FPL

Florida Power & Light Company, 6501 S. Ocean Drive, Jensen Beach, FL 34957

July 5, 2011

L-2011-260
10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Re: St. Lucie Plant Unit 1
Docket No. 50-335
Renewed Facility Operating License No. DPR-67

Information Requested by the Nuclear Performance & Code Review Branch in Support of the St. Lucie Unit 1 Extended Power Uprate License Amendment Request

References:

(1) R. L. Anderson (FPL) to U.S. Nuclear Regulatory Commission (L-2010-259), "License Amendment Request for Extended Power Uprate," November 22, 2010, Accession No. ML103560419.
(2) Email from Tracy Orf (NRC) to Chris Wasik (FPL), "St. Lucie 1 EPU boric acid precipitation question," dated May 3, 2011.
(3) Pedro Salas (AREVA NP Inc.) to Tracy J. Orf (NRC), "Material to Support St. Lucie Plant Unit 1 EPU License Amendment Request, Docket No. 50-335, Renewed License No. DPR-67," June 1, 2011.
(4) Email from Chris Wasik (FPL) to Tracy Orf (NRC), "NRC Request – St. Lucie Unit 1 Use of CEFLASH-4AS," dated June 6, 2011.

By letter L-2010-259 dated November 22, 2010 [Reference 1], Florida Power & Light Company (FPL) requested to amend Renewed Facility Operating License No. DPR-67 and revise the St. Lucie Unit 1 Technical Specifications (TS).

In support of the NRC's review of the License Amendment Request (LAR); in an email from the NRC Project Manager dated May 3, 2011 [Reference 2], FPL was requested to provide the RELAP5 input deck for St. Lucie Unit 1 as well as the analysis report and plots for the last CEFLASH-4AS small break loss of coolant accident (SBLOCA) analysis performed for St. Lucie Unit 1. Reference 3 provided the requested RELAP5 information. In Reference 4, FPL noted that the CEFLASH-4AS methodology had not been used to perform SBLOCA analyses for many years and identified two alternative analyses in response to the staff's request: (1) the 1979 Millstone Unit 2 SBLOCA analysis that was referenced as applicable to St. Lucie Unit 1 in 1984 based on unit similarities; and (2) the results of a 1990 degraded high pressure safety injection flow analysis performed for St. Lucie Unit 1.

A001
NRR

an FPL Group company

During the June 29, 2011 weekly FPL/NRC teleconference and in response to the Reference 4 Email, the NRC requested that both of the aforementioned analyses be provided. Attachments 1 and 2 of this letter provide the requested information.

In accordance with 10 CFR 50.91(b)(1), a copy of this letter is being forwarded to the designated State of Florida official.

This submittal does not alter the significant hazards consideration or environmental assessment previously submitted by FPL letter L-2010-259 [Reference 1].

This submittal contains no new commitments and no revisions to existing commitments.

Should you have any questions regarding this submittal, please contact Mr. Christopher Wasik, St. Lucie Extended Power Uprate LAR Project Manager, at 772-467-7138.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on 05-Jul-2011

Very truly yours,

Richard L. Anderson
Site Vice President
St. Lucie Plant

Attachments

cc: Mr. William Passetti, Florida Department of Health

ATTACHMENT 1
CE POWER SYSTEMS
MILLSTONE UNIT 2
ECCS PERFORMANCE RESULTS
AT 2754 Mwt

APRIL 4, 1979
(137 PAGES)

Interoffice Correspondence

POWER
SYSTEMS

CPCC# 36759

C. Wrazien

Millstone Unit 2
ECCS Performance Results
at 2754 Mwt

P. Thelin
J. Harris
N-LOCA-79-004
April 4, 1979

xc: Distribution

Attachments A and B present the large and small break LOCA ECCS performance results for Millstone Unit 2. Results of these analyses show acceptable performance at the reactor power level of 2754 Mwt and a peak linear heat generation rate of 15.6 kw/ft. The small break ECCS performance results were performed at 16.0 kw/ft for added conservatism.

The large break LOCA analysis resulted in a peak clad temperature of 2081°F with a peak local clad oxidation percentage of less than 16.0%. The small break LOCA analysis resulted in a peak clad temperture of 1971°F and a peak local clad oxidation percentage of 10.3%.

In addition, at the request of NUSCO, the large break ECCS analysis used conservative input data (regarding the rod-to-rod thermal radiation model) to bound subsequent reload cycles.

Also indicated in the Large Break Analysis of Attachment A is a statement regarding the current NRC review of the ECCS rupture strain and steam cooling models. Should the review result in changes imposed by the NRC, it is expected that the changes to these models will have no adverse impact on the results and conclusions contained in this report.

The results reported here have been QA verified. Final documentation to QADM standards will be completed by 4/23/79.

LW:tad
Attachments

ATTACHMENT A

Millstone Unit 2 Cycle 3
Large Break LOCA ECCS Performance Results

1.0 Introduction and Summary

The large break loss-of-coolant accident ECCS performance evaluation for Millstone 2, cycle 3, presented herein demonstrates appropriate conformance with the Acceptance Criteria for Light-Water-Cooled Reactors as presented in 10CFR50.46(1). The evaluation demonstrates acceptable ECCS performance for Millstone 2 during cycle 3 at a reactor power level of 2754 Mwt and a peak linear heat generation rate (PLHGR) of 15.6 kw/ft. The method of analysis and results are presented in the following sections.

2.0 Method of Analysis

The calculations performed for this evaluation used Combustion Engineering's Large Break Evaluation Model which is described in References 2 through 8. Blowdown, refill/reflood, and temperature calculations were performed to incorporate the cycle 3 fuel characteristics and reactor power level of 2754 Mwt into the ECCS performance evaluation. The blowdown hydraulic calculations were performed with the CEFLASH-4A(4) code while the refill/reflood hydraulic calculations were performed with the COMPERC-II(5) code. The hot rod clad temperature and clad oxidation calculations were performed with the STRIKIN-II(6) and PARCH(8) codes. Core wide clad oxidation calculations were also performed in this analysis.

The ECCS analysis assumptions are the same as those stated in Reference 9. The core and system parameters which differ from the previous analysis(9) are shown in Table A1 which is consistent with the PLHGR of 15.6 kw/ft. The containment parameters pertinent to this analysis are listed in Table A2.

In general, all possible break locations are considered in a LOCA analysis. However, it was demonstrated in Reference 2 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 Millstone Unit 2, cycle 3, 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 5.89 ft^2 to twice the flow area of the cold leg.

3.0 Results

Included in the cycle 3 core are 72 partially depleted and 72 fresh low densifying fuel assemblies (Batches D and E), and 73 higher densifying, partially depleted fuel assemblies (Batches B and C). Burnup dependent calculations for the various fuel types were performed with the FATES(7) and STRIKIN-II(6) codes. The results demonstrated that the most limiting fuel rod during cycle 3 operation is a rod in one of the partially depleted batch B assemblies retained from cycle 2.

For the limiting batch B assembly rod, clad rupture was predicted to occur during the blowdown period. Clad rupture during blowdown leads to the highest clad temperatures because of a degradation in the cooling of the fuel rod during the blowdown period and a decrease in the effectiveness of rod-to-rod thermal radiation during the reflood period, as well as increased clad oxidation. In this analysis blowdown rupture for the limiting batch B fuel was first predicted to occur toward the end of the third fuel cycle. Earlier in the cycle at the time of minimum fuel-clad gap conductance, when the fuel stored energy is at a maximum, the fuel pin pressure was not high enough to cause rupture during blowdown. For this reason the highest clad temperatures were not predicted at the time of minimum gap conductance, but at the time when the fuel pin pressure first became high enough to cause blowdown rupture. The spectrum of break sizes was therefore analysed at a burnup of 49,988 MWD/MTU, the time-in-life when blowdown rupture first occurred, to maximize the initial stored energy in the fuel rod. However, for the 0.6 x DES/PD* and 0.6 x DEG/PD** breaks, blowdown rupture did not occur even at the very end of the fuel cycle when the fuel-clad gap pressure was highest. Therefore, these two breaks were analyzed at the time-in-life of minimum gap conductance (6582 MWD/MTU).

The break spectrum analysis described in Section 2.0 was performed for the limiting B assembly rod. It was determined from this analysis that the peak linear heat generation rate (PLHGR) for the B assembly rod is 15.6 kw/ft.

The 0.8 DEG/PD break produced the highest clad temperature of 2081°F. The highest local clad oxidation percentage was less than 16.0%. The 0.8 DEG/PD also resulted in the highest core wide clad oxidation which was less than 0.73 %. The PLHGR of 15.6 kw/ft is therefore demonstrated to be an acceptable limit for cycle 3 operation.

The rupture strain and steam cooling models employed in the performance of this analysis are currently being reviewed by the NRC. Potential changes to these models, which could result following the NRC review, are not expected to adversely impact the results and conclusions of the analyses presented in this report.

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* DES/PD = Double-Ended Slot at Pump Discharge

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

The times of interest for each of the breaks are presented in Table A3. The clad rupture times are included in Table A4, which contains a summary of the peak clad temperatures and oxidation percentages for the break spectrum. Table A5 contains a list of the pertinent variables plotted for each break in this analysis. Table A6 contains a list of additional parameters plotted for the limiting break (0.8 DEG/PD break). Mass and energy release to the containment during blowdown is presented in Table A7 for the worst break. Also presented in this table is the steam expulsion data during reflood. Figure A7 shows the peak clad temperature plotted versus break size and type, demonstrating that the worst break is the 0.8 DEG/PD rupture. The ECC water spillage and containment spray flow rates are presented graphically in Figure A8.

4.0 Conclusion

The results of the ECCS performance evaluation for Millstone 2, cycle 3 demonstrate conformance with the Acceptance Criteria for Light-Water-Cooled Reactors as presented in 10CFR50.46(1). The results of the analysis identified the peak clad temperature as 2081°F, and the peak local clad oxidation percentage as <16.0%. The peak core wide clad oxidation percentage was calculated to be less than 0.73 %. Therefore, it is concluded that operation of Millstone 2 at a reactor power level of 2754 Mwt and a PLHGR of 15.6 kw/ft is acceptable for cycle 3.

5.0 Computer Code Version Identification

The following code versions were used in this analysis:

CEFLASH-4A	Version 76041
COMPERC-II	Version 75097
STRIKIN-II	Version 77036
PARCH	Version 77004

6.0 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-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).

3. CENPD-132, Supplement 2, "Calculational Methods for the CE Large Break LOCA Evaluation Model", July 1975 (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, 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)", February 1975.

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

CENPD-135, Supplement 5-P, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program", April, 1977 (Proprietary).

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

8. CENPD-138, and Supplement 1 "PARCH, A FORTRAN IV Digital Program to Evaluate Pool Boiling, Axial Rod and Coolant Heatup", February, 1975.

9. Letter, D. C. Switzer (NNECO) to R. Reid (NRC) Docket No. 50-336, March 3, 1978.

TABLE A1

Millstone Unit II Cycle III Core Parameters

Quantity	Value	
Core Power Level (102% of Nominal)	2754	Mwt
Average Linear Heat Rate (102% of Nominal)	6.396	kw/ft
Peak Linear Heat Generation Rate (PLHGR)	15.6	kw/ft
Core Inlet Temperature	551	^{o}F
Core Outlet Temperature	602	^{o}F
System Flow Rate (total)	138.9×10^{6}	lbm/hr
Core Flow Rate	133.8×10^{6}	lbm/hr
Gap Conductance at PLHGR*	2000	$BTU/hr\text{-}ft^{2}\text{-}^{o}F$
Fuel Centerline Temperature at PLHGR*	3484	^{o}F
Fuel Average Temperature at PLHGR*	2082	^{o}F
Hot Rod Gas Pressure*	1971	psia
Hot Rod Burnup*	49988	MWD/MTU
Gap Conductance at PLHGR**	1393	$BTU/hr\text{-}ft^{2}\text{-}^{o}F$
Fuel Centerline Temperature at PLHGR**	3685	^{o}F
Fuel Average Temperature at PLHGR**	2304	^{o}F
Hot Rod Gas Pressure**	1392	psia
Hot Rod Burnup**	6582	MWD/MTU

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* At Time-In-Life Of Maximum Gap Pressure

**At Time-In-Life Of Minimum Gap Conductance

Table A 2
Millstone Unit 2
Containment Physical Parameters

Net Free Volume	1.938×10^6 ft^3
Containment Initial Conditions:	
Humidity	100%
Containment Temperature	60°F
Enclosure Building Temperature	60°F
Ground Temperature	40°F
Initial Pressure	14.7 psia
Initial Time for:	
Spray Flow	26 seconds
Fans (3)	0.0 seconds
Additional Fan	14.0 seconds
Containment Spray Water:	
Temperature	50°F
Flow Rate (Total, 2 pumps)	3300 gpm

Fan Cooling Capacity (Per Fan)

Vapor Temperature (°F)	Capacity (BTU/Sec)
60	0.0
145	3360.0
165	5280.0
300	28800.0
350	32400.0

Containment Heat Absorbing Surfaces

1. Surface Areas and Thicknesses
   a. Shell and dome - 71,870 Ft^2
      (1) Paint - 0.003 In. (one side exposed to containment atmosphere)

Table A 2 (Con't)
Millstone Unit 2
Containment Physical Parameters

b. Unlined Concrete - 62,800 Ft^2
  (1) Concrete - 2.0 Ft. (one side exposed to containment atmosphere, one side insulated)

c. Galvanized Steel - 120,100 Ft^2
  (1) Zinc - 0.0036 In. (one side exposed to containment atmosphere)
  (2) Carbon steel - 0.20 In. (one side insulated)

d. Painted Thin Steel - 56,850 Ft^2
  (1) Paint - 0.003 In. (one side exposed to containment atmosphere)
  (2) Carbon steel - 0.2 In. (one side insulated)

e. Painted Steel - 32,600 Ft^2
  (1) Paint - 0.003 In. (one side exposed to containment atmosphere)
  (2) Carbon steel - 0.26 In. (one side insulated)

f. Painted Steel - 22,425 Ft^2
  (1) Paint - 0.003 In. (one side exposed to containment atmosphere)
  (2) Carbon steel - 0.86 In. (one side insulated)

g. Painted Thick Steel - 4,230 Ft^2
  (1) Paint - 0.003 In. (one side exposed to containment atmosphere)
  (2) Carbon steel - 2.94 In. (one side insulated)

h. Containment Penetration Area - 3,000 Ft^2
  (1) Paint - 0.003 In. (one side exposed to containment atmosphere)
  (2) Carbon steel - 0.75 In.
  (3) Concrete - 3.75 Ft. (one side exposed to enclosure building atmosphere)

i. Stainless Steel Lined Concrete - 8,340 Ft^2
  (1) Stainless steel - 0.25 In. (one side exposed to containment atmosphere)
  (2) Concrete - 2.0 Ft. (one side insulated)

Table A 2 (Con't)
Millstone Unit 2
Containment Physical Parameters

j. Base Slab - 11,130 Ft^2

(1) Concrete - 8.0 Ft. (one side exposed to containment sump, one side exposed to ground)

k. Neutron Shield - 1400 Ft^2

(1) Stainless Steel - 0.024 Ft (both sides exposed to containment atmosphere)

2. Thermal Properties

Material	Conductivity (BTU/hr-ft-°F)	Heat Capacity (BTU/ft^3-°F)
a. Concrete	2.0	36
b. Carbon Steel	35.0	55
c. Stainless Steel	10.0	62
d. Paint	1.5	32
e. Zinc	70.0	45

3. Heat Transfer Coefficients

a. Containment atmosphere to sump - 500 $BTU/hr\text{-}ft^2\text{-}^oF$

b. Sump to base slab - 50 $BTU/hr\text{-}ft^2\text{-}^oF$

c. Containment structure to enclosure building atmosphere - 5.0 $BTU/hr\text{-}ft^2\text{-}^oF$

TABLE A3

MILLSTONE UNIT 2 CYCLE 3

TIMES OF INTEREST (SECONDS)

BREAK	START OF SAFETY INJECTION	TIME OF ANNULUS DOWNFLOW	CONTACT TIME	TIME SAFETY INJECTION TANKS EMPTY
1.0 DES/PD	16.1	19.1	33.2	60.7
0.8 DES/PD	16.7	19.8	33.9	61.3
0.6 DES/PD	18.3	21.4	35.5	63.0
1.0 DEG/PD	16.0	19.0	33.1	60.5
0.8 DEG/PD	16.8	19.8	33.9	61.3
0.6 DEG/PD	18.9	22.0	36.1	63.5

TABLE A4

Millstone Unit 2 Cycle 3

Break	Peak Clad Temperature (°F)	Hot Rod Rupture Time (sec)	Peak Local Clad Oxidation (%)	Core-Wide Clad Oxidation (%)
1.0 x DES/PD	2079	9.68	<16.0	<.70
0.8 x DES/PD	2077	9.46	<16.0	<.70
0.6 x DES/PD*	1950	28.05	< 9.0	<.50
1.0 x DEG/PD	2080	9.40	<16.0	<.72
0.8 x DEG/PD	2081	9.64	<16.0	<.73
0.6 x DEG/PD*	1948	32.17	< 9.0	<.45

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*Analyzed at time of minimum gap conductance

Table A5

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 A6

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 Tank Flow into Intact Discharge Legs	L
Water Level in Downcomer During Reflood	M
Hot Spot Gap Conductance	N
Peak 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
Containment Temperature	R
Sump Temperature	S
Hot Rod Internal Gas Pressure	T
Core Bulk Channel Flow Rate	U

Table A7

MILLSTONE UNIT 2 CYCLE 3

BLOWDOWN AND REFLOOD MASS AND ENERGY RELEASE DATA
0.8 DEG/PD

TIME	MASS FLOW	ENERGY RELEASE	INTEGRAL OF MASS FLOW	INTEGRAL OF ENERGY RELEASE
SEC	LBM/SEC	BTU/SEC	LBM	BTU
0.0	0.0	0.0	0.0	0.0
0.05	7.998 × 10^4	4.352 × 10^7	3.054 × 10^3	1.660 × 10^6
0.10	7.180	3.905	6.841 × 10^3	3.720
0.15	7.312	3.975	1.048 × 10^4	5.701
0.20	7.070	3.844	1.406	7.644
0.25	7.138	3.886	1.762	9.584 × 10^6
0.35	6.949	3.788	2.467	1.342 × 10^7
0.45	6.854	3.740	3.157	1.719
0.60	6.830	3.730	4.185	2.280
0.80	6.780	3.706	5.546	3.023
1.00	6.736	3.687	6.897	3.762
1.40	6.497	3.569	9.555 × 10^4	5.220
1.80	5.962	3.283	1.206 × 10^5	6.598
2.20	5.225	2.880	1.428	7.820
2.60	4.838	2.670	1.628	8.924
3.00	4.656	2.525	1.819	9.980 × 10^7
3.40	4.367	2.423	1.999	1.098 × 10^8
3.80	4.105	2.292	2.169	1.192
4.40	3.746	2.125	2.404	1.324
5.20	3.273	1.906	2.684	1.485
6.00	2.957	1.749	2.933	1.631
6.80	2.671	1.609	3.158	1.766
7.60	2.453	1.483	3.362	1.889
8.40	2.276	1.371	3.551	2.003
9.20	2.062	1.250	3.725	2.108
10.0	1.866 × 10^4	1.121 × 10^7	3.880 × 10^5	2.203 × 10^8

Table A7 (cont'd)

TIME	MASS FLOW	ENERGY RELEASE	INTEGRAL OF MASS FLOW	INTEGRAL OF ENERGY RELEASE
SEC	LBM/SEC	BTU/SEC	LBM	BTU
11.0	1.436×10^4	9.548×10^6	4.044×10^5	2.307×10^8
12.0	8.784×10^3	7.680	4.156	2.392
13.0	7.189	6.611	4.236	2.464
14.0	5.494	5.571	4.300	2.525
15.0	3.852	4.385	4.346	2.574
16.0	2.839	3.430	4.379	2.613
17.0	2.182	2.616	4.404	2.644
18.0	1.395×10^3	1.719	4.422	2.665
19.0	9.231×10^2	1.145×10^6	4.433	2.679
19.8	6.144×10^2	7.628×10^5	4.439×10^5	2.686×10^8

TIME OF ANNULUS DOWNFLOW

START OF REFLOOD (VALUES BELOW ARE FOR STEAM ONLY)

TIME	MASS FLOW	ENERGY RELEASE	INTEGRAL OF MASS FLOW	INTEGRAL OF ENERGY RELEASE
33.9	0.0	0.0	4.439×10^5	2.686×10^8
43.9	0.0	0.0	4.439	2.686
53.9	0.0	0.0	4.439	2.686
63.9	2.158×10^2	2.827×10^5	4.445	2.693
73.9	2.187	2.865	4.466	2.721
83.9	2.156	2.824	4.487	2.749
93.9	2.098	2.748	4.509	2.777
103.9	2.074	2.718	4.529	2.805
123.9	2.050	2.685	4.571	2.858
143.9	2.020	2.646	4.611	2.912
163.9	2.005	2.626	4.651	2.964
183.9	2.012×10^2	2.636×10^5	4.692×10^5	3.017×10^8

Table A7 (cont'd)

TIME	MASS FLOW	ENERGY RELEASE	INTEGRAL OF MASS FLOW	INTEGRAL OF ENERGY RELEASE
SEC	LBM/SEC	BTU/SEC	LBM	BTU
203.9	2.001 $\times 10^2$	2.621 $\times 10^5$	4.732 $\times 10^5$	3.070 $\times 10^8$
223.9	2.024	2.651	4.772	3.122
243.9	2.035	2.666	4.813	3.175
263.9	2.042	2.675	4.853	3.229
283.9	2.043	2.676	4.894	3.282
303.9	2032	2.662	4.935	3.336
323.9	2.063	2.703	4.976	3.390
343.9	2.067	2.708	5.017	3.444
363.9	2.054	2.691	5.059	3.498
383.9	2.076	2.719	5.100	3.552
413.9	2072	2.715	5.162	3.633
433.9	2.070 $\times 10^2$	2.712 × 105	5.204 $\times 10^5$	3.688 $\times 10^8$

FIGURE A-1A
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

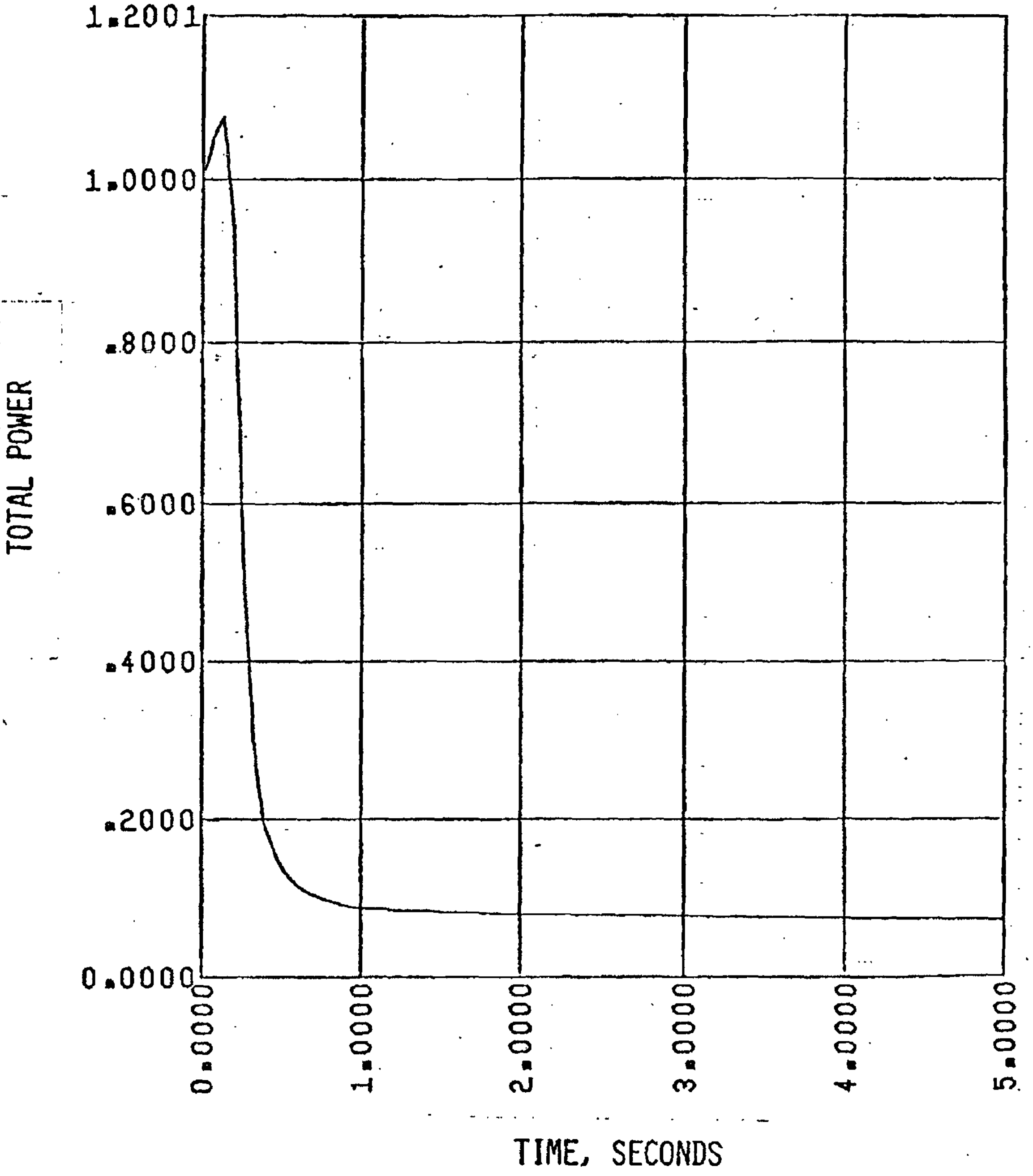


FIGURE A-1B
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

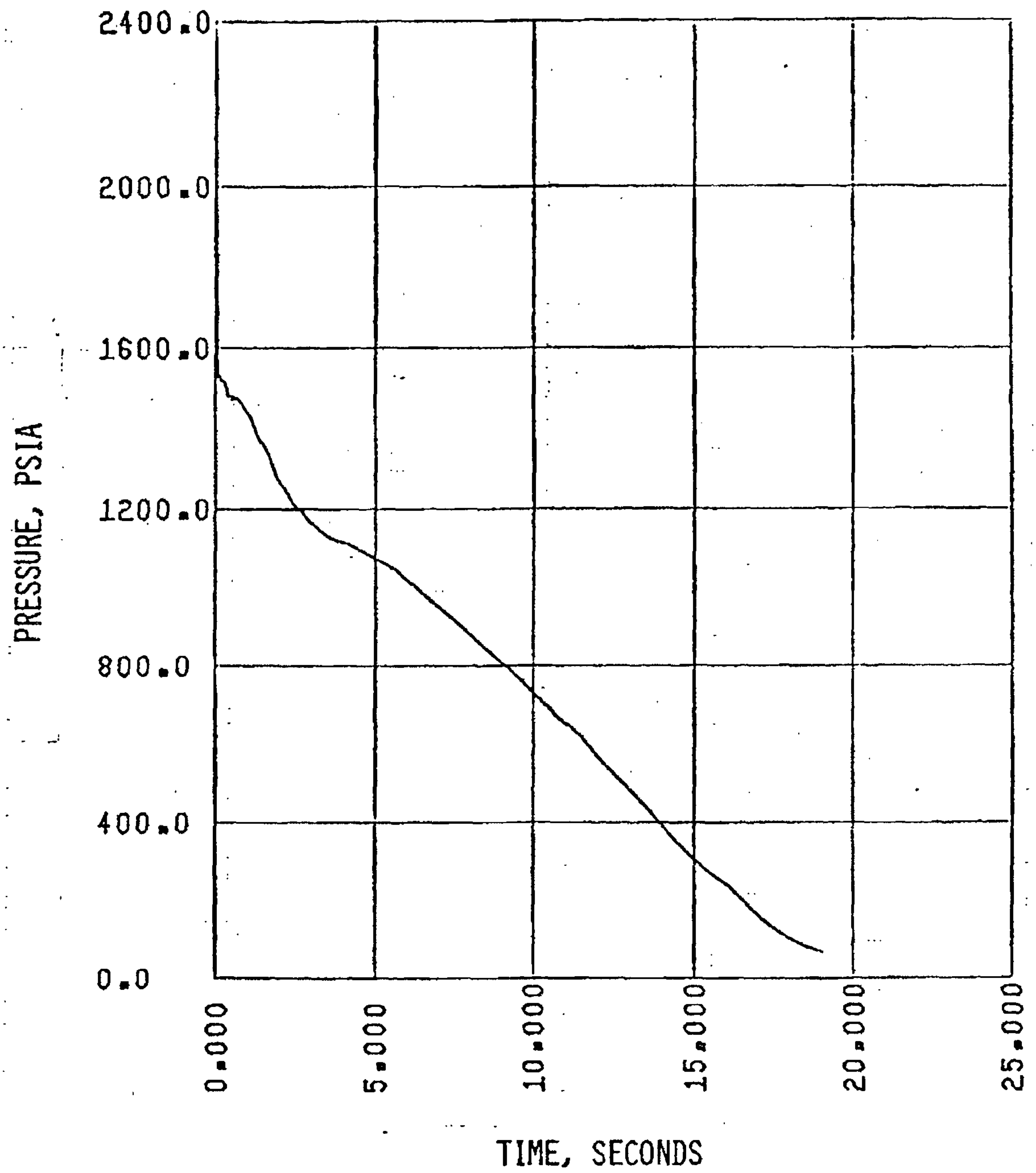


FIGURE A-1C
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

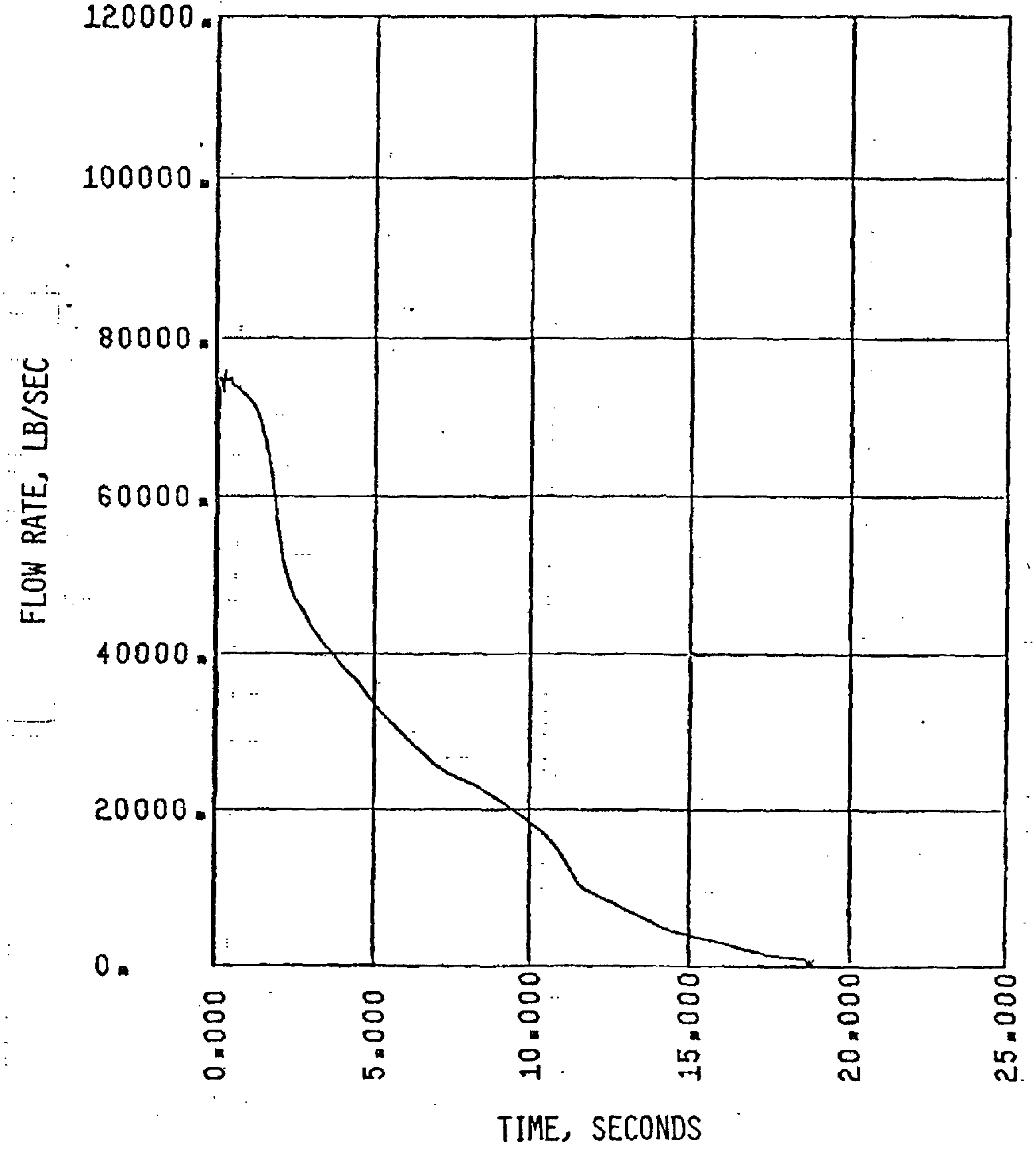


FIGURE A-1D.1
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 16, BELOW HOT SPOT

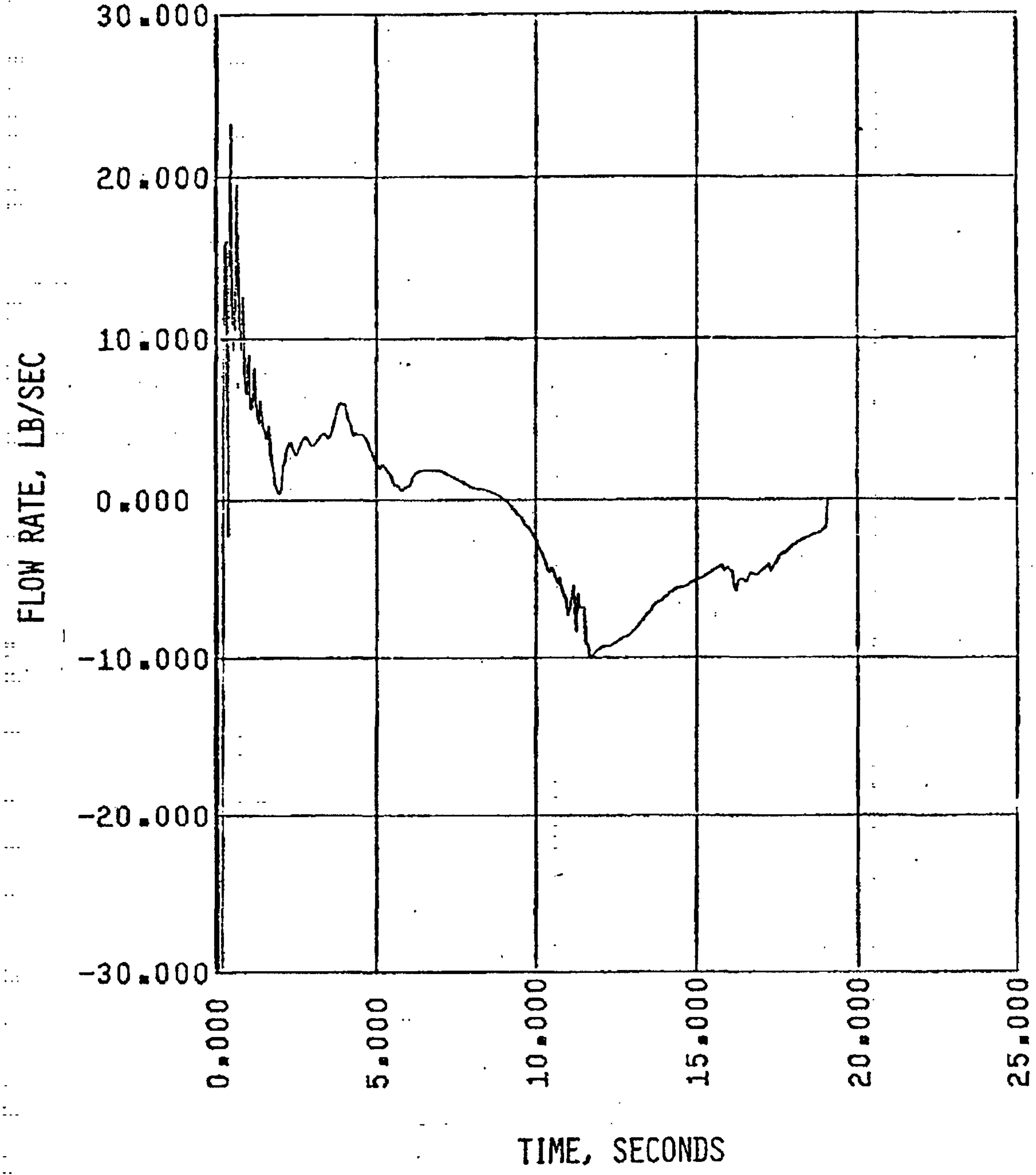


FIGURE A-1D.2
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 17, ABOVE HOT SPOT

