Florida
Power
CORPORATION

October 11, 1979

File: 3-0-3-a-3

Mr. Robert W. Reid
Chief
Operating Reactors Branch #4
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Crystal River Unit 3
Docket No. 50-302
Operating License No. DPR-72

Dear Mr. Reid:

On October 2, 1979, Florida Power Corporation responded to your letter of September 19, 1979 concerning the upgrade of the anticipatory reactor trips on turbine trip or loss of main feedwater at Crystal River Unit 3.

Enclosed is a copy of the B&W report entitled "Anticipatory Trip Functions for 177 FA Plants." This report is being submitted by Florida Power Corporation as additional information to our response to Item 9.a. contained in our October 2, 1979 letter.

If you have any questions concerning our response, please contact us.

Very truly yours,

FLORIDA POWER CORPORATION

G. C. Moore
Assistant Vice President
Power Production

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STATE OF FLORIDA

COUNTY OF PINELLAS

G. C. Moore states that he is the Assistant Vice President, Power Production, of Florida Power Corporation; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission the information attached hereto; and that all such statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

G C Moore

G. C. Moore

Subscribed and sworn to before me, a Notary Public in and for the State and County above named, this 11th day of October, 1979.

Catherine J. Cameron

Notary Public

Notary Public, State of Florida at Large,
My Commission Expires: August 8, 1983

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ANTICIPATORY TRIP

FUNCTIONS

FOR

177 FA PLANTS

8. 1102525-00

Document Identification

Prepared by [signature] 5/15/79 [signature] 5/15/79

Reviewed by [signature] 5/15/79

Approved by [signature] 5/16/79

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INDEX

1.0 INTRODUCTION

For the purposes of this report, an anticipatory trip is defined as a trip function that would sense the start of a loss of OTSG heat sink and actuate much earlier than presently installed reactor trip signals. Possible anticipatory trip signals indicative of changes in OTSG heat removal are: turbine trip, loss of main feedwater, low steam generator level, and low pressurizer level.

This report evaluates the effectiveness of anticipatory trips compared to the existing high RC pressure trip for a LOFW. Qualitative and quantitative arguments are presented which support elimination of the level trips in the pressurizer and steam generators from final design considerations of anticipatory trips.

Functional response is presented in terms of a parametric study of time to trip. Thus, irrespective of the plant specific trip signals and actuation time, the hardware design can proceed with greater flexibility. That is, by presenting system parameters, such as pressurizer fill time, as a function of time to trip, then if one plant's turbine trip signal occurs 2.1 secs after initiation of the event and another plant's trip signal occurs at 2.5 secs, this study will still be applicable to both.

Some of the results presented in this report have already been submitted to the NRC in Reference 1, the balance of the information will be submitted by May 21, 1979. The analyses are performed with the revised setpoints, i.e., high RC pressure trip at 2300 psig and PORV setpoint at 2450 psig. It is shown that anticipatory trips provide additional margin between the peak RC pressure after the reactor trip and the PORV setpoint, but provide little additional margin in the longer term re-pressurization to the PORV setpoint with continued delay of auxiliary feedwater initiation.

2.0 ASSESSMENT OF POSSIBLE ANTICIPATORY TRIPS

In accordance with Directive 79-05B, an evaluation for design basis for anticipatory trips on turbine trip, loss of main feedwater, and low steam generator level has been completed. One of the trip functions investigated was determined not to be anticipatory as discussed below:

Low steam generator level has not been recommended as an anticipatory trip function. Figure 2-1 shows the OTSG start-up level from site data and the CADDS calculated OTSG mass inventory as functions of time following the TMI-2 event. The time of reactor trip on high RC pressure is noted on the figure and clearly demonstrates that a steam generator level trip would not have been anticipatory for a level setpoint that would not interfere with normal operations and maneuvers. The initial rapid fall in OTSG level occurs as the turbine stop valves close, momentarily stopping steam flow out of the generators. The mass inventory increases during this period due to the loss of flow friction ΔP. By the time the reactor trip occurs, at 8 seconds, steam flow is re-established through the bypass system, flow friction ΔP re-establishes the level and both mass and measured level start to decrease uniformly. An OTSG level trip set to trip on the initial drop shown in Figure 2-1 would need to be set restrictively high for normal plant maneuvers and/or lower power levels.

Further level information (in terms of mass inventory) is given in the figures for the analysis in Section 3.0. The results for those cases also indicate that the steam generator low level trip function would not be sufficiently fast to be considered anticipatory.

Anticipatory trips for loss of feedwater and turbine trip can be designed to trip the reactor in a more expedient manner than the high RC pressure trip for some overheating transients. An anticipatory trip will provide more margin to PORV setpoint during the initial overpressurization resulting from loss of feedwater and/or turbine trip. These trips will provide slightly more time to PORV setpoint and pressurizer fill for delayed auxiliary feedwater initiation conditions.

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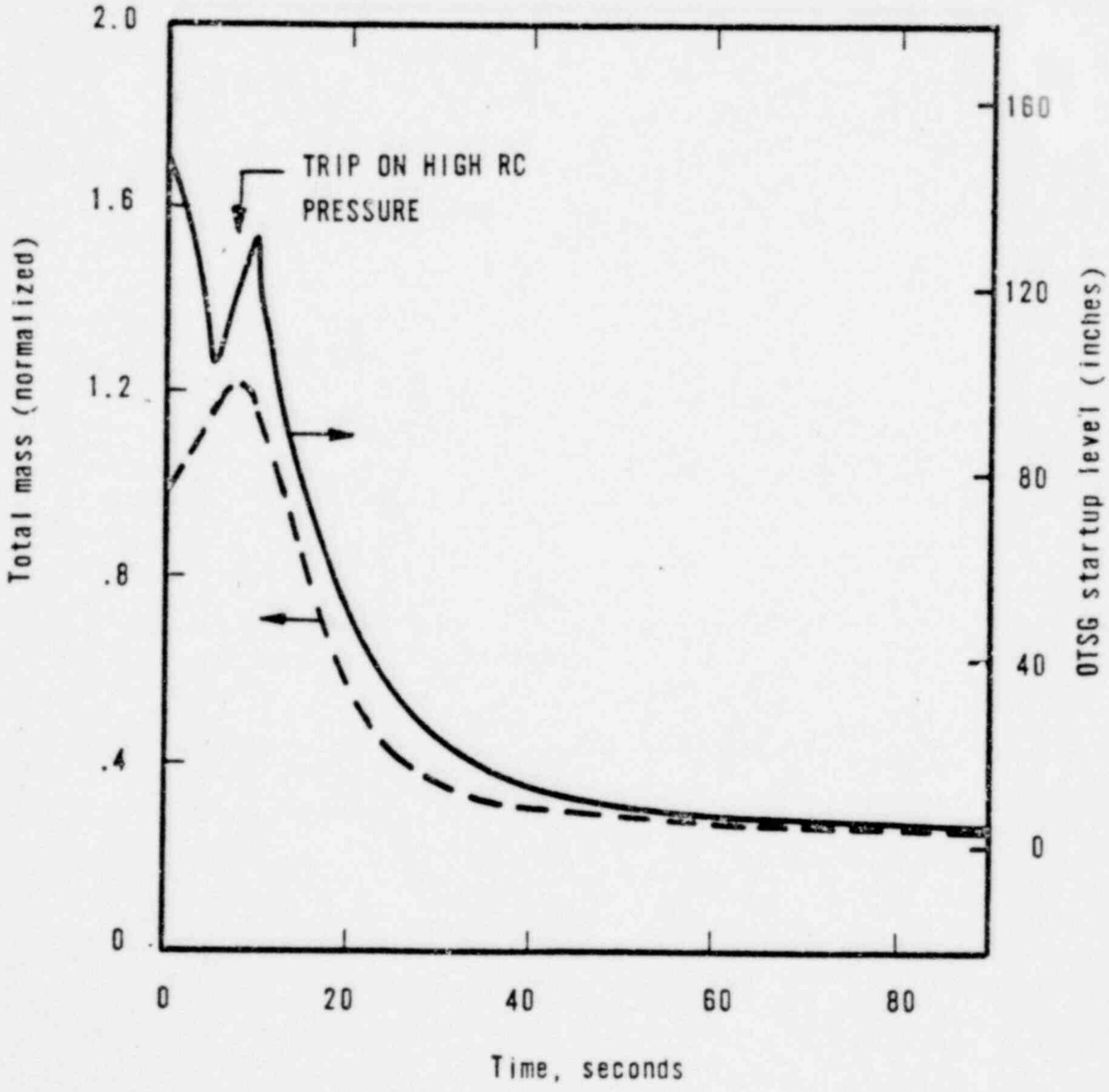
Figure 2-1
LOFW (TMI-2 EVENT)



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3.0 FUNCTIONAL ANALYSIS

A series of LOFW evaluations was performed at 100% full power (2772 MWt) with a reactor trip assumed on an anticipatory signal. With the new high RC pressure setpoint of 2300 psig, a reactor trip would be expected at about 8 seconds after the LOFW. The anticipatory trip study considered reactor trips with 0.4 sec, 2.5 sec, and 5 sec delays from time zero. These studies also included sensitivities to AFW failure and reactor coolant pump coastdown.

