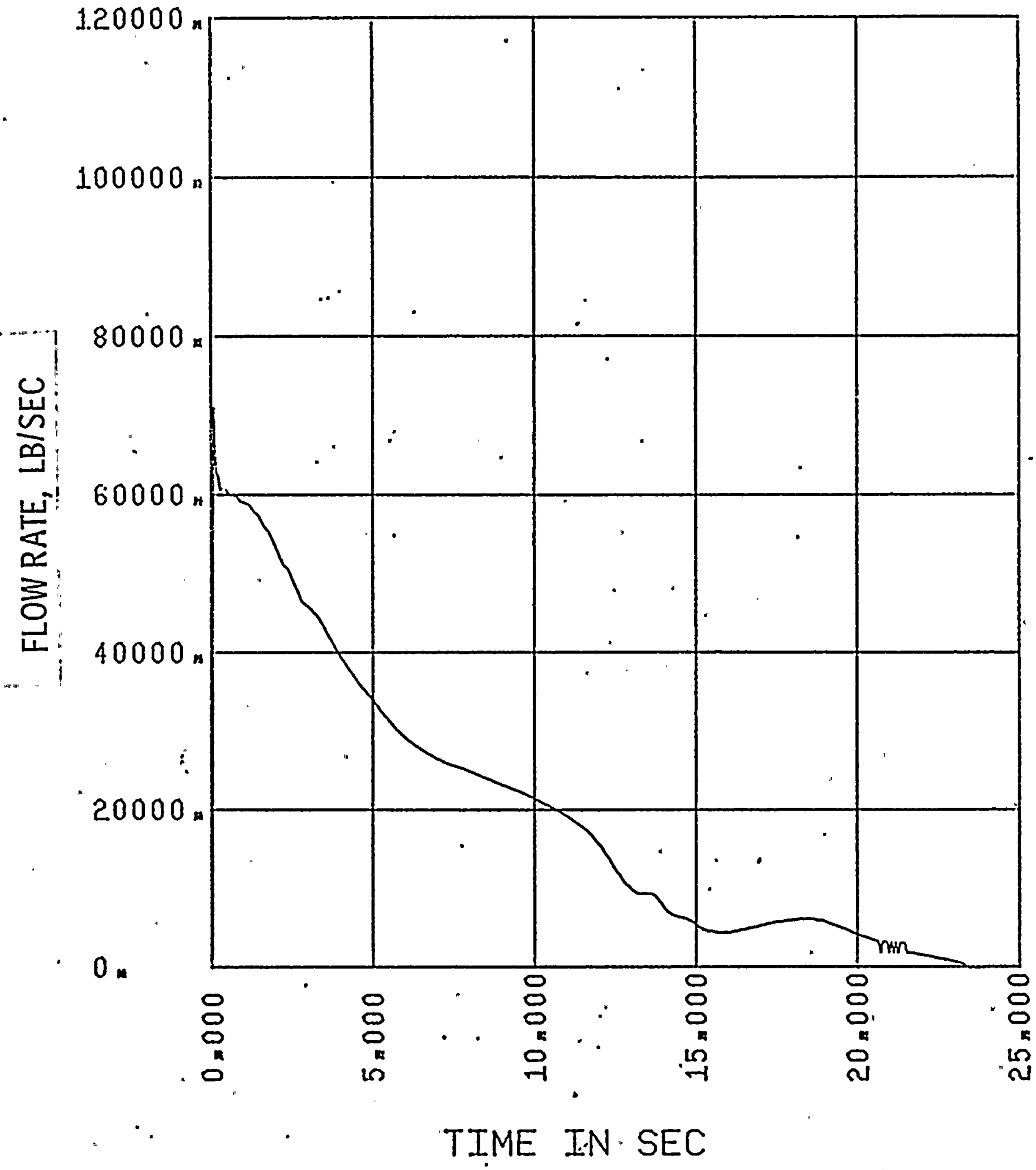


FIGURE II.3-D.1

ST. LUCIE II

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

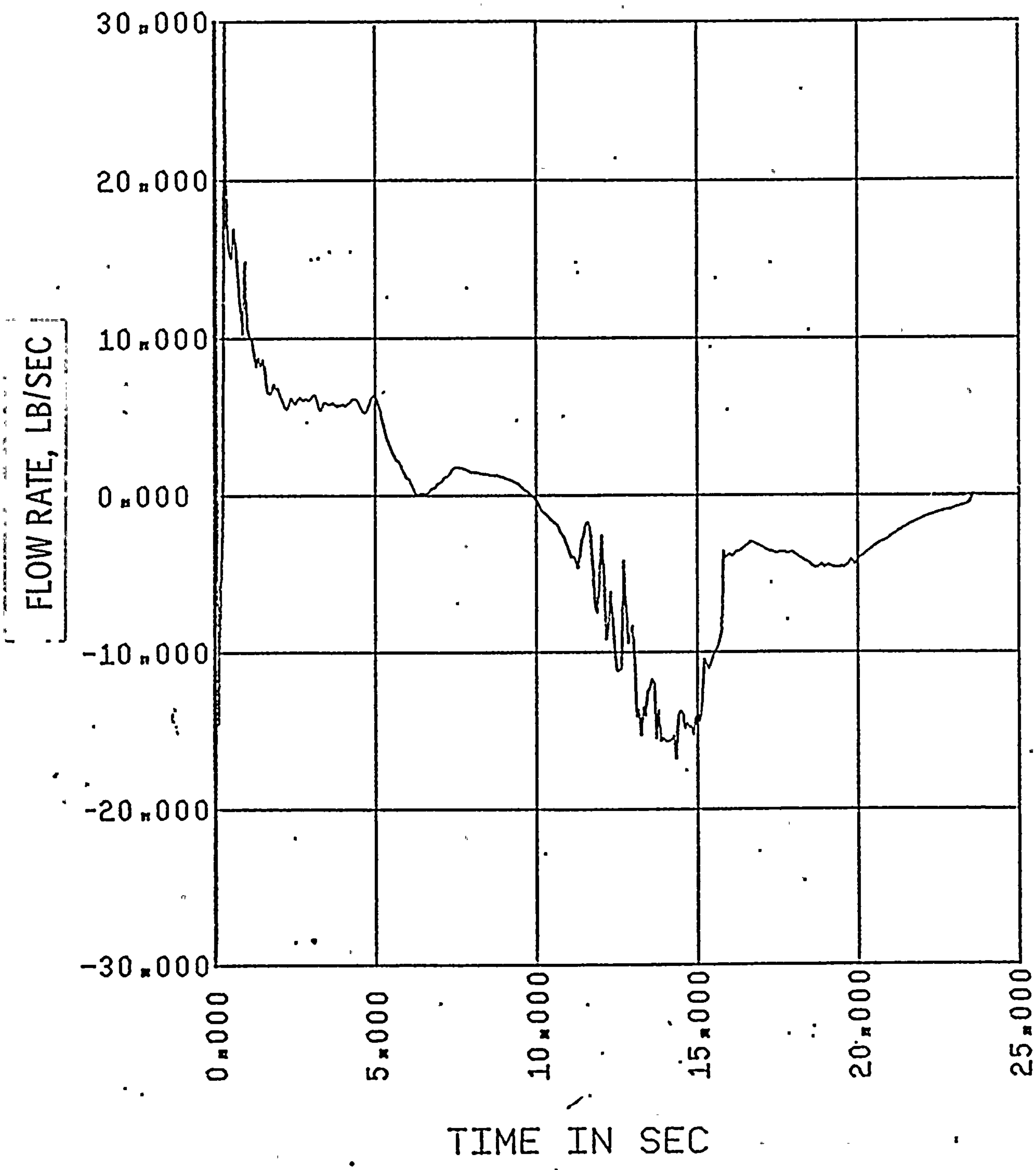


FIGURE II.3-D.2

ST. LUCIE II
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

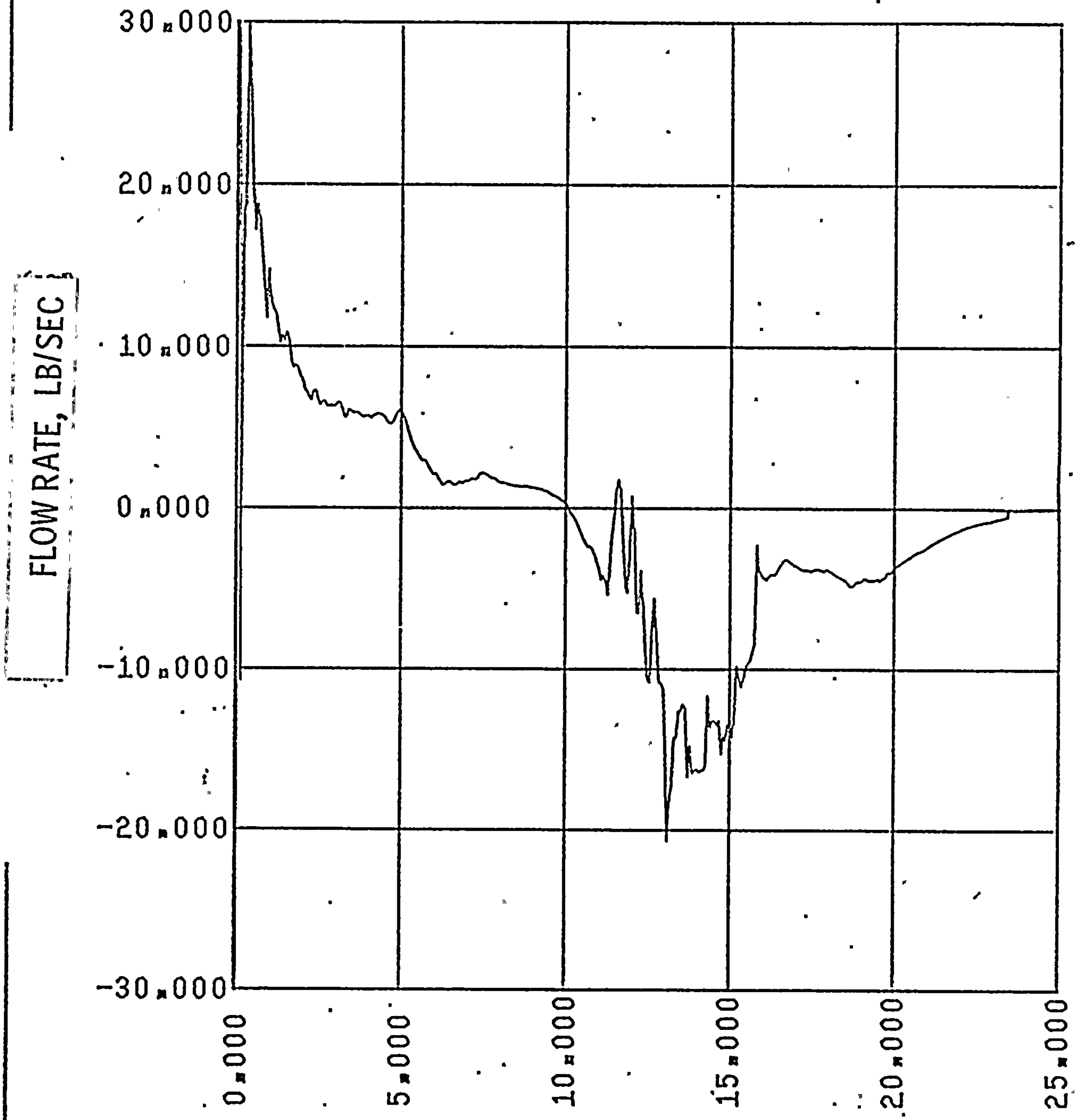


FIGURE II.3-E

ST. LUCIE II
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

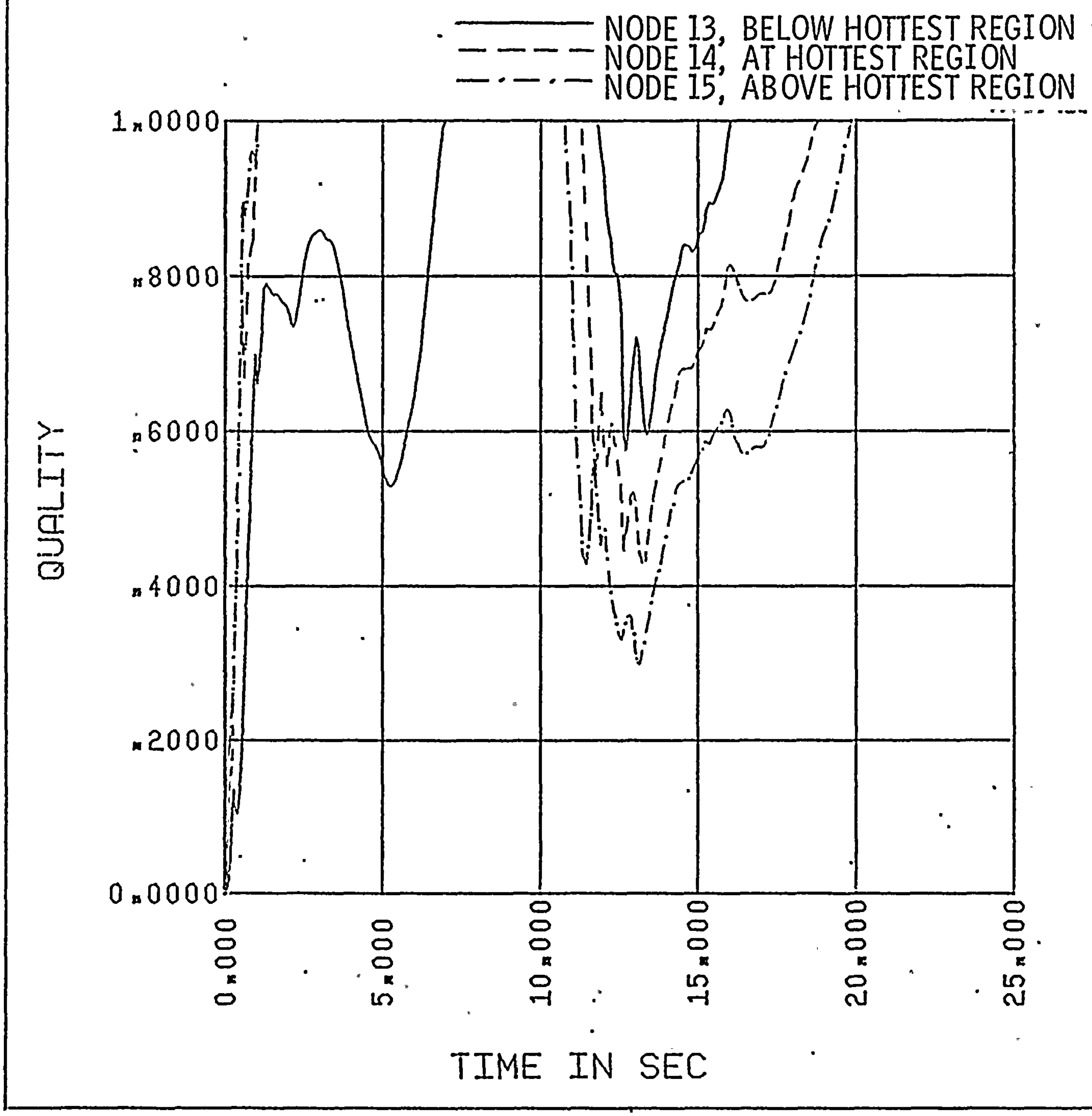


FIGURE II.3-F

ST. LUCIE II

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

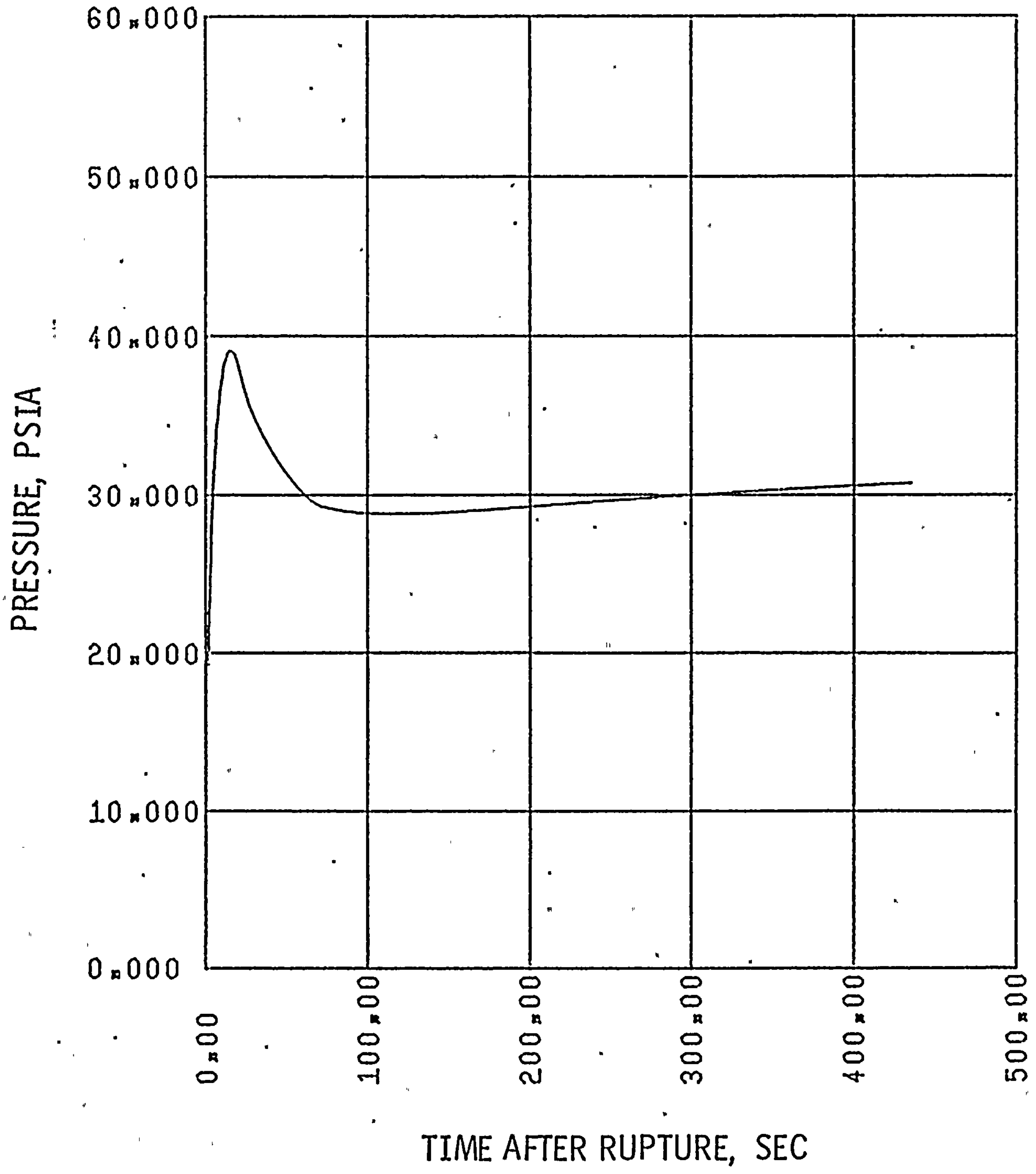


FIGURE II.3-G

ST. LUCIE II
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

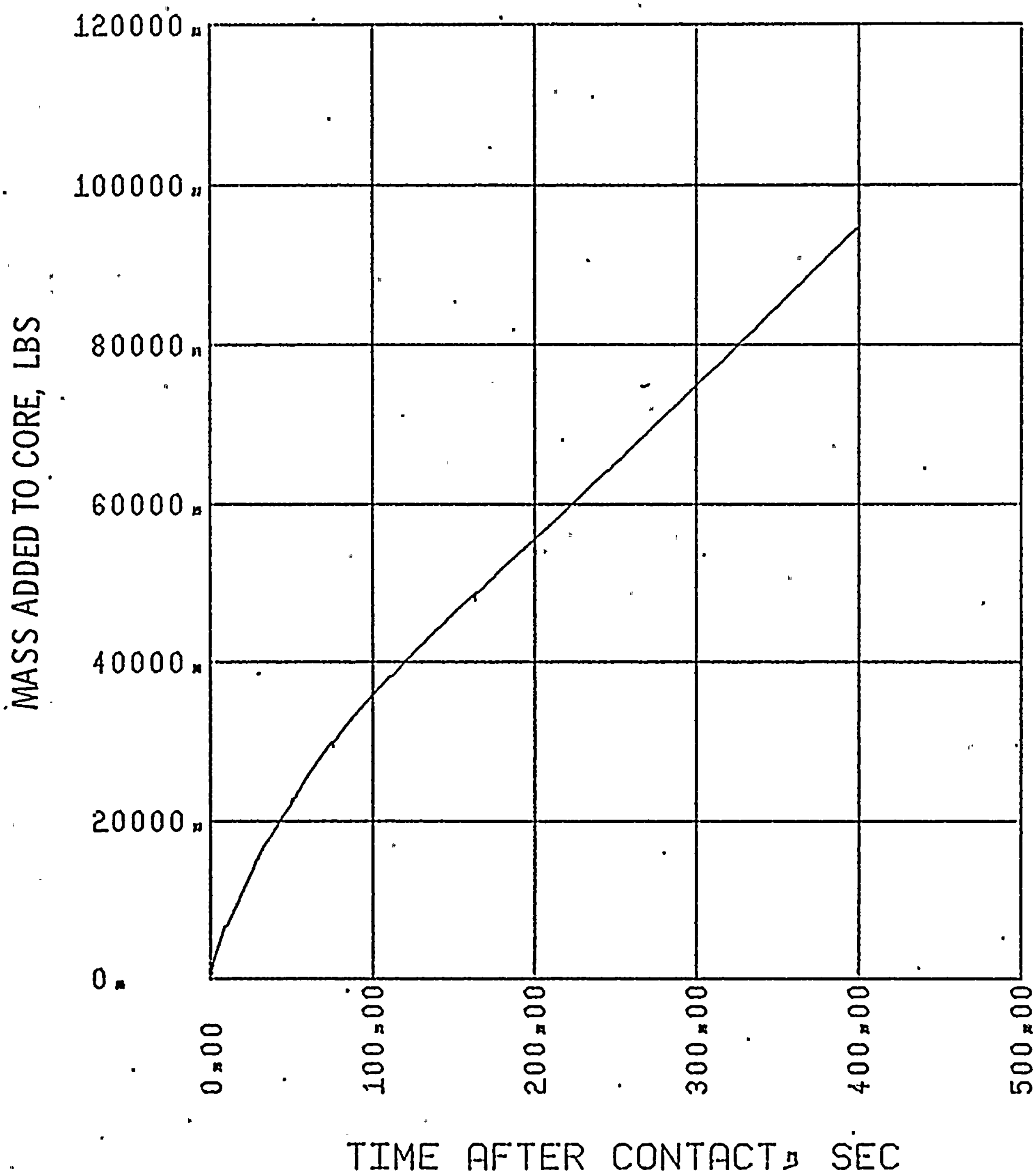


FIGURE II.3-H

ST. LUCIE II

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

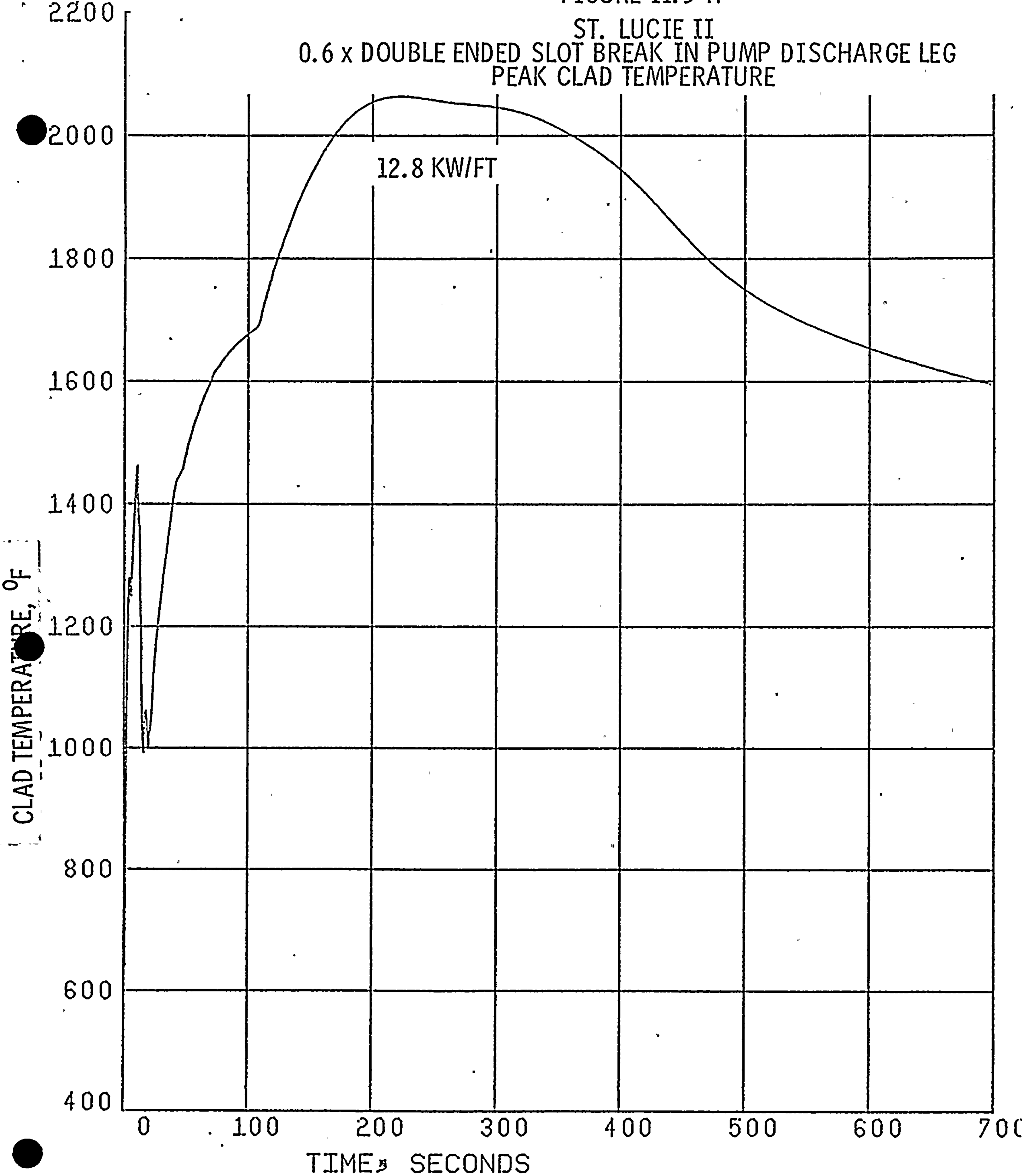


FIGURE II.4-A

ST. LUCIE II

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

CORE POWER

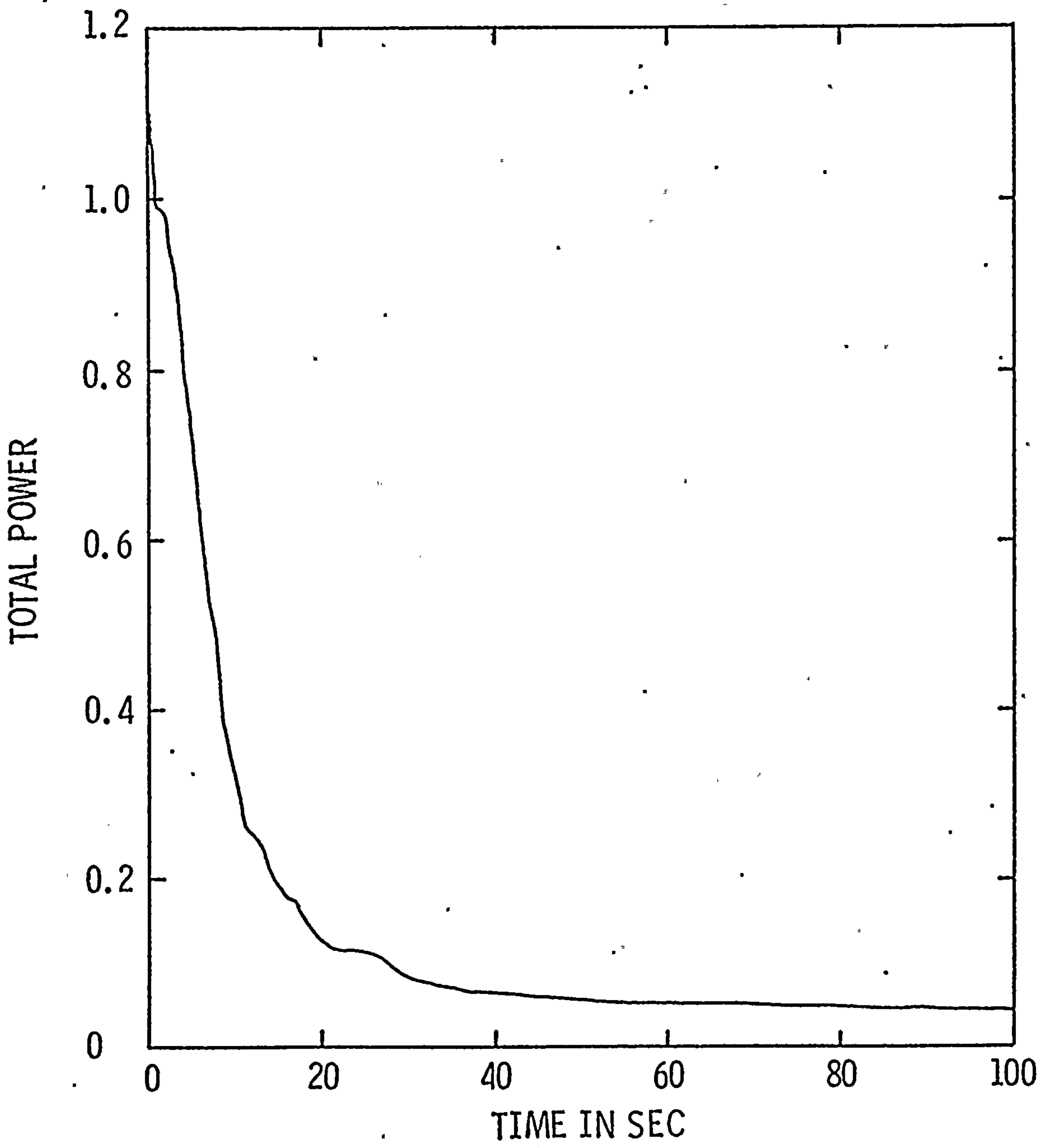


FIGURE II.4-B

ST. LUCIE II
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

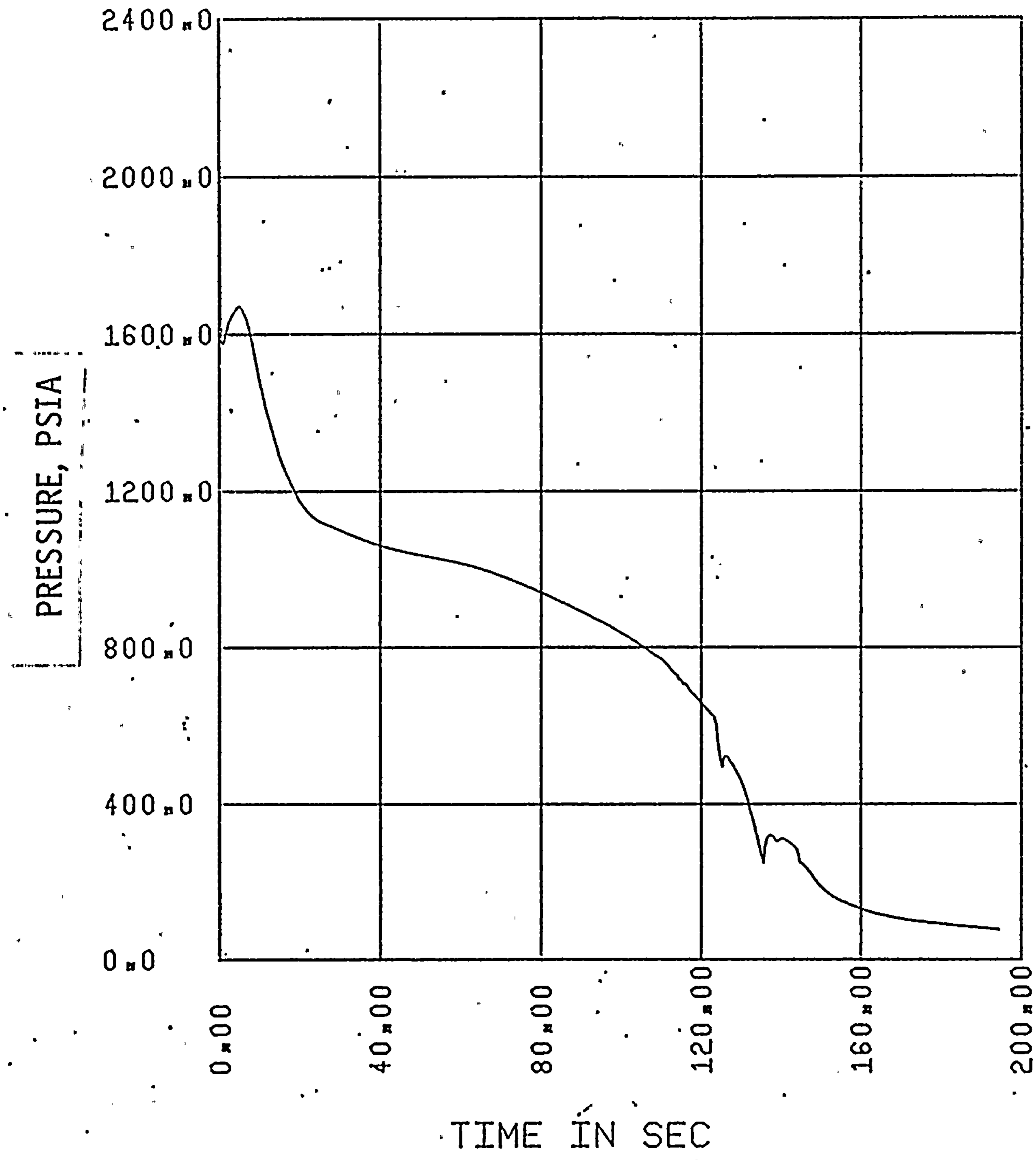


FIGURE II.4-C

ST. LUCIE II
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

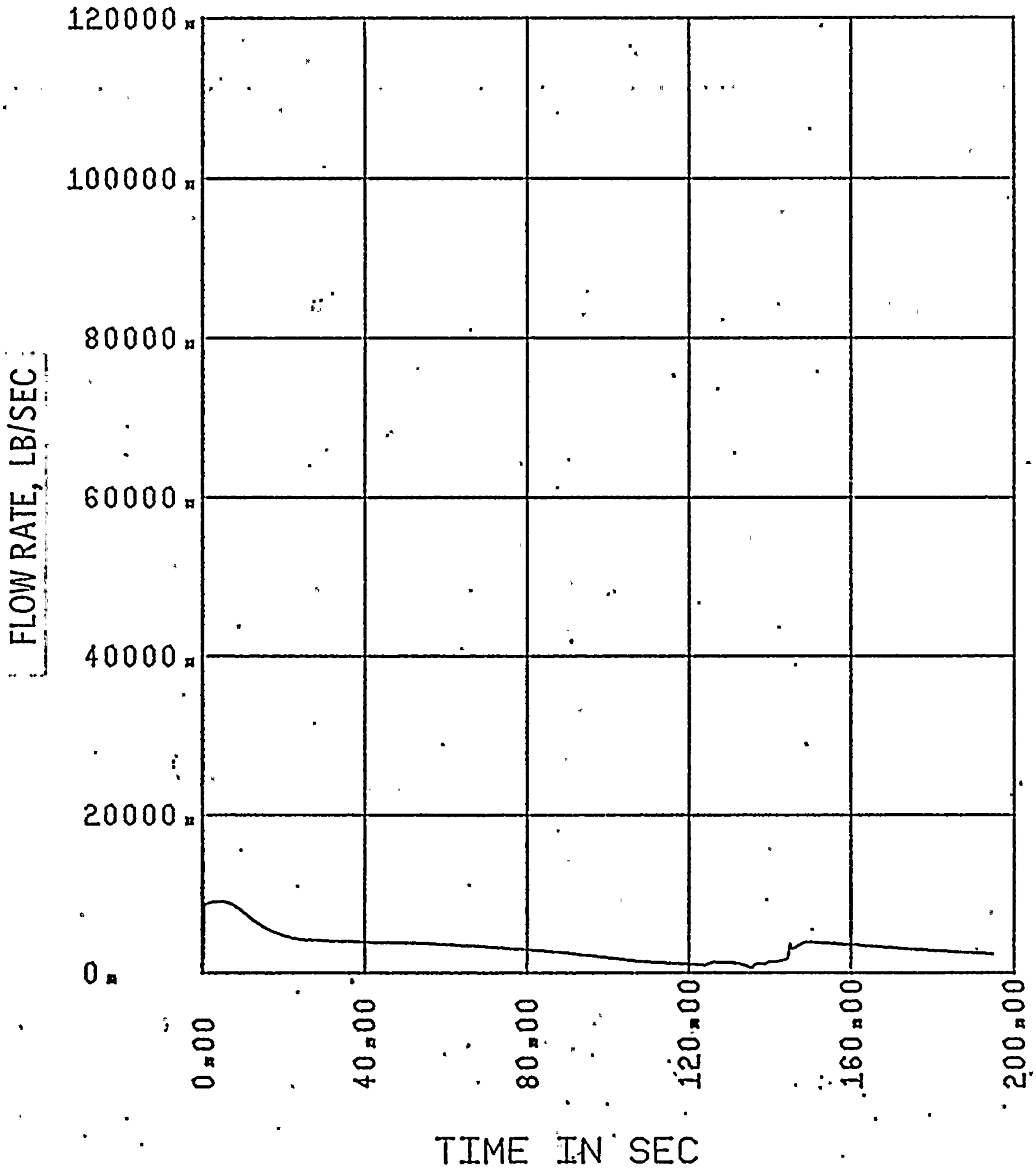


FIGURE II.4-D.1

ST. LUCIE II

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

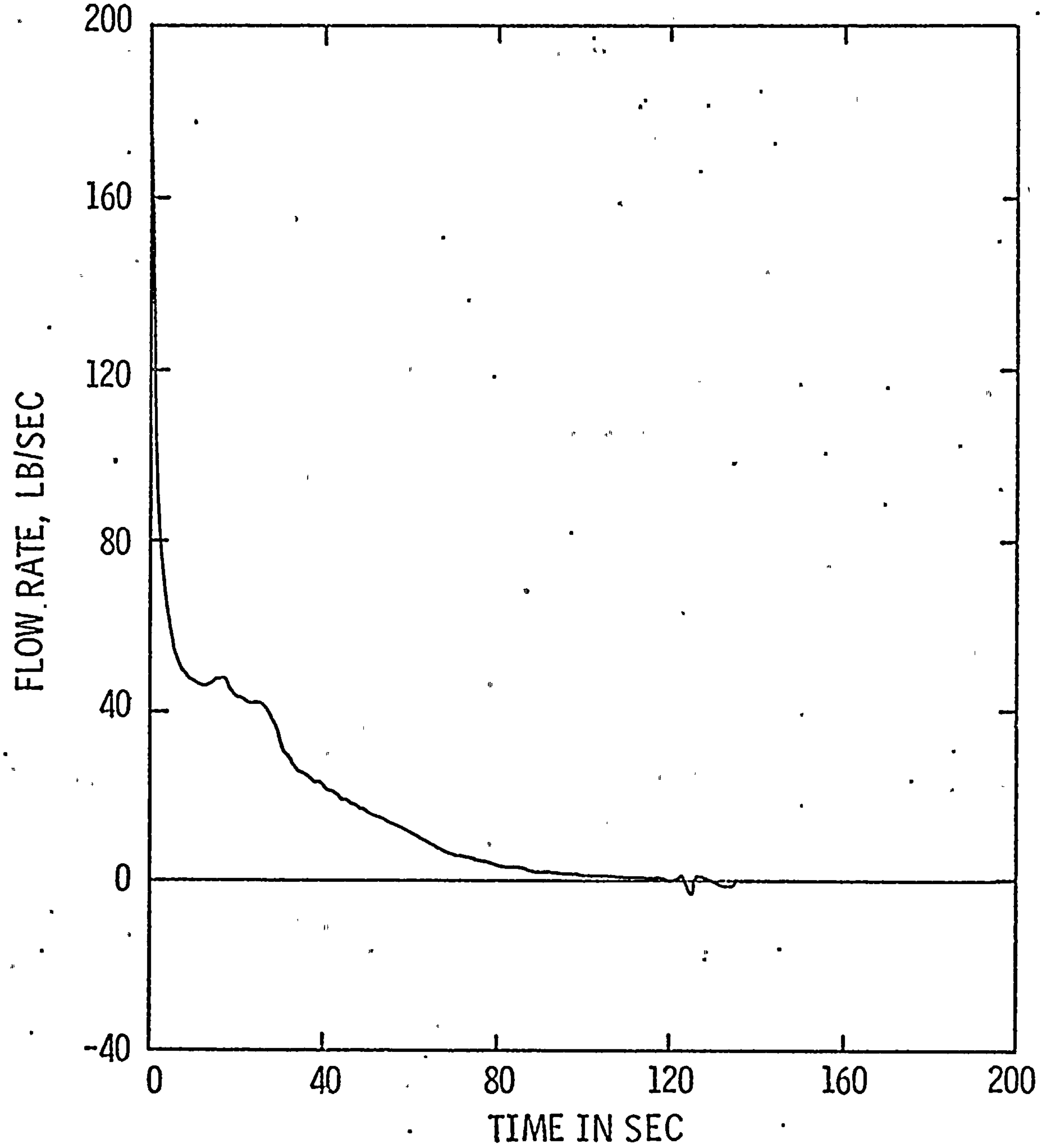


FIGURE II.4-D.2

ST. LUCIE II

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

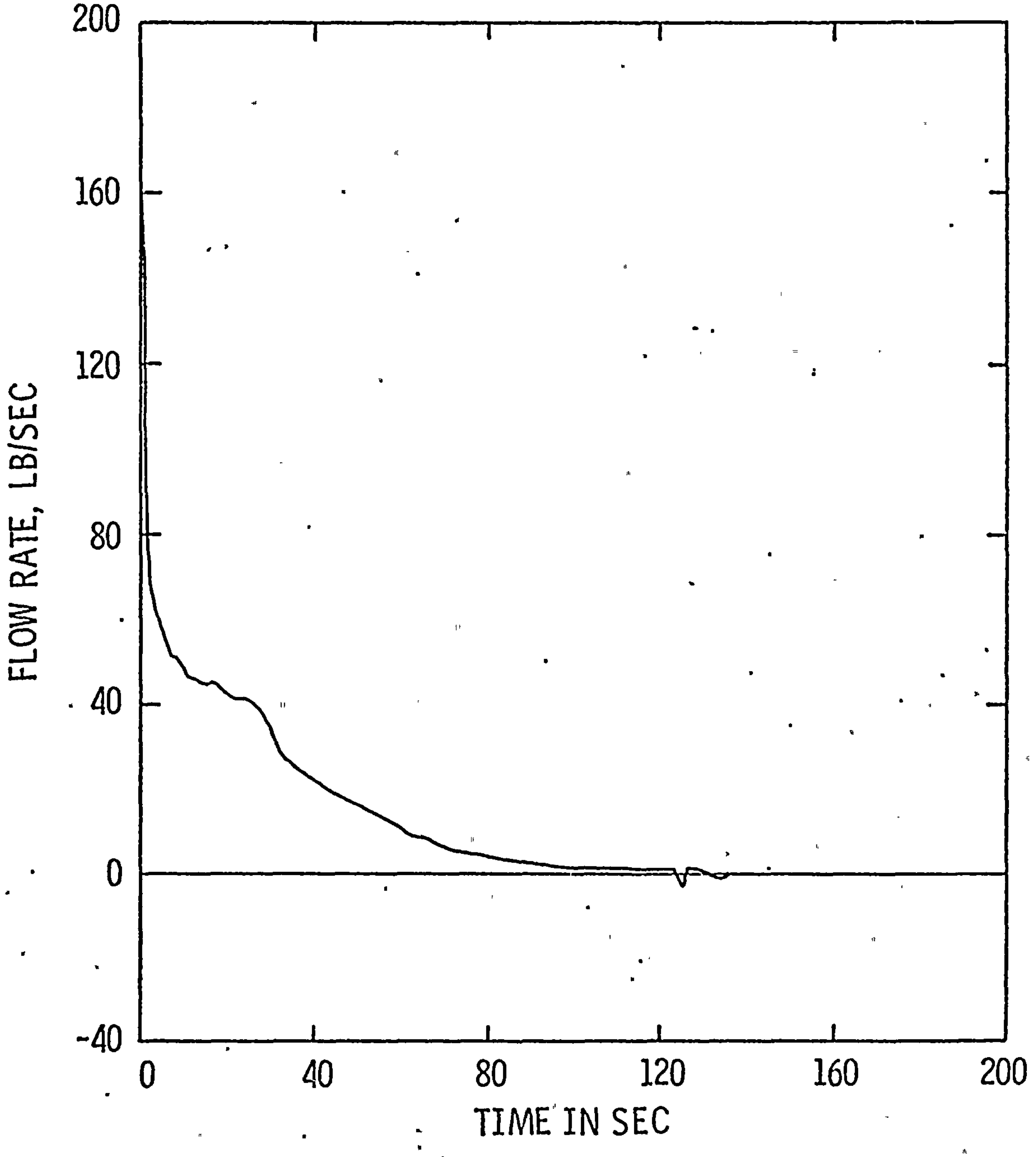


FIGURE II.4-E

ST. LUCIE II
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

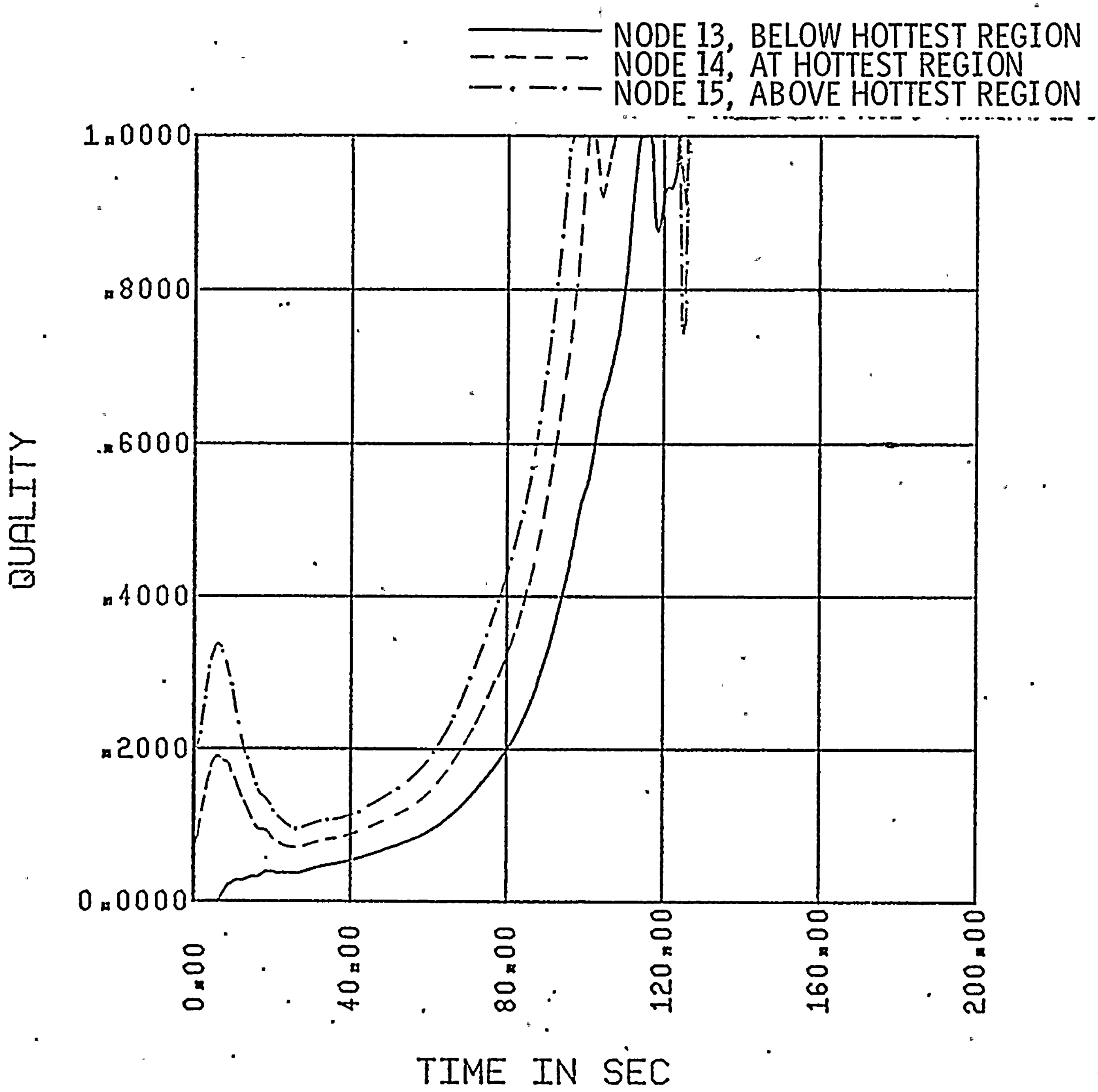


FIGURE II.4-F

ST. LUCIE II

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

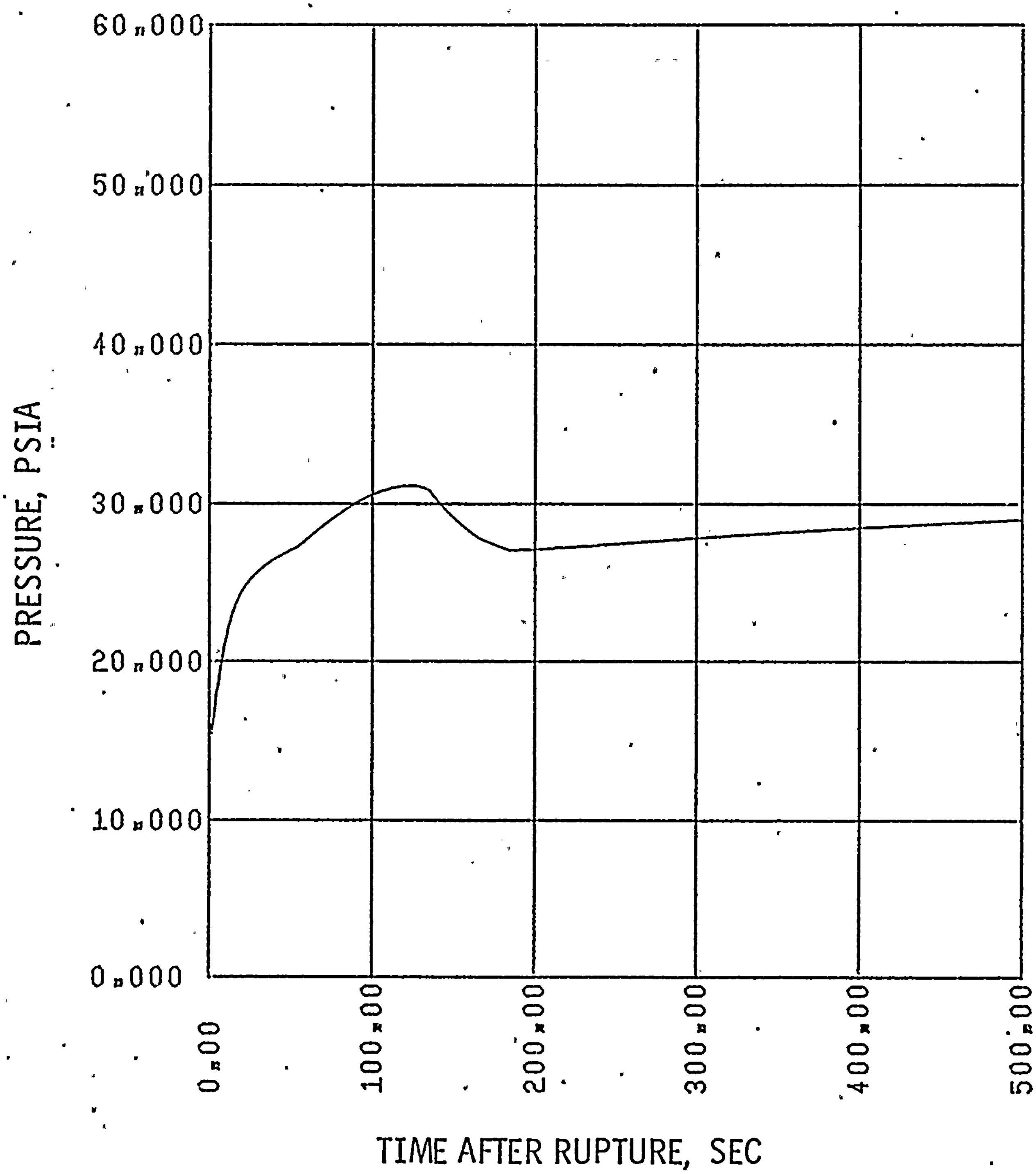


FIGURE II.4-G

ST. LUCIE II
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

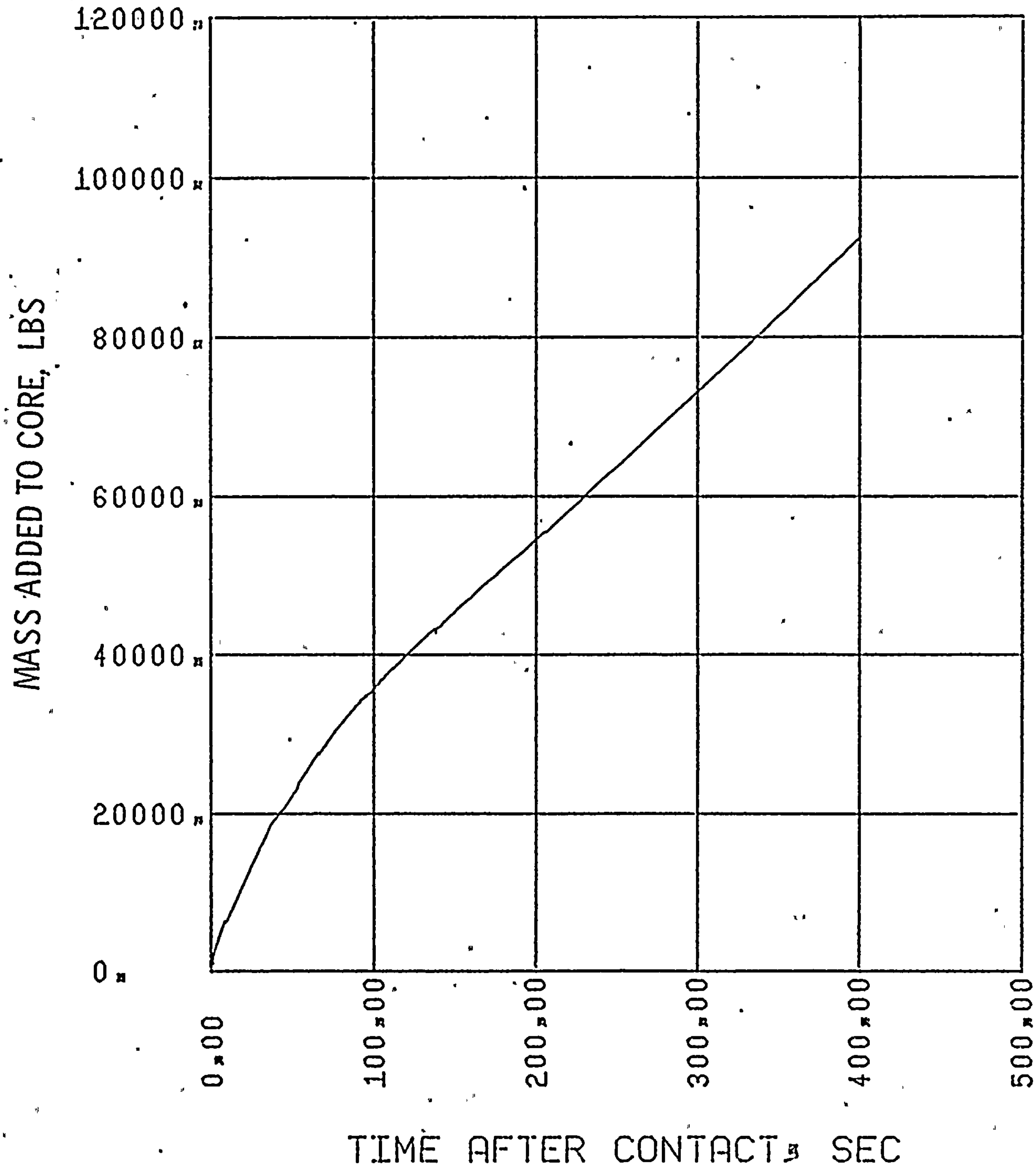


FIGURE II.4-H

ST. LUCIE II

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

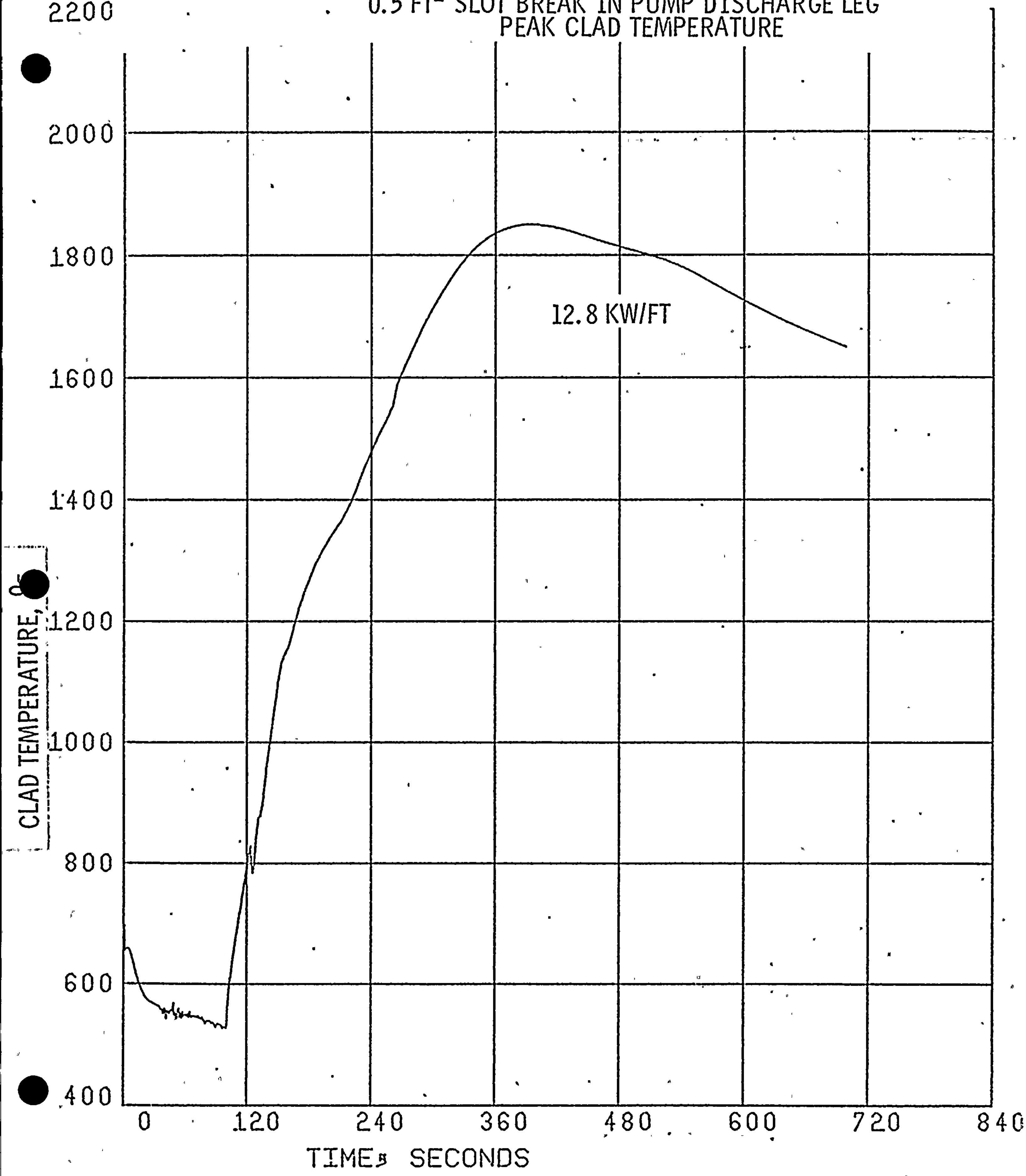


FIGURE II.5-A

