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차세대원자로 안전감압계통의 POSRV 채택에 관한 타당성 연구

Feasibility Study for the Adoption of POSRV for KNGR Safety Depressurization System

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본 보고서를 1998년도"차세대원자로 안전감압계통의 POSRV 채택에 관한 타당성 연구" 과제의 기술보고서로 제출합니다.

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요 약 문

I. 제목

차세대원자로 안전감압계통의 POSRV 채택에 관한 타당성 연구

II. 연구개발의 목적 및 필요성

한국형 차세대원자로는 완전급수상실사고나 중대사고와 같은 초과설계기준사고시 일차계통을 급격히 감압하기 위하여 안전감압계통을 설계에서 채택하고 있다. 이를 위해 SYSTEM 80+ 형태의 방출밸브를 사용하는 경우와 POSRV를 사용하는 경우 두 가지 설계 방안이 검토되고 있다. 첫 번째 설계방안은 영광 3,4호기 및 울진 3,4호기에서 이미 채택되어 운전 중에 있으며, 두 번째 방안은 Power Operated Safety Relief Valve (POSRV)를 사용하여 급속감압과 과압방지 두 기능을 함께 수행하는 설계이다. 본 연구에서 두 가지 설계방안에 대하여 타당성을 조사하였다.

III. 연구개발의 내용 및 범위

차세대원자로 안전감압계통에 프랑스식 세빔 POSRVs의 채택 가능성을 검토하기 위하여 세빔밸브를 사용하는 경우의 TLOFW 해석방법론을 정립하고, 최적설계코드인 CEFLASH-4AS/REM 전산코드를 사용하여 TLOFW 사고와 충전/유출운전 (Feed & Bleed)을 모의한 후, 해석결과에 대하여 논의하였다. 위의 두 가지 설계방안에 대하여, TLOFW시 가능한 여러 충전/유출 운전을 조사하였다.

IV. 연구개발 결과

첫 번째 설계방안에서는 EPRI ALWR 요건서의 충전-유출 기준을 따라 TLOFW 사고시 노심이 노출되지 않는 최소의 해석적 방출면적이 0.028 ft^2임을 결정하였다. 두 번째 설계 방안에서는 방출밸브로서 3개의 Monobloc Sebim POSRV를 사용하였을 때, 고온관이 포화온도에 도달하기 전에 운전원이 두 개의 밸브와 네 대의 HPSI 펌프를 동시에 작동시켜서 충전-유출 운전을 시작하면, 붕괴열 제거와 노심의 냉각재 보충이 성공적으로 수행되었다. 해석결과, 두 가지 안전감압계통 설계방안 모두 완전급수상실사고시 충분한 여유도를 확보하고 있었다. 따라서 POSRV를 한국형 차세대원자로의 안전감압계통 설계에 채택하는 방안의 가능성이 입증되었다.

V. 연구개발결과의 활용계획 및 건의사항

POSRV를 한국형 차세대 원자로의 안전감압계통 설계에 채택하는 방안의 가능성이 입증되었으나 Sebim POSRV는 급속감압과 과압방지 기능을 함께 수행하는 장치이므로 과압 설계기준사고와 돌발적 POSRV 개방사고시의 DNB 측면에서 사용 타당성이 검증되어야 한다

SUMMARY

I. Project Title

Feasibility Study for the Adoption of POSRVfor KNGR Safety Depressurization System

II. Objective and Importance of the Project

Two design approaches were considered for the Korean Next Generation Reactor (KNGR) safety depressurization system (SDS) design. The use of bleed valves similar to those of ABB-CE's System 80+ is design option 1, while in design option 2, the Power Operated Safety Relief Valve (POSRV) is considered to provide the combined function of overpressure protection and rapid depressurization. The design option 1 was already implemented in the SDS design of YGN 3&4 and UCN 3&4 plants. The purpose of this report is to investigate the feasibility of adoption of French Sebim POSRVs for KNGR SDS (design option 2).

III. Scope and Contents of Project

This report provides the methodology to analyze the TLOFW event with Sebim valves and presents the results of thermal hydraulic analyses using a best-estimate version of CEFLASH-4AS/REM for the TLOFW event with feed and bleed. For each design option. For design option 1, the required bleed capacity was determined from the CEFLASH-4AS/REM simulation according to the EPRI Advanced Light Water Reactor (ALWR) requirements. For design option 2, the operator action times for initiating the feed and bleed were investigated by varying the number of Sebim valves and high pressure safety injection (HPSI) pumps.