The anticipatory trip study modeled a generic 177 FA plant, and is considered applicable to raised or lowered loop designs. A feedwater coastdown similar to that estimated to have occurred at the March 28th TMI-2 event was used to generate separate heat demands for each CADDS analysis. The heat demands will change as the reactor trip time is delayed, because the additional heat input will boil off the fixed steam generator inventory at different rates.

For the cases where AFW flow was modeled, 1000 gpm was assumed, starting at 40 seconds. With proper steam generator level and pressure control, the system parameters will begin to stabilize at 195-290 seconds, depending on trip delay time and RCP operation; see Table 3-1 and Figure 3-12. The PORV will not be actuated, nor would the pressurizer fill or empty.

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With the assumption of no AFW, the PORV will be actuated about three minutes into the event, as a result of system swell; the pressurizer fills as 10-12 minutes (see Table 3-1). A delay of reactor trip of 2-3 seconds is seen to reduce PORV time to actuate by about one minute, and pressurizer fill by about 2 minutes. For PORV setpoints other than 2450 psig, the times will vary and can be determined from Figures 3-3, 3-4, 3-8, and 3-10.

In each of these cases, the mass addition and cooling effect of expected make-up system operation is not modeled. One make-up pump running will add about 10 inches per minute to pressurizer level, and ~1/2% heat demand. It should be noted that the May 7 report used a heat demand which reproduced the TMI-2 LOFW event; it has been reported by the operator that two make-up pumps were running from 13 sec into the event, creating a higher heat demand than

the anticipatory trip studies of the report assume. This is shown in Figure 3-12.

The steam generator heat demands, reactor power, RC system pressure, pressurizer level, and RC inlet/outlet temperatures are given in Figures 3-1 through 3-5 for the trip at time zero case and Figures 3-7 through 3-11 for the trip on high RC pressure (t=8 secs) case. The effects of delayed auxiliary feedwater initiation are also shown on the high RC pressure trip curves.

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TABLE 3-1

LOFW EVENT
(LOFW at T=0 sec)

TIME OF REACTOR TRIP ("DELAY")	REACTOR COOLANT PUMPS	AUXILIARY FEEDWATER	PORV OPERATES	PRESSURIZER FULL (400")	S/G Lvl CONTROL (P_{stm}=1025 psig)
0.4	Run	at 40 sec	-	-	195 sec
2.5	Run	at 40 sec	-	-	225 sec
5.0	Run	at 40 sec	-	-	275 sec
0.4	Run	None	235 sec	790 sec	-
2.5	Run	None	180 sec	685 sec	-
5.0	Run	None	140 sec	575 sec	-
0.4	Coastdown	at 40 sec	-	-	255
0.4	Coastdown	None	190 sec	700 sec	-

LOFW EVENT - TIME=0 sec

REACTOR TRIP AT 2300 PSIG

TIME OF TRIP	RCP	AFW	PORV	PRESS. FULL	S/G LEVEL CONT.
8.0	Run	at 40 sec	-	-	260 sec
8.0	Run	None	175 sec	620 sec	-

Figure 3-1 Heat Demand Model for Reactor Trip at Time Zero Studies

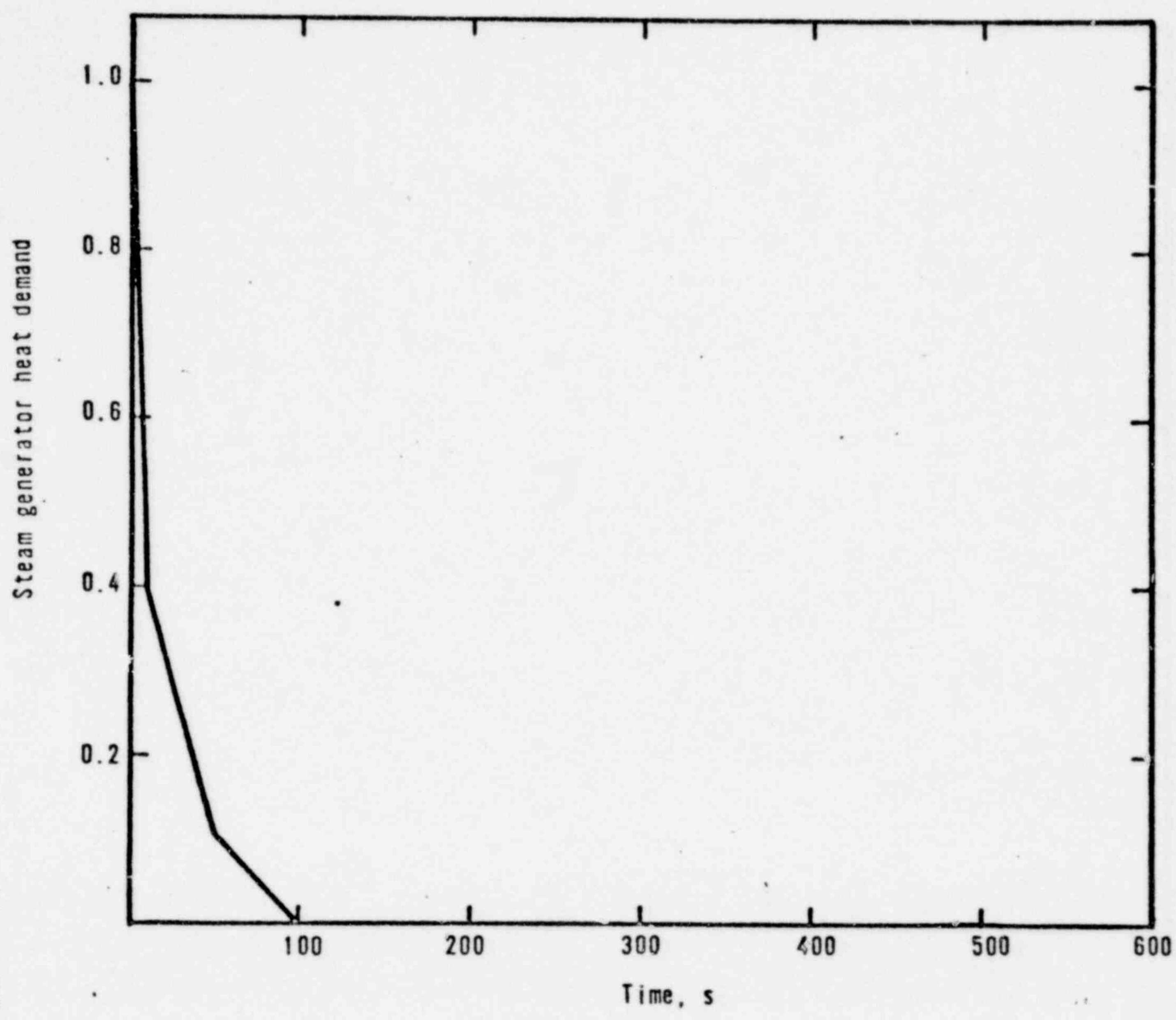

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Figure 3-2 Reactor Trip at T=0, No AFW

