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UHRIG,R.E. Florida Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
REID,R.W. Operating Reactors Branch 4

SUBJECT: Forwards best estimate main steam line break analysis to assess NSSS & containment response w/automatic auxiliary feedwater actuation,in response to NRC 791221 ltr.

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	22 EEB	1	1	23 EFLT TRT SYS	1	1
	3 LPDR	1	1	4 NSIC	1	1
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FLORIDA POWER & LIGHT COMPANY

January 24, 1980
L-79-36

Office of Nuclear Reactor Regulation
Attention: Mr. R. W. Reid, Chief
Operating Reactors Branch #4
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Reid:

Re: St. Lucie Unit 1
Docket No. 50-335
Auxiliary Feedwater Systems

The attached information is submitted in response to your letter of December 21, 1979 on the subject of auxiliary feedwater systems at St. Lucie Unit 1.

Please call if you have further questions on this subject.

Very truly yours,

Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/MAS/cph

Attachments (2)

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

A043 3/3

8001310 294

ATTACHMENT

Re: St. Lucie Unit 1
Docket No. 50-335
Auxiliary Feedwater Systems

BEST ESTIMATE MSLB ANALYSIS TO ASSESS NSSS AND CONTAINMENT RESPONSE WITH AUTOMATIC AUXILIARY FEEDWATER ACTUATION

1.0 INTRODUCTION

A set of calculations has been performed on a generic basis with plant characteristics representative of CE operating plants to model containment building pressure and temperature response and overall NSSS behavior, including core reactivity, following a Main Steam Line Break (MSLB) inside containment. The intent of these calculations is to determine if the containment building response (pressure) and the core reactivity response (return to power) are acceptable following a MSLB when auxiliary feedwater is added without regard to the identification of the affected steam generator. The auxiliary feedwater flow is assumed to be activated at the initiation of the transient to maximize its effects. Main feedwater flow including post trip rampdown is simulated. No isolation of main or auxiliary feedwater is considered unless a high water level condition is reached.

2.0 ASSUMPTIONS AND CASES

Assumptions for the analyses are given in Table 1. The four cases analyzed are listed in Table 2.

3.0 DISCUSSION OF RESULTS

Maximum containment pressure and least negative core reactivity for the four cases are listed in Table 3. Both the containment pressure and the reactivity (return to power) values are within acceptable limits.

Main feedwater flow, auxiliary feedwater flow, core reactivity change, core power, containment pressure, primary loop temperatures, and steam generator secondary temperatures for the four cases are detailed in Figures A-1 through A-7, B-1 through B-7, C-1 through C-7, and D-1 through D-7, respectively.

The results of the analyses using best estimate models for steam generator moisture carryover and containment passive heat sink heat transfer demonstrate that the additional auxiliary feedwater has a negligible impact on containment peak pressure. The containment peak pressure is determined primarily by the initial inventory in the ruptured unit. This inventory is released within the first few minutes, depending upon the break size, so that the contribution of auxiliary feedwater flow to the ruptured unit over this time frame is small. Over the longer time frame, the secondary inventory is boiled off at essentially the decay heat rate which the containment active heat removal systems can accommodate while reducing containment pressure. The excess feedwater which is not boiled off remains in the steam generator, causing the secondary level to rise. The containment peak pressure is essentially an initial inventory limited phenomenon.

The results of the analyses also show that the additional auxiliary feedwater has a negligible impact on core reactivity. Cases A and C assume no stuck rods and a best estimate moderator cooldown curve. For comparison, Cases B and D assume that the most reactive rod is stuck and that the moderator cooldown curve is a licensing curve. All cases took credit for boron injection via three charging pumps; however, safety injection boron credit was not taken. These cases do not have a return to power for the following reason. The initial primary loop temperature decreases are limited by the two-phase blowdown process associated with large break (>2 ft^2), since much of the break flow is saturated liquid which has not absorbed significant amounts of energy from the primary loop. For smaller break areas (<2 ft^2), the blowdown is pure steam which does require large amounts of energy per unit mass to boil via primary to secondary heat transfer; however, the rate of primary-to-secondary heat transfer is controlled by the blowdown flowrate which in turn is limited by the small break area. The net result is that over approximately the first 100 seconds of the event, the amount of core and loop cooldown is about the same regardless of break size. This time frame is most important since the presence of delayed neutrons minimizes the amount of cooldown needed to produce a core criticality problem.

Without a return to power (via primary loop cooldown and delayed neutrons), the remainder of the transient is a gradual increase in reactivity due to loop cooldown which is coupled to the containment pressure, plus a decrease in reactivity due to boron injection. In time (approximately 300 seconds), the reactivity decrease due to boration overtakes the reactivity increases due to loop cooldown; thereafter, the total reactivity steadily decreases. The ruptured steam generator is at the containment backpressure and with

RCPs operating the sensible heat from the non-ruptured unit is quickly removed resulting in RCS and SG secondary temperatures essentially in equilibrium with the containment conditions in about 10 minutes.

With licensing assumptions, the peak in the reactivity transient is calculated to be within the first two minutes of the event. A two minute time delay, if added to the automatic actuation circuit, would justify a statement that automatic auxiliary feedwater actuation will not impact existing SAR core cooldown MSLB analyses.

4.0 COMPARISON WITH LICENSING CALCULATIONS

The following items are important in comparing the results contained herein with those obtained with traditional licensing models and assumptions:

1. The moisture carryover model used is a best estimate model which gives a two-phase blowdown for large break areas. The two-phase blowdown results in a lower containment pressure and less initial primary loop cooldown than a pure steam blowdown. Chapter 15 analyses assume a pure steam blowdown regardless of break size.
2. Chapter 15 analyses assume that the most reactive rod is stuck. Moreover, the remaining rod worth is assigned a conservative value in conjunction with a conservative moderator cooldown curve.
3. A best estimate containment heat transfer model provides containment pressurization results significantly lower than those provided in Chapter 6 analyses.

TABLE 1

ASSUMPTIONS

NSSS Initial Conditions	
Power	2700 MWt
Core Inlet Temperature	548°F
Primary Pressure	2250 PSIA
Secondary Pressure	875 PSIA
Secondary Temperature	529°F
Containment Data	
Free Volume	2.5×10^6 ft^3
Design Pressure	44 psig
Heat Sinks	SAR values
Heat Transfer Model	Best estimate model
Number of Fan Coolers	4 (no single failure)
Fan Cooler Capacity, each	68×10^6 B/hr at 280°F containment temperature 100°F CCW Temperature
Fan Cooler Actuation Setpoint	Fans are operational @ t = 0
Number of Sprays	2 (no single failure)
Spray rate, each	2700 GPM
Spray Actuation Setpoint	10 PSIG + 60 seconds
Other Data	
Steam Generator Isolation Signal (MSIS) setpoint	500 psia
Decay Heat Curve	ANS-5
Main Feedwater Flow	
Ruptured Unit:	Ramped to 10% over 60 seconds following Reactor Trip: (10% represents twice the bypass nominal value of 5%, this accounts for pump run-out with reduced backpressure), temperature is reduced to 100 to account for turbine off-line. Flow terminated if the elevation of upper level tap is reached. See Figures A-1, B-1, C-1, and D-1.

Main Feedwater Flow -- continued	
Unaffected Unit:	Same as ruptured unit except that flow is ramped to 5%. See Figures A-1, B-1, C-1 and D-1.
Auxiliary Feedwater Flow	
Ruptured Unit:	Initiated at t = 0. Flow rate is a function of unit pressure. All control valves assumed to be fully opened.
Unaffected Unit:	No flow; all flow is totally diverted to the ruptured unit.
Reactor Coolant Pumps	Operating during the transient.
CEA Insertion Worth	
All rods in (ARI)	-8.9% (no stuck rod)
Most reactive rod stuck	-7.12% (best estimate)
Moderator Worth	
SAR Value	See Figure 1
Best Estimate Value	See Figure 2
Doppler Worth	See Figure 3
Moisture Carryover On Steam Generator Secondary Side	Best Estimate Model
Boron Injection Parameters	
Safety Injection	Credit Not Taken
Charging Pumps	
Number of Pumps	3
Flow Rate	44 GPM per pump
Actuation Time	SIAS
Boric Acid Concentration	8% by weight
Boron Worth	80 PPM/%
Boric Acid Conversion Factor	1749 PPM boron/% by weight boric acid
Mixing Model Used	Slug Flow Model
Loop Transit Time	10.5 seconds

TABLE 2

CASES

Case	CEA Scram Worth (%)	Moderator Curve	Break Area (Ft^2)
A	-8.9	Figure 2	6.63[(1)]
B	-7.12	Figure 1	6.63[(1)]
C	-8.9	Figure 2	1.99[(2)]
D	-7.12	Figure 1	1.99[(2)]

(1) Double-ended severance of main steam line (two-phase blowdown).

(2) Largest break area corresponding to pure steam blowdown.

TABLE 3

RESULTS

Case	Containment Peak Pressure (PSIG)	Least Negative Core Reactivity %
A	29.7/83.0 (sec.)	-4.31
B	29.7/83.0 (sec.)	-2.34
C	35.0/231.9 (sec.)	-3.54
D	35.0/231.9 (sec.)	-1.55

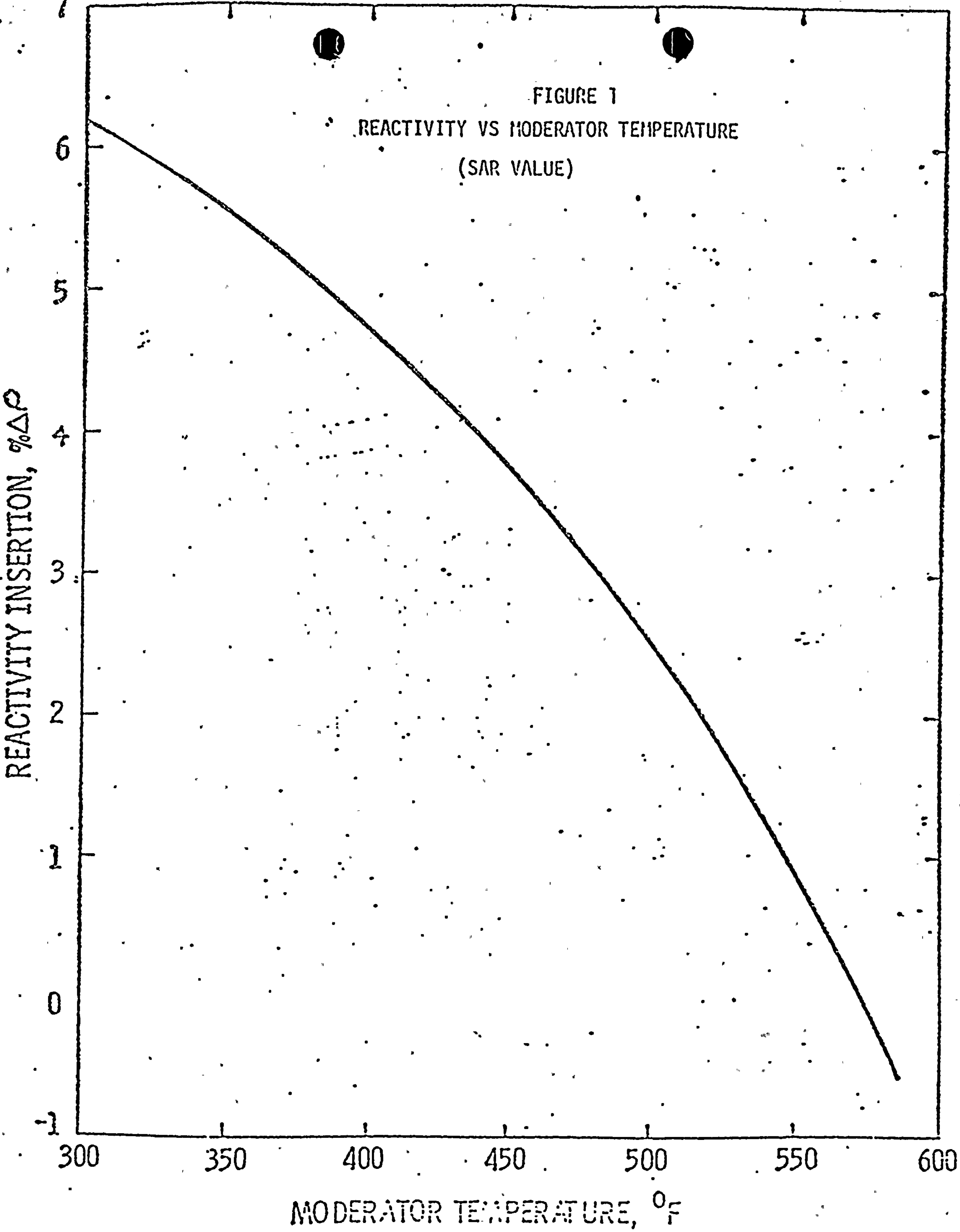


FIGURE 1
REACTIVITY VS MODERATOR TEMPERATURE
(SAR VALUE)