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

CORE POWER

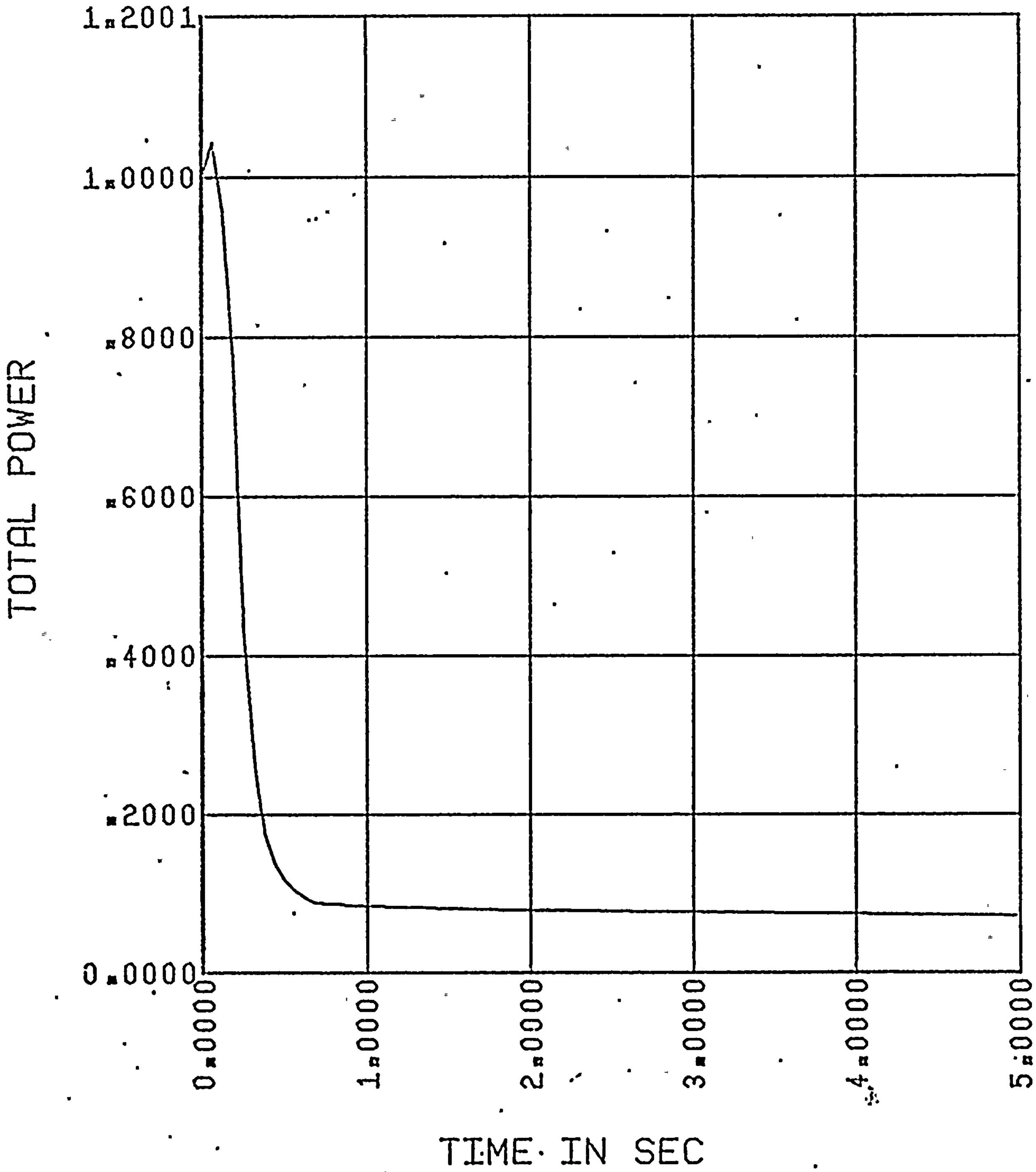


FIGURE II.5-B

ST. LUCIE II
1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

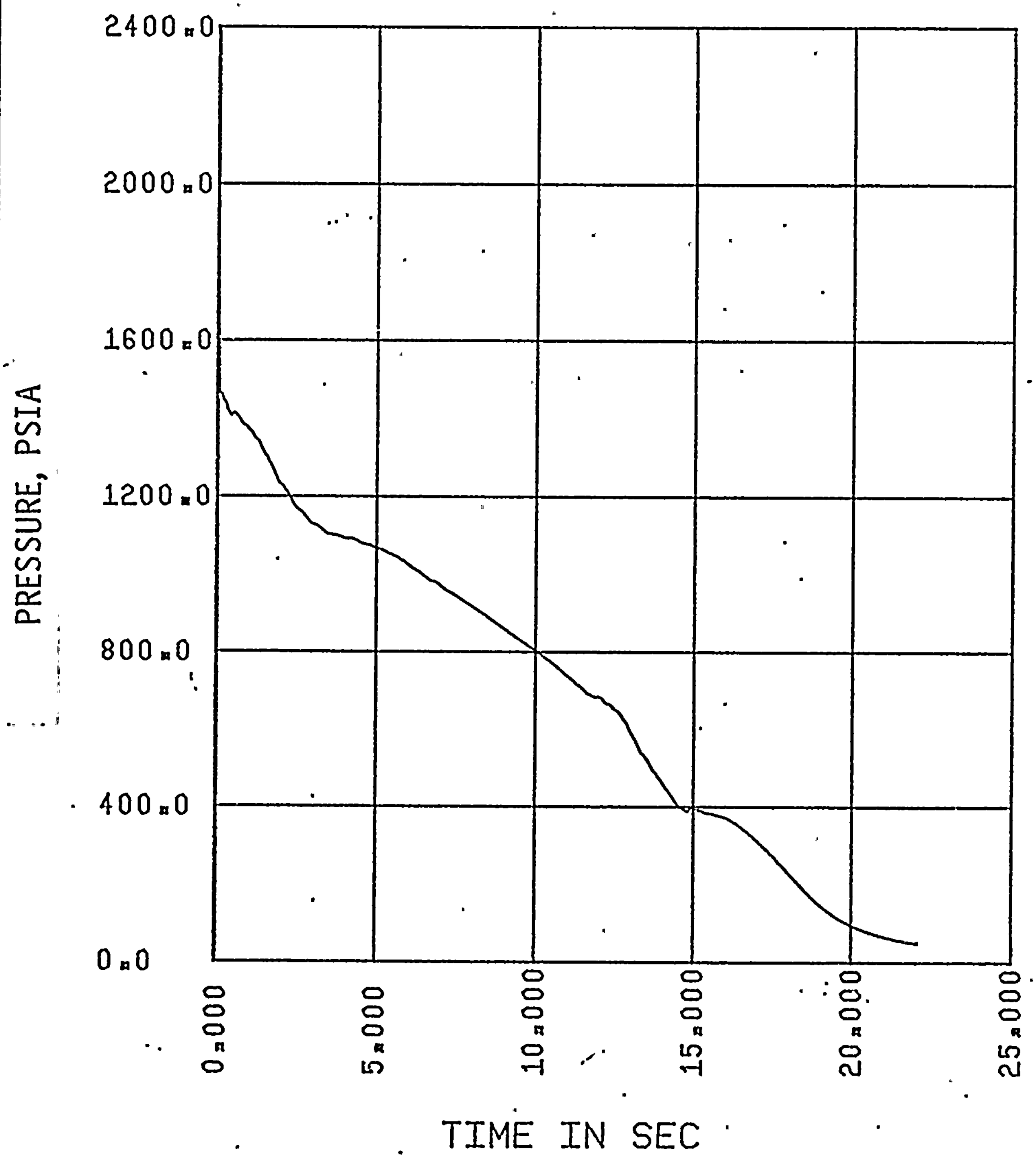


FIGURE II.5-C

ST. LUCIE II
1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
LEAK FLOW

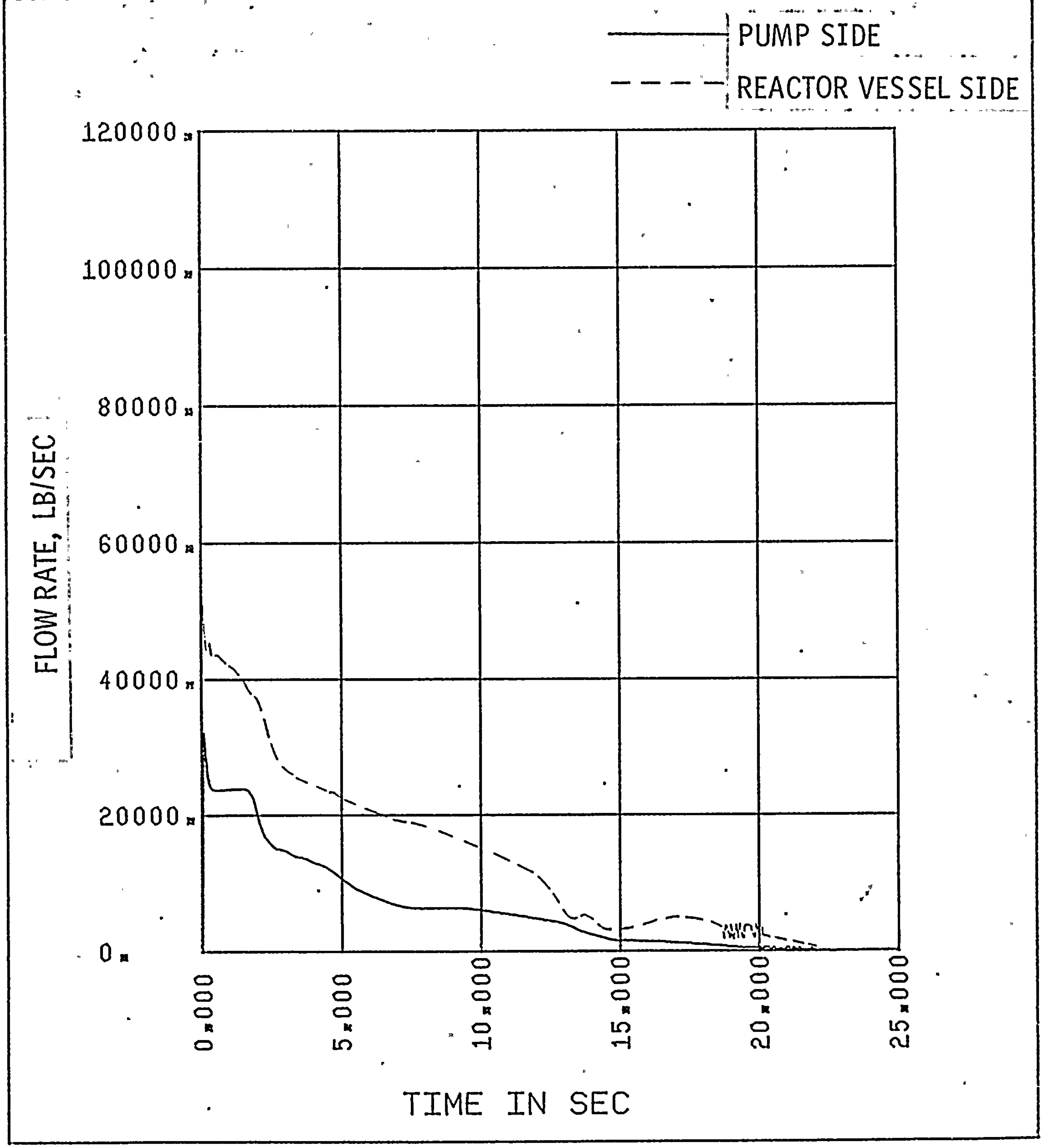


FIGURE II.5-D.1

ST. LUCIE II
1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

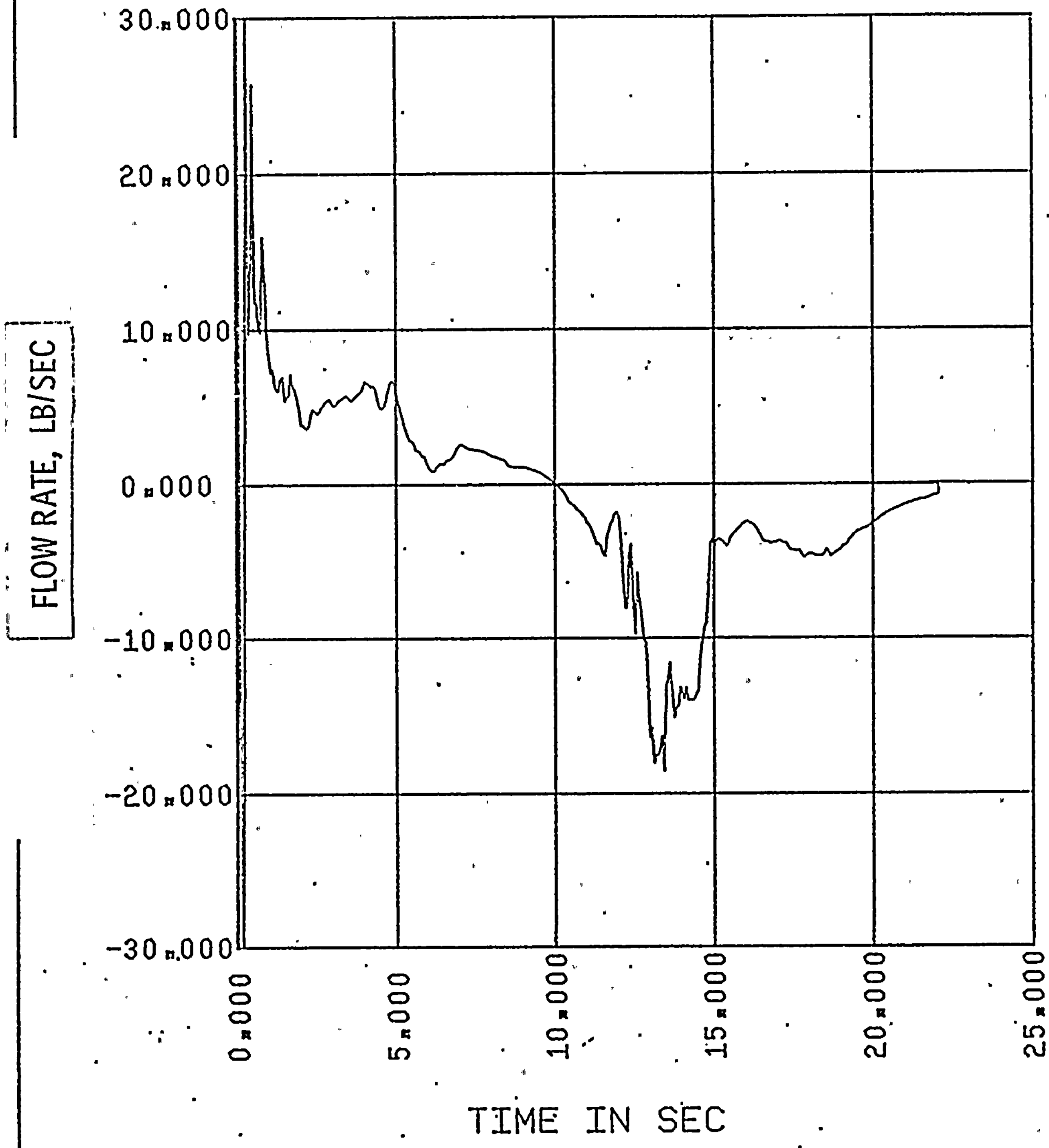


FIGURE II.5-D.2

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

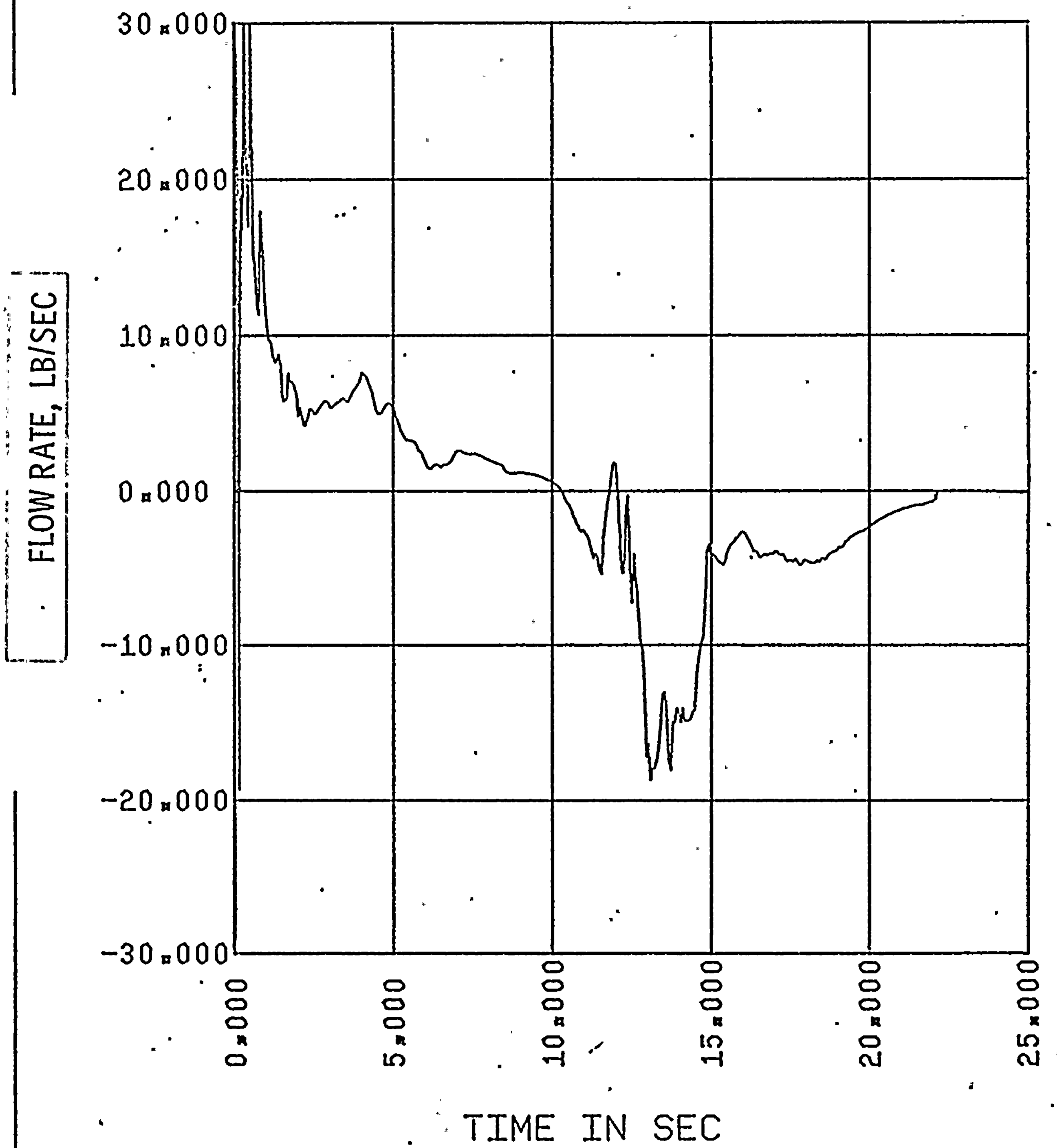


FIGURE II.5-E

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

HOT ASSEMBLY QUALITY

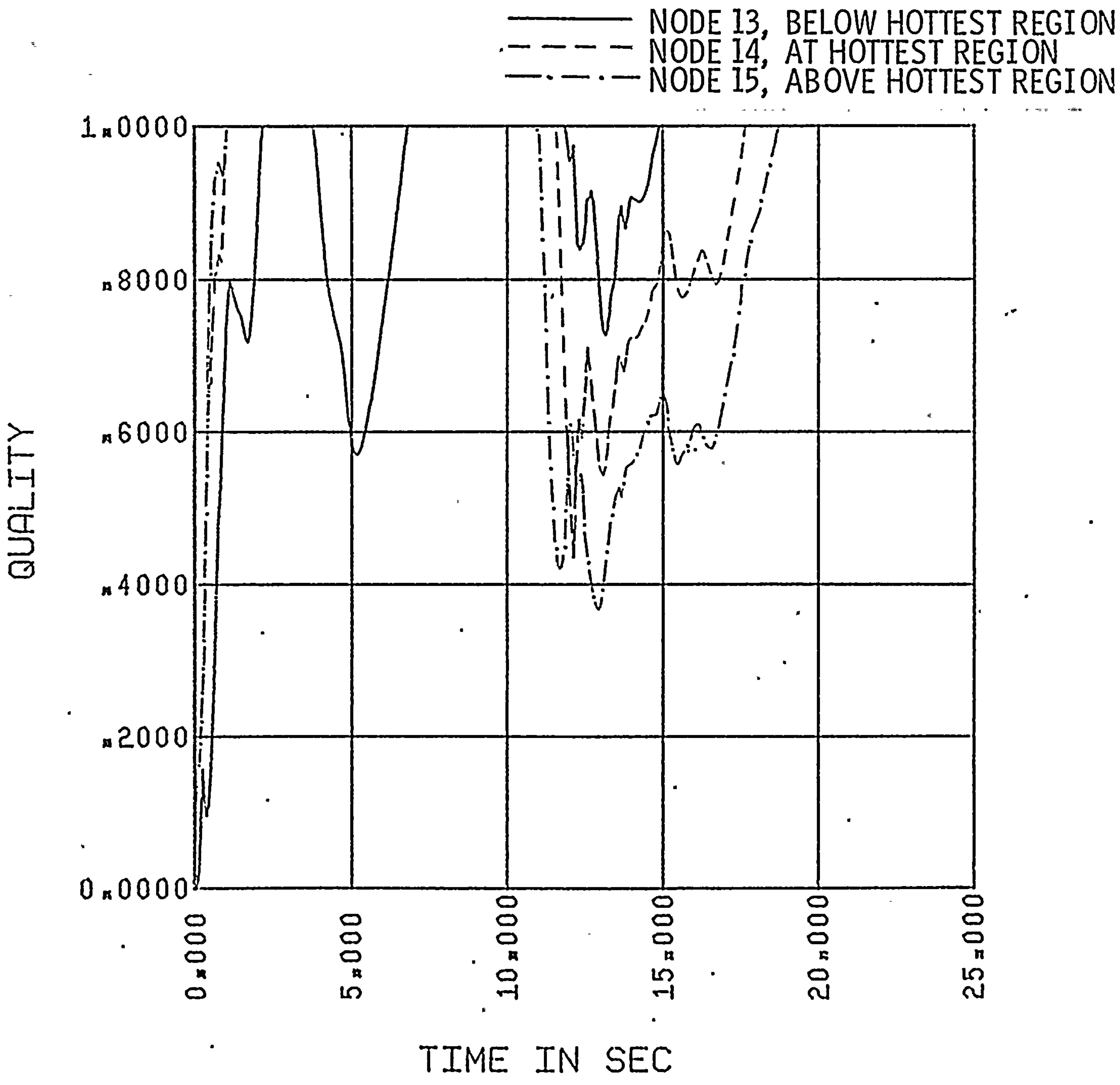


FIGURE II.5-F

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

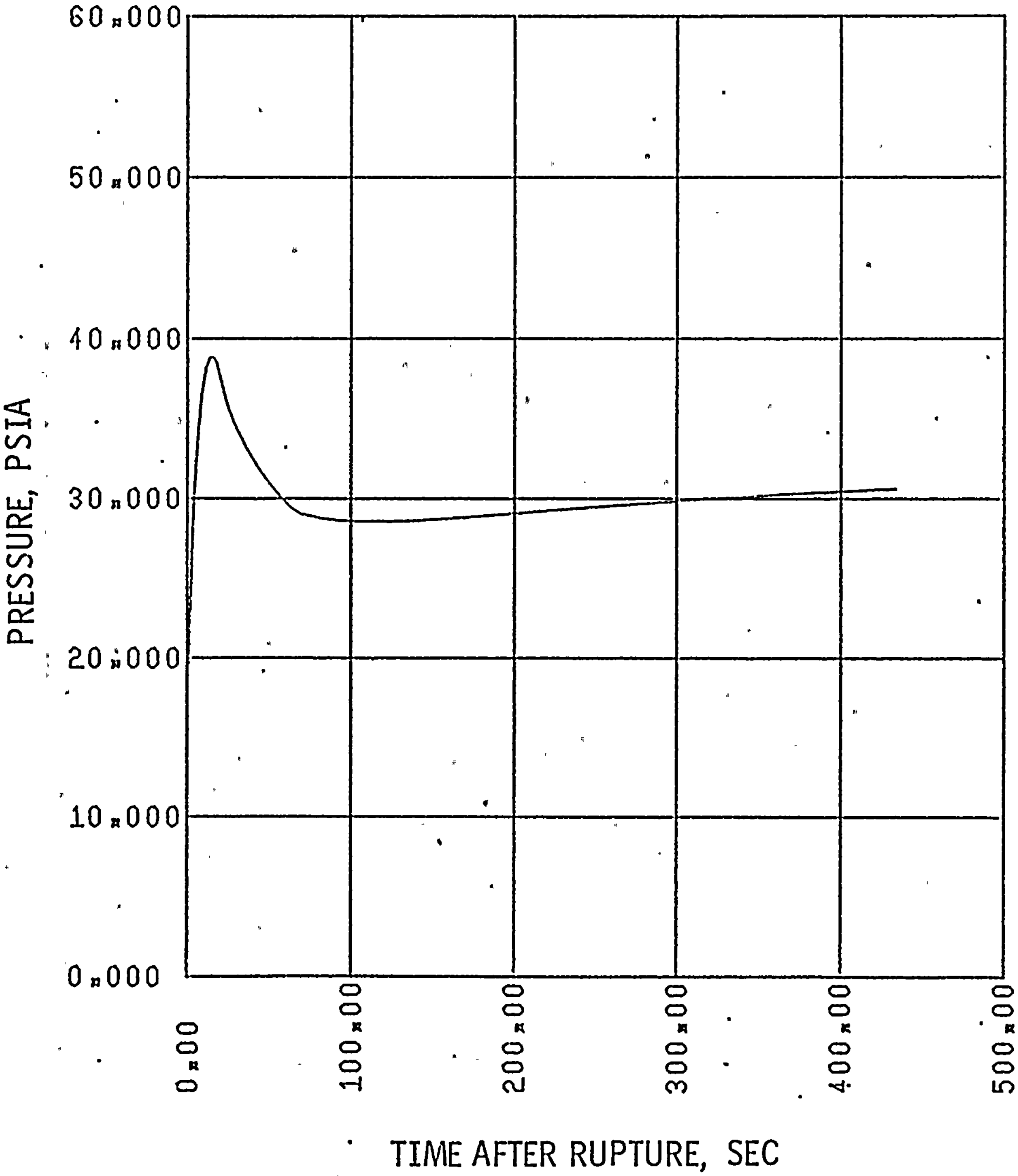


FIGURE II.5-G

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

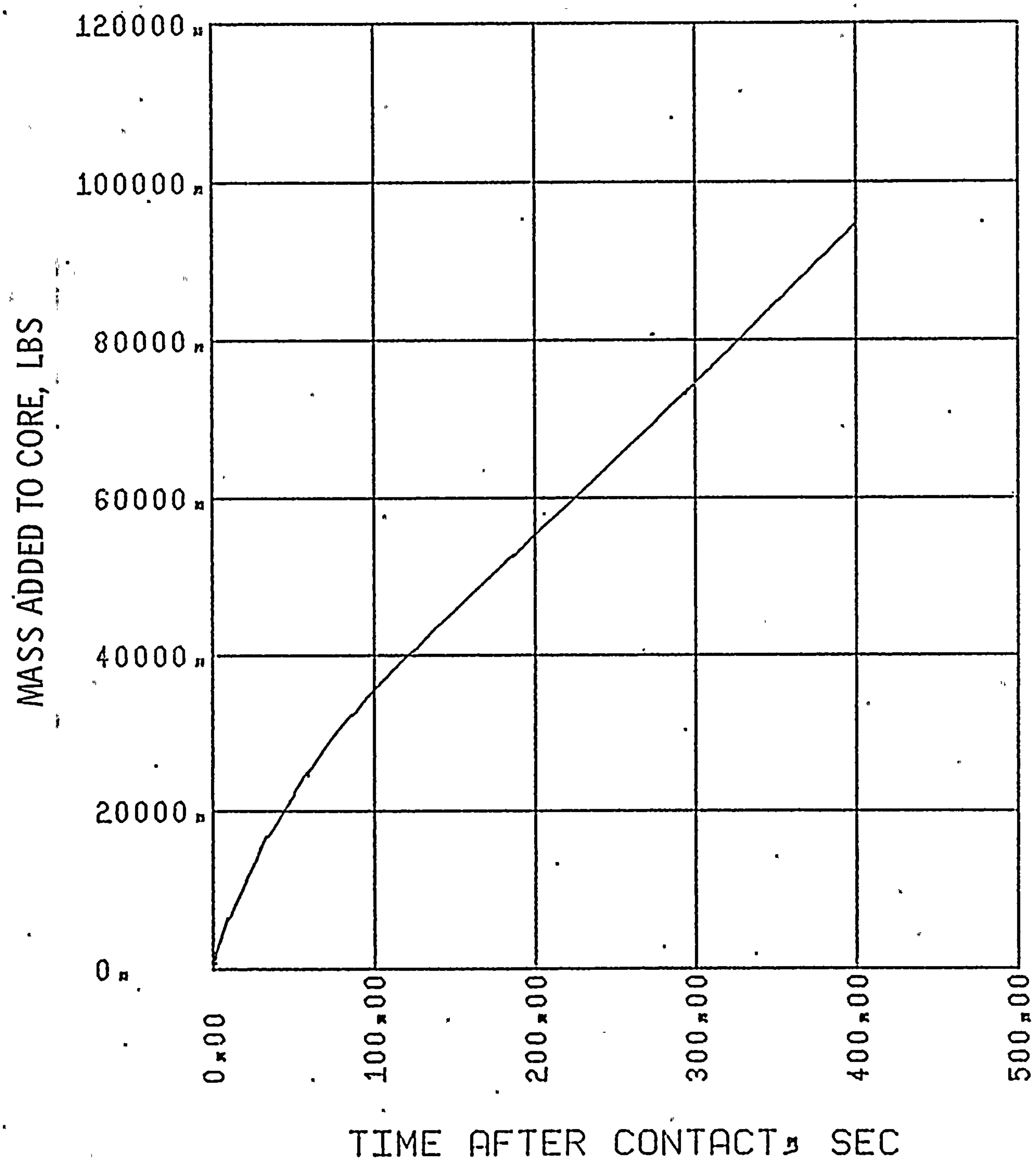


FIGURE II.5-H

ST. LUCIE II

1.0 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

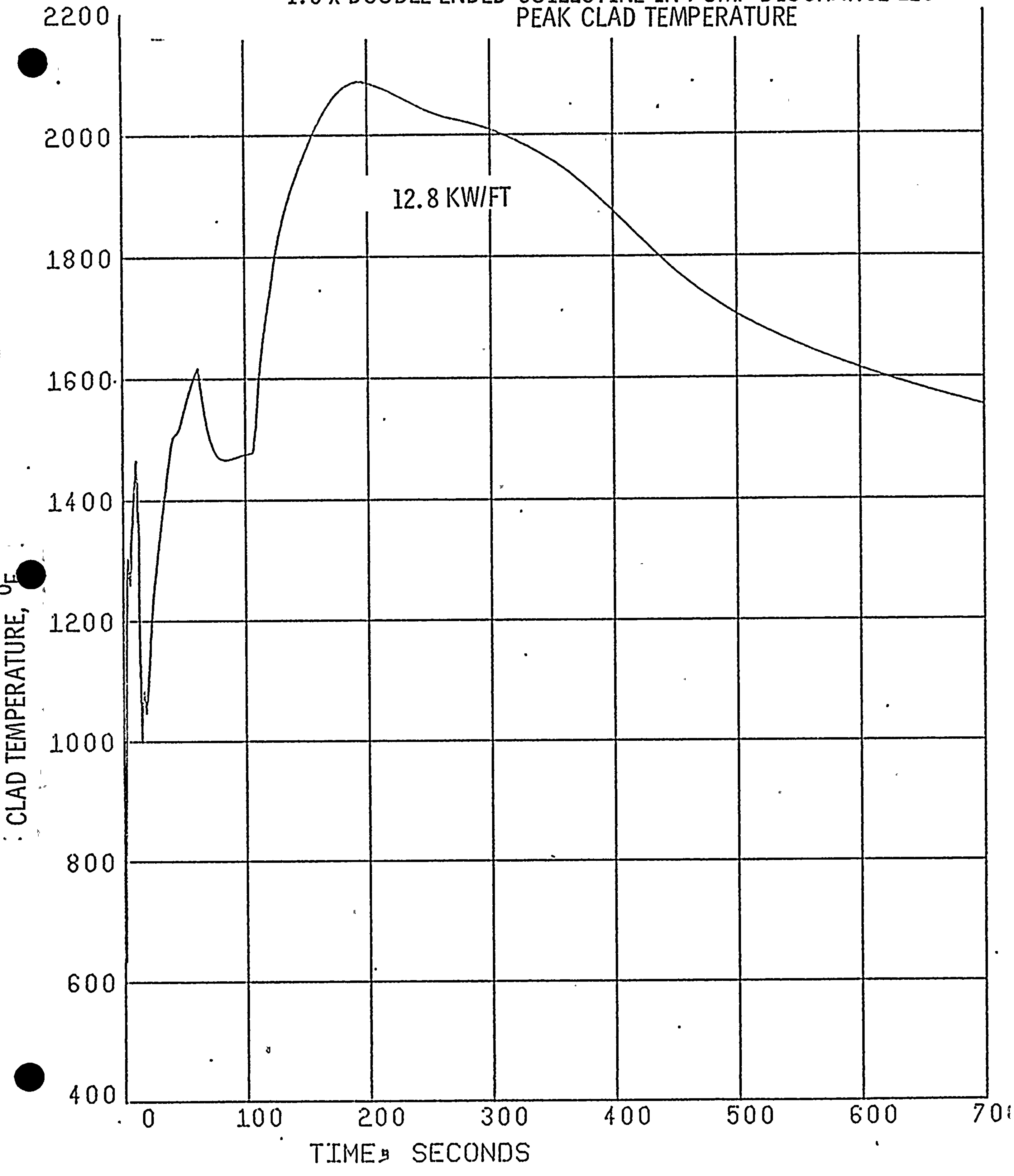


FIGURE II.6-A

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
CORE POWER

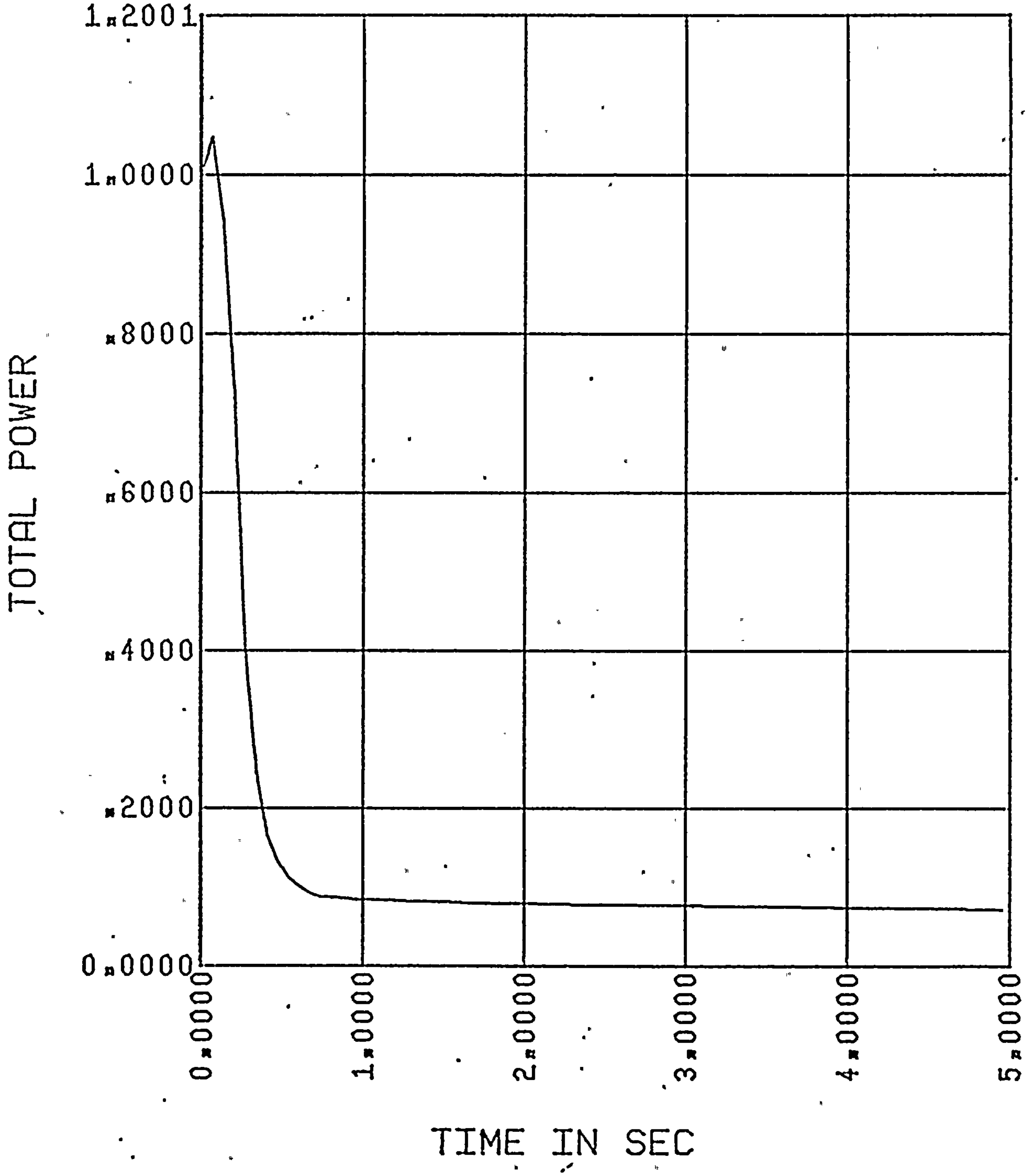


FIGURE II.6-B

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

PRESSURE IN CENTER HOT ASSEMBLY NODE

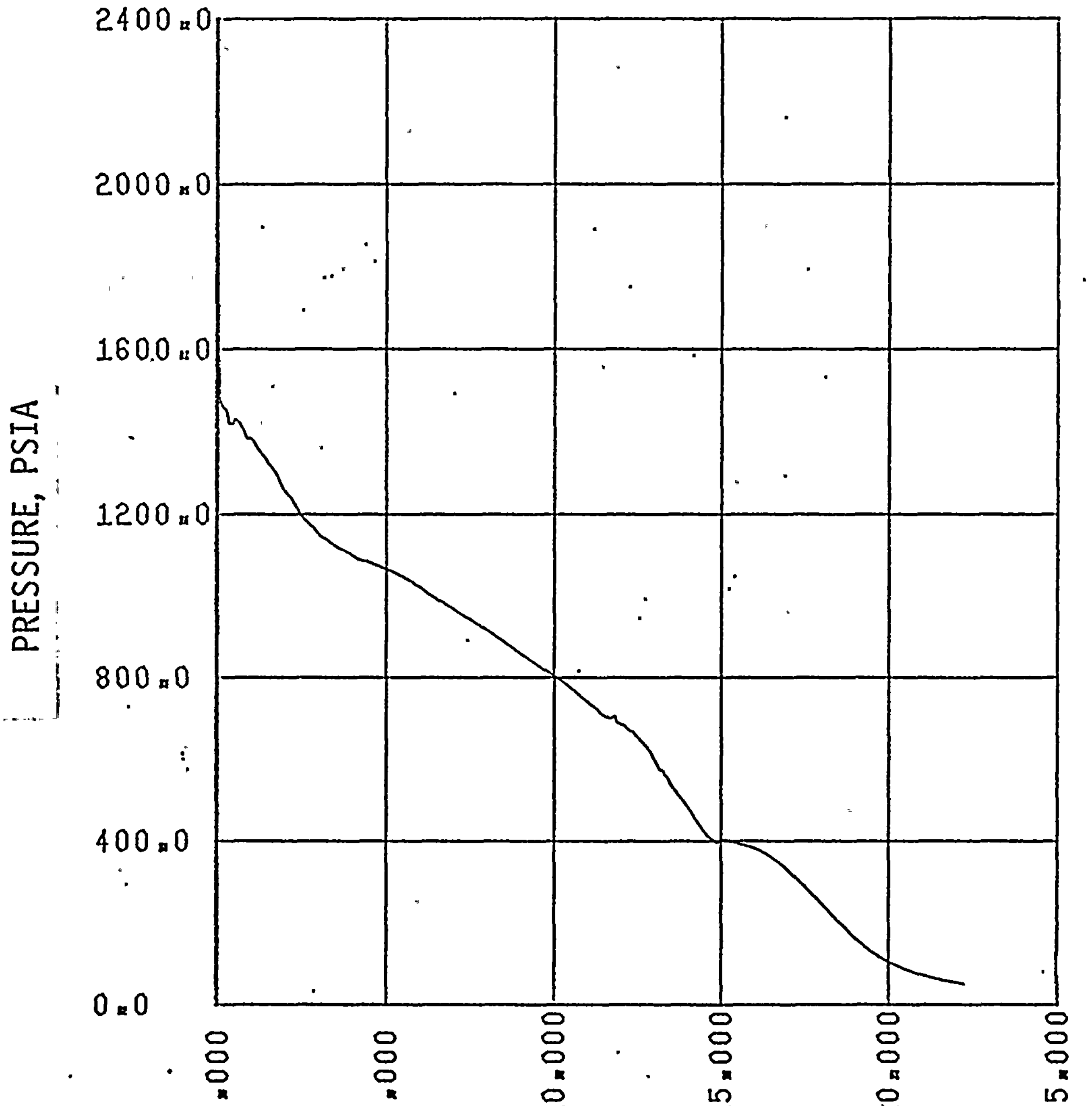


FIGURE II.6-C

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
LEAK FLOW

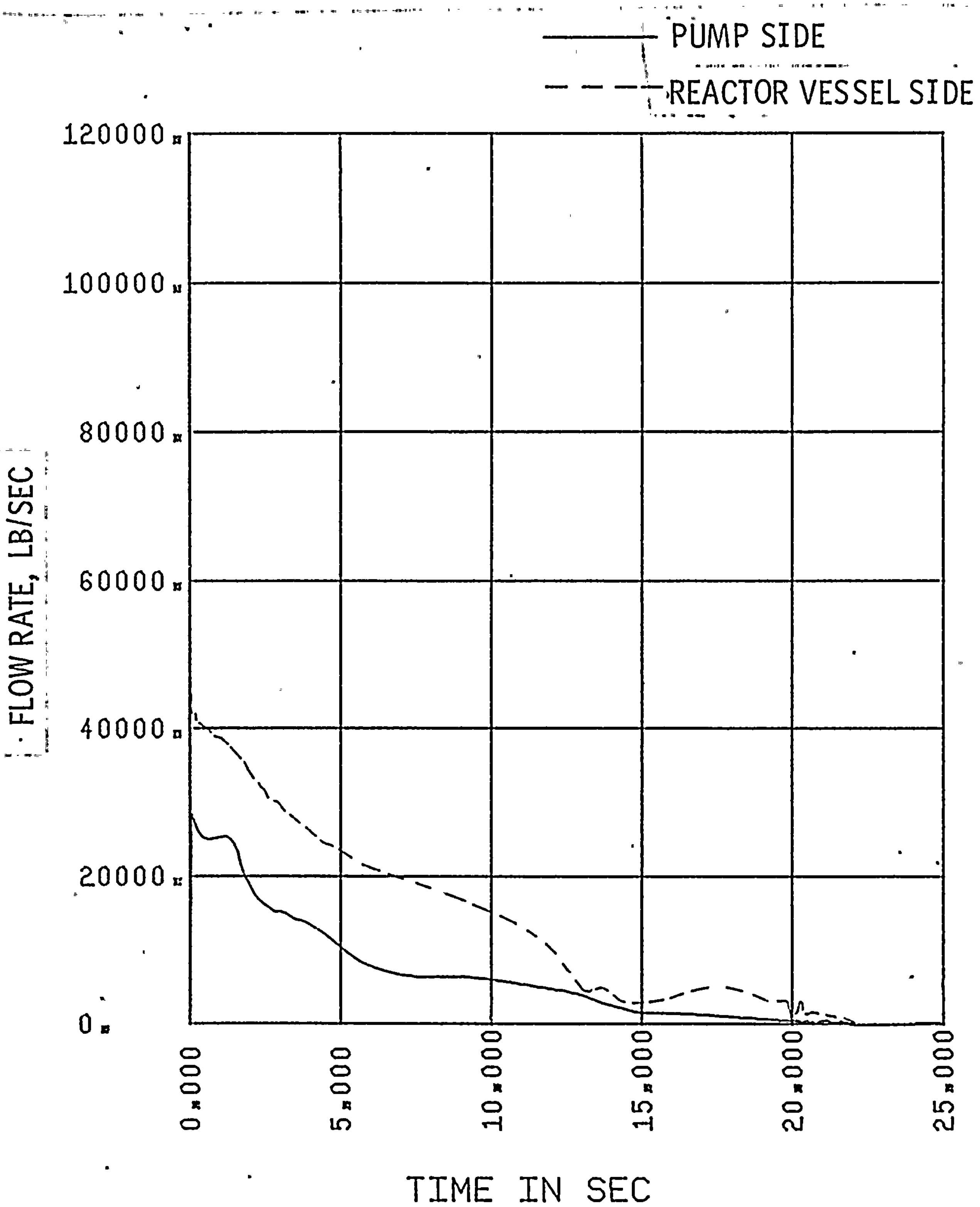


FIGURE II.6-D.1

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

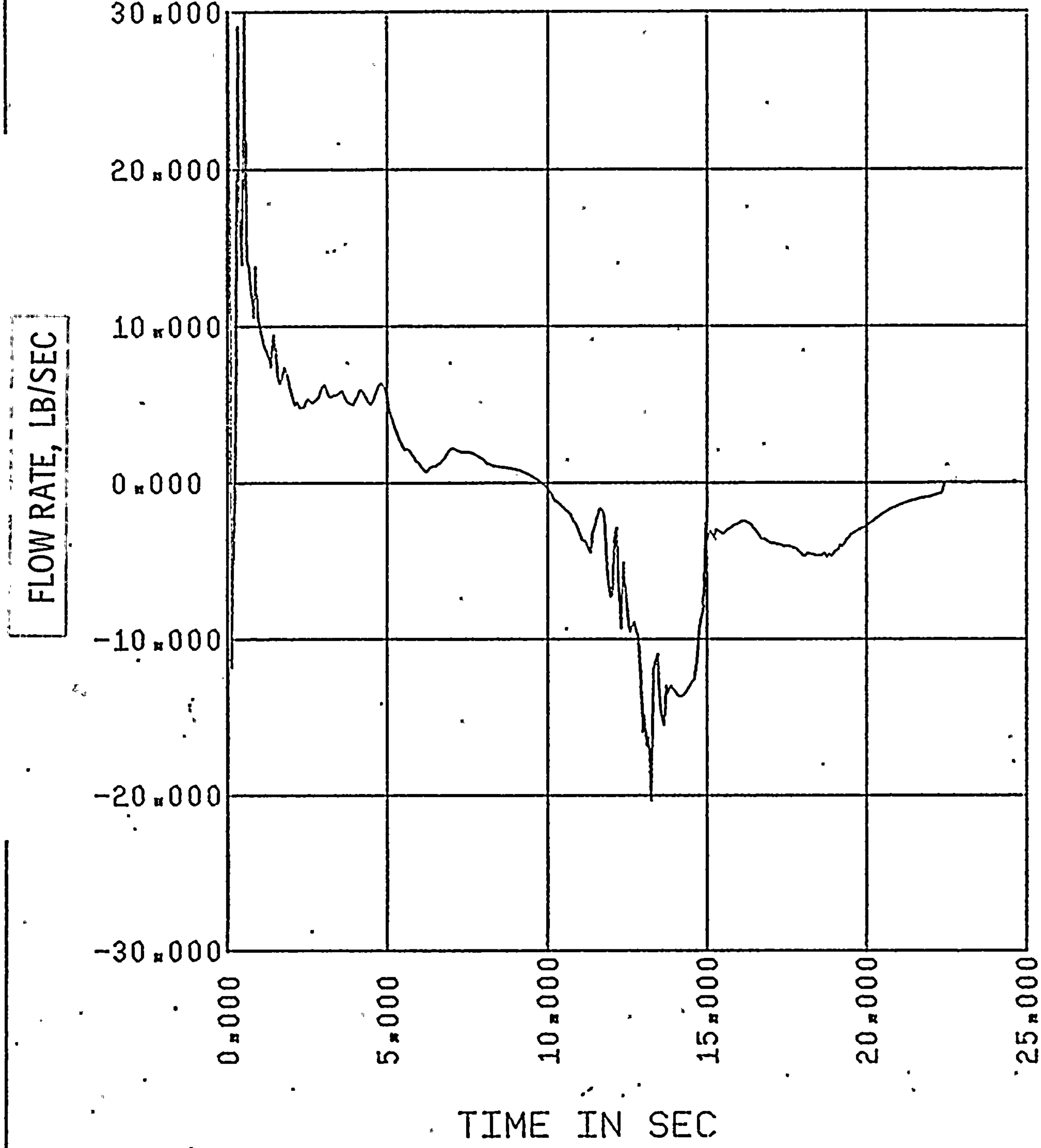


FIGURE II.6-D.2

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

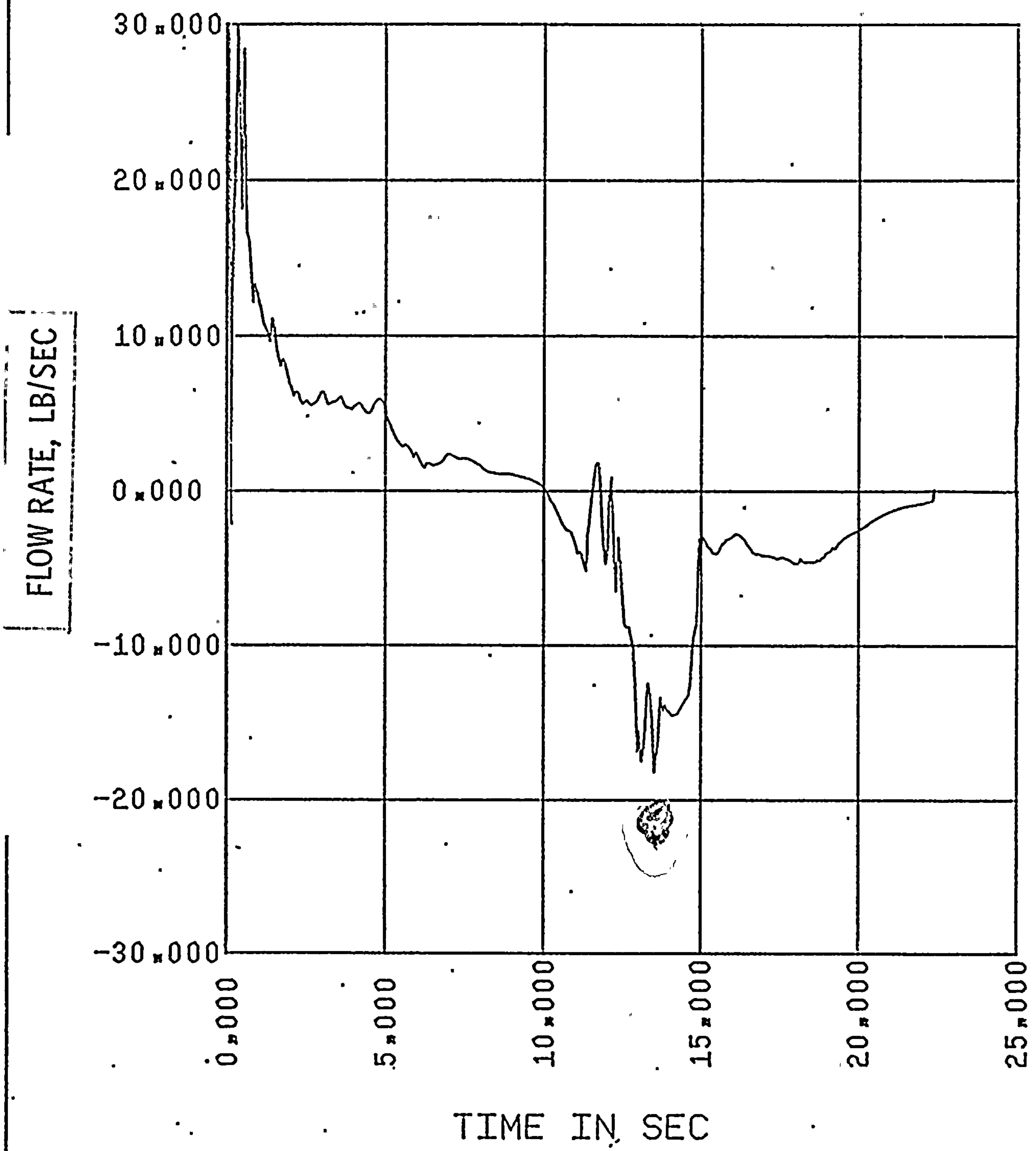


FIGURE II.6-E

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

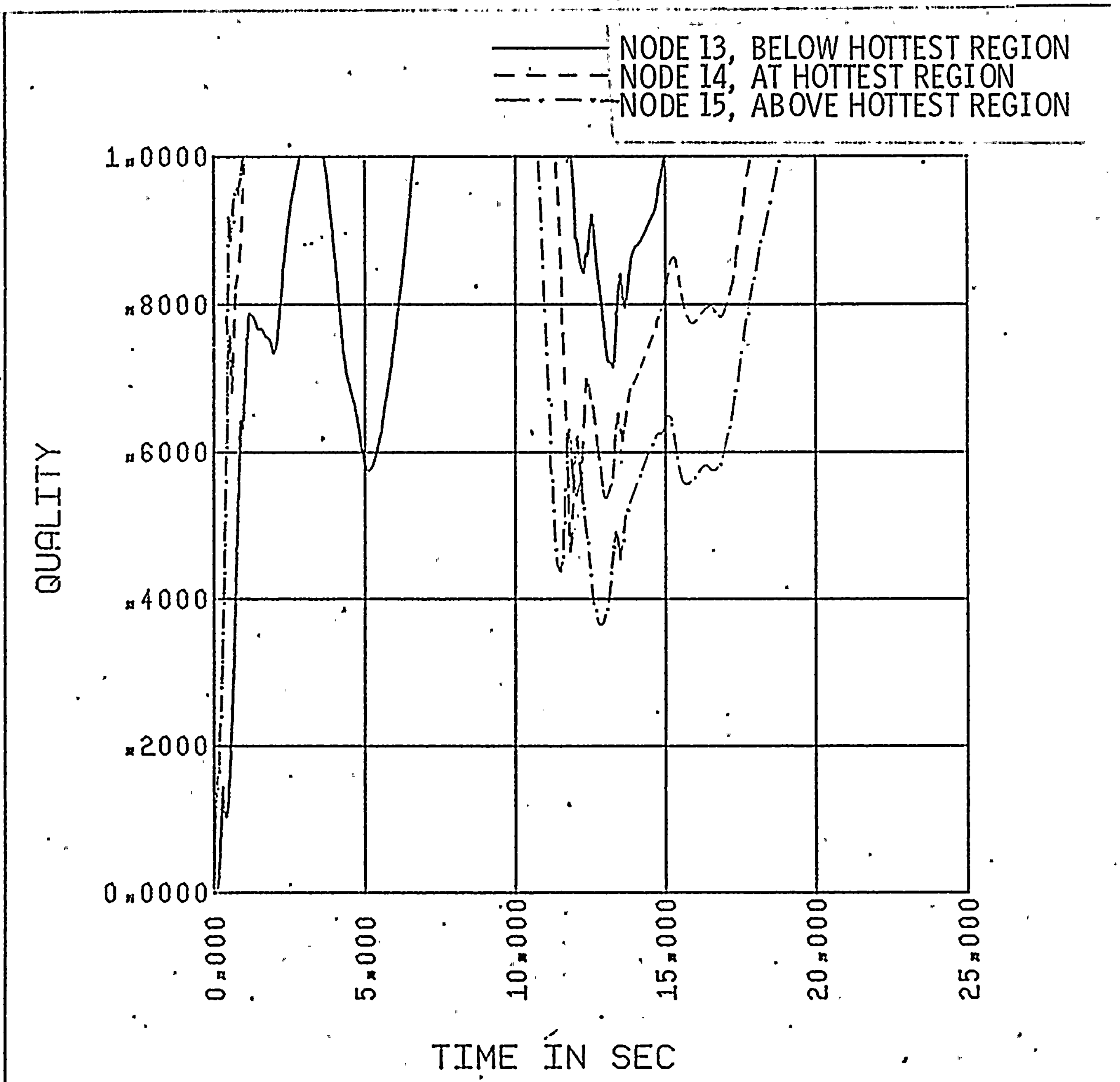


FIGURE II.6-F

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

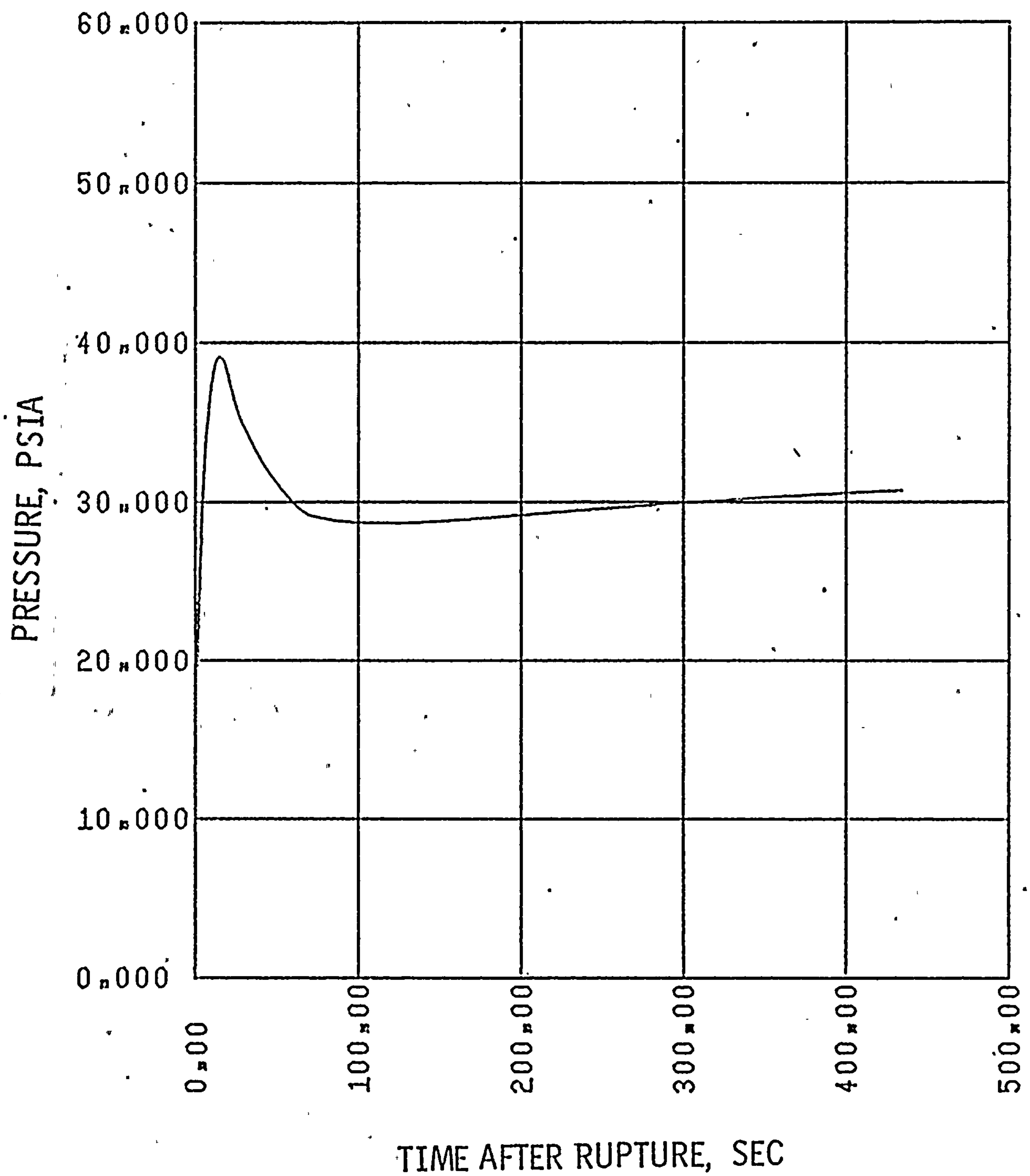
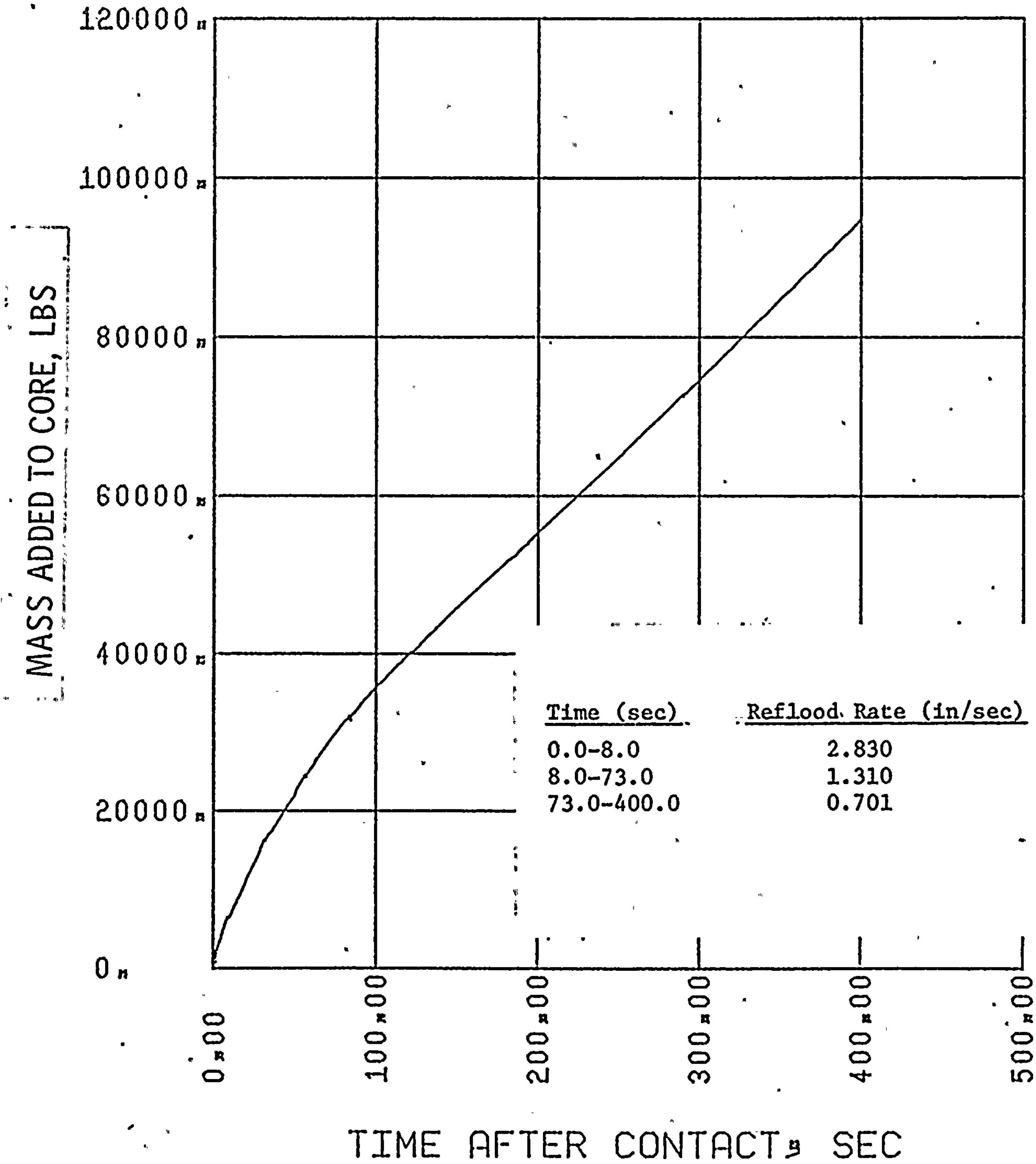