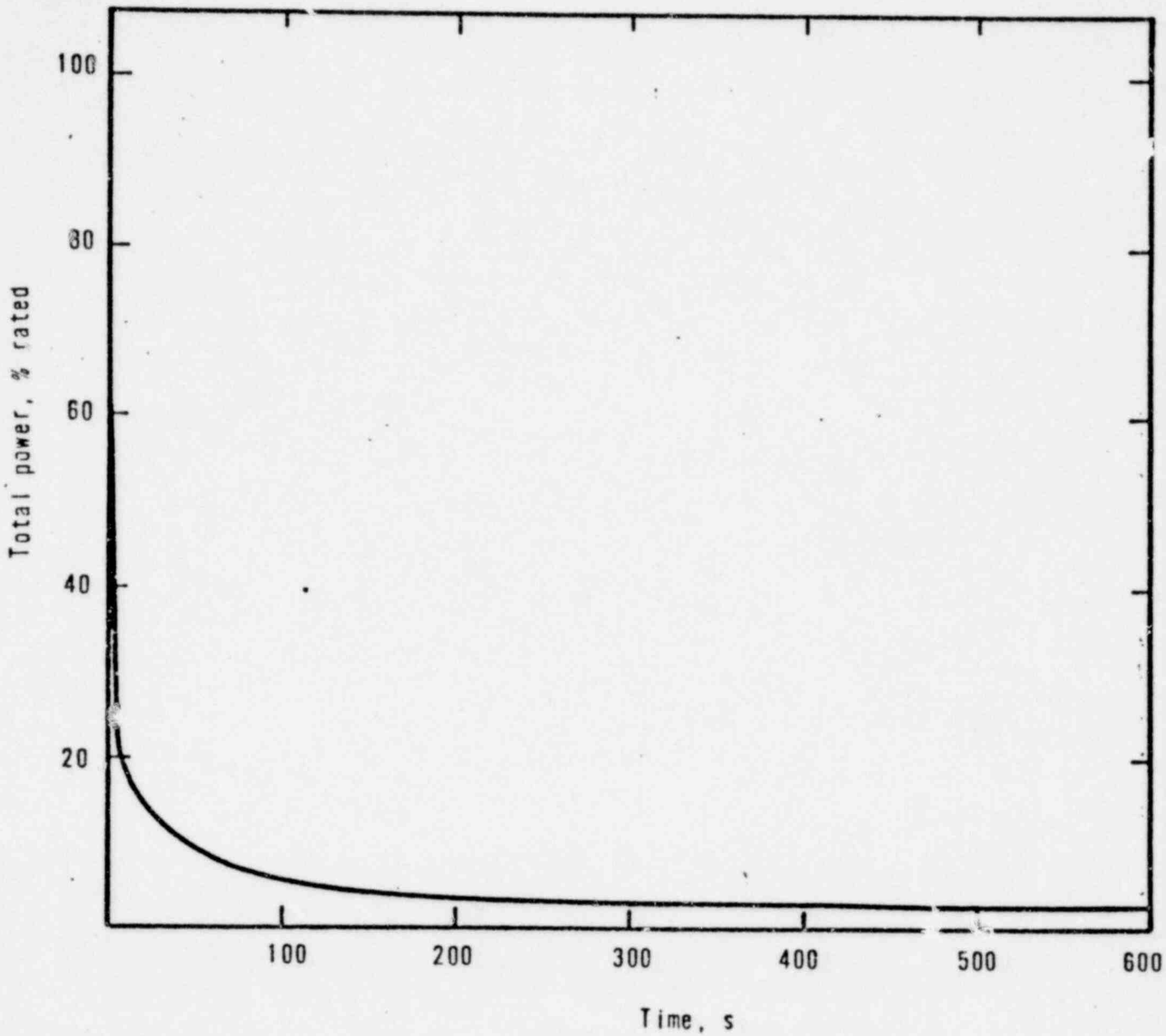

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Figure 3-3 Reactor Trip at T-0, No AFW

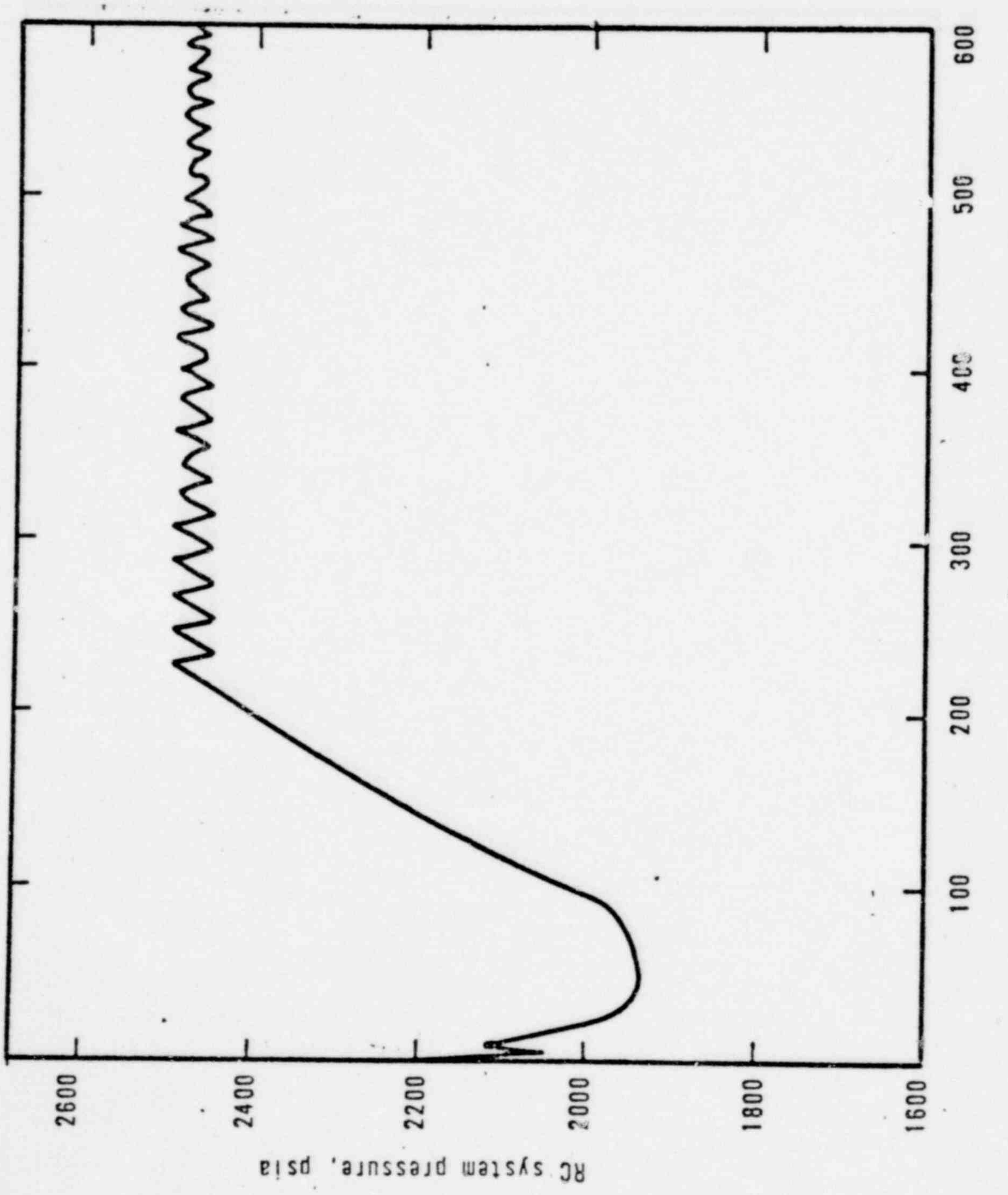

Figure 3-4 Reactor Trip at T=0, No AFW

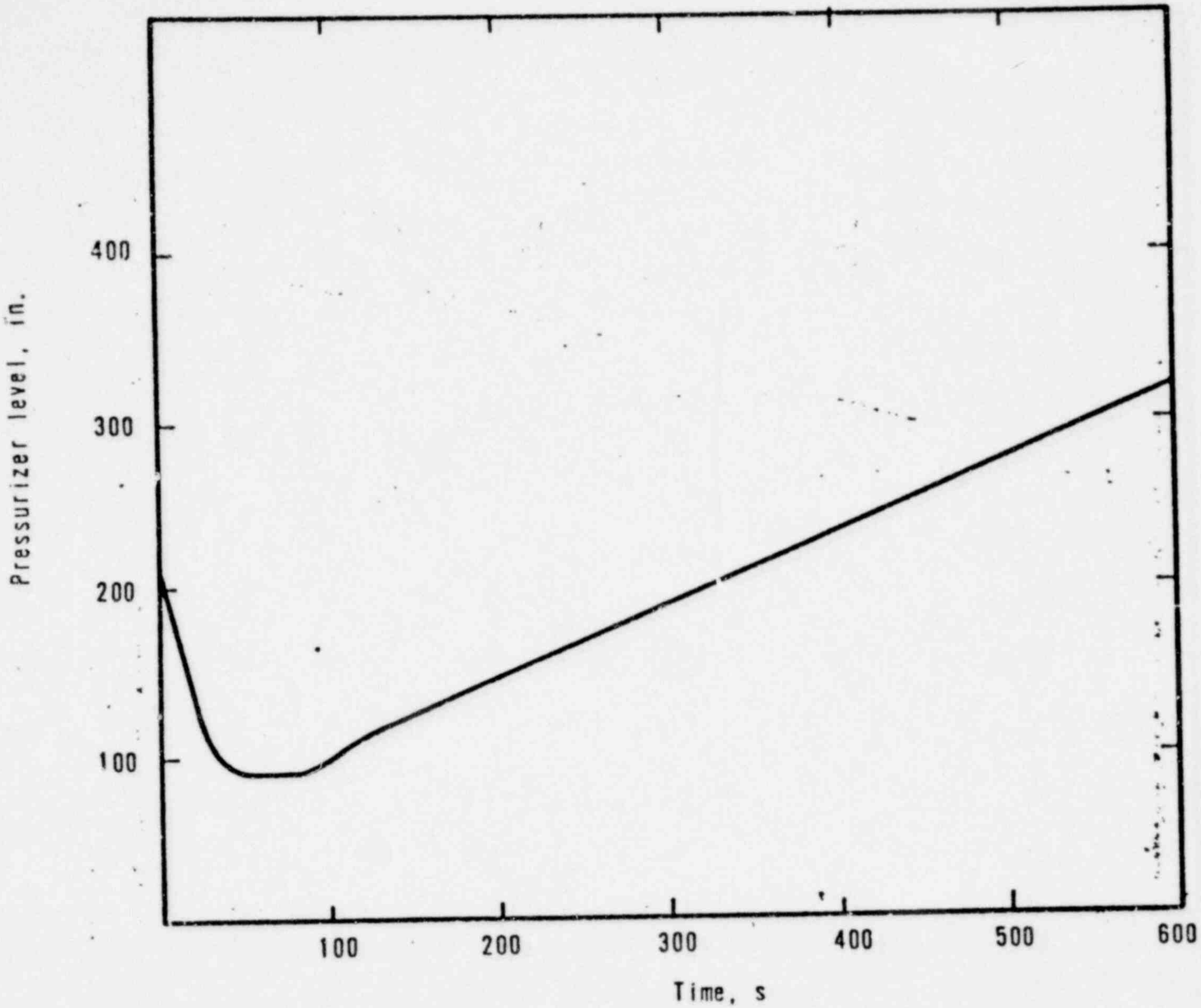

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Figure 3-5 Reactor Trip at T=0, No AFW