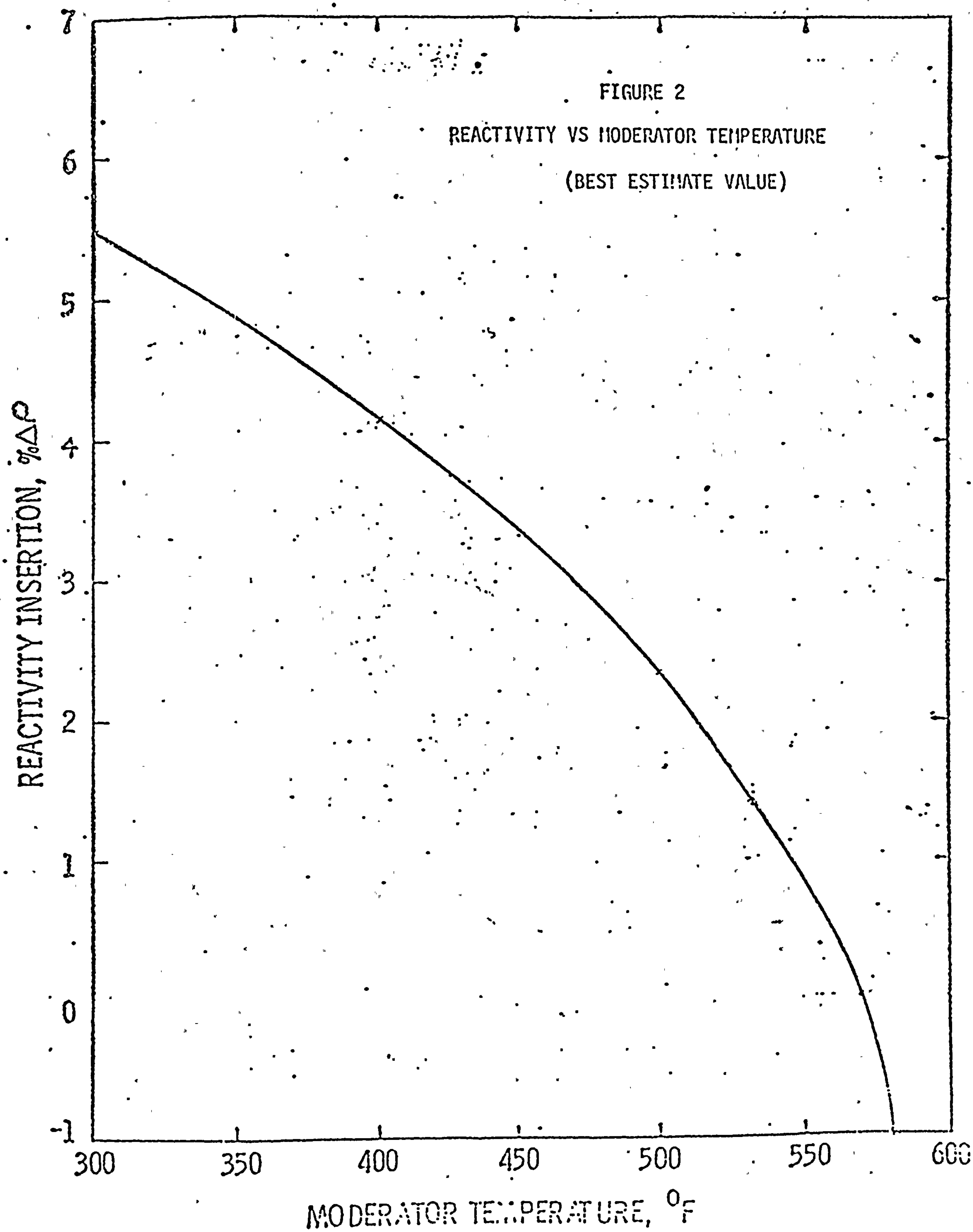
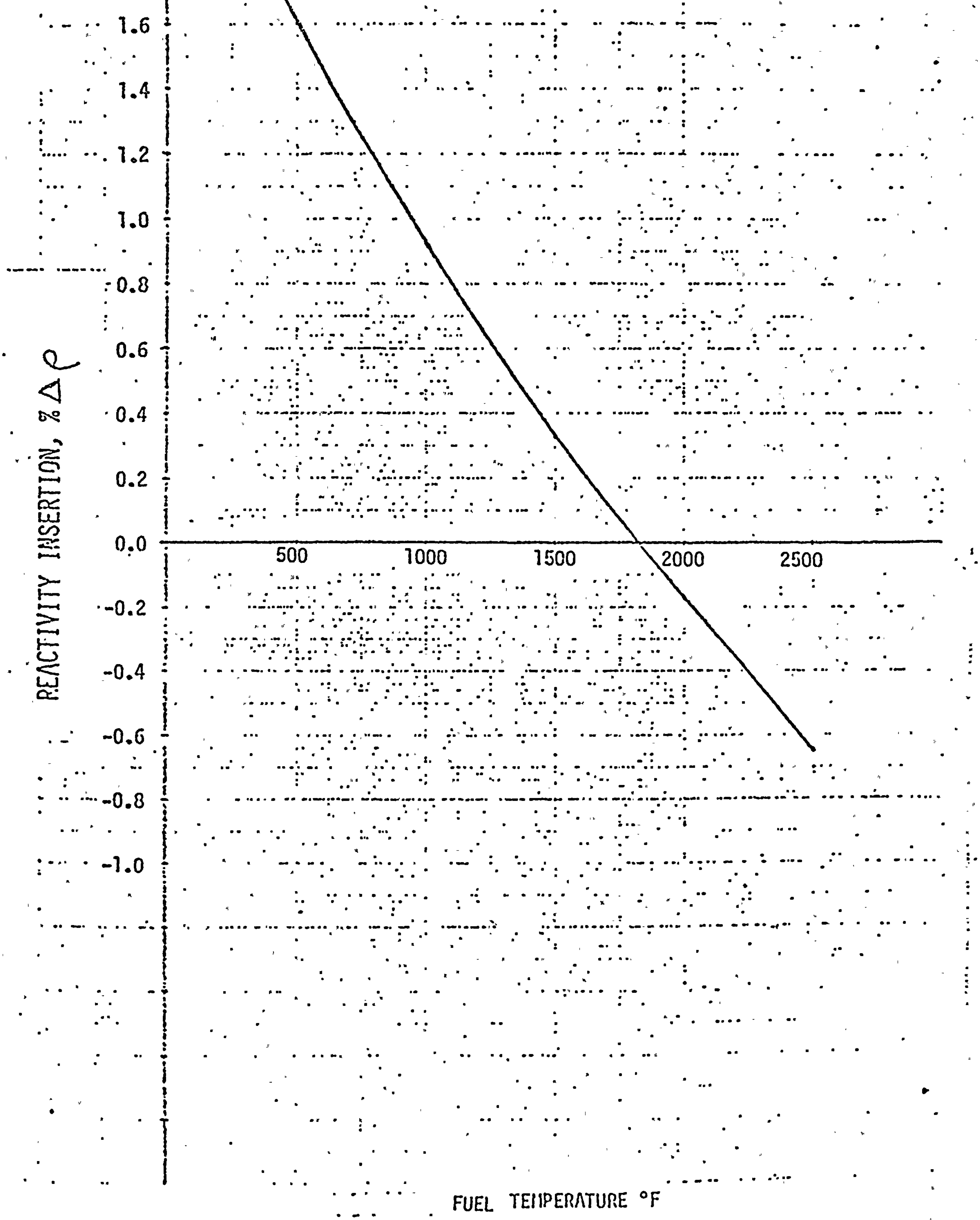
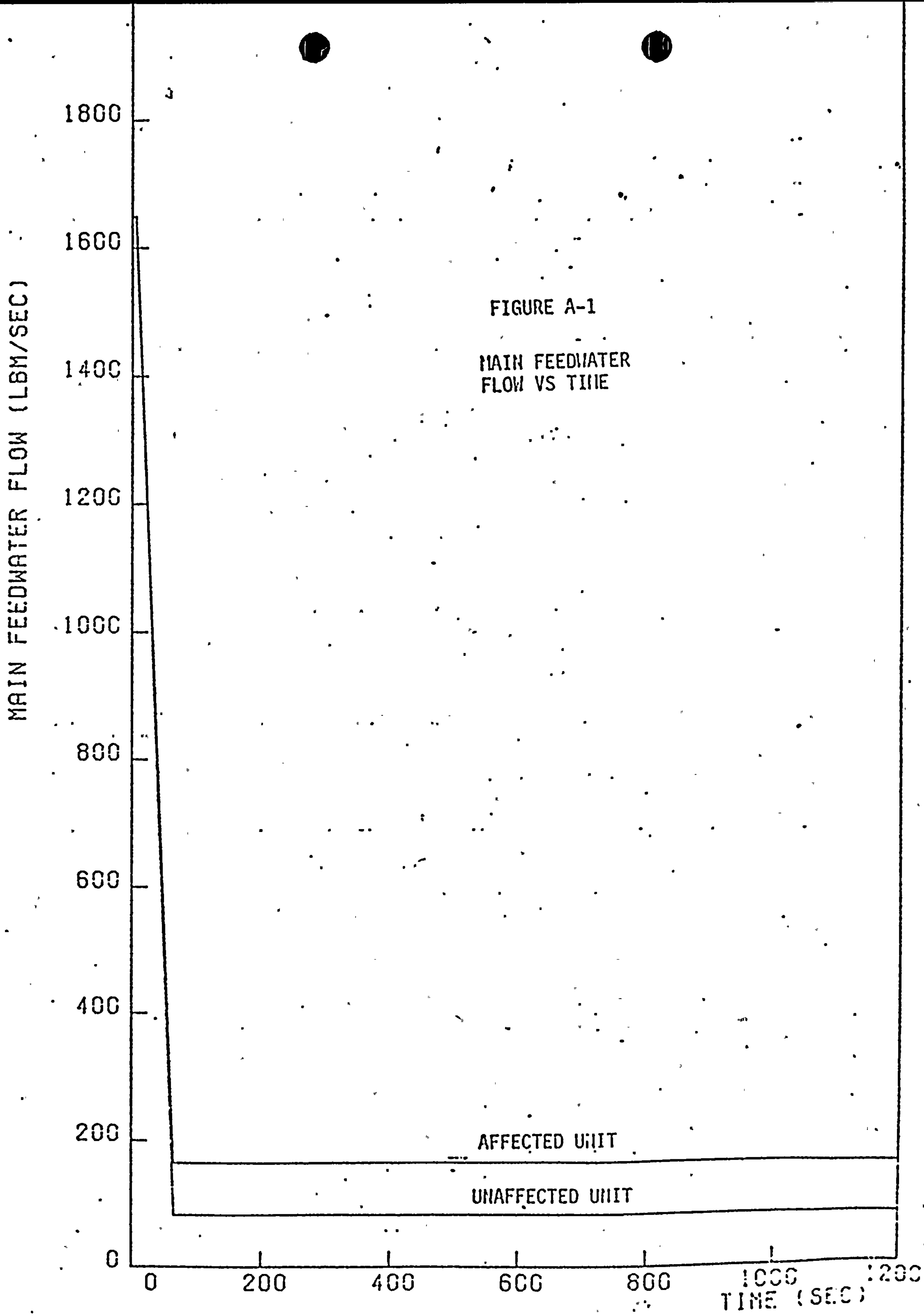


FIGURE 2
REACTIVITY VS MODERATOR TEMPERATURE
(BEST ESTIMATE VALUE)
REACTIVITY INSERTION, %Δρ
7
6
5
4
3
2
1
0
-1
300
350
400
450
500
550
600
MODERATOR TEMPERATURE, °F

FIGURE [illegible]

DOPPLER REACTIVITY VS FUEL TEMPERATURE




MAIN FEEDWATER FLOW (LBM/SEC)
1800
1600
1400
1200
1000
800
600
400
200
0
FIGURE A-1
MAIN FEEDWATER
FLOW VS TIME
AFFECTED UNIT
UNAFFECTED UNIT
0
200
400
600
800
1000
1200
TIME (SEC)

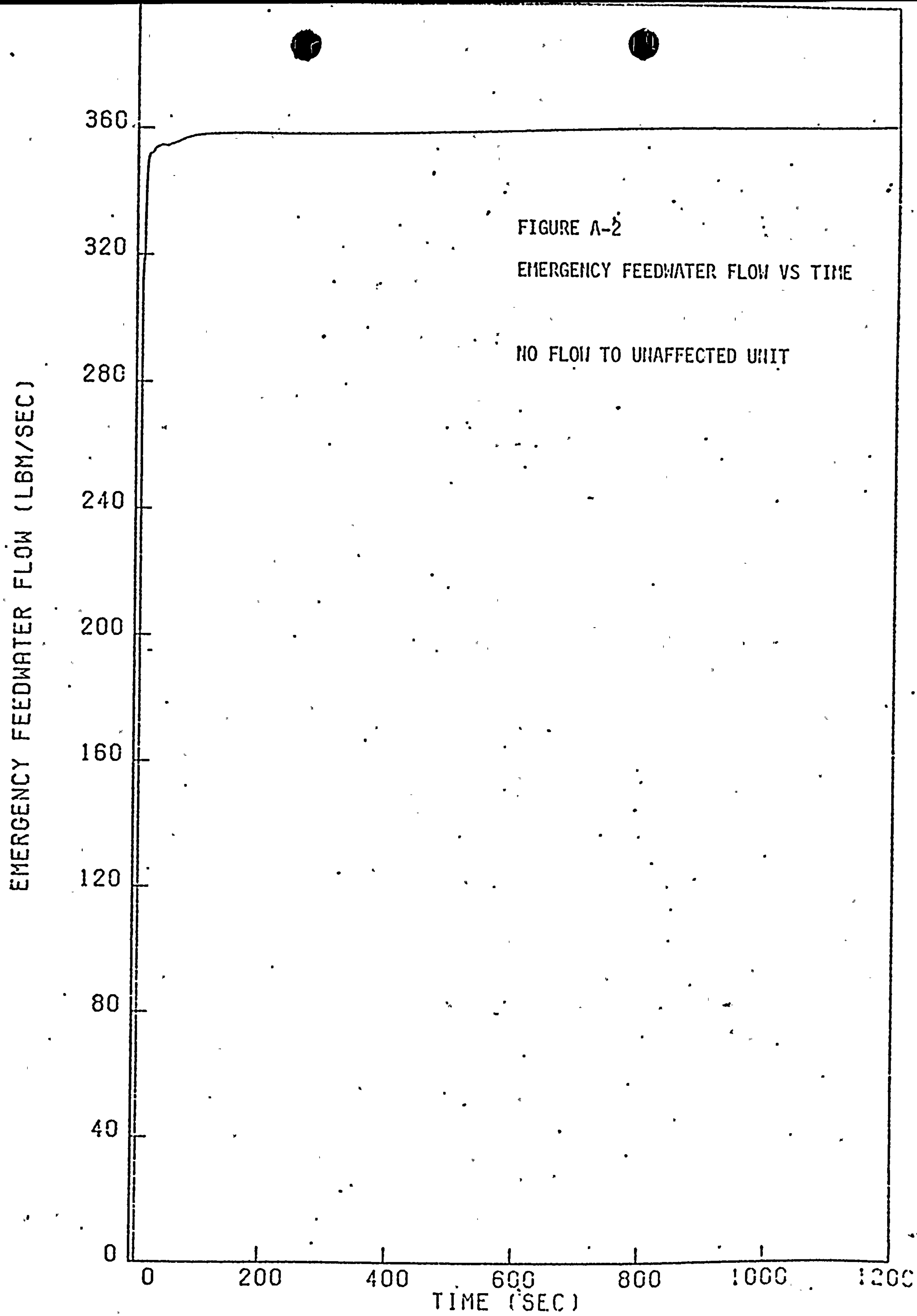


FIGURE A-2
EMERGENCY FEEDWATER FLOW VS TIME
NO FLOW TO UNAFFECTED UNIT
EMERGENCY FEEDWATER FLOW (LBM/SEC)
360
320
280
240
200
160
120
80
40
0
0
200
400
600
800
1000
1200
TIME (SEC)

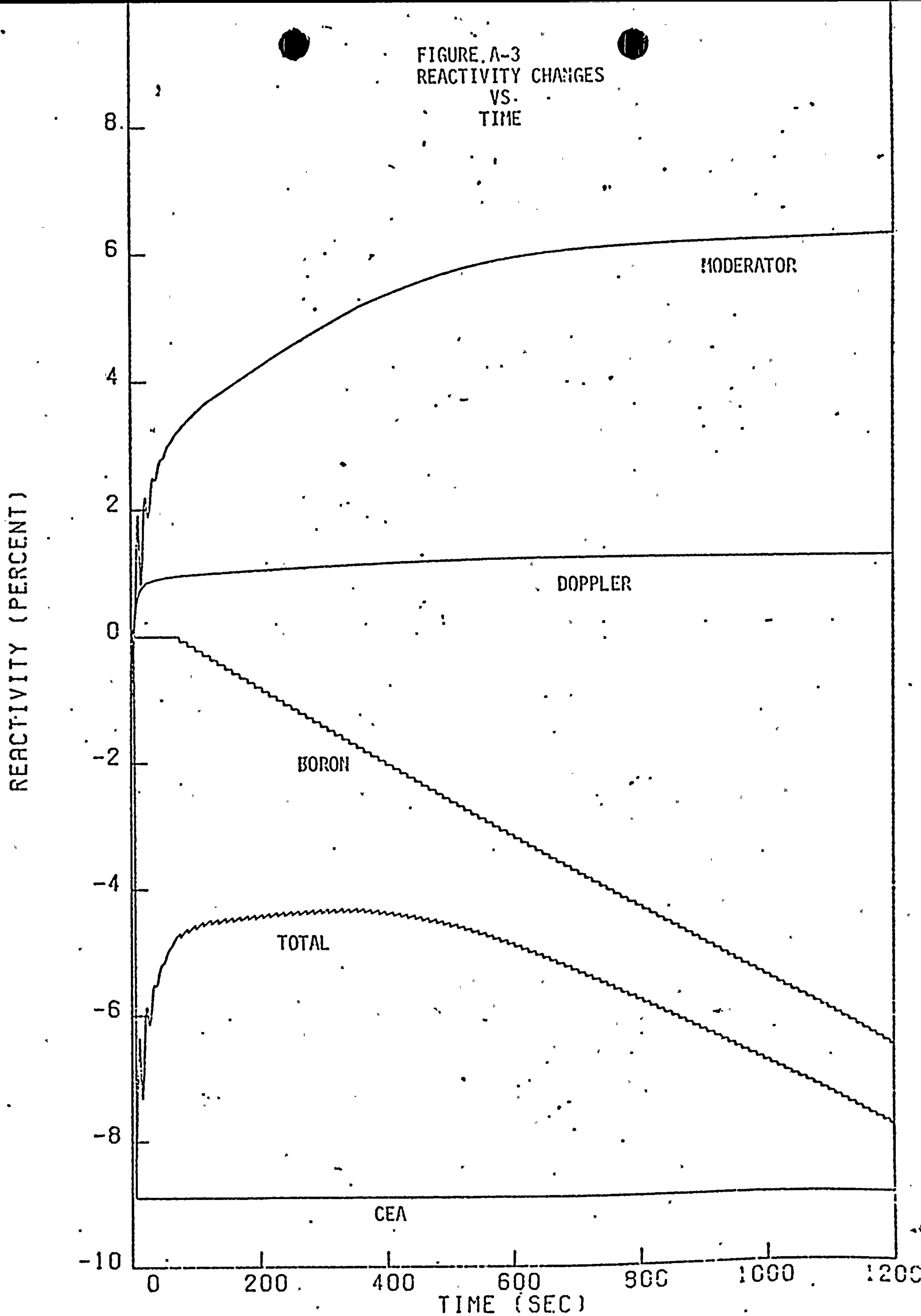


FIGURE. A-3
REACTIVITY CHANGES
VS.
TIME
MODERATOR
DOPPLER
BORON
TOTAL
CEA
REACTIVITY (PERCENT)
8.
6
4
2
0
-2
-4
-6
-8
-10
0
200
400
600
800
1000
1200
TIME (SEC)