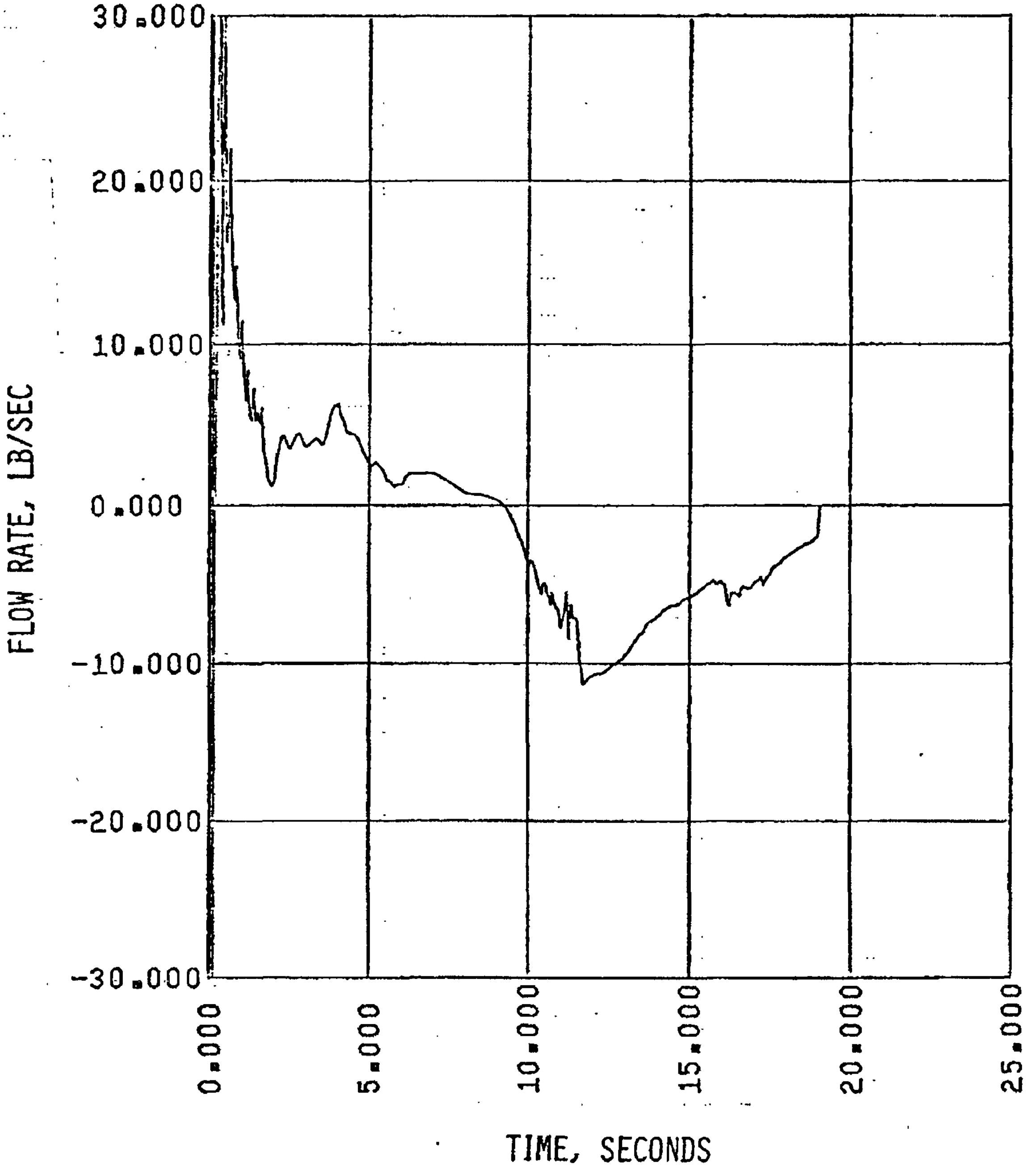


FIGURE A-1E

MILLSTONE UNIT 2 CYCLE 3

1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

HOT ASSEMBLY QUALITY

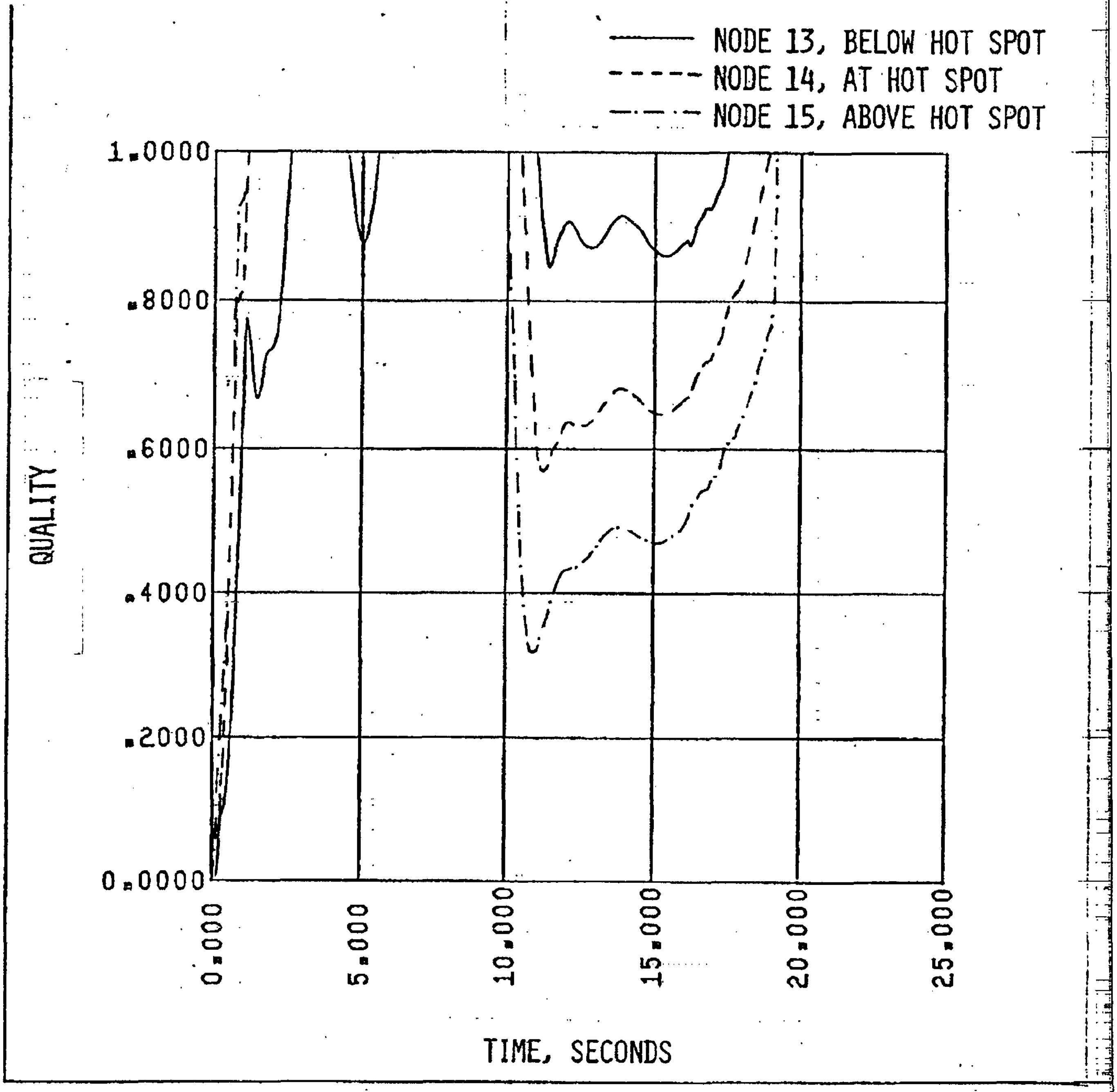


FIGURE A-1F
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

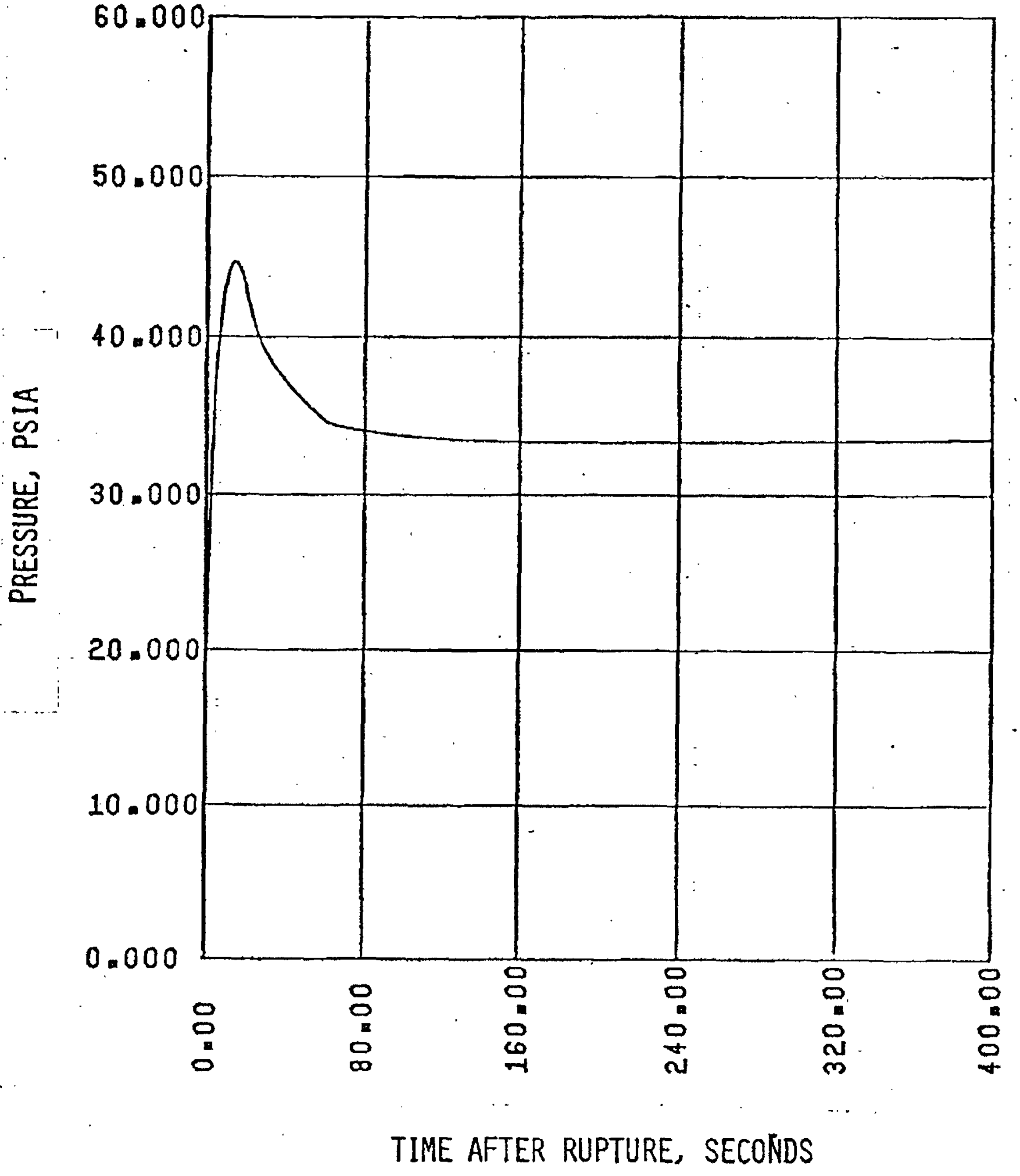


FIGURE A-1G
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

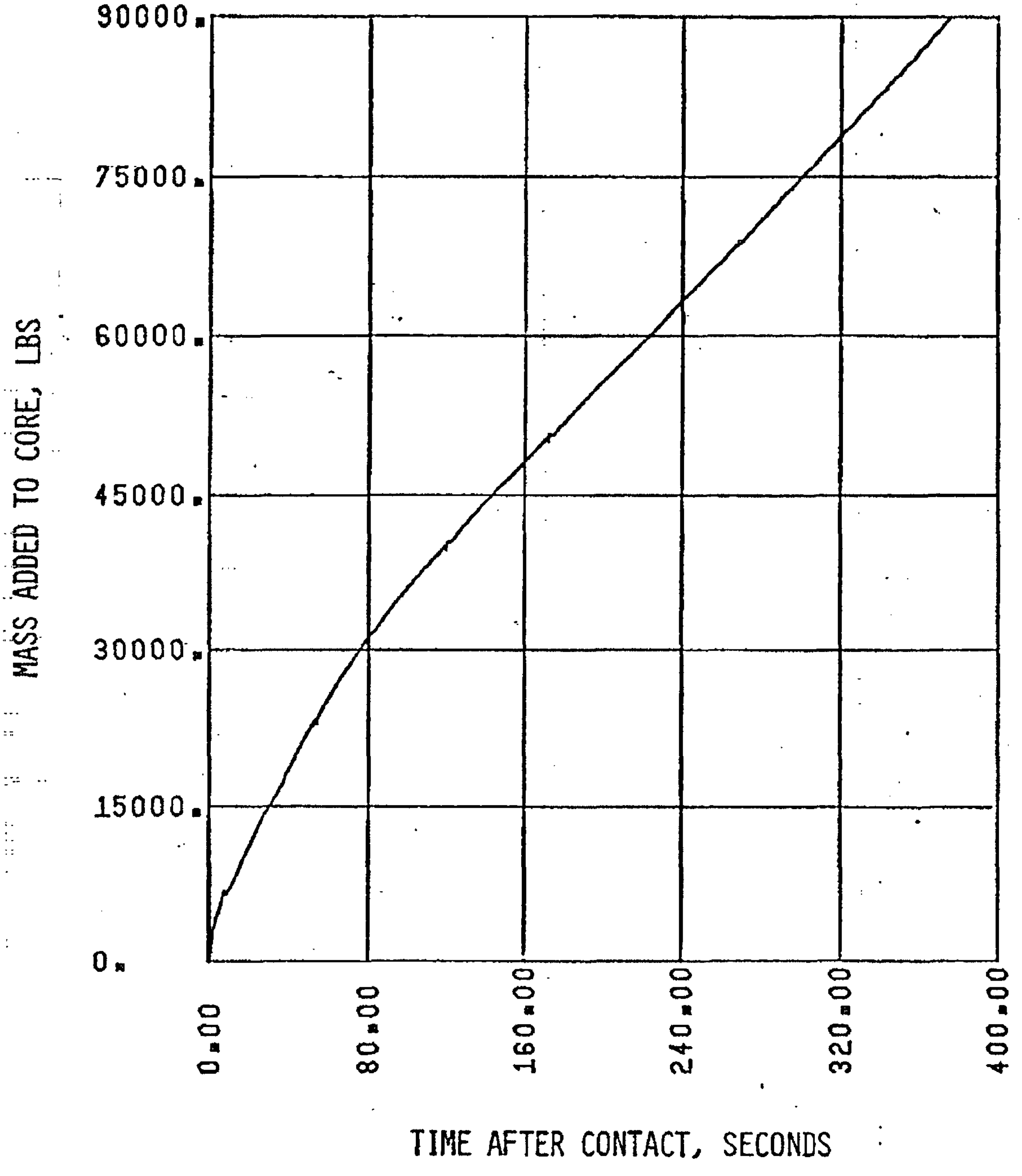


FIGURE A-1H
LLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE

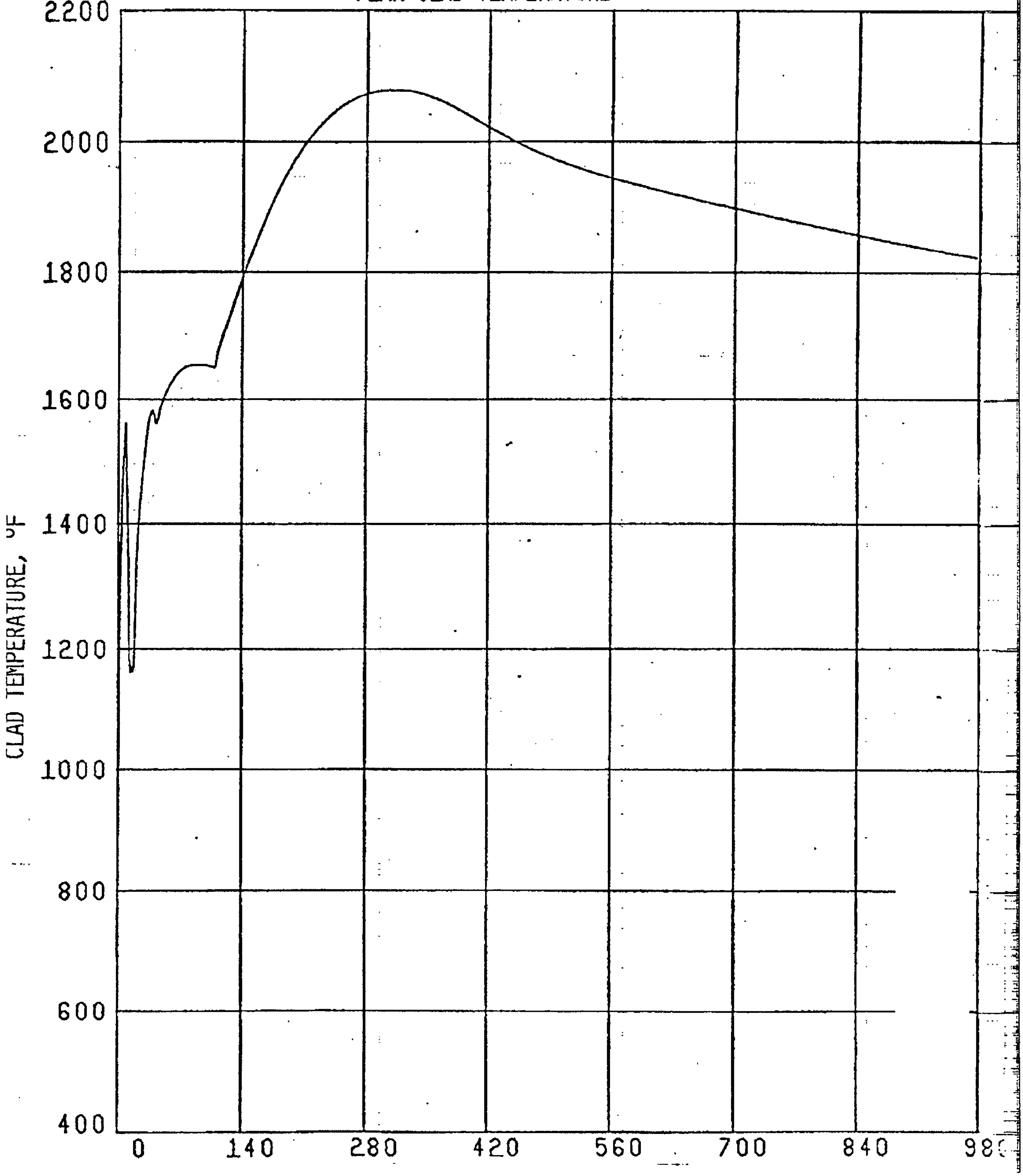


FIGURE A-2A
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

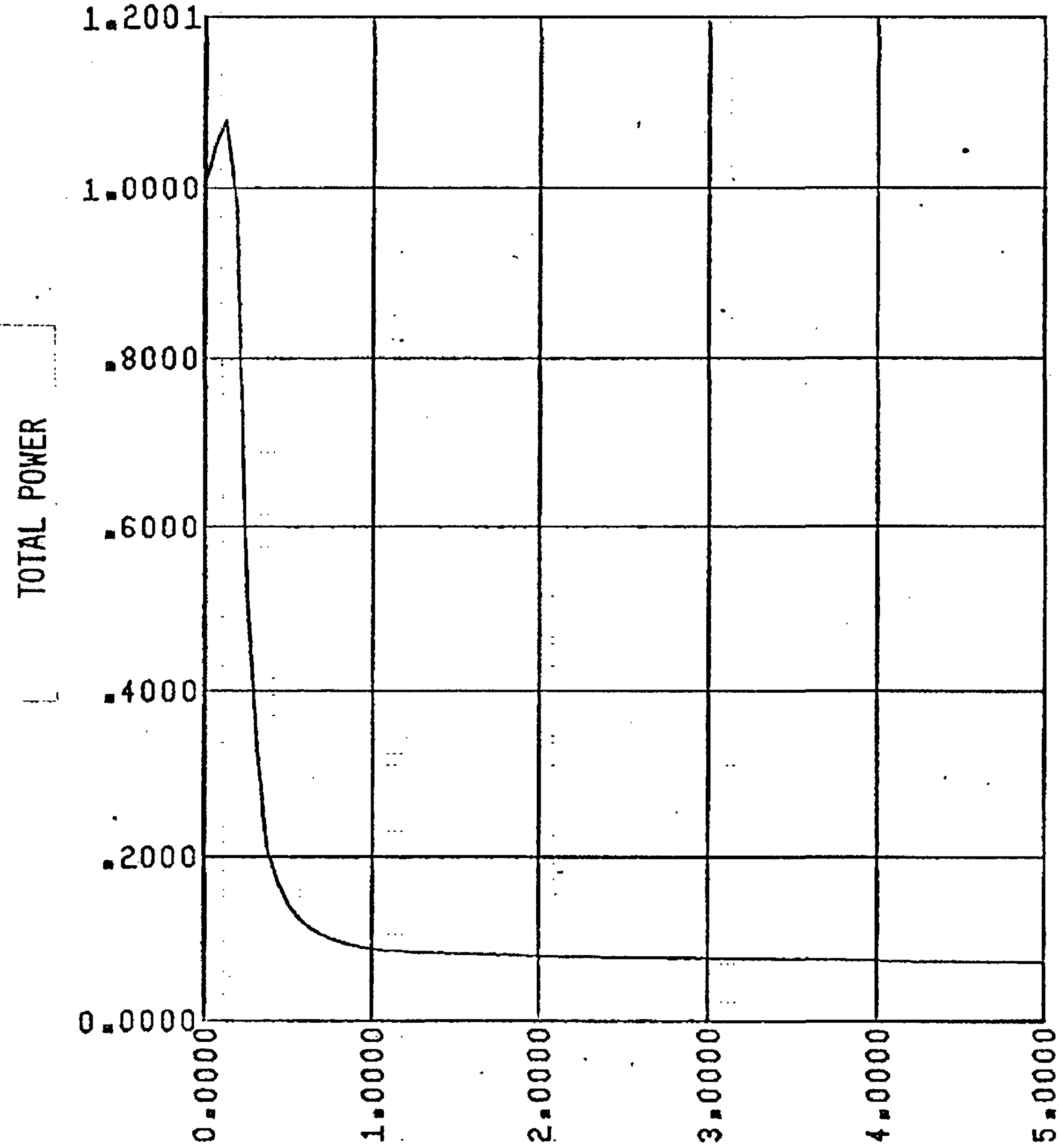


FIGURE A-2B
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

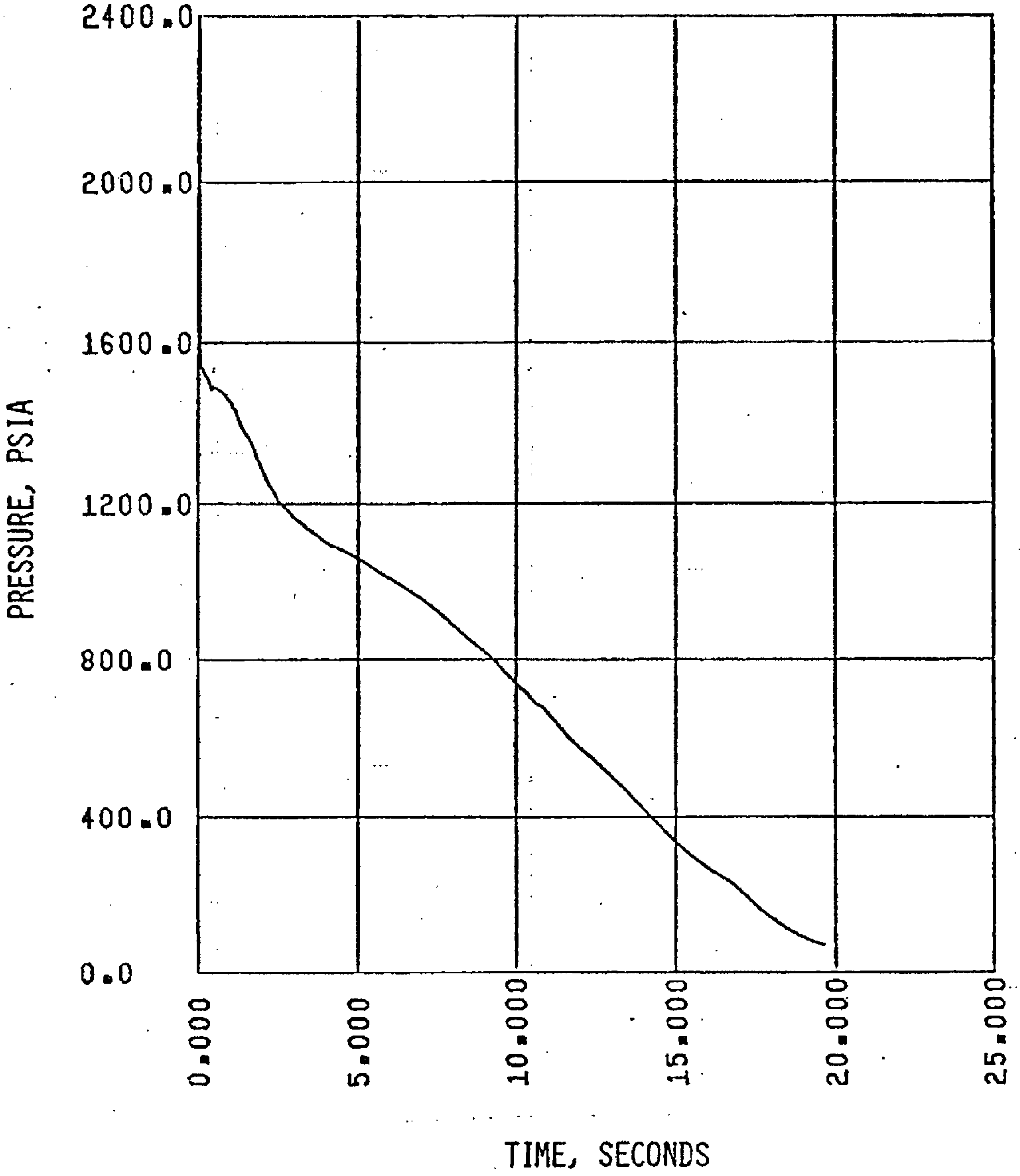


FIGURE A-2C
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

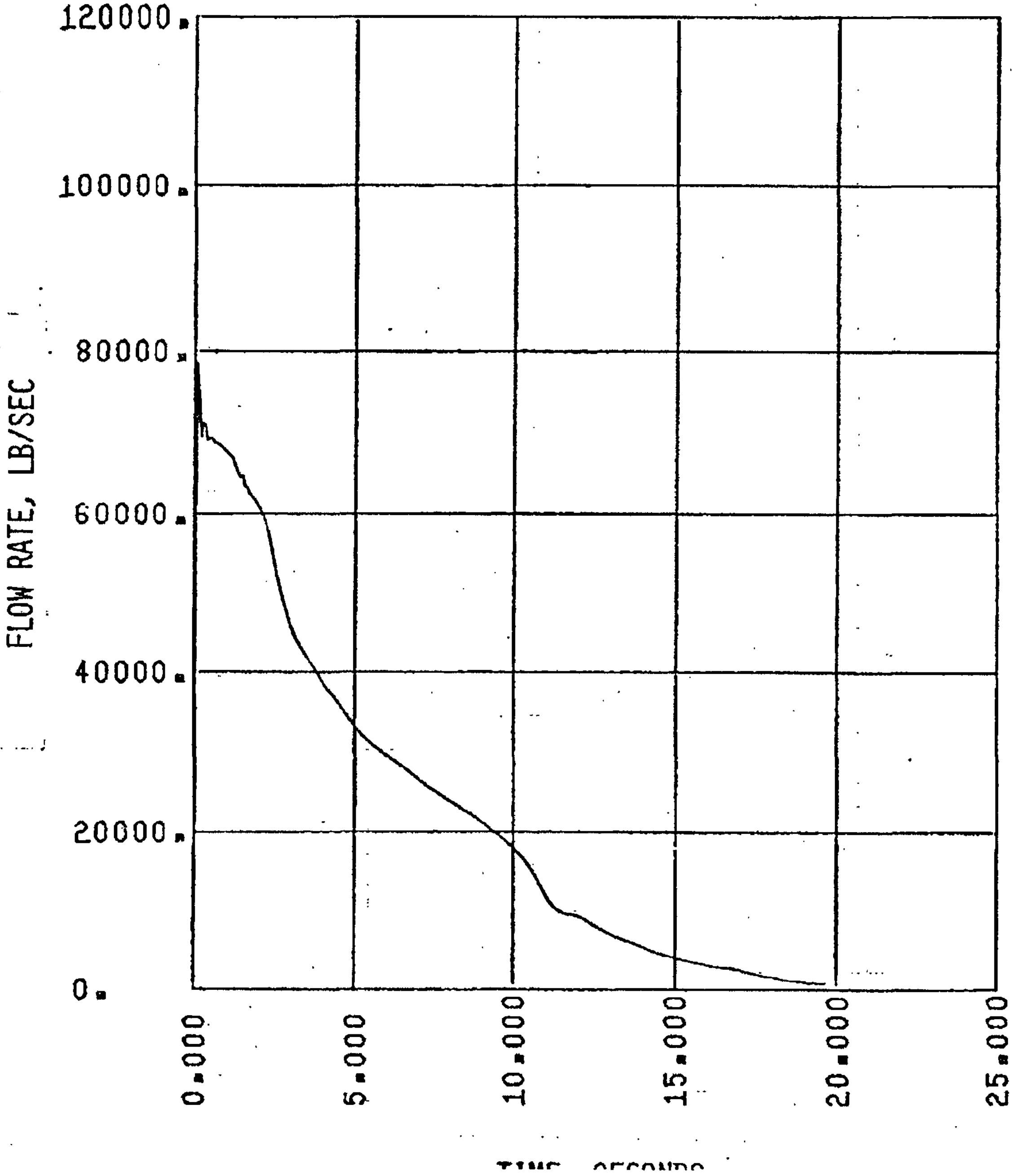


FIGURE A-2D.1

MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 16, BELOW HOT SPOT

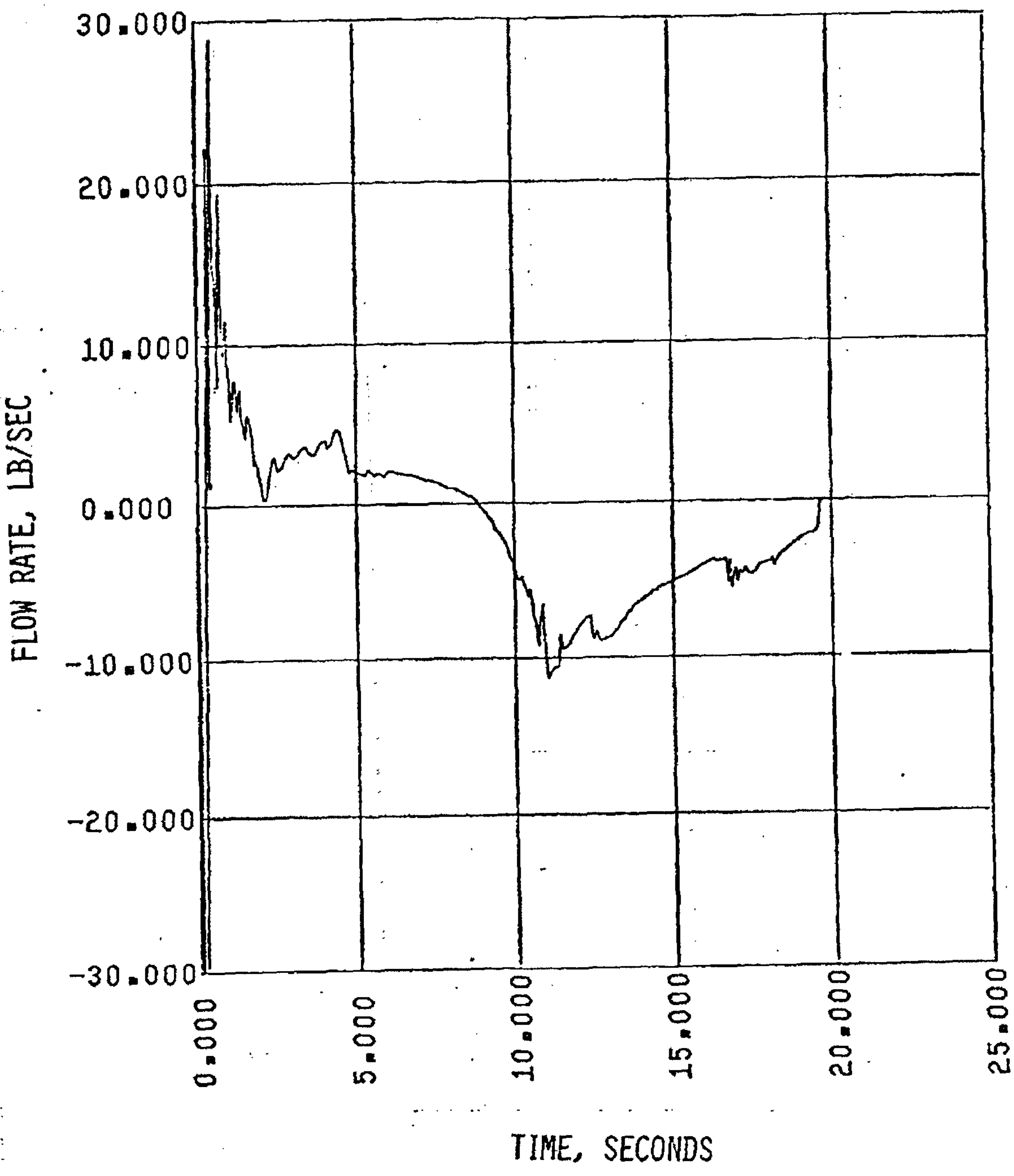


FIGURE A-2D.2
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 17, ABOVE HOT SPOT

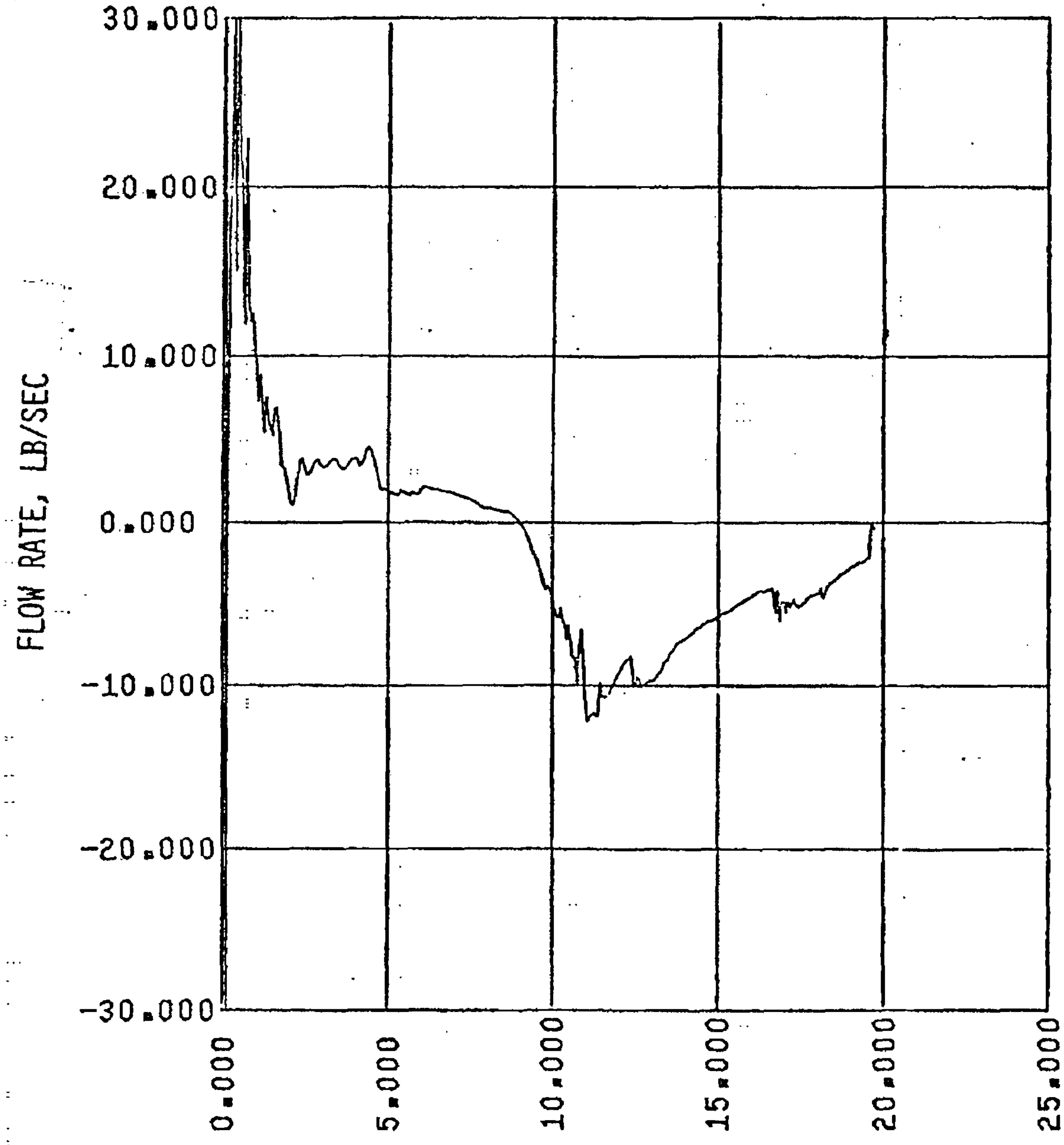


FIGURE A-2E
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

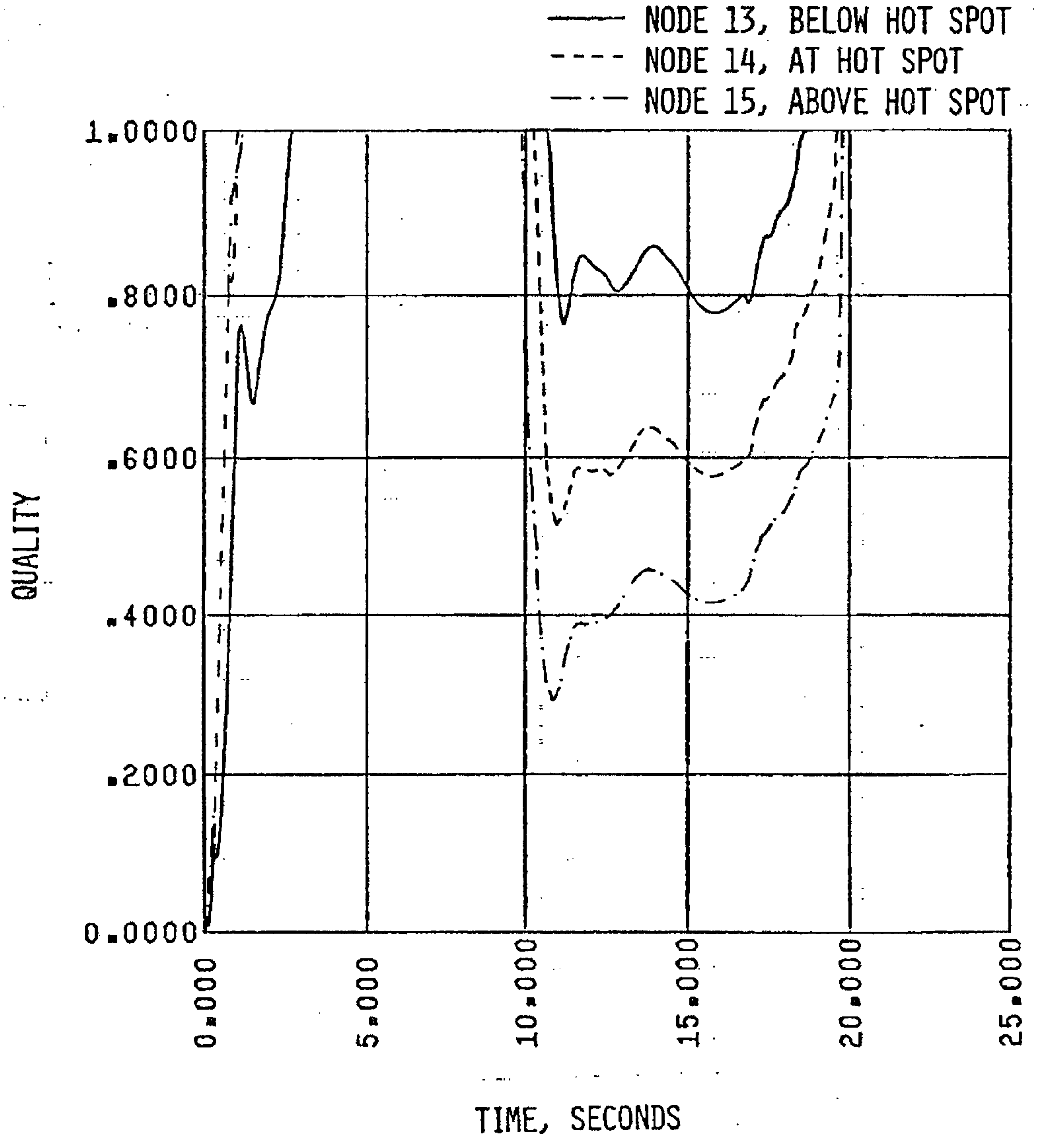


FIGURE A-2F

MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

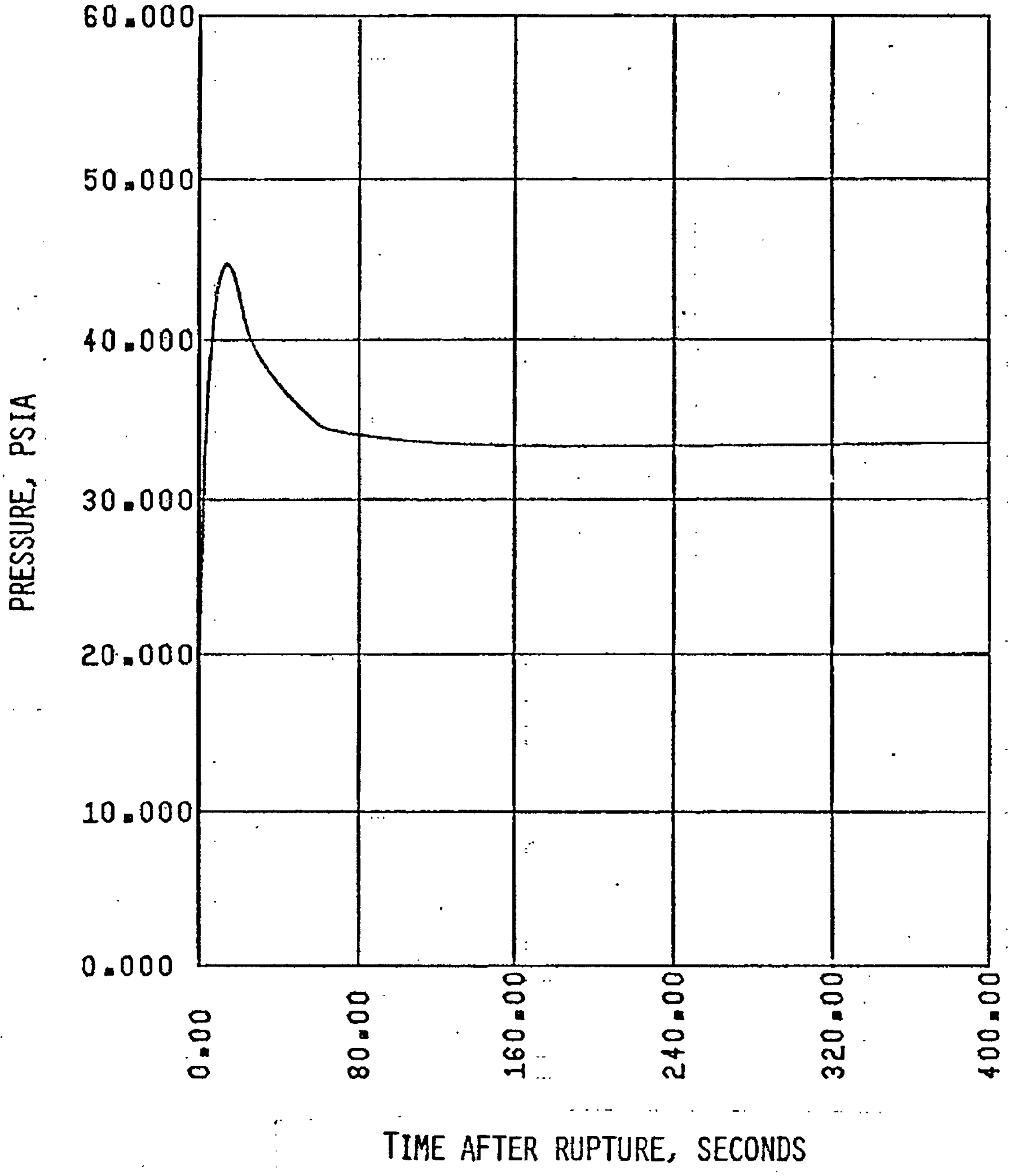


FIGURE A-26
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

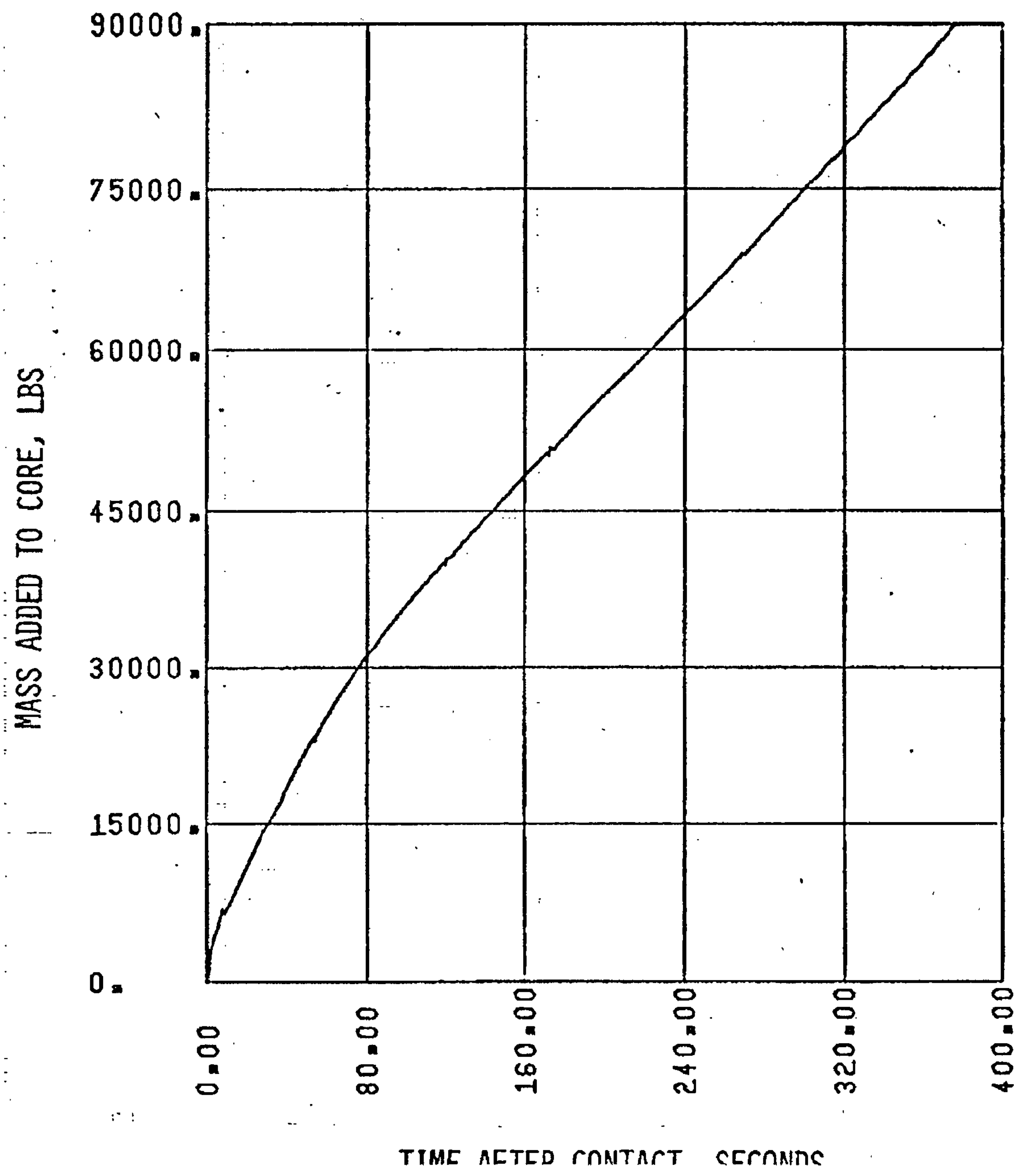


FIGURE A-2H

MILLSTONE UNIT 2 CYCLE 3

0.8 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG

PEAK CLAD TEMPERATURE

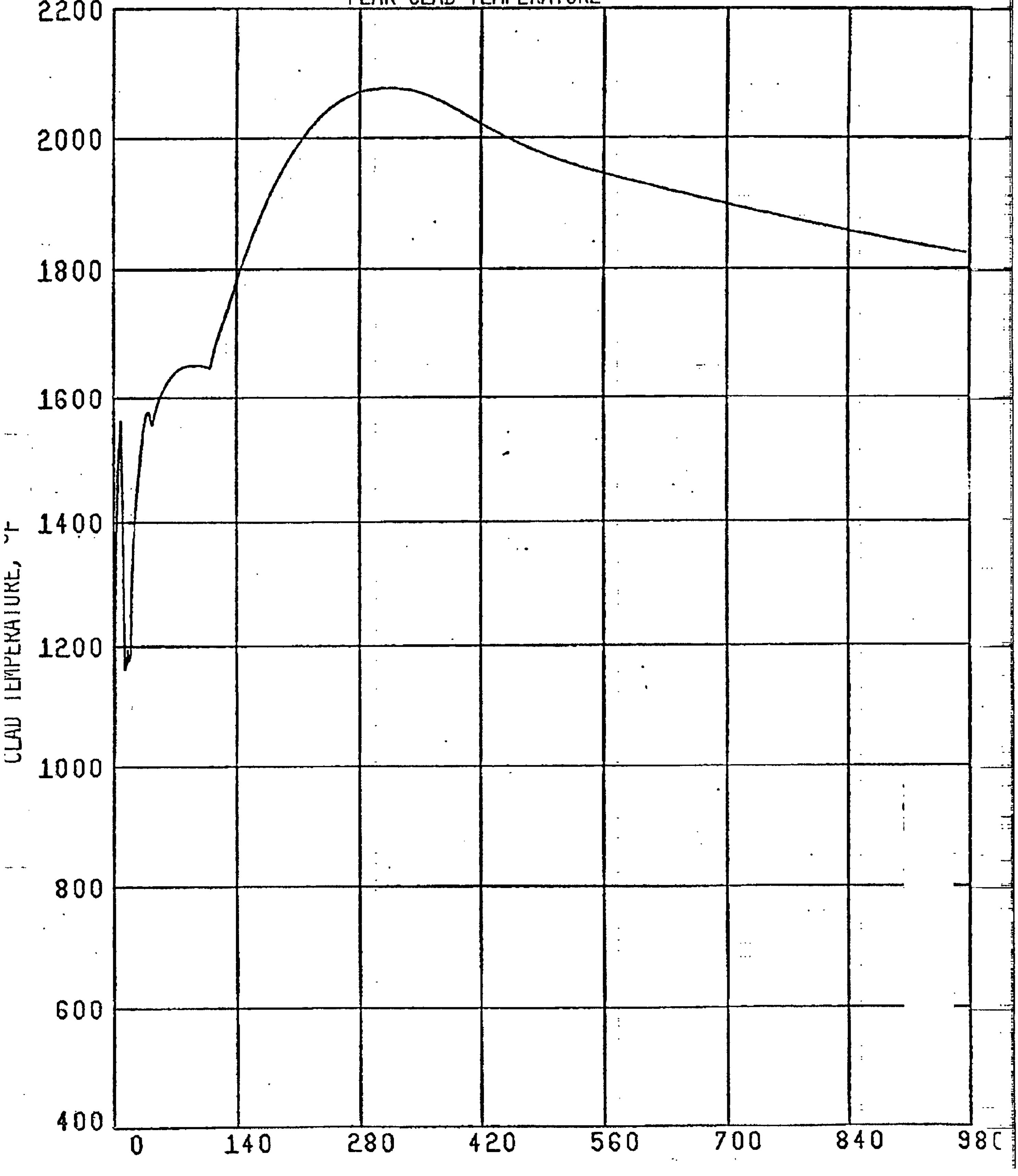


FIGURE A-3A
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CORE POWER

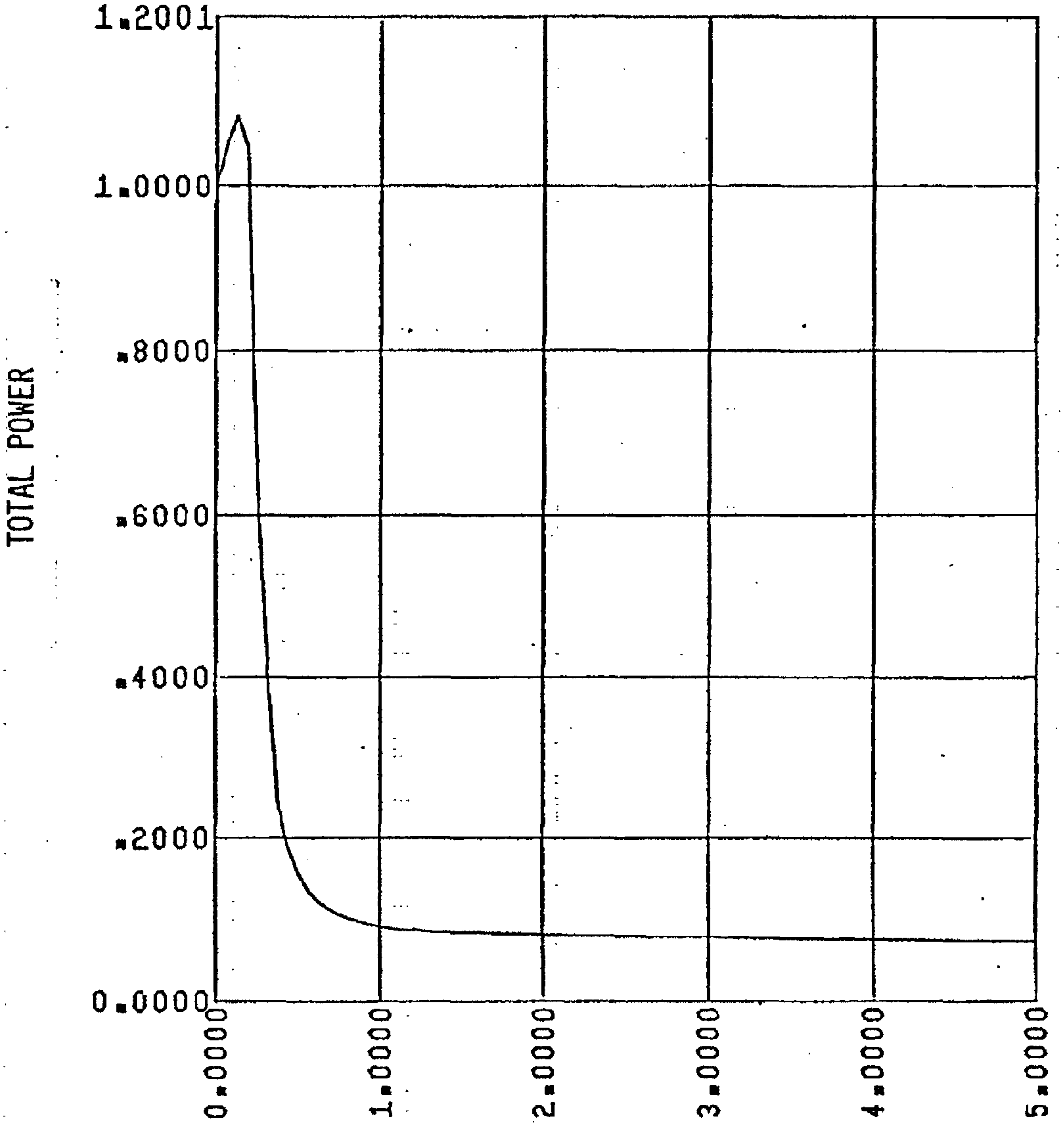


FIGURE A-3B

MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

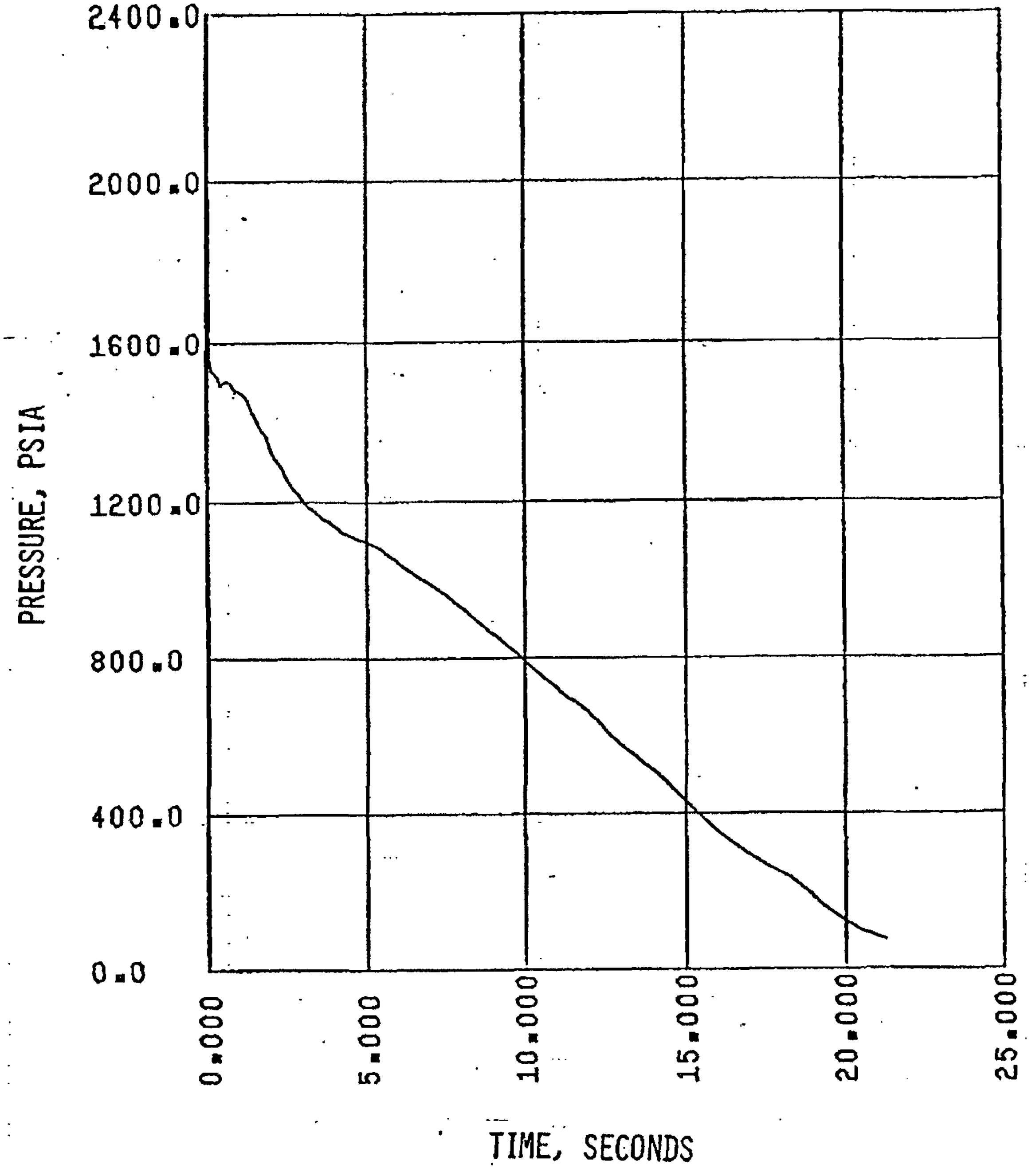


FIGURE A-3C
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

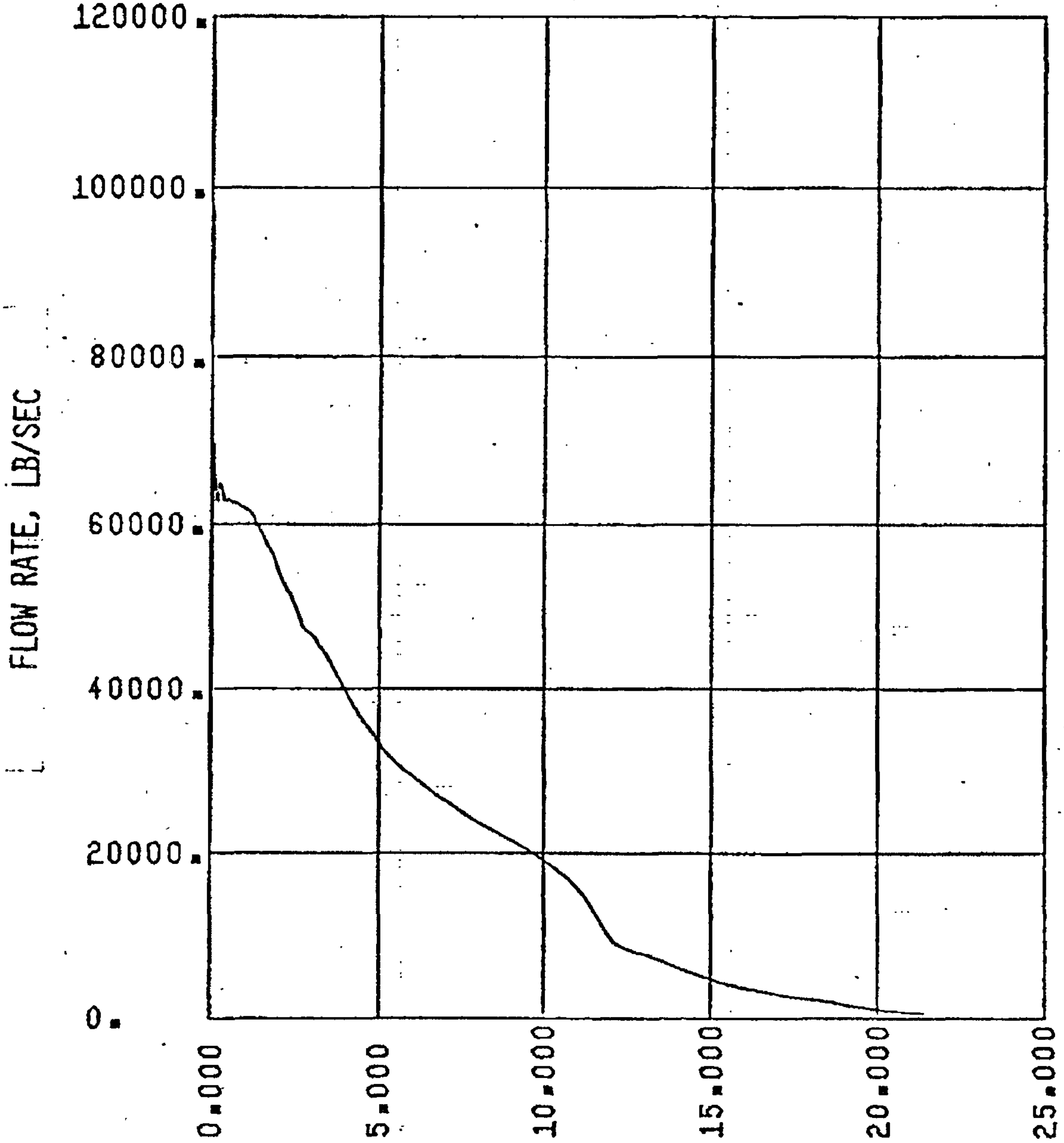


FIGURE A-3D.1
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 16, BELOW HOT SPOT

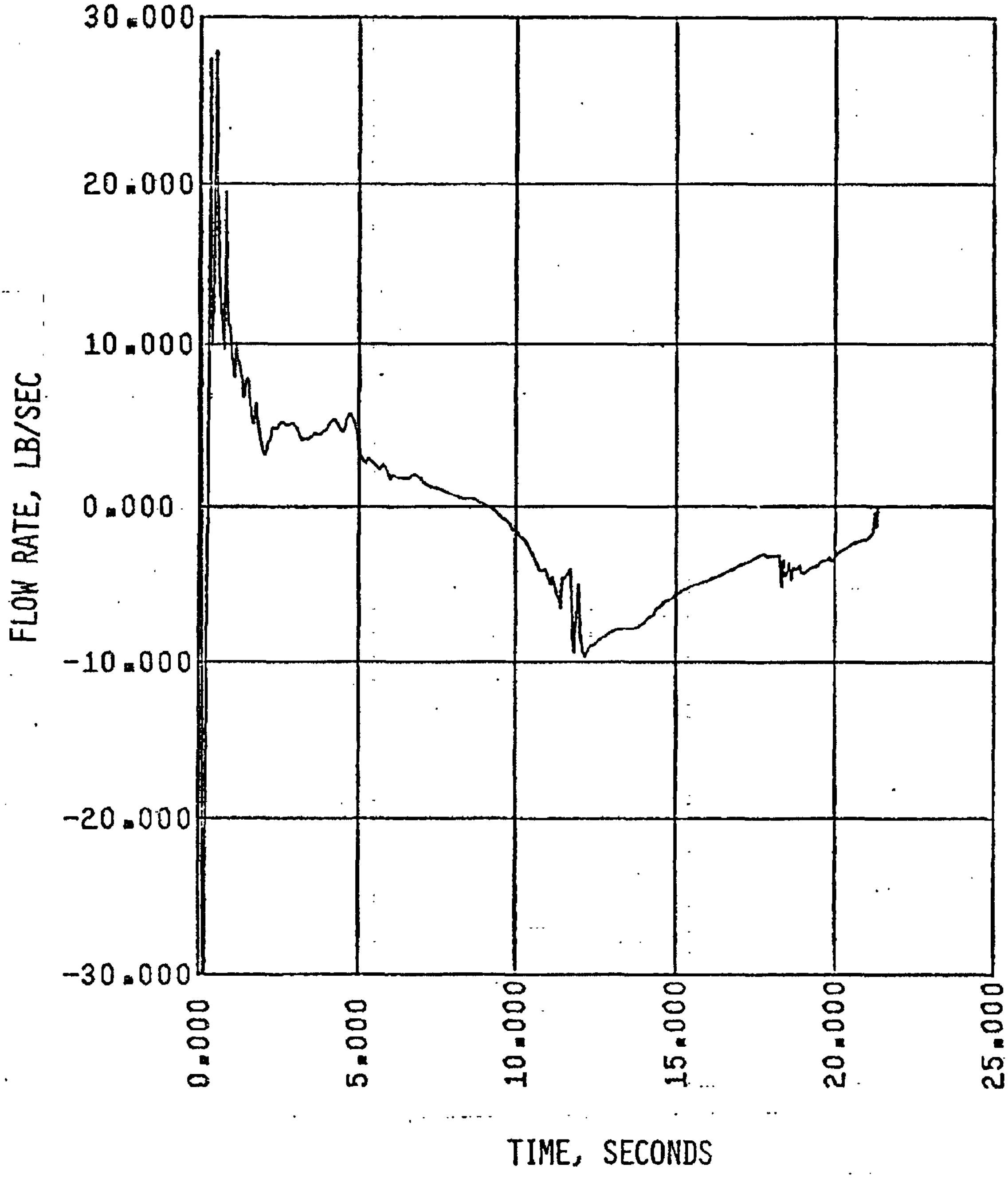


FIGURE A-3D.2
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 17, ABOVE HOT SPOT

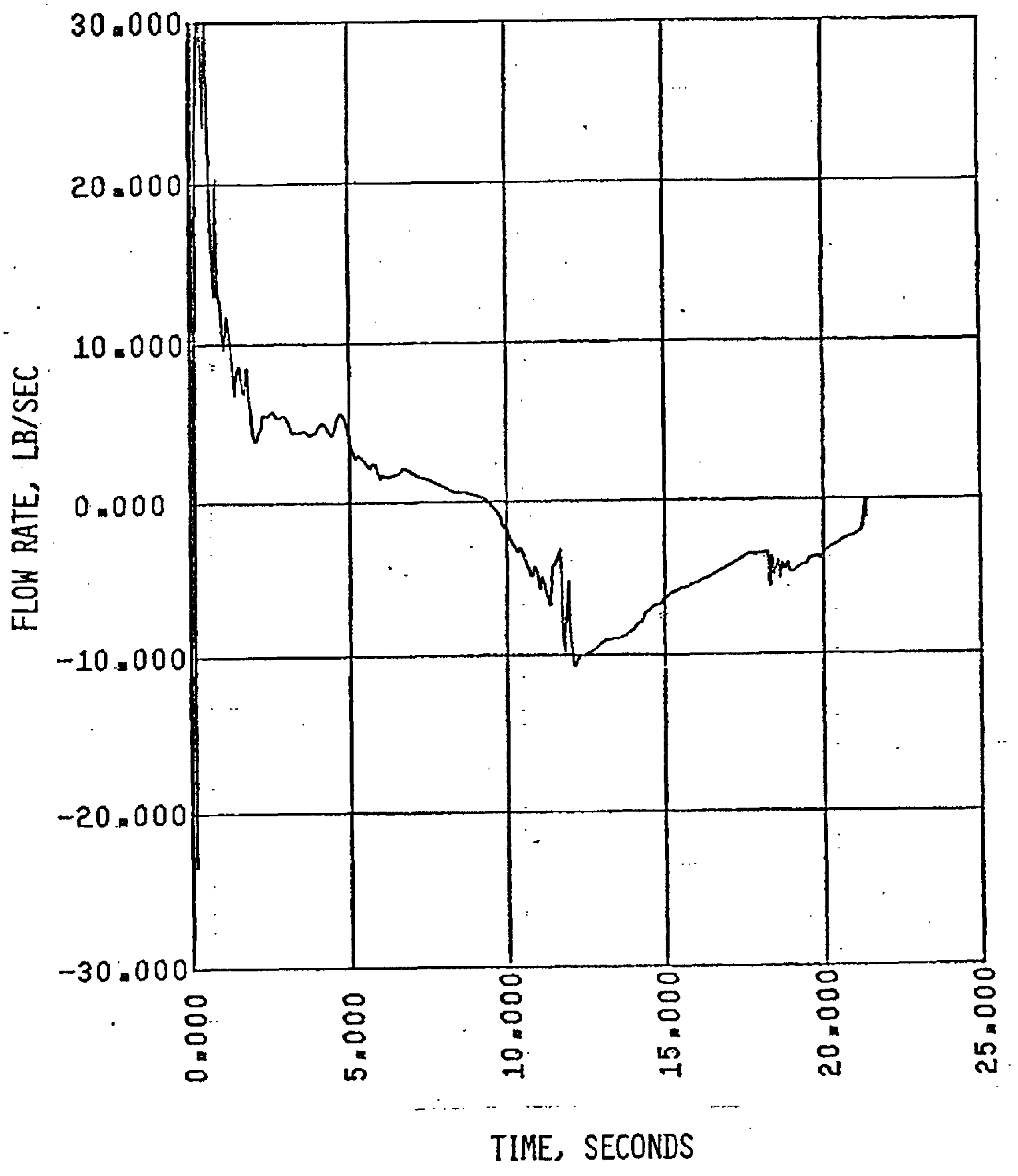


FIGURE A-3E
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

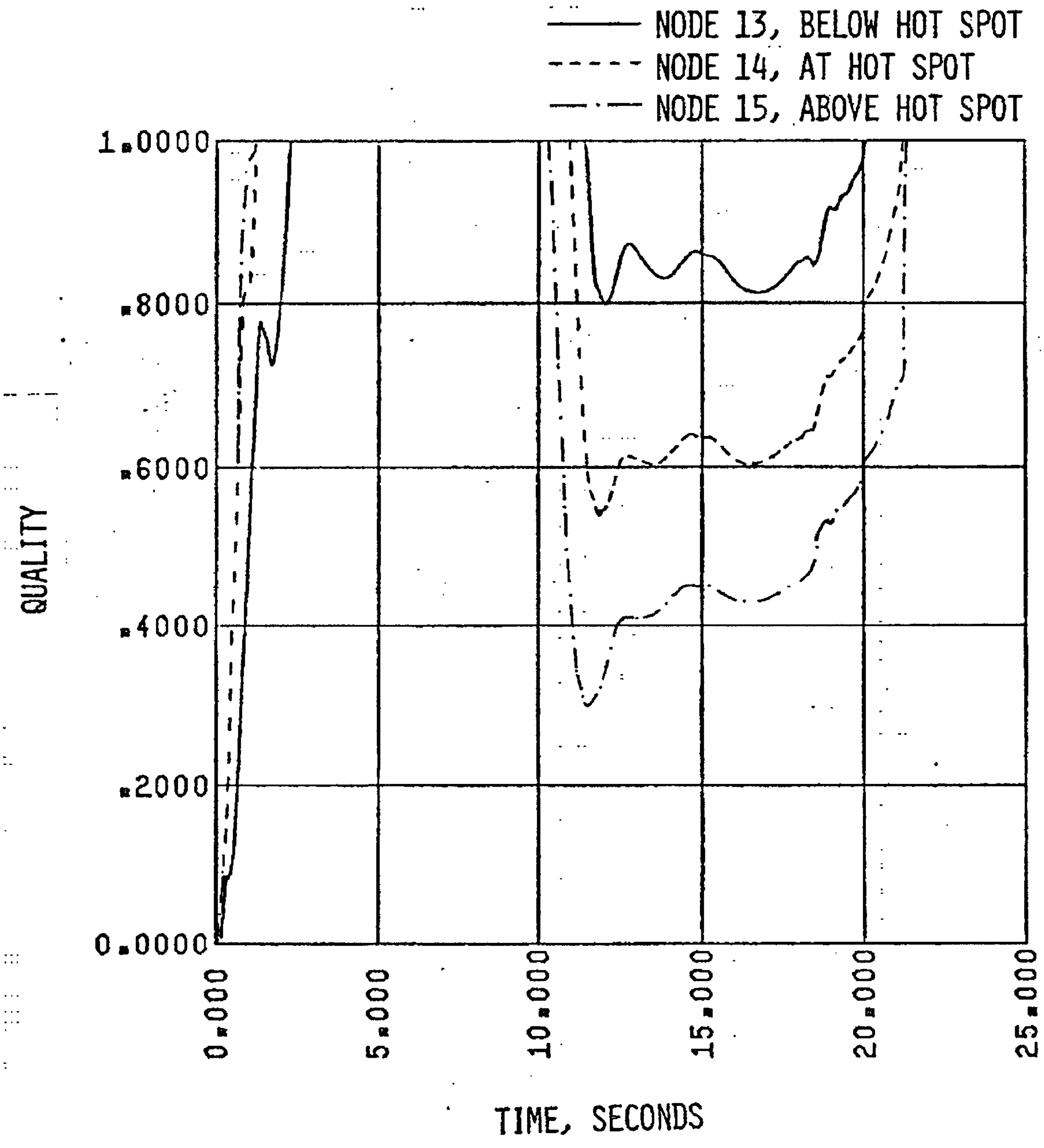


FIGURE A-3F
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

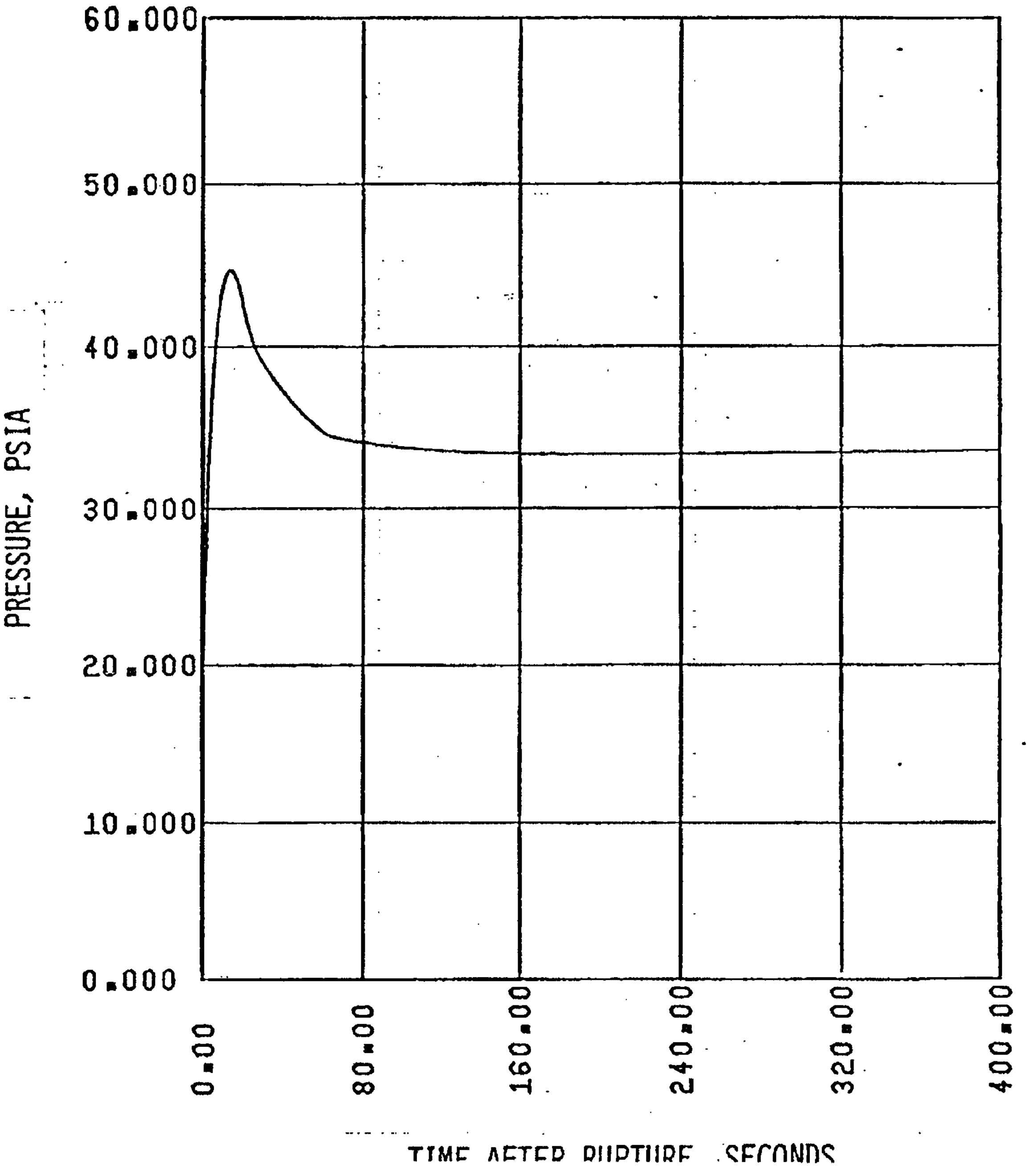


FIGURE A-3G
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

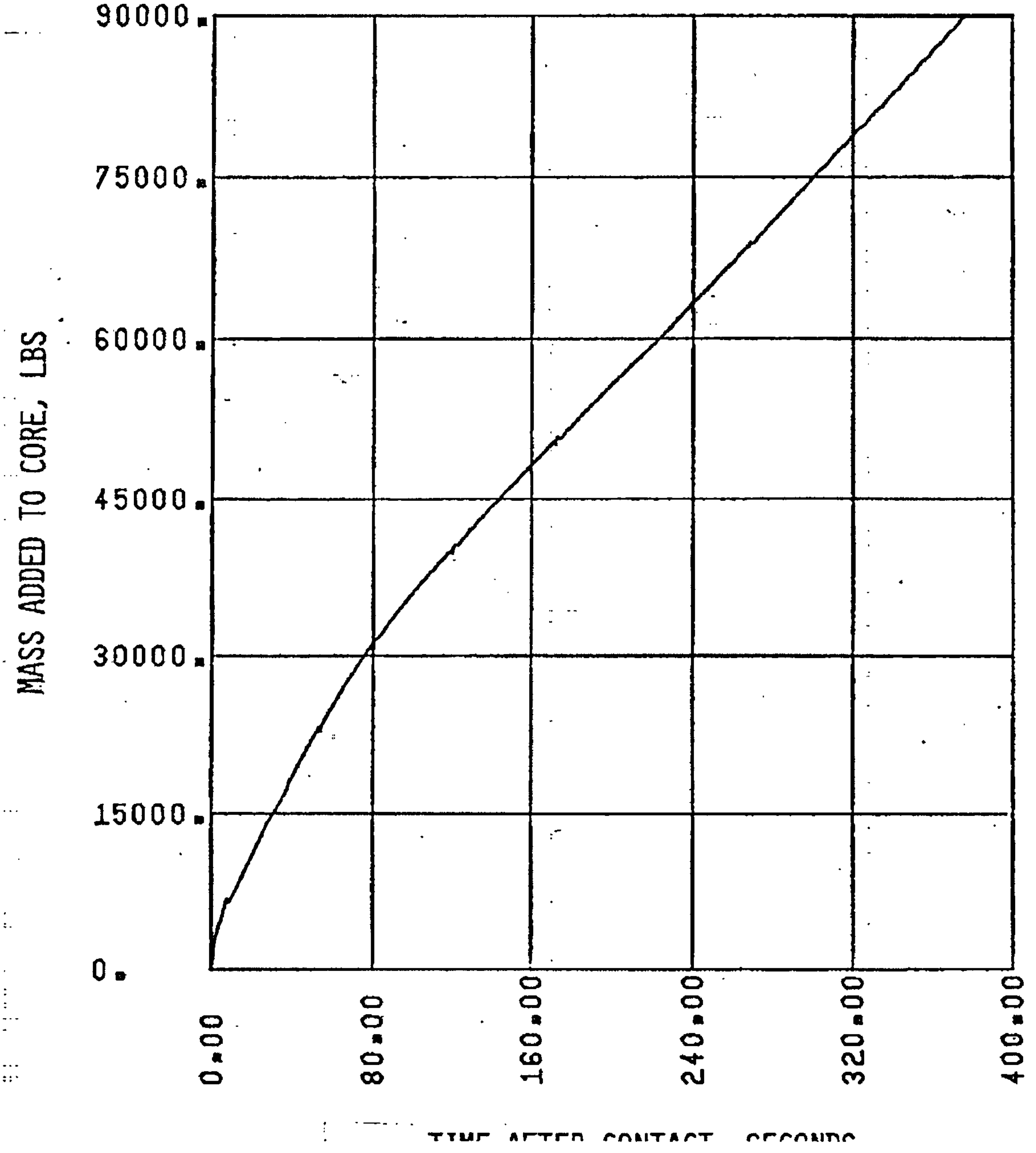


FIGURE A-5H
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED SLOT BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE

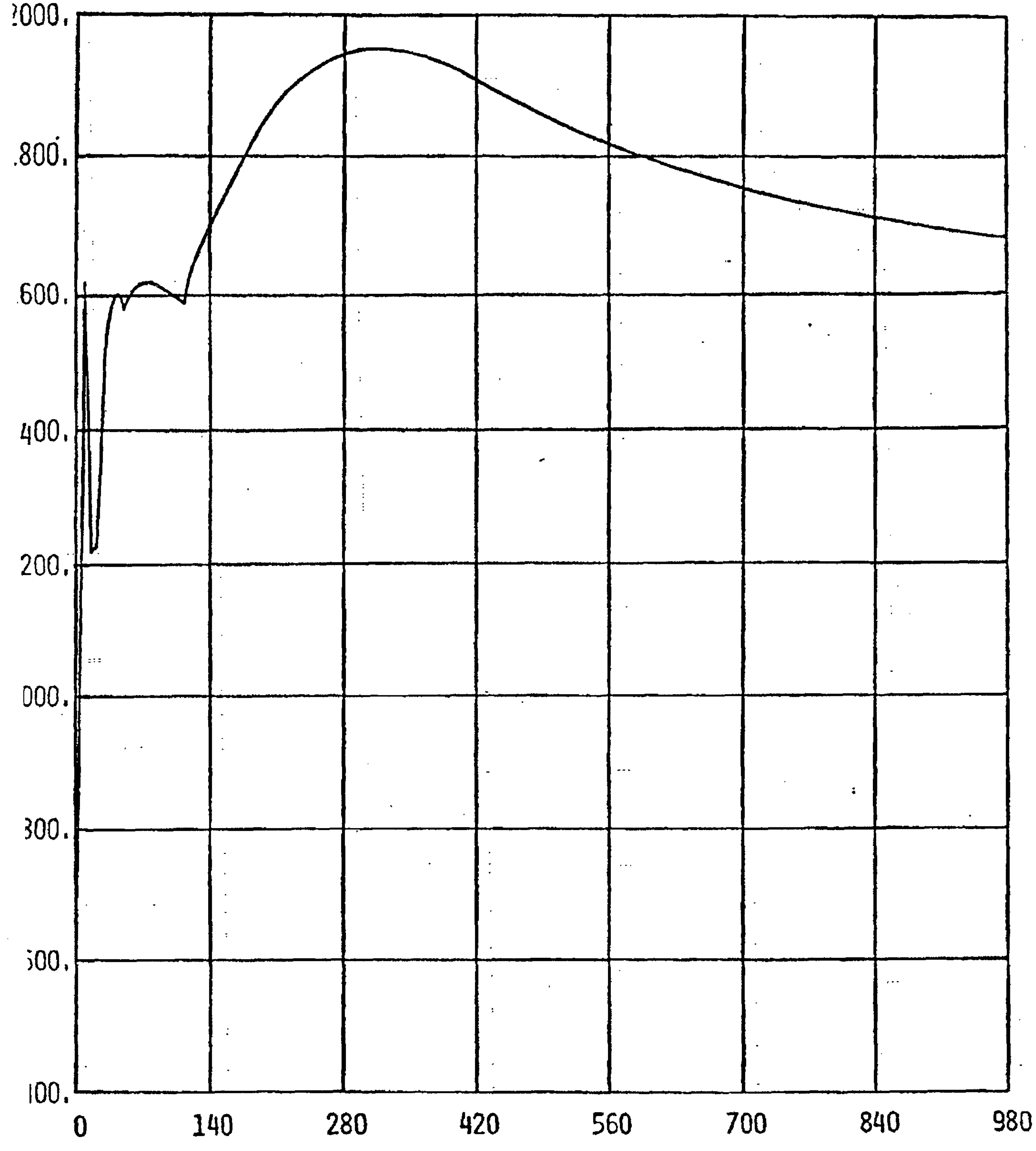


FIGURE A-4A
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CORE POWER

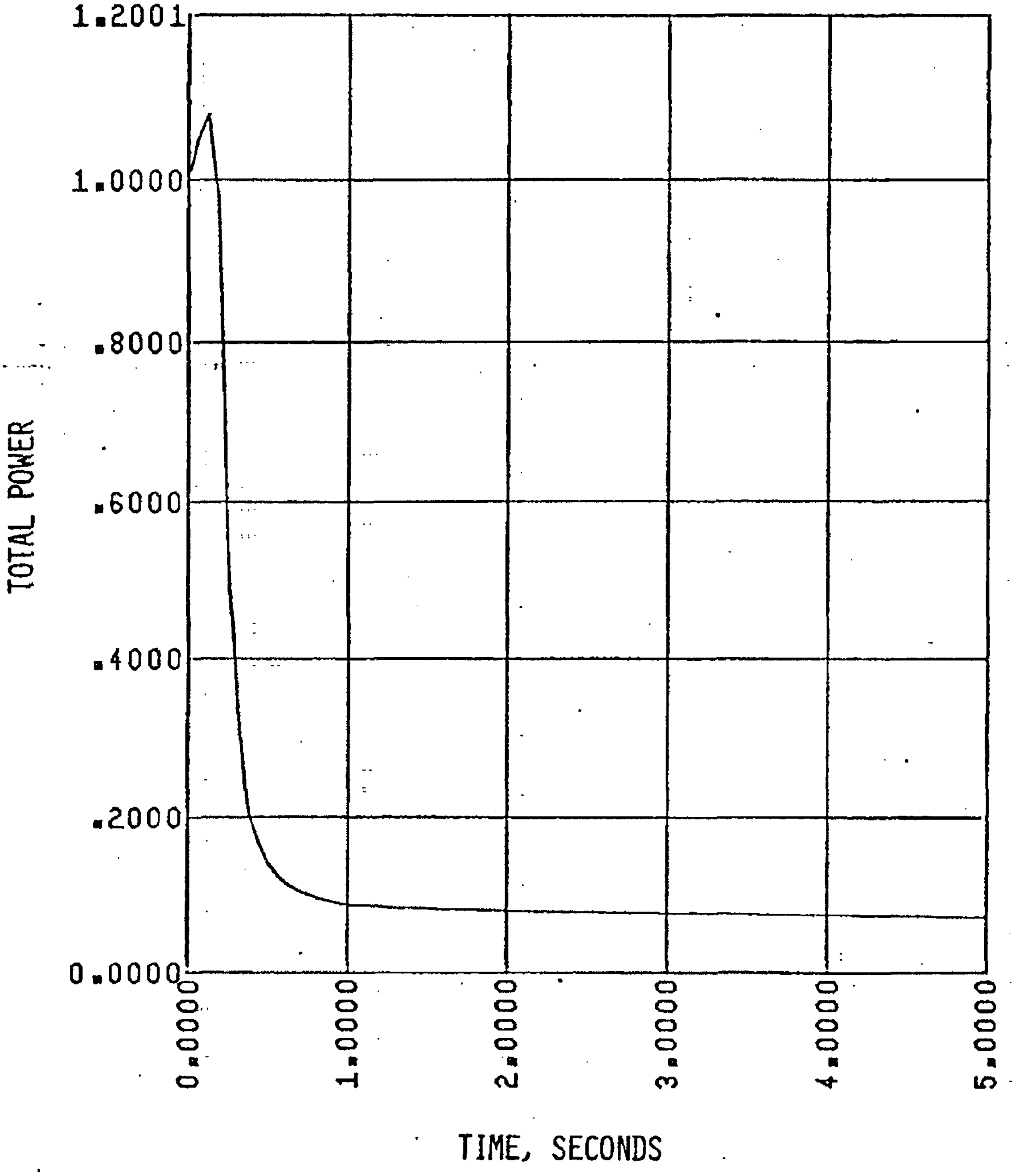


FIGURE A-4B
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

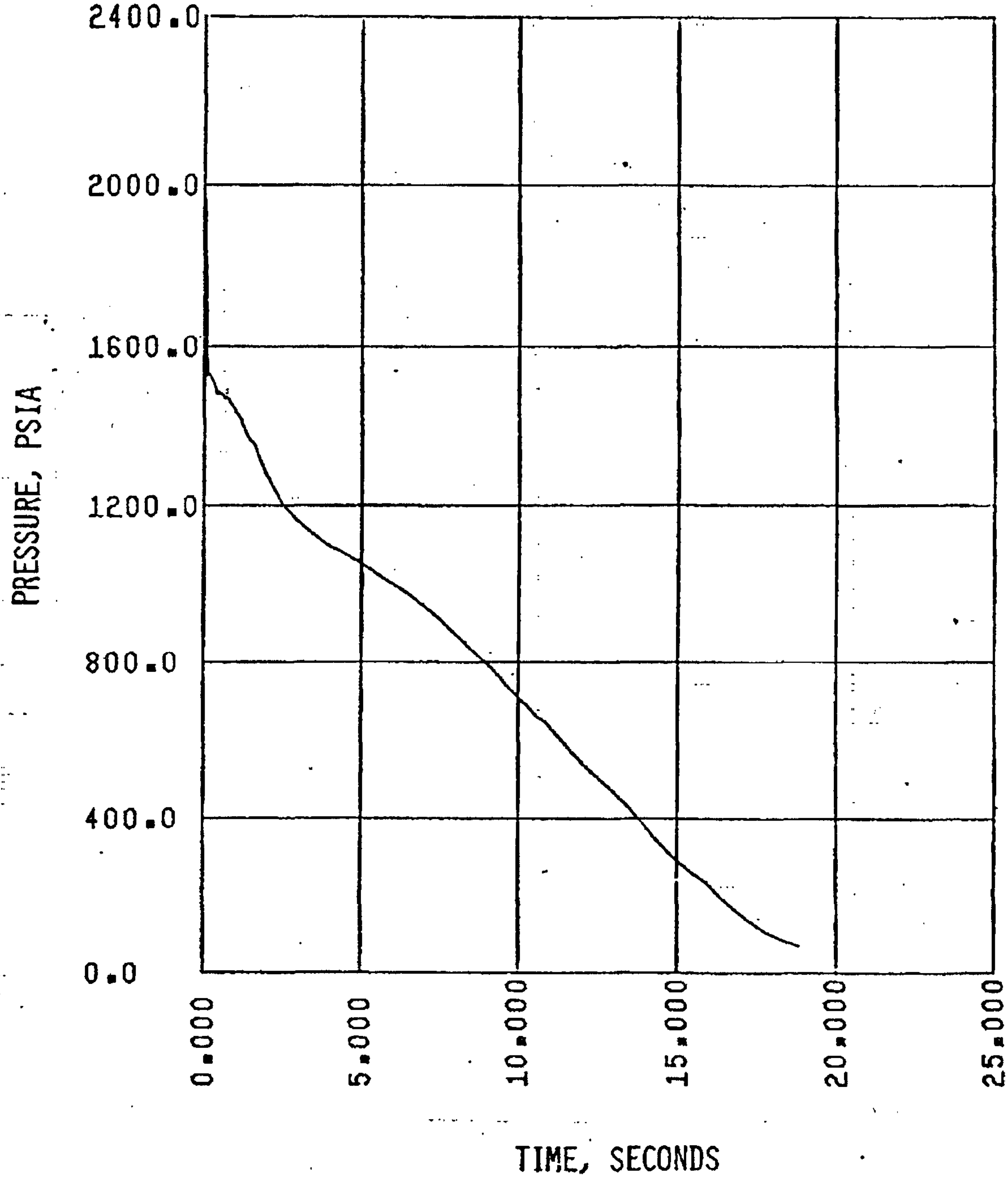


FIGURE A-4C

MILLSTONE UNIT 2 CYCLE 3

1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

LEAK FLOW

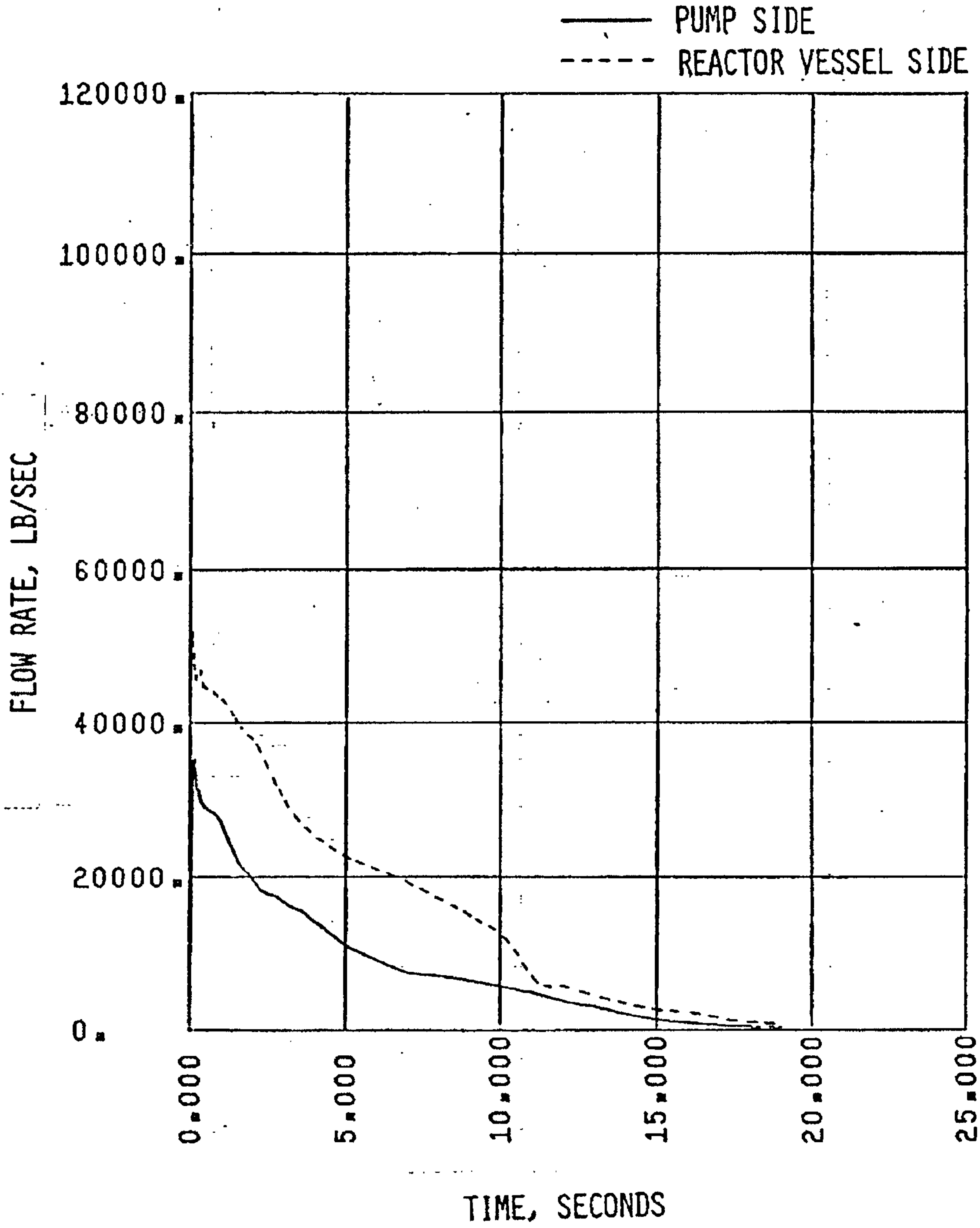


FIGURE A-4D.1
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 16, BELOW HOT SPOT

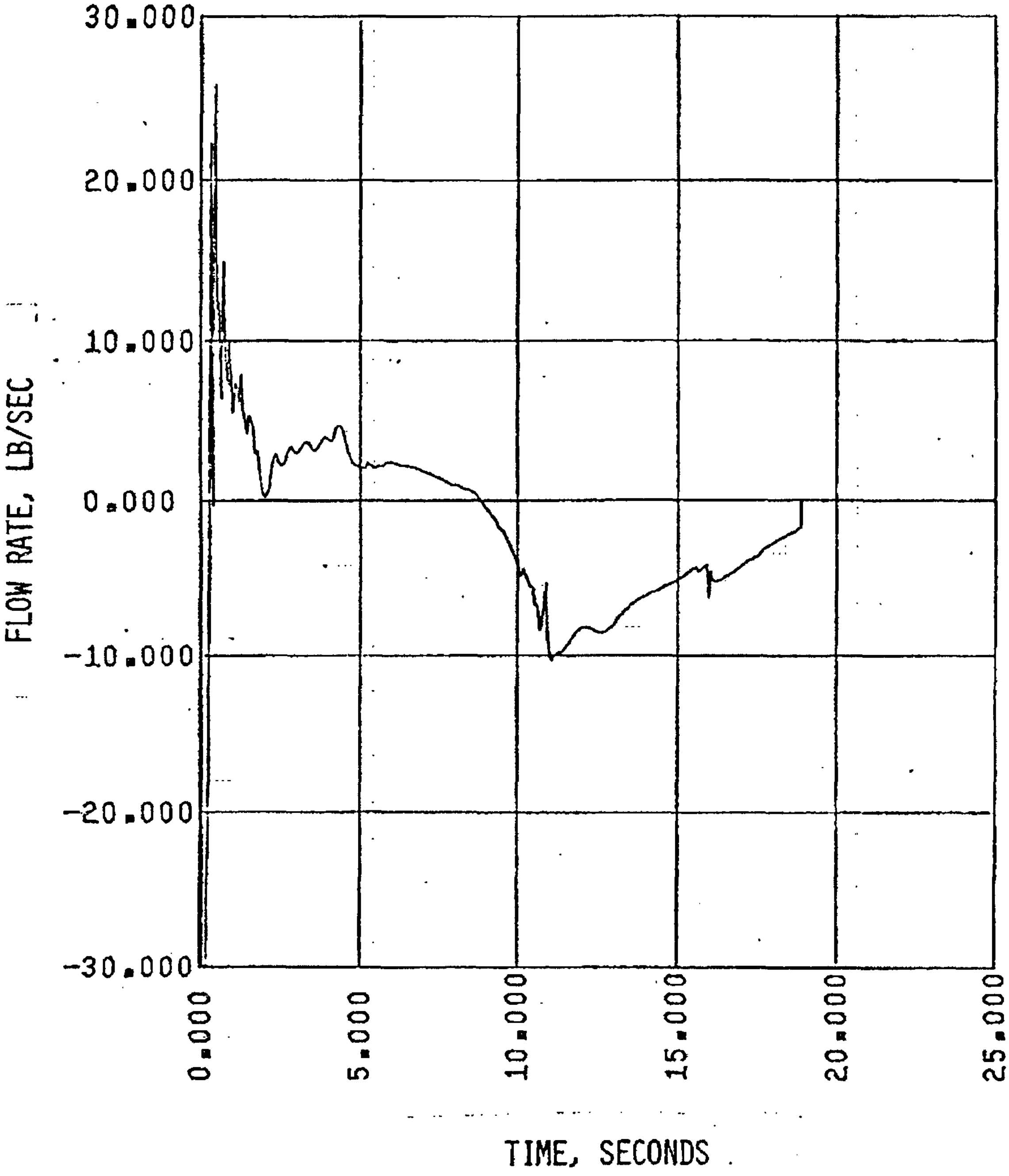


FIGURE A-4D.2
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 17, ABOVE HOT SPOT

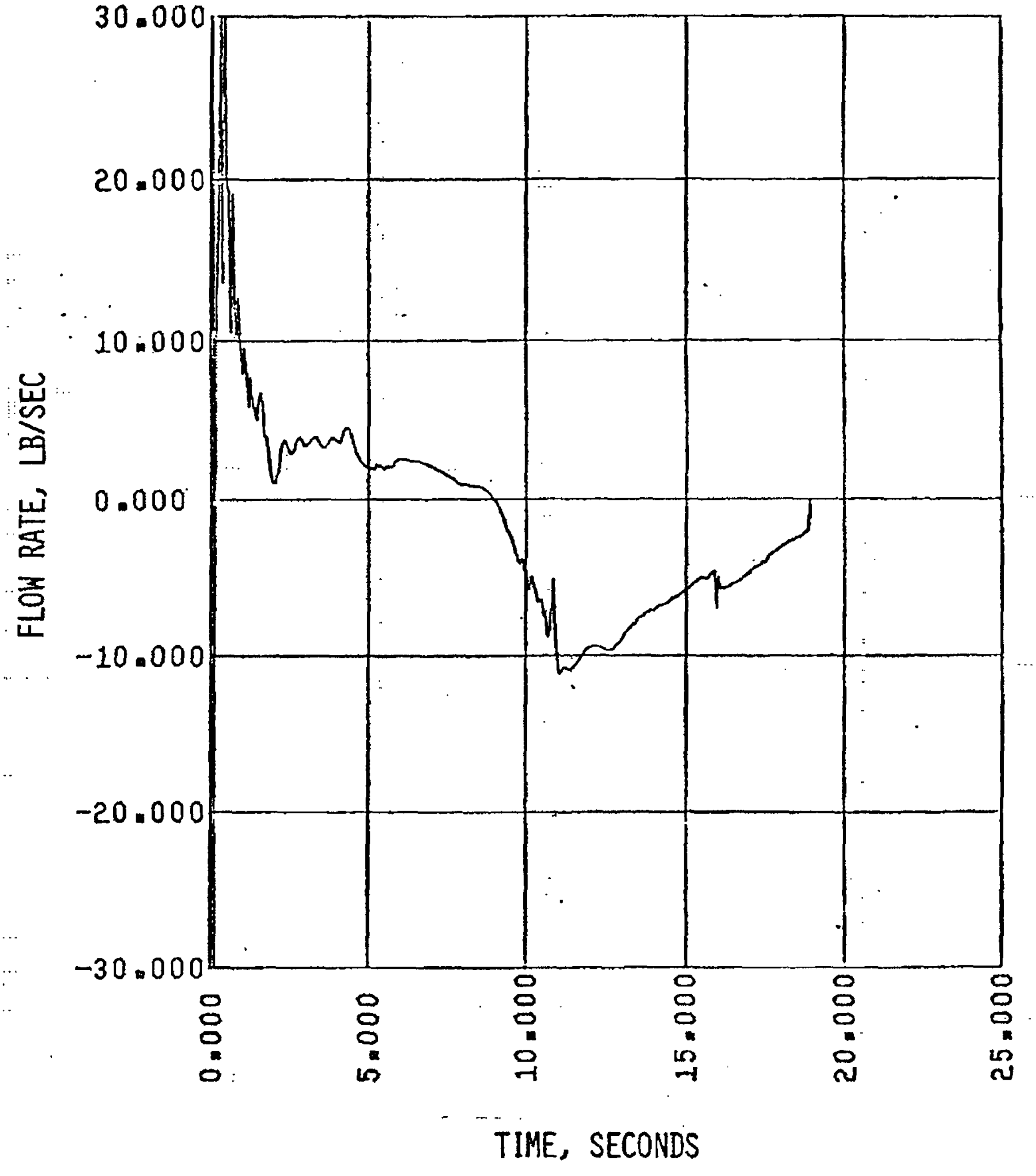


FIGURE A-4E
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

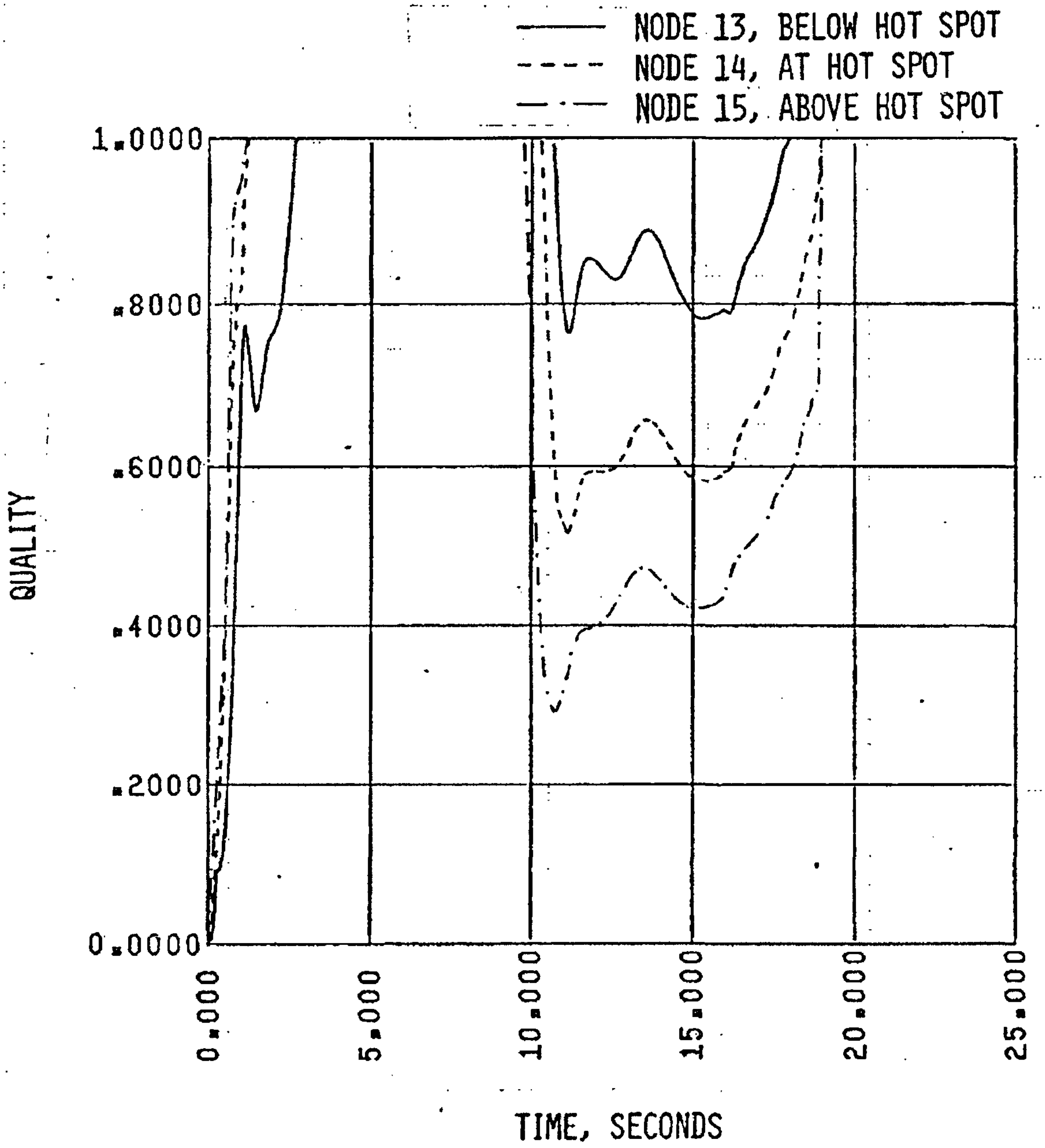


FIGURE A-4F
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

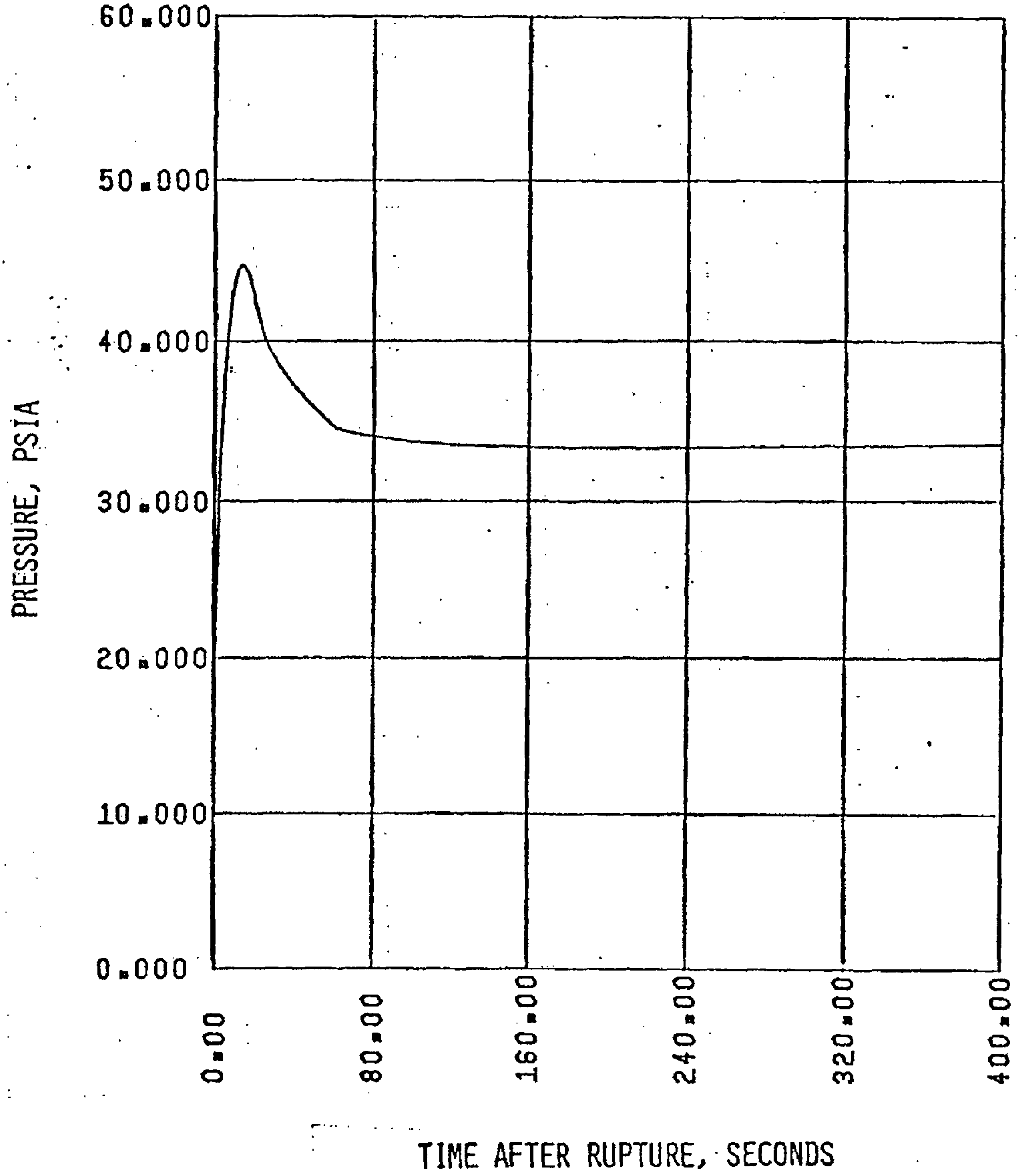


FIGURE A-4G
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

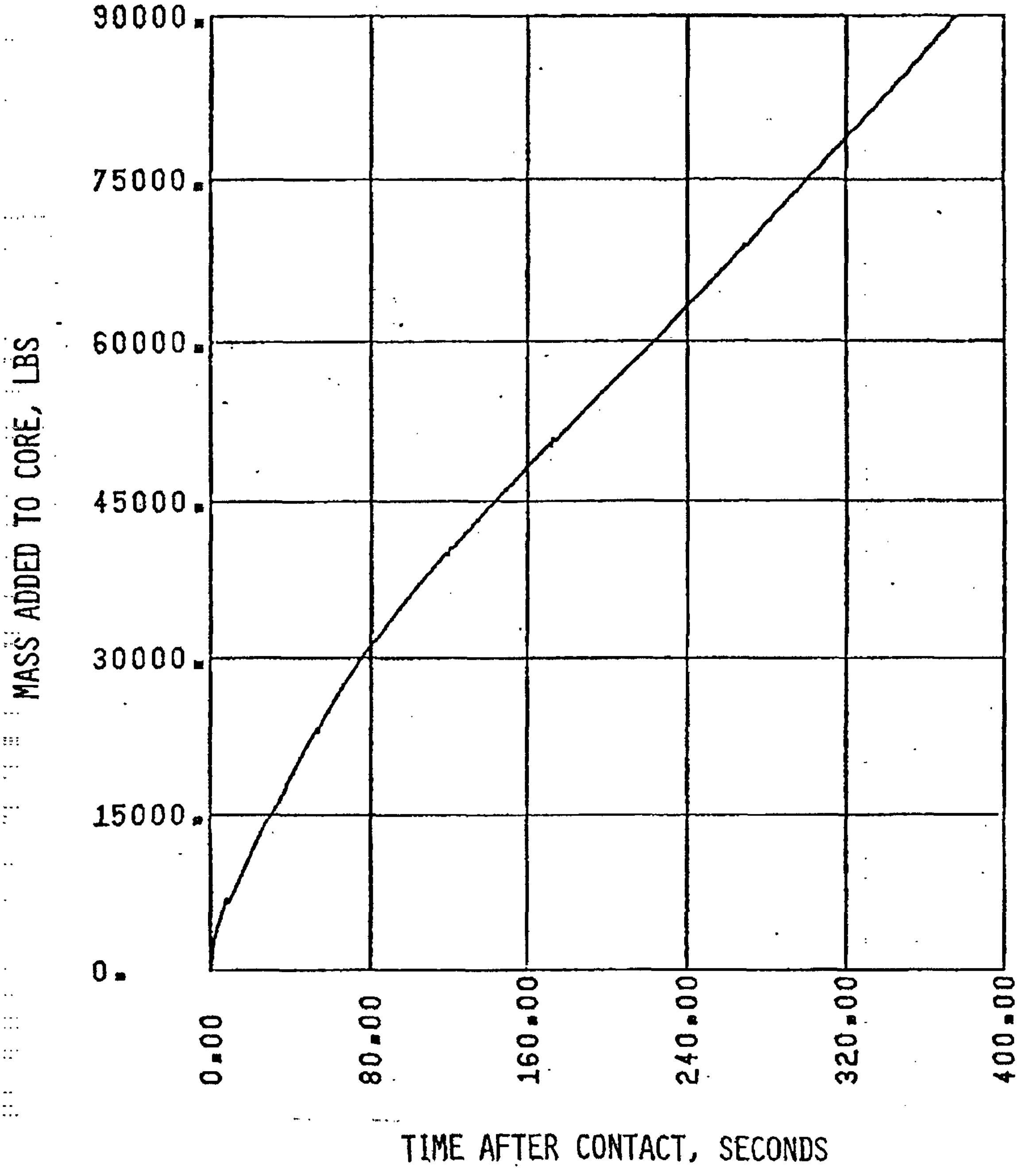


FIGURE A-4H
MILLSTONE UNIT 2 CYCLE 3
1.0 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE

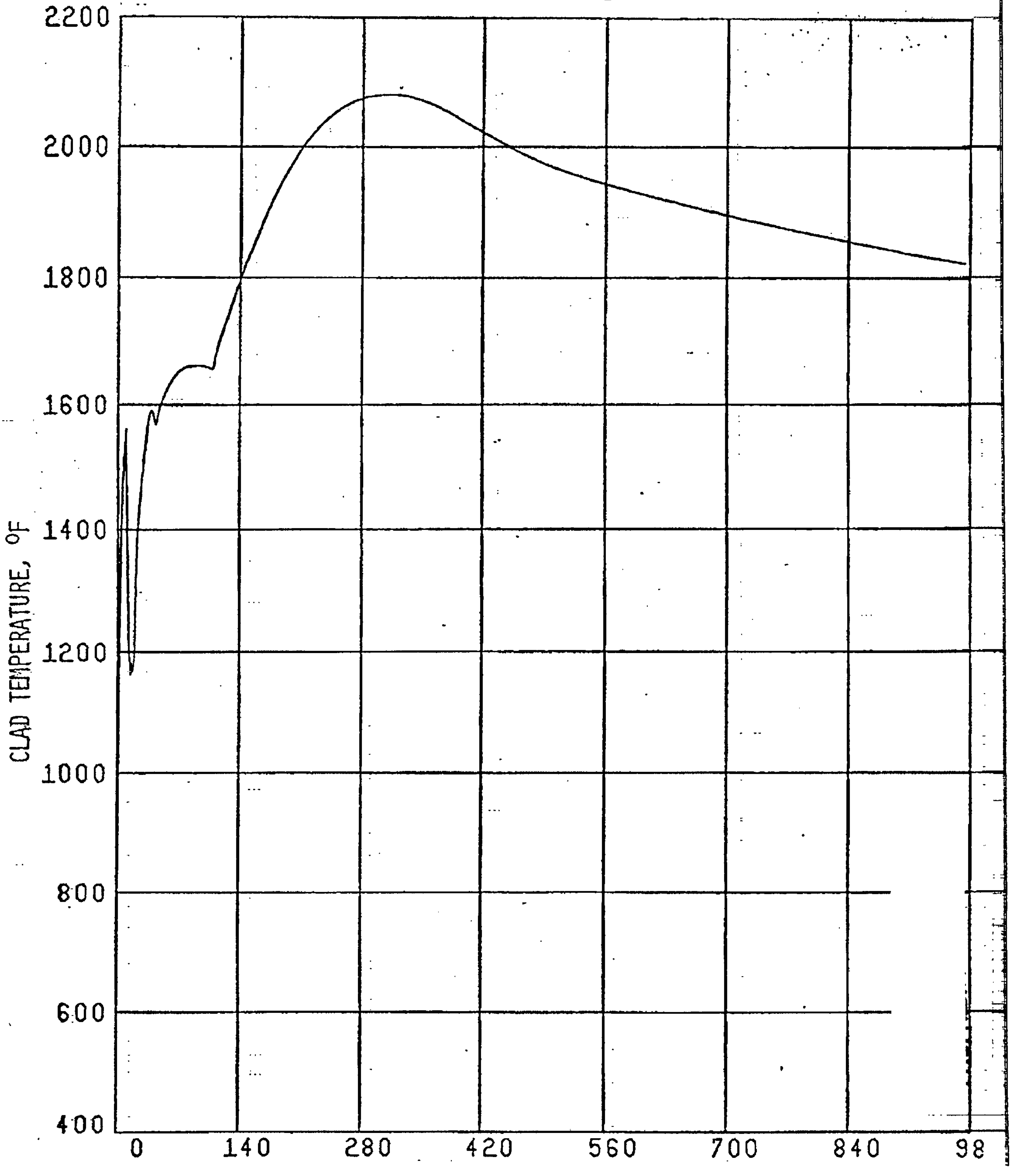


FIGURE-A-5A
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CORE POWER

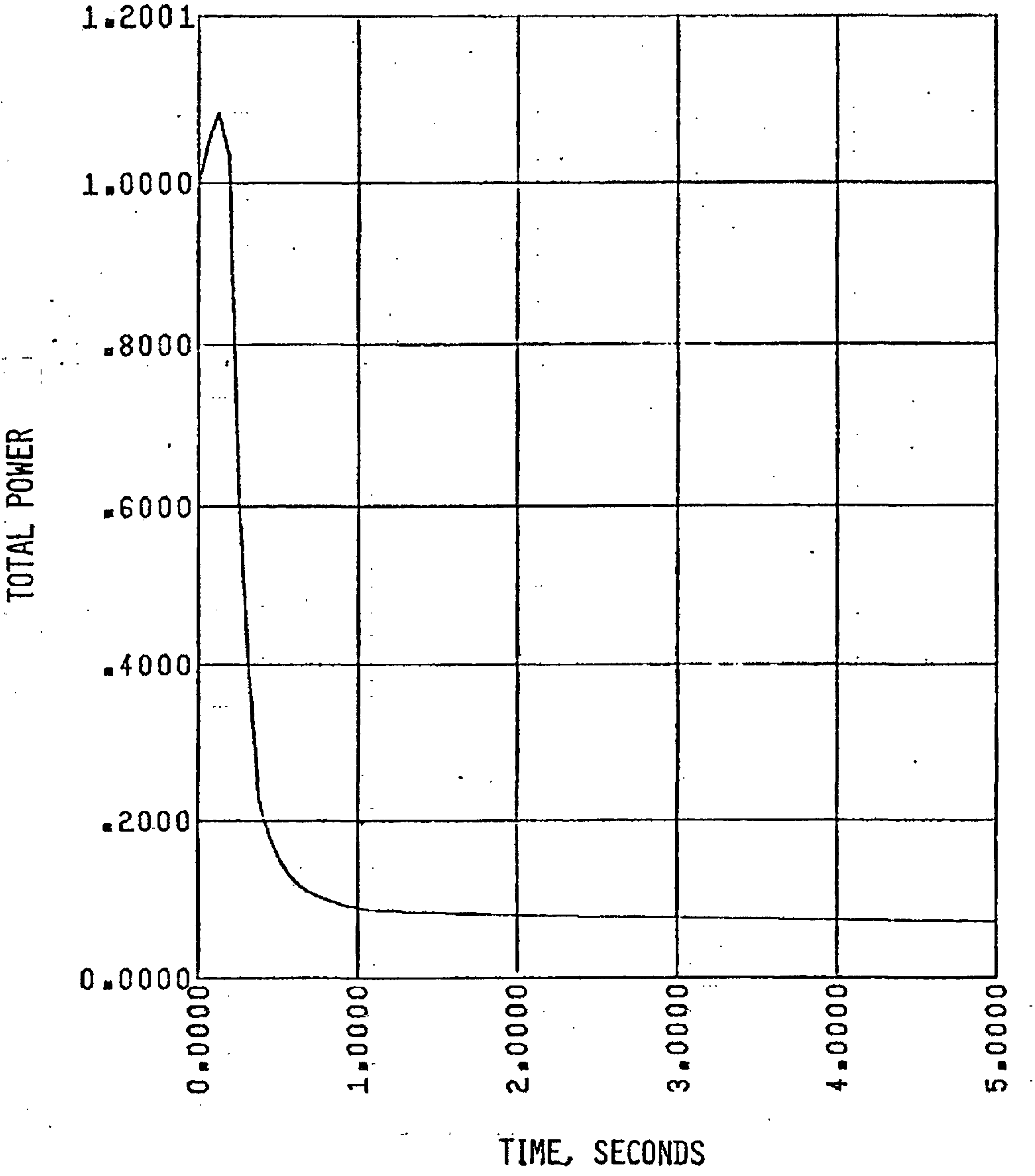


FIGURE A-5B
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

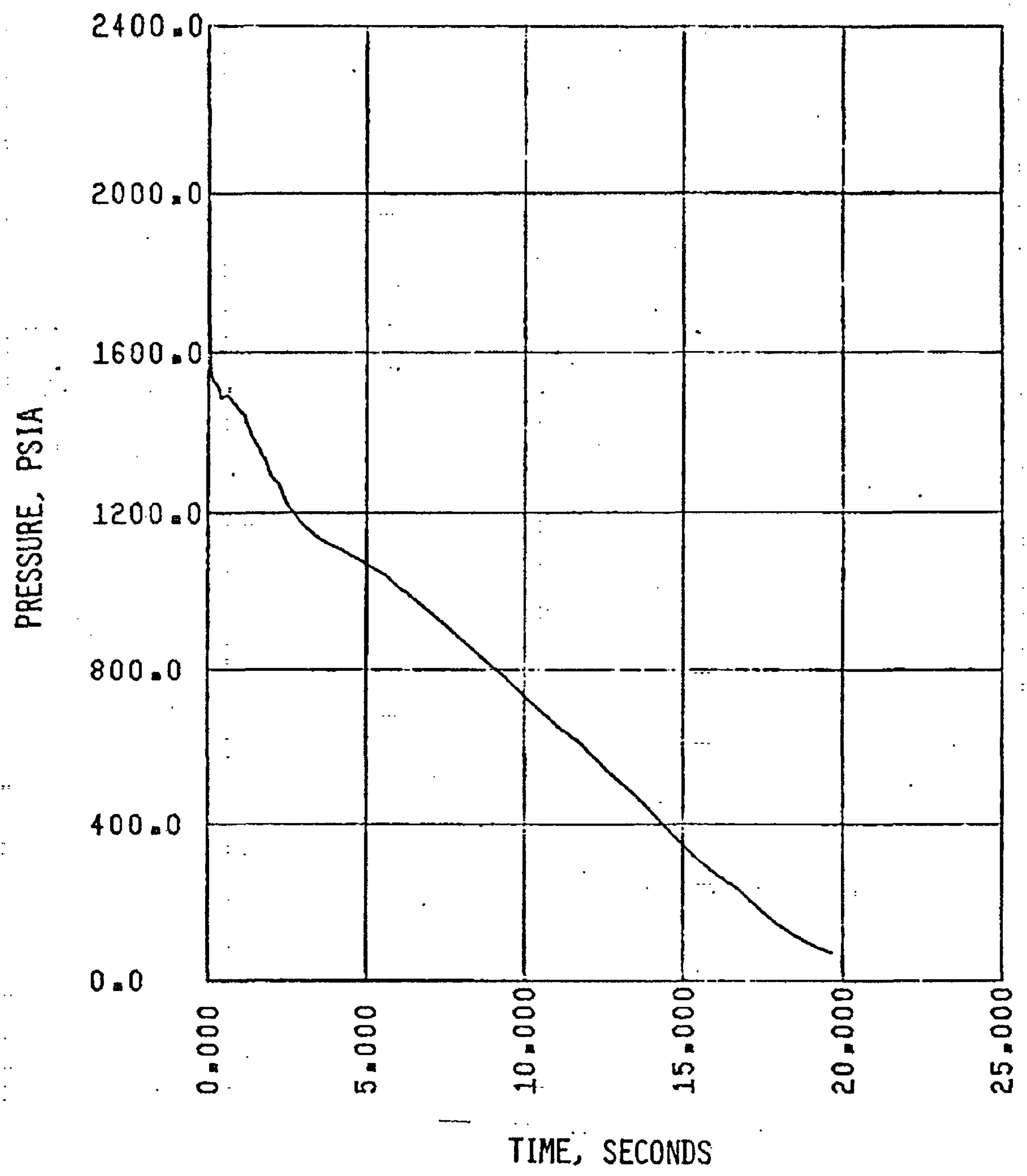


FIGURE A-5C
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

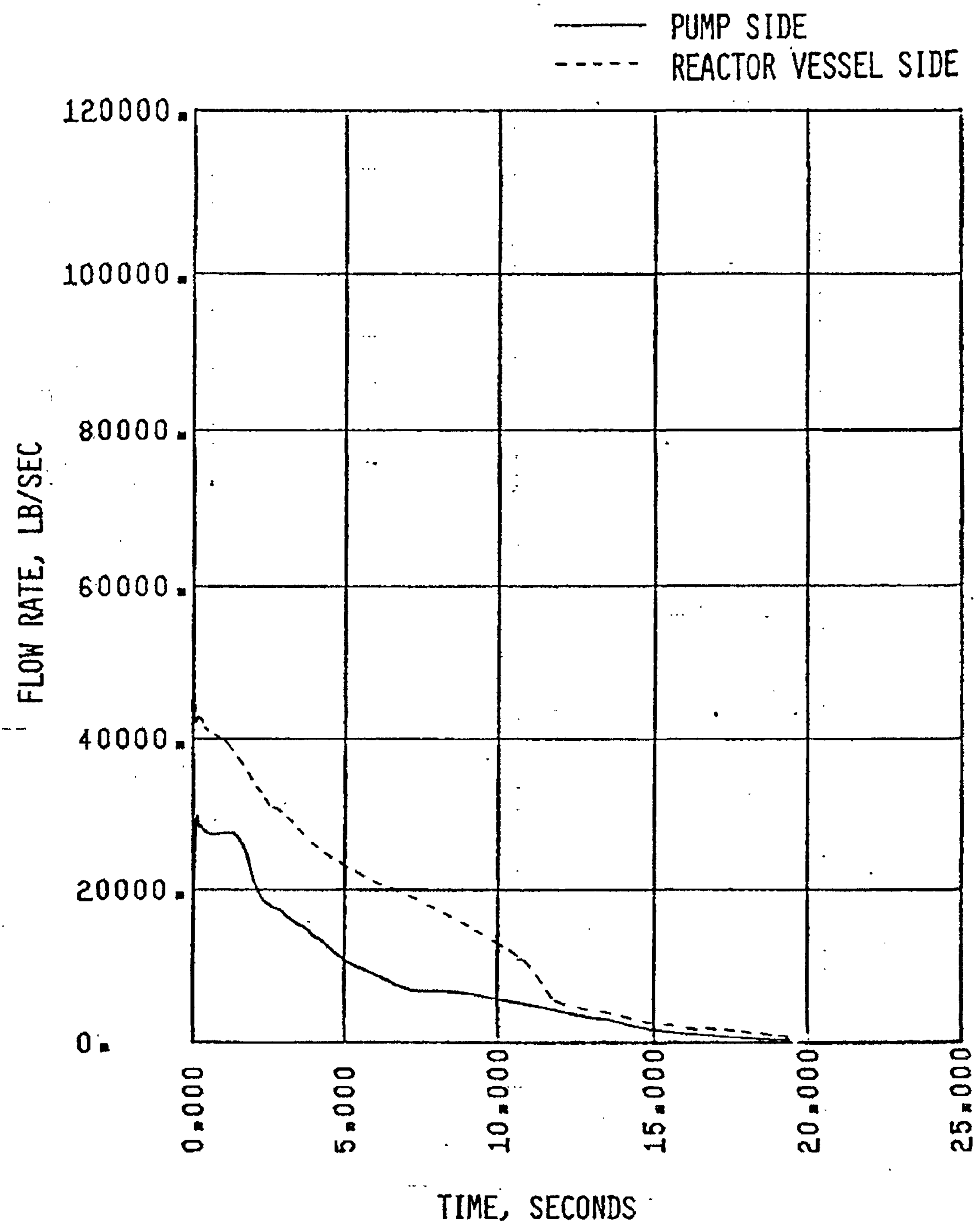


FIGURE A-5D.1
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 16, BELOW HOT SPOT

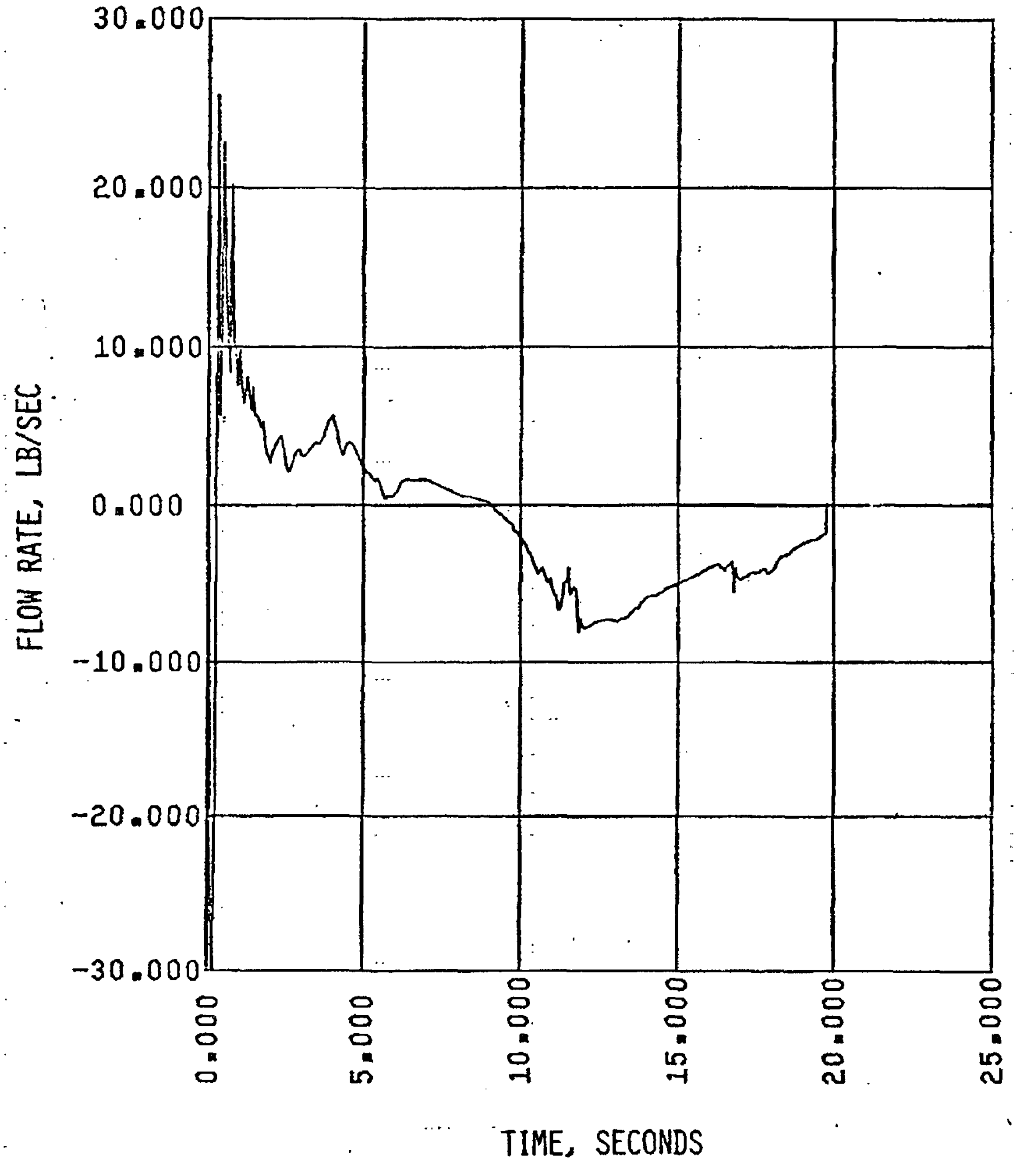


FIGURE A-5D.2

MILLSTONE UNIT 2 CYCLE 3

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

FLOW IN HOT ASSEMBLY-PATH 17, ABOVE HOT SPOT

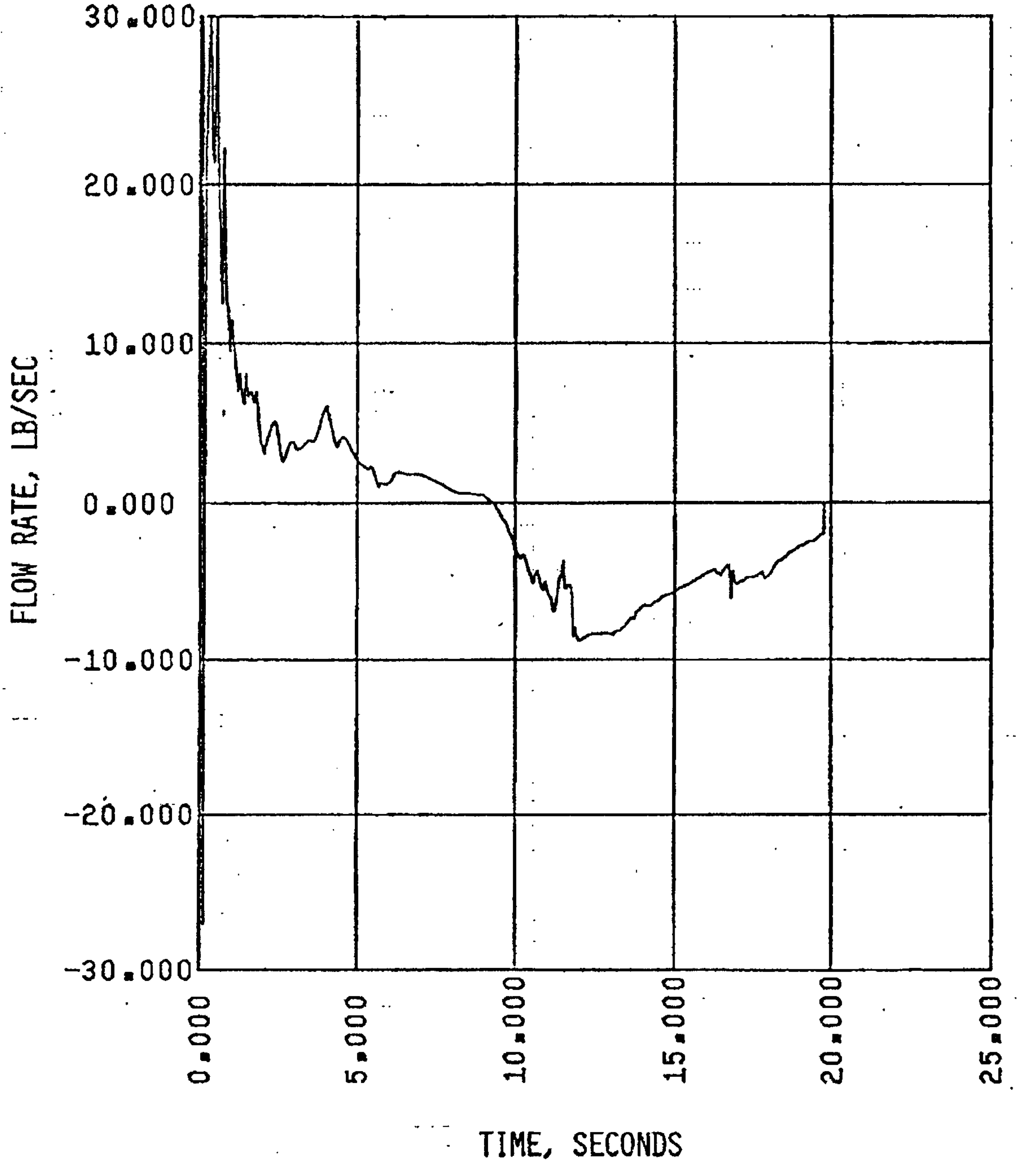


FIGURE A-5E
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
HOT ASSEMBLY QUALITY

