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10 CFR 50.90

TMI-10-035
September 24, 2010

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Technical Specification Change Request No. 351: Maximum Allowable Power with Inoperable Main Steam Safety Valves

In accordance with 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (EGC) requests an amendment to the Technical Specifications (TS), Appendix A of Renewed Facility Operating License No. DPR-50 for Three Mile Island Nuclear Station, Unit 1 (TMI, Unit 1).

The proposed amendment revises Technical Specification (TS) 3.4.1.2.3 to allow up to two (2) Main Steam Safety Valves (MSSVs) per steam generator to be inoperable with no required reduction in power level, and revises the required maximum overpower trip setpoints for any additional inoperable MSSVs. These changes are supported by the plant–specific evaluation provided in Attachment 3, and NUREG-1430, Revision 3, "Standard Technical Specifications-Babcock and Wilcox Plants," dated June 2004. EGC has concluded that these proposed changes do not constitute a significant hazards consideration, as described in the enclosed analysis performed in accordance with 10 CFR 50.91(a)(1).

Attachment 1 provides the Evaluation of Proposed Change. Attachment 2 provides the proposed TS and TS Bases pages marked-up to show the proposed changes. TS Bases pages are provided for information only.

The proposed changes have been reviewed by the TMI, Unit 1 Plant Operations Review Committee and approved by the Nuclear Safety Review Board in accordance with the requirements of the EGC Quality Assurance Program.

There are no new regulatory commitments established by this submittal.

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EGC requests approval of the proposed amendment by September 24, 2011. Approval by September 24, 2011, will allow the orderly implementation of the proposed changes at the plant. Once approved, the amendment shall be implemented within 60 days. The amendment will support MSSV testing prior to the T1R19 refueling outage, planned for the Fall of 2011.

In accordance with 10 CFR 50.91, "Notice for public comment; State consultation," paragraph (b), EGC is notifying the Commonwealth of Pennsylvania of this application for changes to the TS by transmitting a copy of this letter and its attachments to the designated State Official. In addition, copies are being distributed to the Bureau of Radiation Protection and the chief executives of the township and county in which the facility is located.

If you have any questions or require additional information, please contact Wendy E. Croft at (610) 765-5726.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 24th day of September 2010.

Respectfully,

Pamela B. Cowan (signature)

Pamela B. Cowan
Director - Licensing and Regulatory Affairs
Exelon Generation Company, LLC

Attachments:
1. Evaluation of Proposed Change
2. Markup of Technical Specifications Changes
3. TMI Unit 1 Technical Evaluation No. A2148778 E18 for AREVA Document 86-9054640-002, "TMI-1 MSSV Operability Phase 2 Results," dated September 16, 2009

cc: W. M. Dean, Administrator, USNRC Region I
D. M. Kern, USNRC Senior Resident Inspector, TMI, Unit 1
P. J. Bamford, USNRC Project Manager, TMI, Unit 1
D. Allard, Director, Bureau of Radiation Protection - PA Department of Environmental Resources
Chairman, Board of County Commissioners of Dauphin County
Chairman, Board of Supervisors of Londonderry Township

ATTACHMENT 1

Evaluation of Proposed Change

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50

Subject: Technical Specification Change Request No. 351: Maximum Allowable Power with Inoperable Main Steam Safety Valves

1.0 SUMMARY DESCRIPTION

This evaluation supports a request to amend Renewed Facility Operating License No. DPR-50 for Three Mile Island Nuclear Station, Unit 1 (TMI, Unit 1).

The proposed change revises the TMI, Unit 1 Technical Specification (TS) 3.4.1.2.3 to allow up to two (2) Main Steam Safety Valves (MSSVs) per Once Through Steam Generator (OTSG) to be inoperable with no required reduction in power level, and revises the required maximum overpower trip setpoints for any additional inoperable MSSVs up to a maximum of five (5) inoperable MSSVs (i.e., minimum of four (4) operable) on each OTSG. The proposed change incorporates a requirement that with less than four (4) operable MSSVs per OTSG, the plant must be brought to the hot shutdown condition. These changes are consistent with NUREG 1430, Revision 3, "Standard Technical Specifications – Babcock and Wilcox Plants," dated June 2004 (Reference 6.1).

Upon approval, EGC requests that the following changed replacement pages be inserted into the existing Renewed Facility Operating License:

Revised TMI, Unit 1 TS Page: 3-26a
Revised TMI, Unit 1 TS Bases Page (for information only): 3-26c

2.0 DETAILED DESCRIPTION

The existing TMI, Unit 1 TS 3.4.1.2.3 requires that all eighteen (18) MSSVs be operable above 5% power, or if any are not operable, the maximum overpower trip setpoint must be reduced from the nominal operating value of 105.1% power to the value described in Table 1 below.

Table 1

Maximum Number of MSSVs Disabled on Any OTSG	Maximum Overpower Trip Setpoint (% of Rated Power)
1	92.4
2	79.4
3	66.3

In addition, the existing TMI, Unit 1 TS 3.4.1.2.3 specifies that with more than three (3) MSSVs inoperable, at least fifteen (15) MSSVs must be restored to operable status within 4 hours or the plant must be in hot shutdown within the next 6 hours. The loss of a single MSSV results in a required reduction in the overpower trip setpoint, which must be preceded by a decrease in reactor power.

The primary purpose of the MSSVs is to provide overpressure protection for the secondary system. The MSSVs also provide protection against overpressurizing the reactor coolant pressure boundary (RCPB) by providing a heat sink for removal of energy from the Reactor Coolant System (RCS) if the preferred heat sink, provided by the Condenser and Circulating Water System, is not available. Nine (9) MSSVs per OTSG are located on the Main Steam

(MS) System headers, outside containment, upstream of the main steam isolation valves, as described in TMI, Unit 1 Updated Final Safety Analysis Report (UFSAR) Section 10.7.4. The design capacity of the MSSVs is based on the American Society of Mechanical Engineers (ASME) Code, Section III. This capacity is sufficient to limit secondary system pressure to ≤ 110% of design pressure when passing 100% of design steam flow. The MSSV design includes staggered setpoints so that only the needed number of valves will actuate. Staggered setpoints reduce the potential for valve chattering because of insufficient steam pressure to fully open the valves.

MSSV capacity is sufficient to cope with any anticipated operational occurrence or accident considered in the Design Basis Accident and transient analysis. The limiting transient for evaluating the secondary system overpressure protection is the Turbine Trip from full power accident without credit for any power runback and without credit for the Anticipatory Reactor Trip System (ARTS) turbine trip signal.

TMI, Unit 1 transient analyses described in Attachment 3 have shown that overpressure protection is maintained with fewer operable MSSVs than required by the existing TS 3.4.1.2.3 table, shown above. The revised analyses support the proposed change to TS 3.4.1.2.3 to allow up to two (2) inoperable MSSVs per steam generator with no reduction in power. The revised analyses also support revised maximum overpower trip setpoints for any additional inoperable MSSVs up to a maximum of five (5) inoperable MSSVs (i.e., mimimum of four (4) operable) on each OTSG. The proposed change incorporates a requirement that with less than four (4) operable MSSVs per OTSG, the plant must be brought to the hot shutdown condition.

The analyses described in Attachment 3 address revised MSSV operability requirements for both the original installed TMI, Unit 1 OTSGs and the new replacement OTSGs (E-OTSGs) installed in the T1R18 refueling outage (Fall 2009). In this evaluation and TS markup pages, the term OTSG is used. The term E-OTSG was used in analysis to differentiate between the old and new SG design.

The proposed change is an improvement to provide operational flexibility. The existing TS requirements result in unnecessary maneuvering of the plant and reduced output in the event of any inoperable MSSV. The proposed changes are consistent with other Babcock and Wilcox plant TS and with NUREG 1430, Revision 3, "Standard Technical Specifications – Babcock and Wilcox Plants," dated June 2004.

3.0 TECHNICAL EVALUATION

System Description

The design pressure of the MS System is 1050 psig. The secondary system side of the OTSGs has a design pressure of 1150 psig. The MS System is discussed in Section 10.3.1 of the TMI, Unit 1 UFSAR. The MSSVs are provided for overpressure protection of the OTSGs and the MS System. The overpressure protection provisions for the MS System are described in Section 10.7.4 of the TMI, Unit 1 UFSAR. The lowest MSSV setpoint is required to be set equivalent to the design pressure of the system it protects, and accounts for the pressure loss between the OTSG and the MSSV location, resulting in a lowest setpoint value of 1040 psig (one per OTSG). The remainder of the valve setpoints are staggered up to the highest value of 1092.5 psig. The MSSV setpoints and capacities are described in Table 2 below.

Table 2

Nominal Lift Setpoint (psig)	Number per OTSG	Rated Capacity per Valve (lbm/hr *)
1040	1	194,900
1050	3	792,610
1060	2	799,990
1080	2	814,955
1092.5	1	824,265

* Rated capacity is based on saturated steam at the nominal lift setpoint plus 3% accumulation

Plant Specific Analysis

The Turbine Trip event without Integrated Control System (ICS) power runback and without credit for the ARTS trip signal coincident with turbine trip is the limiting transient in terms of secondary system pressure. The TMI, Unit 1 Turbine Trip analyses described in Attachment 3 were performed in accordance with methodology (Reference 6.2) approved by the Nuclear Regulatory Commission (NRC). The limitations and conditions imposed by the NRC Safety Evaluation Report approving the referenced analysis methods have been reviewed and compliance documented within the supporting analysis calculations. This methodology utilizes the plant design bases to establish acceptance criteria and input boundary conditions. The approved methodology includes the manner for determining the responses of the primary system, the secondary system, and the core to postulated accidents. In addition, the approved methodology requires the use of conservative setpoints, valve and pump capacities, and reactivity coefficients to demonstrate adequate margin to the applicable limits. With respect to the inoperable MSSVs, the valve setpoints and sensitivity studies were used to determine the valve or combination of valves that produce the limiting secondary pressure for a given number of valves out of service.

The RELAP5/MOD2-B&W (R5/M2-B&W) computer code (Reference 6.3) was used for the analysis of the Turbine Trip event. This code has been approved by the NRC for use in non-Loss of Coolant Accident (LOCA) safety analyses. This code provides a conservative prediction of the overheating that will occur during the Turbine Trip event (Reference 6.2). The code simulates RCS and secondary system operation. The reactor core model is based on a point kinetics solution with reactivity feedback for control rod assembly insertion, fuel temperature changes, and moderator temperature changes. The RCS model provides for heat transfer from the core, transport of the coolant to the OTSGs, and heat transfer to the OTSGs. The secondary system model includes a detailed depiction of the MS System steam relief to the atmosphere through the MSSVs and simulation of the Turbine Stop Valves. The secondary system model also includes the delivery of feedwater, both main and emergency, to the OTSGs. The key input assumptions for the analyses that demonstrate overpressure protection are:

- The core power is conservatively modeled to be at 102% of 2772 MWt compared to the current licensed power level of 2568 MWt. This core power level accounts for future uprate and heat balance uncertainty.
- No credit is taken for ICS power runback.
- Beginning-of-cycle kinetics parameters are chosen which maximizes RCS heatup.

- The reactor protection system actuates on high RCS pressure. The analysis setpoint was adjusted for instrument uncertainty and a conservative response time is assumed prior to control rod insertion. No credit is taken for the ARTS trip upon turbine trip.
- The tripped rod worth is calculated assuming the minimum TS shutdown margin of 1.0% $\Delta k/k$ at hot zero power.
- The decay heat addition is based on 1.0 times the ANS 1971 standard and includes consideration of heavy actinides. The decay heat assumption bounds the 1979 ANS standard within two standard deviations of uncertainty.
- The heat addition from the reactor coolant pumps is modeled.
- The initial RCS pressure and average temperature (T_{avg}) are set to their nominal values, in accordance with the Reference 6.2 methodology.
- The initial pressurizer level is set to a minimum value, delaying reactor trip and maximizing the heat addition to the secondary system.
- The pressurizer spray function is credited, which likewise delays reactor trip.
- The pressurizer code safety valves are modeled to lift at 103% of their nominal setpoint.
- The MSSVs function as described in Table 2 above.
- A conservatively fast closure time is assumed for the Turbine Stop Valves.
- Offsite power is assumed to be available since control rod insertion is delayed.
- No active single failures could be identified that would produce more limiting consequences. No operator actions were modeled.
- No credit was taken for Turbine Bypass Valves (TBVs) which have a total capacity of about 23.2% of MS flow at 100% Rated Thermal Power (RTP).
- No credit was taken for the Atmospheric Dump Valves (ADVs) which have a total capacity of about 8.8% of MS flow at 100% RTP.

For each of the chosen power levels (102% Full Power (FP), 92% FP, and 62% FP), the limiting secondary system pressurization event, the turbine trip, was analyzed with various combinations of MSSVs out of service. The turbine trip is the event initiator, and after a short delay to close the Turbine Stop Valves, steam flow through the turbine ceases, and the MS System pressure rises due to the mismatch between the continued heat generation in the core and the secondary plant. The MSSVs begin to lift within 2 to 3 seconds after initiation of the event. The analysis determines the number of in-service MSSVs that are required to limit MS System pressure to less than 110% of the design pressure. Sufficient combinations of MSSVs were removed from service that allowed for identification of the most limiting valves to remove from service, generally the lowest setpoint, largest capacity valves. Thus the results ensure that any combination of MSSVs out of service will provide the desired overpressure protection. The results of the analyses at 102% FP, 92% FP, and 62% FP are shown in Table 3 below.

Table 3

Powel Level % of 2772 MWt	MSSVs Inoperable Per OTSG	Maximum Steam Line Pressure (psia)	Maximum OTSG Pressure (psia)
102	2	1159.1	1171.0
92	3	1165.2	1174.4
62	5	1164.9	1169.0

The acceptance criteria for the analysis are that peak steam line pressure remains below 110% of 1050 psig (1169.7 psia), and that peak OTSG pressure remains below 110% of 1150 psig (1279.7 psia). Based on these analyses, a revision to TS 3.4.1.2.3 was developed that accounts for instrument uncertainty to arrive at maximum Technical Specification power levels for a given number of MSSVs out of service.

The proposed nuclear overpower trip setpoints will conservatively ensure that plant operation is maintained below the analyzed power level, including instrument uncertainty.

In addition to the analyzed conditions, a maximum power level was developed for four (4) MSSVs out of service based on the results reported in Table 3 above. The TMI, Unit 1 Technical Specification and Standard Technical Specifications are both based on a linear relationship between the number of valves out of service and the maximum allowed power level. The maximum power level at which four (4) MSSVs can be out of service on each OTSG was calculated using a linear relationship between the analytical results at 92% FP and 62% FP. The maximum power level for four (4) MSSVs out of service on each OTSG was thereby conservatively established to be 77% FP, which provides additional margin to be consistent with the linear interpolation.

Table 4 below summarizes the proposed TS changes to address inoperable MSSVs.

Table 4

Minimum Number of MSSVs Operable on Each OTSG	Analyzed Power Level (% of 2772 MWt)	Maximum Overpower Trip Setpoint (% of Rated Power)
7	102	Per TS Table 2.3-1
6	92	85.1
5	77	70.1
4	62	55.1

Impact on UFSAR accident analyses.

The UFSAR discusses a loss of load with reactor trip in Section 14.1.2.8.3. The acceptance criteria are related to fuel damage, excessive RCS pressure, and radiological consequences. The Turbine Trip without runback event will not result in fuel damage. Fuel damage is prevented because the reactor coolant pumps operate throughout the transient and power remains well below the design overpower limit. Although the RCS pressure increases, the Turbine Trip event is not the limiting event in terms of peak primary system pressure. The analyses demonstrate that the RCS pressure has considerable margin to the limit of 2750 psig. Finally, since excessive OTSG tube loads do not occur for the Turbine Trip event, the RCPB is maintained and the radiological dose to operating personnel or the public will remain significantly less than the allowed values. As a result, the only acceptance criteria evaluated are the peak pressure in the steam generators and steam lines. Therefore, the discussion in this UFSAR section will be unaffected by the proposed amendment.

An evaluation of the impact of the proposed TS change on each of the TMI, Unit 1 UFSAR Chapter 14 design basis accidents is described in Section 8.0 of Attachment 3. These evaluations confirm that the existing UFSAR accident analyses remain bounding.

Summary

The function of the MSSVs is to prevent overpressurization of the MS System and the secondary system side of the OTSGs. Analyses for TMI, Unit 1, performed in accordance with NRC approved methods, have established the number of MSSVs required (as a function of power level) in order to satisfy the design function. Further, the analysis results demonstrate that the existing requirements of TMI, Unit 1 TS 3.4.1.2.3 are overly restrictive. In order to provide greater operational flexibility and to avoid unnecessary maneuvering of the plant and reduced power output, the MSSVs required as a function of power level are proposed to be revised. The proposed revisions continue to ensure that the existing acceptance criteria for the design of the plant are met, and existing safety analyses remain bounding.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements / Criteria

10 CFR 50.36(c)(2)(ii)(B) requires Technical Specification (TS) Limiting Conditions for Operation (LCOs) be established for "A process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier." TMI, Unit 1 TS 3.4.1.2.3 includes restrictions on plant operation if MSSVs are inoperable, to provide assurance that the secondary system pressure limit of 110% of design pressure is met, in accordance with the requirements of the American Society of Mechanical Engineers (ASME) Code.

Consistent with the above requirements, the proposed changes to allow up to two (2) MSSVs per steam generator to be inoperable with no required reduction in power level, and revisions to the required maximum overpower trip setpoints for any additional inoperable MSSVs, establish operating restrictions used as an initial condition of the transient analyses described in the TMI, Unit 1 UFSAR.

4.2 Precedent

The Babcock and Wilcox (B&W) NSSS plant designs have similar numbers of MSSVs and relief capacities, and the other B&W NSSS plant TS allow inoperable MSSVs with no reduction in power. The MSSVs are provided to prevent overpressurization, and the proposed TS change provides assurance that the MSSVs will perform the design safety function. The Arkansas Nuclear One (ANO-1) plant is a Babcock and Wilcox NSSS that is very similar in design to the TMI, Unit 1 plant. The proposed TS amendment for TMI, Unit 1 will bring the MSSV operability requirements in-line with the current ANO-1 Technical Specification for MSSVs (TS Section 3.7.1). ANO-1 TS Section 3.7.1 requires that seven (7) MSSVs per SG be operable. ANO-1 TS Table 3.7.1-1 defines the maximum allowable power level, and the nuclear overpower trip setting to be implemented with multiple MSSVs out of service.

Additionally, the Standard Technical Specifications (STS) for Babcock and Wilcox plants (Reference 6.1), Section 3.7.1, outlines the allowable operational conditions when any number of MSSVs is unavailable. The STS specify the relationship between "maximum allowable power level" and "nuclear overpower trip setpoint" versus operable MSSVs as a curve based on the "required MSSV capacity" and "available MSSV capacity" that allows the plant to reduce operating power in conjunction with the overpower trip setpoint so that the plant can continue to operate with a number of MSSVs out of service. The proposed change is consistent with the STS requirements, except that the existing TMI, Unit 1 TS 3.4.1.2.3 table format specifying the relationship between "minimum number of operable MSSVs per OTSG" and "maximum overpower trip setpoint" is maintained for operator familiarity, rather than incorporation of the STS relieving capacity/maximum nuclear overpower trip setpoint equation relationship. The TMI, Unit 1 proposed format is consistent with ANO-1 TS Section 3.7.1, as described above.

4.3 <u>No Significant Hazards Consideration Determination</u>

EGC has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1. Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No

The proposed amendment is not a change to the plant structures, systems, or components. There is no increase to the likelihood of Main Steam Safety Valve (MSSV) related failures. The MSSVs are relied upon to mitigate the effects of Updated Final Safety Analysis Report (UFSAR) Chapter 14 design basis events including the loss of load (turbine trip), which is the limiting event for secondary system overpressure. Analyses, performed in accordance with NRC approved methods, have demonstrated that with reduced MSSV availability and following the specified power level restrictions, the MSSVs will continue to limit the secondary system pressure to less than 110% of the design pressure of the Once Through Steam Generators (OTSGs) and the Main Steam (MS) System as required by ASME code. Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No

The proposed amendment is not a change to the plant structures, systems, or components (SSCs). Furthermore, within the current licensing basis, the MSSVs are accident mitigation SSCs. The current licensing basis does not include consideration of a MSSV failure as an event initiator. The proposed amendment will not fundamentally alter or create any new operator actions. Therefore, the proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No

The limiting event for secondary system overpressure is a loss of load event (turbine trip). The event has been analyzed for varying MSSVs out of service, using NRC approved methods. The results of the analysis demonstrate that the existing design acceptance criteria (i.e., MS and OTSG pressure remain less than 110% of the design pressure) are met for all combinations of inoperable MSSVs and initial power levels described in the proposed change. Therefore, the proposed change does not involve a significant reduction in a margin of safety.

Based on the above, EGC concludes that the proposed amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of no significant hazards consideration is justified.

4.4 Conclusions

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or a significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

6.1 NUREG-1430, Revision 3, Standard Technical Specifications – Babcock and Wilcox Plants.

6.2 AREVA NP Topical Report BAW-10193PA-00, "RELAP5/MOD2-B&W for Safety Analysis of B&W-Designed Pressurized Water Reactors".

6.3 AREVA NP Topical Report BAW-10164PA-06, "RELAP5/MOD2-B&W--An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis".

ATTACHMENT 2

Markup of Technical Specifications Pages and TS Bases Pages

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50

REVISED TECHNICAL SPECIFICATIONS PAGE

3-26a

REVISED TECHNICAL SPECIFICATIONS BASES PAGE (For Information Only)

3-26c

3.4.1.2.3 Except as provided in Specification 3.4.1.2.2 above, when the Reactor is above HOT SHUTDOWN, **seven (7)** MSSVs **per OTSG** shall be OPERABLE. **If either OTSG has less than seven (7) MSSVs that are** OPERABLE, **then reduce the power and reset** the maximum overpower trip setpoint as follows:

Minimum Number of MSSVs **Operable** on **Each** OTSG	Maximum Overpower Trip Setpoint (% of Rated Power)
7	**see Table 2.3-1**
6	**85.1**
5	**70.1**
4	**55.1**

With less than four (4) MSSVs OPERABLE per OTSG, restore to a condition with at least four (4) MSSVs *on each* OTSG to OPERABLE status within 4 hours or be in HOT SHUTDOWN within the next 6 hours.

3.4.2 RCS temperature less than or equal to 250 degrees F.

3.4.2.1 At least two of the following means for maintaining DHR capability shall be OPERABLE and at least one shall be in operation except as allowed by Specifications 3.4.2.2, 3.4.2.3 and 3.4.2.4.

a. DHR String (Loop "A").

b. DHR String (Loop "B").

c. RCS Loop "A" and its associated OTSG with an EFW Pump and a flowpath.

d. RCS Loop "B" and its associated OTSG with an EFW Pump and a flowpath.

With less than the above required means for maintaining DHR capability OPERABLE, immediately initiate corrective action to return the required loops to OPERABLE status as soon as possible.