FIGURE II.6-G

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD



Time (sec)	Reflood Rate (in/sec)
0.0-8.0	2.830
8.0-73.0	1.310
73.0-400.0	0.701

FIGURE II.6-H

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

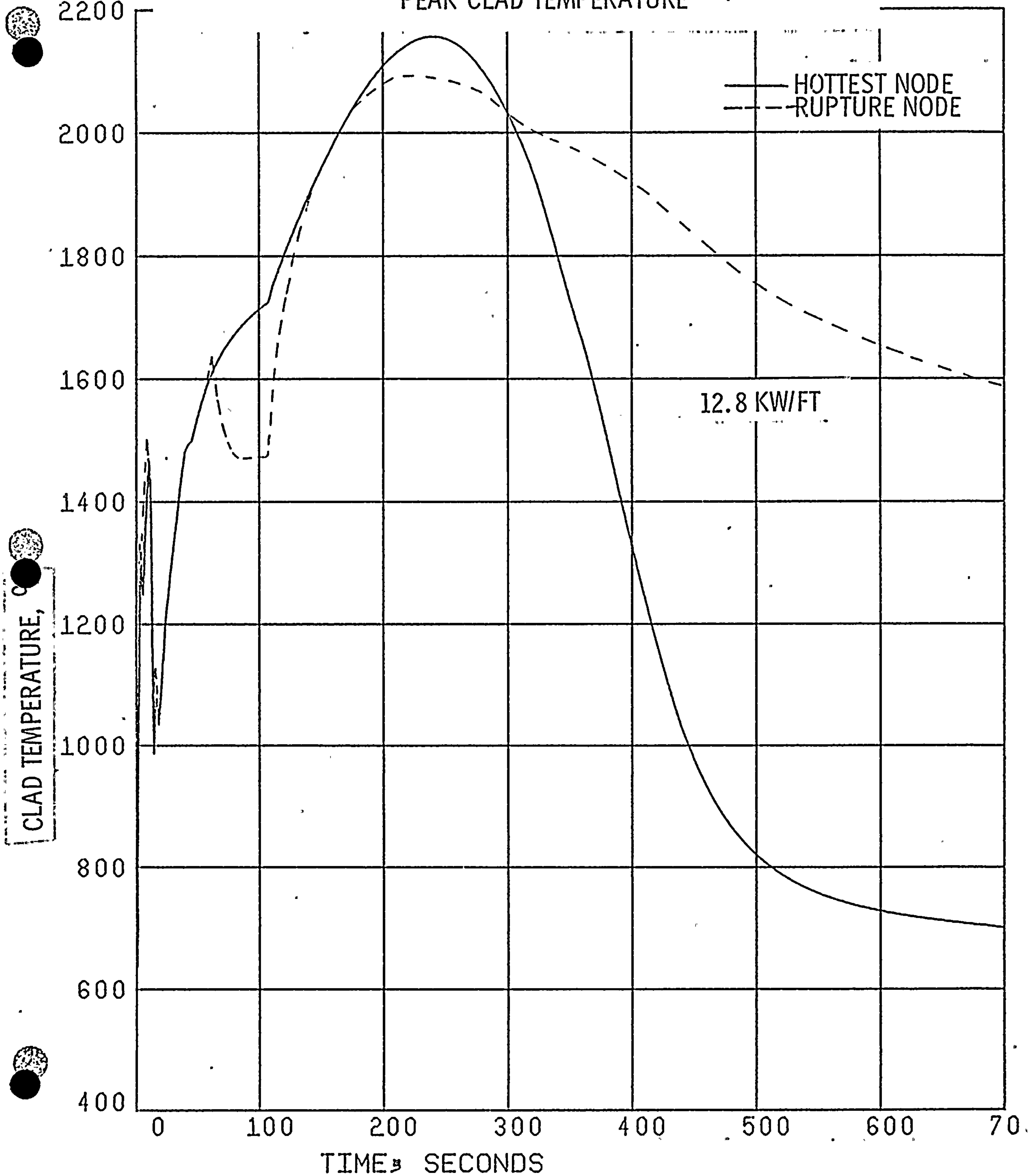


FIGURE II.6-I

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

MID-ANNULUS FLOW

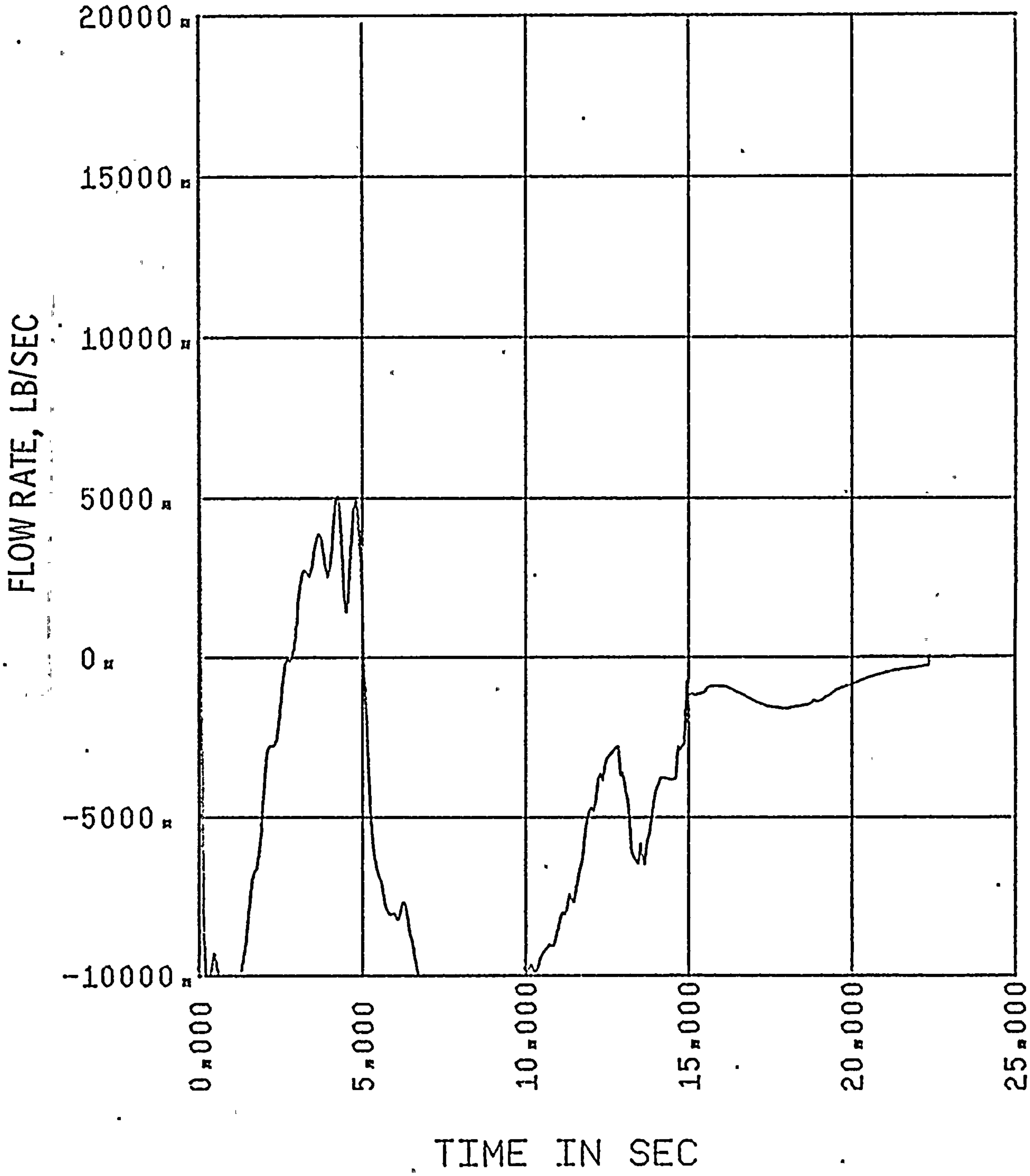


FIGURE II.6-J

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

QUALITIES ABOVE AND BELOW THE CORE

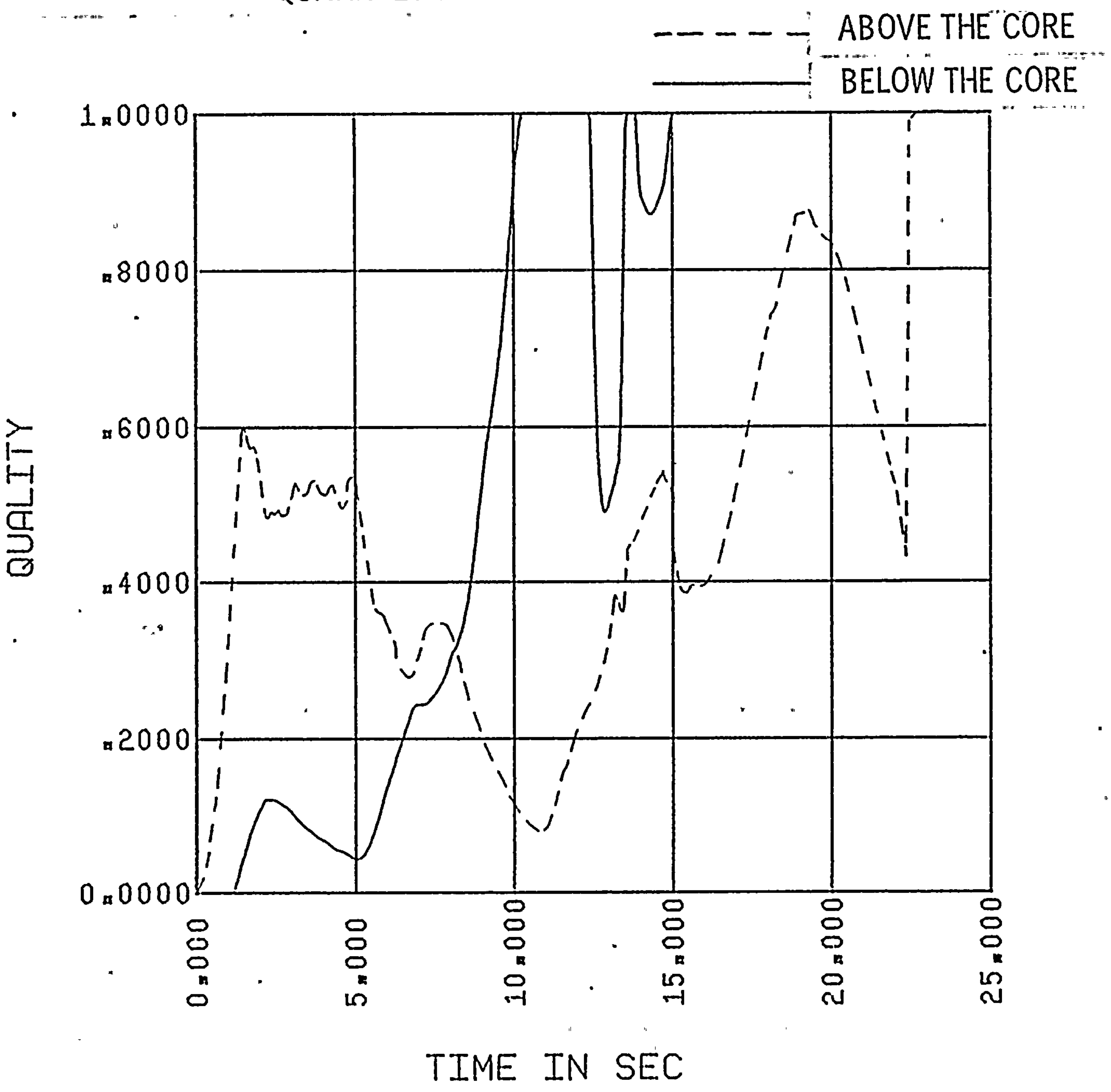


FIGURE II.6-K

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

CORE PRESSURE DROP

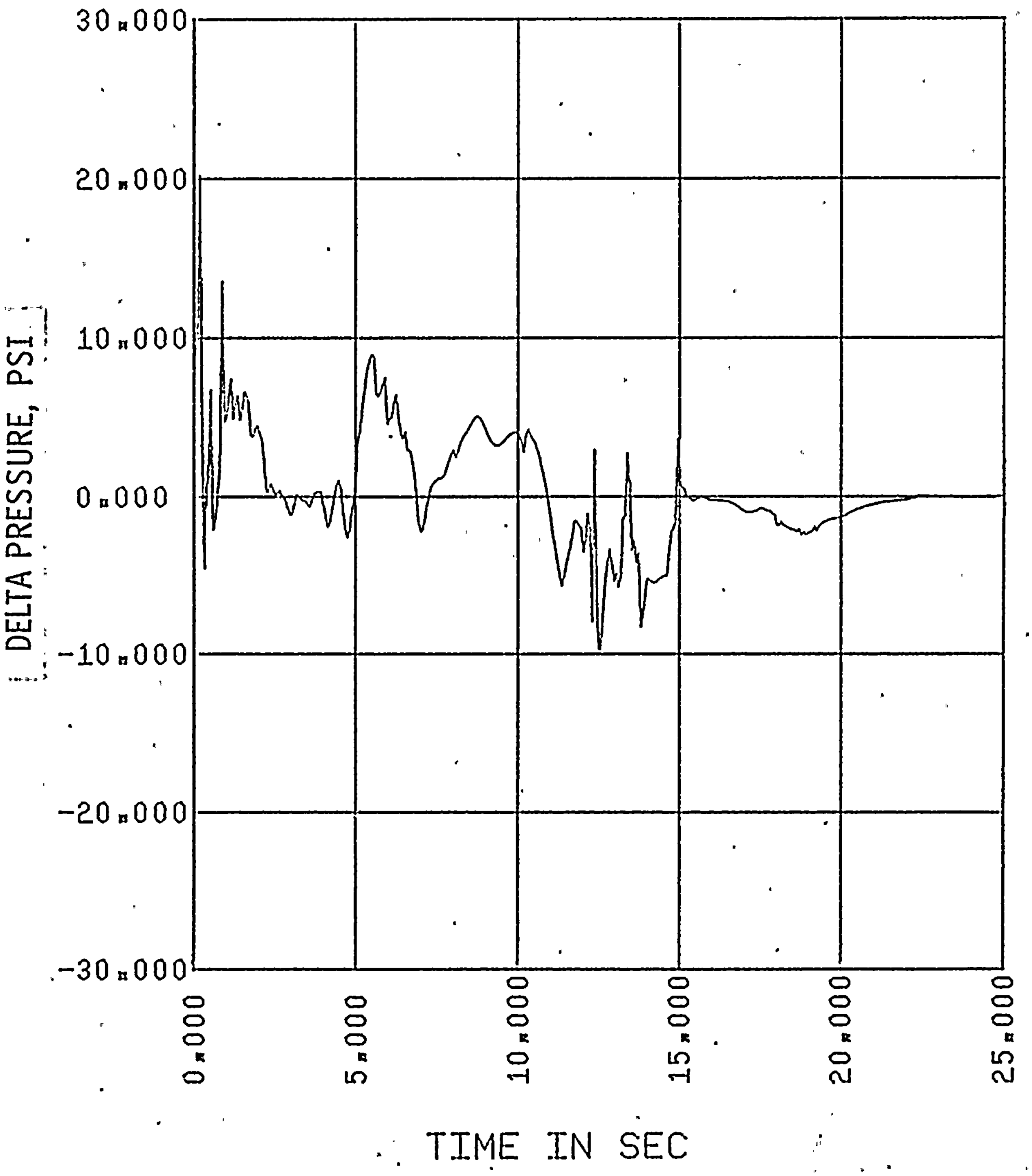


FIGURE II.6-L

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

SAFETY INJECTION FLOW INTO INTACT DISCHARGE LEGS

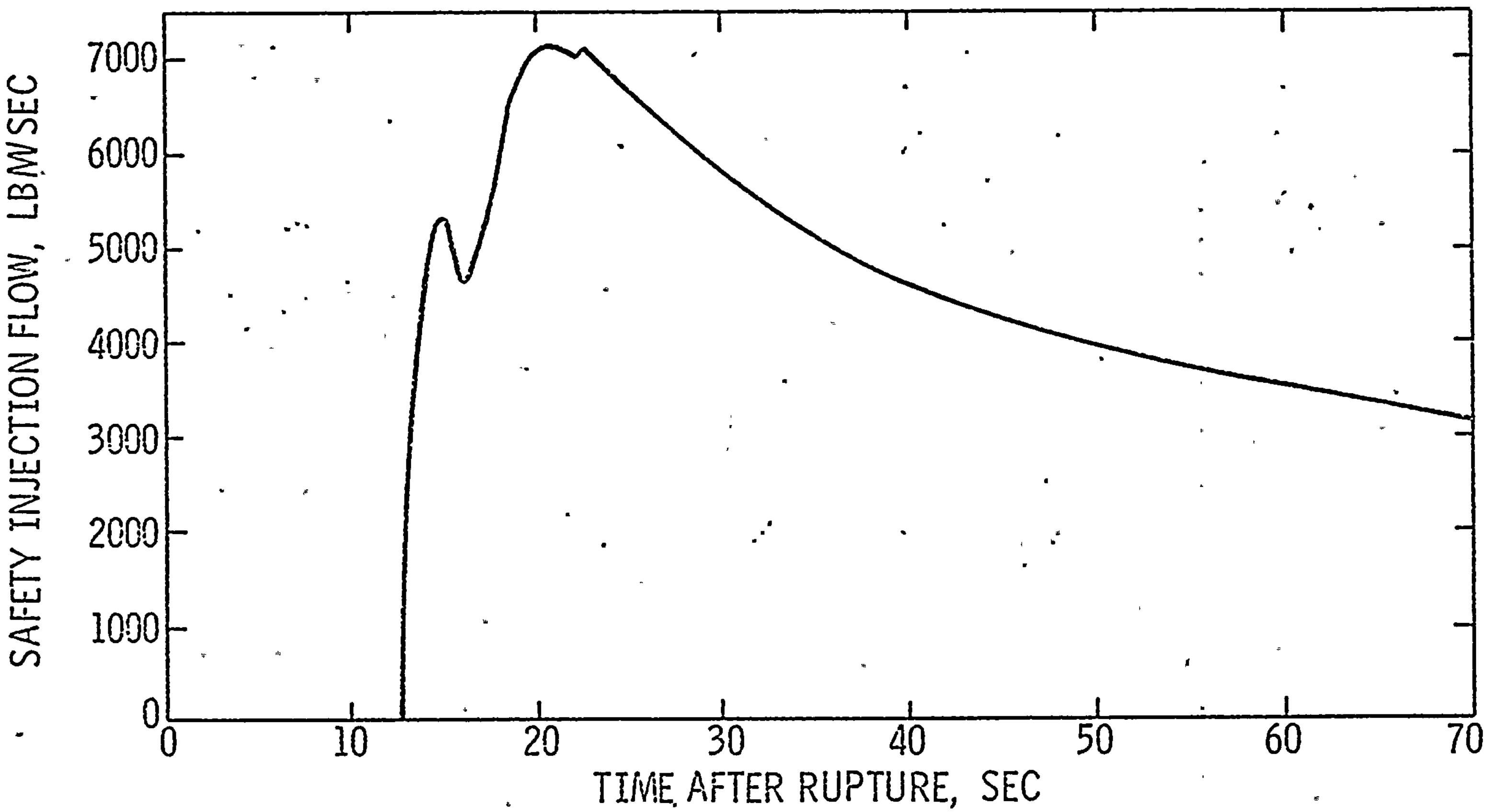


FIGURE II.6-M
ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
WATER LEVEL IN DOWNCOMER DURING REFLOOD

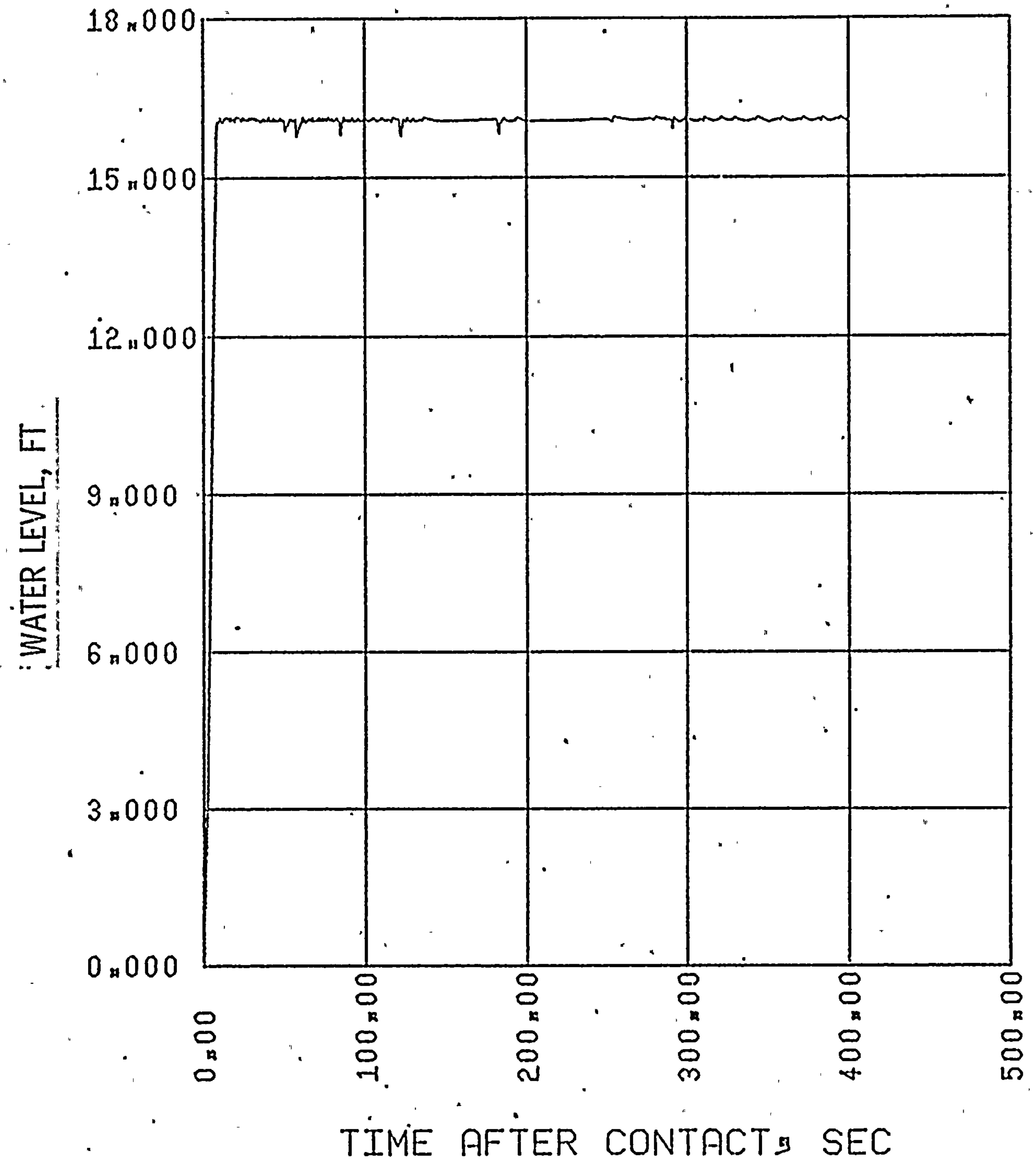
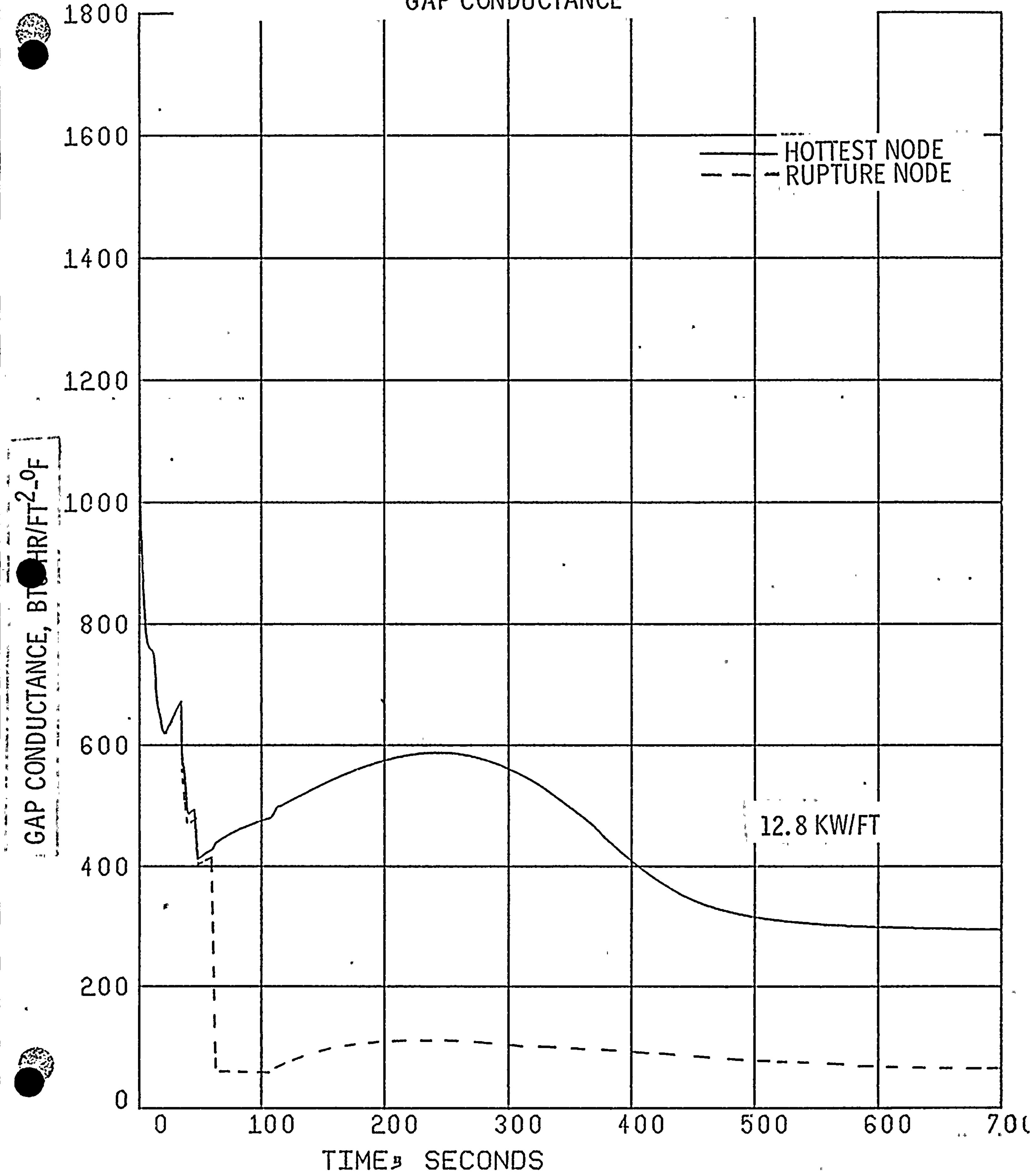


FIGURE II.6-N

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
GAP CONDUCTANCE



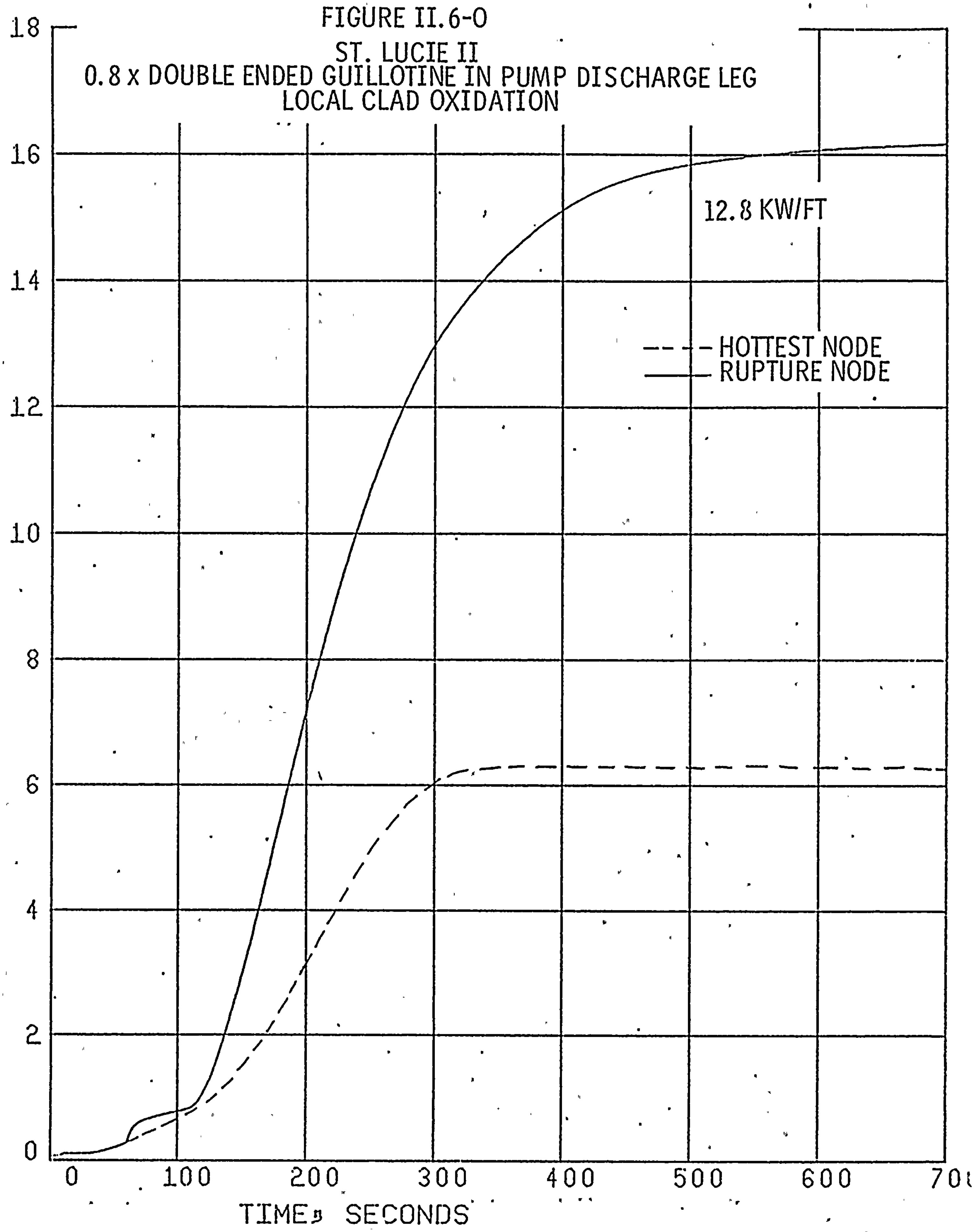


FIGURE II.6-0
ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
LOCAL CLAD OXIDATION
12.8 KW/FT
HOTTEST NODE
RUPTURE NODE
CLAD OXIDATION (%)
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
700
TIME, SECONDS

FIGURE II.6-P

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CLAD TEMPERATURE, CENTERLINE FUEL TEMP., AVE. FUEL TEMP.,
AND COOLANT TEMP. FOR HOTTEST NODE

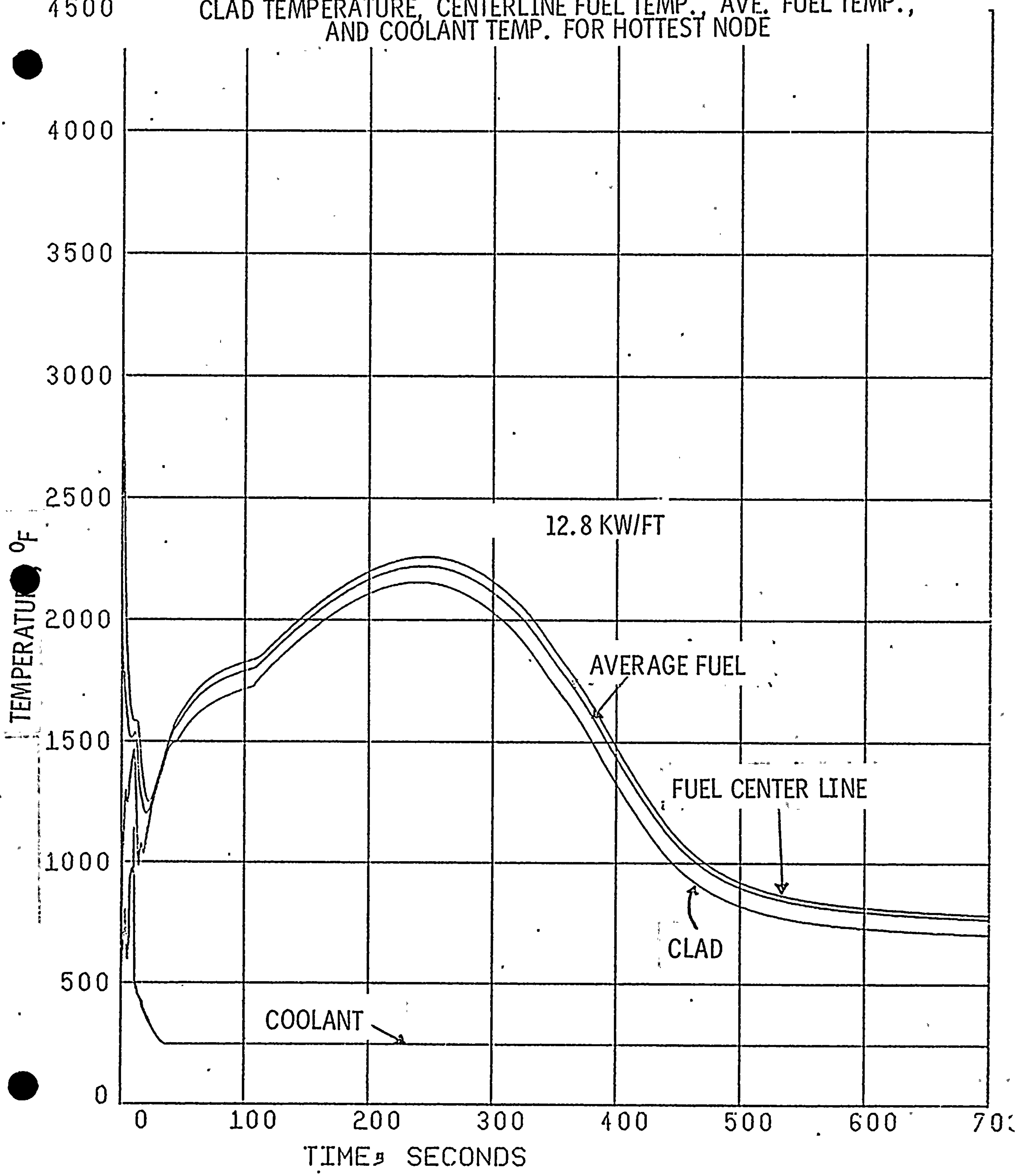


FIGURE II.6-Q

ST. LUCIE II
0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
HOT SPOT HEAT TRANSFER COEFFICIENT

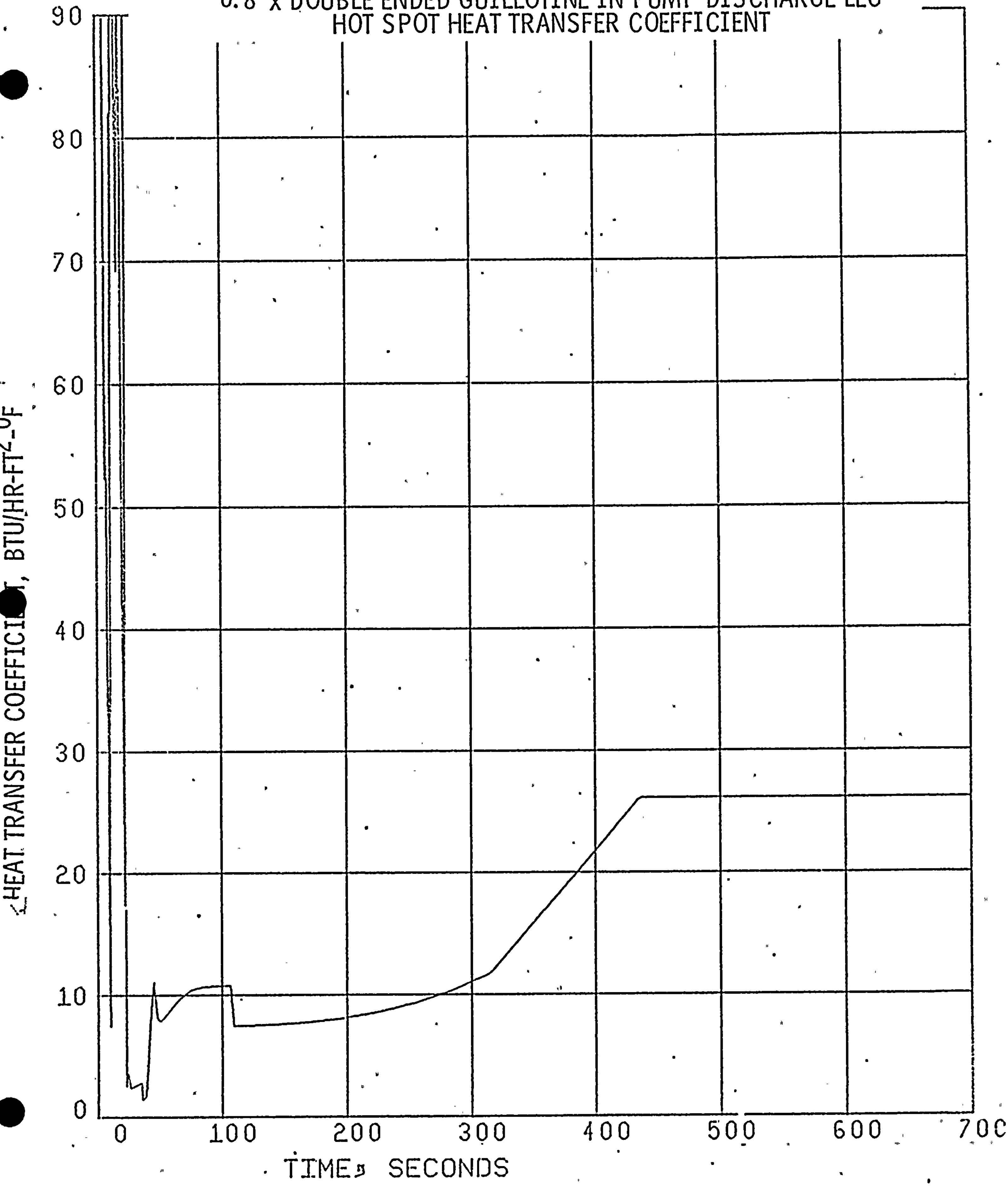


FIGURE II.6-R

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

HOT SPOT HEAT TRANSFER COEFFICIENT DURING REFLOOD

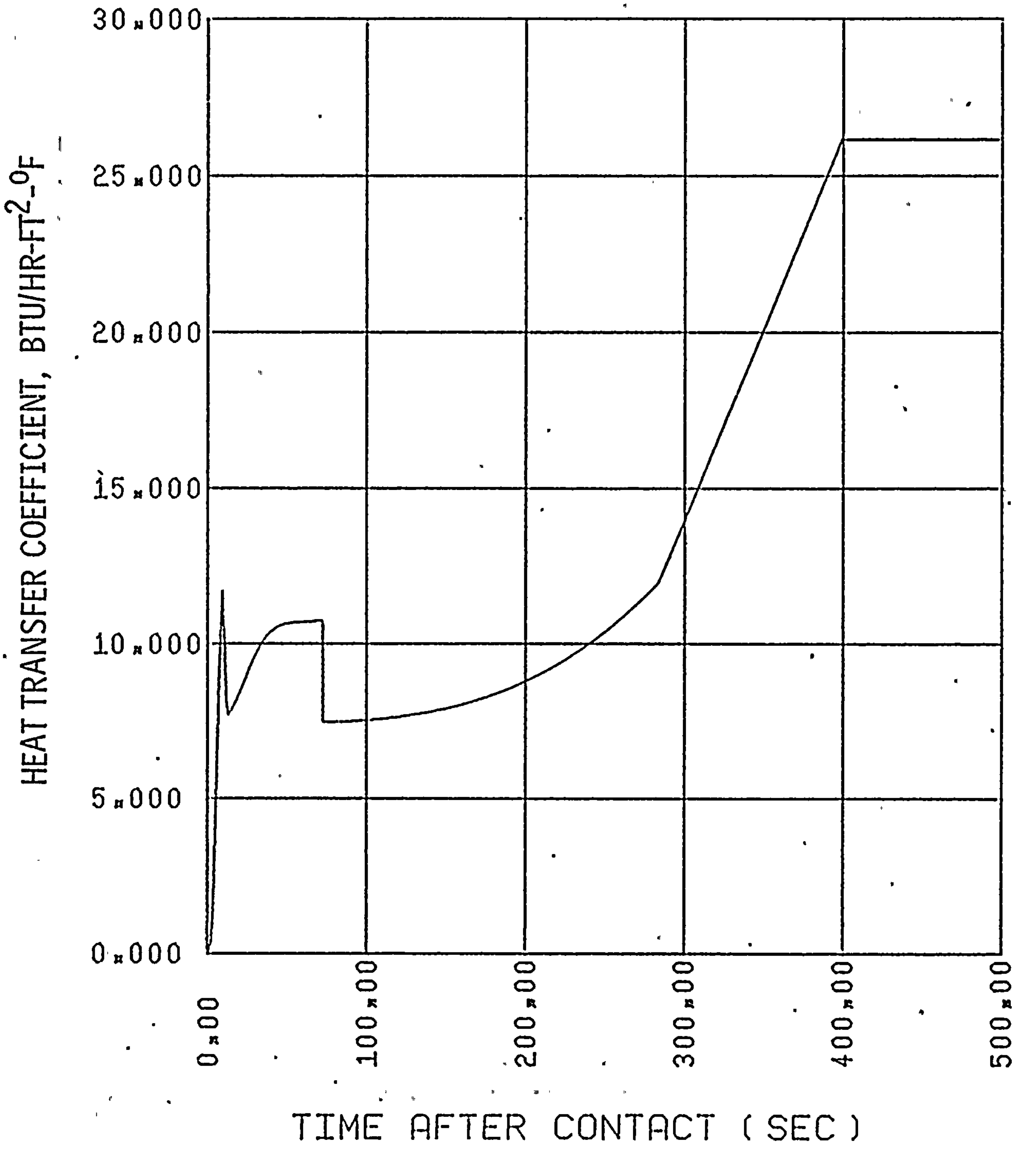


FIGURE II.6-S

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CONTAINMENT TEMPERATURE

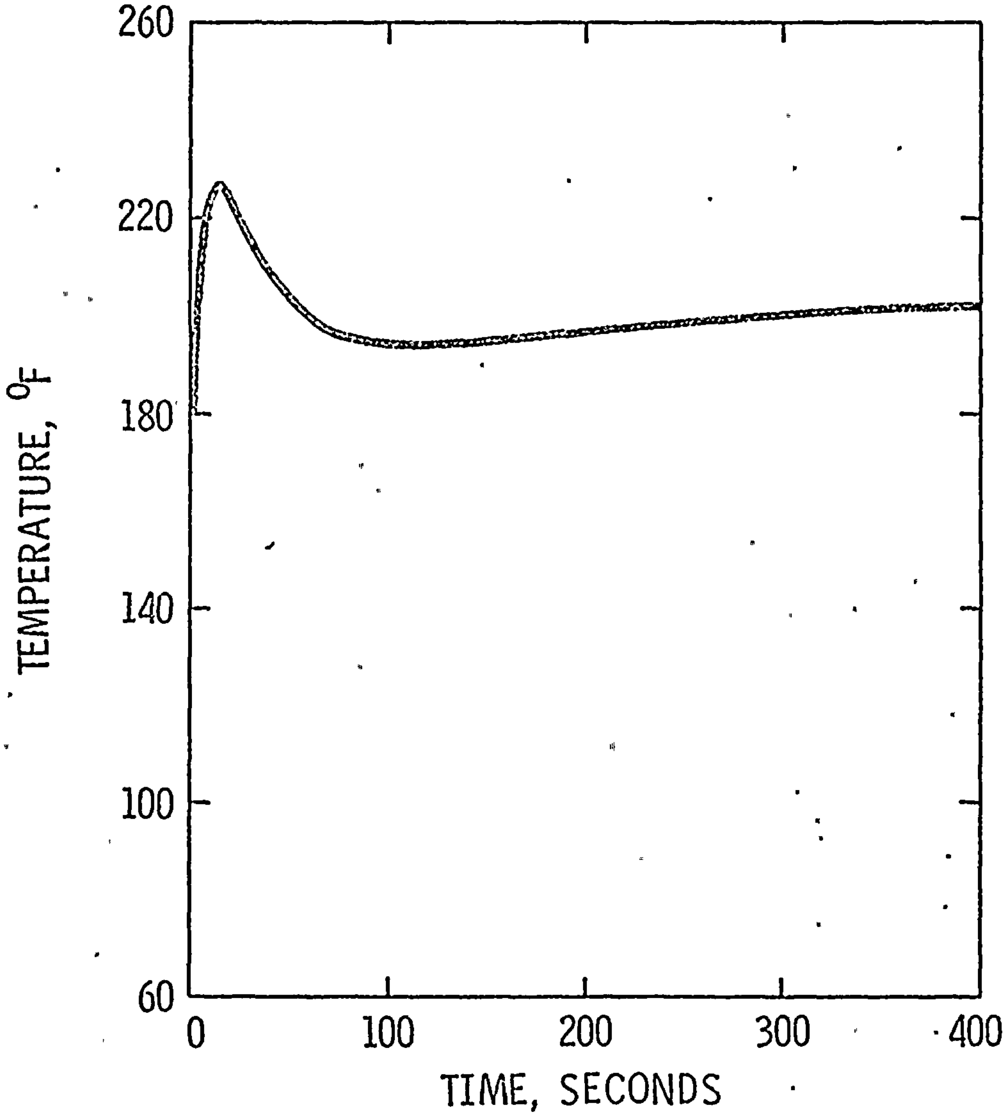


FIGURE II.6-T

ST. LUCIE II

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

SUMP TEMPERATURE

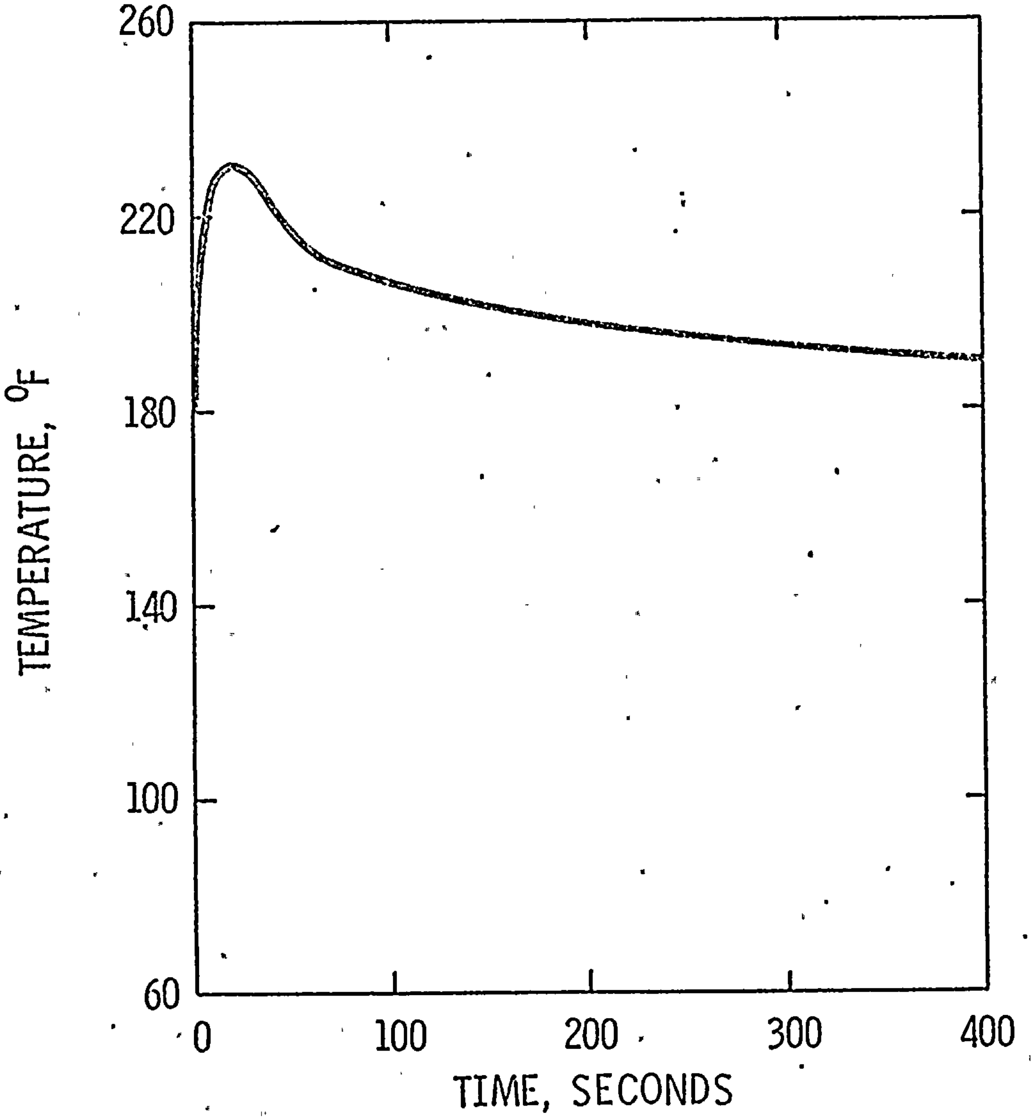


FIGURE II.7-A

ST. LUCIE II
0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
CORE POWER

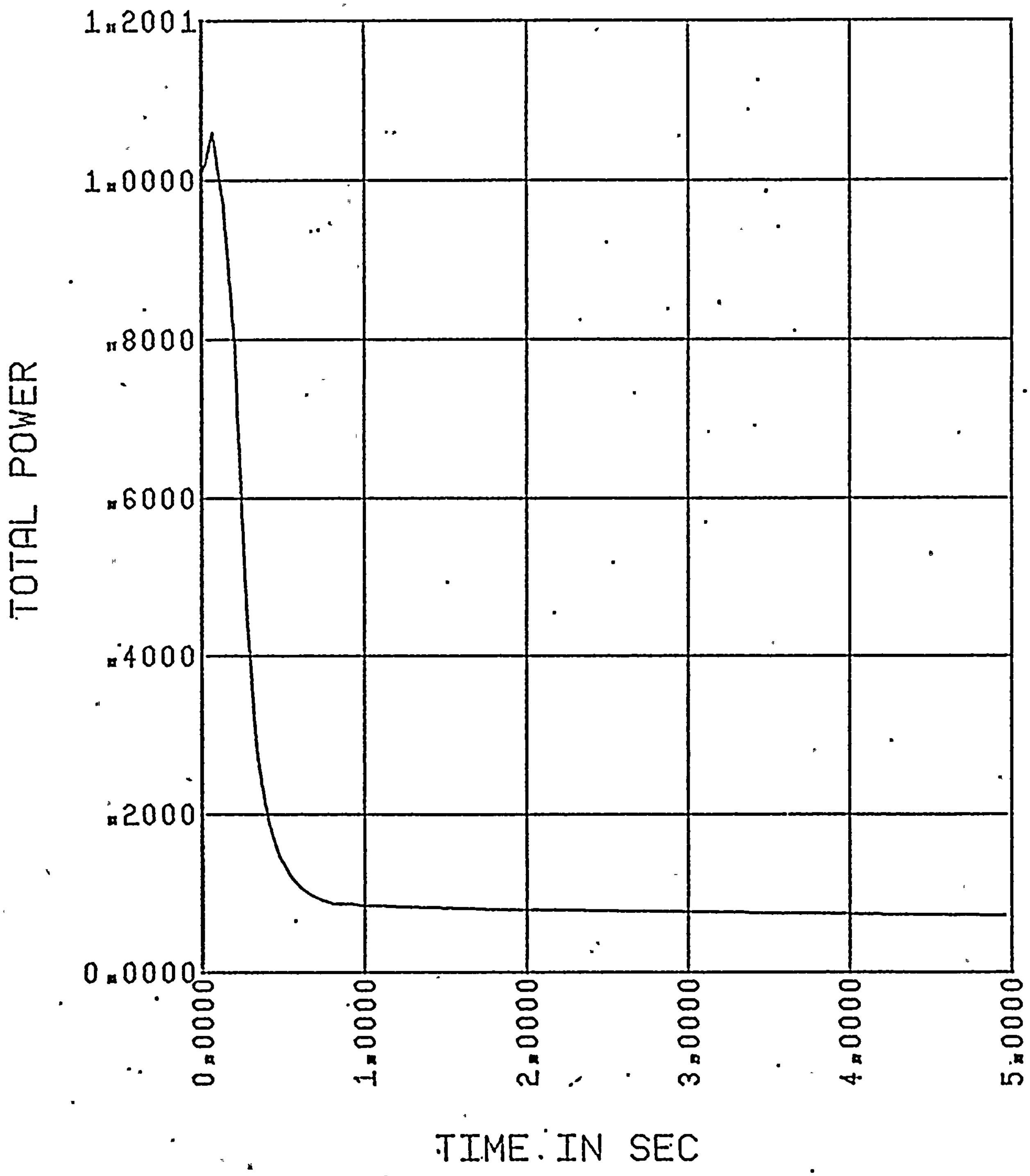


FIGURE II.7-B

ST. LUCIE II
0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

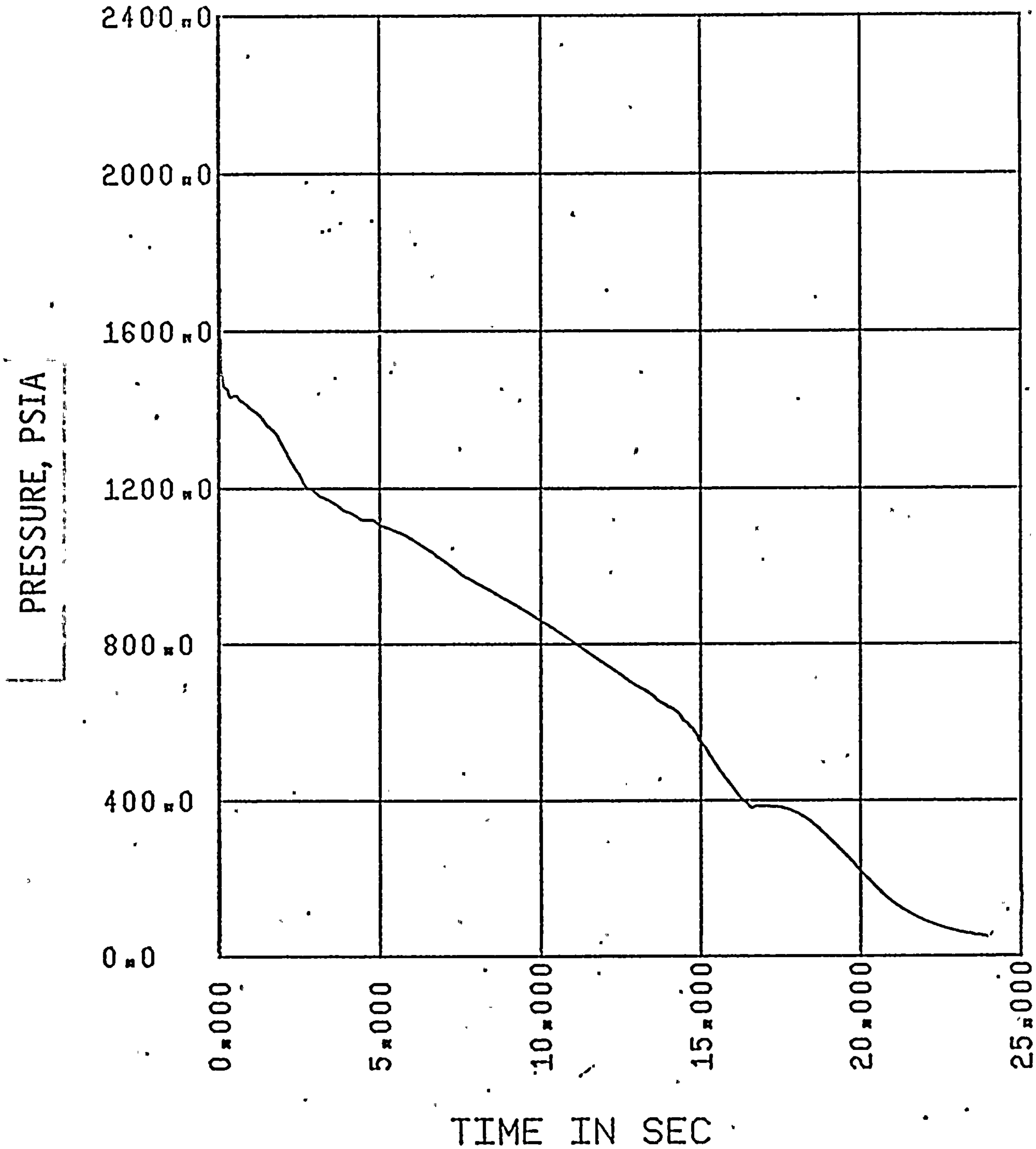


FIGURE II.7-C

ST. LUCIE II
0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
LEAK FLOW

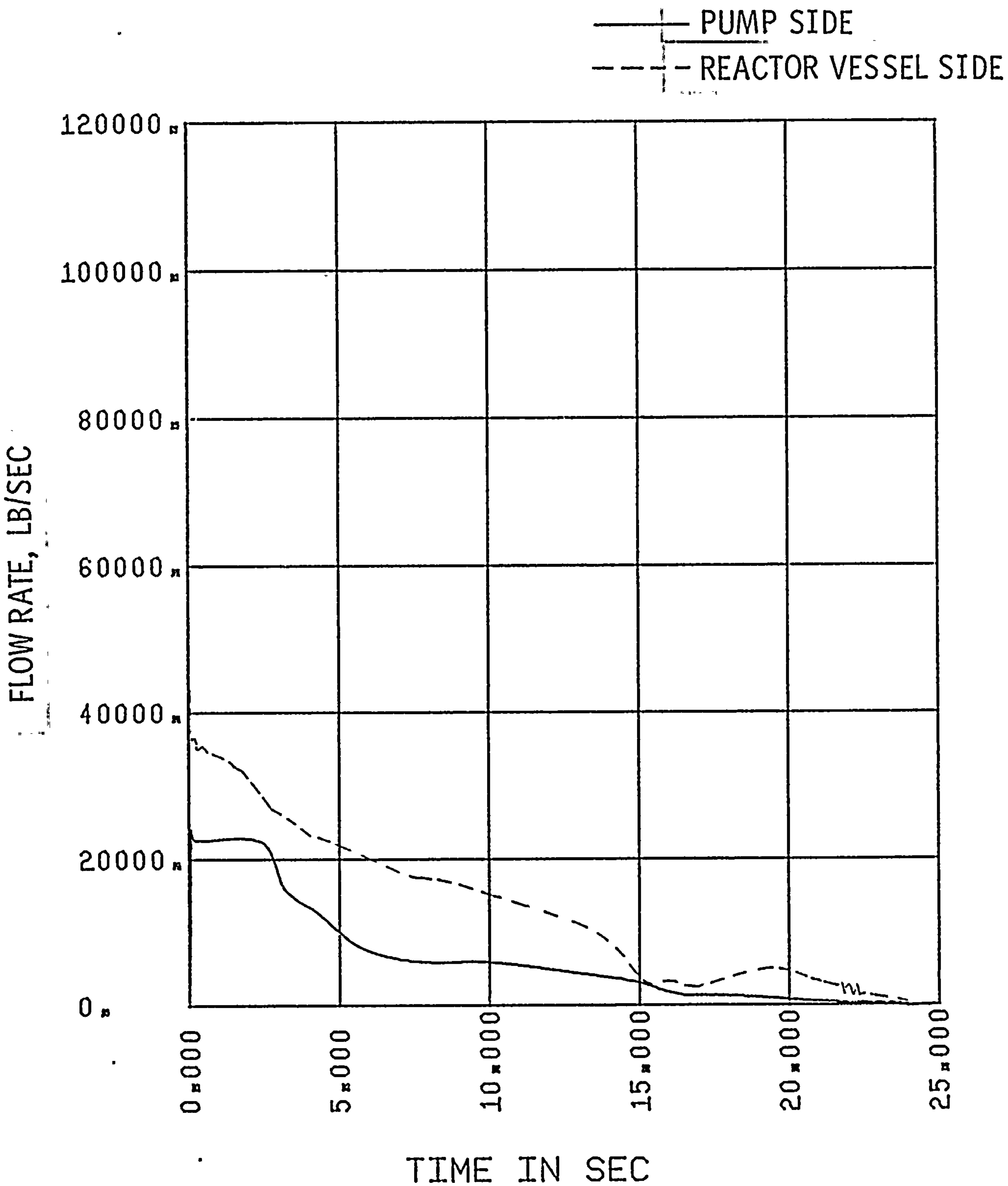


FIGURE II.7-D.1

ST. LUCIE II
0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

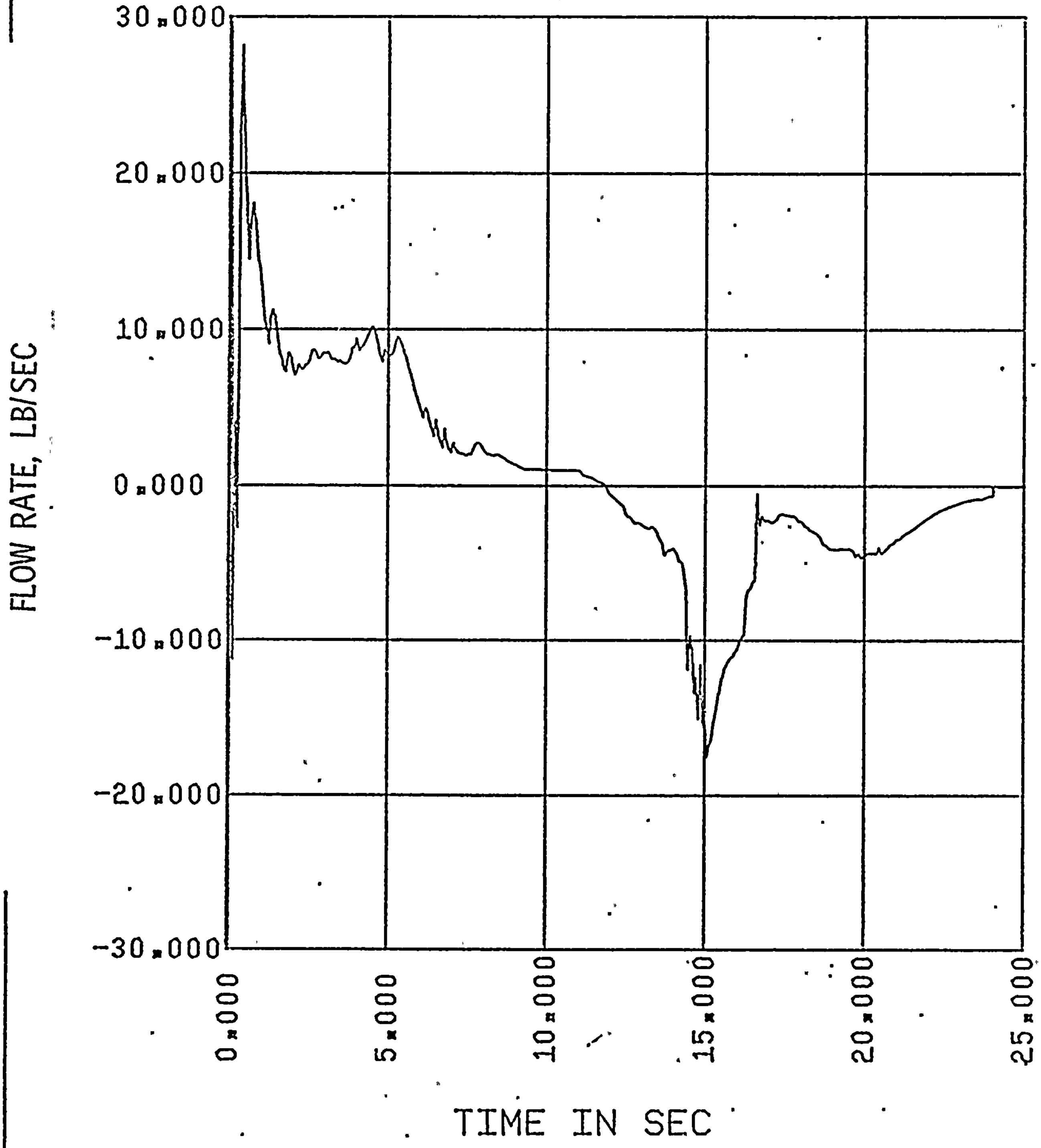


FIGURE II.7-D.2

ST. LUCIE II
0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG.
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

