WESTINGHOUSE CLASS 3

WCAP-11884

# IMPLEMENTATION OF THE STEAM GENERATOR LOW LOW LEVEL REACTOR TRIP TIME DELAY AND ENVIRONMENTAL ALLOWANCE MODIFIER IN THE CALLAWAY PLANT

Authors: C. E. Leach, D. L. Gongaware, C. R. Tuley, L. E. Erin, S. Miranda

August, 1988

Approved: ____________________
Manager,
Instrumentation and
Control Systems Licensing

Approved: ____________________
Manager,
Transient Analysis I

Approved: ____________________
Manager
Process Control Equipment

Prepared by: Westinghouse Electric Co.
Power Systems Division
Nuclear Safety Department

Westinghouse Electric Corporation
Power Systems Division
P. O. Box 355
Pittsburgh, Pennsylvania 15230

8809120094 880831
PDR ADOCK 05000483
P PDC

TABLE OF CONTENTS

## ACRONYMS

| | |
|---|---|
| AC | Alternating Current |
| ATWS | Anticipated Transient Without Scram |
| EAM | Environmental Allowance Modifier |
| EQDP | Equipment Qualification Data Package |
| EQTR | Equipment Qualification Test Report |
| GDC | General Design Criteria |
| HFP | Hot Full Power |
| IEEE | Institute of Electronics and Electrical Engineers |
| LOCA | Loss of Coolant Accident |
| LONF | Loss of Normal Feedwater |
| MTBF | Mean Time Between Failures |
| NAI | Annunciator Interface Card |
| NAL | Comparator Card |
| NCT | Channel Test Card |
| NMT | Master Test Card |
| NPL | PROM Logic Card |
| NRC | Nuclear Regulatory Commission |
| OBE | Operating Basis Earthquake |
| OFA | Optimized Fuel Assembly |
| PMTC | Positive Moderator Temperature Coefficient |
| PROM | Programmable Read Only Memory |
| R/E | Resistance to Voltage |
| RCS | Reactor Coolant System |
| RG | Regulatory Guide |
| RTD | Resistance Temperature Detector |
| RTP | Rated Thermal Power |
| S/G | Steam Generator |
| SAL | Safety Analysis Limit |
| SER | Safety Evaluation Report |

| | |
|---|---|
| SHE | Significant Hazards Evaluation |
| SSE | Safe Shutdown Earthquake |
| SSPS | Solid State Protection System |
| TRAP | Trip Reduction and Assessment Program |
| TTD | Trip Time Delay |
| V-5 | Vantage-5 Fuel Assembly |
| WOG | Westinghouse Owners Group |
| WRD | Water Reactor Division |

SECTION 2.0 LIST OF TABLES

SECTION 4.0 LIST OF TABLES

## SECTION 2.0 LIST OF FIGURES

## SECTION 3.0 LIST OF FIGURES

# 1.0 INTRODUCTION

To address inadvertent feedwater related trips associated with low-low steam generator water level, the protection system may be modified, in accordance with IEEE Std. 279-1971, with the addition of the Environmental Allowance Modifier (EAM) and the Trip Time Delay (TTD) circuitry. The EAM will distinguish between normal and adverse containment environments and enable an adverse environment steam generator low-low level trip setpoint only when an adverse containment environment is present. The TTD will reduce inadvertent reactor trips by delaying the trip, providing time for level transients to stabilize and for water level to be restored. The delay is determined according to the power level of the plant and the number of steam generators with inventories below the low-low level trip setpoint.

## 2.0 SAFETY ANALYSIS DESIGN BASIS

### 2.1 Introduction

The Steam Generator Low-Low Level Reactor Trip Environmental Allowance Modifier (EAM) and Trip Time Delay (TTD) conceptual designs are the result of the Westinghouse Owners Group Trip Reduction and Assessment Program (WOG-TRAP) to develop a means to reduce the frequency of unnecessary feedwater-related reactor trips. The development of these concepts is documented in WCAP-11342-P-A (Reference 1) and WCAP-11325-P-A (Reference 2), respectively. In January 1988, the NRC issued Safety Evaluation Reports (SERs) approving TTD/EAM conceptual designs of WCAP-11325-P-A and WCAP-11342-P-A for Westinghouse PWRs. As documented in the SERs, NRC approval is based on the review of a conceptual design for each system, representative functional requirements, description of the safety analysis methodology and generic safety analysis results. The SERs also list the licensing submittals that will be required by the NRC for review of plant-specific designs.

As described in detail in Section 3 of this report, the Callaway Plant design is a Westinghouse analog implementation of the TTD/EAM logic located in each S/G Low-Low Level protection set, upstream of the SSPS logic. The purpose of this report is to provide safety analysis support, consistent with the requirements specified in the SERs, for the implementation of the TTD/EAM concepts in the Callaway Plant. This report provides:

1. Basic functional description of the Callaway Plant TTD/EAM design

2. Results of calculations performed, consistent with the WCAP-11325-P-A approved methodology, to develop the Safety Analysis Limits (SALs) for the S/G Low-Low Level, power level dependent trip time delays

3. Results of calculations performed to develop the SALs for the S/G Low-Low Level normal and harsh (high temperature) containment environment trip setpoints

4. Evaluation of the impacts of the SALs specified above on the following non-LOCA safety analysis design bases:

   i. FSAR Chapter 15 (excluding S/G Tube Rupture)

   ii. FSAR Chapter 6 Steamline Break Mass/Energy Releases Inside Containment

   iii. Steamline Break Mass/Energy Releases Outside Containment

5. Evaluation of the impact of the SALs specified above on the following LOCA safety analysis design bases:

   i. FSAR Chapter 15

   ii. Rod Ejection Mass/Energy Releases for Dose Calculations

   iii. Reactor Vessel and Loop Blowdown Forces

   iv. Post-LOCA Long-term Core Cooling Subcriticality Requirement

   v. Post-LOCA Hotleg Switchover Time

## 2.2 TTD/EAM Basic Functional Description

The conceptual design of WCAP-11342-P-A (EAM) may be described as an automatic switch that raises the Steam Generator Low-Low Level trip setpoint (to increase the environmental error allowance in the setpoint) whenever a harsh environment is indicated by detection of an elevated containment pressure. The EAM can reduce the frequency of unnecessary feedwater-related reactor trips by increasing the difference between the nominal steam generator water level and the low-low level trip setpoint during normal operation. The S/G Low-Low Level trip setpoint is automatically raised to include the full environmental error allowance for protection during accidents which produce a harsh containment environment.

Once the low-low water level trip setpoint (either the normal environment setpoint or the harsh environment setpoint) is reached, the TTD acts to delay reactor trip, main feedwater isolation and auxiliary feedwater system actuation to allow time for operator corrective action or for natural stabilization of shrink/swell water level transients. The TTD is designed for low power or startup operations. The conceptual design of WCAP-11325-P-A (TTD) may be generally described as a system of pre-determined programmed trip delay times that are based upon (1) the prevailing power level at the time a low-low level trip setpoint is reached, and by (2) the number of steam generators that are affected.

The Callaway TTD design is based on the introduction of two unique nominal power bistable setpoints of 10% and 20% Rated Thermal Power (3565 MWt) and the addition of a 2/4 steam generator trip logic to the existing 1/4 loop logic. The delta-T channels, used for thermal overpower and overtemperature protection, will provide a correlation to power level and will be compared to the 10% and 20% nominal power bistable setpoints. These bistables will enable the transmission of the low-low level signal at the expiration of the enabled TTD delays if steam generator water level has not been recovered. These 10% and 20% nominal power level bistable setpoints are well within the power level range defined by the NRC in the WCAP-11325-P-A SER for plant specific applications. Consistent with the WCAP-11325-P-A methodology, appropriate Safety Analysis Limits will therefore be determined for:

1/4 Steam Generator Logic
Indicated Power ≤ 10% of Rated Thermal Power (RTP)

1/4 Steam Generator Logic
Indicated Power ≤ 20% of RTP and > 10% of RTP

2/4 Steam Generator Logic,
Indicated Power ≤ 10% of RTP

2/4 Steam Generator Logic,
Indicated Power ≤ 20% of RTP and > 10% of RTP

No time delays are considered in this report for indicated power levels greater than 20% of RTP.

When the low-low level trip setpoint, as determined via the EAM logic, is reached, all trip delay timers are actuated. As indicated above, the magnitude of the trip delay for each timer is pre-set according to the power range with which it is interlocked and with the low-low level logic path in which it is placed (e.g., low-low level in a single steam generator or low-low level in more than one steam generator).

If a low-low level condition is detected in one steam generator, then only the timer that is in the single low-low level logic path and interlocked in the appropriate power range can satisfy the logic for transmission of the trip signal at the expiration of its trip delay. If, at any time during this trip delay, a low-low level condition is detected in a second steam generator, then the timer that is in the multiple low-low level logic path and interlocked in the appropriate power range can also satisfy the logic for transmission of the trip signal at the expiration of its trip delay. Since, at any given power level, the trip delay setpoint for two or more low steam generators will be shorter than the trip delay setpoint for one low steam generator, reactor trip will occur at the end of the shorter effective trip delay, thus providing timely protective action for the more severe transient. Since all timers are actuated (at the same instant) by a single low-low level trip signal, it is possible for a second steam generator to reach its low-low level trip setpoint after the appropriate multiple low-low level trip delay has expired. In that case, the reactor trip signal would be transmitted without further delay.

If the power level decreases during a trip delay interval, this logic does not permit the lengthening of effective trip delays, which could result from switching to timers interlocked with lower power ranges. If power level increases, which may occur for a positive moderator temperature coefficient, the effective trip delays are shortened as higher interlocking power ranges become effective. If the water levels in all steam generators are not restored before the expiration of the shortest enabled trip delay, then the EAM/TTD logic routes the low-low level trip signal into the SSPS channel logic.

This system of (1) pre-determined trip setpoints which are dependent on containment environment conditions, (2) power latches, (3) pre-determined trip delay setpoints that are interlocked with power level and protection logic paths, and (4) simultaneous start of all trip delay timers, is consistent with the approved conceptual designs and methodology for plant-specific implementation presented in WCAP-11325-P-A and WCAP-11342-P-A. A detailed description of the specific hardware modifications and protection system logic upstream of the SSPS is provided in Section 3.

## 2.3 Safety Analyses and Evaluations

Analysis/Evaluation Basis:

The safety analyses and evaluations discussed in this report were performed with respect to the most recent design and licensing basis documentation prepared by Westinghouse for the Callaway Plant. The associated references are Rev. OL-2 of the Callaway FSAR and WCAP-10961-P (References 3 and 4, respectively). Safety analysis methodology used for new analyses and sensitivity studies is consistent with that applied for References 3 and 4, unless otherwise noted in this report.

- 100% Core Rated Thermal Power = 3565 MWt
  100% NSSS Power = 3579 MWt

- A maximum positive moderator temperature coefficient of +5 pcm/°F for power levels below 70% Rated Thermal Power, ramping linearly to 0 pcm/°F from 70% to 100% Rated Thermal Power.

- Maximum Heat Flux Hot Channel Factor for V5 Fuel, Fq(z) = 2.50
  OFA Fuel, Fq(z) = 2.32

- Maximum HFP Nuclear Enthalpy Rise Hot Channel Factor for
  V5 Fuel = 1.65
  OFA Fuel = 1.55

- OFA/V-5 Transition Cores and Full V-5 Cores

- 15% maximum plant total steam generator tube plugging, not to exceed 15% in any single steam generator.

### 2.3.1 S/G Low-Low Level Trip Setpoint and Time Delay Safety Analysis Limit Determination

Implementation of the TTD/EAM in the Callaway Plant will require modification of the existing S/G Low-Low Level protection system setpoints and the introduction of time delays. Consistent with the approved analysis methodology of WCAP-11325-P-A, analyses have been done to determine revised SALs for input to the S/G Low-Low Level Technical Specification limits.

As described in Section 2.2, 10% and 20% RTP interlock time delays are introduced for the Callaway Plant TTD design. Associated with these interlocks will be a maximum allowable delay on the transmission of the S/G Low-Low Level trip signal. Callaway-specific Loss of Normal Feedwater analyses have been performed to provide the safety analysis limits for 1/4 and 2/4 logic time delays at the specified power interlocks. Additionally, the FSAR safety analyses which assume protective functions resulting from the S/G Low-Low Level signal have been analyzed assuming a S/G Low-Low Level setpoint of 0% of span. The following cases were analyzed to determine S/G Low-Low Level trip setpoint and time delay SALs:

Case I: Loss of Normal Feedwater to Four Steam Generators for 10% RTP Interlock Time Delay, S/G Low-Low Level Trip Setpoint = 0% of Span

Case II: Loss of Normal Feedwater to One Steam Generator for 10% RTP Interlock Time Delay, S/G Low-Low Level Trip Setpoint = 0% of Span

Case III: Loss of Normal Feedwater to Four Steam Generators for 20% RTP Interlock Time Delay, S/G Low-Low Level Trip Setpoint = 0% of Span

Case IV: Loss of Normal Feedwater to One Steam Generator for 20% RTP Interlock Time Delay, S/G Low-Low Level Trip Setpoint = 0% of Span

Case V: Full Power Loss of Non-Emergency AC Power to the Station Auxiliaries, S/G Low-Low Level Trip Setpoint = 0% of Span

Case VI: Full Power Loss of Normal Feedwater to Four Steam Steam Generators, S/G Low-Low Level Trip Setpoint = 0% of Span

Case VII: Feedline Break with Offsite Power, 20% RTP Interlock Time Delay for 2/4 Logic. S/G Low-Low Level Trip Setpoint = 0% of Span

Note: FSAR Chapter 15.2.8 (Reference 3) Full Power Feedwater System Pipe Break with and without offsite power, the remaining FSAR transient which assumes protective functions from the S/G Low-Low Level signal, is already analyzed for a trip setpoint of 0% of span (See FSAR Section 15.2.8.2.i and Table 15.0-4).

### 2.3.1.1 Cases I through IV Analysis Assumptions

Cases I through IV are Loss of Normal Feedwater transients analyzed to determine the Safety Analysis Limits for the S/G Low-Low Level trip time delays and trip setpoints. These cases are analogous to the generic studies performed for WCAP-11325-P-A to arrive at 1/4 and 2/4 logic curves of time delay versus power level. Cases I through IV are performed specifically for the 10% and 20% RTP interlock time delays. The key analysis assumptions used for these cases are as follows. Analysis results are discussed in Section 2.3.3.

1. Initial Conditions

Consistent with the WCAP-11325-P-A analysis methodology, appropriate power level dependent initial conditions were assumed for Cases I through IV. See Table 2.3.1.

2. Decay Heat

Consistent with the WCAP-11325-P-A analysis methodology, all cases have used the ANS 1979 Decay Heat model (Reference 5). The analyses assumption considers a power rampdown rate from full power of 5% per minute prior to the initiation of the loss of normal feedwater transients. This assumption is consistent with the maximum power coastdown rate documented in the Callaway FSAR Sections 7.7.2.4 and 10.4.7.2.3 (Reference 3).

3. Uncertainties

Of particular importance to Cases I through IV is the uncertainty in power level indication since this function is integral to the TTD design. Cases I, II, III and IV, performed to arrive at time delay SALs for the 10% and 20% RTP interlocks, assumed initial power levels of 19% and 29% of 3565 MWt, respectively. This assumption accounts for a maximum uncertainty in power level indication of 9% of RTP. Power level indication errors and uncertainties are discussed in Section 4.

4. S/G Low-Low Level Trip Setpoint

The S/G Low-Low Level trip setpoint assumed in these analyses is 0% of span.

5. S/G Low-Low Level Trip Time Delays

The total S/G Low-Low Level trip time delays assumed in Cases I through IV include the SAL for the power interlock time delays and an additional 2 second allowance for the time between receipt of the signal and when the control rods are free to drop.

6. 1/4 Loop Loss of Normal Feedwater

Cases II and IV assume a loss of normal feedwater to one steam generator. The loss of normal feedwater to one steam generator is not explicitly analyzed for the current Callaway FSAR since it is not necessary for any setpoint determination and its consequences, given the current plant automatic protection system, are bounded by those shown in the FSAR for loss of normal feedwater to all four steam generators. WCAP-11325-P-A introduced the analysis of loss of feedwater to one steam generator to support the concept of using 2/4 loop protection logic and 1/4 loop protection logic to respond to low level conditions in one or more steam generators.

7. Moderator Temperature Coefficient (MTC)

As indicated in Section 2.3, the analyses and evaluations of this report continue to support the design assumptions of the licensing basis analyses. One of these design assumptions is the maximum positive MTC as a function of power level. Characteristic of a loss of normal feedwater event analyzed assuming a positive MTC is an increase in nuclear power prior to reactor trip, which aggravates the consequences of the event. As previously described, the Callaway TTD design is intended for application at or below 20% indicated power. At these power levels, the design limit for most positive MTC is +5.0 pcm/°F. Therefore, the TTD safety analysis design basis must consider the effects of the most limiting MTC assumption.

[

]$^{a,c}$

Consistent with the WCAP-11325-P-A approved analysis methodology, Cases I through IV assume an essentially constant power transient up to the time of reactor trip. The assumed power levels correspond to the two TTD bistable setpoints plus the 9% allowance for uncertainties and errors.

[

]$^{a,c}$

2.3.1.2 Cases V and VI Analysis Assumptions

Cases V and VI were performed to update the Callaway FSAR analyses to include the revised S/G Low-Low Level trip setpoint of 0% of span. The results of these analyses are discussed in Sections 2.3.2 and 2.3.3. Key assumptions made in these analyses are discussed below.

1. Initial Conditions

   These transients were performed at the same full power initial conditions as the FSAR Chapter 15.2.6 and 15.2.7 analyses. See Table 2.3.1.

2. Decay Heat

   Cases V and VI have incorporated the ANS 1979 Decay Heat model assuming long-term full power operation.

3. Uncertainties and Allowances

   Initial condition and protection system uncertainties and allowances are the same as assumed for the FSAR Chapter 15.2.6 and 15.2.7 analyses except as described below.

4. S/G Low-Low Level Trip Setpoint

   To support the minimum setpoint study determination of a S/G Low-Low Level trip setpoint for normal containment environmental conditions, the safety analysis assumption for cases V and VI is 0% of span. The associated Protection System Setpoint Study revisions are provided in Section 4.

5. S/G Low-Low Level Trip Time Delay

Full power safety analyses do not incorporate a S/G Low-Low Level trip time delay other than the 2 second delay specified in FSAR Table 15.0-4 to account for the time from receipt of the signal to the time when control rods are free to drop.

6. Moderator Temperature Coefficient (MTC)

Cases V and VI, consistent with the design assumptions listed in the forward to Section 2.3, have assumed a most positive MTC at full power conditions to be 0 pcm/°F.

### 2.3.1.3 Case VII Analysis Assumptions

Case VII was performed to verify that the SALs for the S/G Low-Low Level power interlock time delays do not invalidate the conclusions stated in FSAR Chapter 15.2.8 regarding the limiting Feedline Break transient results. The results of this Case are discussed in Sections 2.3.2 and 2.3.3. Key analysis assumptions are discussed below.

1. Initial Conditions

Consistent with the WCAP-11325-P-A analysis methodology, appropriate power level dependent initial conditions were assumed for Case VII. See Table 2.3.1.

2. Decay Heat

Consistent with the WCAP-11325-P-A analysis methodology, Case VII used the ANS 1979 Decay Heat Model (Reference 5). The analysis assumption considers a power rampdown rate from full power of 5% per minute prior to the initiation of the feedline break transient. This assumption is consistent with the maximum power coastdown rate documented in the Callaway FSAR Sections 7.7.2.4 and 10.4.7.2.3 (Reference 3).

3. Uncertainties

As with Cases III and IV, the initial core power level assumption for Case VII is 29% of 3565 MWt. This assumption accounts for a maximum uncertainty in power level indication of 9% of Rated Thermal Power (RTP).

4. S/G Low-Low Level Trip Setpoint

The S/G Low-Low Level trip setpoint assumed in Case VII is 0% of span. This assumption is consistent with the FSAR Chapter 15.2.8 Feedline Break analysis assumption. The FSAR feedline break trip setpoint assumption of 0% of span accounts for the possibility of a harsh containment environment resulting from the feedline break accident.

5. S/G Low-Low Level Trip Time Delay

The total S/G Low-Low Level trip time delay assumed in Case VII includes the SAL for the 20% RTP interlock time delay and an additional 2 second allowance for the time between receipt of the signal and when the control rods are free to drop. The total time delay for Case VII corresponds to that assumed for Cases III and IV.

6. Moderator Temperature Coefficient (MTC)

Case VII assumes a moderator temperature coefficient of +5 pcm/°F.

### 2.3.2 Verification of Design Basis Safety Analyses

The analyses described in Section 2.3.1 established Safety Analysis Limits for the S/G Low-Low Level signal delay times and trip setpoint. The purpose of this section is to document the evaluation of these Safety Analysis Limits on the design basis safety analyses outlined in Section 2.1.

Safety analyses affected by the SALs determined in the Section 2.3.1 analyses are those which assume reactor trip, main feedwater isolation, and auxiliary feedwater initiation to result from reaching the S/G Low-Low Level trip setpoint. For Callaway, these are:

FSAR Chapter 15.2.6
Loss of Non-emergency AC Power to the Station Auxiliaries

FSAR Chapter 15.2.7
Loss of Normal Feedwater Flow

FSAR Chapter 15.2.8
Feedwater System Pipe Break

WCAP-10961-P (Reference 5)
Steamline Break Mass/Energy Releases Outside Containment

Evaluations of the effects of the S/G Low-Low Level time delay and trip setpoint SALs on these transients follow.

2.3.2.1 Loss of Non-emergency AC Power to the Station Auxiliaries

Loss of non-emergency AC power to the station auxiliaries is analyzed for the Callaway Plant FSAR in Chapter 15.2.6. The Condition II accident postulates the loss of all power to the station auxiliaries due to a complete loss of the offsite grid accompanied by a turbine generator trip or due to loss of the onsite AC distribution system. Two consequences of this event are loss of forced reactor coolant flow and loss of normal feedwater due to the loss of power to the reactor coolant pumps and the condensate pumps, respectively. The FSAR Loss of Non-emergency AC Power analysis is performed to demonstrate the adequacy of the reactor protection system, the engineered safeguards systems (e.g., the auxiliary feedwater system) and natural circulation to remove long term decay heat and prevent excessive heatup of the RCS with possible resultant RCS overpressurization or loss of RCS water inventory.

The FSAR safety analysis assumptions for loss of non-emergency AC power are conservatively chosen to maximize the resulting primary side heat-up transient and, therefore, the dependency on the auxiliary feedwater system to adequately remove decay heat. For this reason, no credit is taken for the immediate control rod insertion which would occur upon loss of power to the control rod drive mechanisms or the initiation of auxiliary feedwater from two diesel powered motor-driven auxiliary feedwater pumps within 1 minute of the receipt of a loss of power signal. Instead, actuation of these safety features is assumed to occur due to the eventual receipt of the S/G Low-Low Level trip signal as a result of the loss of normal feedwater to the steam generators.

The TTD/EAM logic is designed to avoid unnecessary feedwater-related reactor trips on S/G Low-Low Level. Since, in the event of an actual loss of non-emergency AC power, plant protection design provides for a reactor trip in advance of reaching the S/G Low-Low Level setpoint, the TTD/EAM would not delay reactor trip upon loss of AC power to the station auxiliaries. However, since the FSAR conservatively assumes reactor trip to occur on S/G Low-Low Level, it is appropriate to evaluate the effects of the introduction of the TTD/EAM logic on the FSAR Chapter 15.2.6 transient under the same analysis assumptions.

The limiting loss of AC power case presented in the FSAR is performed at full power. Case V was analyzed at full power initial conditions to provide FSAR transient results which incorporate a safety analysis trip setpoint assumption of 0% of span. The assumed total trip time delay is 2 seconds which is consistent with the assumption documented in FSAR Table 15.0-3 (Reference 3) and is appropriate for initial condition power levels above the maximum TTD power level interlock. Therefore, there is no effect on the FSAR case due to the TTD logic. The results of this case are shown in Table V and Figures V.1 through V.3 of Section 2.3.3. The transient results indicate that the natural circulation and auxiliary feedwater heat removal capacity are sufficient to offset the core decay heat and that the pressurizer does not fill. These transient characteristics ensure that the applicable Condition II acceptance criteria are met.