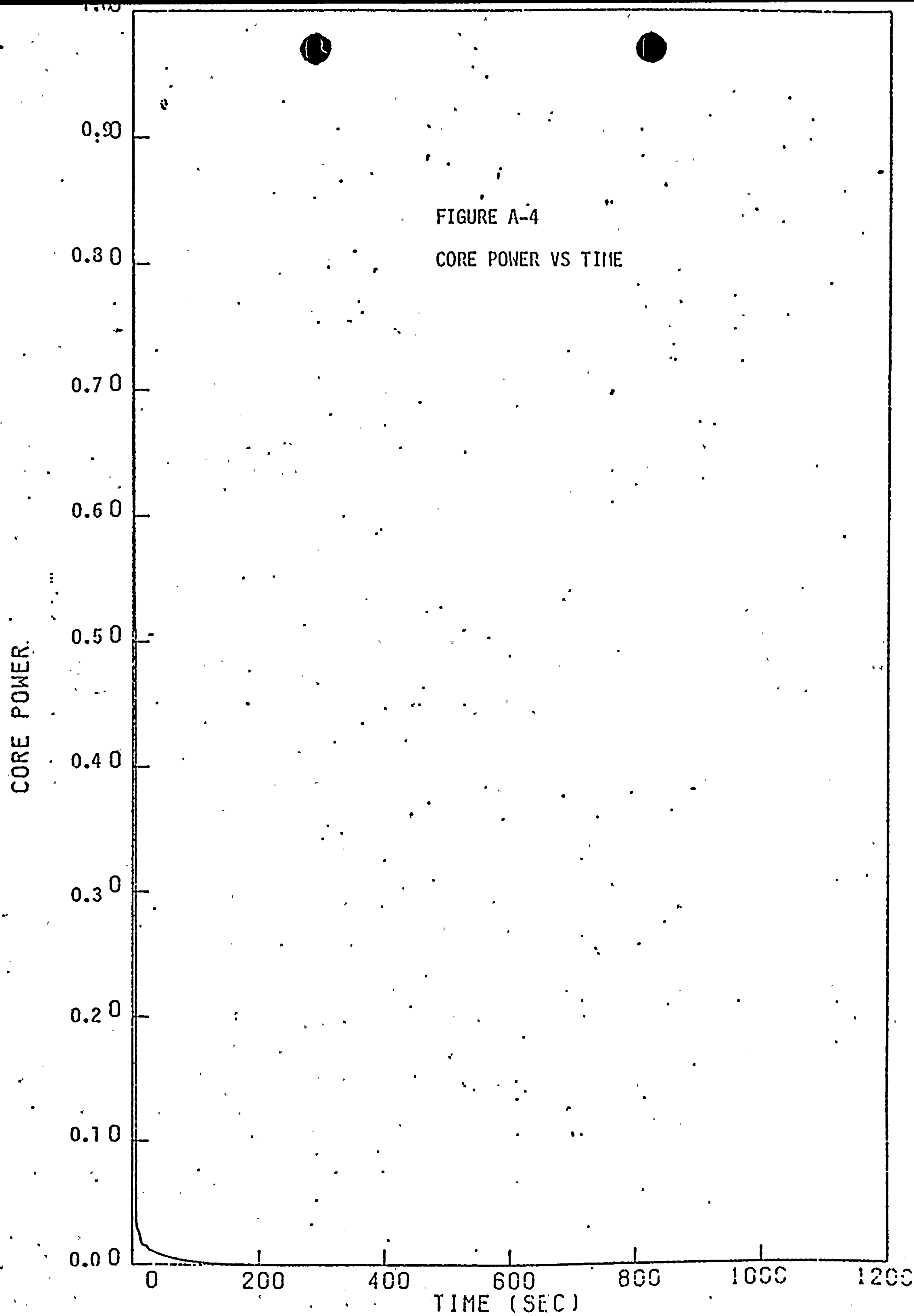
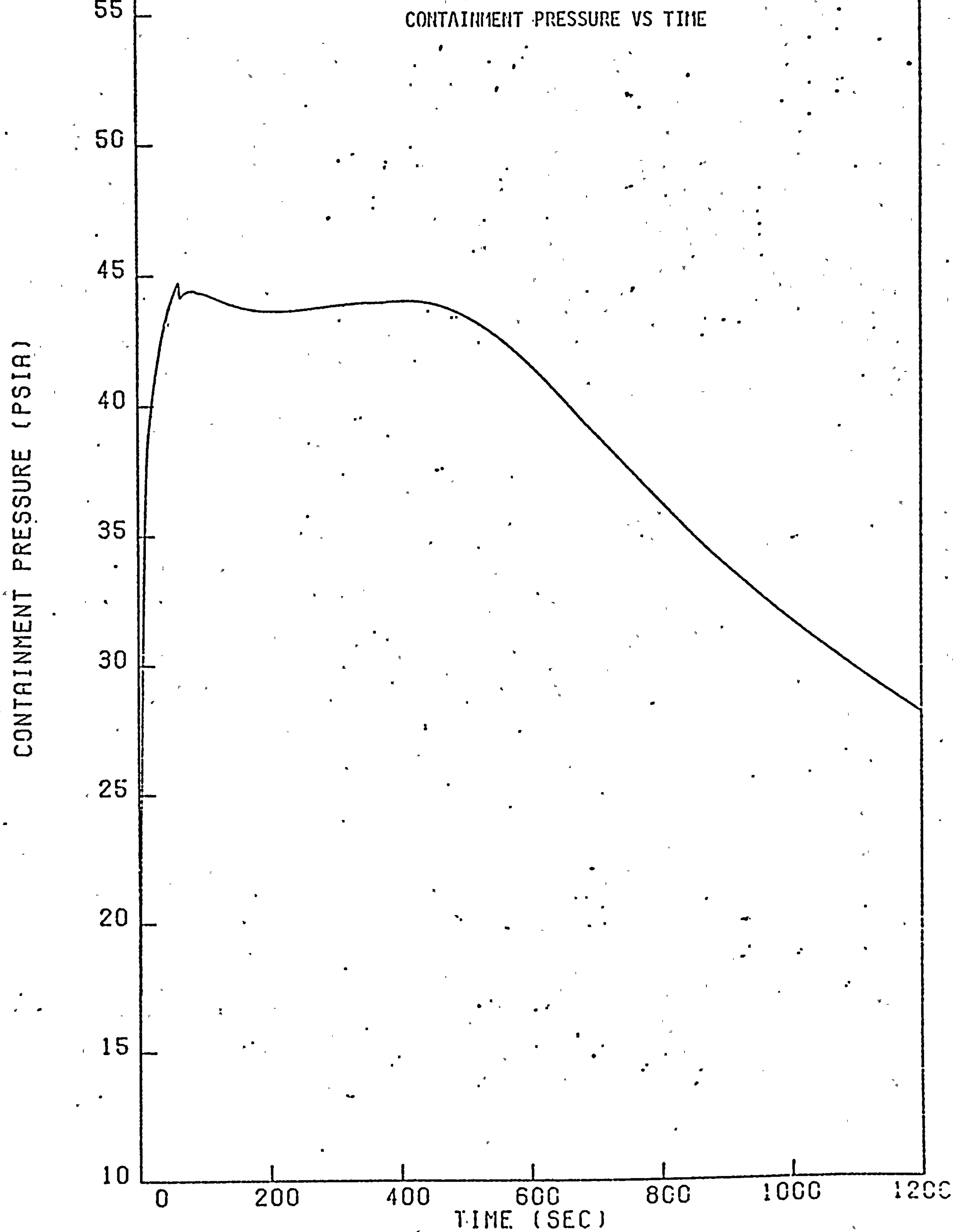


FIGURE A-4
CORE POWER VS TIME
CORE POWER
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
200
400
600
800
1000
1200
TIME (SEC)

FIGURE A-5

CONTAINMENT PRESSURE VS TIME



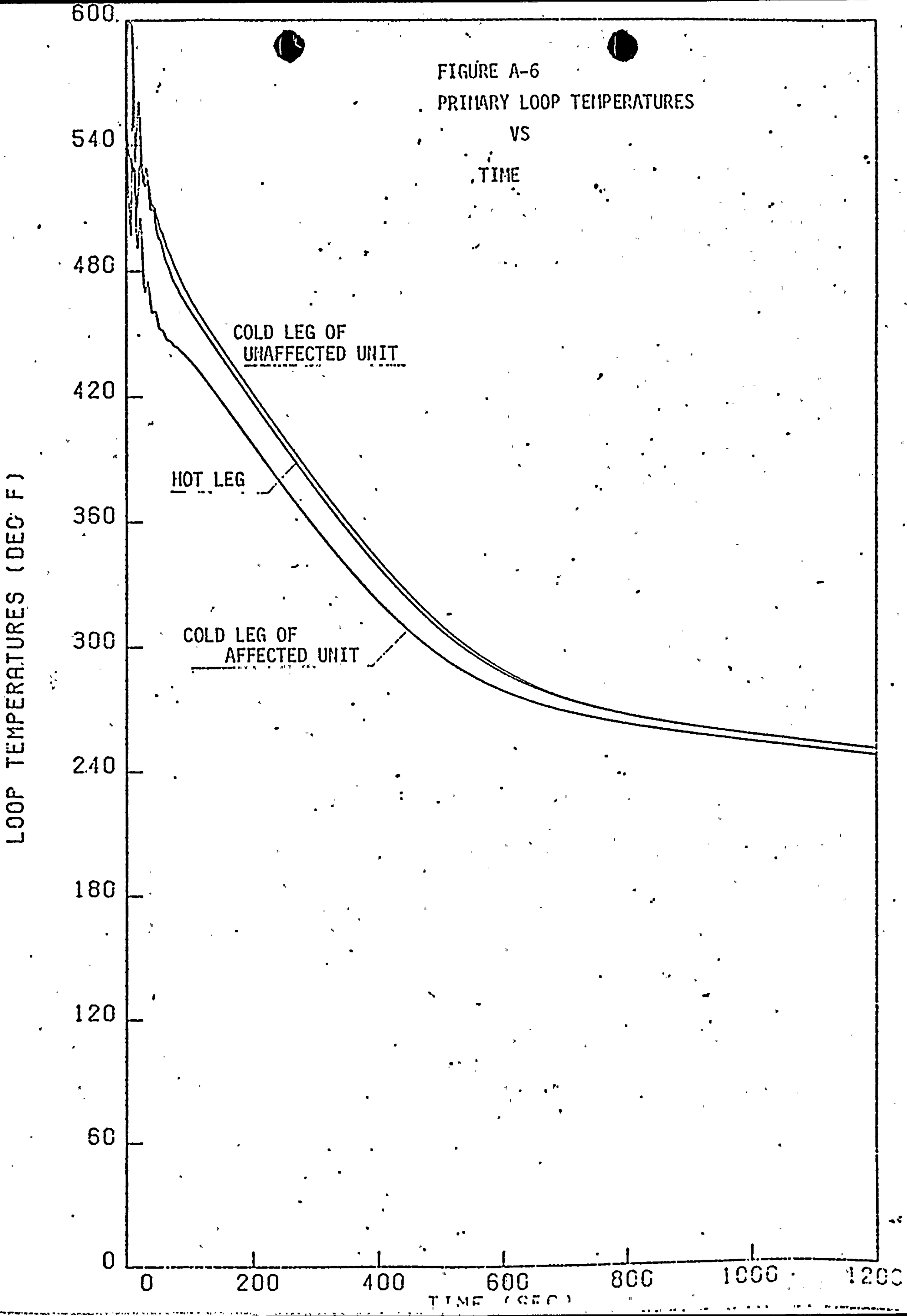
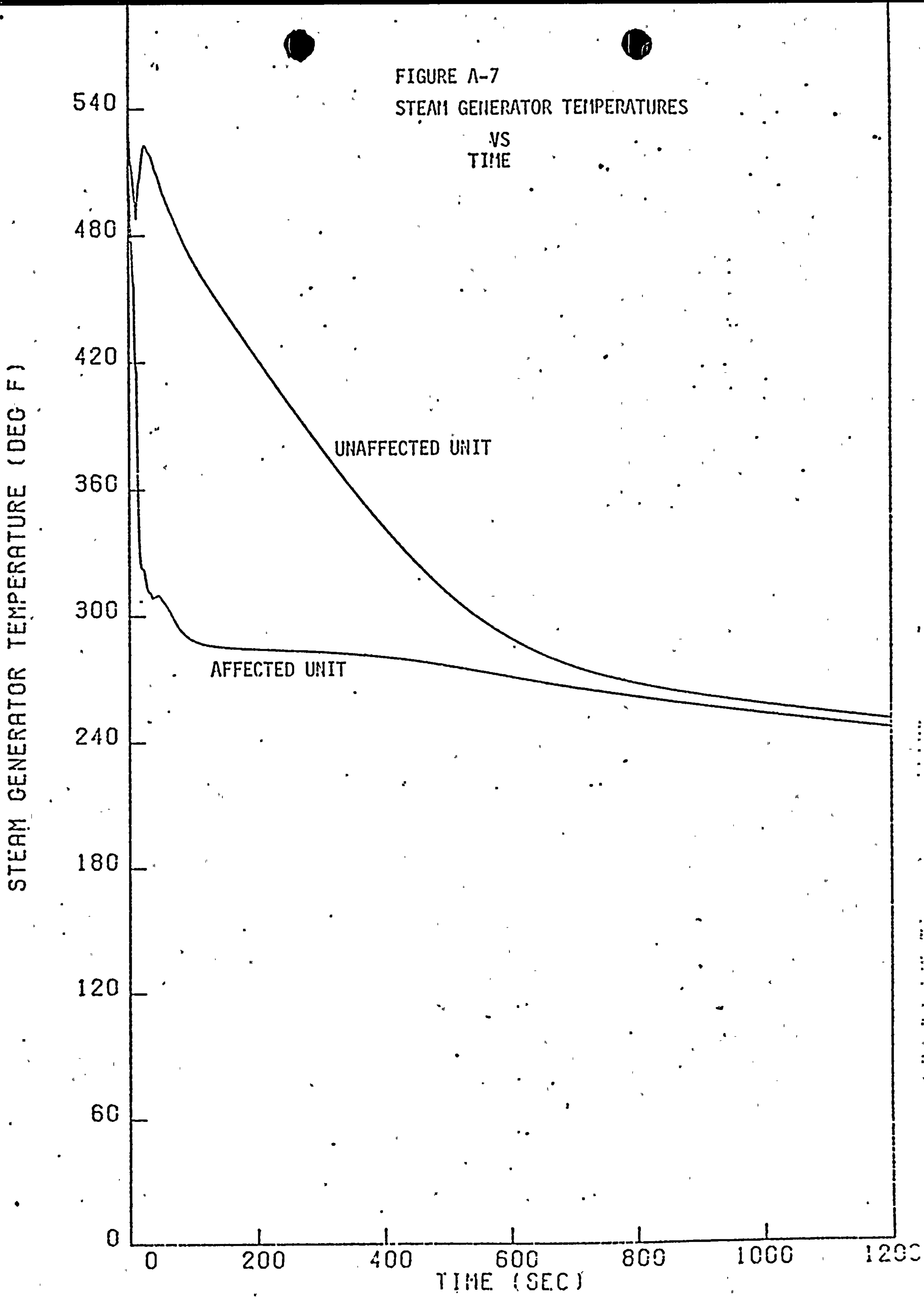


FIGURE A-6
PRIMARY LOOP TEMPERATURES
VS
TIME
COLD LEG OF
UNAFFECTED UNIT
HOT LEG
COLD LEG OF
AFFECTED UNIT
LOOP TEMPERATURES (DEG F)
600
540
480
420
360
300
240
180
120
60
0
0
200
400
600
800
1000
1200