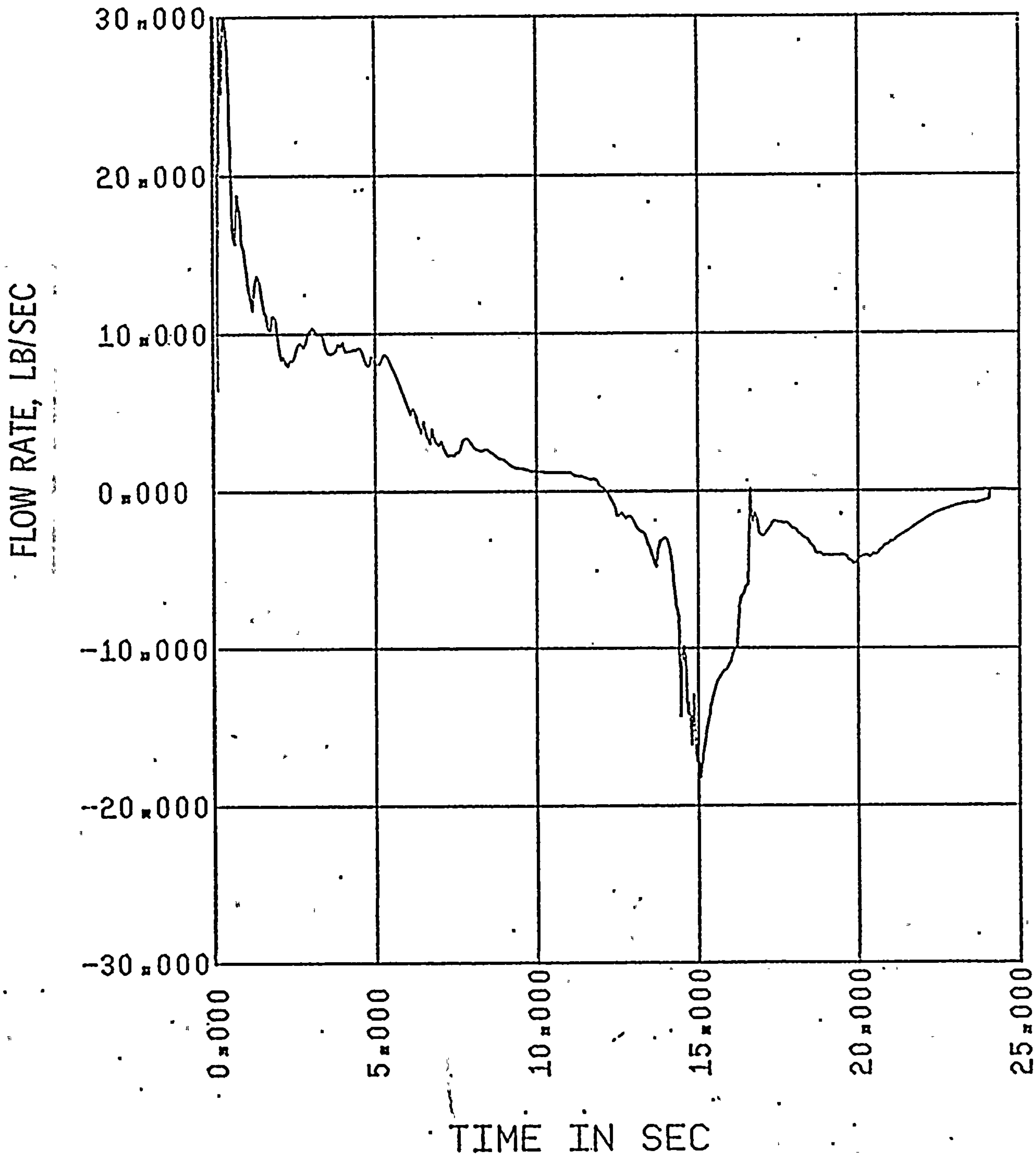


FIGURE II.7-E

ST. LUCIE II

0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

HOT ASSEMBLY QUALITY

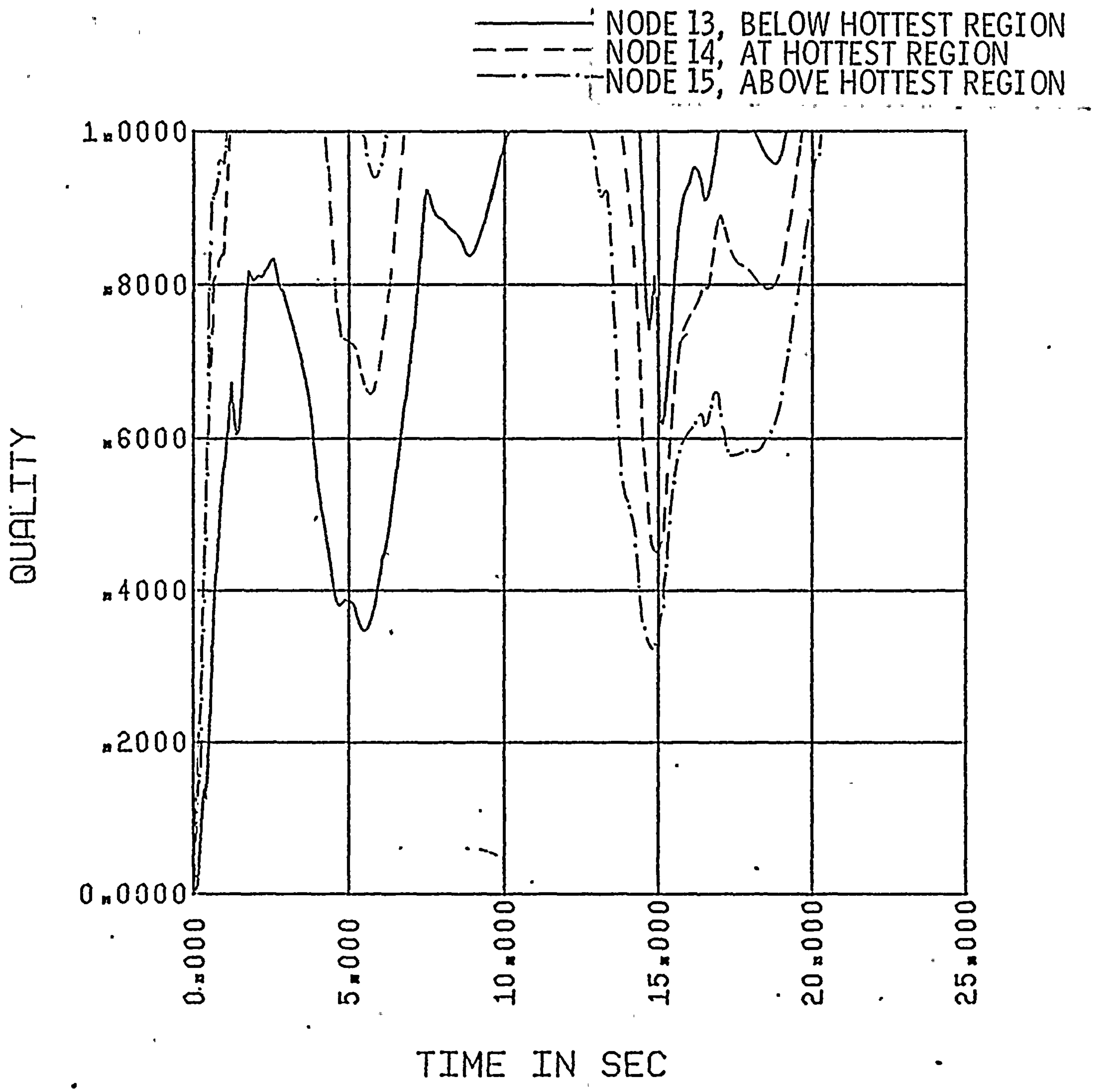


FIGURE II.7-F

ST. LUCIE II

0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

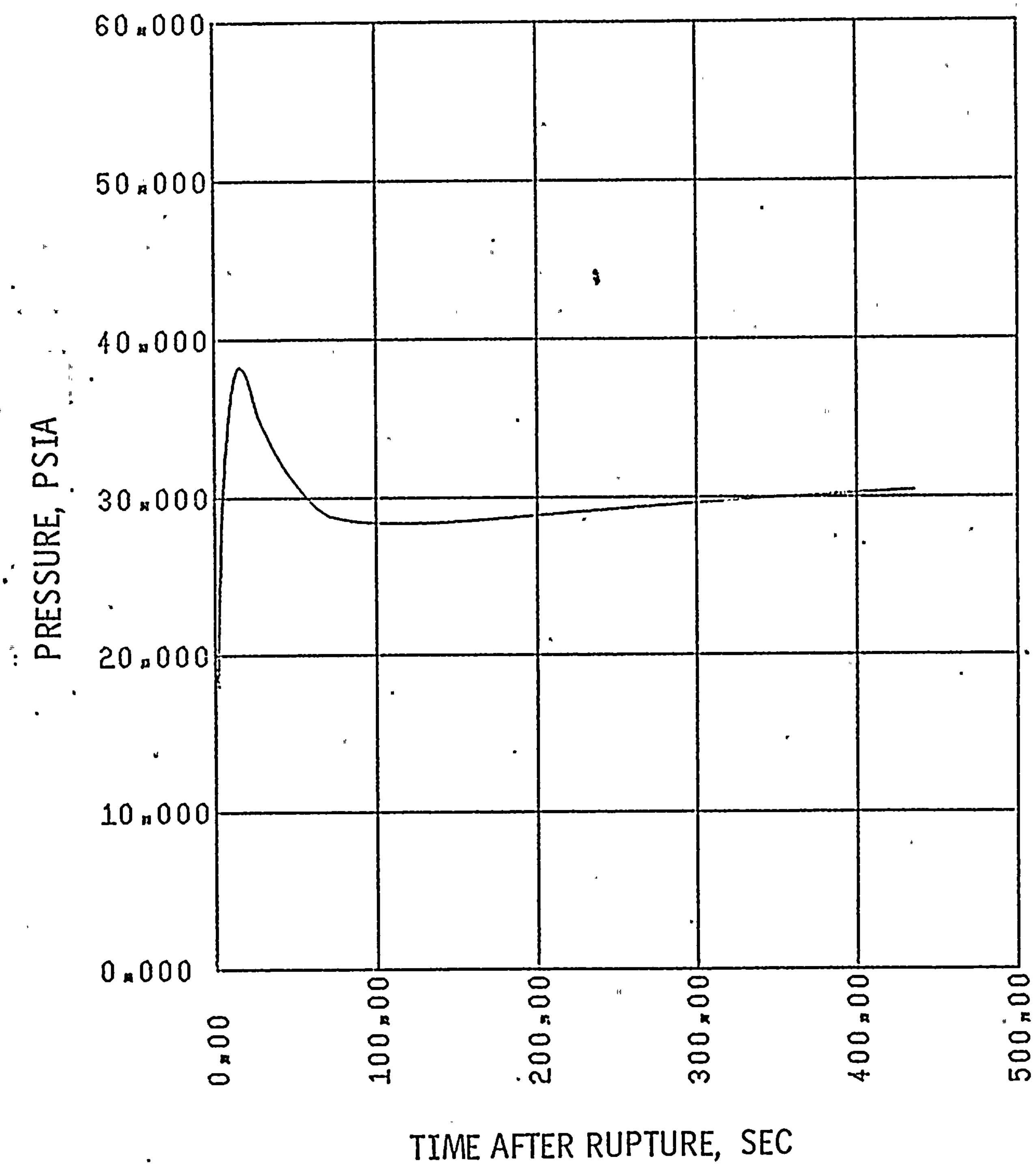


FIGURE II.7-G

ST. LUCIE II

0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

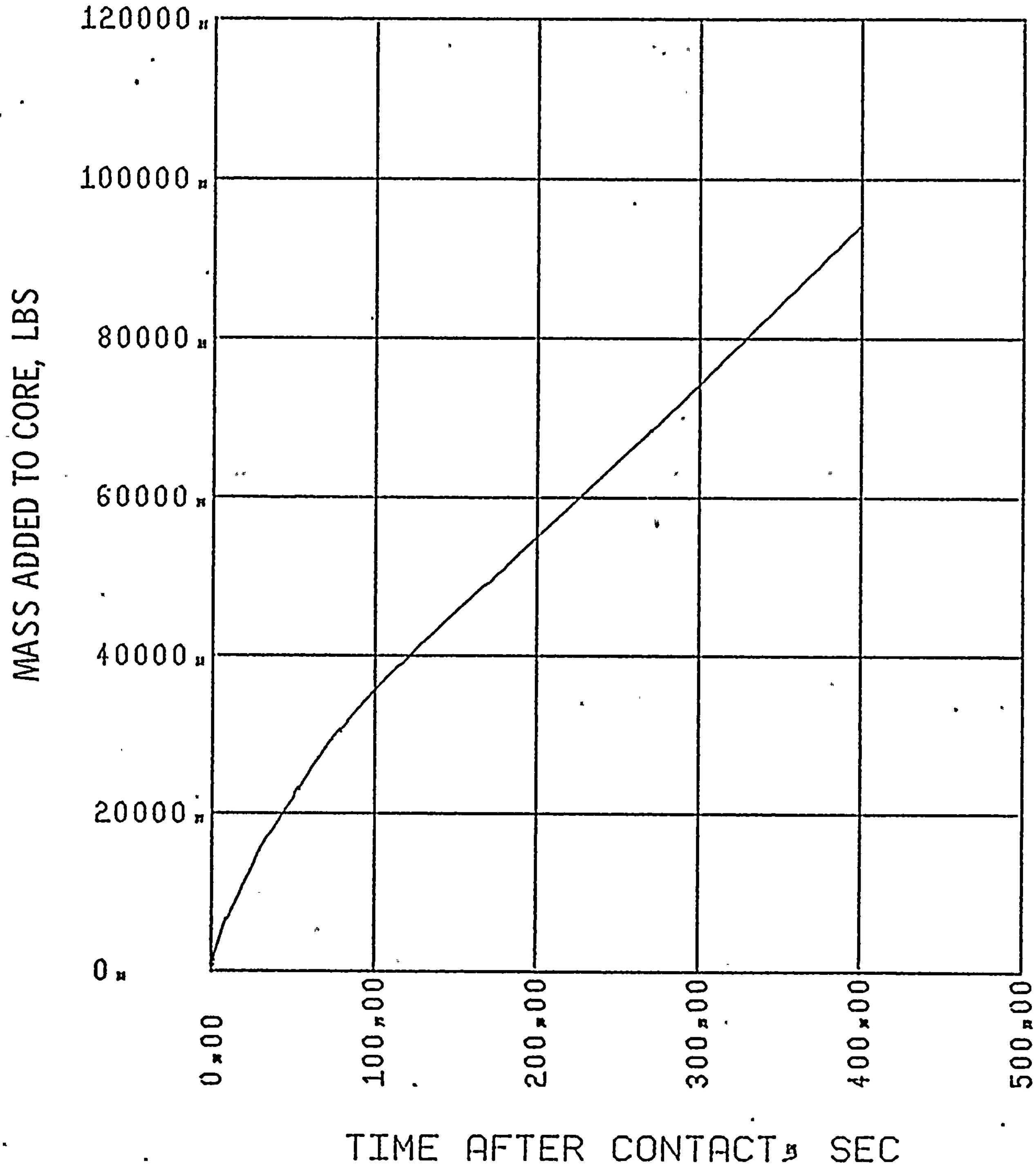


FIGURE II.7-H

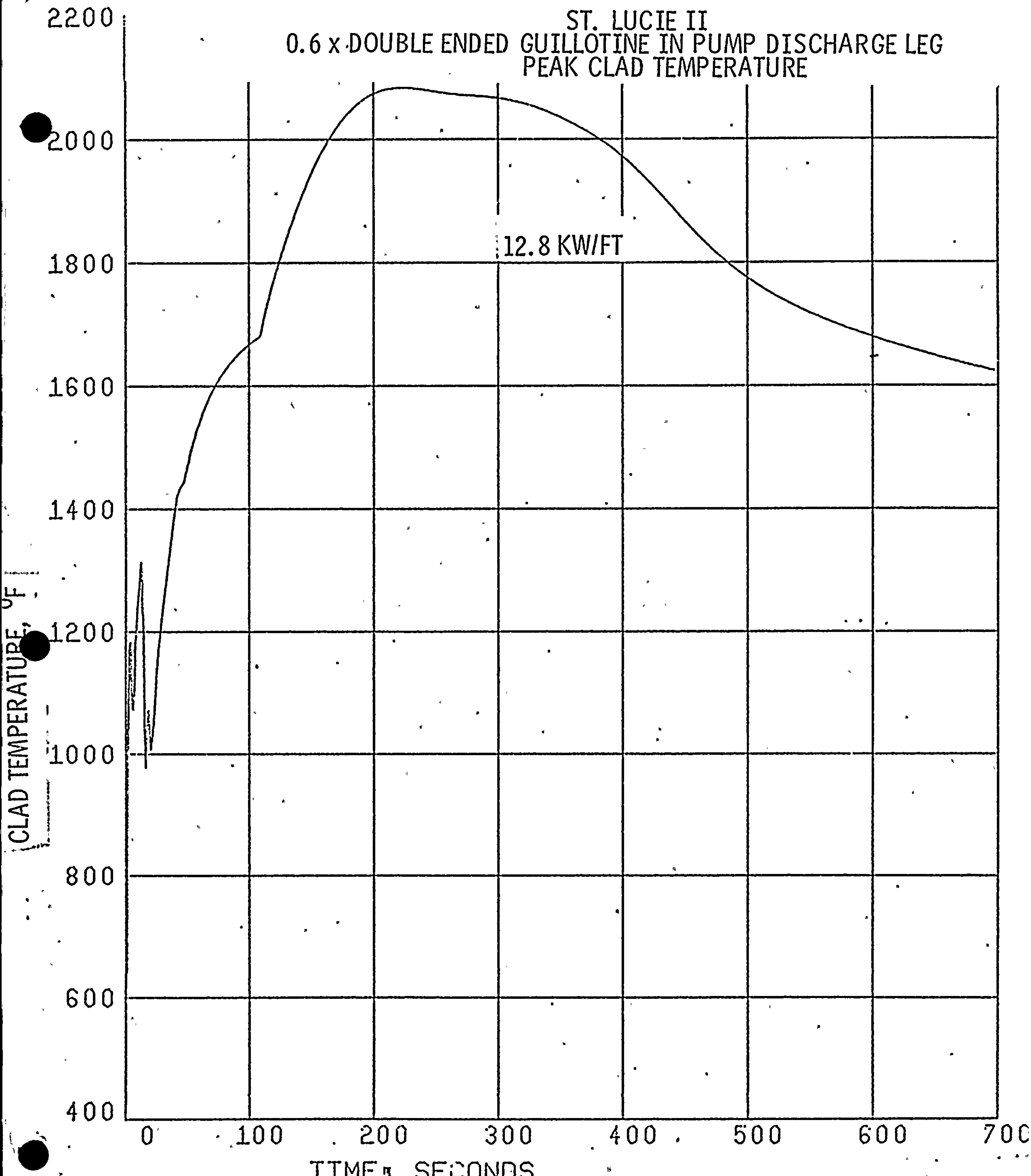

ST. LUCIE II
0.6 x DOUBLE ENDED GUILLOTINE IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE
12.8 KW/FT
CLAD TEMPERATURE, °F
2200
2000
1800
1600
1400
1200
1000
800
600
400
0
100
200
300
400
500
600
700
TIME, SECONDS

FIGURE II.8
ST. LUCIE II
PEAK CLAD TEMPERATURE vs BREAK AREA

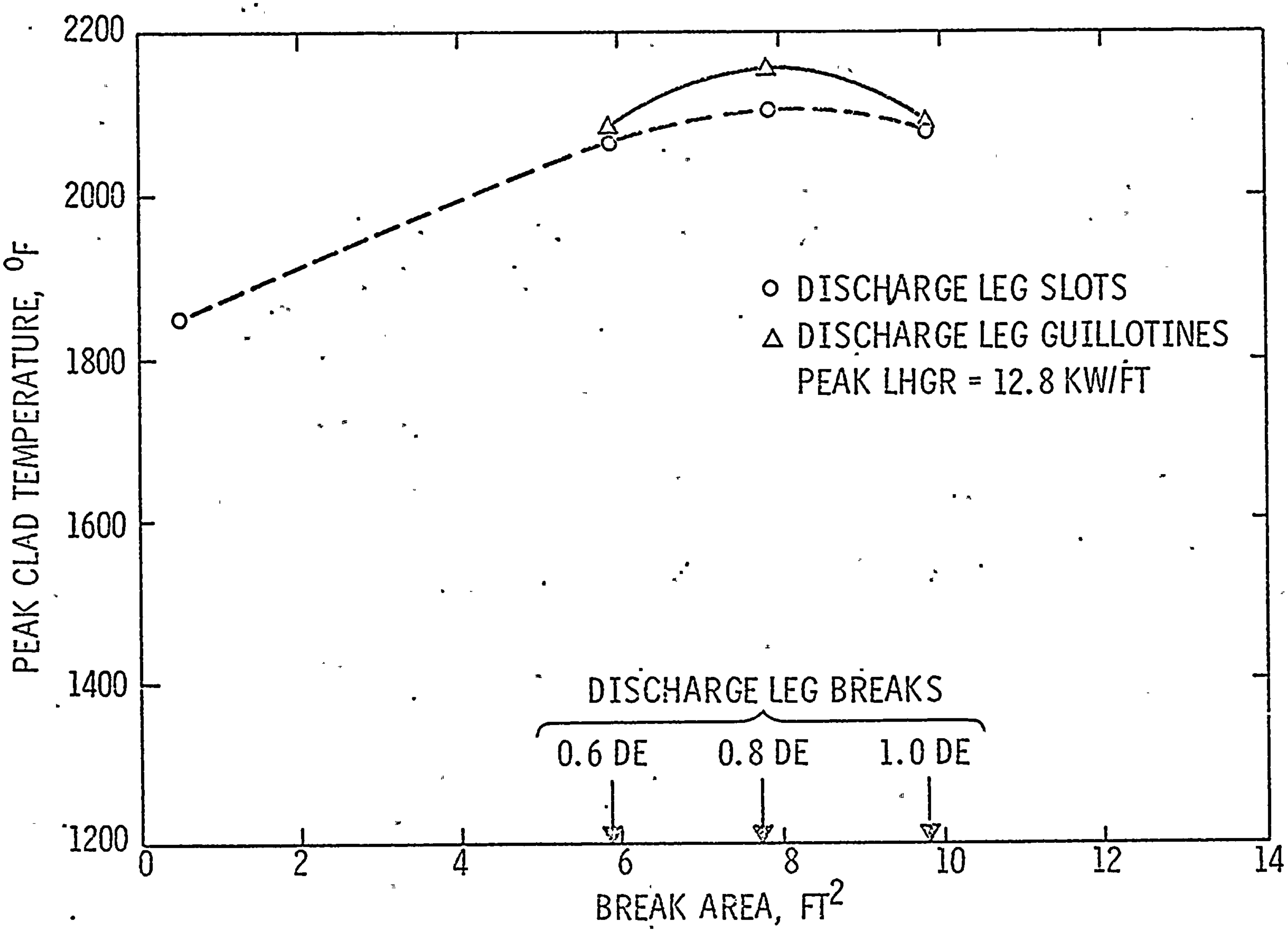
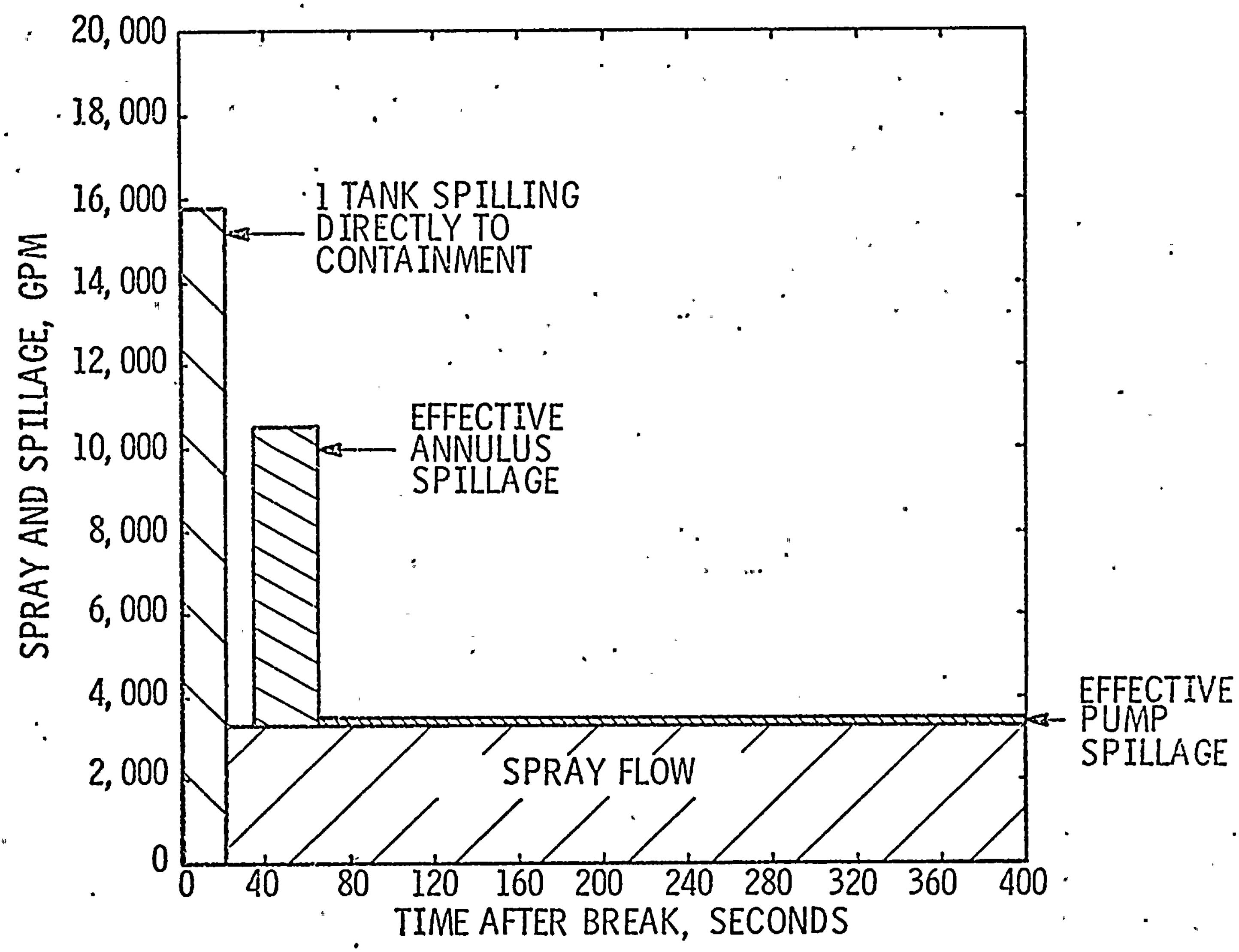


FIGURE II.9

ST. LUCIE - UNIT 2

COMBINED SPILLAGE AND SPRAY INTO CONTAINMENT



St. Lucie I ECCS Performance Results

I. Introduction and Summary

On January 4, 1974, the Atomic Energy Commission issued New Acceptance Criteria for Emergency Core Cooling Systems for Light Water-Cooled Reactors (1). The analysis presented herein demonstrates that the St. Lucie I ECCS design satisfies these new criteria. The analysis has been performed using the CE large break evaluation model (CENPD-132). The large break evaluation model results are presented in Section II and cover primary system ruptures larger than 0.5 ft^2. As demonstrated in CENPD-137[8], breaks smaller than 0.5 ft^2 are not limiting. Therefore, a small break spectrum analyses has not been performed.

CE has recognized the similarity which exists for the NSSS of the 2560 MWt Reactor Plants (Calvert Cliffs I, Millstone Point 2, St. Lucie I, and Calvert Cliffs II) and has performed a generic blowdown calculation to be used for all of these ECCS performance evaluation analyses. The features of each of these reactors have been compared and the appropriate parameters for the calculation were selected on the basis of conservatism (e.g. stored energy in the fuel has been maximized). However, due to the sensitivity of the thermal behavior of the hottest rod to the unique features of the fuel, containment building, and safeguard systems, explicit refill, reflood, and hot rod thermal transient calculations have been performed for St. Lucie I.

Peak clad temperature calculations were performed for the entire spectrum of break sizes at a peak linear heat generation rate (LHGR) of 14.5 kw/ft. Since at this LHGR the peak clad temperature for the worst break (1.0 x DEG/PD*) was only 2128°F, this case was rerun at a peak LHGR of 14.6 kw/ft. This latter calculation included corrections as a result of the quality assurance procedure and produced a peak clad temperature of 2178°F, which is still below the criteria limit of 2200°F, thus demonstrating that operation at a peak LHGR of 14.6 kw/ft is acceptable.

---

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

The results of this study supercede those reported in Reference 2 and show that the plant meets the AEC 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 spectrum analysis yielded a peak clad temperature of 2178°F for the 1.0 x DEG/PD break at a peak linear heat generation rate of 14.6 kw/ft.

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

The spectrum analysis yielded a local peak clad oxidation percentage of 10.88% for the 1.0 x DEG/PD break.

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 fuel, excluding the cladding surrounding the plenum volume, were to react".

The 0.8 x DEG/PD break produced the highest core-wide oxidation which was <0.788%.

Criterion (4) Coolable Geometry. "Calculated changes in core geometry shall be such that the core remains amenable to cooling".

The clad swelling and rupture model which is part of the CE Evaluation Model[3] accounts for the effects of changes in core geometry if such changes are predicted to occur. With these core geometry changes, core cooling was enough to lower temperatures. No further rupture can occur since the calculations were carried to the point at which the temperatures were decreasing. Thus, a coolable geometry has been maintained.

Criterion (5) Long Term Cooling. "After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core".

The spectrum analysis presented in this report shows that the rapid insertion of borated water from the ECCS will suitably limit the peak clad temperature and cool the core within a short period of time. Subsequently, the safety injection pumps would supply cooling water from the refueling water tank to remove decay heat resulting from the long-lived radioactivity remaining in the core. When the refueling water tank is nearly empty, the safety injection pumps would then be lined up to recirculate water from the containment sump. In this manner, the core would be cooled for an indefinite period of time.

II. Large Break Analysis

A. Method of Calculation

The calculations reported in this section were performed using Combustion Engineering's new large break evaluation model which is described in Reference 3. In this model the CEFLASH-4A[4] computer program is used to determine the primary system flow parameters during the blowdown phase and the COMPERC-II[5] computer program is used to describe the system behavior during the refill and reflood phases. The core flow and thermodynamic parameters from these two codes are used as input to the STRIKIN-II program[6] which calculates the hot rod clad temperature transient. The peak clad temperature and peak local clad oxidation percentage are therefore obtained from the STRIKIN-II calculation. The core-wide clad oxidation percentage is obtained from the results of both STRIKIN-II and the COMZIRC[5] computer programs.

During the adiabatic refill and early reflood period, the STRIKIN-II rod-to-rod radiation model described in Reference 3 is used until that time when the FLECHT heat transfer coefficient becomes larger. The FLECHT coefficients are then used throughout the remainder of the reflood period at all locations below the predicted clad rupture location. At the rupture location and above, FLECHT is used until either the reflood rate falls below 1.0 inch/second or rupture occurs, whichever time is greater. After this time, radiation and steam cooling are applied at and above the rupture location.

B. Emergency Core Cooling System Assumptions

The Emergency Core Cooling System consists of three high pressure pumps, two low pressure pumps and four safety injection tanks. Automatic operation of the pumps is actuated by either a low-low pressurizer pressure signal or a high containment pressure signal. Flow is initiated from the safety injection tanks when the cold leg pressure drops below 215 psia plus the elevation head. Parameters pertinent to the calculation of the LOCA are presented in Table II-1.

In performing the LOCA calculations, conservative assumptions are made concerning the availability of safety injection flow. It is assumed that two high pressure pumps are operable at the time of the accident. Furthermore, it is assumed that off-site power is lost and all pumps must await diesel startup before they can begin to deliver flow. (It is assumed, however, that off-site power is available for the containment spray system). Also, it is assumed that all safety injection flow delivered to the broken cold leg is lost.

An analysis of the possible single failures that can occur within the ECCS has shown that the worst single failure for the large break results is the failure of one of the low pressure pumps to start(3). Thus, only one low pressure pump is used in the current LOCA analysis for St. Lucie I.

The above assumptions lead to the conclusion that the following safety injection flows are available:

75% of the flow from two high pressure pumps (one of the three H.P. pumps is not energized on SIAS)

75% of the flow from one low pressure pump

Flow from three safety injection tanks

In the analyses reported in this section, no credit is taken for pump flow until the tanks are empty.

C. Core, System and Containment Parameters

The significant core and system parameters used in the large break calculations are presented in Table II-1. The peak linear heat rate was assumed to occur in the top of the core, the conservative location as identified in Section IV.A.4 of Ref. 3. A conservative beginning-of-life moderator temperature coefficient ($+ .2 \times 10^{-4}$ $\Delta\rho/^{o}F$) was used for all cases.

The gap conductance at the hot spot, as determined by the FATES computer program(7), represents the minimum value for the first cycle. The study of peak clad temperature versus burnup presented in Ref. 3 shows that this procedure is conservative.

Containment parameters as presented in Table II-2 are chosen to minimize containment pressure such that a conservative determination of core reflood rate is made. Pressure suppression equipment start-up times are selected at their minimum values corresponding to off-site power being available.

D. Break Spectrum

In general, all possible break locations are considered in a LOCA analysis. However, it was demonstrated in Reference 3 that ruptures in the cold leg pump discharge location produce the highest clad temperatures. This is due to the minimization of core flow for this break location. Since core flow is a function of the break size, the St. Lucie I large break calculations have been performed for the cold leg pump discharge breaks for both guillotine and slot breaks over a range of break sizes from 0.5 ft^2 to twice the flow area of the cold leg.

E. Results

Table II-3 presents a listing of the large break sizes analyzed in this study along with the figure number presenting the pertinent transient data for each break.

As noted in Table II-3 the results for each of the breaks analyzed are displayed graphically in Figures II.1 through II.7. For each break, the nine variables listed in Table II-4 are plotted as a function of time. For the break having the highest peak clad temperature (1.0 x Double-Ended Guillotine) the additional quantities listed in Table II-5 are also presented. Peak clad temperature calculations for the entire break spectrum are reported at a peak linear heat generation rate (LHGR) of 14.5 kw/ft. The calculation for the 0.8 x DEG/PD and 1.0 x DEG/PD breaks were repeated following completion of the quality assurance procedure, at a peak LHGR of 14.6 kw/ft. The resulting peak clad temperature and local clad oxidation for the latter break are included in Figures II.5-H and II.5-O, respectively.

Times of interest for the various breaks are shown in Table II-6 while Table II-7 summarizes peak clad temperatures and clad oxidation percentages. In order to terminate the clad oxidation reaction completely, it was necessary to run the STRIKIN-II calculations to 500 seconds. The limiting case was run this long but other cases were run only to 300 seconds. In Table II-7, the local clad oxidation percentages for cases run to 300 seconds were increased to approximate the oxidation percentages at 500 seconds.

It should be noted that the hot assembly region power in CEFLASH-4A was based on a peak LHGR of 17.0 kw/ft, thus conservatively allowing flexibility during the determination of the allowable peak LHGR based on the STRIKIN-II prediction of the hot rod thermal behavior. This procedure, however, leads to a very conservative core-wide clad oxidation calculation since the CEFLASH-4A hot assembly fuel and clad temperatures are used to initialize COMZIRC at the beginning of the reflood. A brief evaluation of this conservatism for Millstone Point 2 showed that the core-wide clad oxidation would be reduced from 0.933% to 0.776% by lowering the CEFLASH-4A hot assembly reference peak LHGR from 17.0 to 15.2 kw/ft. Thus, the actual values for core-wide clad oxidation would be less than those reported in Table II-7.

Figure II.8 shows peak clad temperature plotted versus break size and type. It is noticed that the worst break is the 1.0 x Double-Ended Guillotine break, which has a peak clad temperature of 2178 °F at 14.6 kw/ft.

Mass and energy release to the containment during blowdown is presented in Table II-8. Also shown in this table is the steam expulsion data during reflood. The ECC water spillage and containment spray flow rates are presented graphically in Figure II.9.

III. References

1. Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Nuclear Power Reactors, Federal Register, Vol. 39, No. 3 - Friday, January 4, 1974.

2. St. Lucie Plant Unit No. 1, FSAR, Docket No. 50-335, Section 6.3.3.6.1, Large Break Analysis, as amended by revision 15 dated October 11, 1973.

3. CENPD-132, "Calculative Methods for the CE Large Break LOCA Evaluation Model", August 1974. (Proprietary)

   CENPD-132, Supplement 1, "Updated Calculative Methods for the CE Large Break LOCA Evaluation Model", December 1974 (Proprietary).

4. CENPD-133, "CEFLASH-4A, A FORTRAN IV Digital Computer Program for Reactor Blowdown Analysis", April 1974 (Proprietary).

   CENPD-133, Supplement 2, "CEFLASH-4A, A FORTRAN IV Digital Computer Program for Reactor Blowdown Analysis (Modification)", December 1974 (Proprietary).

5. CENPD-134, "COMPERC-II, A Program for Emergency Refill-Reflood of the Core", April 1974 (Proprietary).

CENPD-134, Supplement 1, "COMPERC-II, A Program for Emergency Refill-Reflood of the Core (Modification)", December 1974 (Proprietary).

6. CENPD-135, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program, April 1974 (Proprietary).

CENPD-135, Supplement 2, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program (Modification)", December 1974 (Proprietary).

7. CENPD-139, "CE Fuel Evaluation Model", July 1974 (Proprietary).

8. CENPD-137, "Calculation Methods for the CE Small Break LOCA Evaluation Model", Combustion Engineering Proprietary Report, August, 1974 (Proprietary).

Table II-1

General System Parameters

Quantity	Value	
Reactor Power Level (102% of Nominal)	2611	MWt
Average Linear Heat Rate (102% of Nominal)	6.2126	Kw/ft
Peak Linear Heat Rate	14.60	Kw/ft
Gap Conductance at Peak Linear Heat Rate	784.1	$BTU/hr\text{-}ft^2\text{-}^oF$
Fuel Centerline Temperature at Peak Linear Heat Rate	3981.8	^oF
Fuel Average Temperature at Peak Linear Heat Rate	2602.4	^oF
Hot Rod Gas Pressure	1147.6	psia
Moderator Temperature Coefficient at Initial Density	$+0.2 \times 10^{-4}$	$\Delta\rho/^oF$
System Flow Rate (Total)	139.44×10^6	lbs/hr
Core Flow Rate	134.6×10^6	lbs/hr
Initial System Pressure	2250	psia
Core Inlet Temperature	548	^oF
Core Outlet Temperature	598	^oF
Active Core Height	11.39	Ft.
Fuel Rod OD	0.44	In.
Number of Cold Legs	4	
Number of Hot Legs	2	
Cold Leg Diameter	30	In.
Hot Leg Diameter	42	In.
Safety Injection Tank Pressure	215	psia
Safety Injection Tank Gas/Water Volume	930/1090	Ft^3

Table II-21

Containment Physical Parameters

Net Free Volume	2.5111×10^6 Ft^3
Containment Initial Conditions:	
Humidity	100%
Containment Temperature	60^oF
Enclosure Building Temperature	38^oF
Initial Pressure	14.7 psia
Initial Time for:	
Spray Flow	25 seconds
Fans (4)	25 seconds
Containment Spray Water:	
Temperature	60^oF
Flow Rate (Total, both pumps)	3375 gpm

Fan Cooling Capacity (Per Fan)

Vapor Temperature (^oF)	Capacity (BTU/Sec)
60	0.0
120	220.0
180	4700.0
220	9020.0
264	16666.0

Containment Heat Absorbing Surfaces

1. Surface Areas and Thicknesses
   a. Shell and dome - 86700.0 Ft^2
      (1) Steel - 1.4059 inches
   b. Unlined Concrete - 66186.0 Ft^2
      (1) Concrete - .50 Ft. (one side exposed to containment atmosphere, one side insulated)

Table II-2 (Con't)

Containment Physical Parameters

c. Steel - 621152.0 Ft^2

(1) Steel - .187 in. (one side insulated)

d. Base Slab - 26827.0 Ft^2

(1) Concrete - 1.0 Ft. (one side exposed to containment sump, one side exposed to ground)

2. Thermal Properties

Material	Conductivity (BTU/hr-ft-^oF)	Heat Capacity (BTU/ft^3-^oF)
a. Concrete	1.0	32
b. Steel	30.0	56

3. Heat Transfer Coefficients

a. Containment atmosphere to sump - 500 BTU/hr-ft^2-^oF

b. Sump to base slab - 10 BTU/hr-ft^2-^oF

c. Containment structure to enclosure building atmosphere - 13.0 BTU/hr-ft^2-^oF

Table II-3

Large Break Spectrum

Break Size, Type and Location	Abbreviation	Figure
1.0x Double-Ended Slot Break in Pump Discharge Leg	1.0 x DES/PD	II.1
0.8x Double-Ended Slot Break in Pump Discharge Leg	0.8 x DES/PD	II.2
0.6x Double-Ended Slot Break in Pump Discharge Leg	0.6 x DES/PD	II.3
0.5 ft^2 Slot Break in Pump Discharge Leg	0.5 ft^2 S/PD	II.4
1.0x Double-Ended Guillotine Break in Pump Discharge Leg	1.0 x DEG/PD	II.5
0.8x Double-Ended Guillotine Break in Pump Discharge Leg	0.8 x DEG/PD	II.6
0.6x Double-Ended Guillotine Break in Pump Discharge Leg	0.6 x DEG/PD	II.7

Table II-4

Variables Plotted as a Function of Time for Each Large Break in the Spectrum

Variable	Figure Designation
Core Power	A
Pressure in Center Hot Assembly Node	B
Leak Flow	C
Hot Assembly Flow (below hot spot)	D.1
Hot Assembly Flow (above hot spot)	D.2
Hot Assembly Quality	E
Containment Pressure	F
Mass Added to Core During Reflood	G
Peak Clad Temperature	H

Table II-5

Additional Variables Plotted as a Function of Time for the Large Break Having the Highest Clad Temperature

Variables	Figure Designation
Mid Annulus Flow	I
Qualities Above and Below the Core	J
Core Pressure Drop	K
Safety Injection Flow into Intact Discharge Legs	L
Water Level in Downcomer During Reflood	M
Gap Conductance	N
Local Clad Oxidation	O
Clad Temperature, Centerline Fuel Temperature, Average Fuel Temperature and Coolant Temperature for Hottest Node	P
Hot Spot Heat Transfer Coefficient	Q
Hot Spot Heat Transfer Coefficient During Reflood	R
Containment Temperature	S
Sump Temperature	T

Table II-6

Times of Interest for Each Large Break
(Seconds)

Break	Hot Rod Rupture	SI Tanks on	Start of Reflood	SI Tanks Empty
1.0 x DES/PD	10.2	17.3	37.40	69.87
0.8 x DES/PD	10.1	17.6	37.82	70.33
0.6 x DES/PD	10.6	19.3	39.52	72.09
0.5 ft^2 S/PD	292.1	173.0	193.17	225.22
1.0 x DEG/PD	10.3	17.4	37.52	70.00
0.8 x DEG/PD	10.2	17.9	38.14	70.61
0.6 x DEG/PD	32.0	20.1	40.44	72.95

Table II-7

Peak Clad Temperatures and Oxidation Percentages
for the Break Spectrum

Break	Peak Clad Temperature (°F)	Clad Oxidation (%) Local	Core-Wide
14.5 kw/ft			
1.0 DES/PD	2119	<8.61*	<0.699
0.8 DES/PD	2116	<8.48*	<0.684
0.6 DES/PD	2090	<7.84*	<0.623
0.5 ft^2 S/PD	1691	2.12	<0.136
1.0 DEG/PD	2128	8.86	<0.723
0.8 DEG/PD	2126	8.83	<0.734
0.6 DEG/PD	2046	<6.57*	<0.494
14.6 kw/ft			
1.0 DEG/PD	2178	10.88	<0.775
0.8 DEG/PD	2175	10.81	<0.788

*These cases were run to 300 seconds, long enough to observe the temperature peak for the hottest node, but not long enough to completely terminate clad oxidation in the rupture node, which exhibits the highest local clad oxidation percentage. Total local clad oxidation for these cases was based on the value at 300.0 sec., plus the relative accumulation thereafter for the 1.0 x DEG/PD (worst case), which was run to 500 secs.

TABLE II.8

ST. LUCIE I

BLOWDOWN AND REFLOOD MASS AND ENERGY RELEASE DATA

1.0 × DEG/PD

TIME (SEC)	MASS FLOW (LBM/SEC)	ENERGY RELEASE (BTU/SEC)	INTEGRAL OF MASS FLOW (LBM)	INTEGRAL OF ENERGY RELEASE (BTU)
0	0.0	0.0	0.0	0.0
.05	6.9362 × 10^4	3.7310 × 10^7	3.5061 × 10^3	1.8867 × 10^6
.10	7.4653	4.0171	7.4321 × 10^3	3.9999
.15	7.4171	3.9877	1.1144 × 10^4	5.9962
.20	7.0460	3.7657	1.4752	7.9359
.25	7.0607	3.8000	1.8296	9.8421 × 10^6
.35	6.8995	3.7187	2.5262	1.3594 × 10^7
.45	6.8197	3.6788	3.2102	1.7282
.60	6.7990	3.6707	4.2328	2.2801
.80	6.7690	3.6575	5.5692	3.0128
1.0	6.7344	3.6420	6.9393	3.7428
1.4	6.5348	3.5422	9.6048 × 10^4	5.1856
1.8	6.2657	3.4048	1.2172 × 10^5	6.5788
2.2	5.6606	3.0313	1.4592	7.8957
2.6	4.6288	2.52045	1.6628	9.0039
3.0	4.2854	2.3371	1.8396	9.9677 × 10^7
3.4	4.0611	2.2193	2.0062	1.0877 × 10^8
3.8	3.8998	2.13988	2.1652	1.1747
4.4	3.6669	2.03412	2.3921	1.2998
5.2	3.2849	1.86578	2.6704	1.4560
6.0	2.99319	1.73678	2.9211	1.5999
6.8	2.70596	1.60794	3.1493	1.7358
7.6	2.45546	1.48887	3.3549	1.8575
8.4	2.32611	1.40003	3.5458	1.9729
9.2	2.17739	1.30558	3.7264	2.0813
10.0	1.98277 × 10^4	1.19880 × 10^7	3.8930 × 10^5	2.1815 × 10^8

TABLE II.8 (Cont'd)

TIME SEC	MASS FLOW LBM/SEC		ENERGY RELEASE BTU/SEC		INTEGRAL OF MASS FLOW LBM		INTEGRAL OF ENERGY RELEASE BTU	
11.0	1.71699	× 10⁴	1.05931	× 10⁷	4.0781	× 10⁵	2.2944	× 10⁸
12.0	1.41046	× 10⁴	9.2124	× 10⁶	4.2354	↓	2.3935	↓
13.0	8.8338	× 10³	7.7064	↓	4.3507	↓	2.4780	↓
14.0	6.8269	↓	6.5242	↓	4.4273	↓	2.5488	↓
15.0	4.9511	↓	5.5214	↓	4.4861	↓	2.6081	↓
16.0	3.7906	↓	4.1699	↓	4.5296	↓	2.6553	↓
17.0	2.7142	↓	3.2668	↓	4.5619	↓	2.6924	↓
18.0	1.92799	↓	2.35475	↓	4.5853	↓	2.7206	↓
19.0	1.28730	× 10³	1.58444	× 10⁶	4.6010	↓	2.7398	↓
20.0	5.0392	× 10²	6.3454	× 10⁵	4.6113	↓	2.7525	↓
21.0	9.9743	× 10	1.1412	× 10⁵	4.6169	↓	2.7591	↓
21.1	7.0460	× 10²	8.2612	× 10⁵	4.6172	× 10⁵	2.7595	× 10⁸

↑ TIME OF ANNULUS DOWNFLOW

↓ START OF REFLOOD (VALUES BELOW ARE FOR STEAM ONLY)

TIME SEC	MASS FLOW LBM/SEC		ENERGY RELEASE BTU/SEC		INTEGRAL OF MASS FLOW LBM		INTEGRAL OF ENERGY RELEASE BTU	
38.1	0	0	0	0	4.6172	× 10⁵	2.7595	× 10⁸
48.1	0	0	0	0	4.6172	↓	2.7595	↓
58.1	0	0	0	0	4.6172	↓	2.7595	↓
68.1	0	0	0	0	4.6172	↓	2.7595	↓
78.1	1.8299	× 10²	2.2376	× 10⁵	4.6365	↓	2.7846	↓
88.1	1.7214	↓	2.2385	↓	4.6917	↓	2.8564	↓
98.1	1.6852	↓	2.1914	↓	4.7322	↓	2.9727	↓
108.1	1.6659	↓	2.1664	↓	4.9012	↓	3.1327	↓
118.1	1.6484	↓	2.1436	↓	5.0604	↓	3.3358	↓
128.1	1.6317	× 10²	2.1219	× 10⁵	5.2494	× 10⁵	3.5816	× 10⁸

TABLE II.8 (Cont'd)

TIME	MASS	FLOW	ENERGY	RELEASE	INTEGRAL OF MASS	FLOW	INTEGRAL OF ENERGY	RELEASE
SEC	LBM / SEC		BTU / SEC		LBM		BTU	
136.1	1.6227	× 10^2	2.1102	× 10^5	5.4709	× 10^5	3.8694	× 10^8
146.1	1.6135	↓	2.0981	↓	5.7247	↓	4.1997	↓
156.1	1.6211		2.1081		6.0109		4.5717	
168.1	1.6032		2.0848		6.3293		4.9959	
176.1	1.6137		2.1050		6.6799		5.4418	
188.1	1.6198		2.1064		7.0627		5.9597	
198.1	1.6161		2.1016		4.4779		6.4795	
208.1	1.6191		2.1055		7.9254	↓	7.0615	
228.1	1.6340		2.1248		8.9179	× 10^5	8.5521	↓
248.1	1.6404		2.1352		1.0019	× 10^6	9.8130	× 10^8
268.1	1.6603		2.1590		1.1274	↓	1.1336	× 10^9
288.1	1.6559		2.1572		1.2661		1.3190	↓
308.1	1.6841		2.1900		1.4181		1.5167	
328.1	1.6803		2.1651		1.5835		1.7318	
348.1	1.6876		2.1946		1.7624		1.9648	
368.1	1.7112		2.2253		1.9549		2.2148	
388.1	1.7196		2.2361		2.1610		2.4826	
408.1	1.7182	↓	2.2343	↓	2.3809	↓	2.7687	↓
458.1	1.7366	× 10^2	2.2583	× 10^5	2.7364	× 10^6	3.2310	× 10^9