IV. Results of Project

The analysis results demonstrated that the TLOFW event could be mitigated in a proper manner with a sufficient margin by using design option 1. For design option 2, If the operator opens two out of the three Sebim valves in

conjunction with the four HPSI pumps before a hot leg saturation condition, the decay heat removal and core inventory make-up function could be successfully accomplished.

V. Proposal for Applications

The results of the present investigation demonstrated that the two design options are both feasible to mitigate the consequences of the TLOFW event with a sufficient margin. However, since the Sebim valves have required functions of both overpressure protection and emergency bleed, the number of Sebim POSRVs required should be confirmed from the design basis overpressure transient analysis.

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I. INTRODUCTION

Following the accident at Three Mile Island Unit-2 (TMI-2) in 1979, the potential capability of power-operated relief valves to provide an alternative method of removing decay heat from the reactor core was identified and considered to be beneficial in dealing with beyond design basis events. Recent studies [1-4] discussed appropriate feed and bleed procedures by using existing equipments such as power operated relief valves in terms of implementing Emergency Operation Procedures (EOPs). Therefore, Advanced Light Water Reactors (ALWRs) such as the ABB-CE's System 80+ and the Korean standard nuclear power plants (KSNPPs) of Yonggwang 3&4 (YGN 3&4) and Ulchin 3&4 (UCN 3&4) adopted safety depressurization systems (SDS) to enable feed and bleed operation to mitigate beyond design basis accidents. The SDS consists of two separate lines connected to the top of the pressurizer, and two bleed paths, each of which consists of an isolation valve (gate valve) and control valve (globe valve). It was necessary to perform thermal-hydraulic analyses to determine the minimum required bleed capacity of SDS [5-7].

On the other hand, the TMI-2 accident indicated that the pressurizer safety valves and power-operated relief valves are very important for the safe and reliable operation of PWR power plants. To eliminate the problems experienced with spring-loaded valves in the pressurizer and residual heat removal system, Framatome and Sebim developed the Monobloc Sebim valve [8] for improved reactor coolant system (RCS) overpressure protection. Since the Sebim valve can be manually operated, it can be adopted for the SDS to perform the combined function of overpressure protection and rapid depressurization. Another advantage of using the Sebim valve comes from the French feed and bleed procedure [9], which seems to give less burden on the operator to open bleed valves.

The conceptual design of the Korean next generation reactor (KNGR) includes a SDS in conjunction with an in-containment refueling water storage tank (IRSWT) to provide the feed and bleed capability, which complies with the U.S. NRC's severe accident policy. For the design of the SDS, we have considered two design approaches. The use of bleed valves similar to those of System 80+ is design option 1, while an adoption of Monobloc Sebim valves is design option 2.

This report is the product of design support effort that was conducted to initiate the adoption of Sebim valves for KNGR SDS. In this report, thermal hydraulic analyses using a best-estimate version of CEFLASH-4AS/REM [10] are performed for a total loss of feedwater (TLOFW) event to investigate the feasibility of those two design options. The analysis is concerned with determining the minimum required bleed capacity of the SDS and comparing of the two designs in terms of the appropriateness of feed and bleed procedures. The methodology to analyze the TLOFW event with Sebim valves are described compared to that for option 1. The modified portion of CEFLASH-4AS/REM to simulate Sebim valve is included in Appendix. Since the design and analysis procedures to determine the minimum bleed capacity of design option 1 are well established in the previous works [5-7, 11-12], design option 2 where Sebim valves are adopted for KBGR SDS is a main focus of this report.

II. SDS SYSTEM DESCRIPTION

The KNGR is a two loop 3914 MWt PWR employing various advanced design features. As a dedicated safety system, SDS provides a manual means of quickly depressurizing the RCS when both main and emergency feedwater are unavailable to remove core decay heat through the steam generators. This function is achieved via remote manual operator control. During an unlikely event of TLOFW which results in high RCS pressure with a gradual loss of RCS liquid inventory, the SDS valves may be opened by the operator resulting in a rapid depressurization of the RCS. As the RCS pressure decreases, the high pressure safety injection pumps deliver an increasing amount of safety injection feed flow to the RCS and restore the RCS liquid inventory.

