WESTINGHOUSE CLASS 3

WCAP-11426

UNION ELECTRIC COMPANY

CALLAWAY PLANT

NSSS UPRATING - 3579 MWT

LICENSING REPORT

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REFERENCES

1) R. H. McFetridge, R. T. Marchese, and R. H. Faas, A Review Plan for Uprating the Licensed Power of a Pressurized Water Reactor Power Plant, WCAP-10263, January 1983.

2) ULNRC-1207, Callaway OFA Licensing Submittal, November 15, 1985.

3) ULNRC-1247, Callaway BART LOCA for OFA Submittal, January 28, 1986.

4) ULNRC-1470, Callaway V5 Licensing Submittal, March 31, 1987.

5) SLNRC-86-06, MSLB Superheat Effects on Equipment Qualification, April 4, 1986.

OBJECTIVES

The Callaway Plant is currently licensed to operate at a core thermal power of 3411 MWt (3425 MWt NSSS). This report supports the Union Electric application to the Nuclear Regulatory Commission for approval to operate the Callaway Plant at 3565 MWt core thermal power (3579 MWt NSSS). A safety evaluation of NSSS design, operations and analyses has been performed to provide the following information relevant to that application:

1. A description of the proposed change in the licensed power rating of the Callaway Plant.

2. An assessment of the impact of that change on NSSS equipment designs, safety analyses, and systems operations.

3. A technical basis for establishing that the proposed increase in power rating does not involve an unreviewed safety question in accordance with requirements of 10 CFR 50.59.

SUMMARY

The proposed increase in the licensed power rating of the Callaway Plant has been reviewed in detail with respect to its impact on the following aspects of NSSS design and operation:

1. The consequences of accidents postulated in the FSAR.

2. The capability of systems and equipment to meet design bases specified in the FSAR.

3. The capability of equipment to maintain structural integrity under conditions defined in the FSAR.

4. Definition of NSSS/BOP safety-related interfaces.

5. Operating limits and conditions contained in Technical Specifications that are impacted by the power rating increase.

This review has demonstrated that the Callaway Plant is capable, in its present design configuration, of operating at the proposed power rating and remains in compliance with the design criteria and safety limits specified in the FSAR for NSSS systems and equipment, provided the plant is operated in accordance with the Technical Specification changes proposed in Attachment 2 of the Callaway Uprating Submittal. The review has verified the following:

1. The probability of an accident previously evaluated in the FSAR will not be increased.

2. The consequences of an accident previously evaluated in the FSAR will not be increased.

3. The possibility of an accident which is different than any already evaluated in the FSAR will not be created.

4. The probability of a malfunction of NSSS equipment important to safety, previously evaluated in the FSAR, will not be increased.

5. The consequences of a malfunction of NSSS equipment important to safety, previously evaluated in the FSAR, will not be increased.

6. The possibility of a malfunction of NSSS equipment important to safety, different from any already evaluated in the FSAR, is not created by operation at the uprated power.

7. The margin of safety as defined in the bases to any technical specification will not be reduced by operation at the uprated power.

Therefore, it has been concluded that operation of the Callaway Plant at the increased power rating does not reduce the NSSS safety margins, and does not involve an unreviewed question as defined by 10 CFR 50.59.

SECTION 1
INTRODUCTION

Union Electric has conducted a program to increase the electrical output of the Callaway Plant. The current phase of the program is directed toward gaining approval from the USNRC to operate the plant at a slightly increased power level. At present, the Callaway Plant is licensed to operate at a core thermal power rating of 3411 MWt. Union Electric is applying for an amendment to the operating license to permit operation of the Callaway Plant at 3565 MWt (core thermal power), an increase of 4.5%.

As a part of the program to uprate the Callaway Plant, Union Electric authorized Westinghouse to perform a review of the NSSS systems and equipment designs to verify their capability to meet requirements for operation at 3579 MWt. The review was conducted in accordance with groundrules and criteria put forth in the Westinghouse topical report WCAP-10263, A Review Plan for Uprating the Licensed Power of a Pressurized Water Reactor Power Plant (Reference 1). (This WCAP methodology was followed by both North Anna and Salem for their recent core power upratings.) A summary of the guidelines used in the NSSS design review follow:

1. Scope of Review

   The review encompassed all aspects of the Callaway NSSS design and operation which were impacted by the power increase.

2. Safety Review Acceptance Criteria

   NSSS designs have been reviewed at the uprated power level to verify continued compliance with licensing criteria and standards currently required by the Callaway operating license. In addition, a review has been made as defined in 10 CFR 50.59 to identify any potential unreviewed safety question that might occur as a result of the increased power rating.

3. Structural Review Acceptance Criteria

The structural design of NSSS equipment was reviewed at the increased power rating to assure that compliance has been maintained with industry codes and standards that applied when the equipment was originally built.

4. Functional Capability

A review has been made to verify that NSSS components and systems will continue to meet the functional requirements specified in the FSAR at the increased power rating.

5. Analytical Techniques

Current NRC approved analytical techniques have been used for analyses performed at the increased power rating.

6. Balance of Plant Interfaces

Information provided by Westinghouse to other design groups has been reviewed and revised when impacted by the increase in power rating.

Although Union Electric is applying for a license amendment to operate the Callaway Plant at 3565 MWt (core thermal power), many of the Callaway FSAR analyses and evaluations have already been performed at the engineered safety features design rating of 3579 MWt. To maintain a consistent basis between information reported here and that reported by reference to the FSAR, this evaluation of NSSS capability has also been performed at 3579 MWt. When the term "uprated power" is used in this report, it should be understood to mean 3579 MWt.

SECTION 2
COMPARISON OF PARAMETERS

At the present time, the Callaway Plant is licensed to operate at a core thermal power rating of 3411 MWt (3425 MWt NSSS). This amendment application requests approval to operate the plant at a power rating of 3565 MWt (3579 MWt NSSS). The calculated secondary side steam pressure at these conditions is 950 psia.

Table 2-1 contains a summary of Reactor Coolant System design parameters for the originally licensed conditions of the Callaway Plant, as well as parameters calculated for the increased power rating. A comparison of the two sets of parameters follows:

1. NSSS Power

   The requested changes would raise the NSSS power from its current level of 3425 MWt to 3579 MWt, an increase of 4.5%. This relates to an increase of the licensed core power from 3411 MWt to 3565 MWt.

2. Reactor Coolant Flow and Tube Plugging

   At uprated power conditions, the Callaway Plant will operate at 3579 MWt with a range of 1000 psia to 950 psia steam pressure with 0% to 10% of the steam generator tubes plugged. Table 2-1 lists primary plant parameters for the uprated power operating conditions, for both 10% and 15% Steam Generator Tube Plugging. The 15% steam generator tube plugging parameters constitute the conservative analytical basis for all of the Chapter 15 FSAR uprating analyses and evaluations except for the events associated with an increase in heat removal by the secondary system (Chapter 15.1) and those associated with an increase in RCS inventory (Chapter 15.5). The analytical basis for these events was 10% steam generator tube plugging. These events were analyzed at the uprated power level for Cycle 2 OFA licensing report and explicit reanalyses were not required for the VANTAGE 5 licensing report. The uprating licensing amendment assumes a 10% tube plugging level.

3. Reactor Coolant Temperatures

   Reactor coolant temperatures for the 3579 MWt NSSS power rating do not differ significantly from those for the current 3425 MWt NSSS power level. However, the higher power level and reduced flow rate are reflected by a slightly greater temperature rise in the coolant as it passes through the reactor vessel (see Figure 2-1).

4. Steam Pressure and Temperature

   Operation at 3579 MWt NSSS requires an increase in steam generator heat transfer rate, which is obtained by increasing the temperature difference between reactor coolant and secondary plant steam and by increasing the steam flow rate. Since reactor coolant temperatures for 3579 MWt NSSS operation are nearly the same as those for 3425 MWt NSSS operation, it follows that the higher power rating will be obtained at a lower steam temperature. Steam pressure (saturation pressure at the steam temperature) will be correspondingly lower.

5. Steam Flow

   Steam flow at the 3579 MWt NSSS conditions has increased over the 3425 MWt NSSS conditions roughly in proportion to the thermal power increase.

Comparison of the parameters given in Table 2-1 indicates that the operating conditions proposed for future 3579 MWt NSSS operation do not vary significantly from those at which the Callaway Plant is currently operating.

Figure 2-1 is a graphical comparison of the reactor vessel cold leg, hot leg, and vessel average temperatures as a function of power for both the current

TABLE 2-1

CALLAWAY POWER CAPABILITY PARAMETERS

	Originally Licensed Power	Uprated Power (10% SGTP)	Uprated Power (15% SGTP)
NSSS Power, MWt	3425	3579	3579
Reactor Power, MWt	3411	3565	3565
Thermal Design Flow, Loop gpm	95,700	93,600	93,600
Reactor Flow, Total, 10^6 lbm/hr	142.1	139.4*	139.4*
Reactor Coolant Pressure, psia	2250	2250	2250
Reactor Coolant Temperatures, °F			
Core Outlet	621.4	623.7	623.7
Vessel Outlet	618.2	620.0	620.0
Core Average	591.8	592.2	592.2
Vessel Average	588.5	588.4	588.4
Vessel/Core Inlet	558.8	556.8	556.8
Steam Generator Outlet	558.6	556.6	556.6
Steam Generator			
Steam Temperature, °F	544.6	538.4	537.0
Steam Pressure, psia	1000	950	939
Steam Flow, 10^6 lbm/hr Total	15.1	15.9	15.9
Feedwater Temperature, °F	440	446	446
Zero Load Temperature, °F	557	557	557
Percent Tube Plugging	0	10	15
Core Bypass Percent	5.8	6.3**	6.3**

*Based on T_{IN} = 556.8°F and 2250 psia

**Increased bypass flow is due to VANTAGE 5 fuel design, not uprating.

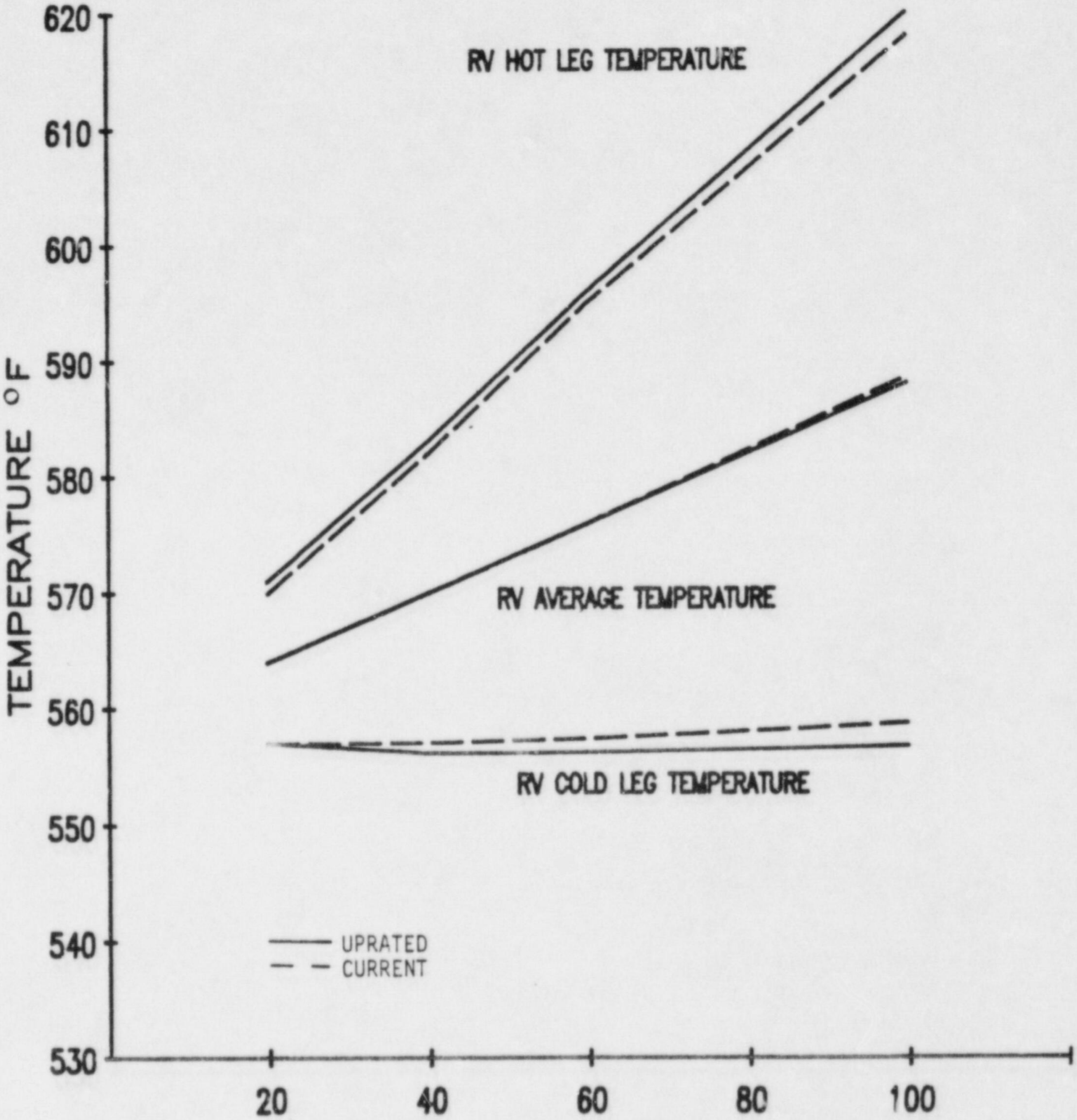


Figure 2-1. Reactor Coolant Temperatures vs. Percent Rated Load

3425 MWt NSSS operating conditions and the proposed 3579 MWt NSSS operating conditions. This figure shows that the Reactor Coolant System temperatures for 3579 MWt NSSS operation do not differ significantly from those for the original 3425 MWt NSSS operation throughout the power range.