Figure II.1-A

2560 MWt PLANTS
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

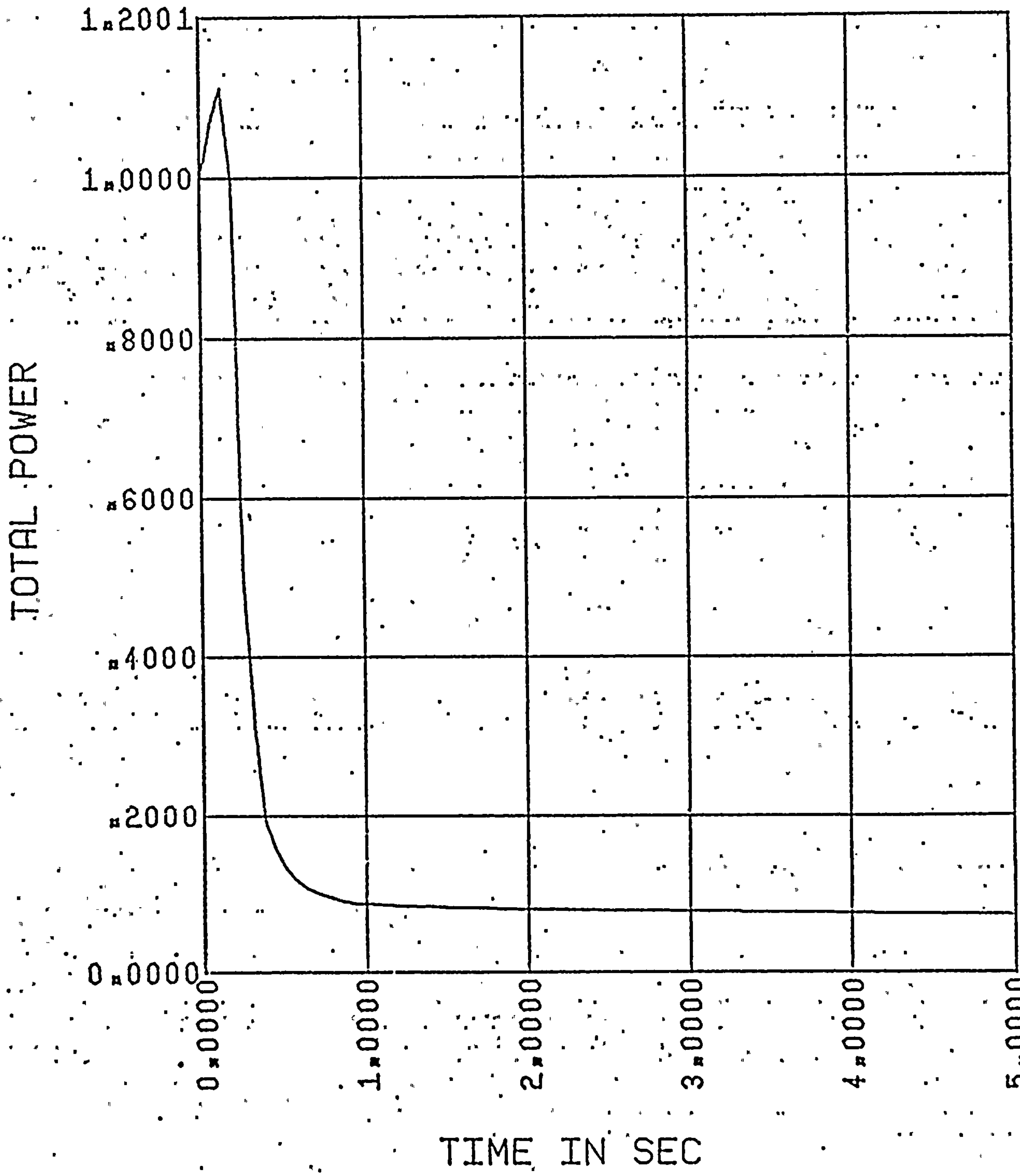


Figure II.1-B

2560 MWt PLANTS
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

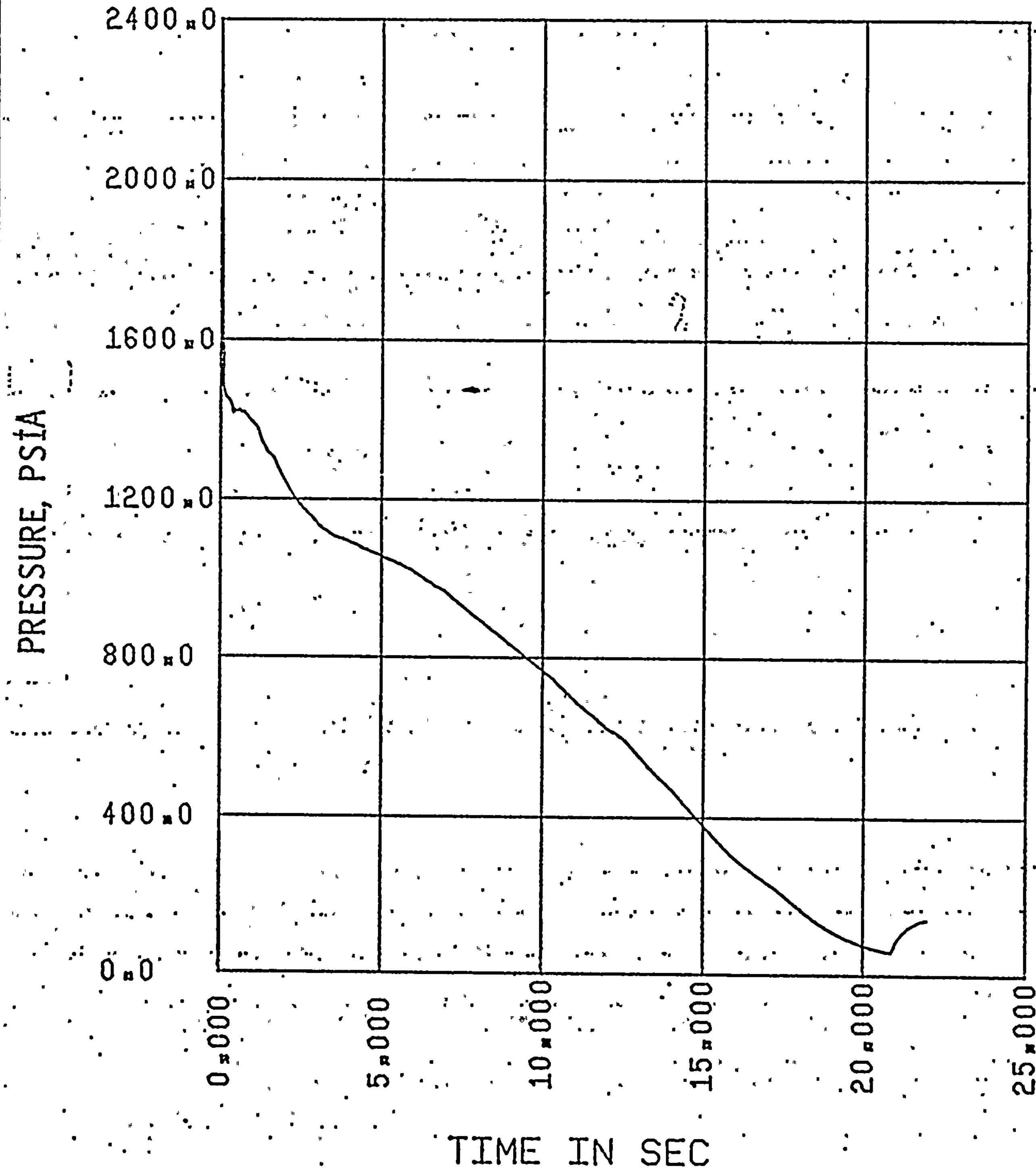


Figure II.1-C

2560 MWt PLANTS

1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

LEAK FLOW

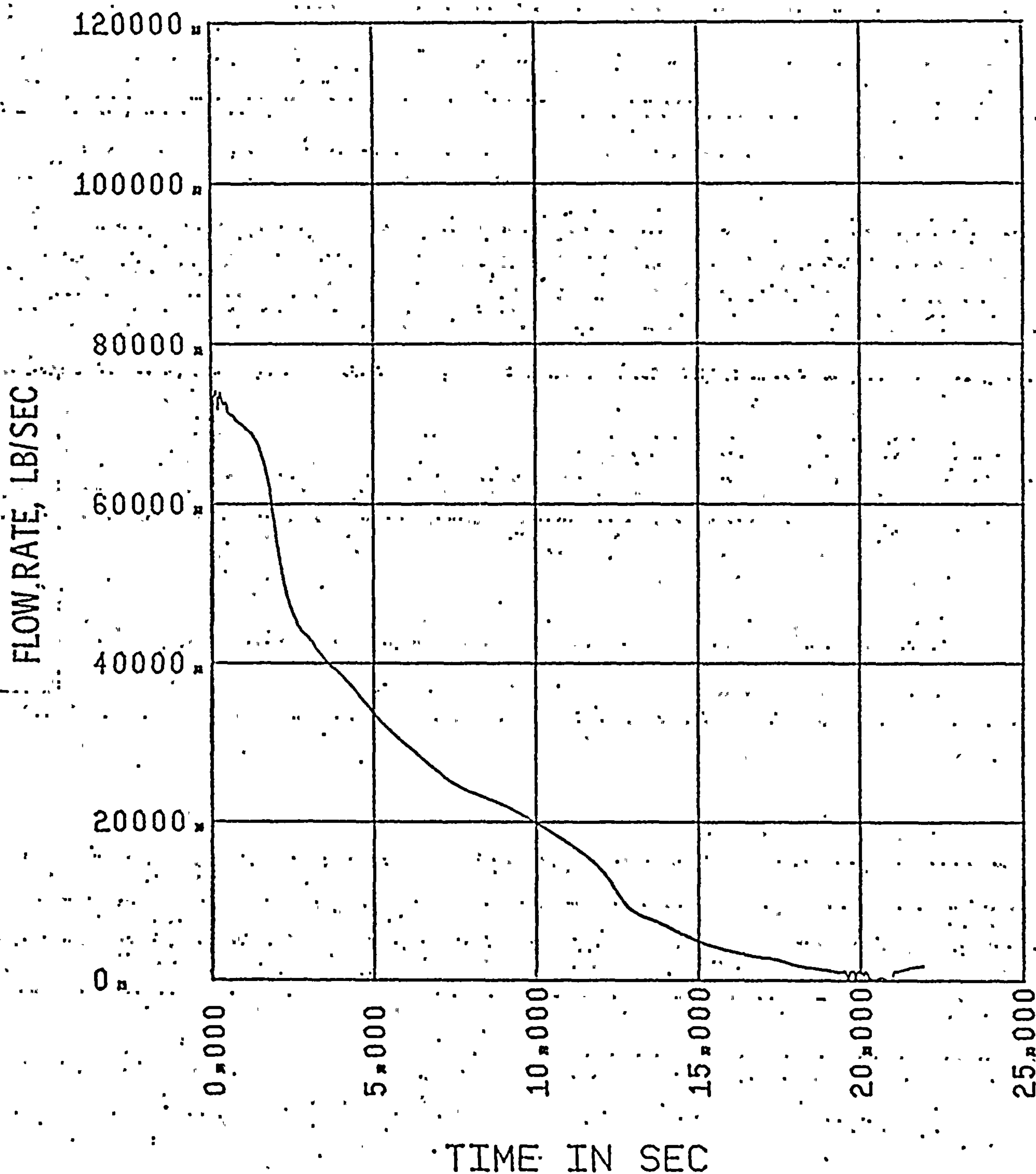


Figure II.1-D.1

2560 MWt PLANTS
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

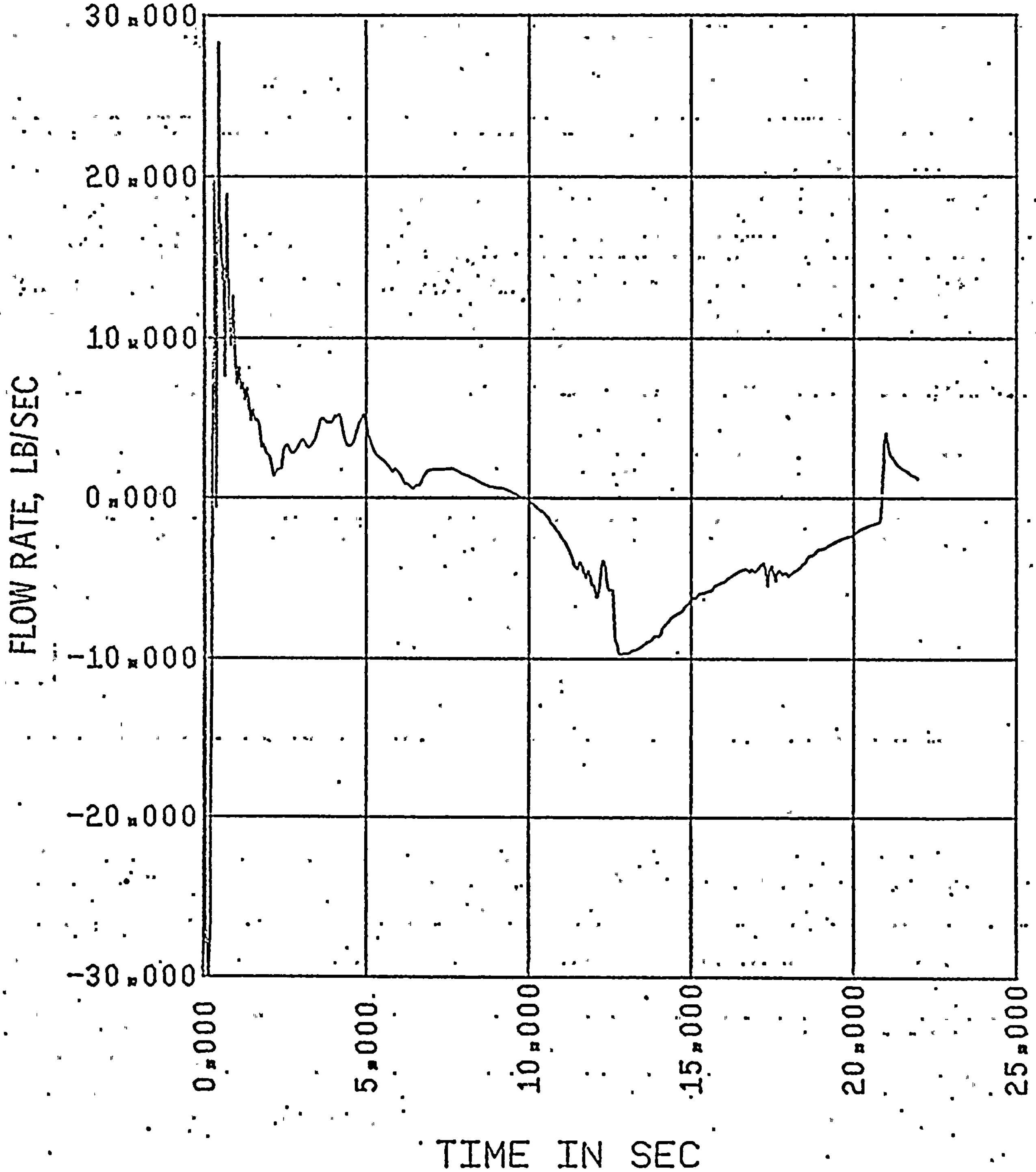


Figure II.1-D.2

2560 MWt PLANTS
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

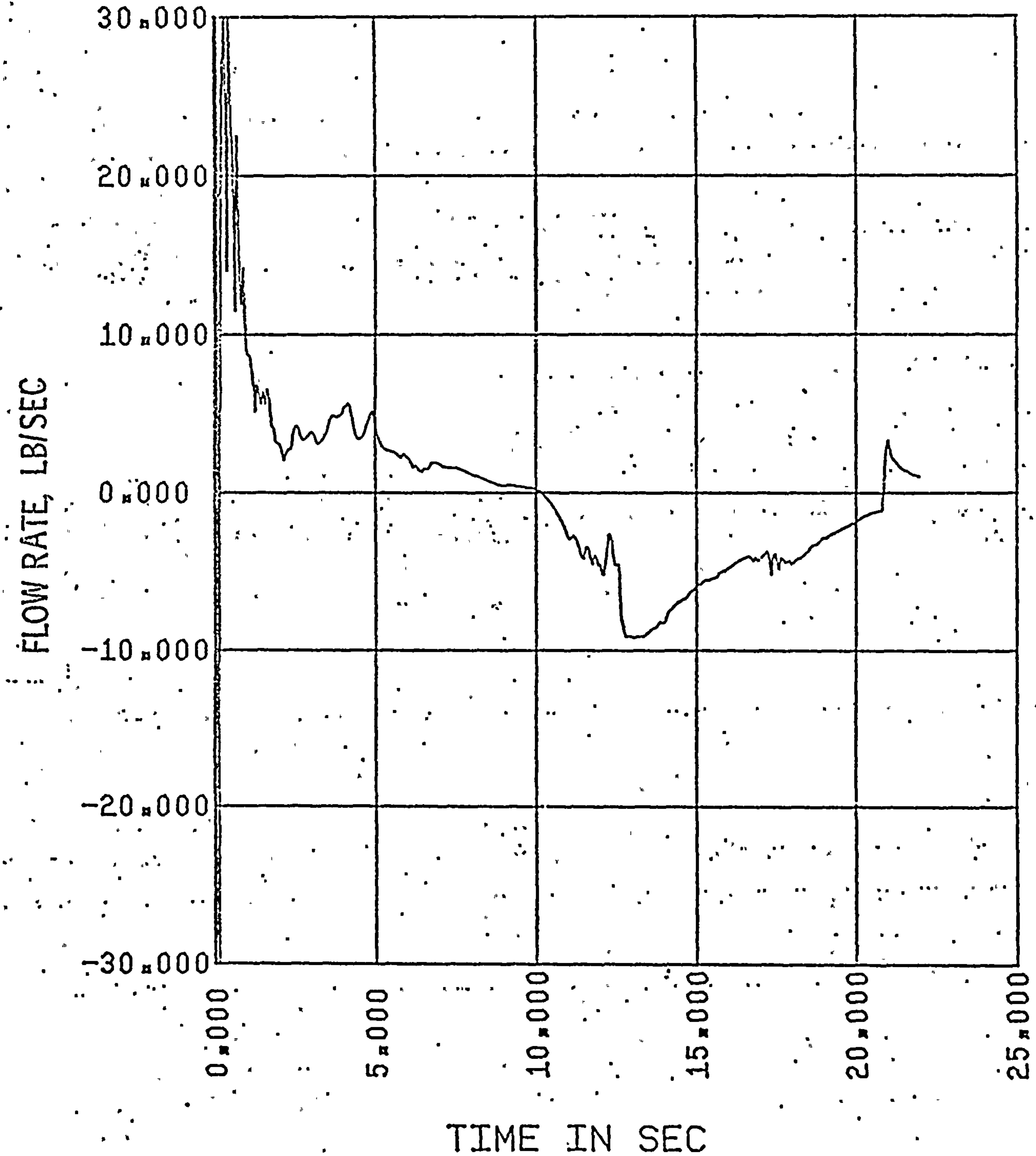


Figure II.1-E

2560 MWt PLANTS
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

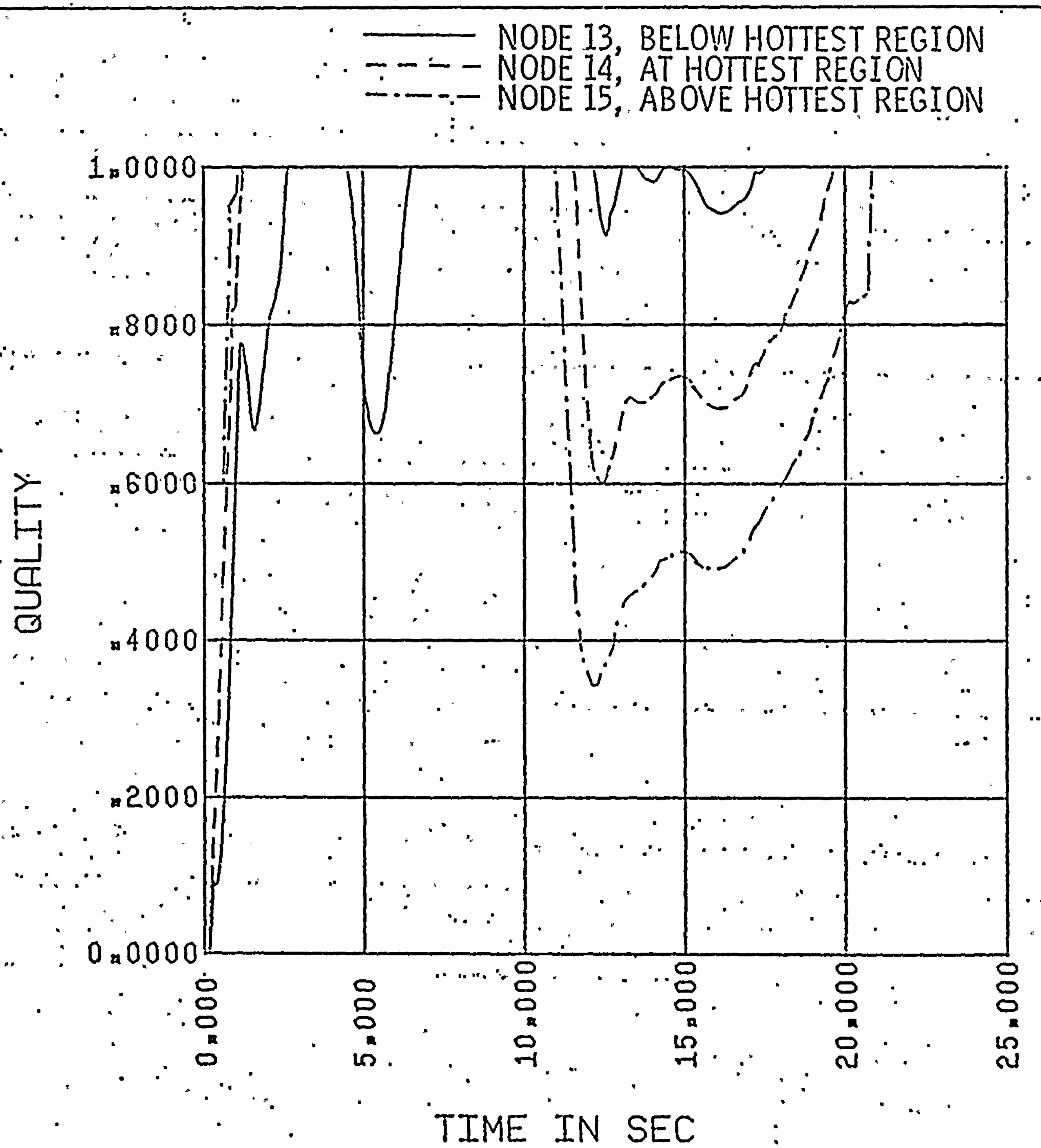


Figure II.1-F
ST. LUCIE I
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

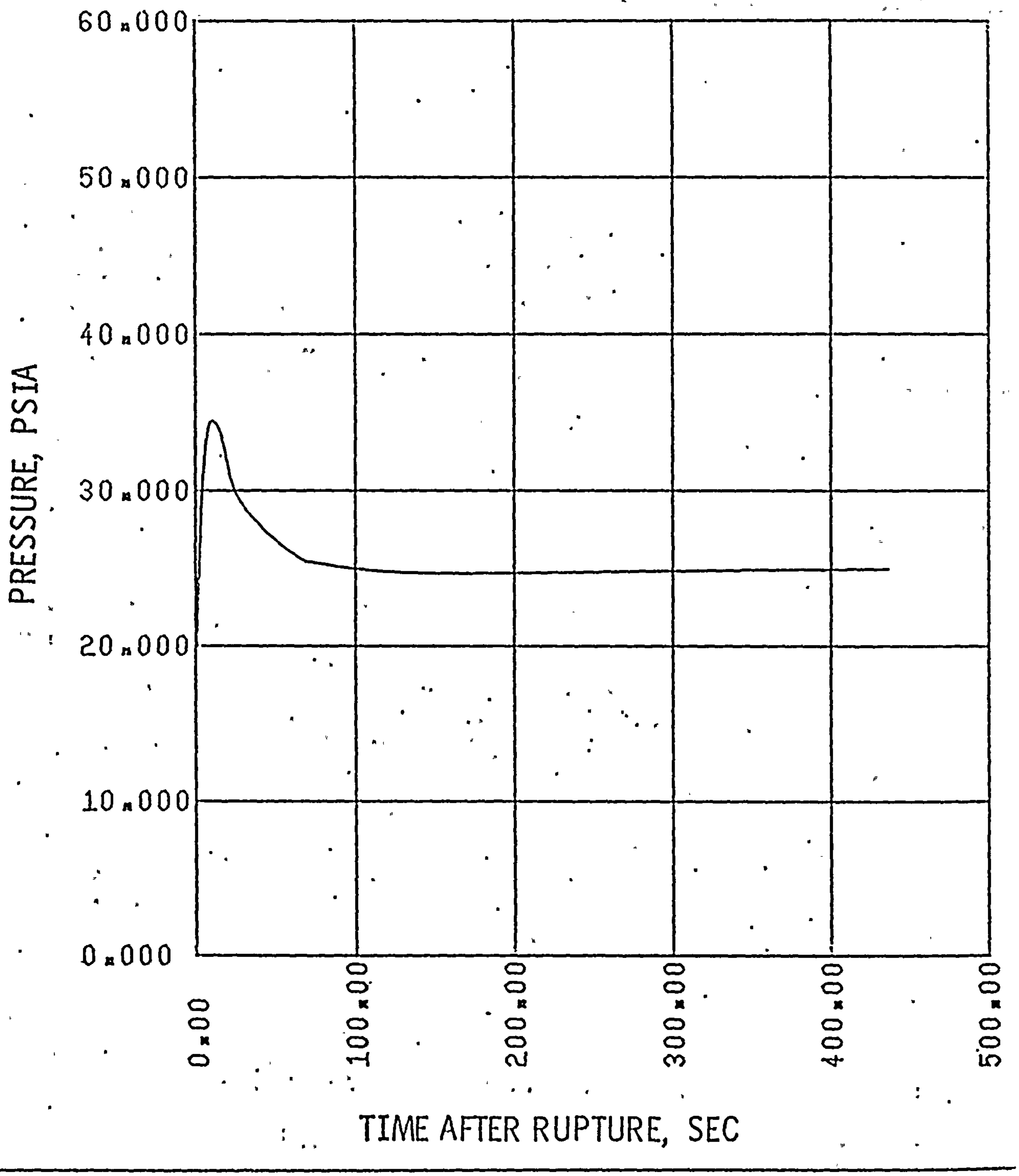


Figure II.1-G

ST. LUCIE I

1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

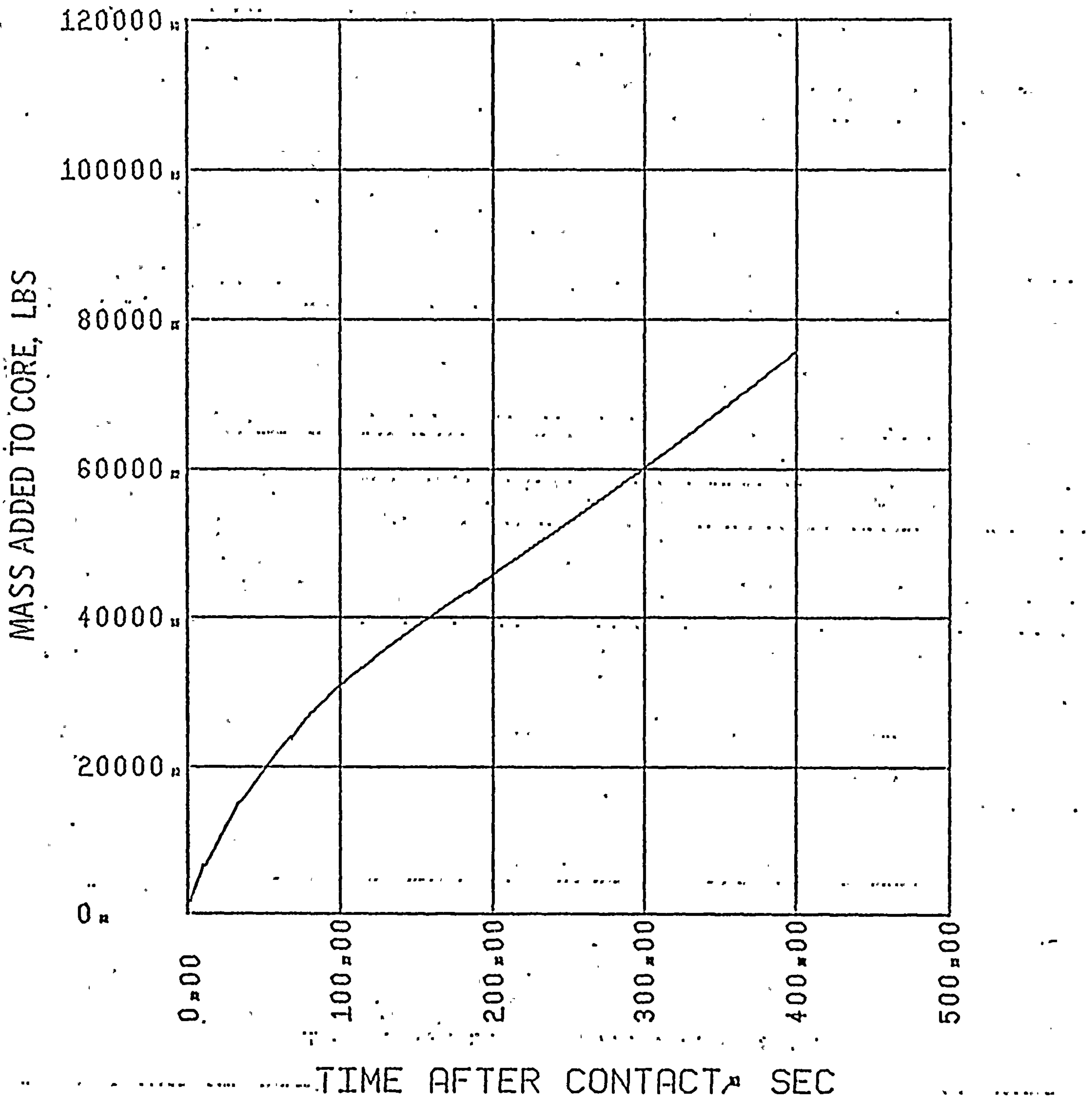


Figure II.1-H

ST. LUCIE I

1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

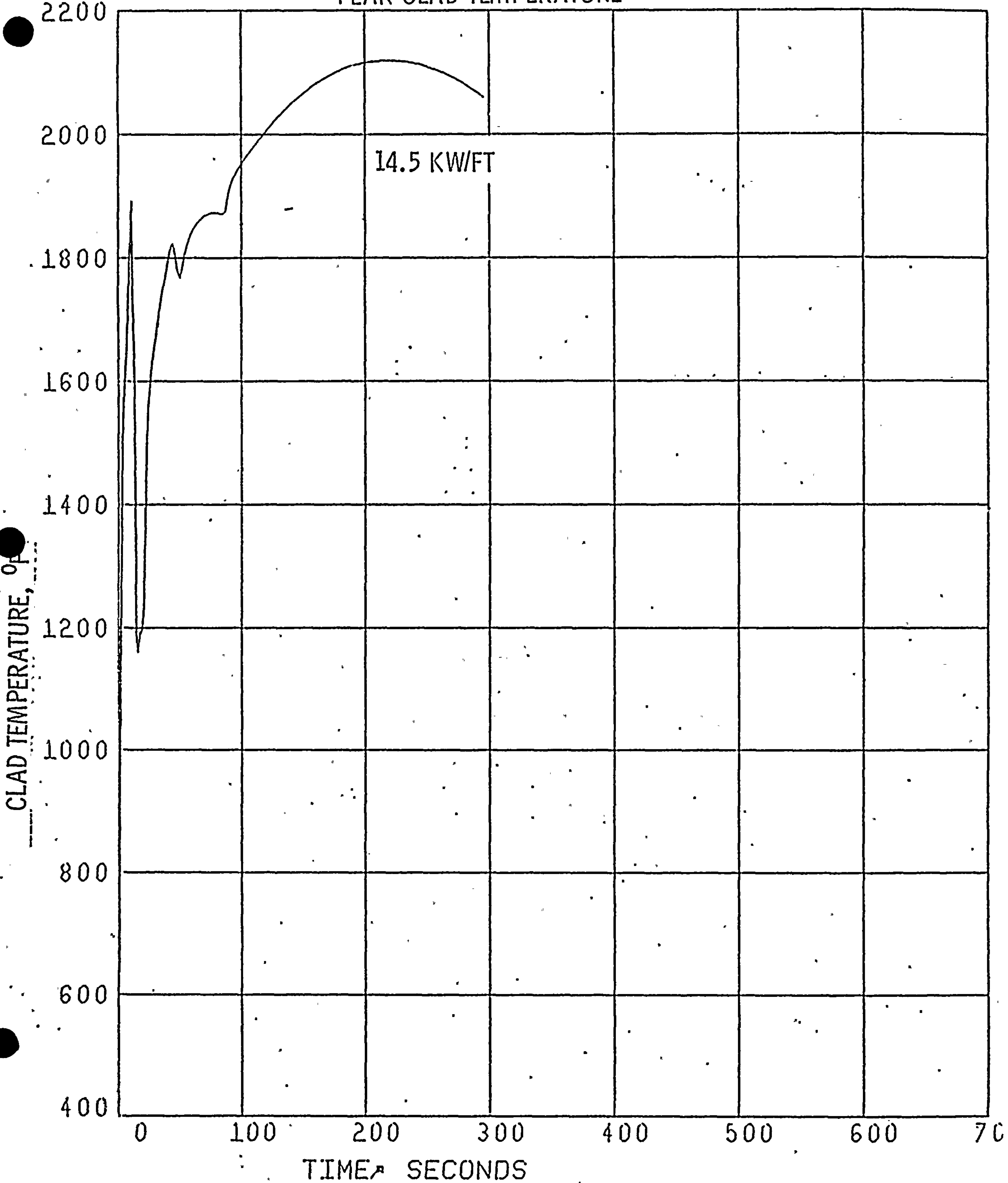


Figure II.2-A

2560 MWt PLANTS
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

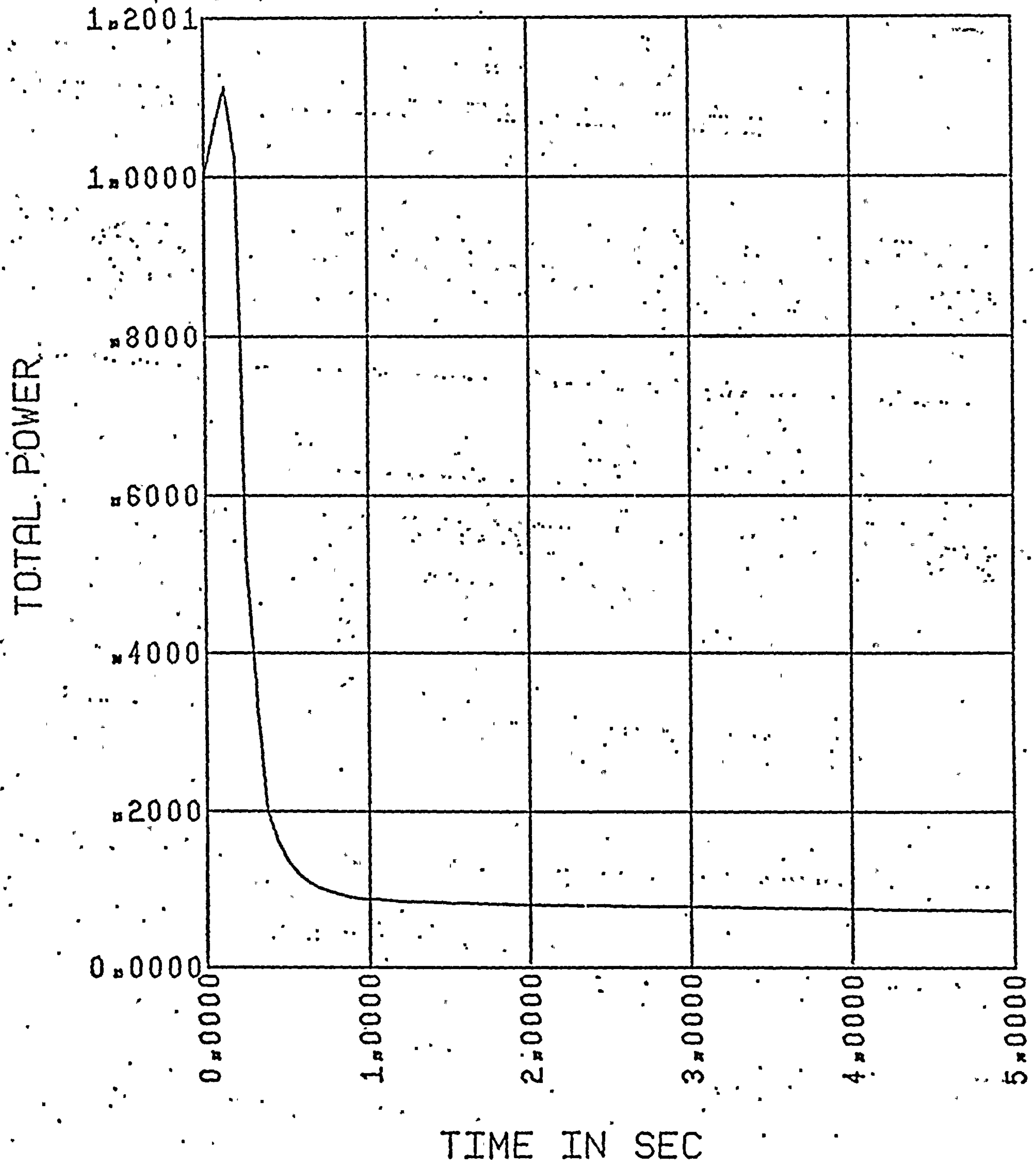


Figure II.2-B

2560 MWt PLANTS
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

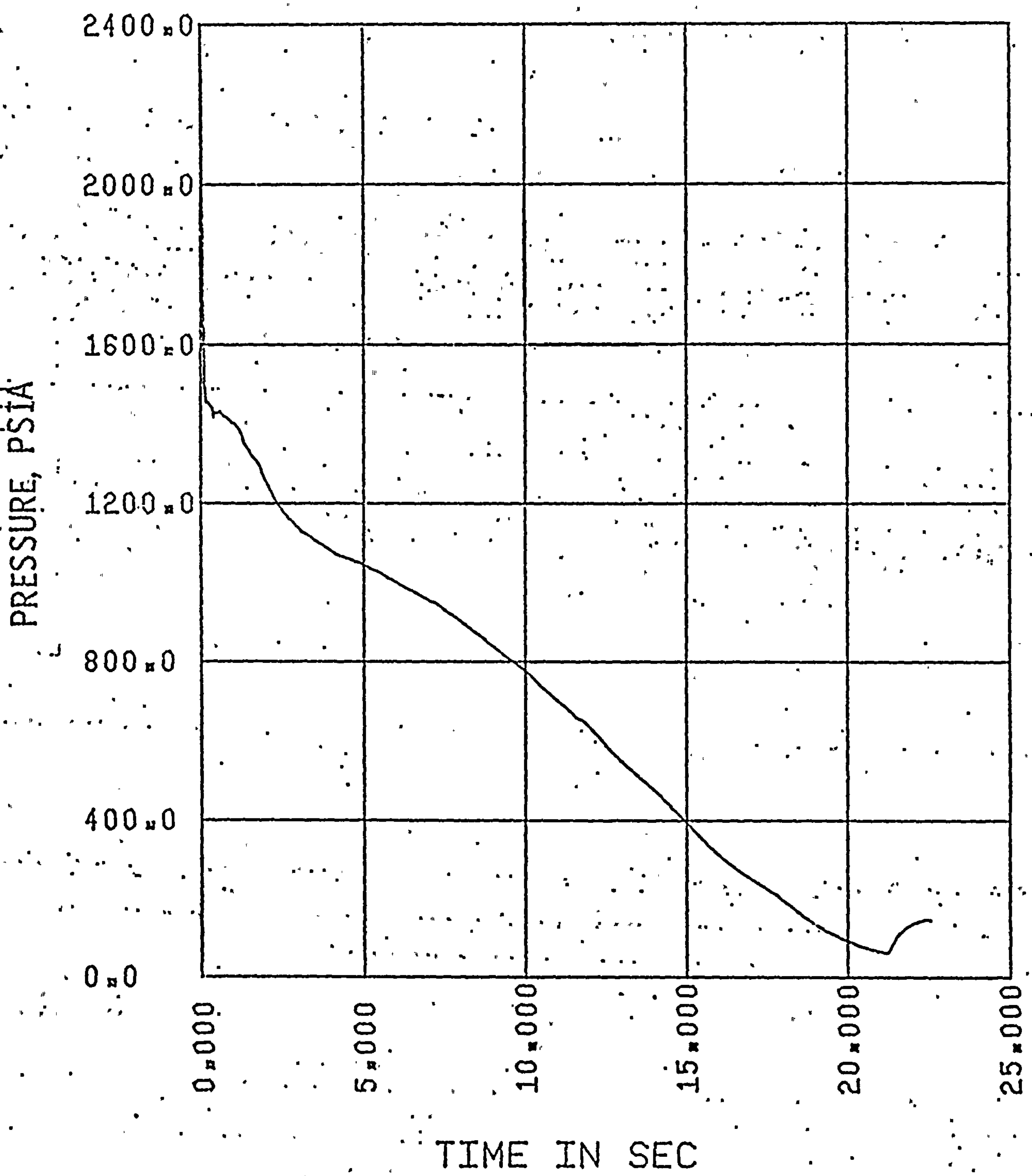


Figure II.2-C

2560 MWt PLANTS

0.8 X DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

LEAK FLOW

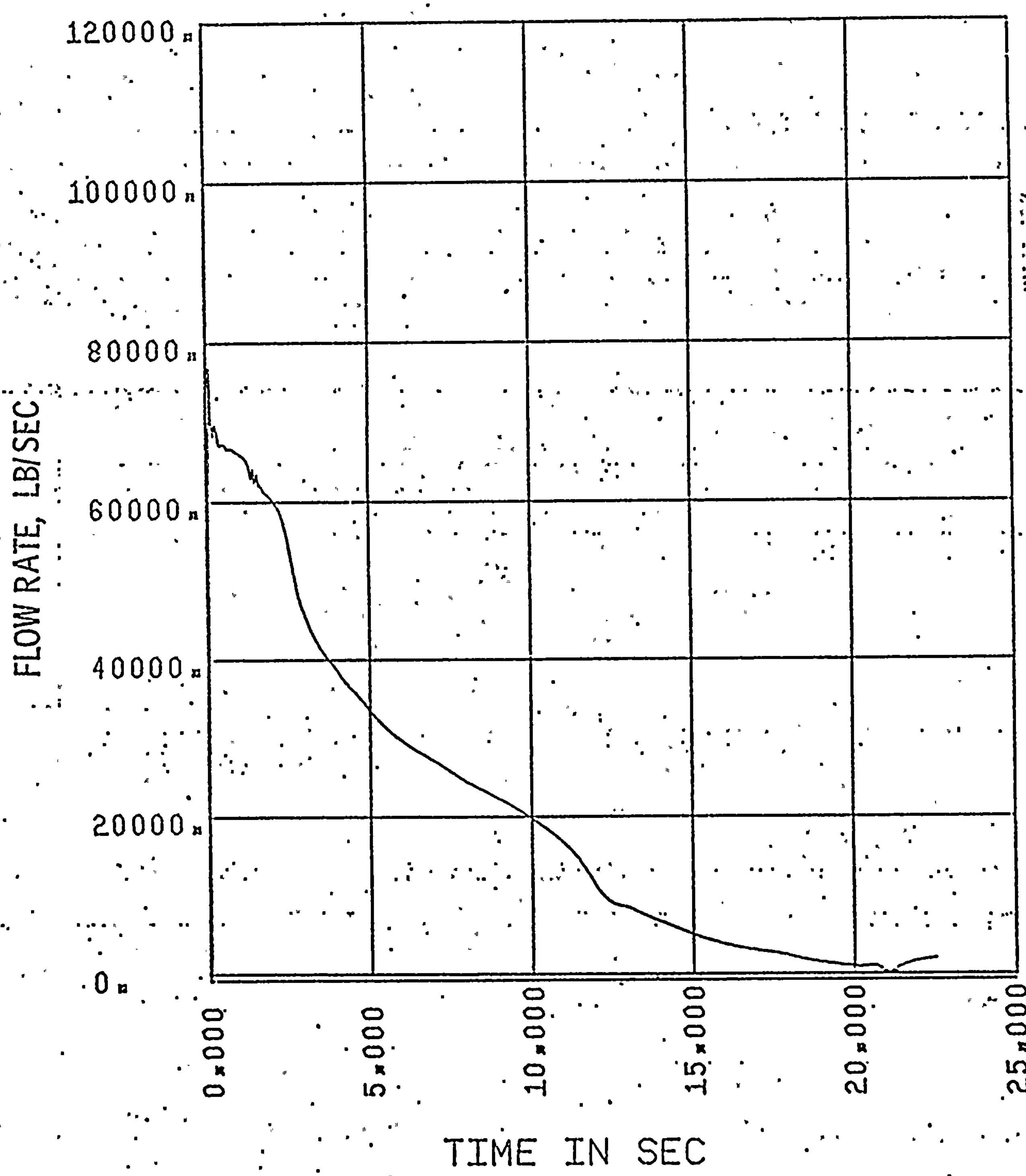


Figure II.2-D.1

2560 MWt PLANTS
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

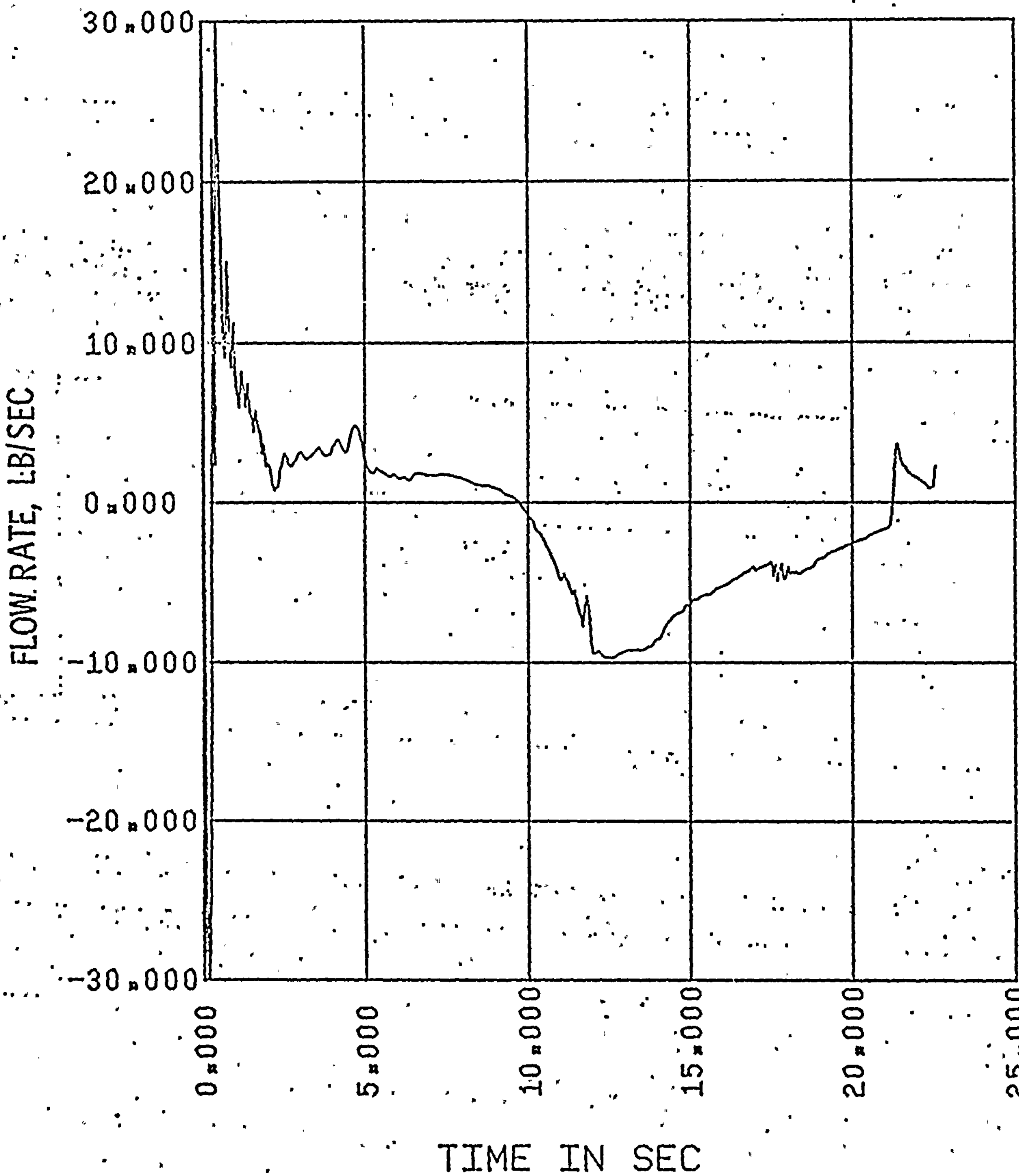


Figure II.2-D.2

2560 MWt PLANTS
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

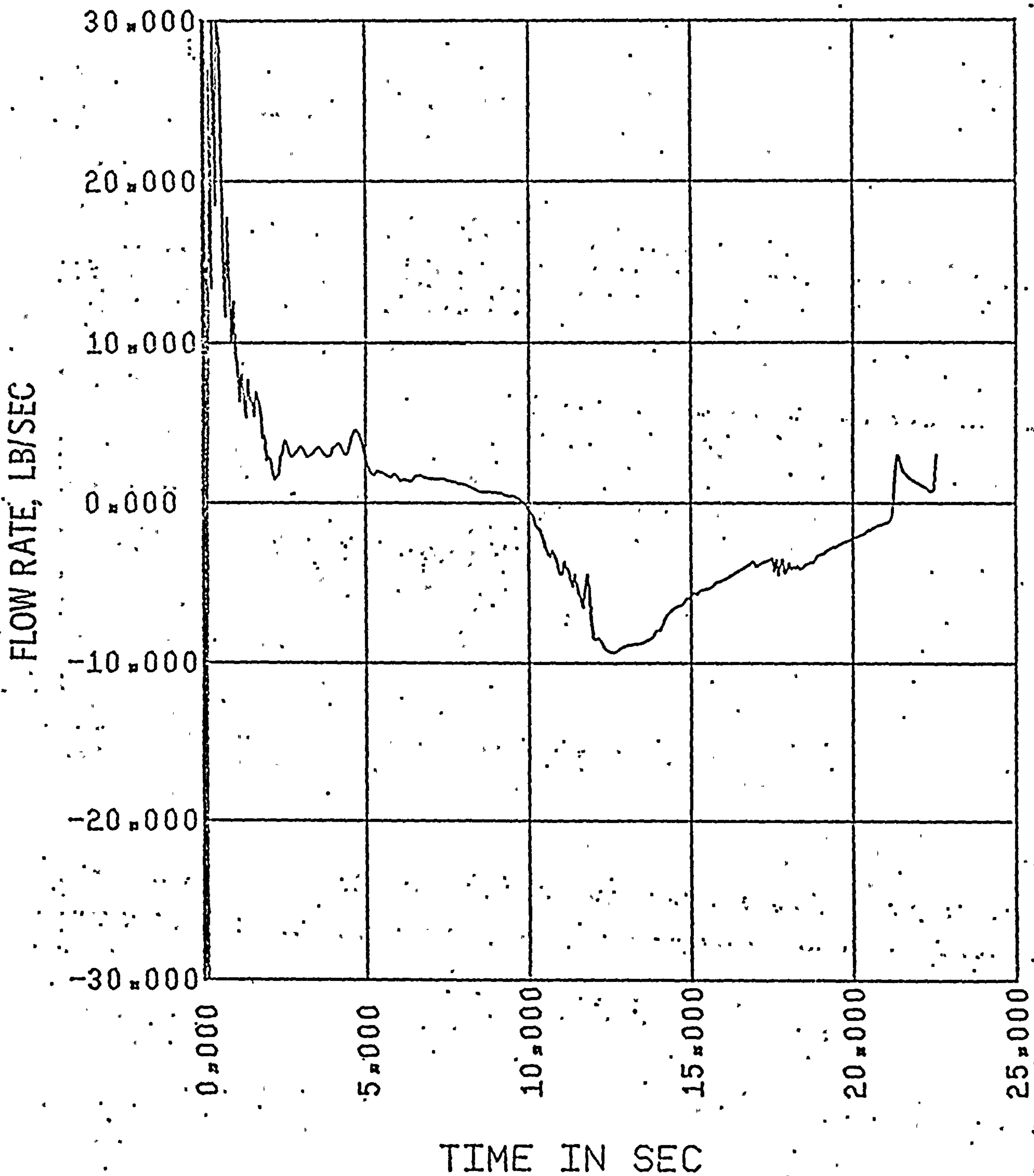


Figure II.2-E

2560 MWt PLANTS
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

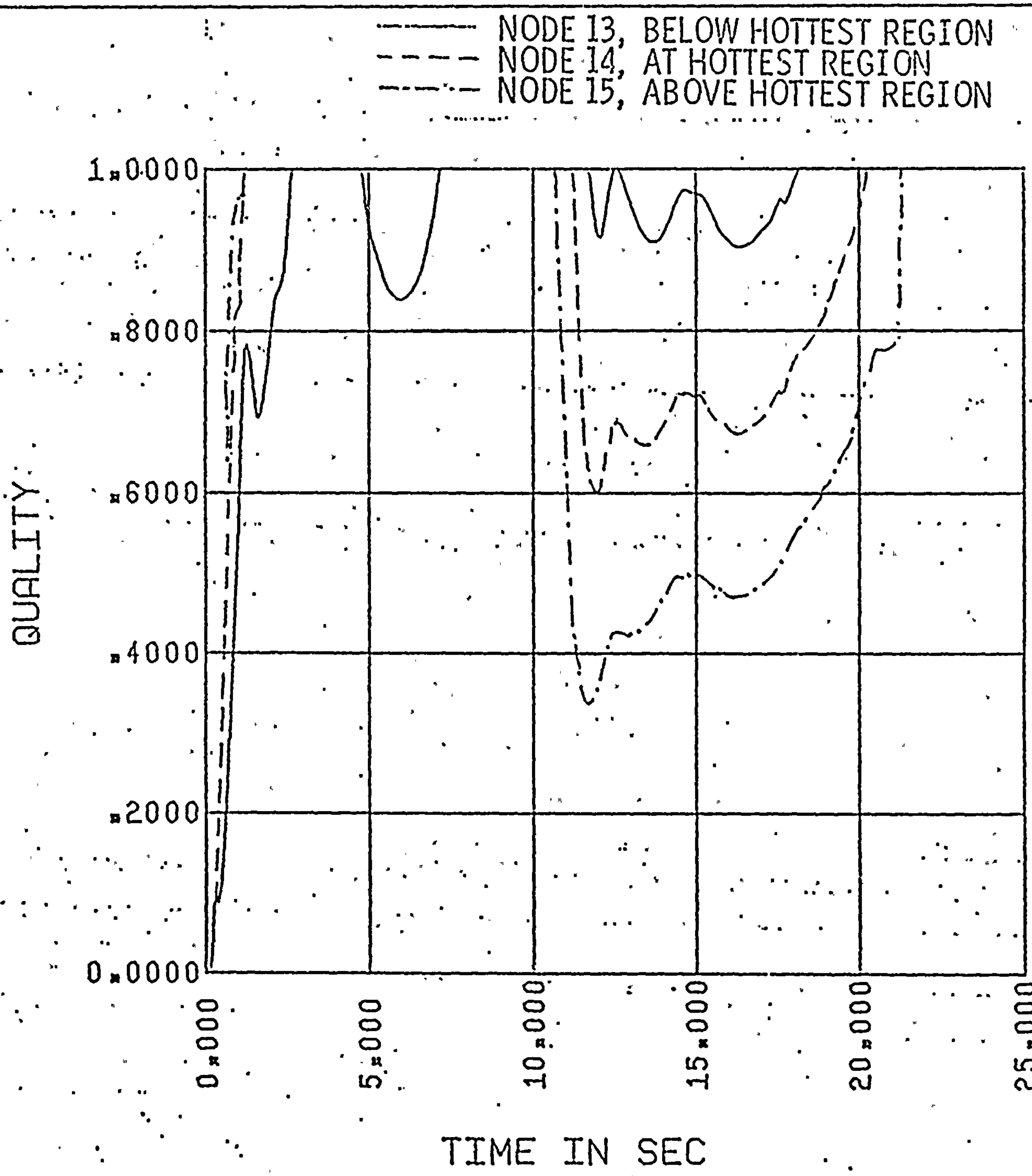


Figure II.2-F

ST. LUCIE I

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

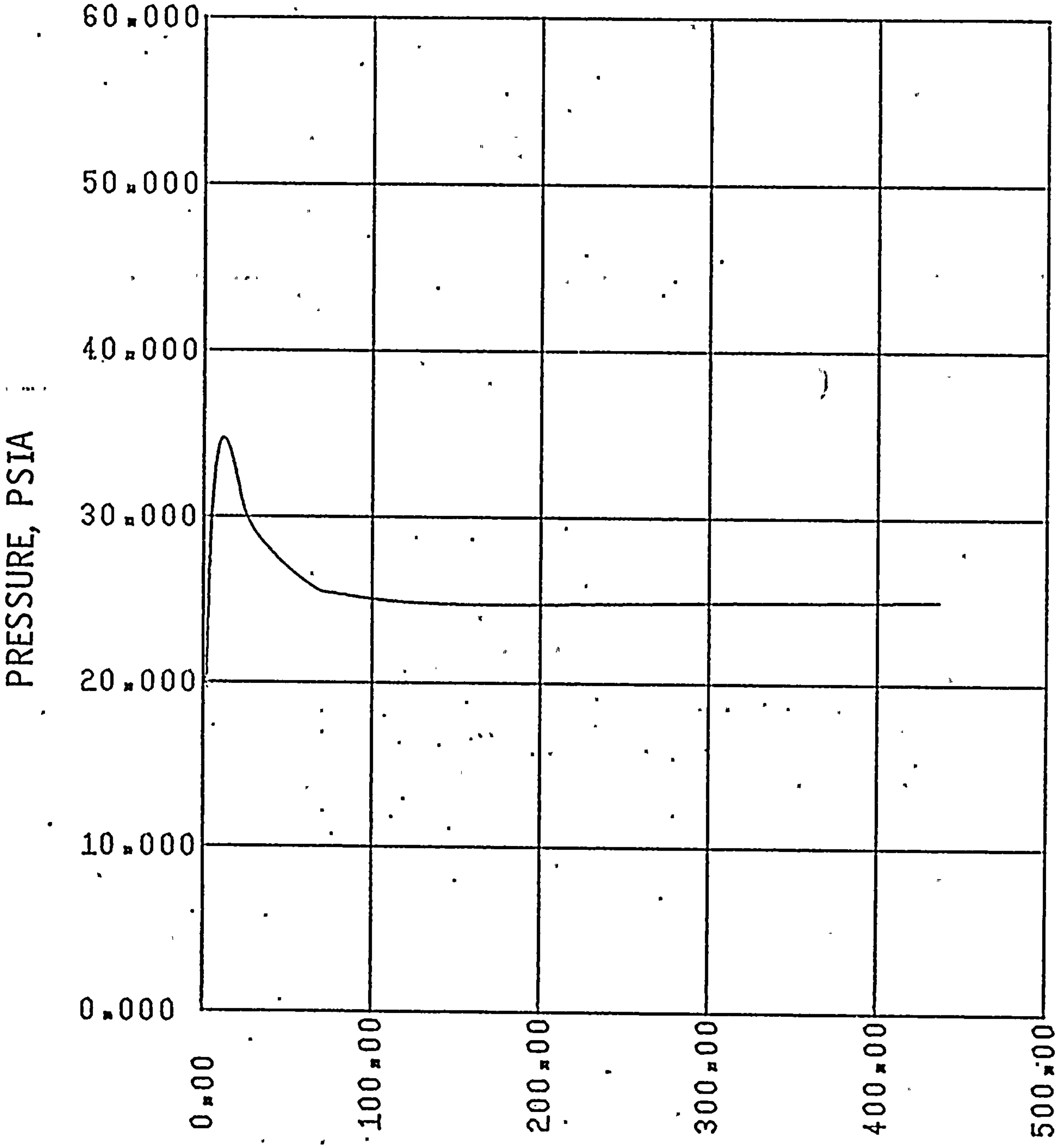


Figure II.2-G

ST. LUCIE I

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

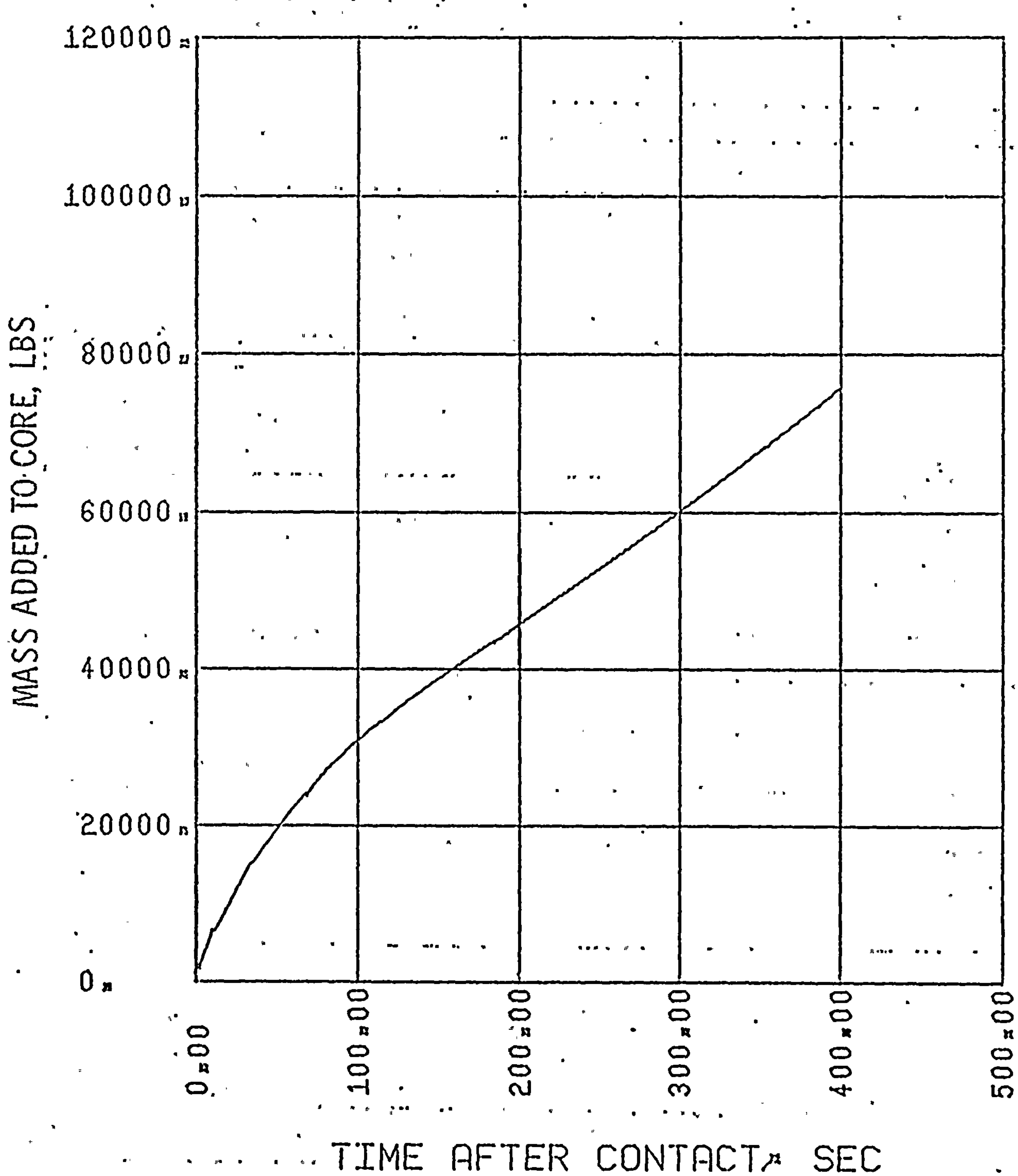


Figure II.2-H

ST. LUCIE I

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

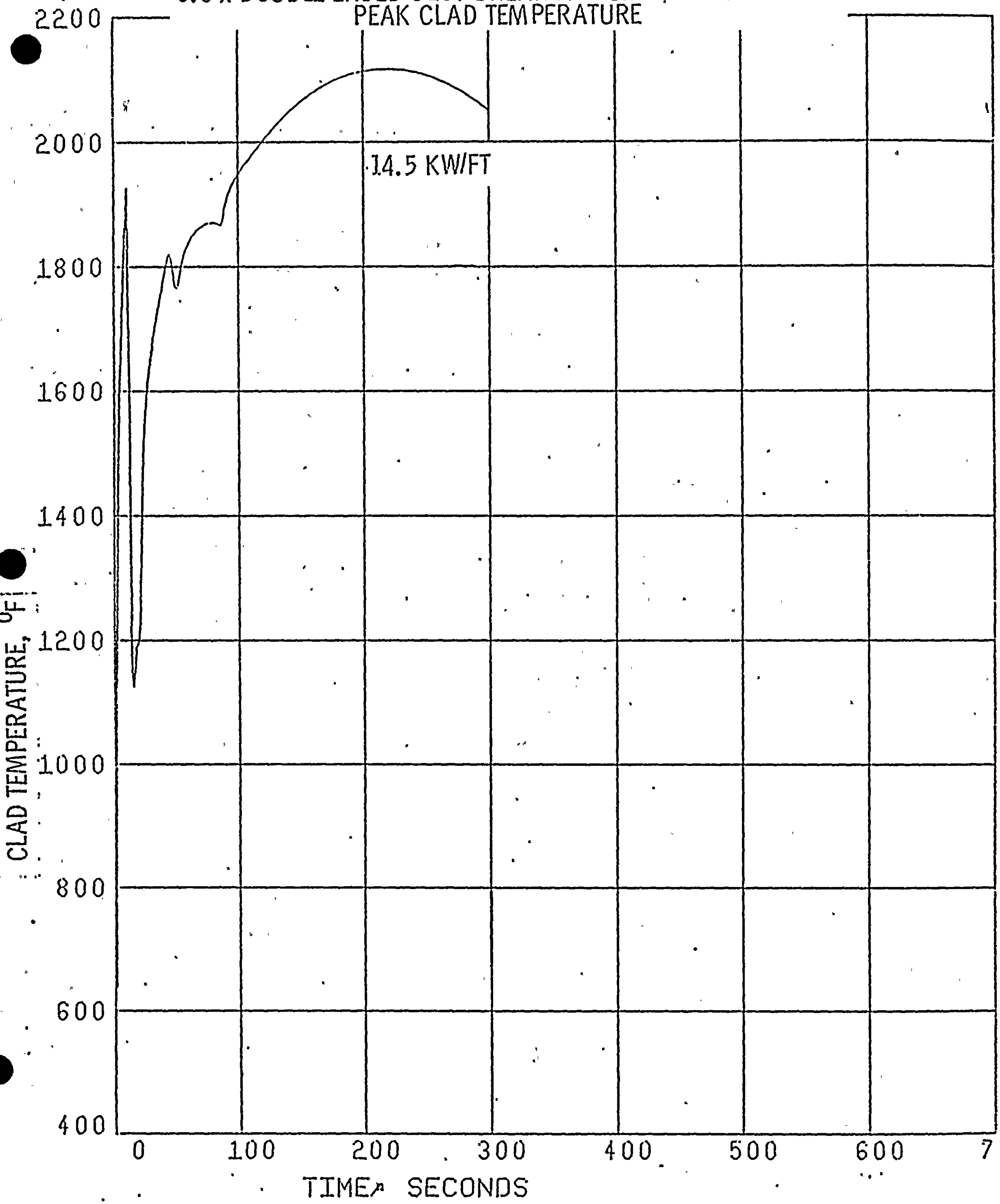


Figure II.3-A

2560 MWt PLANTS
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

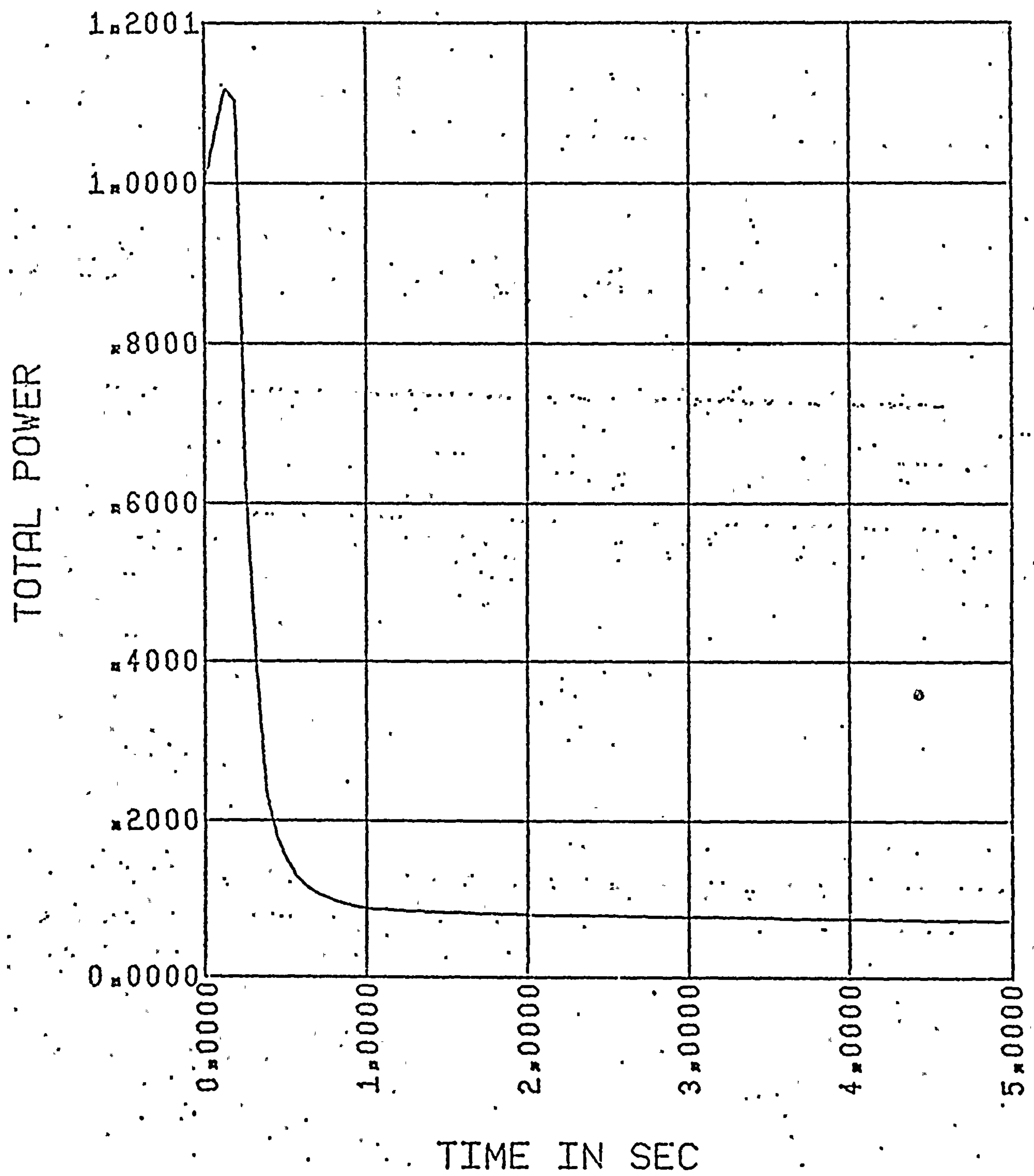


Figure II.3-B

2560 MWt PLANTS
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

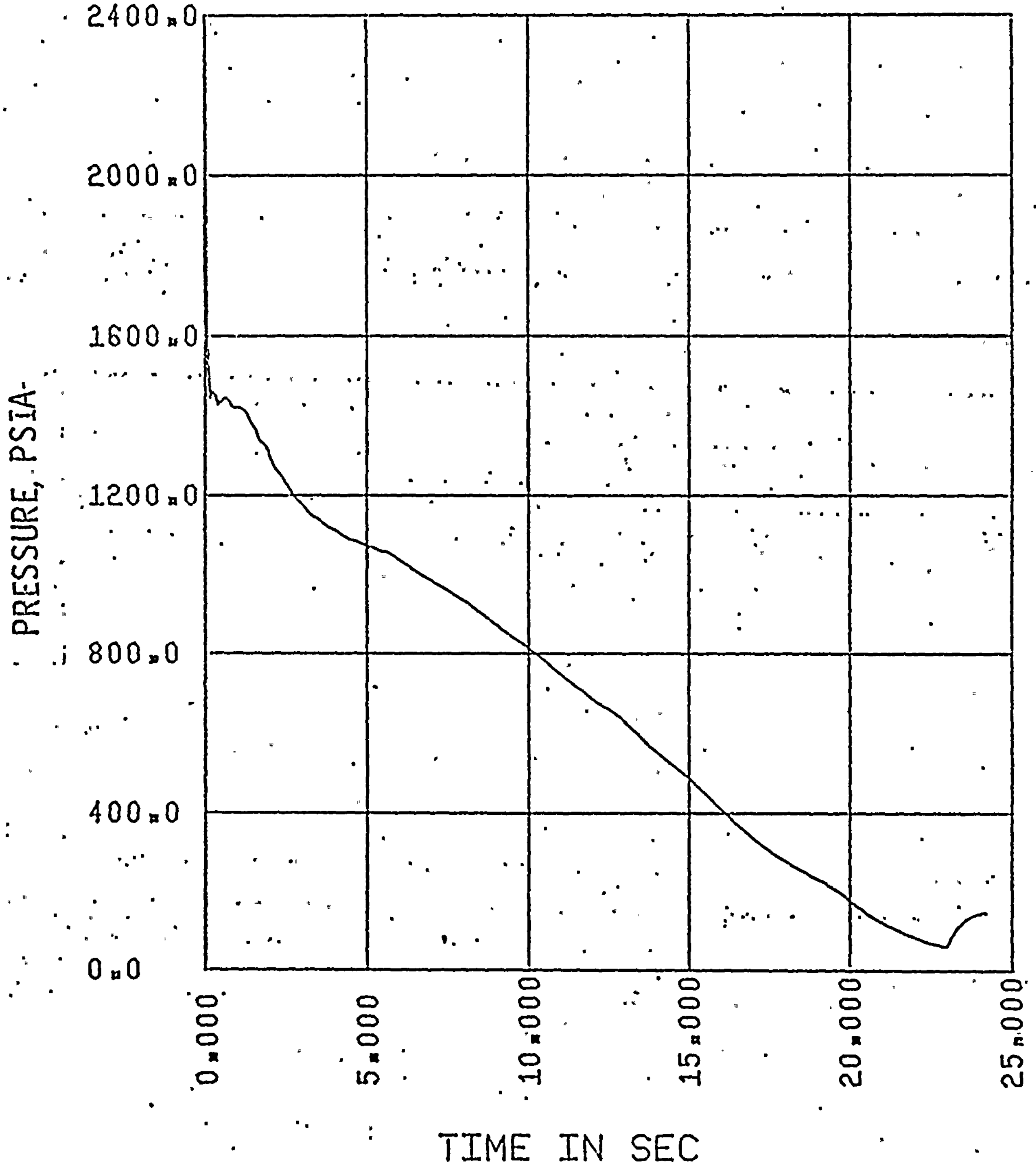


Figure II.3-C

2560 MWt PLANTS
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

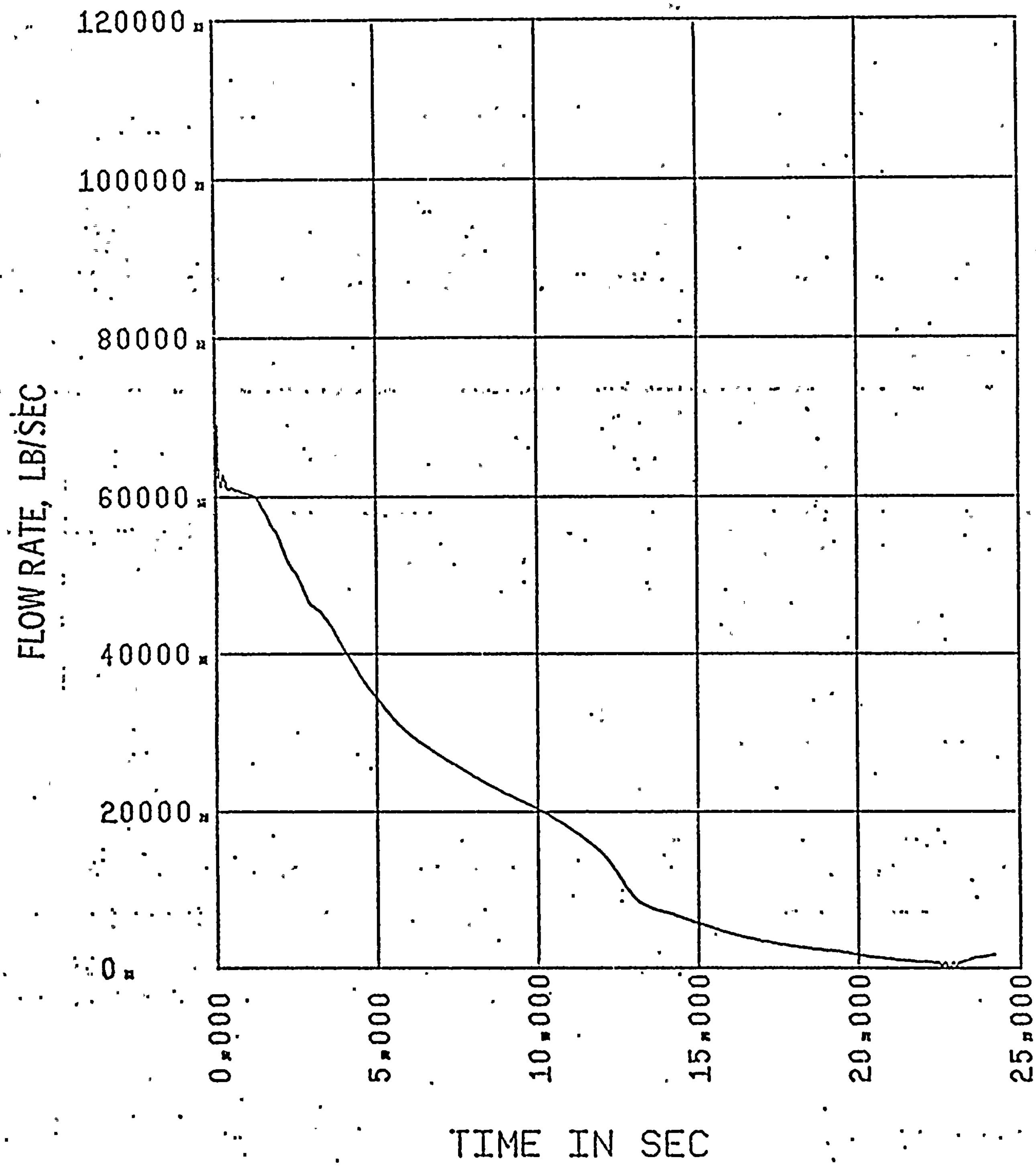


Figure II.3-D.1

2560 MWt PLANTS
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

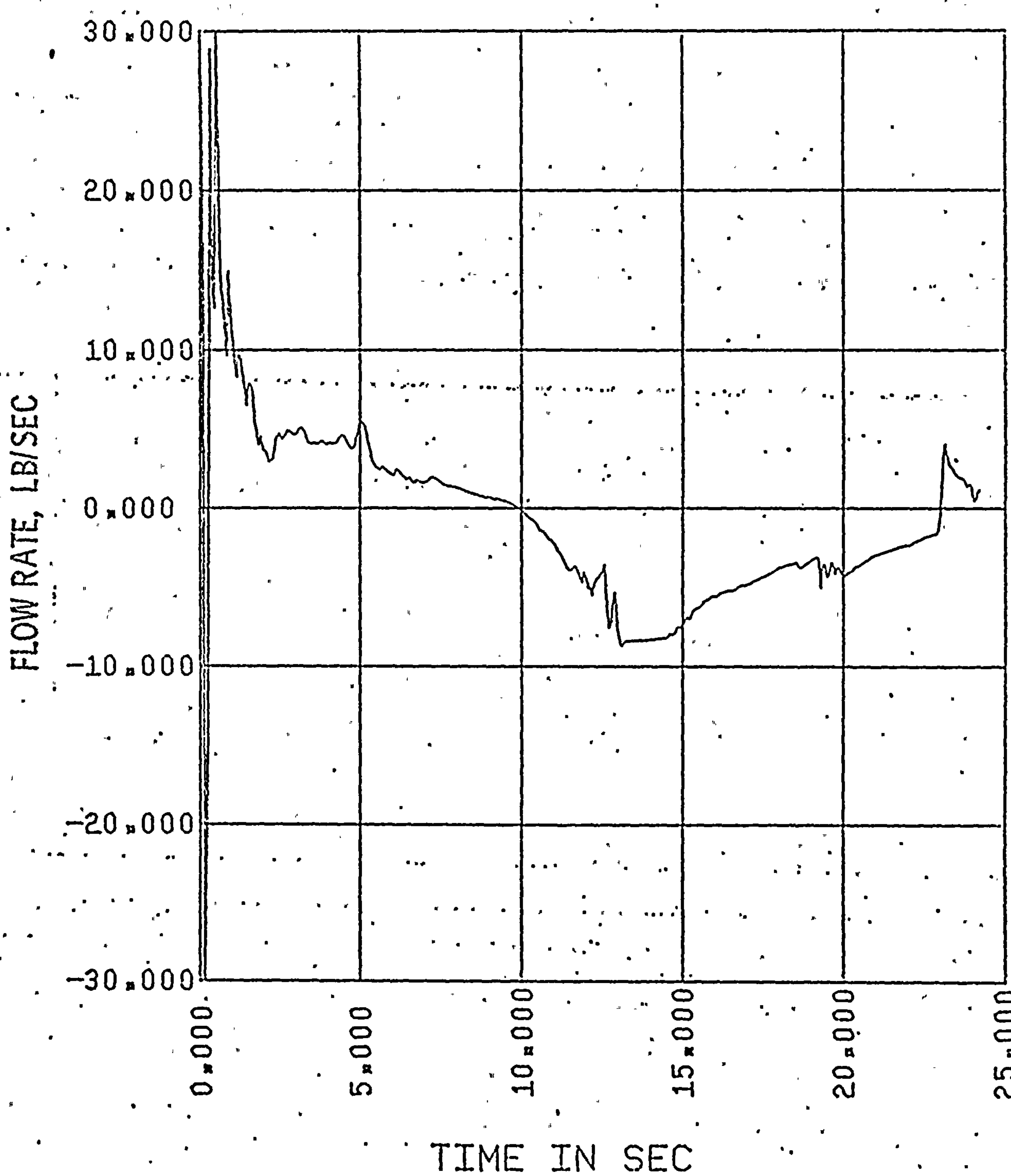


Figure II.3-D.2

2560 MWt PLANTS