3.4.2.2 Operation of the means for DHR may be suspended provided the core outlet temperature is maintained below saturation temperature.

3.4.2.3 The number of means for DHR required to be OPERABLE per Specification 3.4.2.1 may be reduced to one provided that the Reactor is in a REFUELING SHUTDOWN condition with the Fuel Transfer Canal water level greater than or equal to 23 feet above the Reactor Vessel flange.

3.4.2.4 Specification 3.4.2.1 does not apply when either of the following conditions exist:

a. Decay heat generation is less than 188 KW with the RCS full.

b. Decay heat generation is less than 100 KW with the RCS drained down for maintenance.

Bases (Continued)

If EFW were required during surveillance testing, minor operator action (e.g., opening a local isolation valve or manipulating a control switch from the control room) may be needed to restore operability of the required pumps or flowpaths. An exception to permit more than one EFW Pump or both EFW flowpaths to a single OTSG to be inoperable for up to 8 hours during surveillance testing requires 1) at least one motor-driven EFW Pump operable, and 2) an individual involved in the task of testing the EFW System must be in communication with the control room and stationed in the immediate vicinity of the affected EFW flowpath valves. Thus the individual is permitted to be involved in the test activities by taking test data and his movement is restricted to the area of the EFW Pump and valve rooms where the testing is being conducted.

The allowed action times are reasonable, based on operating experience, to reach the required plant operating conditions from full power in an orderly manner and without challenging plant systems. Without at least two EFW Pumps and one EFW flowpath to each OTSG operable, the required action is to immediately restore EFW components to operable status, and all actions requiring shutdown or changes in Reactor Operating Condition are suspended. With less than two EFW pumps or no flowpath to either OTSG operable, the unit is in a seriously degraded condition with no safety related means for conducting a cooldown. In such a condition, the unit should not be perturbed by any action, including a power change, which might result in a trip. The seriousness of this condition requires that action be started immediately to restore EFW components to operable status. TS 3.0.1 is not applicable, as it could force the unit into a less safe condition.

The EFW system actuates on: 1) loss of all four Reactor Coolant Pumps, 2) loss of both Main Feedwater Pumps, 3) low OTSG water level, or 4) high Reactor Building pressure. A single active failure in the HSPS will neither inadvertently initiate the EFW system nor isolate the Main Feedwater system. OTSG water level is controlled automatically by the HSPS system or can be controlled manually, if necessary.

The MSSVs will be able to relieve to atmosphere the total steam flow if necessary. **Specification 3.4.1.2.3 provides limiting conditions of operation if more than two MSSVs are inoperable on a single OTSG. The power level and overpower trip setpoint must be reduced, as stated in Specification 3.4.1.2.3 such that the remaining MSSVs can prevent secondary system overpressure on a turbine trip. The turbine trip event is the limiting event in terms of peak secondary system pressure. Analyses have shown that overpressure will not occur if a turbine trip occurs with two or less MSSVs out of service on each OTSG and an initial power level less than or equal to 102% of 2772 MWth. Having MSSVs out of service as allowed by Specification 3.4.1.2.3 does not adversely impact the transient progression of the remaining Safety Analysis events.**

Below 5% power, only a minimum number of MSSVs need to be operable as stated in Specifications 3.4.1.2.1 and 3.4.1.2.2. This is to provide OTSG overpressure protection during hot functional testing and low power physics testing. Additionally, when the Reactor is between hot shutdown and 5% full power operation, the overpower trip setpoint in the RPS shall be set to less than 5% as is specified in Specification 3.4.1.2.2. The minimum number of MSSVs required to be operable allows margin for testing without jeopardizing plant safety. Plant specific analysis shows that one MSSV is sufficient to relieve reactor coolant pump heat and stored energy when the reactor has been subcritical by 1% delta K/K for at least one hour. Other plant analyses show that two (2) MSSVs on either OTSG are more than sufficient to relieve reactor coolant pump heat and stored energy when the reactor is below 5% full power operation but had been subcritical by 1% delta K/K for at least one hour subsequent to power operation above 5% full power. According to Specification 3.1.1.2a, both OTSGs shall have tube integrity whenever the reactor coolant average temperature is above 200 degrees F. This assures that all four (4) MSSVs are available for redundancy.

ATTACHMENT 3

TMI Unit 1 Technical Evaluation No. A2148778 E18 for

AREVA Document 86-9054640-002

TMI-1 MSSV Operability Phase 2 Results

September 16, 2009

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50

TMI Unit 1 Technical Evaluation No. A2148778 E18

(5 pages)

for

AREVA Document 86-9054640-002

TMI-1 MSSV Operability Phase 2 Results

September 16, 2009

(55 pages)

*** ACTION REQUEST ***

A/R TYPE : EC ECR
REQUEST ORG : TWP
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EVALUATION NBR: 18
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EVAL STATUS : ASIGND

IMPORTANCE CODE: OEAP: SCHEDULE CODE: DATE FIXED:

EVAL DESC: ISSUE TECHNICAL EVALUATION FOR 86-9054640-002

SEE ATTACHMENTS SCANNED ELECTRONICALLY INTO EDMS	MXHE 28JUN10
.	MXHE 28JUN10
ATTACHMENT #1: TECHNICAL EVALUATION DISPOSITION	MXHE 28JUN10
ATTACHMENT #2: CC-AA-309 ATTACHMENT #1: OWNERS ACCEPTANCE	MXHE 28JUN10
REVIEW CHECKLIST FOR EXTERNAL DESIGN	MXHE 28JUN10
DESIGN ANALYSES.	MXHE 28JUN10
ATTACHMENT #3: AREVA CALCULATION 86-9054640-002	MXHE 28JUN10
"TMI-1 MSSV OPERABILITY PHASE 2 RESULTS"	MXHE 28JUN10

========================END OF ACTION REQUEST=============================

ATTACHMENT 1
Owners Acceptance Review Checklist for External Design Analysis
Page 1 of 1

DESIGN ANALYSIS NO. 86-9054640 **REV:** 2

		Yes	No	N/A
1.	Do assumptions have sufficient rationale?	☑	☐	☐
2.	Are assumptions compatible with the way the plant is operated and with the licensing basis? *	☑	☐	☐
3.	Do the design inputs have sufficient rationale?	☑	☐	☐
4.	Are design inputs correct and reasonable with critical parameters identified, if appropriate?	☑	☐	☐
5.	Are design inputs compatible with the way the plant is operated and with the licensing basis? *	☑	☐	☐
6.	Are Engineering Judgments clearly documented and justified?	☑	☐	☐
7.	Are Engineering Judgments compatible with the way the plant is operated and with the licensing basis? *	☑	☐	☐
8.	Do the results and conclusions satisfy the purpose and objective of the Design Analysis?	☑	☐	☐
9.	Are the results and conclusions compatible with the way the plant is operated and with the licensing basis? *	☑	☐	☐
10.	Does the Design Analysis include the applicable design basis documentation?	☑	☐	☐
11.	Have any limitations on the use of the results been identified and transmitted to the appropriate organizations?	☑	☐	☐
12.	Are there any unverified assumptions?	☐	☑	☐
13.	Do all unverified assumptions have a tracking and closure mechanism in place?	☐	☐	☑
14.	Have all affected design analyses been documented on the Affected Documents List (ADL) for the associated Configuration Change? *	☑	☐	☐
15.	Do the sources of inputs **and** analysis methodology used meet current technical requirements and regulatory commitments? (If the input sources **or** analysis methodology are based on an out-of-date methodology or code, additional reconciliation may be required if the site has since committed to a more recent code)	☑	☐	☐
16.	Have vendor supporting technical documents and references (including GE DRFs) been reviewed when necessary?	☑	☐	☐
17.	Have margin impacts been identified and documented appropriately for any negative impacts (Reference ER-AA-2007)?	☑	☐	☐

EXELON REVIEWER: [signature] / Michael Harty **DATE:** 6/22/10
Print / Sign

* The associated configuration change, ECR 07-00633, can not be implemented until TMI-1 TSCR # 351 is approved by the NRC, thus changing the licensing basis

1.0 Reason For Evaluation / Scope

AREVA prepared Calculation No. 86-9054640-002 analyzes the effects of a turbine trip without runback or an ARTS trip for different scenarios where Main Steam Safety Valves (MSSVs) were inoperable. The analysis supports TMI-TSCR #351 "Maximum Allowable Power with Inoperable MSSVs." It cannot be issued as a Calculation through an Engineering Change Request until the License Amendment Request (LAR) is approved by the NRC. This Technical Evaluation describes which section 7.0 recommendations TMI will enact, and provides justification for those that will be disregarded. Furthermore, it documents the owner's acceptance review of AREVA calculation 86-9054640-002.

This Technical Evaluation has been prepared in accordance with CC-AA-309-101 "Engineering Technical Evaluations." A risk assessment has been completed in accordance with HU-AA-1212. The consequence risk level is High for section C.1. Combined with a low probability of error for the 2 human performance risk factors identified, a risk ranking of 2 was determined. An independent review by the station is required. This evaluation is approved as the independent review requirement will be met by the Technical Verification Team review and PORC review of the TSCR.

2.0 Detailed Evaluation

In this analysis, AREVA recommends reduced power overpower trip setpoints to ensure normal operation is restricted to power levels that are less than the acceptable analyzed power levels with inoperable MSSVs. The recommendations for Maximum Overpower Trip Setpoint at reduced power outlined in section 6.0 of 86-905640-002 have been adopted for the TMI-TSCR #351; however, they are recognized as being overly conservative. The basis for reducing the analyzed power level by 6.9% to establish an overpower trip setpoint comes from the difference between 112% full power, and the 105.1% overpower trip setpoint applied to normal operations at 100% power. The function of the 105.1% overpower trip setpoint is to prevent core thermal power from exceeding 112% to protect against fuel damage in a reactivity transient. The normal function of the overpower trip setpoint is not to protect against secondary side overpressure. Therefore 6.9% margin for the overpower trip setpoint is not applicable to the administrative method used to keep steady state reactor power below the analyzed power level for conditions with inoperable MSSVs.

Secondary side overprotection can be accomplished by setting the overpower trip at 2% below the analyzed power level. A margin of 2% is appropriate because the maximum uncertainty in the measurement of reactor power is less than 2% at 100% power (Reference UFSAR Table 3.2-11). The AREVA recommended overpower setpoint is more conservative than necessary; however, TMI has decided to accept the recommended overpower trip setpoints.

TMI has not adopted the suggested change in 86-9054640-002 section 7.0 which states "At lease one (1) OPERABLE MSSV on each steam generator must have a nominal lift setpoint ≤ 1050 pisg . . . ." One safety valve per OTSG is required to open at the design pressure of the protected component per ASME section III article 9. While the EOTSGs are designed to meet ASME section III, they have a design pressure of 1150 psig. All safety relief valves lift below 1150 psig. The main steam line, between the steam generators and safety relief valves has a design pressure of 1050 psig. This piping is designed to B31.1, 1967 edition "Power Piping," not to ASME section III. There is no requirement for B31.1 piping to have at least 1 safety valve set at the pipe design pressure. The acceptance criterion used to demonstrate sufficient overpressure protection is the ability to remain under 110% of rated design pressure during any anticipated transient. The analysis is bounding in that it demonstrates overpressure protection when the most limiting combinations of MSSVs are out of service. No additional requirement specific to the number of operable MSSVs with lift setpoints ≤ 1050 pisg is necessary to remain within 110% of the system design pressure.

Although changes to technical specification bases do not require NRC approval, the suggested changed to section 3.4, Bases will be incorporated into the TSCR.

Although there is no recommendation in section 7.0, 86-9054640-002 discusses the potential for increasing the setpoints of safety valves MS-V-21A and MS-V-21B. There is no plant initiative to change any MSSV setpoint. For the approval and future implementation of TMI-TSCR #351, any analysis or discussion regarding increasing the setpoints of MS-V-21A and MS-V-21B shall not be applied.

3.0 Conclusions / Findings

The calculation will be used in conjunction with this technical evaluation as a supporting attachment to TMI TSCR #351 "Maximum Allowable Power with Inoperable MSSVs." Upon approval of the LAR, the calculation will be issued as part of the implementing ECR. The implementing ECR will facilitate how the results of the calculation are incorporated into the plant design basis consistent with this technical evaluation.

The independent reviewer of this Technical Evaluation concurs with the analysis of 86-9054640-002 included in attachment #1 only. The preparer of this evaluation has signed as the reviewer on CC-AA-309 Attachment #1, "Owners Acceptance Review Checklist for External Design Analysis" for AREVA calculation 86-905640-002. The checklist documents acceptance of the calculation upon manager approval of this Technical Evaluation

4.0 References:

2.1 ASME Boiler and Pressure Vessel Code Section III, Article 9. 1968 edition.
2.2 TMI-1 TSCR #351 "Maximum Allowable Power with Inoperable MSSVs."
2.3 TMI Updated Final Safety Analysis. Table 3.2-11.

2.5 HU-AA-1212 ""Technical Task/Rigor Assessment, Pre-Job Brief, Independent Third Party Review, and Post-Job Brief.
2.6 ASTM B31.1, 1967 Edition. "Power Piping"

5.0 Approvals

Prepared	Michael Harty	Date 7/1/10
Prepared	Bill McSorley	Date 7/1/10
Reviewed	Steven Dunkelberger	Date 7/1/10
Approved	Pat Bennett	Date 7/1/2010

AREVA

CALCULATION SUMMARY SHEET (CSS)

Document No. 86 - 9054640 - 002 Safety Related: ☒ Yes ☐ No

Title TMI-1 MSSV Operability Phase 2 Results

PURPOSE AND SUMMARY OF RESULTS:

Reference 11 summarizes an evaluation of MSSV operability for TMI-1 with the OTSGs and the current rated thermal power level of 2568 MWt. Reference 11 specifies the maximum overpower trip setpoint and maximum nominal operating power level that is acceptable as a function of the number of MSSVs out of service per steam generator.

Reference 1 used evaluations of the Turbine Trip without runback or ARTS trip for TMI-1 with the E-OTSG to demonstrate that the table of MSSVs out of service versus the maximum allowed power level and the overpower trip setpoint developed in Reference 11 for the OTSGs remains applicable for the E-OTSGs. The purpose of this document is to summarize the analyses methods and results of the E-OTSG evaluations in Reference 1. The evaluations in Reference 1, which used calculations from References 5 and 6, were performed at a stretch rated power level of 2772 MWt, but are applicable to the current rated power level of 2568 MWt.

The Reference 1 results support a revision to TS 3.4.1.2.3 for the E-OTSGs. Suggested changes to the existing TS and Bases are provided in this document, and are the same as was provided in Reference 11.

The calculation in Reference 1 also evaluated the setpoint of MSSVs MS-V21A and MS-V21B. These MSSVs currently have a nominal setpoint of 1040 psig. Evaluations were performed in Reference 1 to support increasing the setpoint of these two MSSVs to 1050 psig with the E-OTSGs. The results of those evaluations are discussed in this document. Note that Reference 8 Section 3.2.3.5 currently requires that at least one MSSV on each steam generator has a nominal setpoint of 1040 psig. This document does not address the potential revision needed to Reference 8 or any other design basis documentation in order to increase the setpoint of MSSVs MS-V21A and MS-V21B.

Revision 2 of this document addresses customer comments and does not affect the results and/or conclusions of the previous revisions of this document.

[redacted]

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE/VERSION/REV	CODE/VERSION/REV
None	

THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

☐ YES
☒ NO

AREVA

AREVA NP Inc.,
an AREVA and Siemens company

0402-01-F01 (20697) (Rev. 014, 04/13/2009)

Document No. 86-9054640-002

TMI-1 MSSV Operability Phase 2 Results

Review Method: ☒ Design Review (Detailed Check)
☐ Alternate Calculation

Signature Block

Name (printed or typed) and Title	Signature	P/R/A and LP/LR	Date	Pages/Sections Prepared/Reviewed/Approved and Comments/Review Method
C.J. Williamson Engineer II	[signature]	P	9/16/09	All
T.S. Beckham Supv. Engr.	[signature]	R	9/16/09	All
K.E. Higar Mgr., Safety Analysis	[signature]	A	9/16/09	All, Independent Review

Note: P/R/A designates Preparer (P), Reviewer (R), Approver (A);
LP/LR designates Lead Preparer (LP), Lead Reviewer (LR)

Project Manager Approval of Customer References (N/A if not applicable)

Name (printed or typed)	Title (printed or typed)	Signature	Date
R.J. Baker	Project Manager	[signature]	9/16/09

Record of Revision

Revision No.	Date	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
000	8/29/2007	All	Initial Release
001	Nov. 2008	All	Changes made to address customer comments. Additional changes made to update references and use latest document form. Addition of Page 2 changes the page numbering of all subsequent pages, requiring a complete reissue. Rev. bars are provided on right hand side next to text affected by customer comments.
002	9/2009	All	Changes made to address customer comments. Additional changes made to update references and use latest document form. Added Figures 4-1 through 4-25. Rev. bars are provided on right hand side next to text affected by customer comments. Revision 002 is a complete reissue.

Table of Contents

Page

List of Tables

Page

List of Figures

List of Acronyms

AIS	Analytical Input Summary
AOR	Analysis of Record
ARTS	Anticipatory Reactor Trip System
ASME	American Society of Mechanical Engineers
ATWS	Anticipated Transient Without Scram
DNB	Departure from Nucleate Boiling
ECCS	Emergency Core Cooling System
E-OTSG	Enhanced Once Through Steam Generator
FP	Full Power
ICS	Integrated Control System
LOCA	Loss of Coolant Accident
MSIV	Main Steam Isolation Valve
MSSV	Main Steam Safety Valve
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
OTSG	Once Through Steam Generator
PORV	Pilot Operated Relief Valve
PSV	Pressurizer Safety Valve
RCP	Reactor Coolant Pump
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
RPS	Reactor Protection System
R5/M2-B&W	RELAP5/MOD2-B&W
SG	Steam Generator
TMI-1	Three Mile Island Unit 1
TCV	Turbine Control Valve
TS	Technical Specifications
TSV	Turbine Stop Valve
UFSAR	Updated Final Safety Analysis Report

1.0 Introduction/Background

The limiting transient for evaluating the secondary side overpressure protection is the Turbine Trip accident without power runback and without credit for the ARTS trip signal coincident with turbine trip. One of the key parameters for the Turbine Trip accident relates to the operability of the MSSVs. Specifically, TMI-1 TS 3.4.1.2.3 [Reference 7] defines the operability requirements for the MSSVs. In particular, the TS requires a reduction in the overpower trip setpoint (and a corresponding reduction in core power) if even one MSSV is declared to be out of service. This requirement is different from what is currently applied to the other B&W-designed plants. In addition, if more than 3 valves are inoperable at TMI-1, the plant is in an action statement to restore at least 15 valves to operable status or be in hot shutdown. The other plants remain operating with as few as 2 operable valves on any SG.

Scoping analyses have been performed for the TMI-1 E-OTSGs at a core power level of 102% of 2772 MWt [Reference 5]. Those results indicate that it may be possible for up to 2 valves on each E-OTSG to be declared inoperable with no required reduction in core power. In addition, with a third valve out of service, the power may only need to be reduced to ~90% [Reference 6]. These results indicate that there is a sufficient basis to revise TS 3.4.1.2.3 for the E-OTSGs to be less restrictive.

Table 1-1 lists the location, size, current nominal lift setpoint, and capacity for the TMI-1 MSSVs. This information was obtained from Reference 5 Table 7-3.

Table 1-1: TMI-1 Main Steam Safety Valve Size, Current Nominal Lift Setpoint, and Capacity

Steam Generator / Steam Line	Valve	Size (inches)	Lift Setpoint (psig)	Rated Capacity[1] (lbm/hr)
SG-A / Line 1	MS-V17A	6 by 10	1050	792,610
	MS-V18A	6 by 10	1060	799,990
	MS-V19A	6 by 10	1080	814,955
	MS-V20A	6 by 10	1050	792,610
	MS-V21A	3 by 6	1040	194,900
SG-A / Line 2	MS-V17B	6 by 10	1050	792,610
	MS-V18B	6 by 10	1060	799,990
	MS-V19B	6 by 10	1080	814,955
	MS-V20B	6 by 10	1092.5	824,265
SG-B / Line 3	MS-V17C	6 by 10	1050	792,610
	MS-V18C	6 by 10	1060	799,990
	MS-V19C	6 by 10	1080	814,955
	MS-V20C	6 by 10	1092.5	824,265
	MS-V21B	3 by 6	1040	194,900
SG-B / Line 4	MS-V17D	6 by 10	1050	792,610
	MS-V18D	6 by 10	1060	799,990
	MS-V19D	6 by 10	1080	814,955
	MS-V20D	6 by 10	1050	792,610

[1] Rated capacity is based on saturated steam at the nominal lift setpoint plus 3% accumulation.

2.0 Purpose

Reference 11 summarizes an evaluation of MSSV operability for TMI-1 with the OTSGs and the current rated thermal power level of 2568 MWt. Reference 11 specifies the maximum overpower trip setpoint and maximum nominal operating power level that is acceptable as a function of the number of MSSVs out of service per steam generator.

Reference 1 used evaluations of the Turbine Trip without runback or ARTS trip for TMI-1 with the E-OTSG to demonstrate that the table of MSSVs out of service versus the maximum allowed power level and the overpower trip setpoint developed in Reference 11 for the OTSGs remains applicable for the E-OTSGs. The purpose of this document is to summarize the analyses methods and results of the E-OTSG evaluations in Reference 1. The evaluations in Reference 1, which used calculations from References 5 and 6, were performed at a stretch rated power level of 2772 MWt, but are applicable to the current rated power level of 2568 MWt.

The Reference 1 results support a revision to TS 3.4.1.2.3 for the E-OTSGs. Suggested changes to the existing TS and Bases are provided in this document, and are the same as was provided in Reference 11.

The calculation in Reference 1 also evaluated the setpoint of MSSVs MS-V21A and MS-V21B. These MSSVs currently have a nominal setpoint of 1040 psig. Evaluations were performed in Reference 1 to support increasing the setpoint of these two MSSVs to 1050 psig with the E-OTSGs. The results of those evaluations are discussed in this document. Note that Reference 8 Section 3.2.3.5 currently requires that at least one MSSV on each steam generator has a nominal setpoint of 1040 psig. This document does not address the potential revision needed to Reference 8 or any other design basis documentation in order to increase the setpoint of MSSVs MS-V21A and MS-V21B.

3.0 Analytical Input Summary Review / Method of Analysis

3.1 Analytical Input Summary Review

Reference 4 is the AIS for the Turbine Trip event with E-OTSGs. Reference 4 was reviewed for applicability to the evaluation of the Turbine Trip event with the E-OTSGs and MSSVs out of service. No substantive changes were required.