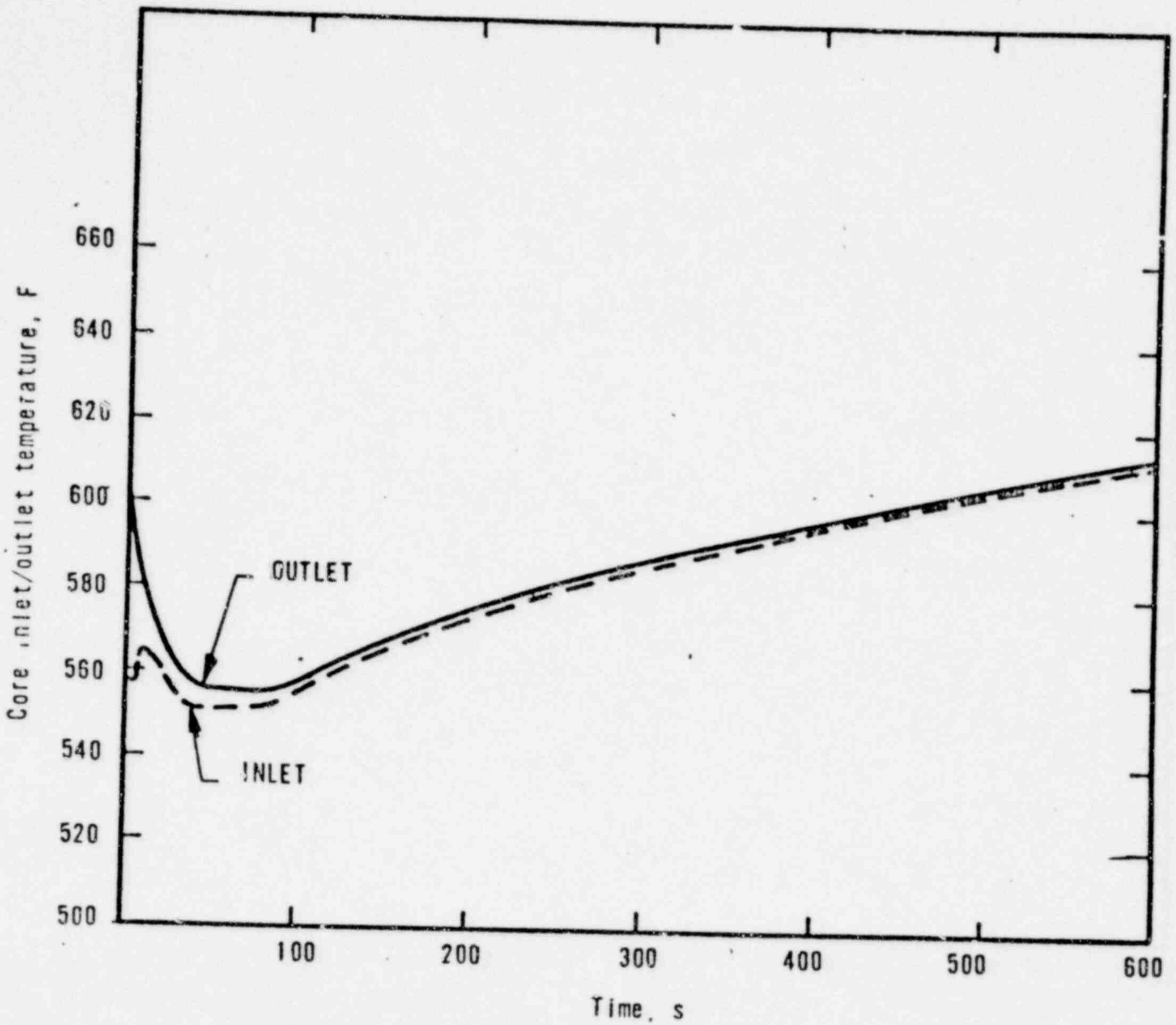

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Figure 3-6 Steam Generator Heat Demand Vs Time Following Loss of Main Feedwater From Rated Power