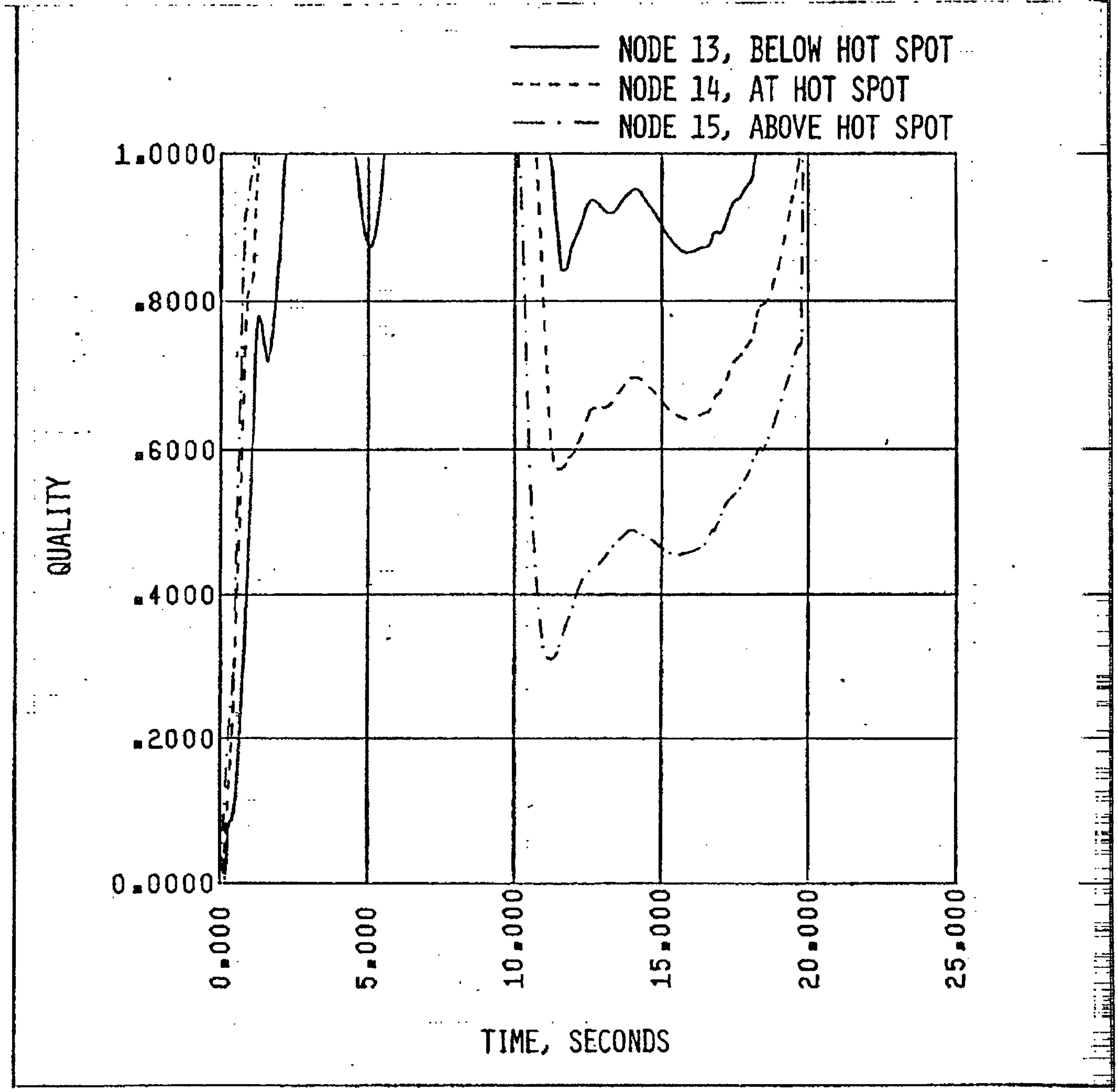


FIGURE A-5F
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

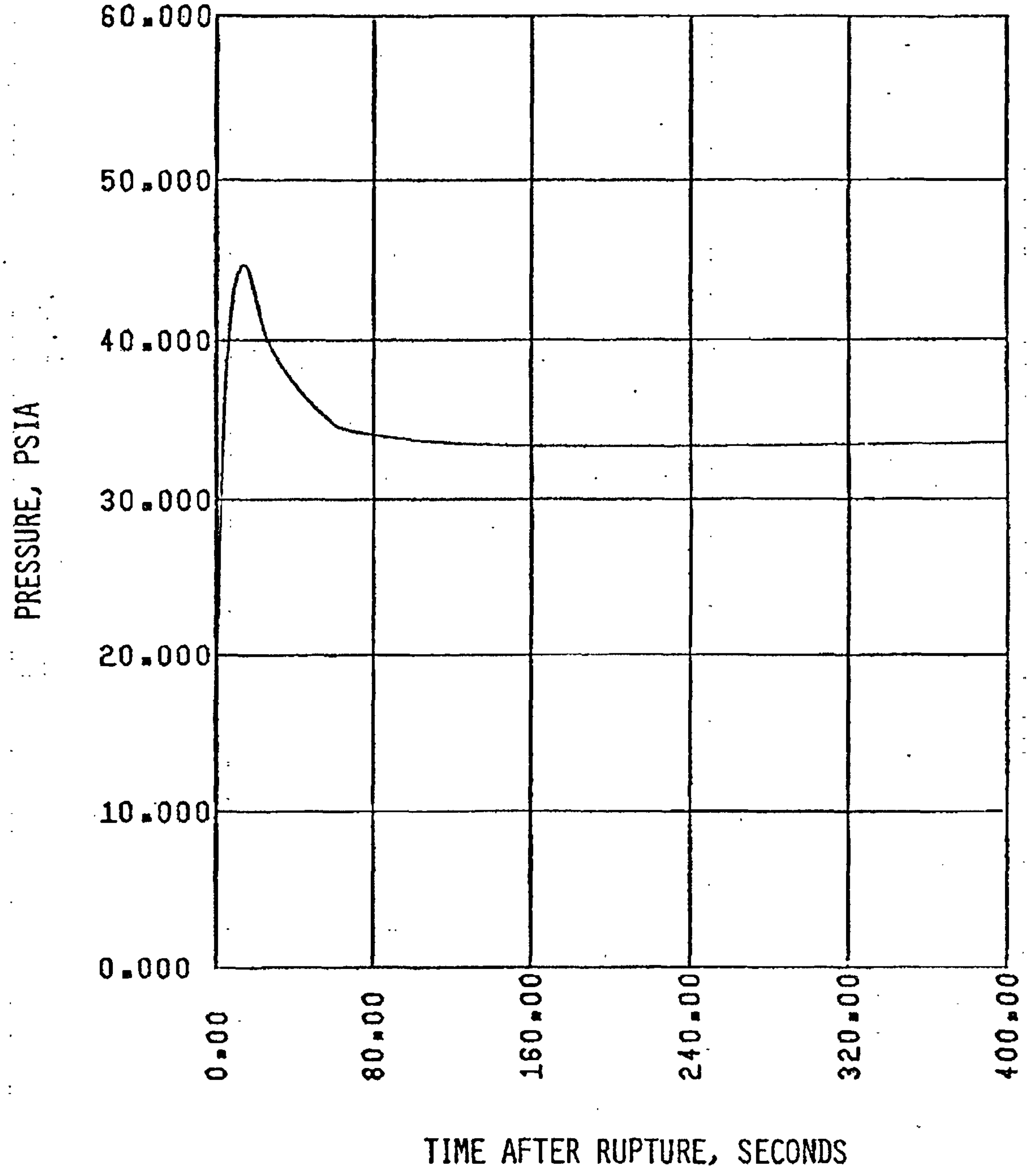
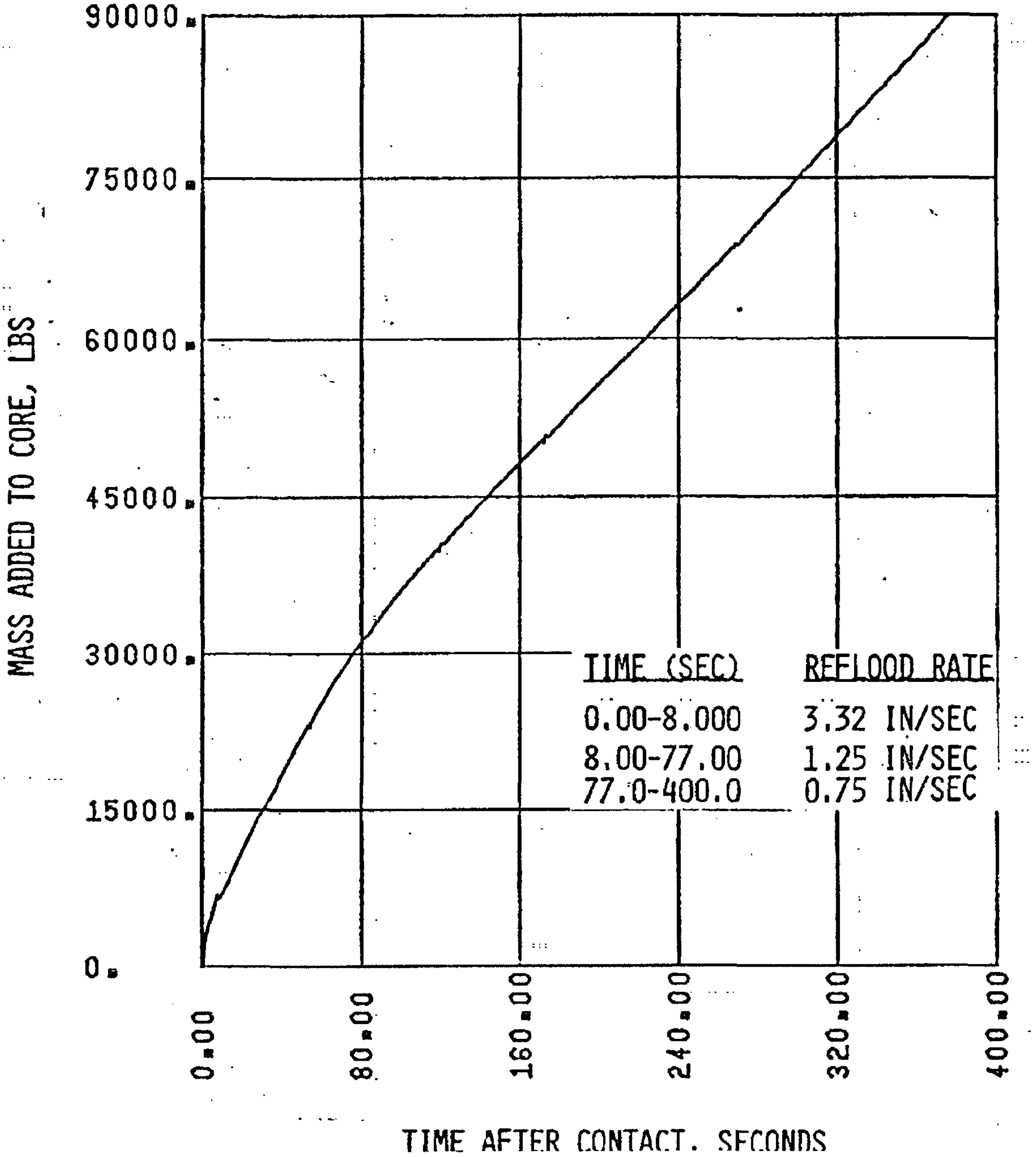


FIGURE A-5G
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD



TIME (SEC)	REFLOOD RATE
0.00-8.000	3.32 IN/SEC
8.00-77.00	1.25 IN/SEC
77.0-400.0	0.75 IN/SEC

FIGURE A-5H
MILLSTONE UNIT 2 CYCLE 7
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE

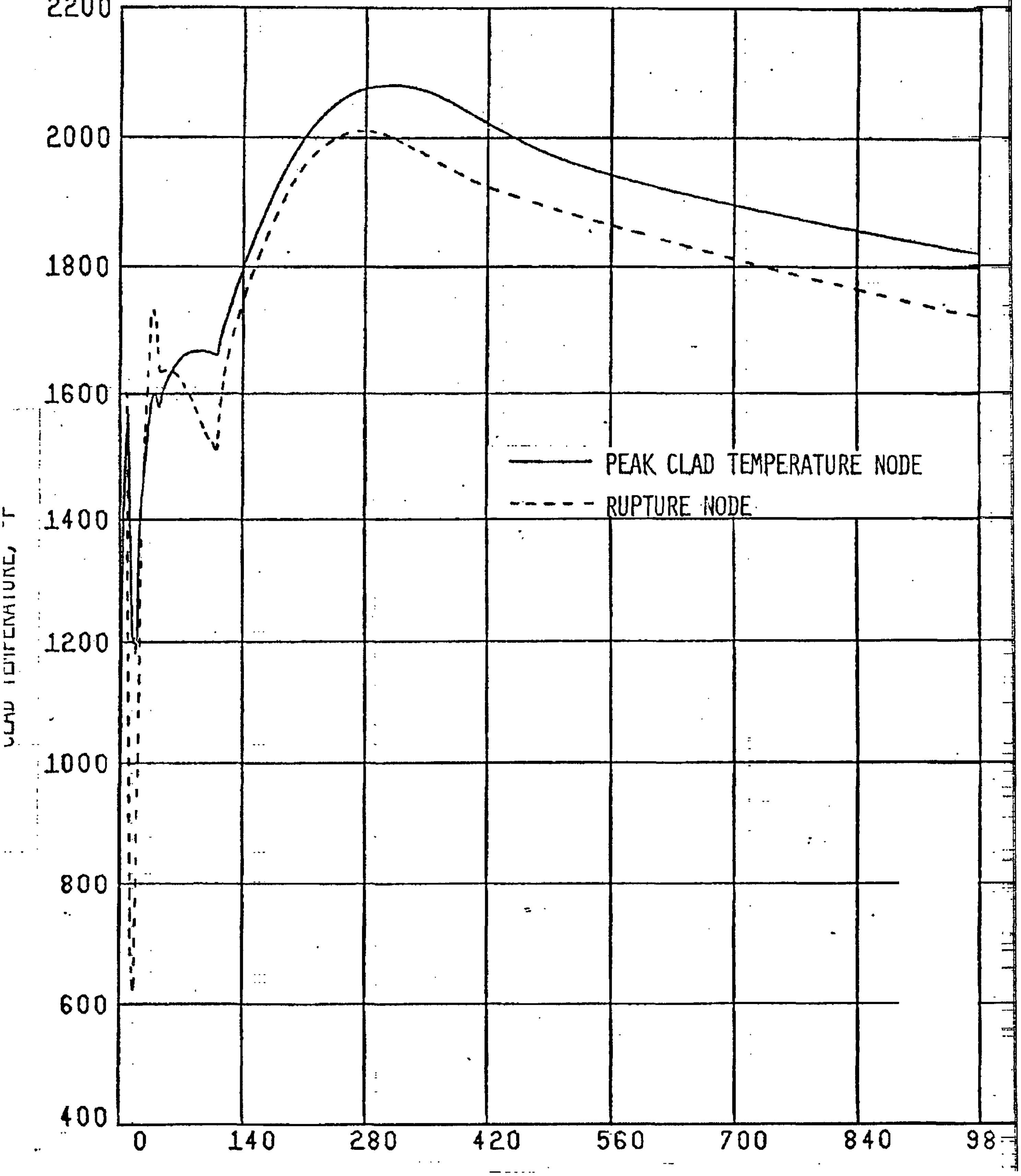


FIGURE A-5I
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
MID ANNULUS FLOW

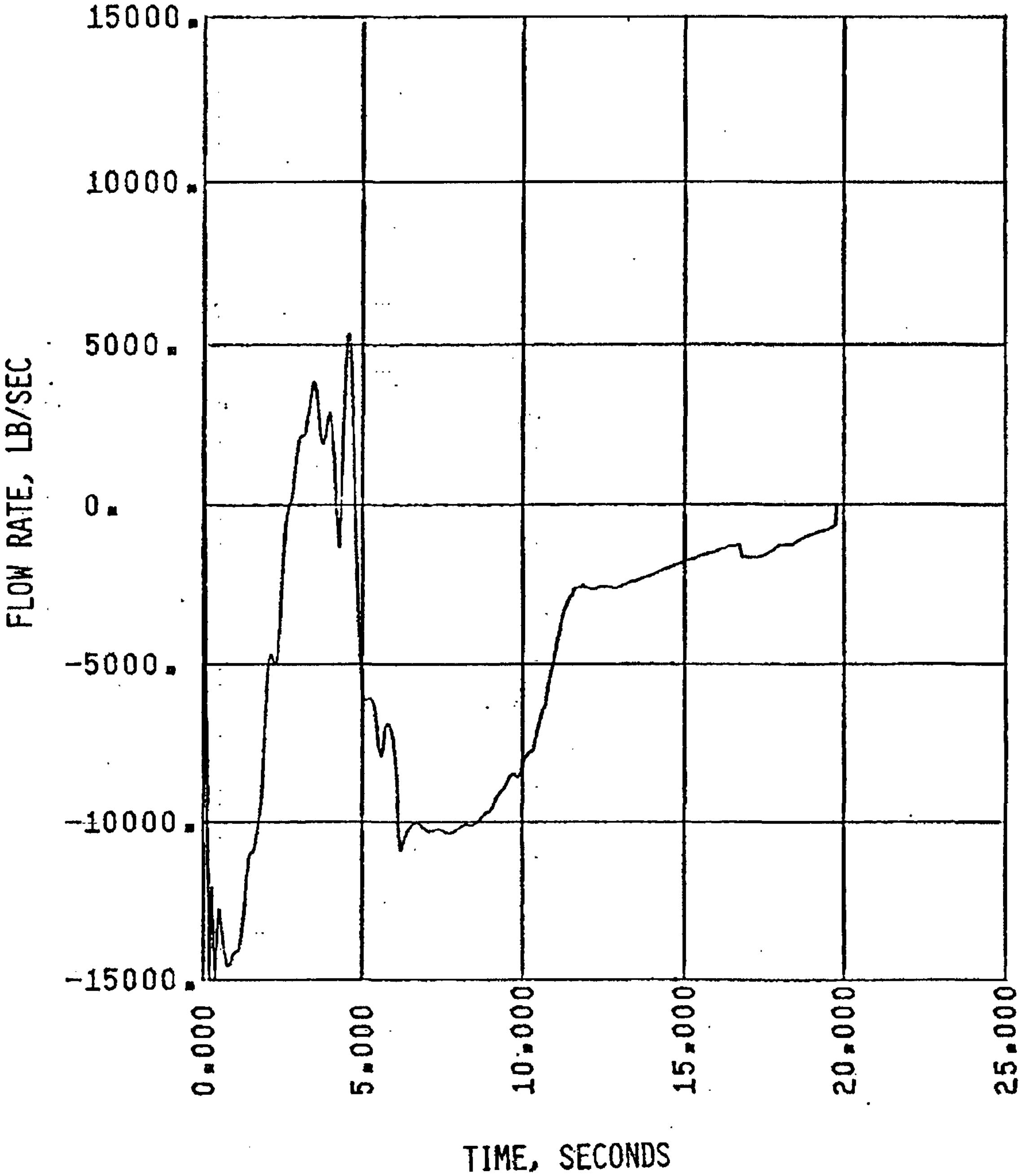


FIGURE A-5J
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
QUALITIES ABOVE AND BELOW THE CORE

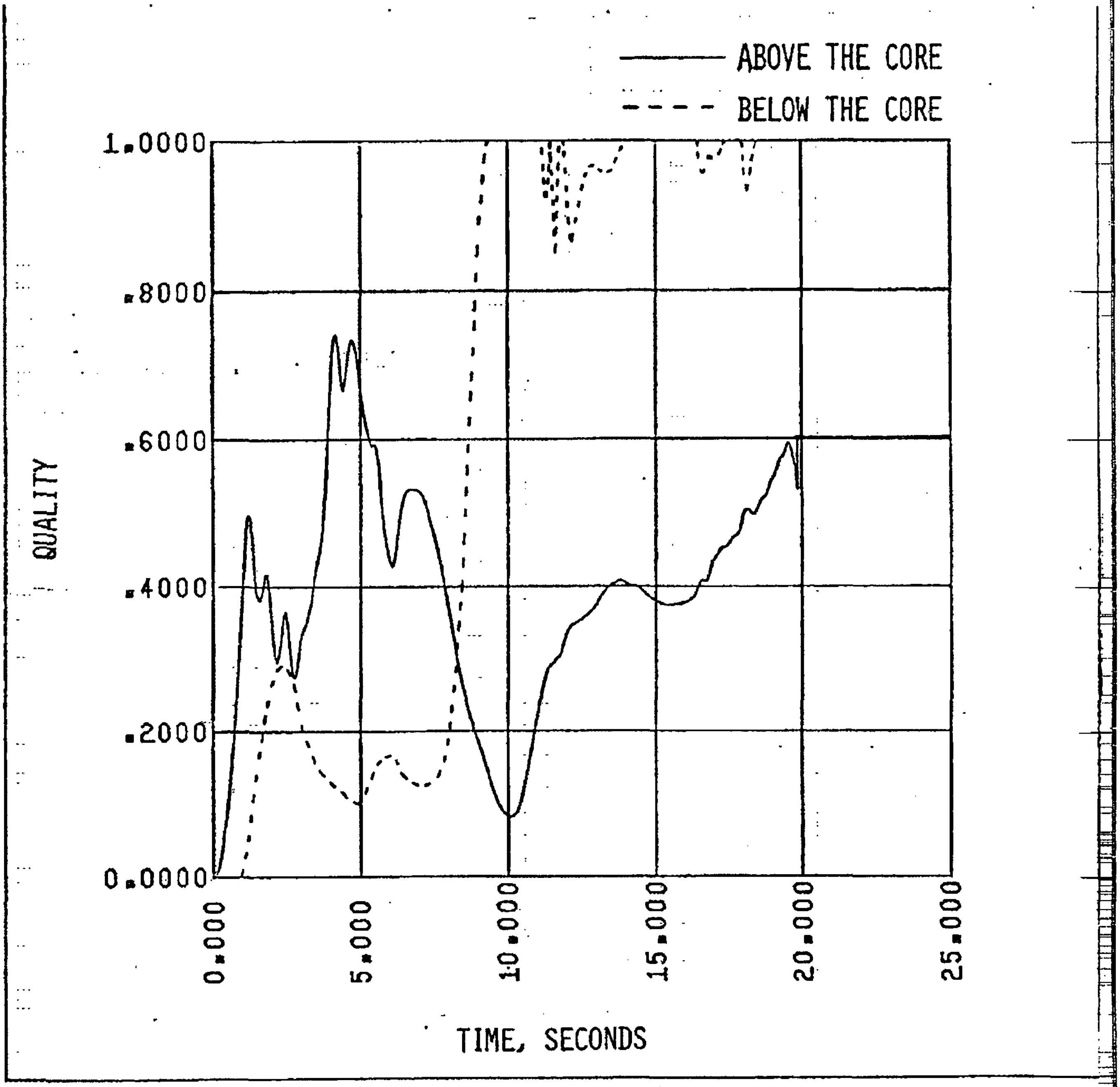


FIGURE A-5K
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CORE PRESSURE DROP

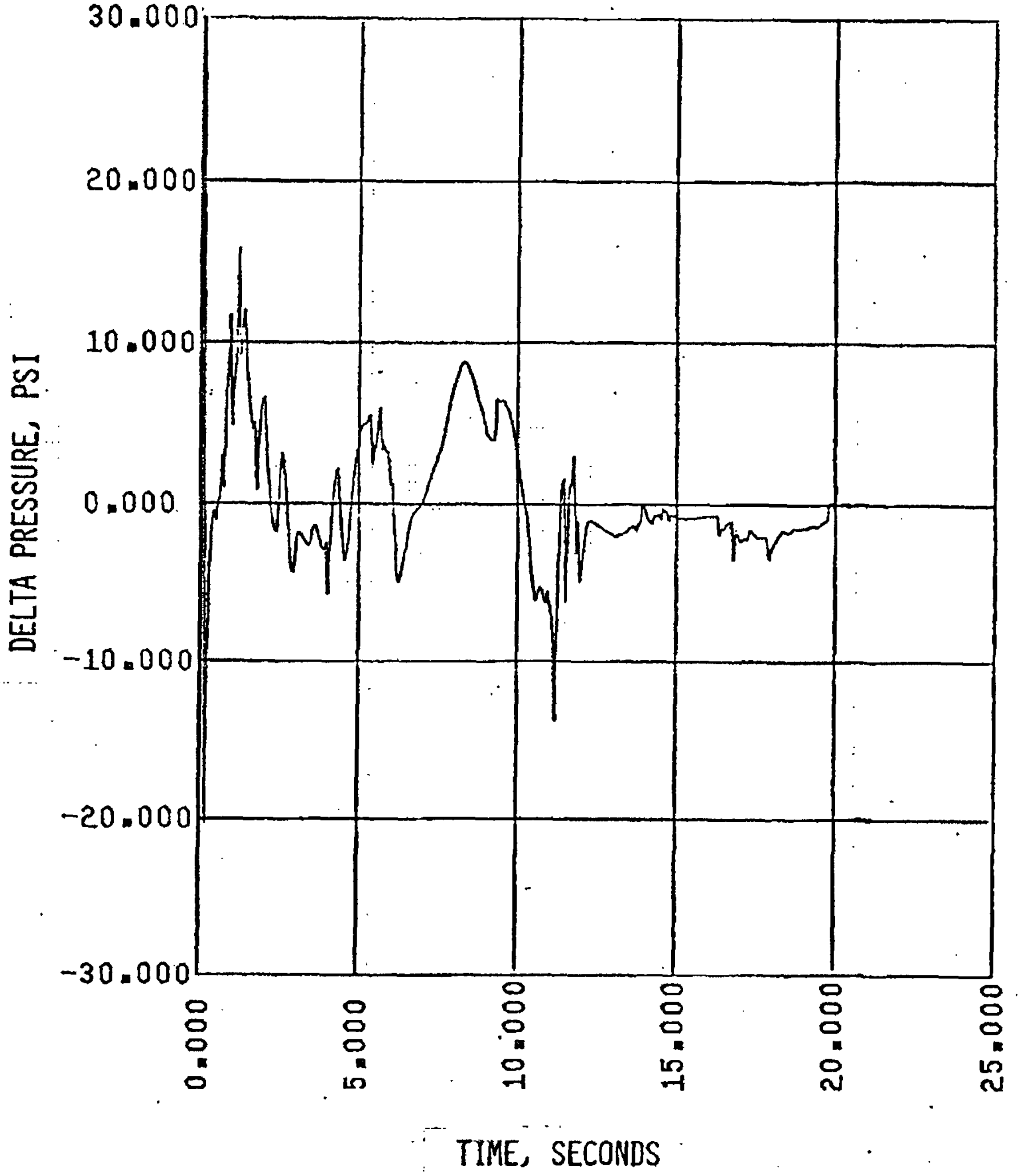


FIGURE A-5L

MILLSTONE UNIT 2 CYCLE 3

0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

SAFETY INJECTINE FLOW INTO INTACT DISCHARGE LEGS

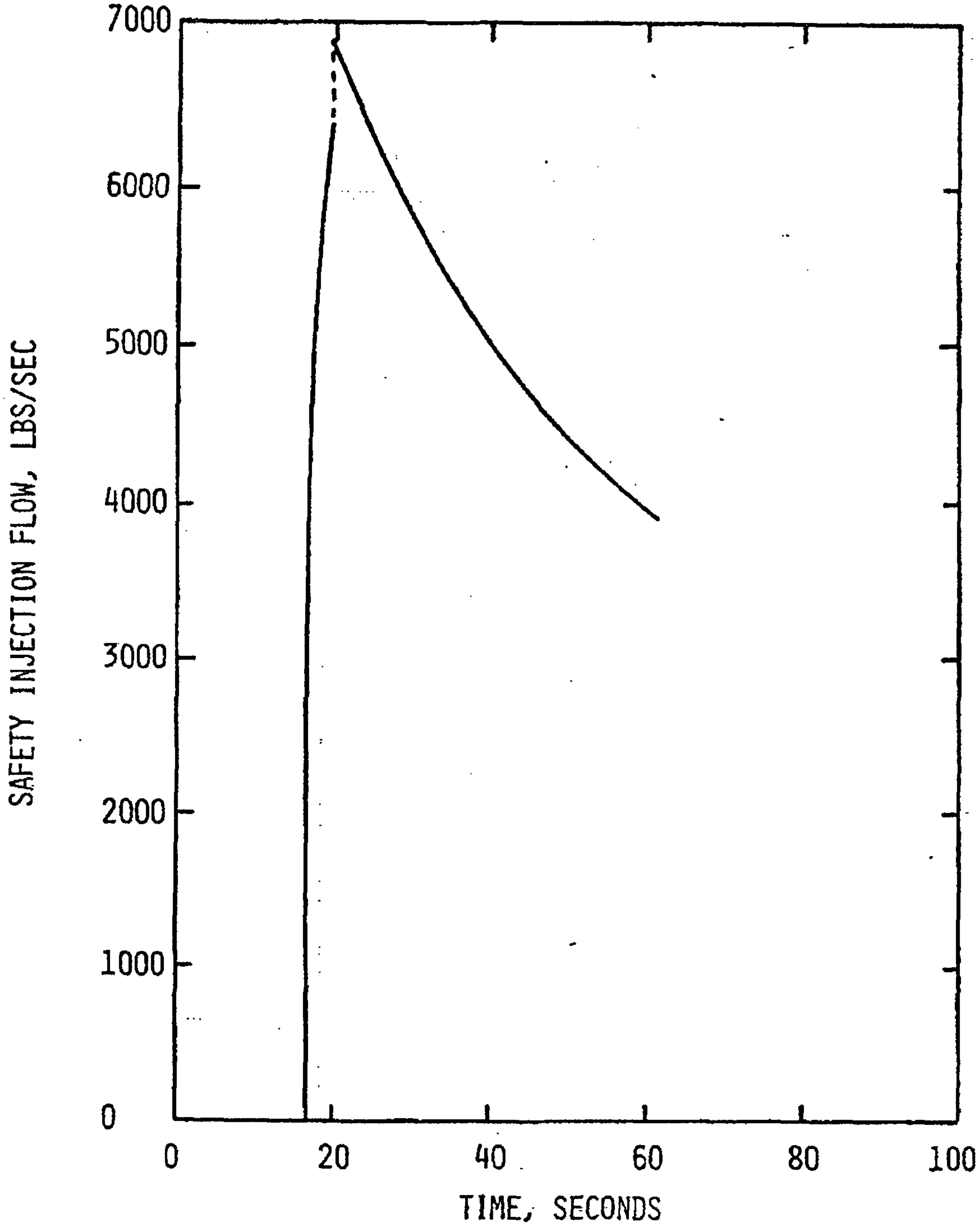


FIGURE A-5M
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
WATER LEVEL IN DOWNCOMER DURING REFLOOD

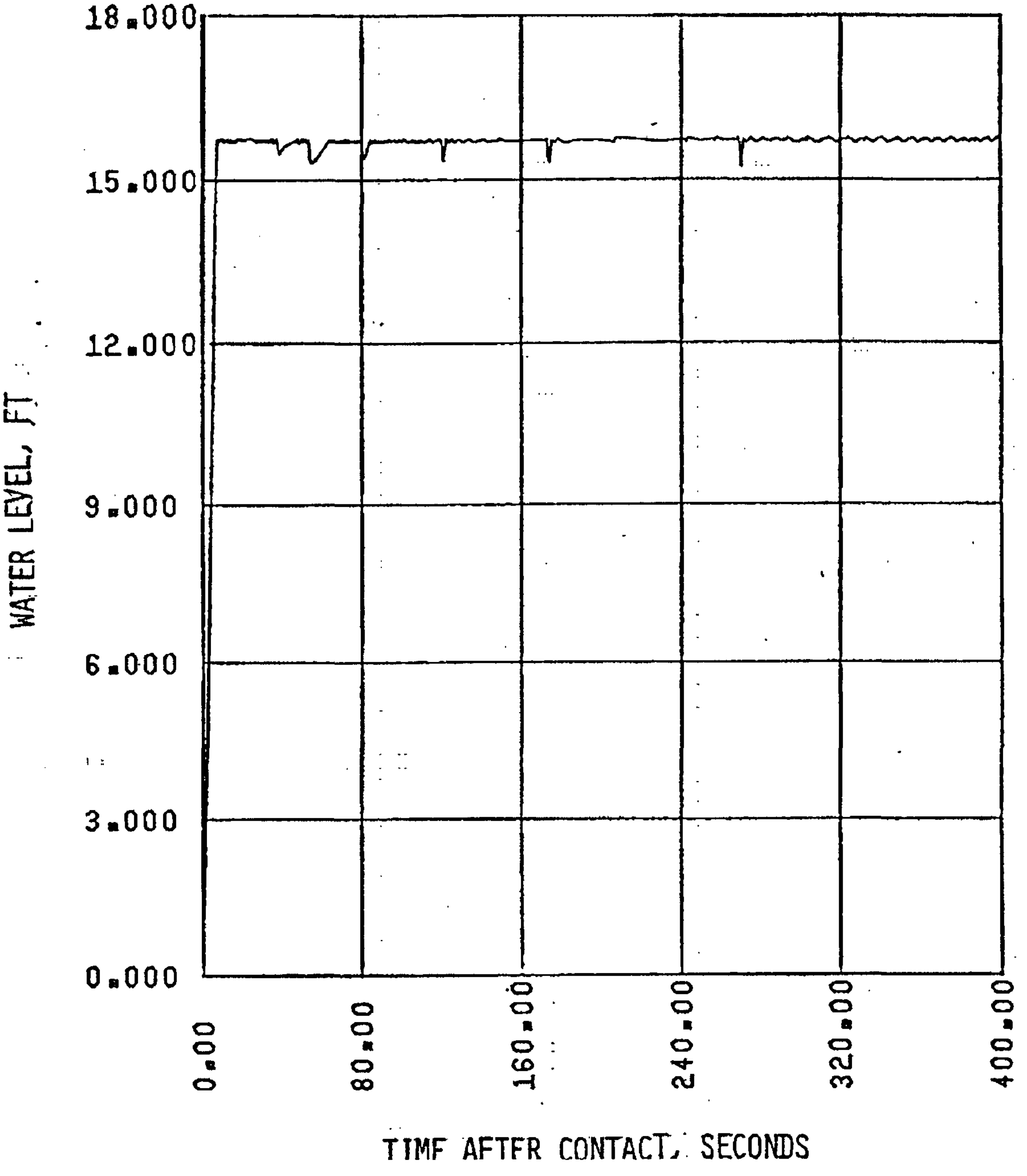


FIGURE A-5N
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE
HOT SPOT GAP CONDUCTANCE

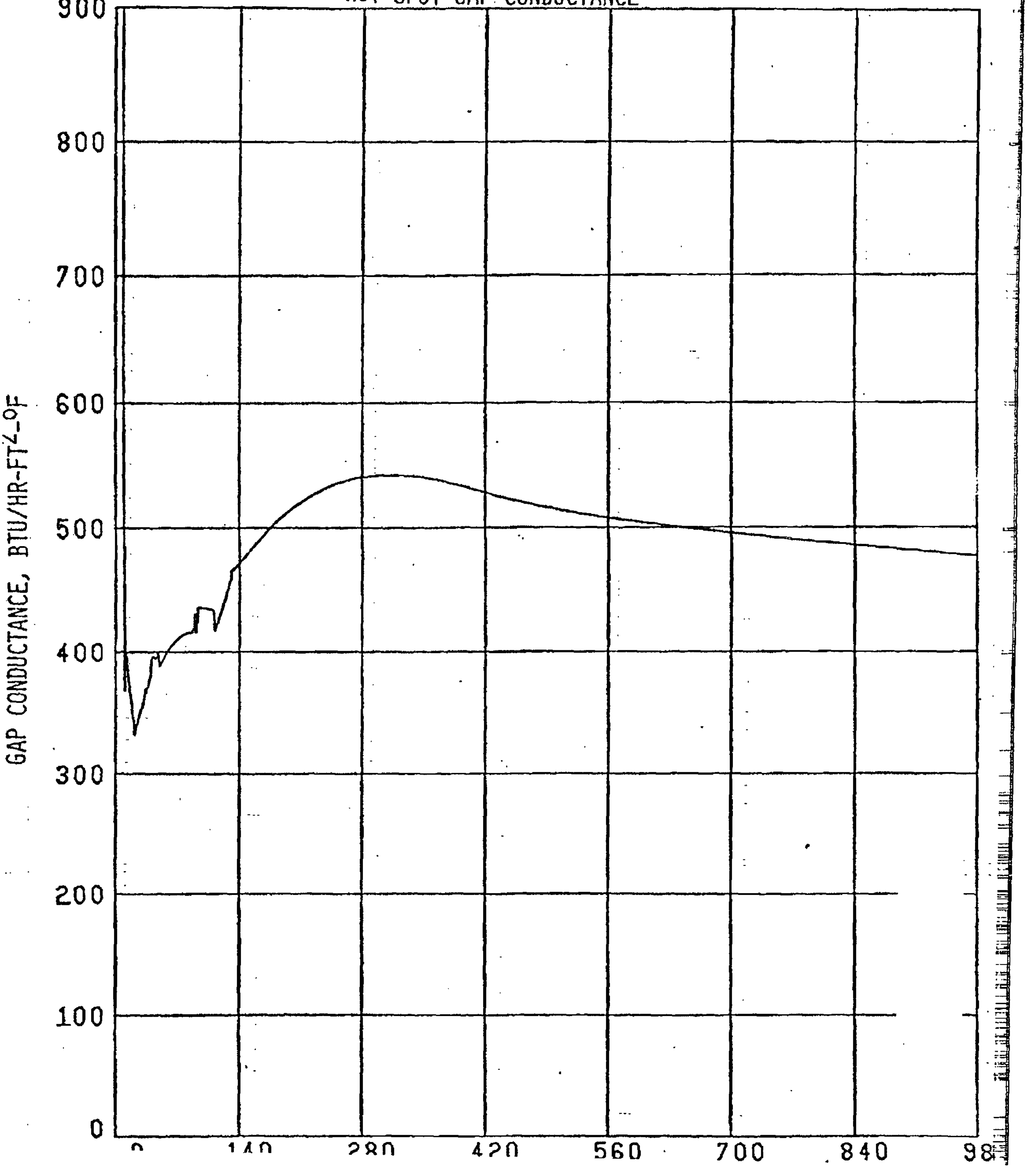


FIGURE A-50
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE
PEAK LOCAL CLAD OXIDATION

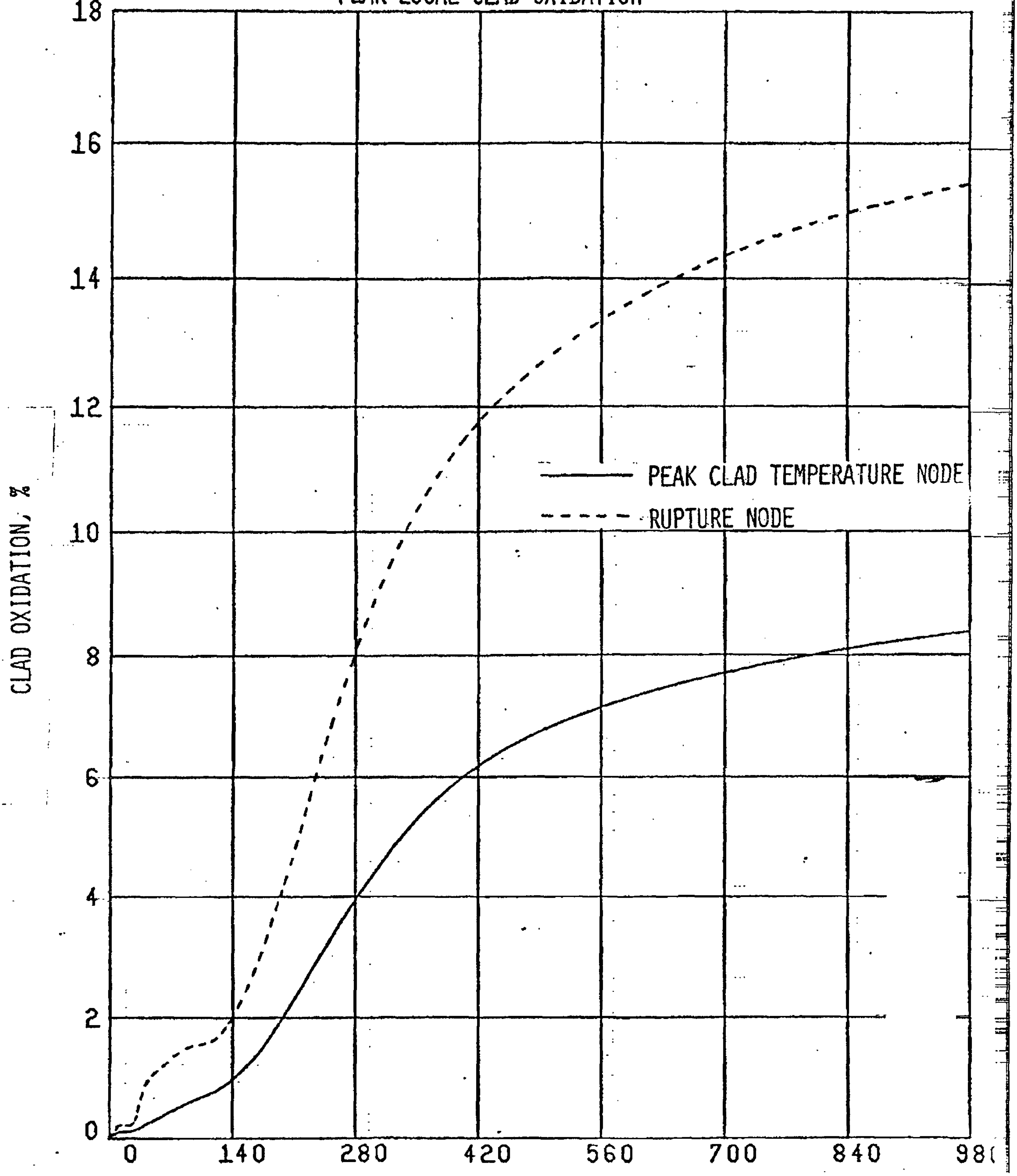


FIGURE A-5P
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE
CLAD TEMPERATURE, CENTERLINE FUEL TEMPERATURE, AVERAGE FUEL TEMPERATURE AND COOLANT TEMPERATURE FOR HOTTEST NODE

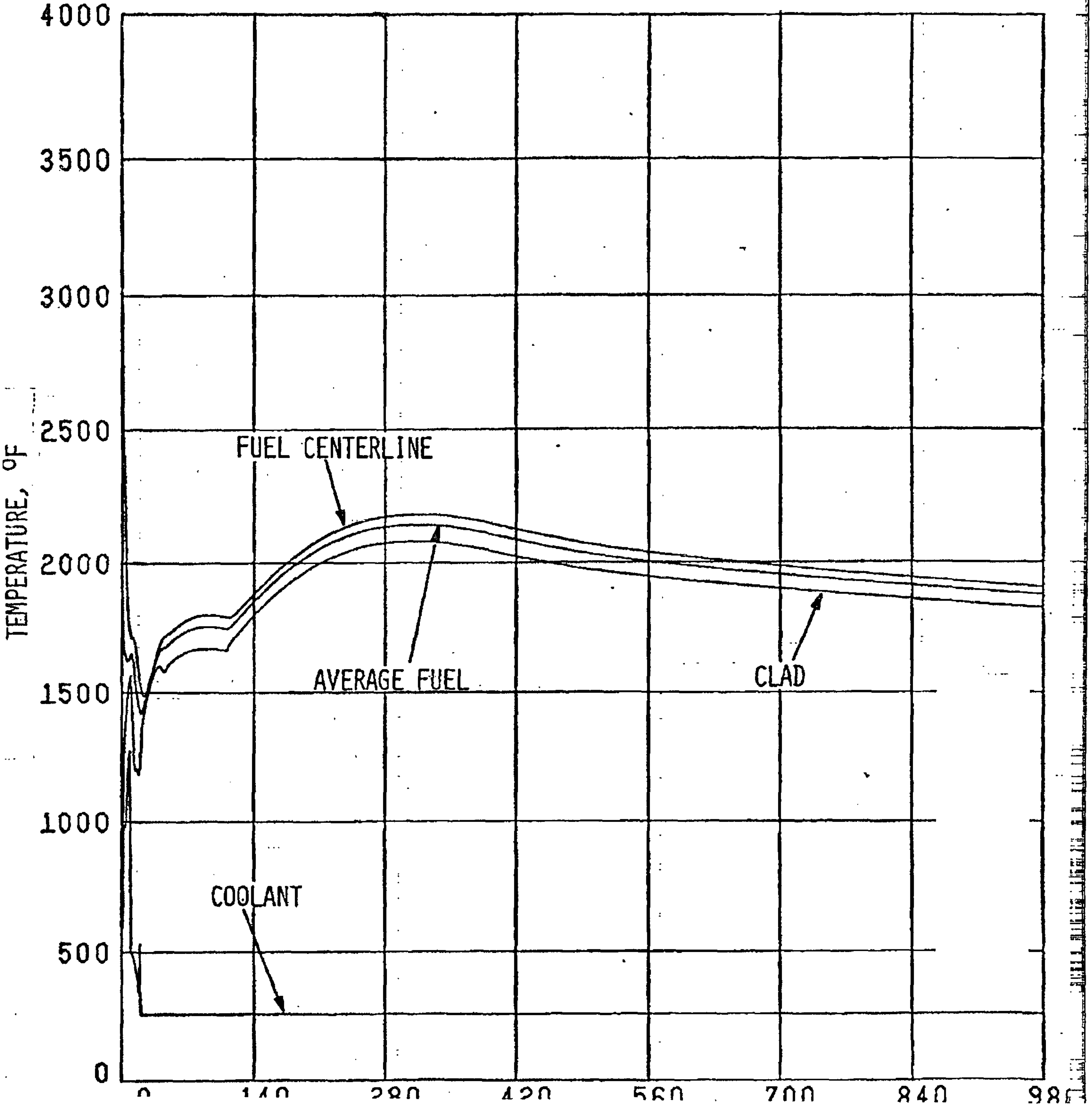


FIGURE A-5Q
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE
HOT SPOT HEAT TRANSFER COEFFICIENT

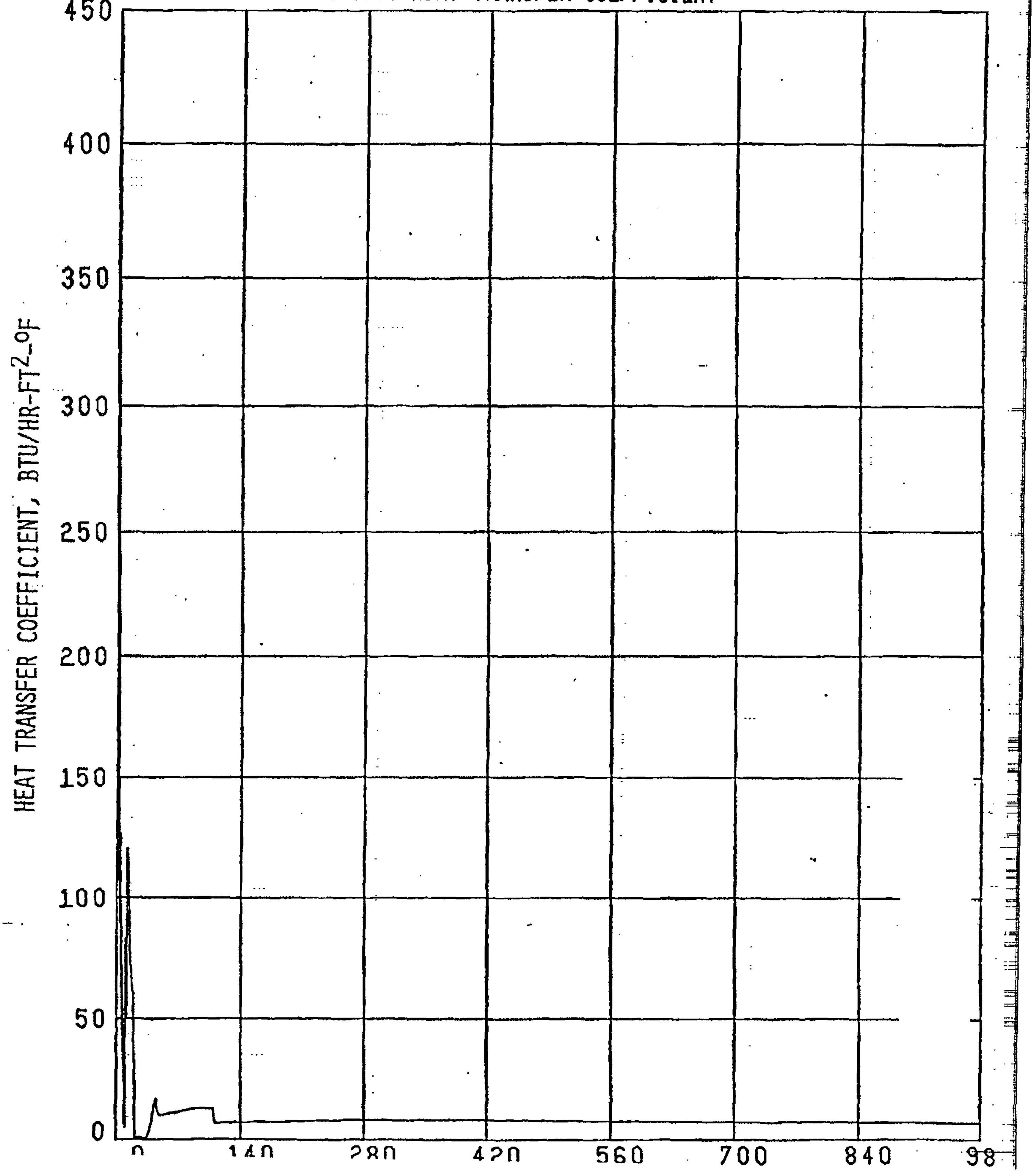


FIGURE A-5R
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CONTAINMENT TEMPERATURE

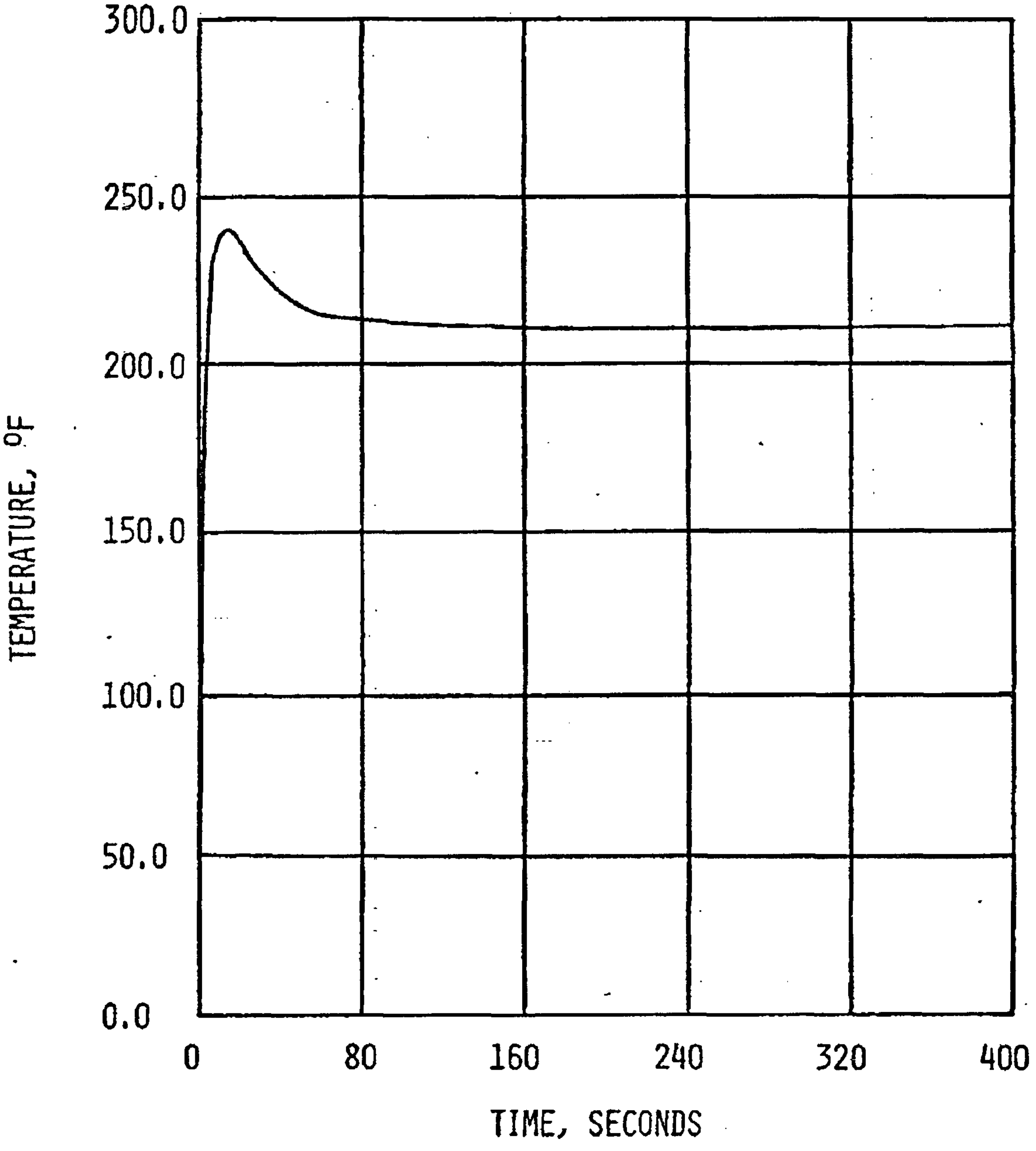


FIGURE A-5S
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
SUMP TEMPERATURE

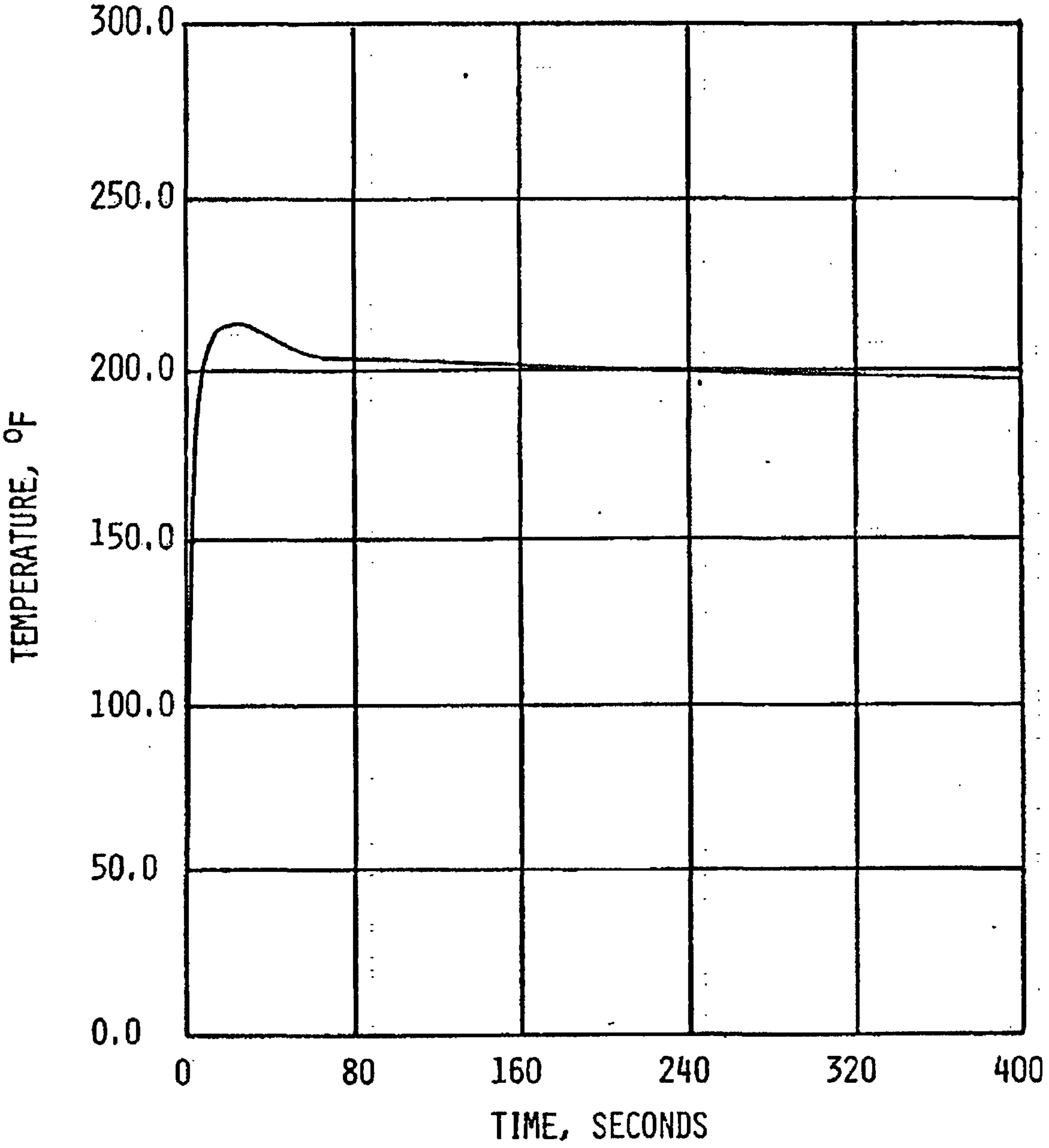


FIGURE A-5T
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
HOT ROD INTERNAL GAS PRESSURE

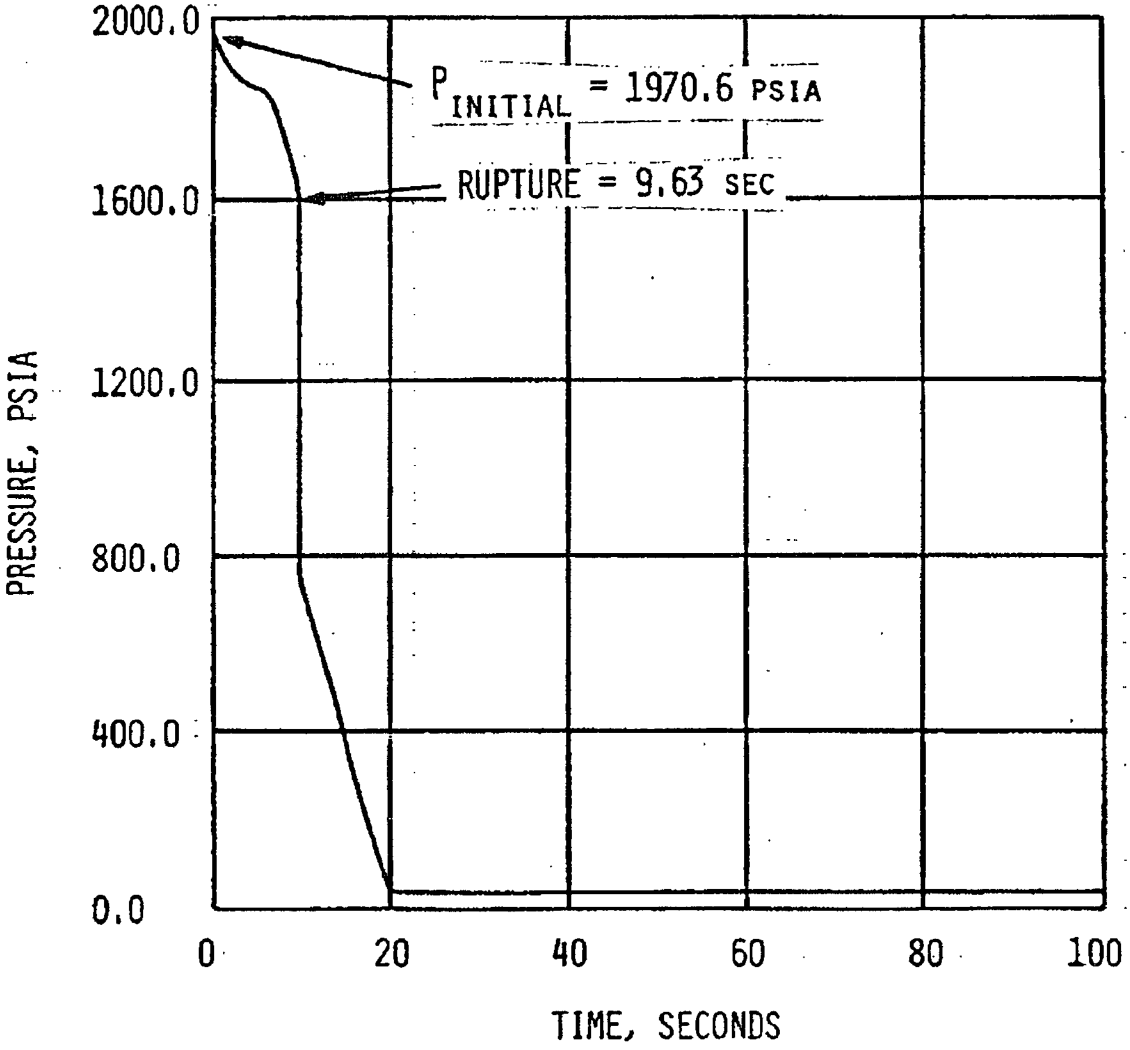


FIGURE A-5U
MILLSTONE UNIT 2 CYCLE 3
0.8 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE
CORE BULK CHANNEL FLOW RATE

