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RECIP.NAME RECIPIENT AFFILIATION
EISENHUT,D.G. Division of Licensing

SUBJECT: Forwards reanalysis of large break LOCA w/ungridded BART model & comparison of results w/& w/o grid mode,per 830823 telcon.Analysis provides addl info for BART Tech Spec amend.

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FLORIDA POWER & LIGHT COMPANY

September 20, 1983
L-83-492

Office of Nuclear Reactor Regulation
Attention: Mr. Darrell G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Eisenhut:

Re: Turkey Point Units 3 and 4
Docket No. 50-250 and 50-251
Additional Analyses (LOCA with Ungridded BART Model)
For $F_{\Delta H}$/BART Technical Specification Amendment

We discussed the proposed $F_{\Delta H}$/BART Technical Specification Amendment request with your staff in a telephone conversation on August 23, 1983. Please find attached a re-analysis of the large break LOCA with ungridded BART model and a comparison of results with and without the grid model as requested in that conversation.

Very truly yours,

J. A. DeMastry

for Robert E. Uhrig
Vice President
Advanced Systems α Technology

REU/JEM/mpc

Attachments

cc: J. P. O'Reilly, Region II
Harold F. Reis, Esquire

A030
1/1

SAFETY ANALYSIS FOR TURKEY POINT UNIT 3 AND 4
LOSS-OF-COOLANT ACCIDENT

The loss-of-coolant accident (LOCA) has been reanalyzed for Turkey Point Unit 3 and 4 in order to remove the BART computer code fuel assembly grid model from the large break LOCA evaluation model used. Documentation of the BART grid model can be found in reference 12. The following report amends the section of the Safety Analysis Report on major reactor coolant system pipe ruptures (Chapter 14.3.2). The analysis presented here is in accordance with the requirements of 10CFR50.46, Appendix K provided in reference 1.

A description of the various aspects of the LOCA analysis is presented in WCAP-8839 (reference 2). The Revised PAD Fuel Thermal Safety Model, described in reference 3, generates the initial fuel rod conditions. The individual computer codes which comprise the Westinghouse Emergency Core Cooling System (ECCS) Evaluation Model are described in detail in references 4, 5, 6, 7, and 8. Code modifications are specified in reference 9. The results of several sensitivity studies are reported in reference 10. These results are for conditions which are not limiting in nature and hence are reported on a generic basis.

The LOCA analysis presented in this report utilized a modified version of the 1981 Westinghouse ECCS Evaluation Model[11]. This version includes the BART[12] computer code which is a mechanistic core heat transfer model. BART calculates the reflood heat transfer normally performed by the WREFLOOD[6] computer code.

Results

The analysis of the loss-of-coolant accident is performed at 102 percent of the licensed core power rating. The peak linear power and total core power used in the analysis are given in Table 2.

Table 1 presents the occurrence time for various events throughout the accident transient.

Table 2 presents selected input values and results from the hot fuel rod thermal transient calculation. For these results, the hot spot is defined as the location of maximum peak clad temperatures. That location is specified in Table 2 for the break case analyzed. The location indicated in feet is the elevation above the bottom of the active fuel stack.

Table 3 presents a summary of the various containment system parameters and structural parameters which were used as input to the COCO computer code[7] used in this analysis.

Tables 4 and 5 present reflood mass and energy releases to the containment, and the broken loop accumulator mass and energy release to the containment, respectively.

Figures 1 through 17 present the transients for the principle parameters for the break case analyzed. The following items are noted:

Figures 1-3:	Quality, mass velocity and clad heat transfer coefficient for the hot spot and burst locations.
Figures 4-6	Core pressure, break flow, and core pressure drop. The break flow is the sum of the flowrates from both ends of the guillotine break. The core pressure drop is taken as the pressure just before the core inlet to the pressure just beyond the core outlet.
Figures 7-9	Clad temperature, fluid temperature and core flow. The clad and fluid temperatures are for the hot spot and burst location.

Figures 10-11 Downcomer and core water level during reflood and flooding rate.

Figures 12-13 Emergency core cooling system flowrates, for both accumulator and pumped safety injection.

Figures 14-15 Containment pressure and core power transient.

Figures 16-17 Break energy release during blowdown and the containment wall condensing heat transfer coefficient for the worst break.

Conclusions - Thermal Analysis

For break up to and including the double-ended severance of a reactor coolant pipe, the Emergency Core Cooling System will meet the Acceptance Criteria as presented in 10CFR50.46(1). That is:

1. The calculated peak clad temperature does not exceed 2200°F based on a total core peaking factor of 2.32.

2. The amount of fuel element cladding that reacts chemically with water or steam does not exceed one percent of the total amount of Zircaloy in the reactor.

3. The localized cladding oxidation limit of 17 percent is not exceeded during or after quenching.

4. The core remains amenable to cooling during and after the break.

5. The core temperature is reduced and decay heat is removed for an extended period of time, as required by the long-lived radioactivity remaining in the core.

References

1. "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Nuclear Power Reactors," 10CFR50.46 and Appendix K of 10CFR50.46. Federal Register, Volume 39, Number 2, January 4, 1974.

2. Bordelon, F. M., Massie, H. W., and Zordan, T. A., "Westinghouse ECCS Evaluation Model-Summary," WCAP-8339, July 1974.

3. Rahe, E. P., Westinghouse Letter to C. O. Thomas of NRC, Letter No. NS-EPR-2673, October 27, 1982, Subject: "Westinghouse Revised PAD Code Thermal Safety Model," WCAP-8720 Addendum 2 (Proprietary).

4. Bordelon, F. M., et al., "SATAN-VI Program: Comprehensive Space-Time Dependent Analysis of Loss-of-Coolant," WCAP-8302 (Proprietary Version), WCAP-8306 (Non-Proprietary Version), June 1974.

5. Bordelon, F. M., et al., "LOCTA-IV Program: Loss-of-Coolant Transient Analysis," WCAP-8301 (Proprietary Version), WCAP-8305 (Non-Proprietary Version), June 1974.

6. Kelly, R. D., et al., "Calculational Model for Core Reflooding After a Loss-of-Coolant Accident (WREFLOOD Code)." WCAP-8170 (Proprietary Version), WCAP-8171 (Non-Proprietary Verison), June 1974.

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

8. Young, M. Y., et al., "BART-A1: A Computer Code for the Best Estimate Analysis of Reflood Transients," WCAP-9561 (Proprietary Version), WCAP-9695 (Non-Proprietary Version), January 1980.

9. Bordelon, F. M., et al., "The Westinghouse ECCS Evaluation Model: Supplementary Information," WCAP-8471 (Proprietary Version), WCAP-8472 (Non-Proprietary Version), January 1975.

10. Salvatori, R., "Westinghouse ECCS - Plant Sensitivity Studies," WCAP-8340 (Proprietary Version), WCAP-8356 (Non-Proprietary Version), July 1974.

11. Eicheldinger, C., "Westinghouse ECCS Evaluation Model, 1981 Version," WCAP-9220-P-A (Proprietary Version), WCAP-9221-A (Non-Proprietary Version), Revision 1, December 1981.

12. Rahe, E. P., Westinghouse Letter to C. O. Thomas of NRC, Letter No. NS-EPR-2806, August 12, 1983, Subject: "BART Grid Model Verification Report and Additional Responses," (Proprietary).

TABLE 1

LARGE BREAK
TIME SEQUENCE OF EVENTS

	DECLG $C_D = 0.4$ (sec)
START	0.00
Rx Trip Signal	0.72
S. I. Signal	1.20
Acc. Injection	15.10
End of Blowdown	31.50
Bottom of Core Recovery	51.50
Acc. Empty	60.10
Pump Injection	26.20

TABLE 2

LARGE BREAK

Results	DECLG $C_D = 0.4$
Peak Clad Temperature ^{o}F	1972
Peak Clad Location Ft.	6.25
Local Zr/H_2O Rxn (max)%	5.43
Local. Zr/H_2O Location Ft.	6.00
Total Zr/H_2O Rxn %	< 0.30
Hot Rod Burst Time sec	42.40
Hot Rod Burst Location Ft.	6.00

Calculation	
NSSS Power MWt 102% of	2200
Peak Linear Power kw/ft 102% of	12.96
Peaking Factor (At License Rating)	2.32
Accumulator Water Volume (per accumulator)	875 ft^3

Fuel region + cycle analyzed	Cycle	Region
Unit 3	9	All
Unit 4	10	All

CONTAINMENT DATA (DRY CONTAINMENT)

Net Free Volume	1.55×10^6 Ft^3
Initial Conditions	
Pressure	14.7 psia
Temperature	90.0 °F
RWST Temperature	39.0 °F
Service Water Temperature	63.0 °F
Outside Temperature	39.0°F
Spray System	
Number of Pumps Operating	2
Runout Flow Rate	1450 gpm
Actuation Time	26 sec.
Safeguards Fan Coolers	
Number of Fan Coolers Operating	3
Fastest Post Accident Initiation of Fan Coolers	26 secs.

STRUCTURAL HEAT SINK DATA

Wall	Material	Thickness (in)	Area (Ft²)
1	Paint	0.006996	
	Carbon Steel	0.2898	87335.8
2	Carbon Steel	0.006996	1000086.0
3	Paint	0.006996	
	Carbon Steel	0.4896	35660.11
4	Carbon Steel	0.4896	12367.5
5	Paint	0.006996	
	Carbon Steel	0.2898	
	Concrete	24.0	50430.0
6	Carbon Steel	0.2898	
	Concrete	24.0	16810.0
7	Paint	0.006996	
	Carbon Steel	1.56	4622.69
8	Carbon Steel	1.56	1540.89
9	Paint	0.006996	
	Carbon Steel	5.496	1277.87
10	Carbon Steel	5.496	425.93
11	Paint	0.006996	
	Carbon Steel	2.748	951.525

STRUCTURAL HEAT SINK DATA

Wall	Material	Thickness (in)	Area (Ft^2)
12	Carbon Steel	2.748	317.175
13	Paint	0.006996	
	Carbon Steel	0.03	23550.0
14	Paint	0.006996	
	Carbon Steel	0.063	80368.5
15	Paint	0.006996	
	Carbon Steel	0.10	42278.25
16	Carbon Steel	0.2898	17190.0
17	Stainless Steel	0.032	113253.4
18	Stainless Steel	2.1264	3704.0
19	Stainless Steel	0.1398	
	Concrete	24.0	14392.0
20	Concrete	24.0	59132.0

TABLE 4

REFLOOD MASS AND ENERGY RELEASES

DECLG $C_D = 0.4$

Time (sec)	$\dot{M}_{total}$ (lbm/sec)	$\dot{M}h_{total}$ (Btu/sec)
51.482	0.000	0.00
52.507	0.027	34.85
53.807	1.997	2586
64.704	54.230	68502
80.104	67.540	84583
97.404	79.540	99075
115.004	90.750	112590
132.404	116.980	128811
149.504	255.360	166280
194.954	325.320	173172
445.154	370.560	158947