Reference 4 states that pressurizer spray should be modeled and that a sensitivity study should be run for the limiting event to determine the effects of pressurizer spray on the peak SG pressure. References 1 and 5 performed sensitivity studies on the effects of pressurizer spray and determined that at full power, the peak SG pressure for the Turbine Trip was more limiting without pressurizer spray. Therefore, the E-OTSG analyses in Reference 1 and Reference 5 do not model pressurizer spray. References 1 and 6 performed sensitivity studies on the effects of pressurizer spray and determined that at reduced power, the peak SG pressure was higher with pressurizer spray modeled but that the effect of pressurizer spray was less than minimal (0.34 psi or less.) Nevertheless, the Reference 6 evaluation modeled pressurizer spray. All other inputs in Reference 4 were deemed applicable to the Turbine Trip analysis with the E-OTSGs. Therefore, a revision to Reference 4 is not warranted for this analysis.

Note that the power level for partial power cases will be conservative for a specified number of MSSVs that are inoperable at that power level.

The event description and methodology are based on the discussion provided in Reference 4.

3.2 Event Description

A loss of electric load event can result from faults within the turbine generator, but more often are caused by circuit breaker operation somewhere within the power grid. Nonetheless, a loss of electric load and/or turbine trip can exist without a loss of emergency power. This type of event may be the result of the inadvertent closure of a main steam isolation valve (MSIV), a turbine control valve (TCV), or a turbine stop valve (TSV).

As a result of the load reduction, the secondary system pressure rapidly increases until the MSSVs lift, allowing for the continued removal of heat through the SGs. The diminished heat removal capability of the SGs causes the reactor coolant temperature to increase, which reduces the fluid density and causes an insurge of reactor coolant into the pressurizer. As the pressurizer level increases, the system pressure also increases due to compressing the steam bubble within the pressurizer. If available, the pressurizer sprays are actuated in an attempt to reduce the pressure increase. Depending on the severity of the loss of heat sink, the actions of the pressurizer spray may be insufficient to prevent the pressurizer pressure and level from increasing. If the system pressure continues to increase to the High Reactor Coolant System (RCS) Pressure trip setpoint, the Reactor Protection System (RPS) will trip the reactor. Further pressure increases are ameliorated by the pressurizer Pilot Operated Relief Valve (PORV) and/or the

Pressurizer Safety Valves (PSVs). The PSVs have sufficient relieving capacity to prevent the system pressure from exceeding the accident acceptance criterion.

At this point during the transient the heat removal capability of the SGs is sufficient to reduce the reactor coolant temperature. Thus, the Turbine Trip event analysis is terminated at this time.

Section 14.1.2.8.2 of the TMI-1 UFSAR [Reference 9] describes a loss of electric load event in which the power is runback to 15 %FP without a reactor trip. This event is not limiting in terms of peak secondary pressure because of the immediate power reduction. Furthermore, this event can not presently occur because the ICS can not reduce power quickly enough to prevent a reactor trip with the current high pressure reactor trip and PORV setpoints.

Section 14.1.2.8.3 of the TMI-1 UFSAR [Reference 9] describes a loss of load event in which the ARTS trip on turbine trip function is credited. This event is not limiting in terms of secondary pressure because of the immediate reactor trip signal coincident with the turbine trip.

The Turbine Trip event analyzed in Reference 1 for determining the number of MSSVs that can be inoperable at a given power level does not take credit for the ICS runback or the ARTS trip signal on turbine trip function. As a result, the Turbine Trip event analyzed in Reference 1 is the limiting event in terms of the peak secondary pressure response.

3.3 Methodology Employed

The Turbine Trip analyses were performed in accordance with methodology [Reference 2] approved by the Nuclear Regulatory Commission (NRC). Where possible, this methodology utilizes the plant design bases to establish acceptance criteria and input boundary conditions. The approved methodology includes the manner for determining the responses of the primary system, the secondary system, and the core to postulated accidents. In addition, the methodology requires the use of conservative setpoints, valve and pump capacities, and reactivity coefficients to demonstrate adequate margin to the applicable limits. With respect to the inoperable MSSVs, the valve setpoints and sensitivity studies were used to determine the valve or combination of valves that produce the limiting secondary pressure for a given number of valves out of service.

A combined representation of the TMI-1 nuclear steam supply system (NSSS) is used to perform the Turbine Trip analysis. This representation includes the:

- reactor vessel and core;
- hot legs, cold legs, and reactor coolant pumps;
- pressurizer;
- replacement steam generators;
- main steam piping and valves; and,
- reactor protection system.

Fuel damage is not postulated for the Turbine Trip event because thermal power will remain less than 112% of full power for the duration of the event. With the reactor coolant pumps (RCPs) operating throughout the event, an excessive power-to-flow ratio is also avoided. Hence, the fuel pins will not experience a Departure from Nucleate Boiling (DNB).

Consistent with typical safety analysis assumptions, the core heat generation rate after reactor trip is based on 1.0 times the ANS-1971 decay heat standard for fission plus the B&W heavy actinides. This combination of decay heat curve and multiplier has been shown to produce more energy than the ANS-1979 decay heat curve plus 2σ uncertainty. While this assumption is conservative for RCS overpressure transients, it does not contribute significantly to secondary side overpressurization since the event is initiated by a turbine trip and the peak secondary pressure is reached soon thereafter just prior to lifting of the MSSVs.

Excessive pressurization of the Reactor Coolant Pressure Boundary (RCPB), i.e. pressurization of the RCS to a pressure that is much greater than the design pressure, is not postulated for the Turbine Trip event. Although the peak RCS pressure will exceed the design pressure of 2500 psig, the peak RCS pressure is significantly less than the peak pressure of 2707.69 psia for the Startup Accident. Thus, the RCPB will not experience excessive pressurization.

The integrity of the RCPB is also maintained because consequential damage to the SG tubes from excessive tube loads will not occur for the Turbine Trip event. Accordingly, the radiological doses to operating personnel (onsite) or to the public (offsite) will remain significantly less than the allowed values provided the integrity of the secondary pressure boundary remains intact.

The applicable acceptance criterion evaluated to determine the number of MSSVs that can be out of service for a given initial power level is the peak secondary side pressure in the SG and steam lines. The maximum steam line pressures reported in this document are taken at the EOTSG steam outlet nozzle where the pressure is greatest. The pressure drop from the steam outlet nozzles to the MSSVs is explicitly accounted for in the supporting analyses which contain detailed modeling of the steam lines. Also, the MSSVs are mounted in close proximity to the steam lines, such that the pressure drop from the steam lines to the MSSVs does not have a significant impact on the lift pressure of the MSSVs in relation to steam line pressure. The pressure drop to the MSSVs is assumed to be negligible because the length of piping is not substantial enough to create any significant pressure drop to the MSSVs. ASME code requirements for the SG and attached piping require the pressure to be limited to 110% of the design pressure. The design pressure for the E-OTSG is 1150 psig, which gives a pressure limit of 1279.7 psia for the E-OTSGs. The design pressure for the steam lines is 1050 psig, which gives a pressure limit of 1169.7 psia for the steam lines for this limited duration transient. The RCS pressure limit is 2764.7 psia, however this limit will not be challenged.

3.4 Computer Code Utilized

The RELAP5/MOD2-B&W (R5/M2-B&W) computer code [Reference 3] was used for the analysis of the Turbine Trip event. This code has been approved by the NRC for use in non-Loss of Coolant Accident (LOCA) safety analyses [Reference 2]. Furthermore, this code is recognized as providing a conservative prediction of the overheating that will occur during the Turbine Trip event [Reference 2].

The code simulates RCS and secondary system operation. The reactor core model is based on a point kinetics solution with reactivity feedback for control rod assembly insertion, fuel temperature changes, and moderator temperature changes. The RCS model provides for heat transfer from the core, transport of the coolant to the SGs, and heat transfer to the SGs. The secondary model includes a detailed depiction of the main steam system, including steam relief to the atmosphere through the MSSVs and simulation of the TSVs. The secondary model also includes the delivery of feedwater, both main and emergency, to the SGs.

4.0 Full Power Results

Reference 5 developed a TMI-1 model at 102% of 2772 MWt with the E-OTSGs. The model is consistent with Reference 4, with the exception of the pressurizer spray model and the RCS average temperature. Reference 5 determined that the peak secondary pressure was higher without pressurizer spray and therefore did not use pressurizer spray for the base analysis. The RCS average temperature used in the Reference 5 model is conservative.

4.1 Full Power with Two MSSVs Out of Service

The scoping analysis done for the E-OTSG at 102 %FP [Reference 5] evaluated the limiting combination of two MSSVs out of service. Table 1-1 shows that Steam Line 1 and Steam Line 3 each have five MSSVs whereas Steam Line 2 and Steam Line 4 each have only four MSSVs. Therefore, the limiting combination will occur if two MSSVs are removed from service on Steam Line 2 or Steam Line 4. On Steam Line 2, valves MS-V17B and MS-V18B were disabled because they are the lowest setpoint valves on that steam line. Similarly, on Steam Line 4, valves MS-V17D and MS-V20D were disabled because they are the lowest setpoint valves on that steam line. Reference 5 determined that the limiting combination of two MSSVs out of service occurred when valves MS-V17D and MS-V20D were inoperable. The results from the limiting case are summarized in Table 4-1.

Table 4-1: Turbine Trip at 102% of 2772 MWt, Two MSSVs Out of Service, E-OTSG

Valves Out of Service	MS-V17D, MS-V20D
Maximum RCS Pressure (psia)	2581.11
Maximum SG Pressure (psia)	1170.97
Maximum Steam Line Pressure (psia)	1159.06

The resulting maximum RCS pressure is 2581.11 psia, which is well below the maximum RCS pressure 2707.69 psia in the Startup Accident. The maximum SG pressure is 1170.97 psia, which is less than the 1279.7 psia Code requirement for the E-OTSGs. The maximum steam line pressure is 1159.06 psia, which is less than the 1169.7 psia Code requirement for the steam lines. The results demonstrate that no reduction in power is required for continued operation with the E-OTSGs with as many as two MSSVs out of service. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

Figure 4–1 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

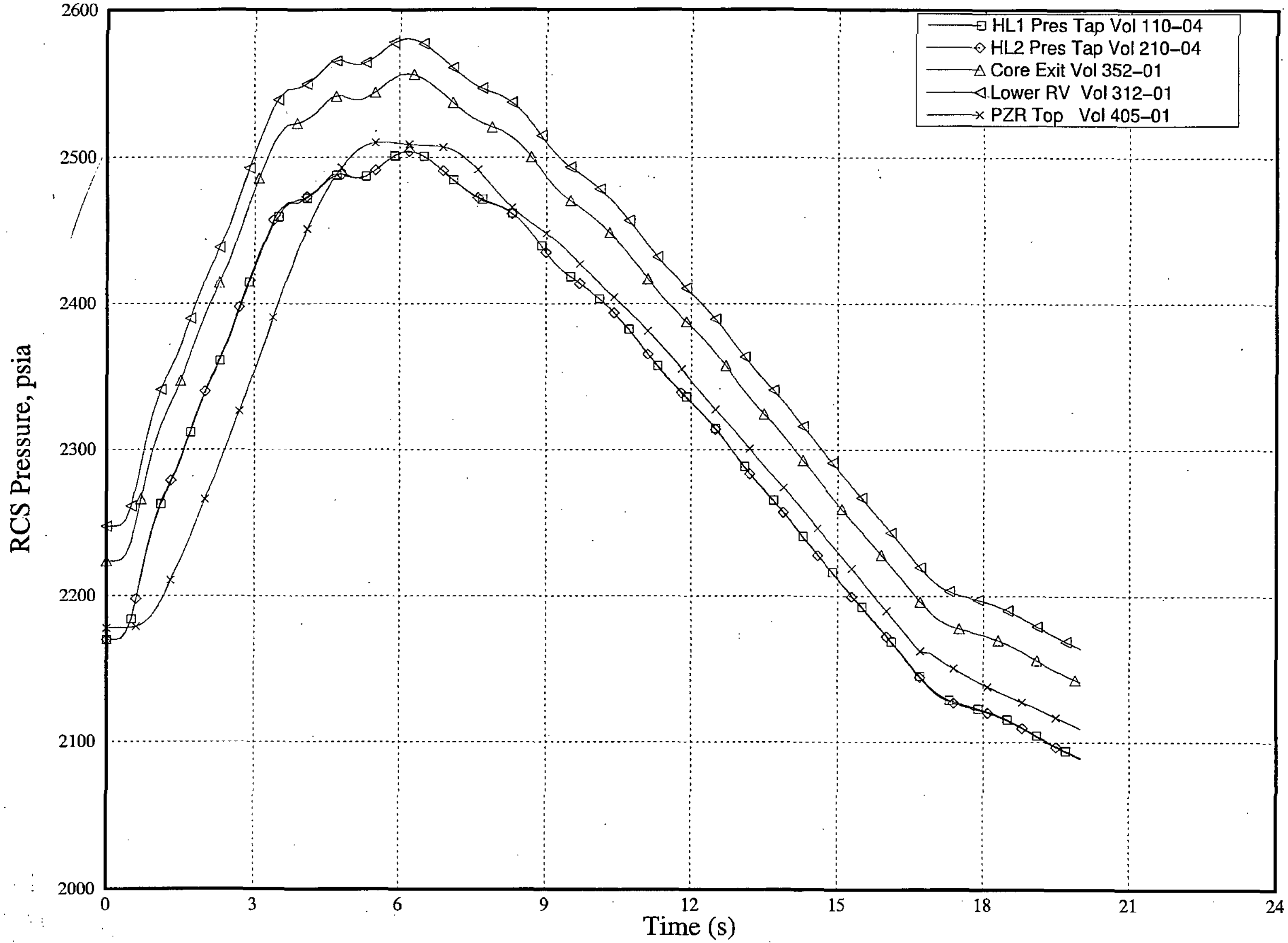

Figure 4–2 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

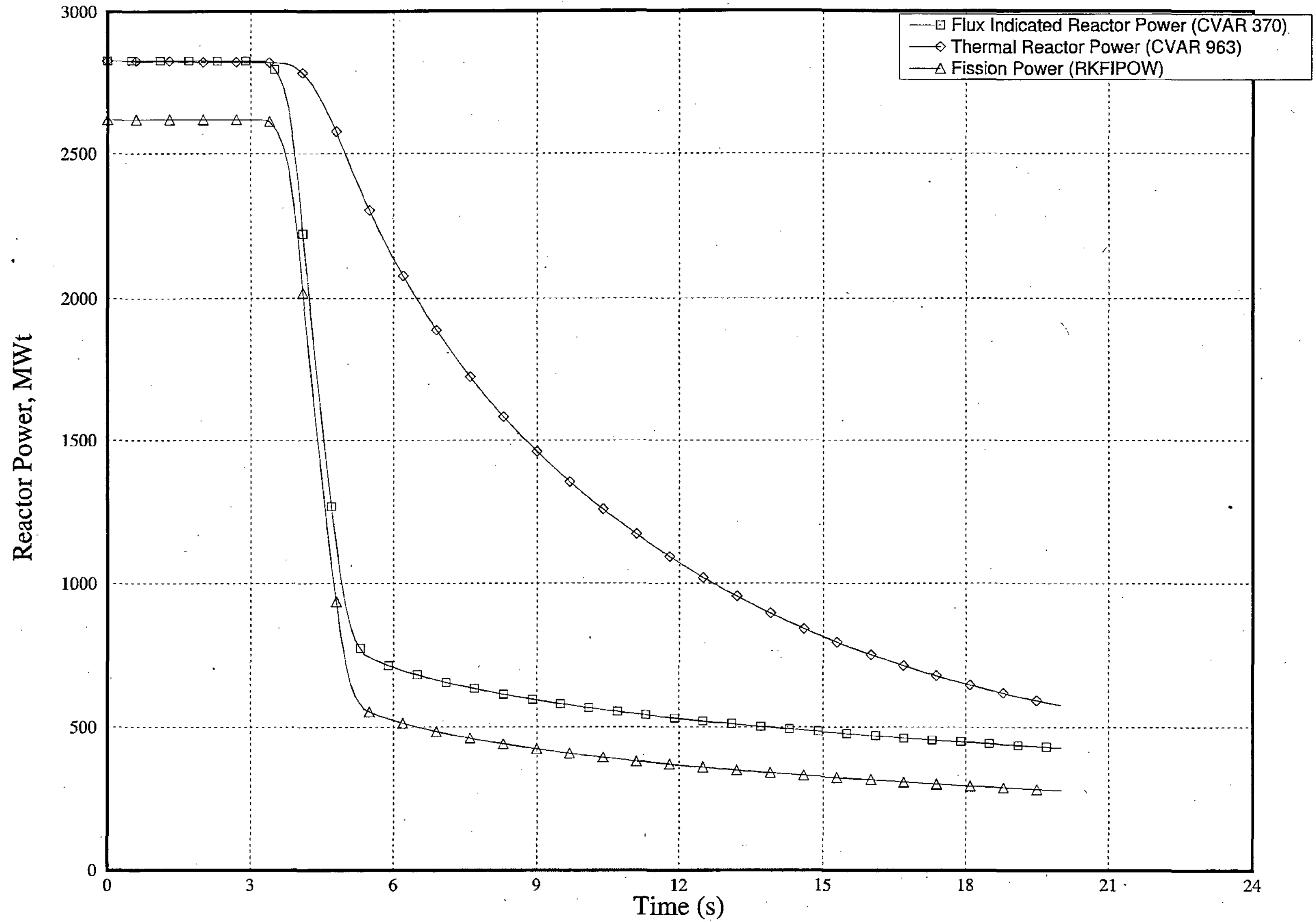

Figure 4–3 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

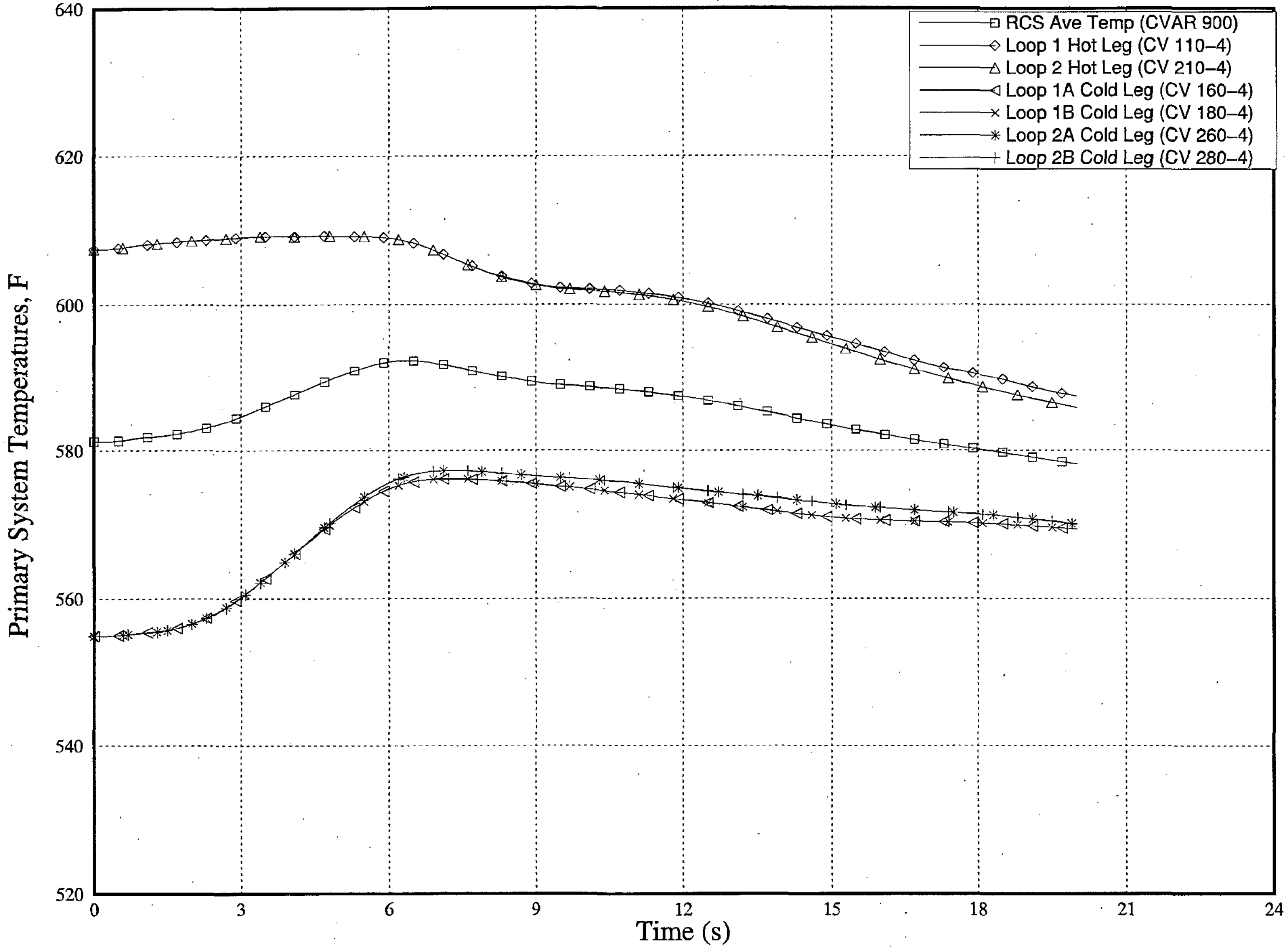

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Figure 4–4 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