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

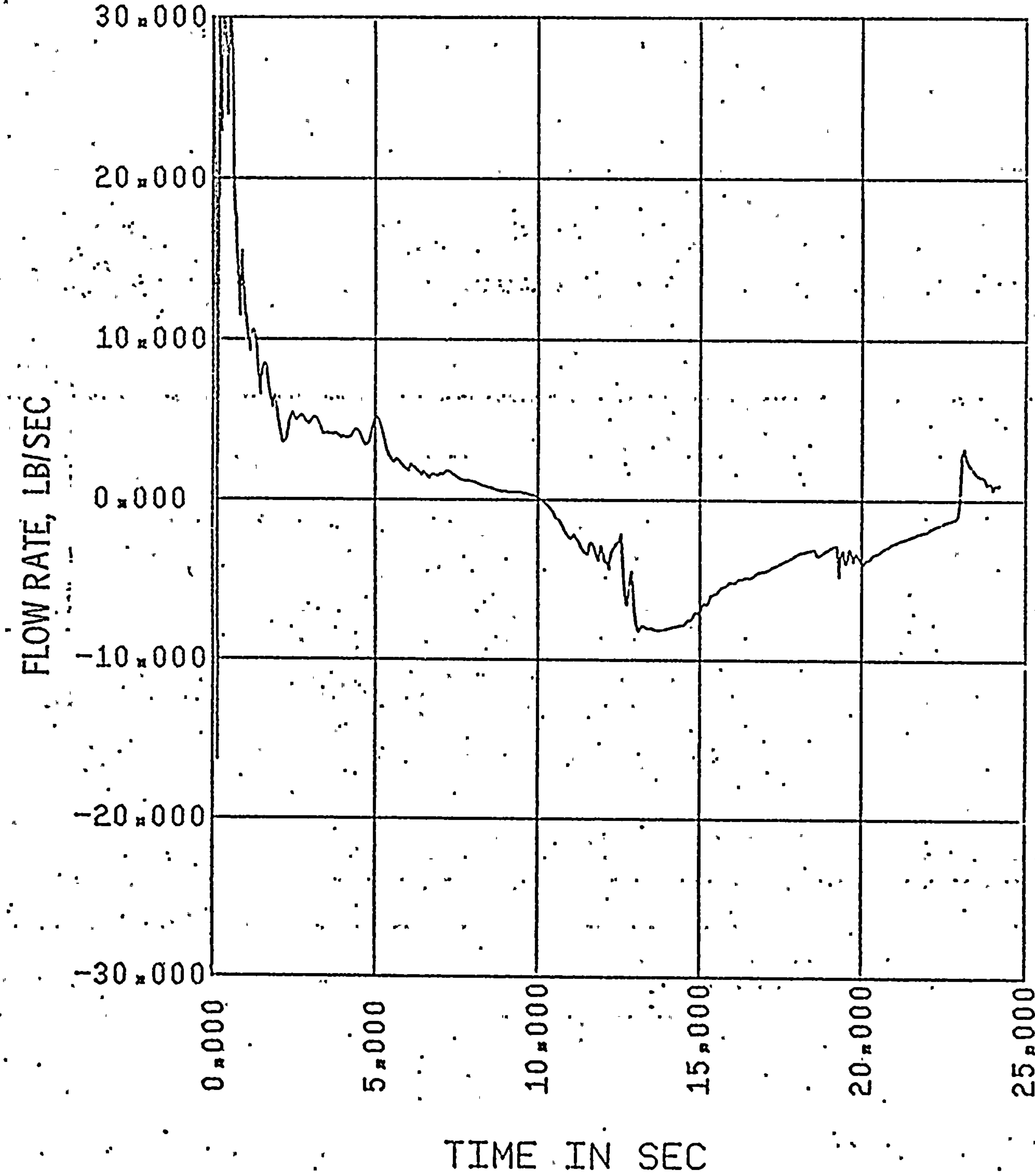


Figure II.3-E

2560 MWt PLANTS
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

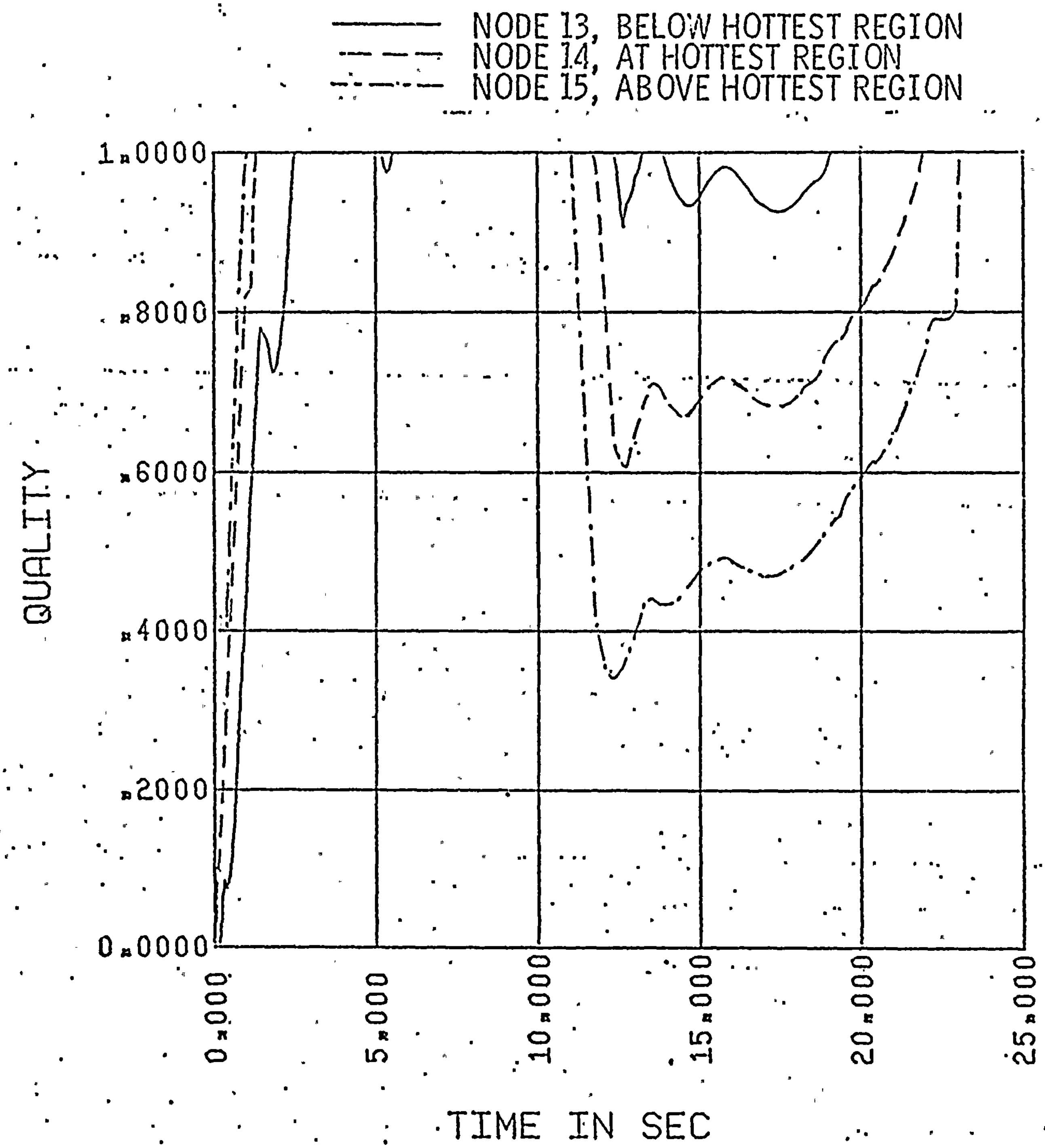


Figure II.3-F

ST. LUCIE I

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

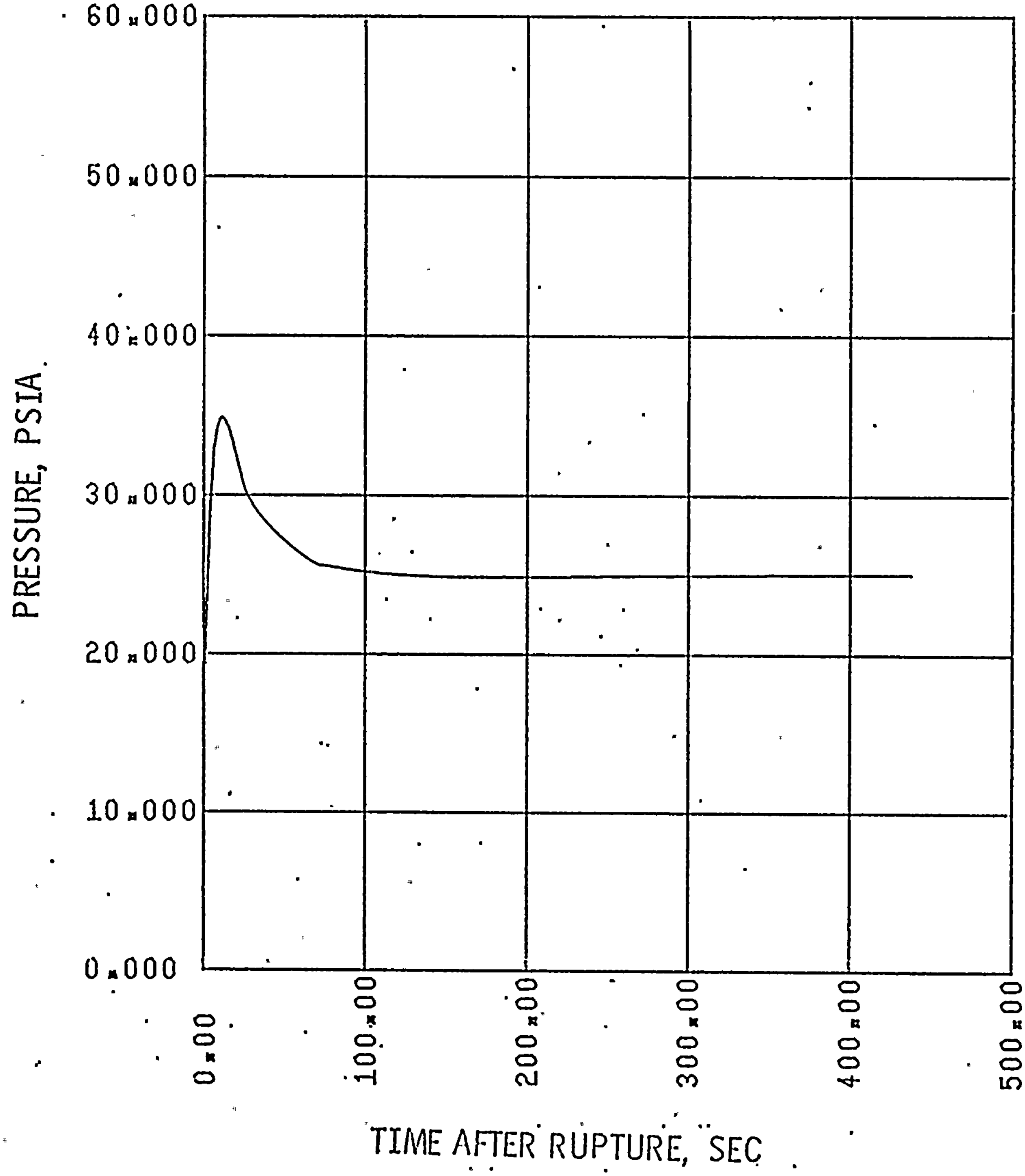


Figure II.3-G

ST. LUCIE I

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

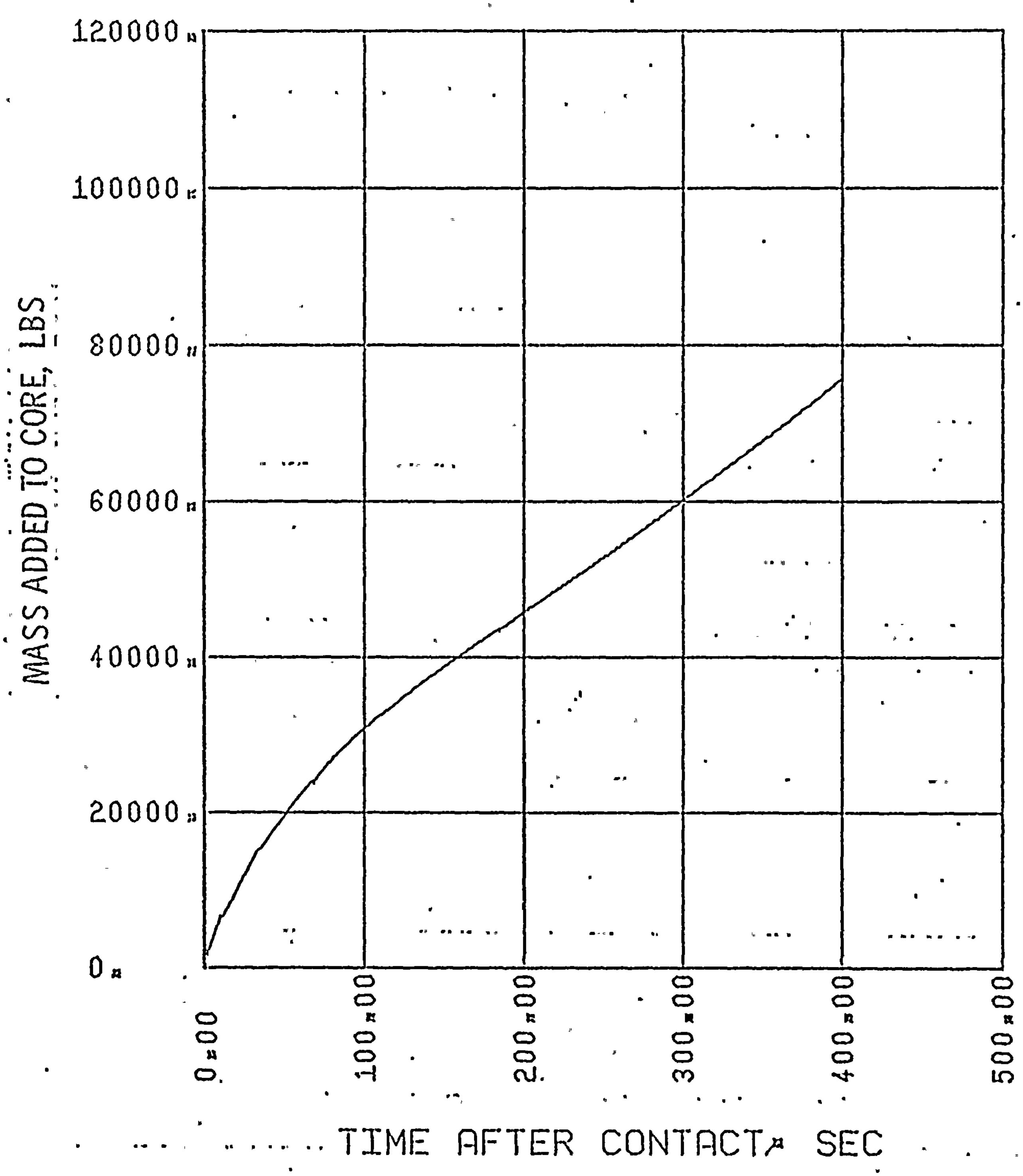


Figure II.3-H

ST. LUCIE I

0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

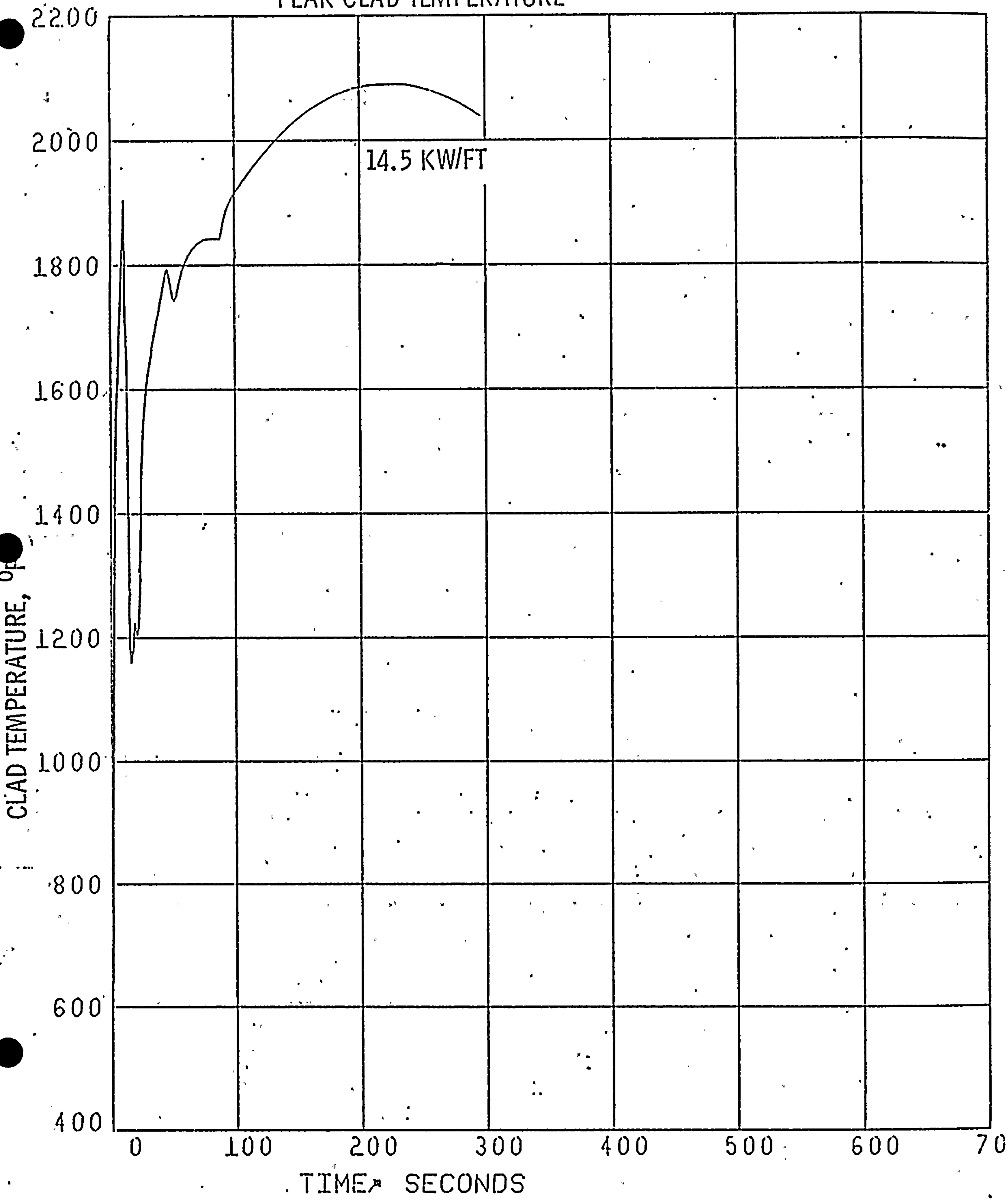


Figure II.4-A

2560 MWt PLANTS
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

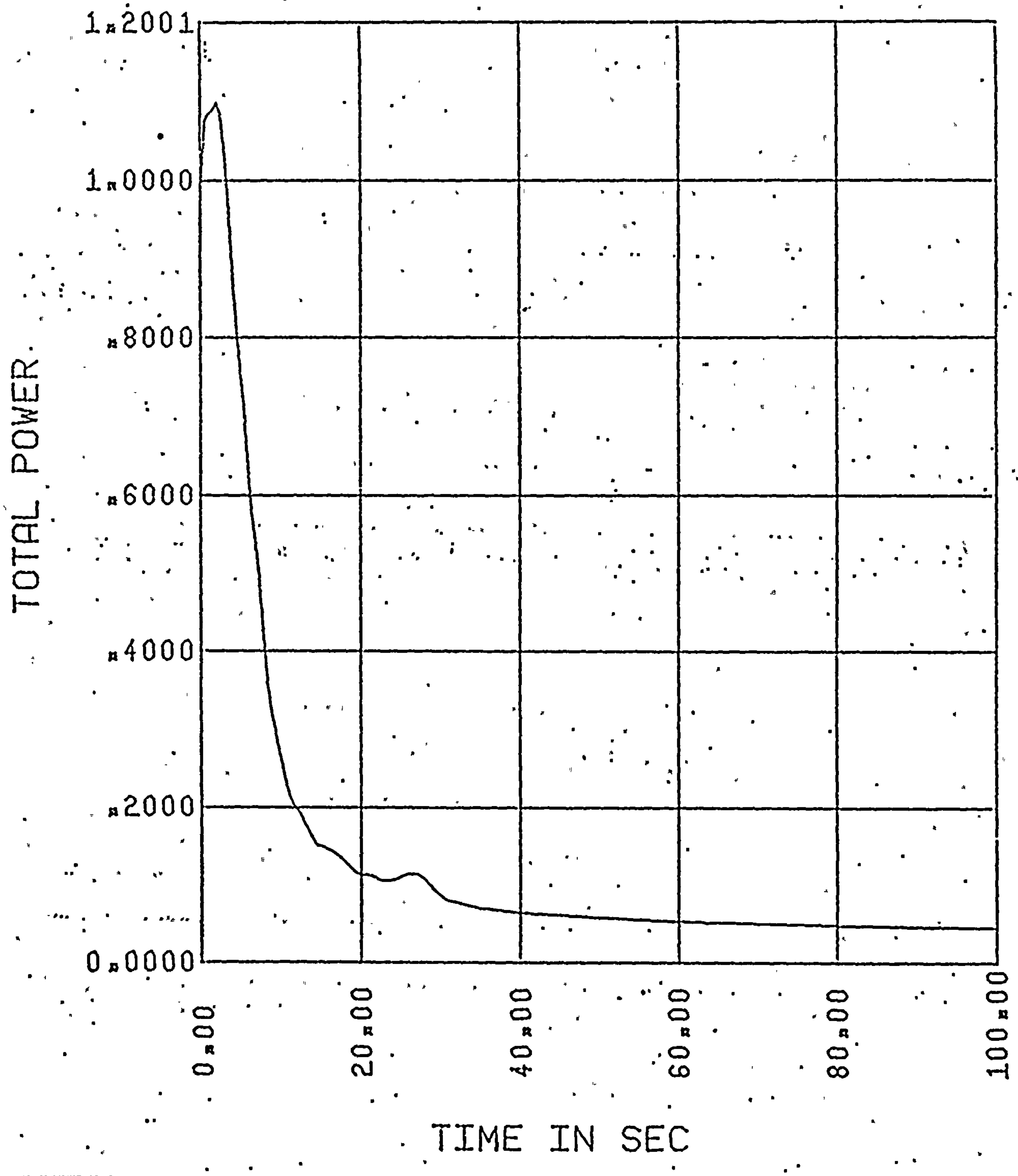


Figure II.4-B

2560 MWt PLANTS
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

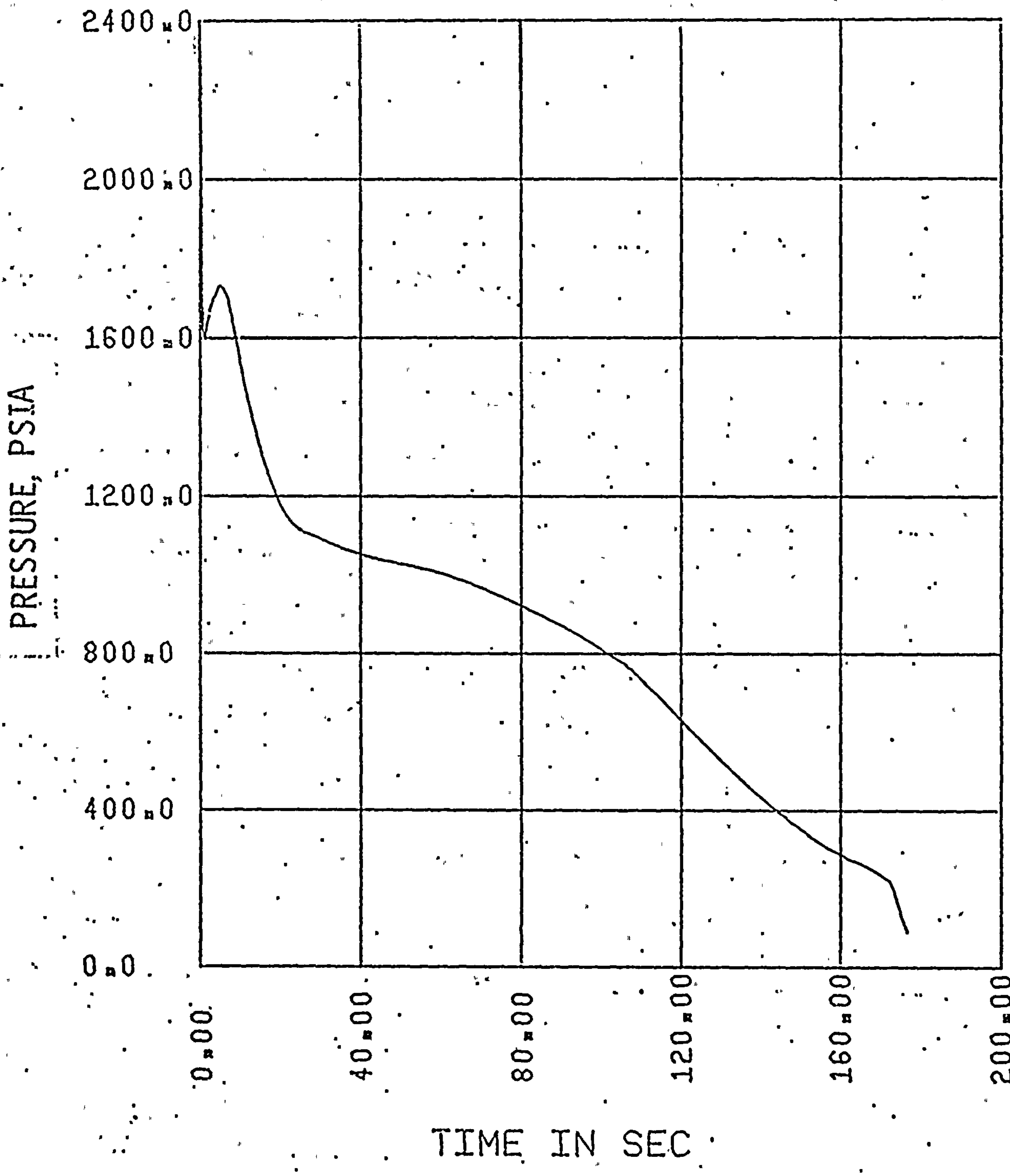


Figure II.4-C

2560 MWt PLANTS
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

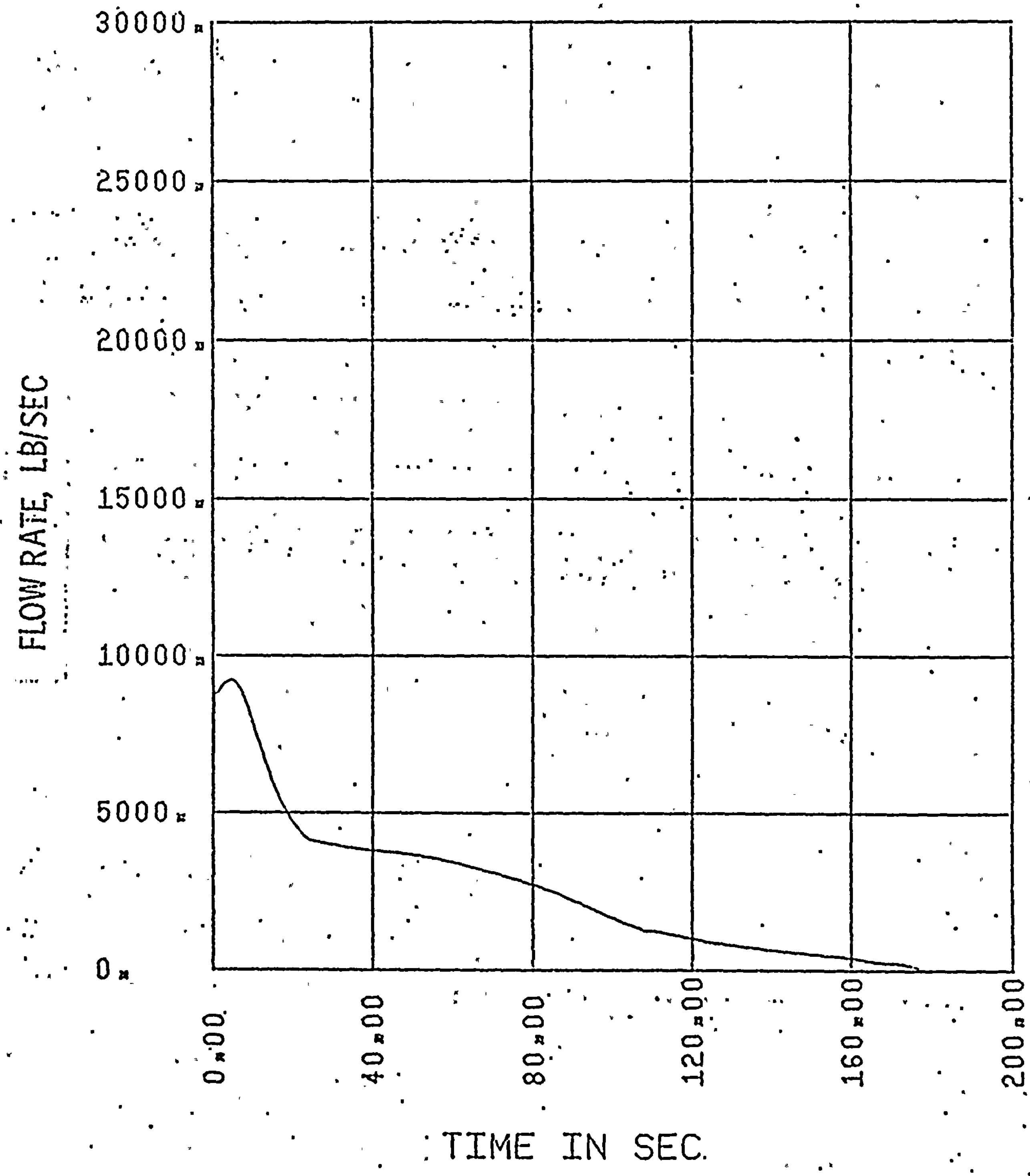


Figure II.4-D.1

2560 MWt PLANTS
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY -- PATH 16, BELOW HOT SPOT

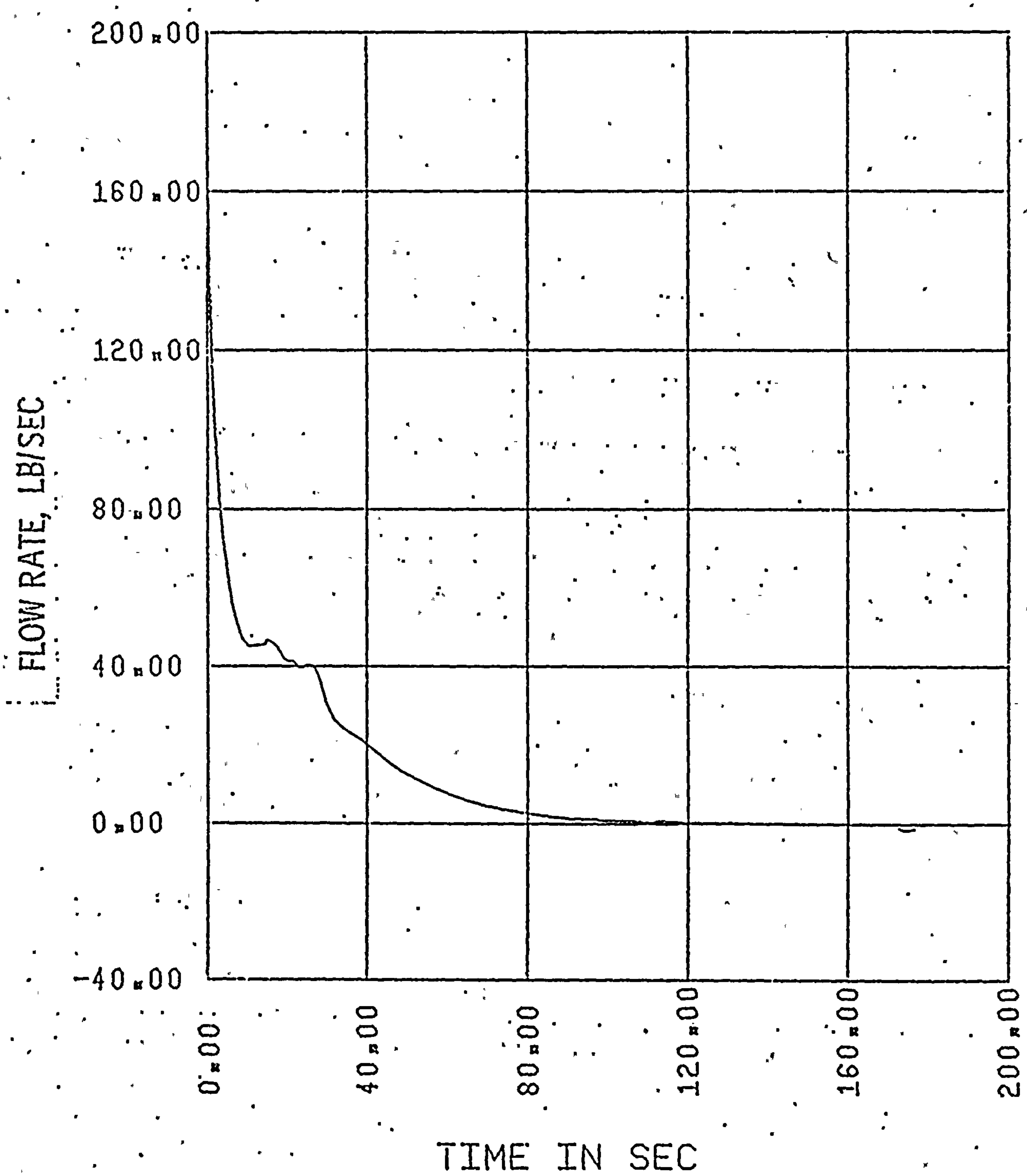


Figure II.4-D.2

2560 MWt PLANTS

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

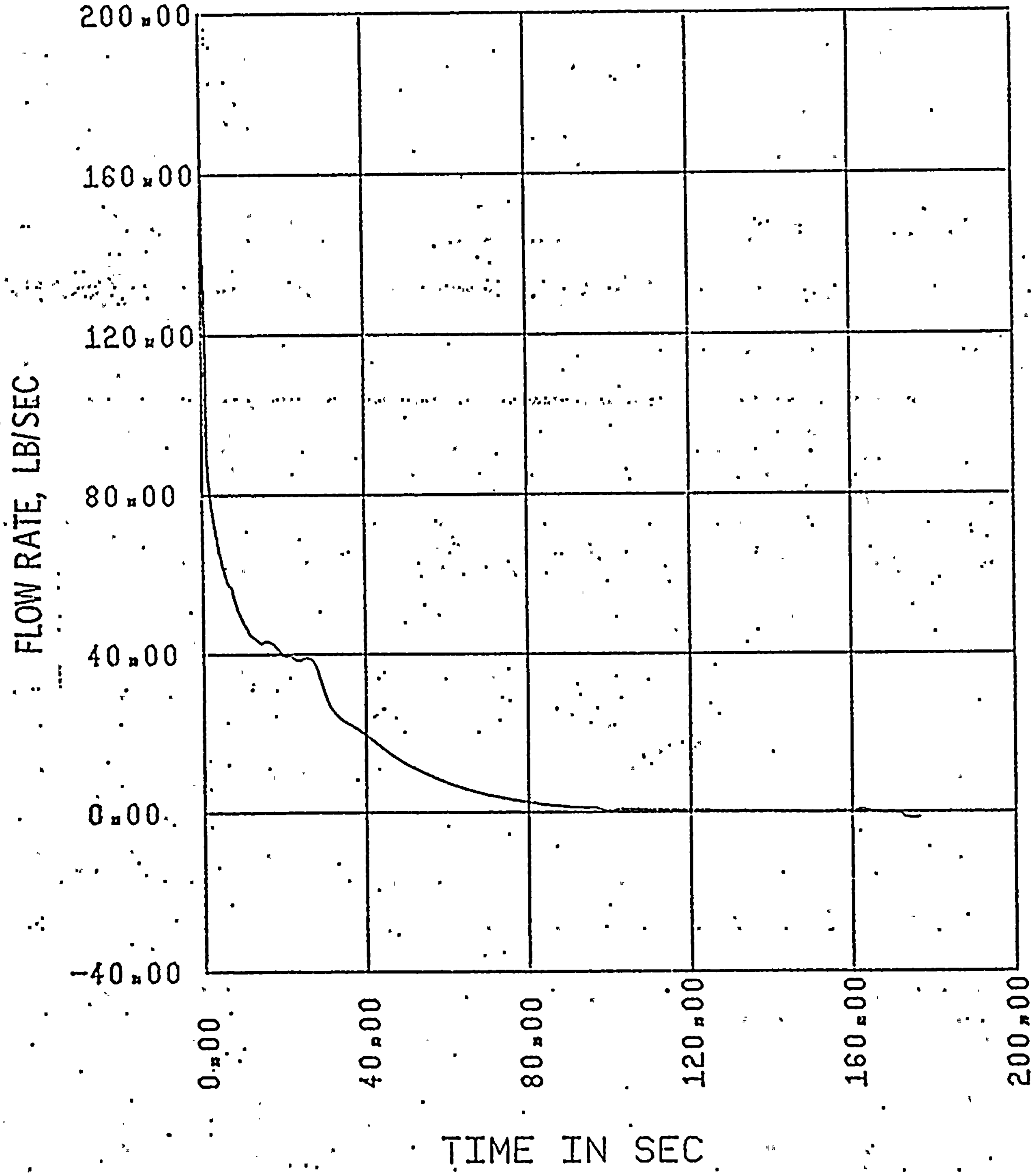


Figure II.4-E

2560 MWt PLANTS
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

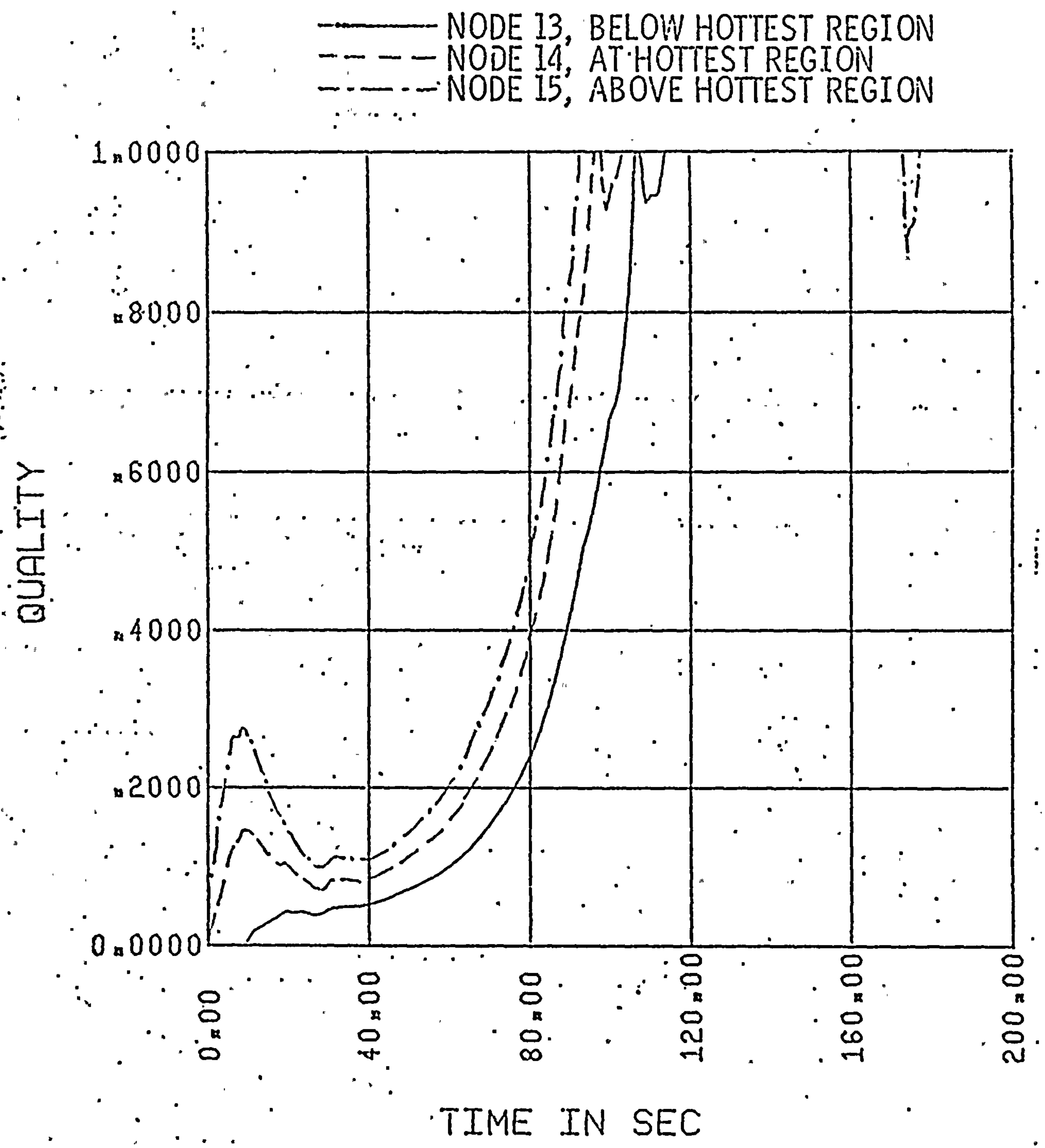


Figure II.4-F
ST. LUCIE I
$0.5\ FT^2$ SLOT BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

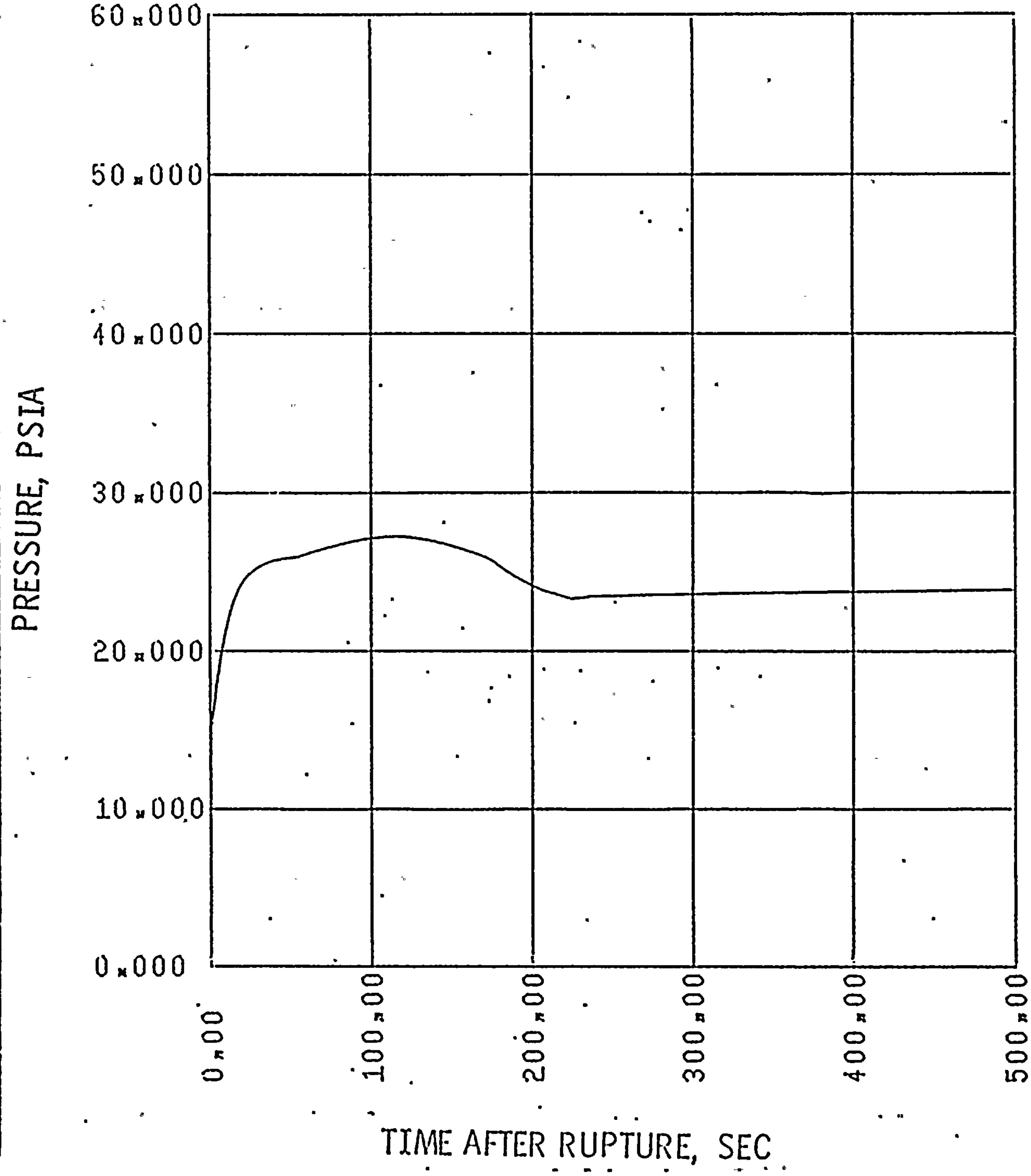


Figure II.4-G

ST. LUCIE I

0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

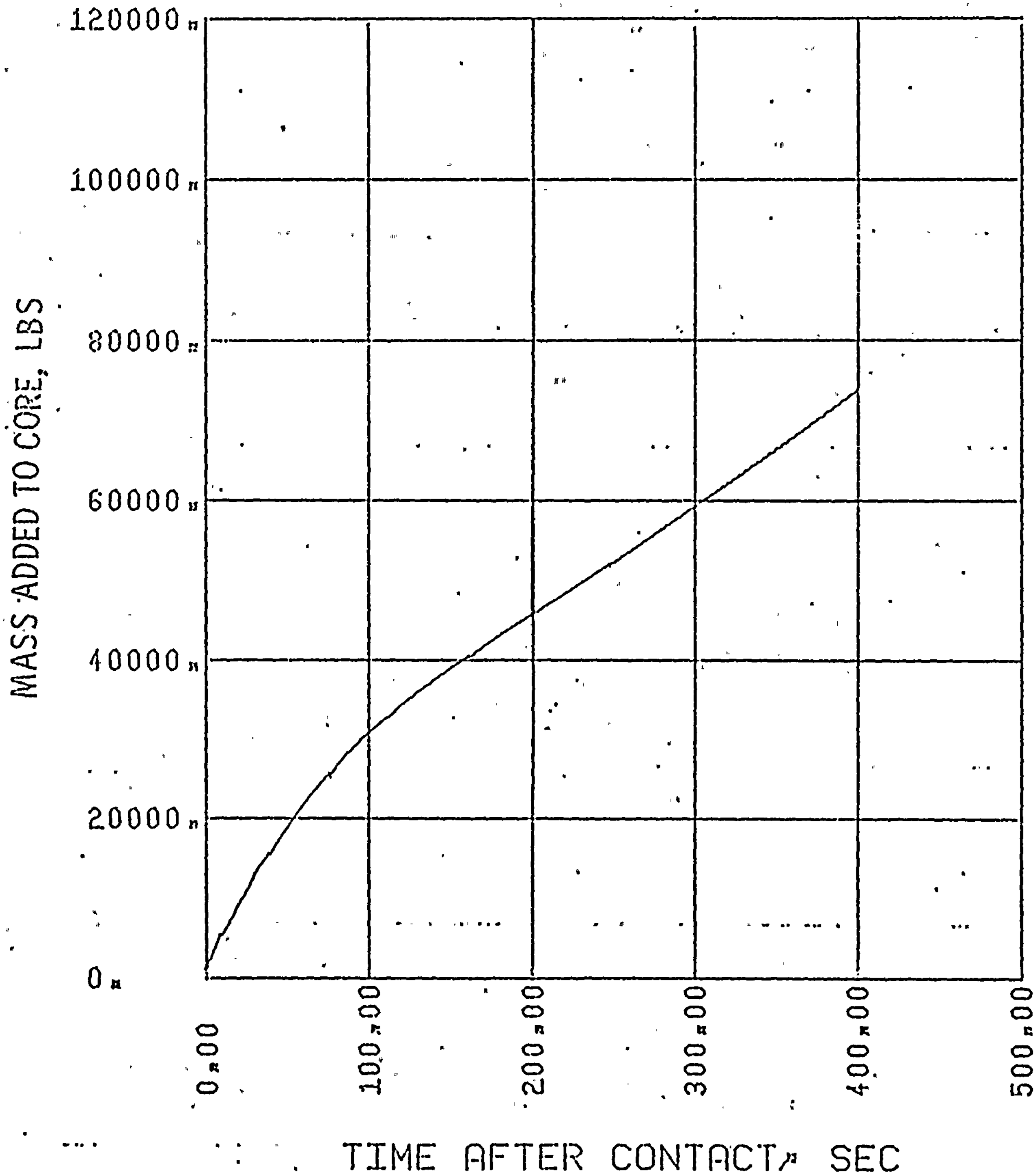


Figure II.4-H

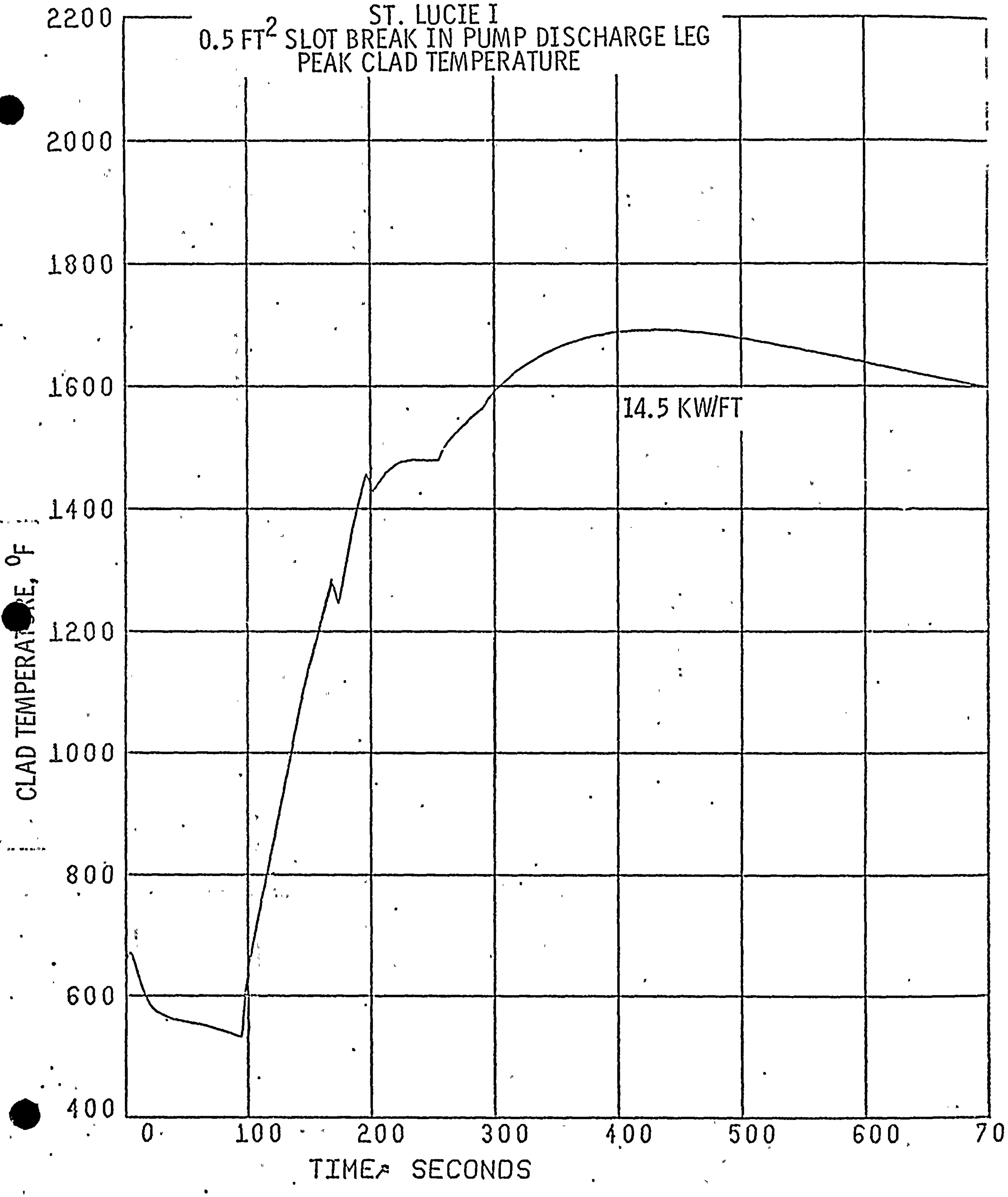

ST. LUCIE I
0.5 FT^2 SLOT BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE
14.5 KW/FT
CLAD TEMPERATURE, ^oF
2200
2000
1800
1600
1400
1200
1000
800
600
400
0
100
200
300
400
500
600
700
TIME, SECONDS

Figure II.5-A

2560 MWt PLANTS

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CORE POWER

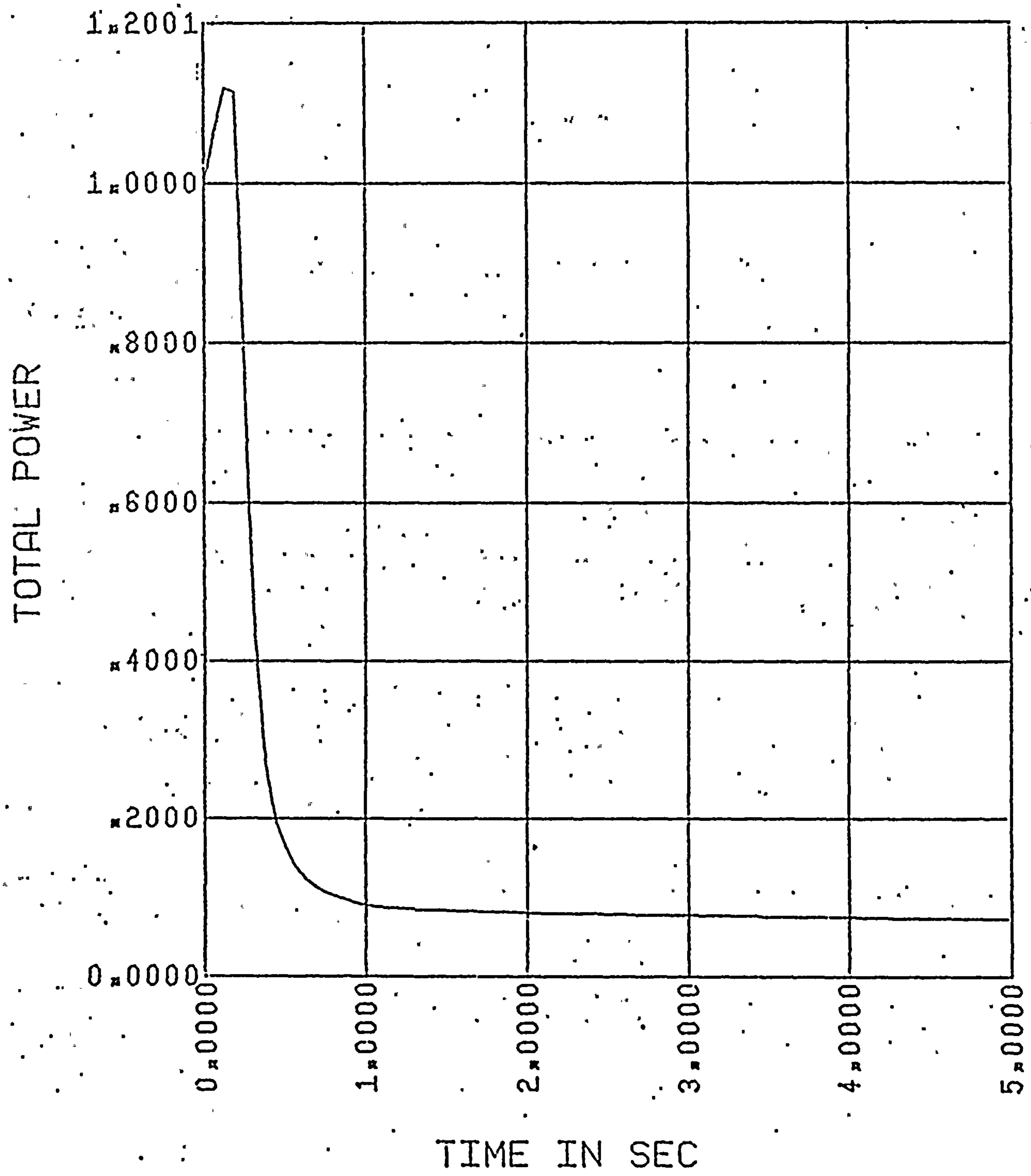


Figure II.5-8

2560 MWt PLANTS

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

PRESSURE IN CENTER HOT ASSEMBLY NODE

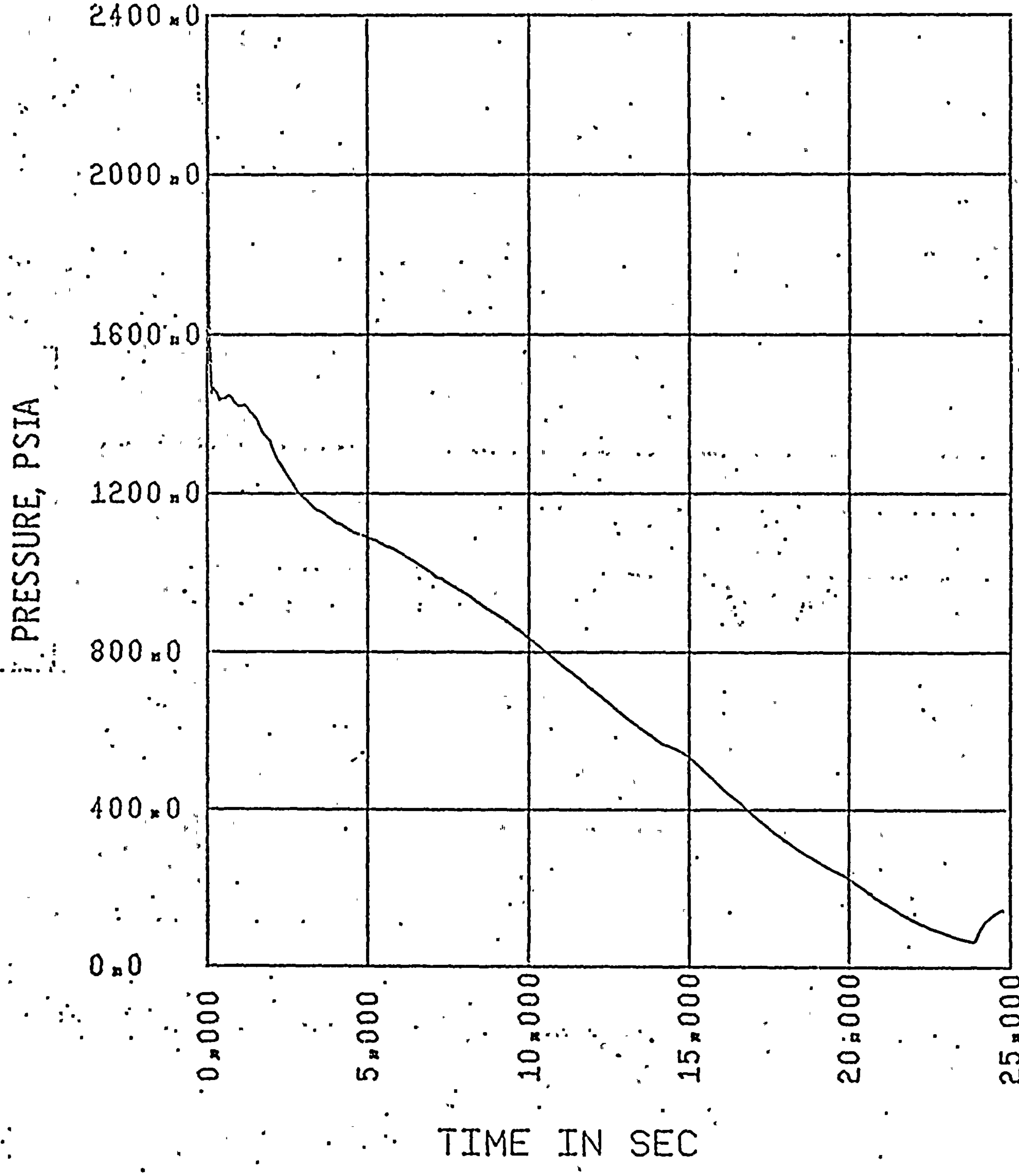


Figure II.5-C

2560 MWt PLANTS
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

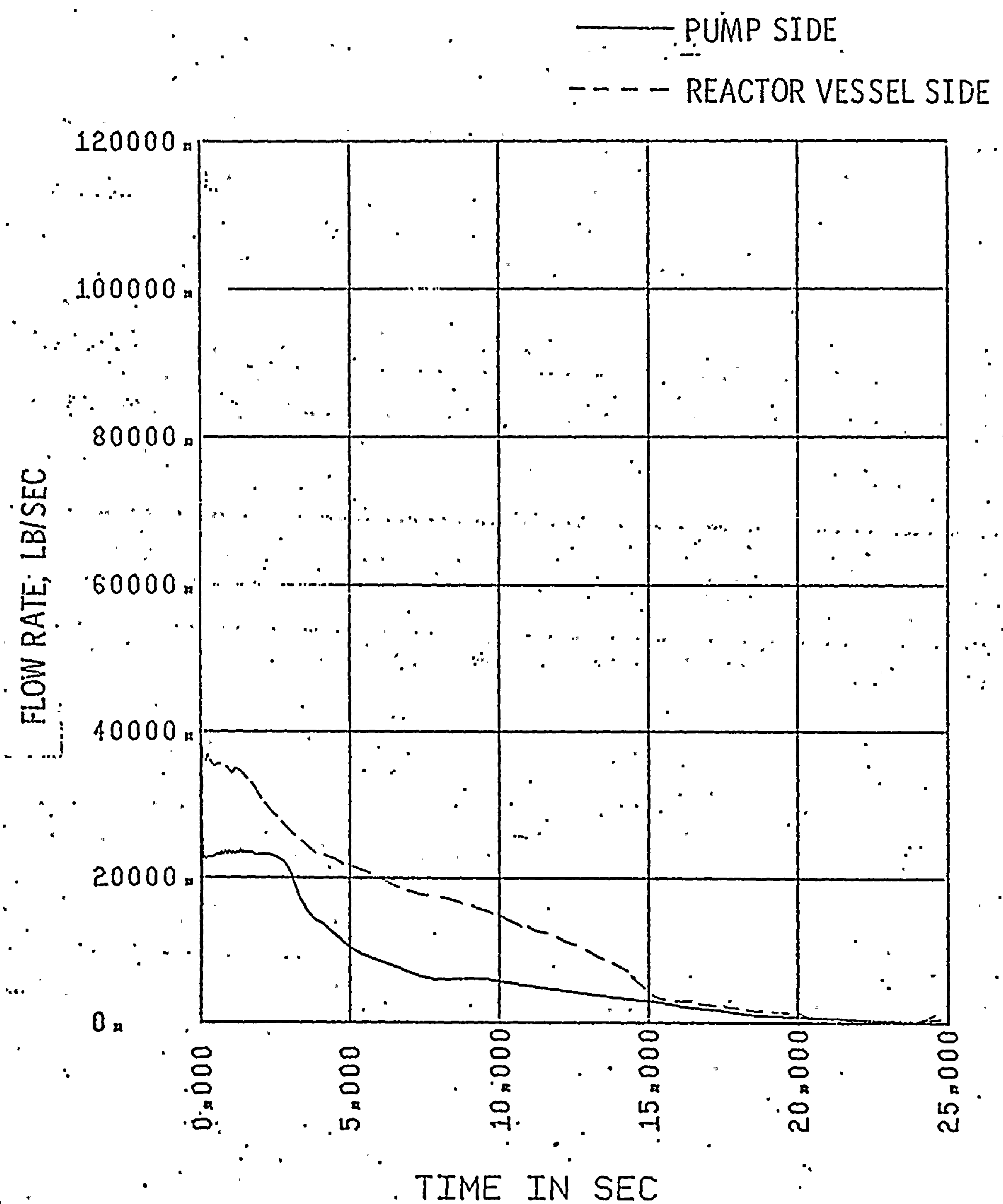


Figure II.5-D.1

2560 MWt PLANTS

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

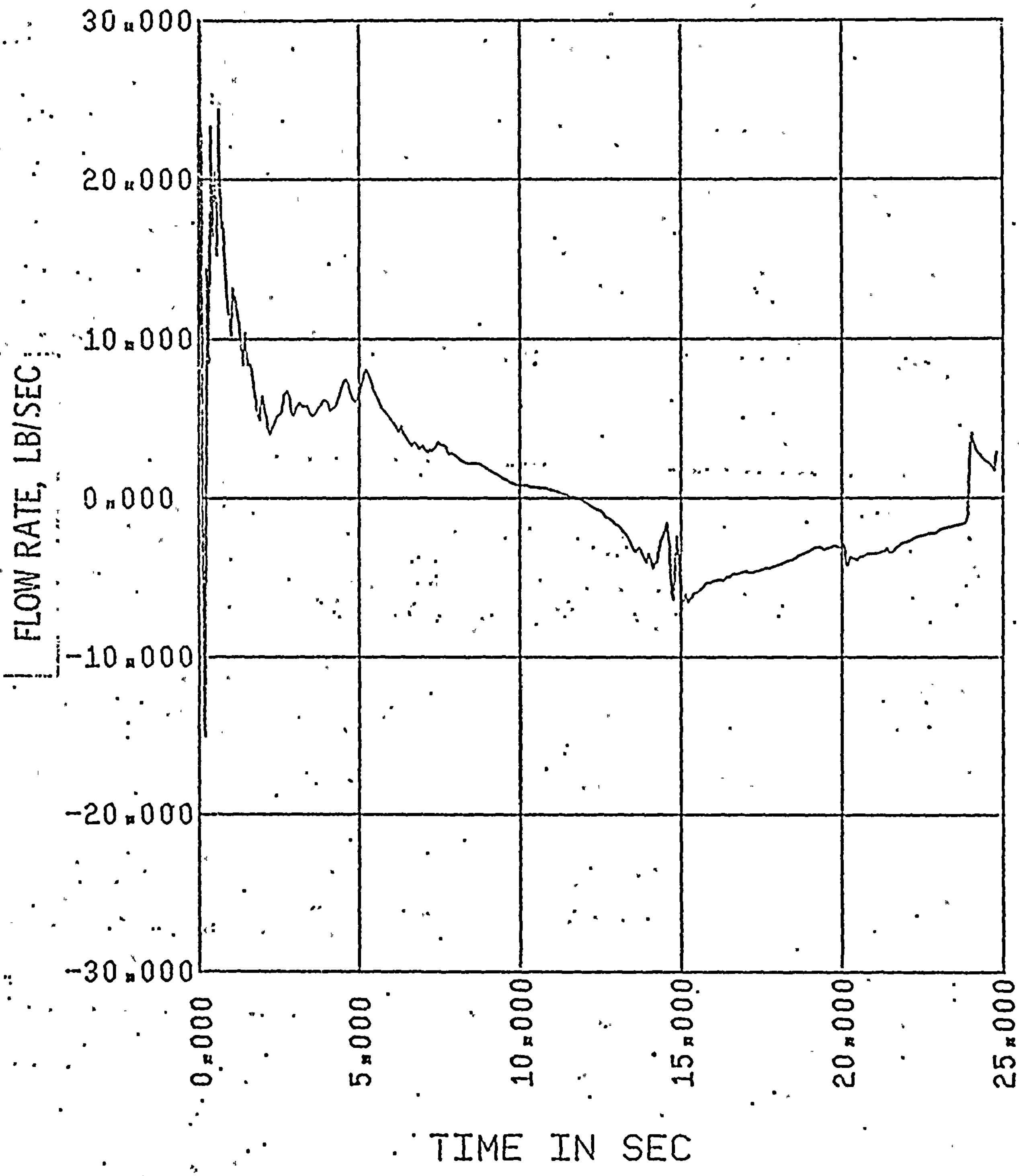


Figure II.5-D.2

2560 MWt PLANTS

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

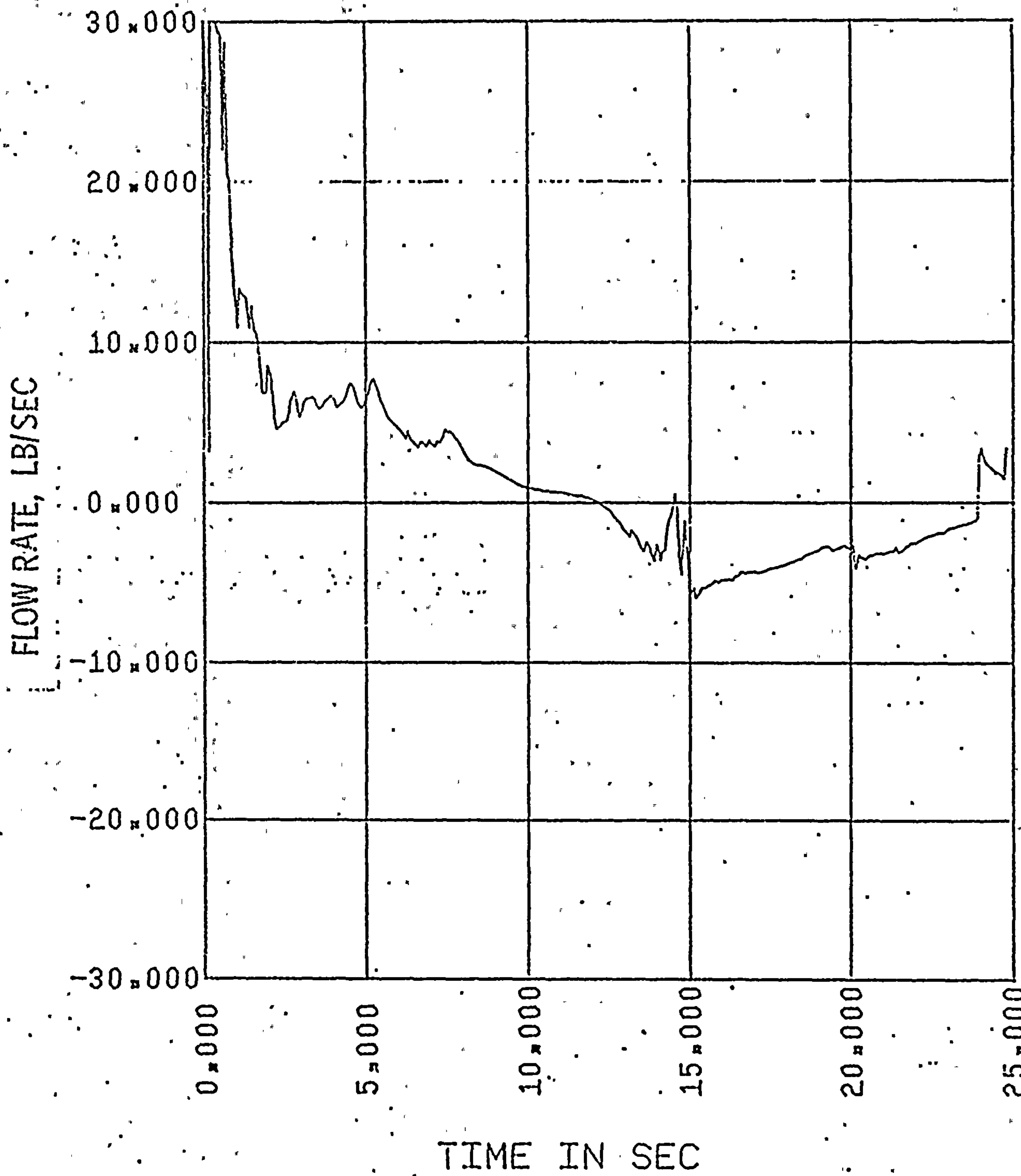


Figure II.5-E

2560 MWt PLANTS
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

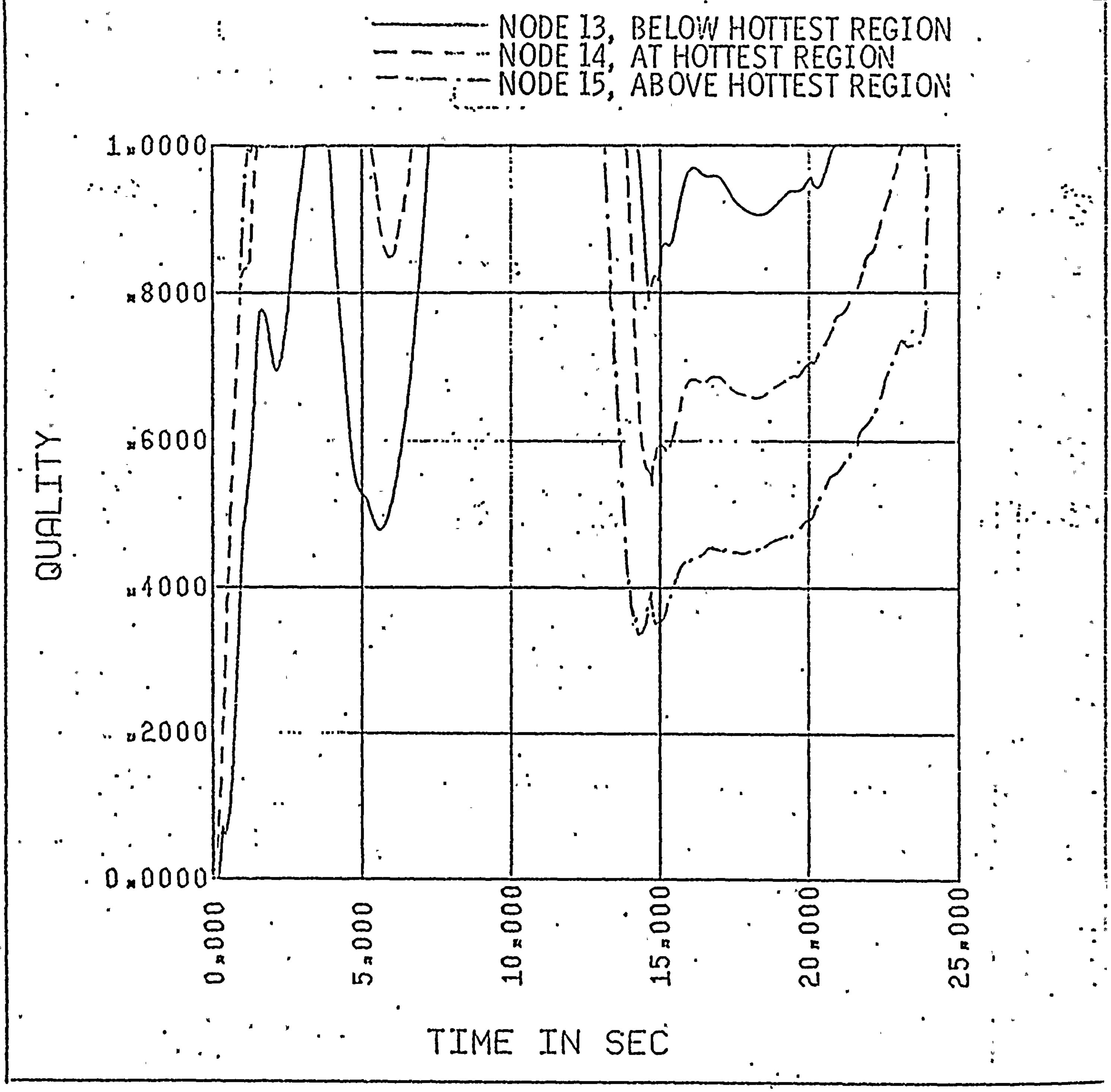


Figure II.5-F
ST. LUCIE I
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

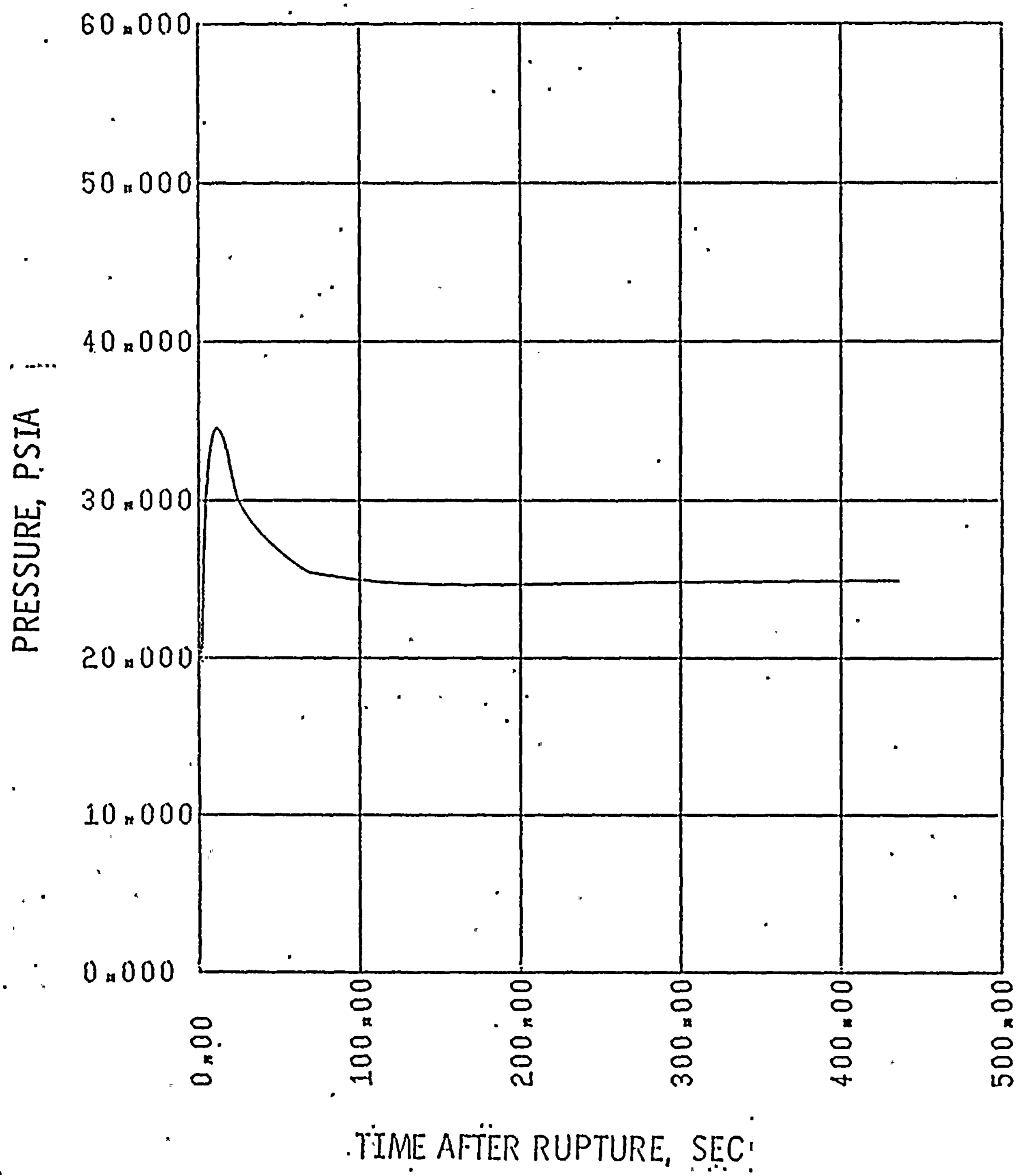
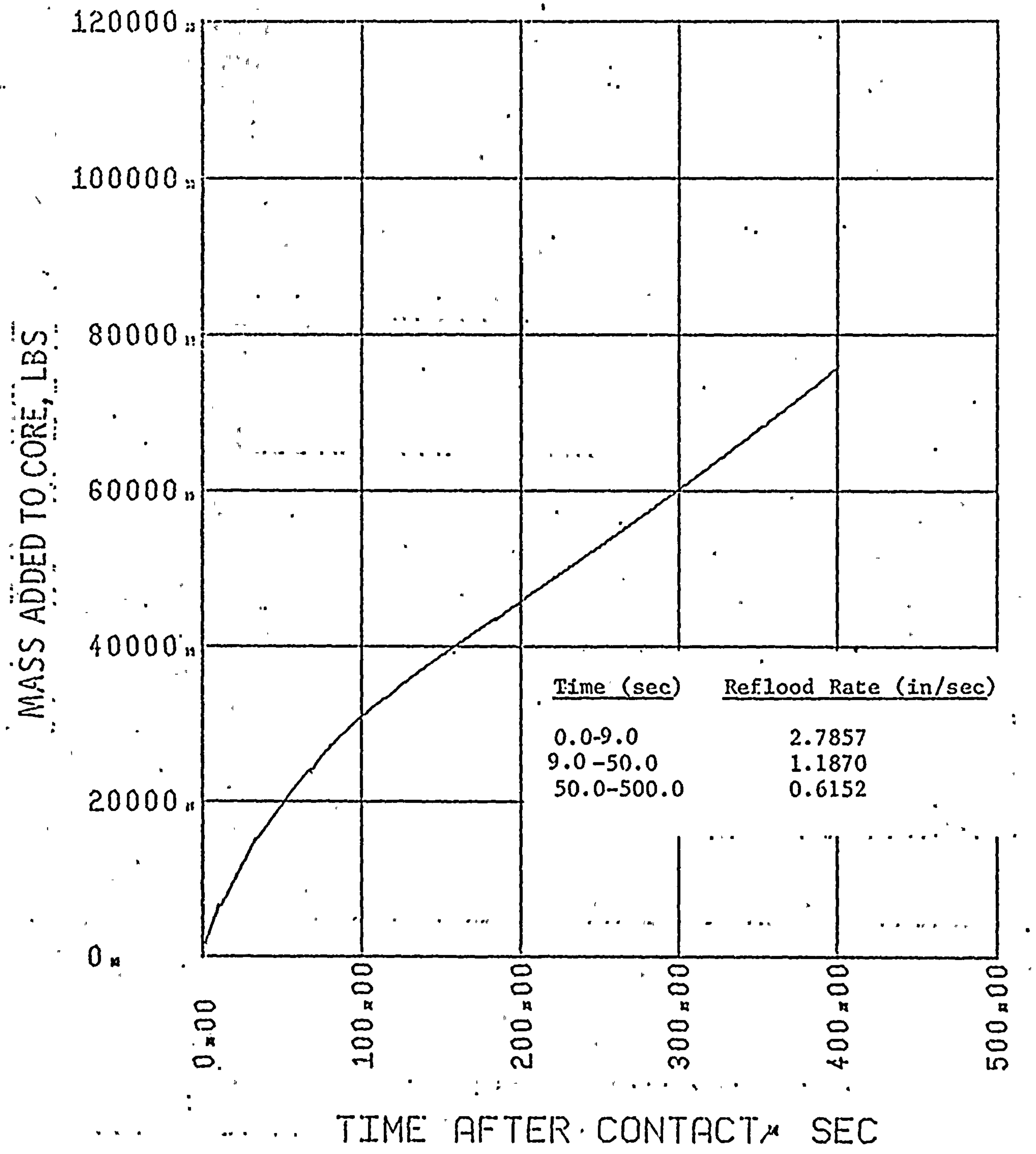