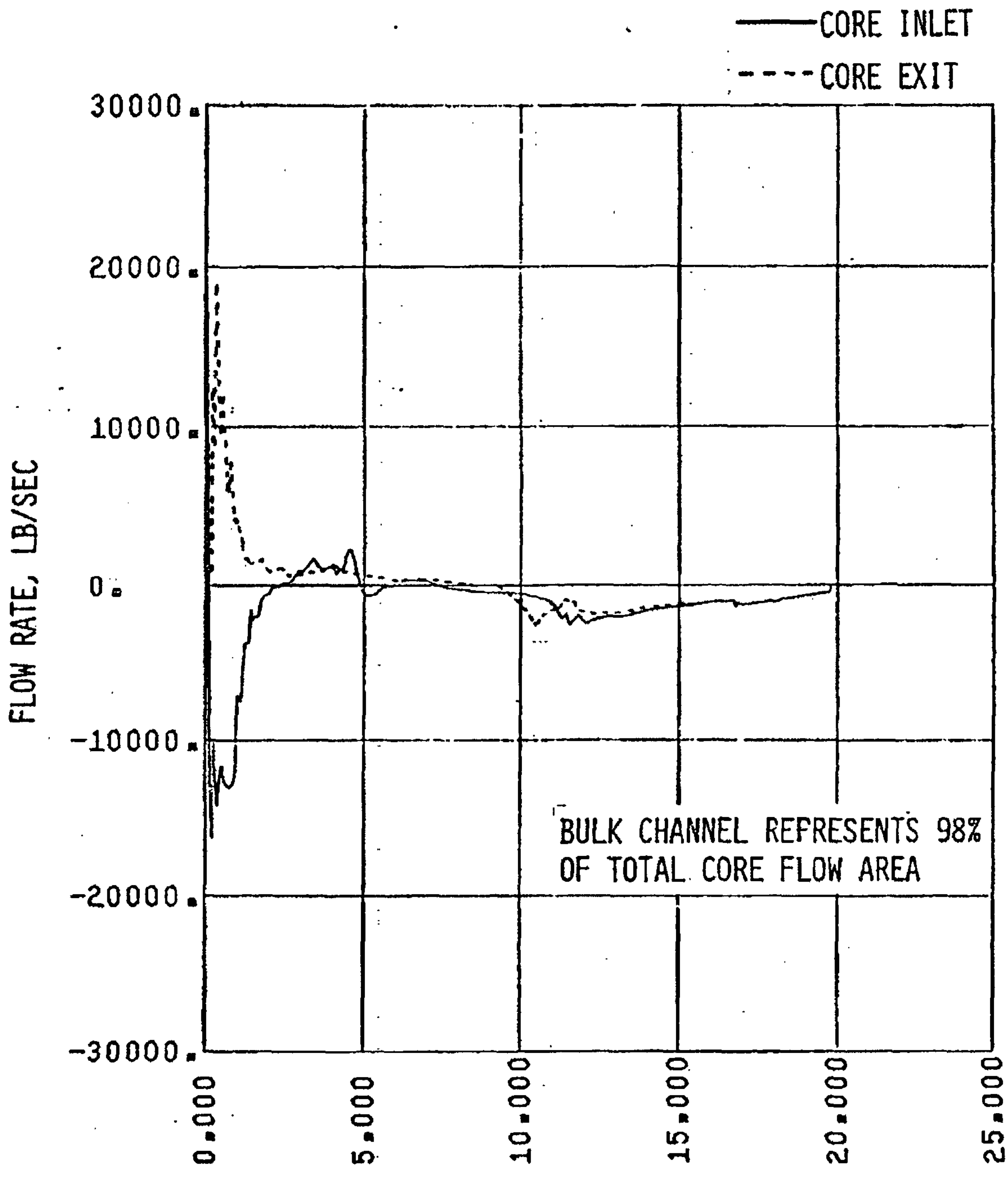


FIGURE A-6A
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CORE POWER

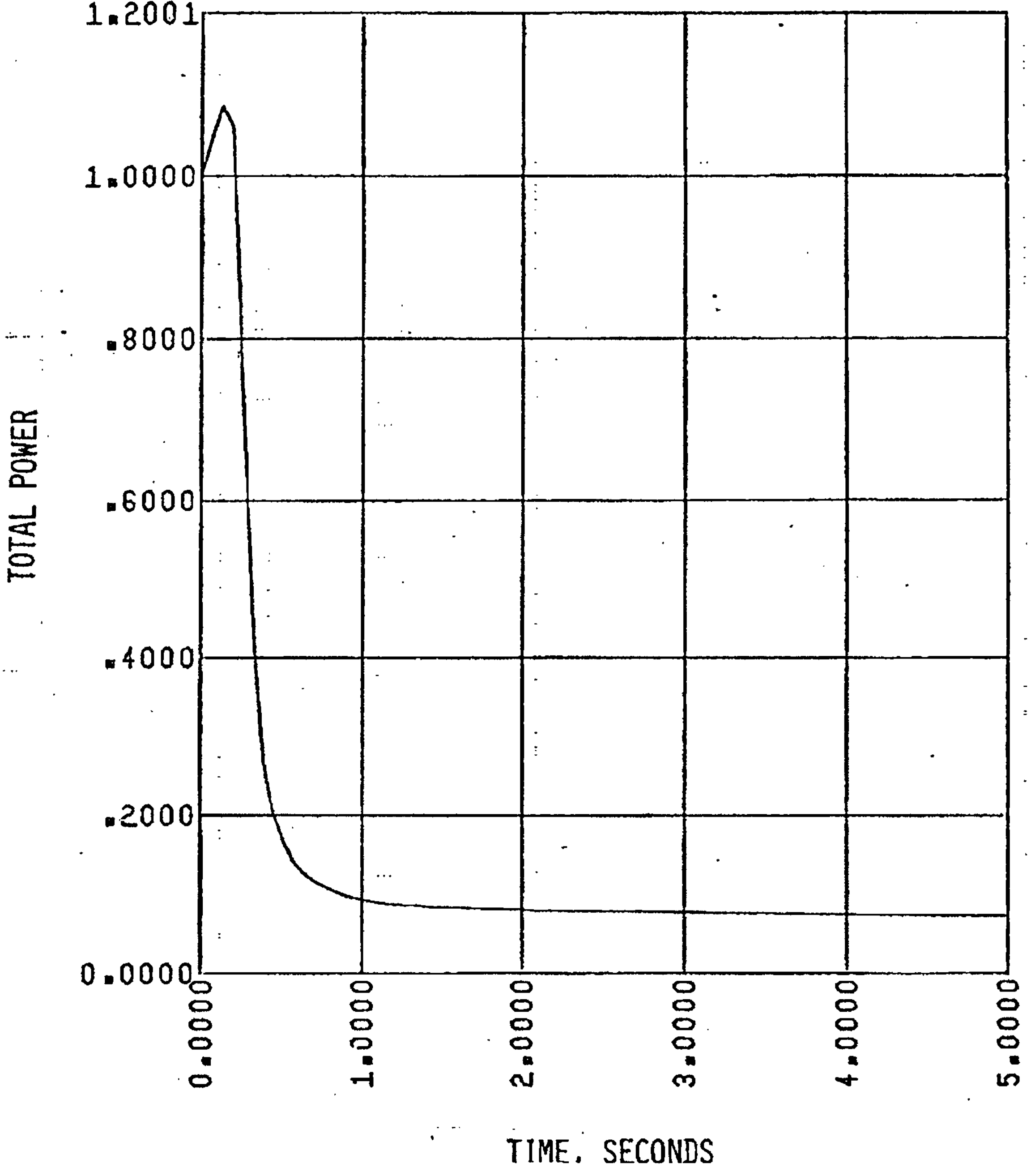


FIGURE A-6B
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PRESSURE IN CENTER HOT ASSEMBLY NODE

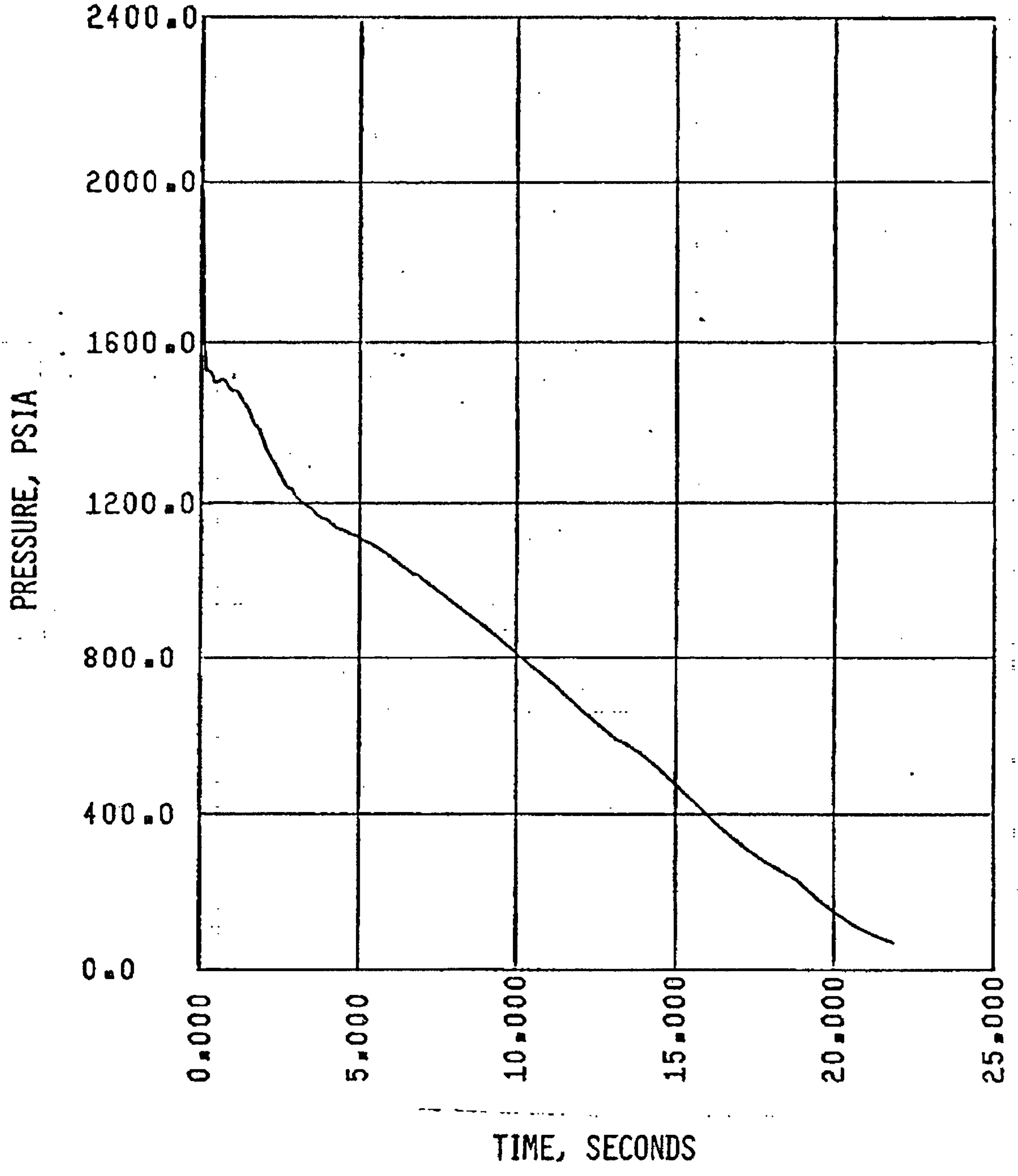


FIGURE A-6C
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
LEAK FLOW

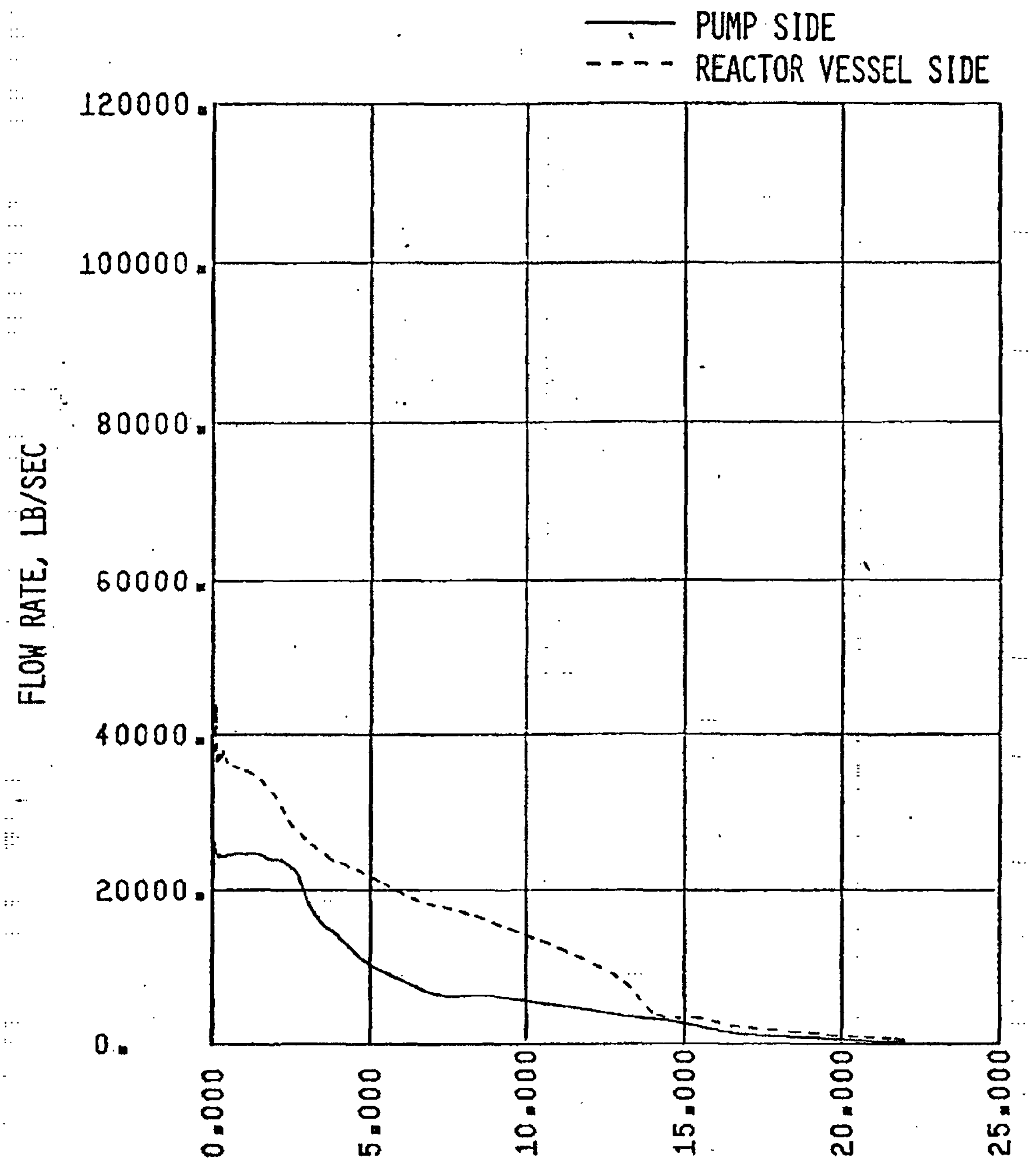


FIGURE A-6D.1
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 16, BELOW HOT SPOT

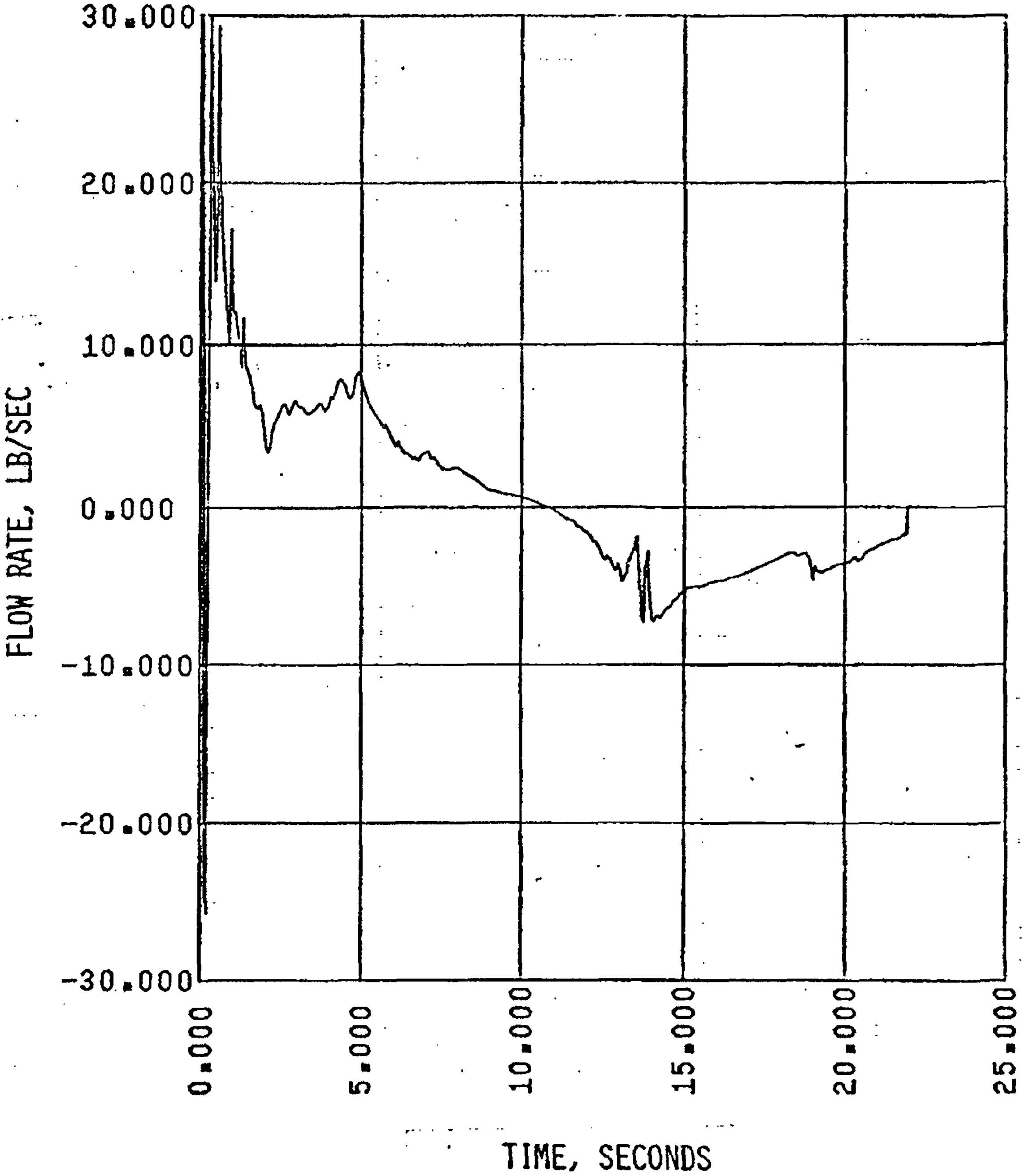


FIGURE A-6D.2
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
FLOW IN HOT ASSEMBLY-PATH 17, ABOVE HOT SPOT

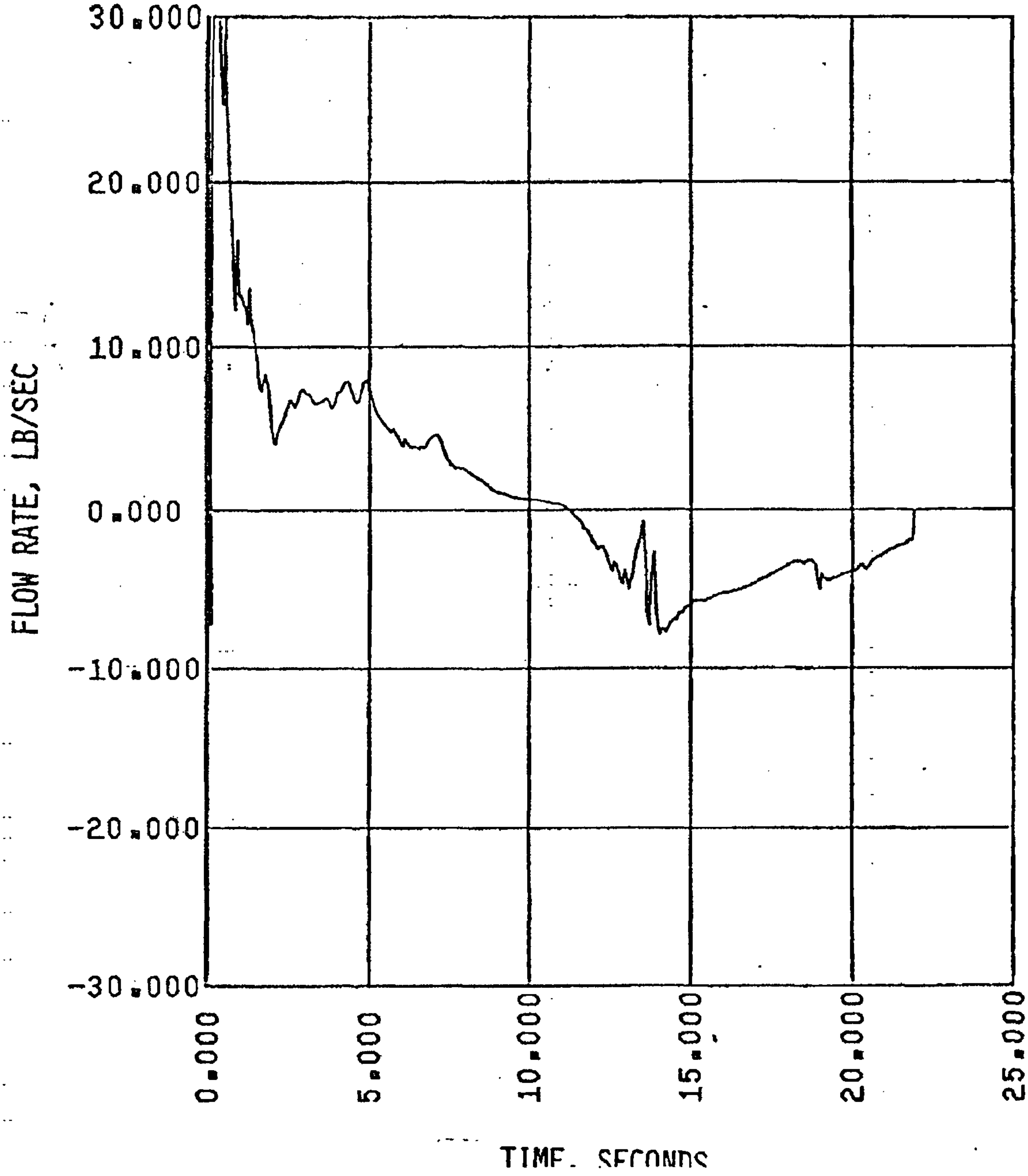


FIGURE A-6E

MILLSTONE UNIT 2 CYCLE 3

0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG

HOT ASSEMBLY QUALITY

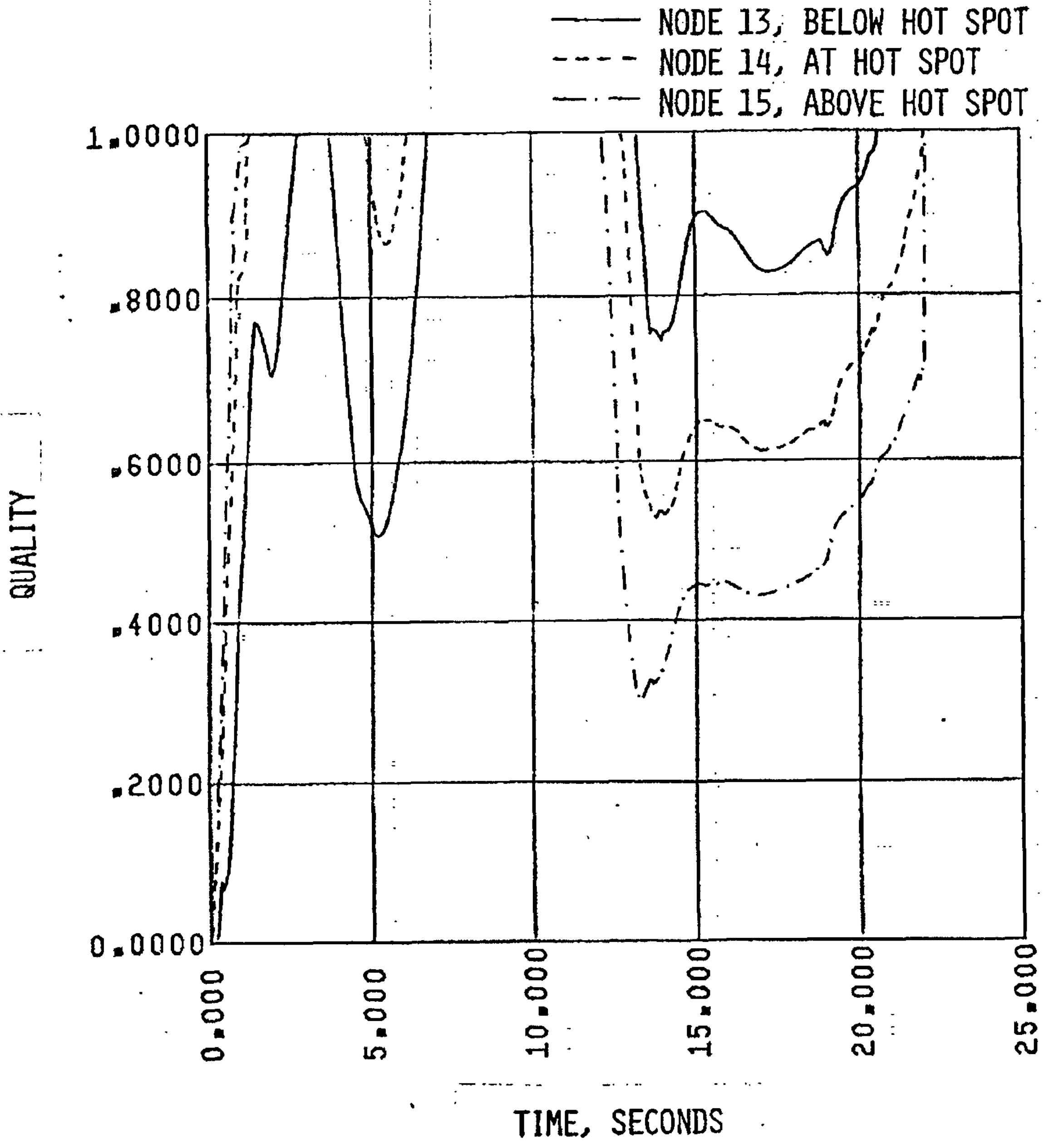


FIGURE A-6F
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
CONTAINMENT PRESSURE

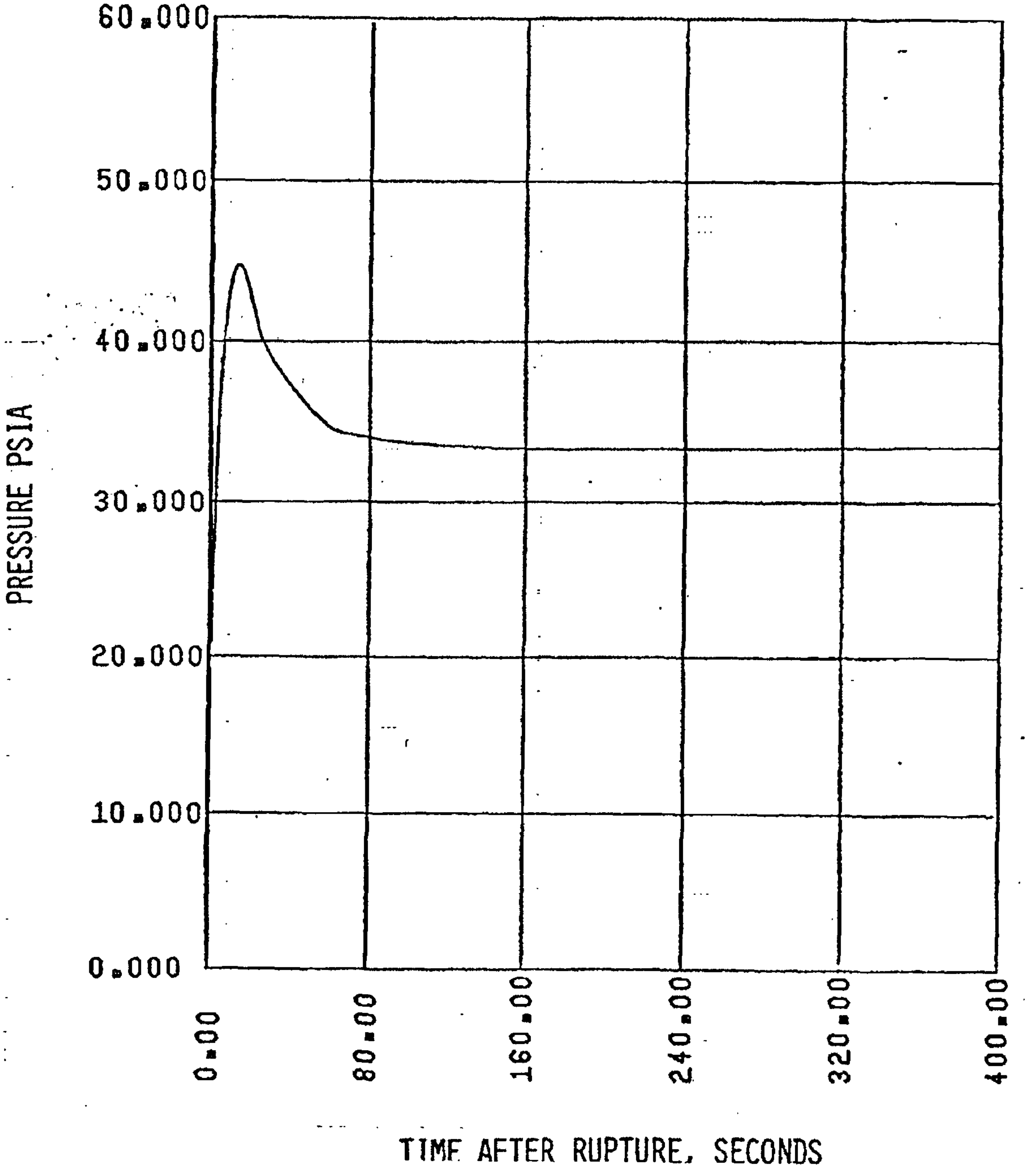


FIGURE A-6G

MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
MASS ADDED TO CORE DURING REFLOOD

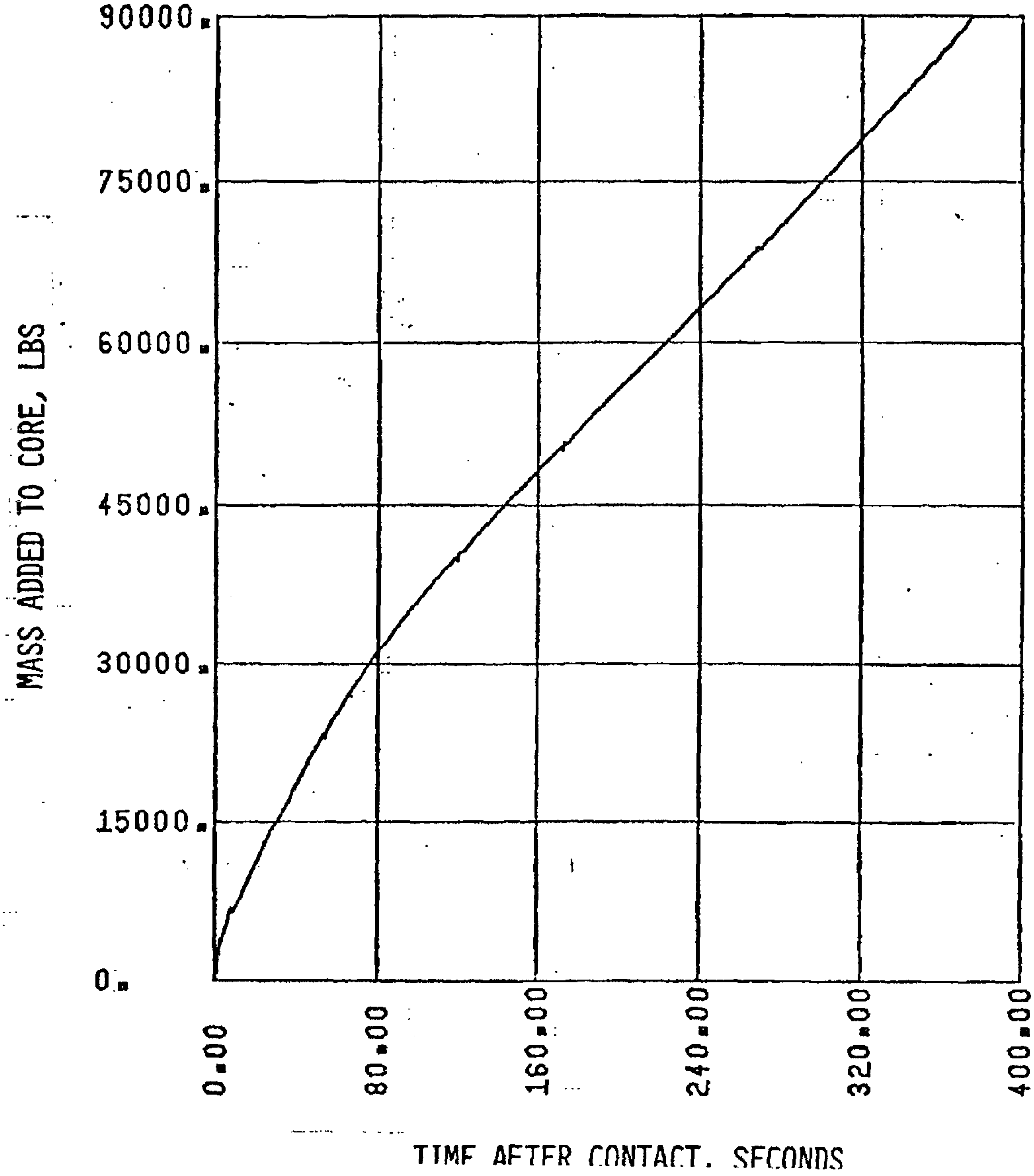


FIGURE A-6H
MILLSTONE UNIT 2 CYCLE 3
0.6 x DOUBLE ENDED GUILLOTINE BREAK IN PUMP DISCHARGE LEG
PEAK CLAD TEMPERATURE

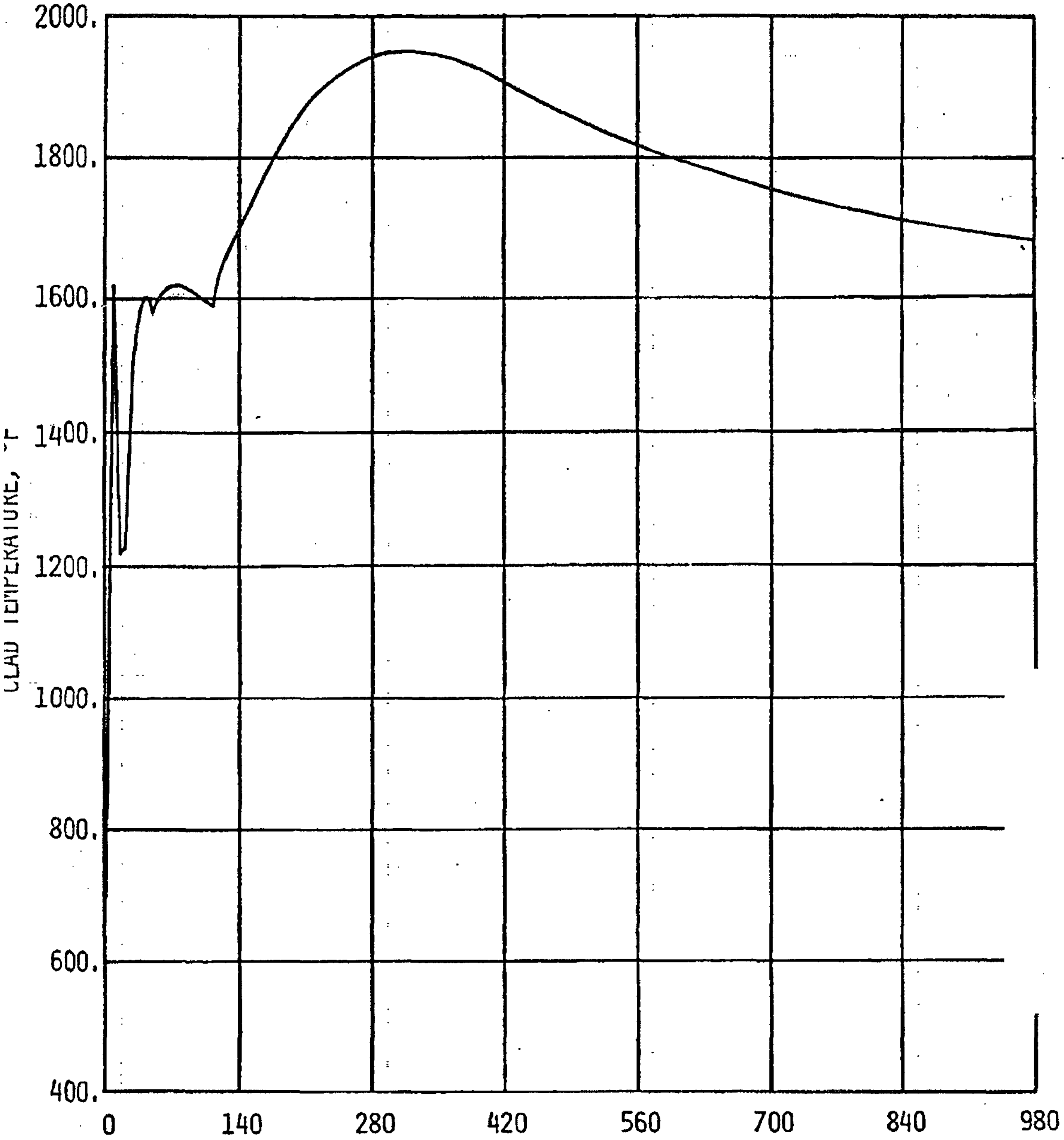


FIGURE A-7
MILLSTONE UNIT 2 CYCLE 3
PEAK CLAD TEMPERATURE vs BREAK AREA

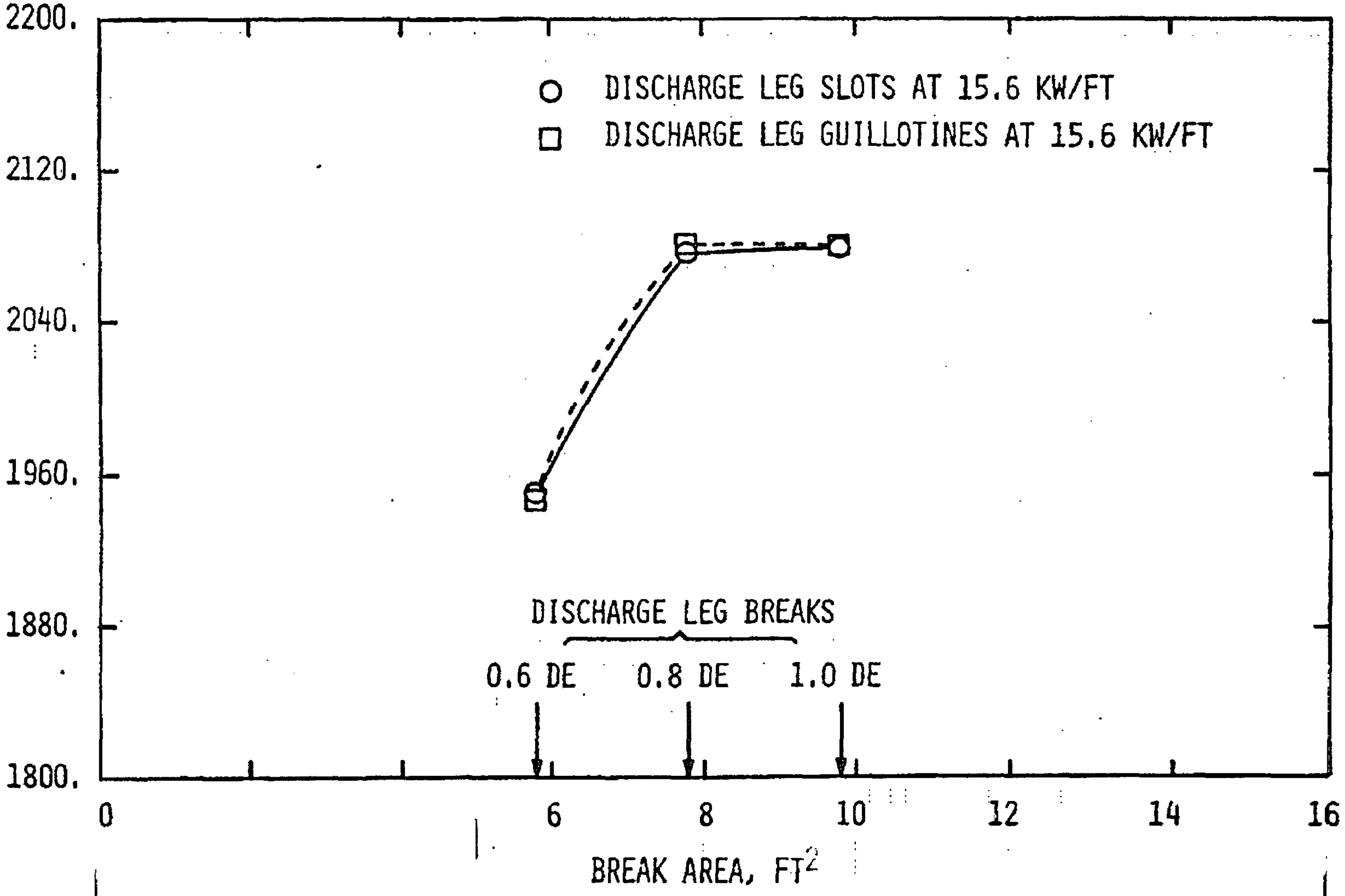
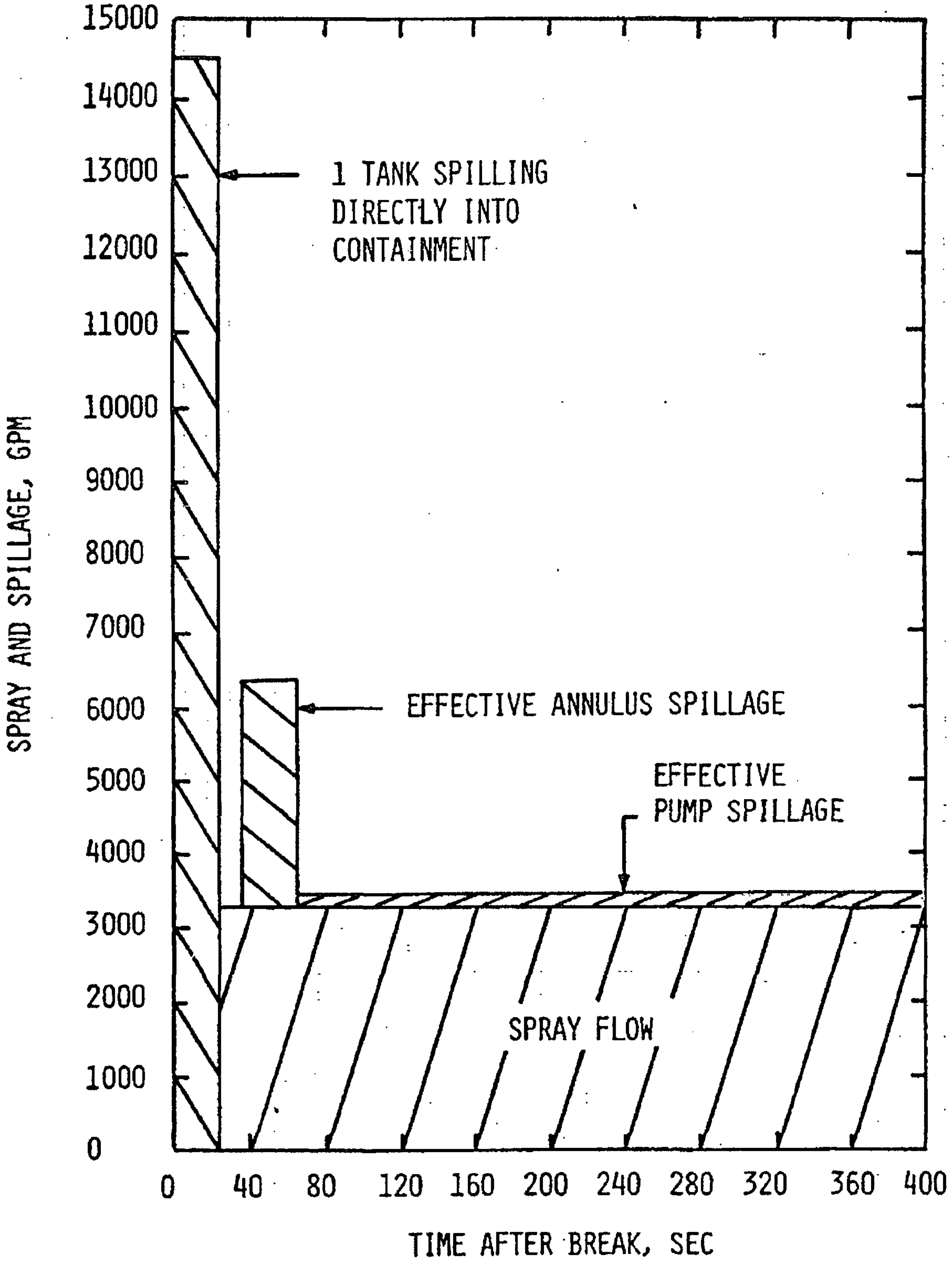


FIGURE A-8
MILLSTONE UNIT 2 CYCLE 3
COMBINED SPRAY AND SPILLAGE INTO CONTAINMENT



ATTACHMENT B

Millstone Unit 2
Small Break ECCS Performance Evaluation

1.0 Introduction and Summary

The ECCS performance evaluation for the small break loss-of-coolant accident (LOCA) for Millstone 2 , presented herein,demonstrates appropriate conformance with 10CFR50.46 which presents the Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Reactors(1). The evaluation demonstrates acceptable small break LOCA ECCS performance for Millstone 2 at a power level of 2754 Mwt and a peak linear heat generation rate (PLHGR) of 16.0 kw/ft. The method of analysis and results are presented in the following sections.

2.0 Method of Analysis

The calculations reported in this section were performed using Combustion Engineering's approved Small Break Evaluation Model which is described in References 2 and 3.

Evaluation of small break transients involves the use of four computer codes. Blowdown hydraulics are calculated using the CEFLASH-4AS(4) code. Reflood hydraulics are calculated using the COMPERC-II code(5). Fuel rod temperatures and clad oxidation percentages are calculated using the STRIKIN-II(6) and PARCH(7) codes. Details of the interfacing of these codes are discussed in Reference 2.

As discussed in Reference 2, the worst single failure for analyses of the small break LOCA is the failure of one of the emergency diesel generators to start. This failure results in the minimum safety injection available to cool the core. Therefore, based on this assumption, the following injection pumps were credited in the small break LOCA analysis:

a. one high pressure safety injection pump
b. one low pressure safety injection pump
c. one charging pump

In addition to the pumped injection, three of the four available safety

As described in Reference 2, the small break LOCA analyses conservatively assumed that offsite power is lost upon reactor trip. As a result, the injection from the above described pumps was assumed to await a 30 second delay (for diesel startup and load sequencing) following a safety injection actuation signal.

The ECCS performance analysis considered a spectrum of cold leg breaks in the reactor coolant pump discharge leg. The break sizes analyzed include the 0.5, 0.2, 0.1, 0.05, and 0.02 ft^2 cold leg breaks.

The significant general system parameters used in the small break calculations which change from those used in the Cycle II(8) analysis are presented in Table B1.

3.0 Results

The analysis demonstrated the 0.1 ft^2 break to be the limiting small break with a peak clad temperature and peak zirconium oxidation percentage of 1971°F and 10.3%, respectively. The analysis was performed using the limiting batch B fuel at the time-in-life when fuel stored energy is highest. The analysis also demonstrated that break sizes 0.02 ft^2 and smaller will not result in core uncovery.

The transient values of parameters which most directly affect fuel rod performance are shown in Figures B1 (A through H) through B5 (A through H). The following parameters are graphically presented for each break size:

(A) Normalized Total Core Power
(B) Inner Vessel Pressure
(C) Break Flow Rate
(D) Inner Vessel Inlet Flow Rate
(E) Inner Vessel Two-Phase Mixture Volume
(F) Hot Spot Heat Transfer Coefficient
(G) Channel Coolant Temperature at Hot Spot
(H) Hot Spot Clad Surface Temperature

The times at which significant events in the performance of the ECCS occurred for each break size are listed in Table B2. A summary of the hot fuel rod performance is provided in Table B3 wherein are given the calculated peak clad outside surface temperatures and locations as well as the amount of core wide zirconium oxidation and the peak local oxidation on the hot rod.

Figure B6 summarizes the peak clad temperatures results of the spectrum analysis.

4.0 Evaluation of Results

Peak clad temperatures during a small break LOCA are produced by different phenomena depending on the break size.

For the 0.5 ft^2 break, the temperature transient is terminated during the reflood period which is controlled primarily by the Safety Injection Tanks (SITs) with some assistance from the Safety Injection (SI) pumps.

The 0.2 ft^2 break is characterized by a relatively slow depressurization rate and recession of the two-phase level in the core. The depletion of the two-phase level and subsequent recovery is controlled by the boiloff rate due to decay heat and the rate at which the coolant is replenished by the high pressure safety injection (HPSI) and charging pump flows. The transient is terminated shortly after recovery of the core two phase level with injection from the SITs.

The 0.1 ft^2 and the 0.05 ft^2 breaks experience similar behavior as the 0.2 ft^2 break, however, the recovery of the core two phase level and termination of the clad temperature transient is controlled entirely by the HPSI and charging pump flows.

The 0.02 ft^2 break does not experience core uncovery since the boiloff rate is exceeded by the HPSI and charging pump flows at a time when the two-phase level in the inner vessel is well above the top elevation of the core.

The 0.10 ft^2 break was determined to be the limiting small break. For breaks smaller than 0.10 ft^2 core uncovery begins later when the fission product decay heat generation is less, and hence the depth of uncovery will be less. In fact, break sizes less than 0.02 ft^2 will not experience core uncovery. For breaks greater than 0.10 ft^2 the depressurization rate is faster such that the clad temperture rise is terminated early in the transient by SIT actuation.

5.0 Conclusions

An analysis of a spectrum of small breaks in the cold leg at the reactor pump discharge for Millstone 2, demonstrates an acceptable ECCS performance at a reactor power level of 2754 Mwt and a PLHGR of 16.0 kw/ft. The results of the limiting 0.1 ft^2 small break resulted in a peak clad temperature of 1971°F and peak local clad oxidation percentage of less than 10.3%, thereby demonstrating the small break LOCA ECCS performance to be less limiting than that for the large break LOCA performance.

6.0 Computer Code Version Identification

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

CEFLASH-4AS: Version No. 77019
STRIKIN-II: Version No. 77036
COMPERC-II: Version No. 74223
PARCH: Version No. 77004

7.0 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, "Calculative Methods for the C-E Small Break LOCA Evaluation Model", August, 1974 (Proprietary).

3. CENPD-137, "Calculative Methods for the C-E Small Break LOCA Evaluation Model", Supplement 1, January 1977 (Proprietary).

4. CENPD-133, Supplement 1, "CEFLASH-4AS, A Computer Program for Reactor Blowdown Analysis of the Small Break Loss-of-Coolant Accident", August, 1974 (Proprietary).

   CENPD-133, Supplement 3, "CEFLASH-4AS, A Computer Program for Reactor Blowdown Analysis of the Small Break Loss-of-Coolant Accident", January 1977 (Proprietary).

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

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

   CENPD-135, Supplement 2-P, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program (Modification)", February, 1975 (Proprietary).

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

   CENPD-135, Supplement 5-P, "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program", April 1977 (Proprietary).

7. CENPD-138, "PARCH, A FORTRAN-IV Digital Program to Evaluate Pool Boiling, Axial Rod and Coolant Heatup", August, 1974 (Proprietary).

   CENPD-138, Supplement 1, "PARCH, A FORTRAN-IV Digital Program to Evaluate Pool Boiling, Axial Rod and Coolant Heatup" (Modification), February 1975 (Proprietary).

   CENPD-138, Supplement 2, "PARCH, A FORTRAN-IV Digital Program to Evaluate Pool Boiling, Axial Rod and Coolant Heatup" (Modification), January 1977 (Proprietary).

