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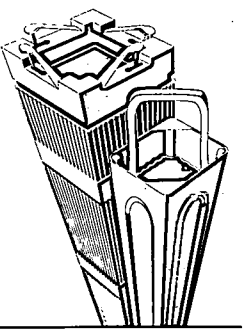
EMF-93-086(NP)
Revision 1

Palisades Loss of Load Analysis

March 1995



Siemens Power Corporation
Nuclear Division

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Palisades Loss of Load Analysis

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Table of Contents

List of Tables

List of Figures

Loss of External Load
With 25% Steam Generator Tube Plugging

1.0 EVENT DESCRIPTION

A Loss of External Load event (Event 15.2.1) is initiated by either a loss of external electrical load or a turbine trip. Upon either of these two conditions, the turbine stop valve is assumed to rapidly close (0.1 second). Normally, a reactor trip would occur on a turbine trip; however, to calculate a conservative system response, the reactor trip on turbine trip is disabled. The steam dump system (atmospheric dump valves - ADVs) is assumed to be unavailable. These assumptions allow the Loss of External Load event to bound the consequences of Event 15.2.2 (Turbine Trip - steam dump system unavailable) and Event 15.2.4 (Closure of both MSIVs - valve closure time is > 0.1 second).

The Loss of External Load event primarily challenges the acceptance criteria for both primary and secondary system pressurization and DNBR. The event results in an increase in the primary system temperatures due to an increase in the secondary side temperature. As the primary system temperatures increase, the coolant expands into the pressurizer causing an increase in the pressurizer pressure. The primary system is protected against overpressurization by the pressurizer safety and relief valves. Pressure relief on the secondary side is afforded by the steam line safety/relief valves. Actuation of the primary and secondary system safety valves limits the magnitude of the primary system temperature and pressure increase.

With a positive BOC moderator temperature coefficient, increasing primary system temperatures result in an increase in core power. The increasing primary side temperatures and power reduces the margin to thermal limits (i.e., DNBR limits) and challenges the DNBR acceptance criteria.

2.0 DEFINITION OF EVENTS ANALYZED

The objectives in analyzing this event are to demonstrate that the primary pressure relief capacity is sufficient to limit the pressure to less than 110% (2750 psia) of the design pressure and that the secondary side pressure relief capacity is capable of limiting the pressure to less than 110% (1100 psia) of design pressure. A steam generator tube plugging level of 25% is assumed for the analysis. No credit is taken for direct reactor trip on turbine trip, the turbine bypass system or the steam dump system. Also, credit from the pressurizer PORVs is conservatively excluded from this analysis. In general, the parameters and equipment operational states are selected to maximize the system pressure.

A loss of load event also challenges thermal margin limits. However, Reference 1 disposed this subevent as being bounded by other more limiting AOO events. Thus, the DNBR for this event is not evaluated.

The Loss of External Load is credible only for rated power and power operation events because there is no load on the turbine at other reactor conditions. The rated power conditions bound the consequences for other reactor power operating conditions because of the increased stored energy. The higher the stored energy in the primary system, the more severe the consequences of this event.

3.0 ANALYTICAL METHODOLOGY

ANF-RELAP was used in accordance with Siemens Power Corporation's approved methodology.[2] The capacities and setpoints used in the analysis for the pressurizer and main steam safety valves are summarized in Table 3.1.

Table 3.1

Safety Valve Setpoints and Capacities

	Nominal Setpoint (psia)	Setpoint with 3% Error (psia)	Flow at Opening* (lb/hr)	Flow at Accumulation **(lb/hr)
Pressurizer Safety Relief Valves				
RV-1039	2,580.0	2,657.4	230,447	237,360
RV-1040	2,540.0	2,616.2	226,874	233,680
RV-1041	2,500.0	2,575.0	223,301	230,000
Main Steam Safety Relief Valves (8 per Bank)				
Bank 1	1000	1030	3,779,417	3,892,800
Bank 2	1020	1050.6	3,855,006	3,970,656
Bank 3	1040	1071.2	3,930,594	4,048,512

* Assumes valve fully open at setpoint plus 3% error.

** Accumulation is 3% above setpoint.

4.0 ANALYSIS RESULTS

The maximum primary pressurization case initiates with a rapid closure of the turbine stop valve in 0.1 seconds. Steam line pressure increases until the safety relief valves open at 10.55 seconds. The maximum pressure in the steam generators of 1040.8 psia is achieved at 13.80 seconds. The maximum required steam line relief valve flow capacity to control the secondary-side pressure is about 3.8 Mlbm/hr.

The pressurization of the secondary side results in decreased primary to secondary heat transfer, and a substantial rise in primary system temperature. A primary coolant temperature increase of about 15.1 °F has occurred by 9.50 seconds. This results in a large insurge into the pressurizer, compressing the steam space and pressurizing the primary system. The reactor trips on high pressure with rods beginning to insert at 7.25 seconds, and the pressurizer safety valves open at 10.80 seconds. The increase in coolant temperature also causes the core power to rise to 2671.2 MWt due to positive moderator feedback. The transient is terminated shortly after reactor scram due to decreasing primary coolant temperature and pressure.

The capacity of one valve is enough to contain the pressurizer pressure to a maximum of 2575.9 psia. The maximum primary system pressure is 2614.9 psia occurring at 10.90 seconds. The maximum PCS pressure is less than the 2750 psia limit. The responses of key system variables are given in Figures 4.1 to 4.9. The sequence of events is given in Table 4.1.