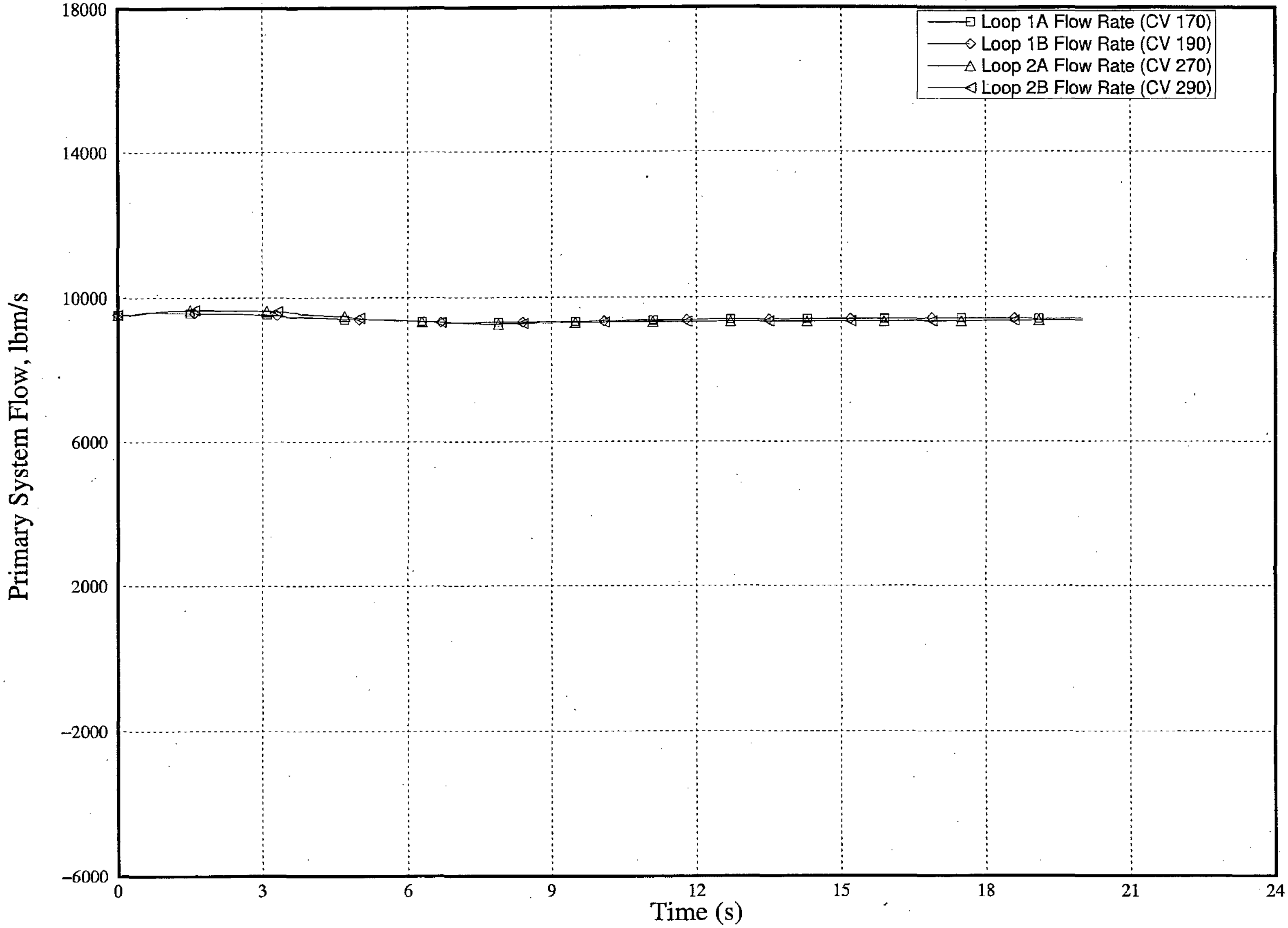

Figure 4–5 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

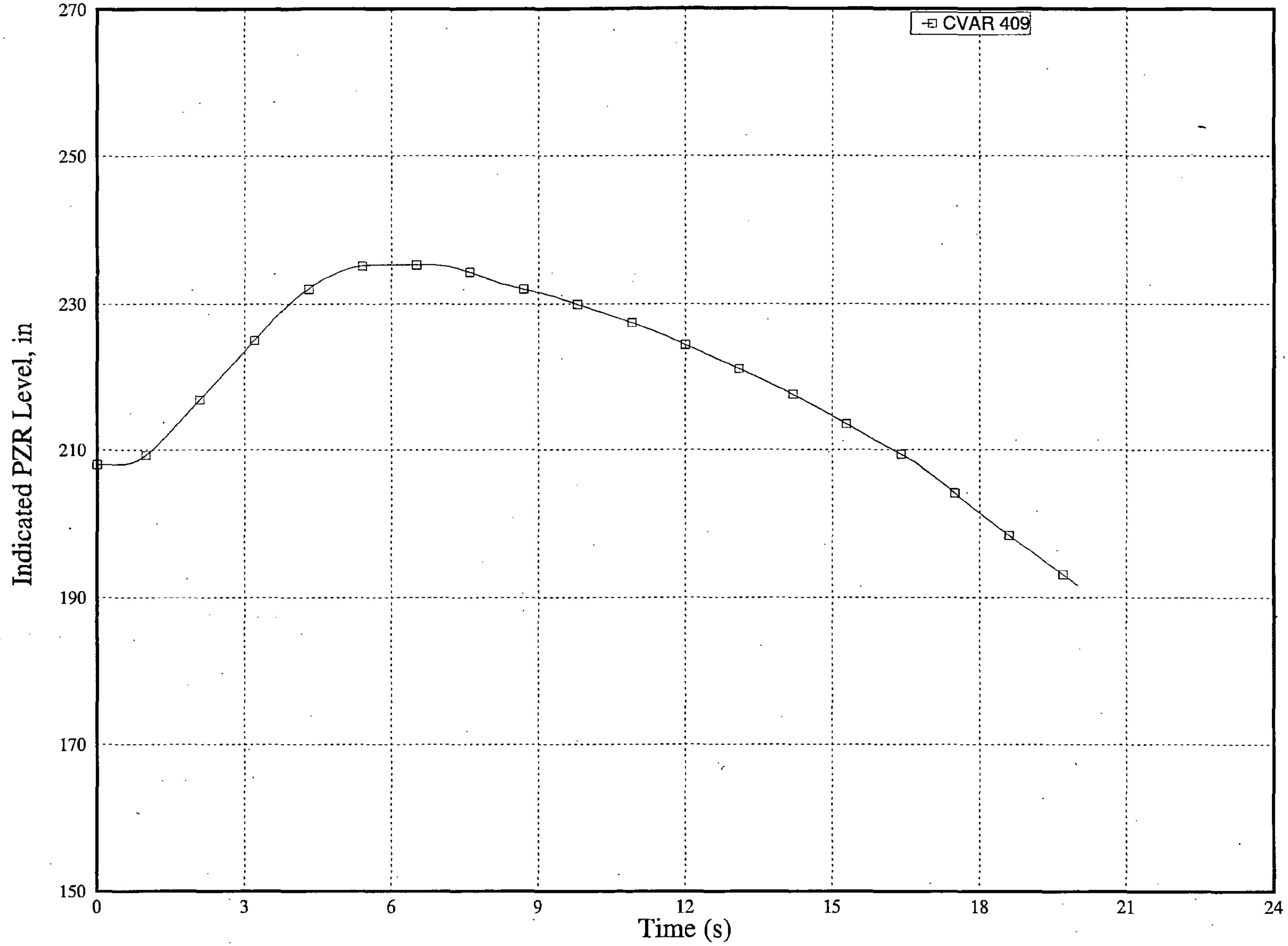

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Figure 4–6 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

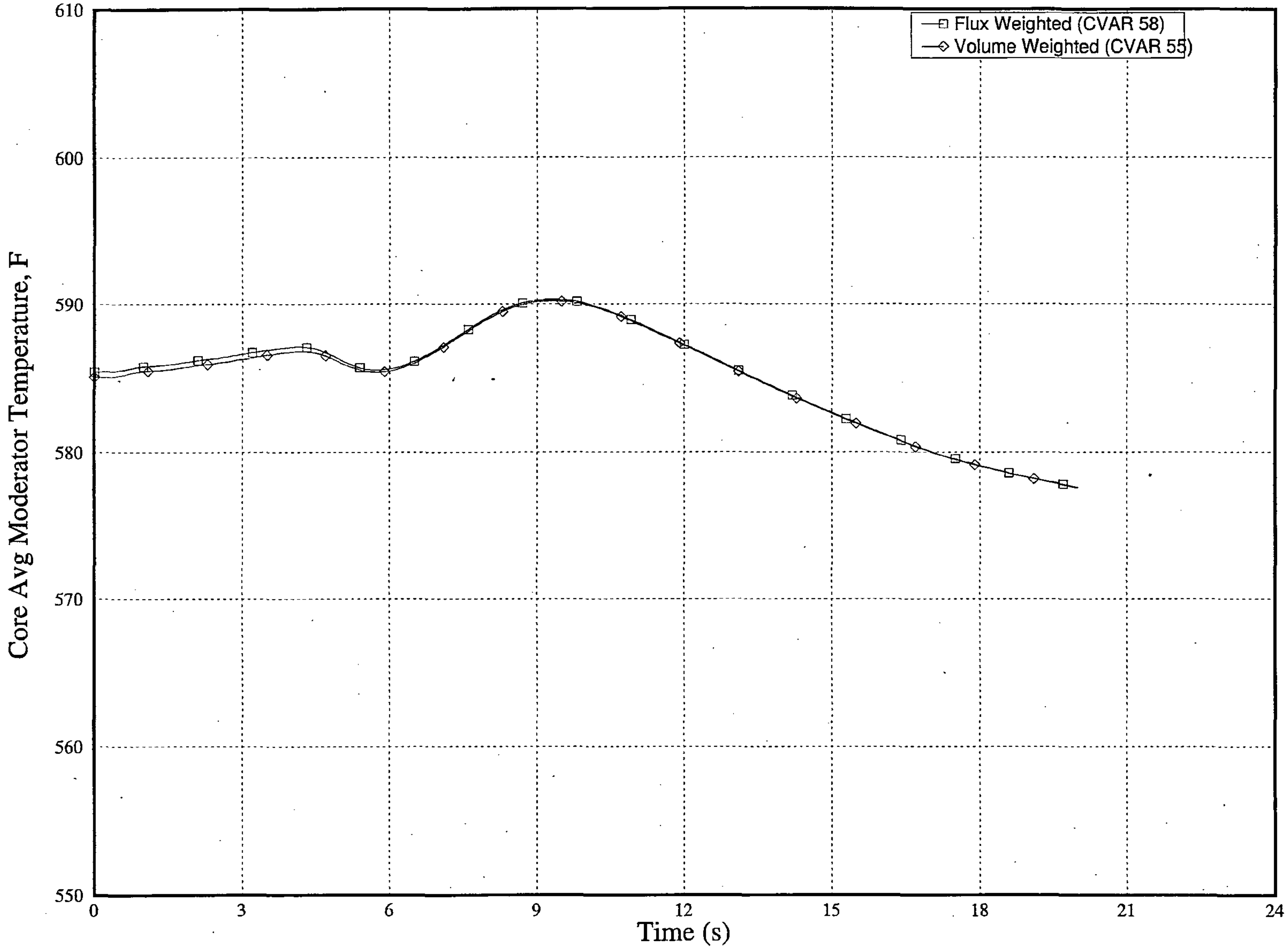

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Figure 4–7 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

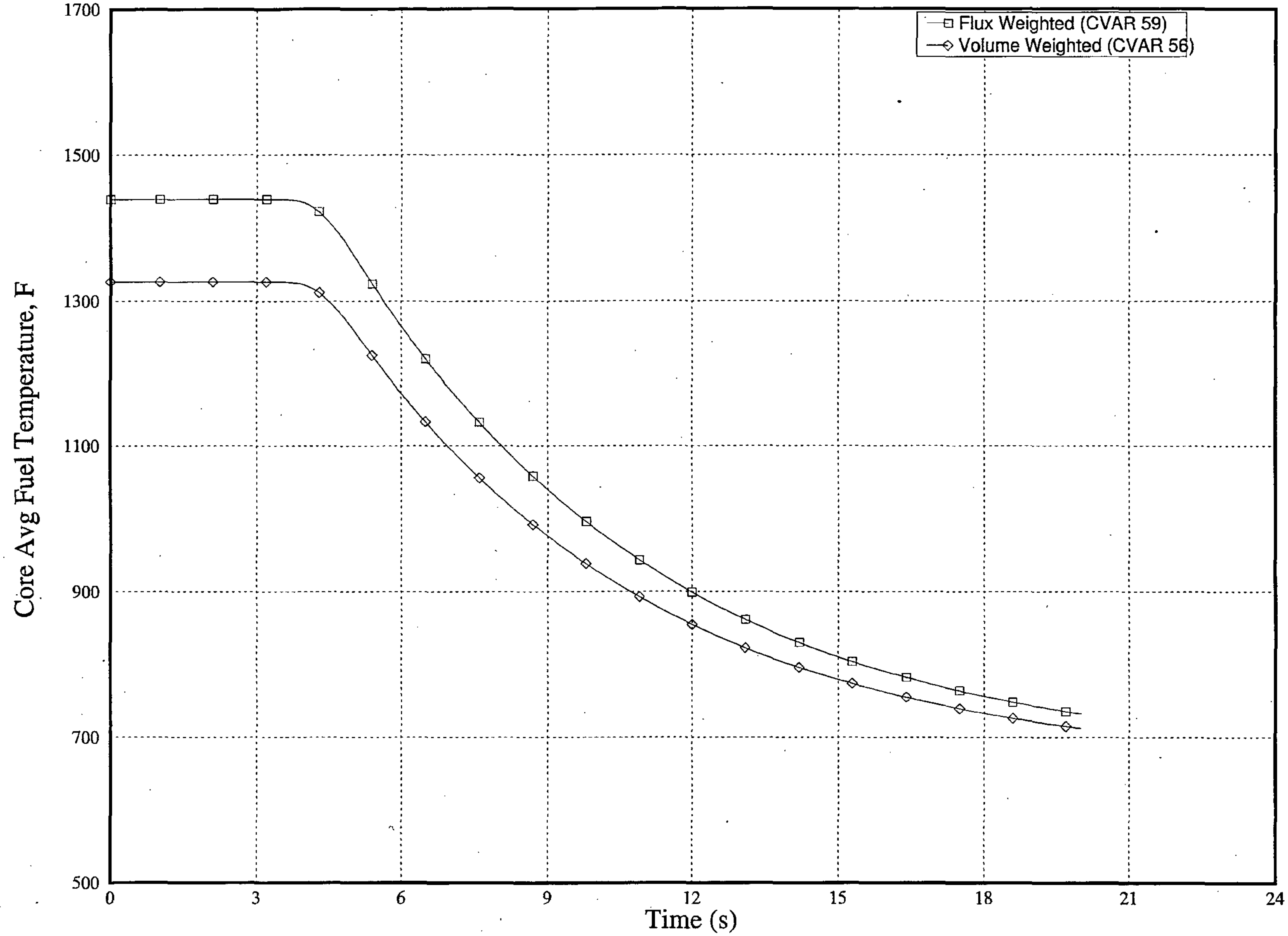

Figure 4-8 TMI-1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

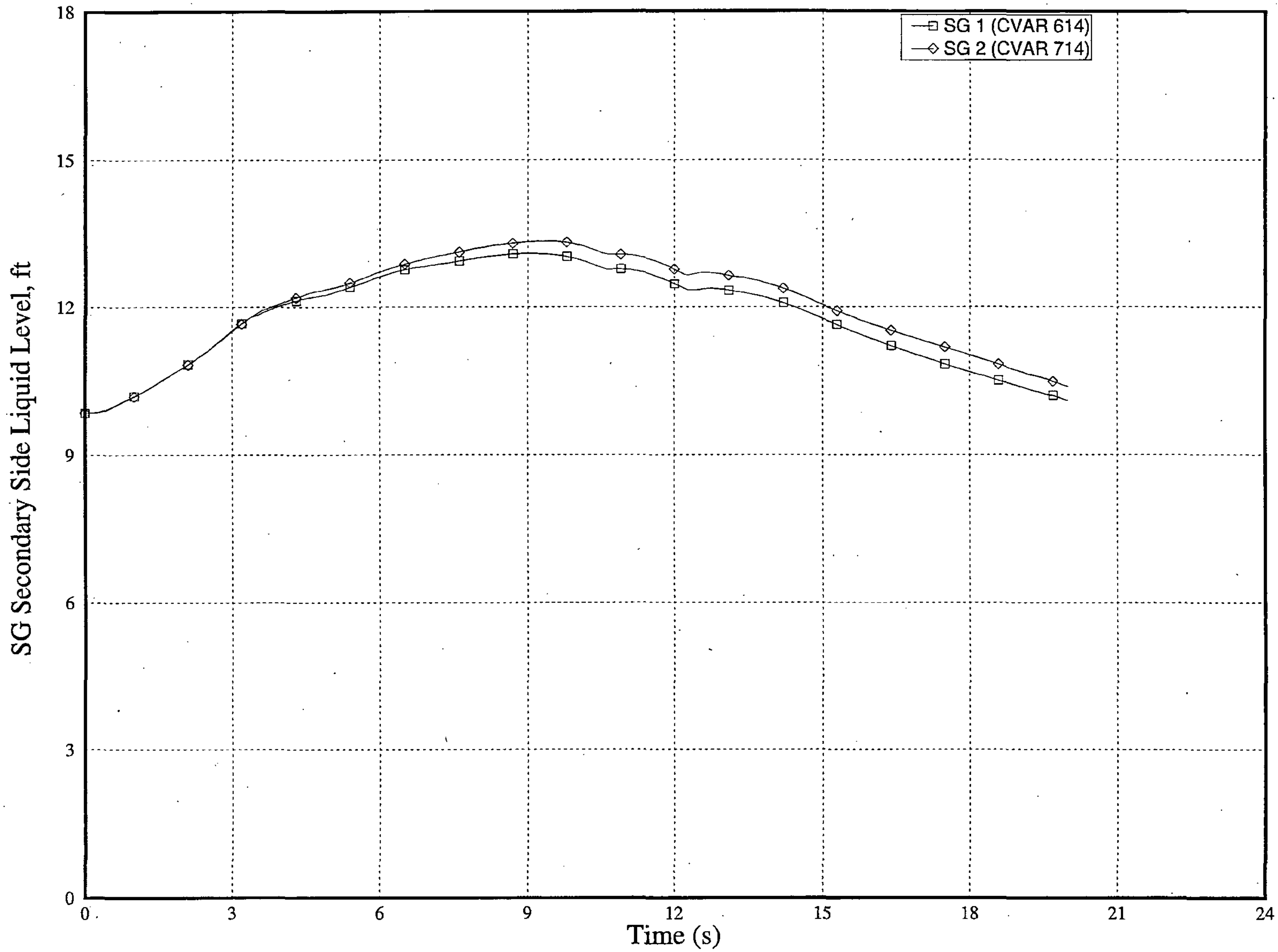

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Figure 4–9 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

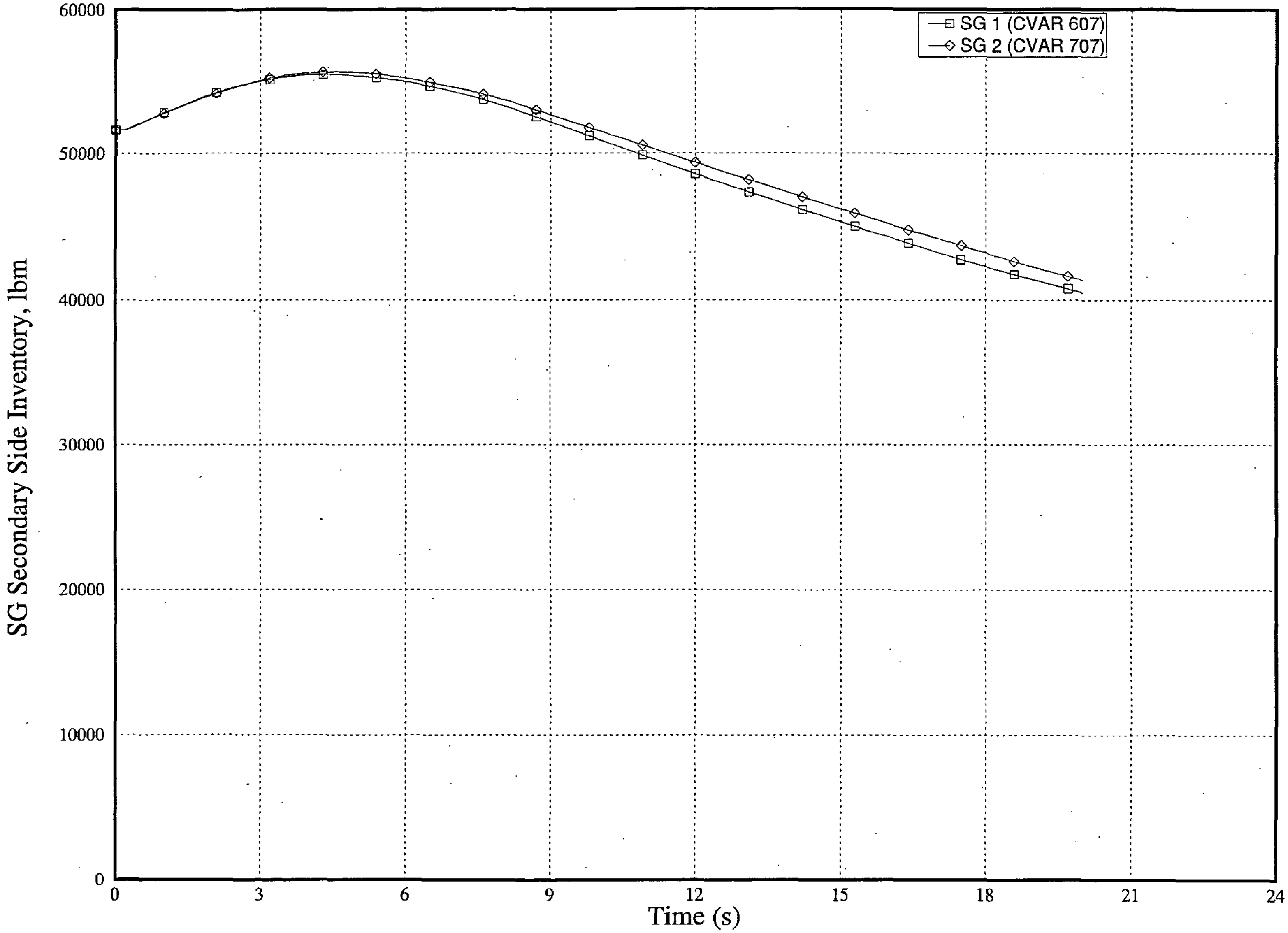

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Figure 4–10 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

