BALTIMORE GAS AND ELECTRIC

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April 13, 1983

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: Mr. R. A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit 2, Docket No. 50-318
Wide Range Steam Generator Level Instrumentation
System (WRSGLIS), Power-Dependent Decalibration

Gentlemen:

During initial startup of Unit 2 Cycle 5 with the new Wide Range Steam Generator Level Instrumentation System (WRSGLIS), a power-dependent decalibration was observed. The WRSGLIS decalibration was due to dynamic effects at the lower sensing points of the new instruments, resulted in the wide range indicated level being lower than the actual level, and could result in early actuation of AFW flow.

Evaluation at startup determined that the limiting Design Bases Event (DBE) impacted by early AFW initiation, the Steam Line Break Event, might not show acceptable results for the more negative moderator temperature coefficient associated with end of cycle 5 but that acceptable consequences would result through a burnup of at least 3000 MWD/MTU.

The enclosure presents the analyses and results which demonstrate acceptable consequences through the end of cycle 5.

Very truly yours,

BALTIMORE GAS AND ELECTRIC COMPANY

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A001

AEL/MEB/lmt

Enclosure (40 copies)

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ENCLOSURE

SAFETY ANALYSIS FOR EARLY AUXILIARY FEEDWATER ACTUATION DUE TO WIDE RANGE LEVEL INDICATION SYSTEM POWER-DEPENDENT DECALIBRATION

Introduction

The Steam Line Break (SLB) event was analyzed in depth for Calvert Cliffs Unit 2 Cycle 5 in Reference (1). This enclosure documents the results of analyses performed to envelop a power-dependent decalibration in the Wide Range Steam Generator Level Indication System and to provide additional flexibility in the AFW flow setpoints.

The level indication decalibration was observed during startup with the new Wide Range (WR) Level Indication System and is due to dynamic flow effects at the lower pressure tap of the WR Level Differential Pressure transmitters. The WR Level indicated at power is lower than the actual (narrow range) level and could result in earlier actuation of AFW flow than considered in Reference (1).

The limiting Design Bases Event (DBE) impacted by early AFW initiation is the Inside-Containment Steam Line Break event with loss of AC power on turbine trip. This event was analyzed for full power (HFP) and zero power (HZP) conditions assuming AFW system runout flow of 1300 gpm was initiated at the time of the Steam Line Break. All other analysis assumptions and initial conditions were identical to those of Table 3-1 and 3-2 of Reference (1). These tables, with the changes highlighted, are repeated in Tables 1 and 2 for completeness. The HFP and HZP moderator cooldown curves (Figures 1 and 2) are also identical to those of Reference (1) (Figures 3-1 and 3-2 respectively) and are likewise included for completeness.

Results

SLB Inside Containment

The sequence of events for the 6.305 ft^2 SLB with Loss of AC (LOAC) on turbine trip initiated from HFP conditions is given in Table 3. The reactivity insertion as a function of time is presented in Figure 3. The NSSS responses during the transient are given in Figures 4 through 8.

The results of the analysis show that the HFP SLB causes the secondary pressure to rapidly decrease until a reactor trip on low steam generator pressure is initiated at 1.7 seconds. The CEAs drop into the core at 3.1 seconds and terminate the power and heat flux increases.

The AFW system runout flow of 1300 gpm is initiated at the time of the Steam Line Break. This flow is assumed to be unaffected by any electrical transient due to LOAC, and is directed in its entirety to the ruptured steam generator until the AFW block valves are completely shut.

A LOAC power on turbine trip is assumed to occur at 3.1 seconds. At this time, RCPs start coasting down and the diesel generators start coming on line. At 13.1 seconds, the diesel generators reach full speed and the shutdown sequencer is initiated to load emergency systems. At 17.0 seconds the safety injection actuation analysis setpoint is reached and diesel generators switch from the shutdown sequencer to the LOCA sequencer to load emergency systems. At 22.0 seconds the HPSI pump is loaded on line and at 52.0 seconds the HPSI pump reaches full speed.

The Steam Generator Isolation Analysis Setpoint is reached at 1.7 seconds. At 2.6 seconds, the MSIVs begin to close and are completely closed at 14.6 seconds. The blowdown from the intact steam generator is terminated at this time.

An AFW isolation signal based on steam generator differential pressure is initiated at 2.9 seconds. At 22.9 seconds, the AFW block valves associated with the steam generator with lowest pressure (i.e., ruptured steam generator) are completely closed and all AFW flow is directed to the intact steam generator.

The continued blowdown from the ruptured steam generator causes the core reactivity to approach criticality. The ruptured steam generator blows dry at 109.1 seconds, which terminates the cooldown of the RCS. A peak reactivity of -0.05% at 144.0 seconds is obtained. A peak R-T-P of 7.5%, consisting of 4.2% fission power and 3.3% decay power, is produced at 144.5 seconds. A transient minimum DNBR of 1.56 at 140.0 seconds is obtained.

The negative reactivity inserted due to boron injection via the HPSI pump terminates the approach to criticality and the core becomes more subcritical.

The sequence of events for the 6.305 ft^2 SLB with LOAC on turbine trip initiated from HZP conditions is given in Table 4. The reactivity insertion as a function of time is presented in Figure 9. The NSSS response during the transient are given in Figures 10 through 14.

The results of the analysis show that the HZP SLB causes the secondary pressure to rapidly decrease until a reactor trip on low steam generator pressure is initiated at 1.3 seconds. The CEAs drop into the core at 2.7 seconds and terminate the power and heat flux increases.

The AFW system runout AFW flow of 1300 gpm is initiated at the time of the Steam Line Break. This flow is assumed to be unaffected by any electrical transient due to LOAC, and is directed in its entirety to the ruptured steam generator until the AFW block valves are completely shut.

A LOAC power on turbine trip is assumed to occur at 2.7 seconds. At this time, RCPs start coasting down and the diesel generators start coming on line. At 12.7 seconds the diesel generators reach full speed and the shutdown sequencer is initiated to load emergency systems. At 22.4 seconds, the safety injection actuation analysis setpoint is reached and the diesel generators switch from the shutdown sequencer to the LOCA sequencer to reload the emergency systems. At 27.4 seconds, the diesel generators load the HPSI pump on line and 30.0 seconds later (i.e., at 57.4 seconds) the HPSI pump reaches full speed.

The Steam Generator Isolation Analysis Setpoint is reached at 1.3 seconds. At 2.2 seconds, the MSIVs begin to close and are completely closed at 14.2 seconds. The blowdown from the intact steam generator is terminated at this time.

An AFW isolation signal based on steam generator differential pressure is initated at 3.4 seconds. At 23.4 seconds, the AFW block valves associated with the steam generator with lowest pressure (i.e., ruptured steam generator) are completely closed. AFW to the ruptured steam generator is terminated, and all AFW flow is directed to the intact steam generator.

The continued blowdown from the ruptured steam generator causes the core reactivity to approach criticality. The ruptured steam generator blows dry at 108.5 seconds, which terminates the cooldown of the RCS. A peak reactivity of +.13% at 130.5 seconds is obtained. A peak R-T-P of 2.32%, consisting almost entirely of fission power is produced at 157.5 seconds. A minimum transient DNBR of 2.6 at 160.0 seconds is obtained.

The negative reactivity inserted due to boron injection via the HPSI pump terminates the reactivity excursion and the core becomes and remains subcritical.

SLB Outside Containment

The primary purpose for analyzing the SLB outside containment is to calculate site boundary dose since, when compared to the inside containment break with respect to R-T-P, it is less adverse. Two sources of radioactivity contribute to the site boundary dose: the initial activity in the steam generator, and the activity associated with primary to secondary leakage. These activities are not affected by increased AFW flow. Therefore, the results forwarded in Reference (1) remain unchanged.

Conclusions

The results of the Steam Line Break inside containment shows that post-trip minimum DNBR is above the design limit of 1.3. These bounding cases demonstrate acceptable results by means of somewhat more HERMITE credit than was used for the Reference (1) analysis. The increased HERMITE credit is, however, entirely justifiable. The SLB outside containment results in a site boundary dose which is within 10CFR100 guidelines. Therefore, the results of the SLB event with LOAC power on turbine trip are acceptable for Unit 2 Cycle 5, even with the runout AFW flow assumed herein.