The effect of the TTD/EAM logic on postulated part-power loss of AC cases must be evaluated as well. Case V sufficiently addresses the effect of the EAM on part-power cases since, for the same trip setpoint, assuming no additional time delays, the full power FSAR case bounds cases initiated at lower power levels. The remaining required verification involves the time delay enabled by the TTD logic at indicated power levels below the maximum power TTD interlock setpoint. [

]a,c

### 2.3.2.2 Loss of Normal Feedwater Flow

Loss of normal feedwater is analyzed for the Callaway Plant in FSAR Chapter 15.2.7. This Condition II accident postulates a loss of normal feedwater to all steam generators. The FSAR loss of normal feedwater analysis is performed to demonstrate the adequacy of the reactor protection system and engineered safeguards systems (e.g., the auxiliary feedwater system) in removing long-term decay heat and preventing excessive heatup of the RCS with possible resultant overpressurization or loss of RCS water inventory. The FSAR safety analysis assumptions are conservatively chosen to maximize the resulting primary side heat-up transient and, therefore, the dependency on the auxiliary feedwater system to adequately remove decay heat. The FSAR transient assumes full power initial conditions and accident protection due to receipt of the S/G Low-Low Level trip signal.

Case VI was analyzed at full power initial conditions to provide FSAR Chapter 15.2.7 transient results which incorporate a safety analysis trip setpoint assumption of 0% of span. The assumed total trip time delay is 2 seconds which is consistent with the assumption documented in FSAR Table 15.0-4 and is appropriate for initial condition power levels above the maximum TTD power level interlock. The results of this case are shown in Table VI and Figures VI.1 through VI.3 of Section 2.3.3. The transient results indicate that the auxiliary feedwater heat removal capacity is sufficient to offset the core decay heat and that the pressurizer does not fill. These transient characteristics ensure that the applicable Condition II acceptance criteria are met.

Consistent with the WCAP-11325-P-A safety analysis methodology, explicit analysis of part-power loss of normal feedwater cases with S/G Low-Low Level trip time delays are performed. These are Cases I through IV as described in Section 2.3.1. The safety analysis acceptance criteria applied to complete loss of normal feedwater transients are applied to partial loss of normal feedwater. Case I analyzes the part-power loss of normal feedwater to four steam generators to determine the safety analysis limit for the TTD 2/4 steam generator logic, 10% RTP interlock time delay. The analysis assumed a trip time delay, in addition to the 2 second time delay documented in FSAR Table 15.0-4, of 240 seconds. The safety analysis assumption for total trip time delay is, therefore, 242 seconds. The results of Case I are provided in Table I and Figures I.1 through I.3 of Section 2.3.3. The results indicate that the auxiliary feedwater heat removal capability is sufficient to remove the decay heat and the pressurizer does not fill. These transient characteristics ensure that all applicable Condition II safety analysis acceptance criteria are met.

Case II analyzes the part-power loss of normal feedwater to one steam generator to determine the safety analysis limit for the TTD 1/4 steam generator logic, 10% RTP power interlock time delay. The analysis assumed a trip time delay, in addition to the 2 second time delay documented in FSAR Table 15.0-4, of 240 seconds. The safety analysis assumption for total trip time delay is, therefore, 242 seconds. The results of Case II are provided in Table II and Figures II.1 through II.3 of Section 2.3.3. The results indicate that Case II is bounded by Case I and; therefore, all applicable Condition II safety analysis acceptance criteria are met.

Case III analyzes the part-power loss of normal feedwater to four steam generators to determine the safety analysis limit for the TTD 2/4 steam generator logic, 20% RTP interlock time delay. The analysis assumed a trip time delay, in addition to the 2 second time delay documented in FSAR Table 15.0-4, of 130 seconds. The safety analysis assumption for total trip time delay is, therefore, 132 seconds. The results of Case III are provided in Table III and Figures III.1 through III.3 of Section 2.3.3. The results indicate that the auxiliary feedwater heat removal capability is sufficient to remove the decay heat and the pressurizer does not fill. These transient characteristics ensure that all applicable Condition II safety analysis acceptance criteria are met.

Case IV analyzes the part-power loss of normal feedwater to one steam generator to determine the safety analysis limit for the TTD 1/4 steam generator logic, 20% RTP interlock time delay. The trip time delay assumed in Case III was also assumed in Case IV. The safety analysis assumption for total trip time delay is, therefore, 132 seconds. The results of Case IV are provided in Table IV and Figures IV.1 through IV.3 of Section 2.3.3. The results indicate that Case IV is bounded by Case III and; therefore, all applicable Condition II safety analysis acceptance criteria are met.

Assuming the TTD/EAM protection system logic, Cases I and II, performed at 19% RTP, bound corresponding cases initiated at lower power levels. Cases III and IV, performed at 29% RTP, bound corresponding cases between 19% and 29% RTP. Case VI, the limiting loss of normal feedwater transient, performed at full power, bounds cases initiated at power levels greater than 29% of RTP.

#### 2.3.2.3 Feedwater System Pipe Break

A Reactor Coolant System heatup caused by a main feedwater line rupture is a Condition IV transient analyzed for the Callaway Plant in FSAR Chapter 15.2.8. Results of the Feedline Break transient, with and without offsite power, are presented in the FSAR to assure that the primary system remains intact, no core damage occurs due to overheating, and consequently, the radiation release limits of 10 CFR 100 are not exceeded. The FSAR transients are performed assuming full power initial conditions. For the present protection system, this assumption maximizes the resulting heat-up transient. Acceptable FSAR transient results demonstrate that:

i. Peak transient RCS and Steam Generator pressures are less than 110% of design pressures,

ii. Sufficient liquid in the RCS is maintained so that the core remains in place and geometrically intact with no loss of core cooling capability. This criterion is met by ensuring hot leg saturation does not occur.

The Feedline Break transients presented in the Callaway FSAR assume reactor trip, main feedwater isolation and actuation of auxiliary feedwater to occur due to receipt of a S/G Low-Low Level trip signal. Each of these safety feature actuations is essential for the successful mitigation of the accident consequences as conservatively predicted by the safety analyses. Rod insertion due to automatic reactor trip terminates the nuclear power contribution to the primary heatup. Automatic main feedwater isolation is necessary, due to the feedline check valve location downstream of the auxiliary feedwater connection, to insure delivery of auxiliary feedwater to the intact loop steam generators. The delivery of auxiliary feedwater is essential for the removal of core decay heat and, therefore, the prevention of fuel damage and core uncovery.

The FSAR Feedline Break safety analysis assumption for the S/G Low-Low Level trip setpoint is 0% of span. Unlike loss of non-emergency AC power and loss of normal feedwater, the FSAR feedline break transient is postulated to result in harsh containment environment conditions. The current Technical Specification S/G Low-Low Level trip setpoint is based on the feedline break SAL and includes the full environmental allowance. With introduction of the EAM, the harsh environment trip setpoint will continue to be determined on this basis. The trip time delay assumed in the FSAR Feedline Break analyses is 2 seconds, as documented in Table 15.0-4. Because the FSAR cases are performed at full power conditions, no additional delays are imposed by the TTD. Therefore, reanalysis of the Feedline Break cases (with and without offsite power) presented in the FSAR is not necessary.

It must also be verified, however, that imposition of trip delays at part power do not invalidate the FSAR conclusions regarding the consequences of the feedline break transient. Case VII assumed power dependent initial conditions, trip time delay consistent with Cases III and IV and the availability of offsite power. The results of this case are shown in Table VII and Figures VII.1 through VII.5 of Section 2.3.3. The transient results indicate that the auxiliary feedwater heat removal capacity is sufficient to ensure that the Condition IV acceptance criteria are met, assuming the applicable trip time delay.

[



]a,c

[

]$^{a,c}$ The limiting FSAR analysis results for the feedline break transient remain the full power cases provided for FSAR Chapter 15.2.8 in Reference 3.

2.3.2.4 Steamline Break Mass/Energy Releases Outside Containment

The Westinghouse Steamline Break mass/energy releases outside containment, documented in WCAP-10961-P (Reference 4), were calculated assuming the availability of the S/G Low-Low Level signal. The cases applicable to the Callaway Plant are designated as "Category 1" in Reference 4. The power levels examined in Reference 4 are 70% and 100% of 3411 MWt core power (the results have been verified to be applicable for Callaway uprated to 3565 MWt core power). Analyses of lower power levels were not performed in WCAP-10961-P since, for the same protection system assumptions, lower initial power levels yield less limiting mass/energy releases. Given that the implementation of the TTD in the Callaway Plant introduces no time delays at indicated power levels greater than 20% RTP and that the Reference 4 analyses are applicable for a trip setpoint SAL of 0% of span, the results of the 100% and 70% cases presented in Reference 4 for Category 1 plants remain applicable for the Callaway S/G Low-Low Level SALs determined in Section 2.3.1.

[

]$^{a,c}$

Therefore, the information provided in Reference 4 applicable to the Callaway plant remains valid for the Callaway S/G Low-Low Level SALs determined in Section 2.3.1.

2.3.2.5 Balance of the Safety Analysis Design Basis Calculations

Safety analysis design basis calculations which do not assume the actuation of automatic protection features by means of the S/G Low-Low Level trip signal are unaffected by the S/G Low-Low Level setpoint SAIs. For these accidents, the conclusions in the FSAR are unaffected as are the FSAR predicted transient behaviors. The FSAR transients in this category are listed below.

| FSAR SECTION | ACCIDENT |
|---|---|
| 15.1.1 | Feedwater System Malfunctions that Result in a Decrease in Feedwater Temperature |
| 15.1.2 | Feedwater System Malfunctions that Result in an Increase in Feedwater Flow |
| 15.1.3 | Excessive Increase in Secondary Steam Flow |
| 15.1.4 | Inadvertent Opening of a Steam Generator Relief or Safety Valve |
| 15.1.5 | Steam System Piping Failure |
| 15.2.2 | Loss of External Electrical Load |
| 15.2.3 | Turbine Trip |
| 15.2.4 | Inadvertent Closure of Main Steam Isolation Valves |
| 15.2.5 | Loss of Condenser Vacuum and Other Events Resulting in Turbine Trip |
| 15.3.1 | Partial Loss of Forced Reactor Coolant Flow |
| 15.3.2 | Complete Loss of Forced Reactor Coolant Flow |
| 15.3.3 | Reactor Coolant Pump Shaft Seizure (Locked Rotor) |
| 15.3.4 | Reactor Coolant Pump Shaft Break |
| 15.4.1 | Uncontrolled RCCA Bank Withdrawal from a Subcritical or Low Power Startup Condition |

| | |
|---|---|
| 15.4.2 | Uncontrolled RCCA Bank Withdrawal at Power |
| 15.4.3 | RCCA Misoperation |
| 15.4.4 | Startup of an Inactive Reactor Coolant Pump at an Incorrect Temperature |
| 15.4.6 | CVCS Malfunction that Results in a Decrease in Boron Concentration of the Reactor Coolant |
| 15.4.7 | Inadvertent Loading and Operation with a Fuel Assembly in Improper Position |
| 15.4.8 | Spectrum of RCCA Ejection Accidents |
| 15.5.1 | Inadvertent Operation of the Emergency Core Cooling System During Power Operation |
| 15.5.2 | CVCS Malfunction that Increases Reactor Coolant Inventory |
| 15.6.1 | Inadvertent Opening of a Pressurizer Safety or Relief Valve |
| 15.6.5 | Loss-of-Coolant Accidents Resulting from a Spectrum of Postulated Piping Breaks within the Reactor Coolant Pressure Boundary |
| 6.2.1.4 | Mass and Energy Release Analysis for Postulated Secondary Pipe Ruptures Inside Containment |

Additional safety analysis design basis calculations which do not assume actuation of protection features to result from the S/G Low-Low Level trip signal include the following:

Rod Ejection Mass/Energy Releases for Dose Calculations

Reactor Vessel and Loop Blowdown Forces

Post LOCA Long-term Core Cooling

Hot Leg Switchover Time to Prevent Post-LOCA Boron Precipitation

In conclusion, evaluations and analyses of the safety analysis design basis transients listed in Section 2.1 support the acceptability of the following S/G Low-Low Level trip setpoint and time delay safety analysis limits:

| | |
|---|---|
| Trip Setpoint | 0% of Span |
| 2/4 Steam Generator Logic,<br>10% RTP Interlock Time Delay | 240 seconds |
| 1/4 Steam Generator Logic,<br>10% RTP Interlock Time Delay | 240 seconds |
| 2/4 Steam Generator Logic,<br>20% RTP Interlock Time Delay | 130 seconds |
| 1/4 Steam Generator Logic,<br>20% RTP Interlock Time Delay | 130 seconds |

## 2.3.3 Analysis Results

Sequence of Events Tables

and

Transient Behavior vs. Time Plots

TABLE 2.3.1 ANALYSIS ASSUMPTIONS

INITIAL CONDITIONS

| | CORE THERMAL POWER | VESSEL Tavg (F) | REACTOR VESSEL COOLANT FLOW (gpm) | PRESSURIZER PRESSURE (psia) | PRESSURIZER WATER VOLUME (FT3) | FEEDWATER TEMPERATURE (F) | MODERATOR TEMPERATURE COEFFICIENT (pcm/F) | S/G LOW-LOW LEVEL TRIP (% of Span) | TTD TIME DELAY (sec) |
|---|---|---|---|---|---|---|---|---|---|
| CASE I | 19% of 3565 MWt | 570.5 | 382, 630 | 2280 | 686 | 267 | 0* | 0 | 240 |
| CASE II | 19% of 3565 MWt | 570.5 | 382, 630 | 2280 | 686 | 267 | 0* | 0 | 240 |
| CASE III | 29% of 3565 MWt | 573.6 | 382, 630 | 2280 | 751 | 297 | 0* | 0 | 130 |
| CASE IV | 29% of 3565 MWt | 573.6 | 382, 630 | 2280 | 751 | 297 | 0* | 0 | 130 |
| CASE V | 102% of 3565 MWt | 583.4 | 382, 630 | 2280 | 1175 | 446 | 0 | 0 | 0 |
| CASE VI | 102% of 3565 MWt | 595.9 | 382, 630 | 2280 | 1175 | 446 | 0 | 0 | 0 |
| CASE VII | 29% of 3565 MWt | 573.6 | 382, 630 | 2280 | 751 | 297 | +5 | 0 | 130 |

* See Sections 2.3.1.1 and 2.3.2.2 for a discussion of the effects of positive MTC.

TABLE I

TIME SEQUENCE OF EVENTS FOR CASE I:

LOSS OF NORMAL FEEDWATER TO FOUR STEAM GENERATORS FOR 10% RTP INTERLOCK

| Event | Time (sec) |
|---|---|
| Main feedwater flow stops | 10.0 |
| S/G Low-Low Level setpoint reached | 337.9 |
| Low-Low Level trip signal transmitted | 577.9 |
| Rods begin to drop | 579.9 |
| First peak water level in pressurizer occurs | 582.0 |
| One motor driven auxiliary feedwater pump starts | 637.9 |
| Feedwater lines are purged and cold auxiliary feedwater is delivered to two steam generators | 872 |
| Core decay heat plus pump heat decreases to auxiliary feedwater heat removal capacity | ~900 |
| Second peak water level in pressurizer occurs | 2992 |

TABLE II

TIME SEQUENCE OF EVENTS FOR CASE II:

LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR
FOR 10% RTP INTERLOCK

| Event | Time (sec) |
|---|---|
| Main feedwater flow stops to one steam generator | 0.0 |
| S/G Low-Low Level setpoint reached in the faulted loop | 310.7 |
| Low-Low Level trip signal transmitted | 550.7 |
| Rods begin to drop | 552.7 |
| First peak water level in pressurizer occurs | 555.0 |
| One motor driven auxiliary feedwater pump starts | 610.7 |
| Feedwater lines are purged and cold auxiliary feedwater is delivered to two steam generators | 844 |
| Core decay heat generation plus pump heat is exceeded by auxiliary feedwater heat removal capacity | 844 |
| Second peak water level in pressurizer occurs | 2304 |

## TABLE III

### TIME SEQUENCE OF EVENTS FOR CASE III:

### LOSS OF NORMAL FEEDWATER TO FOUR STEAM GENERATORS FOR 20% RTP INTERLOCK

| Event | Time (sec) |
|---|---|
| Main feedwater flow stops | 10.0 |
| S/G Low-Low Level setpoint reached in all S/Gs | 218.25 |
| First peak water level in pressurizer occurs | 286.0 |
| Low-Low Level trip signal transmitted | 348.25 |
| Rods begin to drop | 350.25 |
| One motor driven auxiliary feedwater pump starts | 408.25 |
| Feedwater lines are purged and cold auxiliary feedwater is delivered to two steam generators | 642.0 |
| Core decay heat generation plus pump heat is exceeded by auxiliary feedwater heat removal capacity | 642.0 |
| Second peak water level in pressurizer occurs | 2816 |

TABLE IV

TIME SEQUENCE OF EVENTS FOR CASE IV:

LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR
FOR 20% RTP INTERLOCK

| Event | Time (sec) |
|---|---|
| Main feedwater flow stops | 0.0 |
| S/G Low-Low Level setpoint reached in faulted steam generator | 202.4 |
| Low-Low Level trip signal transmitted | 332.4 |
| Rods begin to drop | 334.4 |
| First peak water level in pressurizer occurs | 335.0 |
| One motor driven auxiliary feedwater pump starts | 392.4 |
| Feedwater lines are purged and cold auxiliary feedwater is delivered to two steam generators | 626.0 |
| Core decay heat generation plus pump heat is exceeded by auxiliary feedwater heat removal capacity | 626.0 |
| Second peak water level in pressurizer occurs | 1894 |

TABLE V

TIME SEQUENCE OF EVENTS FOR CASE V:

FSAR CHAPTER 15.2.6 LOSS OF NON-EMERGENCY AC POWER TO THE STATION AUXILIARIES

| Event | Time (sec) |
|---|---|
| Main feedwater flow stops | 10.0 |
| S/G Low-Low Level setpoint reached in all S/Gs | 61.3 |
| Low-Low Level trip signal transmitted | 61.3 |
| Rods begin to drop | 63.3 |
| AC power is lost and reactor coolant pumps begin coastdown | 65.3 |
| First peak water level in pressurizer occurs | 74.0 |
| One motor driven auxiliary feedwater pump starts | 121.3 |
| Feedwater lines are purged and cold auxiliary feedwater is delivered to two steam generators | 355.0 |
| Core decay heat plus pump heat decreases to auxiliary feedwater heat removal capacity | ~1630 |
| Second peak water level in pressurizer occurs | 1670 |

TABLE VI

TIME SEQUENCE OF EVENTS FOR CASE VI:

FSAR CHAPTER 15.2.7 LOSS OF NORMAL FEEDWATER

| Event | Time (sec) |
|---|---|
| Main feedwater flow stops | 10.0 |
| S/G Low-Low Level setpoint reached | 61.1 |
| Low-Low Level trip signal transmitted | 61.1 |
| Rods begin to drop | 63.1 |
| First peak water level in pressurizer occurs | 66.0 |
| One motor driven auxiliary feedwater pump starts | 121.1 |
| Feedwater lines are purged and cold auxiliary feedwater is delivered to two steam generators | 355.0 |
| Core decay heat generation plus pump heat is exceeded by auxiliary feedwater heat removal capacity | 355.0 |
| Second peak water level in pressurizer occurs | 2972 |

TABLE VII

TIME SEQUENCE OF EVENTS FOR CASE VII:

FEEDLINE BREAK WITH OFFSITE POWER
20% RTP INTERLOCK TIME DELAY FOR 2/4 LOGIC

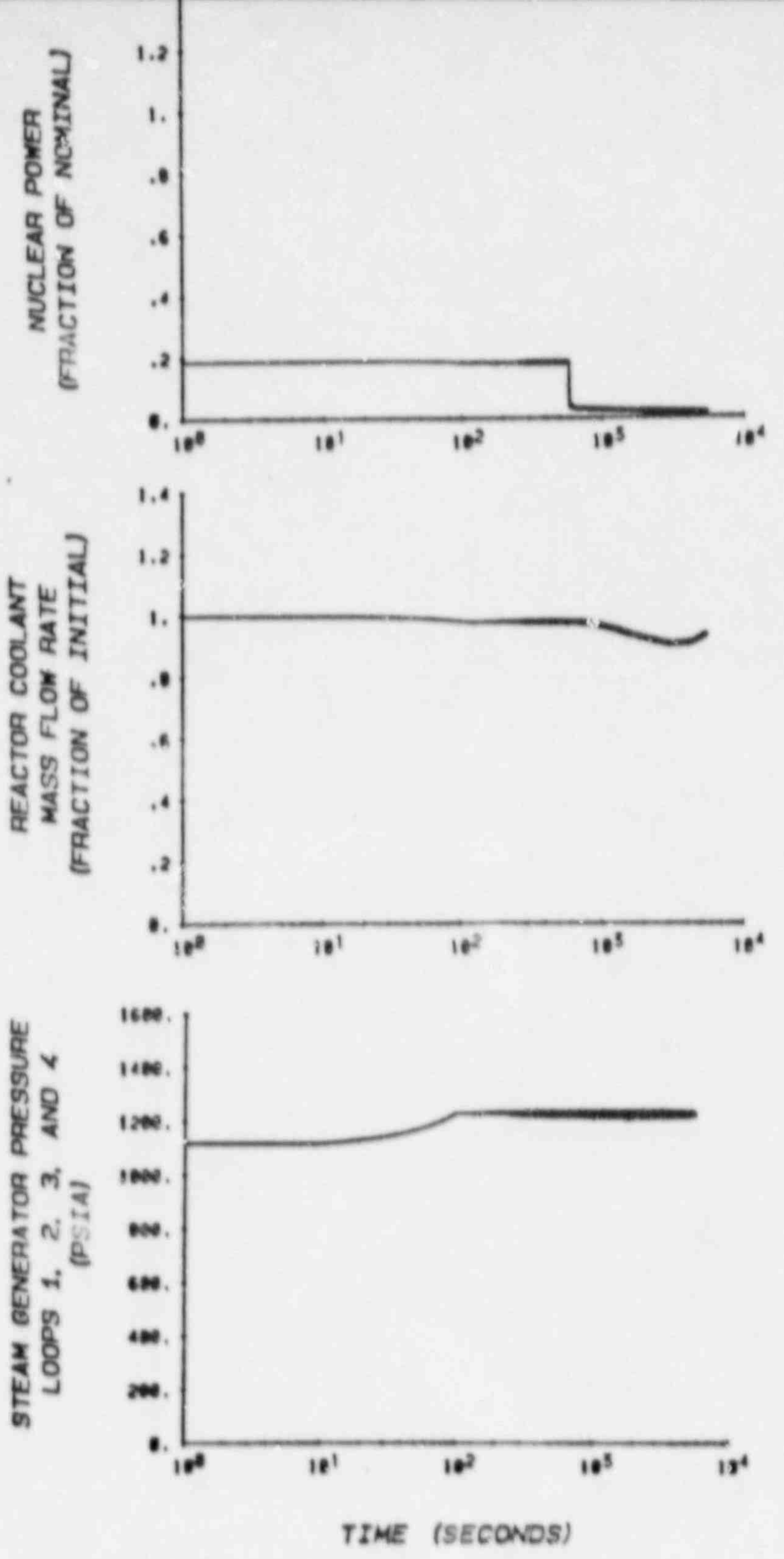
| Event | Time (sec) |
|---|---|
| EAM enables harsh environment S/G Low-Low Level trip setpoint | <10.0 |
| Feedwater control system malfunction occurs due to harsh environment | 10.0 |
| Steam generator safety valve setpoint reached (first occurrence) | 77.0 |
| S/G Low-Low Level setpoint reached in ruptured steam generator | 203.9 |
| Low-Low Level trip signal transmitted | 333.9 |
| Rods begin to drop. Double ended feedwater line rupture blowdown is assumed to begin | 335.9 |
| Low Steamline Pressure setpoint reached in ruptured steam generator | 349.9 |
| All main steamline and feedline isolation valves close on Low Steamline Pressure | 356.9 |

TABLE VII (cont.)