SECTION 3
ACCIDENT ANALYSIS REVIEW

3.1 NON-LOCA EVENTS

All FSAR Chapter 15 Non-LOCA safety analyses applicable to the Callaway Plant and performed by Westinghouse have been analyzed or evaluated in support of the uprated NSSS power of 3579 MWt. Results of these analyses and evaluations are presented in the Callaway OFA (Ref. 2) and VANTAGE 5 (Ref. 4) fuel licensing submittal reports. All applicable safety analysis acceptance criteria have been satisfied.

3.2 LOCA EVENTS

Both the Large and Small Break LOCA ECCS analyses applicable to the Callaway Plant and performed by Westinghouse have been analyzed at the uprated NSSS thermal power of 3579 MWt. Results of these analyses are presented in the Callaway OFA (Ref. 2 and 3) and VANTAGE 5 (Ref. 4) fuel licensing submittal reports. All applicable safety analysis acceptance criteria have been satisfied.

3.3 HOT LEG SWITCHOVER

An analysis has been performed for the Callaway Plant to determine the maximum boron concentration in the reactor vessel following a hypothetical LOCA. This analysis considered Callaway with an uprated NSSS thermal power rating of 3579 MWt and maximum boric acid concentration of 2100 ppm in the RWST and accumulators and 2000 ppm in the RCS.

The analysis considers the increase in boric acid concentration in the reactor vessel during the long term cooling phase of a LOCA, assuming a conservatively small effective vessel volume. This volume includes only the free volumes of the reactor core and upper plenum below the bottom of the hot leg nozzles. This assumption conservatively neglects the mixing of boric acid solution with directly connected volumes, such as the reactor vessel lower plenum. The calculation of boric acid concentration in the reactor vessel considers a cold leg break of the reactor coolant system in which steam is generated in the core from decay heat while the boron associated with the boric acid solution is completely separated from the steam and remains in the effective vessel volume.

The results of the analysis show that the maximum allowable boric acid concentration of 23.53 weight percent established by the NRC, which is the boric acid solubility limit less 4 weight percent, will not be exceeded in the vessel if hot leg recirculation is initiated 18 hours after the LOCA inception. The operator should reference this switchover time against the reactor trip/SI actuation signal. The typical time interval between the accident inception and the reactor trip/SI actuation signal is negligible when compared to the switchover time.

Procedures philosophy assumes that it would be very difficult for the operator to differentiate between break sizes and locations. Therefore one hot leg switchover time is used to cover the complete break spectrum.

3.4 HYDRAULIC FORCES

The effect of the uprating on the LOCA Hydraulic Forcing Functions was evaluated. The uprating effect was shown to result in an approximate 2% increase in the peak X-directional force acting on the vessel, with a resulting force of approximately 6.962×10^6 Lb_f. The LOCA Hydraulic Forcing Functions are based on a break area of 144 square inches. However per WCAP-9643, Callaway's actual maximum break area is 73 square inches. The application of a more conservative break area of 80 square inches to the analysis results in a decrease of approximately 25% which more than offsets the effect of the uprating. Therefore, the effects of the uprating in combination with the credit for the break area reduction result in Hydraulic Forcing functions which are bounded by the original analyses.

SECTION 4
NSSS COMPONENTS IMPACT

4.1 BASIS FOR EVALUATION

The mechanical design of NSSS equipment has been reviewed to assure that structural integrity of the plant will be maintained under conditions specified in the FSAR when the Callaway Plant is operated at the uprated power. The review was performed in accordance with the following guidelines:

1. The review encompassed all aspects of the Callaway Plant NSSS equipment mechanical design which were impacted by the power increase.

2. The review was performed in accordance with licensing criteria and standards currently applicable to the Callaway Plant.

3. Equipment mechanical designs were evaluated against the original industry design codes and standards to which the equipment was built.

4. Current techniques have been used for those analyses required in the course of the NSSS equipment review.

These are the criteria put forth in WCAP-10263 as a basis for reviewing the mechanical design of NSSS equipment during an uprating safety evaluation.

4.2 EQUIPMENT REVIEWS

4.2.1 Reactor Vessel

To assess the impact of the uprating on the reactor vessel design and operation, the vessel stress report and fracture mechanics analyses were reviewed. This review verified that the existing reactor vessel stress analysis bounds the uprated conditions, so the reactor vessel remains in compliance with the currently applicable codes and standards.

A separate review was performed to assess the reactor vessel fracture mechanics. It was based on the following inputs:

1. The end-of-life fluence levels were calculated for the uprated conditions and low leakage fuel. Assuming 32 effective full power years, the total fluence at the end-of-life at the reactor vessel inner radius is 1.95×10^{19} n/cm^2.

2. The original design transients applicable for the Callaway Plant are unchanged.

3. Generic fracture mechanics evaluations have been performed at a power level that bounds the uprated power to evaluate the effect of a large steamline break, large LOCA, and small LOCA transients on reactor vessel integrity. These evaluations indicate that the proposed power increase will not significantly change the results of the reactor vessel integrity evaluation.

Review of the reactor vessel fracture mechanics has indicated that operation at the uprated power conditions is bounded by the original design criteria.

4.2.2 Reactor Internals

The reactor vessel internals review for the uprated conditions included three separate areas: a thermal assessment, a hydraulic assessment, and a structural assessment. The review indicated that the original reactor internals design remains in compliance with the current FSAR design requirements when operating at the uprated power conditions.

Since the design transients for the uprated power are bounded by those used for the original reactor internals design, only components which are directly influenced by the core radiation heat generation need be structurally evaluated. These components are the baffle-barrel-former region, the upper core plate and the lower core plate. Results of the reactor internals evaluations and analyses are summarized as follows:

1. The increase in the core bypass flow is not associated with the power increase, but results from the mechanical design of the VANTAGE 5 fuel.

2. Because of the decrease in fluid density at the uprated conditions, hydraulic lift forces and resultant loadings are bounded by those at the conditions used in the original reactor internals design.

3. The potential for flow induced vibrations is not increased.

4. Stresses and fatigue usage factors for components in the baffle-barrel-former region of the internals are bounded by the original analysis.

5. Stresses and fatigue usage factors for the upper and lower core plates are bounded by analyses performed for other plants using the same core plate design.

Based on these evaluations and analyses, the Callaway reactor internals remain in compliance with the requirements of all applicable design criteria as defined in the FSAR.

4.2.3 Reactor Coolant Pumps

Review of the reactor coolant pump design indicated that operating conditions for 3579 MWt operation are bounded by the original thermal and structural design analyses.

4.2.4 Control Rod Drive Mechanisms

Review of the control rod drive mechanism design showed that operating conditions for 3579 MWt operation are bounded by the original thermal and structural design analyses.

4.2.5 Reactor Coolant Piping

The stress analyses for the reactor coolant loop, reactor coolant loop bypass, and pressurizer surge line piping were reviewed for the 3579 MWt operating conditions. The review demonstrated that piping stresses and support loads at the uprated conditions remain in compliance with the requirements of all applicable design criteria as defined in the FSAR.

4.2.6 Pressurizer

Review of the pressurizer design verified that operating conditions for 3579 MWt NSSS operation are bounded by the original thermal and structural design analyses.

As indicated in Section 5.2.1, review of the Reactor Coolant System design has established that the existing pressurizer safety valves and power operated relief valves are adequate for operation at the uprated conditions.

4.2.7 Steam Generators

Modifications to the model F series steam generator stress report have been made using a set of operating parameters which bound conditions for the Callaway Plant at 3579 MWt NSSS operation. The ASME Boiler and Pressure Vessel Code, Section III 1971 Edition with Addenda to and including Summer 1973, was used to determine acceptable states of stress for the components. The evaluation established that the model F series steam generator stress report satisfies all applicable ASME Code requirements when updated to the enveloping set of plant operating parameters. An appendix to that report shows that the Callaway operating parameters for 3579 MWt NSSS are conservatively bounded by the enveloping parameters.

4.2.8 Reactor Coolant System Supports

Uprating of the Callaway Plant to 3579 MWt has a negligible impact on the Westinghouse supplied portion of the Reactor Coolant System supports. It was established in Section 4.2.5 that design loads on the supports remain in compliance with the requirements of all applicable design criteria as defined in the FSAR.

4.2.9 Nuclear Fuel

Fuel performance evaluations completed for each fuel region demonstrate that the design criteria will be satisfied for all fuel in the core under the planned operating conditions. These fuel rod design evaluations were performed using the currently NRC-approved model PAD 3.3 (WCAP-8720, October, 1976).

4.2.10 Auxiliary Systems Components

The Callaway auxiliary systems components supplied by Westinghouse were evaluated based on a comparison of the original design requirements to the systems design requirements at the uprated conditions. In each case the conditions used in the original design enveloped those required for operation of the Callaway Plant at 3579 MWt NSSS.

4.3 CONCLUSIONS

Review of Callaway equipment designs that are impacted by the power uprating has shown that in most cases requirements for operation at the higher power are enveloped by either the original Callaway design, or by the generic component design. In a few cases, it has been necessary to perform additional design calculations to verify the capability of a component for operation and compliance with the original design codes and standards at the uprated conditions. In every case, however, it has been shown that the NSSS equipment originally provided for the Callaway Plant is capable of operation at 3579 MWt NSSS without modification.

SECTION 5
NSSS SYSTEMS REVIEW

5.1 BASIS OF EVALUATION

NSSS systems designs have been reviewed to verify that they will remain in compliance with the functional requirements specified in the FSAR when the Callaway Plant is operated at the increased power rating. That review was performed in accordance with the following guidelines:

1. The review encompassed all aspects of the Callaway NSSS design and operation which were impacted by the power increase.

2. The review was performed in accordance with licensing criteria and standards which currently apply to the Callaway Plant.

3. Current techniques have been used for those analyses required in the course of the NSSS review.

These are the criteria put forth in WCAP-10263 that apply to the review of the design and operation of NSSS systems and components.

5.2 SYSTEMS EVALUATION

5.2.1 Fluid Systems

Westinghouse has evaluated the impact of uprating the Callaway Plant to 3579 MWt on the reactor coolant system and the auxiliary fluid systems listed in Table 5-1. The only system which is impacted is the performance of the residual heat removal system for plant cooldown. As a result of the higher decay heat associated with the power uprating, plant cooldown times will increase slightly. Operation of the Residual Heat Removal System is initiated at a reactor coolant temperature of 350°F, approximately four hours after reactor shutdown. The original 16 hour plant design cooldown time from 350°F

TABLE 5-1

SYSTEMS REVIEWED FOR UPRATING IMPLEMENTATION

1. Reactor Coolant - (BB)

2. Chemical and Volume Control - (BG)

3. Residual Heat Removal - (EJ)

4. High Pressure Coolant Injection - (EM)

5. Accumulator Safety Injection - (EP)

6. Containment Hydrogen Control - (GS)

to 140°F will now require 19.3 hours. However, this increase in plant cooldown time is not considered to be significant; safety requirements are still satisfied with respect to a single train cooldown under accident conditions. No changes have been recommended for the RHR heat exchangers or for the required tubeside or shellside flow rates. The changes in plant cooldown performance for the residual heat removal system as a result of the uprating have been reflected in Table 5-2.

Changes in pressure, temperature, and flow rate around the reactor coolant loops are so small that there is essentially no impact on pressurizer spray capability, pressurizer safety and relief valve discharges, pressurizer surge line capability, and RTD bypass delay time.

5.2.2 Control Systems

Based on Reactor Coolant System operating parameters for the uprated power conditions, studies were performed to assess operating margin and control system capability. The capability of the NSSS control systems (e.g., rod control, steam dump, pressurizer pressure, and level control) was found to be adequate for operation at the uprated power. Minor changes to the T_{ref} program which feeds the rod control, steam dump control, and pressurizer level control have been identified for operation at the uprated power based on these studies.

5.2.3 Protection Systems

The protection system setpoint changes necessary for the uprating (OTΔT and OPΔT) were incorporated as part of Cycle 2 (Ref. 2). The VANTAGE 5 licensing submittal (Ref. 4) contains additional changes to Technical Specification Table 2.2-1 which are due to the combined effects of VANTAGE 5 fuel, the uprating, and 15% steam generator tube plugging.