References

1. A. E. Lundvall to R. A. Clark letter dated 11/17/82, "Supplement 1 to Fifth Cycle License Application"

TABLE 1

KEY PARAMETERS ASSUMED IN THE INSIDE CONTAINMENT STEAM LINE BREAK EVENT INITIATED FROM HFP

Parameter	Units	Cycle 5
Initial Core Power	MWt	2754.0
Initial Core Inlet Temperature	^{o}F	550.0
Initial RCS Pressure	psia	2300.0
Initial Steam Generator Pressure	psia	860.0
Low Steam Generator Pressure Analysis Trip Setpoint	psia	600.0
Auxiliary Feedwater Actuation Analysis Setpoint	% Wide Range Steam Generator Level Indication	(1)*
Steam Generator Differential Pressure Analysis Setpoint	psid	250.0
Safety Injection Actuation Signal	psia	1645.0
Minimum CEA Worth Available at Trip	% delta Rho	-6.89
Doppler Multiplier		1.15
Moderator Cooldown Curve	% vs. density	See Figure 1
Inverse Boron Worth	ppm/% delta Rho	95.0
Effective MTC	x 10^{-4} delta Rho/^{o}F	-2.2
Beta Fraction (including uncertainty)		.0060

*change from Reference (1)

(1) NA - 1300 gpm AFW flow is initiated at the time of SLB.

TABLE 2

KEY PARAMETERS ASSUMED IN THE INSIDE CONTAINMENT STEAM LINE BREAK EVENT INITIATED FROM HZP

Parameter	Units	Cycle 5
Initial Core Power	MWt	1.0
Initial Core Inlet Temperature	^{o}F	532.0
Initial RCS Pressure	psia	2300.0
Initial Steam Generator Pressure	psia	900.0
Low Steam Generator Pressure Analysis Trip Setpoint	psia	600.0
Auxiliary Feedwater Actuation Analysis Setpoint	% Wide Range Steam Generator Level Indication	(1)*
Steam Generator Differential Pressure Analysis Setpoint	psid	250.0
Safety Injection Actuation Signal	psia	1645.0
Minimum CEA Worth Available at Trip	% delta Rho	-5.2
Doppler Multiplier		1.15
Moderator Cooldown Curve	% vs. density	See Figure 2
Inverse Boron Worth	ppm/% delta Rho	90.0
Effective MTC	x 10^{-4}delta Rho/^{o}F	-2.2
Beta Fraction (including uncertainty)		.0060

*Change from Reference (1)

(1) NA - 1300 gpm of AFW flow is initiated at the time of SLB.

TABLE 3

SEQUENCE OF EVENT FOR INSIDE CONTAINMENT
STEAM LINE BREAK EVENT WITH
LOSS OF AC POWER ON TURBINE TRIP INITIATED FROM HFP

Time (sec)	Event	Setpoint or Value
0.0	Steam Line Break Occurs	6.305 ft^2
0.0	Auxiliary Feedwater is Initiated; All Flow is Directed to the Ruptured Steam Generator	1300 gpm
1.7	Low Steam Generator Pressure Analysis Trip Setpoint is Reached; Steam Generator Isolation Analysis Setpoint is Reached	600.0 psia
2.6	Trip Breakers Open; Main Steam Isolation Valves Begin to Close; Main Feedwater Isolation Valves Begin to Close	
2.9	Steam Generator Differential Pressure Analysis Setpoint is Reached	delta P = 250.0 psid
3.1	CEAs Enter Core; Loss of AC Power on Turbine Trip; RCP Coastdown Begins; Diesel Generator Start Coming on Line; Main Feedwater Rampdown Begins	
13.1	Diesel Generators Reached Rated Speed Following LOAC Power; Shutdown Sequencer Initiated	
14.6	Main Steam Isolation Valves Completely Close	—
17.0	Safety Injection Actuation Analysis Setpoint is Reached; LOCI Sequencer Initiated	1645.0 psia
19.0	Pressurizer Empties	
22.0	Power Provided to High Pressure Safety Injection Pumps	

TABLE 3
(continued)

Time (sec)	Event	Setpoint or Value
22.9	AFW Block Valve Completely Closed; All Flow Directed to Undamaged Steam Generator	1300 gpm
23.1	Main Feedwater Rampdown Completed	8% of full power feedwater flow
52.0	High Pressure Safety Injection Pump at Full Speed	—
82.6	Main Feedwater Isolation Valve Completely Closed	—
109.1	Affected Steam Generator Blows Dry	—
144.0	Peak Reactivity	-0.051% delta Rho
144.5	Peak Return to Power	7.5% of 2700 MWt