As for the feed system, the KNGR has four trains of HPSI pumps which are mechanically independent. Two diesel generators supply power to each of the two trains of the HPSI pumps. The HPSI flow is injected into the upper downcomer through four direct vessel injection (DVI) nozzles.

The two design approaches have been considered for the SDS design of the KNGR. System description of each design option is presented in the following section.

1. Design Option 1

The original SDS design (design option 1) is depicted in Fig. II-1, where the SDS consists of two separate lines connected to the top of the pressurizer, and the flow through each line discharges into the IRWST. The two bleed paths consist of an isolation valve and control valve in series per path. According to the valve tests for the UCN 3&4 SDS [12], their stroke times to close are 25 and 67 seconds, respectively. The IRWST provides the volume for receiving the steam and liquid from the discharge lines, and prevents the release of effluent to the containment. However, the IRWST is not modeled in this analysis. The primary feed and bleed consists of a depressurization of the primary system (bleed) and a feeding with the high pressure safety injection (HPSI) pumps starting at 1835 psia delivering borated water into the downcomer.

An emergency procedure guideline (EPG) [13] specifies that the operator manually initiates the feed and bleed at the time of pressurizer safety valve (PSV) lift when all of the feedwater to the steam generators are unavailable. This feed and bleed procedure is consistent with the EPRI requirements for the advanced light water reactor, which is described in Section III.B.

2. Design Option 2

For design option 2, the SDS consists of three separate lines connected to the top head of the pressurizer and the flow through the Sebim valves is discharged to the IRWST as shown in Fig. II-2. The pressurizer is provided with three separate relief lines. Each of the three lines comprises two hydraulic pilot-operated valves mounted back to back as a tandem in series. The first valve in each line serves as a safety or relief valve and the second serves as an isolation valve. All valves for safety, relief and isolation functions are of identical type and size. The safety valves remain closed during normal operation and open only in case of reactor coolant system overpressure. The isolation valves remain open during normal operation and close if its associated safety valve fails to close after opening. Details of the configuration adopted for a tandem of safety valves and their associate cabinets for one of the three discharge lines are shown in Fig. II-3.

As shown in Fig. II-4, a bellow element, capable of taking full system pressure, is welded to the valve disk (C) and sealed towards the valve body to prevent leakage of primary fluid along the valve stem to the atmosphere. The valve operating piston (V) is provided with springs which are dimensioned to provide a force greater than the traction force of the bellows. A pressure of around 5 to 7 bar is necessary to open the valve. Each valve pilot cabinet contains a pilot detector, which consists of a hydraulic piston (P) and a setting spring (R). The detector is connected to the impulse line from the pressurizer. The pilot detector operates two impulse valves (R1 and R2) by means of a cam. The combined operation of these two valves (R1 and R2) allows the pressurization or depressurization of the pilot operated valve head and thus provokes the closing or opening of the main valve. A valve electromagnet actuator (E) is installed at the bottom of the pilot detector and acts directly on the shaft and cam that serve to operate the two impulse valves. This electromagnet provides a means of directly depressurizing the pilot operated valve head to provoke the forced opening of the valve.

The three lines assure the hot overpressure protection function. The operation of the safety valves is purely hydraulic and no electrical signal is required. The opening pressure for the three safety valves are stepped in order to avoid the simultaneous ejection of the three water seals into the discharge header and therefore to decrease loading of the header. The isolation valves remain open through the period of operation of the safety valves, as the RCS pressure remains above the closure setpoint. However, in the case of a failure of one of the safety valves to close after opening, the three isolation valves close when the RCS pressure falls below the closure setpoint, in order to avoid the uncontrolled depressurization of the primary system.

In the case when make up of the RCS using the safety injection system becomes necessary, the valve lines can be forced open by the operator using the electromagnet actuators to perform feed and bleed. The operator puts the control switch for the isolation valve in its forced open position. The operator then turns the safety key for the safety valve to the forced open allowed position and he maintains the control switch in this position as long as the line must remain open. The safety valve will reclose as soon as the operator releases the control switch.

The Sebim valves have operational advantages with respect to feed and bleed operation. The valves ensure stable operation without the risk of valve chatter for any type of discharge flow conditions encountered, such as steam and saturated or under saturated water, while maintaining specified operating and closing characteristics. During feed and bleed operation, the flow condition through the bleed path changes from pure steam to single phase water or two-phase mixture. Such phase transients of discharge flow are dependent on the feed and bleed procedure. The Sebim valves ensure that an adequate reliability of valve re-closing is maintained, thus providing control of bleed flow through the throttling of the flow area, as well as reliable isolation of the RCS in case of a stuck open valve. The Sebim valves provide the capability for remote manual opening and closing operation under post-accident conditions using fully qualified equipment.