5.2.4 AMSAC

The AMSAC operating bypass setpoint, C-20, is currently set at 40% of nominal turbine load or 1370 MWt. This setpoint is based on analyses which

TABLE 5-2

CALLAWAY PLANT COOLDOWN FOR 3579 MWt

Time After Shutdown (Hours)	Reactor Coolant Temp °F	RHR Heat Exchanger Parameters Heat Load Per Heat Exchanger 10^6 Btu/hr	on Component Cooling Water Inlet Temp. (°F)	Outlet Temp. (°F)
4.0	350.0			
5.0	300.0	118.0	116.6	147.6
6.0	250.0	115.0	116.0	146.3
7.0	205.0	93.5	112.4	137.0
8.0	183.0	74.5	109.2	128.8
9.0	172.8	65.7	107.7	125.0
10.0	167.5	61.3	106.8	123.0
11.0	164.5	58.7	106.5	121.8
12.0	162.4	57.0	105.9	120.9
13.0	160.8	55.7	105.6	120.3
14.0	155.9	51.6	104.9	118.4
15.0	150.0	46.5	103.9	116.2
16.0	147.0	44.0	103.4	115.0
17.0	145.3	42.6	103.1	114.3
18.0	144.1	41.6	102.8	113.8
19.0	143.1	40.9	102.6	113.4
20.0	142.3	40.3	102.4	113.0
21.0	141.5	39.6	102.3	112.7
22.0	140.8	39.0	102.2	112.5
23.0	140.1	38.4	102.1	112.2
23.3	140.0	38.2	102.1	112.2

demonstrate that in the event of a loss of heat sink ATWS occurring at that power level, the resulting peak reactor coolant system pressure would be below the Level C acceptance criteria of 3200 psig and that bulk RCS boiling would not occur. The analyses were performed for a limiting plant configuration as described in WCAP-8330 and in Westinghouse letter NS-TMA-2182 "ATWS Submittal" from T. M. Anderson to S. Hanauer (NRC), Dec., 1979. The Callaway Plant with a power level of 3425 MWt is enveloped by this limiting plant configuration. At the uprated power level conditions of 3579 MWt, Union Electric will set the C-20 setpoint at (or below) the same absolute power level, 1370 MWt, or approximately 38.3% of the uprated turbine load.

5.3 CONCLUSIONS

Review of NSSS systems design and operating capability has verified that they will remain in compliance with the functional requirements specified in the FSAR when the Callaway Plant is operated at the increased power rating. A few system parameters and setpoints have been revised to reflect operation at the higher power, but those operating conditions have been shown to be within the design capability of the systems as they currently exist.

SECTION 6
NSSS/BOP INTERFACES

6.1 INTRODUCTION

To coordinate the NSSS review with the Balance of Plant (BOP) review, a program was established to examine plant design data in those areas where the power uprating could have an impact on the BOP design. This section presents the results of that evaluation. In addition, Westinghouse investigated the impact on the performance requirements for the systems identified in Table 6-1. The review indicated that the current system performance requirements remain applicable at the uprated conditions.

6.2 MASS AND ENERGY RELEASE DATA

The original Loss of Coolant Accident data for containment integrity evaluations was based on an NSSS power rating of 3579 MWt. This data remains applicable since this is the uprated power. The original steamline break mass and energy release analyses for containment integrity were performed for various power levels up to 3425 MWt NSSS power. Additional cases had to be performed at 3579 MWt NSSS power. These calculations were performed using current Westinghouse methodology. As such, superheated steam is modeled and no credit is taken for entrainment. All other modeling assumptions are consistent with the current FSAR Section 6.2.1.4 text. Results are discussed in Appendix B of Attachment 5 to the Callaway Uprating submittal.

A separate review has been performed to assess the effects on equipment qualification of steamline breaks outside containment with superheated blowdowns. This review used the mass and energy release information developed by Westinghouse and reported in WCAP-10961-P. The effects of uprating to 3579 MWt were considered in this EQ review. (Ref. 5.)

6.3 AUXILIARY FEEDWATER SYSTEM

The design basis transients and accidents that govern the Auxiliary Feedwater System (AFS) performance requirements were specifically performed as part of

TABLE 6-1

SYSTEM PERFORMANCE REQUIREMENTS REVIEWED FOR UPRATING IMPLEMENTATION

1. Reactor Makeup Water - (BL)
2. Borated Refueling Water Storage - (BN)
3. Containment Spray - (EN)
4. Containment Atmosphere Control - (GR)
5. Containment Purge - (GT)
6. Gaseous Radwaste - (HA)
7. Liquid Radwaste - (HB)
8. Solid Radwaste - (HC)
9. Boron Recycle - (HE)
10. Reactor Protection System - (SB)
11. Reactor Instrumentation - (SC)
12. Ex-Core Neutron Instrumentation - (SE)
13. Reactor Control - (SF)
14. Incore Neutron Instrumentation - (SR)

the Callaway Cycle 2 reload analysis and it was demonstrated that the existing AFS requirements are unchanged by the uprating.

6.4 RADIATION SOURCE TERMS

The radiological source terms were evaluated as part of the Cycle 3 reload analysis at the uprated power level. (Ref. 4)

6.5 COMPONENT COOLING WATER INTERFACE REQUIREMENTS

Interface requirements for the component cooling water system have been evaluated. The only heat load which changes for Westinghouse supplied equipment is the load to the residual heat removal heat exchanger. Operation of the residual heat removal system is initiated at a reactor coolant temperature of 350°F approximately four hours after reactor shutdown. At this point in plant cooldown, both RHR heat exchangers are capable of removing a heat load composed of decay heat generated by the reactor core plus heat input from the reactor coolant pumps, plus sensible heat released by a 50°F/hr plant cooldown. The increased power level from the uprating means that the core decay heat load will increase in proportion to the core power rating.

For "Plant Shutdown at Four Hours," the heat load for each of the residual heat exchangers should increase from the current value of 116×10^6 BTU/HR per heat exchanger to 118×10^6 BTU/HR per heat exchanger. Note that the fractional increase in the residual heat removal heat load is less than the fractional increase in core power because the core power affects only a portion of the residual heat removal heat load.

The component cooling water requirements for the RHR heat exchangers remain unchanged. This is consistent with calculated plant cooldown performance for the uprated conditions under the assumption that shellside cooling water flow rates would remain unchanged.

There are no other impacts on component cooling water from Westinghouse designed systems.

CALLAWAY UPRATING SUBMITTAL

ATTACHMENT 5: APPENDICES

APPENDIX B

BOP UPRATING - LICENSING REPORT

SECTION I - BECHTEL REVIEW

BOP UPRATING LICENSING REPORT

I. INTRODUCTION

The Callaway Plant is currently licensed to operate at a core power level of 3411 MWt. Union Electric has proposed uprating the plant to the 3565 MWt core power level (3579 MWt NSSS).

In order to determine the impact of uprating on the existing design and identify the required modifications, if any, a feasibility study was conducted. The feasibility study demonstrated that no hardware modifications are required to achieve the uprated NSSS power level of 3579 MWt.

For the feasibility study Bechtel used the Valves Wide Open (VWO) heat balance (Figure 1) as the basis for reviewing system and component performance. For final implementation, Bechtel evaluated performance using the VWO heat balance, but with the modified pressure, temperature, and flow from cases shown in Table 1. These cases reflect extreme conditions which might be encountered should the full 3579 MWt be obtainable (as opposed to being limited to the VWO heat balance power of 3562 MWt).

Table 2 contains a breakdown of systems that Bechtel reviewed for final implementation. System review includes confirmation that all design criteria envelop the uprating parameters; confirmation that all stress analyses are adequate for the new conditions; and that the components meet new operational criteria.

This report summarizes the results of the final implementation review.

II. SUMMARY AND CONCLUSION

The BOP systems listed in Table 2 were reviewed to determine the impact of uprating the Callaway Plant from the current licensed core power level of 3411 MWt to 3565 MWt. The review consisted of comparing the existing design with the performance requirements at the uprated power level and determining if modifications were required to the plant and the documentation. Bechtel evaluated performance using the VWO heat balance but with the modified pressure, temperature, and flow from cases shown in Table 1. These cases reflect extreme conditions which might be encountered should the full 3579 MWt be obtainable (as opposed to being limited to the VWO heat balance power of 3562 MWt). Operating data was also reviewed to assure that the plant will be able to achieve the uprated power level. This was necessary because the operating data could be significantly different from the design conditions.

The impact on containment pressures and temperatures following a main steam line break was evaluated: four (4) main steam line break cases at 102% of uprated power level were analyzed and the effect on equipment qualification was checked.

The turbine-generator system is designed to operate at 3562 MWt power. The performance of the system will be monitored closely by U.E. between 3562 MWt and 3579 MWt power.

In conclusion, all the secondary side systems were reviewed, and it was concluded that, with the exception of the turbine-generator system, they have the capability to function properly at the uprated power level of 3579 MWt NSSS power without any modifications to the existing design.

III. SYSTEM EVALUATION

Main Feedwater System

The main feedwater system consists of the feedwater pumps, high pressure feedwater heaters, feedwater flow control valves, and associated piping. The feedwater pumps take suction from the condensate system and from the heater drain pumps and discharge through the high pressure heaters to the steam generators.

At an uprated power level of 3579 MWt, the extreme conditions for the main feedwater system would occur when no steam generator tubes are plugged. The temperature and flow under this condition would be 446°F (max.) and 15.96×10^{6} lb/hr (17,743 gpm) respectively. The design temperature for the feedwater system is 444.5°F, and the design flow is 15.85×10^{6} lb/hr (17,620 gpm). Therefore, at an uprated power level, the feedwater system will see a rise in temperature of 1.5°F and a flow increase of less than 1 percent from the previous VWO design flow.

The effect of such a small increase in flow on the flow velocities, system pressure drop and the high pressure heater performance will be negligible. For the small change in flow, there will be no impact on the performance of the pumps. These pumps, including their turbine drivers, have sufficient capacity to produce the uprated flow.

The main feedwater bypass control valves are used until 20% (approximately) power level is reached and, therefore, will not be affected by the uprating. At higher power levels, the feedwater flow is controlled by feedwater control valves which have a range of $0-4.8\times10^{6}$ lb/hr, well within the uprated flow of 3.99×10^{6} lb/hr.

Condensate Systems

A) The condensate system delivers water from the main condenser hotwell to the steam generator feedwater pumps. The system consists of the main condenser, condensate pumps, low pressure feedwater heaters, and the associated piping and instrumentation.

The condensate system is designed to handle 50 percent greater than normal flow. This was done to permit full feedwater flow upon loss of heater drain pump flow. Therefore, a small increase in flow of less than 1 percent due to uprating will not have any impact on this system.

B) The condensate storage and transfer system supplies or receives condensate, as required, by the condenser hotwell level control system. At uprated level, there will be an increase in the main steam flow to the condenser, but this will result in a proportional increase in the condensate flow. Therefore, the hotwell level and the demand on CST system will not change due to uprating.

C) In order to maintain the purity of feedwater, the condensate goes through the condensate demineralizer system prior to flowing to low pressure heaters and to the steam generator feedwater pumps. The condensate demineralizer system (CDS) removes the corrosion products and condenser leakage impurities from the condensate. At present, the CDS is designed for VWO steady state flow of 21,600 gpm. At an uprated level of 3579 MWt NSSS power, there will be an increase in main steam flow of less than 1 percent. This will increase the flow to the condensate demineralizer system by a similar small percentage and is judged to be acceptable.

Auxiliary Feedwater System

The auxiliary feedwater system provides a reliable source of safety grade water to the steam generators when the main feedwater system is not available. It may also be used following the reactor shutdown to cool the reactor coolant system.

As evaluated by Westinghouse, the design basis transients and accidents that govern auxiliary feedwater performance as well as its safety grade water storage requirements for Callaway are based on an uprated NSSS power level of 3579 MWt. Therefore, uprating will not have any impact on the existing auxiliary feedwater system.

Main Steam System

The main steam system provides steam from the steam generators to the turbine generator system and other auxiliary systems for power generation. The major components of this system are the main steam piping, power-operated relief valves, main steam safety valves, flow restricters, main steam isolation valves, main steam isolation bypass valves and the turbine bypass valves.

The main steam system is designed for VWO flow of 15.85×10^6 lb/hr. At the uprated power level of 3579 MWt, the system may have a flow of 15.96×10^6 lb/hr, which is an increase of less than 1 percent. The increase in the velocities and the pressure drop will be insignificant due to this increased flow. Therefore, the turbine throttle pressure will remain unchanged.

Each main steam line is provided with five (5) spring loaded safety valves for overpressure protection and one power operated relief valve. Higher plant rating would require higher relieving capacity. However, this will not be a problem since the safety valves were sized based on the NSSS engineered safety features (ESF) design rating of 3579 MWt, and the increase in steam flow is relatively small. There will be no change in the relief valve thrust forces.

Safety Valves No.	Required Capacity at 3% Accumulation (lb/hr) At 3579 MWt	Actual Capacity at 3% Accumulation (lb/hr)
1	796,500	893,160
2	796,500	902,096
3	796,500	911,779
4	796,500	920,715
5	796,500	929,652

In order to limit the steam flow following a steam line break, a flow restricter of 1.4 square feet at the steam generator outlet nozzle is installed. This restrictor will not affect uprated steam flow requirements.

In addition, the steam dump valves will have sufficient capacity to satisfy the uprating requirements, and the main steam isolation valves, as well as the bypass isolation valves, will not be affected.