TIME SEQUENCE OF EVENTS FOR CASE VII:

FEEDLINE BREAK WITH OFFSITE POWER
20% RTP INTERLOCK TIME DELAY FOR 2/4 LOGIC

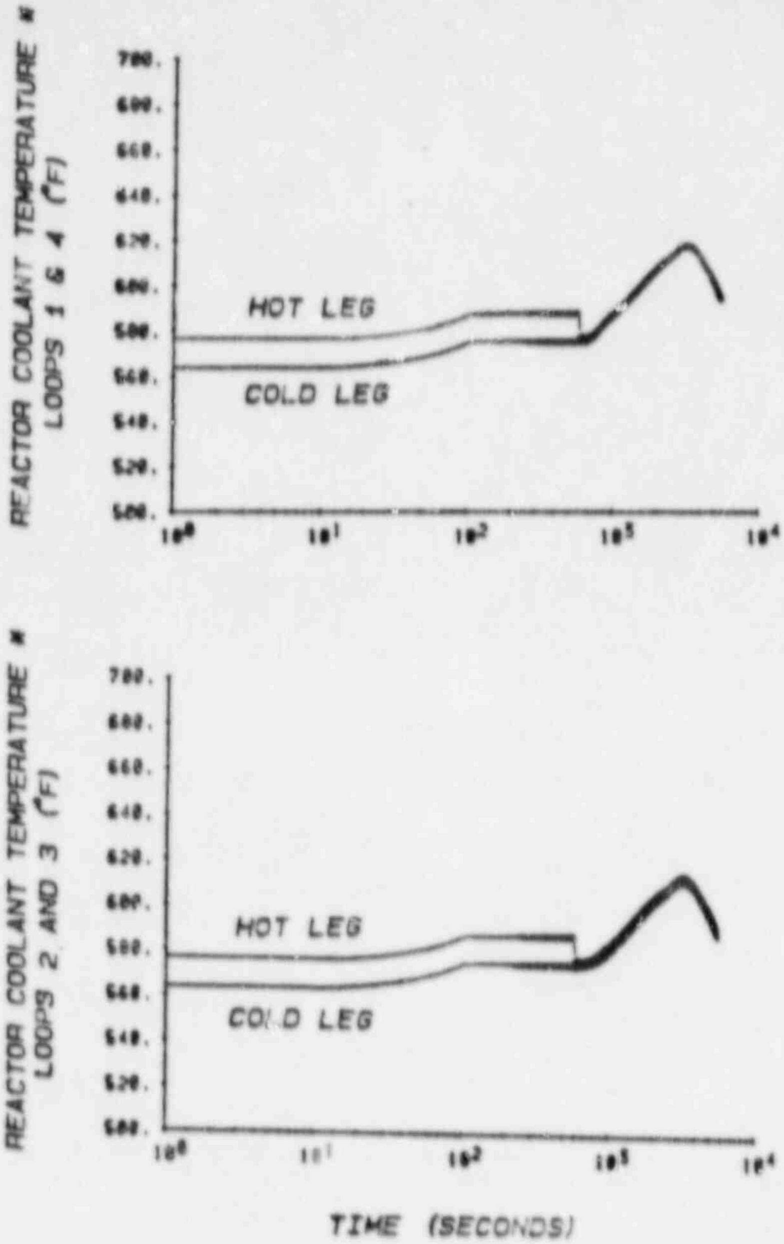
| Event | Time (sec) |
|---|---|
| Pressurizer water relief begins | 624.0 |
| Cold auxiliary feedwater is delivered to intact steam generators | ~678 |
| Steam generator safety valve setpoint reached in intact steam generators (second occurrence) | 700 |
| Core decay heat plus pump heat decreases to auxiliary feedwater heat removal capacity | 840 |




CALLAWAY PLANT

FIGURE I.1

NUCLEAR POWER, REACTOR COOLANT MASS FLOW RATE AND STEAM GENERATOR PRESSURE TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS

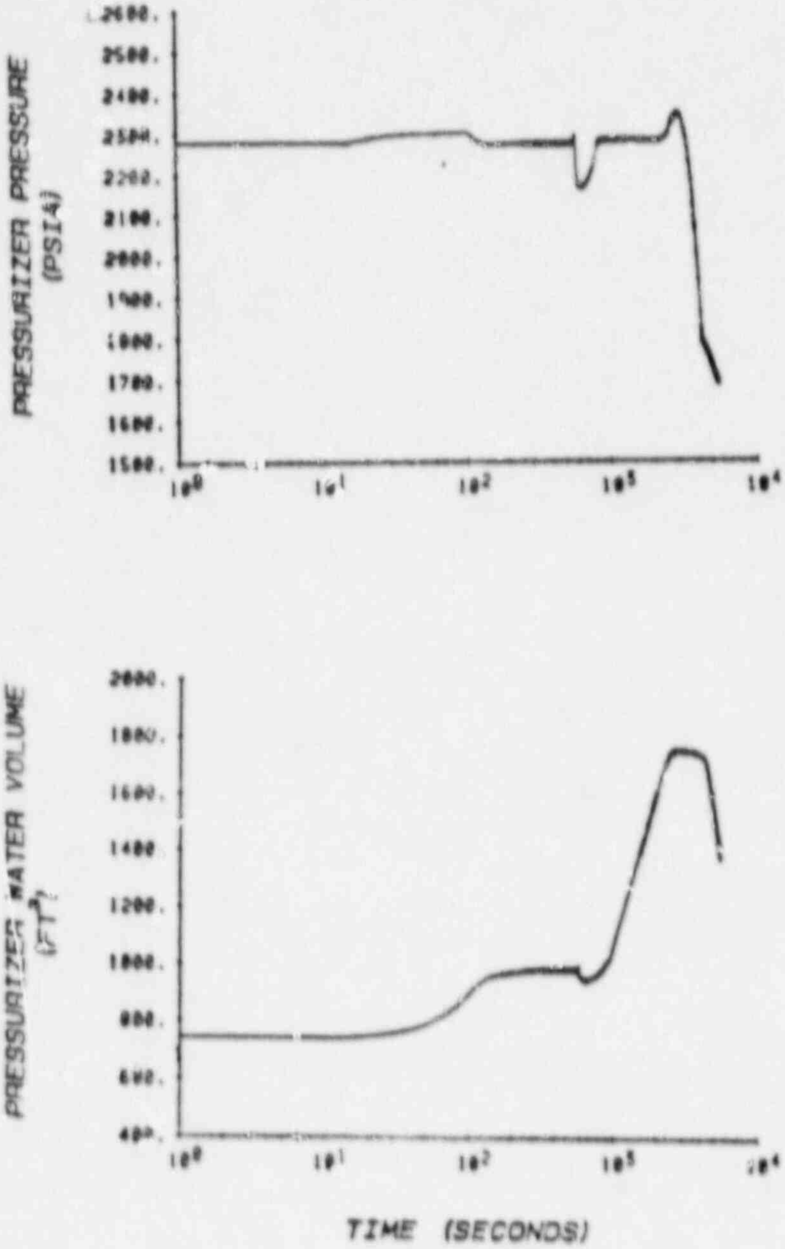



* Assumes motor-driven auxiliary feedwater pump A supplies flow to steam generators B and C (LOOPS 2 AND 3).

CALLAWAY PLANT

FIGURE I.2

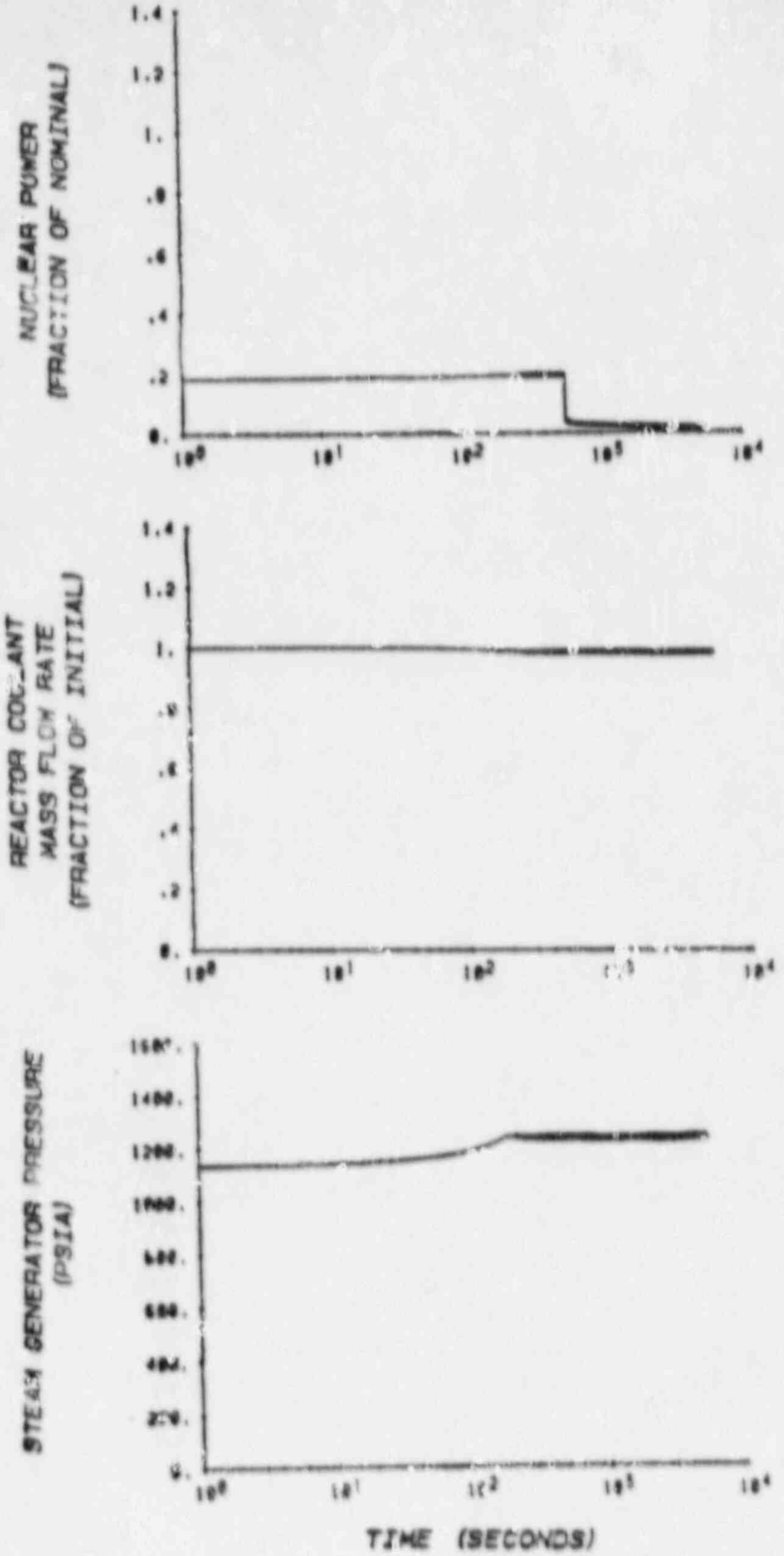
REACTOR COOLANT TEMPERATURE TRANSIENT FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS




CALLAWAY PLANT

FIGURE I.3

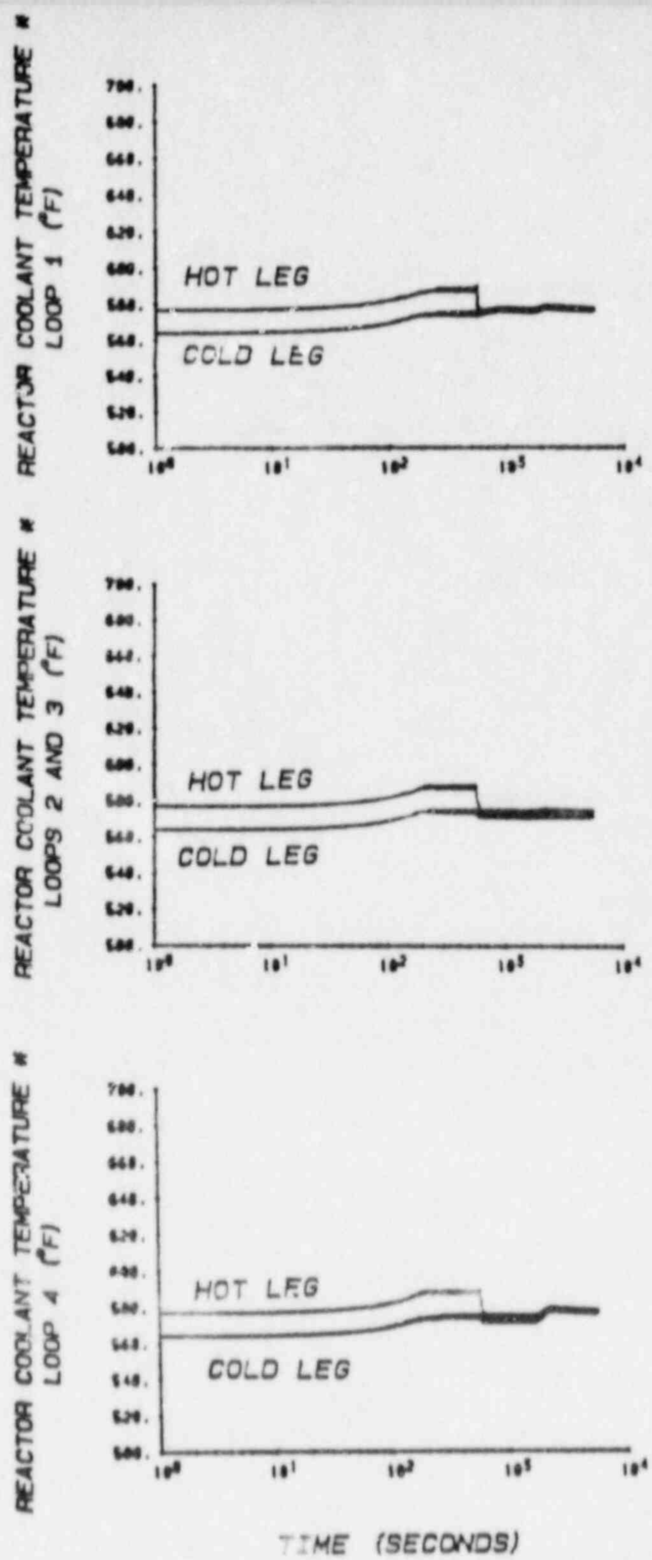
PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS




CALLAWAY PLANT

FIGURE II.[illegible]

NUCLEAR POWER, REACTOR COOLANT MASS FLOW RATE AND STEAM GENERATOR PRESSURE TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR

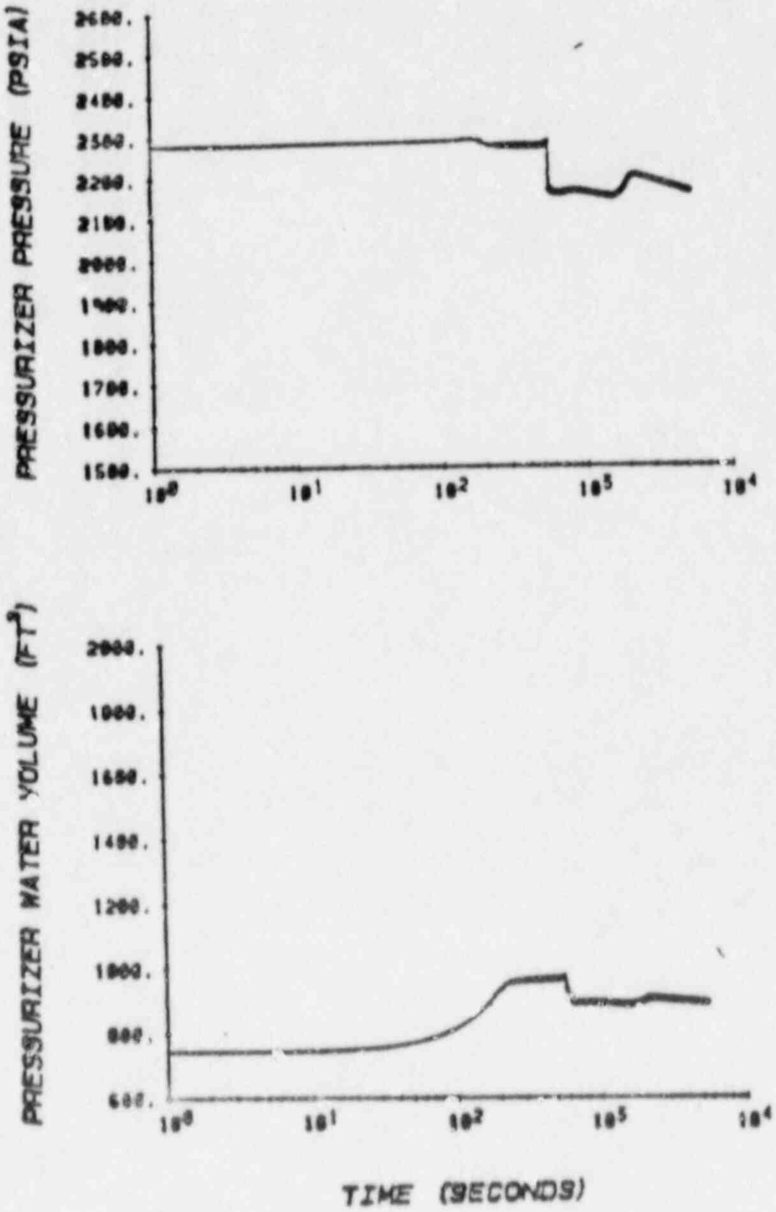



* Assumes motor-driven auxiliary feedwater pump A supplies flow to steam generators B and C (LOOPS 2 AND 3)

CALLAWAY PLANT

FIGURE II.2

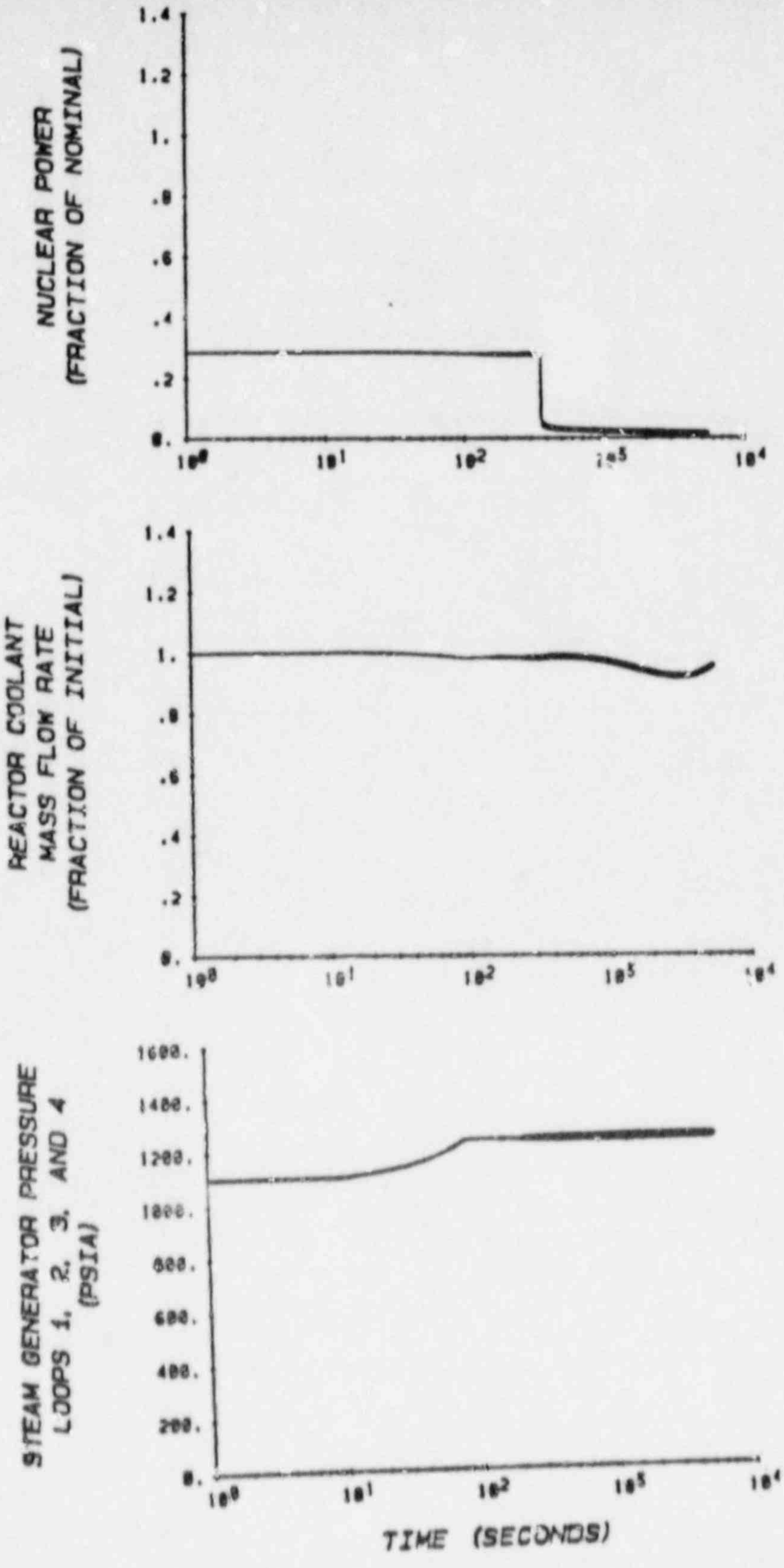
REACTOR COOLANT TEMPERATURE TRANSIENT FOR LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR




CALLAWAY PLANT

FIGURE II.3

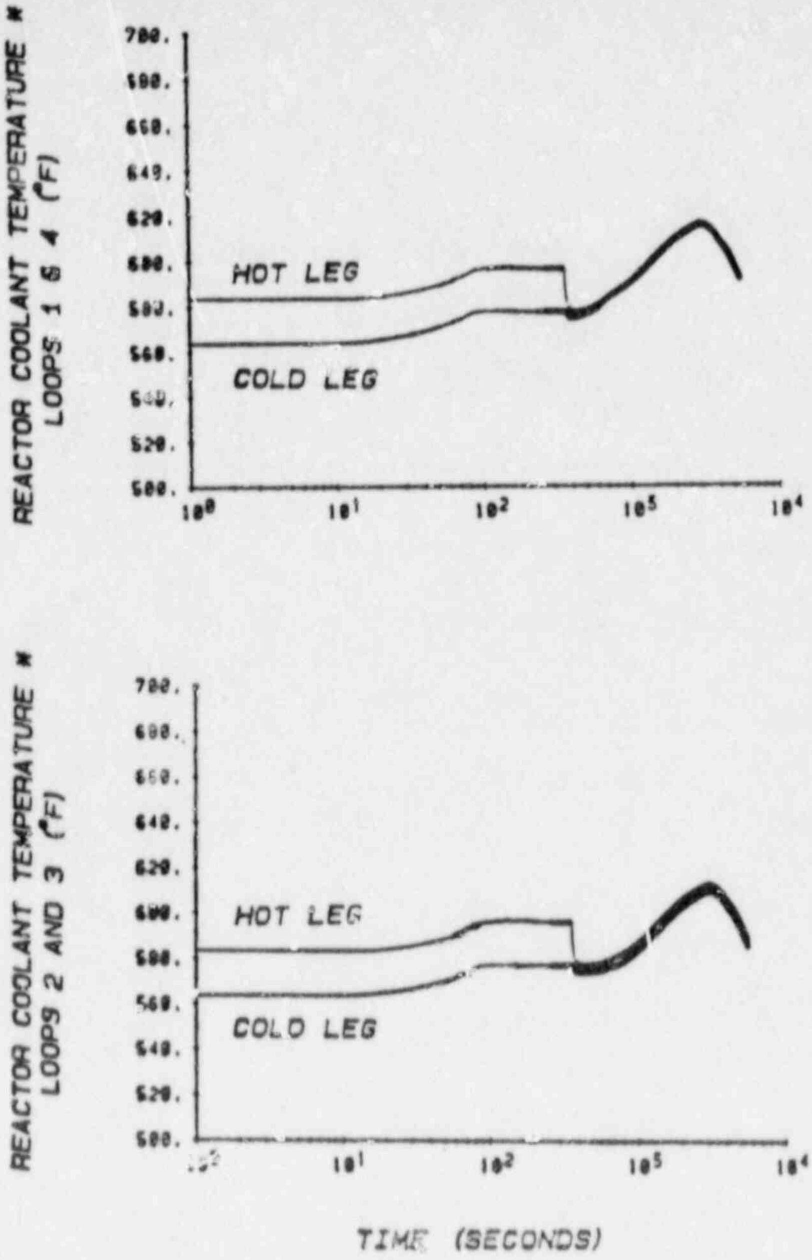
PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR




CALLAWAY PLANT

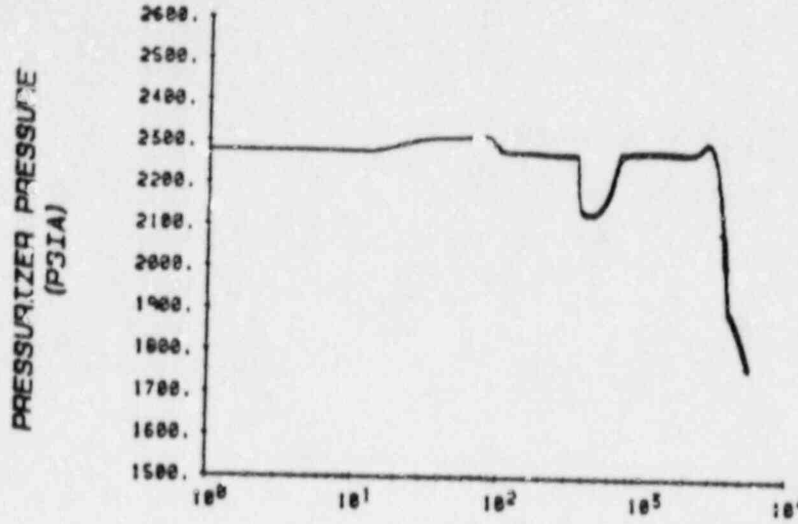
FIGURE III.1

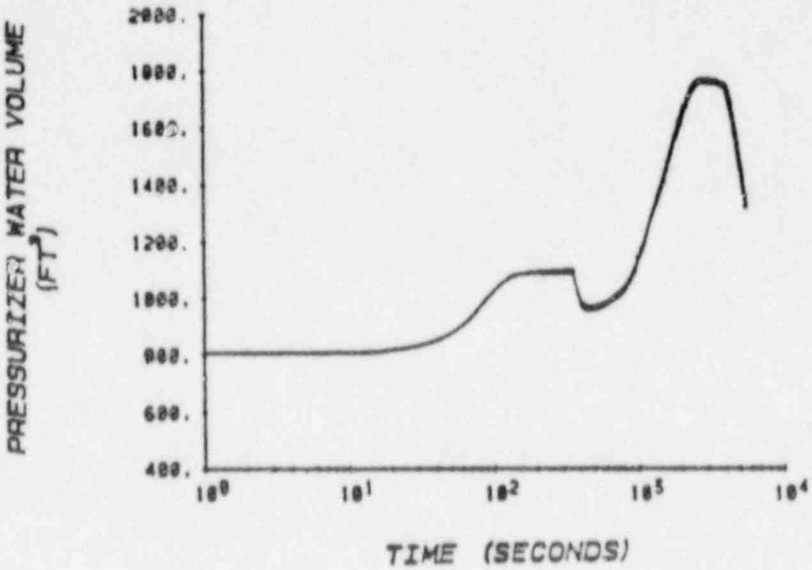
NUCLEAR POWER, REACTOR COOLANT MASS FLOW RATE AND STEAM GENERATOR PRESSURE TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS




* Assumes motor-driven auxiliary feedwater pump A supplies flow to steam generators B and C (LOOPS 2 AND 3)

| CALLAWAY PLANT |
|---|
| FIGURE III.2<br>REACTOR COOLANT TEMPERATURE TRANSIENT FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS |

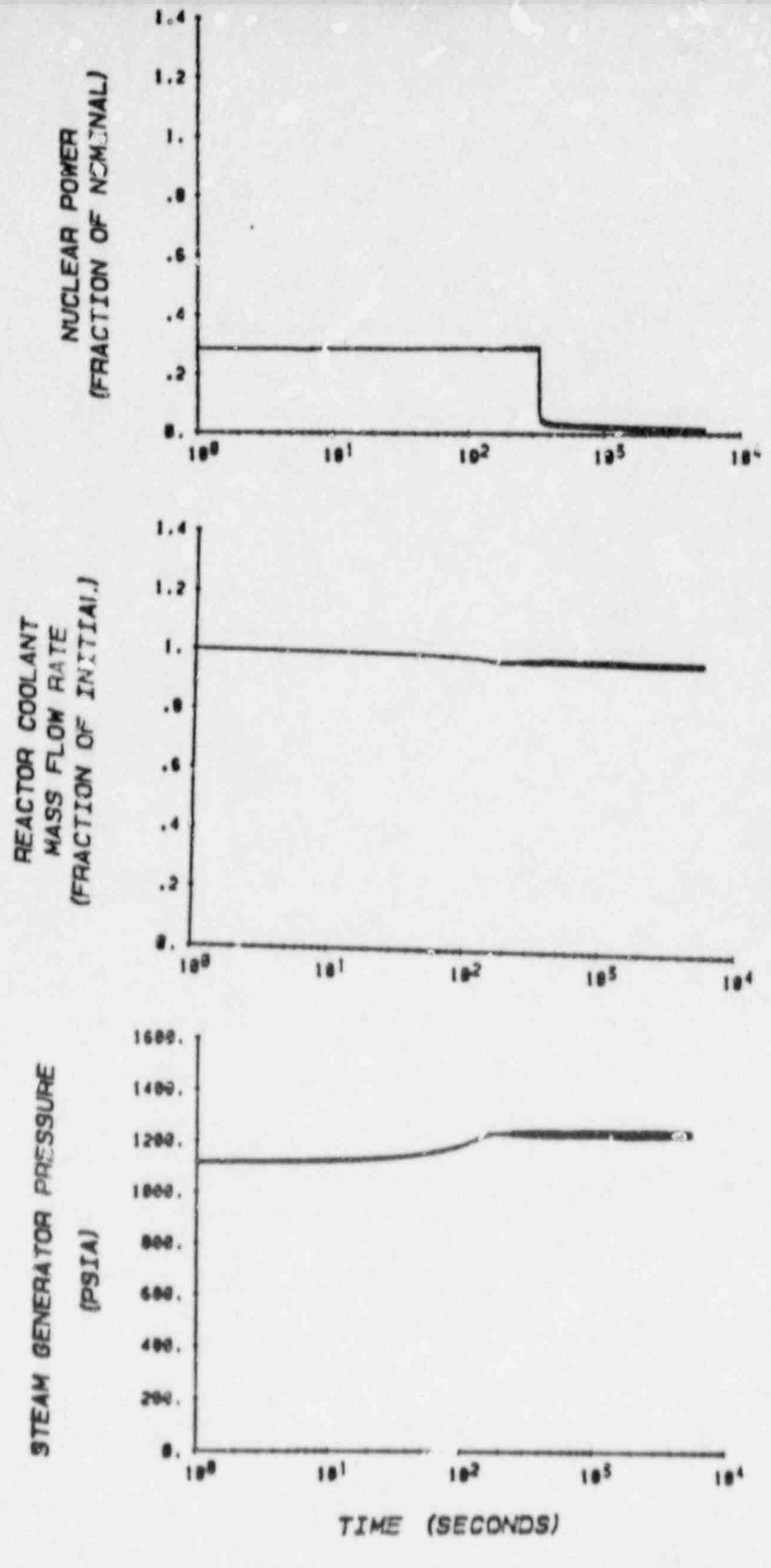



CALLAWAY PLANT

FIGURE III.3

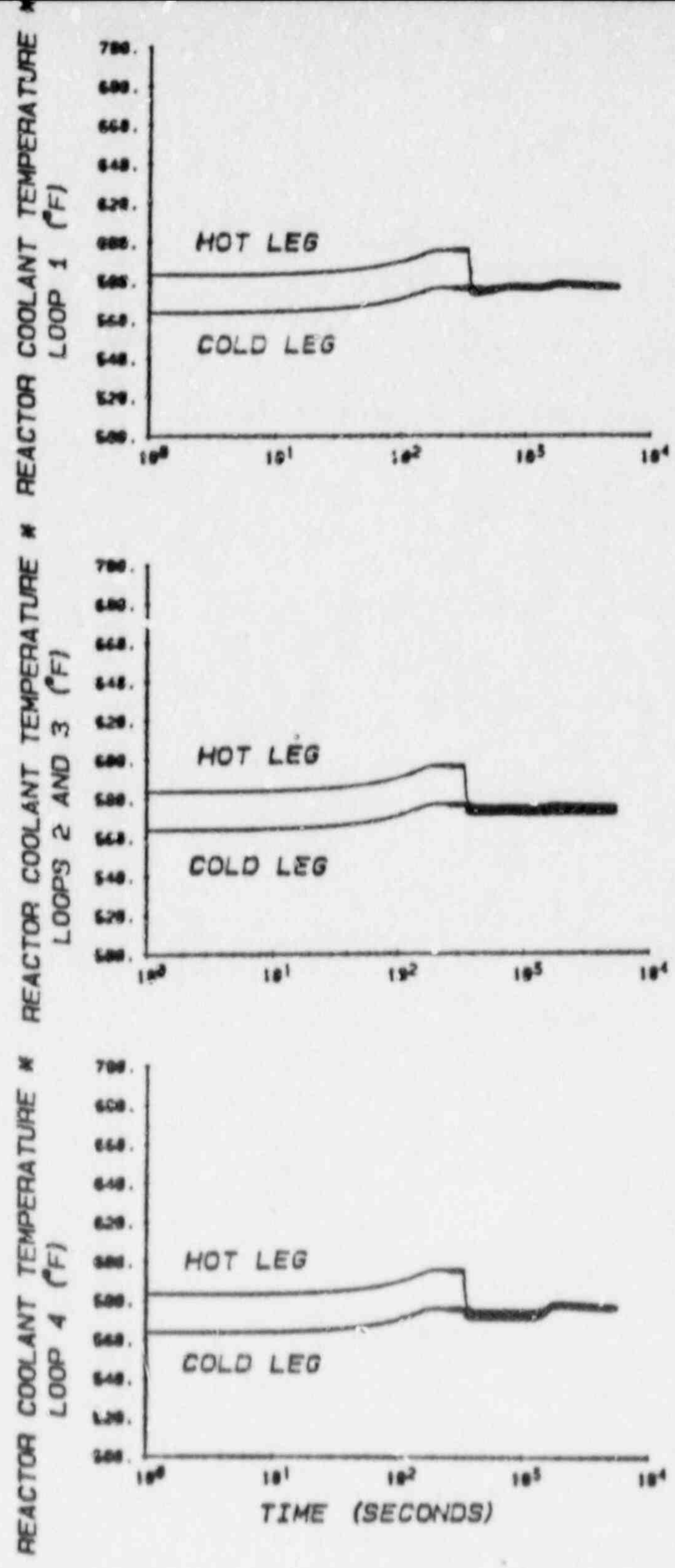
PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS




CALLAWAY PLANT

FIGURE IV.1

NUCLEAR POWER, REACTOR COOLANT MASS FLOW RATE AND STEAM GENERATOR PRESSURE TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR

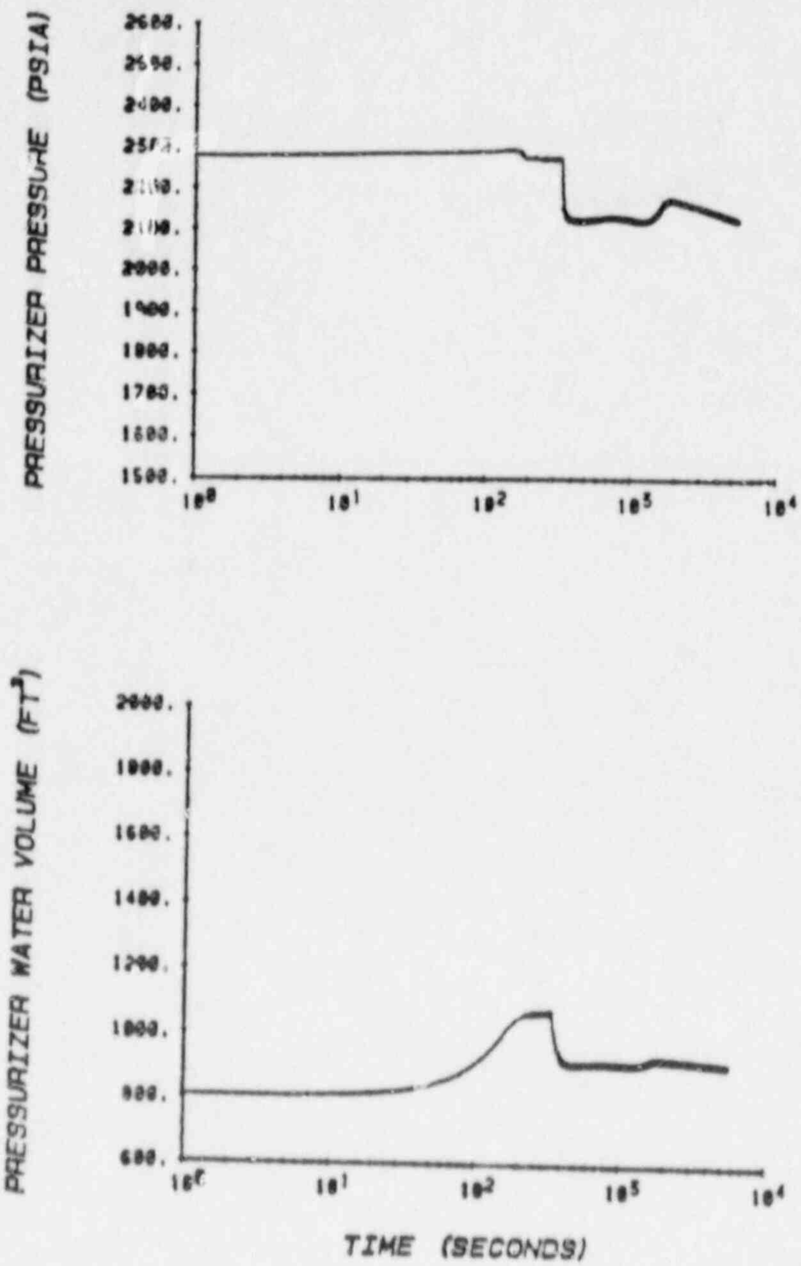



* Assumes motor-driven auxiliary feedwater pump A supplies flow to steam generators B and C (LOOPS 2 AND 3)

CALLAWAY PLANT

FIGURE IV.2

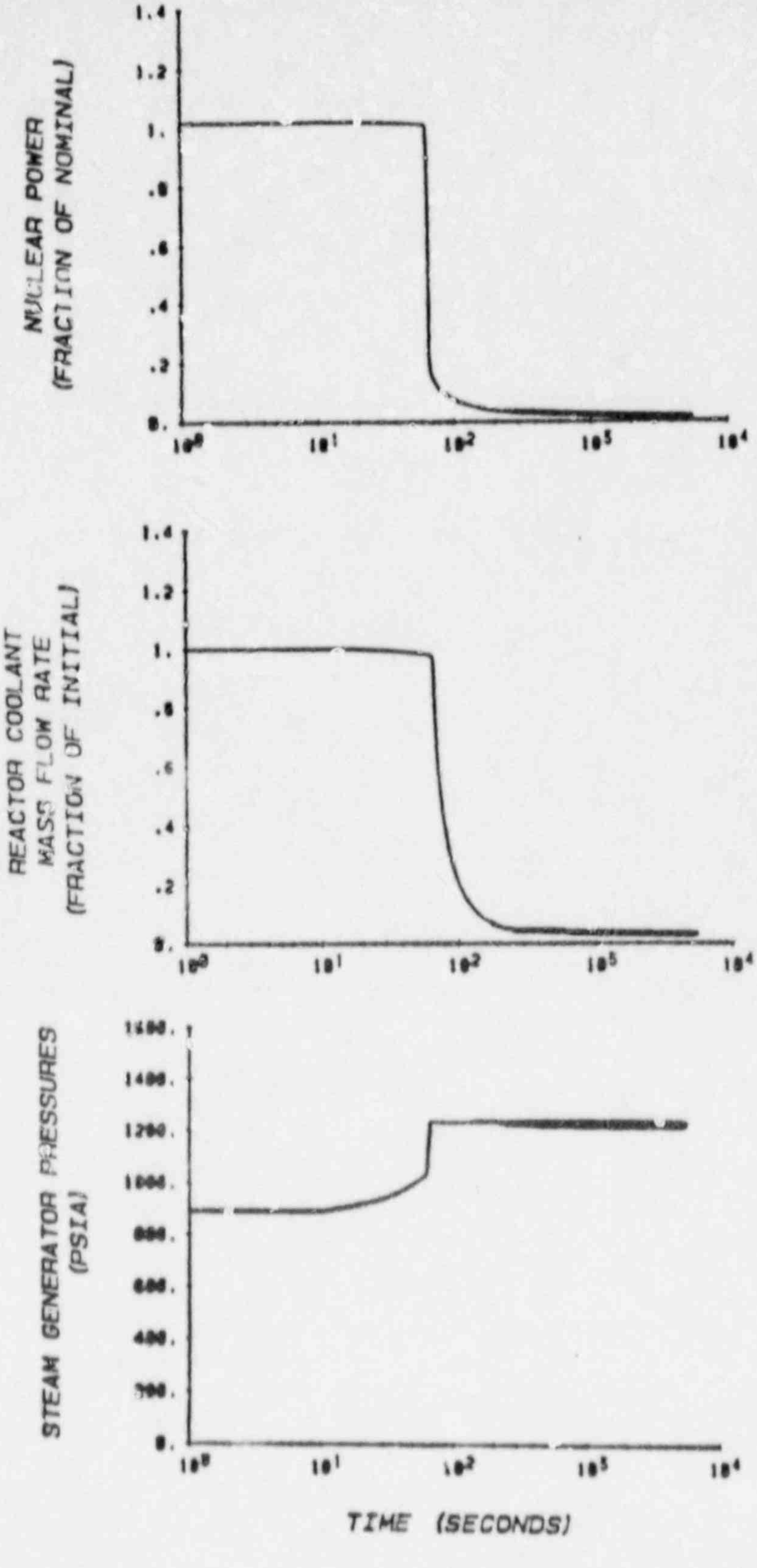
REACTOR COOLANT TEMPERATURE TRANSIENT FOR LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR




CALLAWAY PLANT

FIGURE IV.3

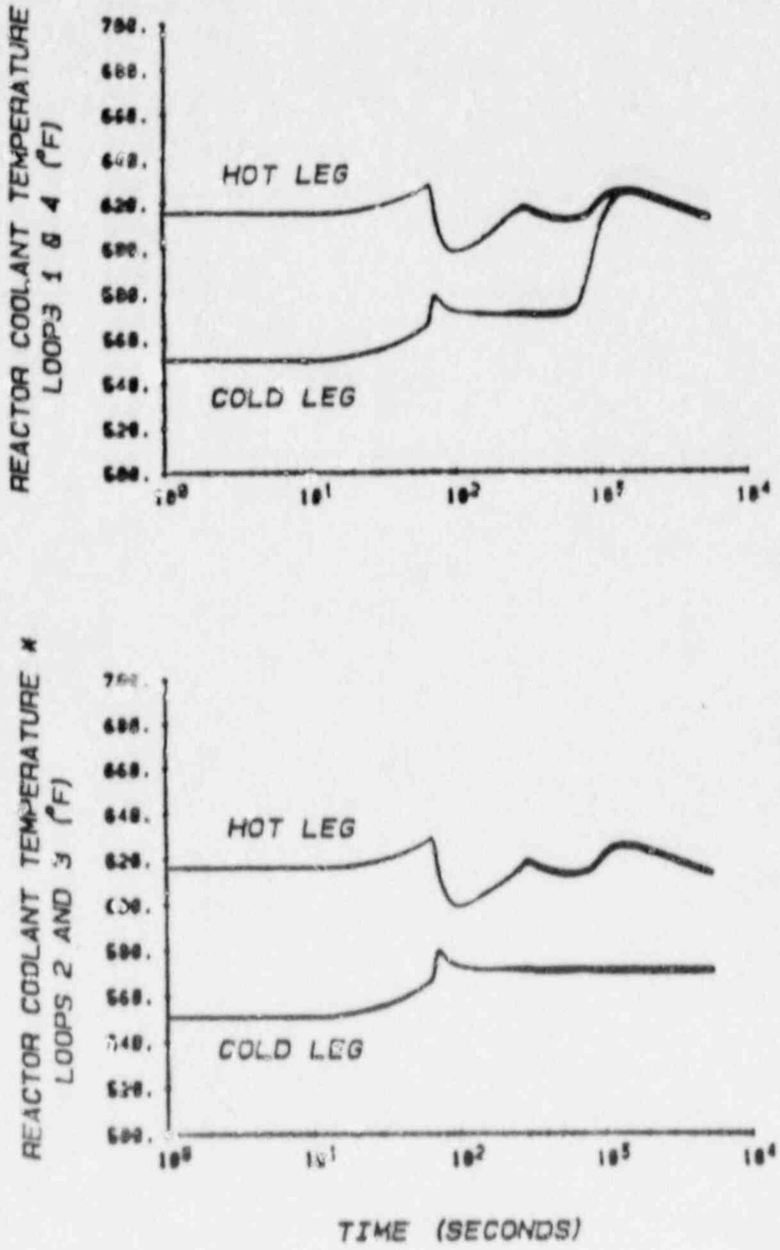
PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ONE STEAM GENERATOR




CALLAWAY PLANT

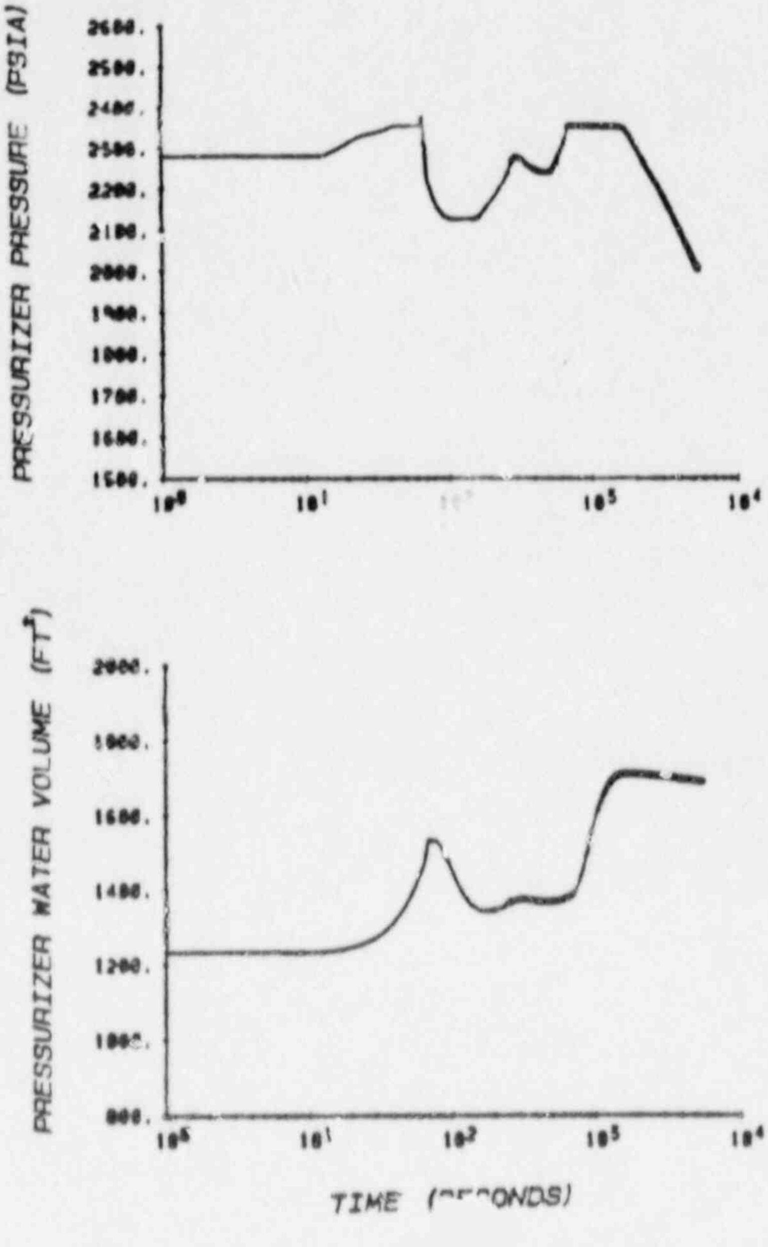
FIGURE V.1

NUCLEAR POWER, REACTOR COOLANT MASS FLOW RATE AND STEAM GENERATOR PRESSURE TRANSIENTS FOR LOSS OF AC POWER




* Assumes motor-driven auxiliary feedwater pump A supplies flow to steam generators B and C (LOOPS 2 AND 3).