FIGURE A-7
STEAM GENERATOR TEMPERATURES
VS
TIME



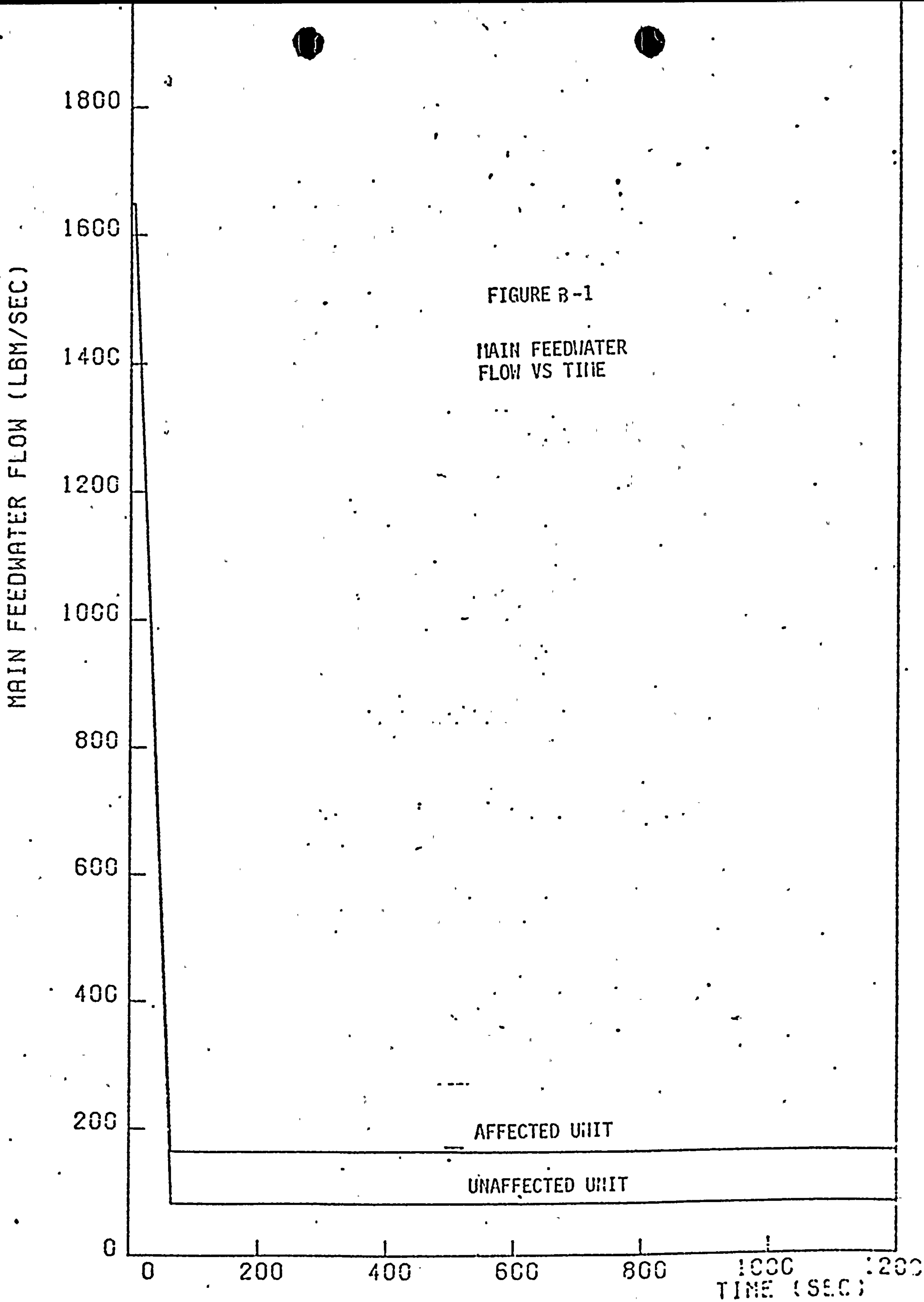


FIGURE B-1
MAIN FEEDWATER FLOW VS TIME
MAIN FEEDWATER FLOW (LBM/SEC)
1800
1600
1400
1200
1000
800
600
400
200
0
AFFECTED UNIT
UNAFFECTED UNIT
0
200
400
600
800
1000
1200
TIME (SEC)

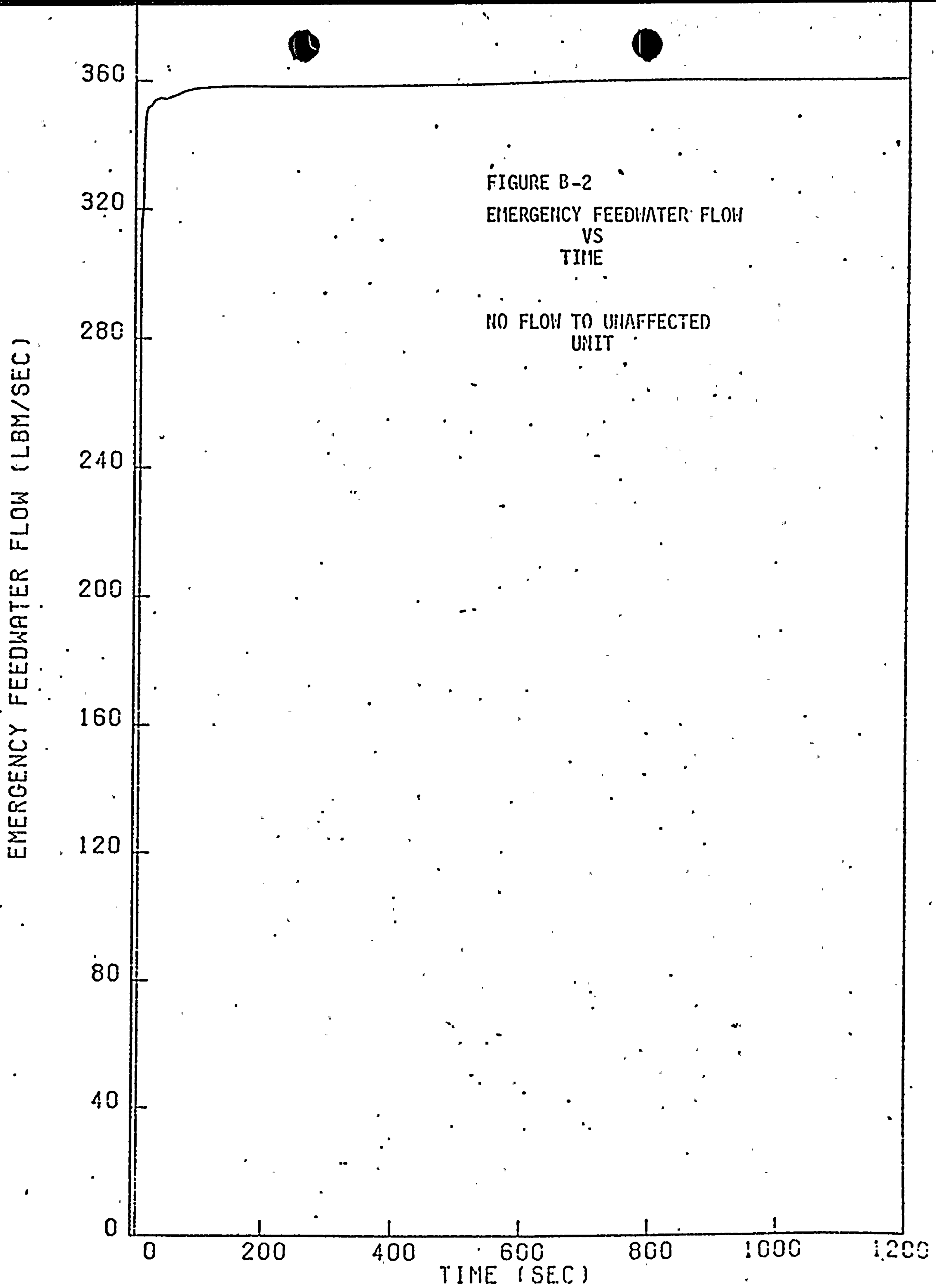
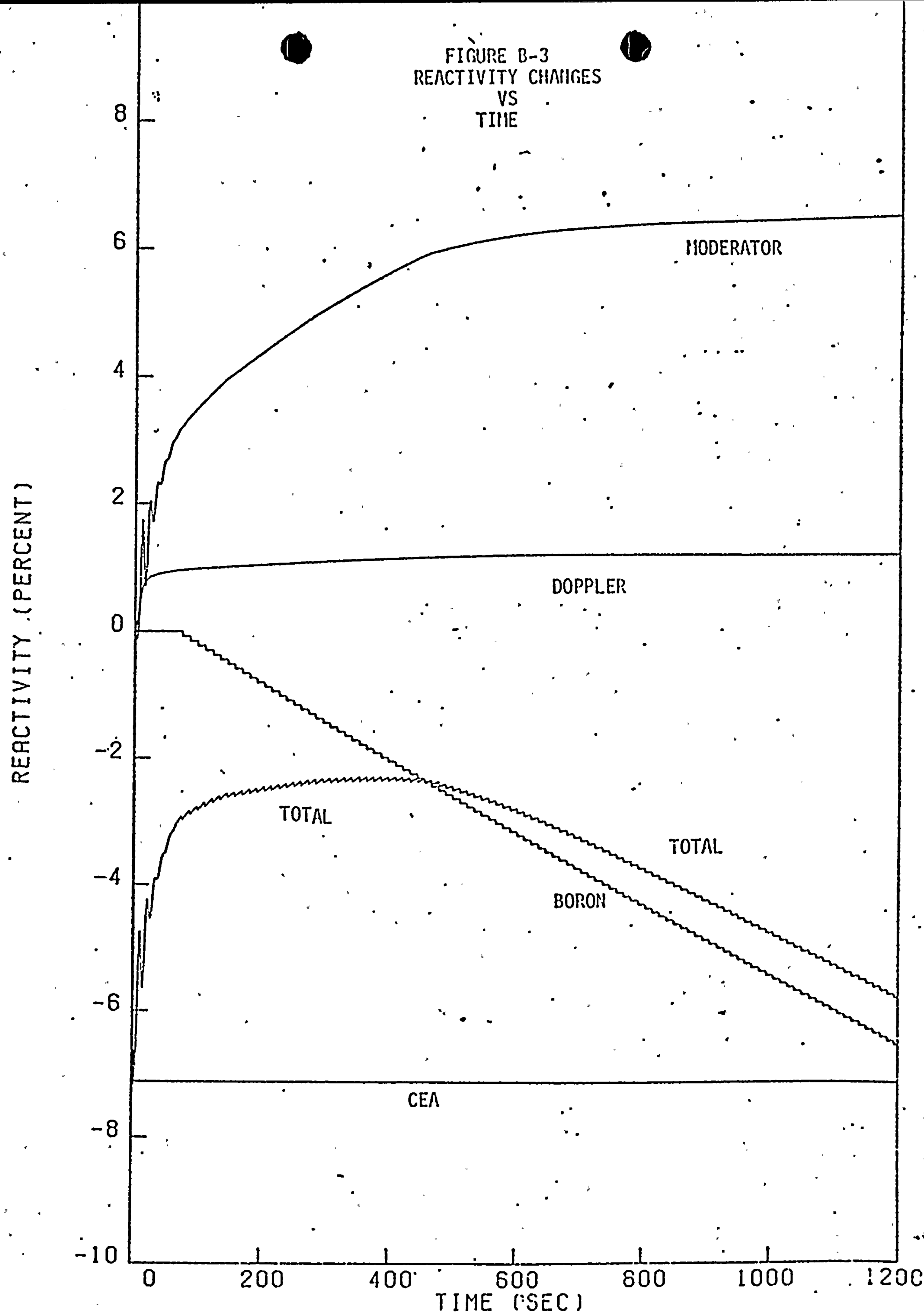


FIGURE B-2
EMERGENCY FEEDWATER FLOW
VS
TIME
NO FLOW TO UNAFFECTED
UNIT
EMERGENCY FEEDWATER FLOW (LBM/SEC)
360
320
280
240
200
160
120
80
40
0
0
200
400
600
800
1000
1200
TIME (SEC)

FIGURE B-3
REACTIVITY CHANGES
VS
TIME



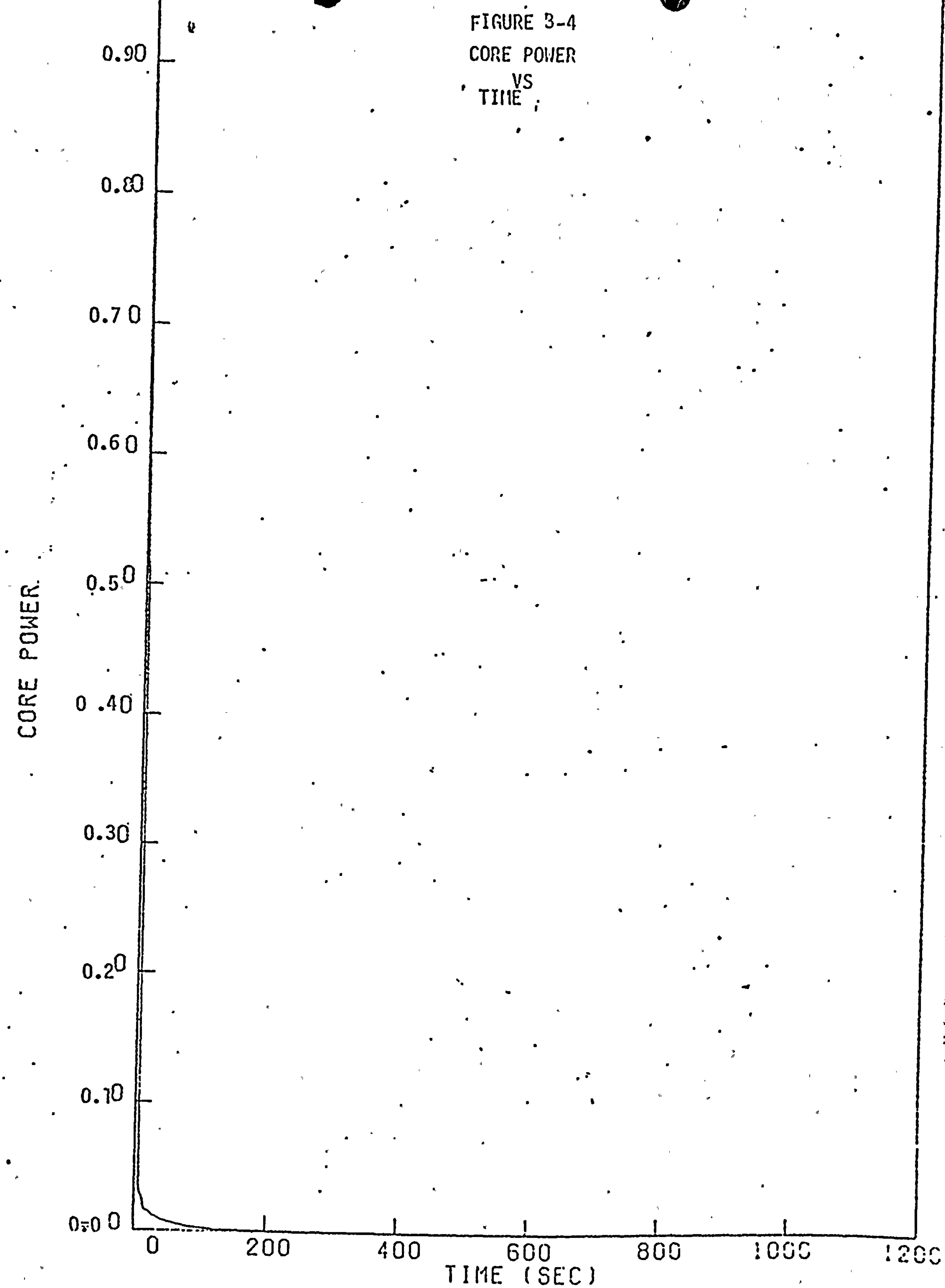


FIGURE 3-4
CORE POWER
VS
TIME
CORE POWER
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
200
400
600
800
1000
1200
TIME (SEC)