TABLE 5

DECLG C_D=0.4

Broken Loop Injection Spill During Blowdown

THE BROKEN LOOP INJECTION SPILL DURING BLOWDOWN IS

TIME	MASS	ENERGY	ENTHALPY
0.000	3535.277	210914.639	59.660
1.010	3141.651	187430.924	59.660
2.010	2860.790	170674.748	59.660
3.010	2644.289	157758.278	59.660
4.010	2470.732	147403.882	59.660
5.010	2327.014	138829.651	59.660
6.010	2204.531	131522.319	59.660
7.010	2098.115	125173.549	59.660
8.010	2004.118	119565.664	59.660
9.010	1920.165	114557.023	59.660
10.010	1844.473	110041.277	59.660
11.010	1775.820	105945.393	59.660
12.010	1713.335	102217.588	59.660
13.010	1656.217	98809.927	59.660
14.010	1603.810	95683.328	59.660
15.010	1555.497	92800.962	59.660
16.010	1510.806	90134.687	59.660
17.010	1469.260	87656.030	59.660
18.010	1430.312	85332.398	59.660
19.010	1393.989	83165.360	59.660
20.010	1360.196	81149.315	59.660
21.010	1328.768	79274.276	59.660
22.010	1299.586	77533.298	59.660
23.010	1272.391	75910.839	59.660
24.010	1246.995	74395.704	59.660
25.010	1223.331	72983.901	59.660
26.010	1201.261	71667.223	59.660
27.010	1188.372	68705.285	57.815
28.010	1169.855	67596.183	57.782
29.010	1152.163	66536.555	57.749
30.010	1135.222	65521.964	57.717
31.010	1119.132	64558.282	57.686

Figure 1. Fluid Quality
DECLG(CD = 0.4)

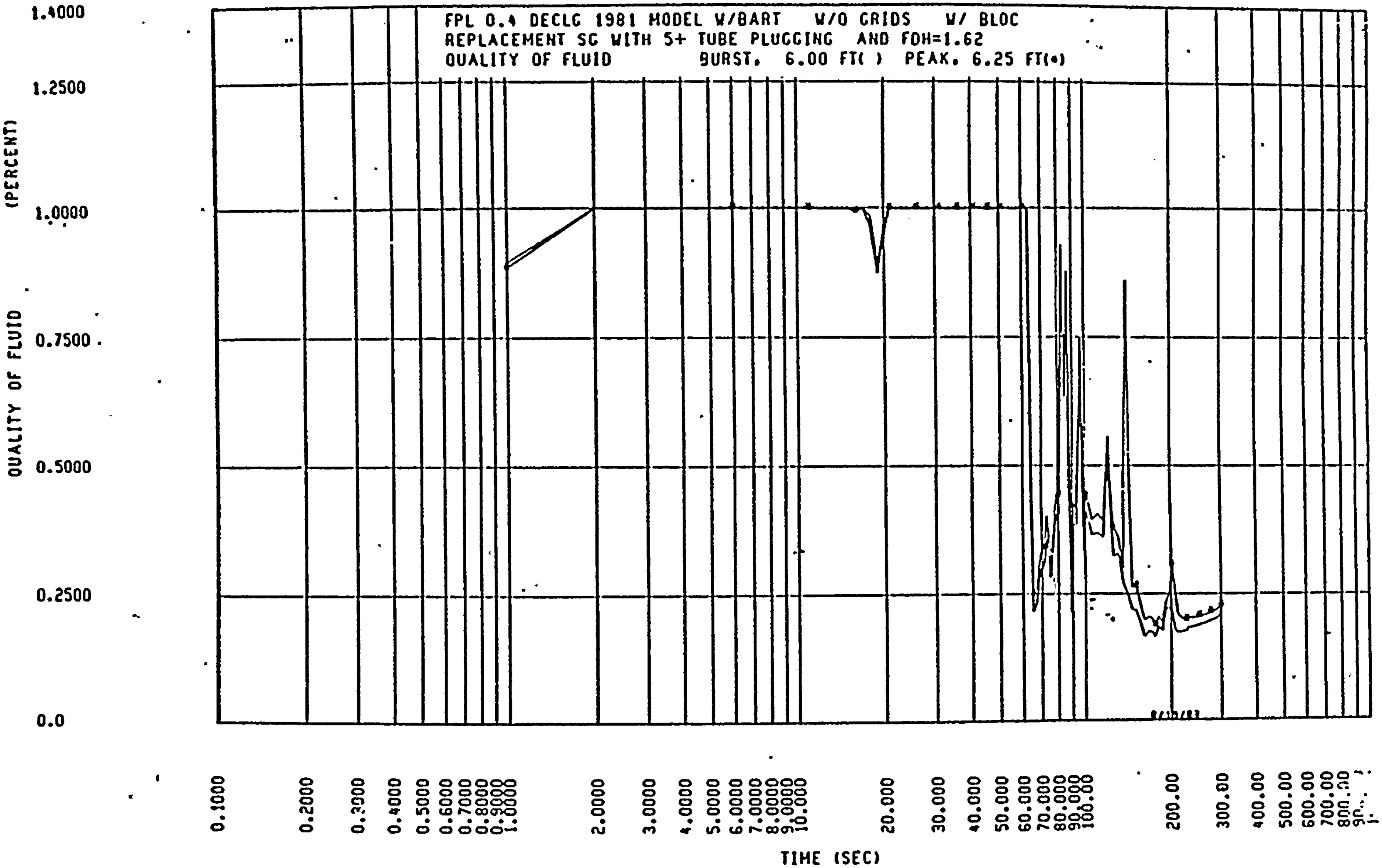


Figure 2. Mass Velocity
DECLG(CD = 0.4)

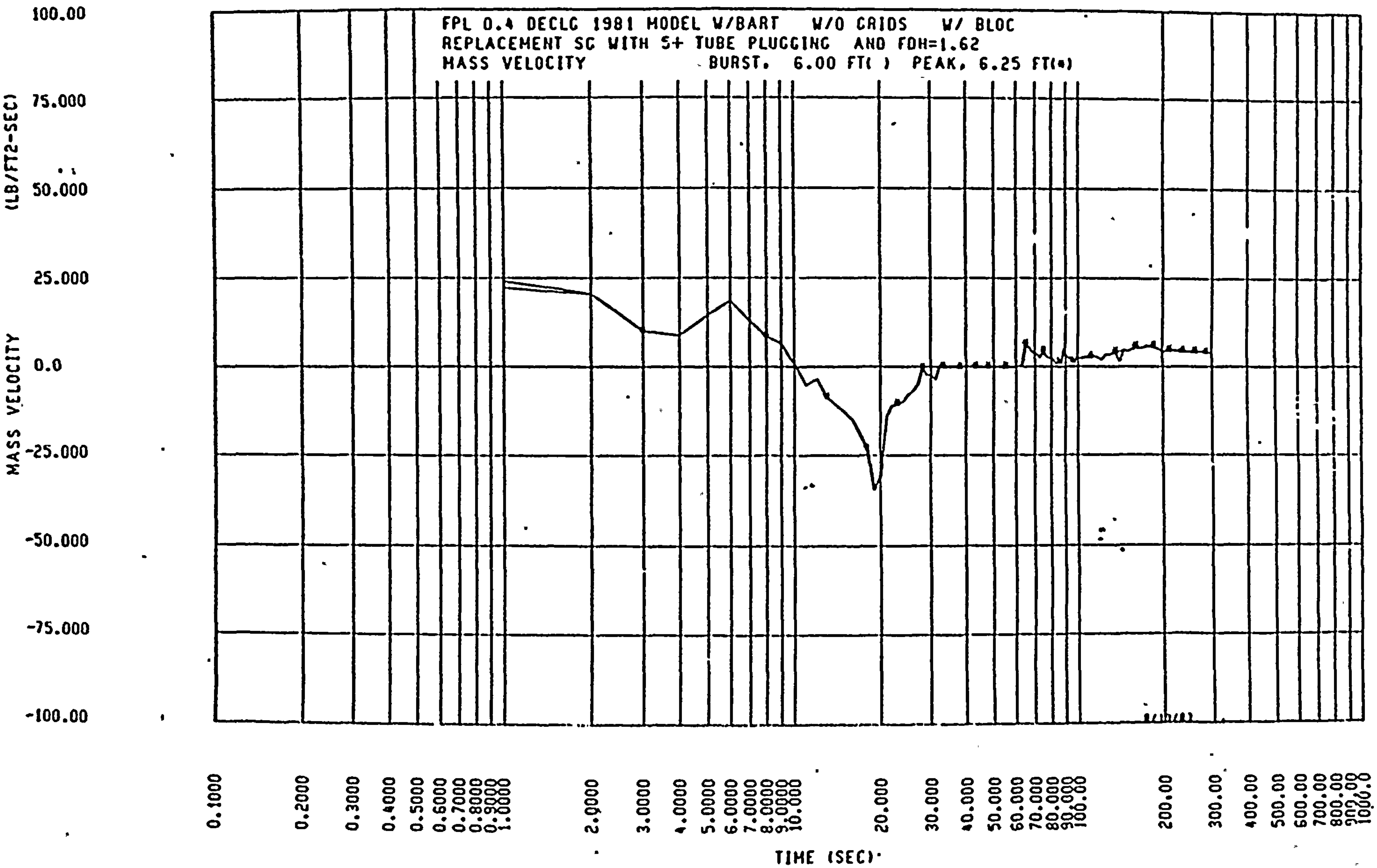


Figure 3. Heat Transfer Coefficient DECLG(CD = 0.4)