Feedwater Heater Extraction, Drains and Vents

The drains from the low pressure heaters No. 2, 3, and 4 cascade to the No. 1 heater, which drains to the main condenser. Drains from the heater No. 7 cascade to the shell of heater No. 6 which drains to the heater drain tank. The heater drain tank also receives drains from the No. 5 heater and the moisture separator drain tank. Two 50 percent capacity pumps inject this drain flow into the suction of the steam generator feedwater pump. Level control valves on the drain lines of the low pressure heaters and on high pressure heaters No. 6 and 7 automatically maintain the normal water level in the heaters. High pressure heater No. 5 drains by gravity only. The increase in main steam flow of less than 1 percent due to plant uprating up to 3579 MWt power will result in correspondingly increased condensate flow of less than 1 percent. The change in the flow rates of the heater drains will be similar. As a result of the small increase in drain flow, the level control valves will modulate open wider to maintain the desired water level in the heaters. The set points of the level controllers will not be changed, and the drain system need not be modified due to uprating.

The heater extraction system provides extraction steam from the high pressure turbine to high pressure heaters and from the low pressure turbines to the low pressure heaters. Also, the scavenging steam from the moisture separator reheater (MSR) first and second stage reheaters is directed to feedwater heaters No. 6 and 7. The extraction flows will increase by less than 1 percent in proportion to increases in condensate/feedwater flows.

The heater vent system removes the non-condensible gases from the shell side of the heaters. The plant uprating will not significantly increase the amount of these gases, and therefore, this system will not be impacted.

Steam Generator Blowdown System

The steam generator blowdown system (SGBS), in conjunction with the condensate and feedwater chemical addition system, and the condensate demineralizer system, maintains the secondary side water chemistry within the NSSS specifications.

At present, the extent of blowdown processing during full power operation is determined by the operator depending upon the type and level of operation. At uprated level, the processing capability of the blowdown system will be utilized to the extent required to keep the water chemistry within specification. In fact, the increase in feedwater/main steam flow at uprated level is so small (less than 1 percent increase) that no impact on SGBS is expected.

Cooling Water Systems

The component cooling water system (CCWS) provides cooling water to several reactor auxiliary systems during a loss of coolant accident. The system serves as an intermediate barrier between the intake cooling water system and the potentially radioactive systems. The CCWS consists of four 100 percent capacity circulating pumps, two heat exchangers, two surge tanks, one chemical addition tank, and associated piping, valves and instrumentation.

Increased heat loads from the spent fuel pool due to the uprating (and the use of VANTAGE 5 fuel) have been calculated. These loads have been evaluated and can be accommodated by the CCWS.

Westinghouse's evaluation has shown that heat loads imposed on CCWS from the residual heat removal (RHR) heat exchangers are expected to increase slightly. The impact of this will be that the time to cool the plant from 350°F to 140°F will now take 19.3 hours instead of 16 hours. No other impact on component cooling water due to uprating, and no significant impact from the secondary side systems is expected.

The closed cooling water system (ClCW) provides cooling to the various components inside the turbine building such as steam generator feedwater pump turbine lube oil coolers, condensate pump motor bearing oil coolers, heater drain pump motor bearing oil coolers, etc. Any increase in the heat load to the closed cooling water system will be small and well within the system design limit. Note that the normal load on the closed cooling water system is 3.5×10^6 Btu/hr and that it is designed for 7.56×10^6 Btu/hr.

The service water system provides a source of water to the non-essential auxiliary plant equipment at a maximum temperature of 95°F. The essential service water system provides cooling water to the plant components which are required for the safe shutdown of the plant. The components served by these systems, except for the component cooling water heat exchangers, will not experience any significant increase in heat load. Since the CCWS increase was already considered in the original design, these systems will not be significantly affected by the uprating. The service and essential service water systems have sufficient margin to adequately supply any increase in flow required in the future due to conditions such as fouling in the heat exchangers.

Containment Spray System

The objectives of the containment spray system are: 1) to reduce the containment atmosphere temperature and pressure in the event of a loss of coolant accident (LOCA), or a main steam line break (MSLB) inside the containment; and 2) to limit the offsite radiation levels in the event of a postulated LOCA.

The pressure and temperature analysis for various main steam line breaks was done at an uprated level of 3579 MWt. The temperatures and pressures were found to be within the maximum pressures and temperatures for which the containment performance was previously evaluated (Ref. Table 3). For LOCA, there is no increase in containment temperature, pressure, or radiation levels. Therefore, the containment spray system will not be affected by the uprating.

Reactor Makeup Water System

The reactor makeup water system (RMWS) stores demineralized water and supplies it to various NSSS auxiliaries, radwaste systems, and the fuel pool cooling and cleanup system.

An increased spent fuel pool evaporation rate due to increased heat loads has been calculated. The present RMWS design provides sufficient makeup water for this demand. No other change in the demand for reactor makeup water is likely due to the uprating.

HVAC Systems

The following systems were reviewed to determine the impact of uprating to 3579 MWt NSSS power.

- Central Chilled Water System
- Auxiliary Building HVAC
- Containment Cooling System
- Containment Atmosphere Control System
- Containment Purge System

There is negligible increase in heat loads for the containment due to uprating. The increase in heat loads due to any increase in the system operating temperatures is negligible.

Radwaste Systems

The gaseous radwaste, liquid radwaste, solid radwaste, and the secondary liquid waste systems collect and process waste prior to storage or discharge. This is a batch process, and if there is any increase in demand on these systems due to uprating, it will be slight and accommodated easily by more frequent processing. The boron recycle system (BRS) receives the reactor coolant effluent for the purpose of processing and recycling. No change is anticipated in the boron concentration or radioactivity level of the reactor coolant. Therefore, the BRS should not be affected by the uprating.

Turbine Generator Review

At present, the turbine generator is designed to operate at 3562 MWt and produce 1234 MWe (gross). Union Electric considers it unlikely that this power level is limiting for the turbine generator and will carefully monitor the performance of the turbine generator system beyond 3562 MWt to the uprated power level of 3579 MWt.

Main Generator System

The main generator system generates power from a turbine generator which then is transmitted through an isolated phase bus and a main step-up transformer to the offsite power system. It also serves to step down voltage through a unit auxiliary transformer for normal operation of the plant unit auxiliaries.

The plant's generator is sized for 1,373,100 KVA at 0.90 power factor. Therefore, the plant's generator has adequate capacity and margin for uprating the plant to 3579 MWt/1246 MWe.

Excitation and Voltage Regulation

The excitation and voltage regulation system provides the source of field current for excitation of the main generator and control of the generator voltage by varying the field current to the exciter.

The existing exciter and voltage regulation system have adequate capacity and margin for uprating the plant.

Startup Transformer

The startup transformer receives power from the offsite power grid and steps down the voltage to supply the onsite electrical distribution system for startup and shutdown of the plant. The startup transformer also serves as the source of power for one load group of the Class IE power system.

The startup transformer is fed from the offsite power grid which is unaffected by the uprating. The transformer is sized for full loading of the plant's equipment assuring adequate capacity to the plant auxiliaries.

Lower Medium Voltage System - 4.16 KV AC (IE)

The lower medium voltage system receives power from two 12/16 MVA ESF transformers and distributes it to the two redundant load groups in the Class IE system.

The emergency loads to the system are not affected by the plant uprating. Additionally, the ESF transformers are sized for full loading of the plant's equipment assuring adequate capacity to the two redundant load groups.

Standby Generators

The standby generators provide the power required for safe shutdown of the reactor in the event of loss of the preferred power source.

The emergency loads to the standby generator are not affected by the plant uprating. All equipment loads required to safely shut down the plant are unchanged with the uprating.

Load Shedding and Emergency Load Sequencing

The load shedding and emergency load sequencing system provides for removing selected loads from the Class IE buses under degraded bus voltage conditions or upon generation of a SI signal and reloading the equipment in a predetermined sequence. This ensures that the voltage and frequency of the Class IE buses are not degraded due to heavy starting loads of actuated equipment.

Load shedding and subsequent reloading of equipment onto IE buses is unaffected by the plant uprating.

Miscellaneous Plant Power Systems

The miscellaneous plant power systems include 13.8 KVAC (non IE), 4.16KVAC (IE and non IE), 480 VAC (IE and non IE), 250 VDC (non IE), 125 VDC (IE and non IE), instrument AC (IE and non IE), and uninterruptible AC. These systems serve the balance-of-plant as well as turbine and NSSS systems. These systems are required for normal operation and safe shutdown, as applicable.

The plant electrical systems listed above are sized for full load equipment operation, and, because the uprating of the plant does not require additional equipment, these systems are adequate for the uprating.

Process Sampling System

The process sampling system provides representative samples of non-nuclear process fluids for analyses necessary for plant operation, corrosion control, and monitoring of equipment and system performance.

Plant uprating will slightly increase the temperatures of certain fluids being analyzed (i.e., feedwater, steam generator blowdown, etc.). However, the system has more than sufficient capacity to absorb the increases in sample heat loads.

Nuclear and Post Accident Sampling Systems

The nuclear and post accident sampling systems provide representative samples of process fluids for radiological and chemical analyses necessary for plant operation, corrosion control, and monitoring of equipment and system performance.

Plant uprating will slightly increase the temperatures of certain fluids analyzed during normal and accident conditions; however, these systems have adequate capacity to absorb the projected increases in temperature and pressure.

IV. MAIN STEAM LINE BREAK (MSLB) PRESSURE/TEMPERATURE ANALYSIS

FSAR Table 6.2.1-56 lists the 16 cases that were analyzed originally to determine the worst case containment pressures and temperatures following a main steam line break. Out of these cases, the following four cases were reanalyzed to determine the impact of plant uprating to 3579 MWt.

1. Full double-ended rupture at 102 percent uprated power (Case 1).

2. 0.60 ft^2 double-ended rupture at 102 percent uprated power (Case 2).

3. 0.80 ft^2 split rupture at 102 percent uprated power (Case 3).

4. Full double-ended rupture at 102 percent uprated power (Case 16) assuming failure of MSIV.

The method and assumptions used in the analysis are consistent with Chapter 6 of the FSAR. The 8 percent revaporization of condensate as allowed by NUREG 0588 was modeled. The analysis was based on the new mass and energy release data provided by Westinghouse.

The analysis for the 0.8 ft^2 split rupture was an iterative process. For the uprated condition, the time to reach Hi-1 set pressure of 6.0 psig and Hi-2 set pressure of 20 psig were found to be 16.6 seconds and 61.6 seconds, respectively. This information was provided to Westinghouse to obtain the total mass and energy release data for the 0.8 ft^2 split break case.

The reanalysis of the four cases described above indicated that the maximum temperatures and pressures inside containment for the uprated condition are similar to the ones calculated earlier for the current power level of 3425 MWt.

Figures 2 thru 9 provide the revised pressure and temperature profiles for the uprated cases. A summary of the results is given in Table 3.

V. EQUIPMENT QUALIFICATION

From FSAR Table 6.2.1-2, the maximum pressure and temperature inside the containment at the current power level of 3425 MWt are 48.1 psig and 384.9°F, respectively. Table 3 indicates that the temperatures and pressures will increase at the uprated power for some of the main steam line breaks, but they will remain within the maximum levels specified above. Further, a comparison was done between the temperature profiles of MSLB at the uprated power level and the EQ envelope given in Figure 3.11 (B)-3 of the FSAR. Only in one instance, for the full double-ended rupture with no MSIV (Case 16), the maximum temperature of 352°F at 45 seconds exceeded the EQ limit.

In order to confirm that equipment qualification will not be affected, all equipment inside the containment was reviewed. The review indicated that the equipment is either qualified for the EQ temperature and pressure envelopes (FSAR Figures 3.11(B)-3 and 3.11(B)-6), as revised by the new Case 16 parameters, or it was determined that, even during these peak conditions inside the containment (with consideration given to the new Case 16 results), the actual conditions of the equipment will be within the limits for which it is qualified (Reference 1). Therefore, no impact on equipment qualification will occur due to the plant uprating.

VI. REVIEW OF OPERATING DATA

The secondary side operating data was taken when the plant was operating at 99.66 percent of full power. The feedwater and main steam data for each individual loop was evaluated. For some of the feedwater heaters, minor deviations in temperatures and water levels were noted, but their overall performance was good. This was confirmed by the final feedwater temperature being very close to the expected values. These data indicate no anticipated problems with operation of the secondary side at uprated conditions.

The evaluation of component cooling water and closed cooling water heat exchangers was performed based on the operating data provided. The closed cooling water heat exchangers will see the bigger difference in operating heat load at uprated conditions. The operating data indicated no significant performance problem such as would be caused by extensive tube fouling. Therefore, it is our judgement that these units will perform adequately at uprated conditions.

VII. EFFECT ON PIPE STRESS EVALUATION

The pipe stress analyses of the systems were originally done using the VWO conditions at 3562 MWt NSSS power level. At 3579 MWt, the temperature of main feedwater will increase by only 1.5°F, and the main steam pressure may decrease. For other systems also, the changes in pressures and temperatures will be negligible. The increase in flow in the systems, if any, will also be too small to impact pipe stresses of systems for which transient analysis was done. Considering the insignificant changes in system operating conditions and the conservatism in stress analyses and the pipe support design, no pipe stress reanalysis will be required due to uprating.