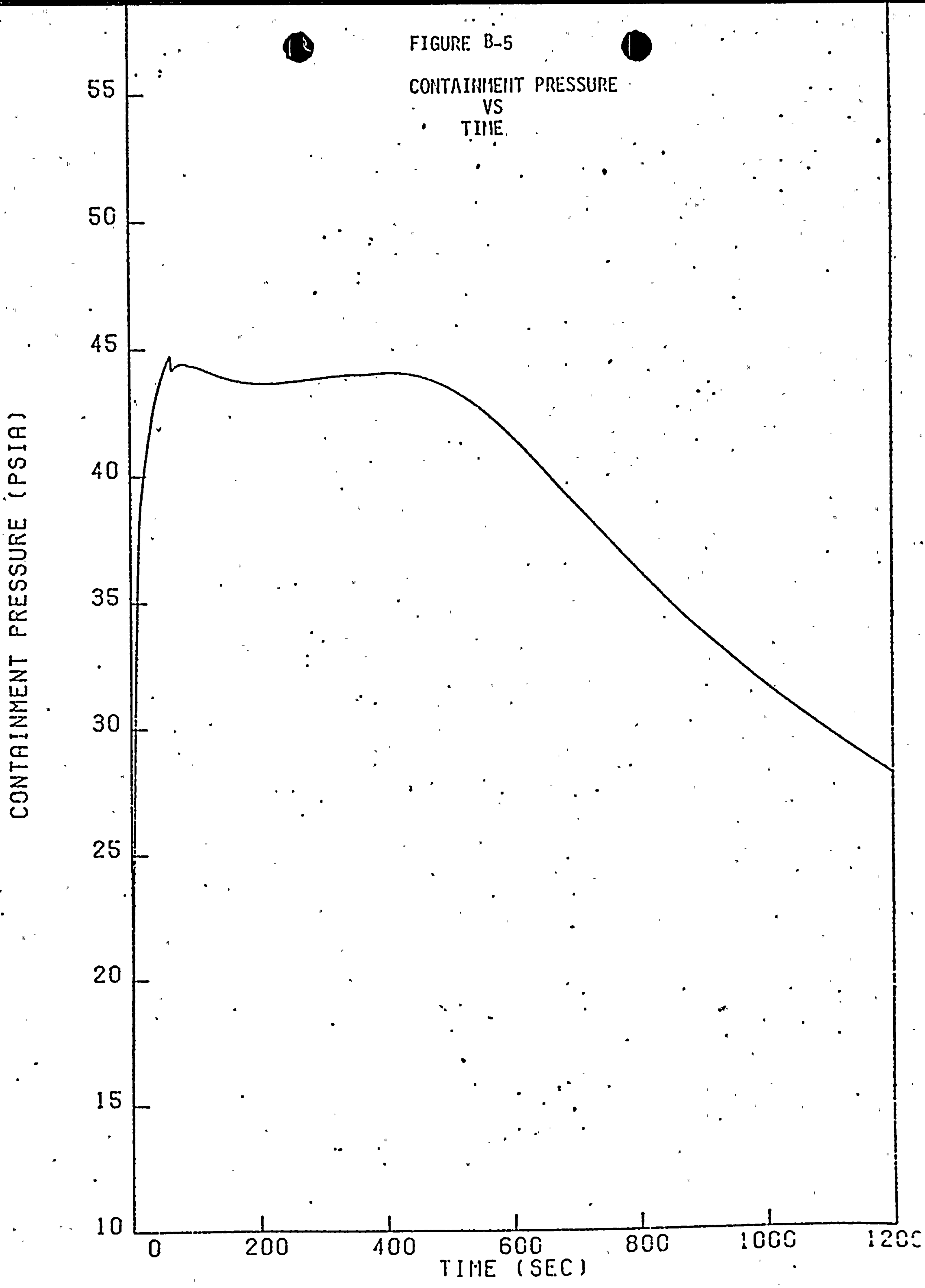


FIGURE B-5
CONTAINMENT PRESSURE
VS
TIME
CONTAINMENT PRESSURE (PSIA)
55
50
45
40
35
30
25
20
15
10
0
200
400
600
800
1000
1200
TIME (SEC)

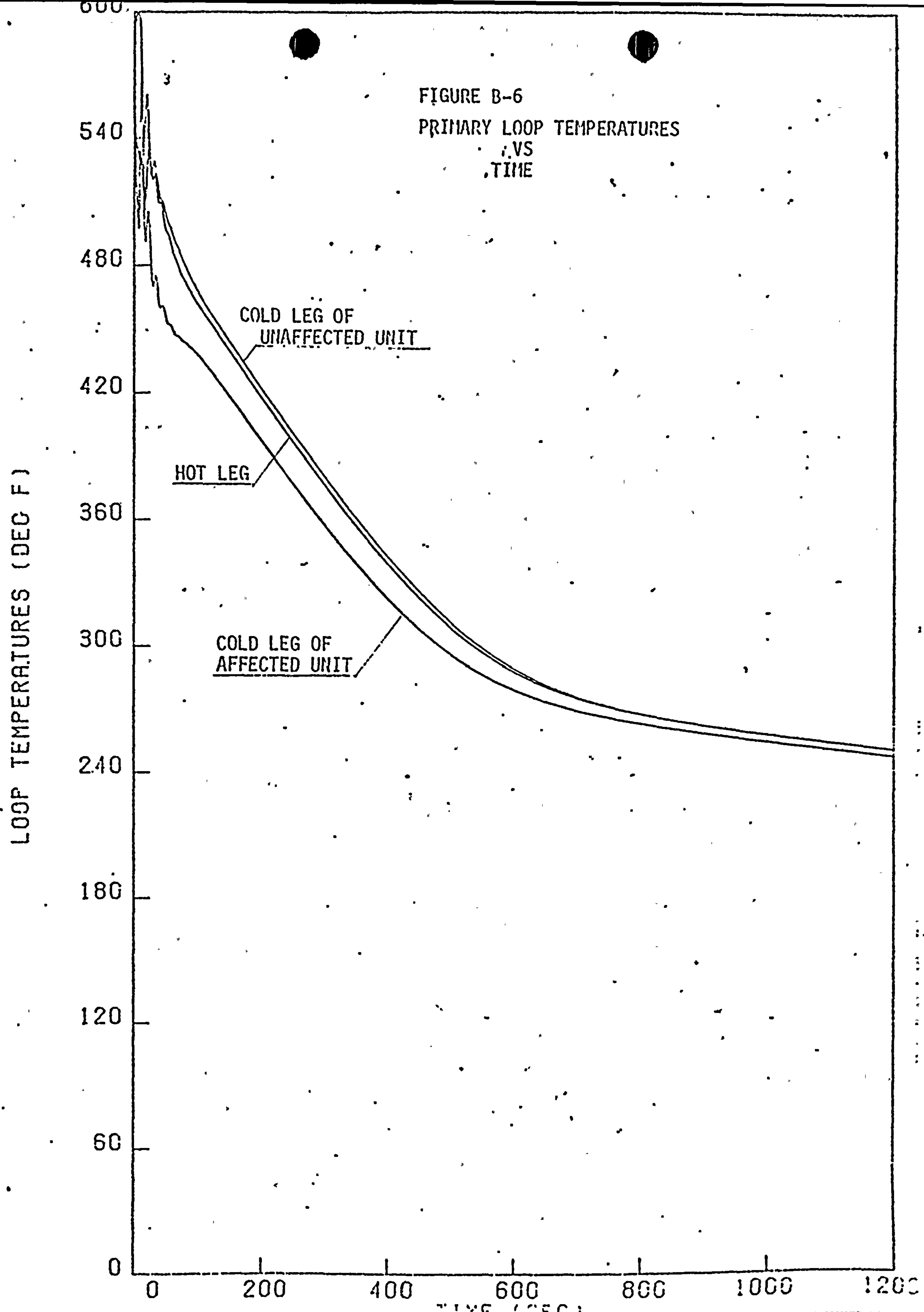


FIGURE B-6
PRIMARY LOOP TEMPERATURES
VS
TIME
COLD LEG OF
UNAFFECTED UNIT
HOT LEG
COLD LEG OF
AFFECTED UNIT
LOOP TEMPERATURES (DEG F)
600
540
480
420
360
300
240
180
120
60
0
0
200
400
600
800
1000
1200

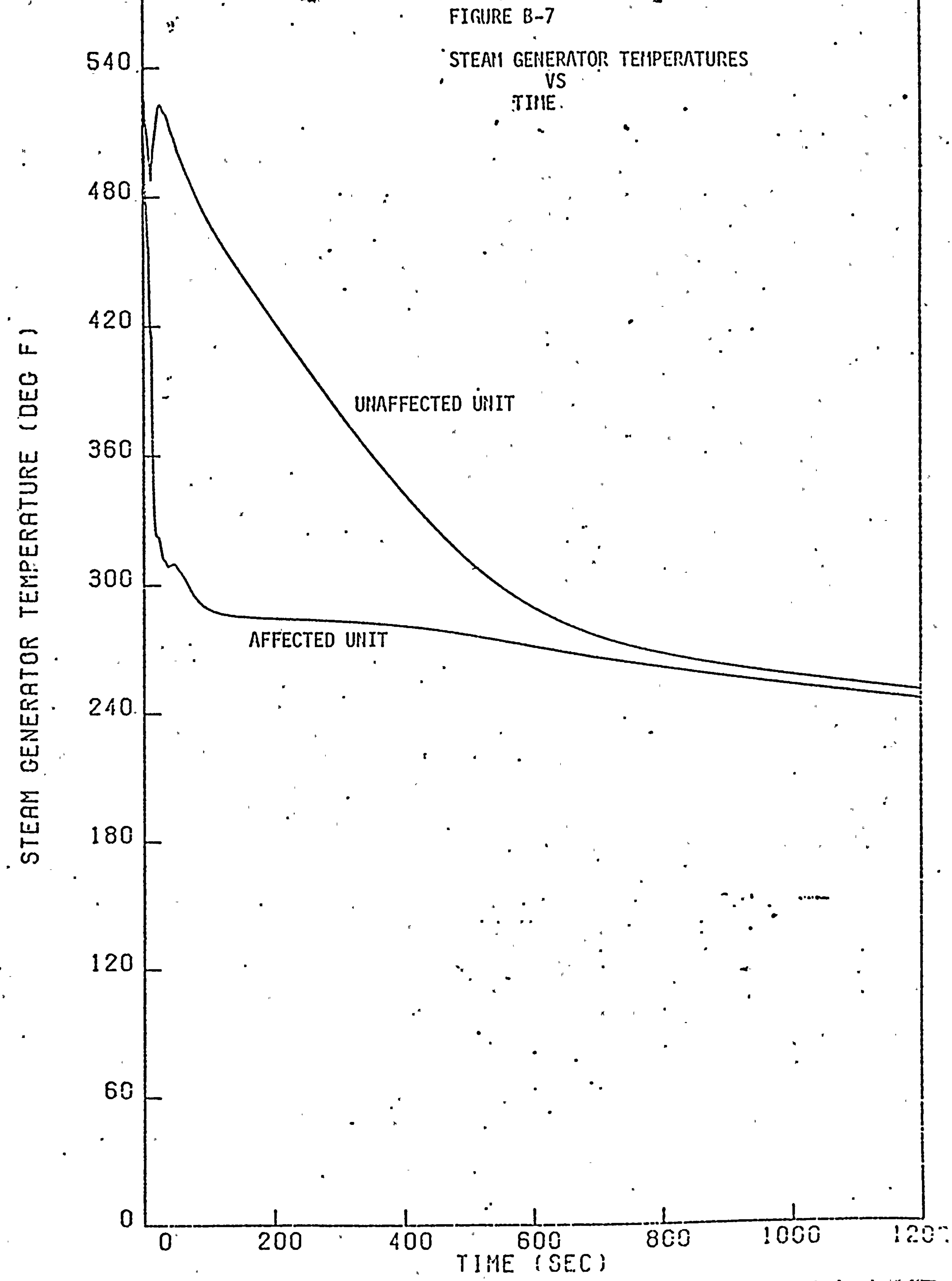


FIGURE B-7
STEAM GENERATOR TEMPERATURES
VS
TIME
UNAFFECTED UNIT
AFFECTED UNIT
STEAM GENERATOR TEMPERATURE (DEG F)
540
480
420
360
300
240
180
120
60
0
0
200
400
600
800
1000
TIME (SEC)

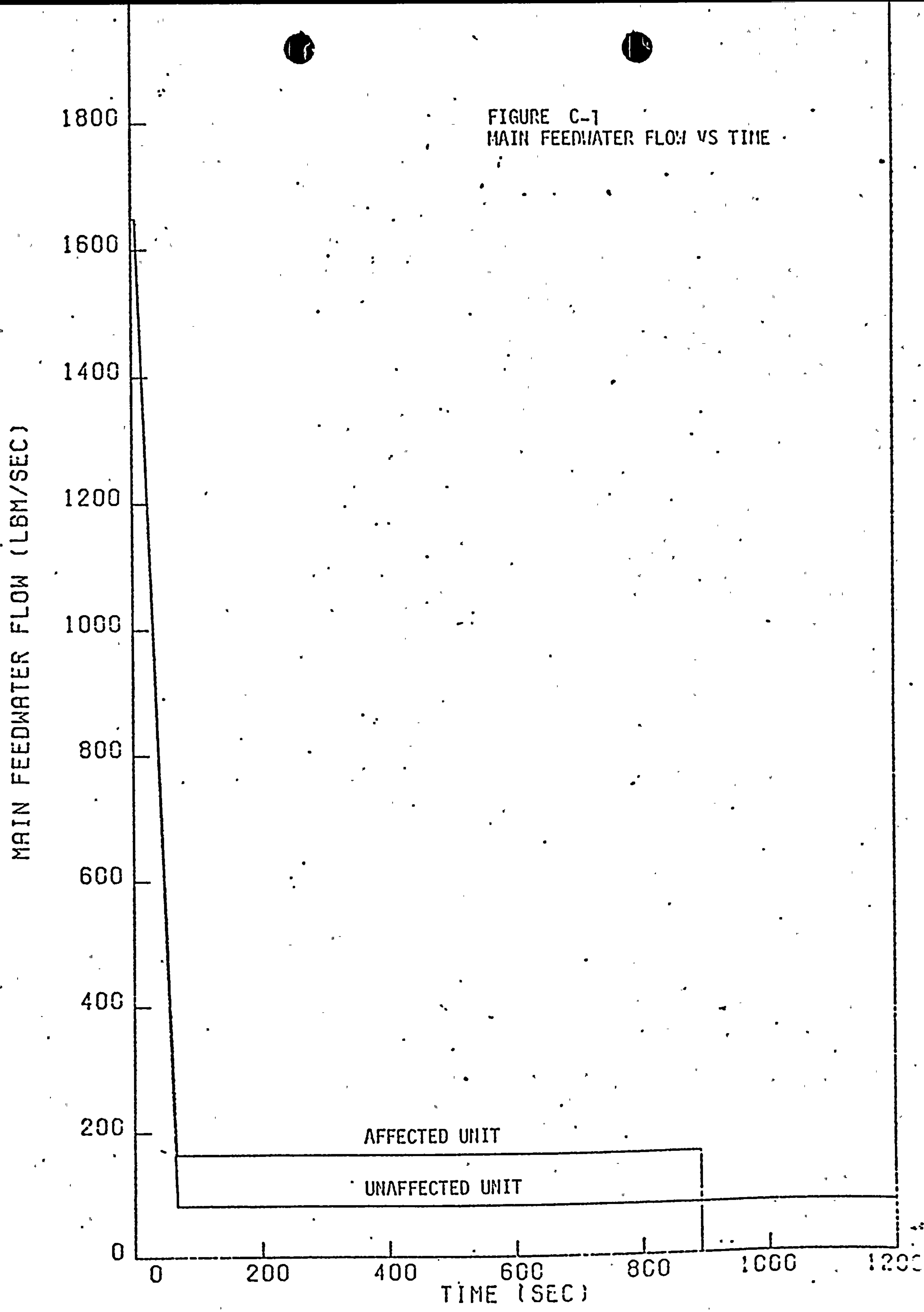


FIGURE C-1
MAIN FEEDWATER FLOW VS TIME
MAIN FEEDWATER FLOW (LBM/SEC)
1800
1600
1400
1200
1000
800
600
400
200
0
AFFECTED UNIT
UNAFFECTED UNIT
0
200
400
600
800
1000
TIME (SEC)

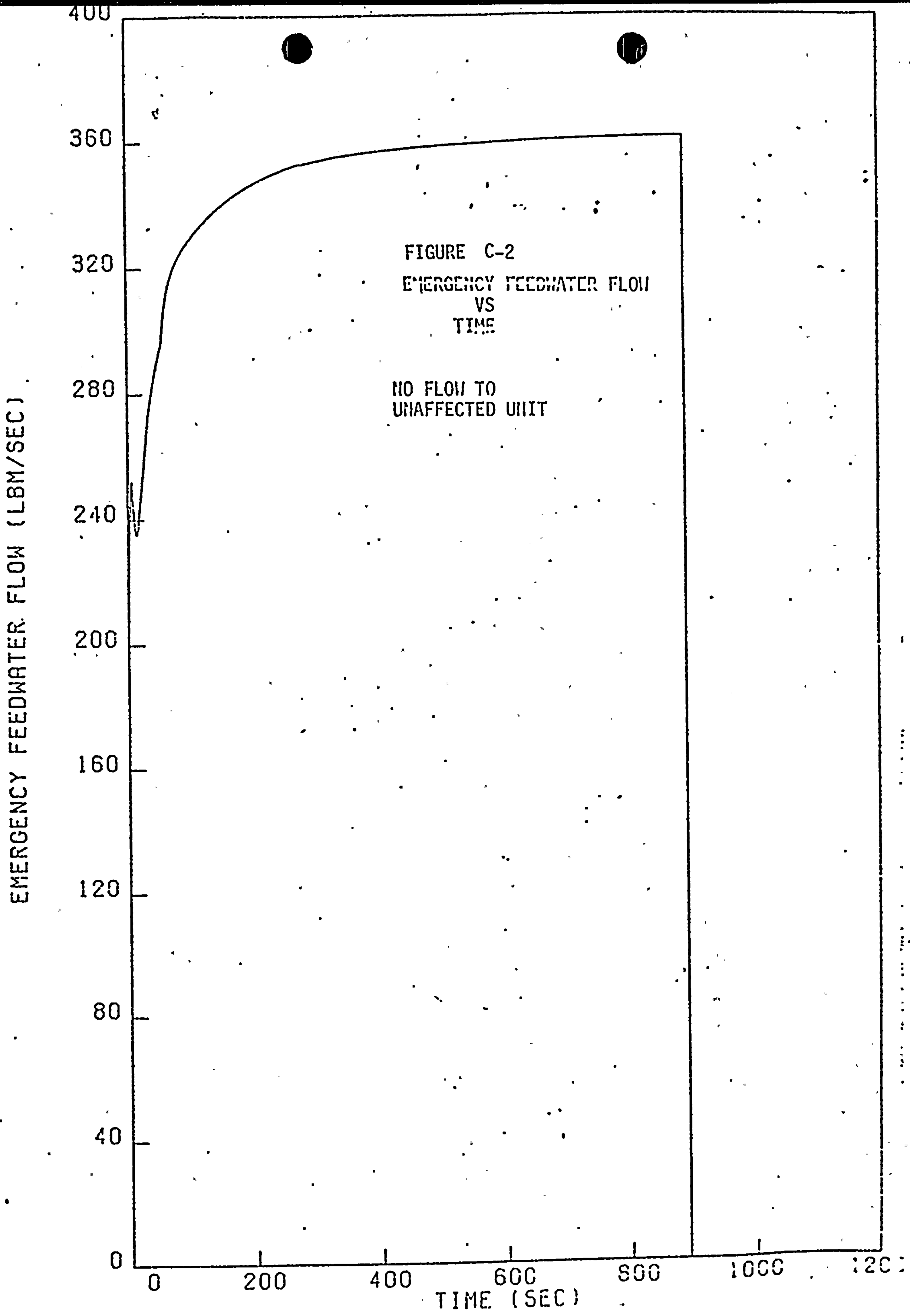


FIGURE C-2
EMERGENCY FEEDWATER FLOW
VS
TIME
NO FLOW TO
UNAFFECTED UNIT
EMERGENCY FEEDWATER FLOW (LBM/SEC)
TIME (SEC)
0
40
80
120
160
200
240
280
320
360
400
0
200
400
600
800
1000