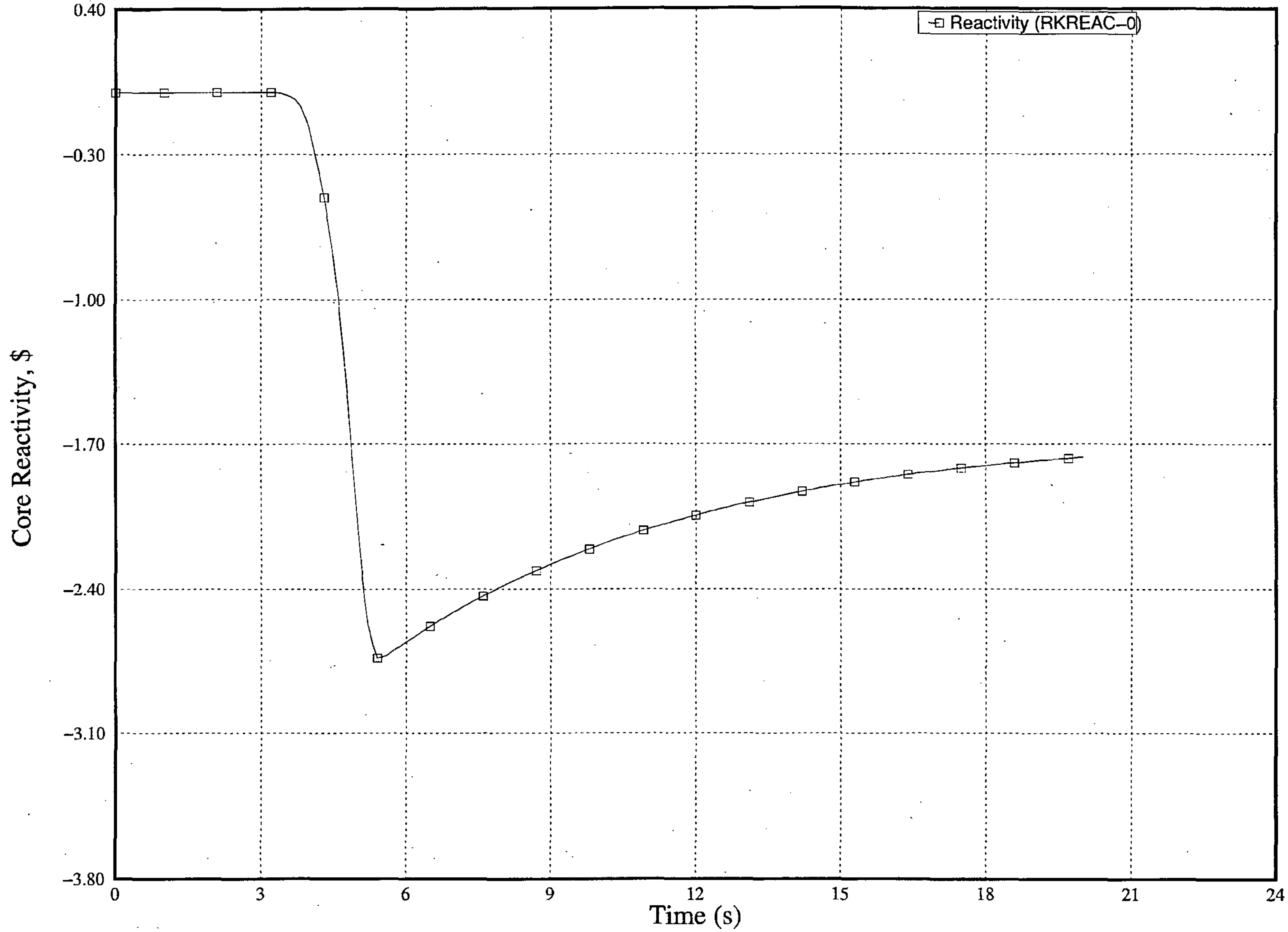

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Figure 4–11 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

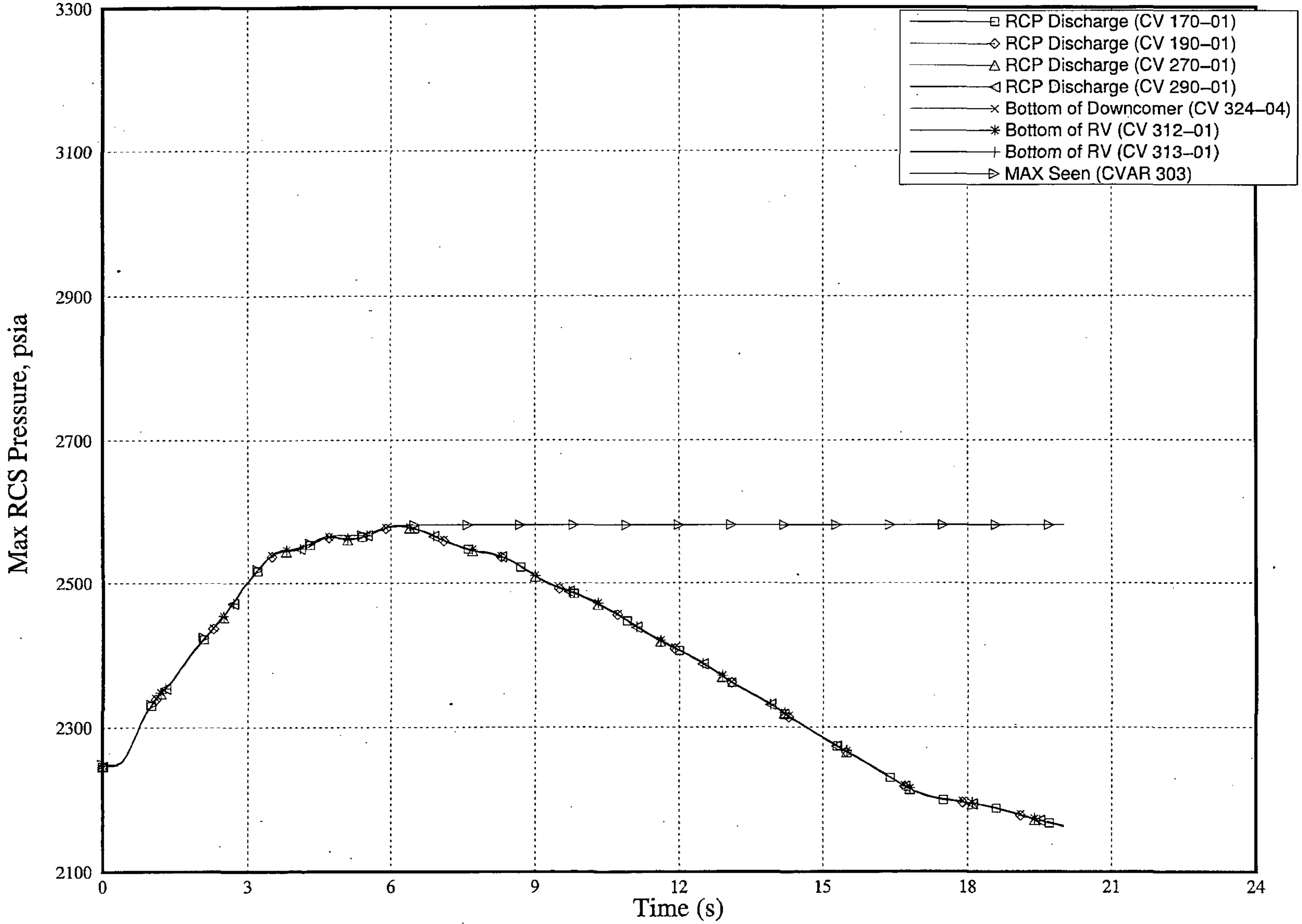

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Figure 4–12 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

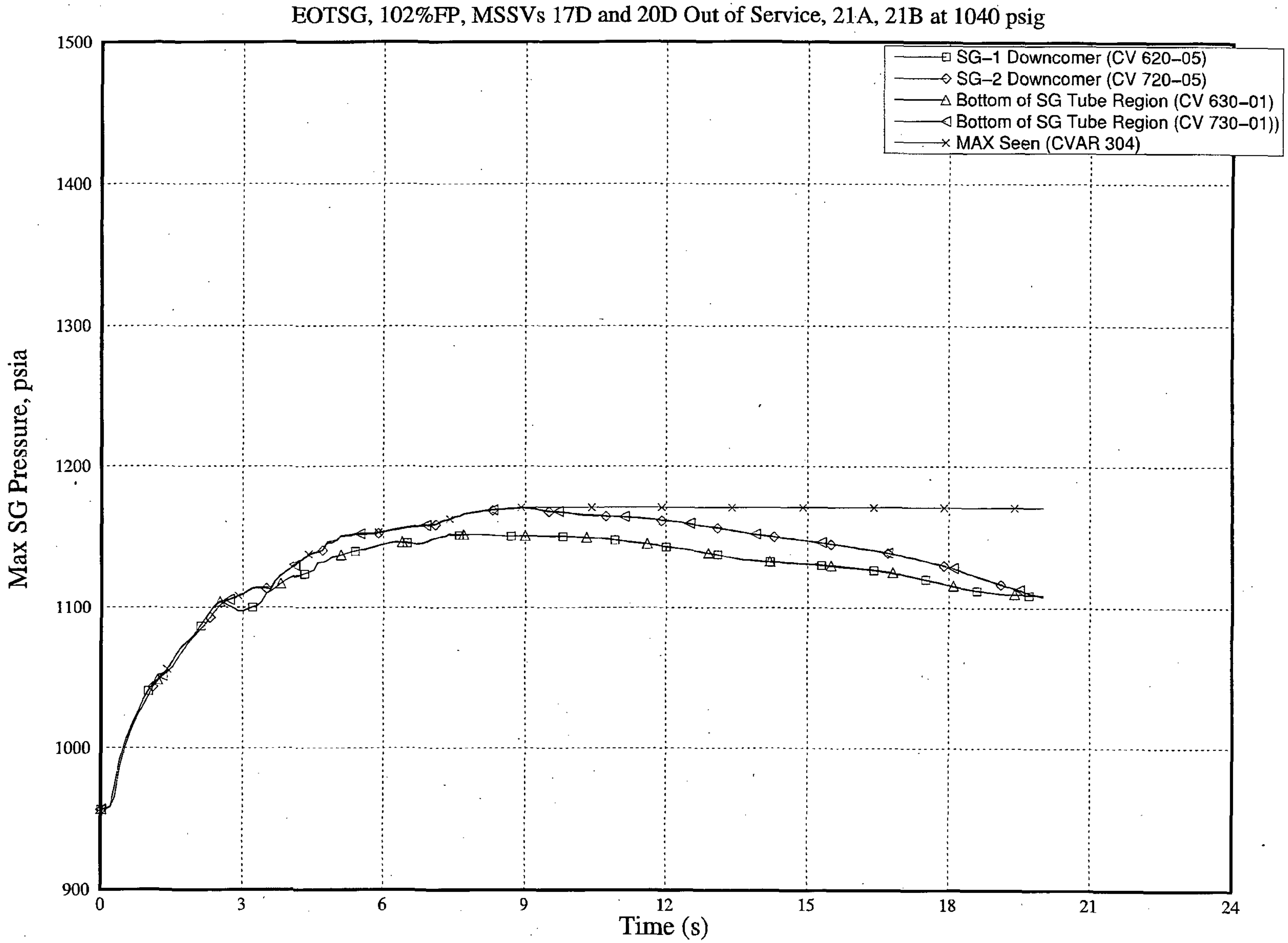

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Figure 4-13 TMI-1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

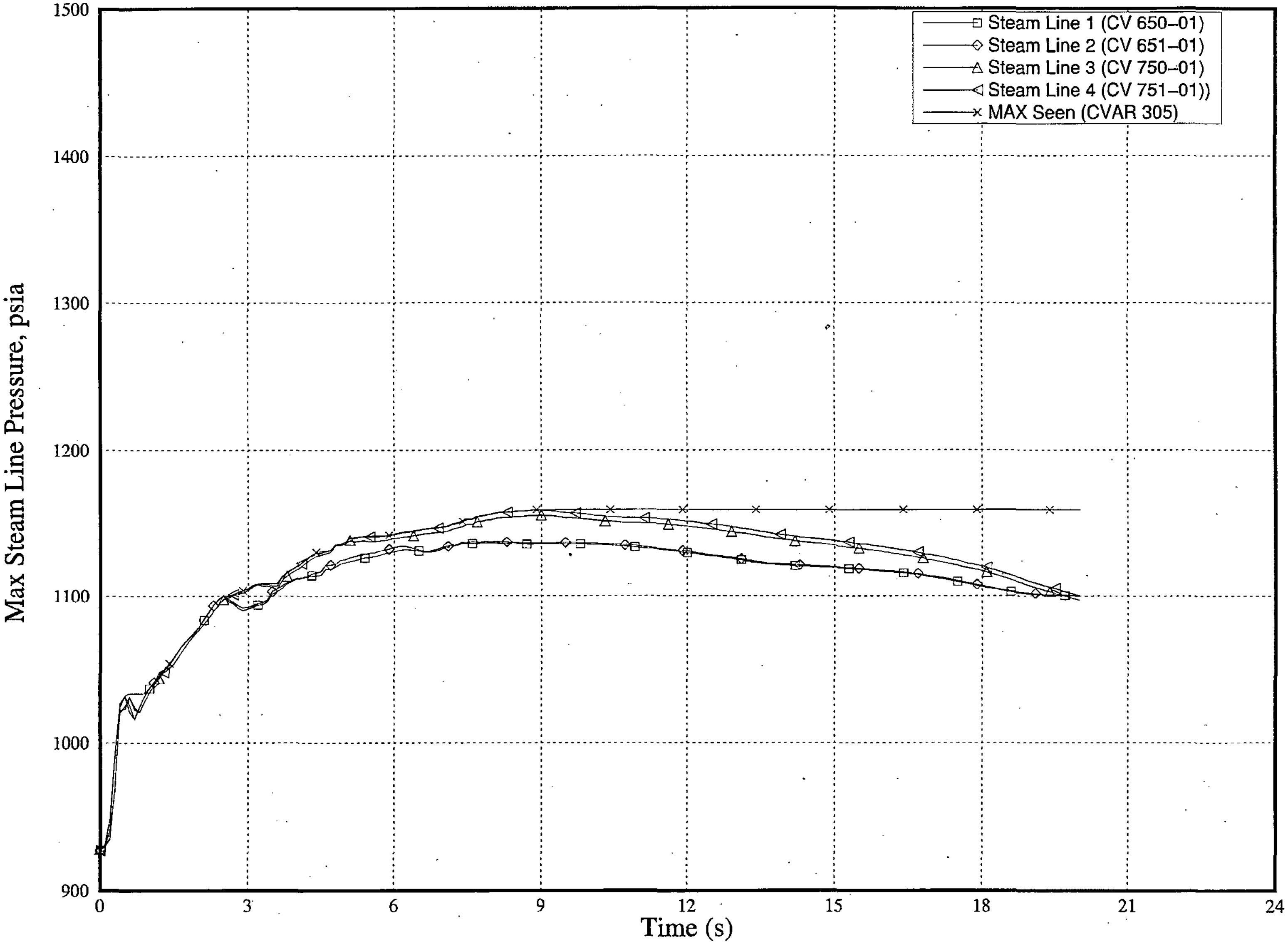

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Figure 4–14 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

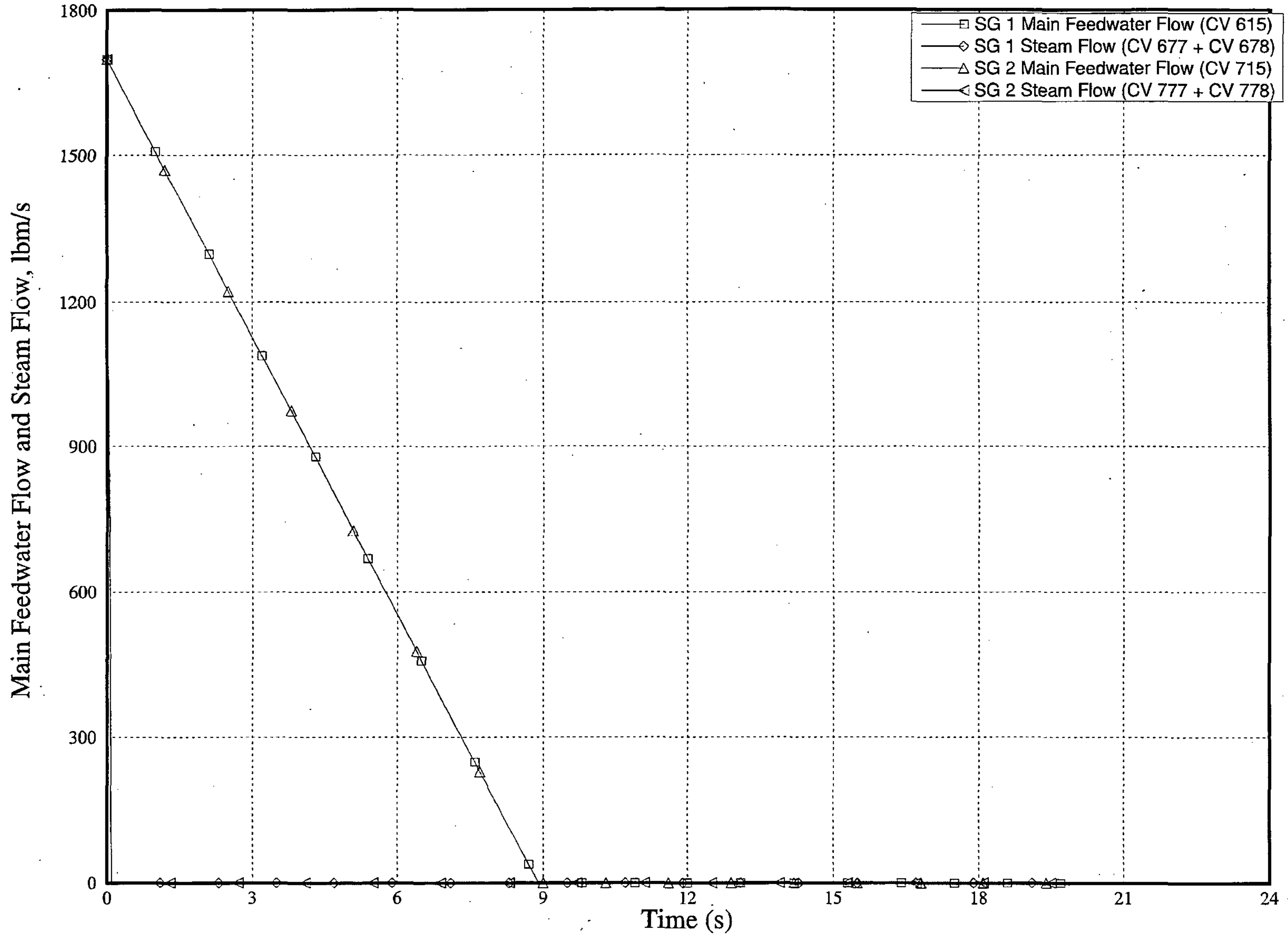

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Figure 4–15 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