VIII. HAZARDS ANALYSES

Uprating the Callaway Plant from the current licensed core power level of 3411 MWt to a new licensed core power level of 3565 MWt can be accomplished without design changes in the BOP systems. Therefore, no changes to the facility will be made to achieve the uprated power level. The following hazards analyses were reviewed in the uprating study.

1) II/I Analysis: The existing stress analyses of the II/I piping systems will not be affected because no significant changes in their operating conditions will occur. Also, no modification to the piping geometry of any kind will be made. Therefore, uprating will not have any impact on the II/I evaluation.

2) Pipe Break and Jet Analysis: The changes in pressures and temperatures of safety-related main steam and main feedwater piping are too insignificant to have any effect on the existing break locations. Current jet impingement analyses are unaffected as these analyses are generally conservative, and the increase in the flow rates are less than one (1) percent. The operating conditions of other safety-related high energy systems evaluated will not change due to uprating. Therefore, their pipe break locations and jet analyses will not be affected.

   For main steam line breaks inside containment, pressure and temperature analyses were done and it was found that the maximum temperatures and pressures will remain within the peak pressure and temperature used in the evaluation of containment performance. In addition, equipment inside containment was reviewed, and it was confirmed that their environmental qualification will not be affected.

3) Flooding: The only systems with an increase in flow rates are main feedwater, condensate, and main steam systems. This increase is less than one (1) percent and, therefore, will not have any significant impact on the flooding analysis in safety-related areas of the plant.

4) Moderate Energy Cracks: None of the moderate energy lines will experience any significant change in their operating conditions due to uprating. Therefore, the "No Crack Zones" as well as the evaluation done for the moderate energy cracks will not be affected.

5) Missile: The increase in the speeds of fans will be insignificant if any. Therefore, uprating will not cause any additional concern due to missiles.

6) Fire Hazards: The fire protection systems are independent of the plant power level and will not be affected by the uprating.

IX. REFERENCES

1) SLNRC 86-02 dated 1/17/86, "Report of Independent Review of Environmental Qualification Programs to NUREG-0588", Volume 2

2) SLNRC 86-06 dated 4/4/86, "Main Steam Line Break Superheat Effects on Equipment Qualification"

TABLE 1

CALLAWAY UPRATING PARAMETERS

Parameter	VWO Heat Balance	Uprating (Case 1)	Uprating (Case 2)	Uprating (Case 3)
NSSS Power (MWth)	3562	3579	3579	3579
S/G Tube Plugging (%)	0	0	10	15
Throttle Press. (psia)	975	975	925	914
Feedwater Temp. (F)	444.5	446 (1)	446 (1)	446 (1)
Steam/Feed Flow (MLBM/HR)	15.85	15.96 (2)	15.92 (2)	15.91 (2)
Generator Output (MWe)	1234	1246 (3)	1246 (3)	1246 (3)

EXTREME CASES

Max. Steam/Feed Flow = 15.96 MLBM/HR
Max. Feedwater Temp. = 446 F
Min. Throttle Pressure = 914 psia
Max. Generator Output = 1246 MWe
House Loads = 53 MW, 23 MVAR (4)

Notes:

(1) Assumed; based on extrapolating Feedwater Temp. vs. Power.

(2) Calculated as follows:

$$(\text{Flow MLBM/HR}) = \frac{(\text{Power MWt})\ (3.41214\ \text{BTU/W.HR})}{(\text{h steam - h feed BTU/LBM})}$$

Where:

h steam = 1191.4 BTU/LBM (Case 1)
= 1193.1 BTU/LBM (Case 2)
= 1193.5 BUT/LBM (Case 3)
(assumes saturated steam at throttle pressure + 25 psi, 0.25% moisture)

h feed = 426.2 BTU/LBM
(assumes 446 F, 1150 psia)

(3) Maximum output; based on extrapolation to 3579 MWt and lower circulating water temperature.

(4) Based on plant operating data; not expected to change significantly due to uprating.

TABLE 2

SYSTEMS REVIEWED FOR IMPLEMENTATION

1) Main Steam - (AB)
2) Main Turbine (AC)
3) Condensate - (AD)
4) Main Feedwater - (AE)
5) Feedwater Heater Extraction, Drains and Vents - (AF)
6) Condensate Demineralizer - (AK)
7) Auxiliary Feedwater - (AL)
8) Demineralized Water Storage and Transfer - (AN)
9) Condensate Storage and Transfer - (AP)
10) Reactor Makeup Water - (BL)
11) Steam Generator Blowdown - (BM)
12) Borated Refueling Water STorage (BN)
13) Steam Seals - (CA)
14) Main Turbine Lube Oil - (CB)
15) Generator H2 and CO2 - (CC)
16) Generator Seal Oil - (CD)
17) Stator Cooling Water - (CE)
18) Lube Oil Storage and Transfer System - (CF)
19) Condenser Air Removal - (CG)
20) Main Turbine Control Oil - (CH)
21) Service Water - (EA)
22) Closed Cooling Water - (EB)
23) Essential Service Water - (EF)
24) Component Cooling Water - (EG)
25) Containment Spray - (EN)
26) Auxiliary Turbines - (FC)
27) Central Chilled Water - (GB)
28) Auxiliary Building HVAC - (GL)
29) Containment Cooling - (GN)
30) Containment Atmosphere Control - (GR)
31) Containment Purge - (GT)
32) Gaseous Radwaste - (HA)

TABLE 2

SYSTEMS REVIEWED FOR PHASE II (IMPLEMENTATION) (cont'd)

33) Liquid Radwaste - (HB)
34) Solid Radwaste - (HC)
35) Boron Recycle - (HE)
36) Secondary Liquid Waste - (HF)
37) Main Generator - (MA)
38) Excitation and Voltage Regulation - (MB)
39) Startup Transformer - (MR)
40) 4.16 KV AC (IE) - (NB)
41) Standby Generator - (NE)
42) 480 V AC (IE) - (NG)
43) 125 V DC (IE) - (NK)
44) Instrument AC (IE) - (NN)
45) 13.8 Kv AC - (PA)
46) 4.16 Kv AC - (PB)
47) 480 V AC - (PG)
48) 250 V DC - (PJ)
49) 125 V DC - (PK)
50) Instrument AC - (PN)
51) Uninterruptible AC - (PQ)
52) Process Sampling - (RM)
53) Nuclear Sampling - (SJ)

TABLE 3

SUMMARY OF RESULTS

MSLB Case	P_{max} @ t (psig @ sec)	T_{max} @ t (°F @ sec)	Hi-1 (sec)	Hi-2 (sec)	Hi-3 (sec)	dryout (sec)
full DEB	39.55 @ 1800.	348. @ 110.	2.13	11.86	78.5	186.
FSAR	38. @ 1800	318. @ 145.	2.69	29.05	110.	164.
0.6 ft.^{2} DEB	36.79 @ 1800.	338. @ 310.	10.7	120.2	275.	355.6
FSAR	37. @ 1800.	372. @ 310.	11.39	123.7	280.	388.
full DEB, no MSIV	34.55 @ 185.9	352. @ 45.	2.13	8.46	51.4	186.
FSAR	33.1 @ 124.	302.4 @ 120.	2.69	14.61	89.	164.
0.8 ft.^{2} split	45.6 @ 1800.	336. @ 204.	16.6	61.6	169.	529.
FSAR	44. @ 1800.	380. @ 160.	15.4	58.8	135.	506.

Note: from FSAR table 6.2.1-2 the absolute maximum values are: P_{max} = 48.1 psig and T_{max} = 384.9 °F for all breaks inside containment.

449 HB 872

VWO

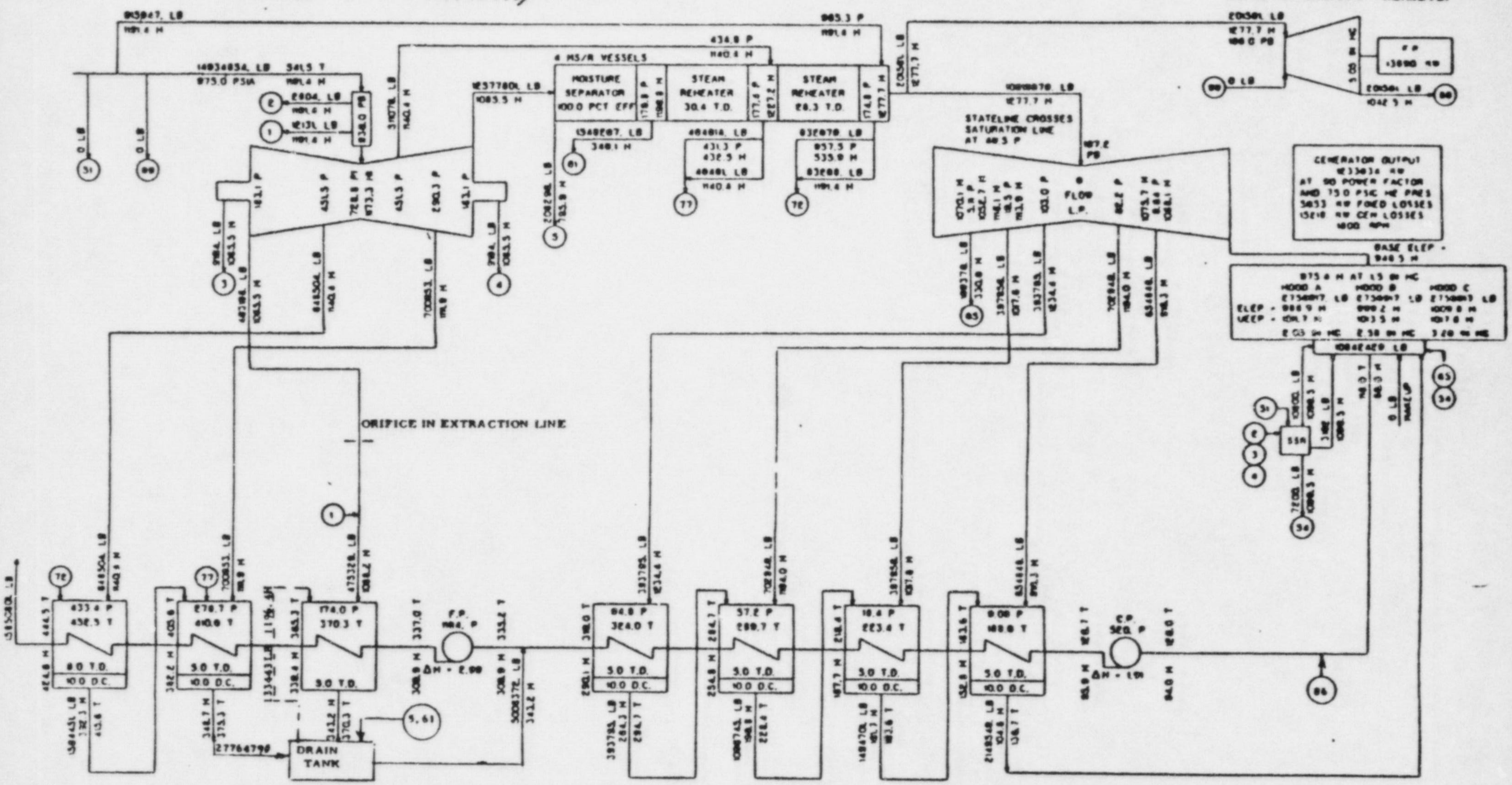
EXTRACTION ARRANGEMENT IS SCHEMATIC ONLY

CALCULATED DATA - NOT GUARANTEED

RATING FLOW (GUARANTEED) IS 14E2387L LB AT INLET STEAM CONDITIONS OF 875. PSIA 1191.4 H TO ASSURE THAT THE TURBINE WILL PASS THIS FLOW, CONSIDERING VARIATIONS IN FLOW COEFFICIENTS FROM EXPECTED VALUES, SHOP TOLERANCES ON DRAWING AREAS, ETC. WHICH MAY AFFECT THE FLOW, THE TURBINE IS BEING DESIGNED FOR A DESIGN FLOW (RATING FLOW PLUS 5.0 PERCENT) OF 14834854. LB

SG FLOW = 15,850,801 LB
+4.72% > RATING (449HB873)

2-1/2 SIZE FP TB
AUX. TB PERFORMANCE BY GE(MDTD)



VALVE BEST POINT NET HEAT RATE = $\frac{1385080L\ (1191.4 - 424.0)}{1233834.}$ = 8853 $\frac{BTU}{KW\text{-}HR}$

LEGEND - CALCULATIONS BASED ON 1967 ASME STEAM TABLES
LB - FLOW-LB/HR
P - PRESSURE-PSIA
H - ENTHALPY-BTU/LB
T - TEMPERATURE-F DEGREES

1192498 KW .83 / .97 / 1.20 IN HG ABS 6 PCT MU
TCDF 38.0 IN LSB 1800 RPM
875 PSIA 1191.4 BTU/LB 2 STAGE REHEAT
GEN- 1373100 KVA 75.0 PSIG H2 PRES 90 PF LB

FIGURE 1

GENERAL ELECTRIC COMPANY, SCHENECTADY N.Y.