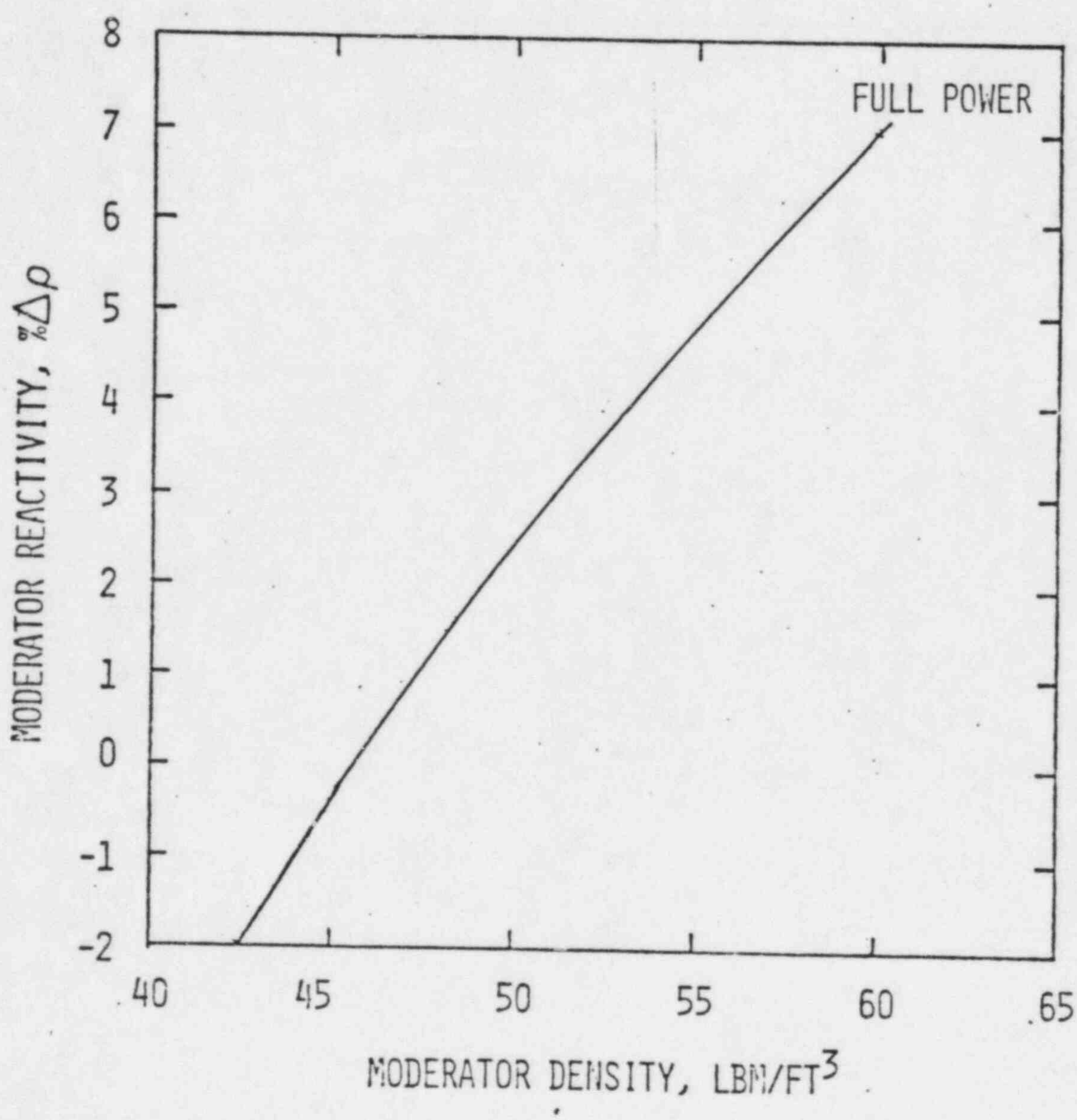
TABLE 4

SEQUENCE OF EVENT FOR INSIDE CONTAINMENT
STEAM LINE BREAK EVENT WITH
LOSS OF AC POWER ON TURBINE TRIP INITIATED FROM HZP

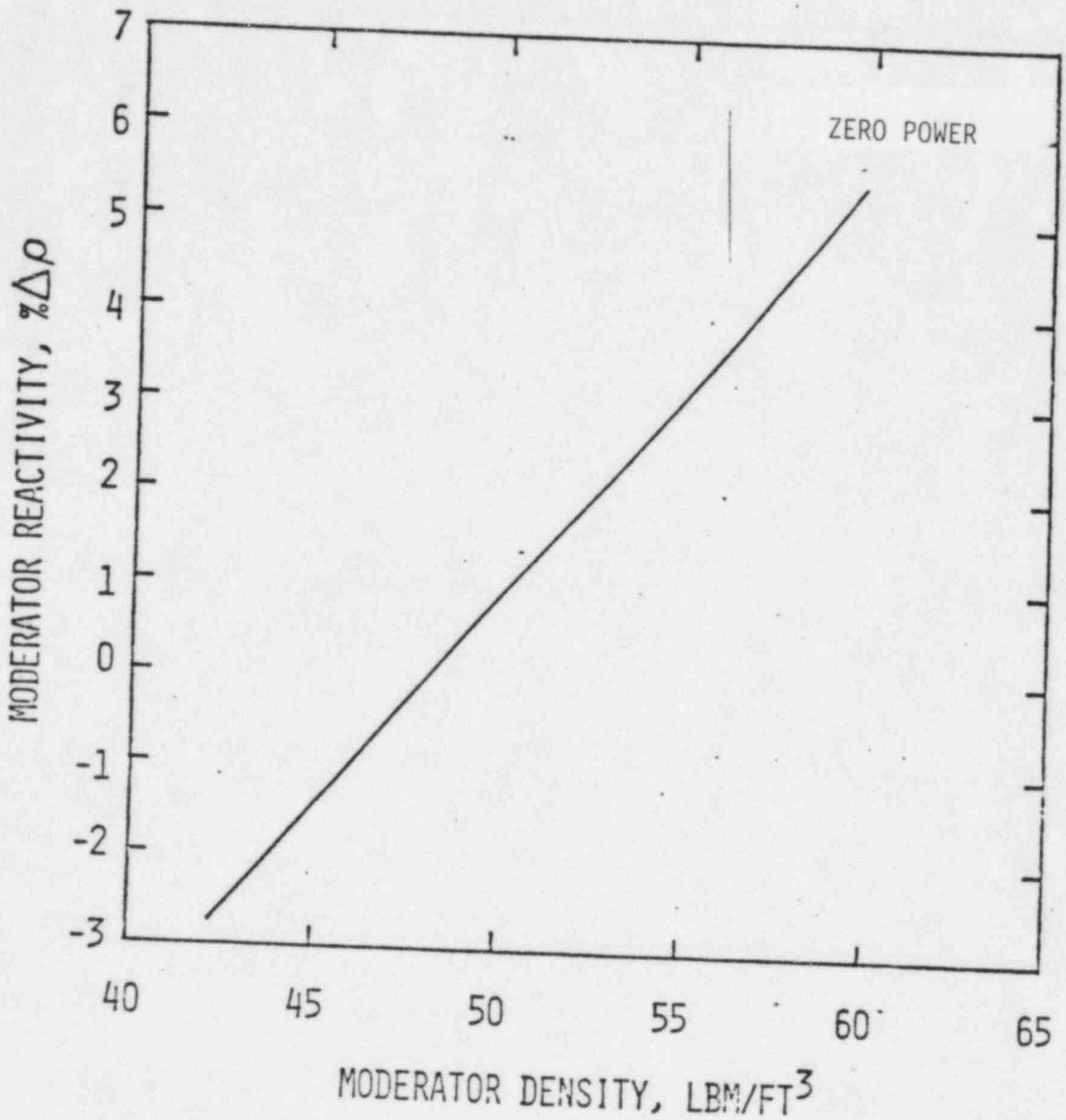
Time (sec)	Event	Setpoint or Value
0.0	Steam Line Break Occurs	6.305 ft^2
0.0	Auxiliary Feedwater is Initiated; All Flow is Directed to the Ruptured Steam Generator	1300 gpm
1.3	Low Steam Generator Pressure Analysis Trip Setpoint is Reached; Steam Generator Isolation Analysis Setpoint is Reached	600.0 psia
2.2	Trip Breakers Open; Main Steam Isolation Valves Begin to Close; Main Feedwater Isolation Valves Begin to Close	—
2.7	CEAs Enter Core; Loss of AC Power on Turbine Trip; RCP Coastdown Begins; Diesel Generators Start Coming on Line	
3.4	Steam Generator Differential Pressure Analysis Setpoint is Reached	delta P = 250.0 psid
12.7	Diesel Generators Reached Rated Speed Following LOAC Power; Shutdown Sequencer Initiated	
14.2	Main Steam Isolation Valves Completely Close	—
17.7	Power Provided to High Pressure Safety Injection Pumps	
22.4	Safety Injection Actuation Analysis Setpoint is Reached; LOCI Sequencer Initiated	1645.0 psia

TABLE 4
(continued)

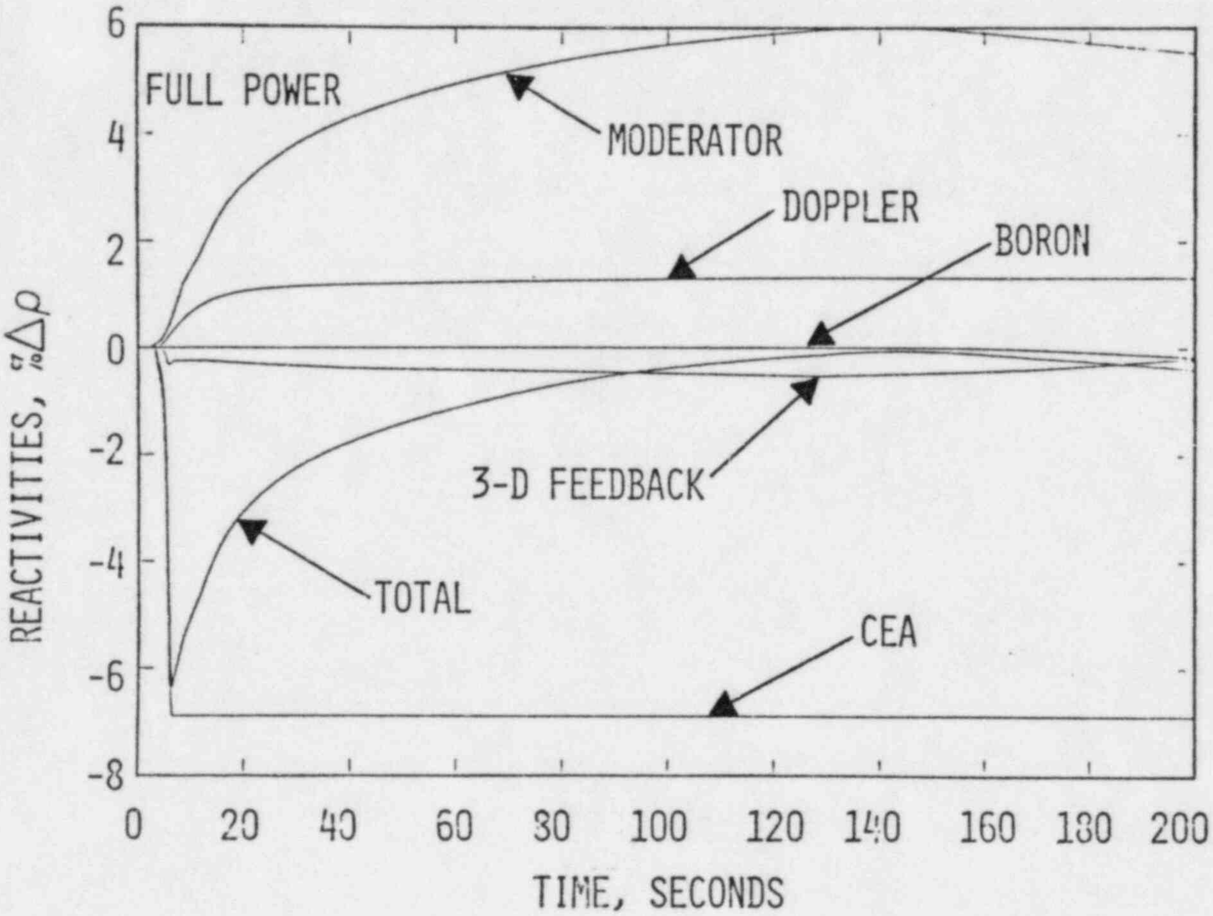
Time (sec)	Event	Setpoint or Value
23.4	AFW Block Valve Completely Closed; All Flow Directed to Undamaged Steam Generator	—
26.9	Pressurizer Empties	
27.4	Power Provided to HPSI Pump	
57.4	High Pressure Safety Injection Pump at Full Speed	—
108.5	Affected Steam Generator Blows Dry	—
130.5	Peak Reactivity	+.127% delta Rho
157.5	Peak Power	2.32% of 2700 MWt