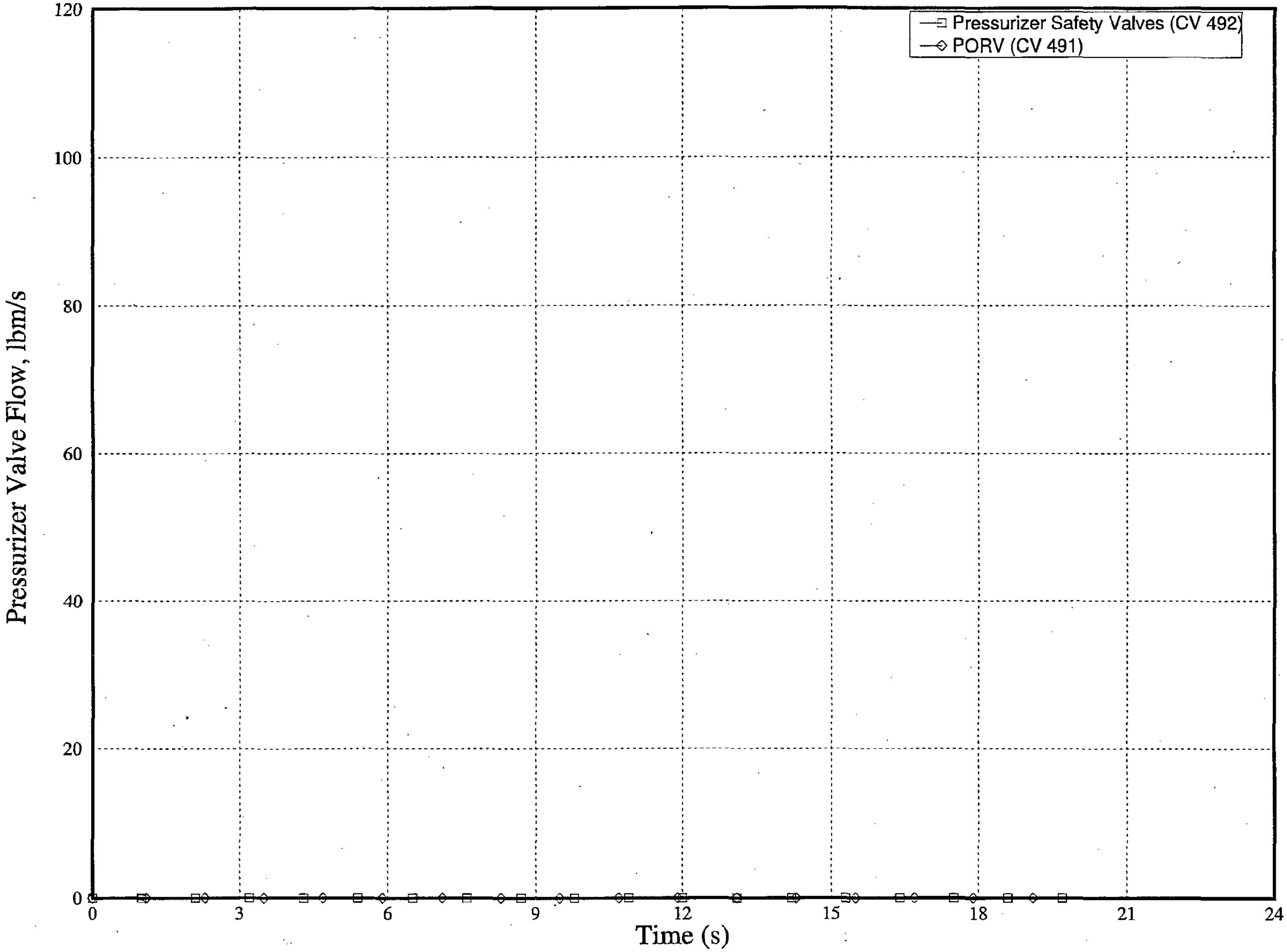

Figure 4–16 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

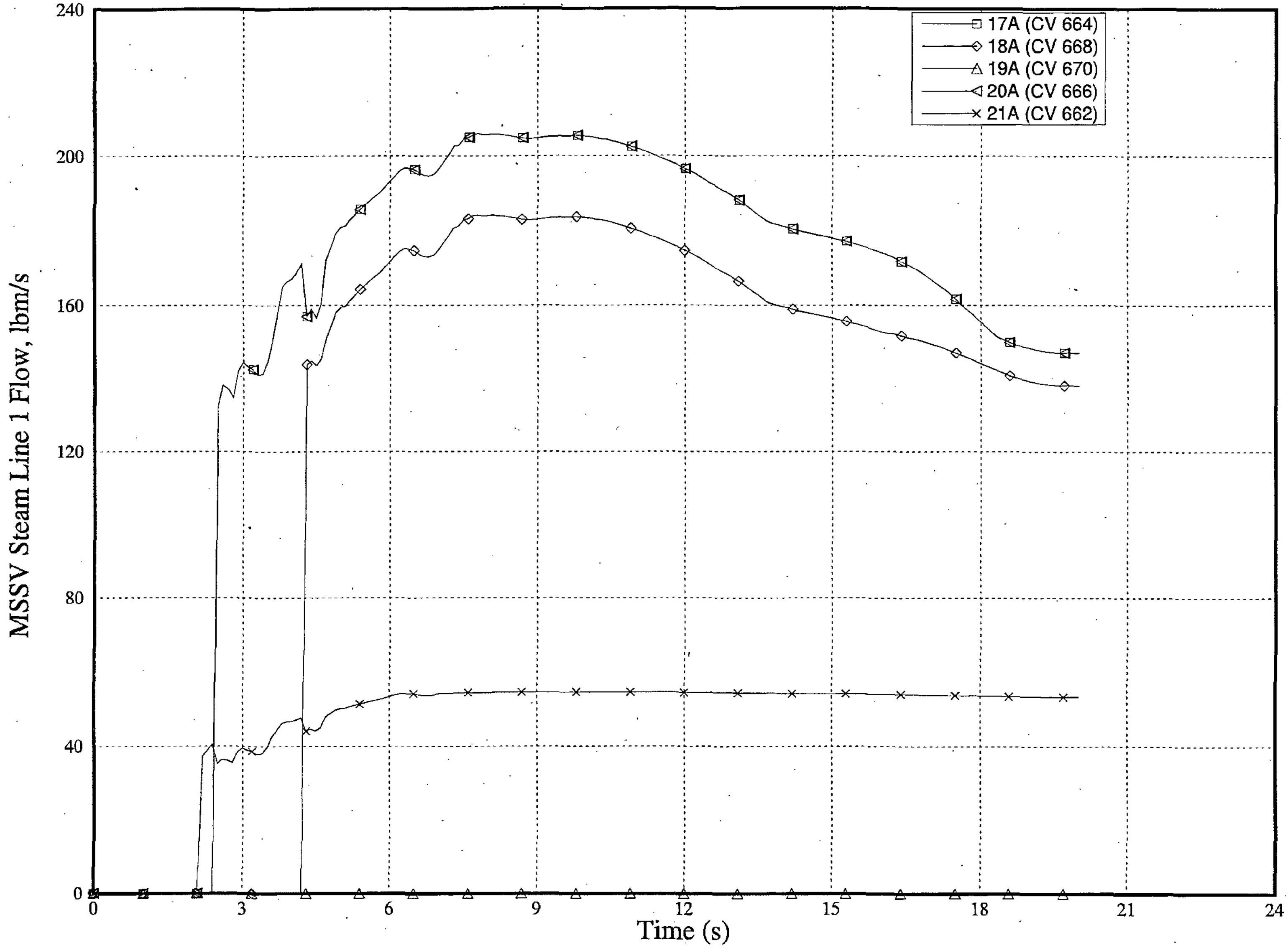

Figure 4–17 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

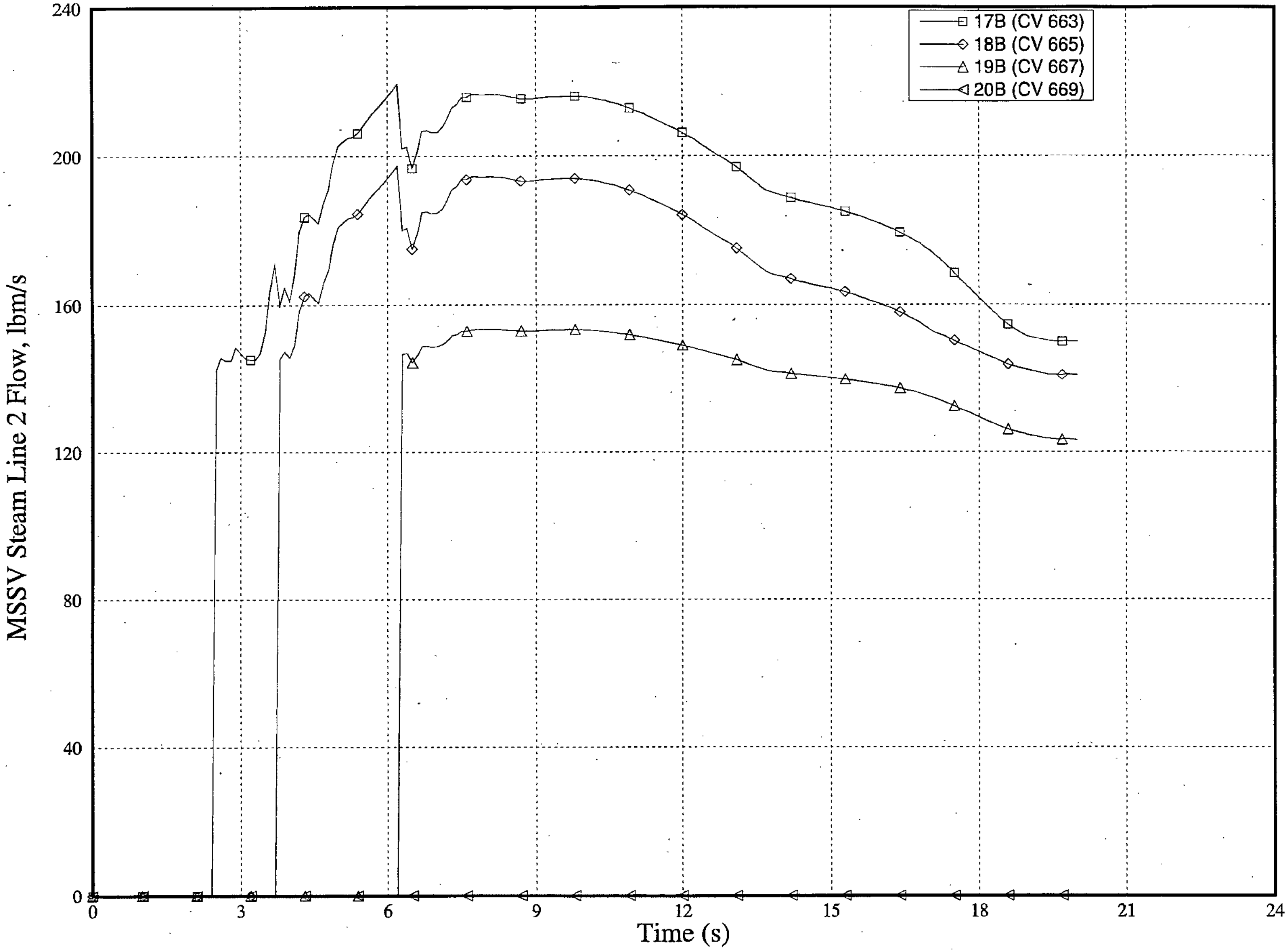

Figure 4–18 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

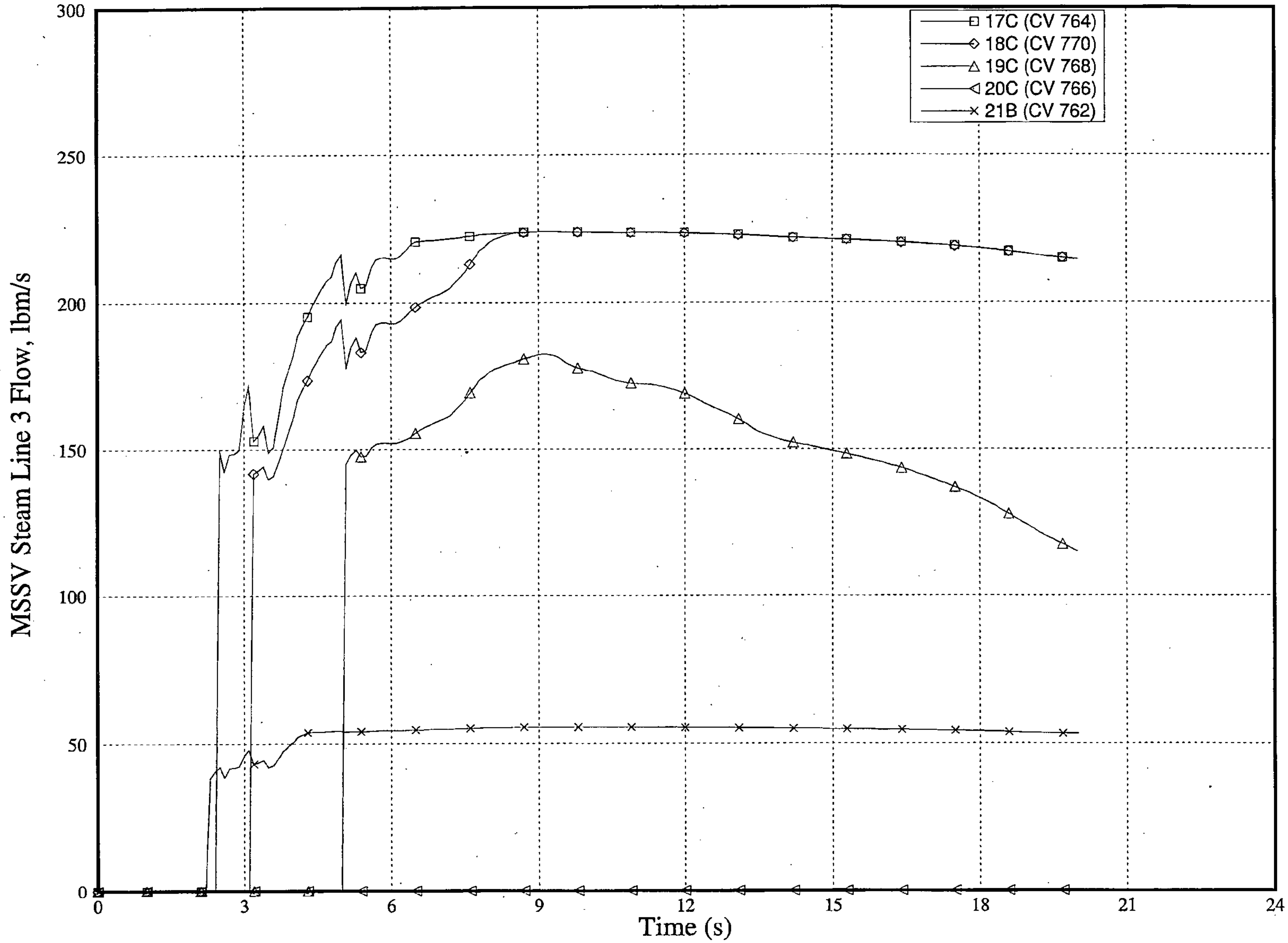

Figure 4–19 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

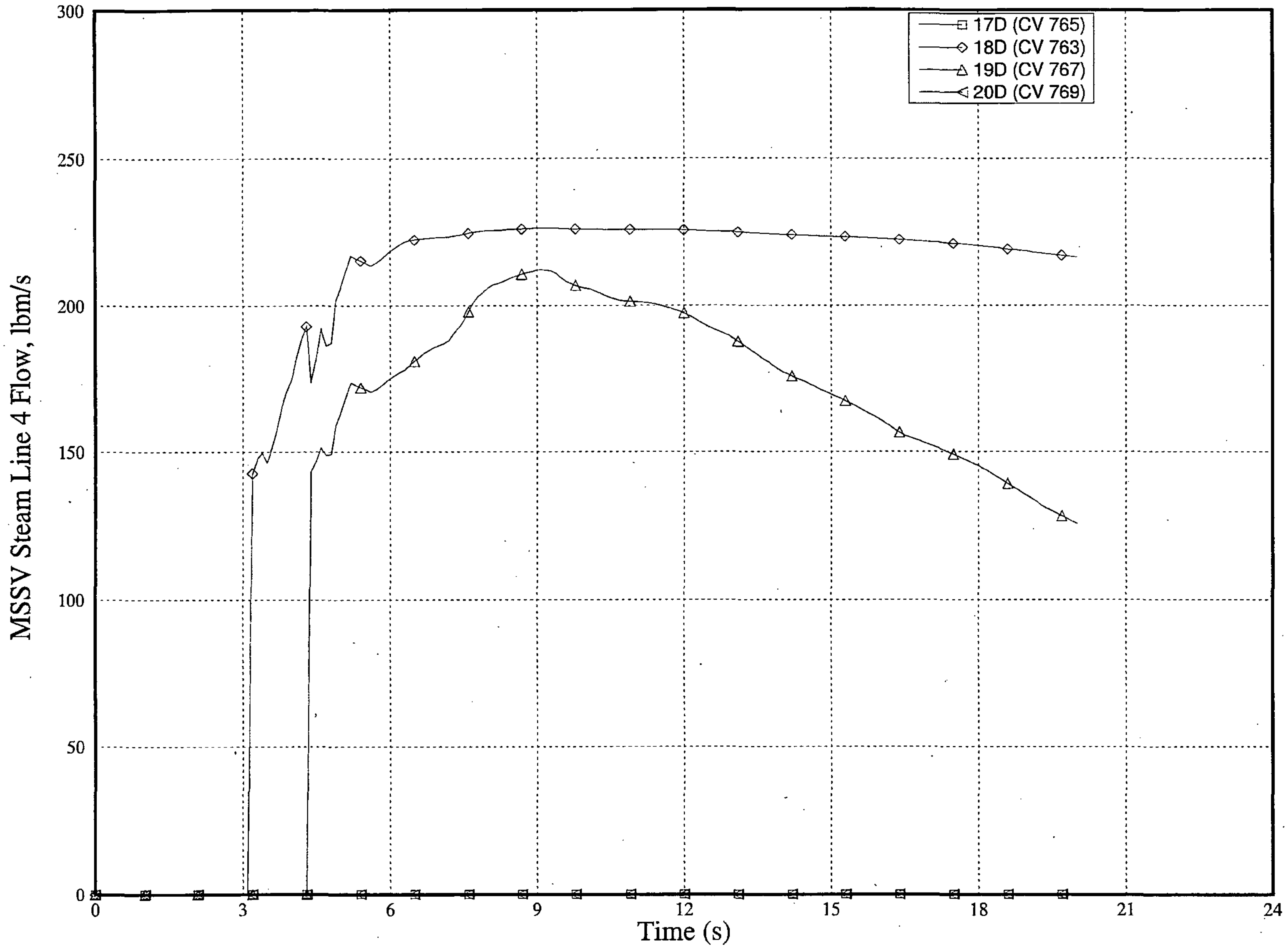

Figure 4–20 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

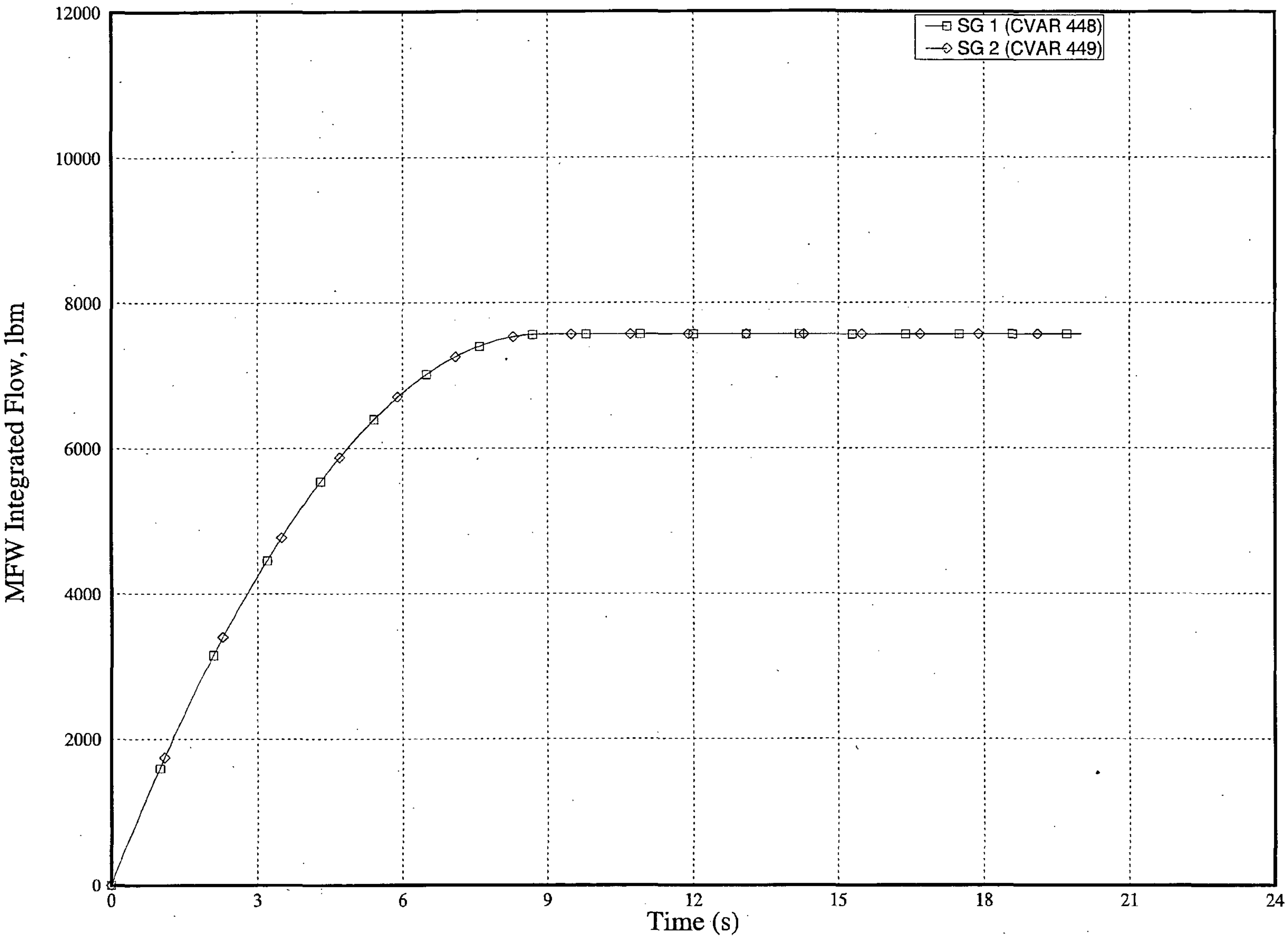

Figure 4–21 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

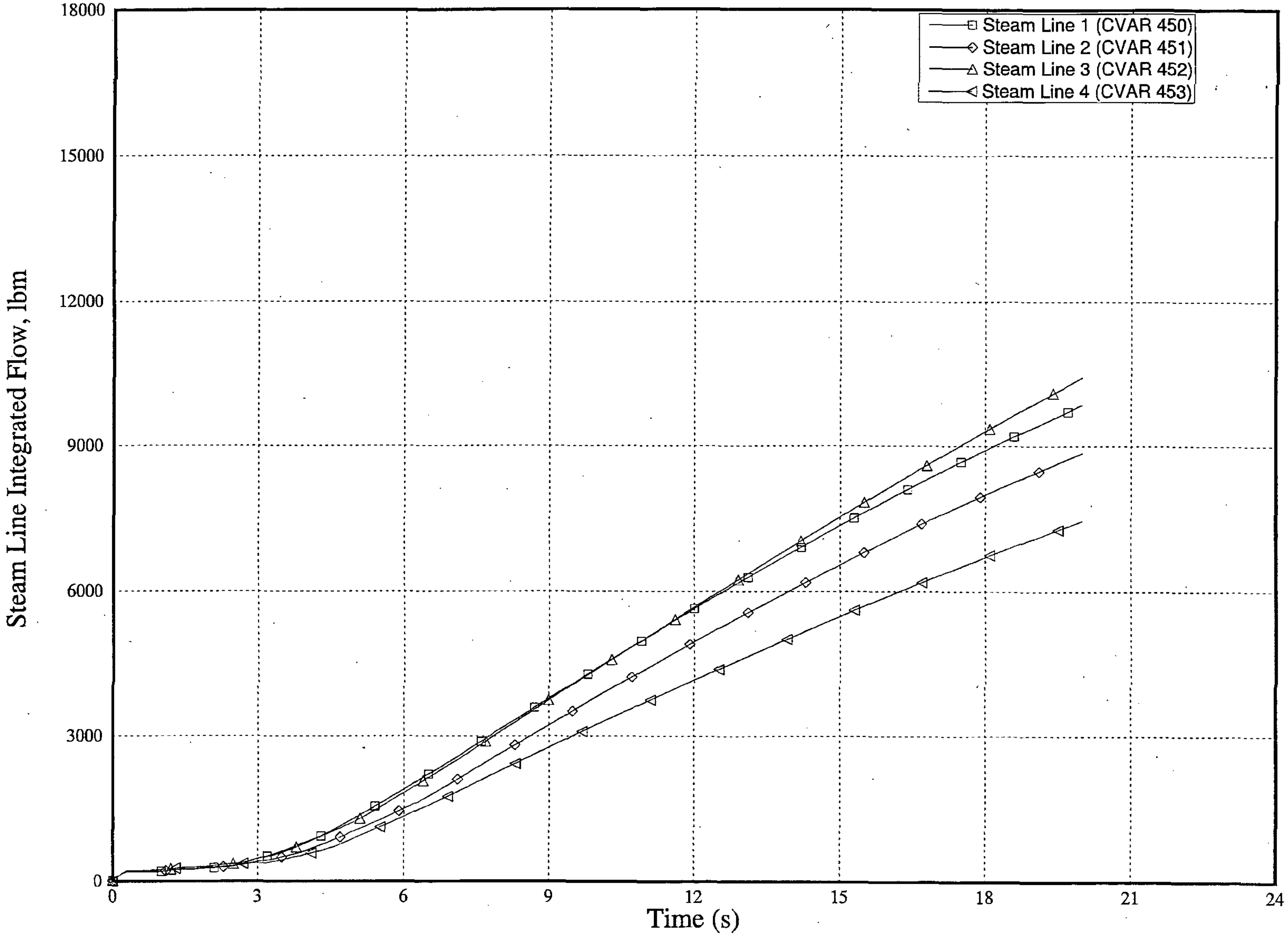

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Figure 4–22 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