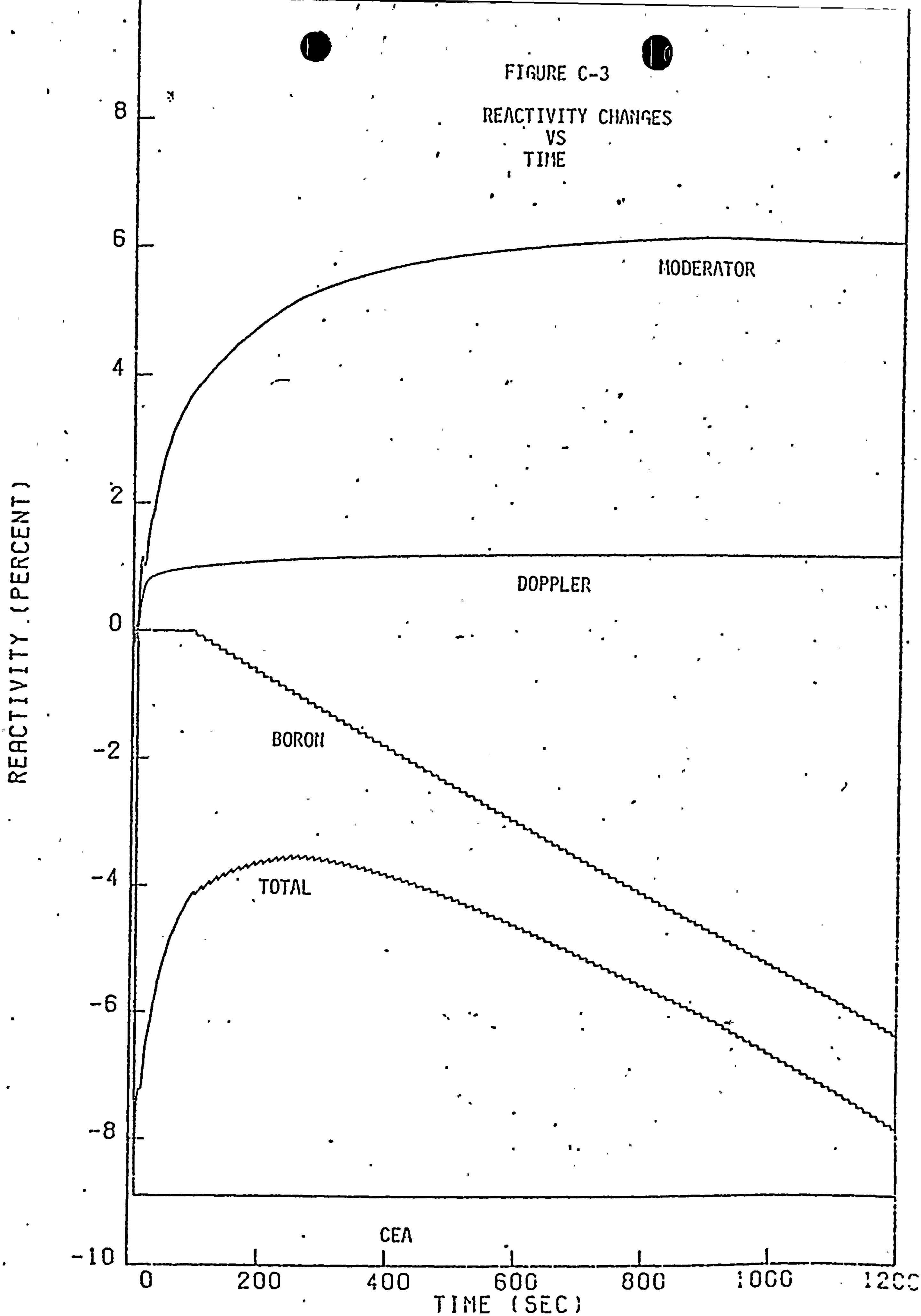


FIGURE C-3
REACTIVITY CHANGES
VS
TIME
MODERATOR
DOPPLER
BORON
TOTAL
CEA
REACTIVITY (PERCENT)
TIME (SEC)
8
6
4
2
0
-2
-4
-6
-8
-10
0
200
400
600
800
1000

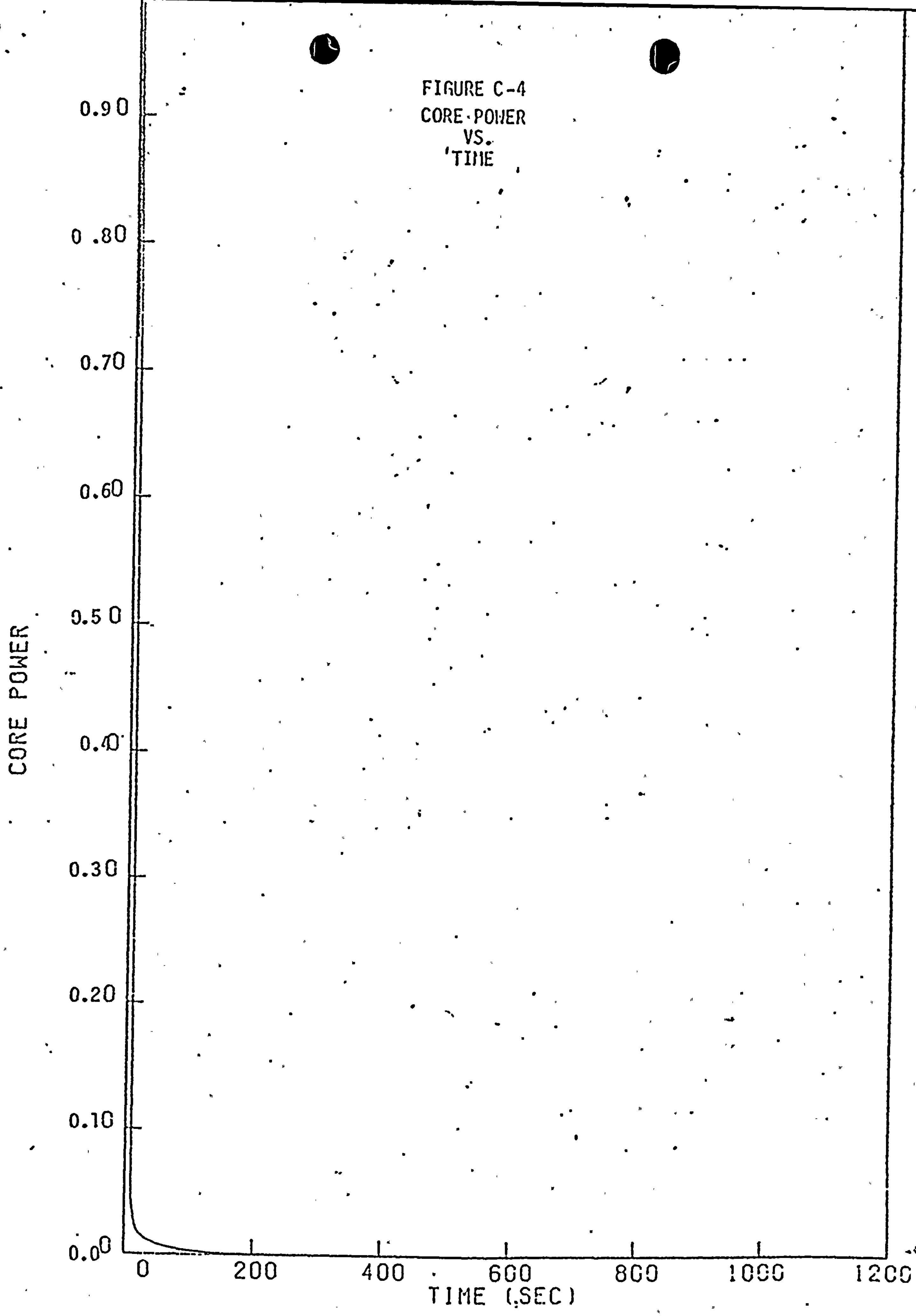


FIGURE C-4
CORE POWER
VS.
TIME
CORE POWER
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
200
400
600
800
1000
1200
TIME (SEC)

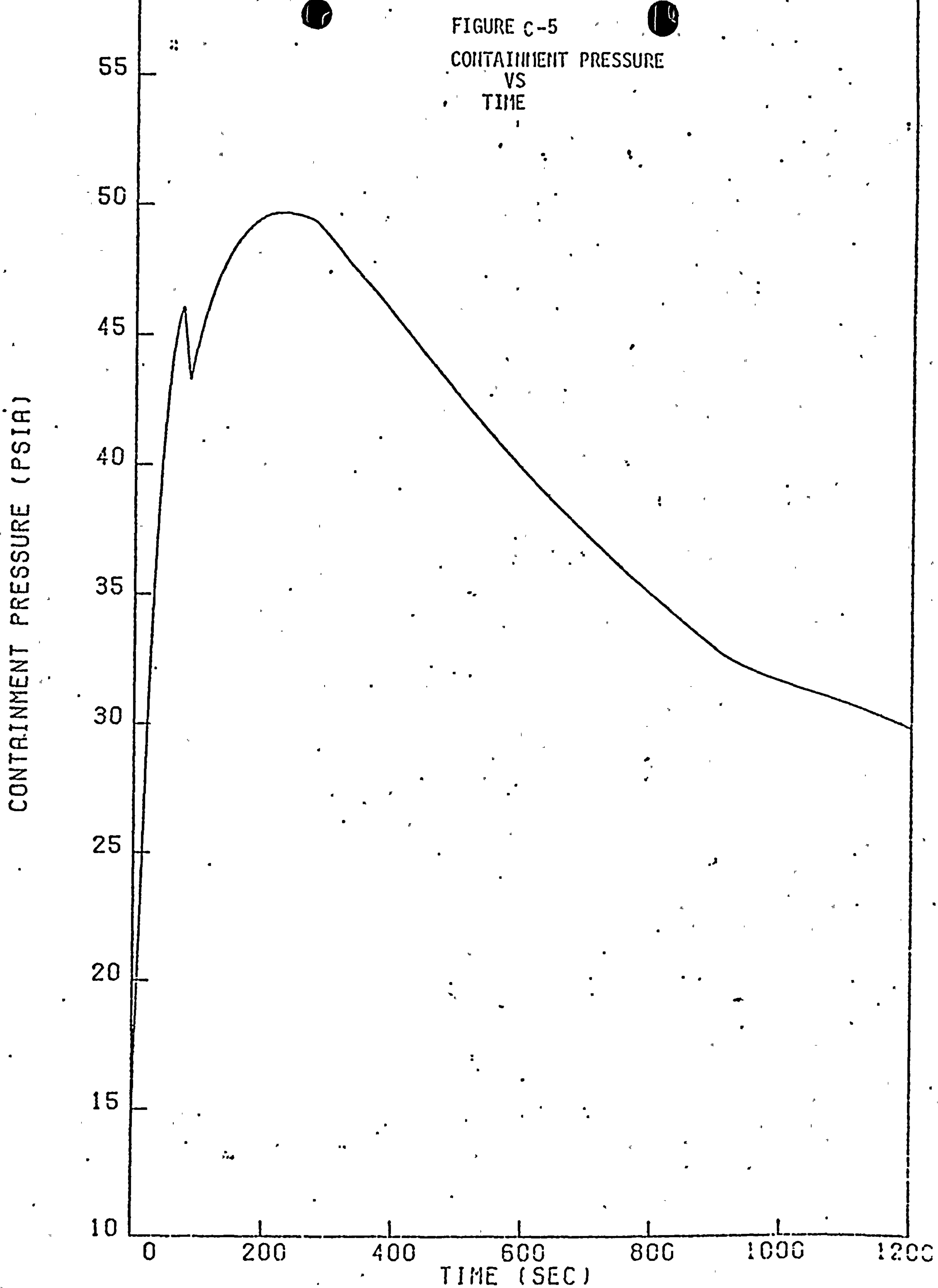


FIGURE C-5
CONTAINMENT PRESSURE
VS
TIME
CONTAINMENT PRESSURE (PSIA)
55
50
45
40
35
30
25
20
15
10
0
200
400
600
800
1000
1200
TIME (SEC)