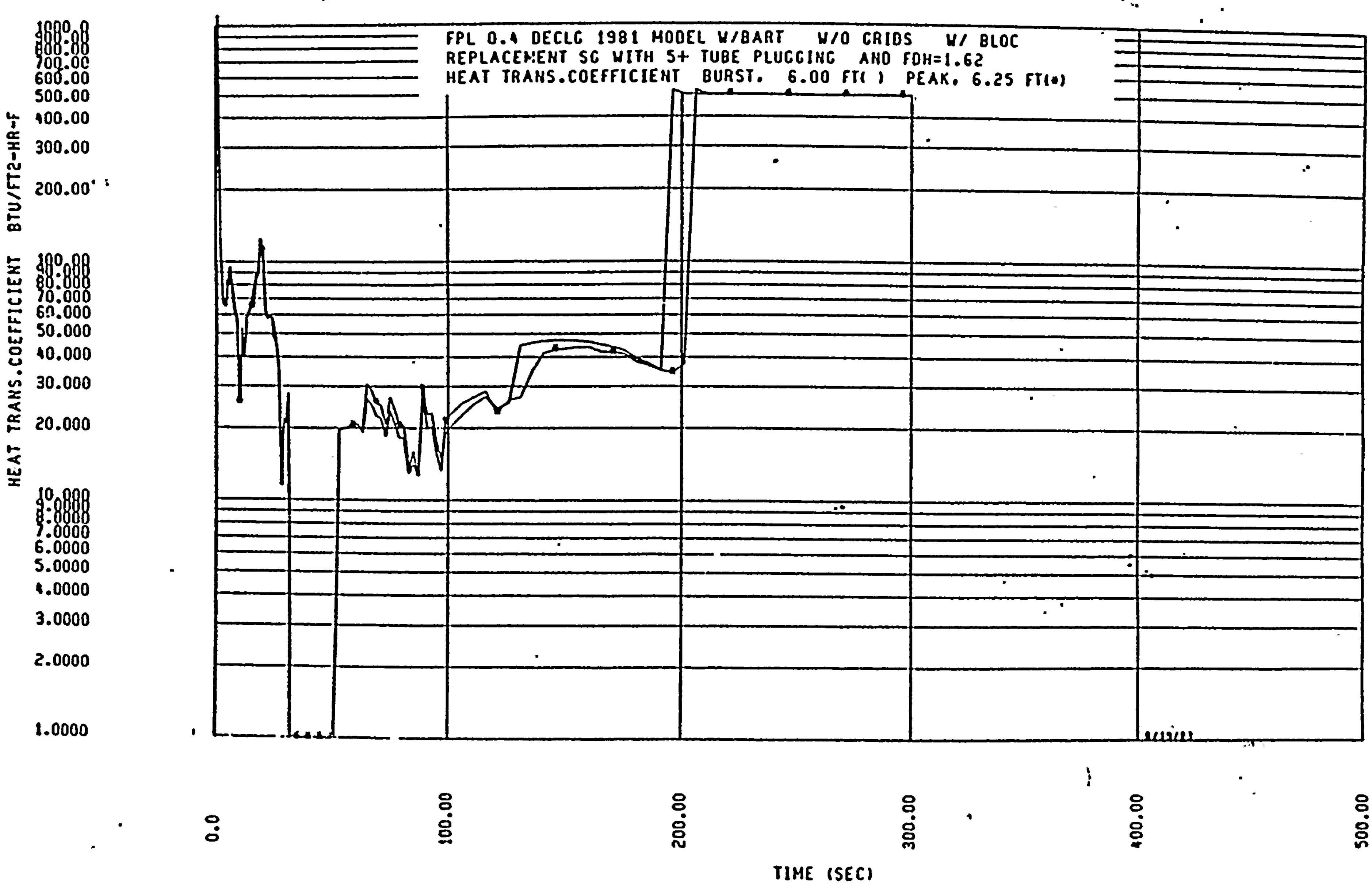


Figure 4. Core Pressure
DECLG(CD = 0.4)

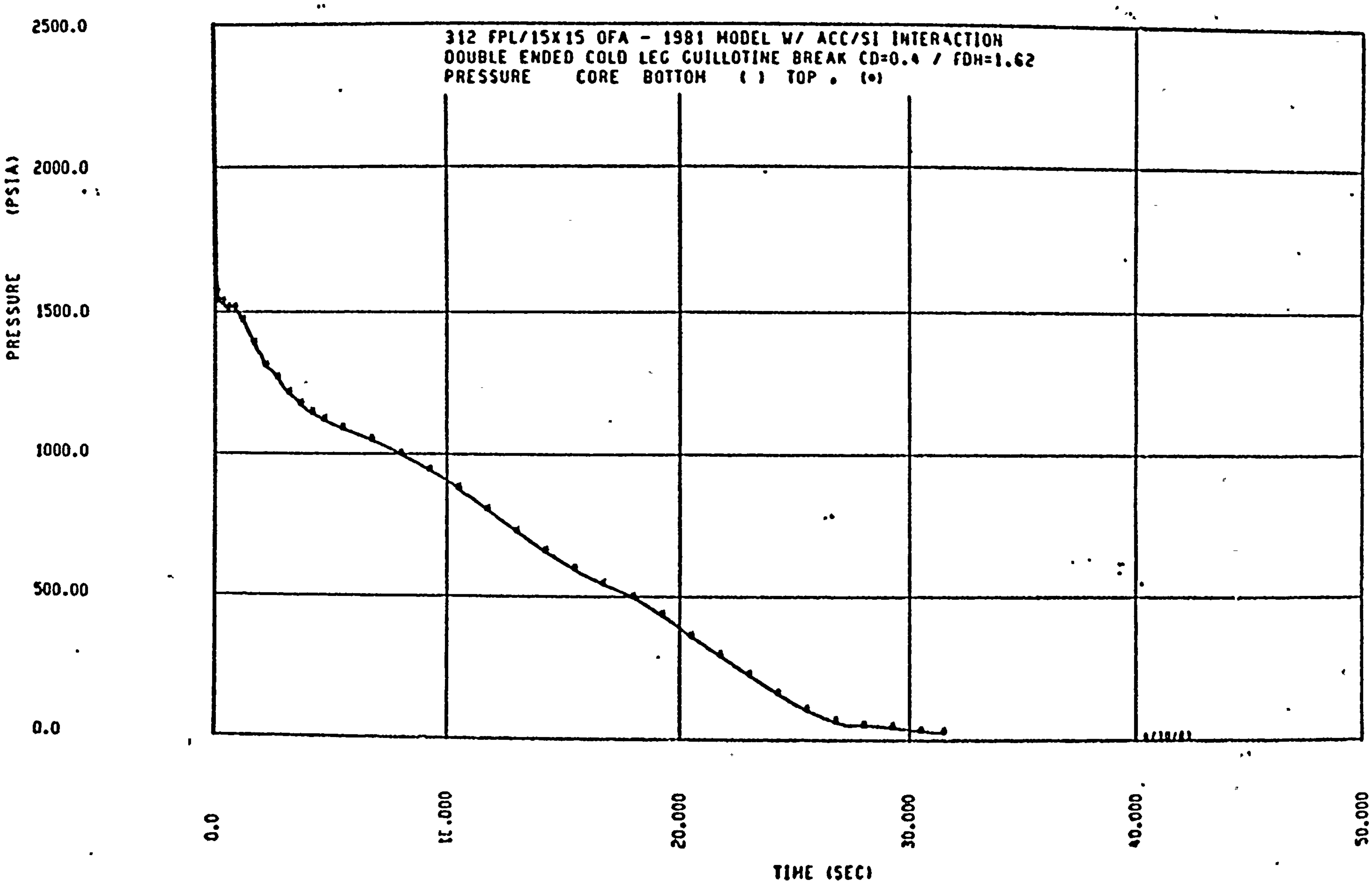


Figure 5. Break Flow Rate
DECLG(CD = 0.4)

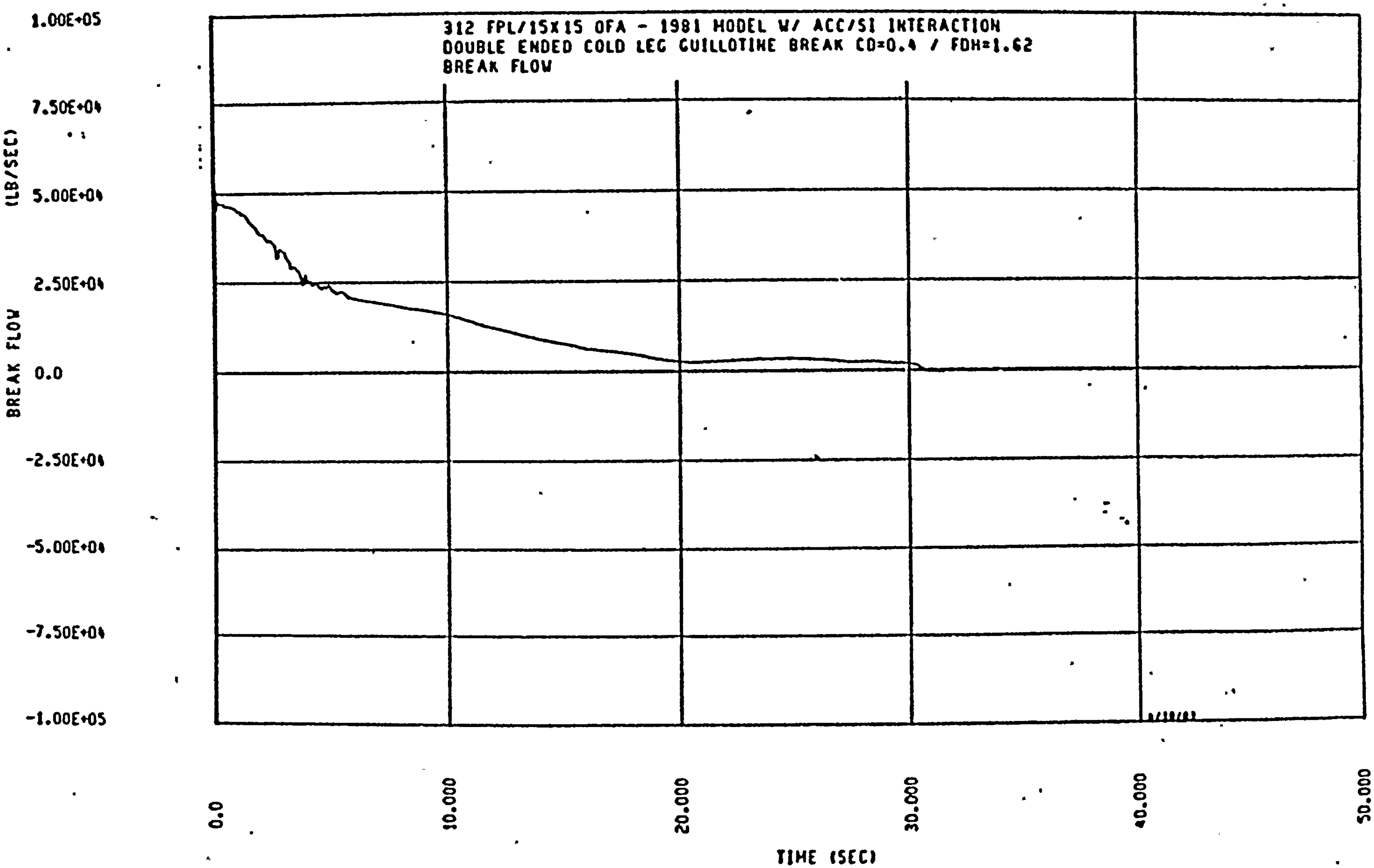


Figure 6. Core Pressure Drop
DECLG(CD = 0.4)