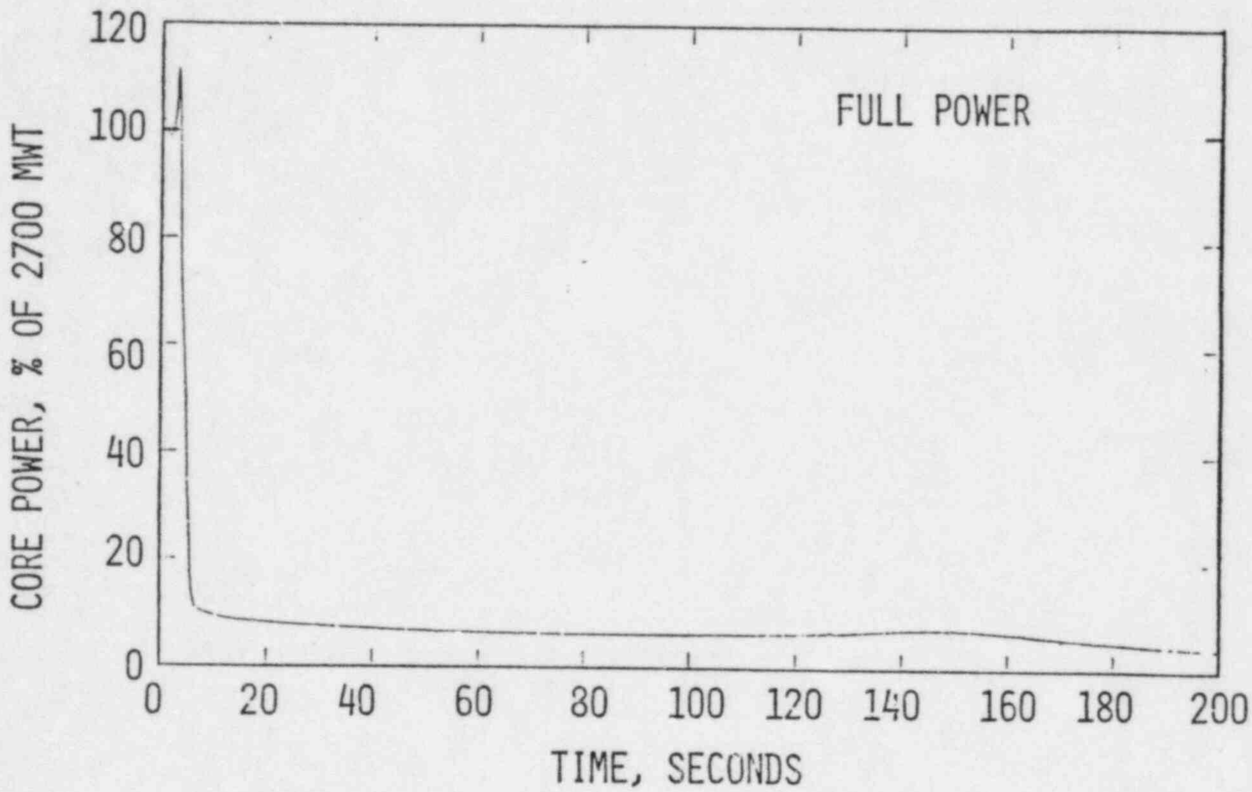
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT MODERATOR REACTIVITY VS MODERATOR DENSITY	FIGURE 1



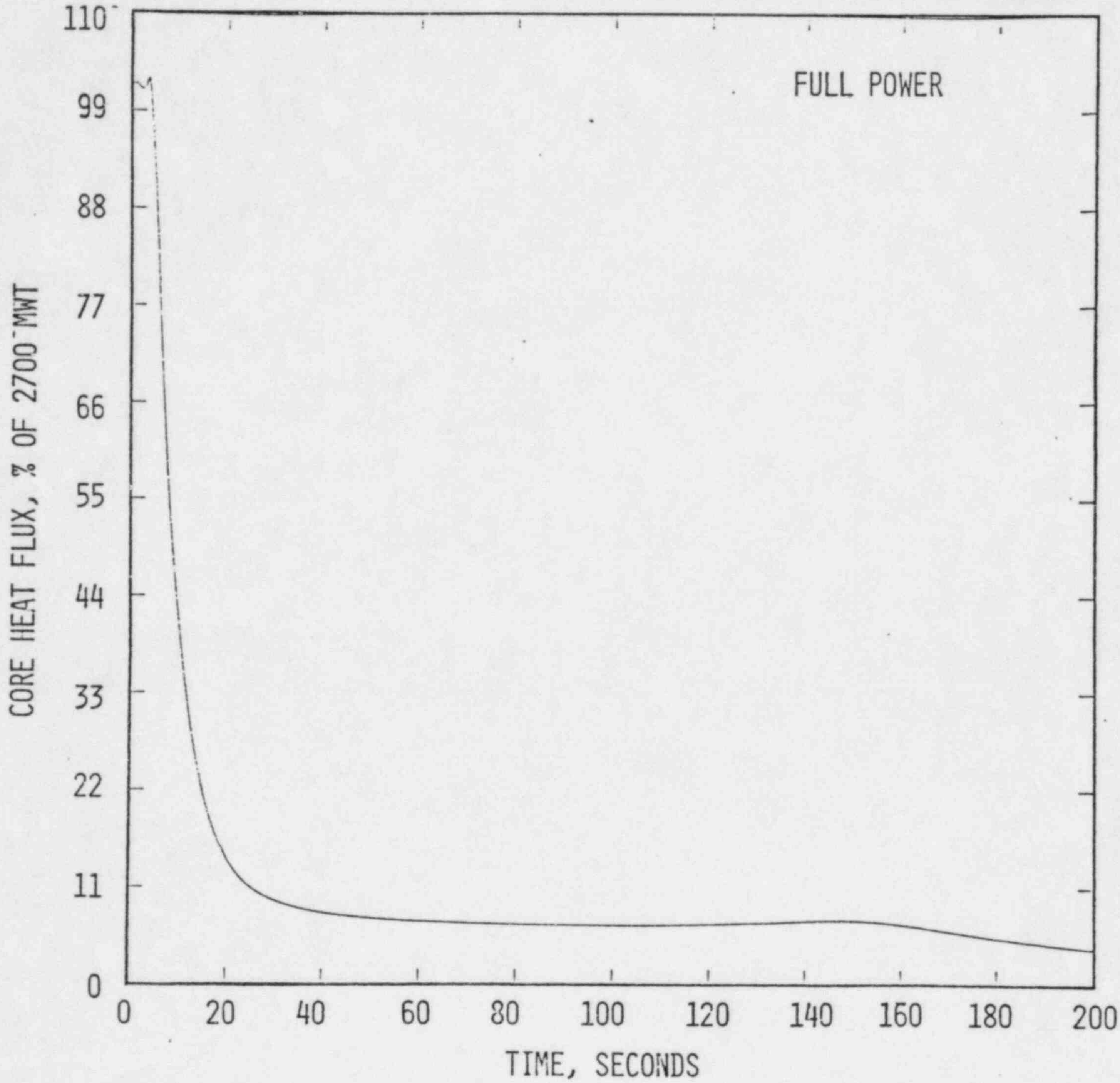
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT MODERATOR REACTIVITY VS MODERATOR DENSITY	FIGURE 2