As discussed in the introduction, since the Sebim valves are capable of both overpressure protection and bleed functions, the SDS design with Sebim valves (design option 2) is competitive with the design option 1 in terms of design simplification and cost.

III. ANALYSES METHODOLOGY OF TLOFW

1. TLOFW Event Definitions

The TLOFW event is a beyond design basis accident resulting from a hypothetical loss of both main feedwater and emergency feedwater to both steam generators. This scenario is very unlikely, since the reliability of the emergency feedwater system is very high for KNGR.

The total loss of feedwater results in decreasing water level and increasing pressure and temperature in the steam generators. The RCS pressure and temperature also rise until a reactor trip occurs either due to low steam generator water level or high pressurizer pressure. Assuming the Reactor Regulating System (RRS) and Pressurizer Pressure Control System (PPCS), and Pressurizer Level Control System (PLCS) are in the automatic mode of operation, the reactor trip occurs due to a low steam generator level trip at about 30 seconds. The decreased core heat after insertion of the Control Element Assemblies (CEAs) is removed by boiling off the remaining water inventory of the steam generators through the Turbine Bypass Valves (TBVs) and/or Main Steam Safety Valves (MSSVs).

Emergency feedwater flow would be automatically initiated on a low steam generator level for core decay heat removal. However, the emergency feedwater is assumed to fail for the highly unlikely TLOFW event scenario. Therefore, core decay heat is removed by the Steam Bypass Control System (SBCS) until water inventory of steam generator is depleted. Since the steam generator water inventory depletion results in RCS pressurization, the PSVs open just after the steam generators dry out. The core decay heat in combination with PSVs opening maintains the RCS pressure between PSVs opening and closing pressures. Since the RCS pressure is above the HPSI pumps shutoff head, the inventory loss of through the PSVs cannot be compensated by HPSI injection flow. Partial inventory loss can be compensated by the charging pumps, however charging flow is not credited in this analysis. The continued depletion of RCS inventory will result in core uncovery, which will eventually lead to core damage.

To mitigate TLOFW event, the operator opens the SDS valves. This allows the RCS pressure to decrease below HPSI shutoff head, which enables the RCS makeup by HPSI inflow and maintains the core mixture level above top of the core. The decay heat is removed by once through cooling of the core by the HPSI inflow and SDS valve discharge flow.

2. Performance Objectives

The use of feed and bleed is a trade-off between allowable time before operator action and the bleed capacity of the system. The longer the time, the larger the system capacity must be. A shorter allowable time before operator action increases the possibility of inadvertent actuation and resultant containment contamination. Therefore, appropriate design criteria are required. Followings are design requirements used for the KNGR;

(1) Each SDS flow path, in conjunction with two of four HPSI pumps, is designed to have sufficient capacity to prevent core uncovery with two feet margin following a TLOFW event if one SDS path is opened simultaneously with the opening of the PSVs.

(2) Both SDS flow path are designed to have sufficient total capacity with all HPSI pumps operating to prevent core uncovery with two feet margin following a TLOFW event if both SDS paths are opened up to one hour from the time of the PSVs lift.

For both conditions, analyses shall show a margin to core uncovery of at least two feet, using best estimate methods.

This feed and bleed procedure is consistent with the EPRI requirements for the advanced light water reactor (ALWR) [14]. The similar two performance requirements for successful feed and bleed procedure were implemented for the SDS designs of YGN 3&4 and UCN 3&4 [11,12]. However, the one hour delay time for operator to open the SDS paths in the second requirement was not accomplished for those plants.

In the French practice [9], the operator manually opens the Sebim valves when steam gennerators are unavailable (e.g., TLOFW), or when steam generators are partially available, but the hot leg temperature reaches saturation. Safety injection is manually or automatically actuated.

In this report, comparative analyses for the feed and bleed procedure using design option 1 and French feed and bleed practices using design option 2 are performed to investigate the feasibility of those two design approaches.