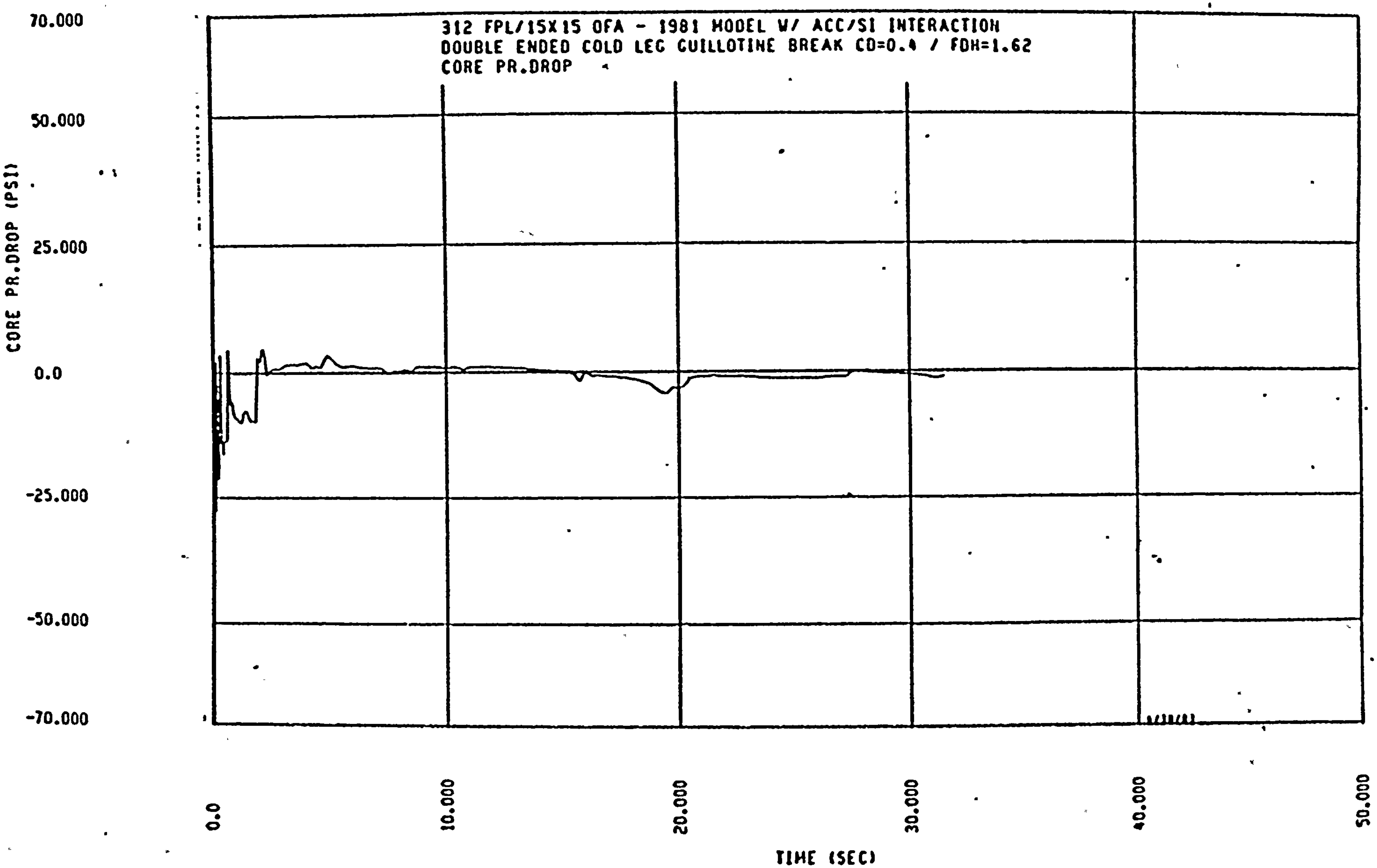


Figure 7. Peak Clad Temperature
DECLG(CD = 0.4)

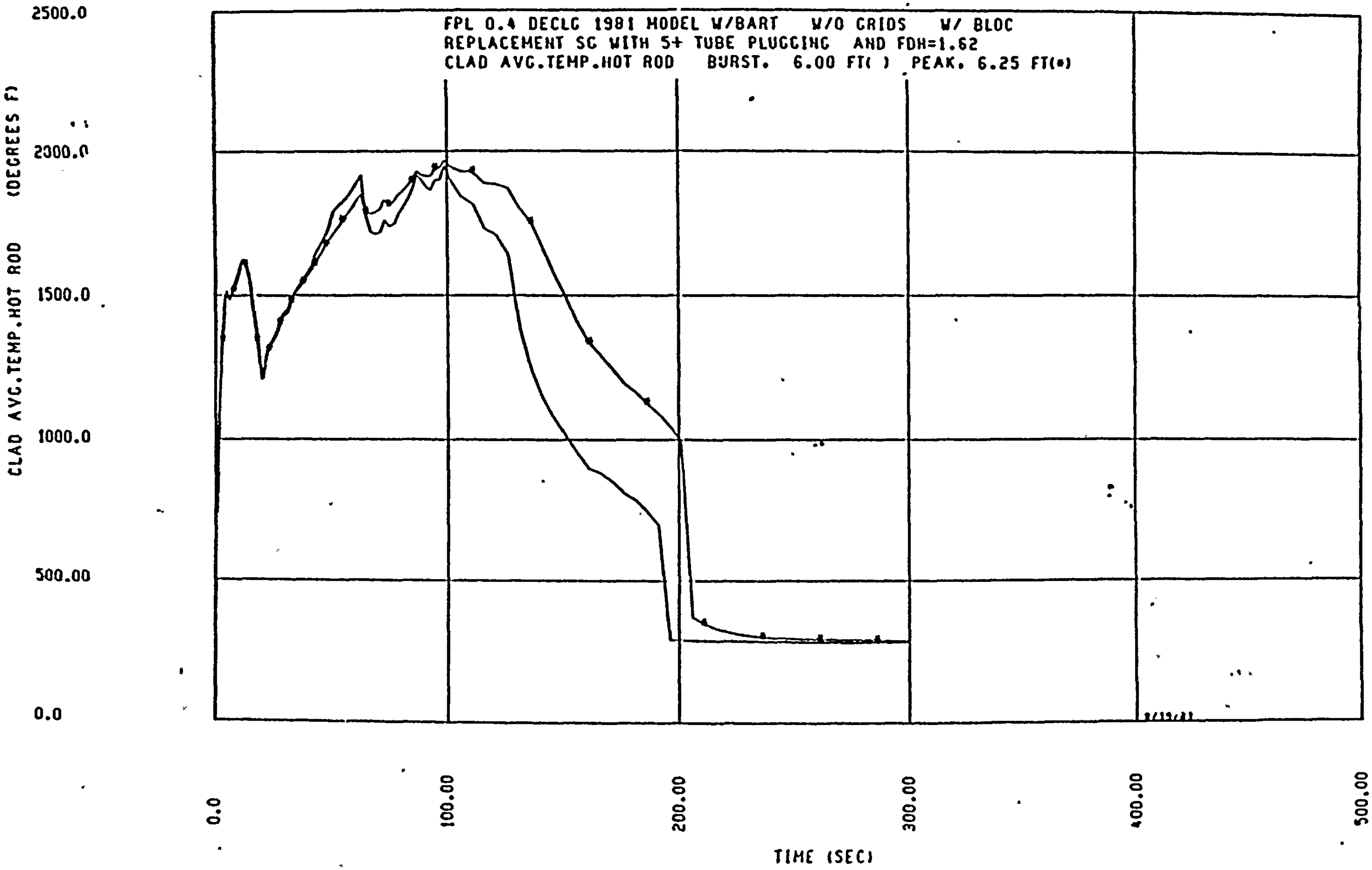


Figure 8. Fluid Temperature
DECLG(CD = 0.4)

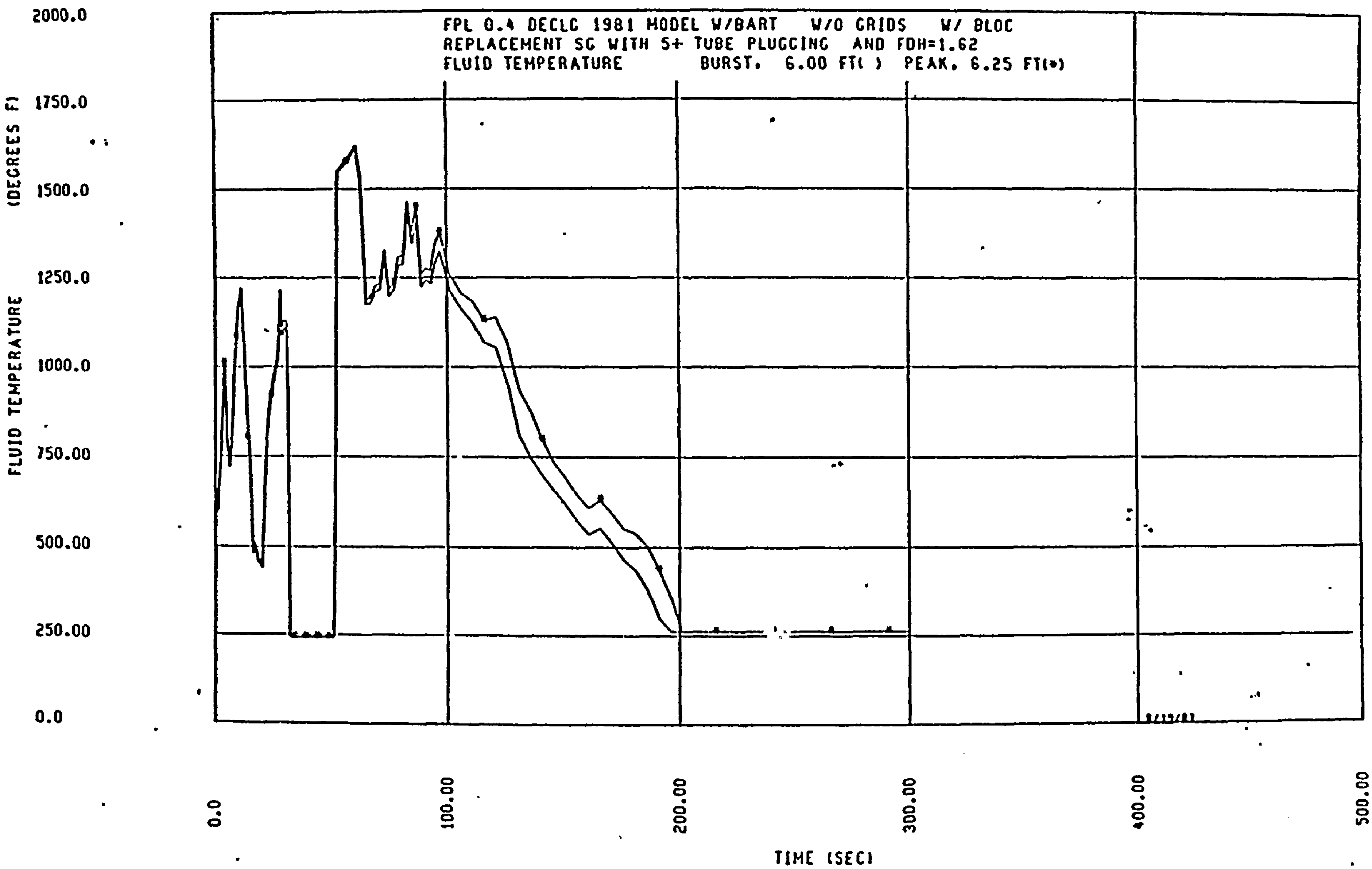


Figure 9. Core Flow
(Top and Bottom)
DECLG(CD = 0.4)