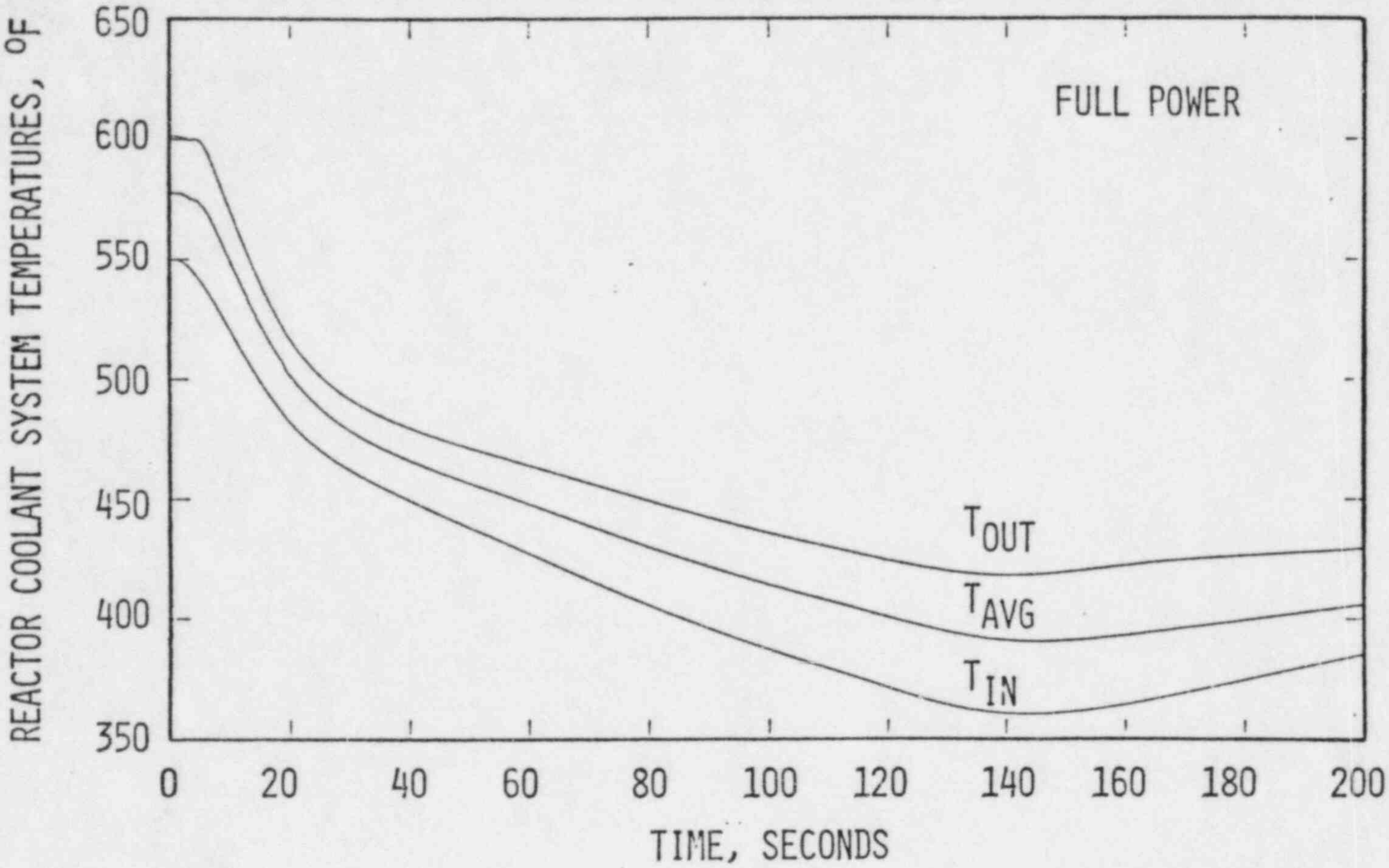
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT REACTIVITIES VS TIME	FIGURE 3



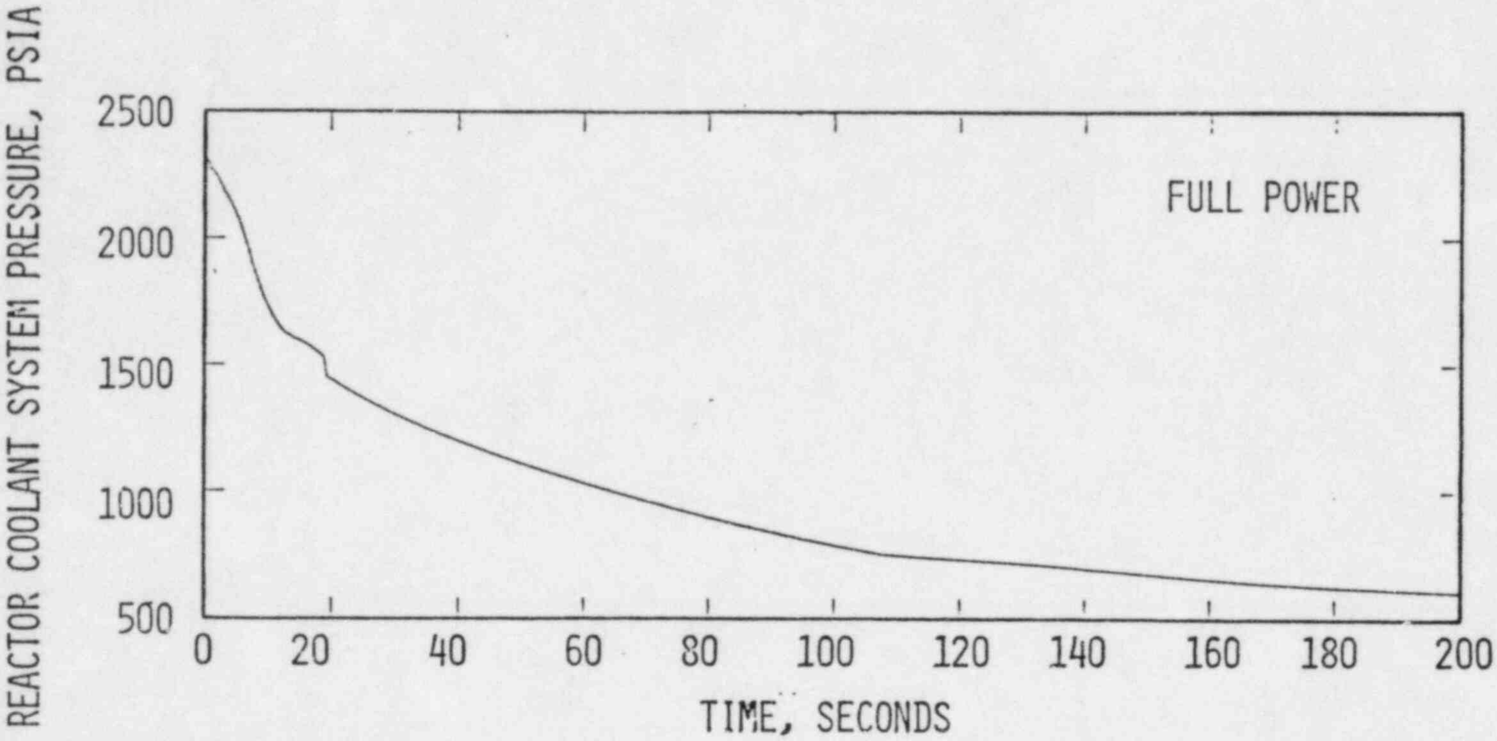
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT CORE POWER VS TIME	FIGURE 4



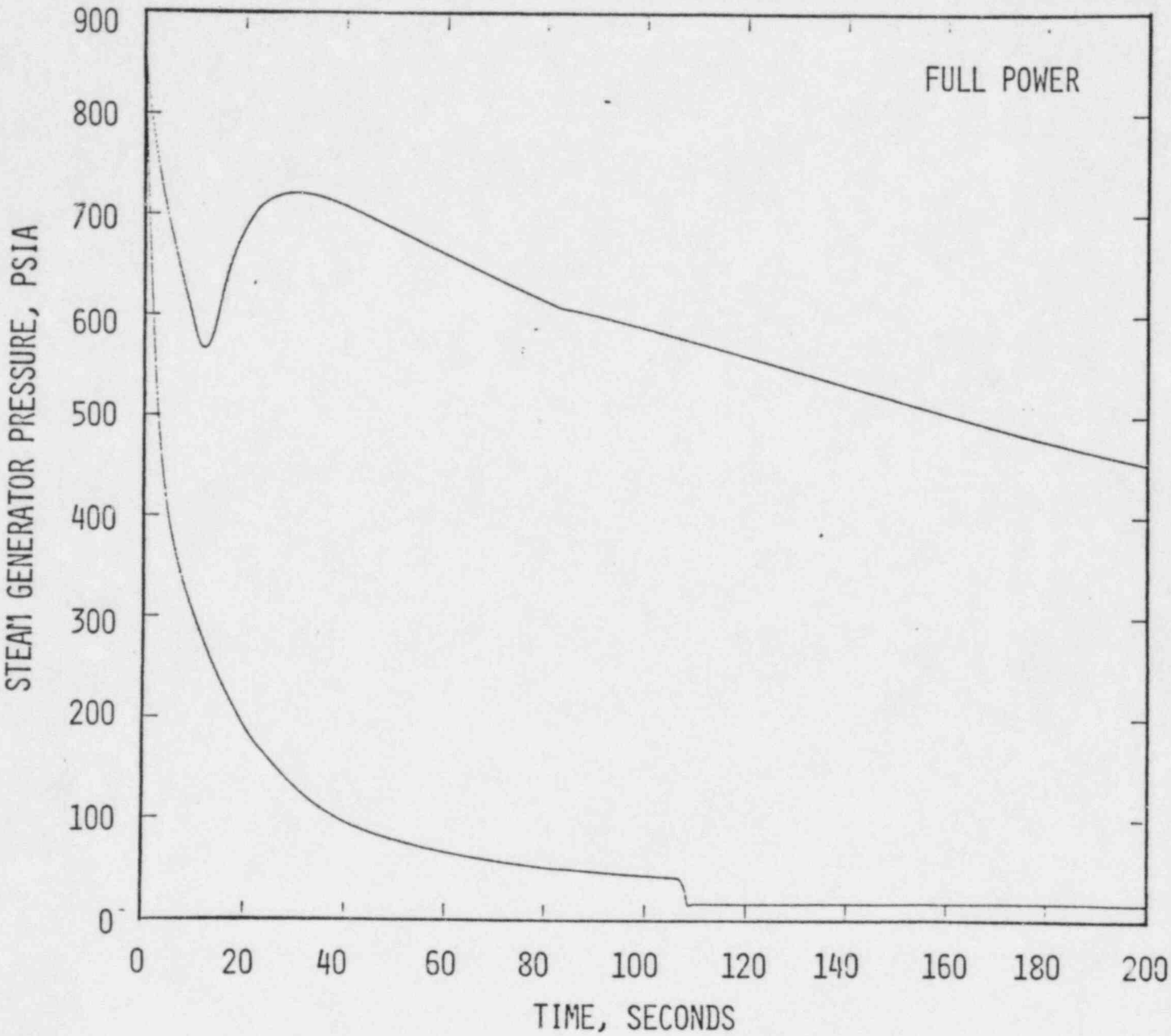
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT CORE HEAT FLUX VS TIME	FIGURE 5