C5000 313MR 790000000 0 6/17/76
449 HB 872

FULL DOUBLE ENDED BREAK AT 102% POWER

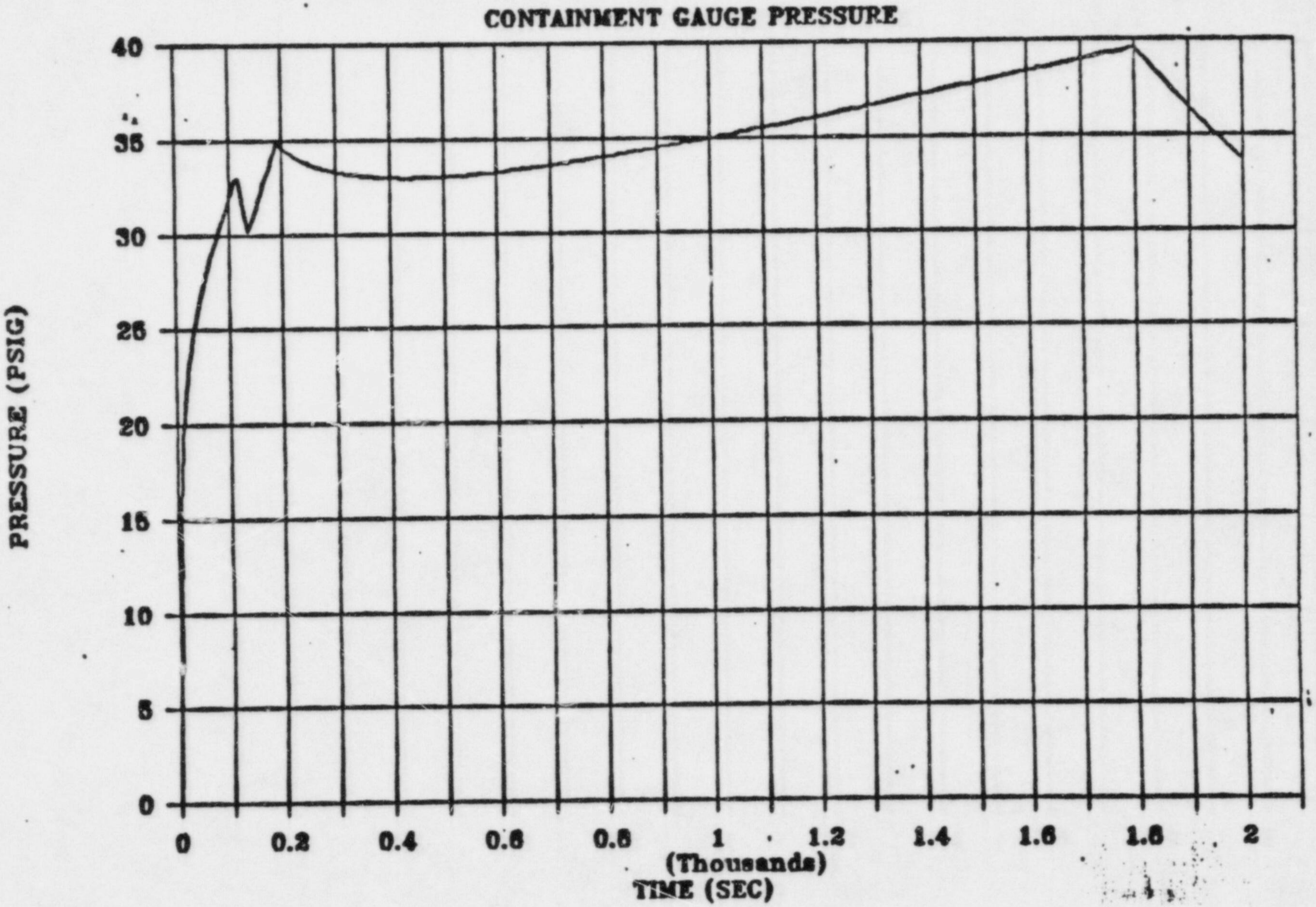
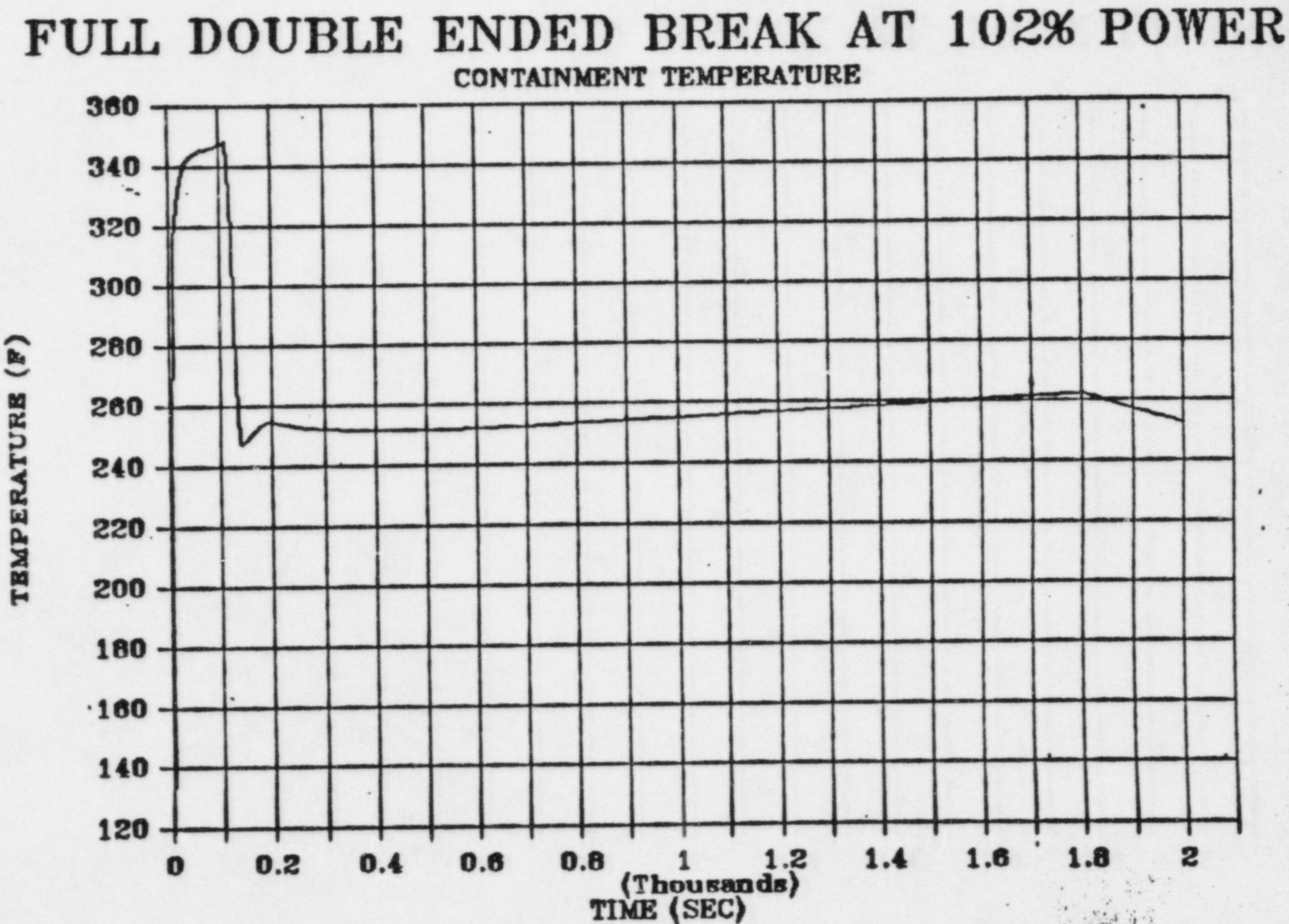


FIGURE 2



FULL DOUBLE ENDED BREAK AT 102% POWER
CONTAINMENT TEMPERATURE
TEMPERATURE (F)
360
340
320
300
280
260
240
220
200
180
160
140
120
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (SEC)

FIGURE 3

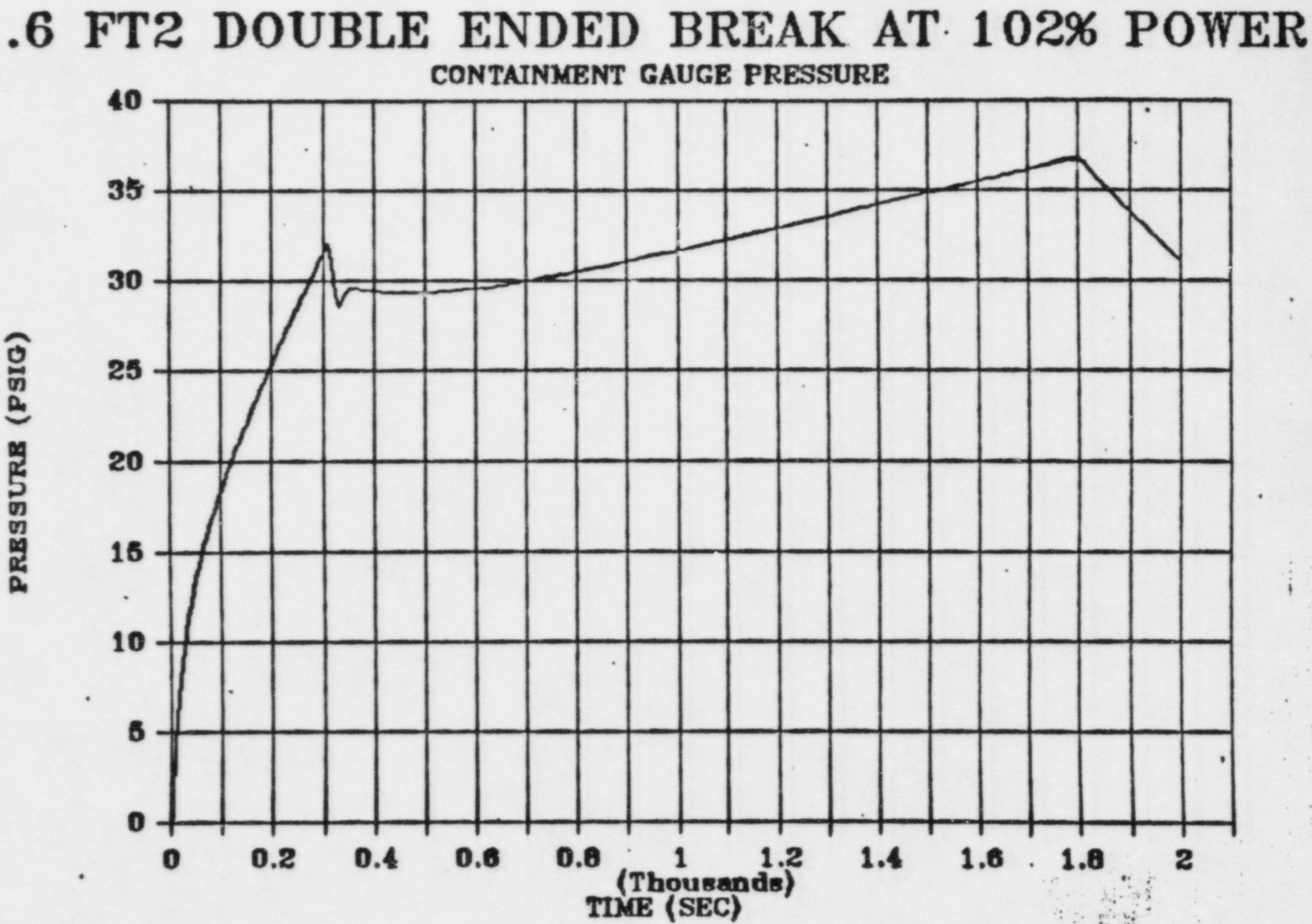

.6 FT2 DOUBLE ENDED BREAK AT 102% POWER
CONTAINMENT GAUGE PRESSURE
40
35
30
25
20
15
10
5
0
PRESSURE (PSIG)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (SEC)