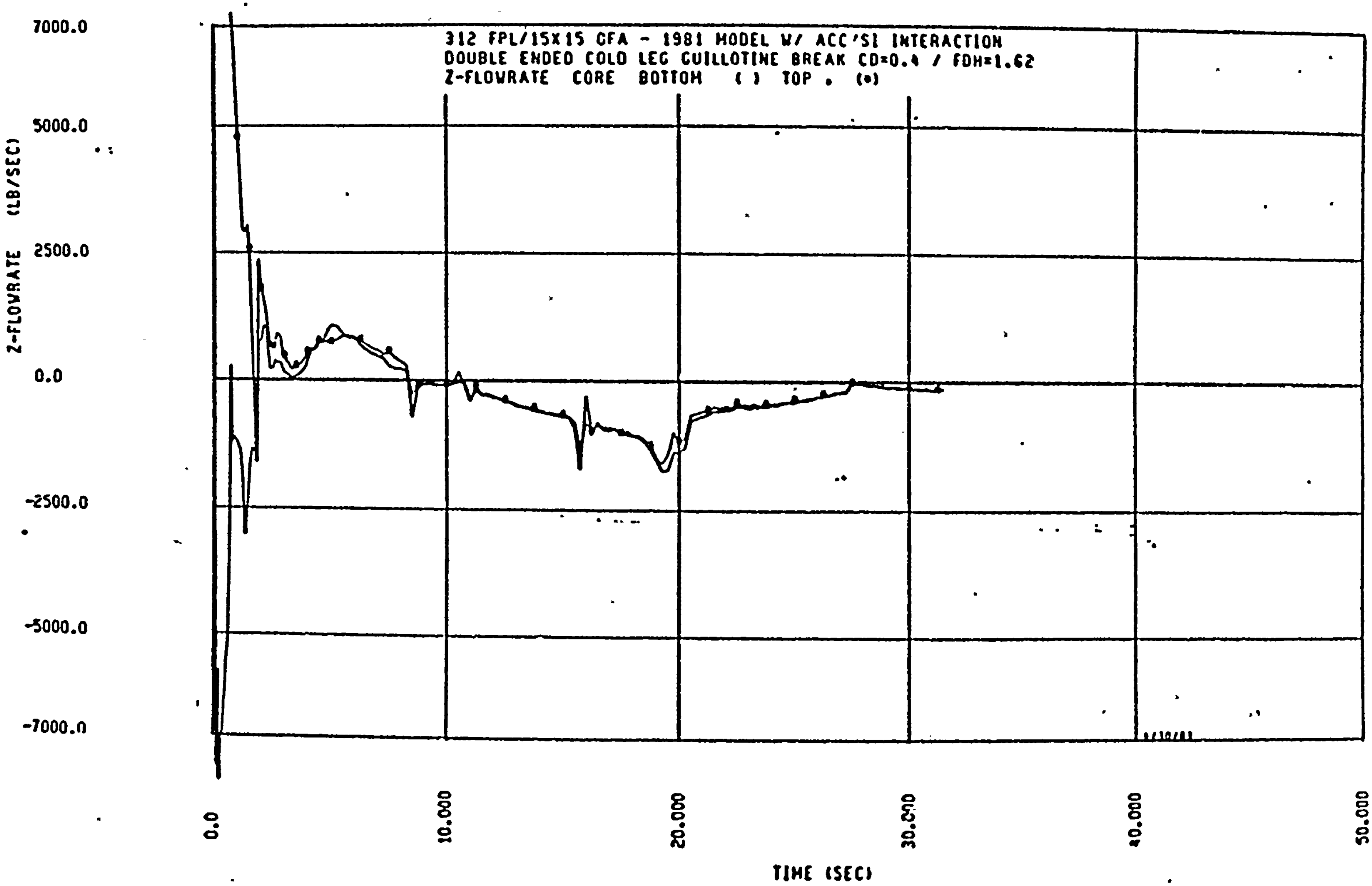


Figure 10. Reflood Transient - Core & Downcomer Water Levels DECLG(CD = 0.4)

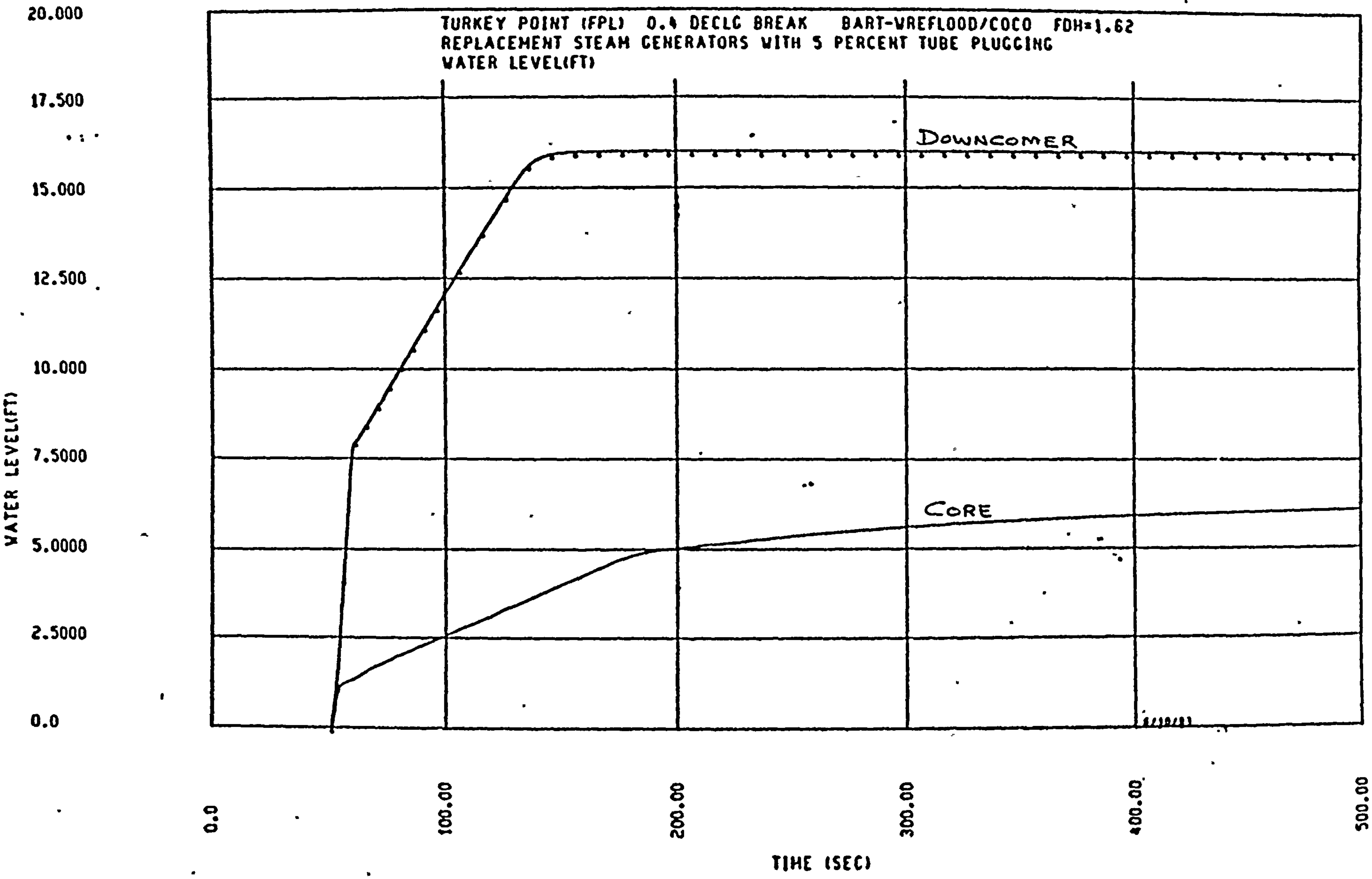


Figure 11. Reflood Transient
Core Inlet Velocity
DECLG(CD = 0.4)

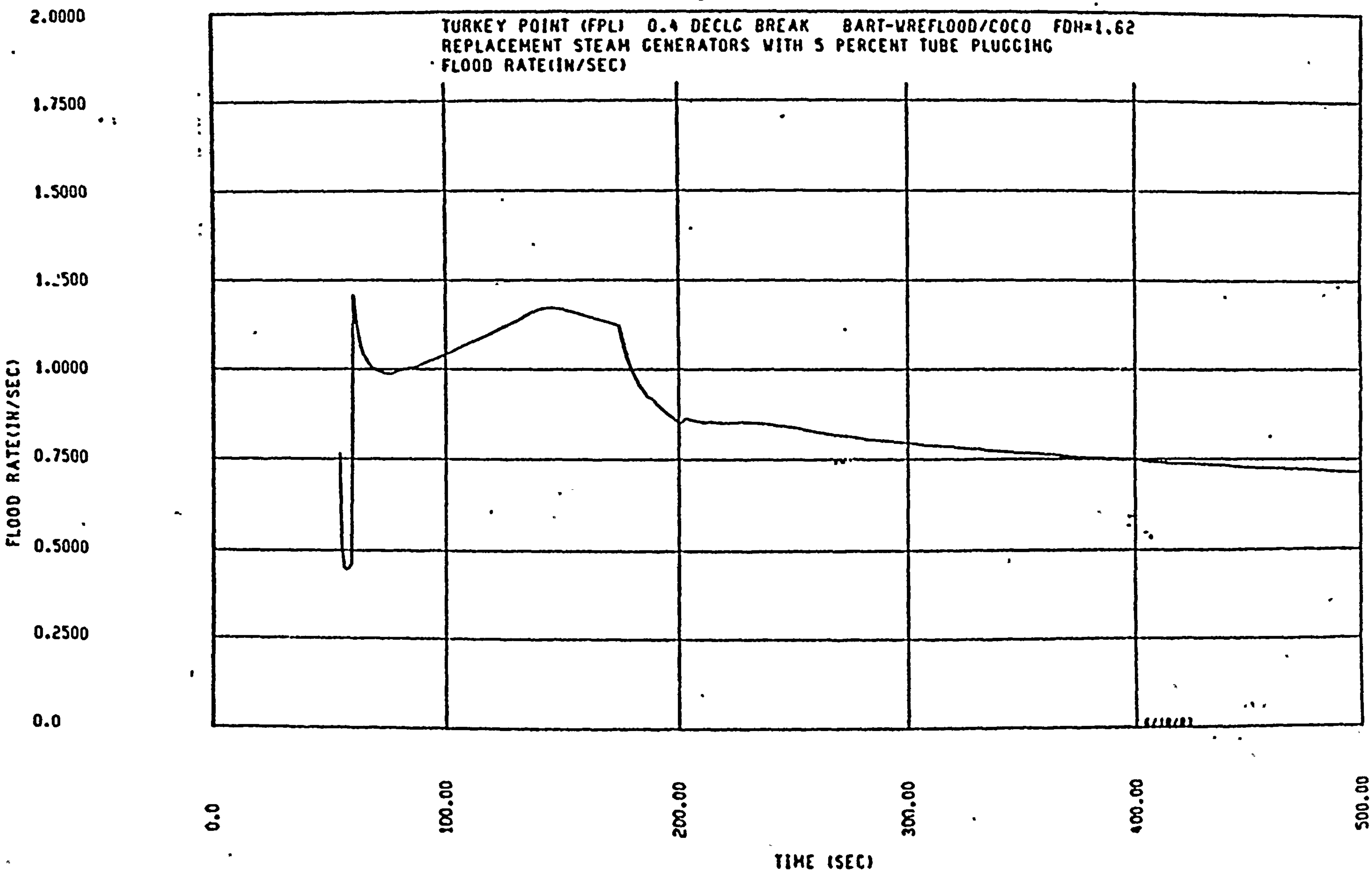


Figure 12. Accumulator Flow
(Blowdown)
DECLG(CD = 0.4)