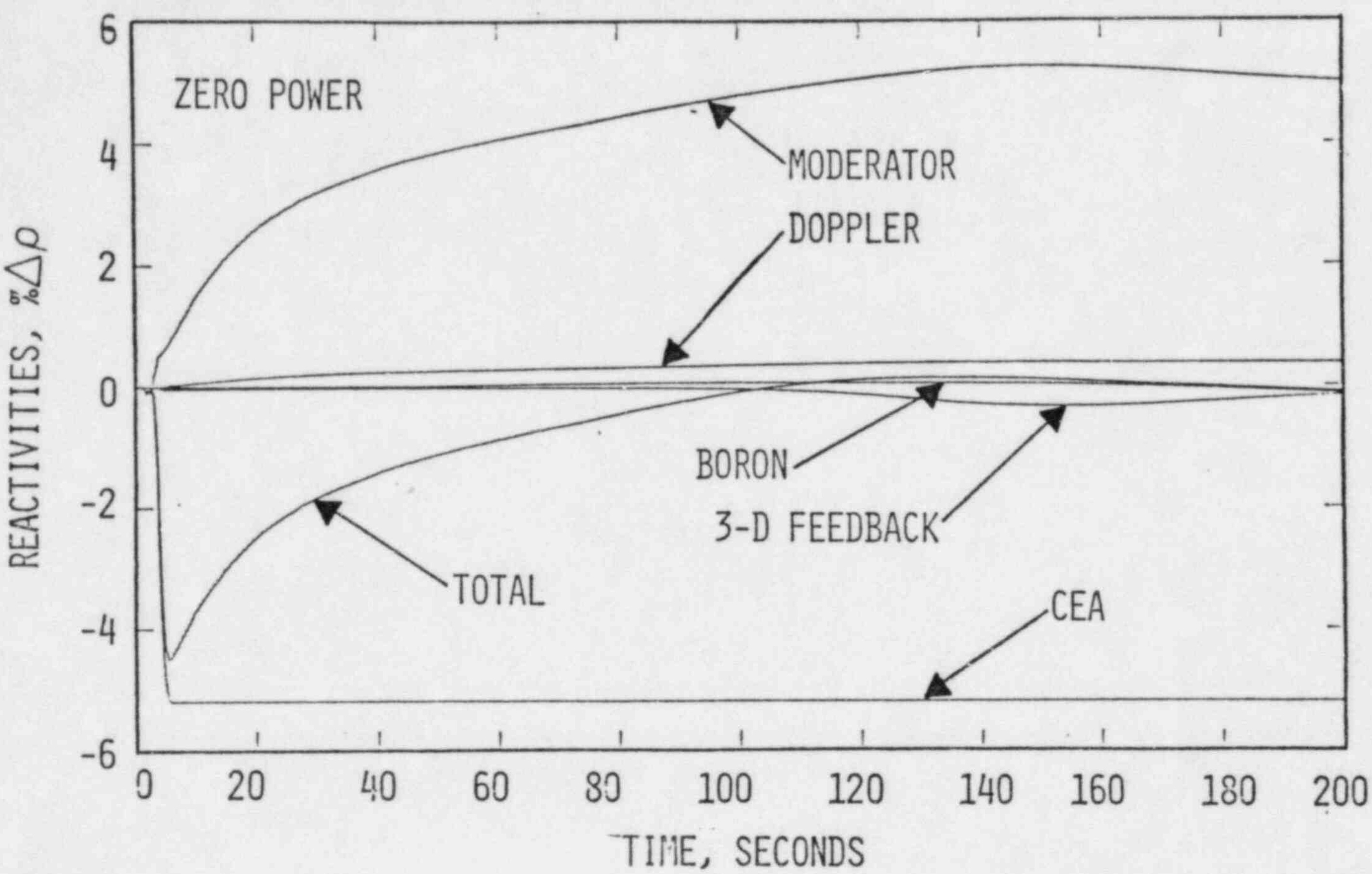
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT REACTOR COOLANT SYSTEM TEMPERATURES VS TIME	FIGURE 6



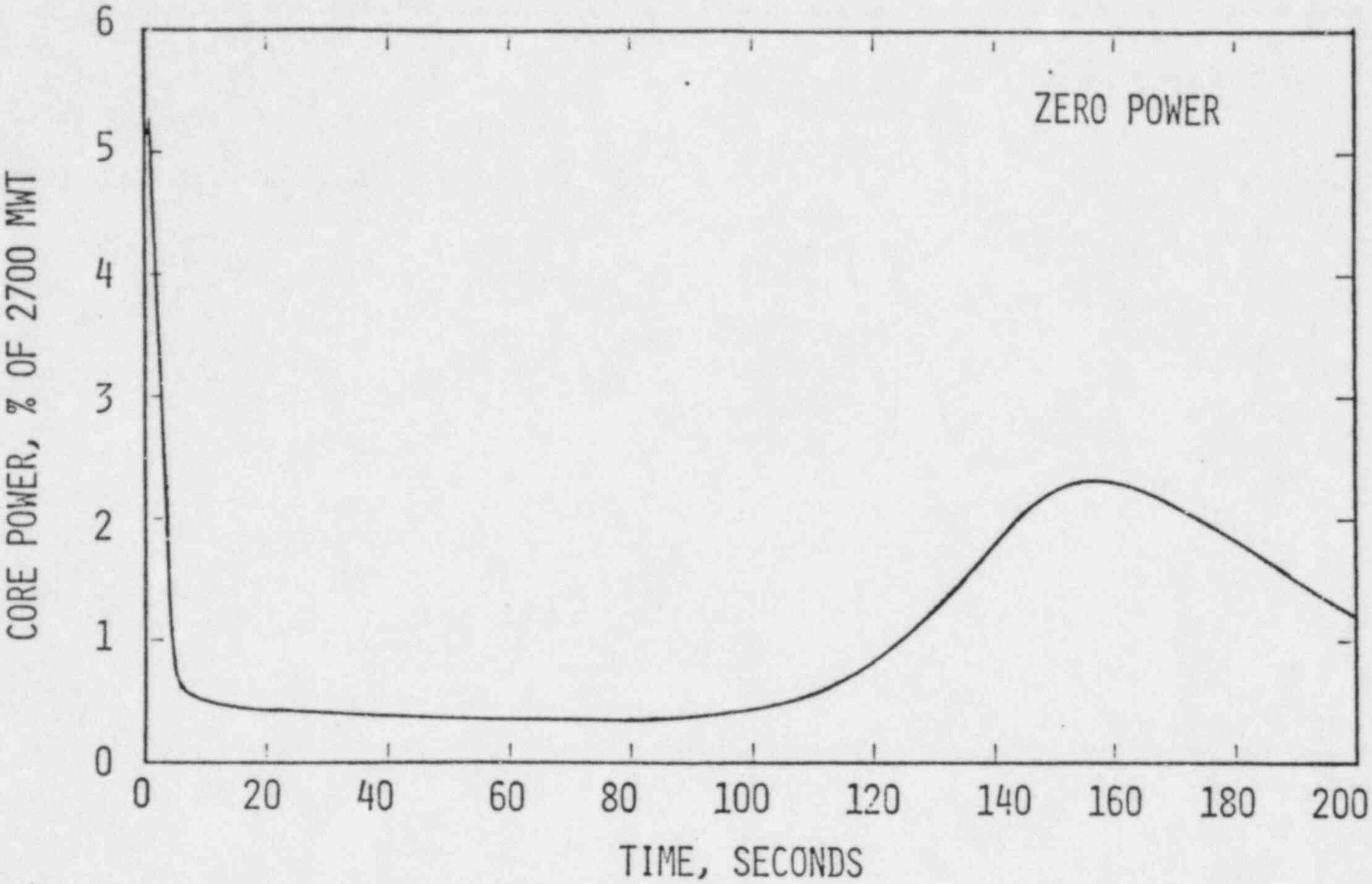
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT REACTOR COOLANT SYSTEM PRESSURE VS TIME	FIGURE 7