8. Cycle II Small Break Analysis (to be supplied by NEU).

Table B-1

General System Parameters
Millstone Unit 2 Cycle 3

Quantity	Value
Reactor power level (102% of Nominal)	2754 MWt
Average linear heat rate (102% of Nominal)	6.396 kw/ft
Peak linear heat rate	16.0 kw/ft
Gap conductance at peak linear heat rate	1388. BTU/hr-ft^2-$^{\circ}$F
Fuel centerline temperature at peak linear heat rate	3780.$^{\circ}$F
Fuel average temperature at peak linear heat rate	2358.$^{\circ}$F
Hot rod gas pressure	1392 psia
Hot rod burnup*	6582 MWD/MTU
System flow rate (total)	138.9 x 10^6 lbm/hr
Core flow rate	133.8 x 10^6 lbm/hr
Charging pump flow delivered to reactor vessel	0.5 pump
Reactor vessel inlet temperature	551°F
Reactor vessel outlet temperature	602°F

---

*At time-in-life of minimum gap conductance

Table B-2

Millstone Unit 2 Cycle 3

Times of Interest for Small Breaks
(seconds)

Break Size	HPSI and Charging Pump On	LPSI Pump On	SI Tanks On	Time for SI H_2O To Reach Bottom of Fuel	Hot Spot Peak Clad Temperature Occurs
(ft^2)	(sec)	(sec)	(sec)	(sec)	sec
0.5	40	168	168	b	203
0.2	48	598	598	b	588
0.1	60	a	c	b	1439
0.05	96	a	c	b	2129
0.02	350	a	c	d	e

---

a - calculation terminated before time of LPSI pump activation

b - core never totally uncovered

c - calculation terminated before SIT actuation

d - top of core never uncovers

e - clad temperature during transient never exceeds initial fuel clad temperature

Table B-3

Fuel Rod Performance Summary

Break Size	Maximum Clad Surface Temperature	Elevation of Hot Spot (from bottom of core)	Core Wide Zirconium Oxid.	Peak Percent Zirconium Oxid.
ft^2	^oF	ft	%	%
0.5	1629	9.7	< .063	< .48
0.2	1612	10.3	< .07	< .41
0.1	1971	9.7	< .317	<10.3
0.05	1824	9.7	< .274	< 6.29
0.02	558	9.7	< .00010	< .0001

FIGURE B-1A

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE NORMALIZED TOTAL CORE POWER (SMALL BREAK ANALYSIS)

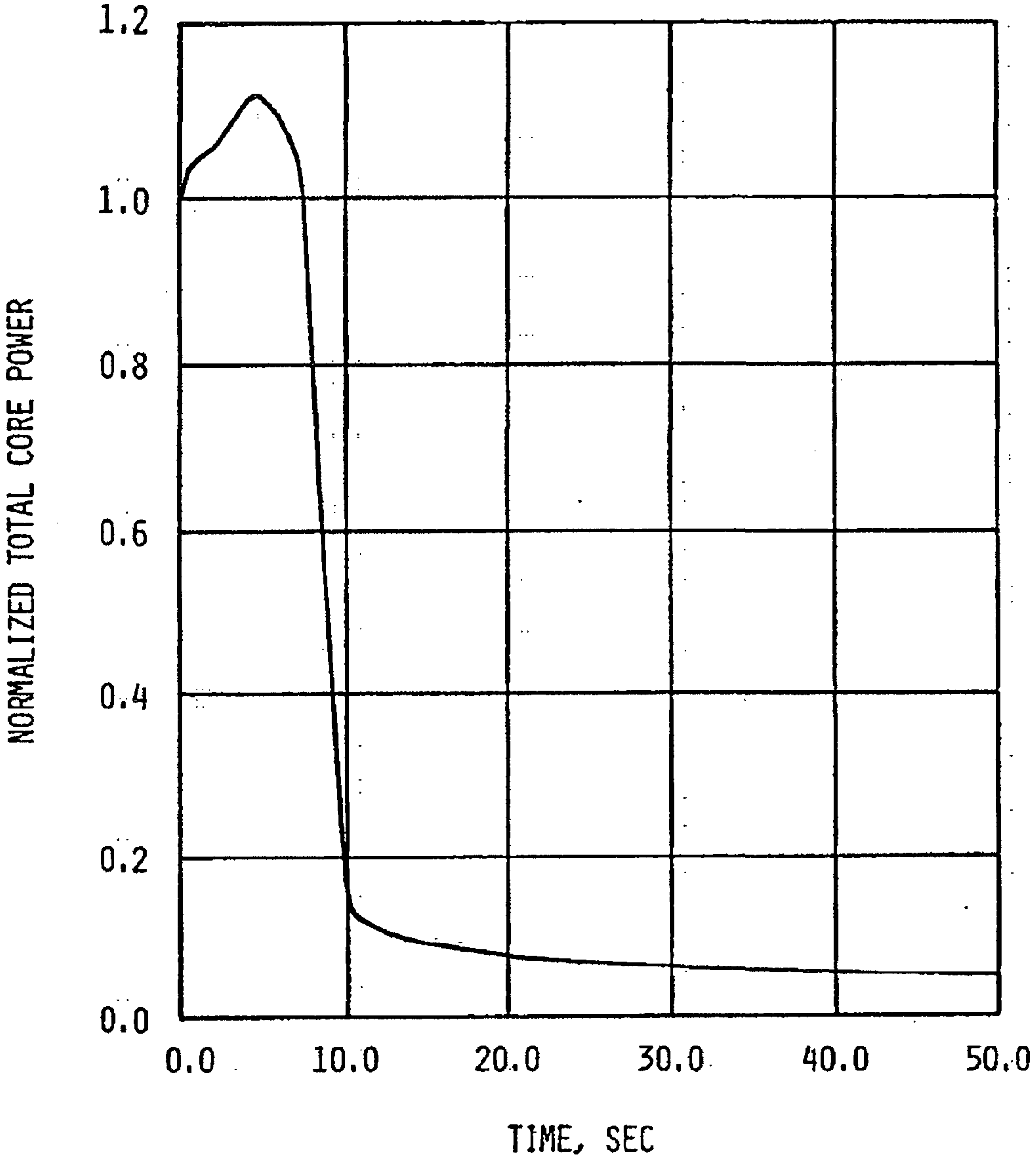


FIGURE B-1B

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL PRESSURE
(SMALL BREAK ANALYSIS)

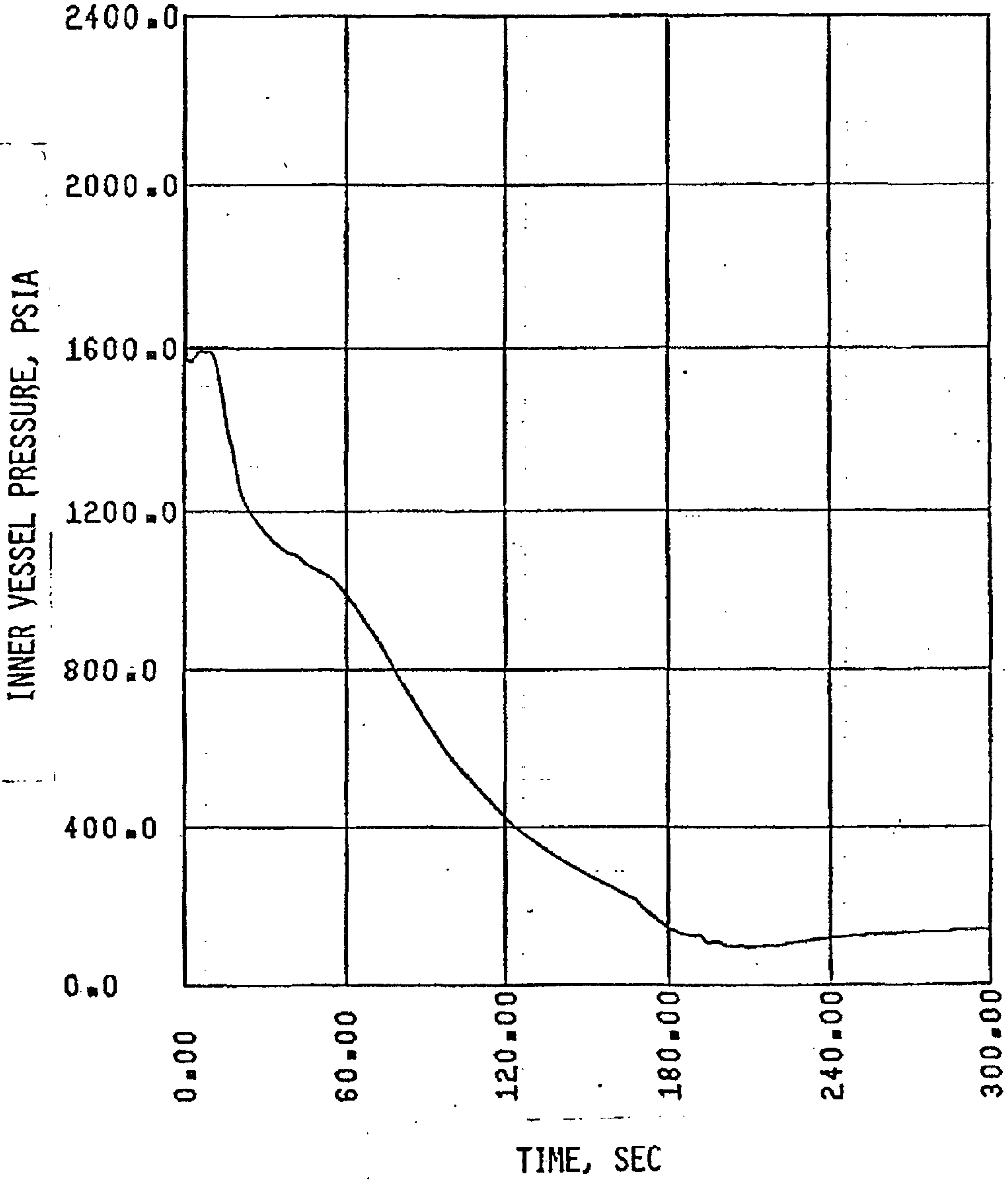


FIGURE B-1C

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
BREAK FLOW RATE
(SMALL BREAK ANALYSIS)

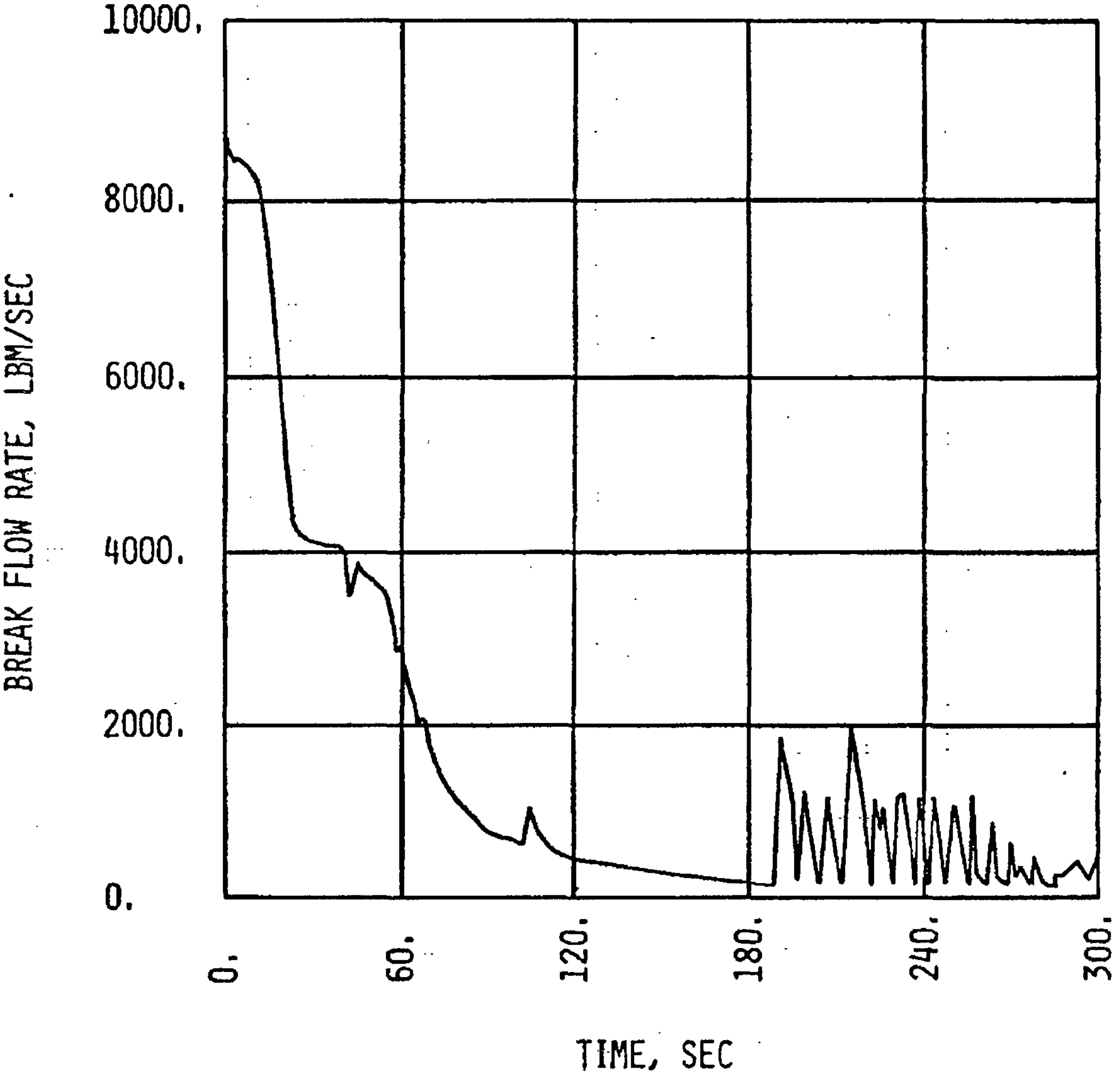


FIGURE B-1D

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE INNER VESSEL INLET FLOW RATE (SMALL BREAK ANALYSIS)

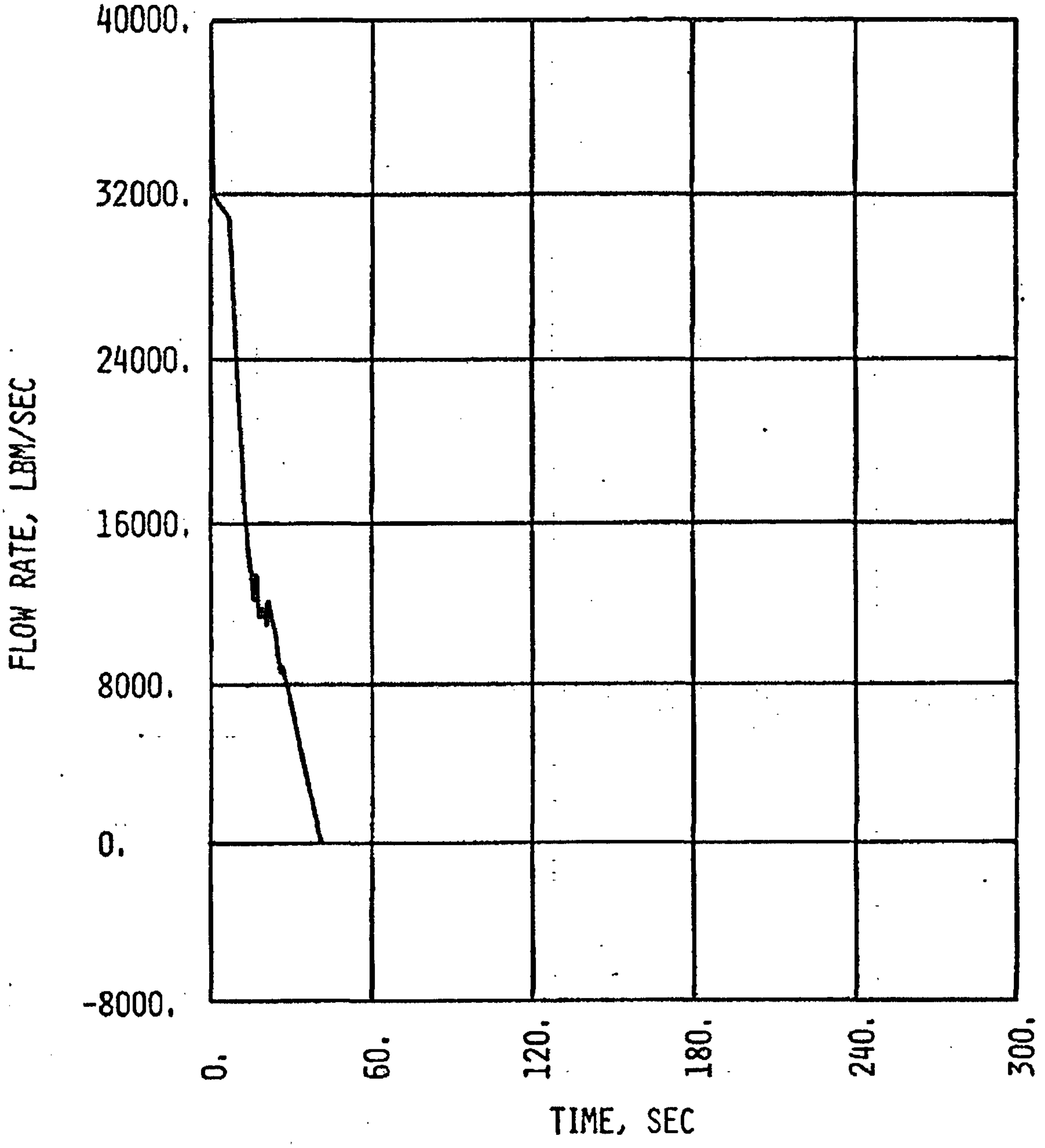


FIGURE B-1E

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL TWO-PHASE MIXTURE VOLUME
(SMALL BREAK ANALYSIS)

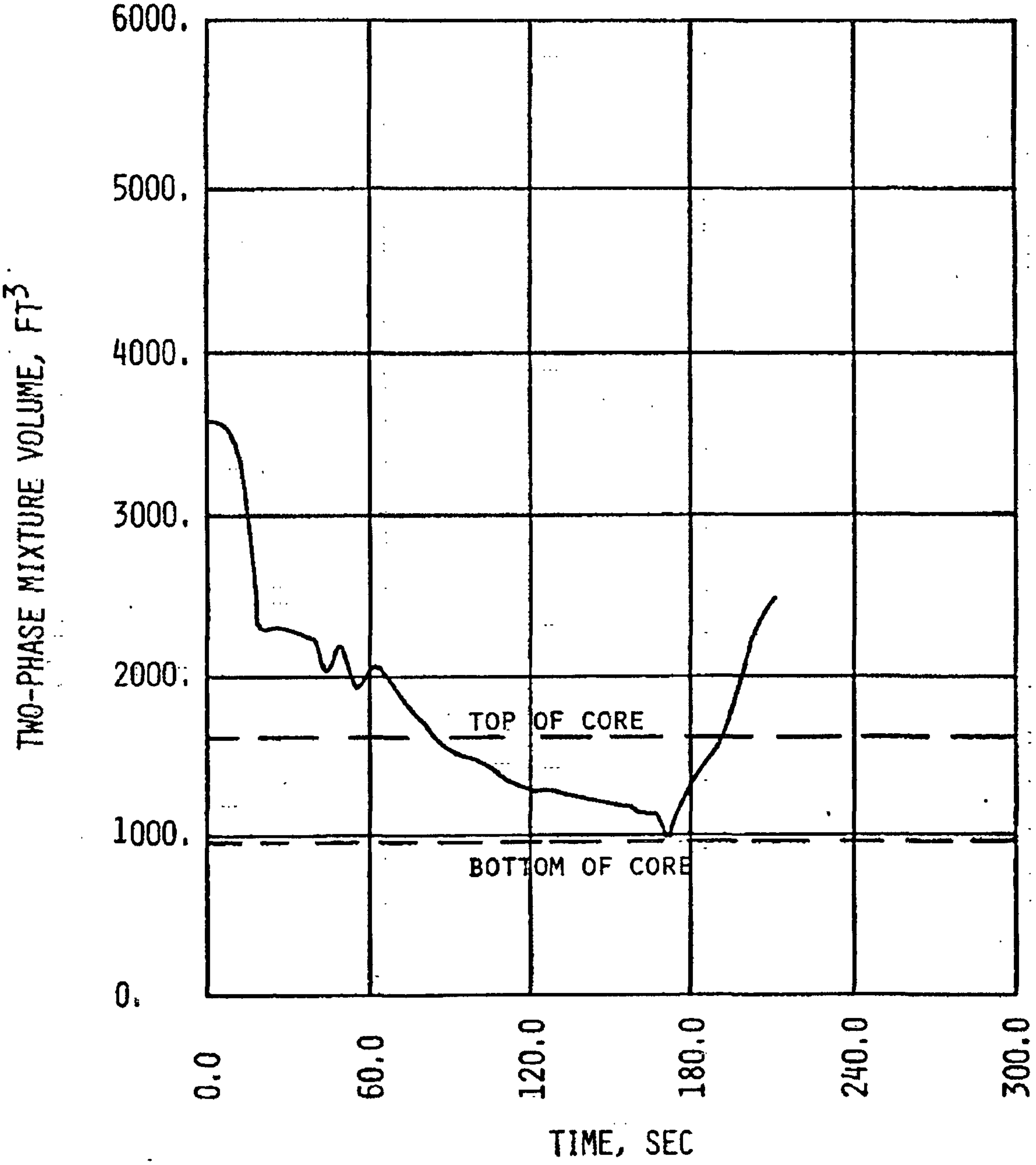


FIGURE B-1F

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE HEAT TRANSFER COEFFICIENT AT HOT SPOT (SMALL BREAK ANALYSIS)

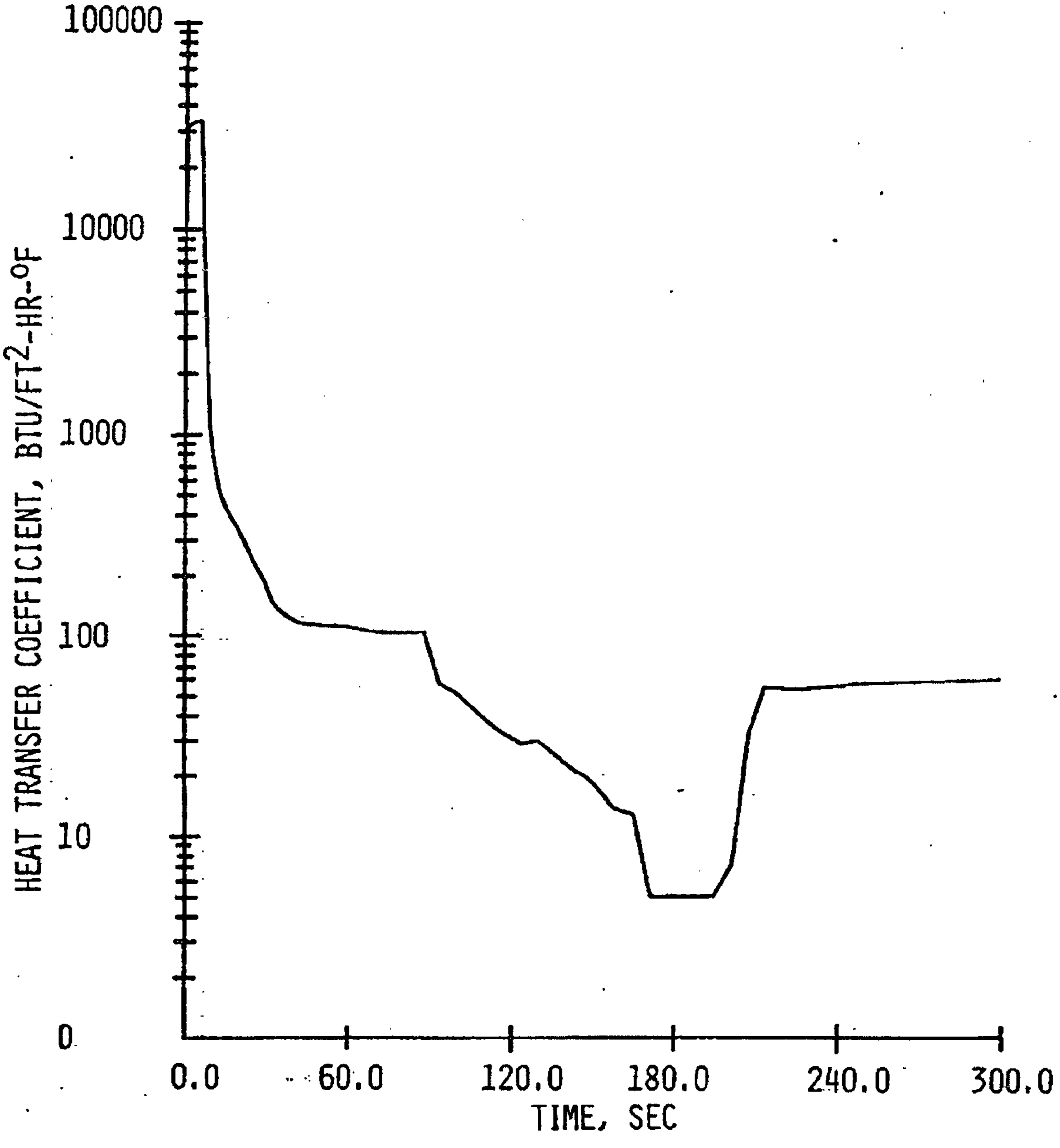


FIGURE B-1G

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
COOLANT TEMPERATURE AT HOT SPOT
(SMALL BREAK ANALYSIS)

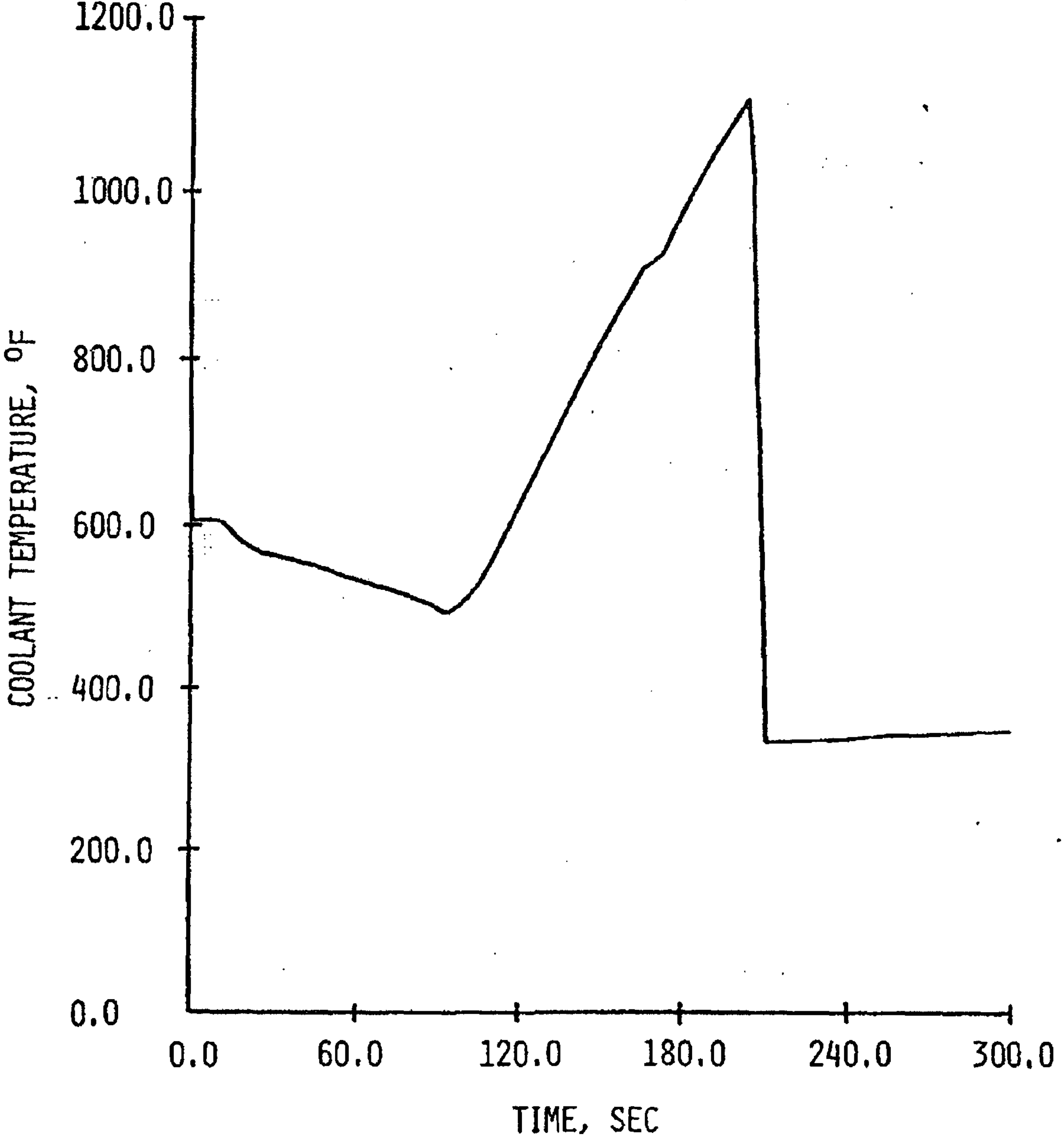


FIGURE B-1H

MILLSTONE 2

0.50 FT^2 COLD LEG BREAK AT PUMP DISCHARGE HOT SPOT CLAD SURFACE TEMPERATURE (SMALL BREAK ANALYSIS)

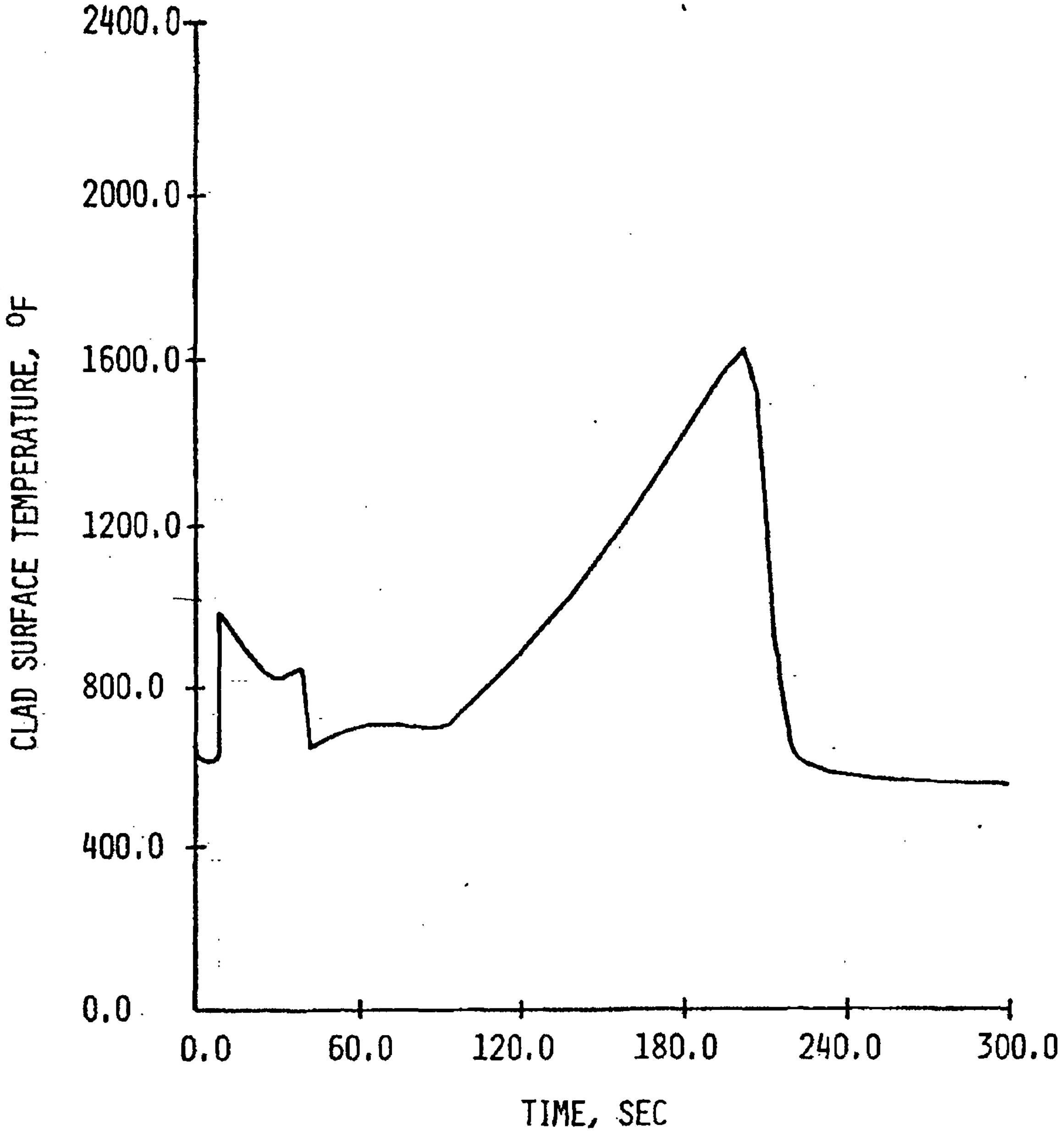


FIGURE B-2A

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
NORMALIZED TOTAL CORE POWER
(SMALL BREAK ANALYSIS)

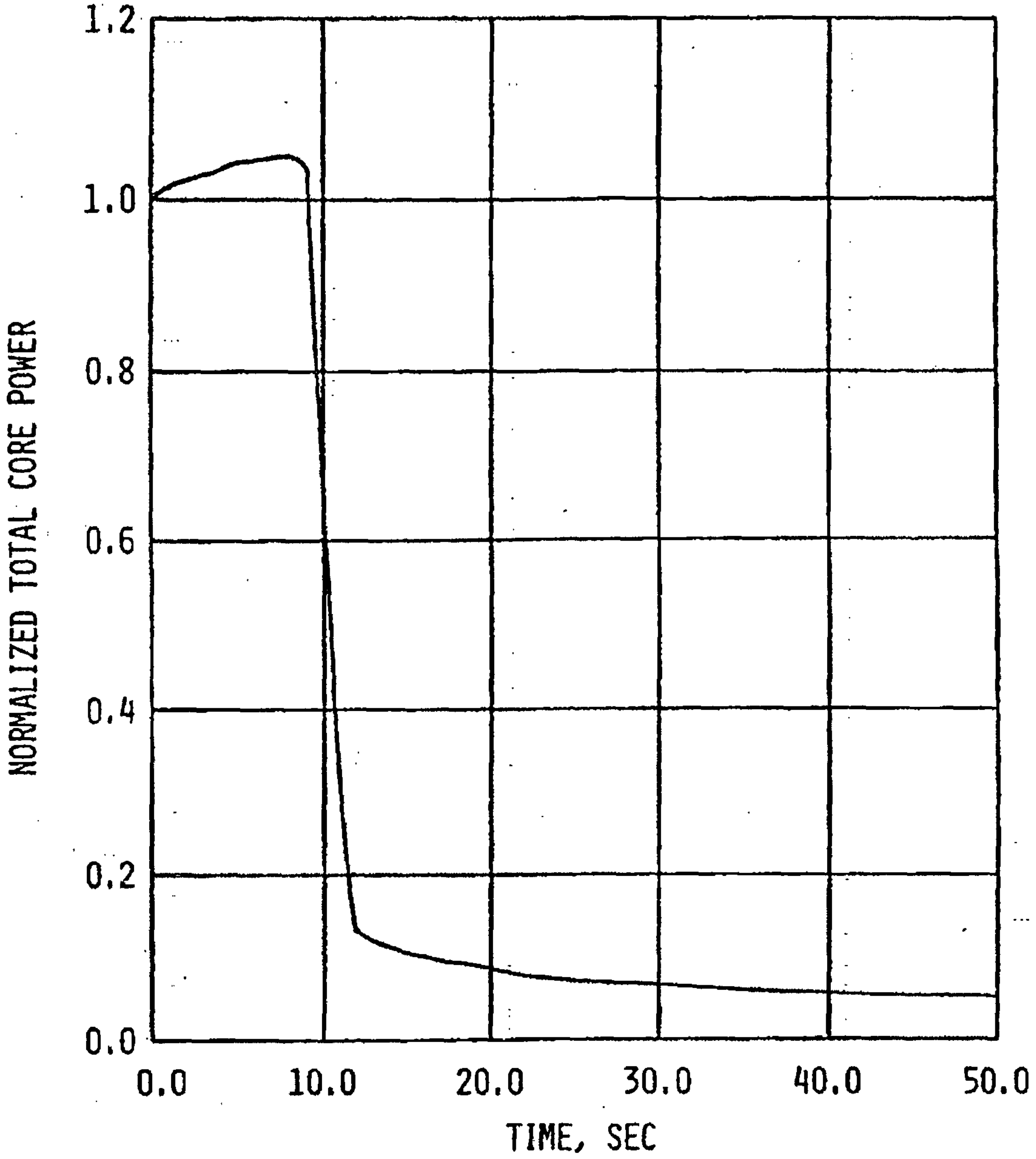


FIGURE B-2B

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL PRESSURE
(SMALL BREAK ANALYSIS)

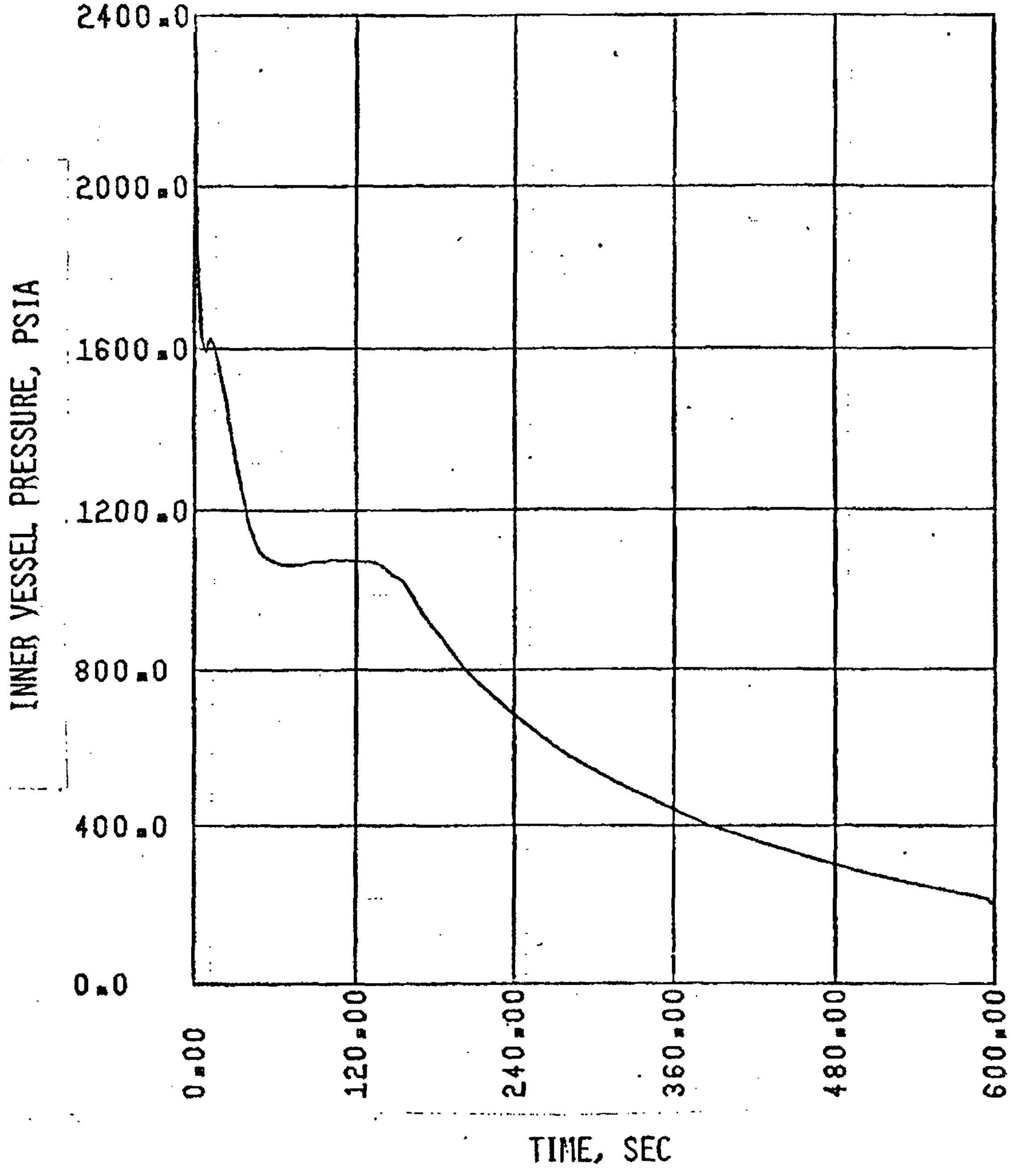


FIGURE B-2C

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE

BREAK FLOW RATE

(SMALL BREAK ANALYSIS)

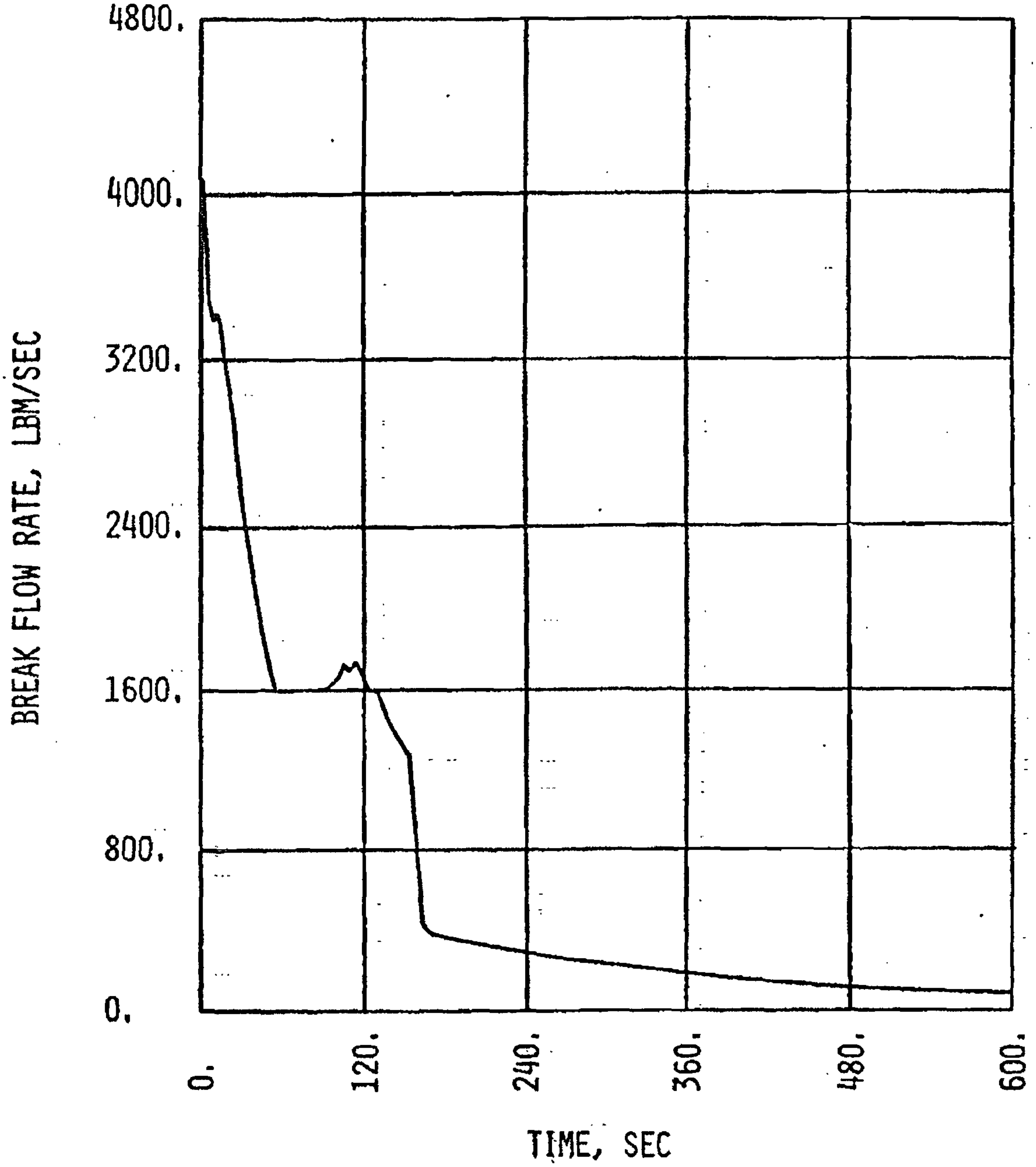


FIGURE B-2D

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL INLET FLOW RATE
(SMALL BREAK ANALYSIS)

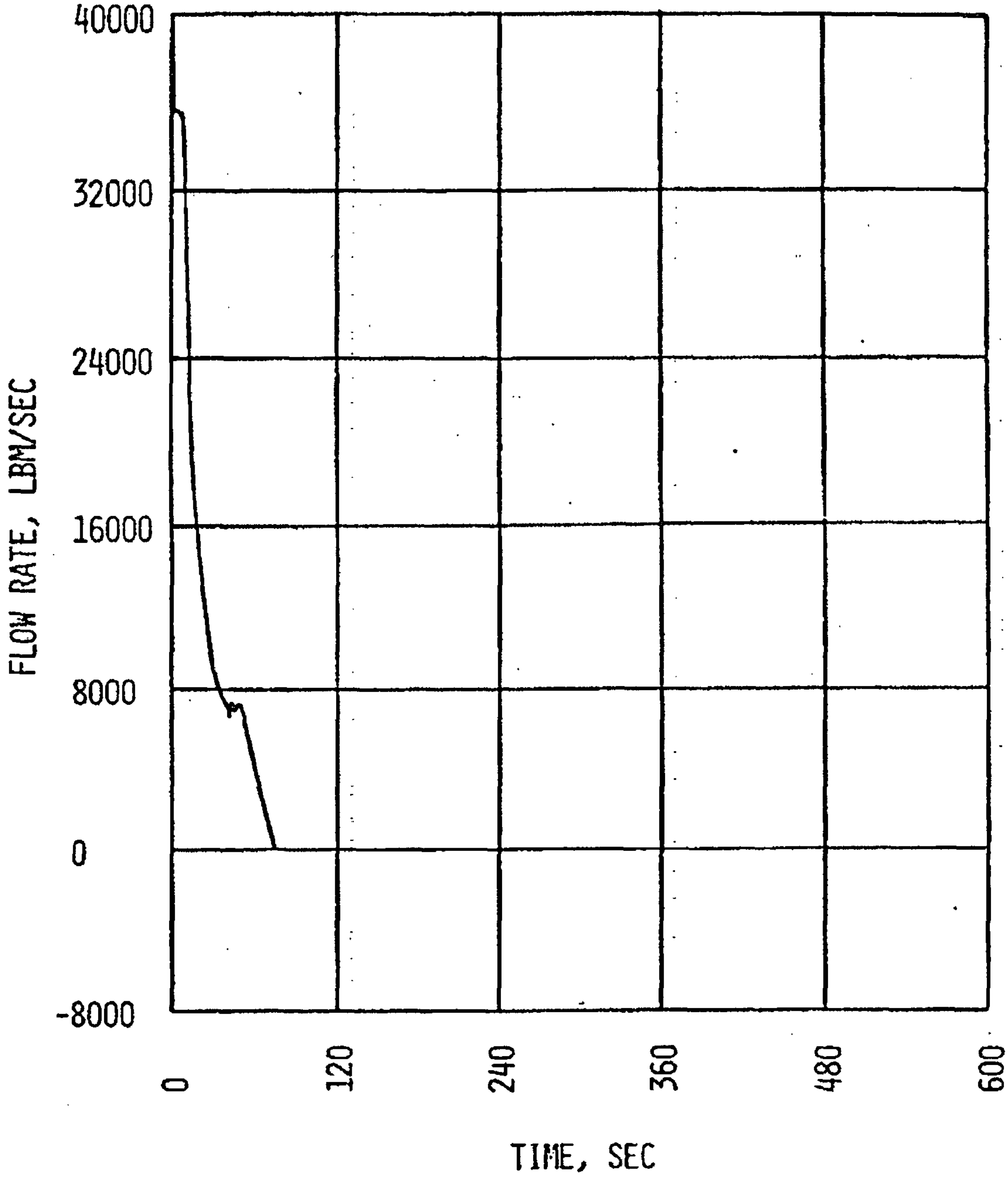


FIGURE B-2E

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL TWO-PHASE MIXTURE VOLUME
(SMALL BREAK ANALYSIS)

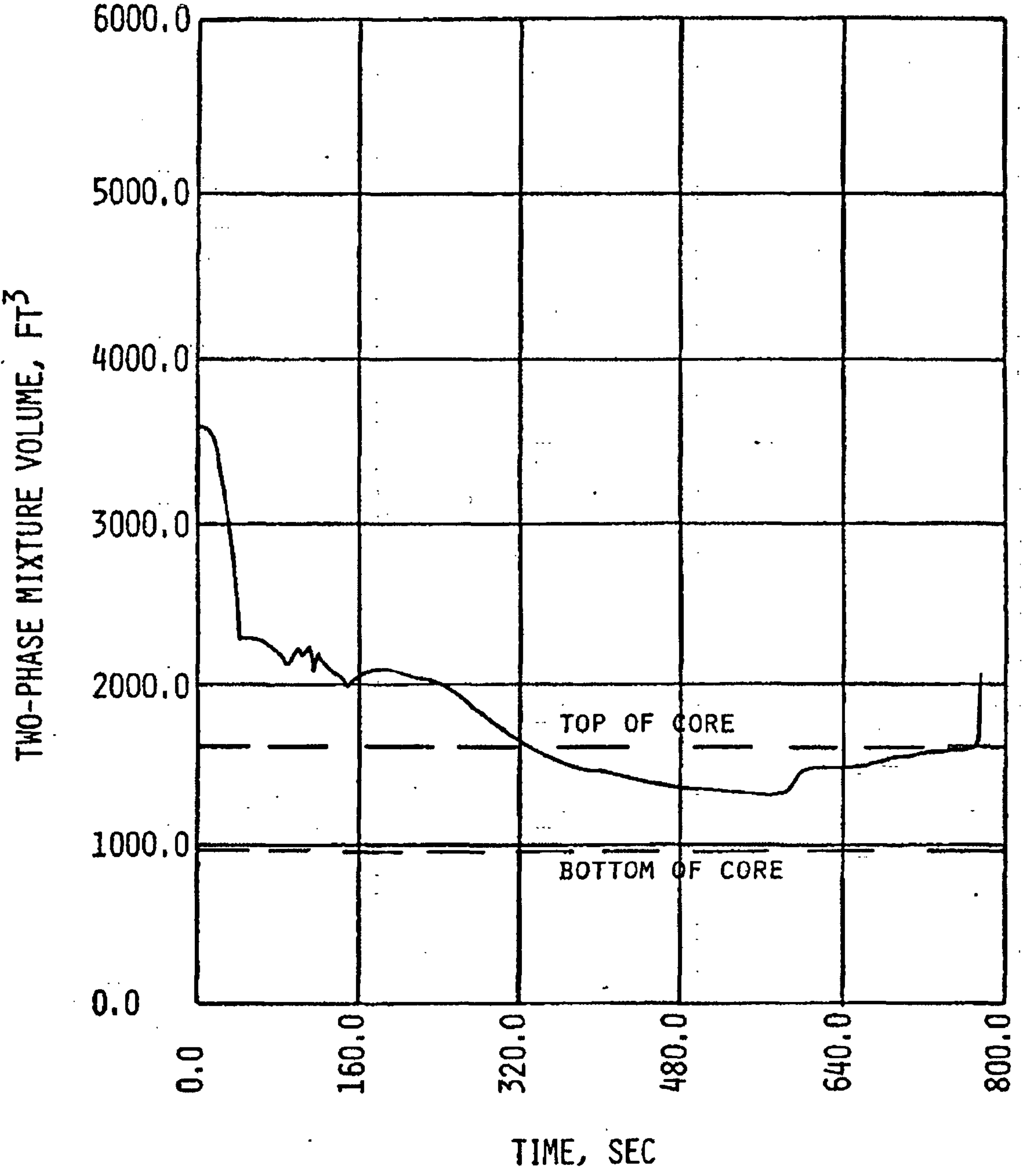


FIGURE B-2F

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE HEAT TRANSFER COEFFICIENT AT HOT SPOT (SMALL BREAK ANALYSIS)

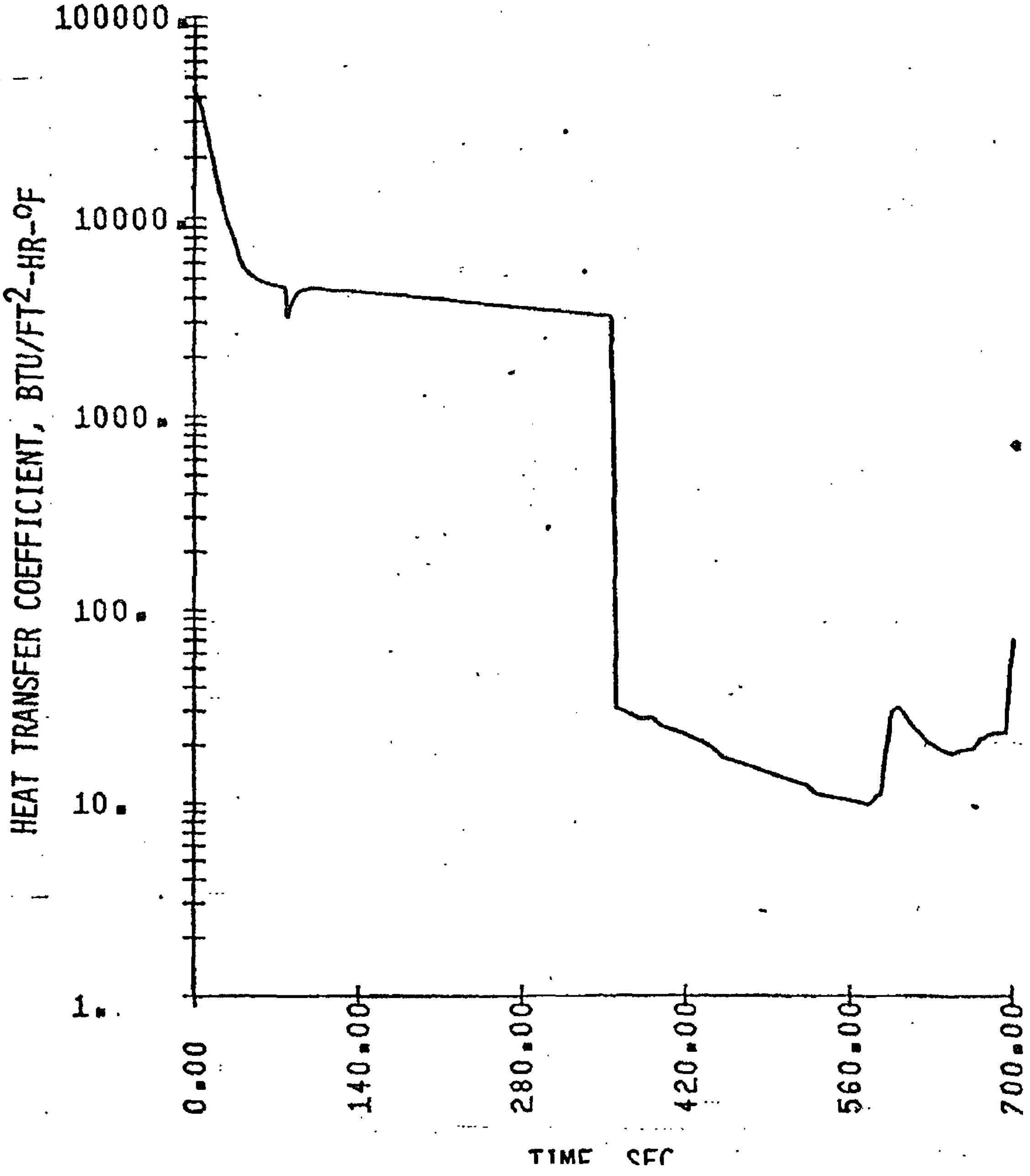


FIGURE B-2G
MILLSTONE 2
0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
COOLANT TEMPERATURE AT HOT SPOT
(SMALL BREAK ANALYSIS)

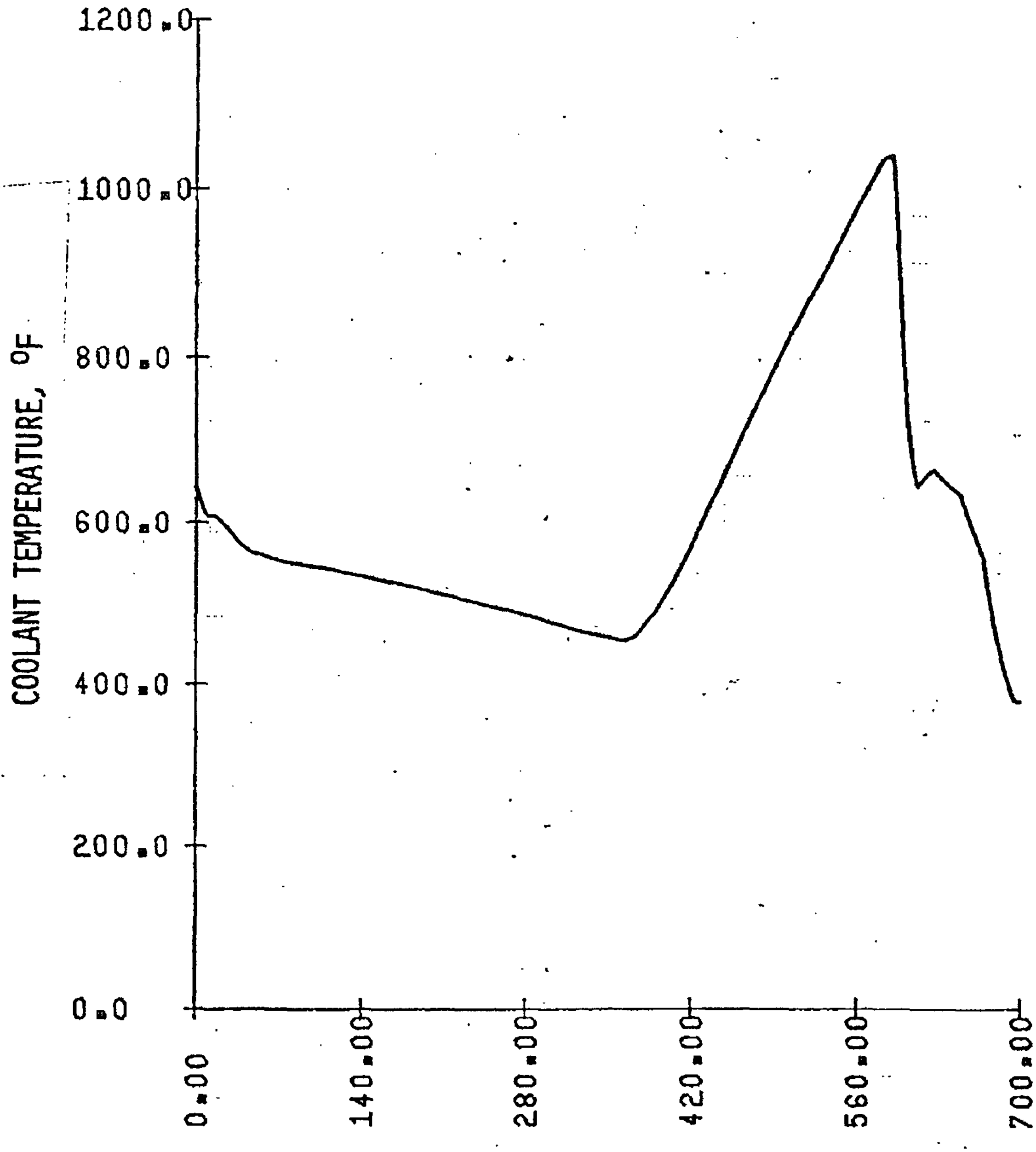


FIGURE B-2H

MILLSTONE 2

0.20 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
HOT SPOT CLAD SURFACE TEMPERATURE
(SMALL BREAK ANALYSIS)

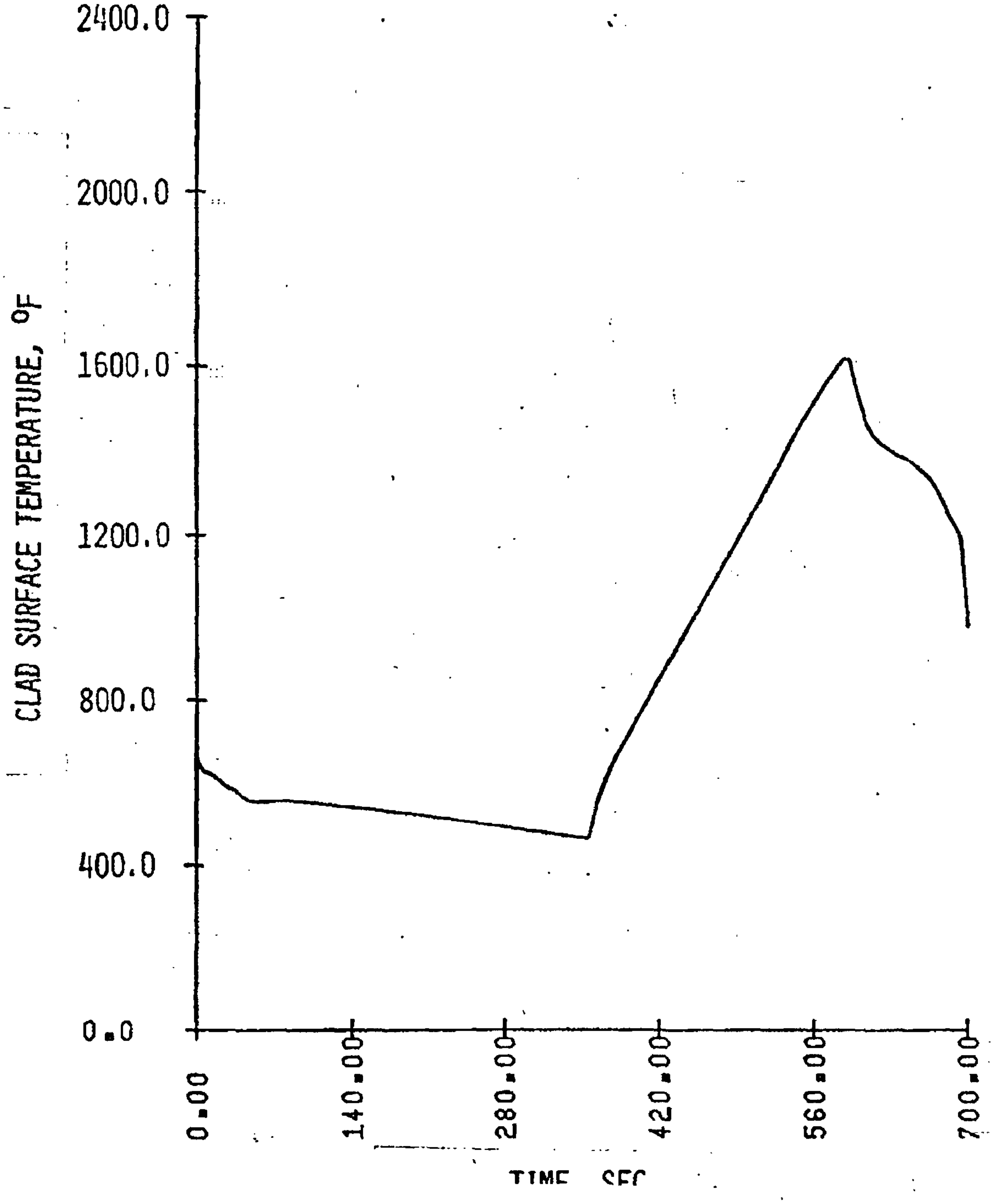


FIGURE B-3A

MILLSTONE 2

0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE NORMALIZED TOTAL CORE POWER (SMALL BREAK ANALYSIS)