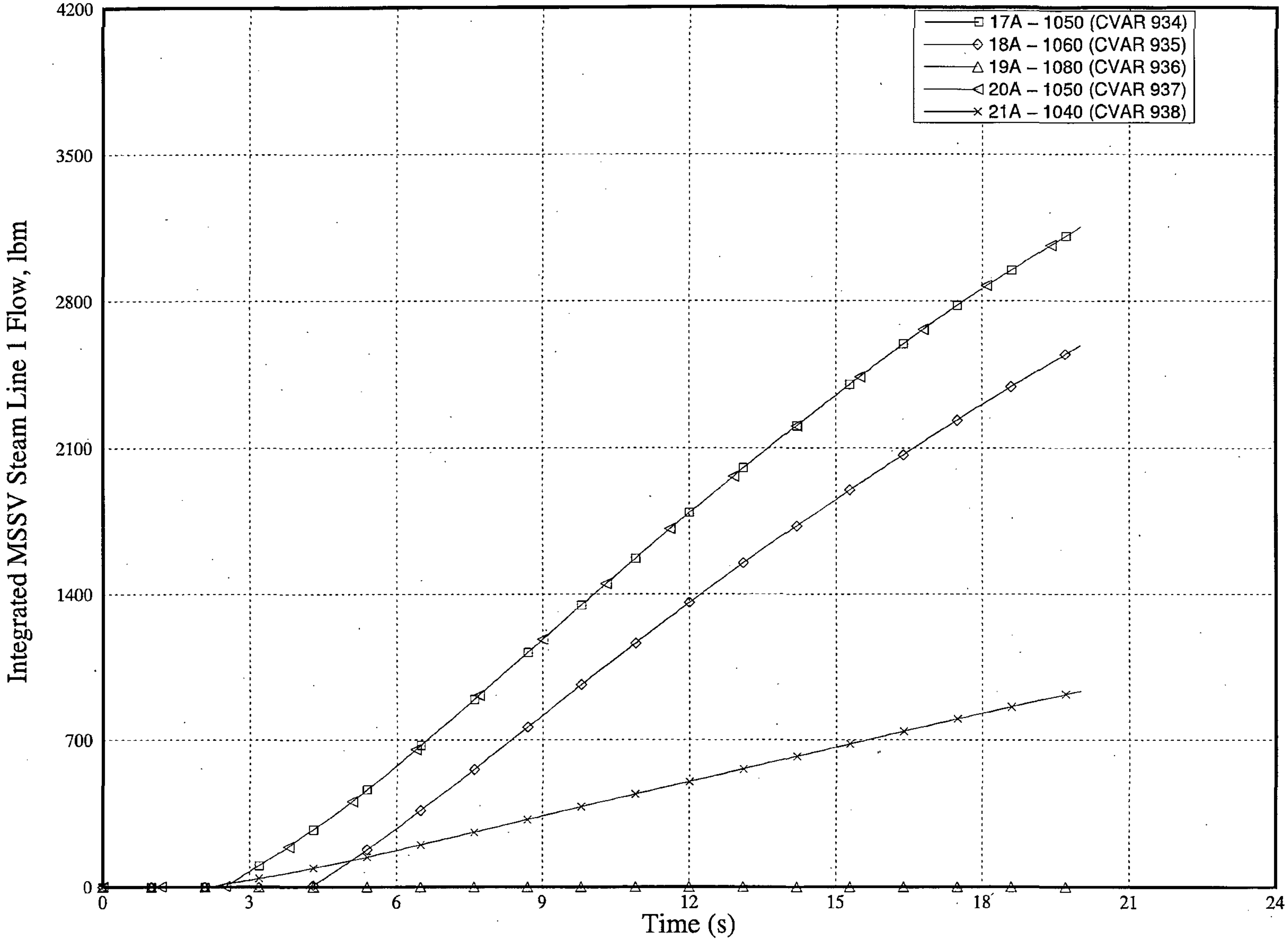


Figure 4–23 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP; MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

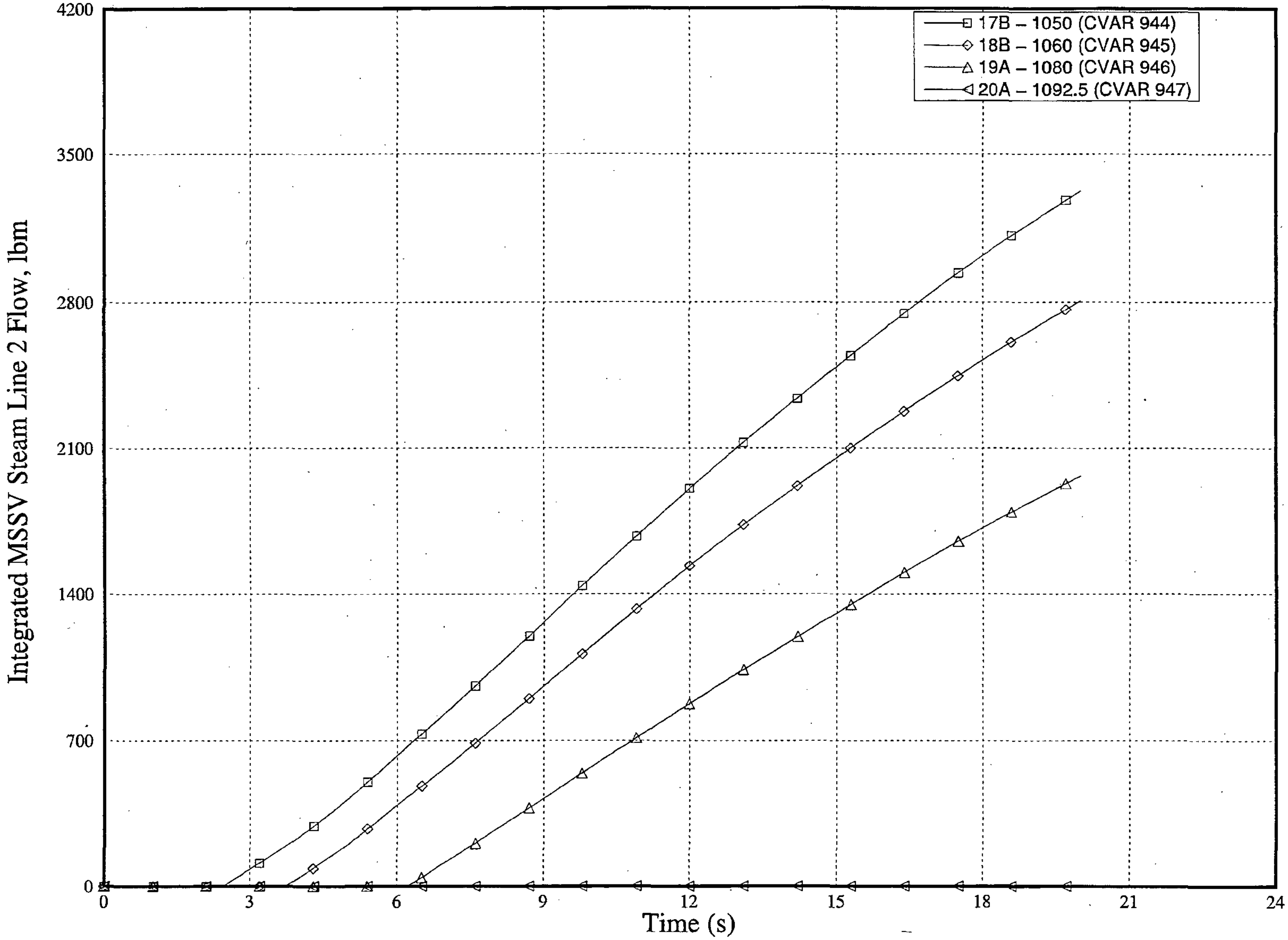


Figure 4–24 TMI–1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig

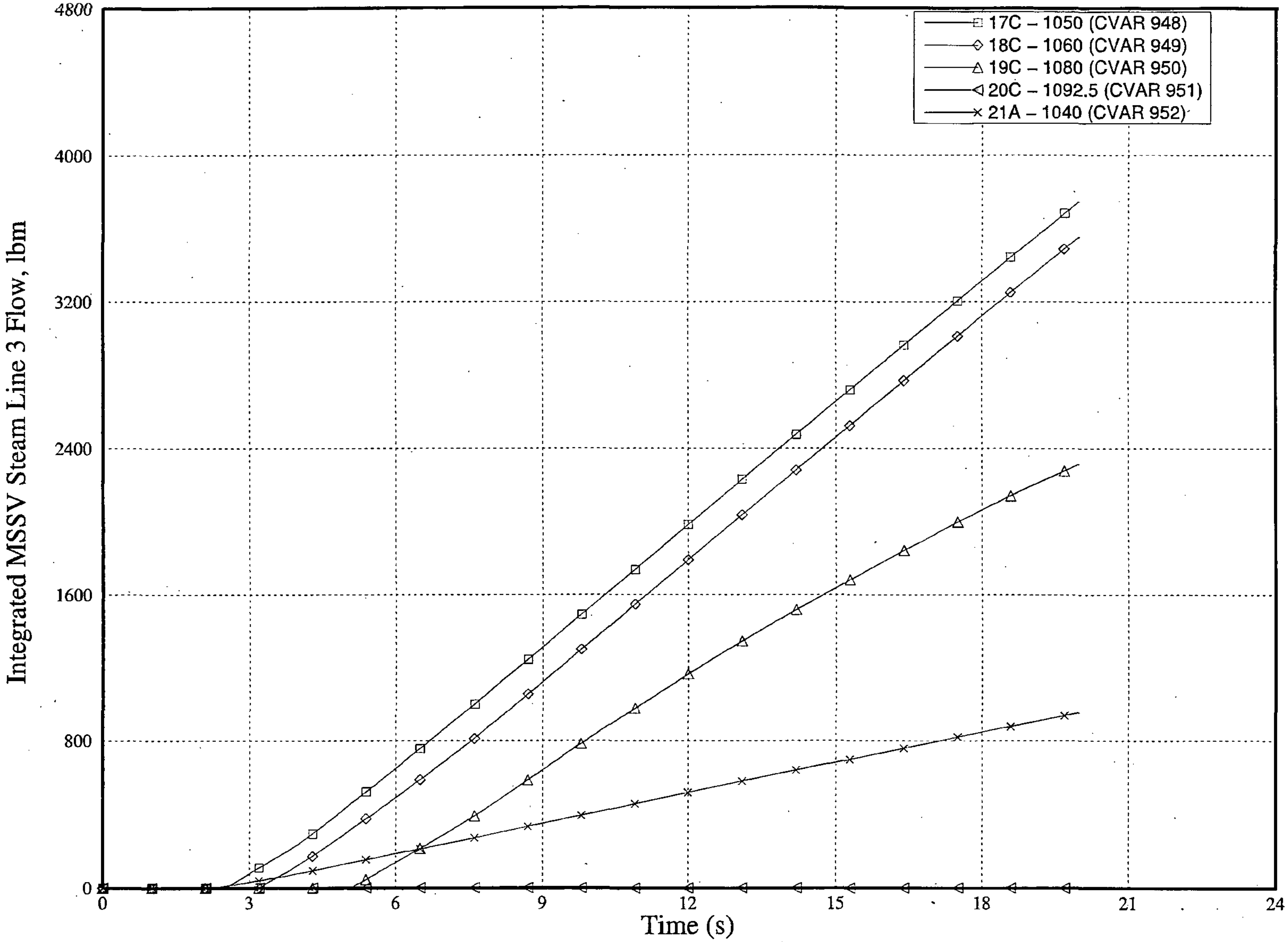
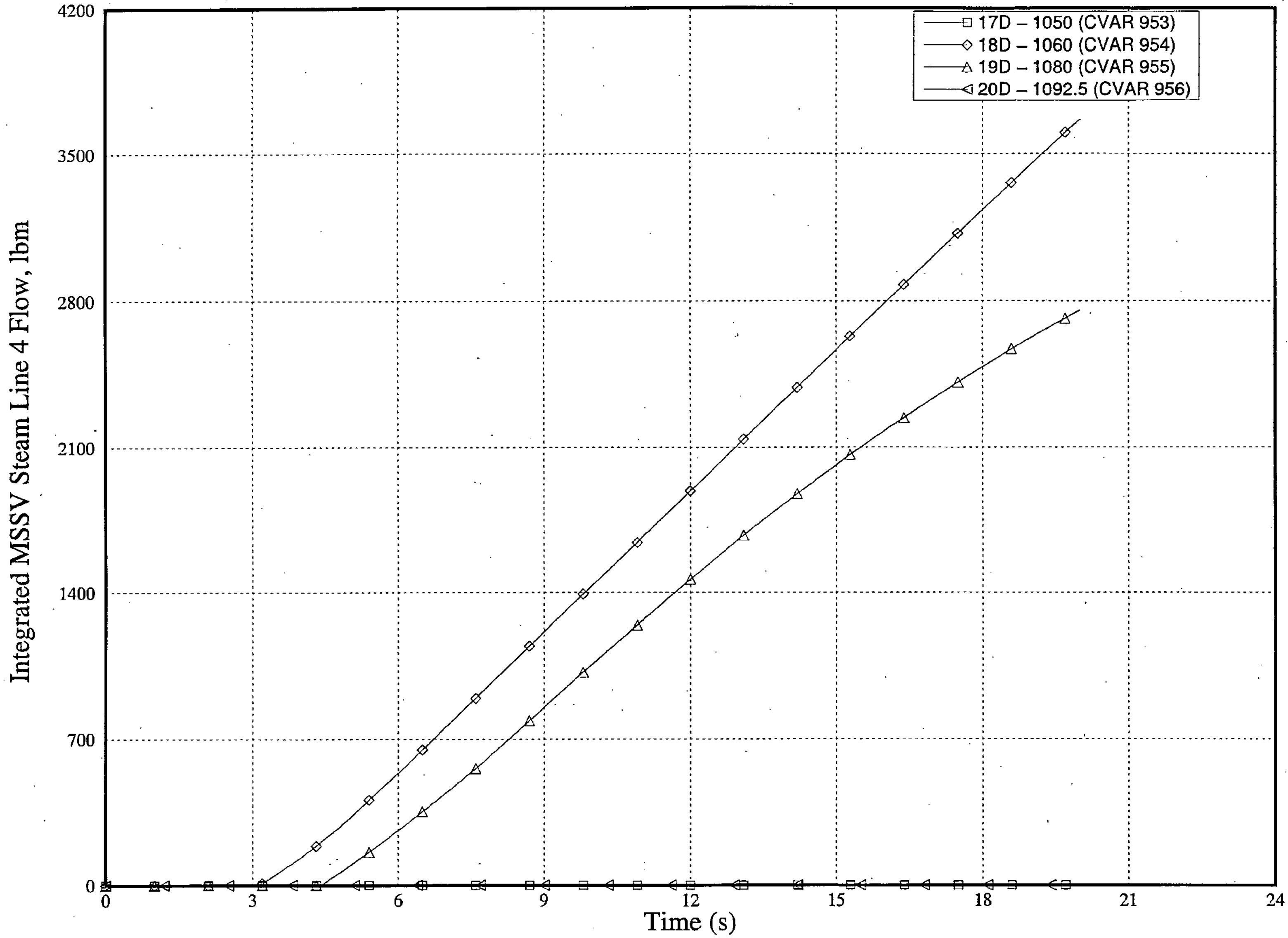


Figure 4–25 TMI-1 EOTSG Turbine Trip (2827.44 MWt)

EOTSG, 102%FP, MSSVs 17D and 20D Out of Service, 21A, 21B at 1040 psig



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4.2 Full Power with Three MSSVs Out of Service

Since there was several psi of margin to the SG pressure limit with two MSSVs out of service, additional evaluations of the Turbine Trip event were performed in References 1 and 5 at 102% of 2772 MWth and three MSSVs out of service. The limiting case for three MSSVs out of service occurs when valves MS-V17D, MS-V18D, and MS-V20D are inoperable. Table 1-1 shows that these three valves are all on the same steam line. Furthermore, two of the valves have a nominal setpoint of 1050 psig and one valve has a nominal setpoint of 1060 psig. This case leaves only one 6 by 10 valve on Steam Line 4 with a nominal setpoint of 1080 psig. Furthermore, of the MSSVs remaining on SG-B, only one 6 by 10 valve has a nominal setpoint of 1050 psig. Two other cases were evaluated which disable the three 6 by 10 MSSVs on each SG with a nominal setpoint of 1050 psig. The results from these analyses are summarized in Table 4-2.

Table 4-2: Turbine Trip at 102% of 2772 MWt, Three MSSVs Out of Service, E-OTSG

Valves Out of Service	MS-V17D, MS-V18D, MS-V20D	MS-V17C, MS-V17D, MS-V20D	MS-V17A, MS-V20A, MS-V17B
Maximum RCS Pressure (psia)	2584.43	2585.56	2583.04
Maximum SG Pressure (psia)	1181.86	1177.13	1176.94
Maximum Steam Line Pressure (psia)	1172.76	1164.69	1163.83

All cases in Table 4-2 had a maximum RCS pressure that is well below the maximum RCS pressure from the Startup Accident. All cases in Table 4-2 also had a maximum SG pressure that is well below the 1279.7 psia Code requirement for the E-OTSGs. In two cases, having three MSSVs inoperable produced acceptable results when compared to the 1169.7 psia Code requirement for the steam lines. Although two cases had acceptable results with three MSSVs out of service, the case with MS-V17D, MS-V18D, and MS-V20D out of service resulted in a maximum steam line pressure of 1172.76 psia, which exceeds the Code requirement and is unacceptable. Therefore, full power operation should not be allowed if more than two MSSVs are out of service on a single SG. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

4.3 Additional Full Power Analyses

Reference 11 summarizes full power OTSG analyses that demonstrate that the number of MSSVs out of service on one steam generator does not affect the number of MSSVs that can be out of service on the other steam generator. Reference 11 also demonstrated that for the OTSG, increasing the nominal setpoint for MSSVs MS-V21A and MS-V21B to 1050 psig has a less than minimal effect on the peak secondary pressures experienced during the Turbine Trip event initiated from 102 %FP.

Reference 1 includes an evaluation of the Turbine Trip event at 102% of 2772 MWt with the E-OTSG that evaluates MSSVs out of service on both steam generators and the increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig. The results are summarized in Table 4-3 along with the results from similar transients listed in Table 4-2.

Table 4-3: Turbine Trip at 102% of 2772 MWt, Additional Evaluations

Valves Out of Service	MS-V17C, MS-V17D, MS-V20D	MS-V17A, MS-V20A, MS-V17B	MS-V17A, MS-V17C, MS-V20A, MS-V17D, MS-V17B, MS-V20D, Increased Setpoint
Maximum RCS Pressure (psia)	2585.56	2583.04	2584.32
Maximum SG Pressure (psia)	1177.13	1176.94	1176.60
Maximum Steam Line Pressure (psia)	1164.69	1163.83	1164.19

All three cases in Table 4-3 meet the applicable acceptance criteria. The peak steam line pressure is comparable in all three cases. The results confirm that having MSSVs out of service on one steam generator does not affect the number that can be out of service on the other steam generator. The results also demonstrate that it is acceptable to increase to the nominal setpoint for MS-V21A and MS-V21B to 1050 psig. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

5.0 Reduced Power Results

Reference 6 developed a TMI-1 model at 92% of 2772 MWt with the E-OTSGs. Reference 1 developed a TMI-1 model at 62% of 2772 MWt with the E-OTSGs. Both models are consistent with Reference 4.

5.1 92% of 2772 MWt with Three MSSVs Out of Service

The Turbine Trip event was evaluated in Reference 6 using an initial power level of 92% of 2772 MWt for three MSSVs out of service. The full power analysis determined that the limiting combination of three MSSVs out of service occurred when valves MS-V17D, MS-V18D, and MS-V20D were removed from service. This combination was repeated in Reference 6 at 92 %FP with and without pressurizer spray. The Reference 6 results for peak RCS pressure and peak SG pressure are presented in Table 5-1. The peak steam line pressure results from Reference 6 were adjusted in Reference 1 to remove excess conservatism and provide a consistent basis for comparison to other Reference 1 evaluations. Table 5-1 contains the adjusted peak steam line pressures from Reference 1. Table 5-1 also contains the results from an analysis in Reference 1, which has the same MSSVs out of service but with the nominal setpoint for MS-V21A and MS-V21B increased to 1050 psig.

Table 5-1: Turbine Trip at 92% of 2772 MWt, Three MSSVs Out of Service, E-OTSG

Valves Out of Service	MS-V17D, MS-V18D, MS-V20D, Pressurizer Spray	MS-V17D, MS-V18D, MS-V20D, No Pressurizer Spray	MS-V17D, MS-V18D, MS-V20D, No Pressurizer Spray, Increased Setpoint
Maximum RCS Pressure (psia)	2568.13	2578.82	2578.30
Maximum SG Pressure (psia)	1174.42	1174.08	1174.28
Maximum Steam Line Pressure (psia)	1165.19	1164.85	1164.87

The resulting maximum RCS pressure is well below the maximum RCS pressure 2707.69 psia in the Startup Accident. The maximum SG pressure is significantly less than the 1279.7 psia Code requirement for the E-OTSGs. The maximum steam line pressure of 1165.19 psia is less than the 1169.7 psia Code requirement for the steam lines and is therefore acceptable. The results show that pressurizer spray increases the maximum steam line pressure by 0.34 psia and increasing the nominal setpoint for MSSVs MS-V21A and MS-V21B to 1050 psig increases the maximum steam line pressure by 0.02 psia. The results demonstrate that operation is acceptable at 92% of 2772 MWt with the E-OTSGs, as many as three MSSVs out of service, and an increase in the nominal setpoint for MSSVs MS-V21A and MS-V21B to 1050 psig. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

5.2 92% of 2772 MWt with Four MSSVs Out of Service

Since there was margin to the limit with only three MSSVs out of service, the Turbine Trip event was evaluated in Reference 1 using an initial power level of 92% of 2772 MWt for four MSSVs out of service. The combination of MSSVs removed from service completely removes all MSSVs from a single steam line while also removing two full-sized MSSVs with the lowest nominal setpoint of 1050 psig. Since the peak pressure the steam lines is more limiting than the peak pressure in the E-OTSG, the combination chosen is the limiting combination for four MSSVs out of service. Table 5-2 shows the results.

Table 5-2: Turbine Trip at 92% of 2772 MWt, Four MSSVs Out of Service, E-OTSG

Valves Out of Service	MS-V17D, MS-V19D, MS-V18D, MS-V20D
Maximum RCS Pressure (psia)	2583.80
Maximum SG Pressure (psia)	1194.62
Maximum Steam Line Pressure (psia)	1187.43

The maximum RCS and SG pressure were less than the applicable limits, however, the steam line pressure of 1187.43 psia exceeded the 1169.7 psia Code requirement for the steam lines and is therefore unacceptable. As a result, operation at 92% of 2772 MWt should not be allowed if more than three MSSVs are out of service on a single SG. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

5.3 62% of 2772 MWt with Four MSSVs Out of Service

The Turbine Trip event was evaluated in Reference 1 using an initial power level of 62% of 2772 MWt for four MSSVs out of service. The combination of valves chosen represents the limiting combination for four MSSVs out of service, as explained in Section 5.2. Table 5-3 shows the results.

Table 5-3: Turbine Trip at 62% of 2772 MWt, Four MSSVs Out of Service, E-OTSG

Valves Out of Service	MS-V17D, MS-V19D, MS-V18D, MS-V20D
Maximum RCS Pressure (psia)	2578.72
Maximum SG Pressure (psia)	1153.43
Maximum Steam Line Pressure (psia)	1149.36

The maximum RCS and SG pressure were less than the applicable limits. Furthermore, the steam line pressure of 1149.36 psia is considerably less than the 1169.7 psia Code requirement for the steam lines. The results demonstrate that operation at 62% of 2772 MWt is acceptable with the E-OTSGs with as many as four MSSVs out of service. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

5.4 62% of 2772 MWt with Five MSSVs Out of Service

With four MSSVs out of service at 62% of 2772 MWt, the peak steam line pressure from a Turbine Trip still had ~ 20 psi of margin to the limit. Therefore, the Turbine Trip event was evaluated with additional MSSVs out of service. For conservatism, the evaluation removed five full sized MSSVs from service on both steam generators and also removed MS-V21A and MS-V21B from service. The evaluation bounds the case with five MSSVs out of service per steam generator and the nominal setpoint increased in MS-V21A and MS-V21B to 1050 psig. The results are shown in Table 5-4.