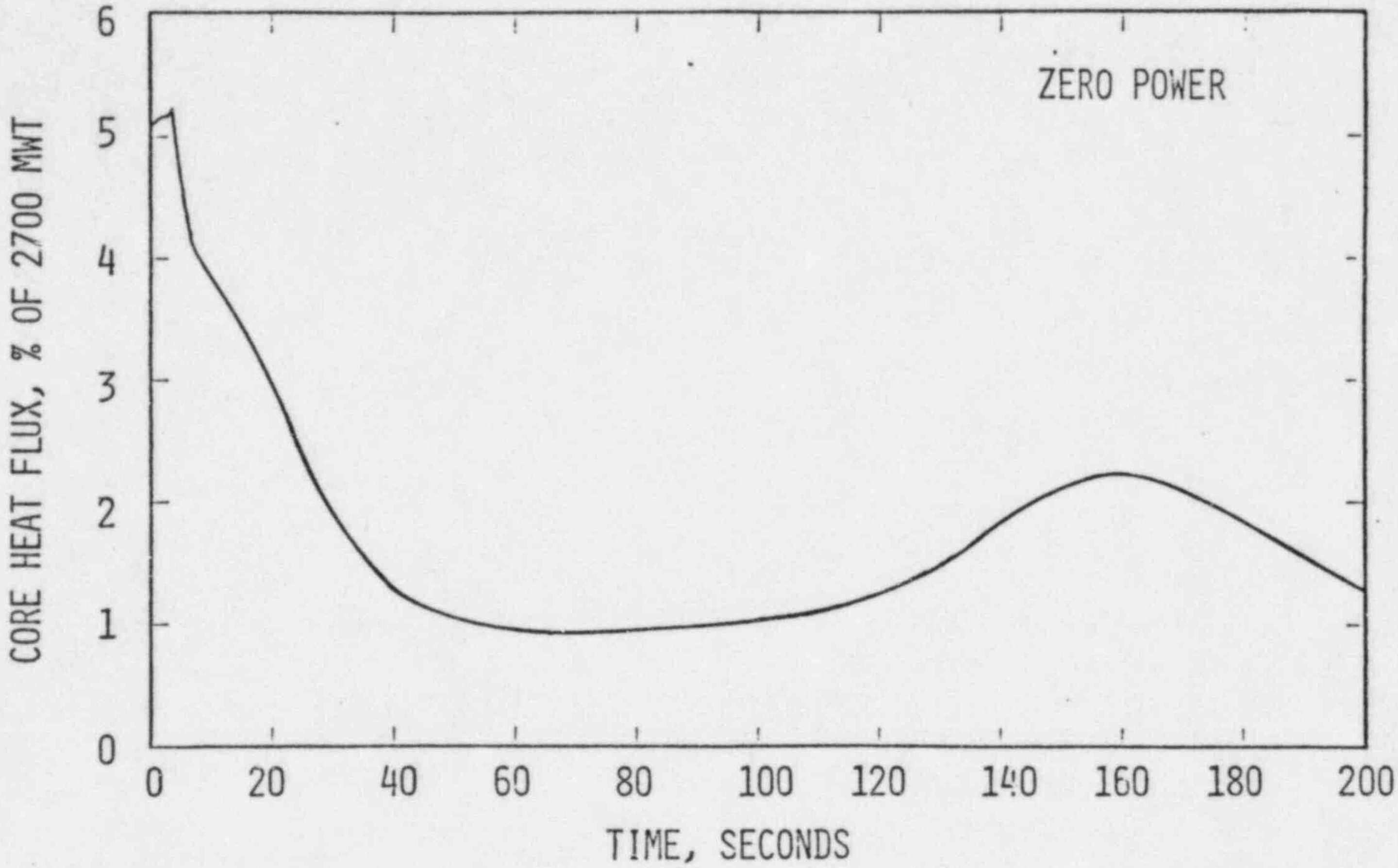
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT STEAM GENERATOR PRESSURE VS TIME	FIGURE 8



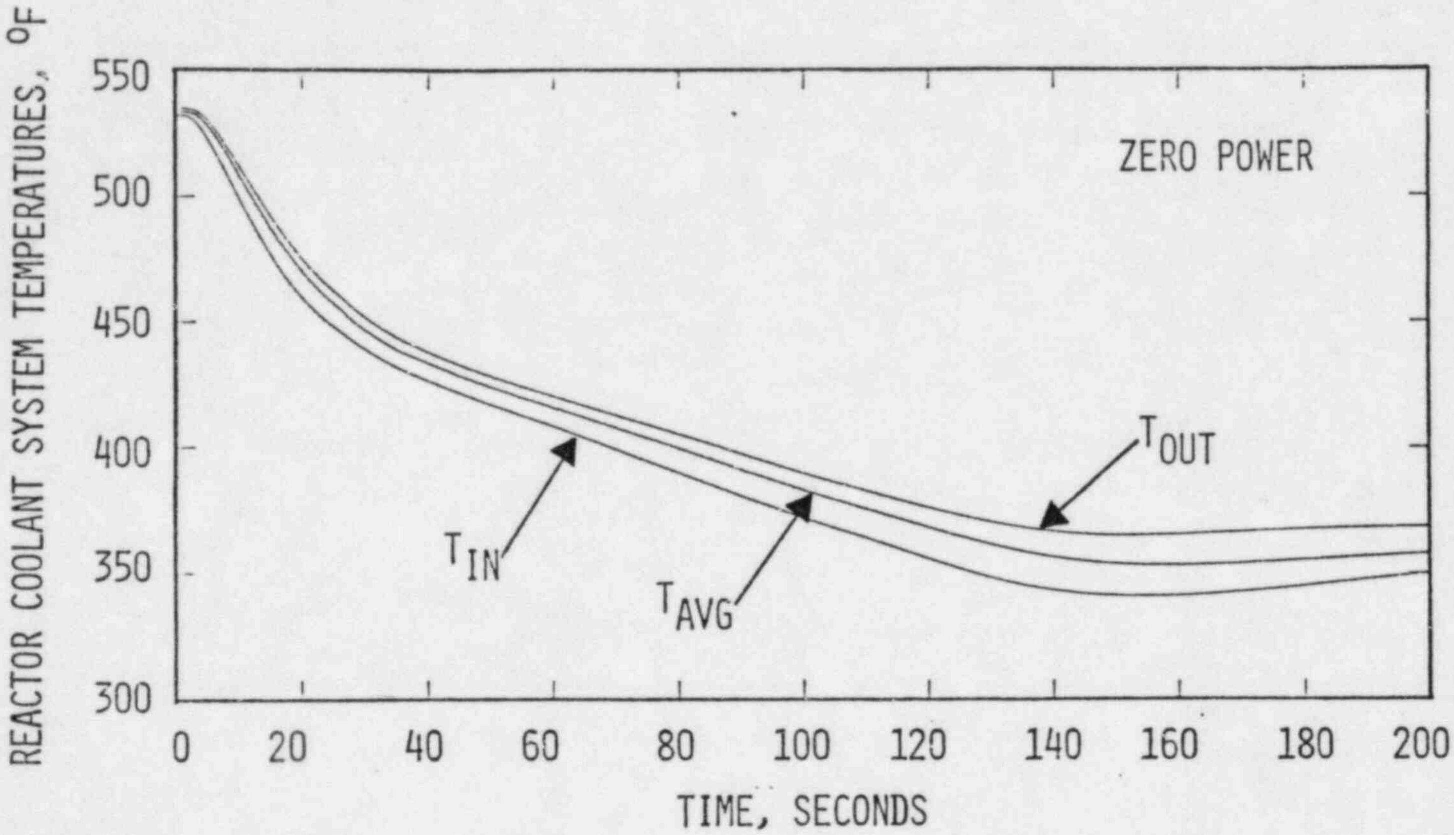
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT REACTIVITIES VS TIME	FIGURE 9