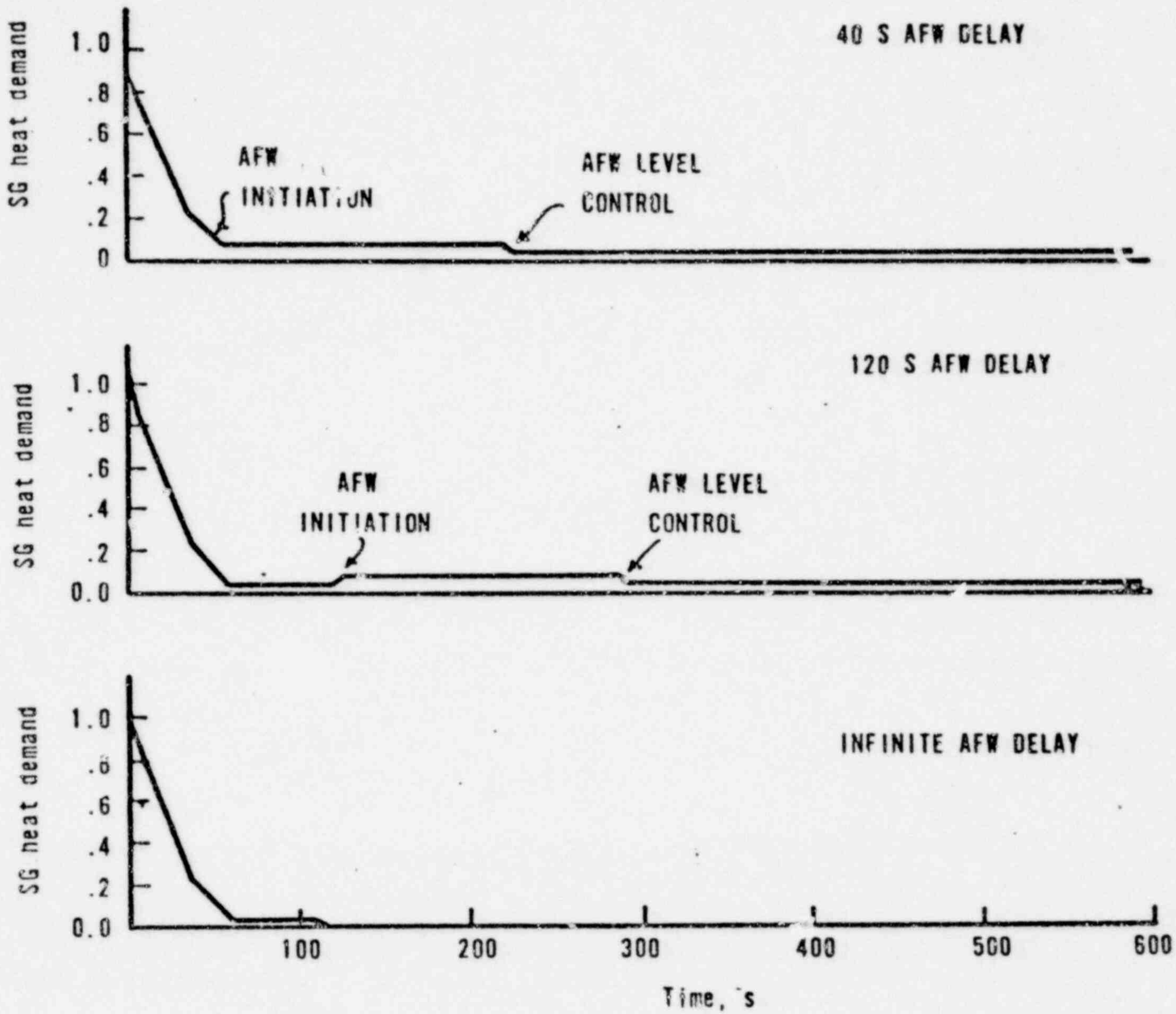

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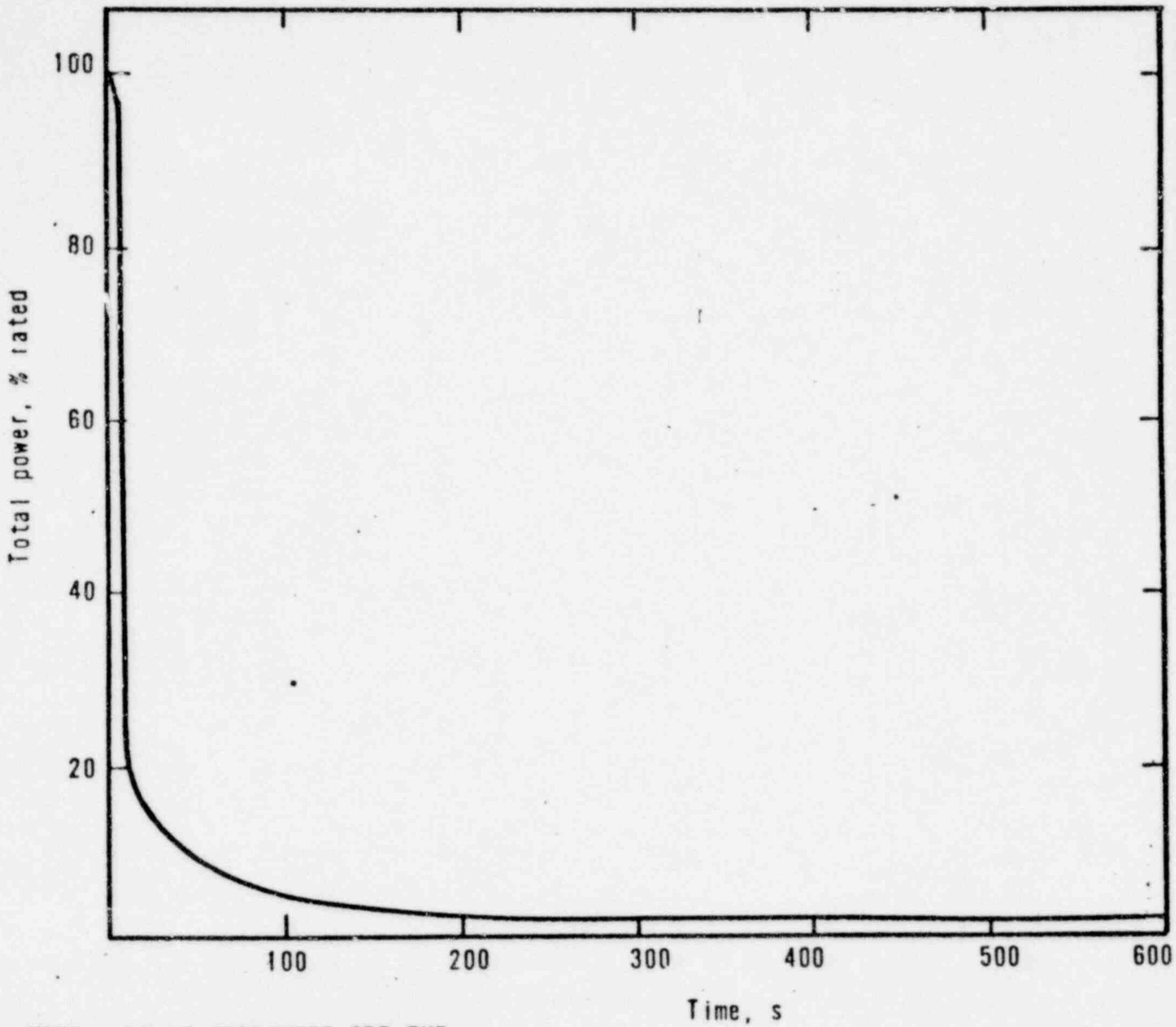
Figure 3-7 Total Power Vs Time Following Loss of Main Feedwater for Various AFW Initiation Times



NOTE: POWER RESPONSES ARE THE SAME FOR 40, 120, AND INFINITE AFW DELAY TIMES

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Figure 3-8 RC System Pressure Vs Time Following Loss of Main Feedwater From Rated Power

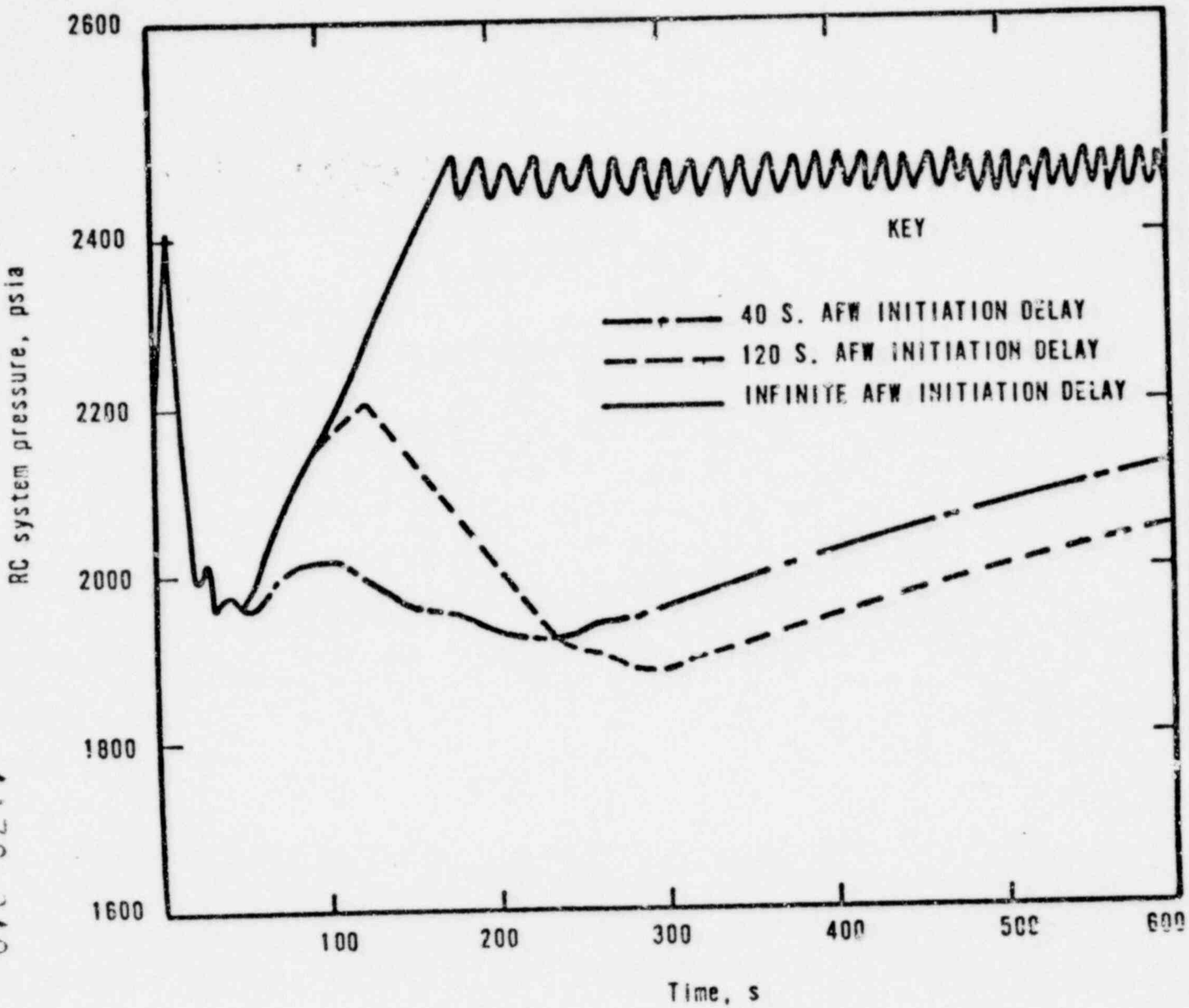

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Figure 3-9 Pressurizer Pressure Vs Time Following Loss of Main Feedwater From Rated Power

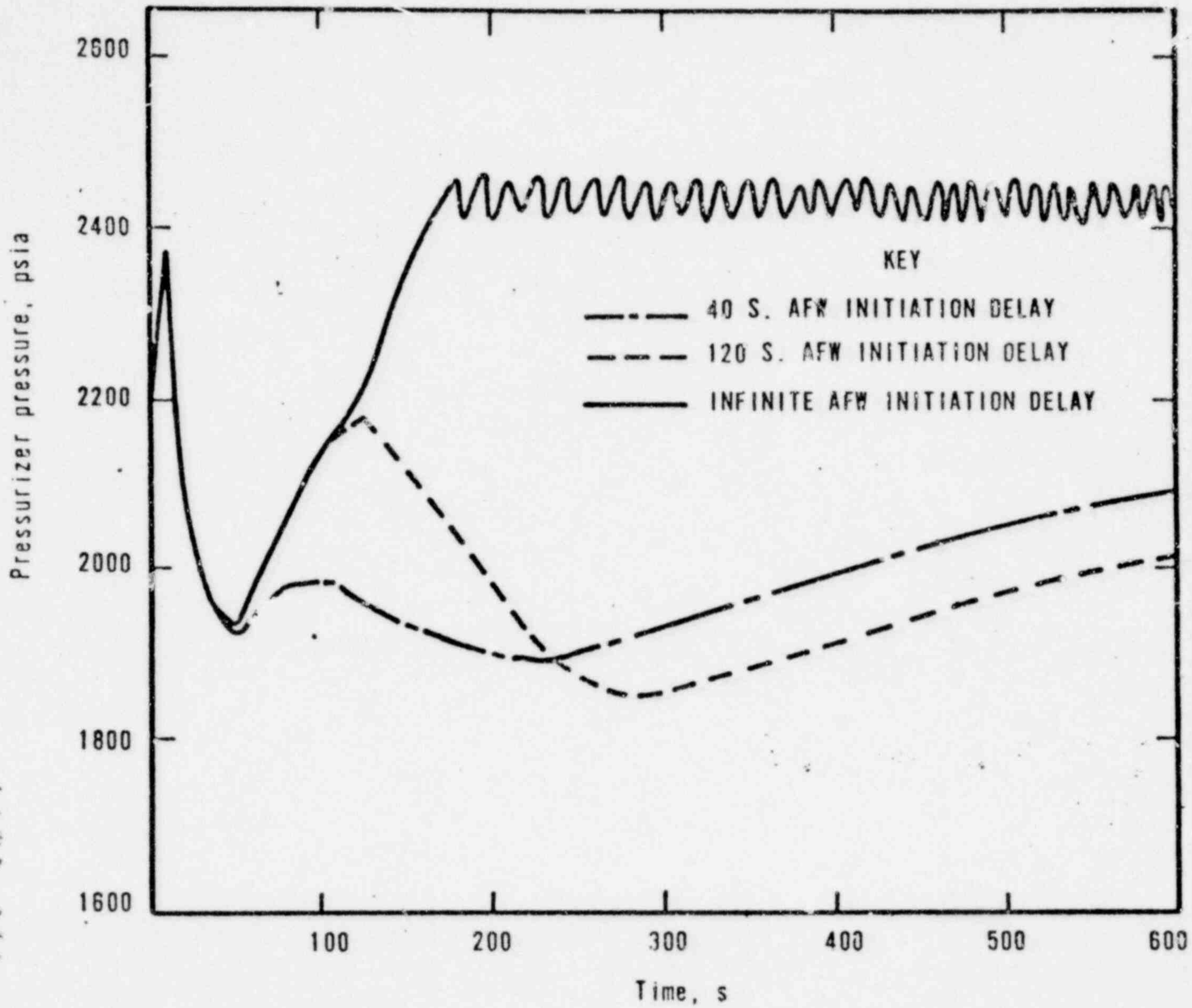

Figure 3-10 Pressurizer Level Vs Time Following Loss of Main Feedwater From Rated Power