Table 5-4: Turbine Trip at 62% of 2772 MWt, Five Full-Sized MSSVs Out of Service per E-OTSG

Valves Out of Service	MS-V17A, MS-V18A, MS-V19A, MS-V20A, MS-V21A, MS-V17B	MS-V21B, MS-V17C, MS-V17D, MS-V18D, MS-V19D, MS-V20D
Maximum RCS Pressure (psia)	2598.09	
Maximum SG Pressure (psia)	1169.01	
Maximum Steam Line Pressure (psia)	1164.94	

The RCS pressure of 2598.09 psia is well below the maximum RCS pressure for the Startup Event. The maximum SG pressure of 1169.01 psia remained below the 1279.7 psia Code requirement for the E-OTSGs. The maximum steam line pressure of 1164.94 psia is also less than the 1169.7 psia Code requirement for the steam lines. Since acceptable results are obtained when MS-V21A and MS-V21B are completely removed from service, it follows that the results would also be acceptable if the nominal setpoint is increased to 1050 psig. Section 3.3 provides additional information regarding the determination of the peak steam line pressure location.

5.5 Limits at Intermediate Power Levels

Reference 1 used explicit evaluations of the Turbine Trip event with the E-OTSG to determine that two MSSVs can be out of service per SG at 102% of 2772 MWt, that three MSSVs can be out of service per SG at 92% of 2772 MWt, and that five MSSVs can be out of service per SG at 62% of 2772 MWt. Reference 1 determined that for the OTSG, four MSSVs can be out of service at 77 %FP. Reference 1 used a linear relationship between the power and the peak SG pressure to verify that 77 %FP is conservative for allowing four MSSVs out of service per SG with the E-OTSGs.

The Turbine Trip at 92% of 2772 MWt with MS-V17D, MS-V18D, MS-V19D and MS-V20D out of service resulted in a peak steam line pressure of 1187.43 psia. The Turbine Trip at 62% of 2772 MWt with MS-V17D, MS-V18D, MS-V19D and MS-V20D out of service resulted in a peak steam line pressure of 1149.36 psia. Based on a linear relationship, the peak steam line pressure would be less than or equal to the 1169.7 psia Code requirement for the steam lines for power levels less than or equal to

78% of 2772 MWt. Therefore, the 77 %FP maximum power determined for four MSSVs out of service for the OTSGs is applicable for the E-OTSGs with a 1 %FP of margin. The 1 %FP margin is more than sufficient to account for the effects of pressurizer spray and the increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig.

Table 5-5 summarizes the maximum analyzed power levels shown to be acceptable as a function of the number of MSSVs that can be out of service per SG.

Table 5-5: Maximum Analyzed Power Level versus Number of MSSVs Allowed Out of Service

Maximum Number of MSSVs Allowed Out of Service per Steam Generator	Total Number of MSSVs Allowed Out of Service	Maximum Acceptable Power Level Analyzed (%FP)
2	4	102
3	6	92
4	8	77
5	10	62

The licensing basis of the plant ensures that full power operation will not exceed 102% of the rated thermal power level. Therefore, analyzing the full power case at 102% of the rated power level is sufficient for verifying that two MSSVs can be out of service at full power. For more than two MSSVs out of service on a single SG, the overpower trip setpoint should be reset as described in Section 6.0 to ensure that the analyzed power level is protected.

6.0 Overpower Trip Setpoints and Nominal Operating Power

The analyzed power levels of 102%, 92%, 77%, and 62% of 2772 MWt represent the maximum power that the plant can be at when a Turbine Trip occurs with as many as 2, 3, 4, and 5 MSSVs out of service per SG, respectively. The licensing basis of the plant ensures that normal full power operation will occur at 100% of the rated thermal power level and will not exceed 102% of the rated power level. Therefore, allowing 2 MSSVs out of service per SG at full power is protected by the analyzed power level of 102% of rated thermal power and the plant licensing basis. For more than two MSSVs out of service on a single SG, normal operation should be restricted to power levels that are less than the acceptable analyzed power level to provide margin to the limit. Furthermore, if more than two MSSVs are out of service on a single SG, the overpower trip setpoint should be adjusted to ensure that the plant does not exceed the maximum acceptable analyzed power level for a given number of MSSVs out of service on a single SG.

The overpower trip setpoint should be reduced in the event that more than 2 MSSVs are out of service on a single SG. The overpower trip setpoint is listed in TMI-1 TS [Reference 7 Table 2.3-1] as 105.1 %FP. Reference 1 notes that the 105.1 %FP overpower trip setpoint ensures that a reactor trip will occur during a transient prior to the core power reaching 112% FP when all uncertainties are considered. Using the 6.9 %FP string error for the overpower trip setpoint (112 %FP – 105.1 %FP = 6.9 %FP), the overpower trip setpoint becomes 85.1 %FP (92 %FP – 6.9 %FP) with three MSSVs out of service per SG, 70.1 %FP (77 %FP – 6.9 %FP) with four MSSVs out of service per SG, and 55.1 %FP (62 %FP – 6.9 %FP) with five MSSVs out of service per SG.

The normal operating power should also be adjusted with more than 2 MSSVs out of service on a single SG. Normal full power operation is 100 %FP, which has 5.1 %FP of margin between the nominal operating power and the overpower trip setpoint. This margin will be preserved for the reduced power cases. The recommended nominal power level is therefore 80 %FP (85.1 %FP – 5.1 %FP) with three MSSVs out of service per SG, 65 %FP (70.1 %FP – 5.1 %FP) with four MSSVs out of service per SG, and 50 %FP (55.1 %FP – 5.1 %FP) with five MSSVs out of service per SG.

Table 6-1 summarizes the overpower trip setpoints and the recommended maximum nominal operation power level as a function of the number of MSSVs that can be out of service per SG. Table 6-2 presents the same information in Table 6-1, but lists the information by the number of MSSVs that must be in service instead of the number that can be out of service. Table 6-1 and Table 6-2 do not restrict which MSSVs are removed from service on a SG. However, the ASME code requires each SG to have an operable MSSV with a nominal setpoint that is ≤ 1050 psig. Table 6-1 and Table 6-2 are applicable for the E-OTSGs and a rated power level of ≤ 2772 MWt.

Table 6-1: Overpower Trip Setpoint and Maximum Nominal Power Level versus Number of MSSVs Allowed Out of Service

Maximum Number of MSSVs Out of Service per Steam Generator	**Total Number of MSSVs Allowed Out of Service**	**Maximum Overpower Trip Setpoint (%FP)**	**Maximum Nominal Operating Power (%FP)**
2	4	See TS Table 2.3-1	100
3	6	85.1	80
4	8	70.1	65
5	10	55.1	50

Table 6-2: Overpower Trip Setpoint and Maximum Nominal Power Level versus Number of Required Operable MSSVs

Minimum Number of MSSVs Operable per Steam Generator	**Minimum Number of MSSVs Operable**	**Maximum Overpower Trip Setpoint (%FP)**	**Maximum Nominal Operating Power (%FP)**
7	14	See TS Table 2.3-1	100
6	12	85.1	80
5	10	70.1	65
4	8	55.1	50

7.0 Summary of Suggested Changes

The following are the suggested changes to TMI-1 TS 3.4.1.2.3 and the associated bases. These are the same changes suggested for the OTSG in Reference 11, except for the power level (2772 MWt) in the bases.

3.4.1.2.3 Except as provided in Specification 3.4.1.2.2 above, when the Reactor is above HOT SHUTDOWN, seven (7) MSSVs per steam generator shall be OPERABLE. If either Steam Generator has less than seven (7) MSSVs that are OPERABLE, then reduce the power and reset the overpower trip setpoint (see Table 2.3-1) as follows:

Minimum Number of MSSVs Operable on each Steam Generator	Maximum Overpower Trip Setpoint (% of Rated Power)
7	see Table 2.3-1
6	85.1
5	70.1
4	55.1

With less than four (4) MSSVs OPERABLE per steam generator, restore at least four (4) MSSVs on each steam generator to OPERABLE status within 4 hours or be in HOT SHUTDOWN within the next 6 hours.

At least one (1) OPERABLE MSSV on each steam generator must have a nominal lift setpoint ≤ 1050 psig. If either steam generator does not have at least one (1) OPERABLE MSSV with a nominal lift setpoint ≤ 1050 psig, restore at least one (1) MSSV with a nominal setpoint ≤ 1050 psig on each steam generator to OPERABLE status within 4 hours or be in HOT SHUTDOWN within the next 6 hours.

3.4 Bases

The MSSVs will be able to relieve to atmosphere the total steam flow if necessary. Below 5% power, only a minimum number of MSSVs need to be operable as stated in Specifications 3.4.1.2.1 and 3.4.1.2.2. This is to provide steam generator over pressure protection during hot functional testing and low power physics testing. Additionally, when the Reactor is between hot shutdown and 5% full power operation, the overpower trip setpoint in the RPS shall be set to less than 5% as is specified in Specification 3.4.1.2.2. The minimum number of MSSVs required to be operable allows margin for testing without jeopardizing plant safety. Plant specific analysis shows that one MSSV is sufficient to relieve reactor coolant pump heat and stored energy when the reactor has been subcritical by 1% delta K/K for at least one hour. Other plant analyses show that two (2) MSSVs on either OTSG are more than sufficient to relieve reactor coolant pump heat and stored energy when the reactor is below 5% full power operation but had been subcritical by 1% delta K/K for at least one hour subsequent to power operation above 5% full power. According to Specification 3.1.1.2a, both steam generators shall be operable whenever the reactor coolant average temperature is above 250 degrees F. This assures that all four (4) MSSVs are available for redundancy.

During power operations at 5% full power or above, if more than two MSSVs are inoperable on a single steam generator, the power level and overpower trip setpoint must be reduced, as stated in Specification 3.4.1.2.3 such that the remaining MSSVs can prevent overpressure on a turbine trip. The turbine trip event is the limiting event in terms of peak secondary pressure. Analyses have shown that overpressure will not occur if a turbine trip occurs with two or less MSSVs out of service on each steam generator and an initial power level less than or equal to 102% of 2772 MWth. Having MSSVs out of service as allowed by Specification 3.4.1.2.3 does not adversely impact the transient progression of the remaining Safety Analysis events. The Code requires that at least one MSSV on each steam generator be set at or below the MS System design pressure. Therefore, Specification 3.4.1.2.3 requires that each steam generator has at least one operable MSSV with a nominal setpoint ≤ 1050 psig.

8.0 Disposition of Events

Reference 1 reviewed the UFSAR [Reference 9] Chapter 14 events with respect to having MSSVs out of service as allowed by Table 6-1. Reference 1 also considered the potential increase in the nominal setpoint for MSSVs MS-V21A and MS-V21B from 1040 psig to 1050 psig. The results of the Reference 1 disposition of events as applicable to the E-OTSGs are summarized here.

The Turbine Trip event without ICS power runback and without credit for the ARTS trip signal coincident with turbine trip is the limiting transient in terms of secondary pressure for the following reasons:

- Reactor power continues at the initial power level for several seconds after the turbine has tripped, resulting is a large amount of heat transferred to the secondary side.
- Reactor coolant pumps continue to operate, adding heat and providing forced primary coolant flow that maintains a high heat transfer to the secondary side.
- Main feedwater is isolated coincident with reactor trip and emergency feedwater does not have time to initiate before the peak secondary side pressure is reached.

All other UFSAR Chapter 14 events are less limiting in terms of the peak secondary pressure response. Since the Turbine Trip event without ICS power runback and without credit for the ARTS trip signal coincident with turbine trip was used to determine Table 6-1, it follows that the peak secondary pressure for all UFSAR Chapter 14 events will also be acceptable with the MSSVs out of service as allowed by Table 6-1. Furthermore, since the Turbine Trip event without ICS power runback and without credit for the ARTS trip signal coincident with turbine trip was used to justify an increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig, it follows that the peak secondary pressure for all UFSAR Chapter 14 events will also be acceptable with an increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig.

In addition to the peak secondary pressure considerations, the UFSAR Chapter 14 events were reviewed in Reference 1 to determine if having MSSVs out of service as allowed by Table 6-1 or increasing the nominal setpoint for MS-V21A and MS-V21B would affect the ability of the AOR to meet the applicable acceptance criteria.

For the following UFSAR Chapter 14 events, the MSSV characteristics do not have any bearing on the ability of the transient to meet the applicable acceptance criteria. This is true for both OTSGs and E-OTSGs. Therefore, MSSV characteristics are not considered in the AOR:

- UFSAR Section 14.1.2.1 – Uncompensated Operating Reactivity Changes
- UFSAR Section 14.1.2.2 – Startup Accident
- UFSAR Section 14.1.2.5 – Cold Water Accident
- UFSAR Section 14.1.2.6 – Loss of Coolant Flow
- UFSAR Section 14.2.2.1 – Fuel Handling Accident
- UFSAR Section 14.2.2.5 – Maximum Hypothetical Accident

- UFSAR Section 14.2.2.6 – Waste Gas Tank Rupture
- UFSAR Section 14.2.2.8 – Fuel Cask Drop Accident

For the following UFSAR Chapter 14 events, the MSSVs may open following reactor trip, but the ability of the transient to meet the acceptance criteria is limited by the system characteristics that occur before the MSSVs open. This is true for both OTSGs and E-OTSGs. Therefore, the MSSV characteristics do not change the ability of the following events to meet the applicable acceptance criteria.

- UFSAR Section 14.1.2.3 – Rod Withdrawal at Rated Power Operation
- UFSAR Section 14.1.2.4 – Moderator Dilution Accident
- UFSAR Section 14.1.2.7 – Stuck-Out, Stuck-In, or Dropped Control Rod Accident
- Reference 10 – Dropped Rod without leadscrew
- UFSAR Section 14.1.2.11 – Anticipated Transients Without Scram (Loss of Main Feed Water)
- UFSAR Section 14.2.2.2 – Rod Ejection Accident
- UFSAR Section 14.2.2.7 and Reference 12 – Loss of Feedwater Accident
- UFSAR Section 14.2.2.9 and Reference 15 – Feedwater Line Break Accident

The remaining Chapter 14 events are dispositioned separately as summarized below.

The Loss of Electric Power event with ICS unit runback, described in UFSAR Section 14.1.2.8.2, is not possible with the current RPS high pressure trip setpoint and PORV setpoint. Nevertheless, if the analysis were performed with the original RPS and PORV setpoints, MSSVs out of service as allowed by Table 6-1, and an increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig, the effect on the AOR would be less than minimal. By definition, this transient maintains the RCS pressure below the RPS trip setpoint and therefore does not challenge the RCS pressure acceptance criteria. Similarly, the ICS runback on unit power ensures that fuel damage does not occur from an excessive power-to-flow ratio. There is no effect on the dose consequences of the AOR because the steam relief to the condenser and atmosphere through the turbine bypass valves and the MSSVs can be accomplished with the MSSV capacity available with MSSVs out of service as allowed by Table 6-1 and with the increased setpoint for MS-V21A and MS-V21B. This event was not re-analyzed for E-OTSG since it is no longer credible.

The Loss of Electric Power event with reactor trip via the ARTS trip signal coincident with turbine trip, described in UFSAR Section 14.1.2.8.3, does not challenge the UFSAR acceptance criteria and is bounded by the Turbine Trip event without the ARTS trip signal analyzed in References 1, 5, and 6.

The Station Blackout event, described in UFSAR Section 14.1.2.8.4, results in immediate reactor trip and therefore ensures that fuel damage does not occur from an excessive power-to-flow ratio. The dose consequences of the Station Blackout event are bounded by the Loss of Electric Power event with ICS unit runback. The peak primary pressure in the Station Blackout event does not occur until after the MSSVs have opened. However, the peak primary pressure in the Station Blackout event is driven by the PSV setpoint and capacity, which is not being changed. Therefore, MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B do not affect the ability of the AOR for the Station Blackout event to meet the applicable acceptance criteria. The effect of MSSV characteristics on the Station Blackout event is not dependent on the steam generator design and is therefore true for both the OTSGs and E-OTSGs.

The Steam Line Break event, described in UFSAR Section 14.1.2.9 and analyzed in Reference 13 for the E-OTSG, uses MSSVs in the unfaulted loop after the repressurization occurs. The Steam Line Break transient progression is dominated by the blowdown and post-trip overfeed of the faulted steam generator and is less than minimally impacted by the MSSV characteristics. Therefore, MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B do not affect the ability of the AOR for the Steam Line Break event to meet the applicable acceptance criteria.

The Steam Generator Tube Rupture event, described in UFSAR Section 14.1.2.10 and analyzed for both the OTSG and E-OTSG in Reference 14, uses the MSSVs after reactor and turbine trip to provide steam relief. The MSSV capacity with MSSVs out of service as allowed by Table 6-1 is sufficient for steam relief during the Steam Generator Tube Rupture event. The Steam Generator Tube Rupture event results in a less limiting dose consequence if the MSSV setpoint is increased or if higher setpoint MSSVs are used for steam relief. Therefore, the dose release from the AOR is bounding for a case with MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B. In addition, MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B have a less than minimal impact on the temperature gradients that might result in additional tube failures.

The Loss of Main Feedwater event is identified in UFSAR Section 14.1.2.11 as the most limiting ATWS event, particularly in terms of peak RCS pressure. As noted above, the peak RCS pressure in a Loss of Main Feedwater ATWS is based on the primary side conditions that occur prior to the turbine trip. Therefore, the MSSV characteristics do not affect the ability of the AOR for the Loss of Main Feedwater to meet the acceptance criteria. The Turbine Trip event is also a possible ATWS event. Since the ATWS analyses utilize more realistic assumptions than those typically assumed in standard safety analyses, such as realistic MSSV lift setpoints and the ICS power runback upon turbine trip, the Turbine Trip event without ICS power runback and without credit for the ARTS trip signal that was used to determine Table 6-1 is bounding in terms of secondary pressure response.

The Large Break LOCA transient, described in UFSAR Section 14.2.2.3 and verified as applicable to the E-OTSGs in Reference 16, is driven by the primary side conditions, the break size, the core decay heat, the fuel pin properties, the metal-water reaction, and the ECCS flow rates. Note that the evaluation performed in Reference 16 is based on a smaller tube plugging level for the EOTSG than the OTSG, however, the MSSVs don't play a significant role in mitigating the consequences of this event regardless of the tube plugging level. For the larger break sizes, the secondary pressure never reaches the MSSV lift setpoint and the MSSV characteristics have no affect on the Large Break LOCA transient. For those break sizes that do use the MSSVs, the MSSV characteristics have a less than minimal effect on the parameters that dominate the transient progression. Therefore, MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B have a less than minimal impact on the AOR for the Large Break LOCA.

The Small Break LOCA transient, described in UFSAR Section 14.2.2.4 and verified as applicable to the E-OTSGs in Reference 16, utilizes the MSSVs for steam relief and to control secondary side pressure (Note that the evaluation performed in Reference 16 is based on a smaller tube plugging level for the EOTSG than the OTSG, however, the MSSVs don't play a significant role in mitigating the consequences of this event regardless of the tube plugging level). For a significant portion of the Small Break LOCA transient, the secondary pressure is maintained at or near the lift setpoint for the lowest setpoint MSSVs. The AOR modeled the lift setpoint for the lowest setpoint MSSVs as 1065 psia. MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig does not invalidate the lift setpoint for the lowest setpoint MSSVs modeled in the Small Break LOCA AOR. The capacity of the MSSVs is sufficient to maintain the secondary side pressure at or near 1065 psia during the Small Break LOCA even with MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig. Therefore, MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B have a less than minimal impact on the AOR for the Small Break LOCA.

This concludes the disposition of events. For all UFSAR Chapter 14 events, MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B was shown to have a less than minimal impact on the ability of the AOR and E-OTSG specific analyses to meet the applicable acceptance criteria. Furthermore, the Turbine Trip event without ICS power runback and without credit for the ARTS trip signal coincident with turbine trip is the limiting transient in terms of secondary pressure. Therefore all UFSAR Chapter 14 events will have an acceptable peak secondary pressure with MSSVs out of service as allowed by Table 6-1 and an increase in the nominal setpoint for MS-V21A and MS-V21B to 1050 psig.

8.1 Technical Bulletin TB-07-6

Westinghouse Electric Company TB-07-6 is a technical bulletin concerning the credited relief capacity of the atmospheric steam relief system in Westinghouse designed NSSS. The atmospheric relief system in Westinghouse designed NSSS most closely correlates to the Atmospheric Dump Valves at TMI-1. Although TB-07-6 does not mention B&W designed NSSS or the MSSVs, the main concerns identified in TB-07-6 were evaluated in Reference 1 with respect to the MSSV operability study.

The main concern of TB-07-6 is that some Westinghouse analyses credited steam relief capacity of SG the atmospheric steam relief without considering the following:

- The length of piping between the main steam line and the steam relief valves
- The actual size of the installed inlet and outlet piping valves
- The diffuser being smaller than the nominal size of the valves

Reference 1 explains that the length of piping between the main steam line and the MSSVs is negligible. Any pressure drop that might occur in the connecting piping is bounded by the conservatisms in the model, such as the conservative form loss added to account for flow turning from the steam line into the MSSVs. Reference 1 also determined that the MSSV flow areas used in the model are conservative relative to the size of the inlet and outlet piping and flanges. Therefore, the capacity of the MSSVs in the Reference 1 analysis is conservative.

9.0 References

1) AREVA Document No. 32-9045537-000, "TMI-1 MSSV Operability."
2) AREVA Document No. 43-10193PA-00, "RELAP5/MOD2-B&W For Safety Analysis of B&W-Designed Pressurized Water Reactors."
3) AREVA Document No. 43-10164PA-06, "RELAP5/MOD2-B&W – An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis."
4) AREVA Document No. 51-9007375-003, "TMI-1 Turbine Trip with E-OTSG AIS."
5) AREVA Document No. 32-9017996-000, "TMI-1 E-OTSG Turbine Trip at Full Power."
6) AREVA Document No. 32-9020126-000, "TMI-1 Turbine Trip at Reduced Power with E-OTSG."
7) *Three Mile Island, Unit 1, Technical Specifications, Amendment 269.
8) *TMI Document SDBD-T1-411 Revision 3, "System Design Basis Document for Main Steam System. (with postings)"
9) *TMI-1 Updated Safety Analysis Report, Revision 19 (with postings).
10) AREVA Document No. 86-9020266-001, "TMI Dropped Rod w/o Leadscrew Analysis Summary."
11) AREVA Document No. 86-9052402-001, "TMI-1 MSSV Operability Phase 1 Results."
12) AREVA Document No. 32-9016024-000, "TMI-1 EOTSG Loss of Feedwater Analysis."
13) AREVA Document No. 32-9012205-002, "TMI-1 EOTSG – MSLB Analysis."
14) AREVA Document No. 32-9028274-001, "TMI-1 EOTSG/OTSG Steam Generator Tube Rupture."
15) AREVA Document No. 32-9019665-001, "TMI-1 EOTSG Feedwater Line Break (FWLB) Analysis."
16) AREVA Document No. 51-9007383-003, "TMI-1 EOTSG LOCA Safety Evaluation."

* The project manager signature on page 2 documents approval to use this reference.