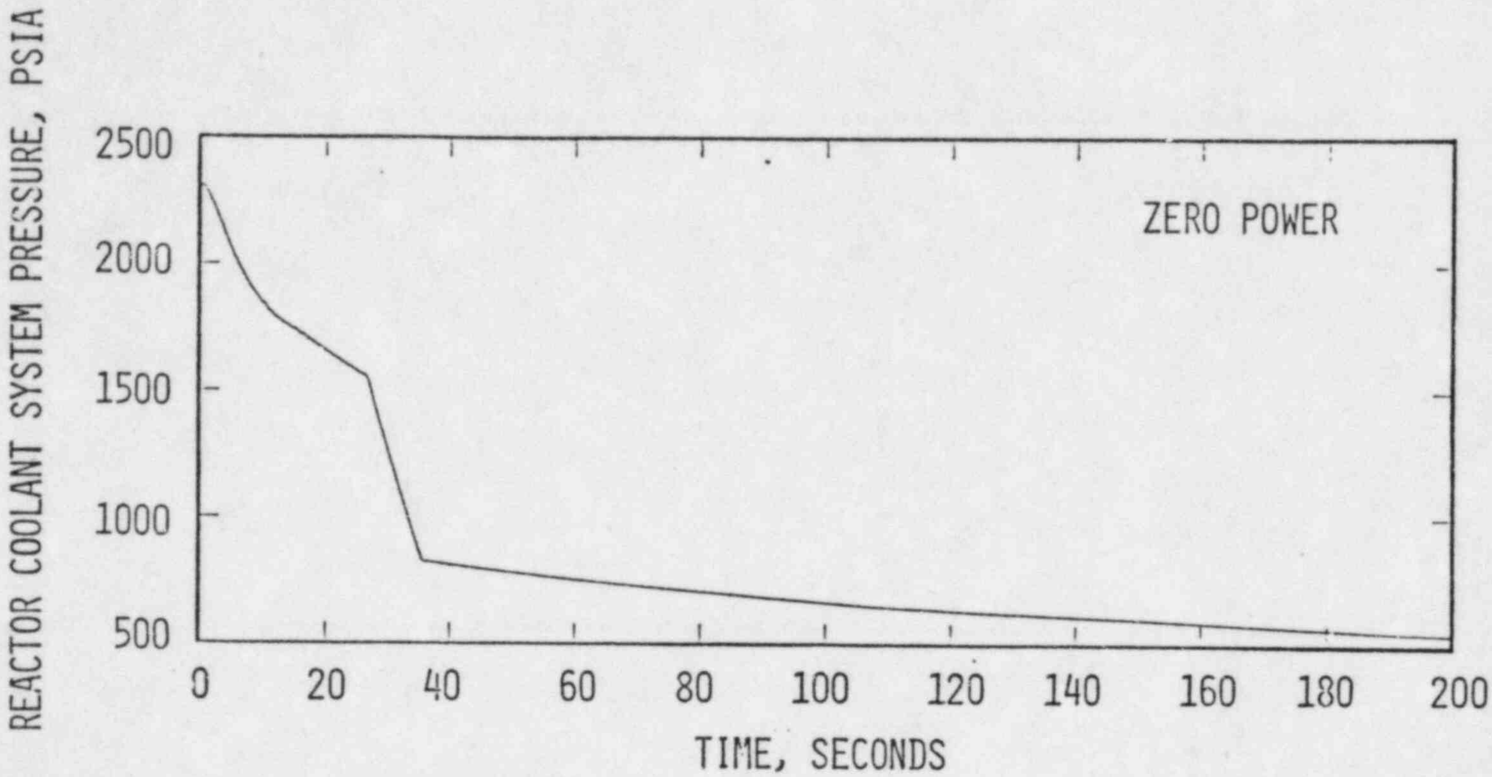
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT CORE POWER VS TIME	FIGURE 10



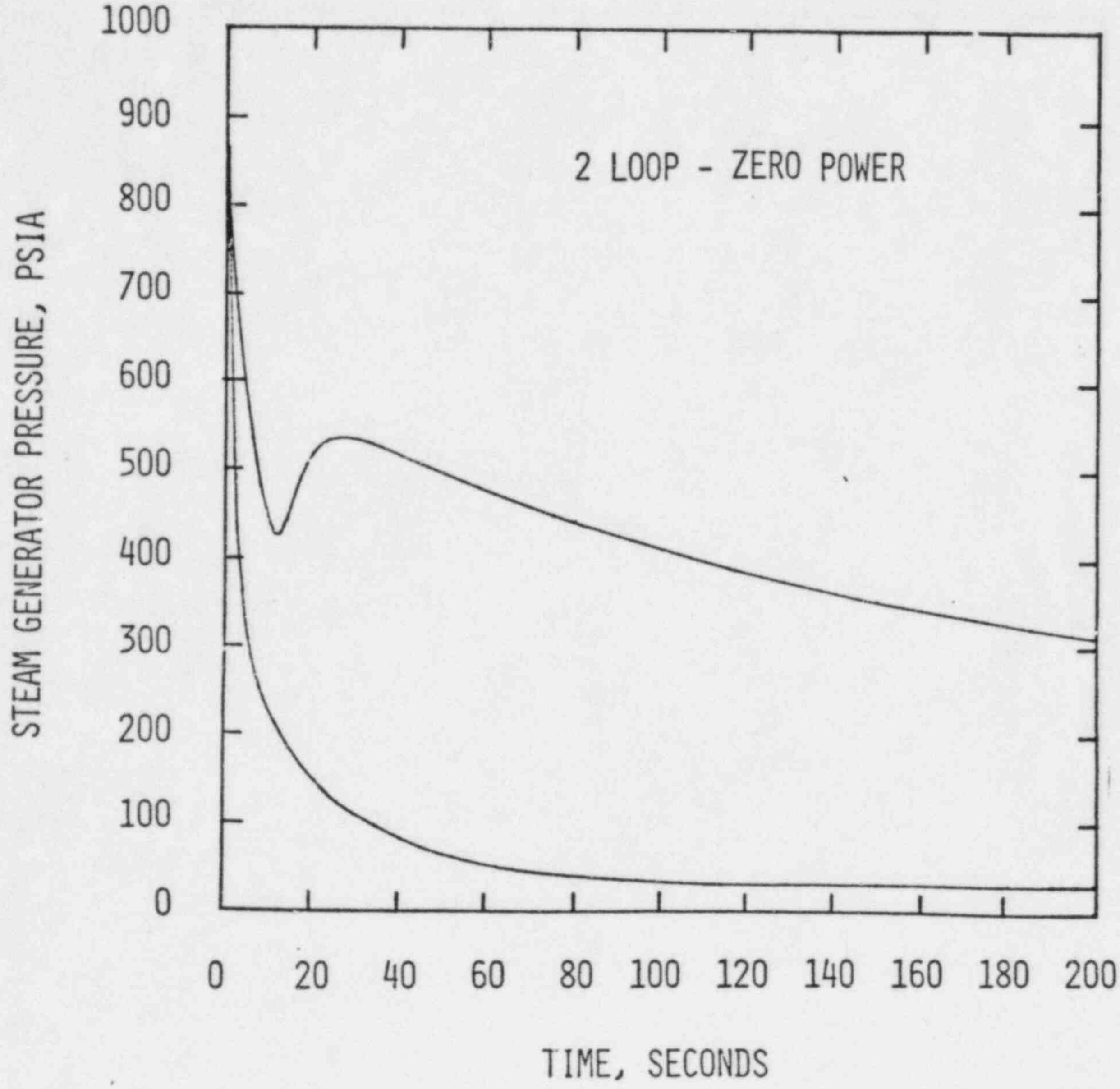
BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT CORE HEAT FLUX VS TIME	FIGURE 11



BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT REACTOR COOLANT SYSTEM TEMPERATURES VS TIME	FIGURE 12



BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT REACTOR COOLANT SYSTEM PRESSURE VS TIME	FIGURE 13



BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	STEAM LINE BREAK EVENT STEAM GENERATOR PRESSURE VS TIME	FIGURE 14