FIGURE 4

.6 FT2 DOUBLE ENDED BREAK AT 102% POWER

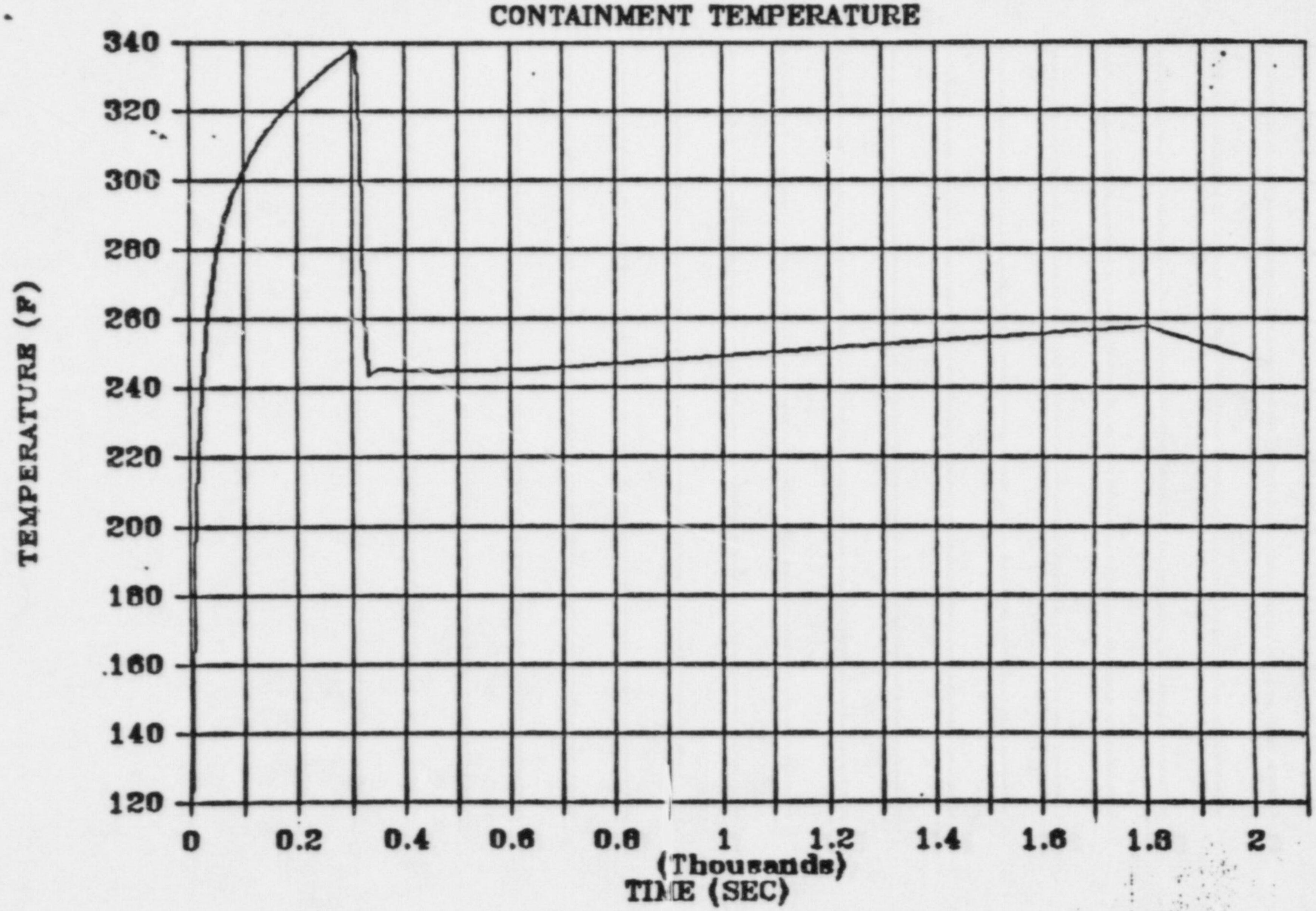


FIGURE 5

0.8 FT2 SPLIT BREAK AT 102% POWER

CONTAINMENT GAUGE PRESSURE

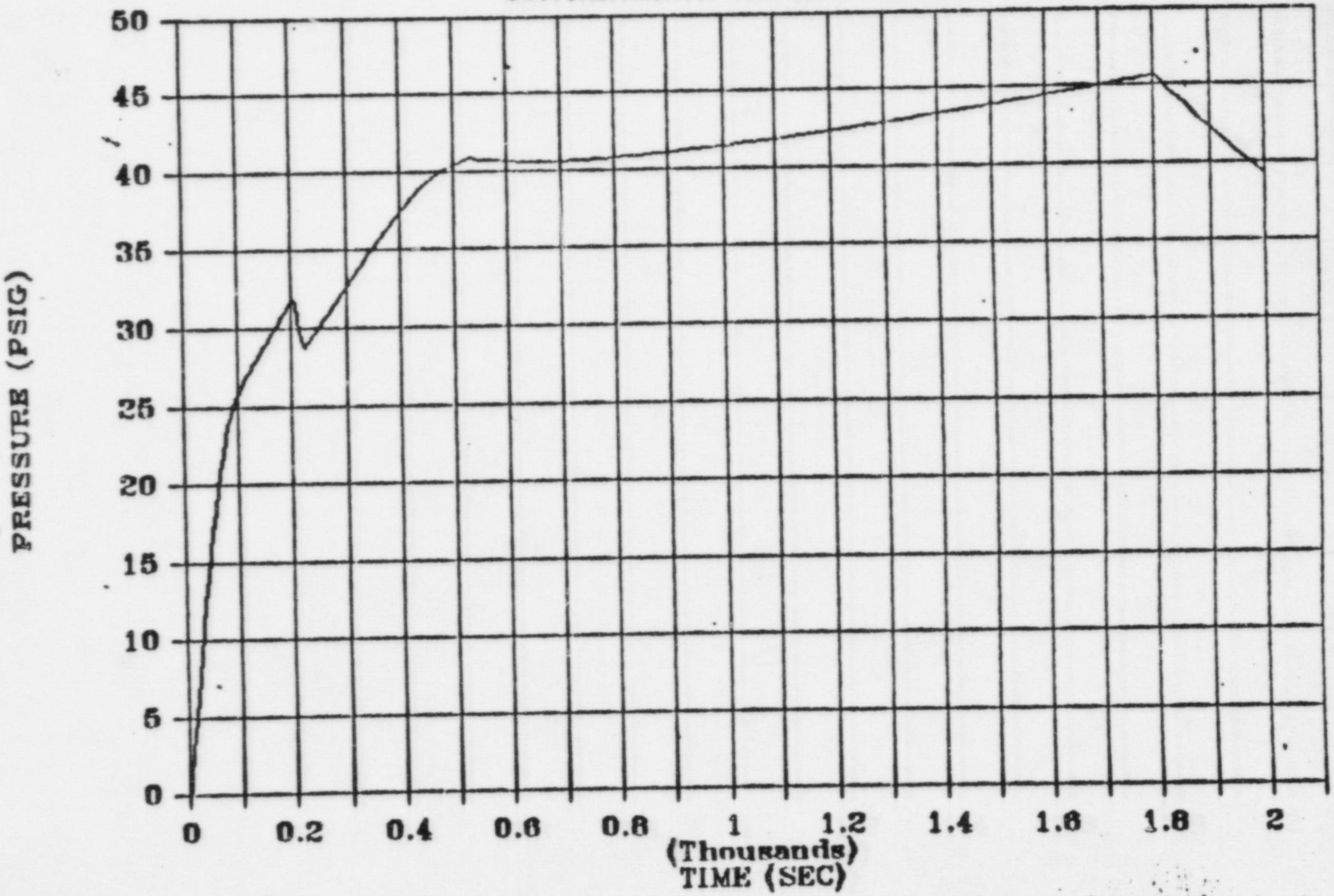


FIGURE 6

0.8 FT2 SPLIT BREAK AT 102% POWER

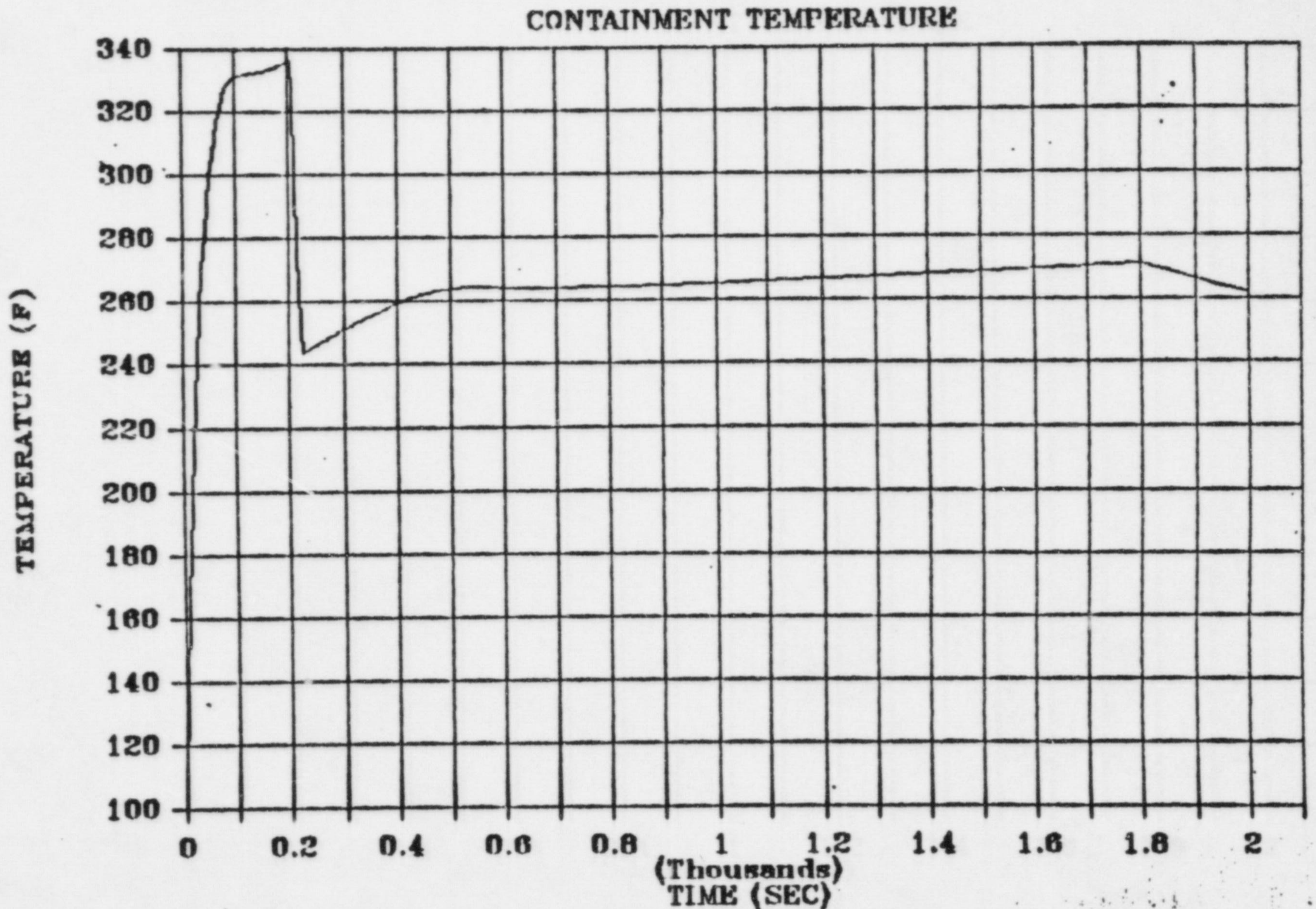


FIGURE 7

FULL DEB AT 102% POWER, FAILED MSIV

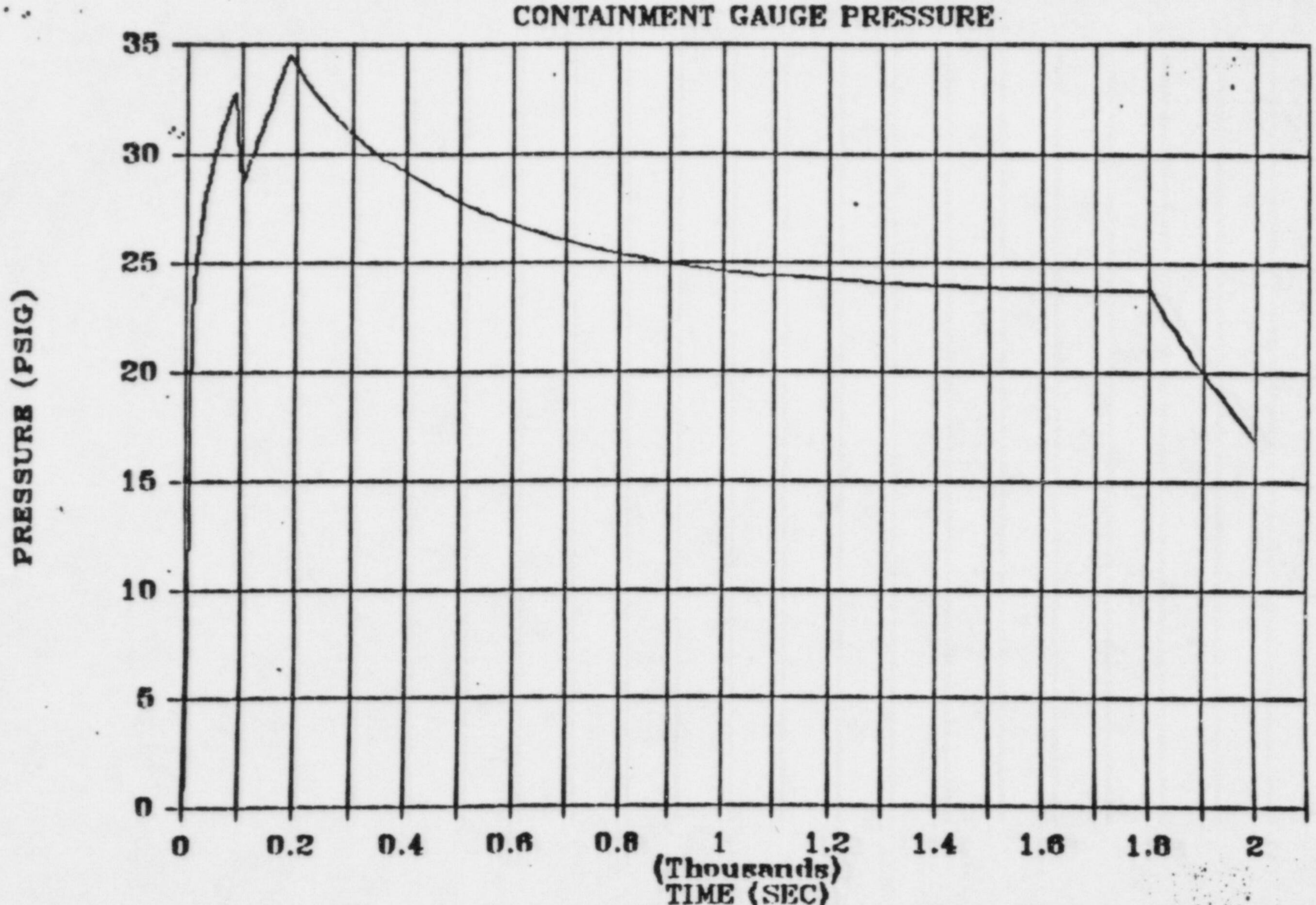


FIGURE 8

FULL DEB AT 102% POWER, FAILED MSIV

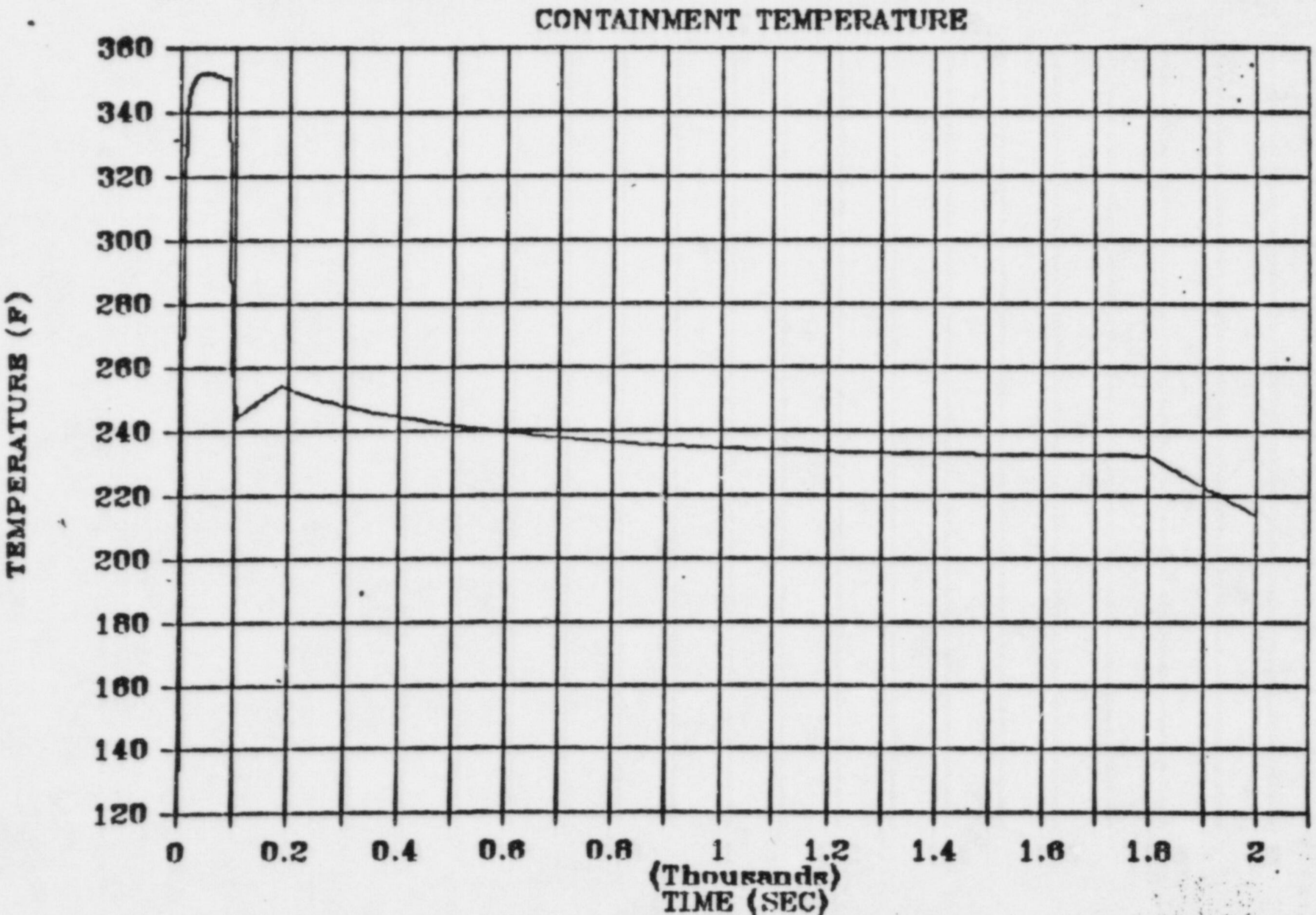


FIGURE 9

CALLAWAY UPRATING SUBMITTAL
ATTACHMENT 5: APPENDICES
APPENDIX B
BOP - UPRATING LICENSING REPORT
SECTION II - UNION ELECTRIC REVIEW

I. INTRODUCTION

The Callaway Plant is currently licensed to operate at a core power level of 3411 MWt which corresponds to a NSSS power level of 3425 MWt. Union Electric has proposed uprating the plant to a core power level of 3565 MWt which corresponds to a NSSS power level of 3579 MWt. All plant systems were screened for possible impact due to an uprating. Those systems that are clearly not dependent upon thermal power level were excluded from further engineering and licensing review. The results from a review of balance of plant systems performed by Bechtel are presented in Section I of Appendix B. Section II documents the results of a review performed by Union Electric on those balance of plant systems not included in the Bechtel review. Systems reviewed in Section II are listed in Table 1.

II. SUMMARY AND CONCLUSION

The BOP systems that were reviewed by Union Electric include: circulating water; cooling tower makeup and blowdown; intake and water treatment; EHV switchyard bus; EHV switchyard 125 VDC; outgoing EHV lines; and the BOP computer. The Union Electric review also included the fuel pool cooling and cleanup system and the fuel building HVAC system.

In conclusion, Union Electric's review of these secondary side systems verifies that they have the capability to function properly at the uprated power level of 3579 MWt NSSS thermal power. The fuel pool cooling and cleaning system is not impacted by plant operation at uprated conditions, nor is the ability of the fuel building HVAC system impacted by plant operation at the increased power level.

The balance of plant systems reviewed can function properly without modification to their existing design.

III. SYSTEM EVALUATIONS

Circulating Water System and Cooling Tower

The circulating water system, along with the condenser and cooling tower have been optimally designed to operate at the turbine-generator valves wide open (VWO) rating of 1234 MWe, 3562 MWt. The system and components are also capable of operating up to the uprated condition of 3579 MWt.

The circulating water system is designed to supply cooling water at a constant rate of 530,000 gpm to condense steam while maintaining the turbine exhaust pressure below 5.0 in HgA. The uprated power level results in a greater water temperature rise and turbine exhaust pressure than experienced under the turbine generator guarantee rating. This results in losses in efficiency and power, as with the guarantee rating (3425 MWt).

The temperature of the water supplied to the condenser from the cooling tower is highly dependent on the weather conditions. The cooling tower is designed to supply 95 F water with a range of 28.6 F under weather conditions of 79 F WBT and 95 F DBT. However, weather conditions that result in water temperatures greater than 95 F do occur. Above approximately 97 degrees F water temperature, the 5.0 in HgA turbine exhaust back pressure limit is reached and turbine load must be reduced. However, this occurrence is infrequent and of short duration.

The higher return water temperature due to the increased rating acts to increase the heat transfer capacity of the cooling tower, offsetting the greater heat rejection required, with the net result being a negligible change in cooling tower performance at the higher rating.

In addition to removing heat from the condenser during full power operation, the system must also remove heat when steam is directly bypassed to the condenser. Again, the system is designed to allow 40% of VWO main steam flow to the condenser at the uprated conditions.

Increased duty on the Service Water System (EA) from the uprating as reflected in slightly warmer service water returned to the circulating water system will have a negligible effect on the circulating water sytem.

In summary, the circulating water system, cooling tower and condenser were orginally designed for the 3562 MWt rating and are operating within design at the guarantee rating. They are expected to operate within design at the uprated condition of 3579 MWt. The difference in the pressures, temperatures, and flows listed in the FSAR for the 3562 MWt rating and the values at the 3579 MWt rating are insignificant.

Cooling Tower Makeup and Blowdown, Intake and Water Treatment