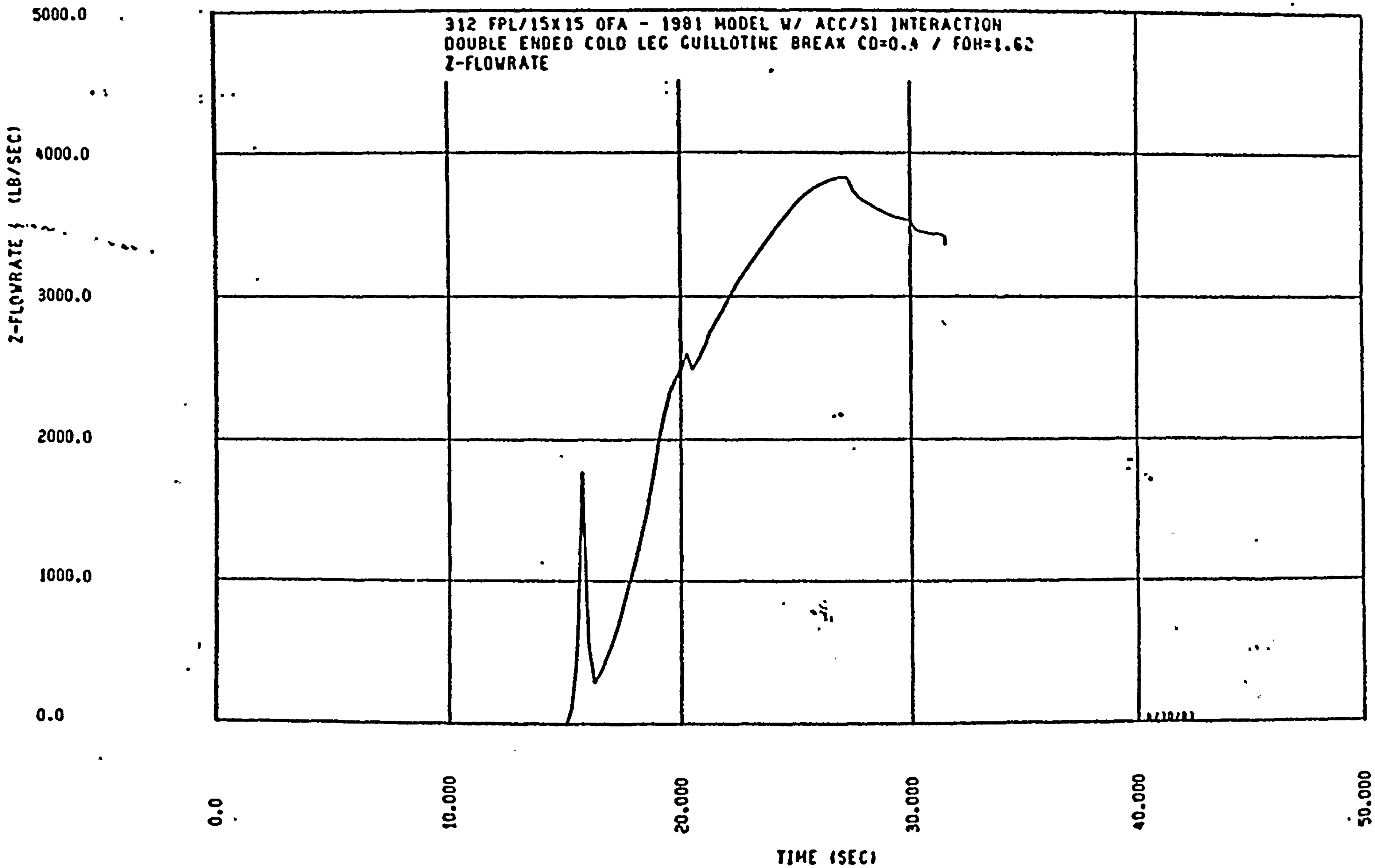


Figure 13. Pumped ECCS Flow (Reflood) DECLG(CD = 0.4)

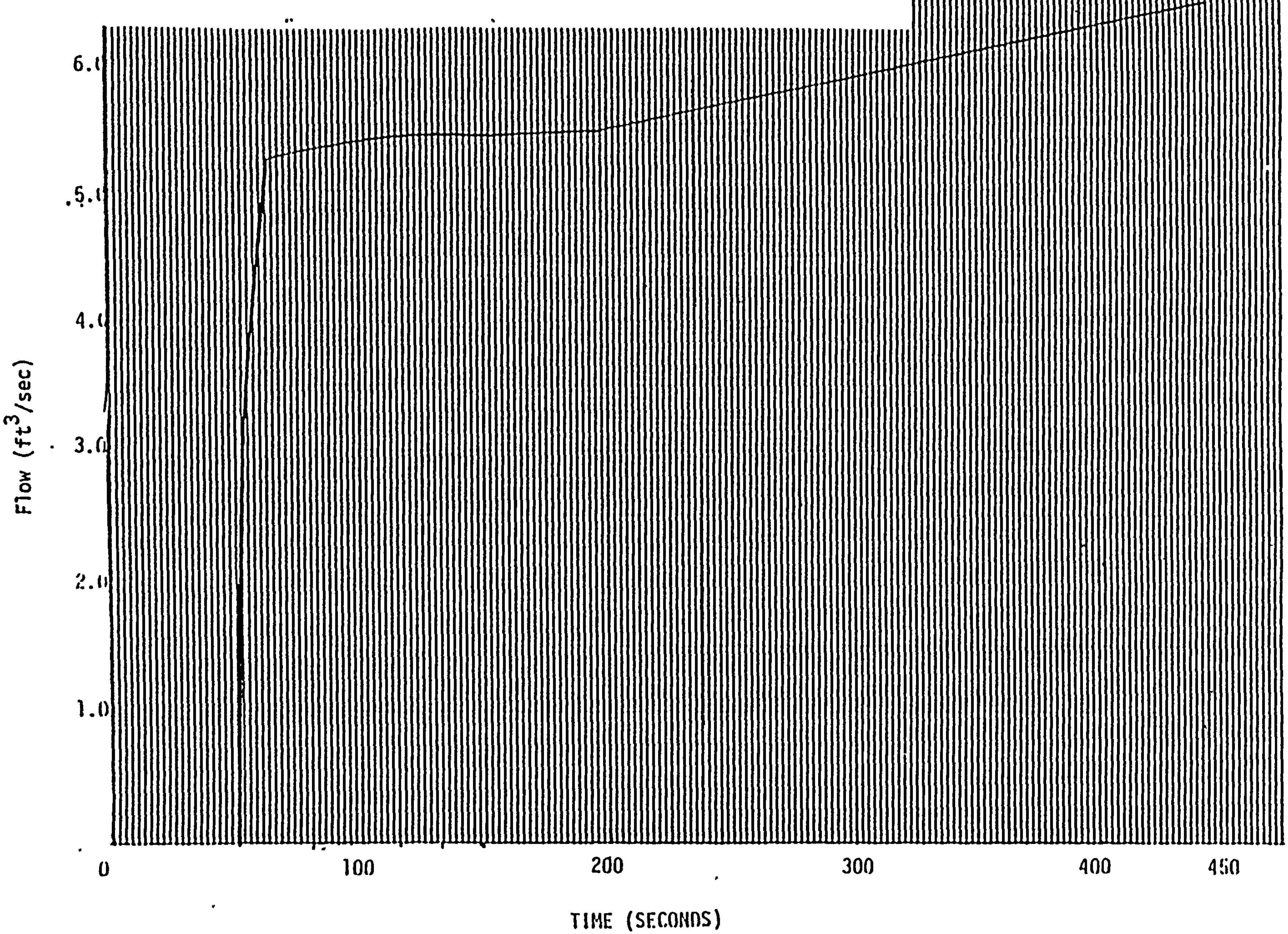


Figure 14. Containment Pressure
DECLG(CD = 0.4)