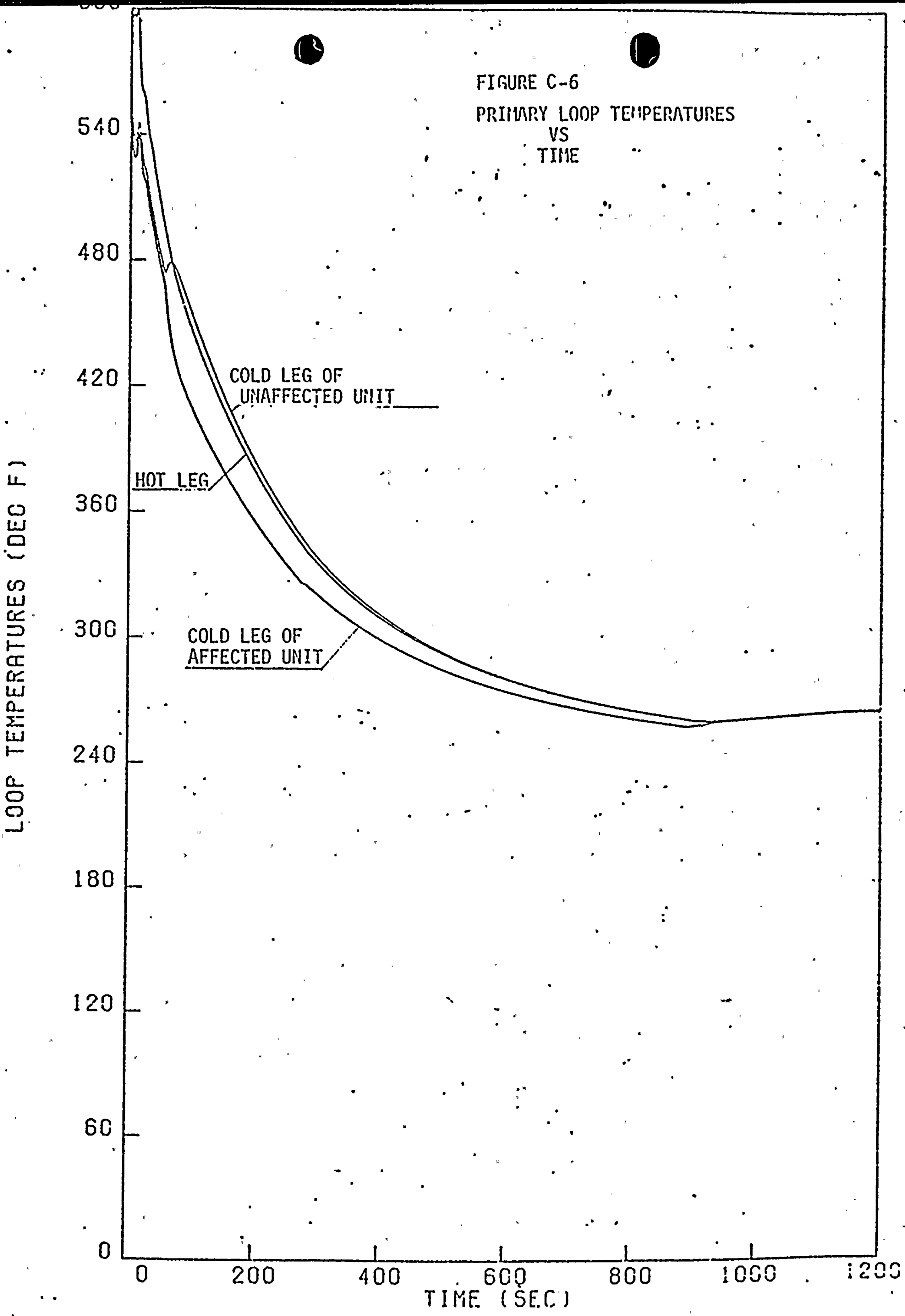
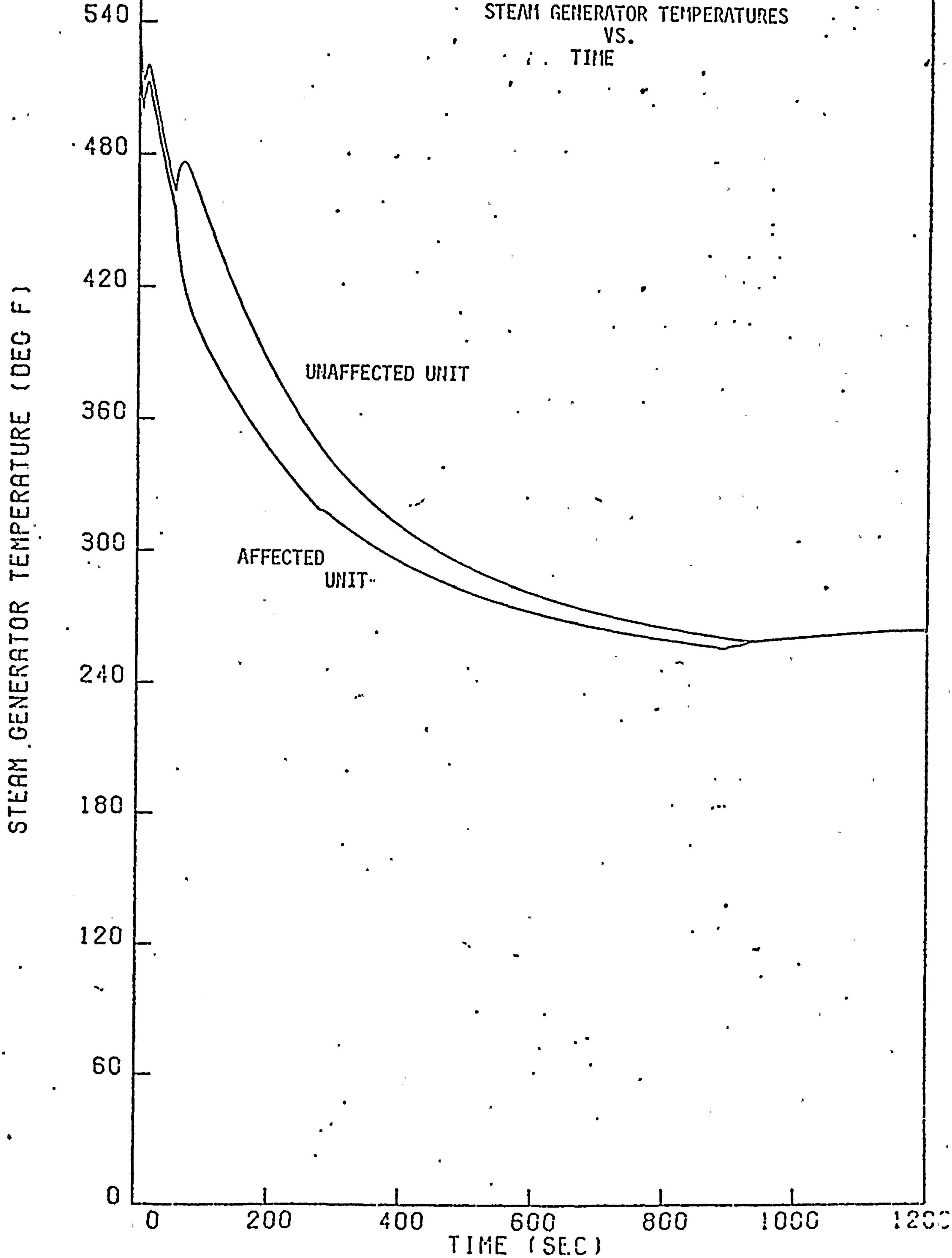


FIGURE C-6
PRIMARY LOOP TEMPERATURES
VS
TIME
COLD LEG OF
UNAFFECTED UNIT
HOT LEG
COLD LEG OF
AFFECTED UNIT
LOOP TEMPERATURES (DEG F)
540
480
420
360
300
240
180
120
60
0
0
200
400
600
800
1000
1200
TIME (SEC)

FIGURE C-7

STEAM GENERATOR TEMPERATURES VS. TIME



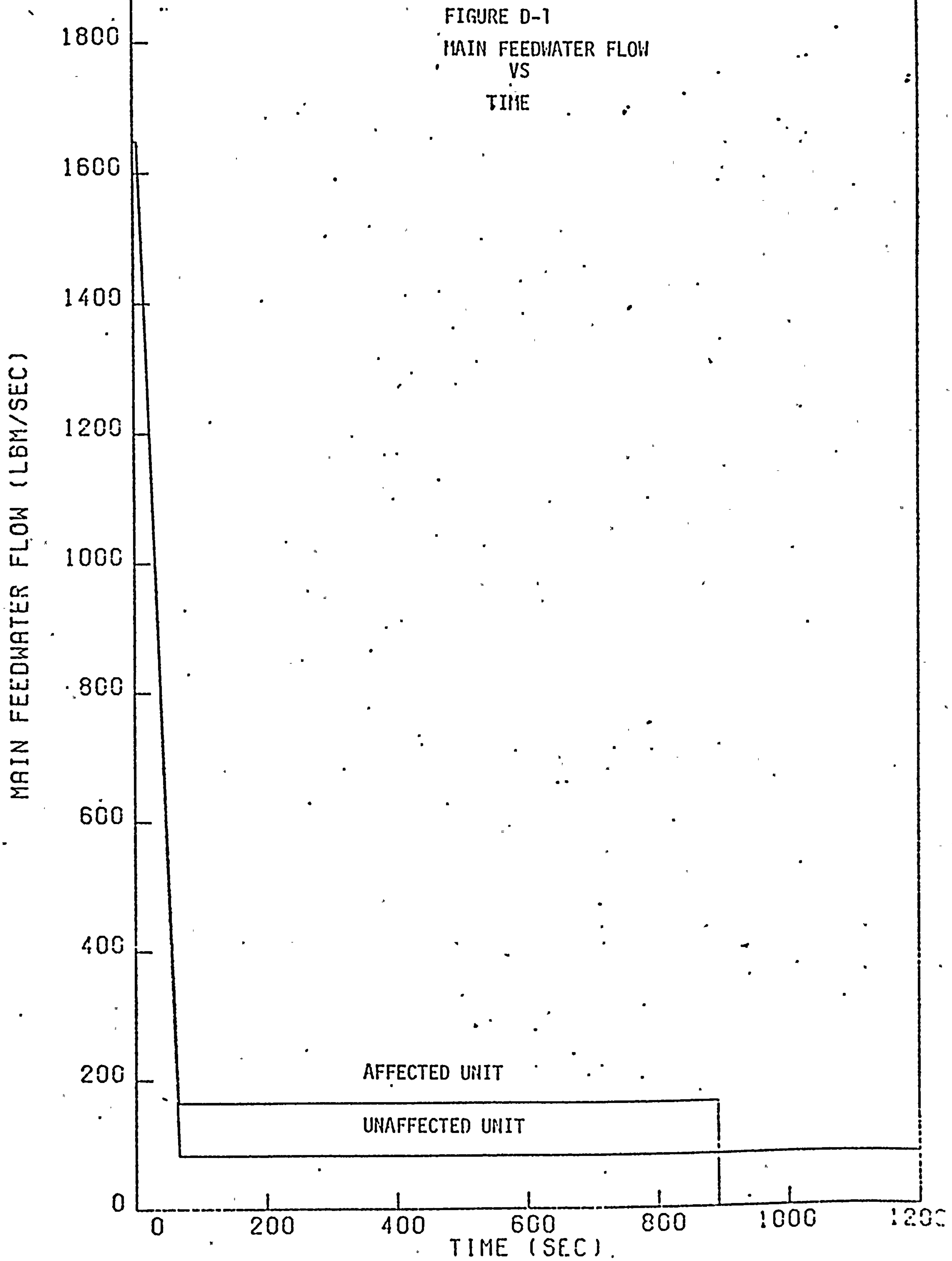


FIGURE D-1
MAIN FEEDWATER FLOW
VS
TIME
MAIN FEEDWATER FLOW (LBM/SEC)
1800
1600
1400
1200
1000
800
600
400
200
0
AFFECTED UNIT
UNAFFECTED UNIT
0
200
400
600
800
1000
TIME (SEC)

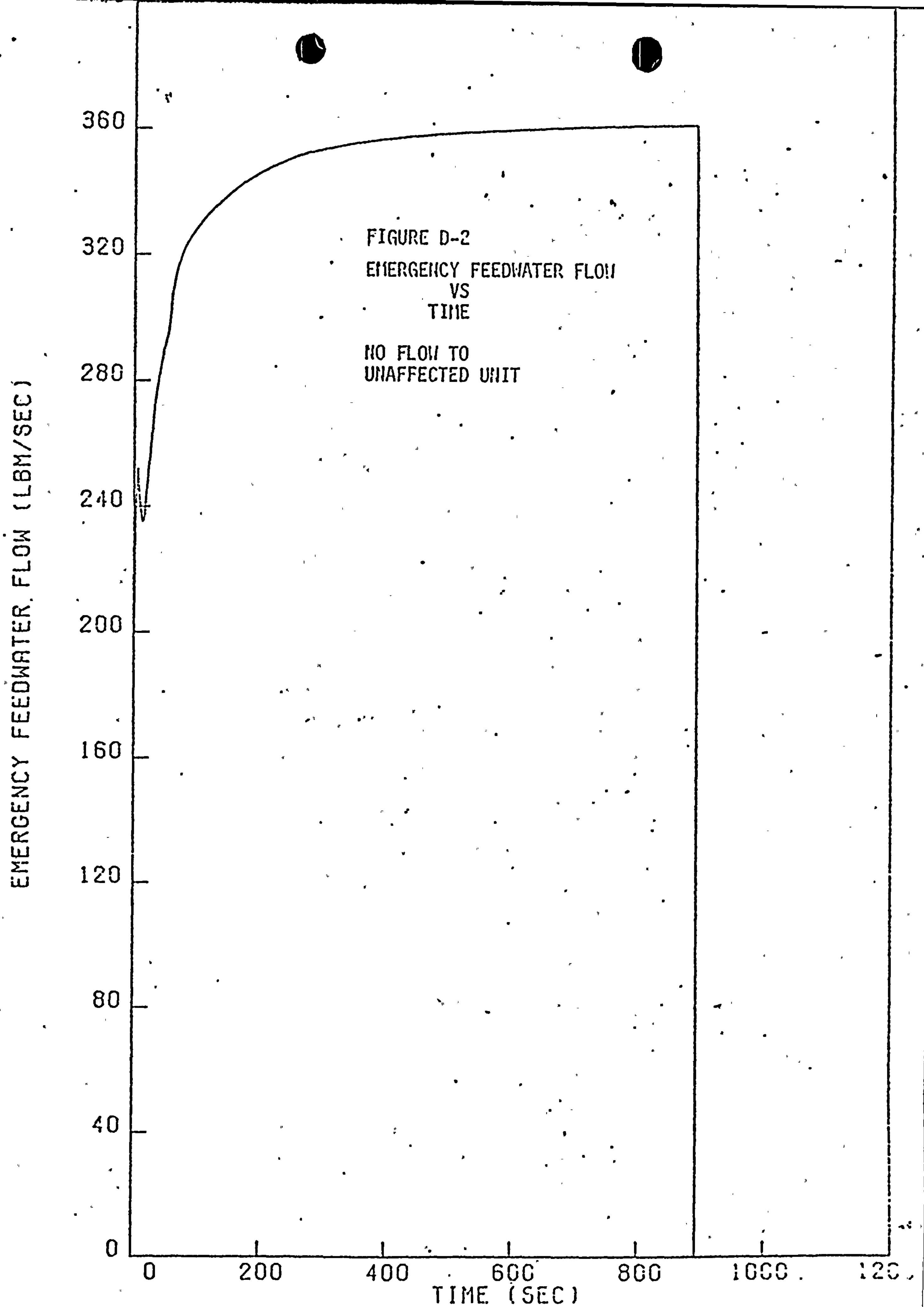
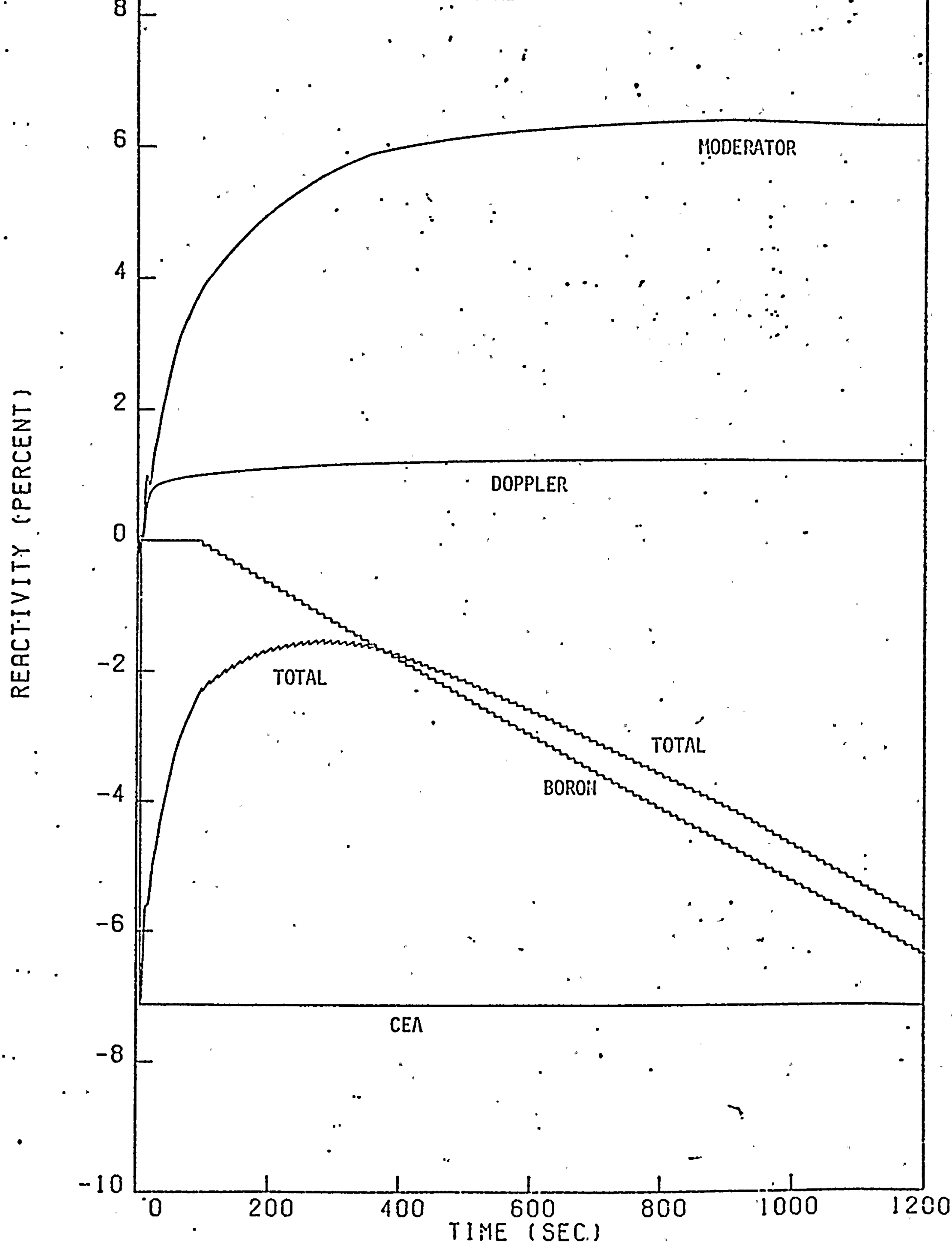