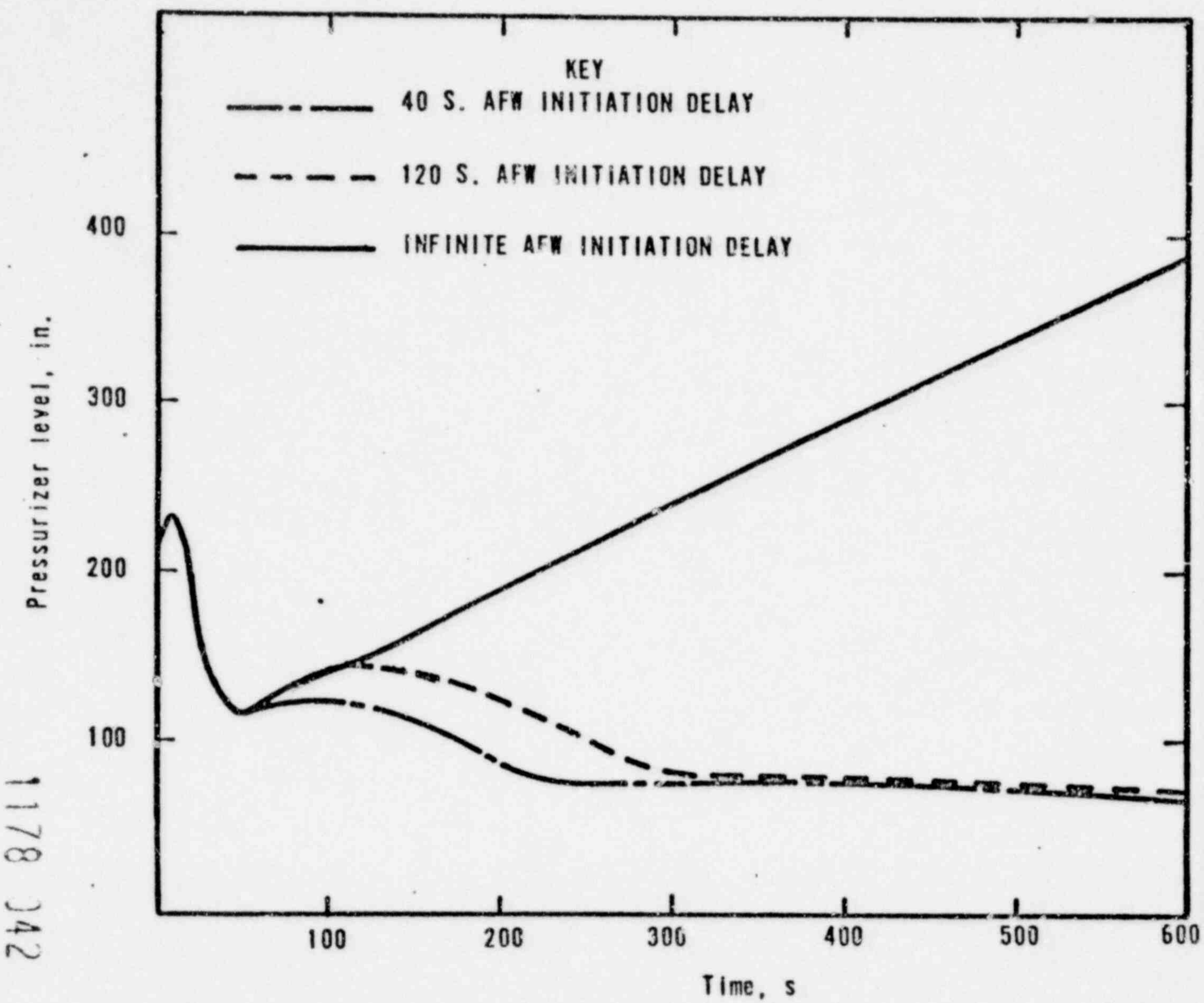

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Figure 3-11 Core Inlet and Outlet Temperature Vs Time Following Loss of Main Feedwater From Rated Power