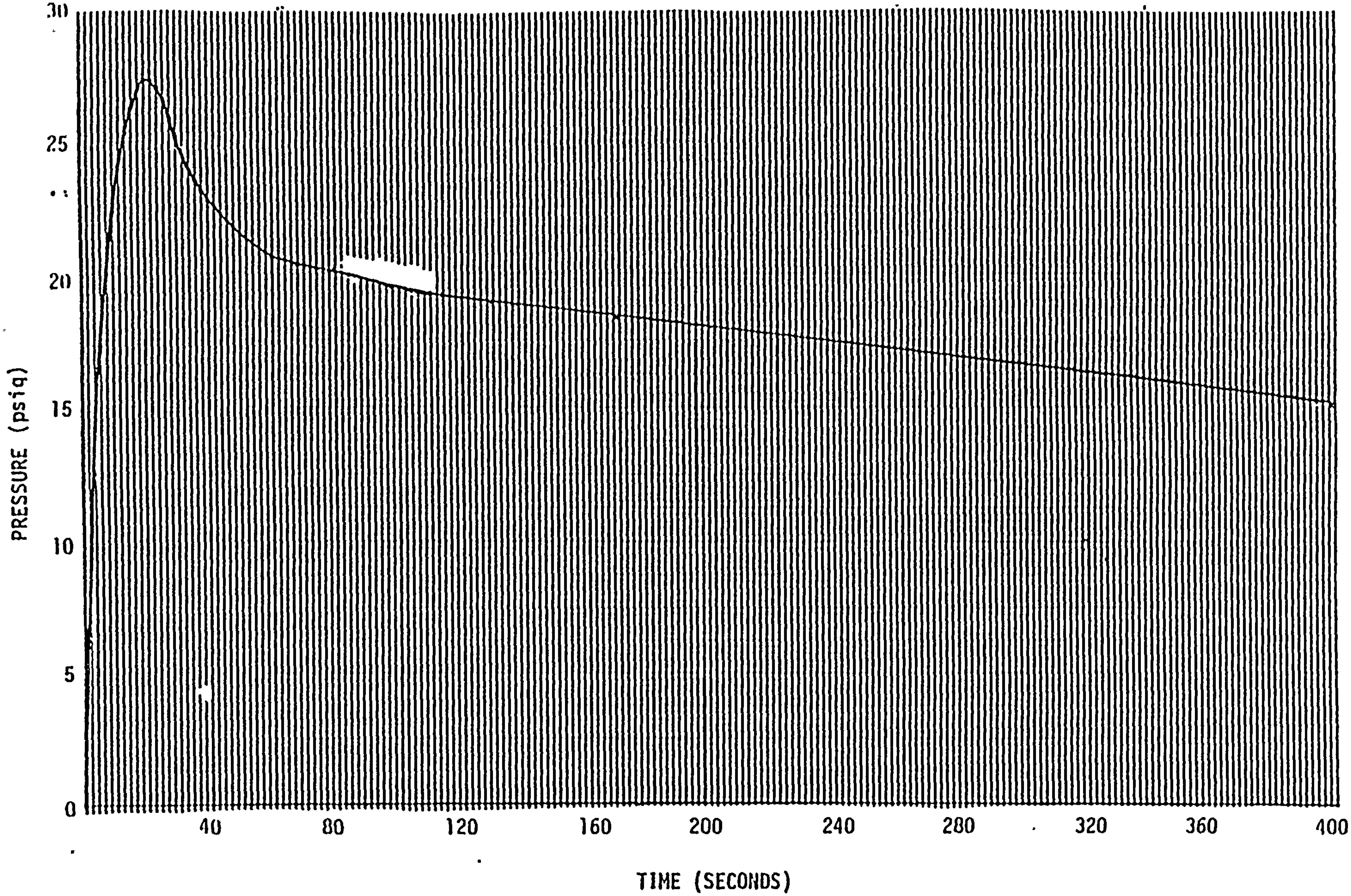


Figure 15. Core Power Transient
DECLG(CD = 0.4)

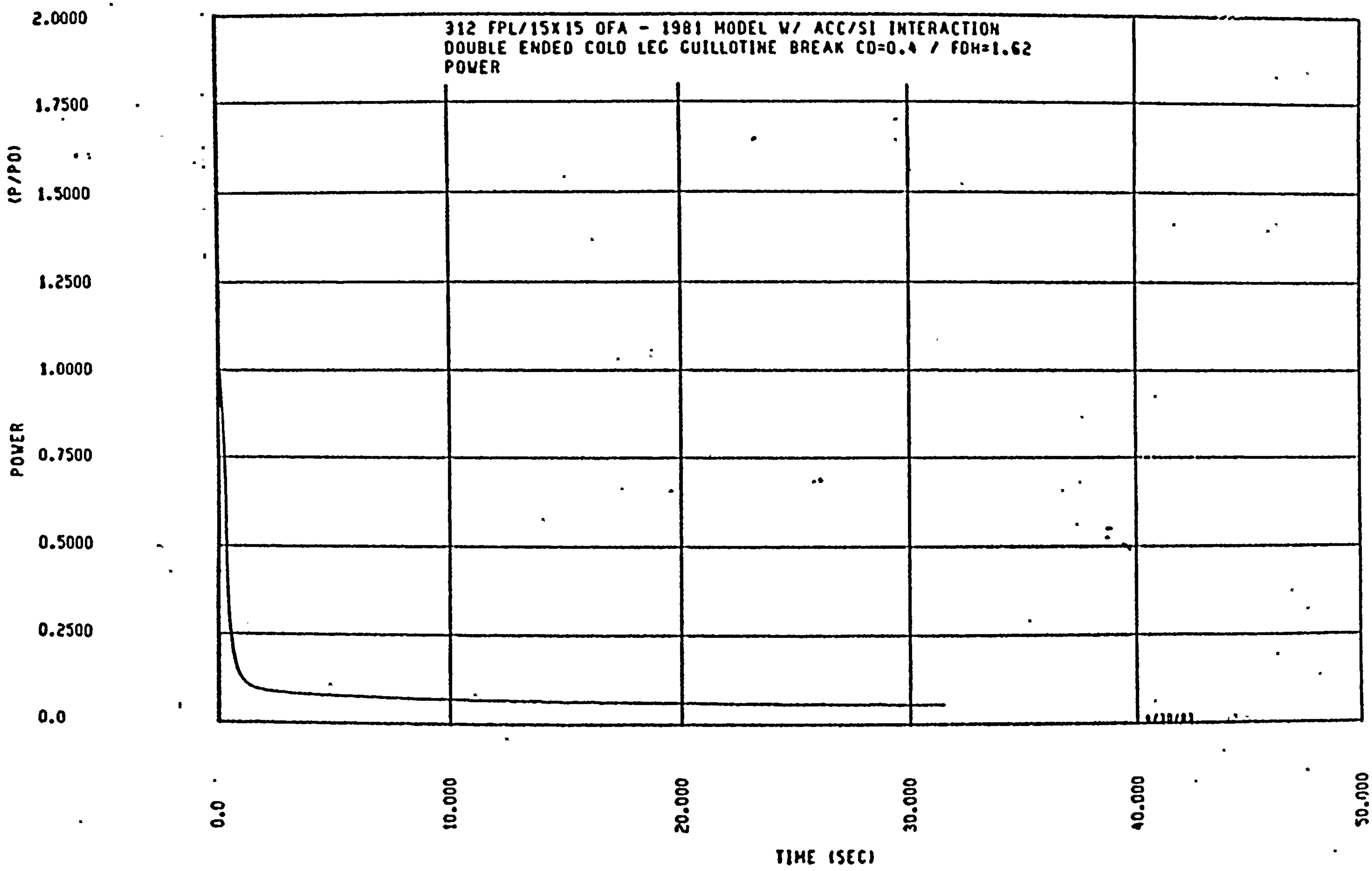
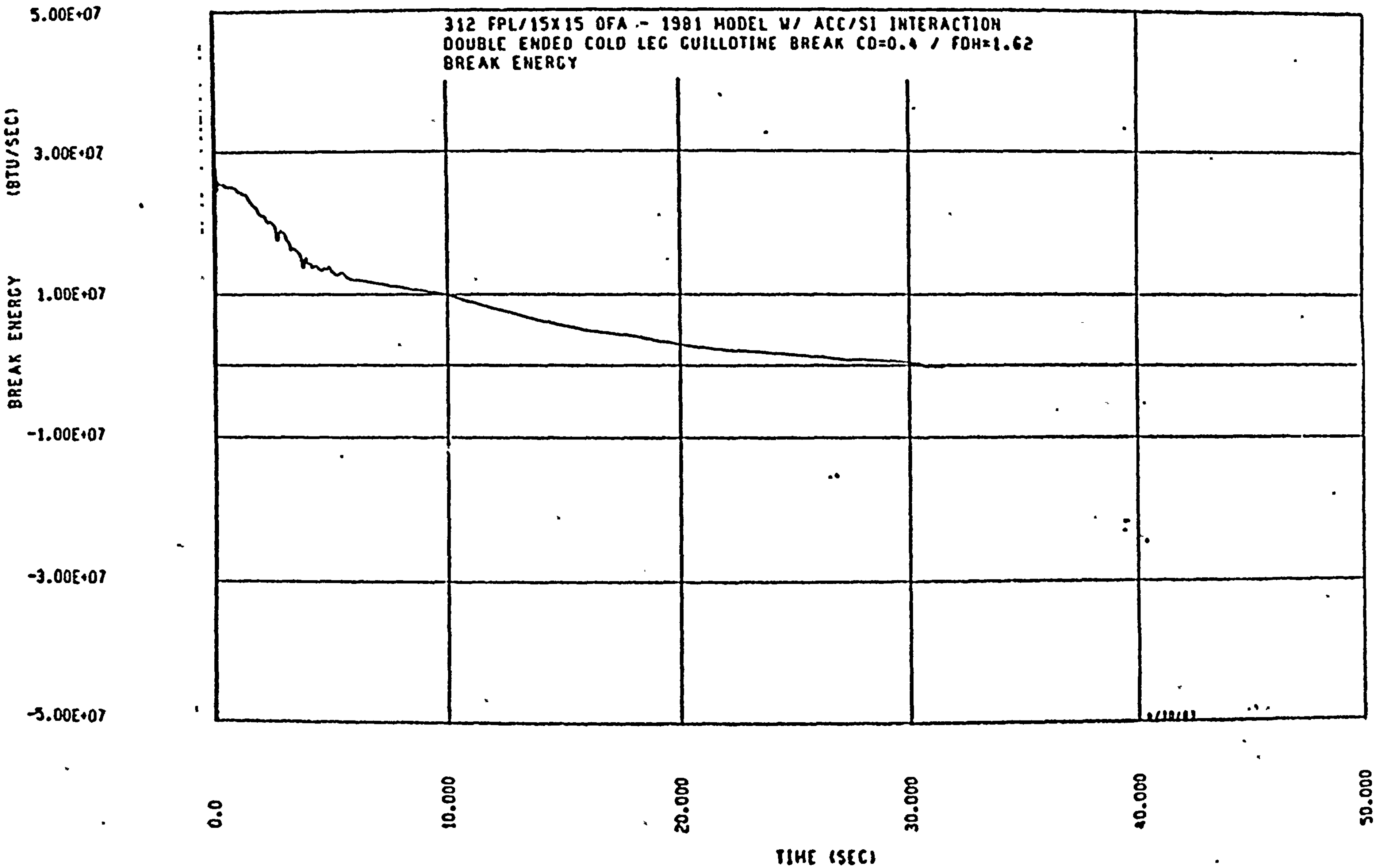


Figure 16. Break Energy Released
to Containment
DECLG(CD = 0.4)