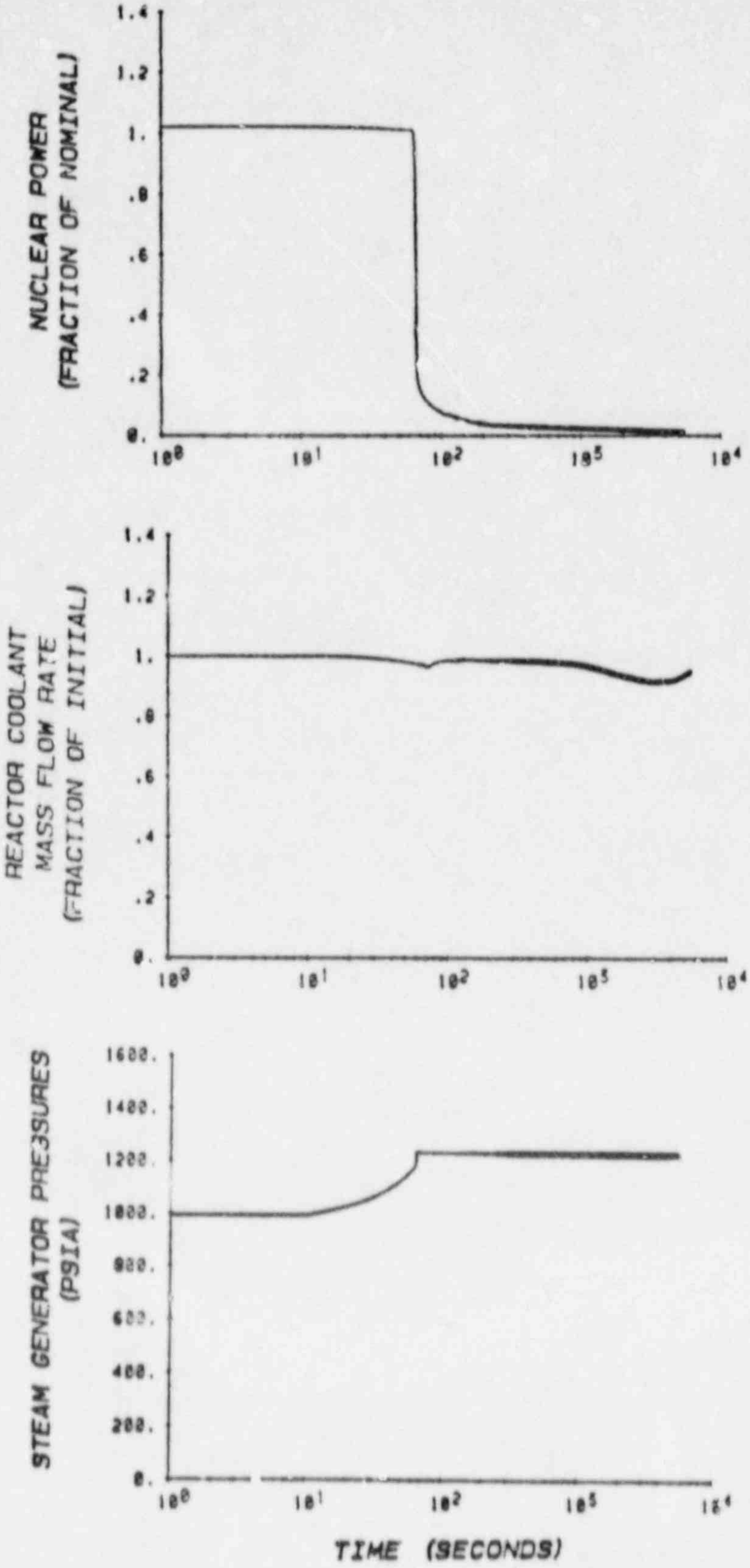
| CALLAWAY PLANT |
| --- |
| FIGURE V.2<br><br>REACTOR COOLANT TEMPERATURE TRANSIENT FOR LOSS OF AC POWER |




CALLAWAY PLANT

FIGURE V.3

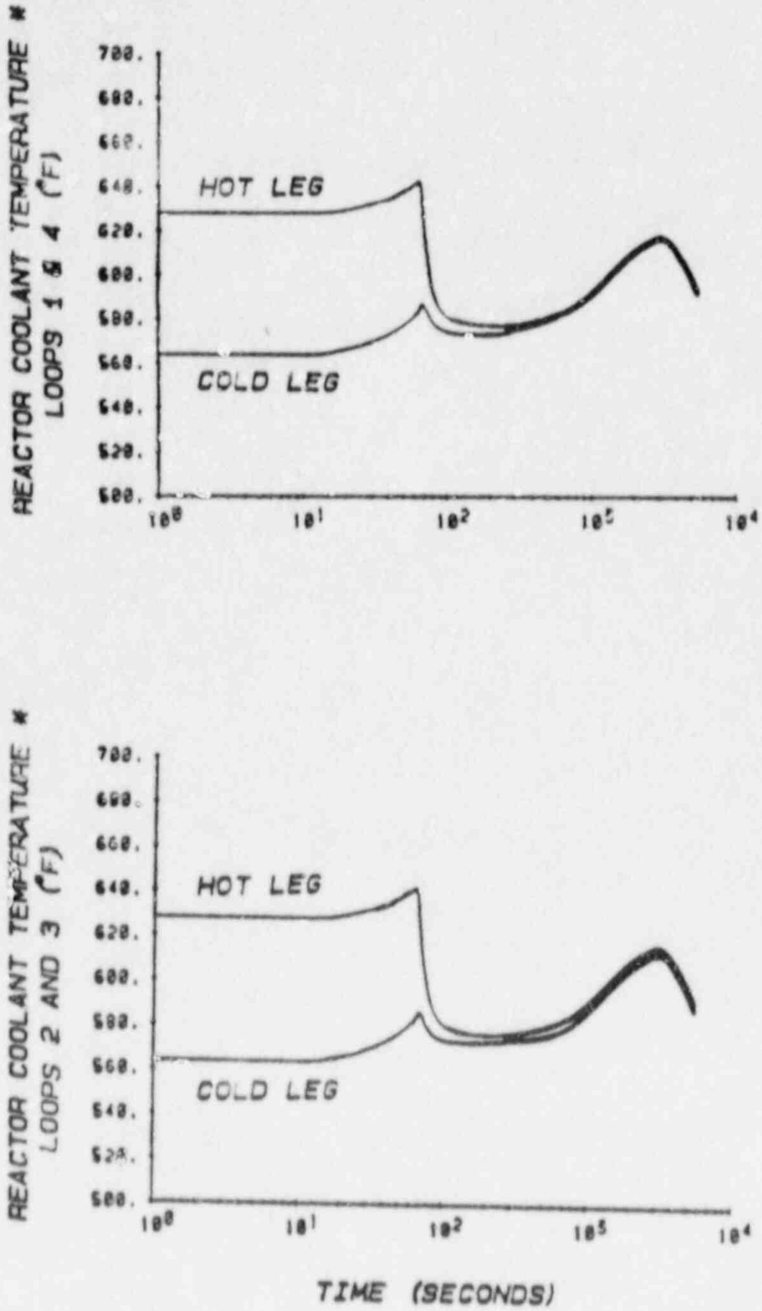
PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR LOSS OF AC POWER




CALLAWAY PLANT

FIGURE VI.1

NUCLEAR POWER, REACTOR COOLANT MASS FLOW RATE AND STEAM GENERATOR PRESSURE TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS

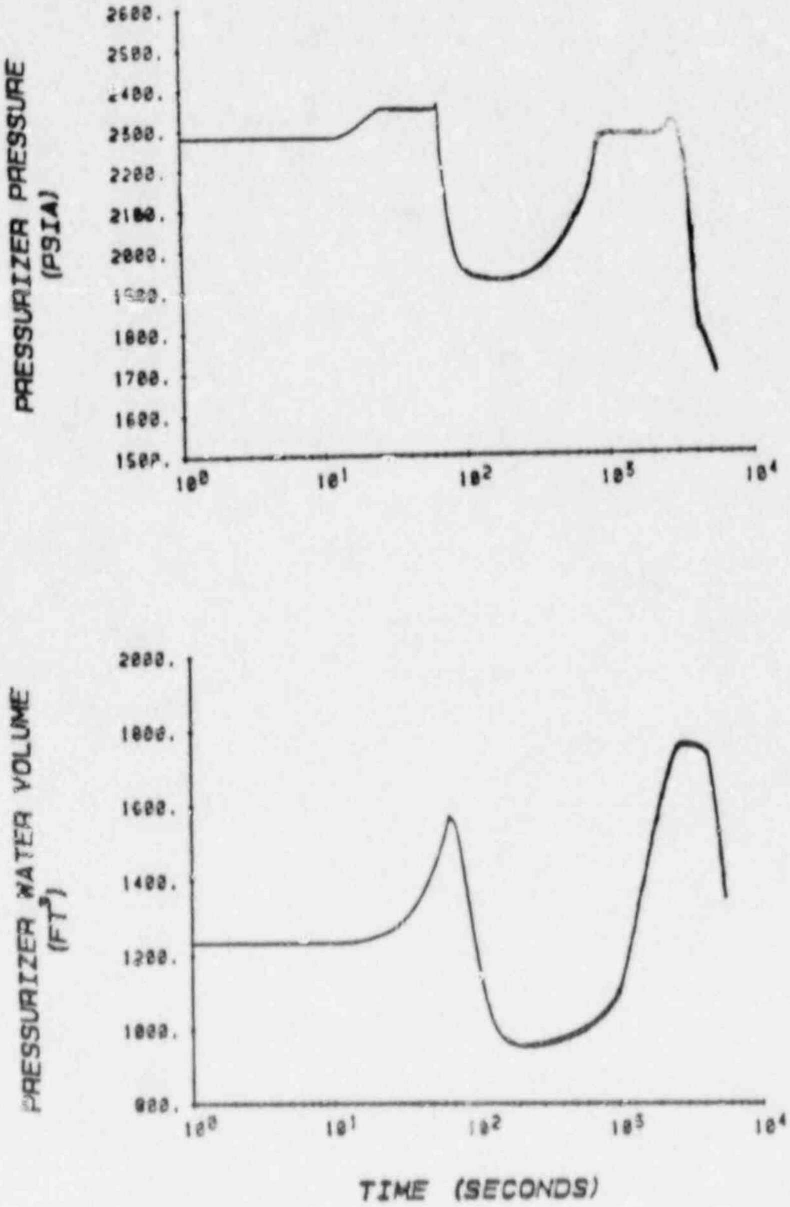



* Assumes motor-driven auxiliary feedwater pump A supplies flow to steam generators B and C (LOOPS 2 AND 3)

CALLAWAY PLANT

FIGURE VI.2

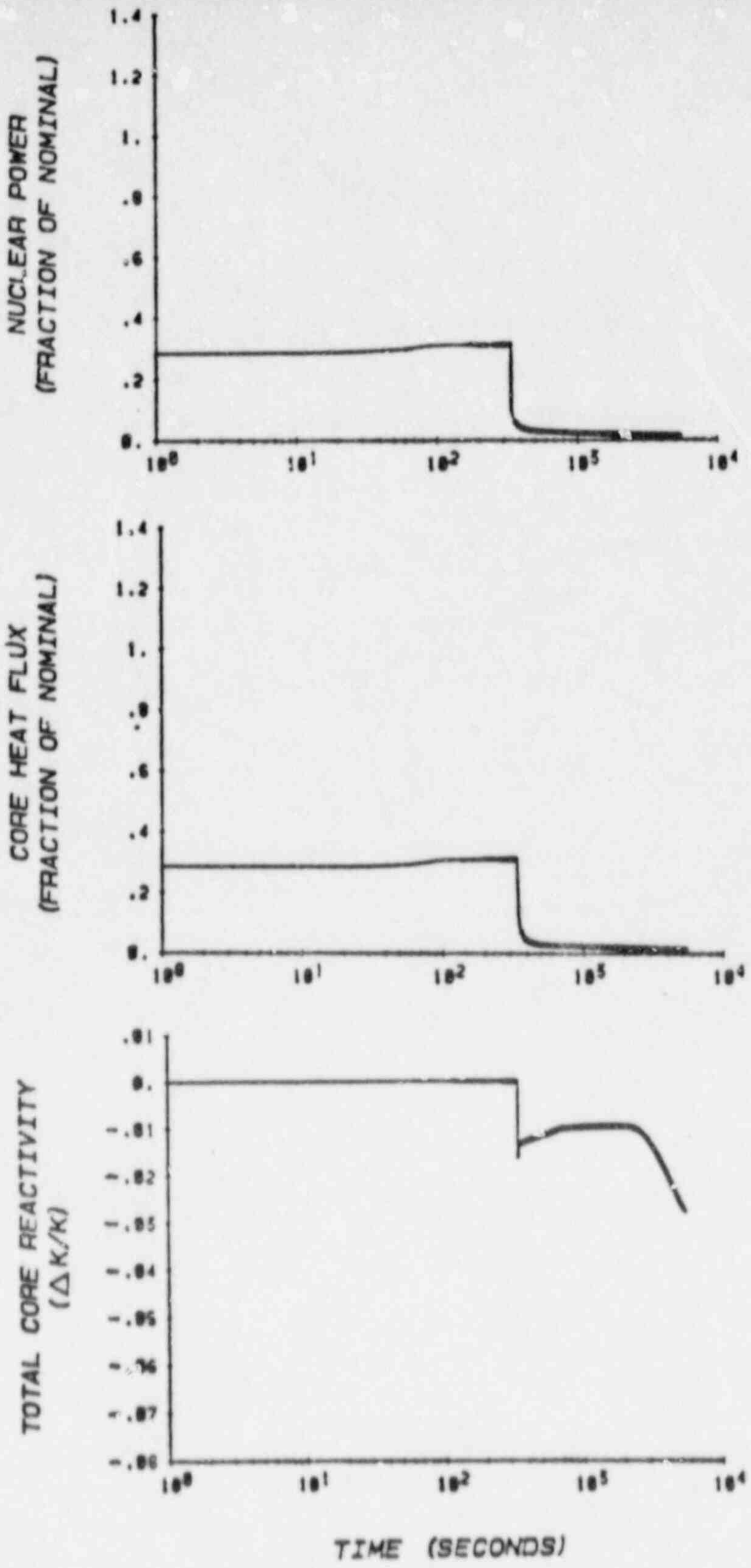
REACTOR COOLANT TEMPERATURE TRANSIENT FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS




CALLAWAY PLANT

FIGURE VI.3

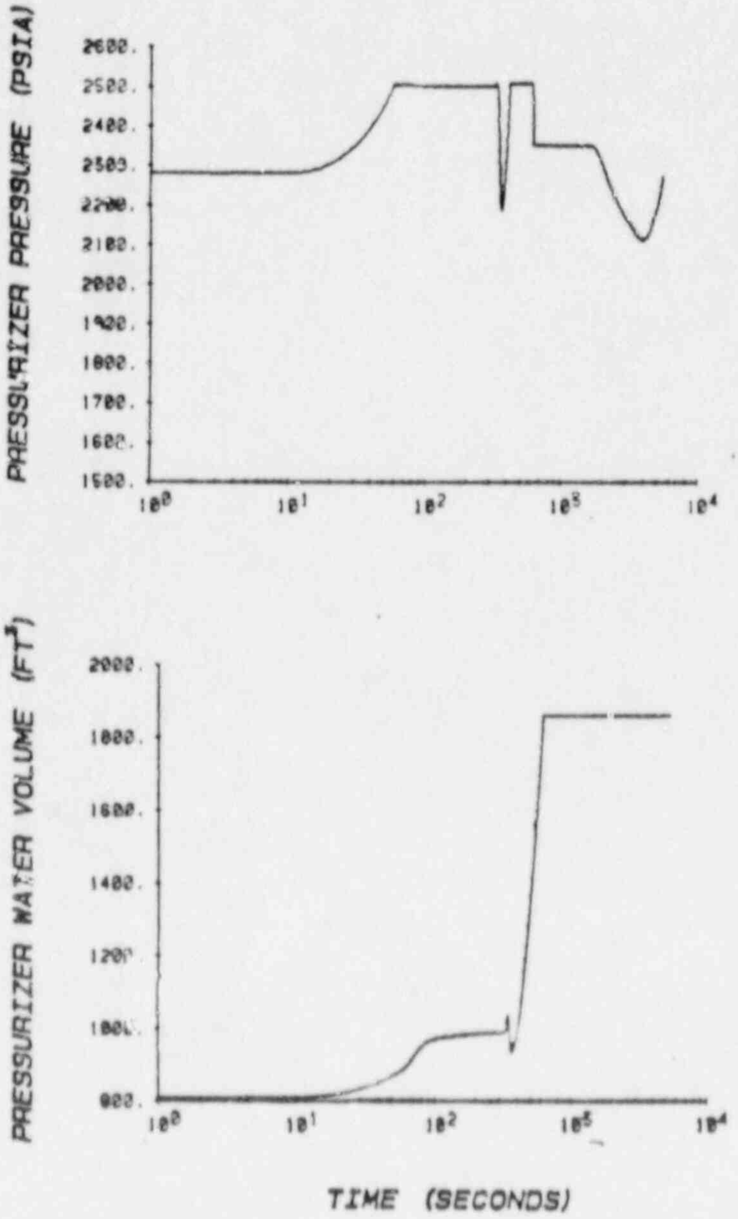
PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR LOSS OF NORMAL FEEDWATER TO ALL STEAM GENERATORS



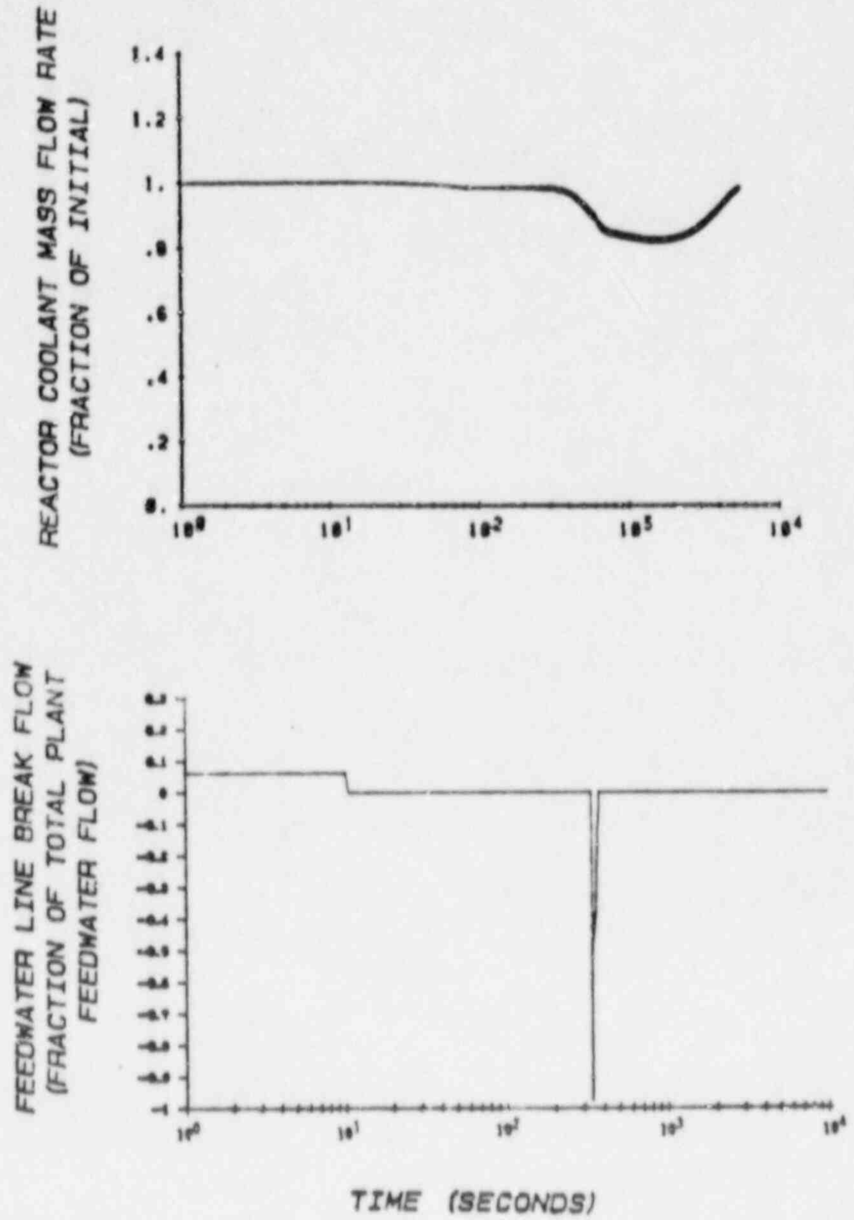

CALLAWAY PLANT

FIGURE VII.1

NUCLEAR POWER, CORE HEAT FLUX AND TOTAL CORE REACTIVITY TRANSIENTS FOR MAIN FEEDWATER LINE RUPTURE WITH OFFSITE POWER AVAILABLE