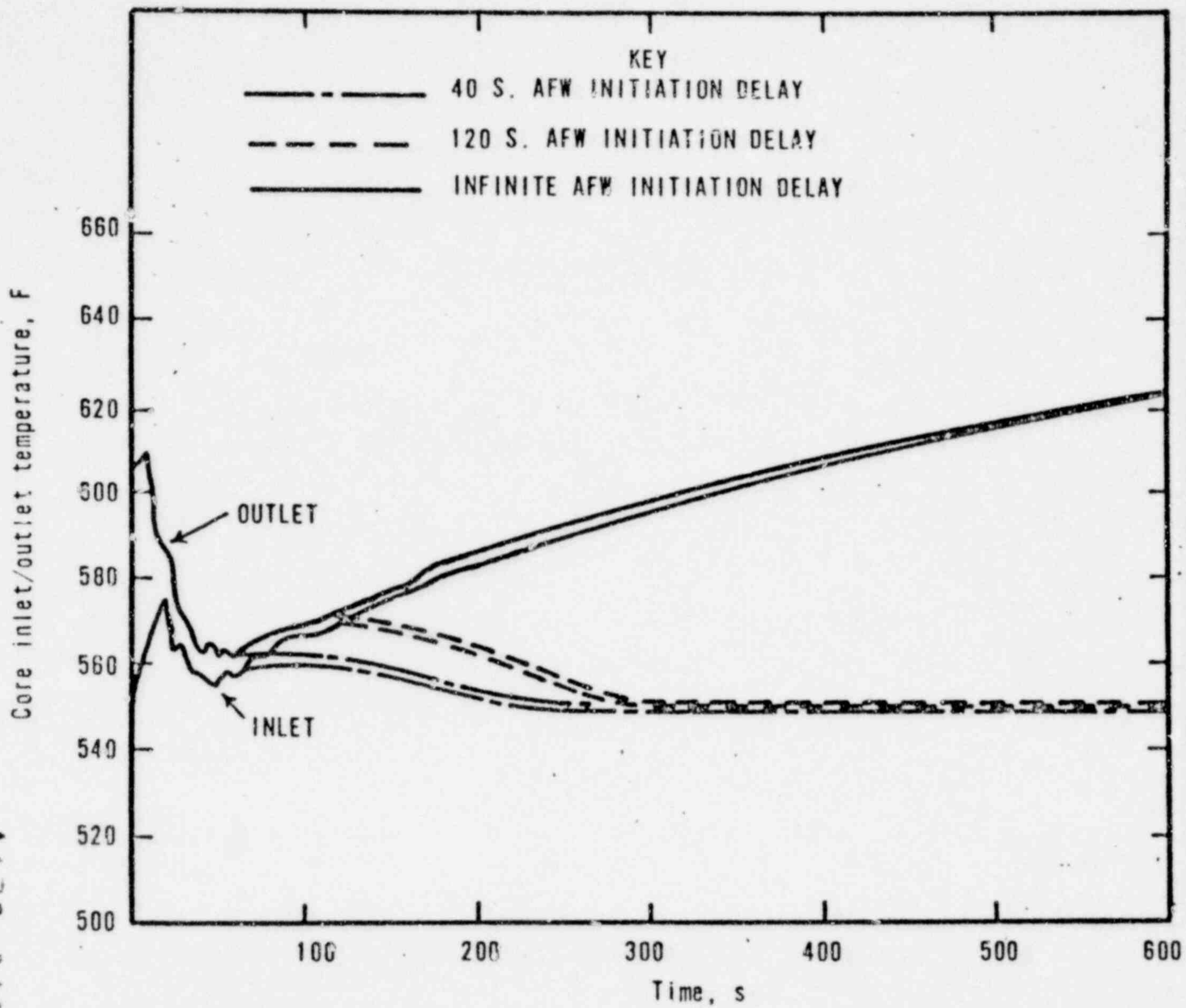

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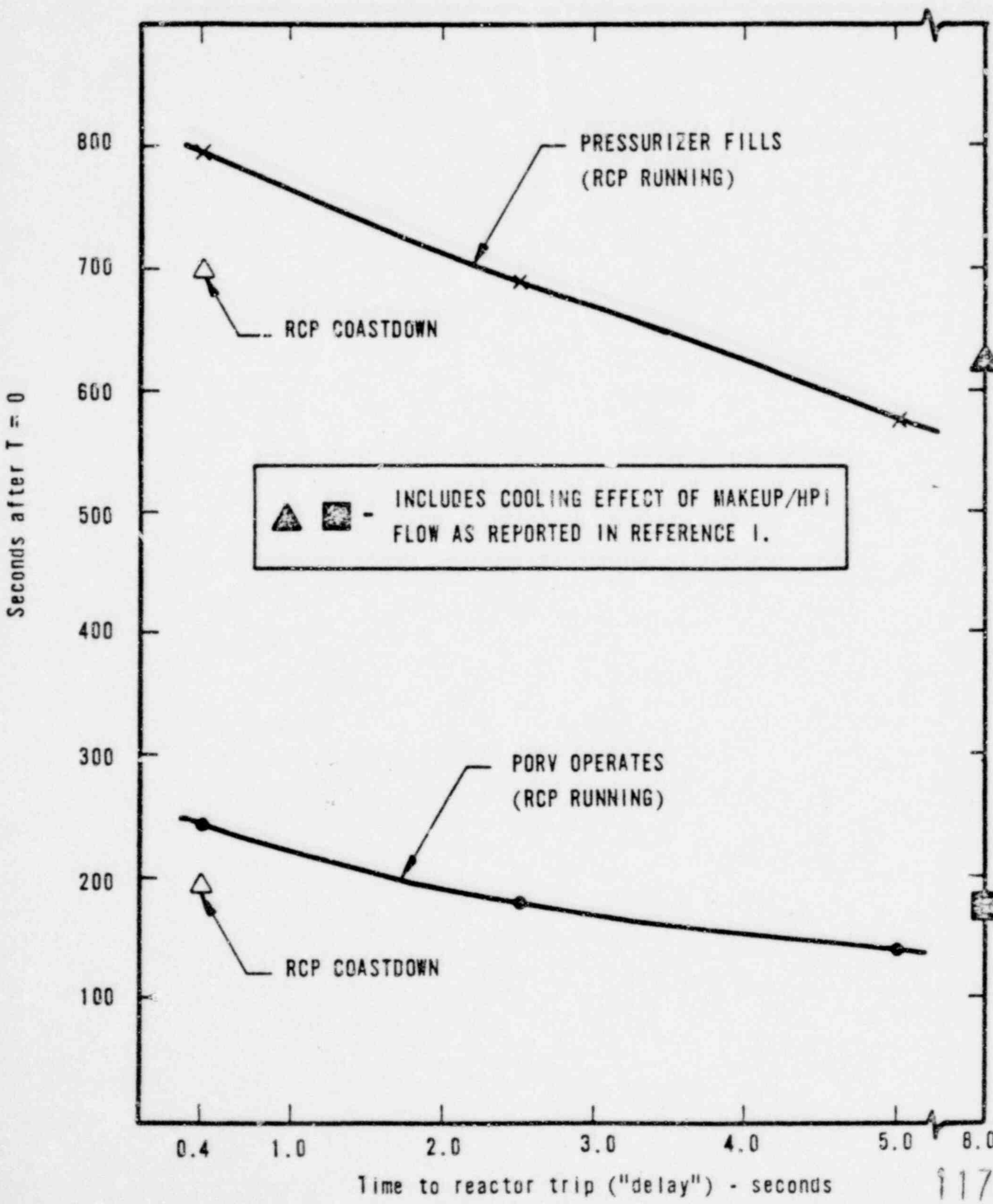
Figure 3-12

LOSS OF FEEDWATER AT T = 0 SEC NO AUXILIARY FEEDWATER



4.0 CONCLUSIONS AND SUMMARY

A spectrum of delay times, representing anticipatory trips, has been analyzed for the loss of feedwater transient. The spectrum included trips at time zero, with a 0.4 second instrument delay, up to high RC pressure trip at time 8.0 seconds. Since a high RC pressure trip occurs very soon after a loss of heat sink (overpressurization) transient from 100% FP, only turbine trip and direct loss of feedwater detection trips would be considered anticipatory.

For all trips considered, including high RC pressure, the PORV is not actuated when normal system operations occur. The pressure rise in the primary side is less for the anticipatory trips providing additional margin to PORV lift. If auxiliary feedwater is significantly delayed, then an anticipatory trip will, at best, provide about 1 minute additional time to PORV lift and about 3 minutes additional time to filling of the pressurizer. These results can be seen in Table 4-1 which shows the sequence of events for a LOFW transient with trip on high RC pressure (2300 psig) and trip at time zero.

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TABLE 4-1. LOFW-SEQUENCE OF EVENTS COMPARISON

EVENT	40-s AFW	120-s DELAY	NO AFW	TRIP AT ZERO, NO AFW
Loss of feedwater initiated	0	0	0	0 (trip occurs) (0.4 delay)
High-pressure trip (2300 psig)	8	8	8	a
PORV opens (2450 psig)	a	a	175	235
Peak RCS pressure	10	10	175	235
Pressurizer full	a	a	620	790

[a] Does not occur for these cases

REFERENCE:

1) B&W Report to the NRC, May 7, 1979, "Evaluation of Transient Behavior and Small Reactor Coolant System Breaks in the 177 Fuel Assembly Plant".

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APPENDIX A

LOSS OF ONE FEEDWATER PUMP

A special analysis was performed at the B&W Owner's Group request. This analysis considered the loss of one main feedwater pump with the plant operating at 100% FP, RC pumps running, no power runback or auxiliary feedwater initiation and a RC high pressure trip setpoint at 2300 psig. The base parameters for this study are the same as those used in the "realistic" analysis presented in Section 4.2 of the May 7, 1979, B&W Report for 177 FA plants.

The objectives of this study were two-fold:

1) Determine if the PORV will lift under a loss of one feedwater pump situation, and,
2) Determine if the OTSG level would be a viable anticipatory trip, i.e., how rapidly does the steam generator inventory decrease in relation to the time a high RC pressure trip would occur.

RC system pressure and pressurizer level as functions of time are shown in Figures A-2 and A-3, respectively. Reactor trip occurs on high pressure (2300 psig) in 15.8 seconds after the loss of one main feedwater pump. Figure A-4 shows the steam generator mass as a function of time and only 30% of the mass is boiled off by the time the reactor trip occurs. This is insufficient inventory decrease to cause a level trip in an anticipatory mode. Figure A-2 shows that no PORV actuation results from this transient.