3. Computer Code Used

The CEFLASH-4AS/REM code [10], developed by ABB-CE, is used for the best-estimate analysis of the TLOFW event. The CEFLASH-4AS/REM code employs two mass, two energy, and one momentum equation. The phase separation phenomena are simulated by a flow regime dependent drift flux model. The CEFLASH-4AS/REM code has been developed from the NRC approved CEFLASH-4AS program [15] which was used by ABB-CE for licensing analysis of small beak LOCAs. The best-estimate analytical models, which distinguish the CEFLASH-4AS/REM code from its predecessor, CEFLASH-4AS, are documented in References 2, 17 and 18. That documentation includes comparisons of the predictions of several individual analytical models to the results of separate effects tests. The verification of the CEFLASH- 4AS/REM code by comparison of its predictions for system behavior to the results of integral experiments, is given in References 16 and 18.

Verification of the CEFLASH-4AS/REM code against experimental data is performed in Reference 19 to verify the capability of the code for use in the analysis of a TLOFW event with feed and bleed. The verification consists of comparisons of the predictions of the system behavior by the CEFLASH-4AS/REM code to the results of two Loss of Fluid Test (LOFT) integral experiments. The LOFT experiments selected are : LP-FW-1 which is a TLOFW with primary side feed (HPSI pump) and bleed (PORV), and L9-1/L3-3 which is a TLOFW with primary side bleed (PORV) but no primary side feed. Detailed discussions on the rationale for the selection of the test cases, CEFLASH-4AS/REM modeling of test, and comparison of the predictions of the CEFLASH-4AS/REM code with the results of experiments can be found in Reference 19.

Based on the good agreement between the experimental results and the analytical predictions by the CEFLASH-4AS/REM modeling, it is concluded that the CEFLASH- 4AS/REM code is applicable to the analysis of an NSSS for a TLOFW with feed and bleed [19]. Also, comparative analysis [15] for a TLOFW event using RELAP5/MOD3 and CEFLASH-4AS/REM demonstrate that CEFLASH-4AS/REM is compatible with RELAP5/MOD3 in simulating a TLOFW event. It justifies the use of CEFLASH/4AS -REM for the present analysis. Since CEFLASH-4AS/REM calculates core mixture level directly, it is better for analyzing conformance to EPRI requirements (section III.B) than RELAP5/MOD3. The CEFLASH-4AS/REM is modified to incorporate the characteristics of the Sebim valve, shown in Fig. III-1, for this analysis. The whole portion of modified CEFLASH-4AS/REM is included in Appendix A.

4. TLOFW Analysis Methods

The CEFLASH-4AS/REM code is used for the best-estimate analysis of TLOFW event. The terminology "best-estimate" means realistic modeling of both the thermal-hydraulic phenomena and systems operation during TLOFW event. The nodalization scheme of CEFLASH/REM for the representation of the KNGR plant is shown in Fig. III-2. Table III-1 provides major KNGR plant parameters and initial conditions used in the analysis. The plant initial conditions are assumed to be at full power, steady state, nominal conditions.

According to the test results for the Sebim Monobloc valve, the minimum valve capacity is equivalent to 220 ton/hr steam under 172.3 absolute bar. The analytical bleed area corresponding to this flow capacity is determined to be 0.0243 ft^2 based on the Murdock-Bauman correlation [20]. The Sebim valves have staggered opening and closing setpoints, as described in section II.B., to minimize hydraulic loads induced by valve actuation during overpressure transients. The opening and closing characteristics of the Sebim valve are shown in Fig. III-1 and their setpoints are presented in Table III-1. High setpoints including uncertainty are used for the analysis in a conservative sense.

The French N4 plant (4200 MWt) has three Monobloc Sebim valves. However, since the KNGR and N4 have different NSSS configurations, it may not be enough to have only three valves for the KNGR. The number of Sebim valves required is determined from the design basis overpressure transient analysis. According to the preliminary analysis for overpressure protection of the RCS, which was performed internally in KAERI, the SDS bleed paths can be conservatively assumed to consist of three assemblies of Sebim valves, where an assembly consists of two pilot-operated valves mounted back to back.

Detail methodology for determination of the bleed capacity are the same as those adopted in the previous works [11,12]. The input data of CEFLASH-4AS/REM for KNGR TLOFW analyses are presented in the reference 21, where the minimum bleed capacity of KNGR SDS for design option 1 was determined.