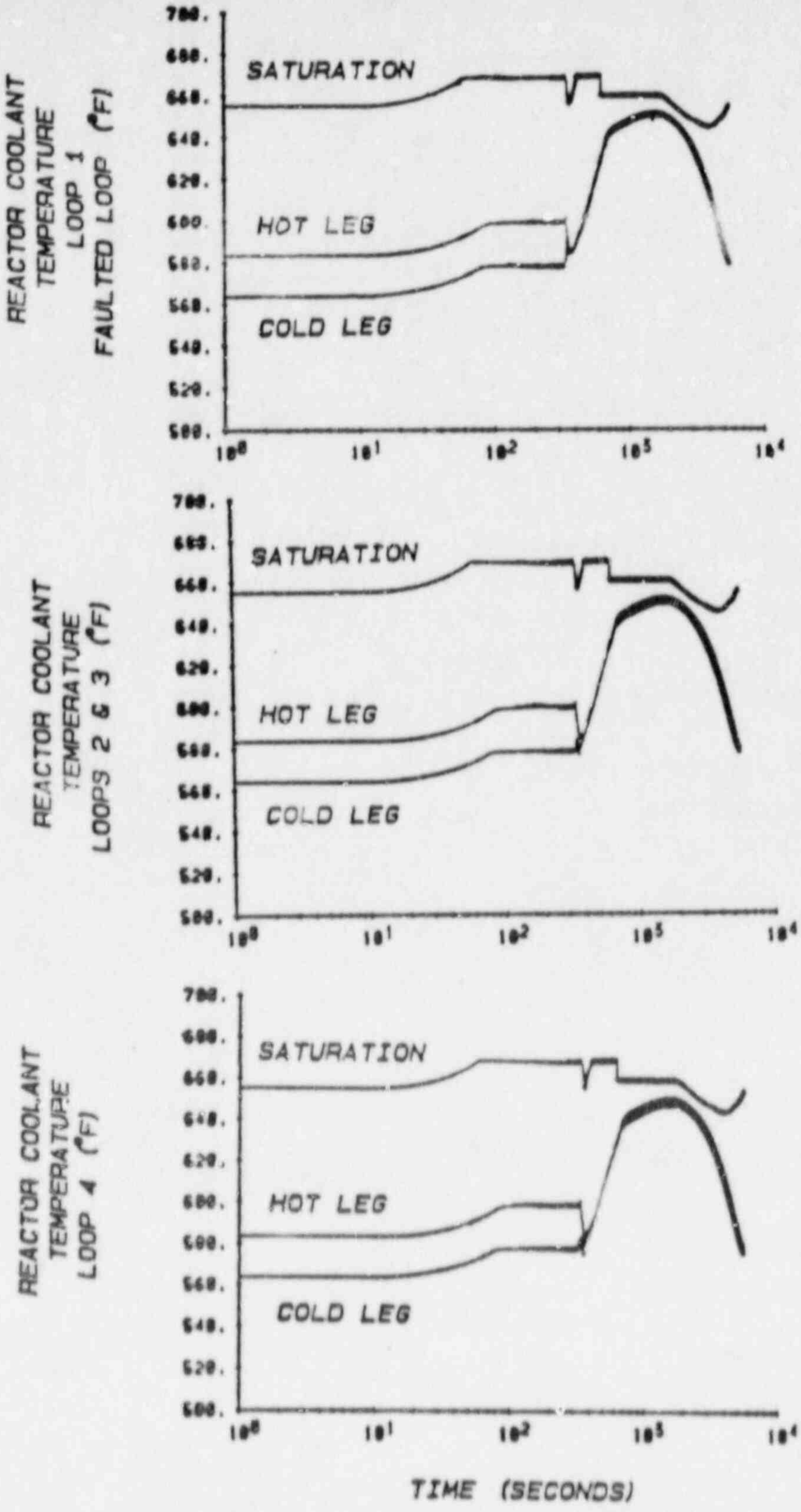

| CALLAWAY PLANT |
| --- |
| FIGURE VII.2<br><br>PRESSURIZER PRESSURE AND WATER VOLUME TRANSIENTS FOR MAIN FEEDWATER LINE RUPTURE WITH OFFSITE POWER AVAILABLE |



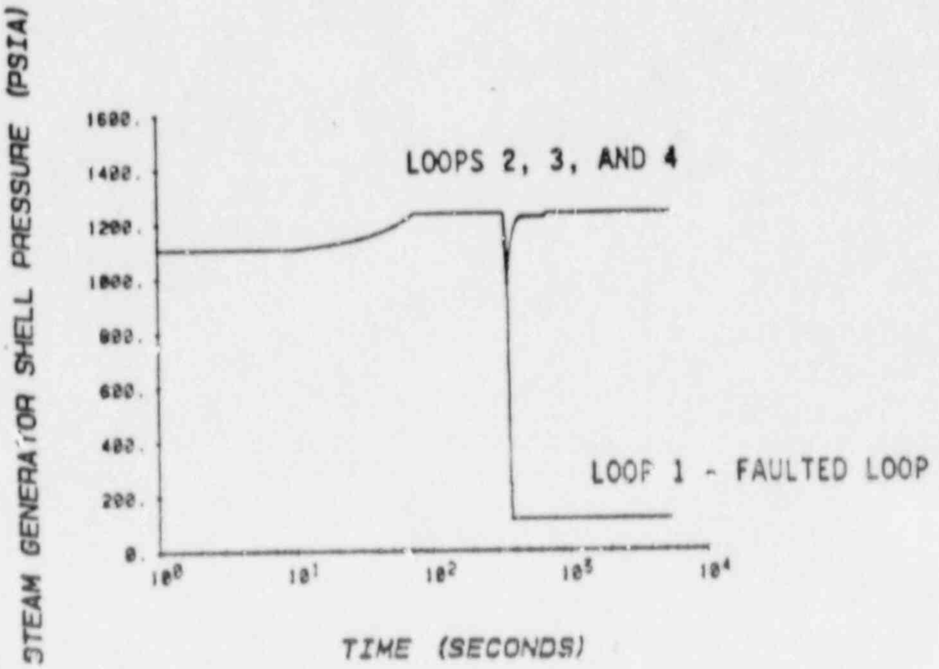

CALLAWAY PLANT

FIGURE VII.3

REACTOR COOLANT MASS FLOW RATE AND FEEDWATER LINE BREAK FLOW TRANSIENTS FOR MAIN FEEDWATER LINE RUPTURE WITH OFFSITE POWER AVAILABLE




| CALLAWAY PLANT |
| --- |
| FIGURE VII.4<br><br>REACTOR COOLANT TEMPERATURE TRANSIENT FOR MAIN FEEDWATER LINE RUPTURE WITH OFFSITE POWER AVAILABLE |




CALLAWAY PLANT

FIGURE VII.5

STEAM GENERATOR SHELL PRESSURE TRANSIENT FOR MAIN FEEDWATER LINE RUPTURE WITH OFFSITE POWER AVAILABLE

## 2.4 Conclusions

Safety analysis support for the implementation of the TTD/EAM in the Callaway Plant is provided by analyses and evaluations, as described in Section 2.3.1, of the following S/G Low-Low Level trip setpoint and time delay safety analysis limits:

| | |
|---|---|
| Trip Setpoint | 0% of Span |
| 2/4 Steam Generator Logic, 10% RTP Interlock Time Delay | 240 seconds |
| 1/4 Steam Generator Logic, 10% RTP Interlock Time Delay | 240 seconds |
| 2/4 Steam Generator Logic, 20% RTP Interlock Time Delay | 130 seconds |
| 1/4 Steam Generator Logic, 20% RTP Interlock Time Delay | 130 seconds |

Safety analysis design basis calculations which do not assume actuation of protection features to result from the S/G Low-Low Level trip setpoint are unaffected by these SALs. These calculations are discussed in Section 2.3.2.5. Transients which do rely on the S/G Low-Low Level trip were analyzed and evaluated in Sections 2.3.2.1 - 2.3.2.4. A summary of results follows.

Loss of Normal Feedwater:
Cases I, II, III and IV were analyzed to support Technical Specification time delays for the S/G Low-Low Level TTD protection logic power interlocks of 10% and 20% RTP. These part-power cases assumed loss of normal feedwater to one steam generator and four steam generators at transient initial conditions which account for a 9% uncertainty in power level indication.

As the results indicate, the loss of normal feedwater to four steam generator cases (I and III) have incorporated time delays which utilize analysis margin made available by the reduced power assumption and the ANS 1979 Decay Heat Model, without violating the applicable Condition II accceptance criteria. The delays assumed in these analyses, above the 2 seconds allocated from the time of signal transmission to when the rods are free to drop, are as follows:

Case I: LONF to 4 S/Gs for 10% RTP Interlock Delay = 240 sec.

Case III: LONF to 4 S/Gs for 20% RTP Interlock Delay = 130 sec.

Analyses assuming power levels and time delays corresponding to Cases I and III were performed in Cases II and IV, respectively for the loss of normal feedwater to one steam generator. The results for Cases II and IV illustrate the additional margin to the safety analysis acceptance criteria of the partial loss of normal feedwater transient relative to the complete loss of normal feedwater transient.

Therefore, a conservative safety analysis limit for the 10% RTP interlock for either the 1/4 or 2/4 logic would be 240 seconds and a conservative safety analysis limit for the 20% RTP interlock for either the 1/4 or 2/4 logic would be 130 seconds. These safety analysis limits are incorporated into the Protection System Setpoint Study in order to account for instrument and measurment uncertainties and to determine the associated maximum allowable Technical Specification time delays for the 10% and 20% RTP interlocks. The safety analyses will support any 1/4 or 2/4 logic time delays for the 10% and 20% RTP interlocks which are less than or equal to the 240 and 130 second safety analysis limits, minus setpoint study adjustments, respectively. The Protection System Setpoint Study revision is found in Section 4. The full power complete loss of normal feedwater transient was also analyzed. Case VI provides revised results for the FSAR transient incorporating the S/G Low-Low Level trip setpoint SAL of 0% of span and the ANS 1979 Decay Heat Model.

The balance of the safety analysis support for the trip setpoint and time delay SALs is provided by evaluation of other transients which assume protection from S/G Low-Low Level. These transients are identified in Section 2.3 as Loss of Non-emergency AC Power, Feedline Break, and Steamline Break Mass/Energy Release Outside Containment. The impact of the proposed TTD on these transients is discussed in Section 2.3.2 and is summarized below.

Loss of Non-emergency AC Power:
Case V provides revised FSAR results for the full power Loss of Non-emergency AC Power transient assuming the trip setpoint of 0% of span and ANS 1979 Decay Heat. Consistent with the approved safety analysis methodology of WCAP-11325-P-A, the impact of trip time delays at part-power conditions has been evaluated and found to be acceptable.

Steamline Break Mass/Energy Release:
Results of a sensitivity study discussed in Section 2.3.2.4 indicate that the Reference 4, Category 1 steamline break mass/energy release data continues to be applicable to the Callaway Plant assuming the above S/G Low-Low Level trip setpoint and time delay SALs.

Feedline Break:
Conclusions regarding feedline break are made on the basis of the Case VII analysis results and the FSAR Chapter 15.2.8 Feedline Break cases. The FSAR cases assume 0% span and, therefore, do not require reanalysis. Case VII provides confirmation that introduction of the S/G Low-Low Level time delay at part-power does not invalidate the conclusions presented in the FSAR for the Feedline Break transient. Case VII analyzed the feedline break transient at 29% RTP incorporating the associated TTD safety

analysis limit for trip delay time of 130 seconds. The analysis results indicate that all applicable safety analysis acceptance criteria are met. Case VII is a sample case which illustrates that acceptable Feedline Break transient results are achieved at part-powers using the time delays determined through analysis of the complete loss of normal feedwater transient. No further part-power analyses are performed for verification. This case confirms the conclusions presented in WCAP-11325-P-A and WCAP-11342-P-A that acceptable part-power Feedline Break transient results support the TTD/EAM modifications to the S/G Low-Low Level protection system.

In summary, the safety analysis design basis calculations outlined in Section 2.1 have been evaluated or reperformed to support the Callaway implementation of the TTD and EAM concepts as reviewed and approved by the NRC in WCAP-11325-P-A and WCAP-11342-P-A, respectively. Analyses and evaluations were performed to provide the safety analysis basis for Technical Specification limits on the TTD time delays and the EAM normal environment trip setpoint. The applicable safety analysis limits are listed at the beginning of this section. The resulting Protection System Setpoint Study revisions are provided in Section 4.

## 3.0 I&C DESIGN INFORMATION

Two design modifications established by WCAP-11342-P-A, "Modification of the Steam Generator Low-Low Level Trip Setpoint to Reduce Feedwater-Related Trips" (Ref. 1), and WCAP-11325-P-A, "Steam Generator Low Water Level Protection System Modifications to Reduce Feedwater-Related Trips" (Ref. 2), to address inadvertent reactor trips due to steam generator low-low level are, as shown in Figure 1, the Environmental Allowance Modifier (EAM) and the Trip Time Delay (TTD). The following is, on a protection set basis, a functional and implementation description of each.

### 3.1 EAM Functional Implementation

#### 3.1.1 Functional Description

The EAM distinguishes between a normal (containment pressure below the EAM setpoint) or an adverse containment environment (containment pressure above the EAM setpoint) and enables a higher adverse environment steam generator low-low level trip setpoint when an adverse containment condition is sensed by elevated containment pressure. The adverse environment level setpoint is higher due to the inclusion of instrument uncertainties related to the harsh environment. Otherwise, a lower setpoint is used in conjunction with a normal environment. Consequently, the frequency of unnecessary steam generator low-low level related trips will be decreased by increasing the operating margin, the distance between the nominal steam generator level and the normal environment low-low level trip setpoint.

#### 3.1.2 Implementation Description

As shown in Figure 2, the EAM utilizes input signals from the existing containment pressure and steam generator level transmitters. A single comparator card is added to each of the four existing containment pressure channels to enable the steam generator low-low level setpoint corresponding to an adverse environment. The EAM circuitry is designed with a latch-in feature that will ensure that this setpoint remains enabled once an adverse environment has been detected. In order to disable the adverse environment setpoint, it is required that containment pressure decrease below its setpoint and that the switch be manually reset. In addition, the latch-in feature has been interlocked with the EAM comparator channel test switch (Figure 5) [

]$^{a,c}$

The existing steam generator low-low level comparator cards operate with a setpoint corresponding to an adverse environment. Eight new steam generator level double comparator cards (two per protection set with each double comparator card handling two steam generators) will be added. These double comparator cards will operate with a setpoint associated with a normal environment.

## 3.2 TTD Functional Implementation

### 3.2.1 Functional Description

The Trip Time Delay may be generally described as a system of pre-determined programmed trip delay times that are based upon the prevailing power level at the time a low-low level setpoint is reached and upon the number of steam generators that are affected. These delay times are longer at low power versus high power (Figure 3). This correlates to the use of timers, each with a preset value, which detain the actuation of the reactor trip, main feedwater isolation, and initiation of auxiliary feedwater so that steam generator level anomalies such as shrink/swell transients may naturally stabilize.

### 3.2.2 Implementation Description

As shown in Figure 1, the input to the TTD circuitry is the EAM logic output and power level. In order to determine power level, the TTD utilizes the Delta-T signal from the Thermal Overpower and Overtemperature protection channels. Four new dual comparator cards (one per protection set), with setpoints corresponding to two power levels (10% and 20%), are added to the existing Delta-T channel. These dual comparator cards enable the appropriate timer associated with the power level at the time a steam generator low-low level condition is detected.

As shown in Figure 4, once the TTD receives a steam generator low-low level signal from the EAM circuitry, all four timers are started. The timer that determines the delay of the trip actuation signal depends on the applicable logic fulfilled for each timer (an enabled condition). The effective time delay of the trip signal will be the shortest delay of all the enabled timers. Timer A is the effective timer with the conditions of a low-low level signal in any one steam generator and the power level below the low power setpoint of 10%. Timer B is the effective timer with power levels between the low power (10%) and high power (20%) setpoints coincident with a low-low level signal in any one steam generator. Timer C is the effective timer at power levels less than 10% with a low-low level signal in two or more steam generators. Finally, timer D is the effective timer with low-low level signals in two or more steam generators coincident with the power level between 10% and 20%. For power levels above the 20% power setpoint, all time delays are bypassed, thus, the latched-in reactor trip signal is not delayed by the TTD circuitry.

Note that, since all timers are started by a single low-low level trip signal, it is possible for a second steam generator to reach its low-low level trip setpoint after the appropriate multiple low-low level trip delay has expired. In that case, the reactor trip signal would be transmitted without further delay.

Timers, once enabled, must be latched in until all steam generator level signals in a protection set are restored to levels above the low-low level setpoint. Restoration of all steam generator levels to levels above the low-low level setpoint will terminate the timing, reset the timers to their predetermined values, and reset the trip logic signals.

In summary, timer B is interlocked with the low power setpoint. Timer C is interlocked with the two out of four steam generator low-low level logic and timer D is interlocked with both the two out of four level signals as well as the low power setpoint. Moreover, above the 20% power setpoint, there is no TTD delay of the trip actuation signal.

## 3.3 Alarms, Annunciators, Indicators, and Status Lights

Alarms, annunciators, indicators, and status lights are necessary to provide the operator with accurate, complete, and timely information pertinent to the protection system status. Status lights and control board indicators provide the operator with specific information with respect to which individual channels generated the alarm and/or trip condition. Presently, for the steam generator low-low level protection system, sixteen instrumentation channels (one per steam generator, per protection set) are provided. Each level channel is configured with a bistable trip status light which is illuminated on the control board anytime that an enabled bistable trip setpoint has been reached. An alarm and annunciator (one per steam generator) is provided to inform the operator that at least one level channel has dropped below its trip setpoint. If more than one level channel for any one steam generator has fallen below its trip setpoint, a "first out" reactor trip alarm and annunciator is provided to alert the operator that a reactor trip has occurred.

After the EAM/TTD modification has been installed, all of the existing alarms, annunciators, and status lights will continue to function as described. However, since these signals originate at the SSPS voting circuitry, they will not be actuated until all applicable time delays have expired.

Additional alarms and annunciators are provided with the EAM/TTD hardware modification. These are to inform the operator that an adverse environment and/or a steam generator water low-low level has been detected. A new low-low level alarm will be provided for each steam generator to signify that the water level in at least one channel has dropped below the low-low level setpoint in that steam generator [

]$^{a,c}$ The operator may then observe the individual channel steam generator level indicators to determine [

]$^{a,c}$ Finally, a common alarm and annunciator will be provided to indicate the presence of an adverse environment. The input to this window is derived from the four containment pressure channels (one per protection set). The operator may then observe the individual channel containment pressure indicators to determine which channel(s) have the adverse steam generator low-low level setpoint enabled.

### 3.4 Hardware Description

### 3.4.1 Printed Circuit Card Descriptions

Presented below is a list of the printed circuit cards that are required for the EAM/TTD modification. A description of each card will follow.

1. NCT - Channel Test Card
2. NMT - Master Test Card
3. NAL - Comparator Card (single, double, and dual comparator cards)
4. NAI - Annunciator Interface Card
5. NPL - PROM Logic Card

NCT - Channel Test Card

Each process protection instrument channel can be tested while the plant is operating and on-line. This is accomplished with the channel test card by means of switching the outputs of the measuring device to monitoring points and disconnecting the associated trip outputs. This card has test jacks (for signal injection), test points, and proving lamps to verify bistable operation when the channel is in the test mode.

NMT - Master Test Card

The NMT card is used in conjunction with the NCT card to provide for specialized test features. Specifically, this card allows for various testing modes which include on-line testing, transmitter calibration, time response, and RTD cross-calibration.

NAL - Comparator Card (single, double, and dual comparator cards)

The NAL card receives an input signal and provides an output trip signal by comparing the input voltage with an internally adjustable setpoint voltage. Provision is made so that either an increasing (high) or decreasing (low) voltage can initiate action. A deadband adjustment range of 0.5 percent to 20 percent of input span is provided for reset action.

NAI - Annunciator Interface Card

The NAI card provides an interface between the 7300 Series Comparator (NAL) Card and a remote device that requires a contact closure. This card contains comparator driven relay coils whose contacts are used to interface with control board alarms, annunciators, and status lights. This card also serves as a qualified isolation device for interface with nonsafety systems.

NPL - PROM Logic Card

The NPL card is a solid state logic card using eight Programmable Read-Only Memory (PROM) modules to perform logic functions, e.g., OR, AND, and timing functions. Logic functions are implemented by five input, eight output, 256 bit PROMs. Each of the outputs is configured to a particular function of the inputs by combining the miniterms of the desired function. The NPL timer module plugs into the PROM sockets on the NPL card and provides an adjustable range of time delays from 20 milliseconds to 21 minutes and 12 seconds.

### 3.4.2 Reliability

The primary element of the availability of each module in the system is its Mean Time Between Failures (MTBF). MTBF data is derived from the sum of the failure rates of all the individual components that make up the printed circuit card. It can also be measured by observing actual failure histories of modules in service or test set-ups.

Reliability is addressed for the active printed circuit cards which are used to provide for a protective action. The following are the active cards to be added for EAM/TTD and the corresponding MTBFs

| <u>Card</u> | <u>MTBF (hours)</u> |
|---|---|
| NAL | |
| NPL | |

a,b,c

These MTBF values are comparable with the values of all of the other cards used in the 7300 Series Process Protection System. The MTBF values of the components being added for the EAM/TTD modification are sufficiently high such that the reliability of the protection system is not degraded.

## 3.5 Equipment Qualification

### 3.5.1 Program Description

All new hardware utilized for the EAM/TTD modification was previously qualified as part of the 7300 Series Process Protection System. The qualification testing of the 7300 Series Process Protection System, per Westinghouse WCAP-8587 methodology, has demonstrated the equipment's capability to perform its designated safety-related functions when subjected to the seismic and environmental conditions specified in the WCAP-8587 supplements for the 7300 Series Process Protection System.

#### 3.5.1.1 Environmental Testing (IEEE Std. 323-1974)

The hardware was tested under both "normal" and "abnormal" environmental conditions.

Normal:

| | |
|---|---|
| Temperature and | 60-80 Degrees F |
| Relative Humidity (Ranges) | 30-50 % R.H. |

Abnormal:

| | |
|---|---|
| Temperature and | 82 Degrees F, 95% R.H. |
| Relative Humidity (Test Points) | 120 Degrees F, 35% R.H. |

#### 3.5.1.2 Seismic Testing (IEEE Std. 344-1975)

The 7300 Series Process Protection Equipment was subjected to multi-axis, multi-frequency inputs in accordance with Regulatory Guide 1.100. The seismic testing demonstrated the capability of the 7300 Process Protection System to reliably and accurately perform its safety-related functions before, during and after a seismic event. The equipment was subjected to both Operating Basis Earthquakes (OBEs) and Safe Shutdown Earthquake (SSE) events.

3.5.2 EQ Documentation

The overall equipment qualification documentation consists of three sets of documents:

1. WCAP-8587, "Methodology for Qualifying Westinghouse WRD Supplied NSSS Safety Related Electrical Equipment" (Non-Proprietary), describes the Westinghouse program for addressing the requirements of IEEE Std. 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations". The NRC has reviewed and approved WCAP-8587 per the SER dated November 30, 1983. Revision 6-A of WCAP-8587 includes the cover letter of the SER which specifically references the individual WCAP supplements also approved by the SER.

2. WCAP-8587, Supplement 1, "Equipment Qualification Data Packages (EQDPs)", is a compilation of the individual EQDPs provided for each item of equipment qualified per a WCAP-8587 program. Westinghouse developed the EQDP format in order to comply with Section 8 of IEEE Std. 323-1974. Each EQDP summarizes the equipment performance requirements and acceptance criteria (Section 1) and qualification program plans to be employed, whether by test (Section 2), experience (Section 3), by analysis (Section 4) or by some combination of these methods. Upon completion of the equipment's qualification program, the EQDP is issued to summarize the specific test/analysis procedures and results.

   The EQDP addressing the qualification of the 7300 Series Process Protection System is ESE-13. All EQDPs are designated "Westinghouse Class 3"; these serve as the non-proprietary "versions" of the EQTRs.

3. WCAP-8687 is the compilation of the individual Equipment Qualification Test Reports (EQTRs) and is supplement 2 to WCAP-8587. Each EQTR details the qualification testing and/or analysis procedures and results. All EQTRs are designated "Westinghouse Proprietary Class 2" and are considered proprietary to Westinghouse. The EQTRs for the 7300 Process Protection System are referenced as WCAP-8687, Supplement 2- :

   1. E13A, "Process Protection System (Seismic Testing)",
   2. E13B, "Process Protection System (Environmental and Supplemental Seismic Testing)",
   3. E13C, "Process Protection System (Seismic and Environmental Testing of Printed Circuit Cards)",
   4. E13D, "Process Protection System (Supplemental Testing of Power Supplies and Circuit Breakers)".

### 3.6 Surveillance Testing

#### 3.6.1 Test Capability

The 7300 System EAM/TTD modification has been configured to provide surveillance test capability (Figure 5). The EAM/TTD steam generator level protection channels receive input signals from the steam generator level, Delta-T (from Thermal Overpower and Overtemperature protection) and containment pressure channels. The test scheme has been designed such that the EAM/TTD steam generator level channels may be removed from service, one at a time, and tested [

]a,c

In order to provide for safe and efficient testing, a number of test interlocks have been designed into the protection system. The interlocks relative to EAM/TTD are associated with steam generator level, Delta-T, and containment pressure signals. The interlocks are described in detail below.

EAM/TTD Steam Generator Level

The steam generator level portion of the EAM/TTD steam generator level channel is removed from service for test purposes by forcing a trip output signal for every comparator associated with a particular level transmitter. This is done via card edge test switches on an NCT printed circuit card. The test circuitry is designed such that tripping the appropriate comparator test switch outputs will automatically disconnect the associated level transmitters, insert test signal injection points, and insert proving lights downstream of all level comparators. Operation of the level comparators is verified by varying the test injection signals and observing operation of the comparator proving lights located on NCT card edges.