Figure A-1

FEEDWATER COASTDOWN TO 50%

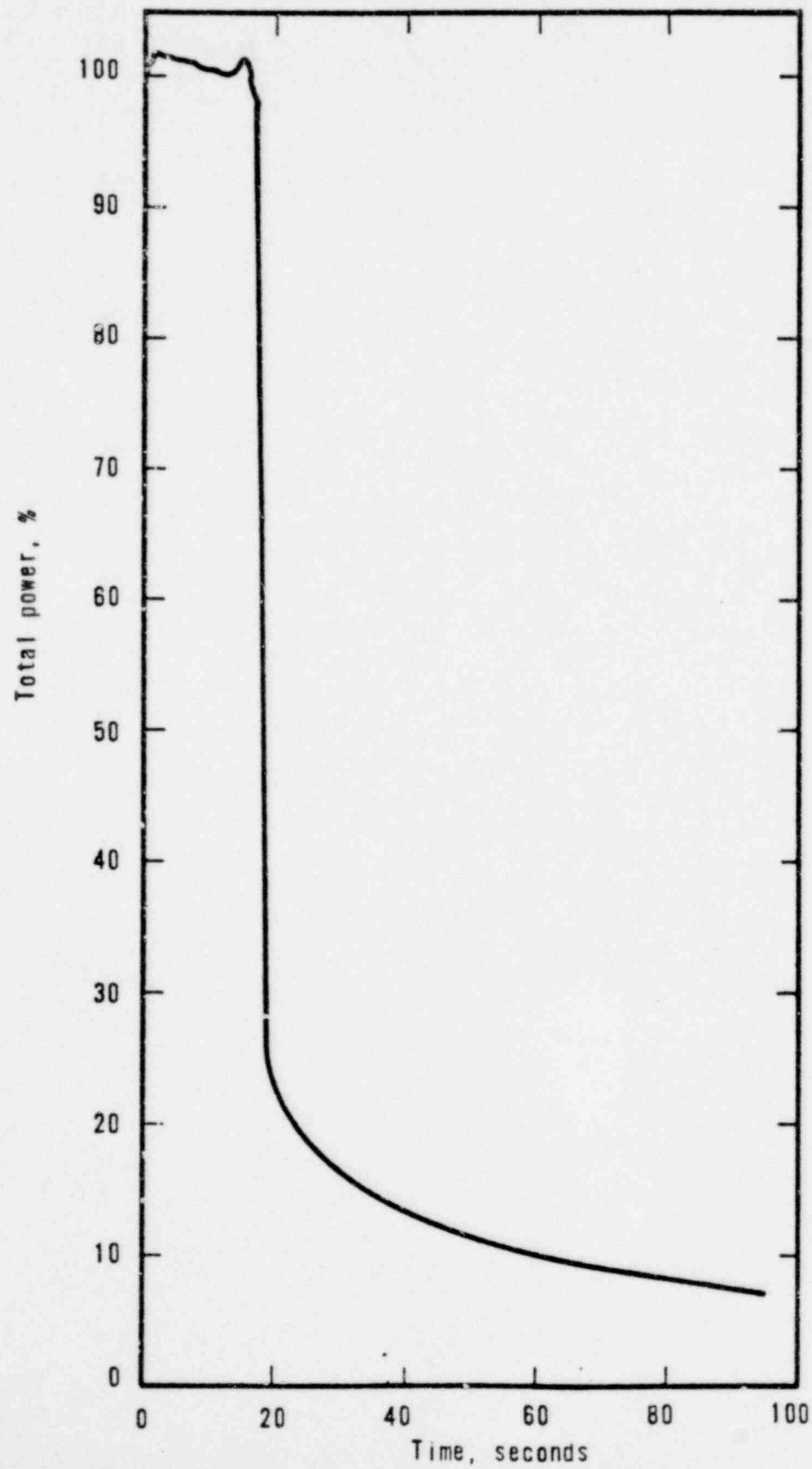

Figure A-2

FEEDWATER COASTDOWN TO 50%

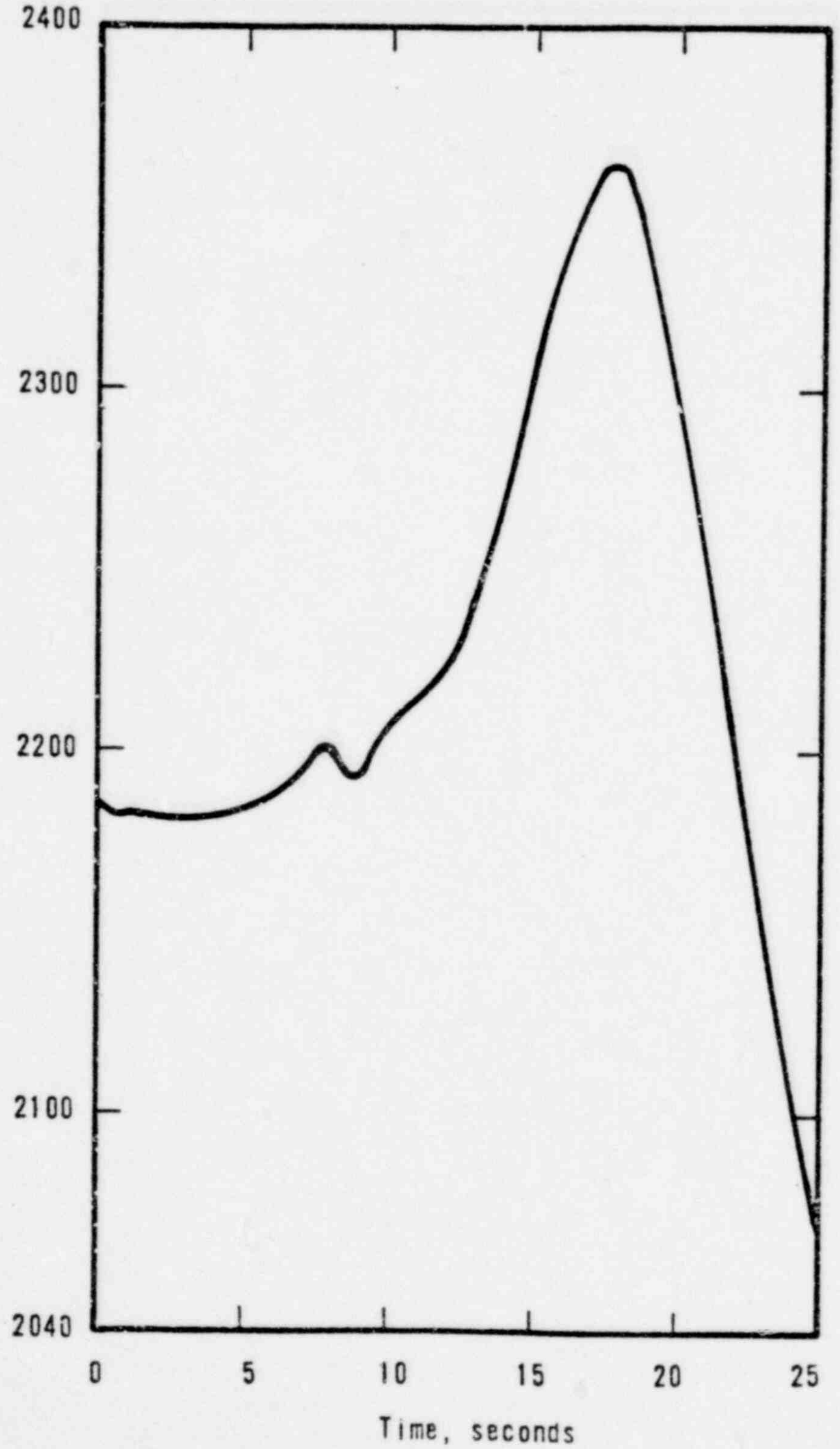

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Figure A-3

FEEDWATER COASTDOWN TO 50%

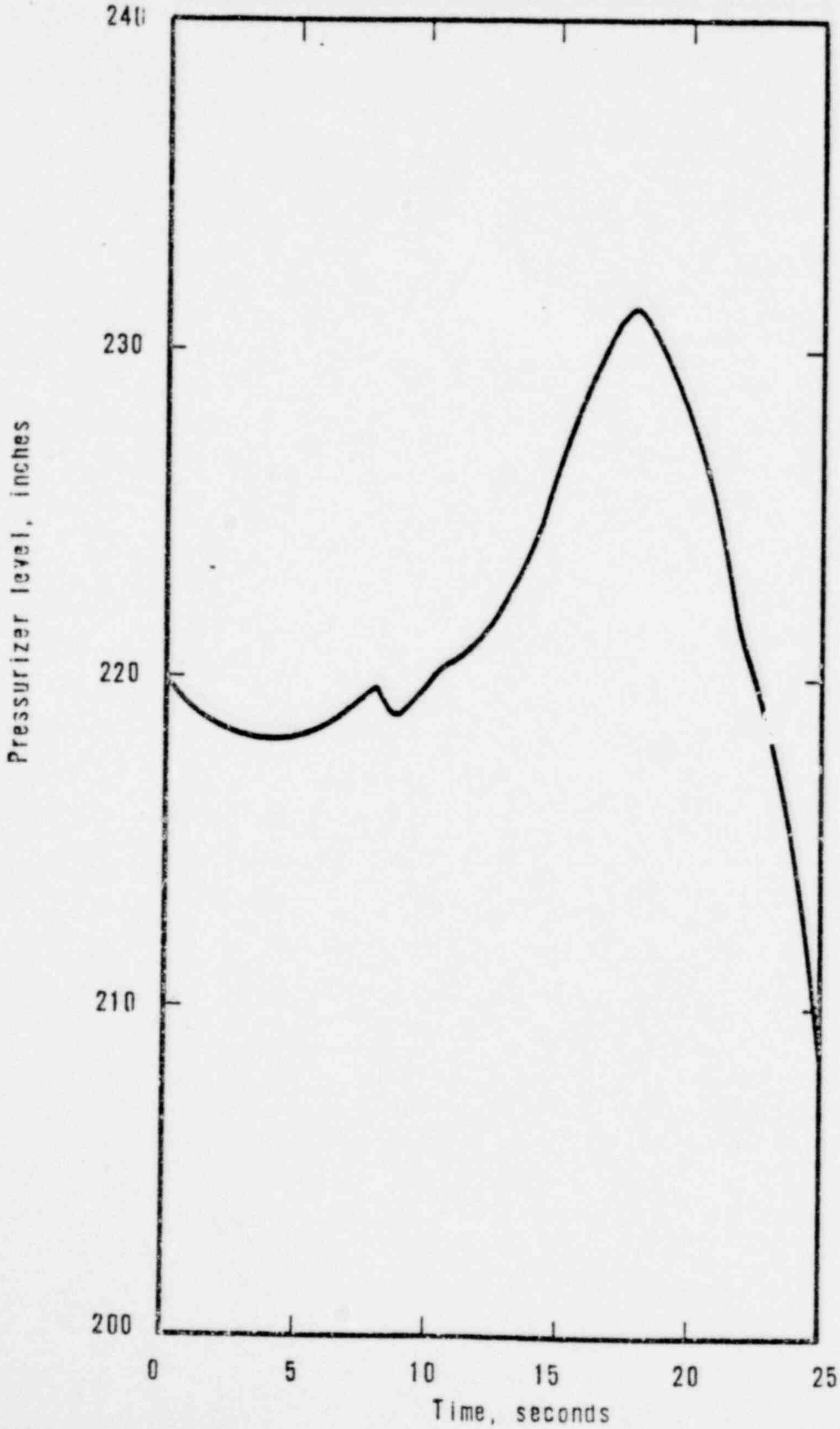

Figure A-4

LOSS OF ONE FEEDPUMP-RAMP TO 50% IN 10 SEC
TOTAL S/G MASS, CADDS