The secondary side pressure relief valves contain sufficient capacity to limit the pressure to less than 110% (1100 psia) of design pressure.

Table 4.1

Event Summary for the Loss of External Load Event

Event	Value	Time (sec)
Turbine Trip		0.00
Pressurizer Heaters on		0.00
Charging Flow on	133 gpm	0.00
Peak Core Average Heat Flux	168,830 Btu/hr-ft^2	0.10
Reactor Scram (High Pressure)		7.25
Peak Power Level	2671.2 MWt	7.90
Steam Line Safety Valves Open		10.55
Pressurizer Safety Valves Open		10.80
Peak PCS Pressure	2614.9 psia	10.90
Peak Core Average Temperature	584.74 °F	11.85
Peak Steam Generator Pressure	1040.8	13.80

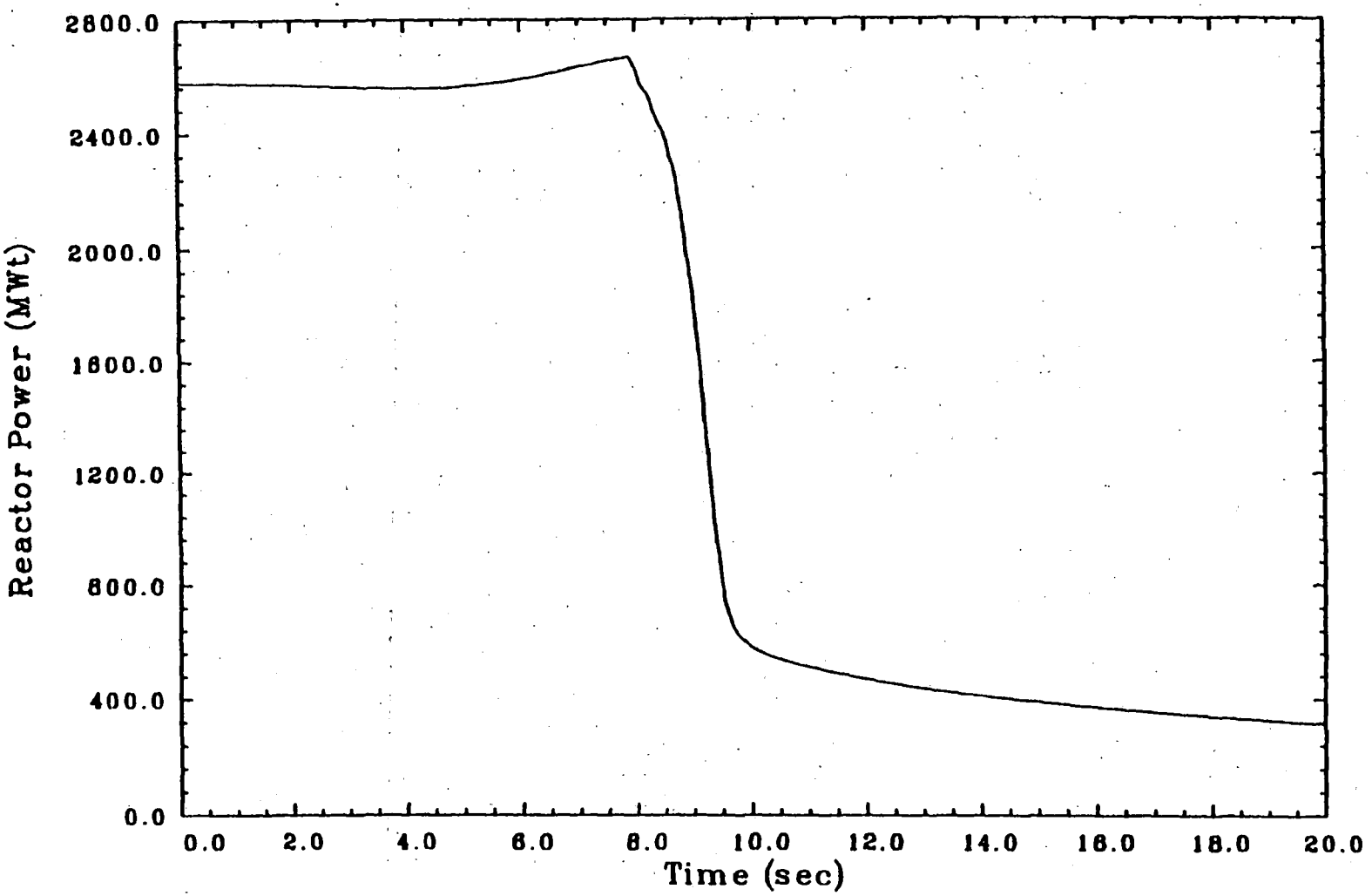

Figure 4.1

Reactor Power for Loss of External Load

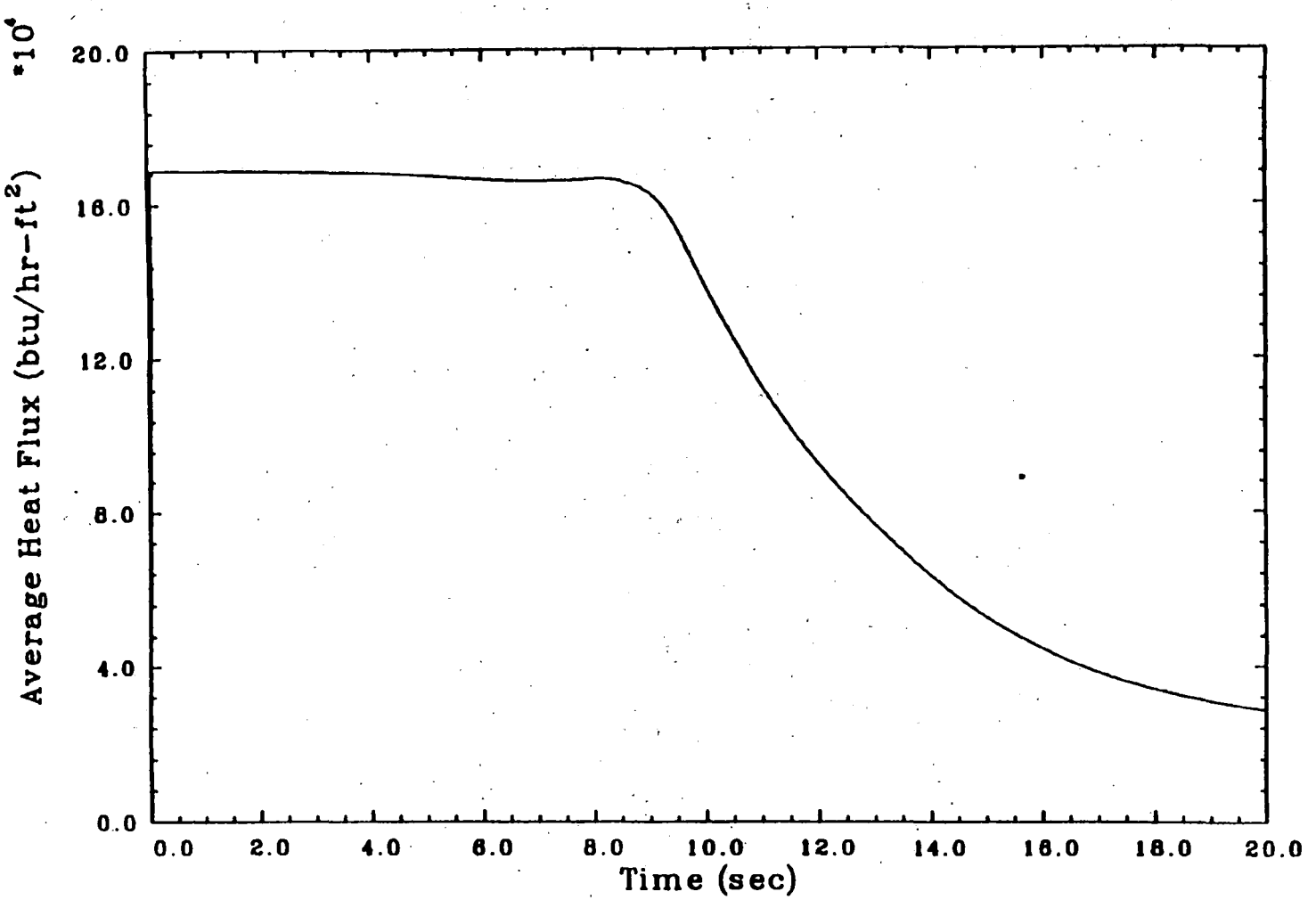

Figure 4.2

Core Average Heat Flux for Loss of External Load

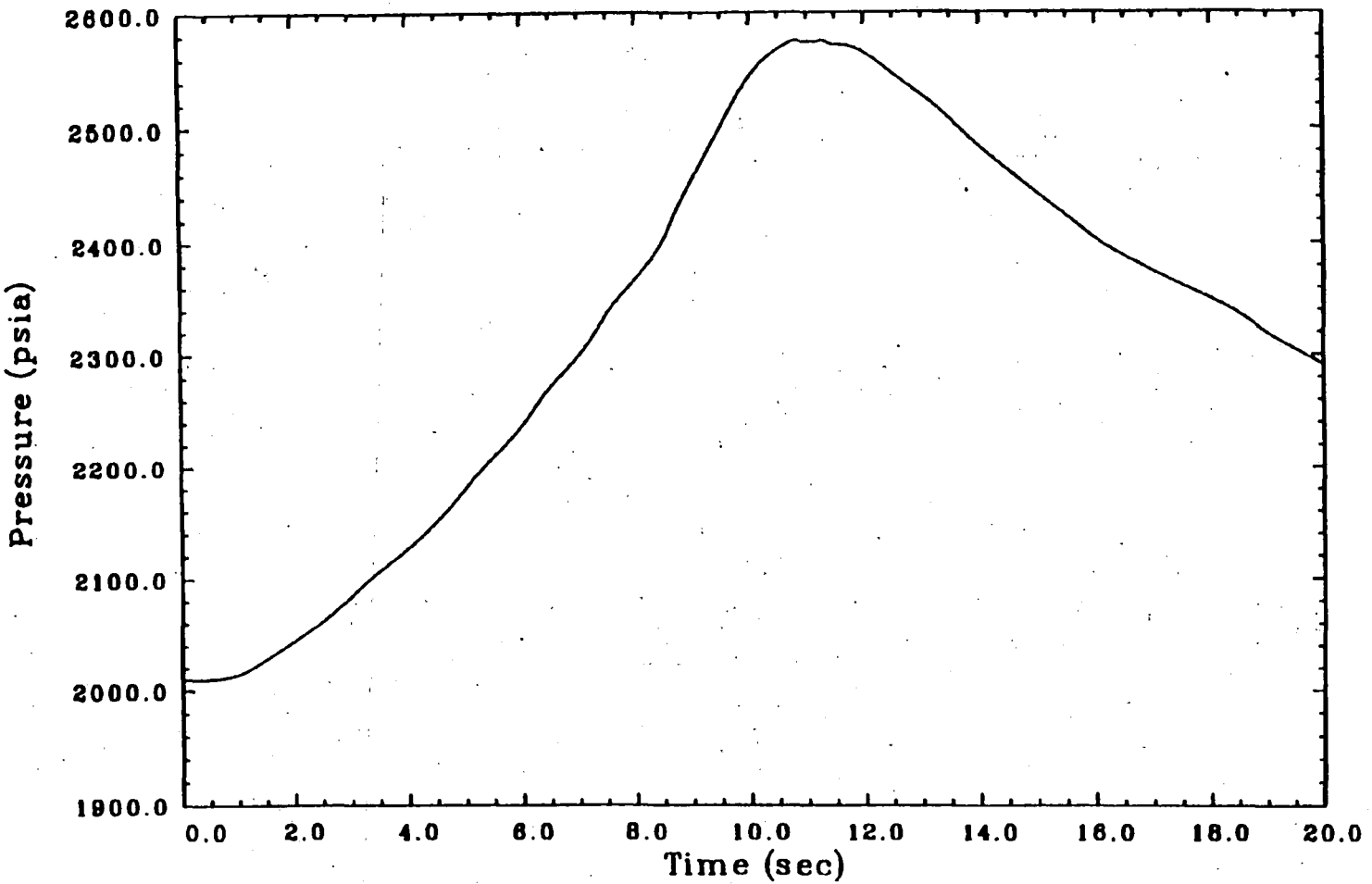

Figure 4.3

Pressurizer Pressure for Loss of External Load