The EAM portion of the EAM/TTD steam generator level channel is removed from service for test purposes by enabling the EAM test interlock. The EAM test interlock will [

]$^{a,c}$ and insert a test signal injection point and a proving light for the EAM comparator. Operation of the EAM comparator is verified by varying the test injection signal and observing operation of the comparator proving light located on the NCT card edge. It should also be noted that the latch-in function for the EAM comparator has been incorporated into the EAM test interlock. [

]$^{a,c}$

Through administrative control of an NMT card and the 7300 system "breakout box", an additional variation of the EAM test interlock is possible. This testing scheme may be used to inject a test signal to the comparator [

]$^{a,c}$

The TTD portion of the EAM/TTD steam genrator level channel is removed from service for test purposes by enabling the TTD test interlock. The TTD test interlock will [

]$^{a,c}$ and insert test signal injection points and proving lights for the Delta-T comparators. Operation of the Delta-T comparators is verified by varying the test injection signal and observing operation of the comparator proving lights located on NCT card edges.

Through administrative control of an NMT card and the 7300 system "breakout box", an additional variation of the TTD test interlock is possible. This testing scheme, again, may be used to inject test signals to these comparators [

]$^{a,c}$

Containment Pressure

A containment pressure transmitter is automatically removed from service for test purposes by 1) forcing a trip output signal for every comparator associated with a particular pressure transmitter except for containment spray actuation, 2) forcing a bypass condition for the containment spray actuation comparator, and 3) enabling the EAM test interlock. The EAM test interlock will [

]$^{a,c}$ and insert a test signal injection point and a proving light for the EAM comparator.

Delta-T

The narrow range hot leg and cold leg RTDs used to determine

Delta-T are automatically removed from the thermal overpower and overtemperature protection channels whenever 1) a trip output signal is forced for all of the comparators in that channel and 2) the TTD test interlock is enabled. The TTD test interlock will [ ]$^{a,c}$ and insert test signal injection points and proving lights for the Delta-T comparators in the TTD circuitry.

### 3.6.2 Test Methodology

#### 3.6.2.1 Monthly Tests

As required in the Callaway Technical Specifications, periodic tests for the steam generator low-low level channels are carried out on a quarterly basis in accordance with the Reactor Trip System (RTS) Instrumentation Surveillance Requirements and on a monthly basis consistent with the Engineered Safety Features Actuation System (ESFAS) Instrumentation Surveillance Requirements. Since the ESFAS surveillance requirements are more restrictive than those for the RTS, the EAM/TTD steam generator level channels will be tested on a monthly basis.

In order to test the EAM/TTD steam generator level channels, [

]$^{a,c}$ The level channels may now be tested one-at-a-time to verify one-out-of-four operation, and with various combinations of two-at-a-time to verify two-out-of-four operation. The EAM and Delta-T comparators will also be tested at this time.

[

]^a,c After the normal environment comparators have been tested, monthly testing of the EAM/TTD timers is required for the surveillance testing to be complete.

Through the use of an NMT card and the 7300 Series System "breakout box", a variation of the TTD test interlock will be performed. This aforementioned test variation will allow injecting test signals to the Delta-T comparators [ ]^a,c Upon simulation of a steam generator low-low level, as previously described, the operability and accuracy of the PROM logic timer modules are verified. The timer operability test is necessary due to the failure modes of the NPL card; all but one of the failure modes were evaluated to be immediately detectable by the operator. The one exception is the failure of a timer chip which could prevent a required trip signal from being actuated. The timer accuracy test is necessary due to the Technical Specification corresponding to the testing of the process racks in the plant. The Callaway Technical Specifications require the analog channel operational testing of the steam generator low-low level channel on a monthly basis. This test is the injection of a simulated signal into the channel as close to the sensor as practicable to verify operability of an alarm, interlock and/or trip functions. This test shall include adjustments as necessary of the alarm, interlock and/or trip setpoint such that the setpoints are within the required range and accuracy. Since the time delay of the TTD timers is considered to be a setpoint, the TTD timers will also be tested for accuracy as part of the monthly channel tests.

3.6.2.2 Outage Tests

[

]^a,c

### 3.7 Applicable I&C Criteria

The following criteria apply to this system.

#### 3.7.1 Nuclear Regulatory Commission

3.7.1.1 10CFR50, Appendix A — General Design Criteria for Nuclear Power Plants

| | |
|---|---|
| Criterion 1 | Quality Standards and Records |
| Criterion 2 | Design Bases for Protection Against Natural Phenomena |
| Criterion 3 | Fire Protection |
| Criterion 4 | Environmental and Dynamic Effects Design Bases |
| Criterion 10 | Reactor Design |
| Criterion 13 | Instrumentation and Control |
| Criterion 15 | Reactor Coolant System Design |
| Criterion 19 | Control Room |
| Criterion 20 | Protection System Functions |
| Criterion 21 | Protection System Reliability and Testability |

| | | |
|---|---|---|
| | Criterion 22 | Protection System Independence |
| | Criterion 23 | Protection System Failure Modes |
| | Criterion 24 | Separation of Protection and Control Systems |
| | Criterion 29 | Protection Against Anticipated Operational Occurrences |
| | Criterion 34 | Residual Heat Removal |
| 3.7.1.2 | 10CFR50, Appendix B | Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants |
| 3.7.1.3 | 10CFR21 | Reporting of Defects and Noncompliance |

3.7.1.4 Regulatory Guides

| | |
|---|---|
| Regulatory Guide 1.22 | Periodic Testing of Protection System Actuation Functions |
| Regulatory Guide 1.38 | Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water Cooled Nuclear Power Plants |

| | |
|---|---|
| Regulatory Guide 1.47 | Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems |
| Regulatory Guide 1.53 | Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems |
| Regulatory Guide 1.62 | Manual Initiation of Protective Actions |
| Regulatory Guide 1.75 | Physical Independence of Electric Systems |
| Regulatory Guide 1.89 | Qualification of Class 1E Equipment for Nuclear Power Plants |
| Regulatory Guide 1.100 | Seismic Qualification of Electric Equipment for Nuclear Power Plants |
| Regulatory Guide 1.105 | Instrument Setpoints |
| Regulatory Guide 1.118 | Periodic Testing of Electric Power and Protection Systems |

3.7.2 Institute of Electrical and Electronic Engineers (IEEE) Standards

| | |
|---|---|
| IEEE Std. 279-1971 | Criteria for Protection Systems for Nuclear Power Generating Stations |
| IEEE Std. 323-1974 | Qualifying Class 1E Equipment for Nuclear Power Generating Stations |
| IEEE Std. 338-1977 | Criteria for Periodic Testing of Nuclear Power Generating Station Safety Systems |
| IEEE Std. 344-1975 | Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations |
| IEEE Std. 379-1977 | Application of the Single Failure Criterion to Nuclear Power Generating Station Class 1E Systems |
| IEEE Std. 384-1974 | Criteria for Independence of Class 1E Equipment and Circuits |

### 3.7.3 Compliance with IEEE Std. 279-1971

The referenced criteria establish the minimum requirements for the safety-related functional performance and reliability of the EAM/TTD in the protection system. The following is a discussion of the EAM/TTD compliance with Section 4 of IEEE Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations".

#### 3.7.3.1 General Functional Requirement

The EAM/TTD modification will not degrade the protection system capability to automatically initiate appropriate protective action whenever a condition monitored by the system reaches a preset level.

#### 3.7.3.2 Single Failure Criterion

For the EAM/TTD modification, the protection system single failure criterion is fulfilled through the use of a level input for each steam generator in each of the four protection sets. Should a single failure of either a protection set or a transmitter associated with a steam generator occur, redundant hardware is available to provide the proper protective action at the system level.

#### 3.7.3.3 Quality of Components and Modules

The quality of the equipment associated with EAM/TTD is consistent with the quality of the current protection system equipment. The reliability of the equipment is discussed in Section 3.4.2.

3.7.3.4 Equipment Qualification

The EAM/TTD equipment is environmentally and seismically qualified in accordance with the current Westinghouse qualification program. The methodology of this program is contained in WCAP-8587, Rev. 6-A, "Methodology for Qualifying Westinghouse WRD Supplied NSSS Safety Related Electrical Equipment". This program has been developed and implemented in accordance with the requirements of IEEE Std. 344-1975, "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations", and IEEE Std. 323-1974, "Qualifying Class 1E Equipment for Nuclear Power Generating Stations". More background is presented in Section 3.5.

3.7.3.5 Channel Integrity

With the addition of the EAM/TTD components, the existing channel integrity continues to maintain necessary functional capability under extreme conditions (as applicable) relating to environment, energy supply, malfuctions, and accidents.

3.7.3.6 Channel Independence

With the addition of the EAM/TTD hardware, independence and physical separation between the four protection sets and train-oriented signals continue to be maintained as described in Callaway FSAR Section 7.1.2.2. Channel independence is maintained throughout the process protection system, extending from the sensor up to the Solid State Protection System at which point two independent Engineered Safety Feature Actuation System and Reactor Trip trains are maintained. Physical separation is used to achieve separation of redundant transmitters. Separation of wiring is achieved using separate wireways, cable trays, conduit runs, and containment penetrations for each redundant channel. Redundant process equipment, including the EAM/TTD hardware, is separated by locating modules in different protection cabinets. Each redundant protection channel set is energized from a separate ac power feed.

3.7.3.7 Control and Protection System Interaction

For the EAM/TTD modification, there is no control and protection system interaction (i.e., only protection channels used for the EAM/TTD modification). All existing interfaces between the protection and control systems remain intact and are not affected by the modification.

3.7.3.8 Derivation of System Inputs

The steam generator level, containment pressure, and narrow range temperature inputs continue to be derived from direct measures of the desired variable. There are no new protection system inputs required for the EAM/TTD modification.

3.7.3.9 Capability for Sensor Checks

Means are provided for checking the operational availability of each system input sensor during reactor operation. The operational availability of each system input sensor during reactor operation is accomplished by cross checking between channels that bear a known relationship to each other and that have readouts available. The EAM/TTD modification will not impact existing schemes for verifying sensor availability.

3.7.3.10 Capability for Test and Calibration

Capability for test and calibration of the steam generator level channels including the EAM/TTD modification is provided. These channels have been configured to provide for overlap testing to verify total system operability. Testing is performed at the 7300 system instrumentation racks by individually introducing dummy input signals into the instrumentation channels and observing the tripping of the appropriate output bistables. Process analog output to the logic circuitry is interrupted during individual channel test by a test switch which, when thrown, inserts a proving lamp in the bistable output, and deenergizes the associated Solid State Protection System (SSPS) logic input. Each channel contains those switches and test points necessary to test the channel. Before starting any of these tests with the plant at power, all redundant reactor trip channels associated with the function to be tested must be in the normal (untripped) mode in order to avoid spurious trips. A detailed description of periodic surveillance test features is provided in Section 3.6.

3.7.3.11 Channel Bypass or Removal from Operation

Two options, coincidence logic or channel bypass, would satisfy the intent of this requirment. The protection system, including the EAM/TTD modification, is designed so as to permit periodic testing of the steam generator level channels during reactor power operation without initiating a protective action, unless a trip condition actually exists. The coincidence logic in the Solid State Protection System (SSPS) required to initiate a reactor trip fulfills the first option. The second option, operation with a channel in the bypass mode, is not anticipated and thus, not provided for in the protection system.

3.7.3.12 Operating Bypasses

Operating bypasses in the existing protection system are not impacted by the addition of the EAM/TTD modification.

3.7.3.13 Indication of Bypasses

Indication of the bypasses in the existing protection system is not impacted by the addition of the EAM/TTD modification.

3.7.3.14 Access to Means of Bypassing

Access to means for bypassing in the existing protection system is not impacted by the addition of the EAM/TTD modification.

3.7.3.15 Multiple Setpoints

By incorporating the EAM/TTD circuitry, there is a need for additional setpoints. The EAM modification requires four additional level bistables (one per steam generator) per protection set. These bistables are for the low-low steam generator level setpoint associated with a normal containment environment. The existing bistable setpoints include an environmental allowance uncertainty and will be used for the steam generator low-low level corresponding to an adverse containment environment. For an adverse environment a containment pressure alarm and annunciator is provided to indicate the more restrictive setpoint is to be enabled. Other positive means of assuring that the more restrictive setpoint is used when necessary is provided by design verification, equipment qualification, installation testing, and periodic surveillance testing.

3.7.3.16 Completion of Protective Action Once It Is Initiated

The existing protection system is designed so that, once initiated, the protective action at the system level (SSPS) shall go to completion. Return to normal operation requires subsequent deliberate operator action. These design features remain unaffected with the addition of the EAM/TTD circuitry.

3.7.3.17 Manual Initiation

The existing protection system design for manual initiation of each protective action at the system level (for example, reactor trip, main feedwater isolation, auxiliary feedwater actuation, etc.) is unaffected by the addition of the EAM/TTD circuitry.

3.7.3.18 Access to Setpoint Adjustments, Calibration, and Test Points

The EAM/TTD as part of the protection system is designed to allow administrative control of access to all setpoint adjustments, module calibration adjustments, and test points.

3.7.3.19 Identification of Protective Actions

The EAM/TTD modification is a part of the existing protection system design which provides for the indication and identification of protective actions down to the channel level through the use of annunciators, indicators, and status lights.

3.7.3.20 Information Read-Out

The existing protection system is designed to provide the operator with accurate, complete, and timely information pertinent to its own status and generating station safety. The EAM/TTD design provides for alarms and annunciators in a manner which is consistent with the existing protection system design.

3.7.3.21 System Repair

The EAM/TTD circuitry, consistent with the existing protection system, is designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

3.7.3.22 Identification

All printed circuit cards utilized for the EAM/TTD modification are provided with labels which identify the proper protection cabinet, card frame, and card slot locations for installation. This is in accordance with the existing protection system technique for identification of equipment.

### 3.8 Conclusions

The incorporation of the Environmental Allowance Modifier (EAM) and the Trip Time Delay (TTD) into the Callaway 7300 Process Protection System satisfies all applicable I&C safety requirements. All of the components to be added in the EAM/TTD are commensurable with those used in the existing process protection system. Therefore, based on the information presented in this report, the proposed EAM/TTD modification, as implemented in the 7300 Process Protection System, is deemed to be an acceptable means for reducing unnecececessary reactor trips associated with the condition of a steam generator low-low water level.

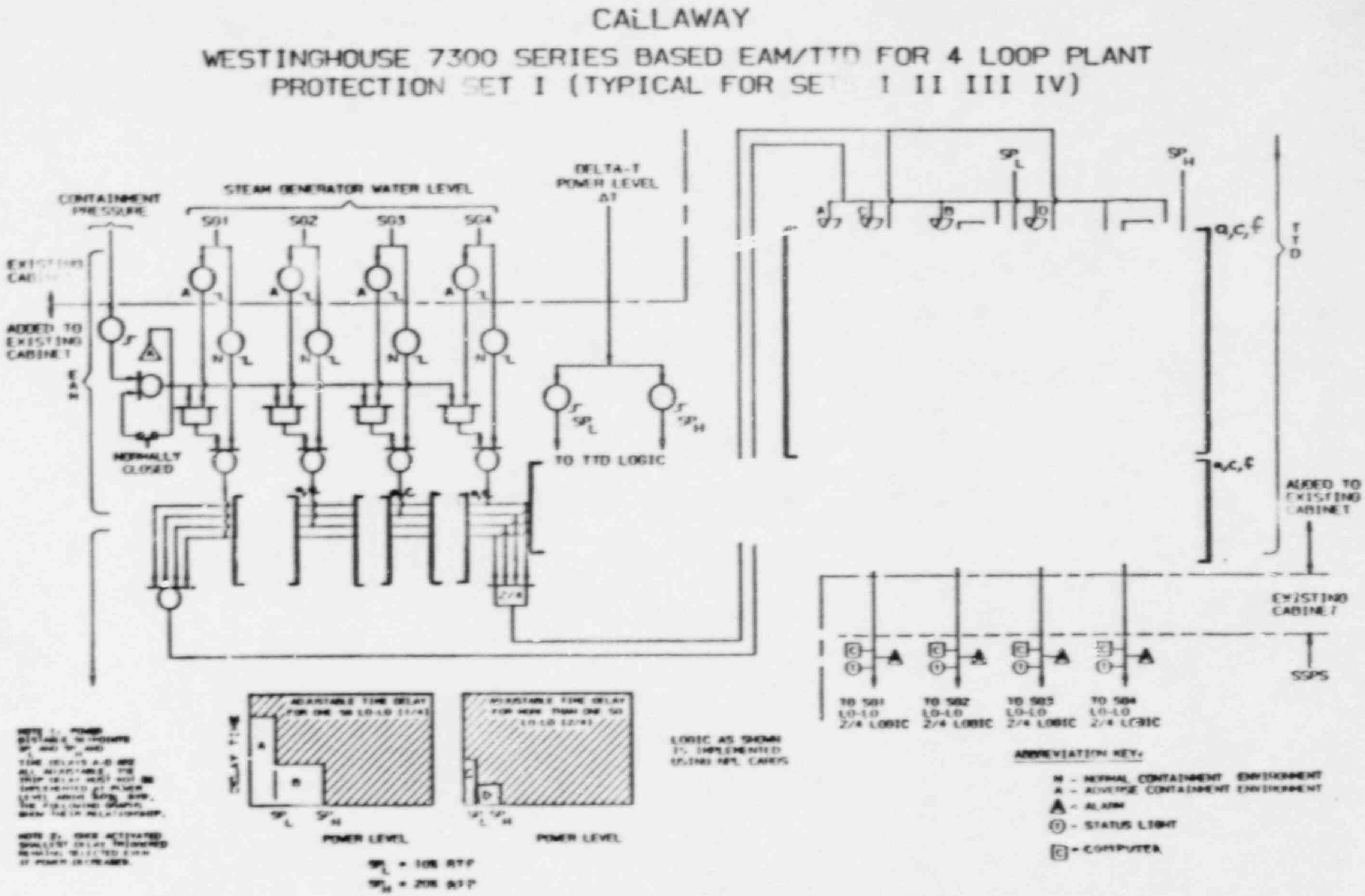



**Figure 1: EAM/TTD Logic Diagram**

052-A-26027-1

CALLAWAY

WESTINGHOUSE 7300 SERIES BASED EAM/TTD FOR 4 LOOP PLANT
PROTECTION SET I (TYPICAL FOR SETS I II III IV)