The subject systems are all interrelated to provide adequate supplies of makeup water to the cooling tower at design ambient temperatures and at the uprated condition of 3579 MWt. The intake and water treatment plant (WTP) and associated makeup and blowdown piping, with the exception of the clarifiers, were designed for two unit operation and can provide up to 30,000 gpm with one intake pump out of service. The Callaway uprating will increase current cooling tower evaporation rates by approximately 4 percent, from 14,015 gpm to 14,575 gpm, total drift and evaporation. Due to blowdown rates required for radwaste dilution, there will be no additional losses incurred for blowdown associated with the increase in evaporation rates.

The WTP clarifier capacity had already been increased due to plant concerns of a clarifier outage during maximum evaporation and blowdown periods. The capacity of each clarifier was modified and tested to provide water at the WTP at the design of 15 ppm total suspended solids in the makeup water. Assuming a failure of one clarifier and a 4 percent increase of makeup water associated with the uprating, the WTP has adequate capacity to provide for cooling tower makeup.

Based on the above, there will be no adverse impact on plant operation of the subject systems due to the uprating.

EHV Switchyard BUS, EHV Switchyard 125 VDC, Outgoing EHV Lines

The review of these systems documented conformance to the safety design bases in the FSAR and conformance to Union Electric Company standards for EHV switchyards and EHV transmission lines. The Callaway uprating will have no impact upon the EHV Switchyard 125 VDC system. The Union Electric transmission system is more than adequate to carry the Callaway gross generation output of 1246 MWe (based on 3579 MWt rating) during both steady-state and transient conditions. A modest limitation on the Callaway Mvar output is required to avoid overloading the Callaway 1245 MVA Generator-Step-Up transformer. At full generation output of 1246 MWe with an assumed auxiliary transformer load of 53 MWe and 23 Mvar, the Callaway Mvar must be limited to 485 Mvar. This limitation, however, is not a problem from a system standpoint. The transmission system and the Callaway GSU transformer with the Mvar limitations are more than adequate to accomodate operation of the Callaway Plant at uprated conditions.

NSSS/BOP Computers

No hardware changes (such as wiring of additional inputs) are required for the NSSS and BOP computers. Software changes will consist of the following: revised alarm limits for steam and feedwater flows and feedwater temperature; revised constant representing 100% power (used in calorimetric); and revised constants associated with steam, feedwater, and RCS flow algorithms. These changes are consistent with changes made to control system setpoints.

Spent Fuel Pool Cooling And Cleanup System

A reanalysis of the spent fuel pool (SFP) cooling system was performed to assure that discharged spent fuel assemblies would be adequately cooled and free from boiling for both normal and off-normal conditions. This reanalysis was performed to assess the impact of the SFP cooling system from the adoption of the VANTAGE 5 fuel design and plant operation at uprated conditions, including higher burnup levels.

The results of the reanalysis show that the calculated peak bulk pool temperatures for normal and off-normal condtions are still within the existing FSAR limits. The calculated peak clad temperatures are below the saturation temperature at the peak clad temperature location.

The SFP cooling system will provide adequate cooling of discharged spent fuel assemblies to limit peak bulk pool temperatures to below existing FSAR limits and to assure that the spent fuel assemblies are free from boiling.

The performance of the SFP cleanup system is not impacted by the adoption of the VANTAGE 5 fuel design or plant operation at uprated conditions.

Fuel Building HVAC

A reanalysis was performed to assure that the plant operation at uprated conditions would not adversely impact the proper operation of the fuel building HVAC.

This analysis demonstrated that the fuel building HVAC is adequate to maintain an environment consistent with personnel comfort and safety.

The ability of the fuel building HVAC to limit the accidental release of radioisotopes to below applicable limits is not impacted by plant operation at uprated conditions.

Table 1

Systems Reviewed for Implementation

Circulating Water - (DA)

Cooling Tower Makeup & Blowdown - (DB)

Intake & Water Treatment - (DE)

Fuel Pool Cooling & Cleanup - (EC)

Fuel Building HVAC - (GG)

EHV Switchyard Bus - (MD)

EHV Switchyard 125 VDC - (ME)

Outgoing EHV Lines - (MH)

BOP Computer - (RJ)

ULNRC- 1471
Attachment 6

Application Fee

CHECK NUMBER
219753
4538

UNION ELECTRIC COMPANY ST. LOUIS, MISSOURI
TO CENTERRE BANK OF KENNETT, MISSOURI

80-0245
815

PAY
TO THE ORDER OF

U S NUCLEAR REGULATORY
COMMISSION
1717 H ST NW
WASHINGTON DC
20555

DATE 03 24 87

AMOUNT $******150 00

CHECKS OVER $25,000 REQUIRE COUNTERSIGNATURE

DFB

ASSISTANT TREASURER

AUTHORIZED SIGNATURE

THIS CHECK
VOID AFTER
90 DAYS

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COUNTERSIGNATURE