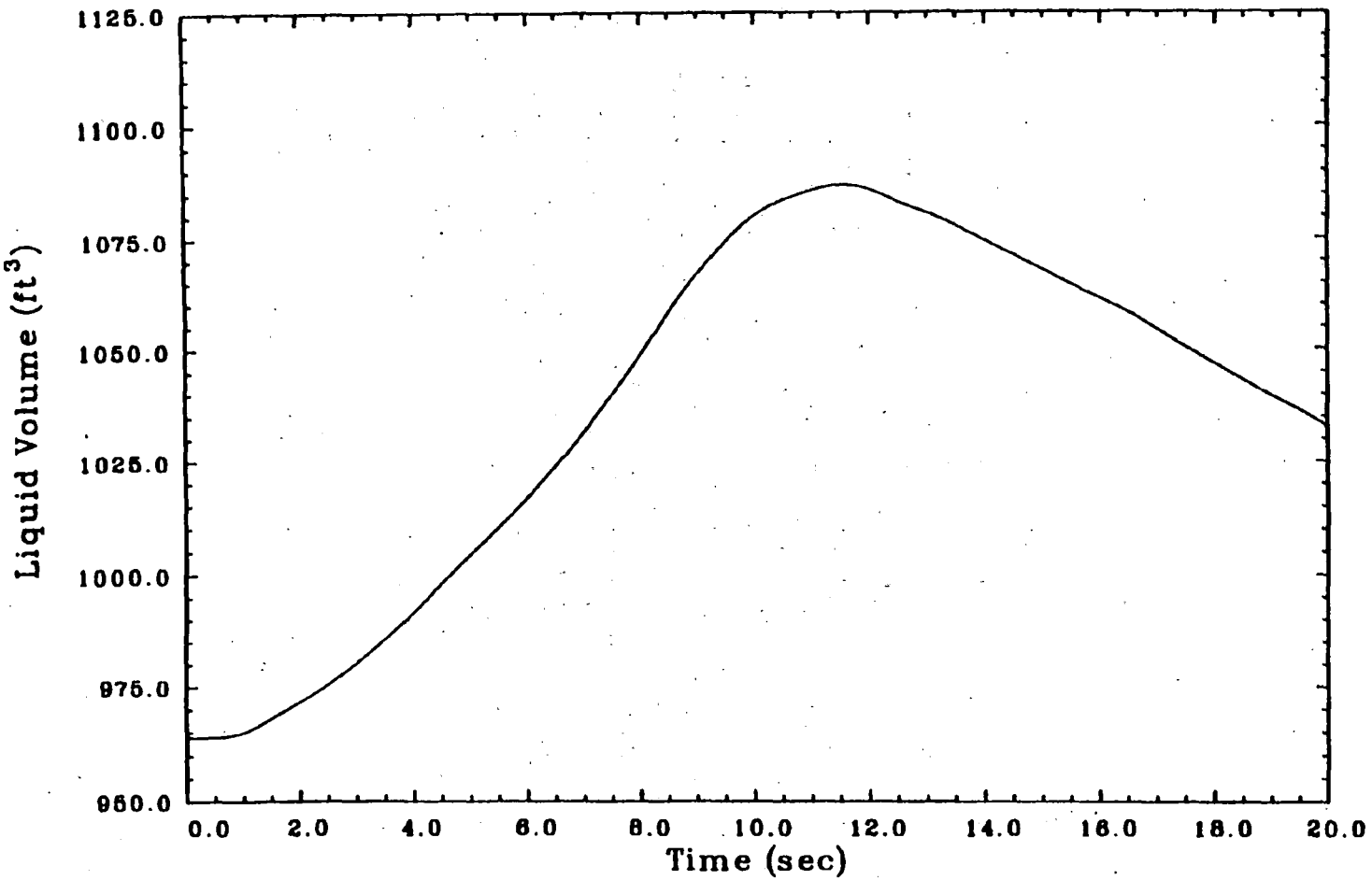

Figure 4.4

Pressurizer Liquid Volume for Loss of External Load

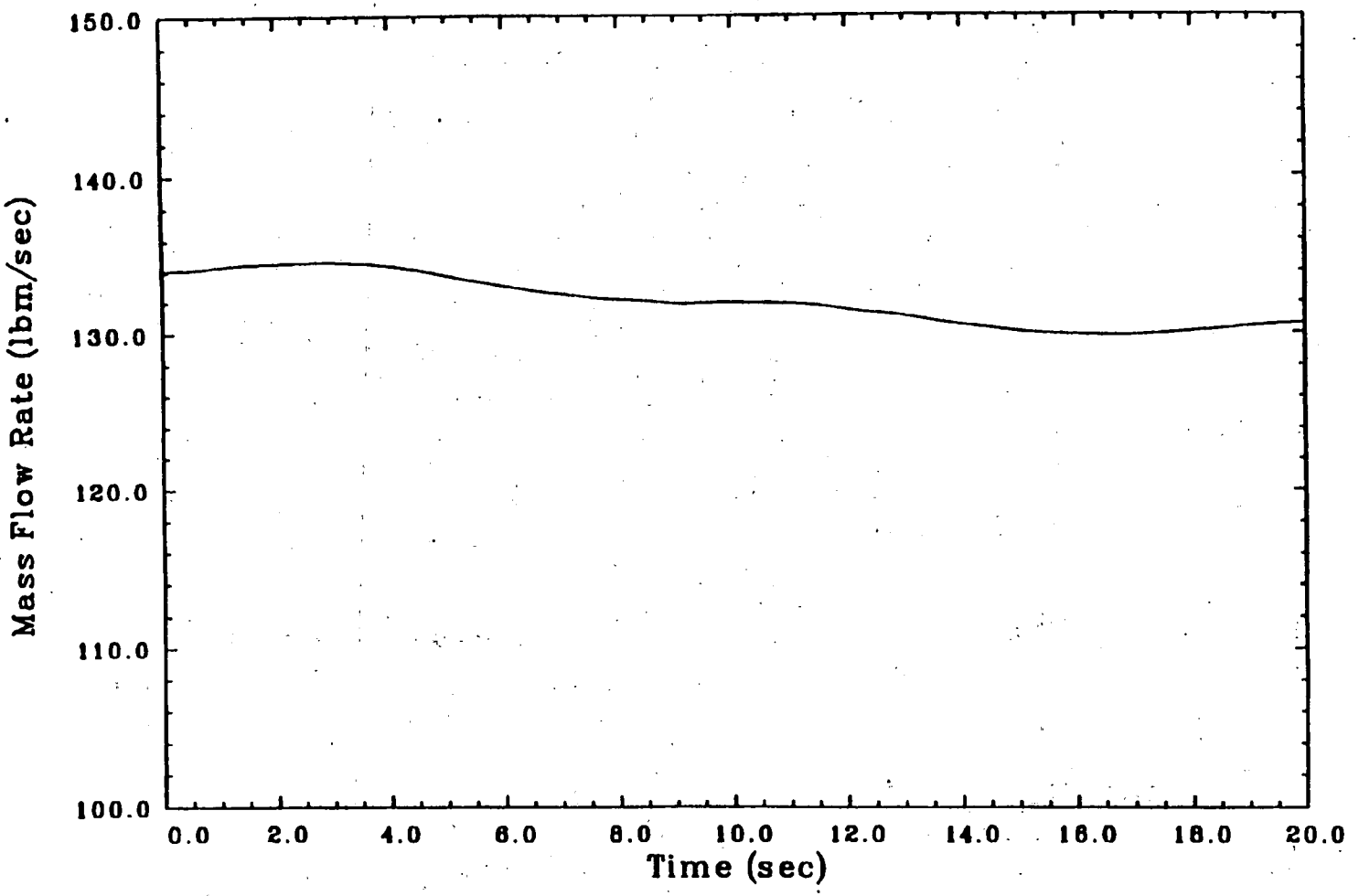

Figure 4.5

Primary Coolant System Mass Flow Rate for Loss of External Load

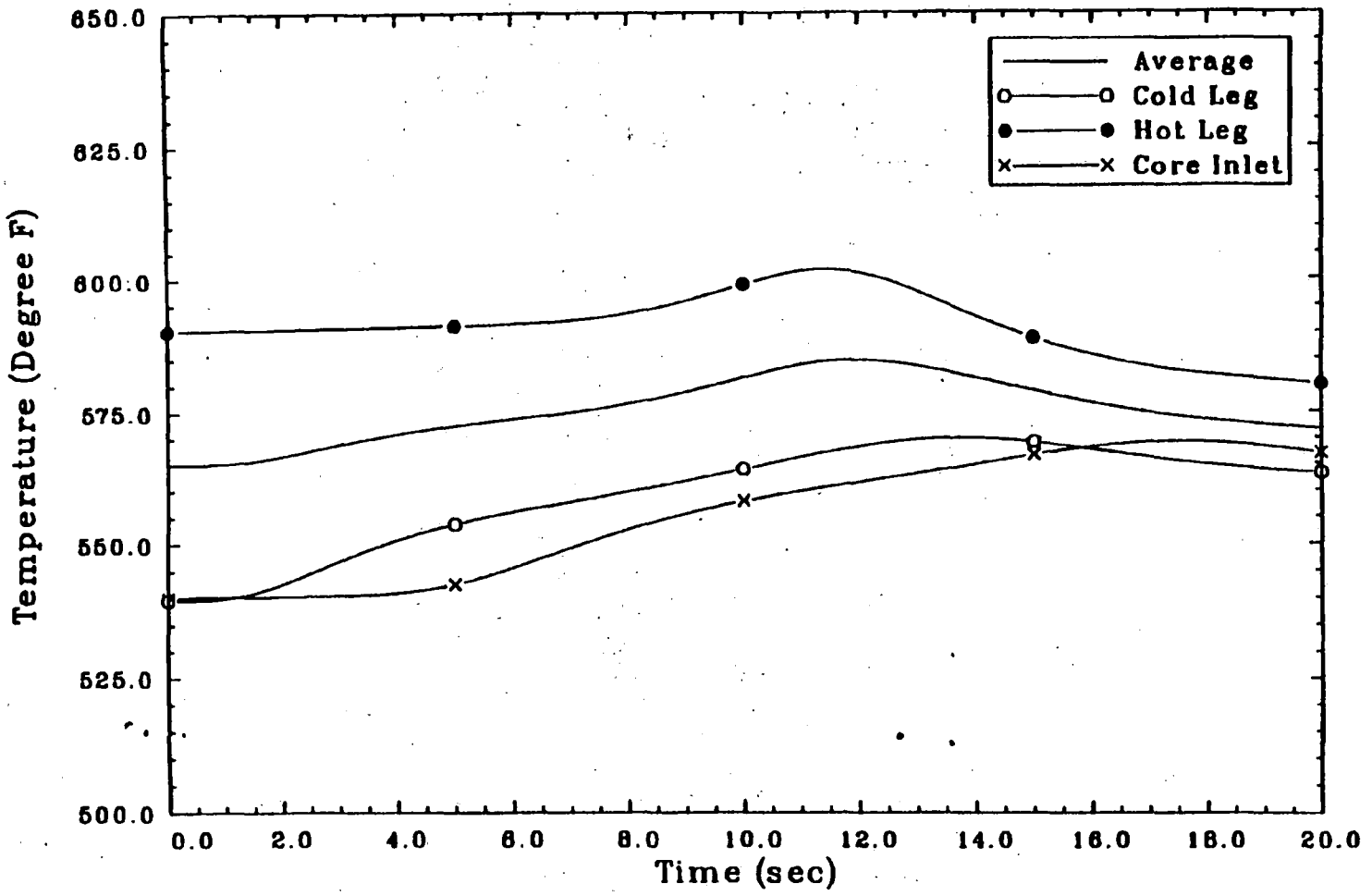

Figure 4.6