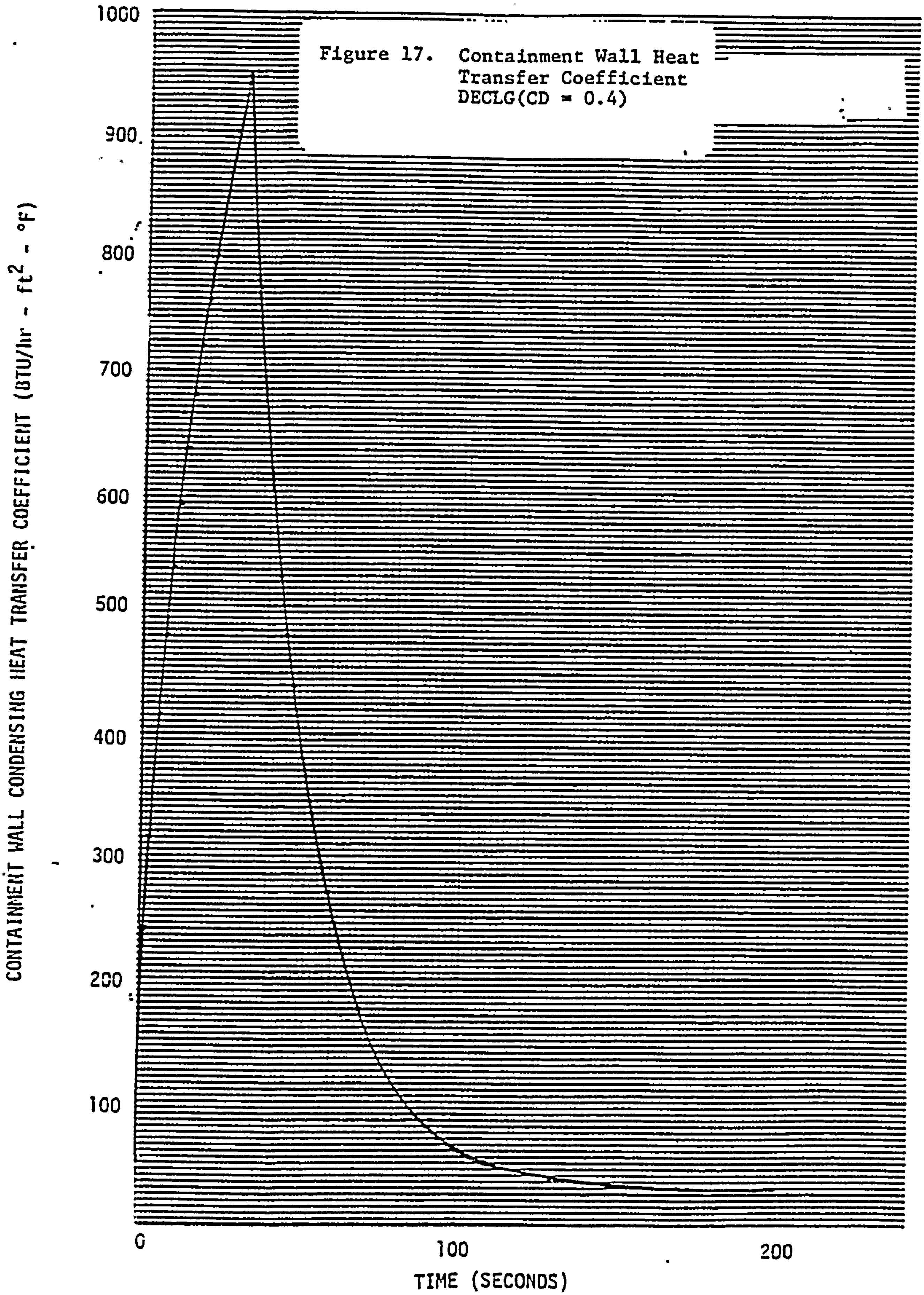


Figure 17. Containment Wall Heat Transfer Coefficient DECLG(CD = 0.4)
1000
900
800
700
600
500
400
300
200
100
0
100
200
TIME (SECONDS)
CONTAINMENT WALL CONDENSING HEAT TRANSFER COEFFICIENT (BTU/hr - ft² - °F)

BART GRID MODEL SENSITIVITY STUDY
FOR TURKEY POINT UNIT 3 AND 4

A sensitivity study has been performed to determine the impact of removing the grid model (documented in reference 1) from the BART[2] computer code. The analysis was performed with the Turkey Point Units 3 and 4 large break loss-of-coolant accident (LOCA) models used for their increased $F_{\Delta H}$ safety evaluation analysis. Both cases utilized a modified version of the 1981 Westinghouse Emergency Core Cooling System (ECCS) Evaluation Model[3]. This version includes the BART[2] computer code, mentioned above, which is a mechanistic core heat transfer model. For the case with the BART grid model removed, the Westinghouse 15x15 fuel grids modeled in the Turkey Point increased $F_{\Delta H}$ safety analysis were neglected. Grids were removed from the 6.5, 8.7 and 10.8-foot elevations. The 15x15 LOPAR grid at 4.4 feet was not modeled in the original Turkey Point increased $F_{\Delta H}$ safety analysis. During the BART analysis of Turkey Point, it was decided to delete the 4.4-foot grid from the calculations for the following reasons:

1. To expedite the analysis.
2. The grid deletion was clearly conservative.
3. Previous standard analyses had shown PCTs near 7.5 feet in which case the 4.4-foot grid was expected to have a minor effect.

Appendix K assumptions were utilized for both analyses compared.

From the comparison of the above cases, a number of observations are drawn:

The BART fuel rod clad temepratures are virtually identical from the 0.0 to 6.5-foot elevation below where the effect of the first grid modeled in BART is encountered. This is observed throughout the reflood transient.

At the 6.75-foot elevation, when the hot rod peak clad temperature is obtained, there is an 80°F BART fuel rod clad temperature effect

associated with that grid. Measurable effects are noted at the 9.0-foot and 11.0-foot grid elevations also. A BART wall temperature vs. elevation comparison 40.0 sec after Bottom of Core Recovery (BOC) is shown in Figures 1 and 2 attached.

The hot rod peak clad temperature for both cases occurs at the 6.25-foot elevation which is below the first grid modeled in the Turkey Point BART model. This results in a negligible impact on the hot rod peak clad temperature predicted by LOCTA-IV[4] when the grids modeled in BART are removed.

Please note that the nature of the large break LOCA transient, particularly with a new model, makes it difficult to predict where peak clad temperature will occur. Burst and blockage complicates this issue more. These, combined with the variables associated with the different Westinghouse fuel assembly grid designs, make it impossible to conclude whether the current grid model in BART also will have a negligible effect on hot rod peak clad temperature for other cases.

References

1. Rahe, E. P., Westinghouse Letter to C. O. Thomas of NRC, Letter No. NS-EPR-2806, August 12, 1983, Subject: "BART Grid Model Verification Report and Additional Responses," (Proprietary).

2. Young, M. Y., et al., "BART-A1: A Computer Code for the Best Estimate Analysis of Reflood Transients," WCAP-9561 (Proprietary Version), WCAP-9695 (Non-Proprietary Version), January 1980.

3. Eicheldinger, C., "Westinghouse ECCS Evaluation Model, 1981 Version," WCAP-9220-P-A (Proprietary Version), WCAP-9221-A (Non-Proprietary Version), Revision 1, December 1981.

4. Bordelon, F. M., et al., "LOCTA-IV Program: Loss-of-Coolant Transient Analysis," WCAP-8301 (Proprietary Version), WCAP-8305 (Non-Proprietary Version), June 1974.

Figure 1. BART Wall Temperature
with Grids
DECLG (C_D=0.4)

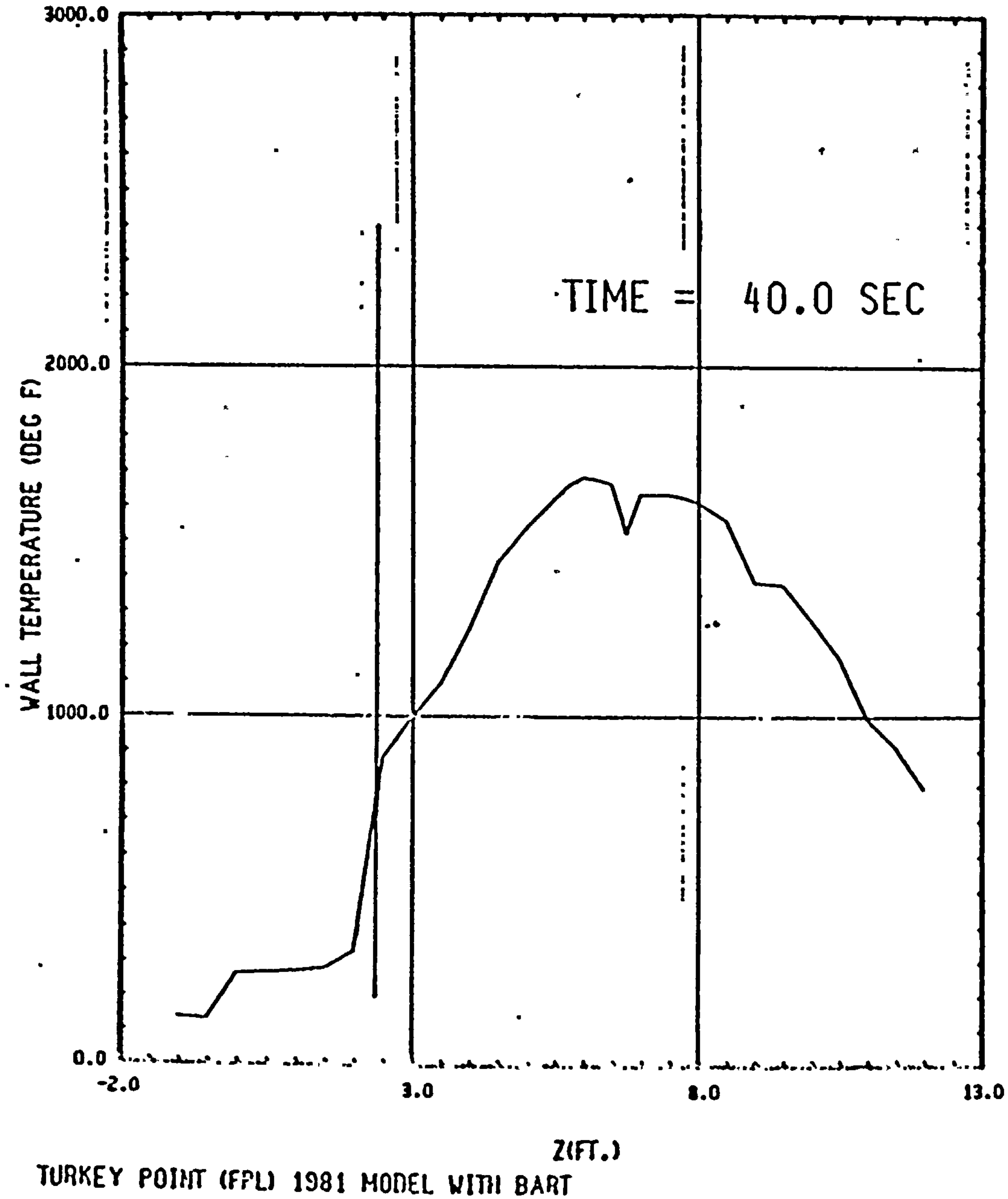


Figure 2. BART Wall Temperature
without Grids
DECLG (C_D=0.4)