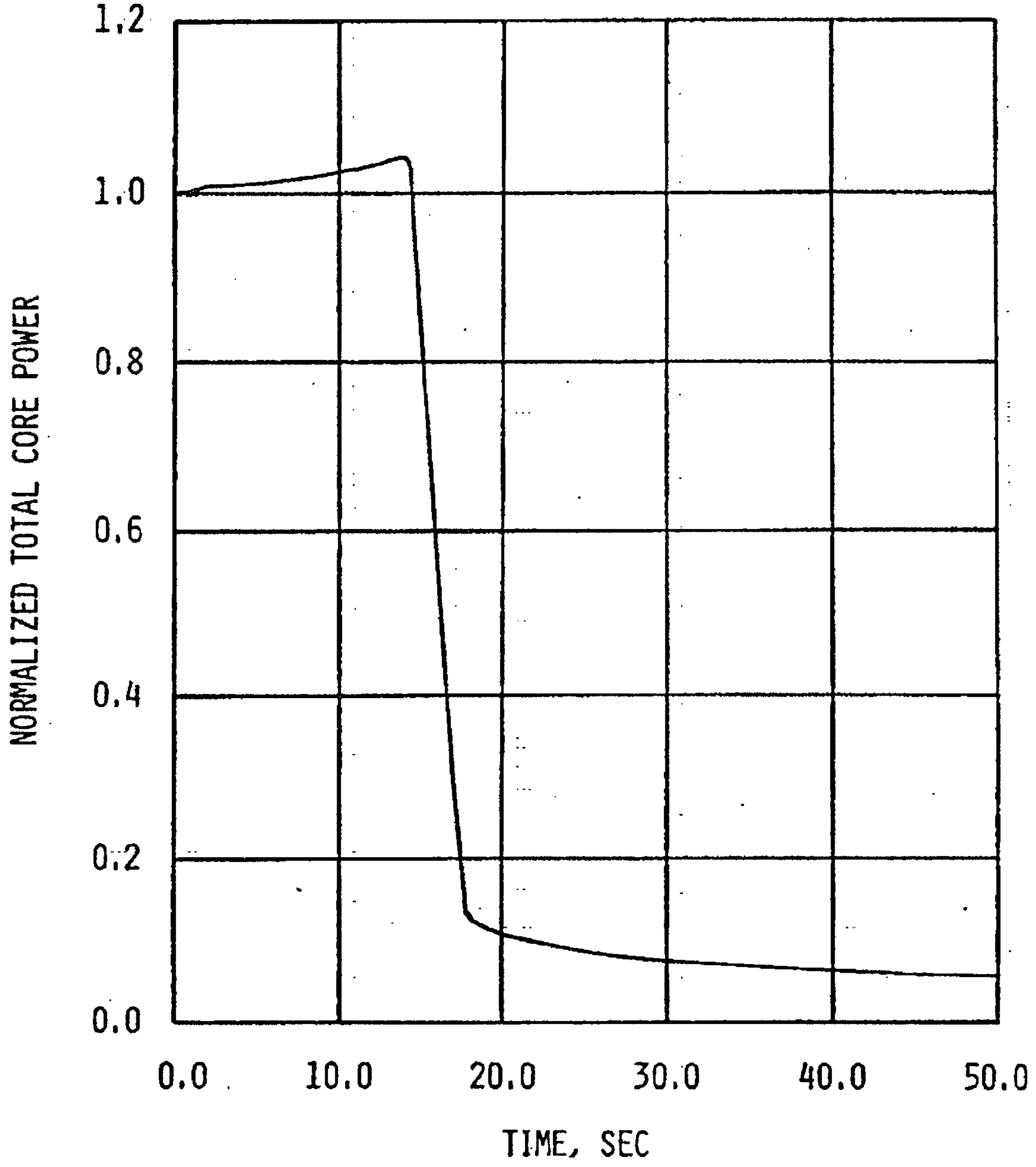


FIGURE B-5B

MILLSTONE 2

0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE INNER VESSEL PRESSURE (SMALL BREAK ANALYSIS)

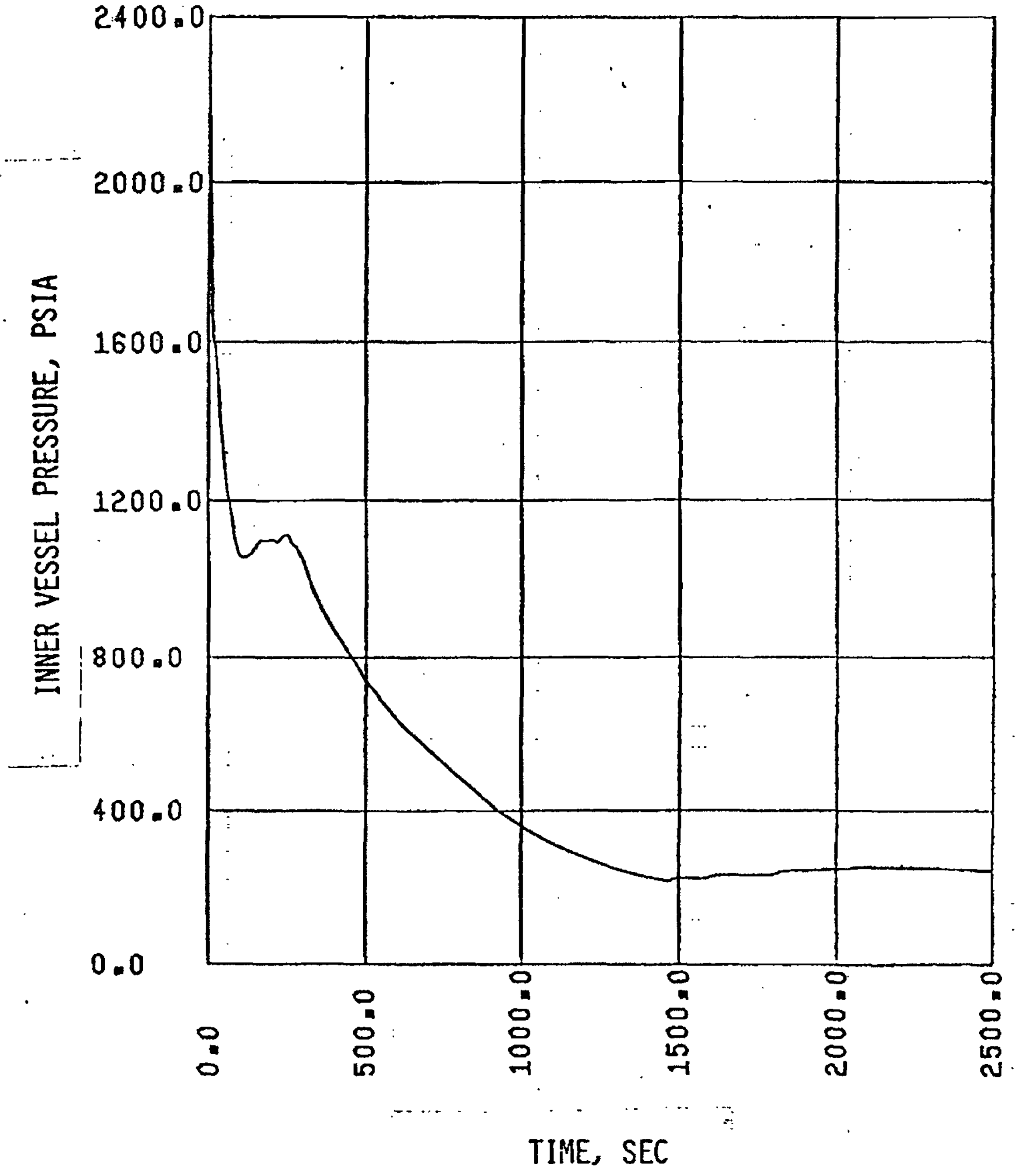


FIGURE B-3C
MILLSTONE 2
0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
BREAK FLOW RATE
(SMALL BREAK ANALYSIS)

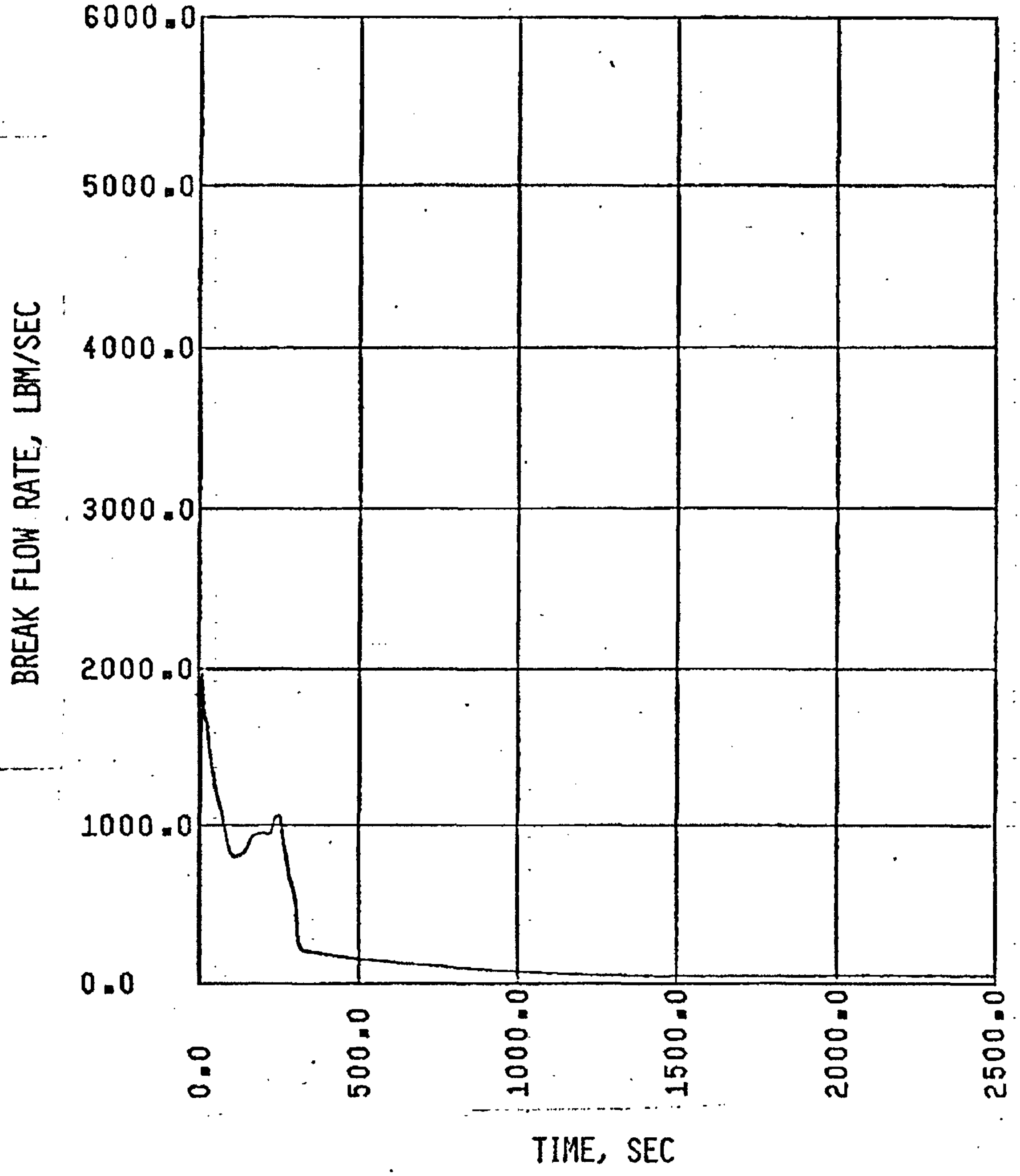


FIGURE B-5D

MILLSTONE 2

0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL INLET FLOW RATE
(SMALL BREAK ANALYSIS)

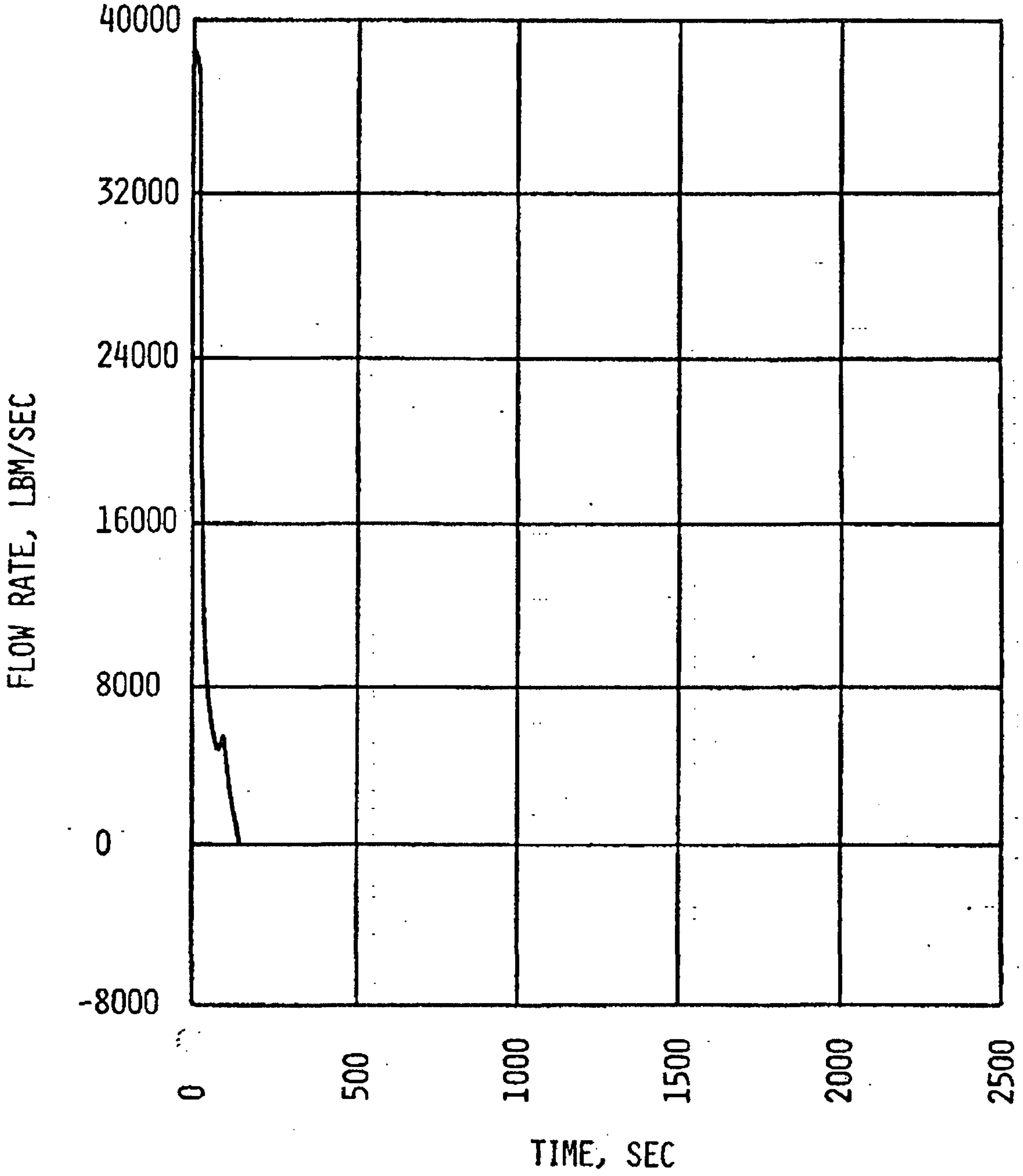


FIGURE B-3E
MILLSTONE 2
0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE INNER VESSEL TWO-PHASE MIXTURE VOLUME (SMALL BREAK ANALYSIS)

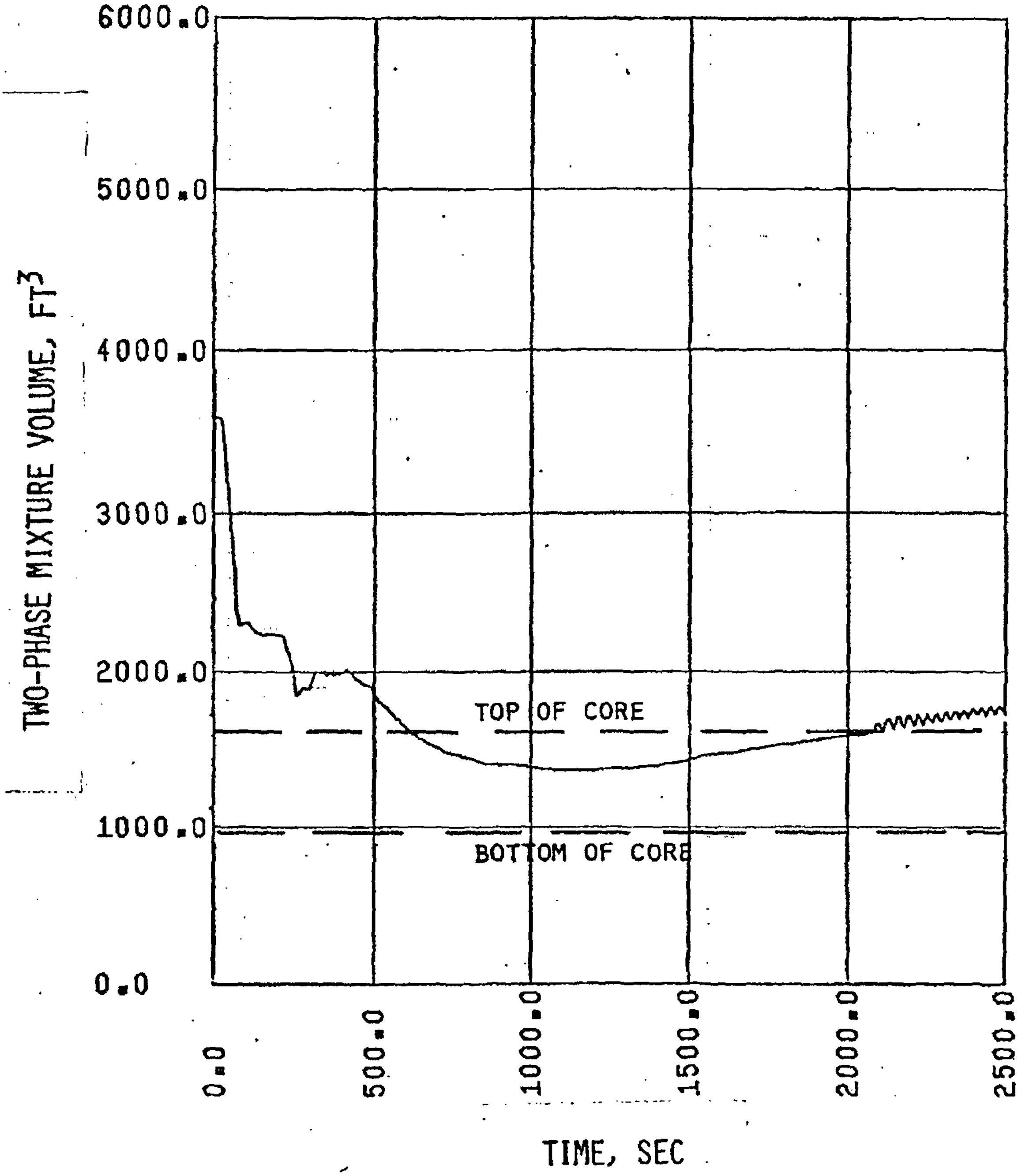


FIGURE B-3F

MILLSTONE 2

0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
HEAT TRANSFER COEFFICIENT AT HOT SPOT
(SMALL BREAK ANALYSIS)

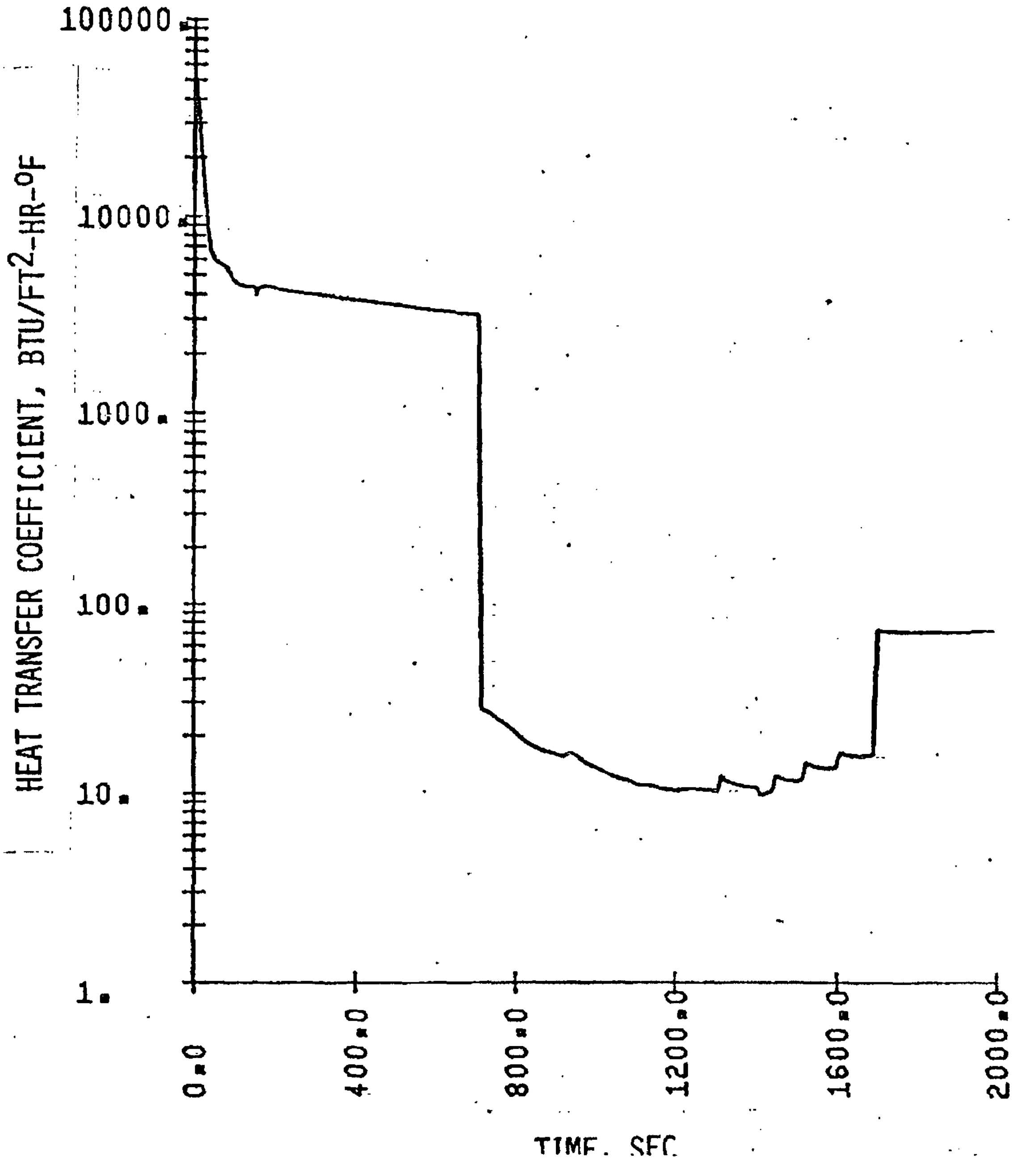


FIGURE B-3G
MILLSTONE 2
0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
COOLANT TEMPERATURE AT HOT SPOT
(SMALL BREAK ANALYSIS)

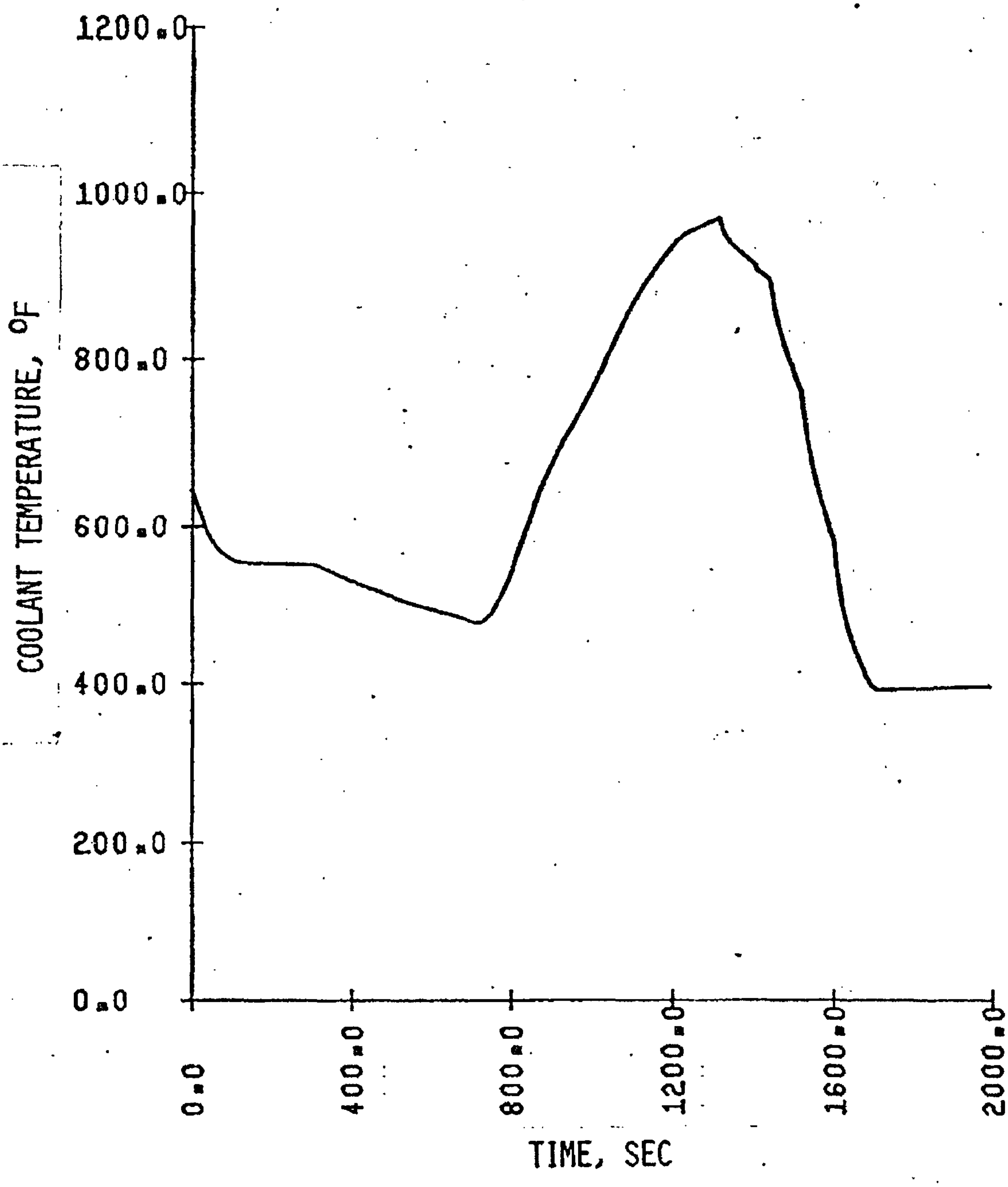


FIGURE B-3H
MILLSTONE 2
0.10 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
HOT SPOT CLAD SURFACE TEMPERATURE
(SMALL BREAK ANALYSIS)

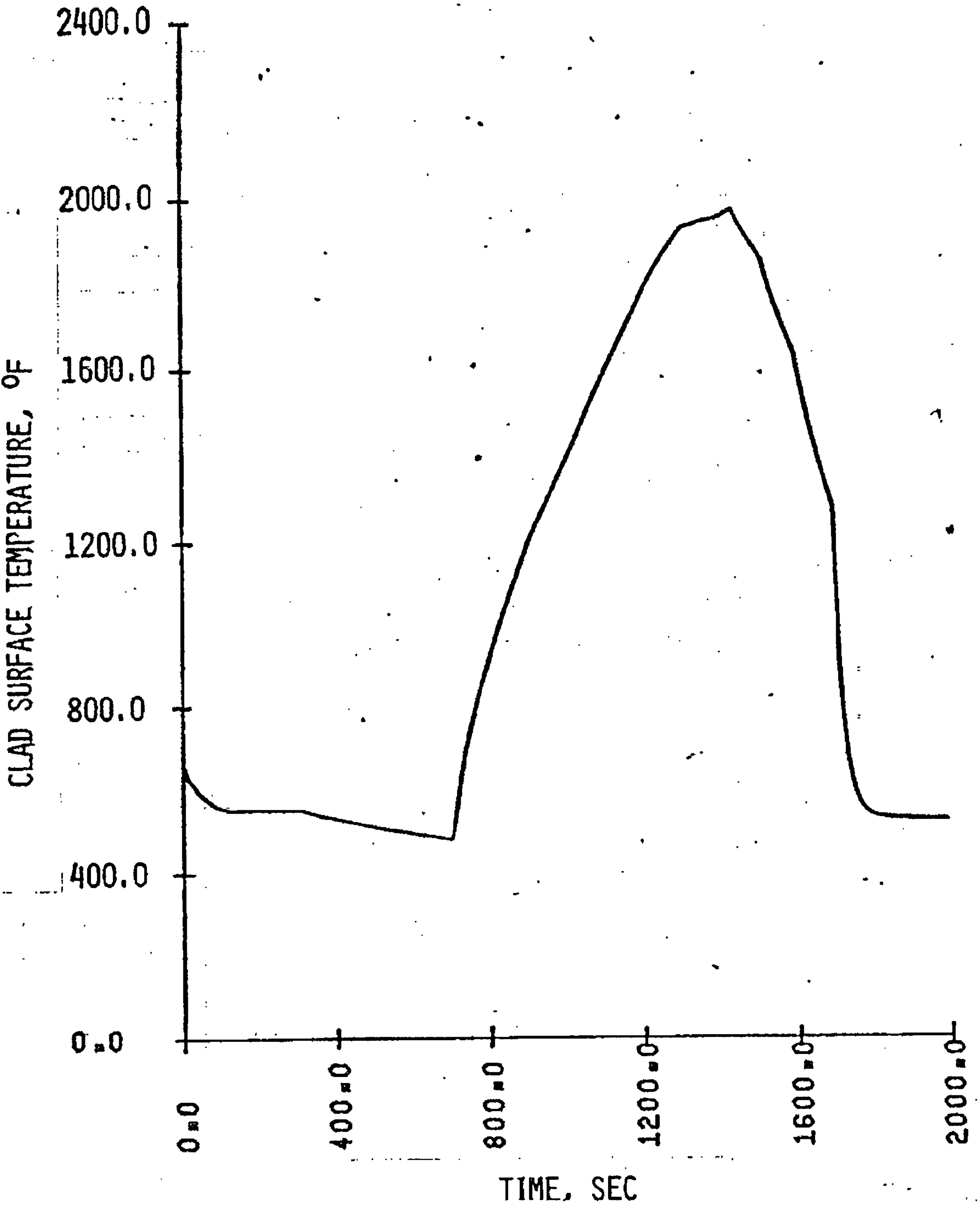


FIGURE B-4A

MILLSTONE 2

0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
NORMALIZED TOTAL CORE POWER
(SMALL BREAK ANALYSIS)

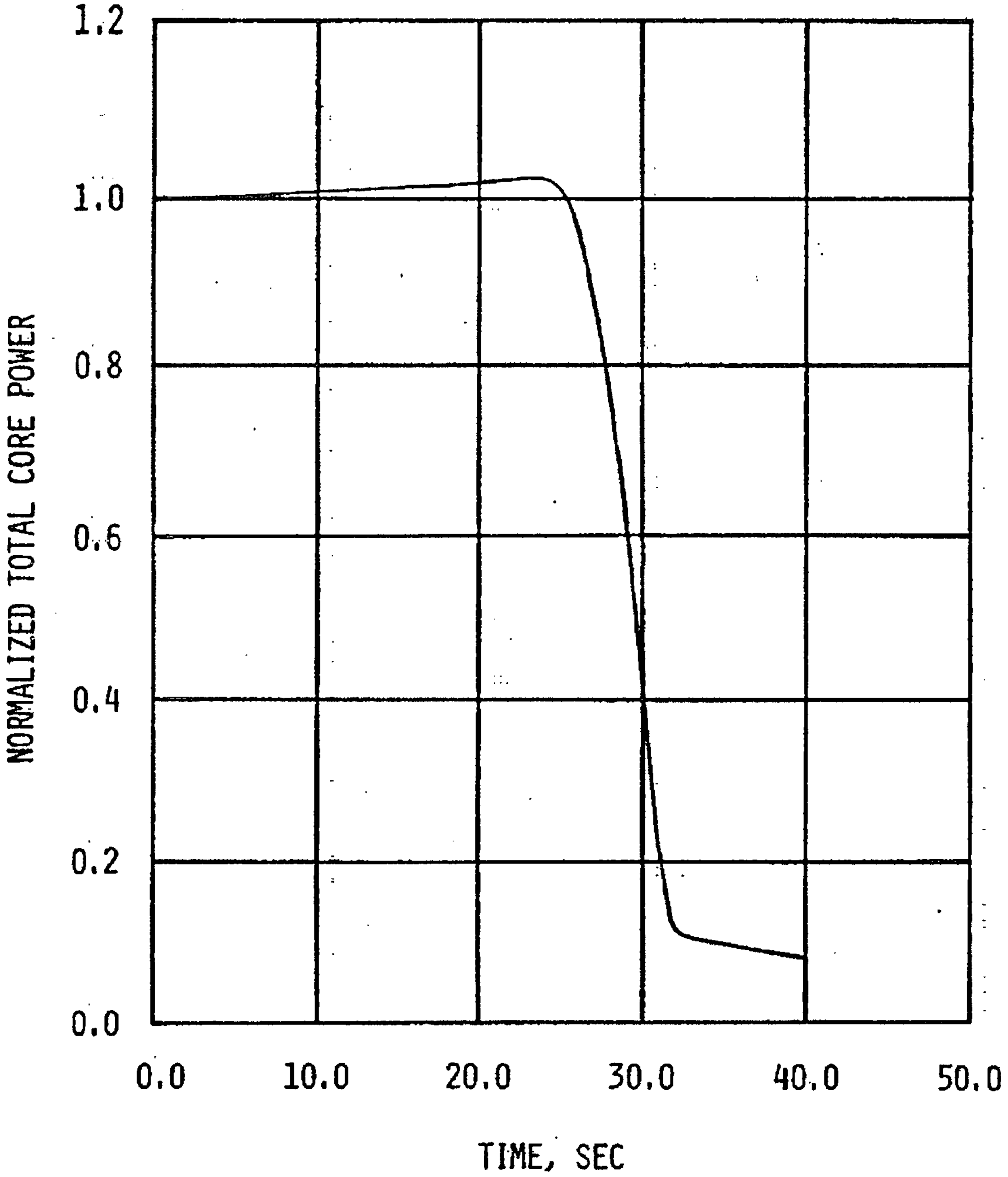


FIGURE B-4B
MILLSTONE 2
0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL PRESSURE
(SMALL BREAK ANALYSIS)

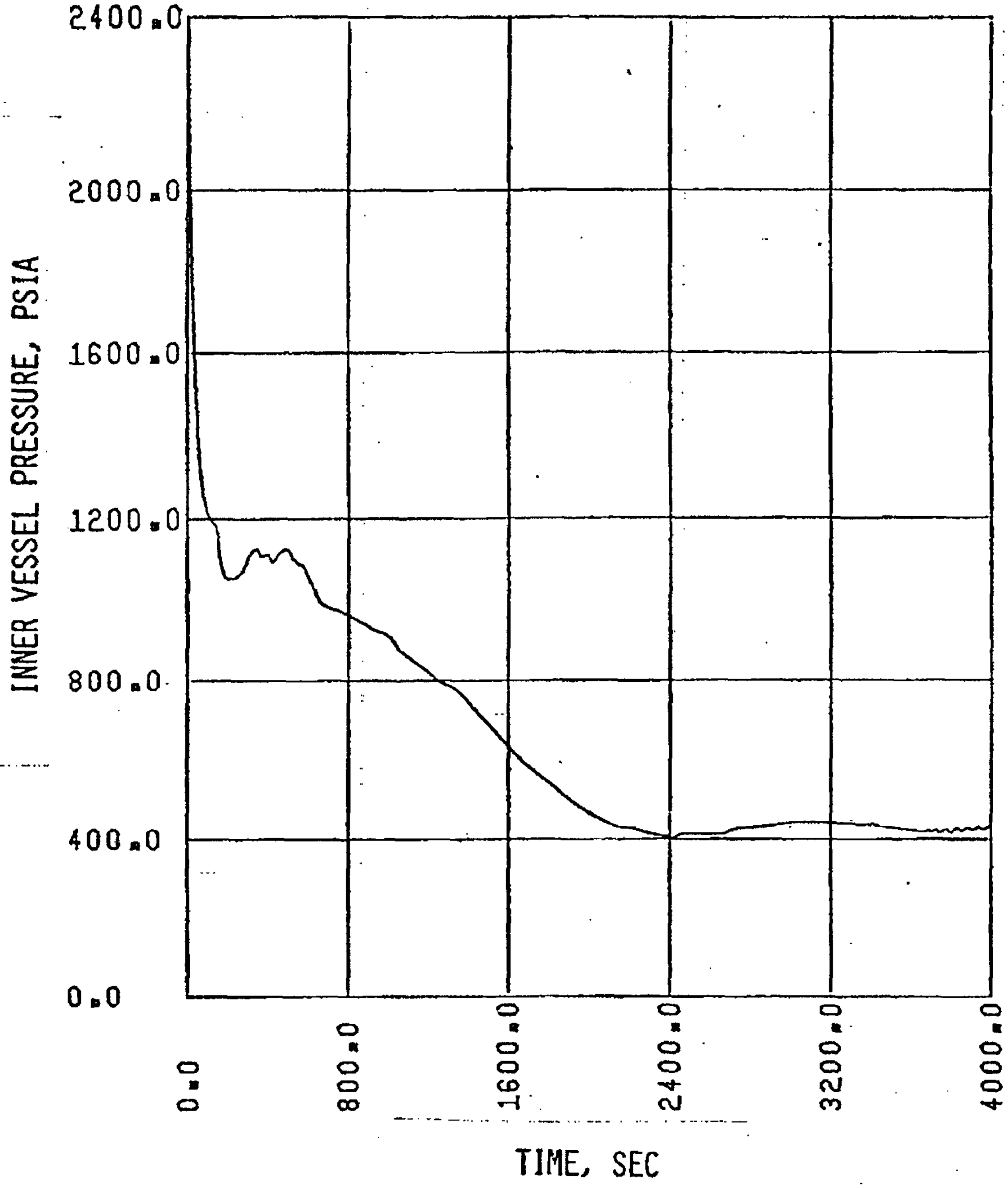


FIGURE B-4C
MILLSTONE 2
0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
BREAK FLOW RATE
(SMALL BREAK ANALYSIS)

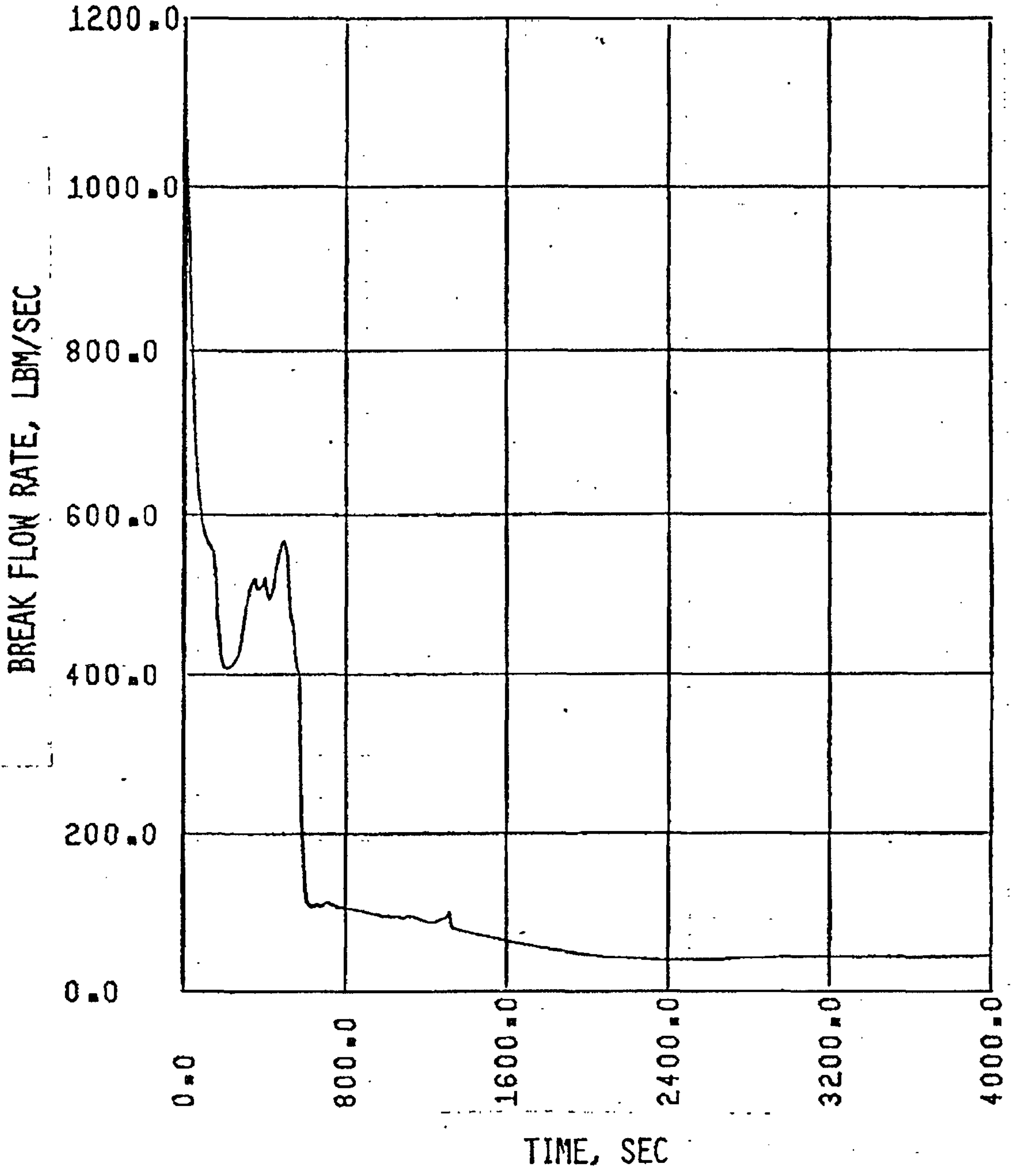


FIGURE B-4D
MILLSTONE 2
0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL INLET FLOW RATE
(SMALL BREAK ANALYSIS)

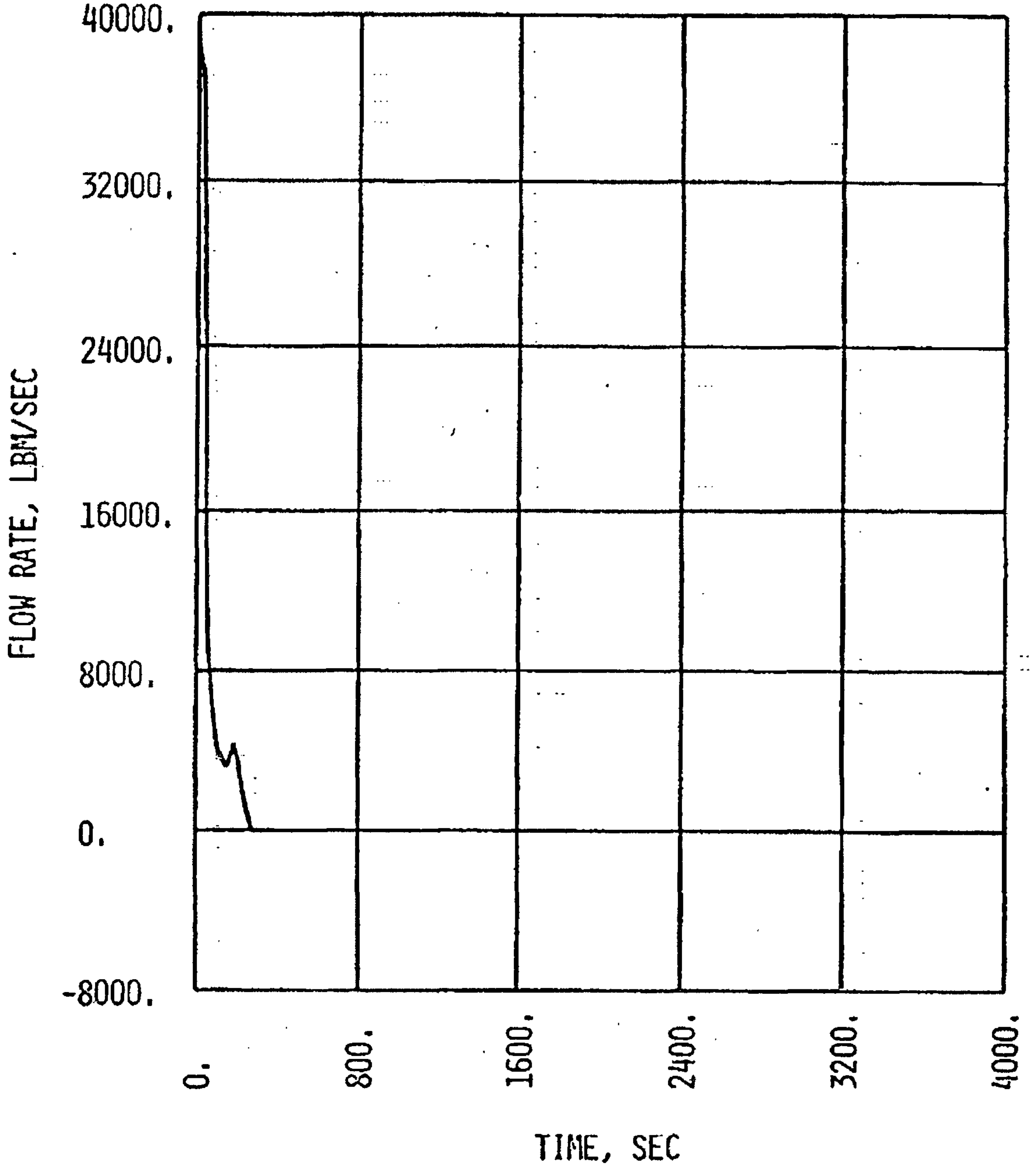


FIGURE B-4E
MILLSTONE 2
0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE INNER VESSEL TWO-PHASE MIXTURE VOLUME
(SMALL BREAK ANALYSIS)

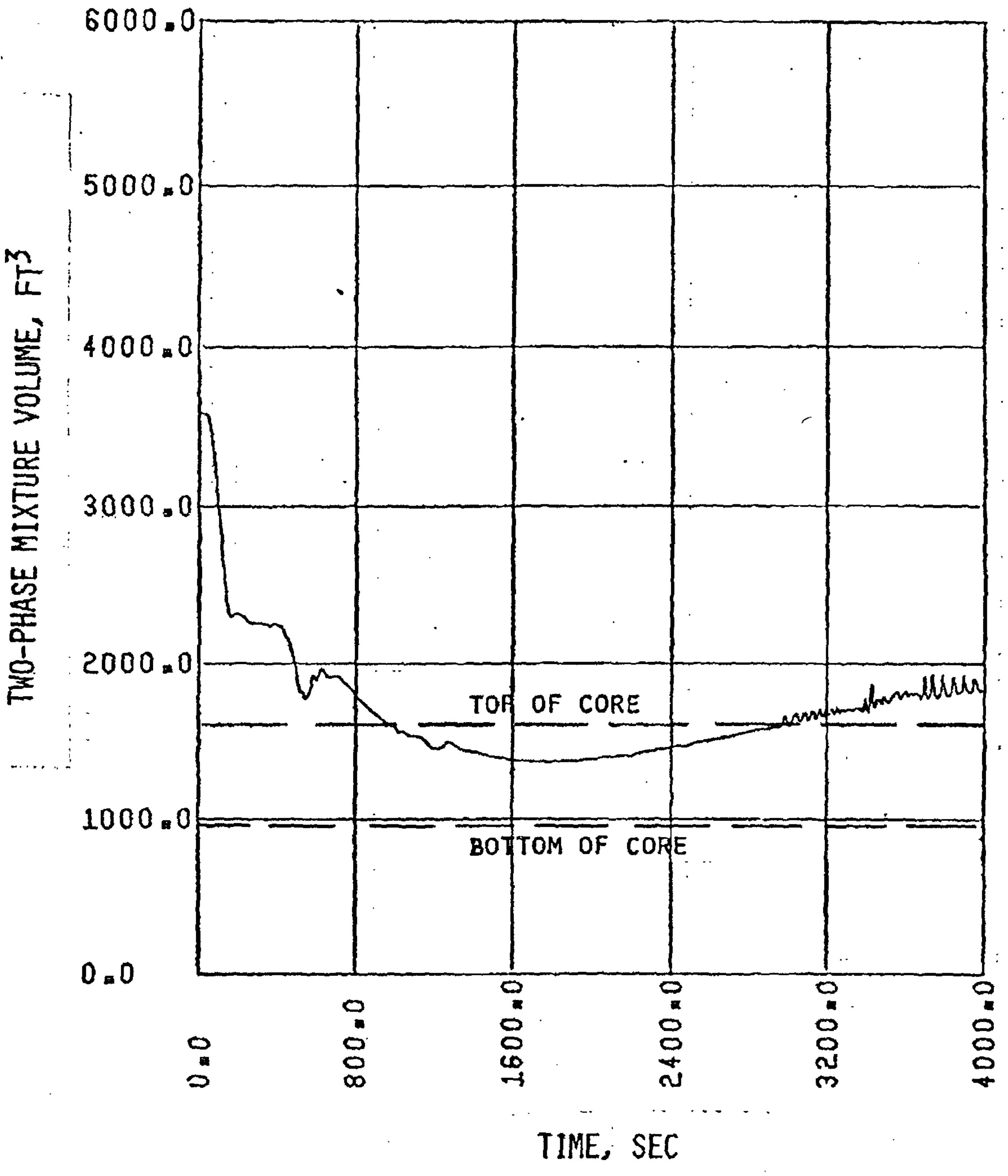


FIGURE B-4F
MILLSTONE 2
0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
HEAT TRANSFER COEFFICIENT AT HOT SPOT
(SMALL BREAK ANALYSIS)

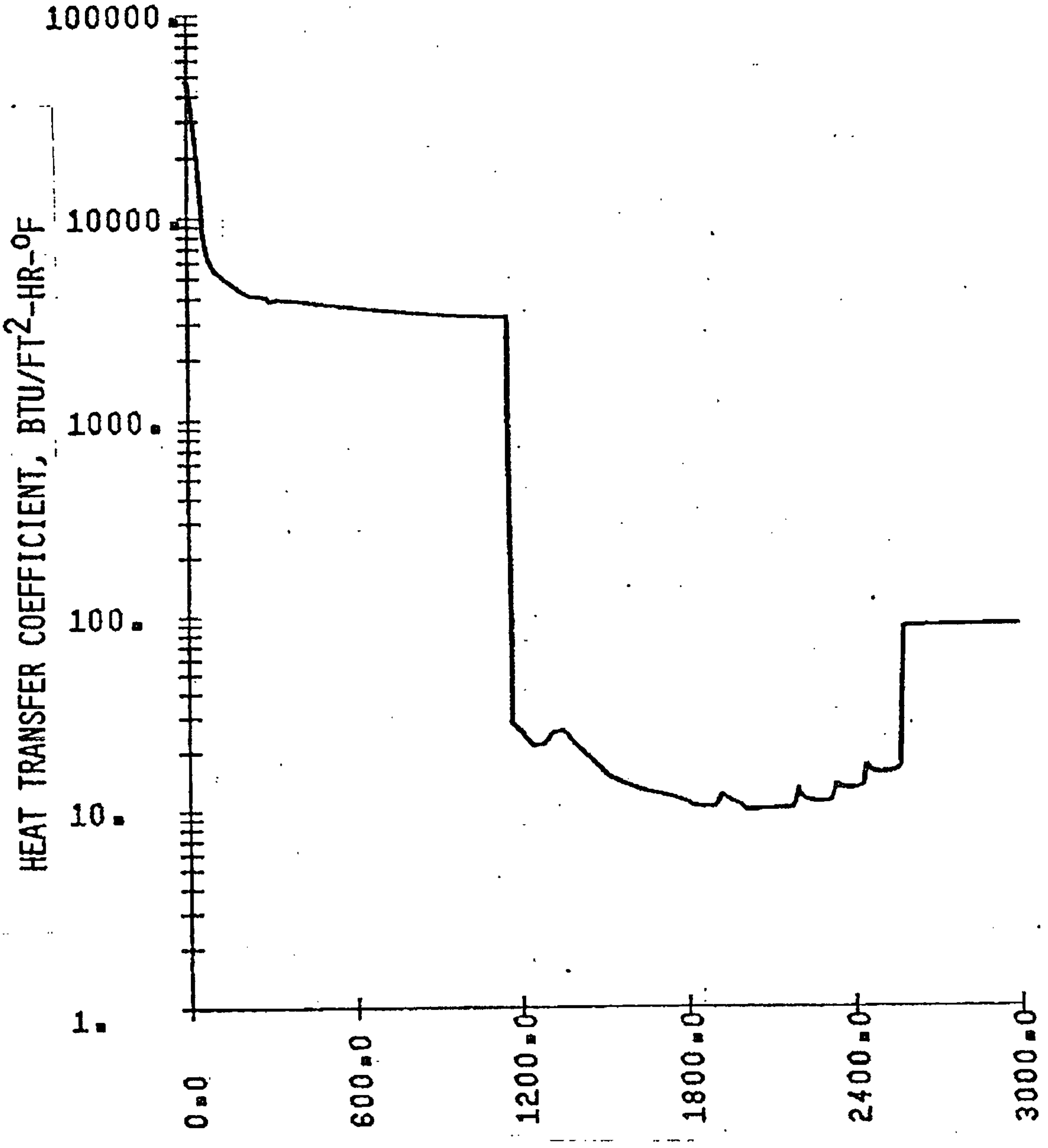


FIGURE B-4G
MILLSTONE 2
0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
COOLANT TEMPERATURE AT HOT SPOT
(SMALL BREAK ANALYSIS)

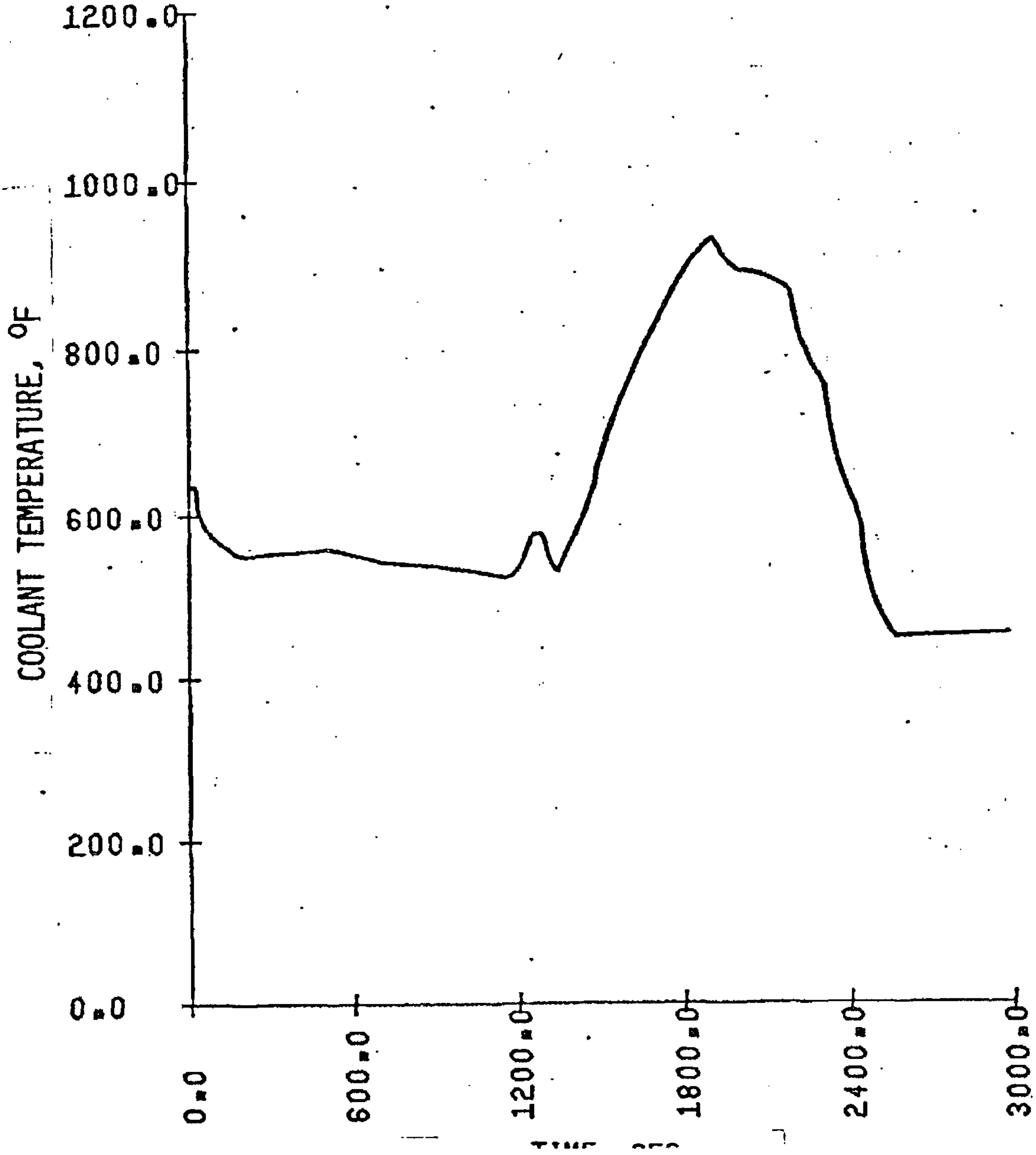


FIGURE B-4H

MILLSTONE 2

0.05 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
HOT SPOT CLAD SURFACE TEMPERATURE
(SMALL BREAK ANALYSIS)

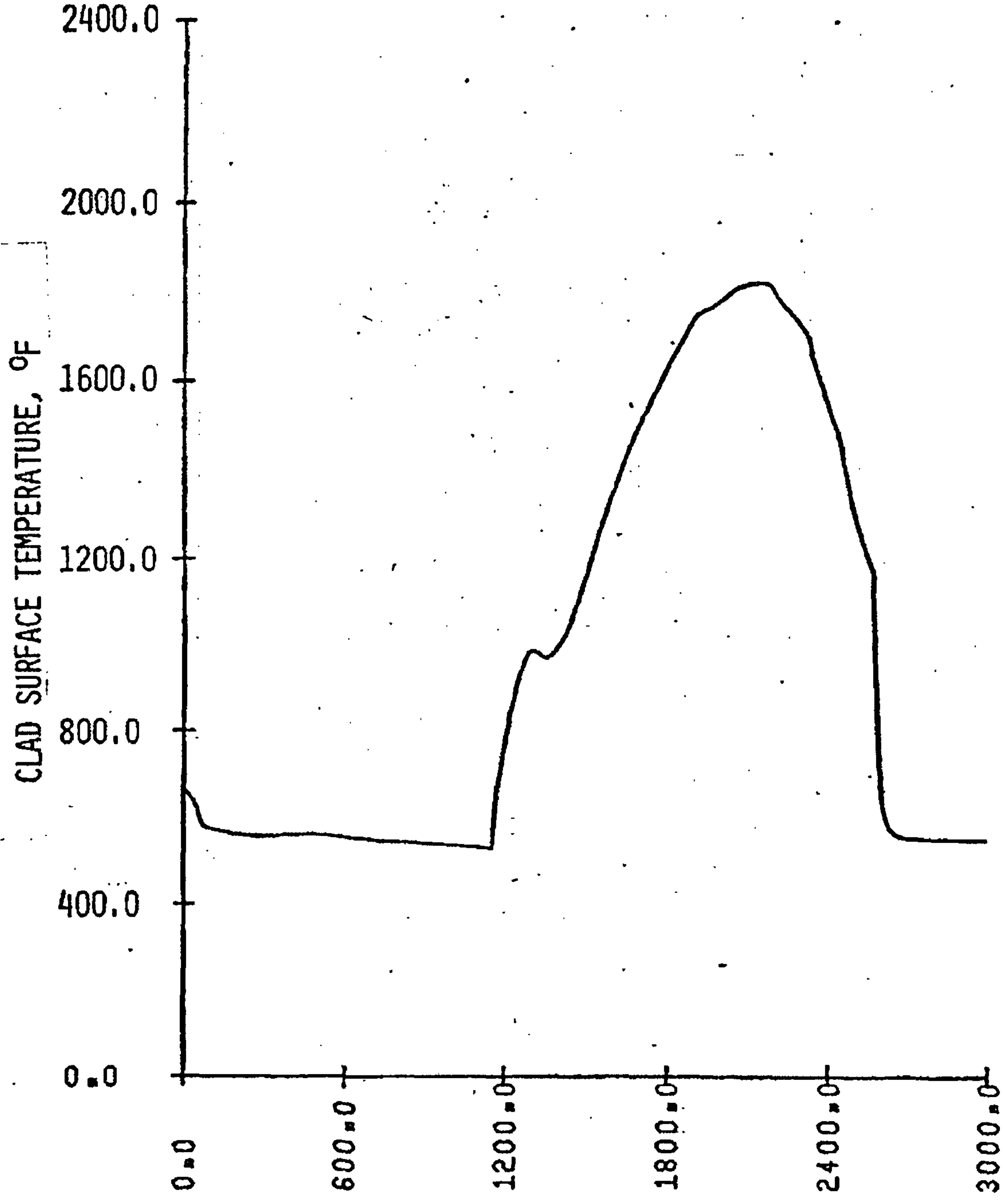


FIGURE B-5A

MILLSTONE 2

0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE NORMALIZED TOTAL CORE POWER (SMALL BREAK ANALYSIS)