Figure II.5-G

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD



Time (sec)	Reflood Rate (in/sec)
0.0-9.0	2.7857
9.0-50.0	1.1870
50.0-500.0	0.6152

Figure II.5-H

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

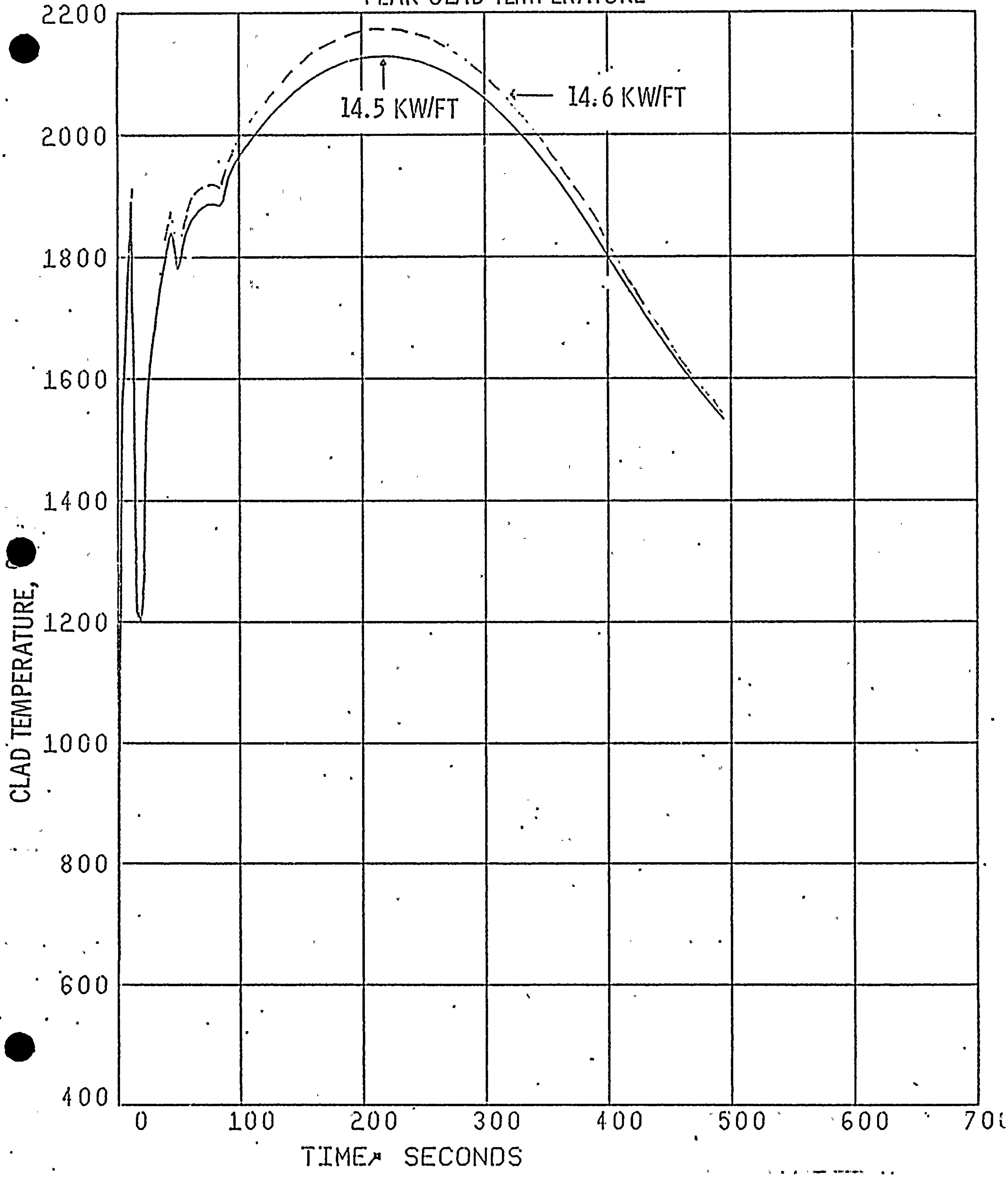


Figure II.5-I
ST. LUCIE I
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
MID ANNULUS FLOW

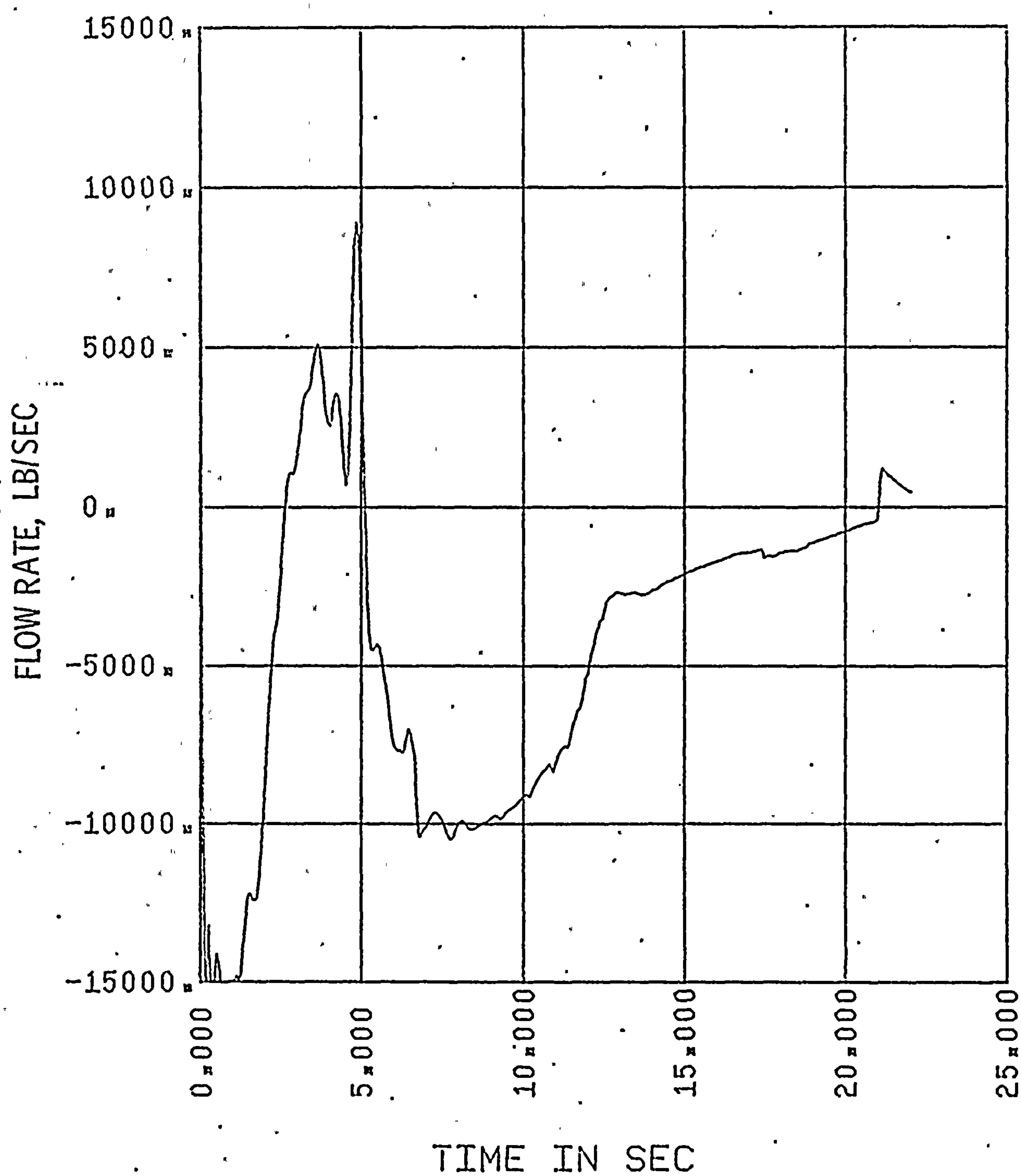


Figure II.5-J

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
QUALITIES ABOVE AND BELOW THE CORE

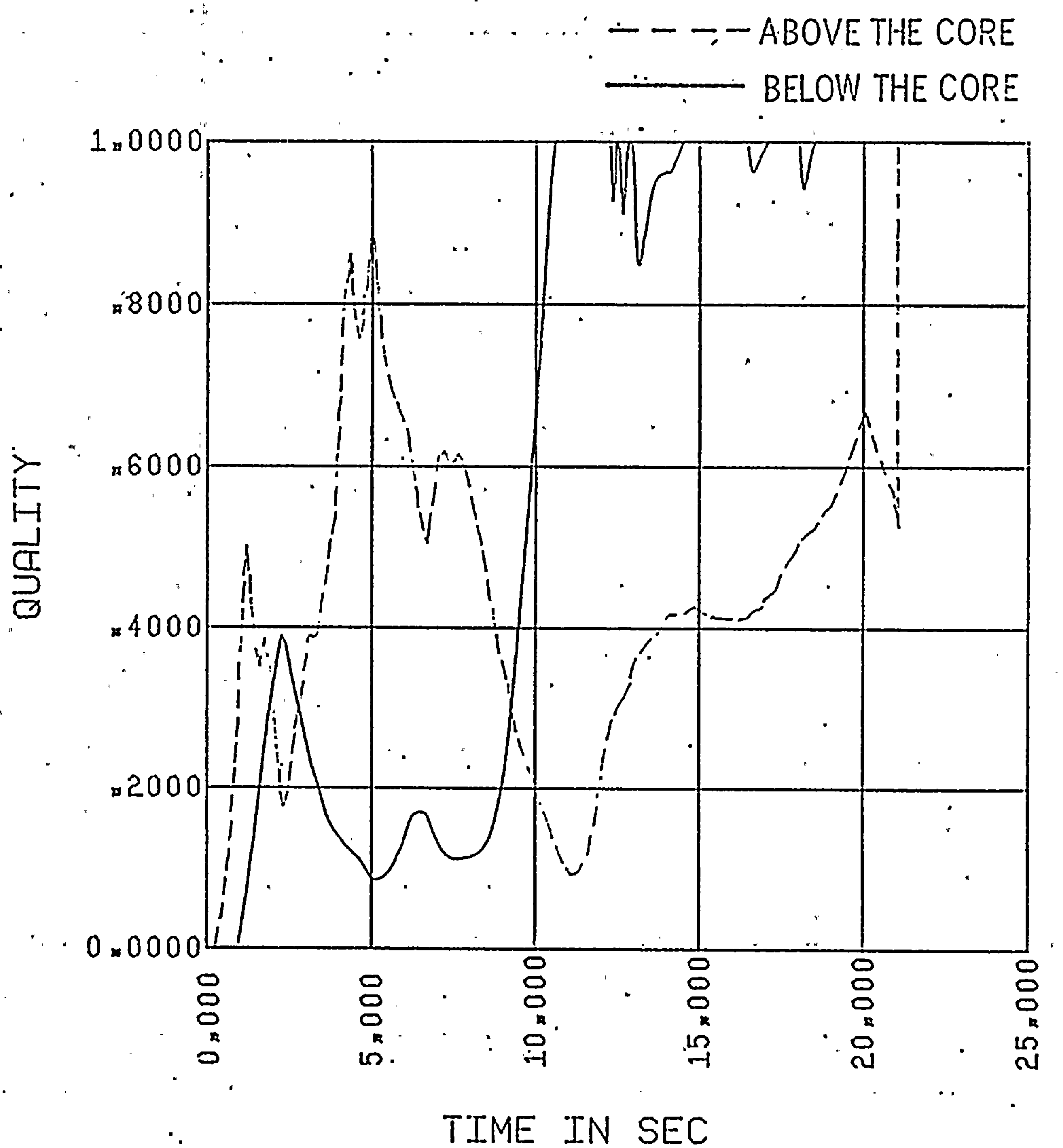


Figure II.5-K

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CORE PRESSURE DROP

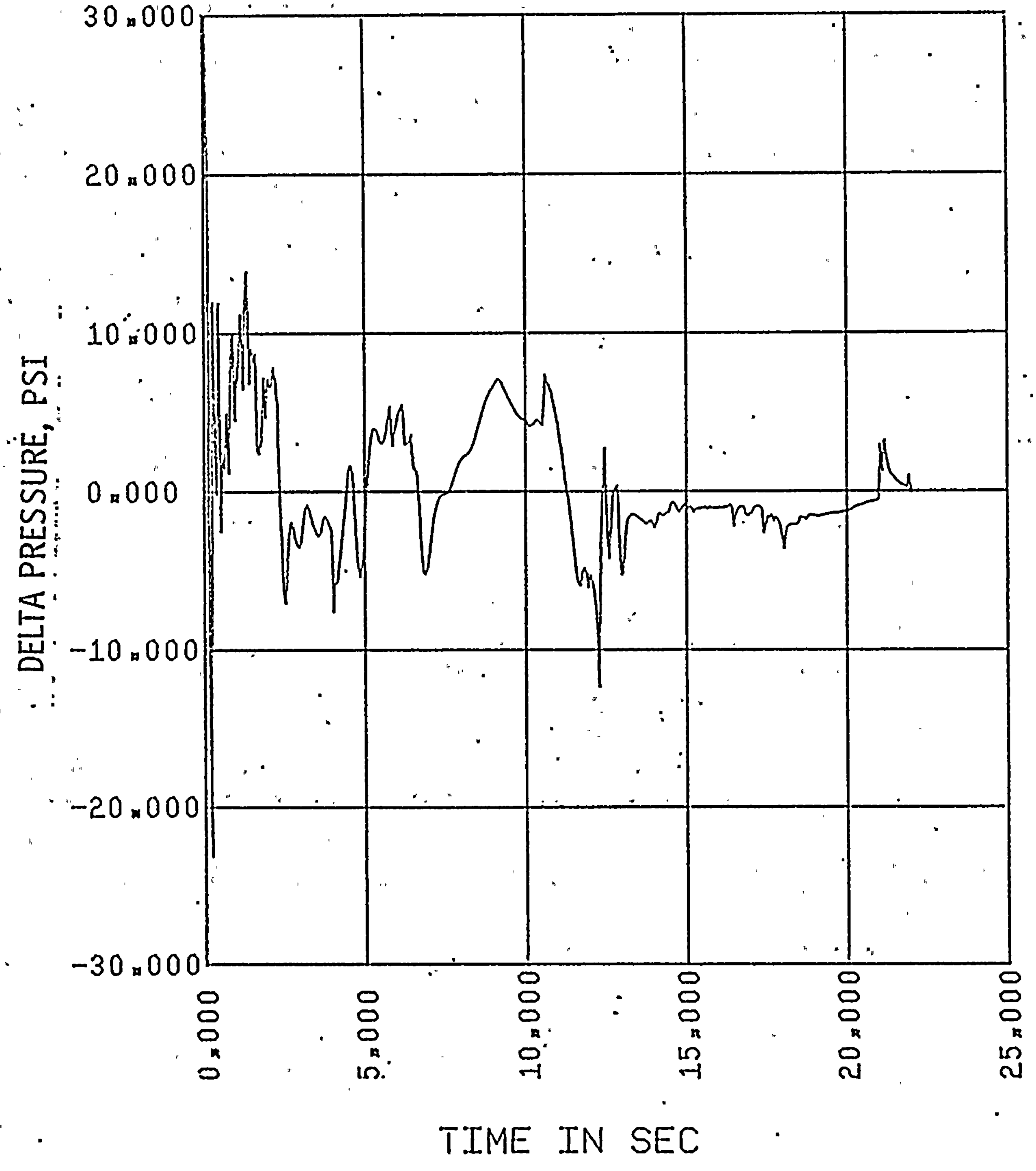


Figure II.5-L

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

SAFETY INJECTION FLOW INTO INTACT DISCHARGE LEGS

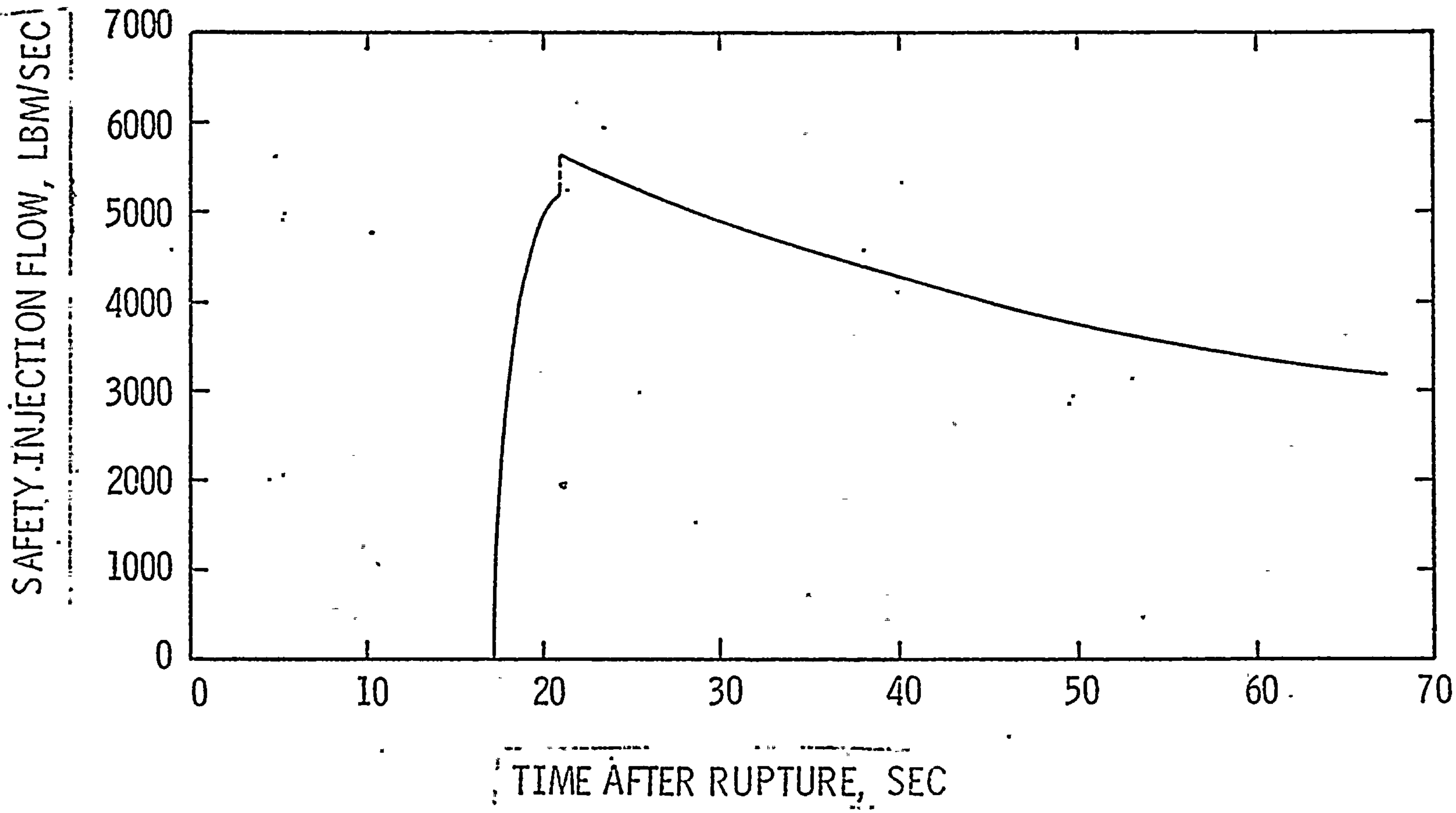


Figure II.5-M

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
TWO-PHASE LEVEL IN DOWNCOMER DURING REFLOOD

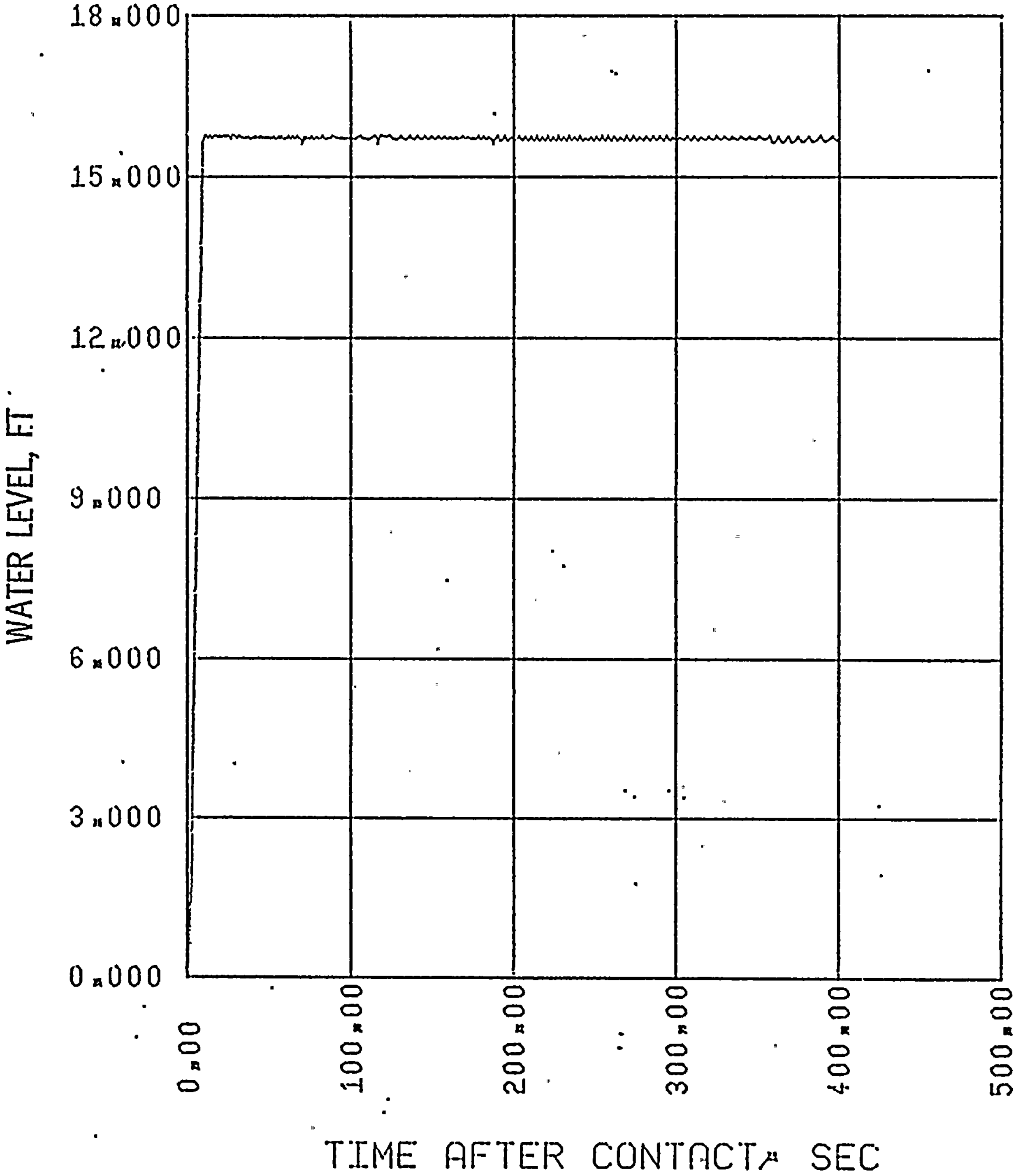


Figure II.5-N

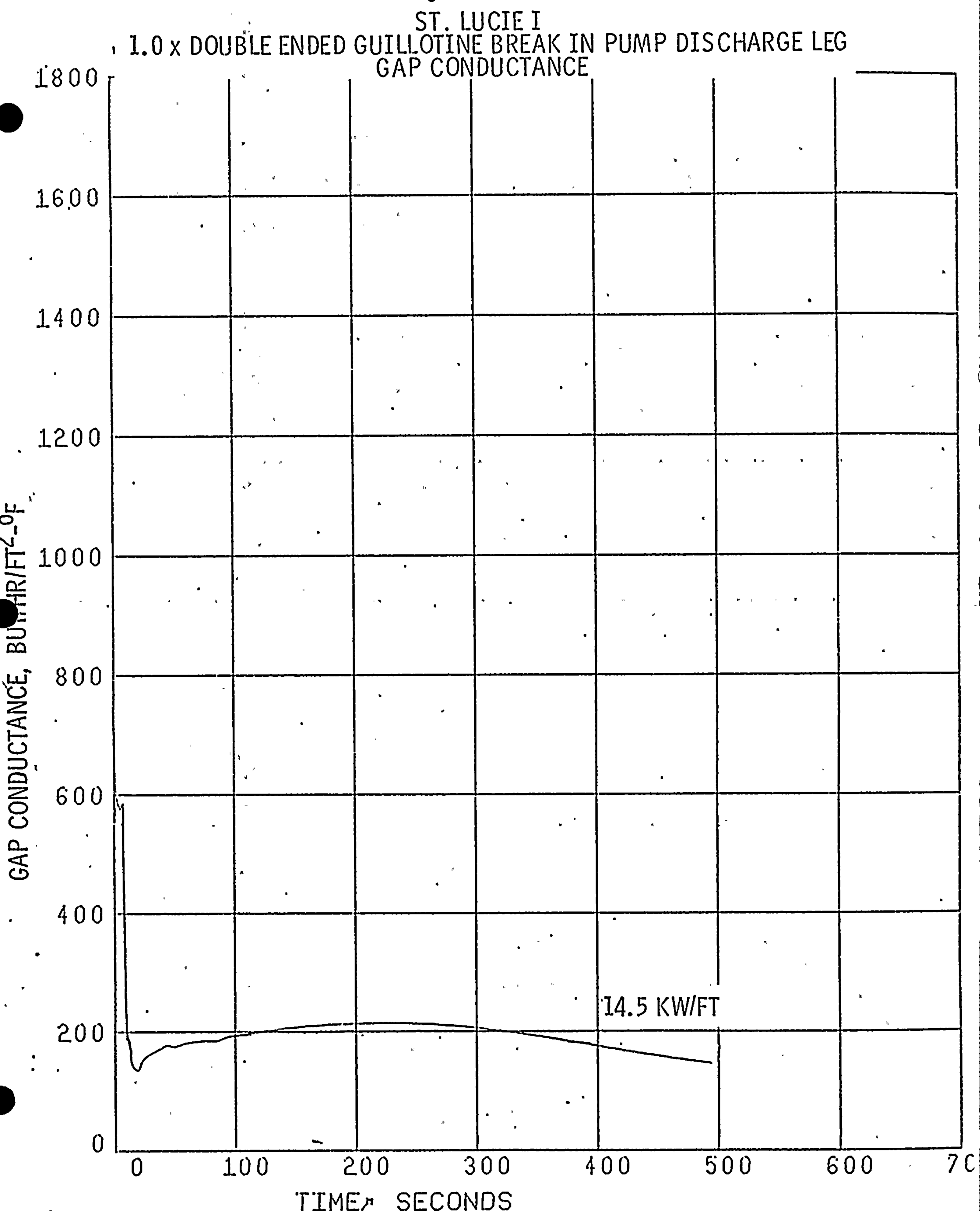

ST. LUCIE I
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
GAP CONDUCTANCE
GAP CONDUCTANCE, BTU/HR/FT^2-^{0}F
1800
1600
1400
1200
1000
800
600
400
200
0
14.5 KW/FT
0
100
200
300
400
500
600
700
TIME, SECONDS

Figure II.5-0

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

LOCAL CLAD OXIDATION

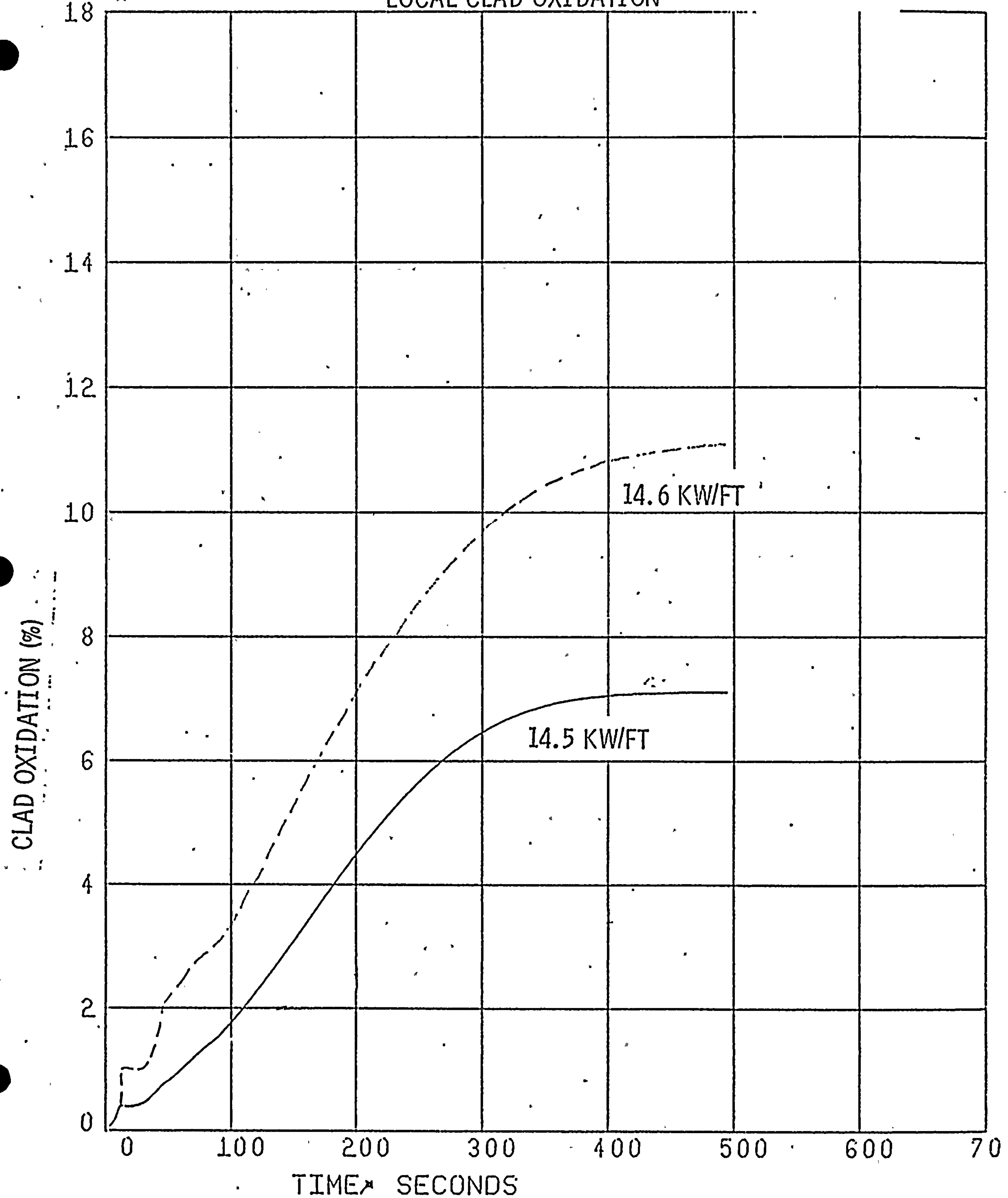


Figure II.5-P

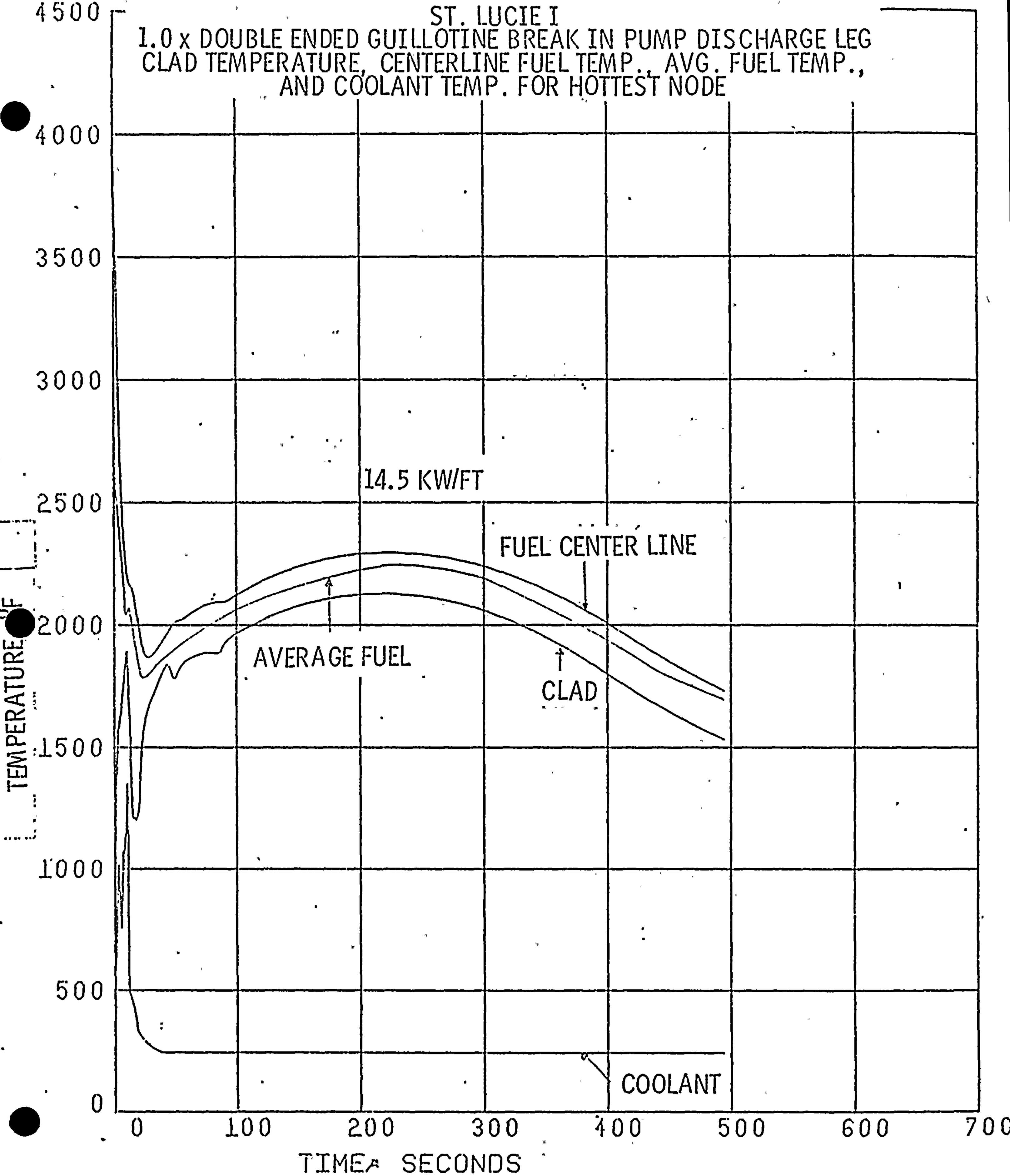

ST. LUCIE I
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CLAD TEMPERATURE, CENTERLINE FUEL TEMP., AVG. FUEL TEMP.,
AND COOLANT TEMP. FOR HOTTEST NODE
14.5 KW/FT
FUEL CENTER LINE
AVERAGE FUEL
CLAD
COOLANT
TEMPERATURE °F
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
100
200
300
400
500
600
700
TIME, SECONDS