During the post-trip CEFLASH-4AS/REM simulation, the main and auxiliary sprays are not credited to conservatively slow the rate of RCS depressurization. The RCS inventory make-up function of charging pump is also conservatively not credited, even though the charging pump is expected to function even after the reactor trip and RCP trip. In this analysis, the Steam Bypass Control System (SBCS) is not credited. The decay heat is based on the ANSI/ANS Standard 5.1-1979 [22] including actinides. For the TLOFW event, the operator will trip all the RCPs after diagnosis of Loss of All Feedwater as suggested in the EPG [13]. The incentive of this operator action is to minimize the heat input to the RCS. All RCPs are assumed to be tripped at 10 minutes after reactor trip. The SDS bleed flow paths are modeled by two orifices on the top head of the pressurizer for the case of design option 1, while three orifices for design option 2. The required flow area for the orifice to ensure that the mixturel level is above the core with a 2 feet margin for TLOFW is determined by changing this area.

For design option 1, the minimum analytical bleed capacity to prevent core uncovery is investigated from the various feed and bleed procedures by varying the area of bleed valve and HPSI pump operating according to the above performance requirements. For design option 2, since the bleed capacity of the Sebim valve is known from the experimental test, the operator's feed and bleed initiation times required to prevent core uncovery are investigated by varying the number of valves in conjunction with the available HPSI pump. In the sections which follow, the results of analyses satisfying the performance objectives described in section Ⅲ.B are presented.

IV. TLOFW ANALYSIS RESULTS

This section describes the results of analyses for TLOFW with feed and bleed to show that the minimum bleed capacity prevents core uncovery with two feet margin.

The cases analyzed for design option 1 are : (1) TLOFW without recovery, (2) TLOFW with recovery where one bleed path is open at the time of PSVs lift and only two out of four HPSI pumps are assumed available, and (3) TLOFW with recovery where the operator opens the two bleed paths 40 minutes after the time the PSVs lift and four HPSI pumps are assumed available.

For design option 2, since the analytical flow area of a Sebim valve is 0.0243 ft^2, investigated are the feed and bleed cases by varying the number of Sebim valve openings and HPSI pumps operating in conjunction with operator action time. The feed and bleed cases considered are : (1) the case for one Sebim valve opening with two HPSI pumps, (2) the case for two Sebim valves opening with two HPSI pumps, (3) the case for three Sebim valves opening with four HPSI pumps. To evaluate the effects of HPSI flow, the case with four HPSI pumps operating are additionally analyzed for the first two cases.

Table IV-1 and Table IV-2 provide the major chronology of TLOFW event cases without recovery action and TLOFW cases with feed and bleed for design option 1 and 2, respectively. The behavior of major system parameters during the transients are presented in Fig. IV-1 through Fig. IV-6 for design option 1, and in Fig. IV-9 through Fig. IV-11 for design option 2.

1. TLOFW without Recovery

The base case is a TLOFW without recovery. The transient is initiated by an assumed instantaneous loss of main feedwater and emergency feedwater. Following the total loss of feedwater, a reactor trip occurs at 30 seconds due to low steam generator secondary liquid level. Upon reactor trip, the turbine stop valves close thereby isolating the steam generators from the turbine. The turbine bypass valves open to regulate secondary system pressure.

The RCS pressure falls following reactor trip due to the decreased heat input from the core. After a short time period, the RCS pressure starts to rise in response to the power-to-flow mismatch and reaches a new steady state. After the RCP trip, which occurs after 630 seconds, the pressurizer pressure increases more rapidly due to RCP coast down. When both steam generators dry out at 1245 seconds, primary to secondary heat transfer stops. This causes the primary side to heat up and volumetric expansion to accelerate.

The RCS pressurization stops when the pressurizer pressure reaches the PSV opening setpoint of 2500 psia. In fact, the PSVs have enough capacity to discharge steam out of the pressurizer to accommodate the increased volumetric expansion caused by the RCS heatup so that the RCS pressure is maintained by the PSVs. Since the setpoints of the PSV and the Sebim valve for the two SDS designs are different, as shown in Table IV-1, the valve opening times and system behaviors are slightly different after this point of time. The PSV lifts after 1275 seconds in the transient for design option 1 (Fig. IV-1), while the Sebim valve lifts after 1270 seconds (Fig. IV-9), where it cycles open and close following the characteristics of Fig. III-1. As shown in Fig. IV-9, the first stage Sebim valve has almost enough capacity to accommodate the increased volumetric expansion during the entire transient. However, the second stage Sebim valve opens briefly after 3300 seconds for 100 seconds. The PSV flow rates and steam generator secondary pressure for design option 1 are shown in Fig. IV-2, Fig. IV-3, respectively.