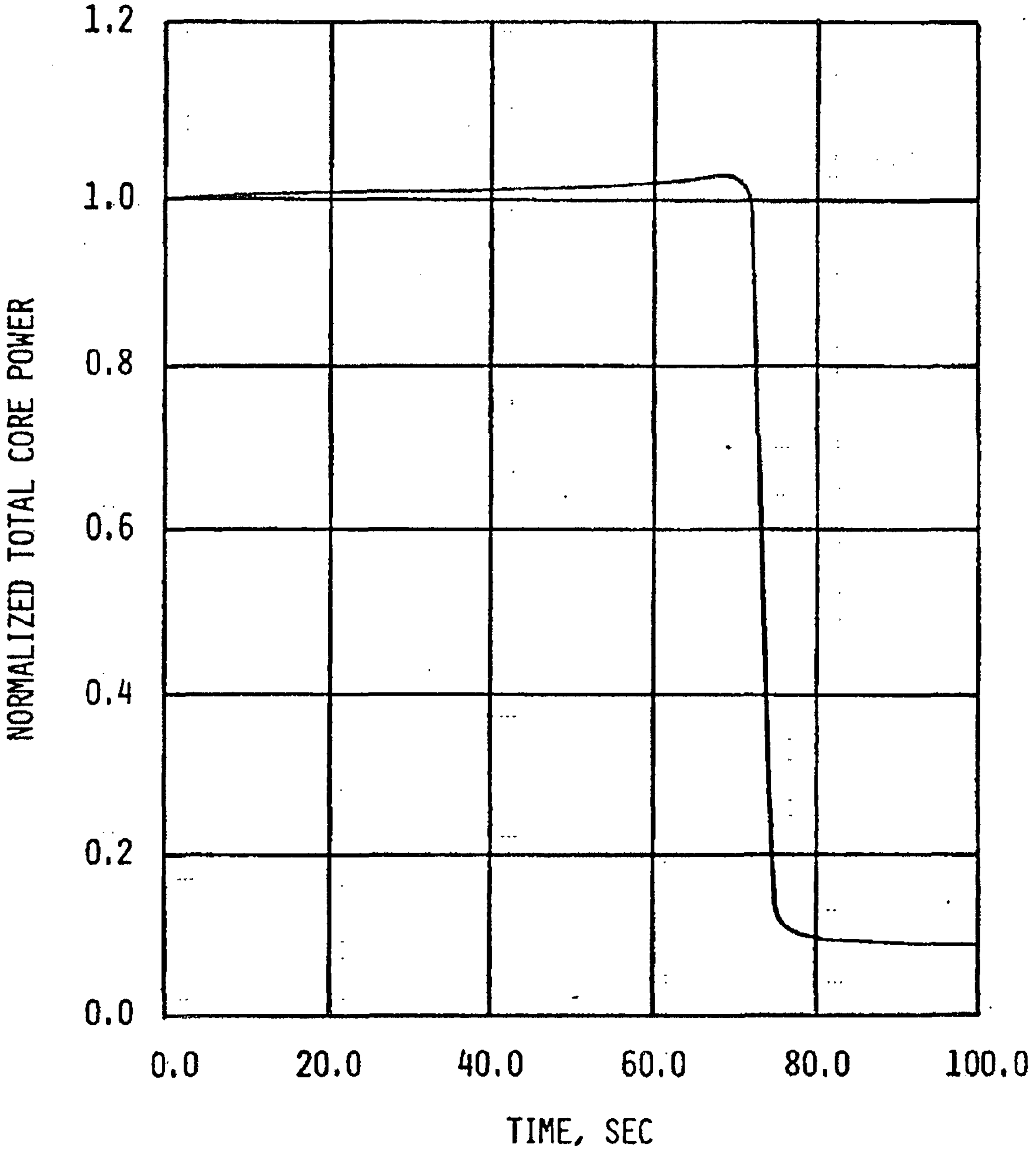


FIGURE B-5B

MILLSTONE 2

0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL PRESSURE
(SMALL BREAK ANALYSIS)

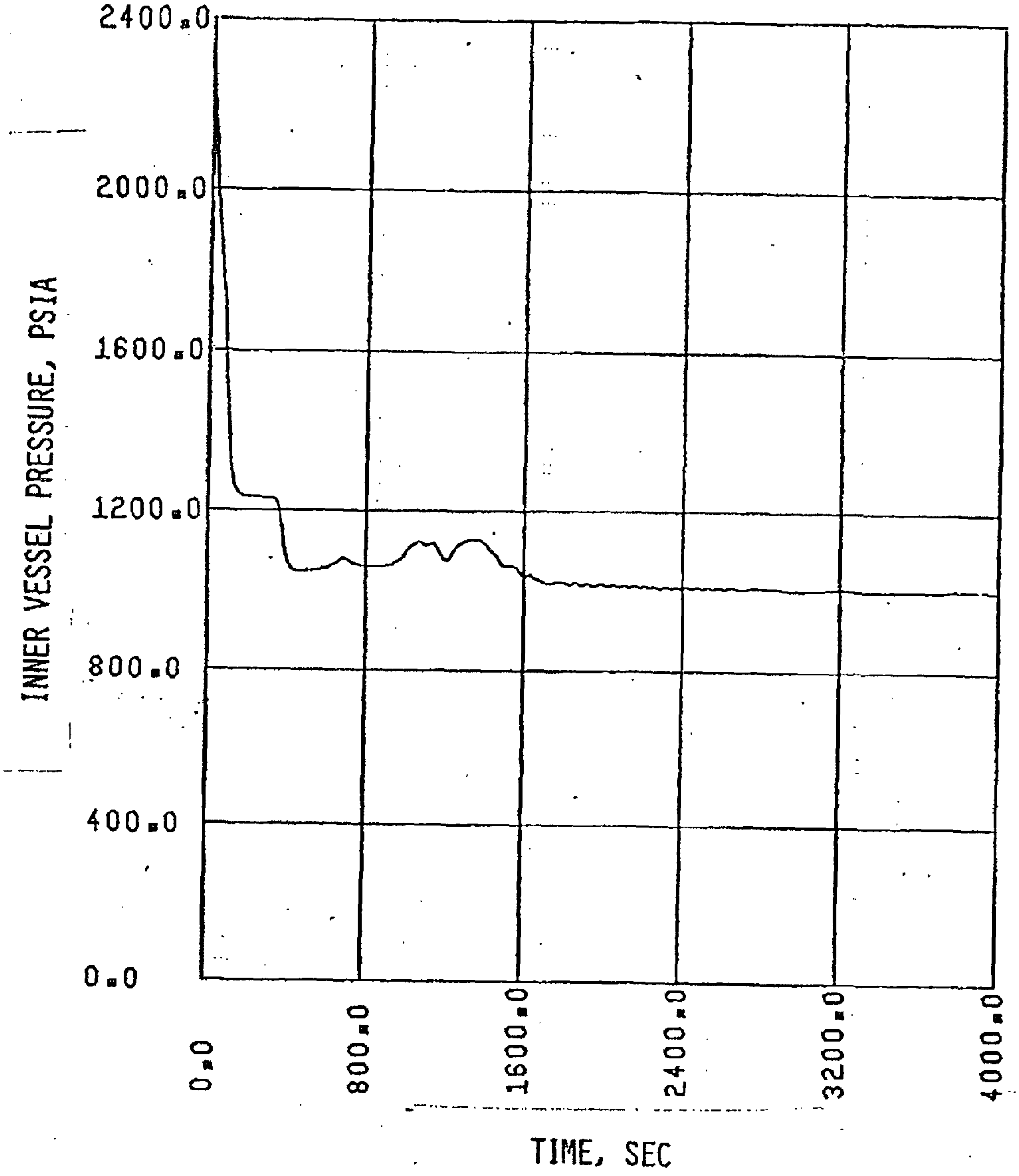


FIGURE B-5C
MILLSTONE 2
0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
BREAK FLOW RATE
(SMALL BREAK ANALYSIS)

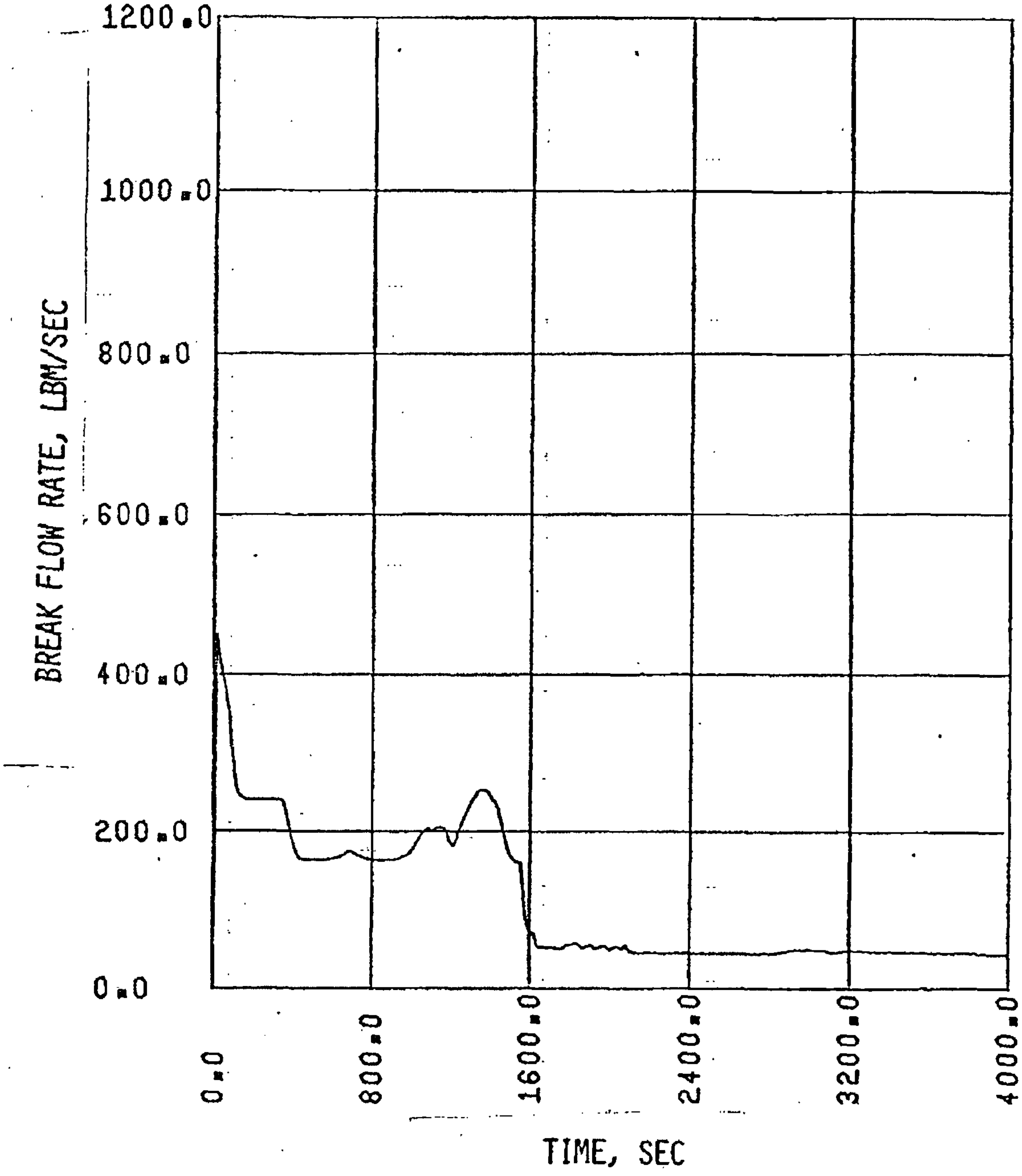


FIGURE B-5D

MILLSTONE 2

0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE INNER VESSEL INLET FLOW RATE (SMALL BREAK ANALYSIS)

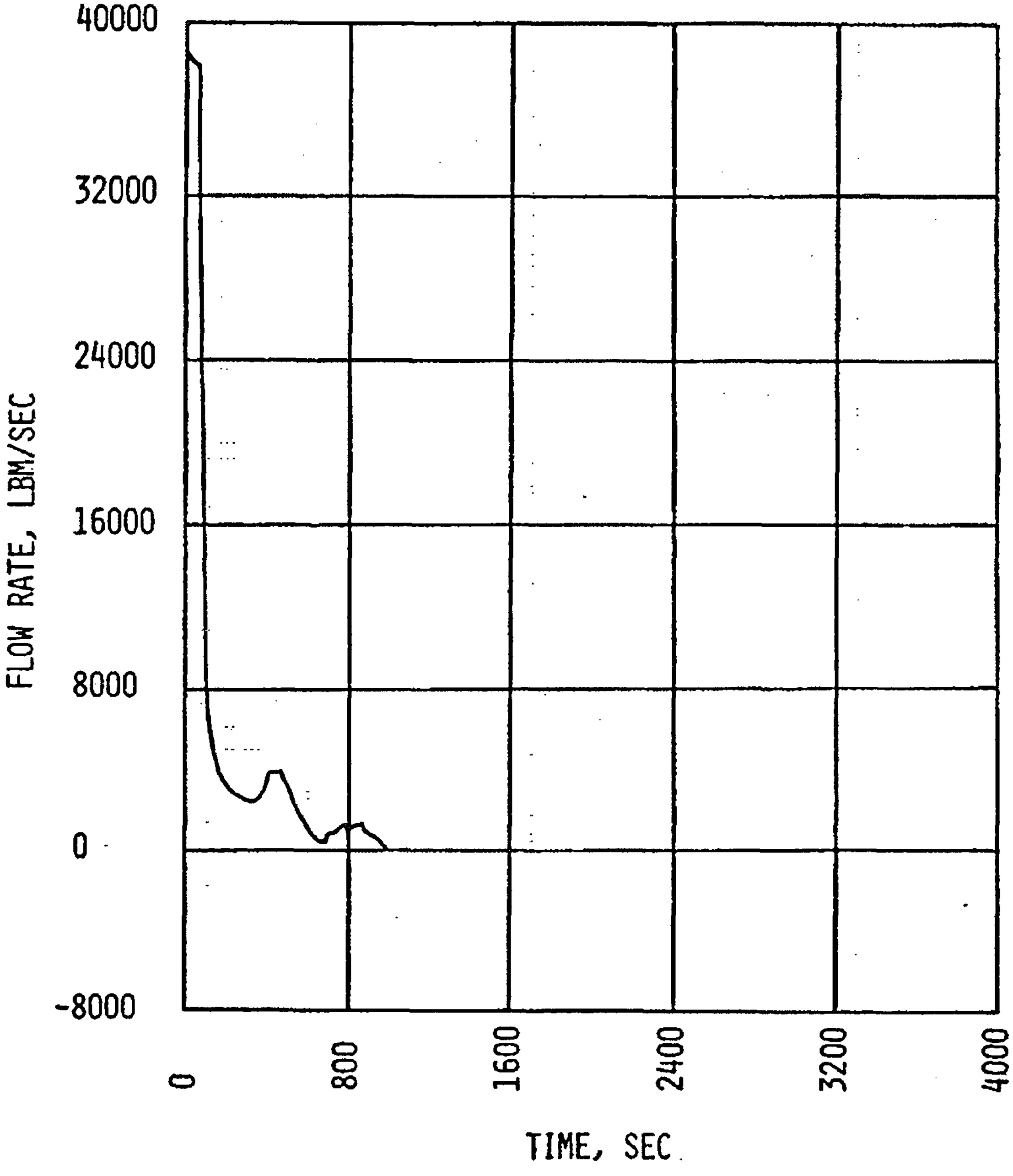


FIGURE B-5E

MILLSTONE 2

0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
INNER VESSEL TWO-PHASE MIXTURE VOLUME
(SMALL BREAK ANALYSIS)

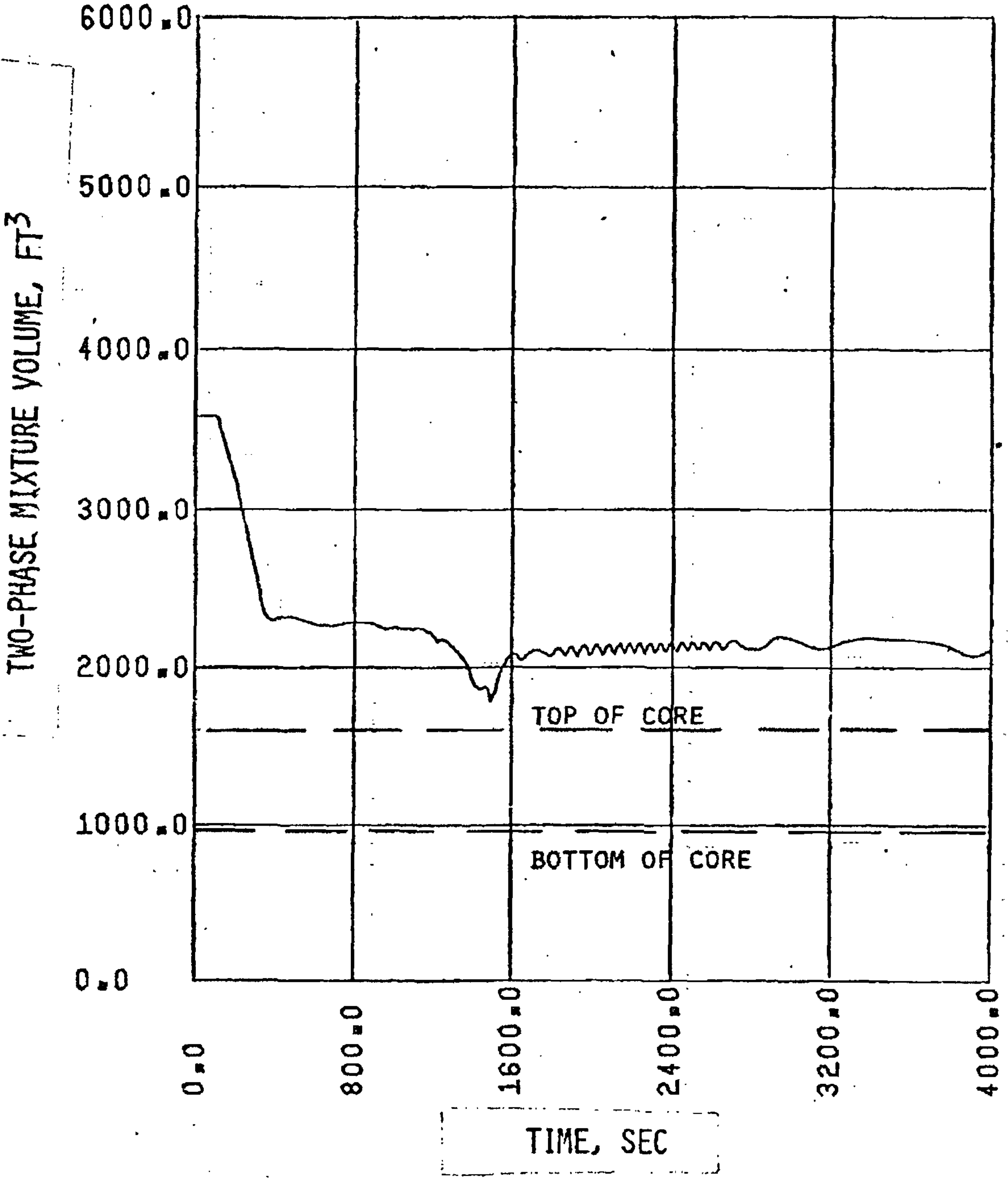


FIGURE B-5F

MILLSTONE 2

0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE HEAT TRANSFER COEFFICIENT AT HOT SPOT (SMALL BREAK ANALYSIS)

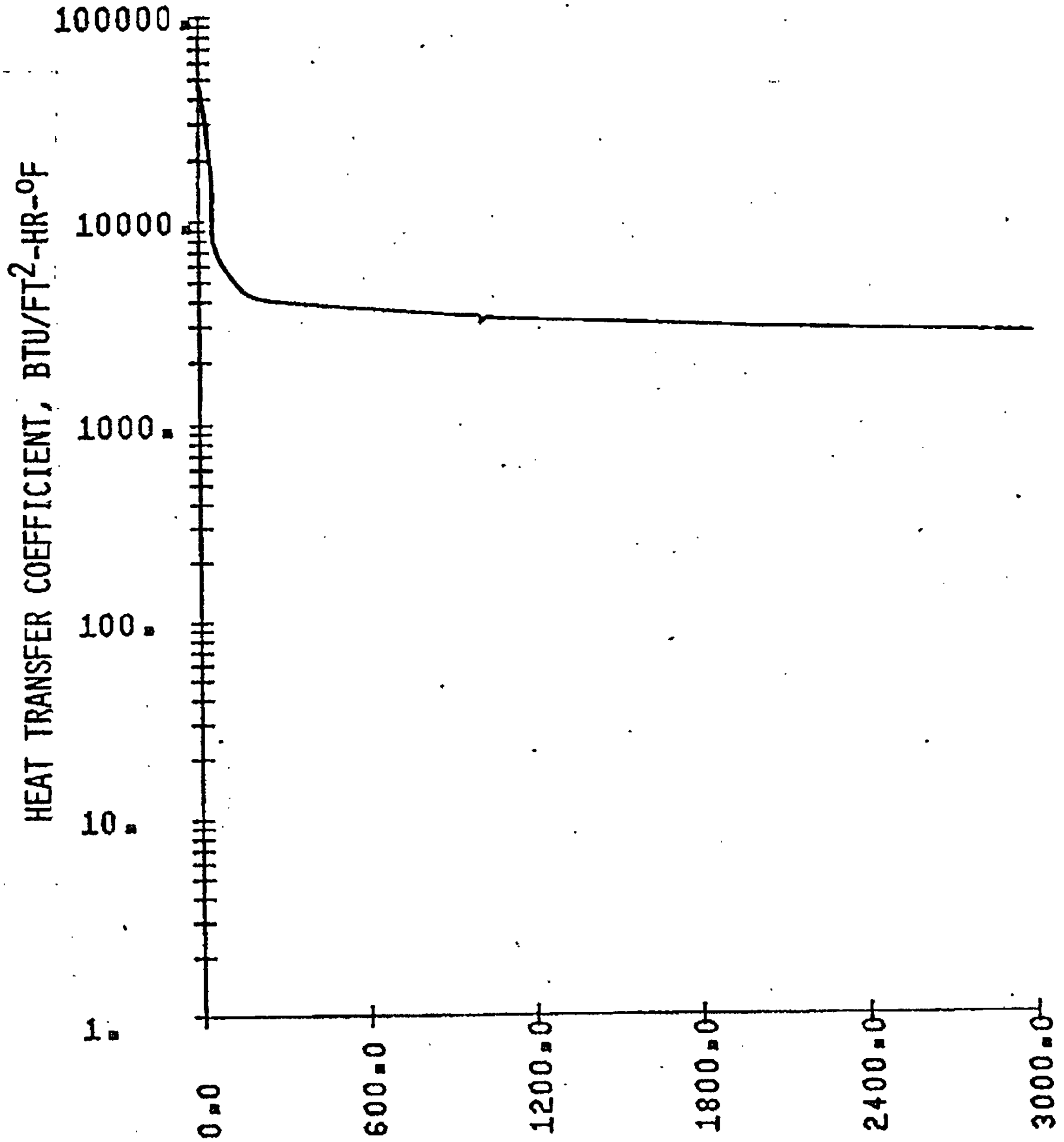


FIGURE B-5G
MILLSTONE 2
0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE
COOLANT TEMPERATURE AT HOT SPOT
(SMALL BREAK ANALYSIS)

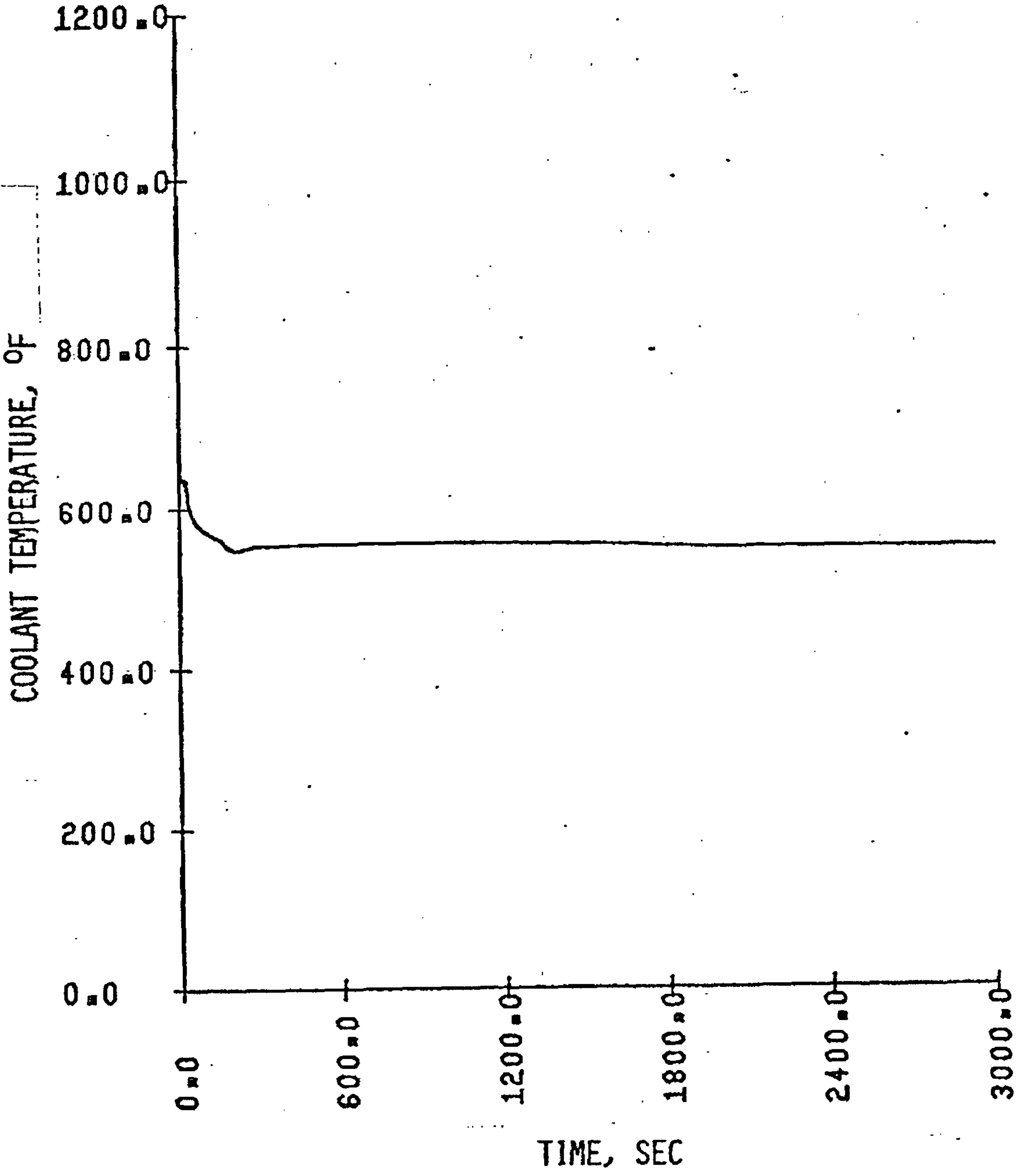


FIGURE B-5H
MILLSTONE 2
0.02 FT^2 COLD LEG BREAK AT PUMP DISCHARGE HOT SPOT CLAD SURFACE TEMPERATURE
(SMALL BREAK ANALYSIS)

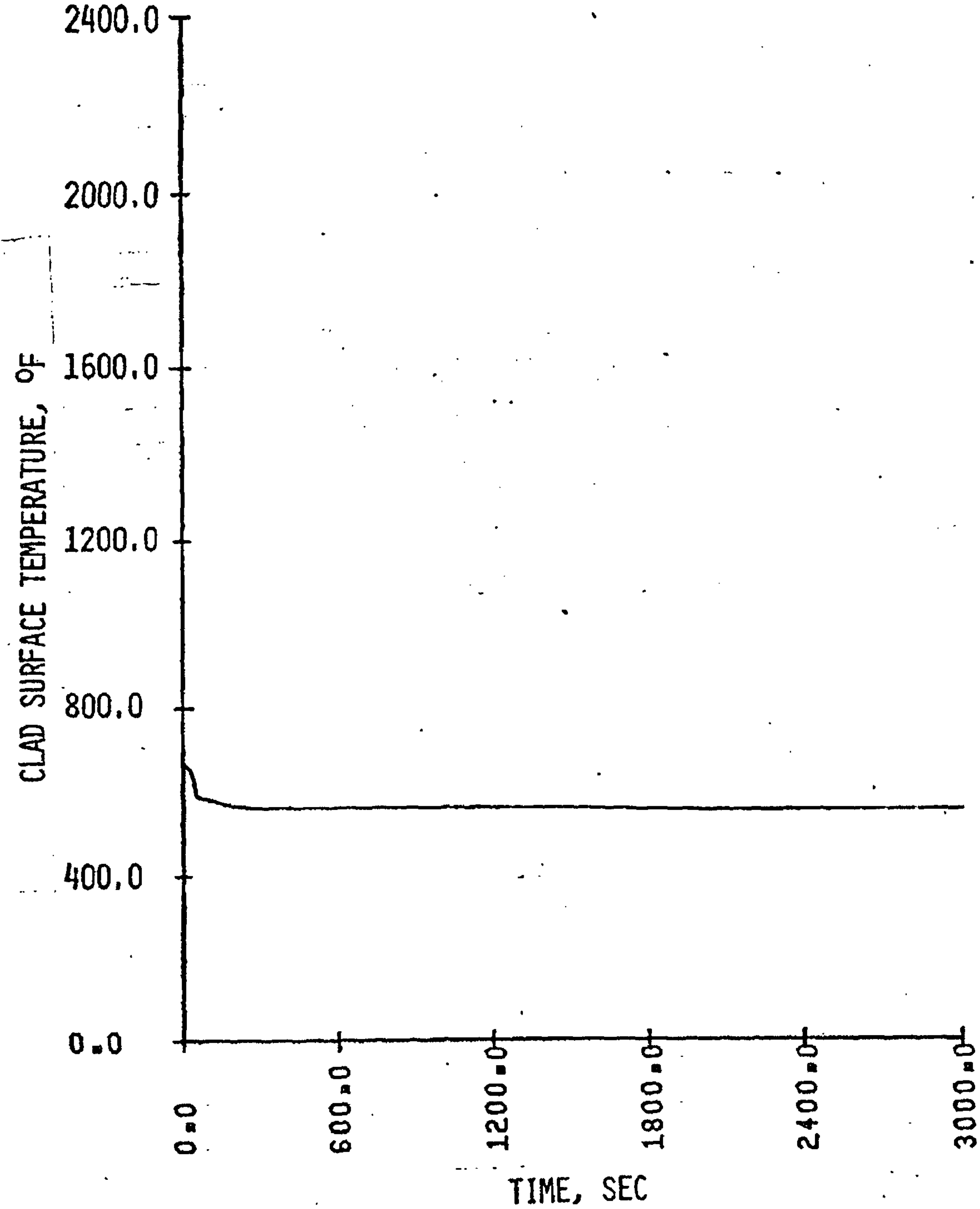
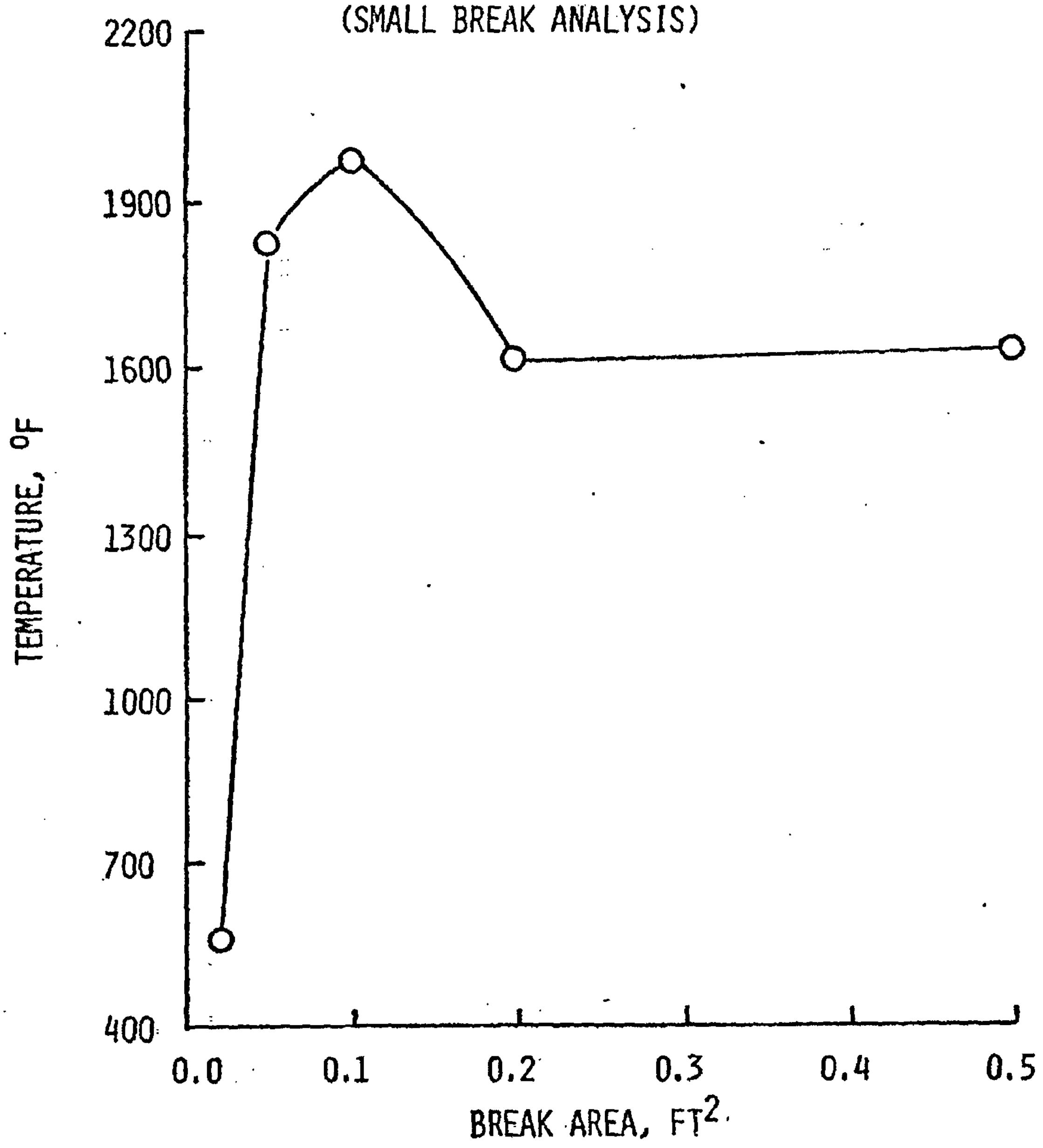


FIGURE B-6

MILLSTONE 2

MAXIMUM HOT SPOT CLAD TEMPERATURE VS BREAK SIZE

(SMALL BREAK ANALYSIS)



ATTACHMENT 2
COMBUSTION ENGINEERING, INC
FUEL ENGINEERING DEPARTMENT
TRANSIENT METHODS AND LOCA
CALCULATION NUMBER 19367-TML-039 REVISION 0

MAY 8, 1990
(39 PAGES)

Combustion Engineering, Inc.
Nuclear Power Systems
QUALITY RECORD
Date 5/14/90 Initials

NEA12302

COMBUSTION ENGINEERING, INC.
FUEL ENGINEERING DEPARTMENT
TRANSIENT METHODS AND LOCA

Page 1

Contract 19367

Calculation 39 pages
Appendix 1 — pages
Appendix 2 — pages
Appendix 3 — pages
Fiche 9 pages

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Computer Run Summary Pg 10

Calculation Number 19367-TML-039 Revision -0-

Title St. Lucie 1 HPSI Pump System Flow Degradation: Retrospective Analysis

Author FRED COHEN Date May 8, 1990

Calculation contains safety related design information:
✓ Yes ___ No
The safety related design information contained in this document has been reviewed and satisfies (where applicable) the items contained on checklist(s) 2, —, and — of the Quality Assurance Procedures Manual. This review is so certified.

Independently Reviewed by T. J. Robert Luh Date 5-8-90

Approved by J D Young Title Supv Date 5-9-90
Distribution QA Files

Summary Purpose: To determine if St. Lucie 1 was operating safely with a degraded HPSI Pump System.

Method of Review: X Design Review ___ Alternate Analysis ___ Testing
___ Other (specify) ___

Results of Review:
The results and calculations in this recorded calculation have been reviewed and conform to the QAPM Procedures Checklist #2. The calculations, computer code input and results are correct.

ABSTACT

Purpose

The purpose of this analysis is to perform a realistic assessment to show that if a Small Break Loss-of-Coolant Accident (SBLOCA) had occurred with the High Pressure Safety Injection System (HPSIS) in a degraded condition as found by recent testing(1), the system performance would be adequate to be in compliance with 10CFR 50.46 acceptance criteria(7).

Method

The method employed was to use the NRC approved C-E SBLOCA model (References 2-5) modified to use ANS 5.1-1979 decay heat

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power (with + 2σ uncertainty) in place of the 120 percent of the 1971 ANS proposed standard.

A few key limiting plant parameter are based on worst measured values. These are shown in Calculation Input section.

Assumption's

Assumption's used are the same as those stated in CENPD-137 - References 2 and 3 - except as stated above.

Results

The analysis demonstrates acceptable ECCS performance criteria as stated in 10 CFR 50.46. This analysis explicitly accounts for 500 tubes plugged per steam generator. (From previous experience this analysis should hold for up to(6) 700 tubes plugged per steam generator).

The results are as follows:

Peak Clad Temperature < 1763 °F at 1580.5 sec. in Node 17.

Peak Local Oxidation < 3% in Node 18.
Node 18 ruptures at ~ 1495 sec.

These values are well within NRC acceptance criteria of 10 CFR 50.46(7) which are as follows:

Peak Clad Temperature ≤ 2200 °F

Peak Local Oxidation ≤ 17%.

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INTRODUCTION

Testing of the St. Lucie Unit 1 HPSIS valves on February 3, 1990 by Florida Power & Light showed that HPSI Pump flow rates were below those assumed in the SBLOCA safety analysis of record(6). Since the test of February 3, 1990, the flow rates for the Unit 1 HPSI pumps have been restored to levels which bound the SBLOCA safety analysis(1). Before commencing Cycle 10 operation it is necessary to asses the condition of the plant during past cycles when the reduced HPSI flow rates are assumed to have been present. This analysis will address safety concerns regarding past operation of the unit with regard to a SBLOCA.

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RESULTS

A retrospective analysis of the St. Lucie Unit 1 plant was performed using Appendix K models — References 2-5 — with best-estimate decay heat standard (ANS 5.1-1979 decay heat power with + 2σ uncertainty) and a few key plant parameters based on worst measured values. The results from this analysis are as follows:

Peak Clad Temperature < 1763°F
at 1580.5 sec at Node 17.
Peak Local Clad Oxidation < 3%
at Node 18.

Rupture occurs in Node 18 at 1495 seconds.
Safety Injection Tanks actuated at 1450 seconds
(A conservative recovery of two-phase level used after SIT's come on - see PARCH calculation Section).

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RESULTS - Cont.

The computer codes used to generate these results are as follows:

CE FLASH-4AS Version # 84135LIC
PARCH Version # 35018LIC

The run identifications are provided on the following page.

The results of this analysis are well within the Acceptance Criteria of Reference 7.

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Catalogued microfiche included as part of this calculation

Run	User Hash	JSN*	Run Date	Pgs	Description	Log No.
1	AL3A	DJPN	4/3/90	8	CEFLASH-4AS	06284
2	AL3A	AFHQ	4/10/90	1	PARCH	06285
3						
4						
5						
6						
7						
8						
9						
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						
Total				9		

*JSN–Job Sequence Number

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CALCULATIONAL INPUTS

The small break LOCA analysis of record for St. Lucie Unit 1(6) is based on the NSSS of Millstone-2 being essentially identical to St. Lucie Unit 1 and the ECCS performance characteristics of St Lucie Unit 1 being equivalent to or bounding that of Millstone-2.(8) The present analysis is based on St. Lucie Unit 1's NSSS being essentially identical to Calvert Cliffs Unit 1 Cycle 10.(14) {Calvert Cliffs actually has 40.0ft³ less of liquid volume above the core - per Ref. 19 which is negligible} The "as-found" HPSI'S performance as well as St. Lucie Unit 1's worst measured operating values of a few key parameters will be imposed on the Calvert Cliffs Unit 1 Cycle 10 plant.(9) Both plants have limiting small break LOCA sizes of 0.1 ft² in the pump discharge

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CALCULATIONAL INPUTS - cont.

Ref(8,9): The worst measured operating parameters used in their analyses are:

- most negative ASI power shape at full power
- Low Pressurizer Pressure Trip Set-point.
- Low Pressurizer SIAS Set-point
- MTC of $+0.2 \times 10^{-4}\ \Delta\rho/°F$
- Full Insertion Time of Control Rods: 3.1 sec.
- Peak Linear Heat Generation Rate of 13.91 kW/ft.
- The Charging Pumps are actuated on SIAS and therefore credit for a single Charging Pump (loss of off-site power and failure of one diesel-generator to start accounted for in SBLOCA Analysis) at a flow of 40 gpm.

(Data for these items are from Reference 10)

Further details of these values are given in the CE FLASH-4AS and PARCH Input descriptions following.

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CALCULATIONAL INPUTS - cont.

A-CEFLASH-4AS Inputs

1 - Axial Power Shape (Vector Inputs 5191-5192)

The Axial Power Shape used is given in Attachment 1 to Reference 10 as shown on page 16. This data was plotted per Figure 1 (pg.18). The data points for CEFLASH-4AS was taken from Figure 1 and given in Table 1 (pg.17).

2 - HPSI "As Found" Flow (Vector Inputs 10021-10029)

From Reference 10, Attachment 2, (pg.19) the HPSI run-out flow for most limiting pump (Pump 1B) is 535 gpm. St. Lucie 1 licensing calculation is based on a HPSI pump performance resulting in 640 gpm(8) (480 gpm delivered to three legs with 25% spillage) or the 'as found' run-out flow was 55 gpm below the run-out flow of the licensing calculation. The entire HPSI pump performance curve used in the licensing calculation is shown in Table 2 as derived from Reference 3. The HPSI pump performance curve used for this analysis was conservatively constructed by reducing the licensing pump performance flow by 55 gpm at all pressures. This is also shown in Table 2. Again from Attachment 2 of Reference 10, the minimum flow to lowest 3 lines (break assumed in line receiving most flow - line 1A 1) is 388 gpm at run-out conditions or a percent spillage of 33.7%. This percentage of spillage is assumed at all pressures, the resulting minimum flow to three legs is also shown in Table 2.

Until the break uncovers (system pressure >1000 psia break essentially covered) no spillage from pump has to be credited. Therefore to sys. pressure of 1100 psia no spillage is credited and between 1100 psia and 1009 psia the HPSI flow is held constant at 195.0 gpm, the no-spillage flow at 1100 psia

Vector Inputs 10041-10042

Credit of 40 GPM was taken for Charging Pump throughout pressure range since charging pumps inject flow into cold legs 1A 2&1B 1 (the broken leg is 1A1 which results in minimum delivered flow to RCS).

ATTACHMENT 1

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DATA for FIG. 1

```
St Lucie Unit 1 Cycle 8


Snapshot = A559035
Date = 4-22-87


ASI = -0.0361 ASIU
Peak Fz = 1.2685 @ X/L = 0.583
PLHR = 14.31 KW/FT          Includes: Augmentation Factor 1.029
                                      Uncertainty  Factor 1.124
                            Full Power Average LHR of     6.331


Power Distribution Summary by Axial Level

Node      Average   Peak      Fxy
K         Power     Pin
-----------------------------------

      24    0.185     0.440     2.379
      23    0.650     1.147     1.765
      22    0.856     1.382     1.615
      21    0.999     1.607     1.609
      20    1.095     1.756     1.604
      19    1.159     1.850     1.596
      18    1.204     1.912     1.588
      17    1.234     1.953     1.583
      16    1.255     1.977     1.576
      15    1.265     1.992     1.574
      14    1.268     1.994     1.572
      13    1.262     1.981     1.570
      12    1.252     1.962     1.568
      11    1.234     1.931     1.565
      10    1.214     1.898     1.564
       9    1.188     1.857     1.564
       8    1.153     1.802     1.563
       7    1.111     1.736     1.563
       6    1.056     1.650     1.563
       5    0.987     1.549     1.569
       4    0.894     1.410     1.577
       3    0.762     1.212     1.590
       2    0.580     1.020     1.757
       1    0.136     0.380     2.738
```

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Table 1

Axial Power Shape - Vector Inputs 5191 - 5192

From Figure 1

% From Bottom of Core	Axial Peaking Factor	
10	0.75	
20	1.05	
30	1.139	
40	1.22	
50	1.255	
60	1.263	
70	1.225	input as 1.228 minor error No effect on results R. Luh 5/2/90
80	1.11	
90	0.825	
	9.842	

∴ 0 & 100% 0.158 (normalize shape)

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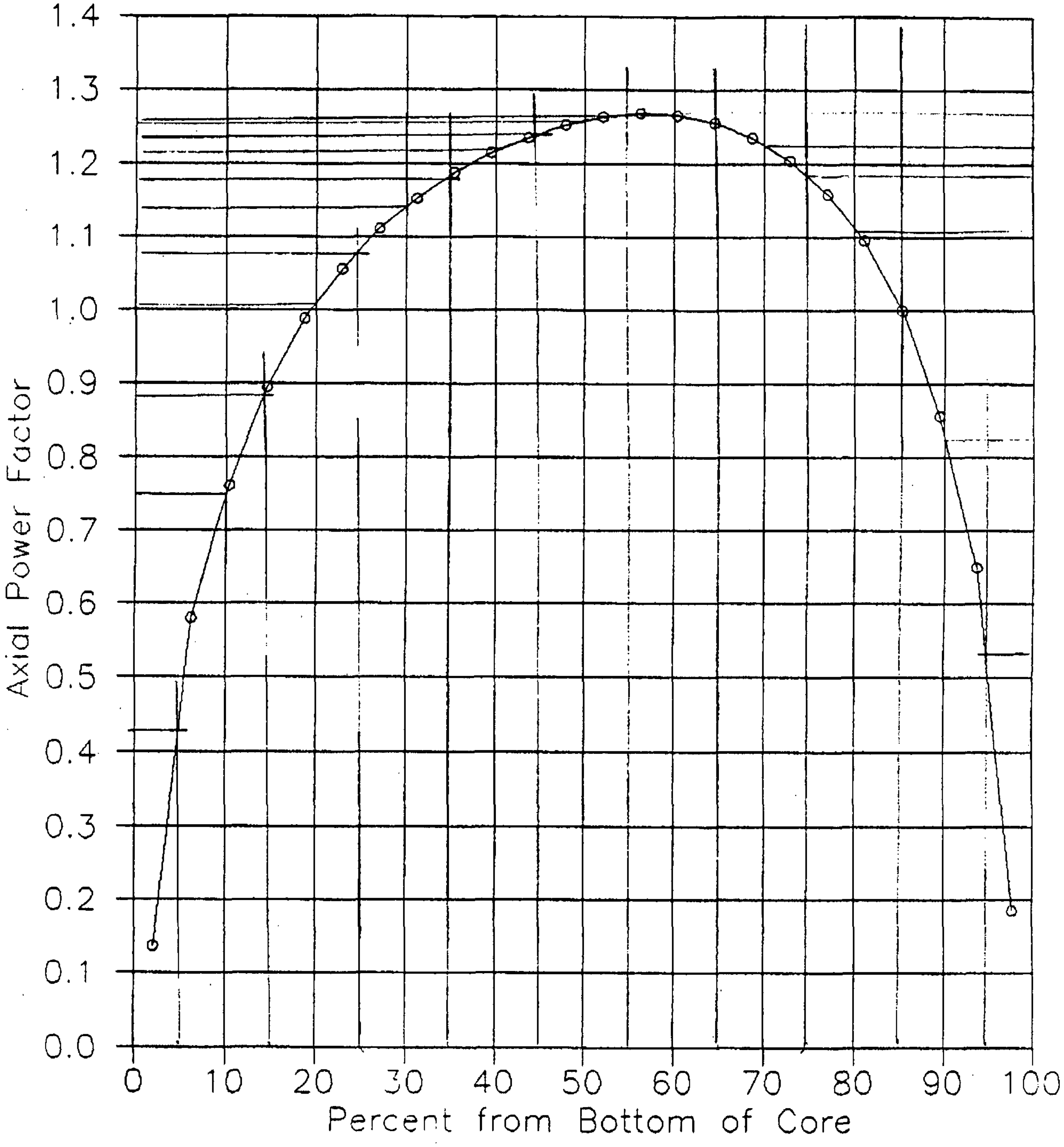
FIGURE 1

St. Lucie Unit 1 Cycle 8
Axial Power Distribution



ATTACHMENT 2

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Attachment to
JPN-PSL-90-0371
Page 1 of 1

AS-FOUND CONDITION OF HPSI FLOW PERFORMANCE PER TECH STAFF TEST T-40 RESULTS OF 2-3-90 (REFERENCE NCR #1-387)

RCS LOOP[2]	FLOW RATES HPSI PUMP 1A	HPSI PUMP 1B[3,4]
1A1	205 gpm	195 gpm
1A2	135 gpm	110 gpm
1B1	110 gpm	165 gpm
1B2	152 gpm	110 gpm
Gross Total	602 gpm	580 gpm
Corrected Total[1] (4 lines)	607 gpm	585 gpm
Corrected Lowest 3 Lines[1]	400 gpm	388 gpm

Notes:

[1] The above flowrates represent HPSI flow at runout conditions (RCS pressure - 14.7 psia). The corrected total considers the effects of instrument error, increased reactor water level (from accident assumptions), and shutdown cooling being in service during the test.

[2] For information purposes, the charging system is normally aligned to deliver a total flow of 44 gpm to the 1A2 and 1B1 RCS cold legs.

[3] For analysis purposes, assume a degraded pump performance curve parallel to those curves utilized in the groundrules.

[4] 1C HPSI pump not tested. However, 1B HPSI pump results would envelope the 1C HPSI pump.

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TABLE 2

HPSI Pump Performance for St. Lucie 1

Present Licensing Calc.*		'As-Found' Condition (Pump 1B)	To Three Legs (Break in Leg 1A1)
Pressure psia	Flow gpm	Flow gpm	Flow gpm
14.7	640.0	585.0	388.0
200.0	590.7	535.7	355.0
400.0	530.7	475.7	315.0
600.0	470.7	415.7	276.0
800.0	400.0	345.0	229.0
1000.0	314.7	259.7	172.0
1100.0	250.7	195.7 ← [input in 1950 minor error] c luh 5/2/90	+ 130.0
1150.0	210.7	155.7	+ 103.0
1200.0	140.0	** 85.0	+ ** 56.0
1250.0	0.0	(1230 psia) 0.0	(1230 psia) 0.0

** Based on extrapolation of degraded curve.

+ These values not input as zero spillage considered to system pressures of 1100 psia - see page 15.

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* Calc. No. 19367-LOCA-022, "St. Lucie I Stretch Power Small Break LOCA Analysis", T. A. Morgan, Dec. 28, 1979.

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3- Set-points

a- The Low Pressurizer Set-Point for Trip used in the analysis is 1728 psia
(1750 psia − 22 psi uncertainty) per Reference 10.

∴ Reactor Trip is initiated at an RCS pressure of 1728 psia (Vector input 6001)

& Steam Generators are isolated (main feedwater flow and turbine steam admission valves closed)
(Vector input 7011)

& Main Reactor Coolant Pumps shut down
(Vector input 8006).

b- SIAS is initiated on Low Pressurizer Pressure set point of 1578 psia
(1600 psia − 22. psi uncertainty) per Ref. 10

The delay for Safety Injection same as BG&E - 30 seconds.
Vector Inputs 10001 & 10011-10013. References 9&10

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4- Secondary Relief Valve Setpoint

St. Lucie Unit 1 Secondary Relief Valve Setpoint is 1000 psia. Conservatively left at BG&E setpoint value of 1010 psia (Reference 9). Vector location 4941.

5- Moderator Temperature Coefficient (MTC)

St. Lucie Unit 1 most positive MTC at full power is $+0.2 \times 10^{-4}\ \Delta\rho/°F$ (Reference 10). The St. Lucie Unit 2 most positive MTC at full power is $+0.3 \times 10^{-4}\ \Delta\rho/°F$(11). The St. Lucie Unit 2 moderator density vs. reactivity was used for this analysis,(12) as given in Table 3. The density was corrected to agree with the steady state density predicted by base deck.

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Vector Locations 11001 - 11006

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TABLE 3

Moderator Density vs. Reactivity

F2 Reactivity(*) Δk/k	Density(*) lbm/ft³	F2 Corrected Density(**) lbm/ft³
- 0.38999	0.0	0.0
- 0.24183	4.254	4.025
- 0.13921	10.497	10.268
- 0.07186	16.739	16.51
- 0.03093	22.982	22.753
- 0.00897	29.225	28.996
- 0.00410	31.722	31.493
- 0.00097	34.219	33.99
0.00073	36.716	36.487
0.00122	39.213	38.984
0.00074	41.71	41.452
0.0	43.303	43.074(**)
- 0.00055	44.208	43.979
- 0.00249	46.705	46.476
- 0.00368	47.953	47.722
- 0.00368	50.0	50.0
- 0.00368	60.0	60.0

Should be 41.481 minor error R. Luh 5/2/90

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* From Calc. No. 13172-LOCA-028 – Reference 12.

** From Run No. AL3ADJPN, Fiche No. 06284, the density at steady state is 43.074 lbm/ft³. Density curve therefore shifted by 0.229 lbm/ft³ (43.303 - 43.074) lbm/ft³.

6 - Full Insertion Time of Control Rods
(Vector Locations 6021 - 6025)

The full insertion time of control rods for St. Lucie Unit 1 is 3.1 seconds(10). The full insertion time for the control rods used in the Calvert Cliffs Unit 1 Cycle 10 analysis(9) is 2.68 seconds. For this analysis the time scale for rod insertion vs. reactivity was scaled up 3.1/2.68 relative to BG&E Unit 1 Cycle 10 analysis. Rod insertion was initiated ½ second following reactor trip.

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7- ANS 5.1 - 1979 Decay Heat $+2\sigma$
(Vector Location 6002)

The ANS 5.1 - 1979 Decay Heat $+2\sigma$ decay heat fractions were used in place of the 1971 ANS proposed standard with 20% uncertainty. This is discussed in Reference 13. As also shown in Reference 13, the 1979 Decay Heat $+2\sigma$ uncertainty is approximately equivalent to the 1971 ANS standard without uncertainty. Therefore in the CEFLASH-4AS run, the multiplication factor on decay heat was changed to unity - no uncertainty on the 1971 ANS standard or essentially the 1979 standard plus 2σ uncertainty.

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B- PARCH Inputs

1- '79 + 2σ Standard Decay Heat Fractions
(Vector locations 401 - 425)

As discussed in CE-FLASH 4AS Inputs, The ANS 5.1-1979 Decay Heat + 2σ was used in this analysis and it is equivalent to the 1971 ANS standard with no uncertainty accounted for. The 1971 ANS standard is given in Table 4 and was obtained from Reference 9, removing the 20% uncertainty.

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Table 4

Nominal Decay Heat Fractions Based on 1971 ANS Standard

Time sec. Vec. Loc's. 201-225	Decay Heat Fraction Vec. Loc's 401-425
0.0	0.07200
1.0	0.06600
4.0	0.06000
10.0	0.05300
20.0	0.04800
30.0	0.04400
40.0	0.04200
50.0	0.04000
60.0	0.03850
70.0	0.03750
80.0	0.03650
90.0	0.03550
100.0	0.03500
200.0	0.03050
300.0	0.02800
400.0	0.02650
500.0	0.02500
600.0	0.02400
700.0	0.02350
800.0	0.02250
900.0	0.02200
1000.0	0.02150
2000.0	0.01800
3000.0	0.01600
4000.0	0.01490

2 - Axial Power Shape
(Vector Locations 122 - 142)

The axial power shape is discussed in CEFLASH-4AS Inputs section. The below axial power factors are from Figure 1 of that section.

Table 5

Elevation from BOC %		Axial Power Factor	
0.0		0.106	
5.0		0.428	
10.0		0.750	
15.0		0.882	
20.0		1.050	
25.0		1.075	
30.0		1.139	
35.0		1.180	
40.0		1.220	
45.0		1.240	
50.0		1.255	
55.0		1.268	
60.0		1.268	
65.0		1.260	
70.0		1.225	
75.0		1.185	
80.0	95.0	1.110	0.534
85.0	100.0	1.000	0.106
90.0		0.825	

3- Vector 9 Power for Hot Channel Calculation Switched to ANS Decay Heat Curve

Vector 9 = 28.535 seconds

{Reference: From CEFLASH-4AS Run
AL3A/DJPN - 4/3/90}

4- Vector 22 Radial Peaking Factor (F_R)

From Table 5, the axial peak $=_s 1.268 = F_{AX}$.

From Reference 10, peak KW/ft = 13.91.

Also from Ref. 10 (Attachment 1), avg. KW/ft = 6.331

$$F_R = \frac{\text{Peak KW/ft}}{\text{Avg. KW/ft} \times F_{AX}}$$

or $$F_R = \frac{13.91}{6.331 \times 1.268} = 1.732.$$

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5- Vector 19

$$\text{Vector } 19 = \underbrace{\frac{0.944}{1.07}}_{\text{Ref 9}} \times F_R = \frac{0.944}{1.07} \times 1.732$$

or Vector 19 = 1.528

6- The Mixture Level, Pressure, and Liquid Mass.

These Tables are from CE-FLASH-4AS Run AL3A/DJPN, 4/3/90.

These values are given in Table 6.

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TABLE 6
PARCH TABLES
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Vector Locations

251-265, 301-315, 351-365	501-515	451-465	551-565
Time seconds	Mixture Level* ft	Pressure psia	Liquid Mass lbm
0.0	11.392	606.9	70889
600.0	11.392	605.9	70889
640.0	11.392	~~570.4~~ 574.4 (minor error) No signif. effect R Lwh 5/2/90	68754
670.0	10.647	553.4	68265
700.0	10.009	532.0	67546
750.0	9.084	496.7	66505
800.0	8.404	462.6	65744
870.0	7.829	413.5	65409
930.0	7.459	339.6	65188
1040.0	7.219	336.9	64703
1160.0	6.845	286.0	65113
1300.0	6.723	243.2	66152
1450.0	6.835	215.1	67954
2500.0	11.392	215.1	67954

FROM CE-FLASH-4AS Run AL3A/DJPN, 4/3/90, Fiche No. 06284, Node 1.

* Height of Lower Plenum is 10.063 ft.

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