Figure II.5-Q

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

HOT SPOT HEAT TRANSFER COEFFICIENT

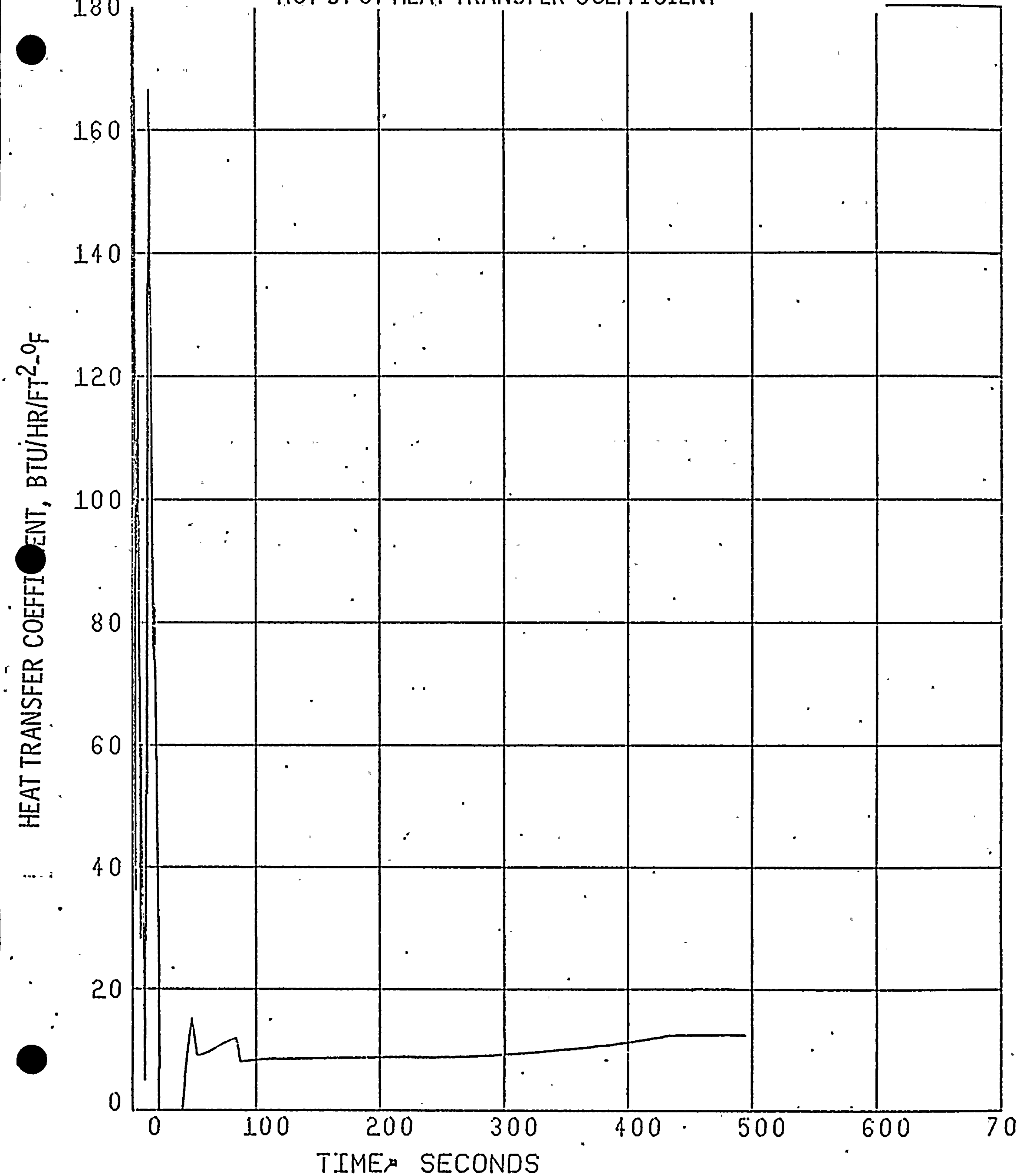


Figure II.5-R

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

HOT SPOT HEAT TRANSFER COEFFICIENT DURING REFLOOD

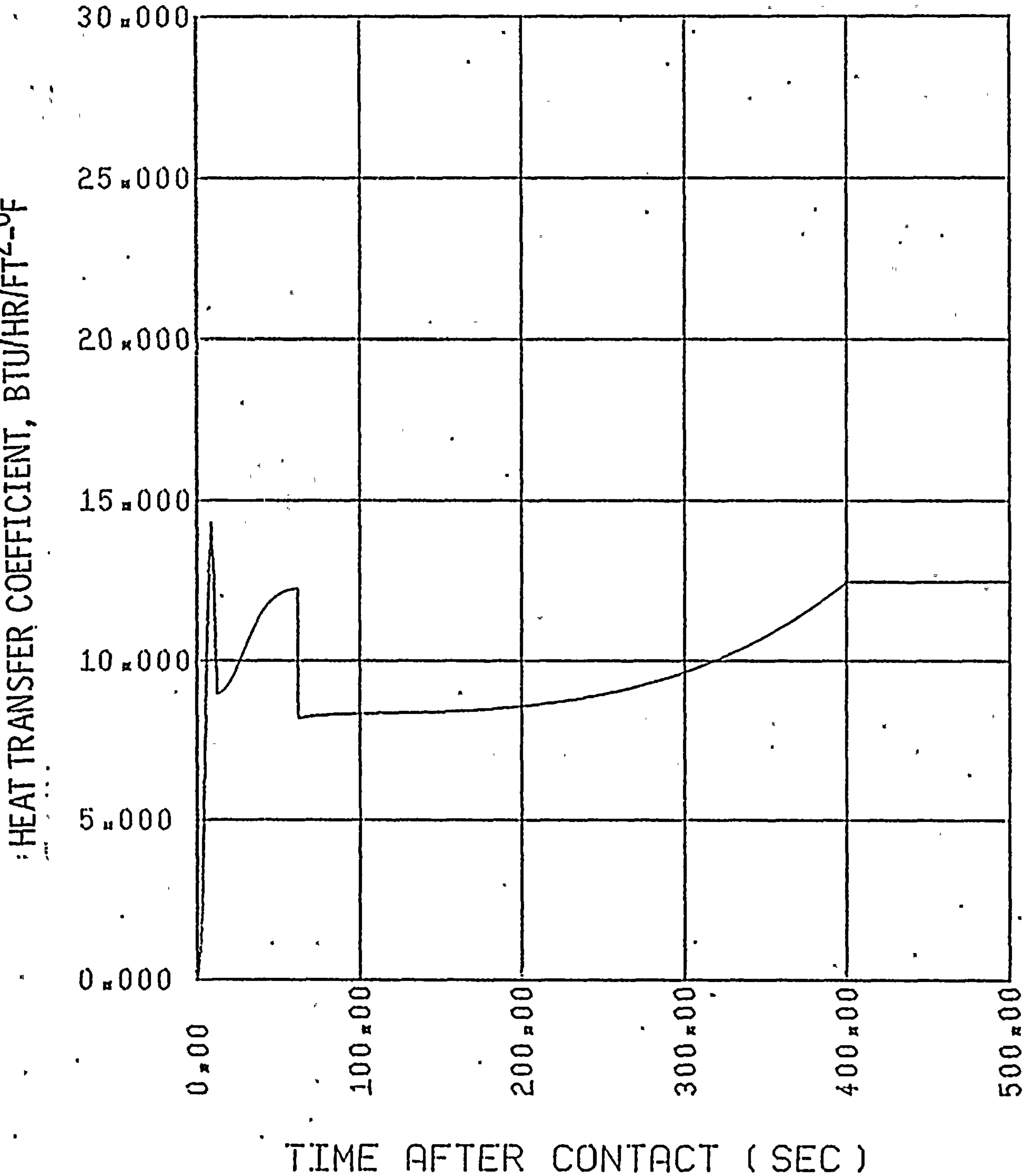


Figure II.5-S

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CONTAINMENT TEMPERATURE

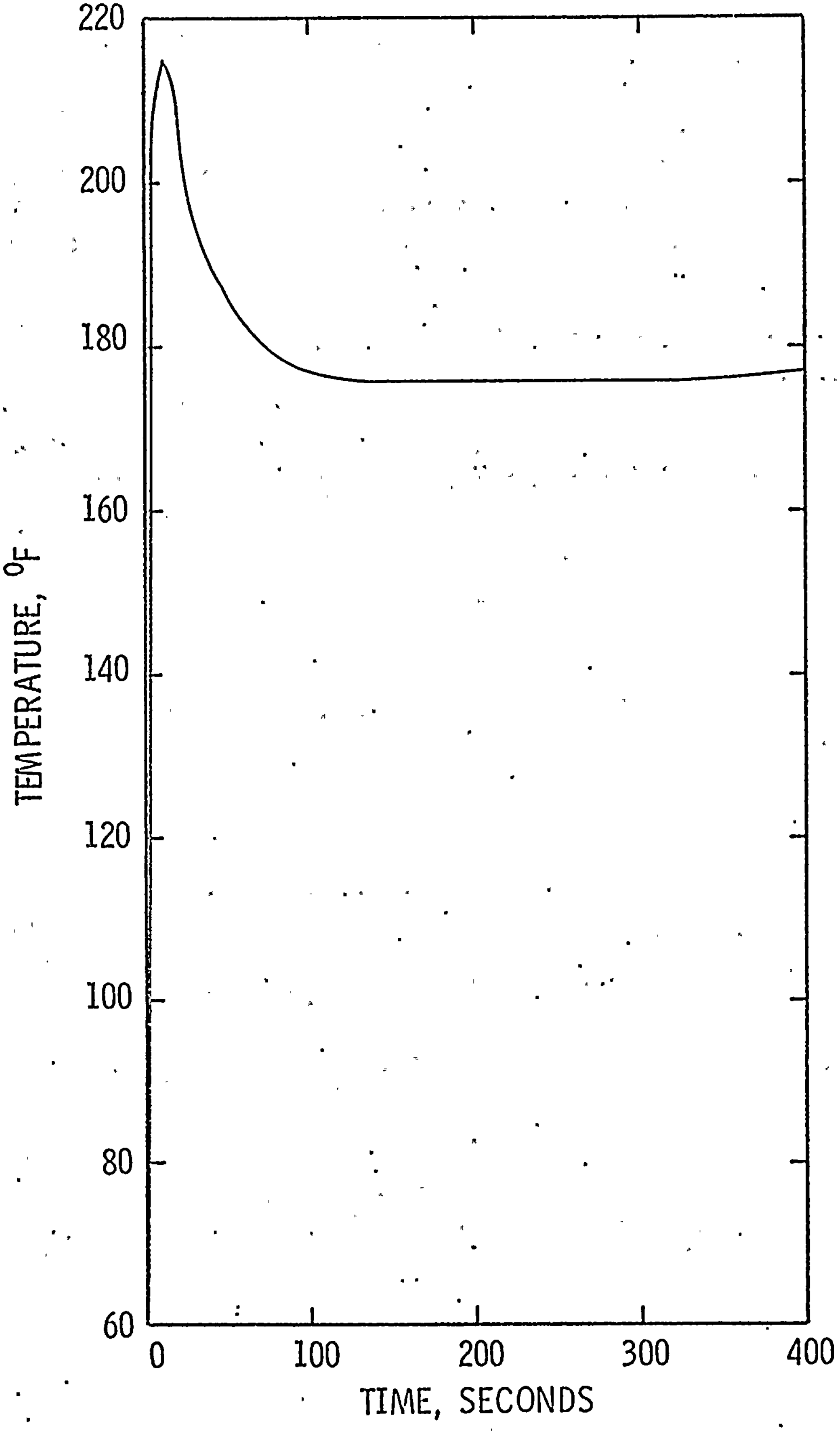


Figure II.5-T

ST. LUCIE I

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

SUMP TEMPERATURE

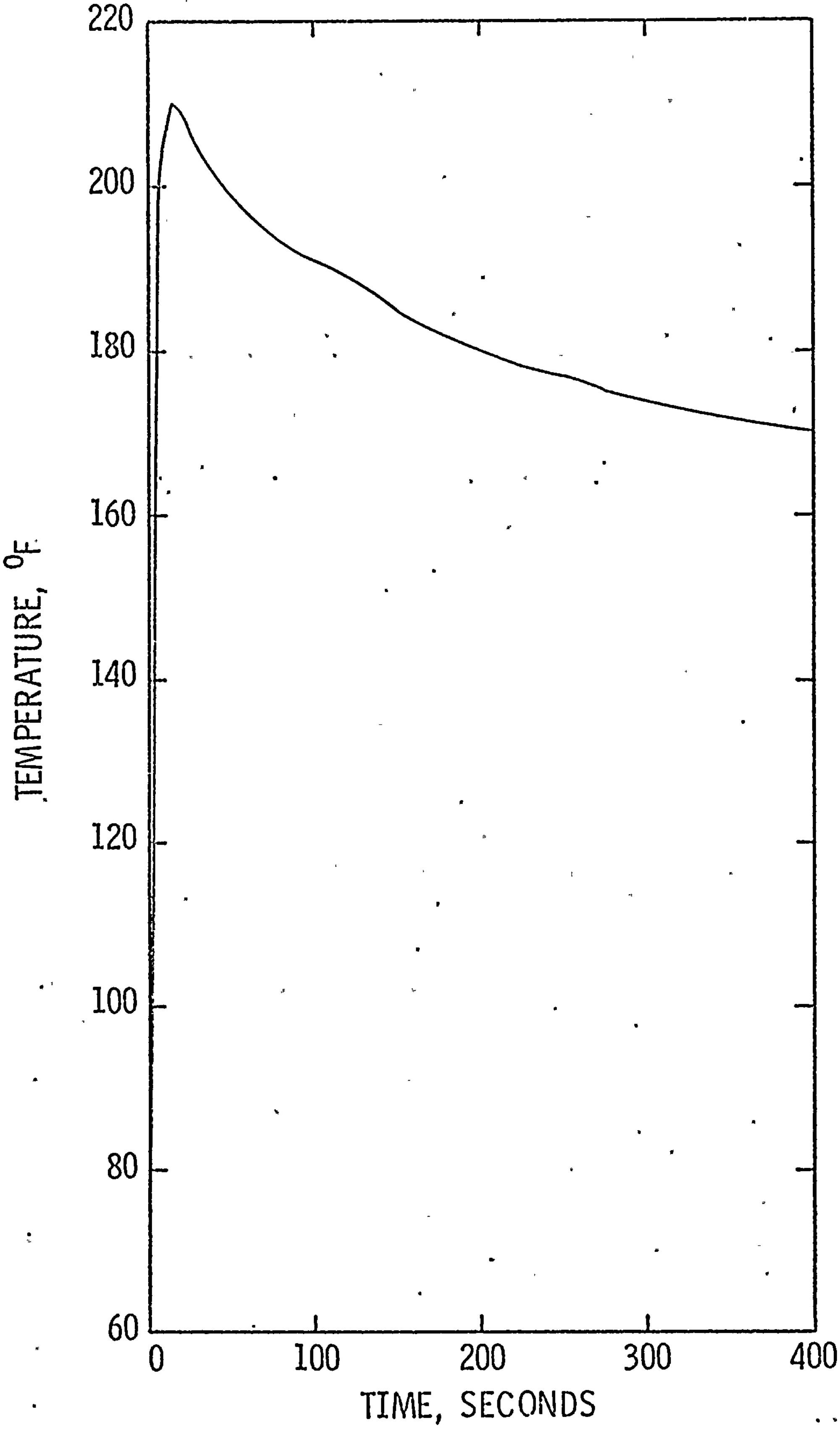


Figure II.6-A

2560 MWt PLANTS
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CORE POWER

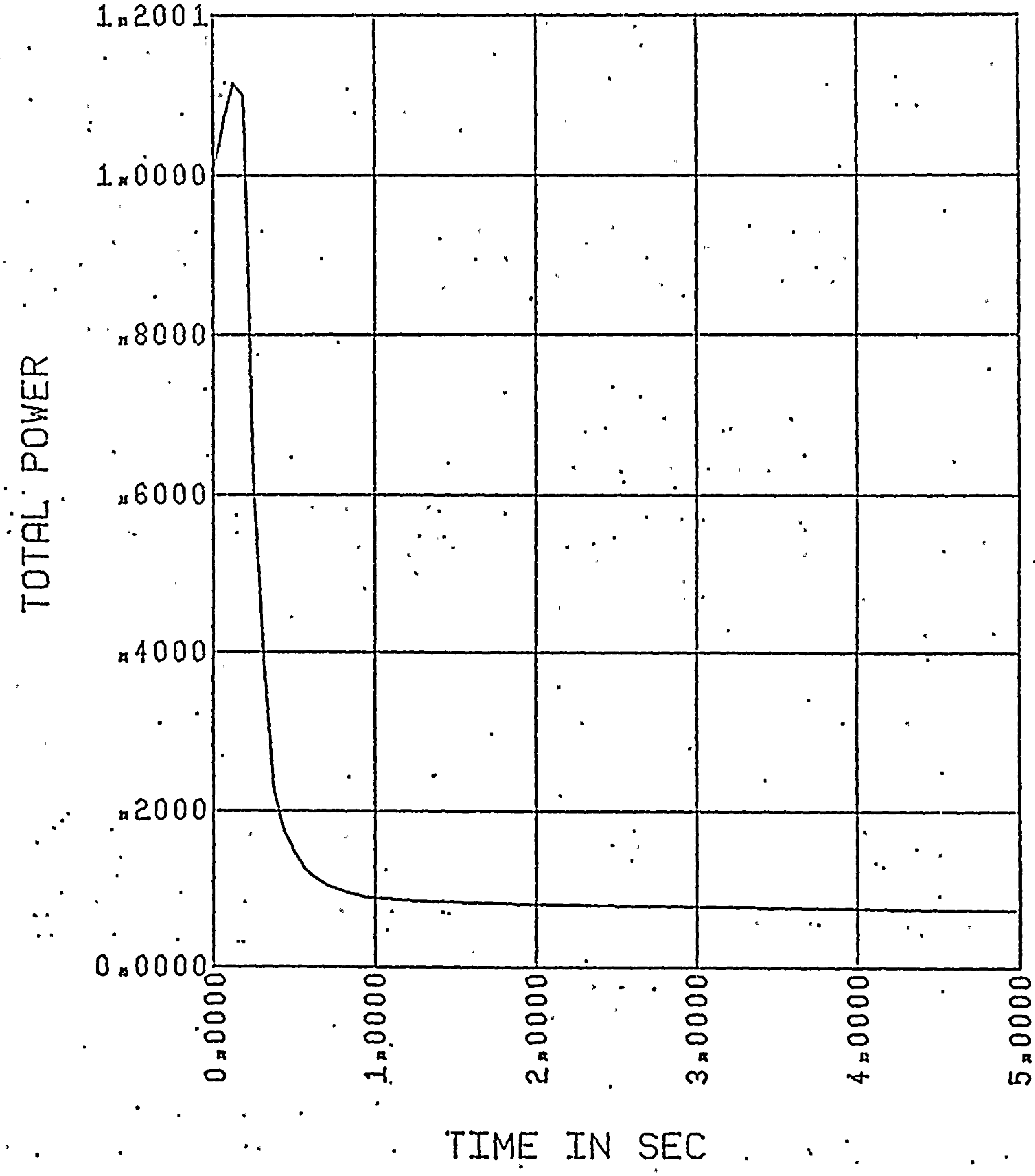


Figure II.6-B

2560 MWt FLANTS
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

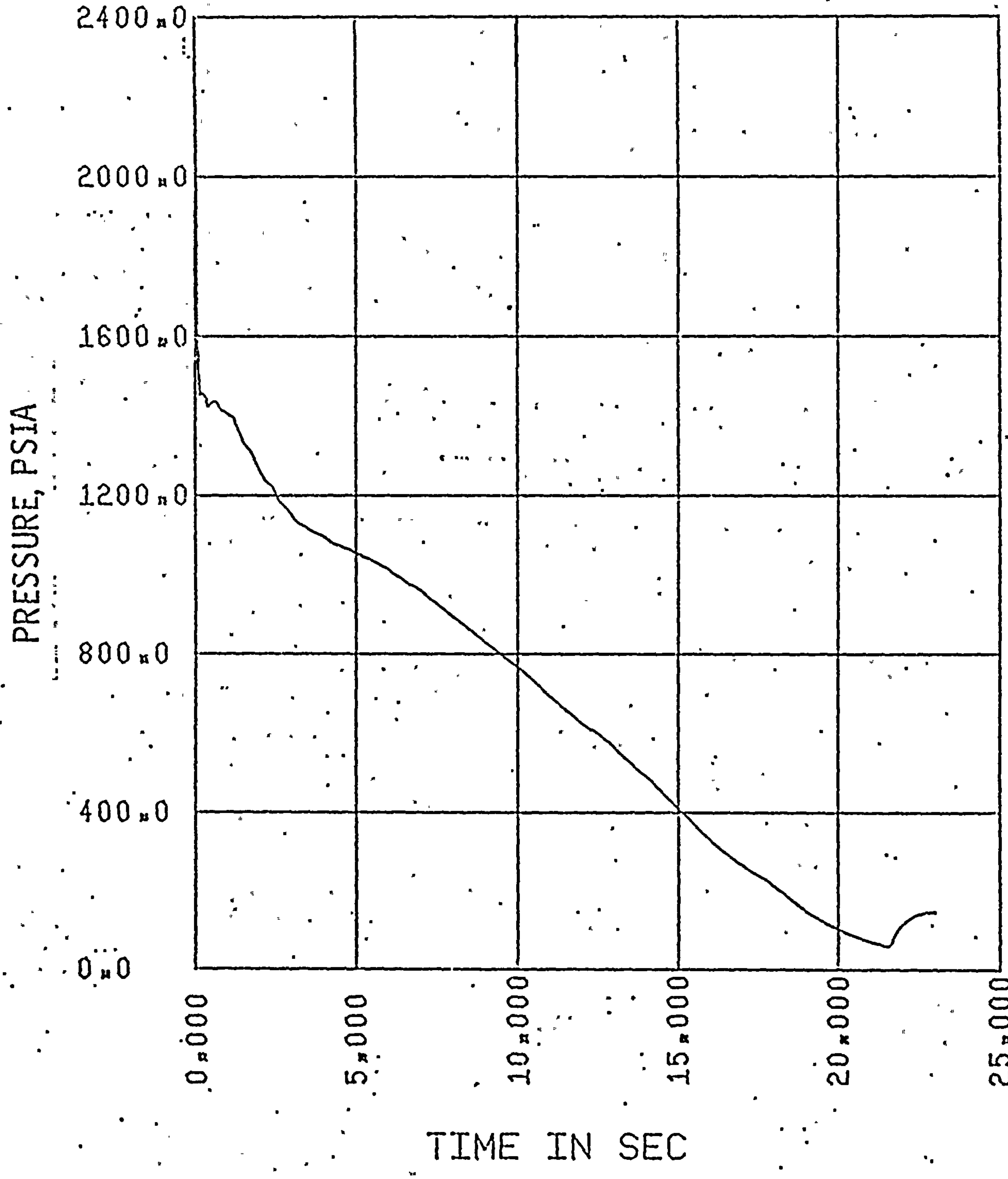


Figure II.6-C

2560 MWt PLANTS
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

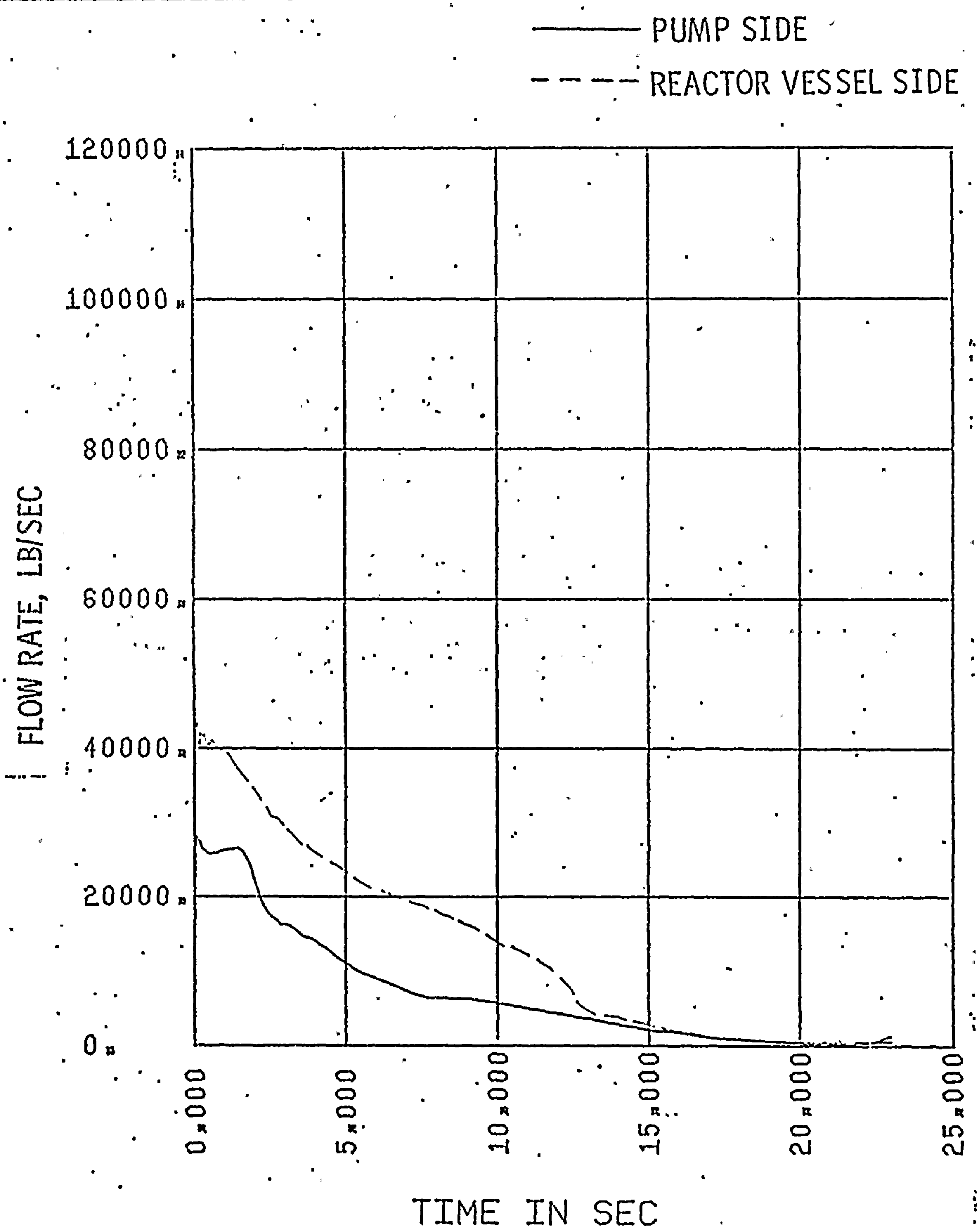


Figure II.6-D.1

2560 MWt PLANTS

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

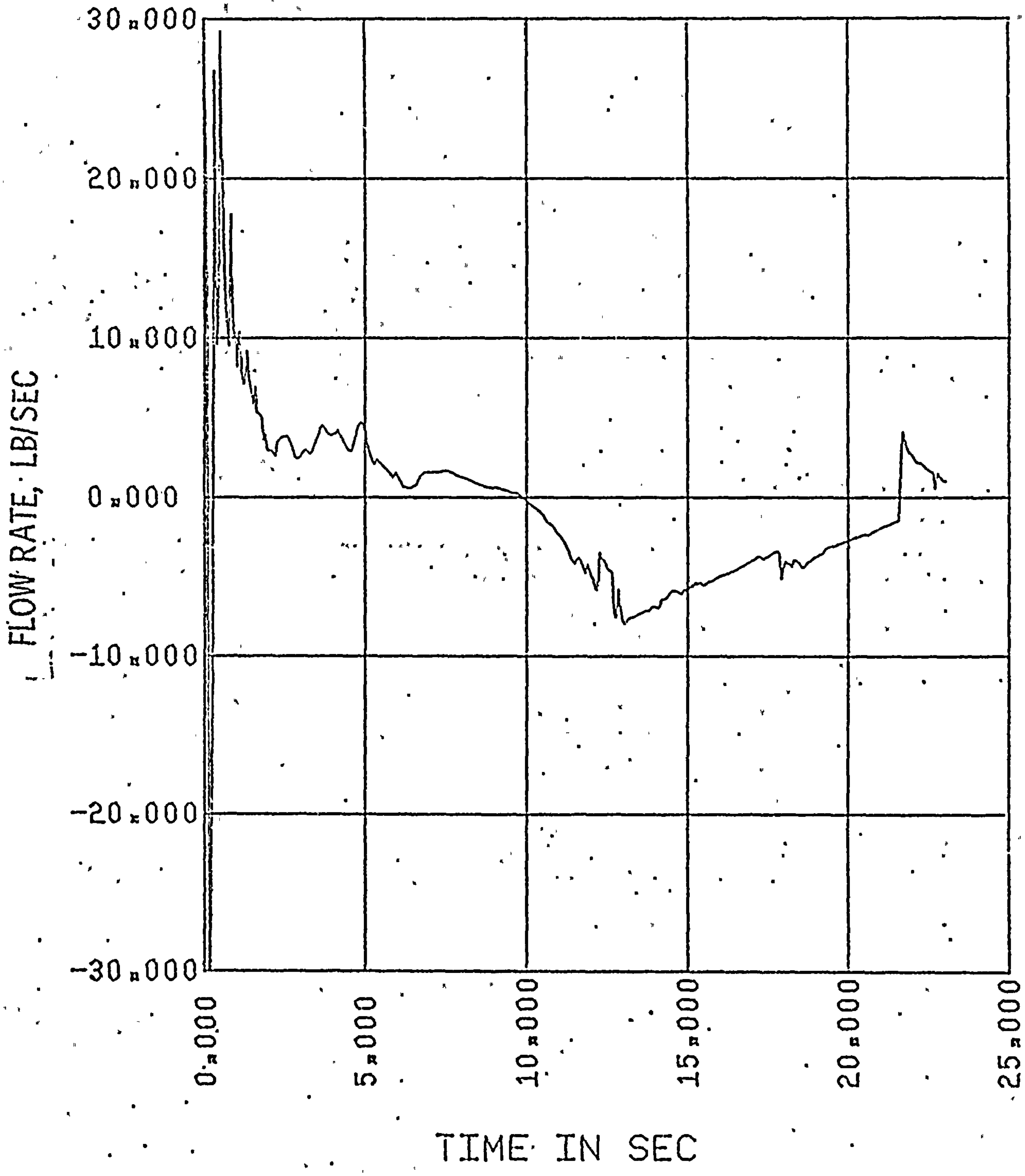


Figure II.6-D.2

2560 MWt PLANTS
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

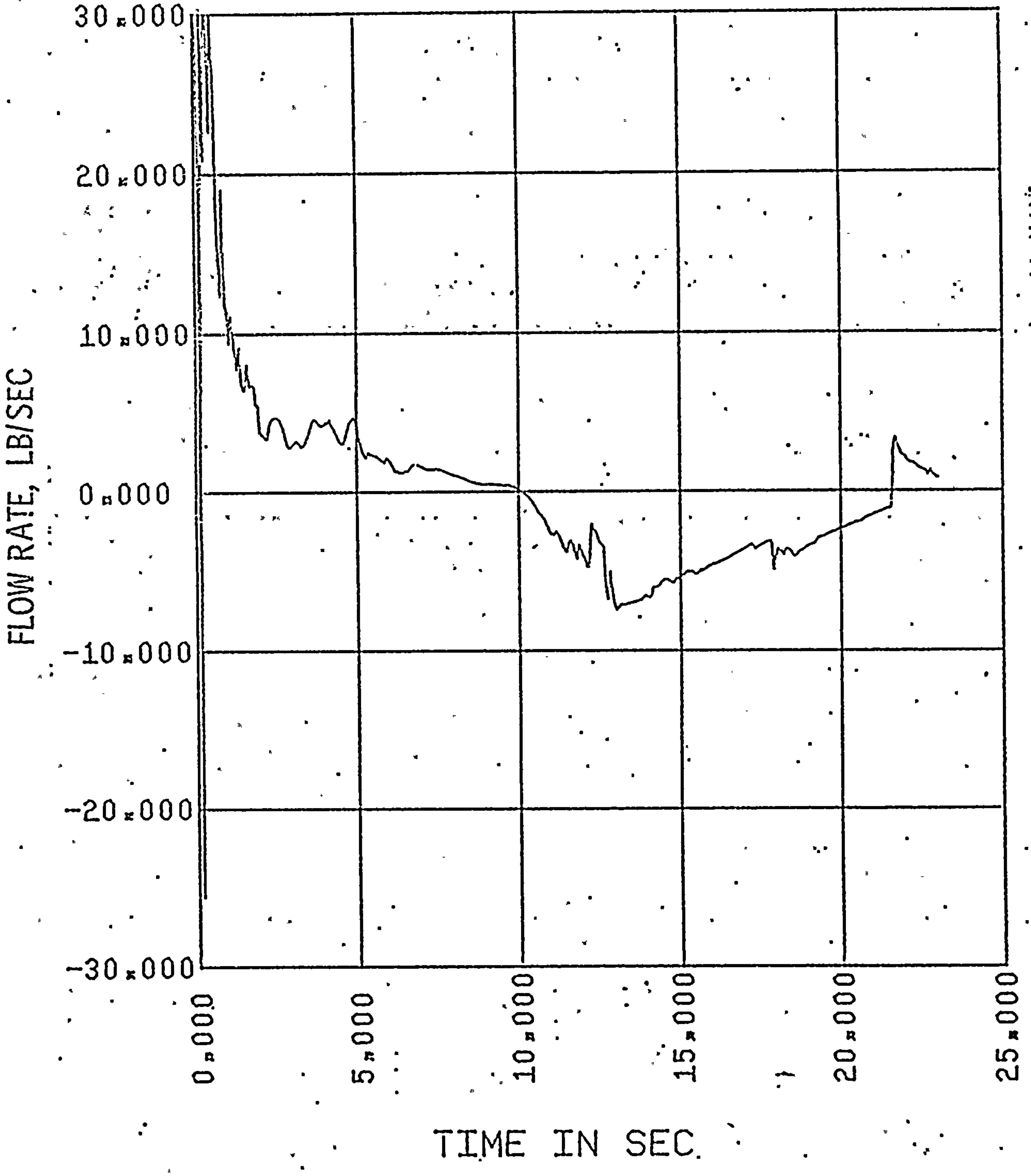


Figure II.6-E

2560 MWt PLANTS

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

HOT ASSEMBLY QUALITY

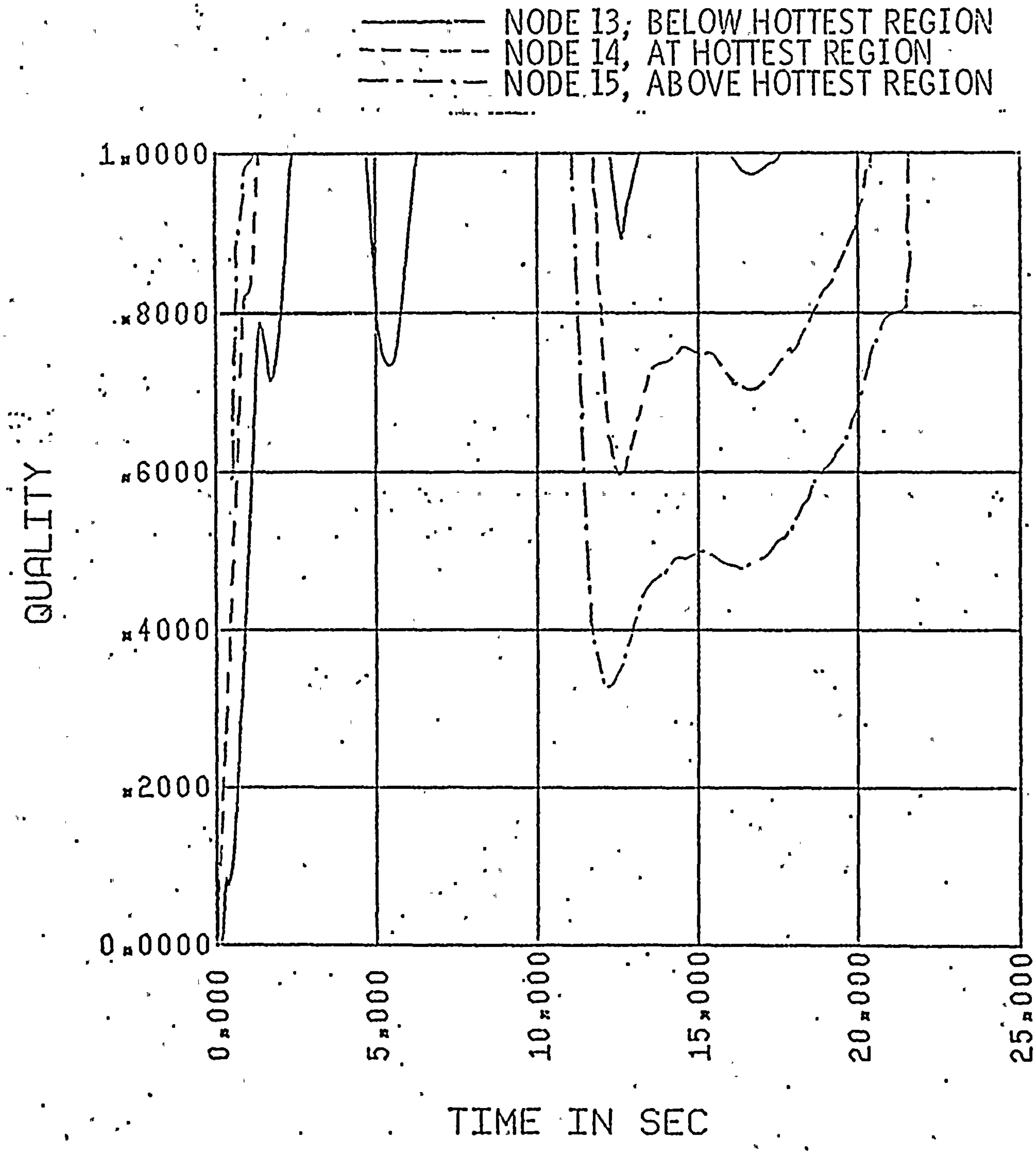


Figure II.6-F

ST. LUCIE I

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

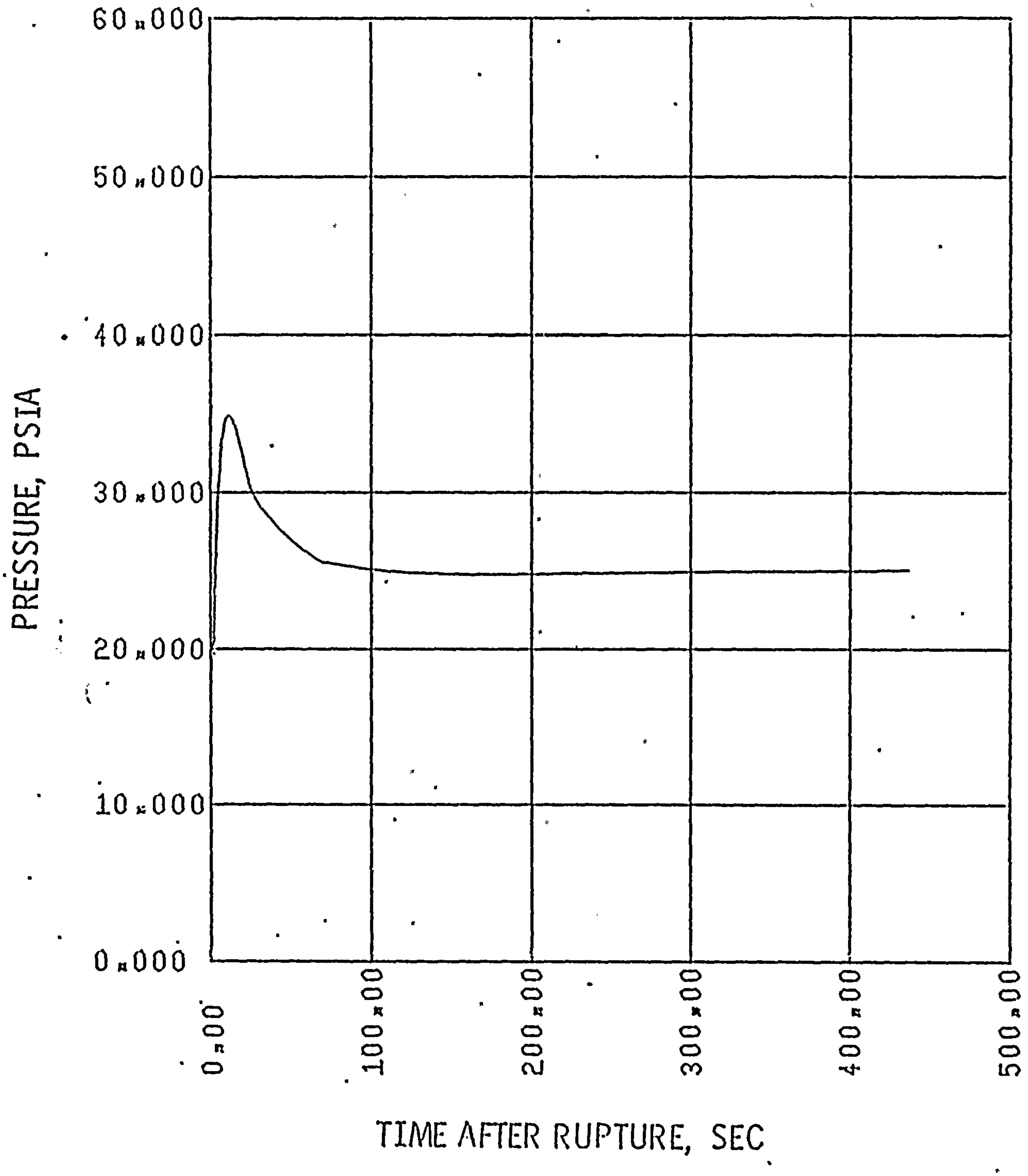


Figure II.6-G

ST. LUCIE I

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

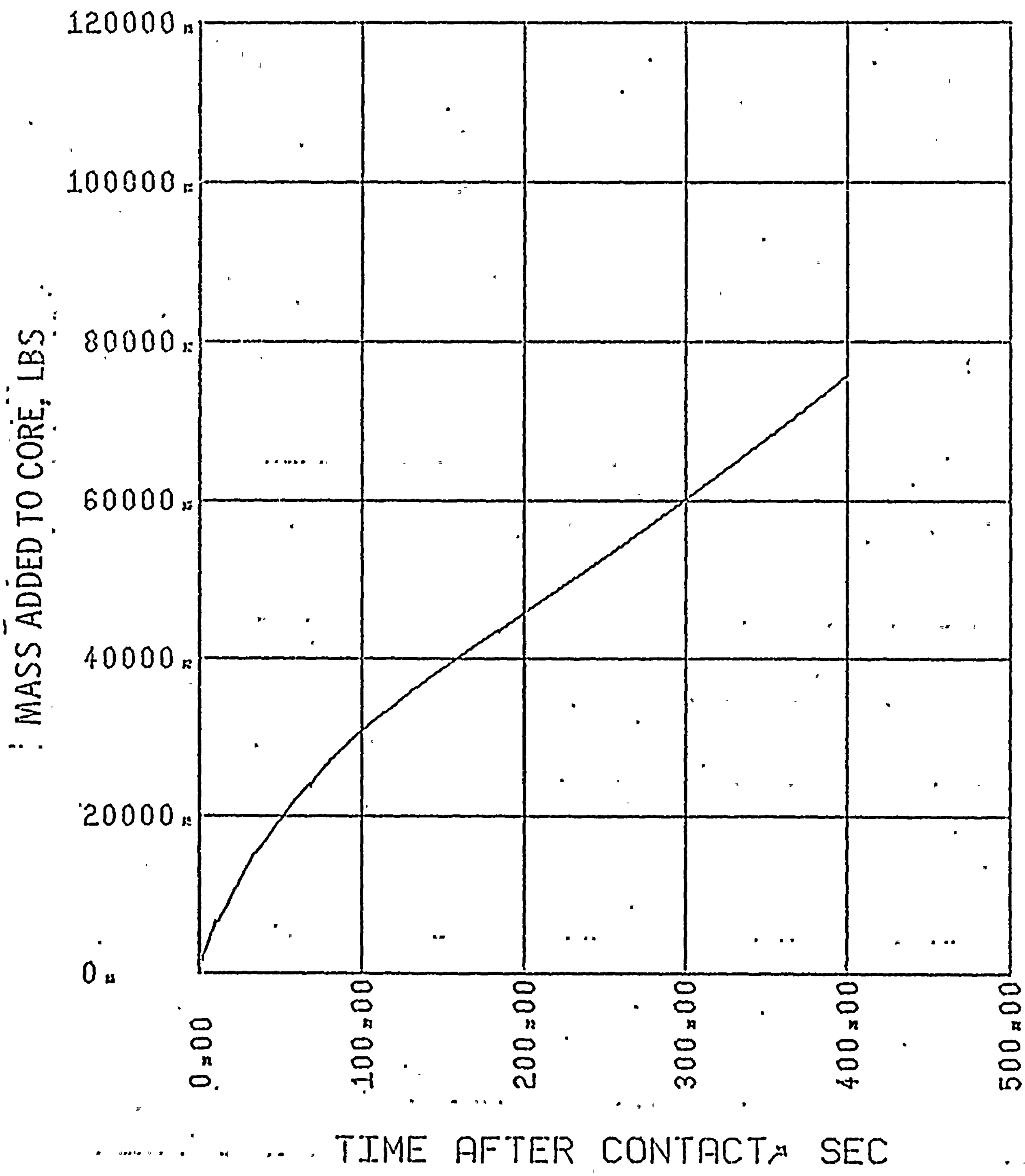


Figure II.6-H

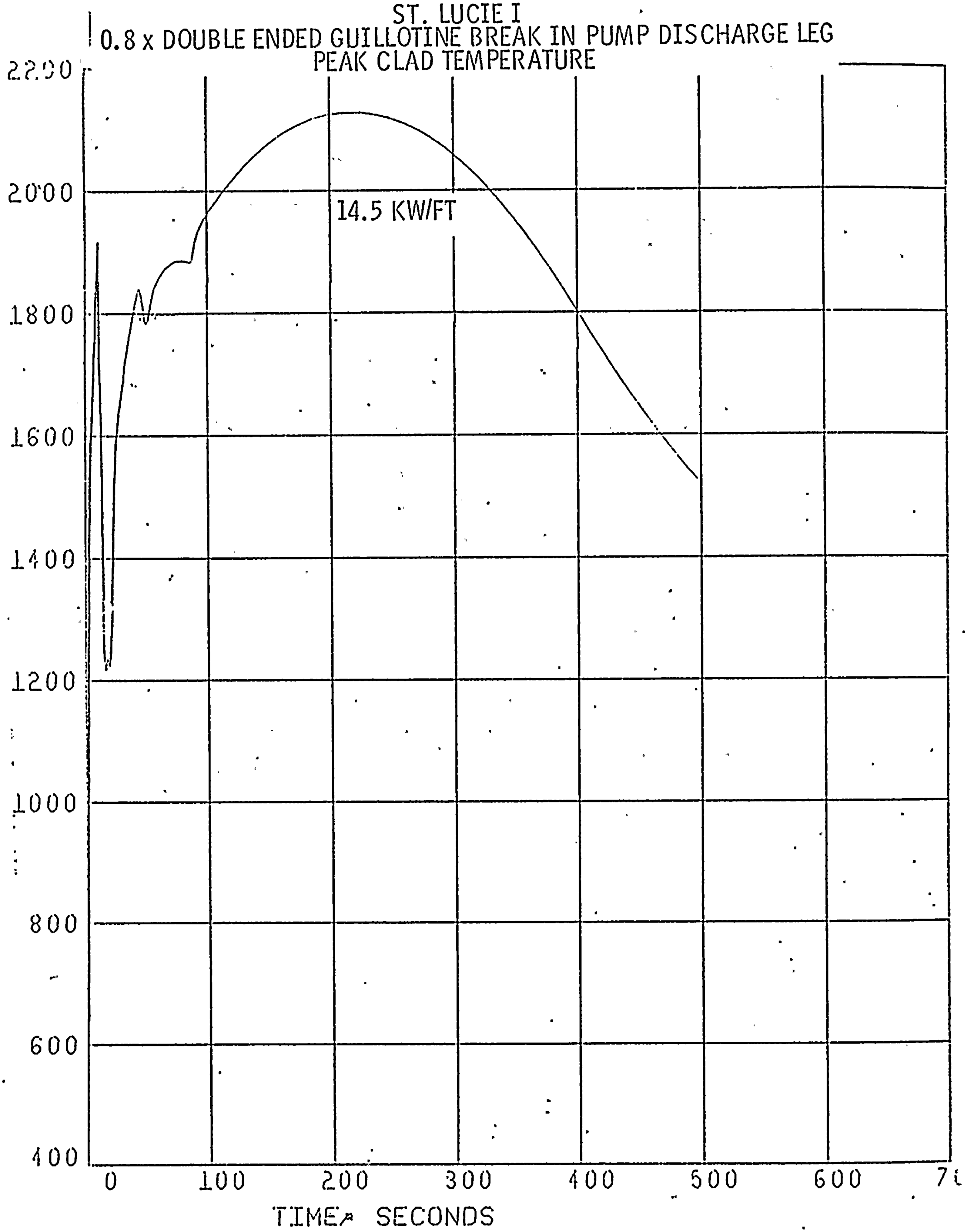

ST. LUCIE I
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE
14.5 KW/FT
CLAD TEMPERATURE, °F
2200
2000
1800
1600
1400
1200
1000
800
600
400
0
100
200
300
400
500
600
TIME, SECONDS

Figure II.7-A

2560 MWt PLANTS
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CORE POWER

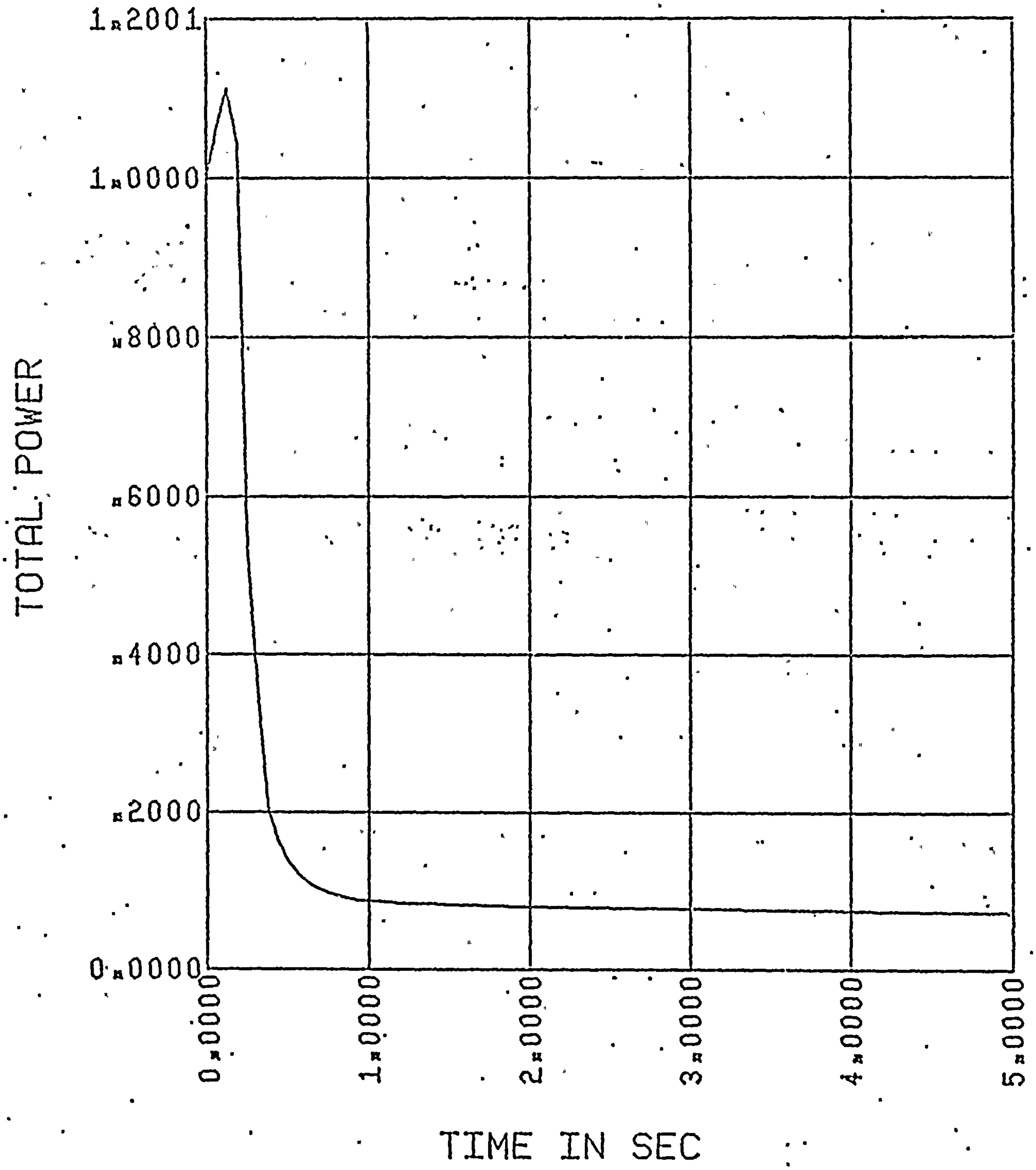


Figure II.7-B

2560 MWt PLANTS
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

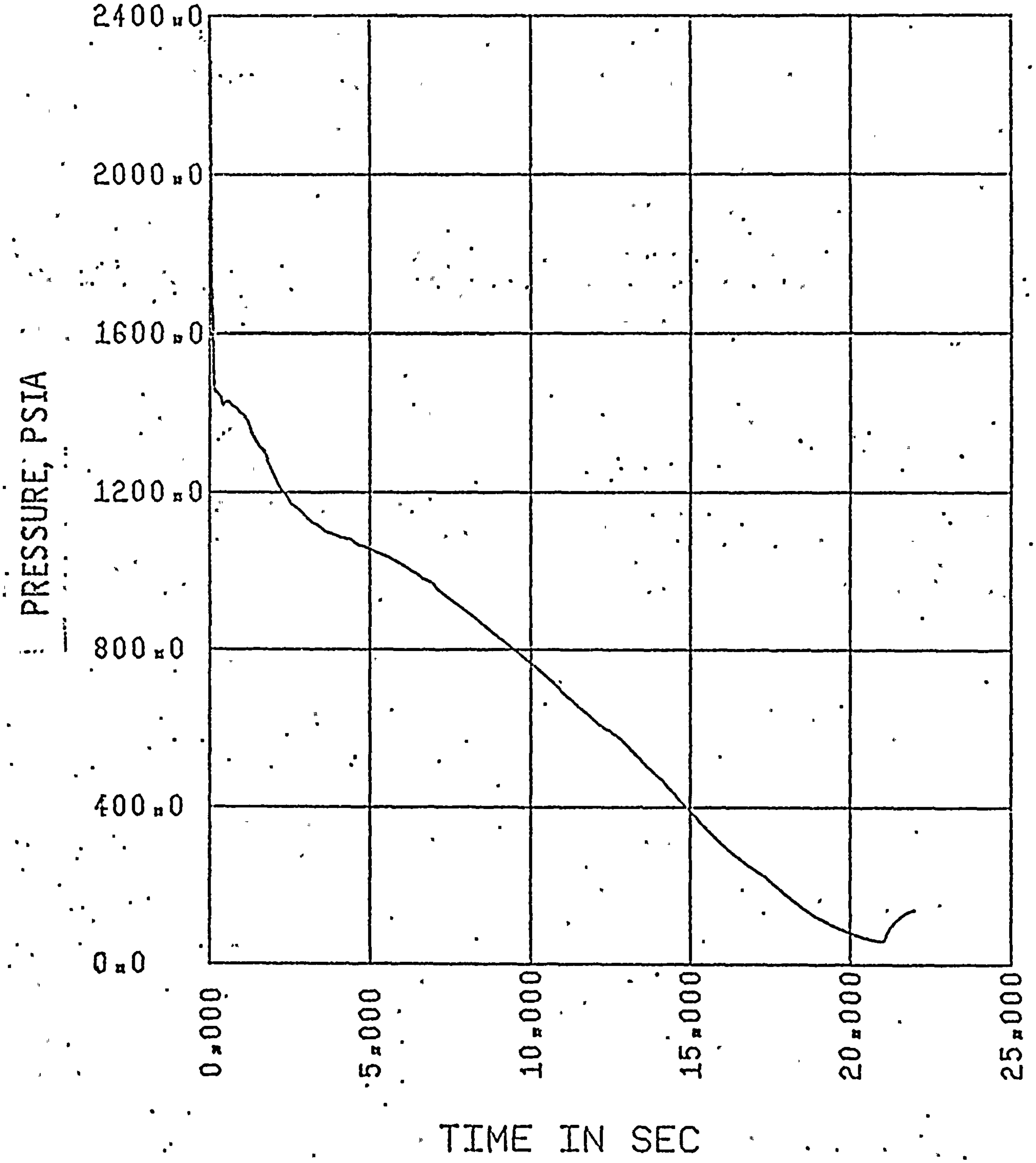


Figure II.7-C

2560 MWt PLANTS
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

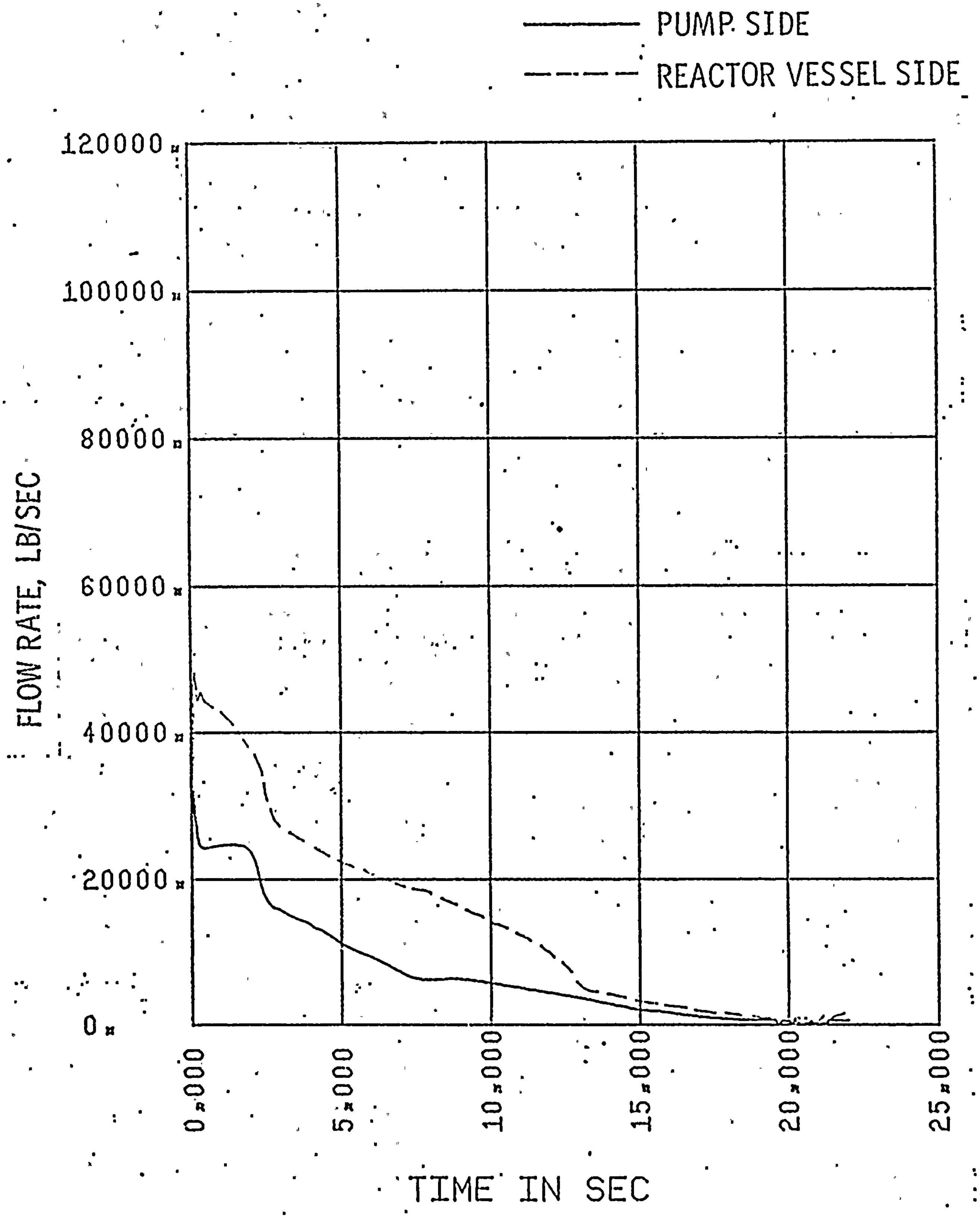


Figure II.7-D.1

2560 MWt PLANTS

0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY - PATH 16, BELOW HOT SPOT

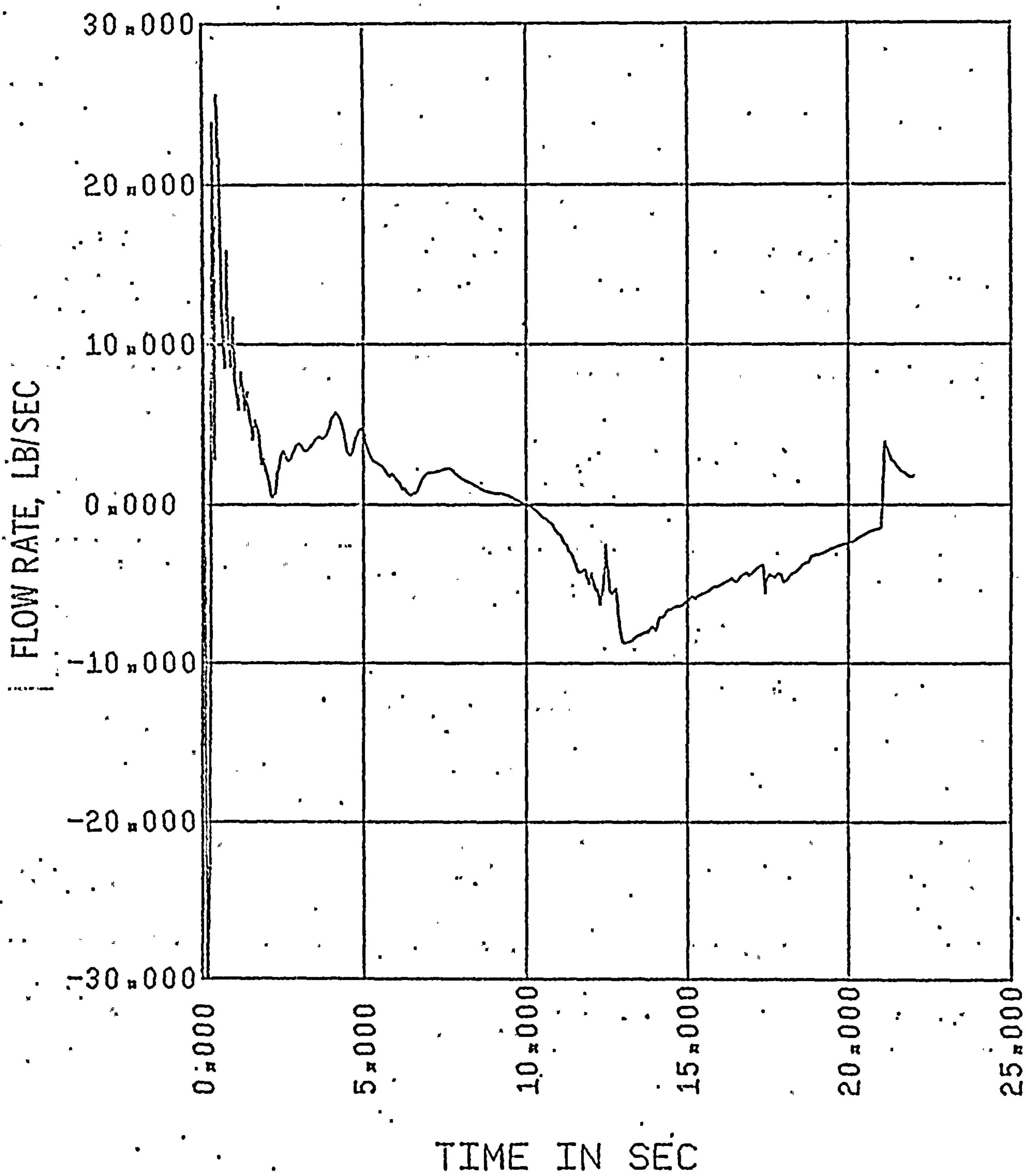


Figure II.7-D.2

2560 MWt PLANTS
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY - PATH 17, ABOVE HOT SPOT

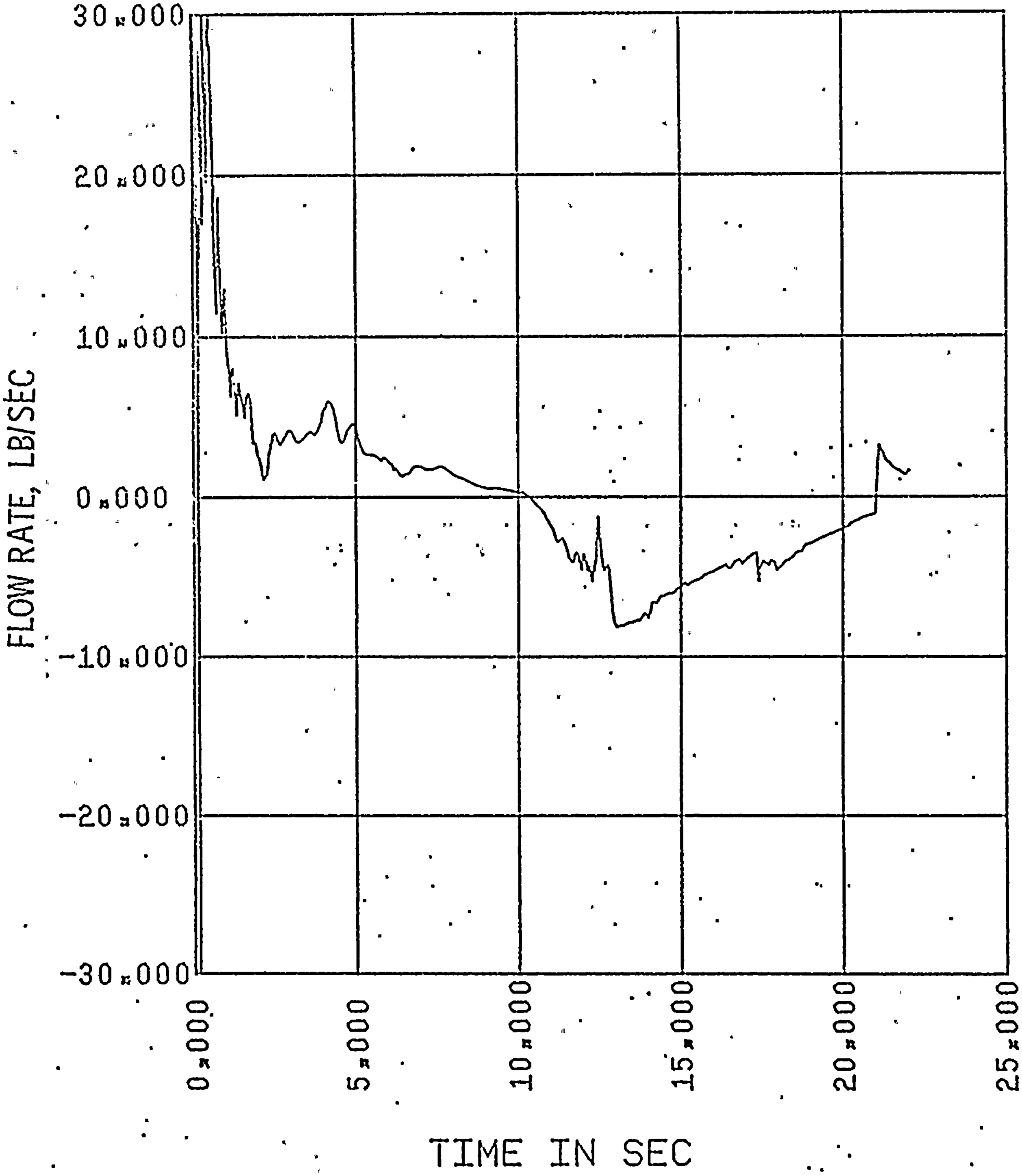


Figure II.7-E

2560 MWt PLANTS
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

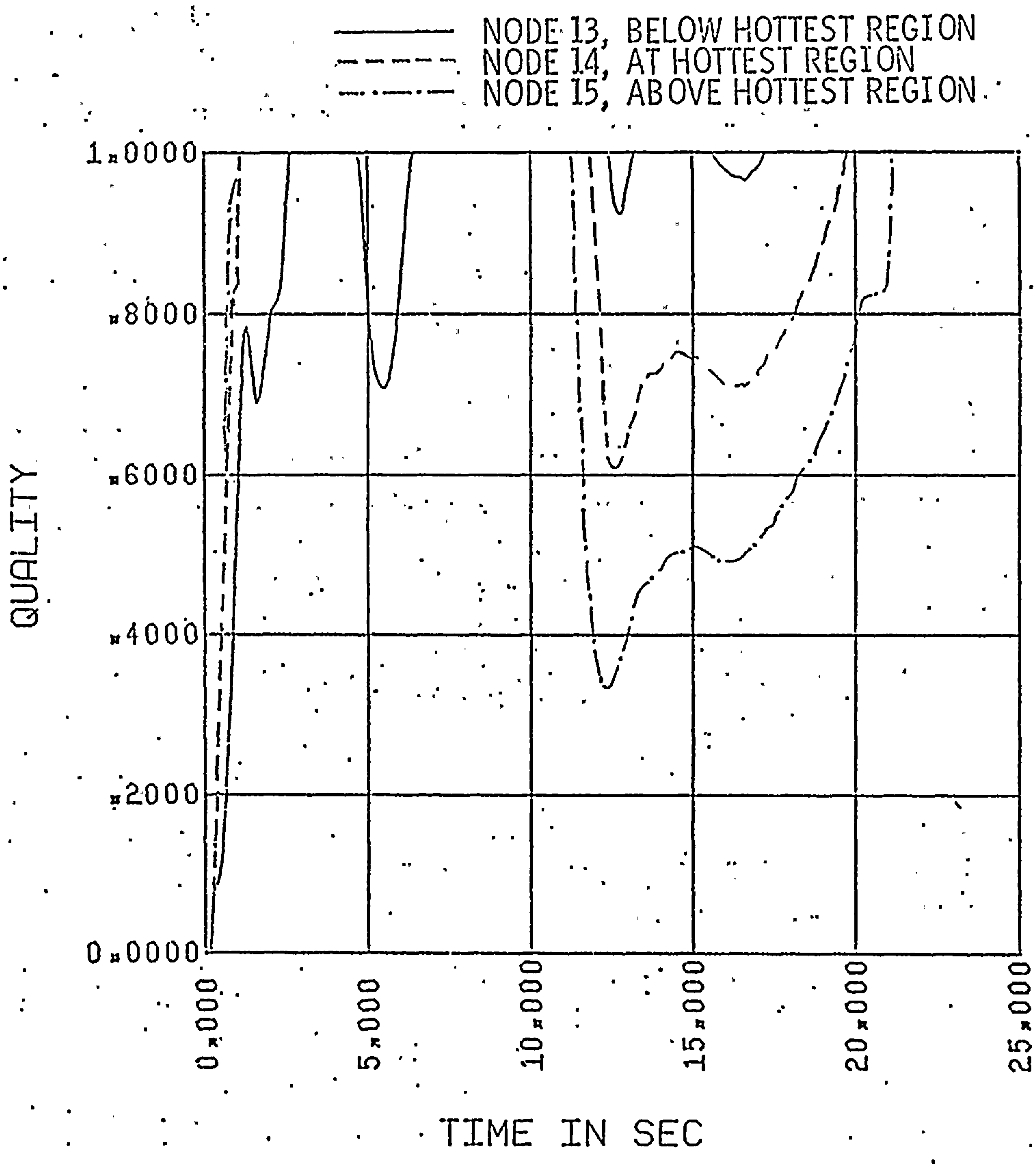


Figure II.7-F

ST. LUCIE I

0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

CONTAINMENT PRESSURE

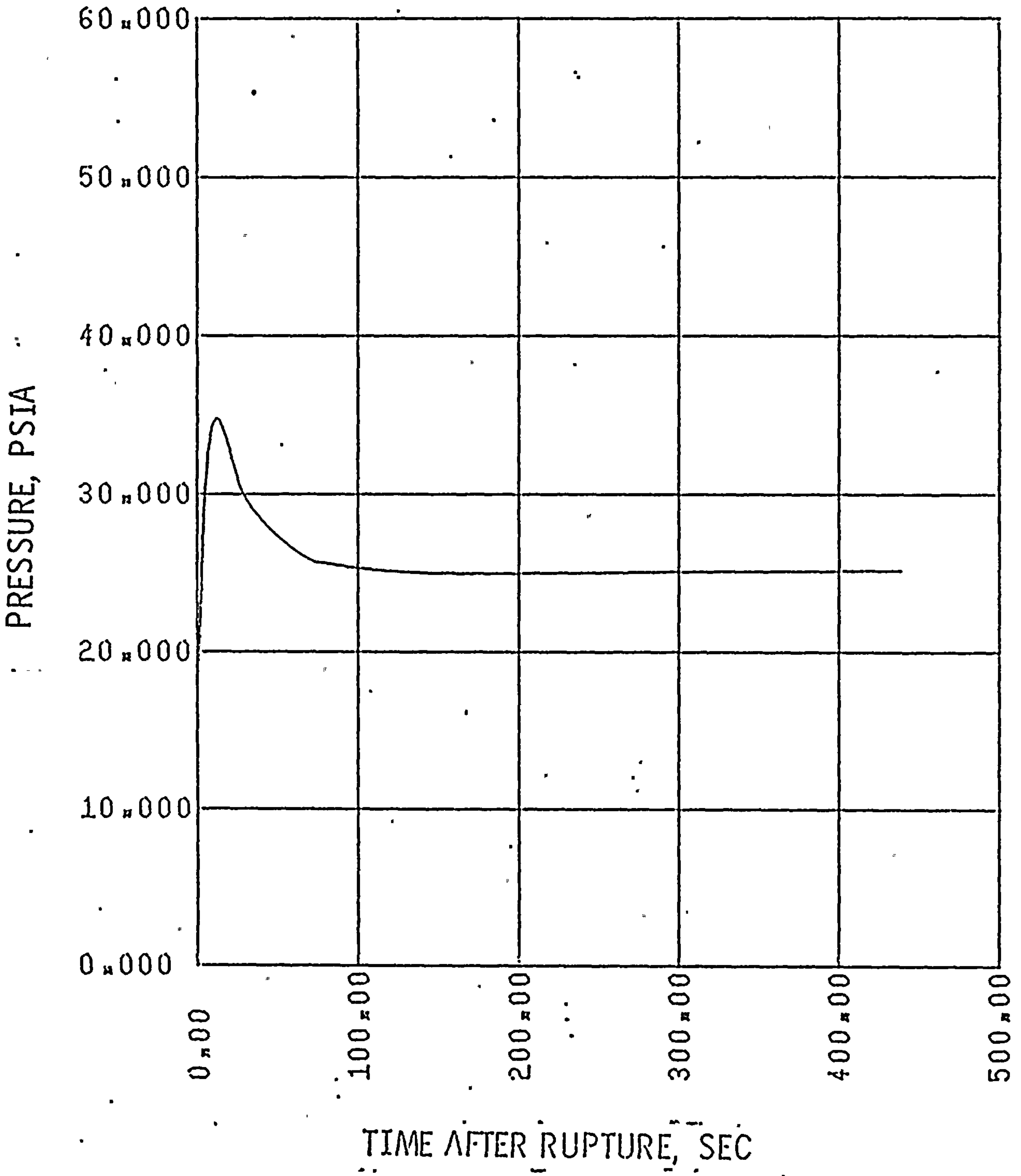


Figure II.7-G

ST. LUCIE I

0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

MASS ADDED TO CORE DURING REFLOOD

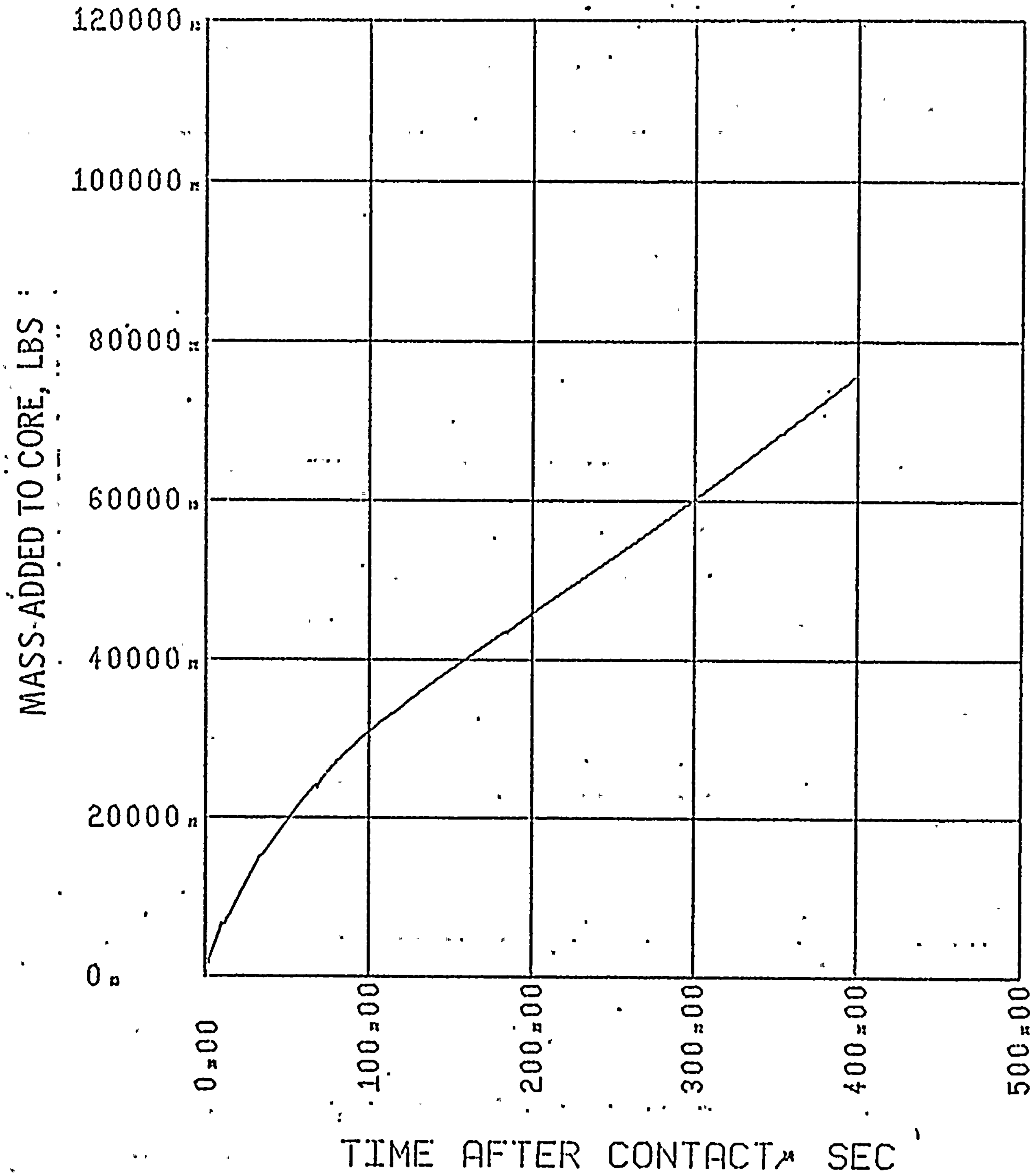


Figure II.7-H

ST. LUCIE I

0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

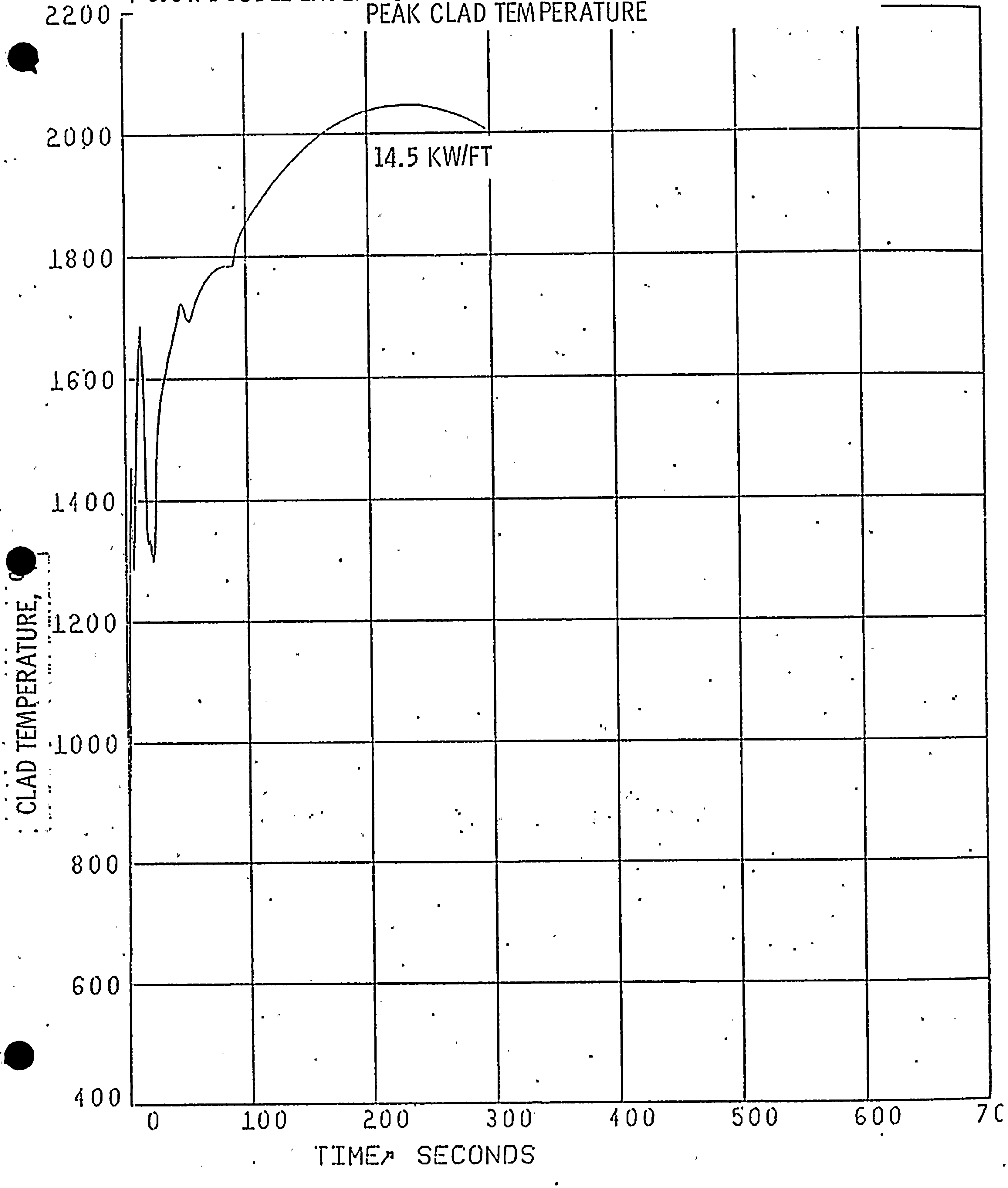


Figure II.8

ST. LUCIE I

PEAK CLAD TEMPERATURE vs BREAK AREA

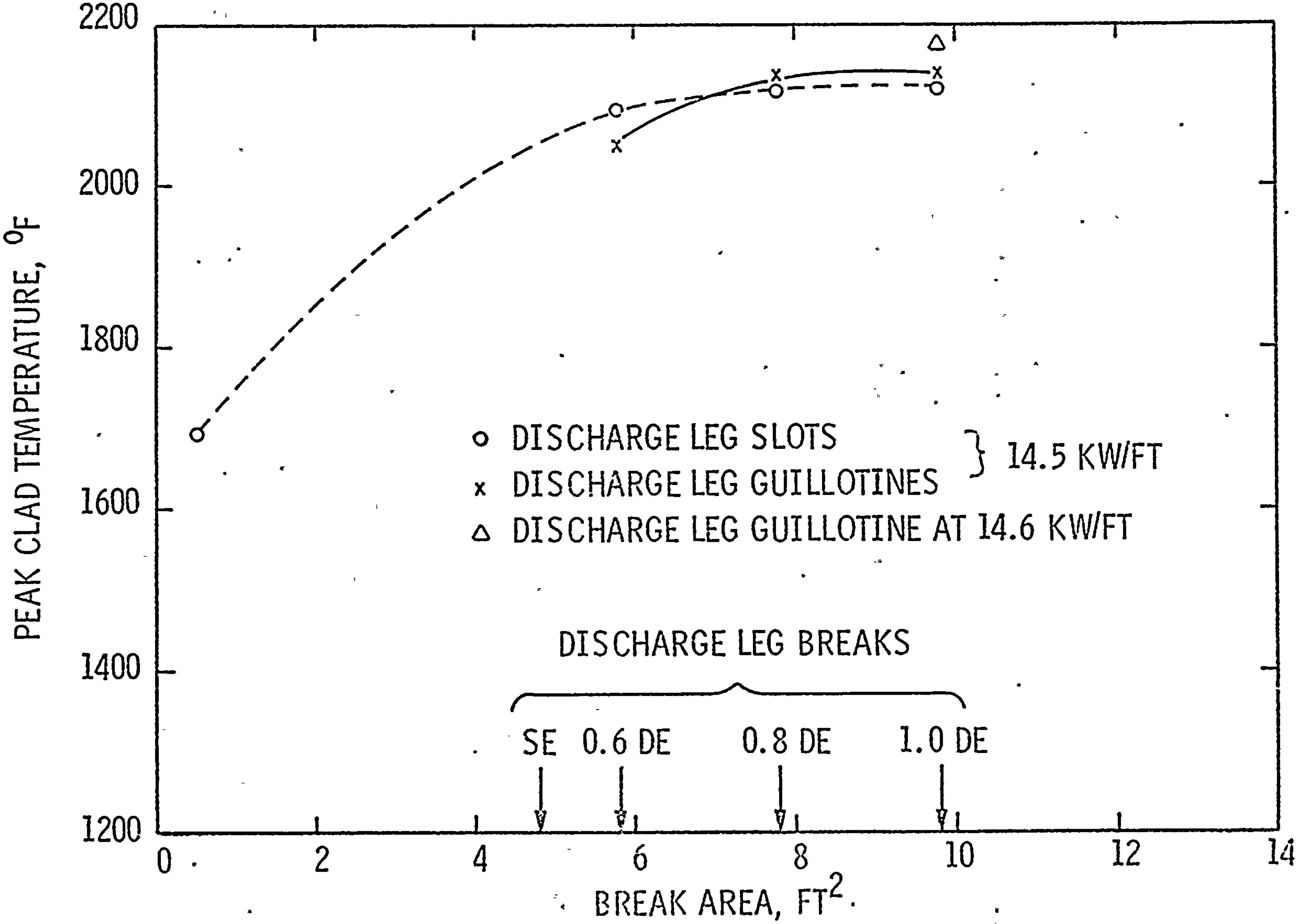


Figure II.9

ST. LUCIE I

COMBINED SPILLAGE AND SPRAY INTO CONTAINMENT