FIGURE D-2
EMERGENCY FEEDWATER FLOW
VS
TIME
NO FLOW TO
UNAFFECTED UNIT
EMERGENCY FEEDWATER FLOW (LBM/SEC)
360
320
280
240
200
160
120
80
40
0
0
200
400
600
800
1000
TIME (SEC)

FIGURE D-3
REACTIVITY CHANGES
VS
TIME



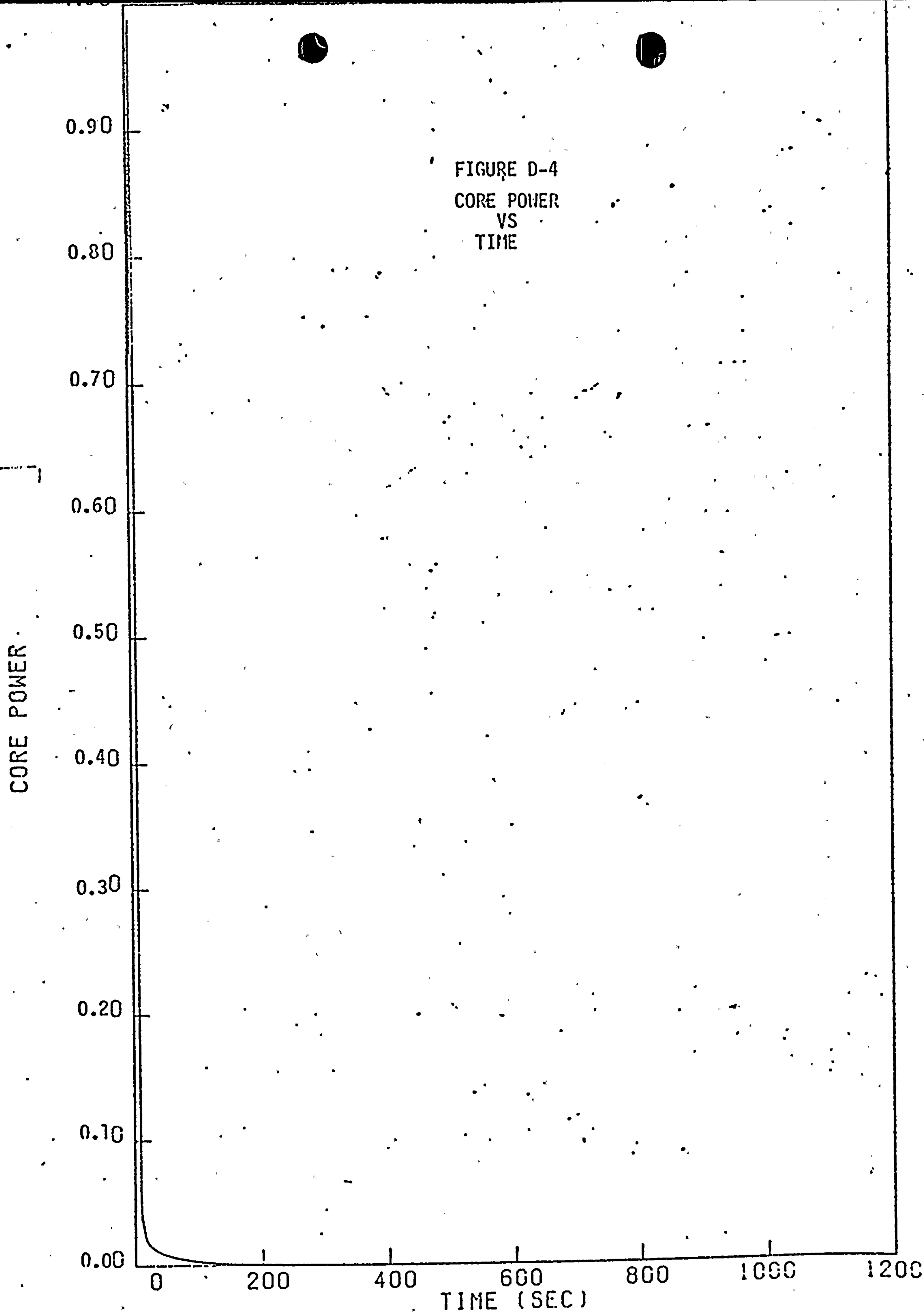
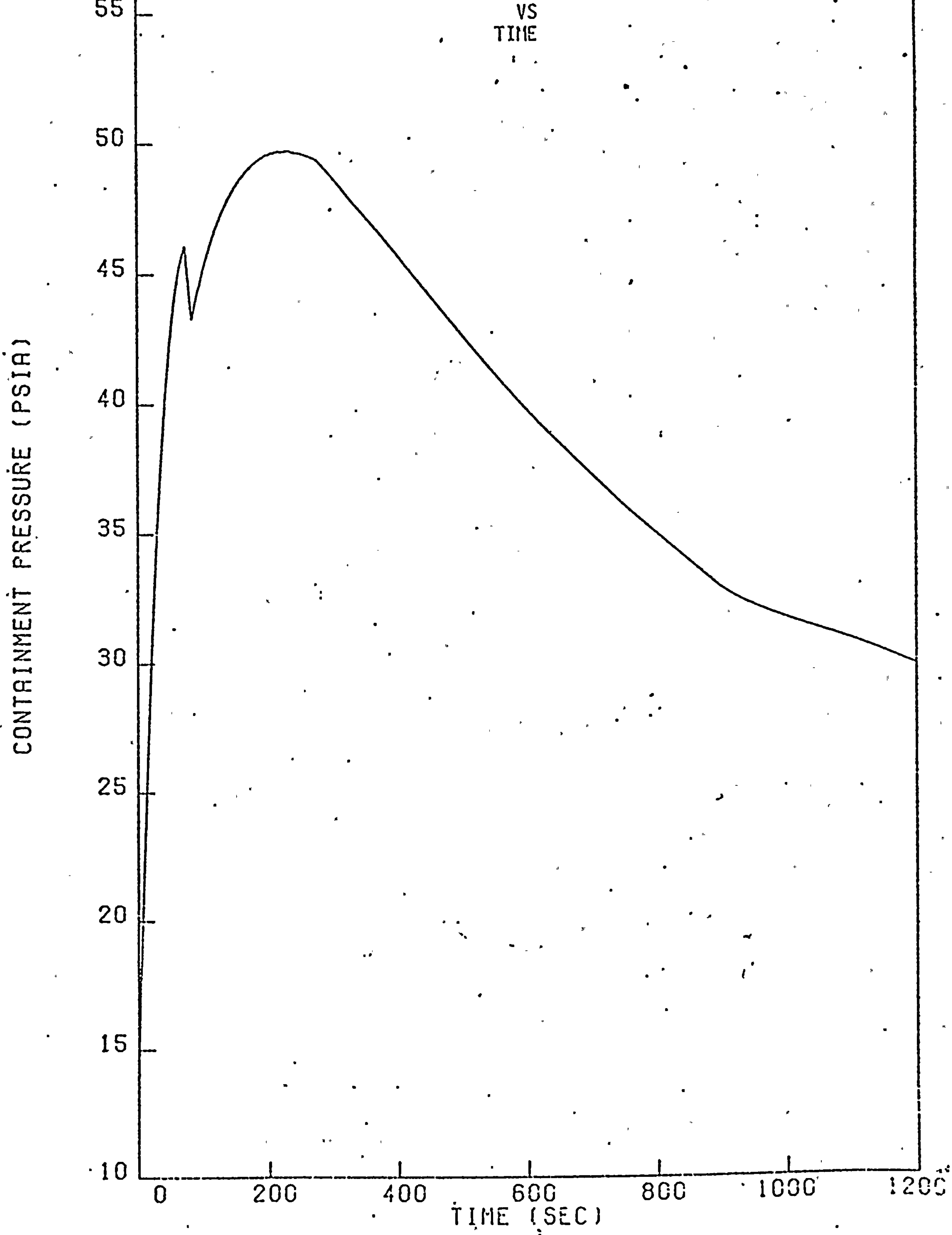


FIGURE D-4
CORE POWER
VS
TIME
CORE POWER
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
0
200
400
600
800
1000
1200
TIME (SEC)

FIGURE D-5

CONTAINMENT PRESSURE VS TIME



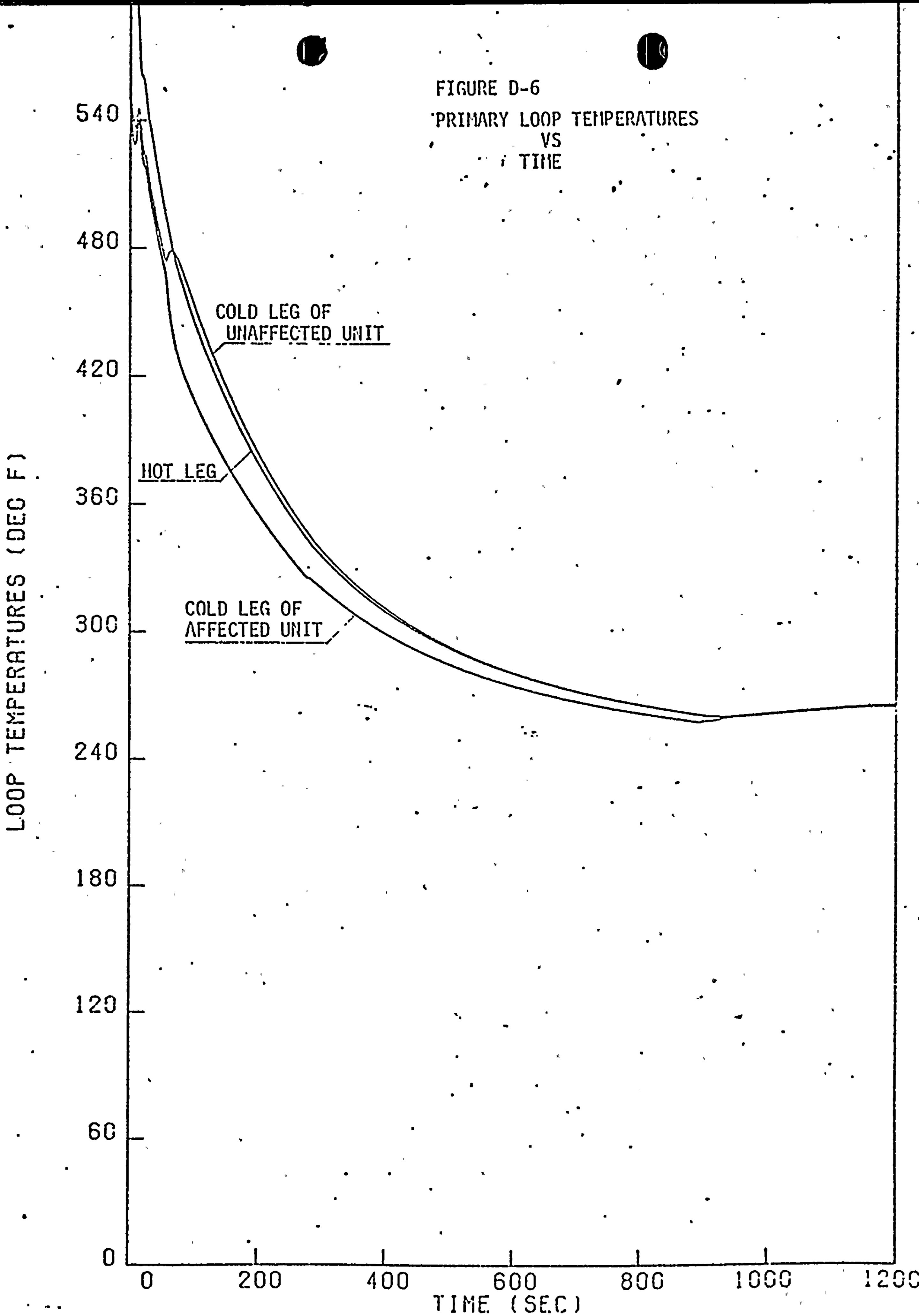


FIGURE D-6
PRIMARY LOOP TEMPERATURES
VS
TIME
COLD LEG OF
UNAFFECTED UNIT
HOT LEG
COLD LEG OF
AFFECTED UNIT
LOOP TEMPERATURES (DEG F)
540
480
420
360
300
240
180
120
60
0
0
200
400
600
800
1000
1200
TIME (SEC)

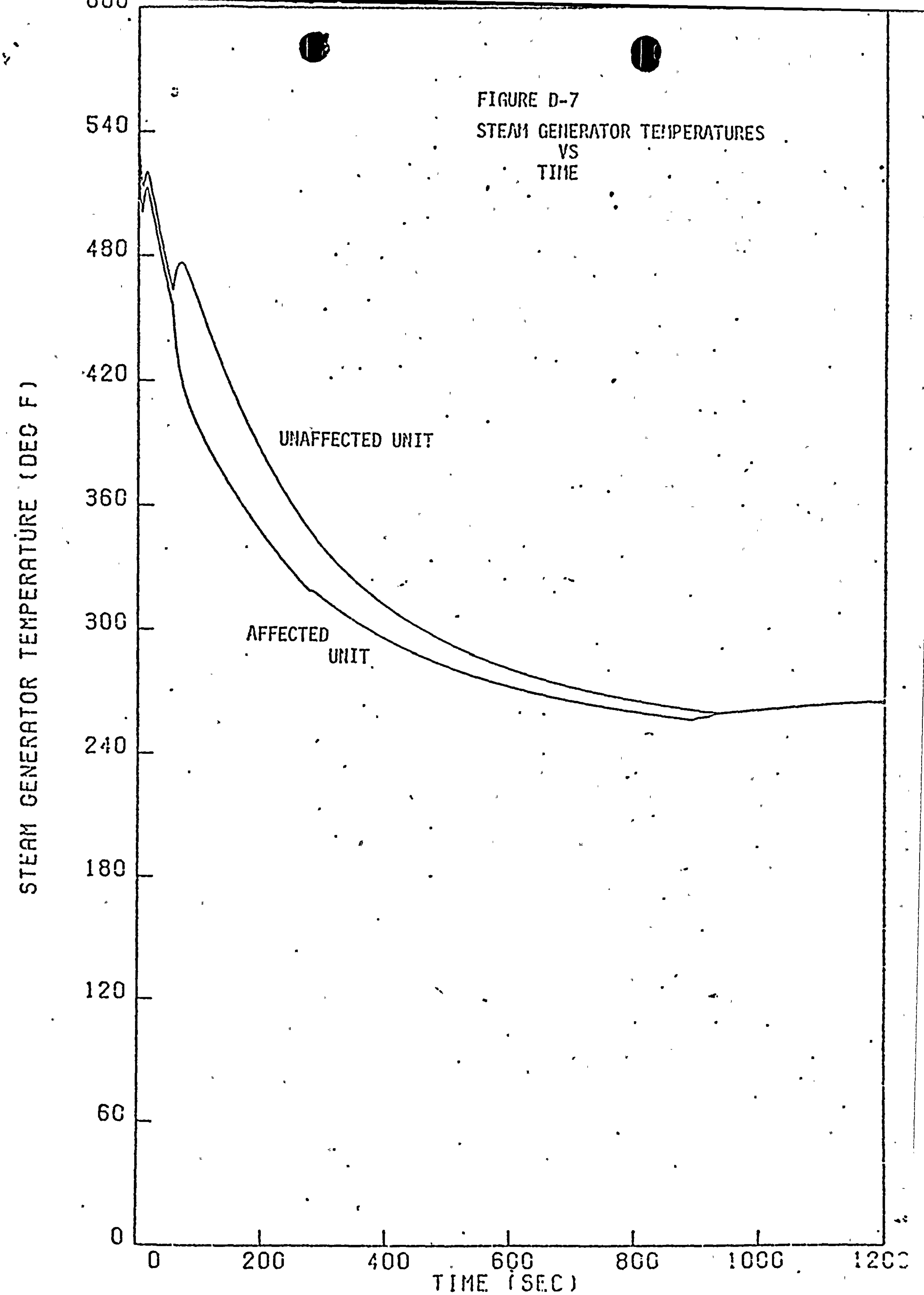


FIGURE D-7
STEAM GENERATOR TEMPERATURES
VS
TIME
UNAFFECTED UNIT
AFFECTED
UNIT
STEAM GENERATOR TEMPERATURE (DEG F)
540
480
420
360
300
240
180
120
60
0
0
200
400
600
800
1000
TIME (SEC)