Primary Coolant System Temperatures for Loss of External Load

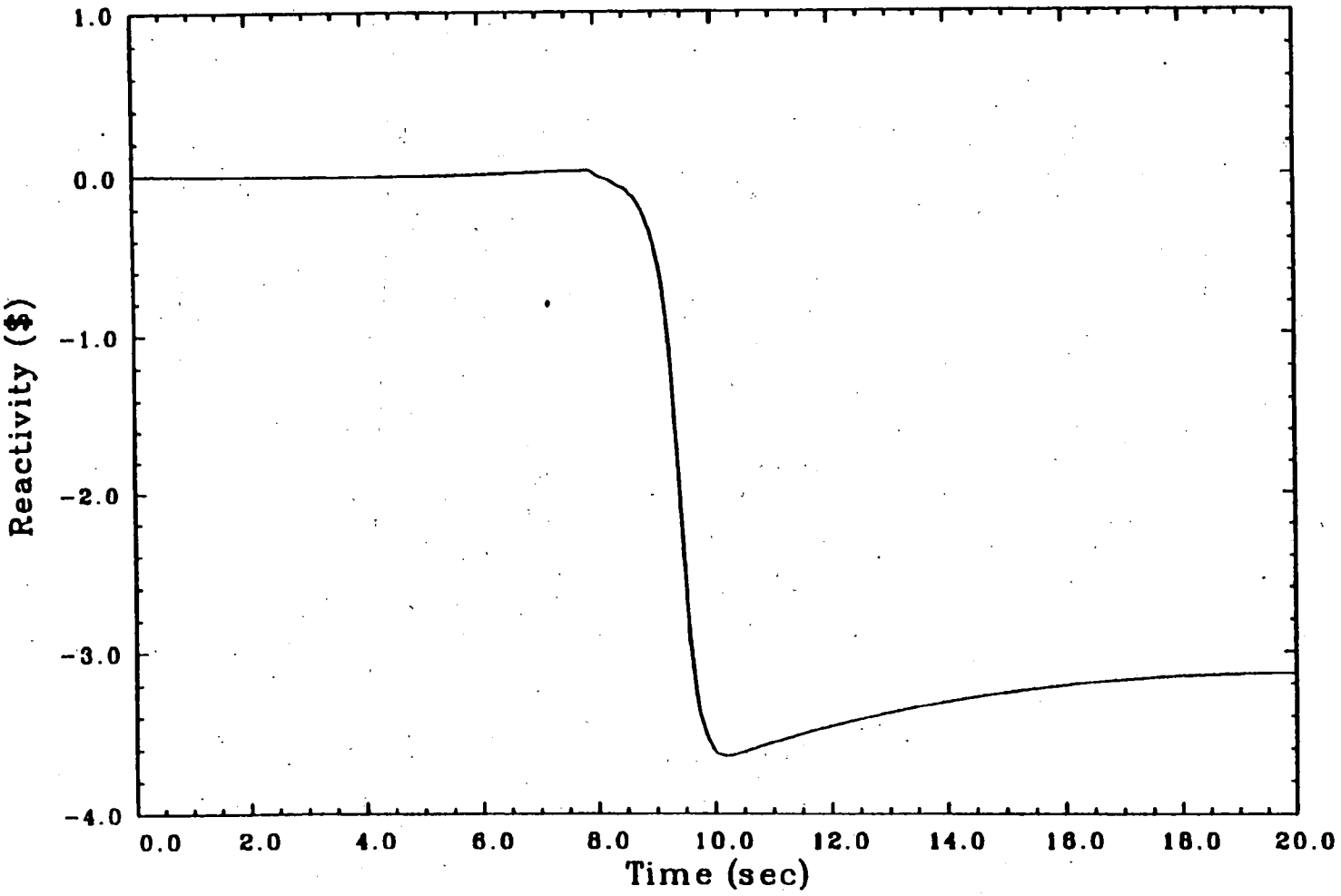

Figure 4.7

Reactivity for Loss of External Load

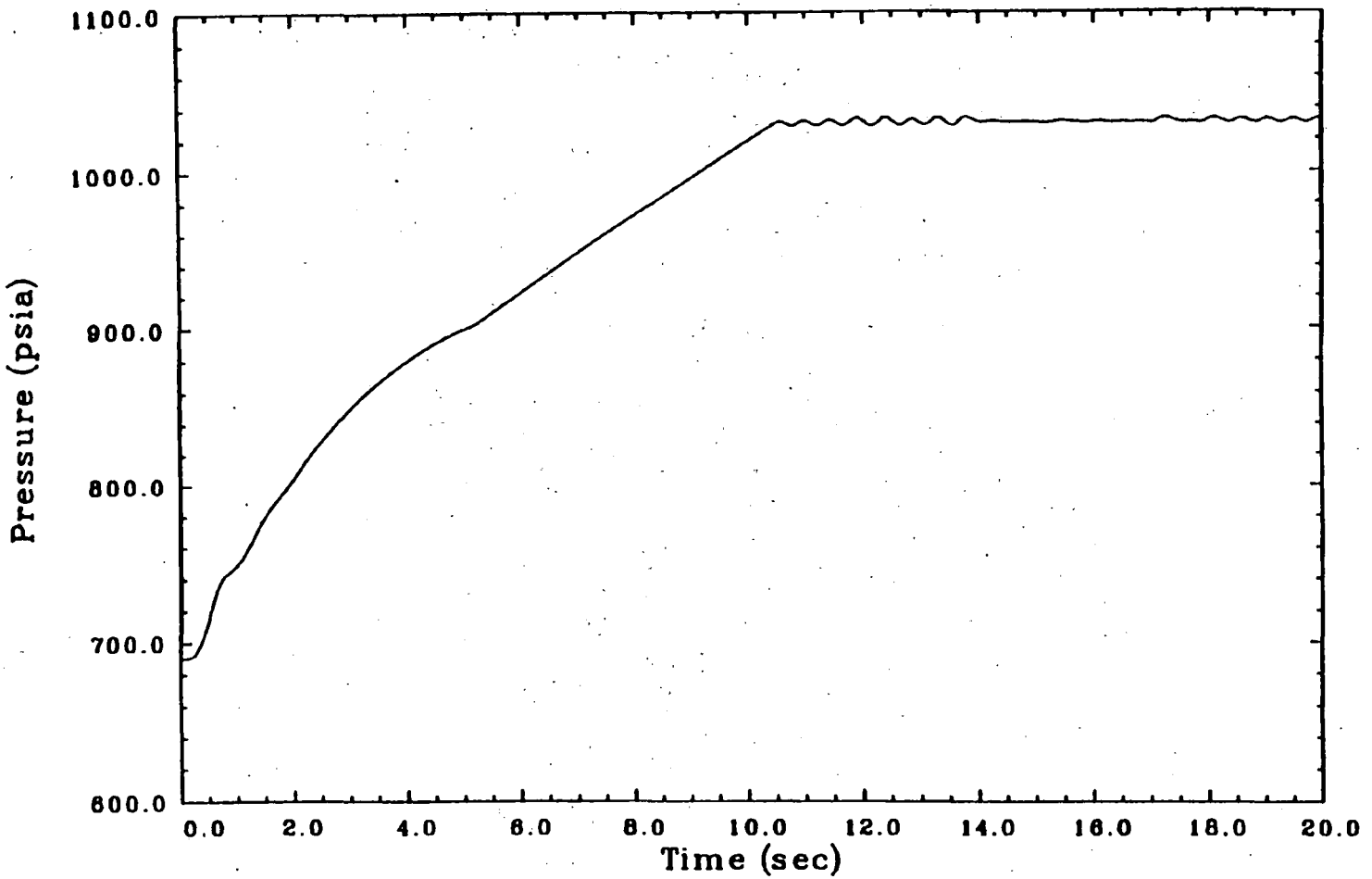

Figure 4.8

Secondary Pressure for Loss of External Load

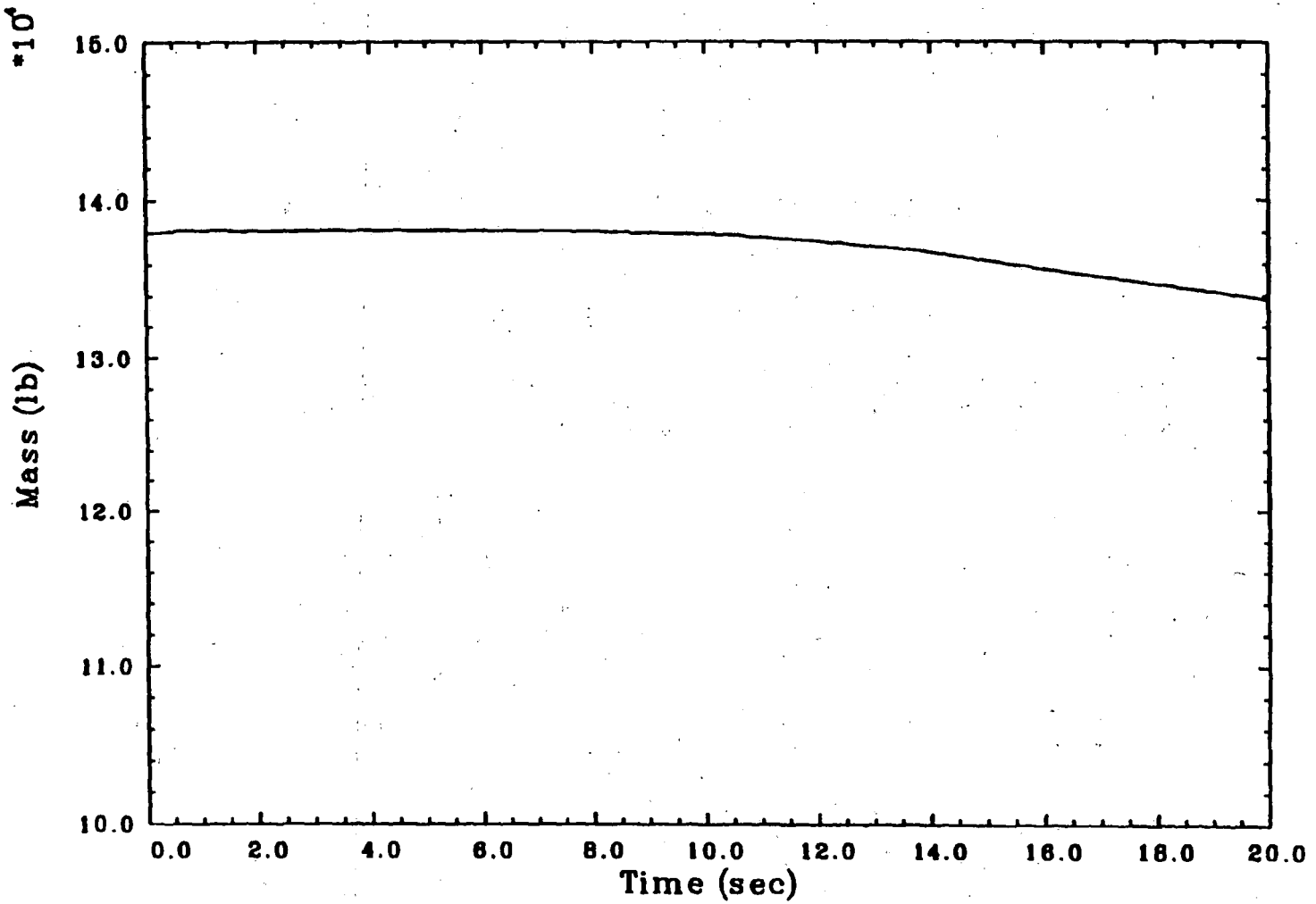

Figure 4.9

Steam Generator Secondary Fluid Mass for Loss of External Load

5.0 CONCLUSION

The maximum pressurizer and secondary side pressure remain below 110% of design pressure. Applicable acceptance criteria for the event are therefore met.

6.0 REFERENCES

1. EMF-92-178, "Siemens Power Corporation Nuclear Division Palisades Cycle 11: Disposition and Analysis of Standard Review Plan Chapter 15 Events," December 1992.

2. ANF-89-151(P)(A), "ANF-Relap Methodology for Pressurized Water Reactors: Analysis of Non-LOCA Chapter 15 Events," April 1992.

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