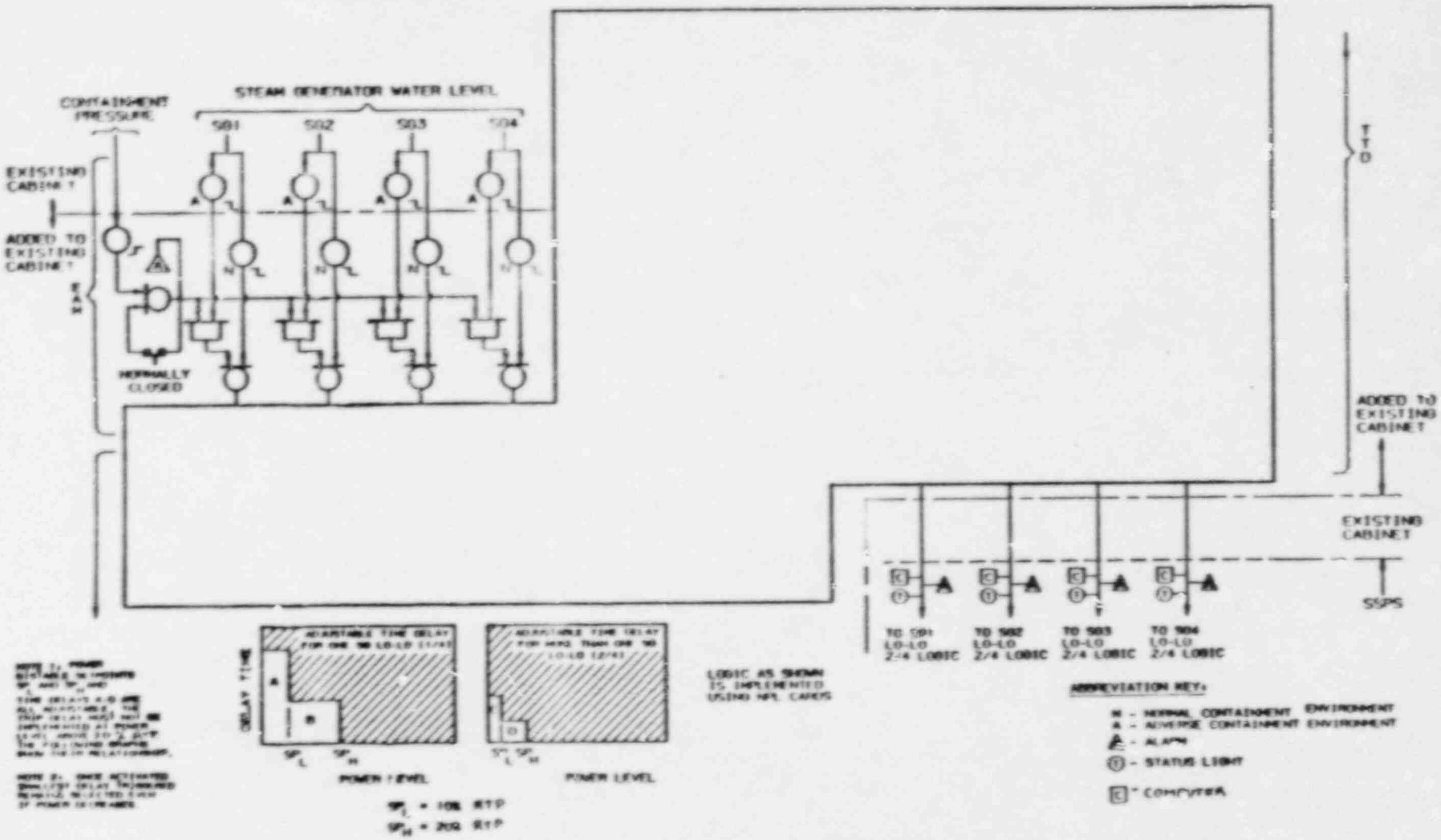



**Figure 2: EAM Logic Diagram**

052-A-26027-2

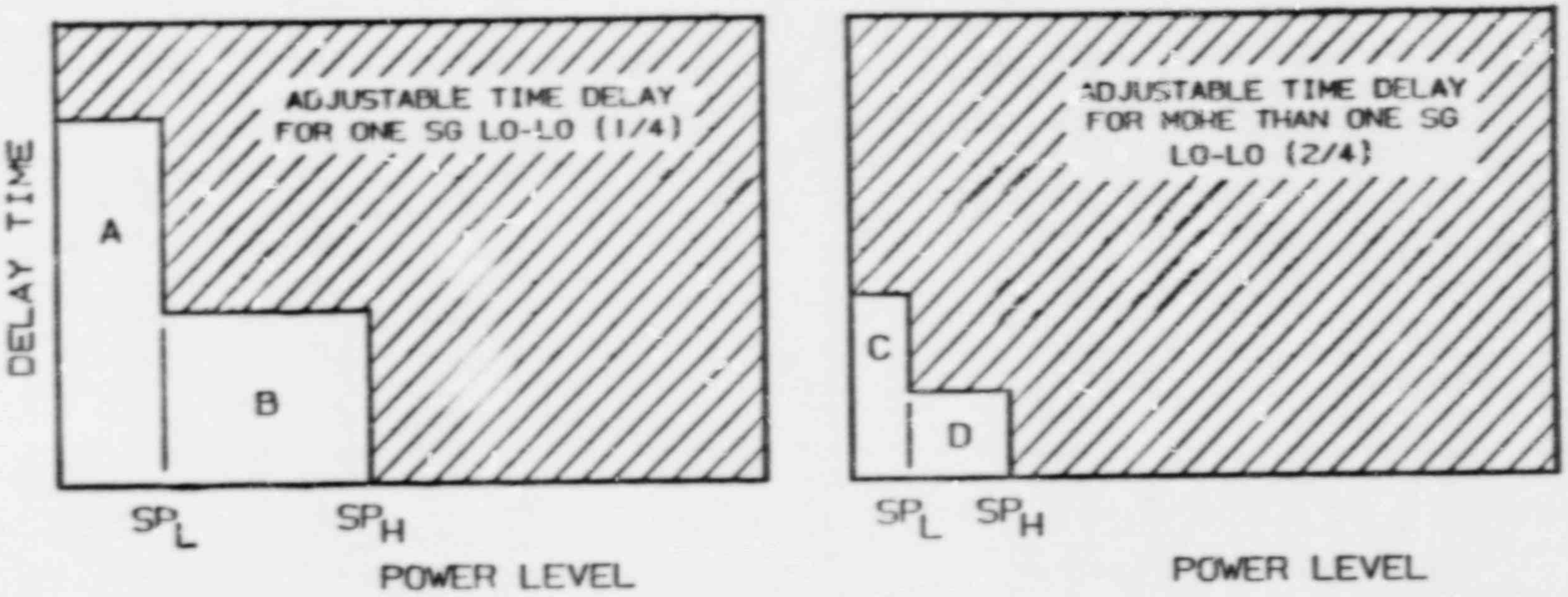



**Figure 3: Possible Delay Time vs. Power Level**

852-A-26027-4

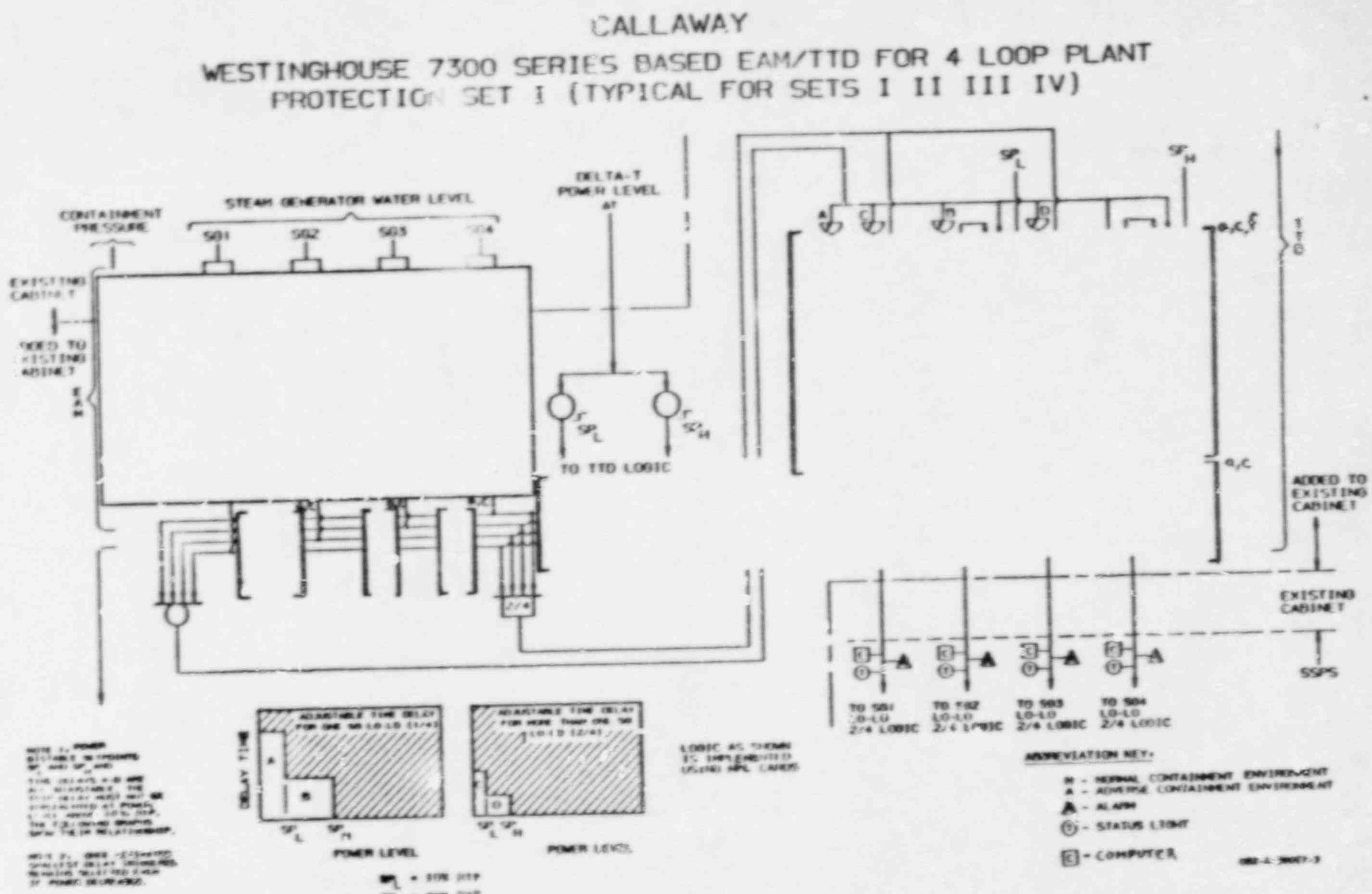



Figure 4: TTD Logic Diagram

052-A-26027-3

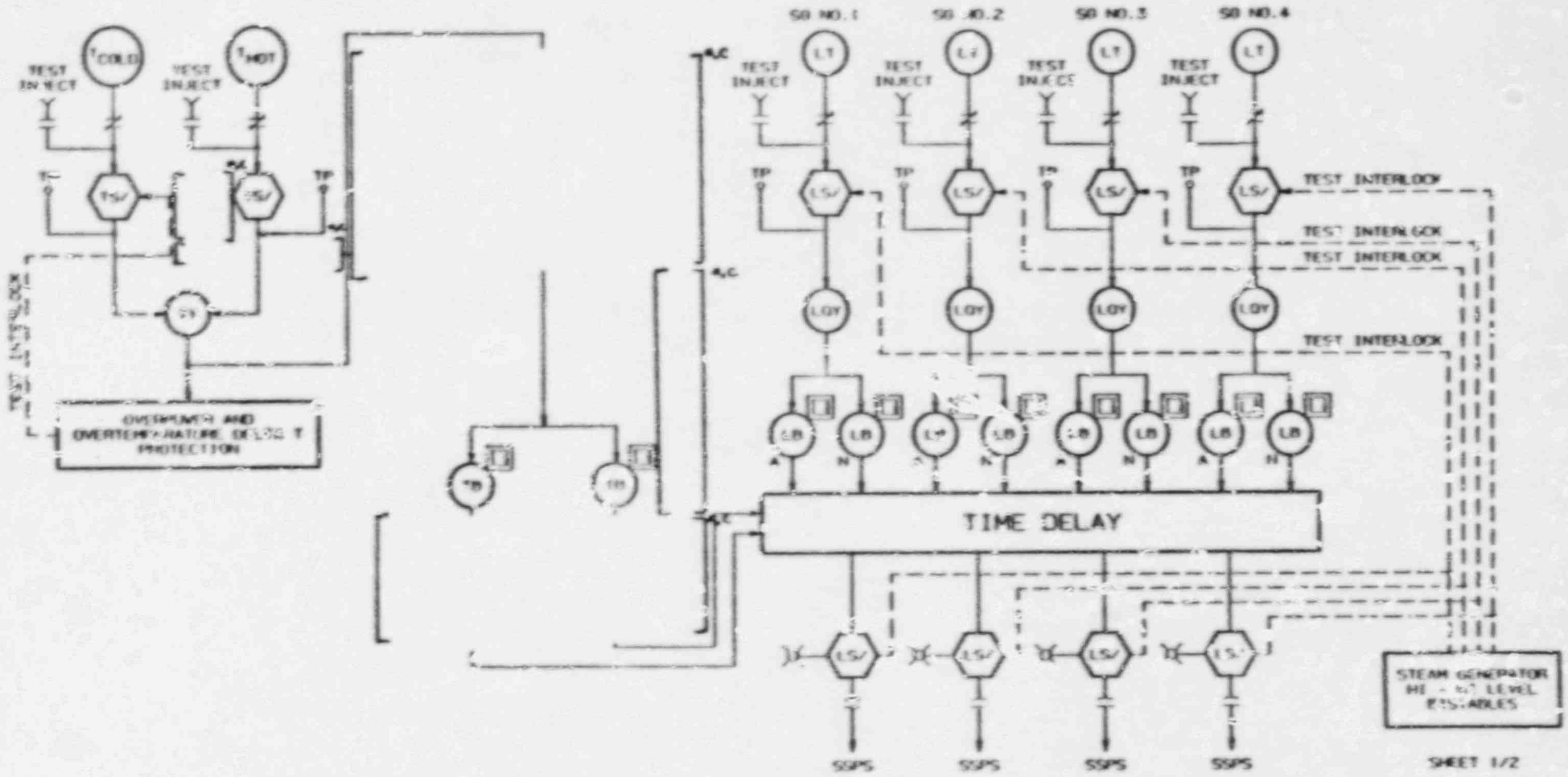



**Figure 5: EAM/TTD Test Logic**

052-A-26027-5

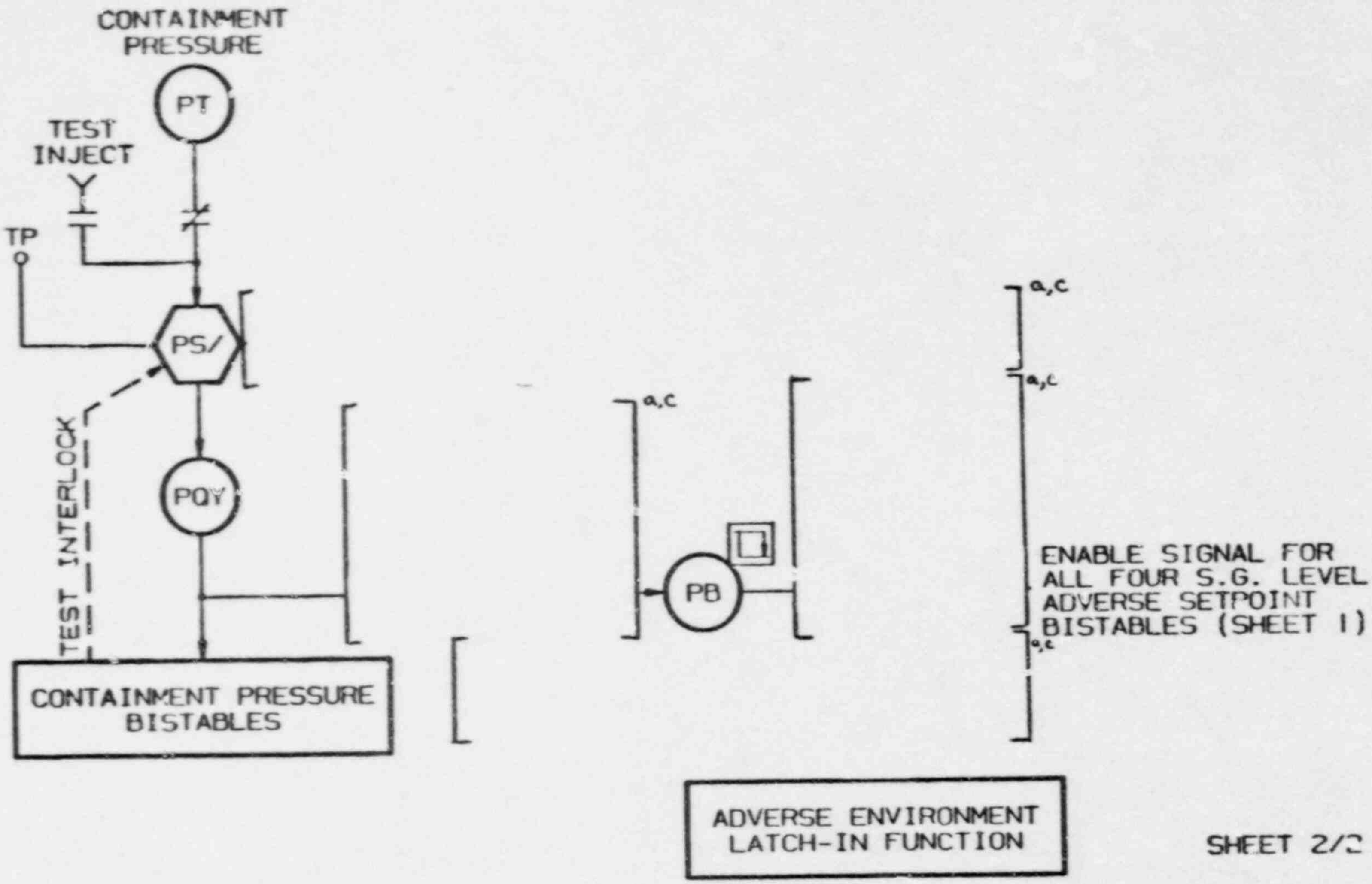



Figure 5 (cont.): EAM/TTD Test Logic

052-A-26

## 4.0 PROTECTION SYSTEM SETPOINT STUDY

Instrument loop uncertainty calculations were performed to confirm necessary Technical Specification values. The methodology used is essentially the same as that noted in report, "Westinghouse Setpoint Methodology for Protection Systems - Callaway." Some minor differences can be noted in the treatment of RTD and R/E uncertainties which reflect the latest methods for use of Delta-T instead of Tavg. The implementation of the TTD requires that two sets of Vessel Delta-T and Time Delay setpoints be noted in the Technical Specifications, one set (Power - 1) for Vessel Delta-T less than or equal to the equivalent of 10.0 % Rated Thermal Power (RTP) and one set (Power - 2) for Vessel Delta-T less than or equal to the equivalent of 20.0 % RTP. The inclusion of the EAM results in two trip setpoints for Steam Generator Water Low-Low Level, one for a maximum containment ambient temperature of 230 $^{O}$F (Normal) and a second that reflects a maximum containment ambient temperature of 320 $^{O}$F (Adverse). The uncertainty analyses performed reflect these ambient conditions.

Changes are required in the Technical Specifications to reflect the addition of the EAM/TTD. Uncertainty calculations were performed and are documented in the following tables for:

Steam Generator Water Low-Low Level -- Normal (containment ambient temperatures 80 to 230 $^{O}$F),

Steam Generator Water Low-Low Level -- Adverse (containment ambient temperatures 230 to 320 $^{O}$F),

Containment Pressure - EAM (uncertainties used in coincidence with Steam Generator Water Low-Low Level -- Adverse)

Delta-T (Power - 1 and Power - 2) (Vessel Delta-T used in coincidence with Steam Generator Water Low-Low Level -- Normal or Adverse).

It should be noted that the Reactor Protection Sy[illegible] and ESFAS time responses noted on Tables 3.3-2 and 3.3-5 for Steam Generator Water Low-Low Level reflect the coincidence with Vessel Delta-T greater than the equivalent of 20 % RTP. The time delays associated with the use of the TTD are noted on Tables 2.2-1 and 3.3-4. The Trip Setpoints noted reflect the uncertainties associated with the generation of the time delays.

TABLE 4-1

STEAM GENERATOR WATER LEVEL - LOW-LOW -- "NORMAL"

| Parameter | Allowance* |
|---|---|
| | +a,c |
| Process Measurement Accuracy<br>Density variations with load ** | |
| Primary Element Accuracy | |
| Sensor Calibration Accuracy<br>Measurement & Test Equipment Accuracy | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance<br>Transmitter<br>Reference Leg Heatup (corresponds to 215 °F)<br>Loop Insulation Resistance | |
| Rack Calibration<br>Rack Accuracy<br>Measurement & Test Equipment Accuracy | |
| Rack Comparator Setting Accuracy<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |

* In % span (100 % span)
** Table 3-27 "Westinghouse Setpoint Methodology for Protection Systems - Callaway".

Channel Statistical Allowance =

[ ] +a,c

TABLE 4-2

STEAM GENERATOR WATER LEVEL - LOW-LOW -- "ADVERSE"

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | +a,c |
| Density variations with load ** | |
| Primary Element Accuracy | |
| Sensor Calibration Accuracy | |
| Measurement & Test Equipment Accuracy | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Transmitter | |
| Reference Leg Heatup (corresponds to 265 °F) | |
| Loop Insulation Resistance | |
| Rack Calibration | |
| Rack Accuracy | |
| Measurement & Test Equipment Accuracy | |
| Rack Comparator Setting Accuracy | |
| One input | |
| Rack Temperature Effects | |
| Rack Drift | |

* In % span (100 % span)

** Table 3-27 "Westinghouse Setpoint Methodology for Protection Systems - Callaway".

Channel Statistical Allowance =

[ ]+a,c

TABLE 4-3

CONTAINMENT PRESSURE - EAM

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| Primary Element Accuracy | |
| Sensor Calibration Accuracy<br>Measurement & Test Equipment Accuracy | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy<br>Measurement & Test Equipment Accuracy | |
| Rack Comparator Setting Accuracy<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>(0.7 psig) | |

[ ]+a,c

* In % span (69 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 4-4

DELTA-T (POWER - 1 & POWER - 2)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]$^{+a,c}$ | [ ]$^{+a,c}$ |
| Primary Element Accuracy | |
| Sensor Calibration Accuracy<br>[ ]$^{+a,c}$<br>Measurement & Test Equipment Accuracy | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift<br>[ ]$^{+a,c}$ | |
| Environmental Allowance<br>Loop Insulation Resistance (+ 0.7 $^{o}$F)(100/87.0) | |
| Rack Calibration<br>[ ]$^{+a,c}$<br>Measurement & Test Equipment Accuracy<br>[± 0.1 % of 120 $^{o}$F span - R/E converter]$^{+a,c}$<br>Rack Accuracy<br>[ ]$^{+a,c}$ | |
| Rack Comparator Setting Accuracy<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |

---

* In % Delta-T Span = 87 $^{o}$F = 150 % RTP

TABLE 4-4 (Continued)

DELTA-T (POWER - 1 & POWER - 2)

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 4-5

CALLAWAY SAM/TID

| PROTECTION CHANNEL | 1 PROCESS MEASUREMENT ACCURACY (1) | 2 PRIMARY ELEMENT ACCURACY (1) | 3 CALIBRATION ACCURACY (1) | 4 MEASUREMENT & TEST EQUIP ACCURACY (1) | 5 PRESSURE EFFECTS (1) | 6 TEMPERATURE EFFECTS (1) | 7 DRIFT (1) | 8 ENVIRONMENTAL ALLOWANCE (1) | 9 CALIBRATION ACCURACY (1) | 10 MEASUREMENT & TEST EQUIP ACCURACY (1) | 11 COMPARATOR SETTING ACCURACY (1) | 12 TEMPERATURE EFFECTS (1) | 13 DRIFT (1) | 14 SAFETY ANALYSIS LIMIT (2) | 15 STS ALLOWABLE VALUE | 16 STS TRIP SETPOINT | 17 TOTAL ALLOWANCE* (1) | 18 CHANNEL STATISTICAL ALLOWANCE (1) | 19 MARGIN (1) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 STEAM GENERATOR WATER LEVEL - LOW-LOW -- "NORMAL" | | | | | | | | | | | | | 1.0 | 0.0 % Span | 13.2 % Span | 14.8 % Span | 14.8 | | |
| 2 STEAM GENERATOR WATER LEVEL - LOW-LOW -- "ADVERSE" | | | | | | | | | | | | | 1.0 | 0.0 % Span | 18.4 % Span | 20.2 % Span | 20.2 | | |
| 3 DELTA-T -- POWER - 1 | | | | | | | | | | | | | 1.6 | 19.0 % RTP | 14.0 % RTP | 10.0 % RTP | 6.0 | | |
| 4 DELTA-T -- POWER - 2 | | | | | | | | | | | | | 1.0 | 20.0 % RTP | 24.0 % RTP | 20.0 % RTP | 0.0 | | |
| 5 CONTAINMENT PRESSURE - SAM | | | | | | | | | | | | | 1.6 | 3.0 psig | 2.2 psig | 1.5 psig | 3.3 | | |

Columns 1–8: SENSOR; columns 9–13: INSTRUMENT RACK.

NOTES

1. All values in % span.
2. Not noted in Table 15.0-4 of FSAR but used in Safety Anal: is.
3. M&TE for R/E (noted in Column 10) i: included in the determ'nation o: this value.

TABLE 4-6

WESTINGHOUSE PROTECTION SYSTEM STS SETPOINT INPUTS

CALLAWAY EAM/TTD

| | PROTECTION CHANNEL | TOTAL ALLOWANCE (TA) (%) | (A) (%) (1) | (S) (%) (2) | (T) (%) (3) | (Z) (%) (4) | INSTRUMENT SPAN | STS TRIP SETPOINT | STS ALLOWABLE VALUE | MAXIMUM VALUE (6) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | STEAM GENERATOR WATER LEVEL - LOW-LOW -- "NORMAL" | 14.8 | [ ]+a,c | 2.0 | 1.4 | 12.18 | 100 % Span | 14.8 % Span | 13.8 % Span | 14.2 % Span | 1 |
| 2 | STEAM GENERATOR WATER LEVEL - LOW-LOW -- "ADVERSE" | 20.2 | | 2.0 | 1.8 | 17.58 | 100 % Span | 20.2 % Span | 18.4 % Span | 18.6 % Span | 2 |
| 3 | DELTA-T -- POWER - 1 | 6.0 | | 2.0 | 2.7 | 2.28 | 150 % RTP | 10.0 % RTP | 14.0 % RTP | 12.4 % RTP | 3 |
| 4 | DELTA-T -- POWER - 2 | 6.0 | | 2.0 | 2.7 | 2.30 | 150 % RTP | 20.0 % RTP | 24.0 % RTP | 22.4 % RTP | 4 |
| 5 | CONTAINMENT PRESSURE - EAM | 3.3 | | 2.0 | 1.2 | 0.71 | 60 psig | 1.5 psig | 2.3 psig | 1.9 psig | 5 |

## NOTES FOR TABLE 4-6

(1) $A = (PMA)^2 + (PEA)^2 + (SPE)^2 + (STE)^2 + (RTE)^2$

(2) $S = SCA + SD$

[ ] +a,c

(3) $T_1 = RCA + RMTE + RCSA + RD$

$T_2 = TA - (A + (S_1)^2 + (S_2)^2)^{1/2} - EA$

$T_3 = ((RCA_1 + RMTE_1 + RCSA_1 + RD_1)^2 + (RCA_2 + RMTE_2 + RCSA_2 + RD_2)^2)^{1/2}$

$T$ = minimum of $T_1$, $T_2$ or $T_3$

(4) $Z = (A)^{1/2} + EA$

(5) All values in % Span

(6) This column provides the maximum value for a bistable assuming that the transmitter is not evaluated and the values for S, Z and TA from this table are used in the following equation: $R = TA - Z - S$. This implies that the transmitter is assumed to be at its maximum allowed calibration and drift deviation in the non-conservative direction. With a bistable's Trip Setpoint found in excess of the value noted in this column, it is possible (but not known absolutely) that a channel would be considered inoperable. This must be tempered by the transmitter assumption noted above, i.e., the transmitter is assumed to be at its worst acceptable condition.

Acronyms as defined in "Westinghouse Setpoint Methodology for Protection Systems - Callaway."

## 5.0 References


1. WCAP-11342-P-A, Rev. 1, Modification of the Steam Generator Low-Low Level Trip Setpoint to Reduce Feedwater-Related Trips, April 1988.

2. WCAP-11325-P-A, Rev.1, Westinghouse Owners' Group Trip Reduction and Assessment Program: Steam Generator Low Water Level Protection System Modifications to Reduce Feedwater-Related Trips, February 1988.

3. Revision OL-2 of the Callaway Plant Final Safety Analysis Report

4. WCAP-10961-P, Steamline Break Mass/Energy Releases for Equipment Environmental Qualification Outside Containment - Report to the Westinghouse Owners' Group High Energy Line Break/ Superheated Blowdowns Outside Containment Subgroup, October 1985.

5. ANSI/ANS-5.1-1979, "American National Standard for Decay Heat Power in Light Water Reactors," August 1979.