Pressurizer goes solid after about 2000 seconds, as shown in Fig. IV-4 and Fig. IV-10, for both designs, and the discharge flow becomes a single phase liquid. After the hot leg reaches saturation condition, steam generated in the core due to decay heat flows from the core to pressurizer via the hot leg and surge line. Thereafter, two phase flow discharges through the PSVs.

After the primary coolant reaches saturation, the core decay heat produces steam (versus heating subcooled liquid prior to saturation). The core mixture levels shown in Fig. IV-5 and Fig. IV-12 begin to drop as the liquid is boiled off by decay heat. Continued depletion of RCS inventory results in the beginning of core uncovery at 4975 and 4894 seconds into the transient for design option 1 and 2, respectively.

Since the duration between the PSV's lift and core uncovery is the maximum theoretical allowable time for the operator to open the bleed paths to prevent core uncovery, the second performance requirement (section III.B) suggested by EPRI seems to be not proper for the KNGR. Therefore, the second performance criterion should be adjusted. It is worth noting that the steam generator inventory dryout of the KNGR occurs earlier than the UCN 3&4 (1370 seconds) [12] because the ratio of steam generator secondary water mass to unit power of the KNGR is lower than that of the UCN 3&4.

2. TLOFW with Recovery (Design Option 1)

The feed and bleed operation is utilized in an attempt to cool the core and make up the RCS inventory. Analyzed in this study are the feed and bleed cases by varying the bleed area and the HPSI pump operating, where the operator action times required to prevent core uncovery with a 2 feet margin are investigated. The major plant parameters are displayed in Fig. IV-1 through Fig. IV-6.

The analysis of the TLOFW event with one SDS train opened at the time of PSVs lift in conjunction with two HPSI pump shows that the pressure rapidly falls following the opening of a bleed path. This initiates HPSI inflow to the RCS and reseats the PSVs. The pressure then rises when the bleed valve discharge changes from steam to low quality two-phase. The transient bleed flow rates are shown in Fig. IV-6. Eventually, the bleed valve discharge becomes high quality two-phase and the RCS depressurization resumes. The continued decrease in RCS pressure results in increased HPSI flow which causes the RCS inventory to rise. The transient behavior of the mixture level inside the core support barrel for this case is given in Fig. IV-5.

The analysis of the TLOFW event with the two SDS trains opened 40 minutes after the time of RSVs lift in conjunction with four HPSI pumps shows that the pressure rises to the PSVs setpoint (2500 psia) and remains at that value until the bleed valves are opened at 3675 seconds. The pressure then drops continuously and somewhat faster than it does for the case with one SDS train. The higher pressure drop results in a further increase in HPSI flow rate. Thus, four HPSI pumps would provide somewhat more safety injection flow rate than does two HPSI pumps.

Fig. IV-7 shows the analysis results in which minimum analytical areas to prevent core uncovery are represented as a function of operator action time. As shown in Fig. IV-7, the feed and bleed is a trade-off between allowable time before operator action and the bleed capacity of the system. Based on the figure, a bleed capacity equivalent to an analytical area of 0.028 ft^2 is determined to be the minimum capacity needed to meet the first EPRI performance criterion if the operator initiates the feed and bleed operation correctly at the time of the PSV's lift.

However, the second EPRI performance criterion for a 60 minute time delay after the PSVs lift for initiation of the feed and bleed can not be satisfied for the KNGR, because after 4875 seconds, equivalent to 60 minutes delay after PSV's lift, the core level is already lowered below two feet from the top of the core, as shown in Fig. IV-5. Therefore, it is necessary to adjust the 60 minutes delay in the second performance criterion as was done in UCN 3&4 [12]. The analysis results indicate that the analytical area required to meet the second performance criterion with a 40 minutes delay is smaller than twice the analytical area needed to meet the first criterion. Since the 40 minutes delay is bigger than the 30 minutes of UCN 3&4, we determined the minimum required bleed capacity from the first performance criterion.

Additionally, the fuel heatup calculations for the hot pin are performed to evaluate the impact of core voiding on the peak cladding temperature (PCT). The heatup analysis quantifies the design margin of asking how long the beginning of the feed and bleed could be delayed in view of USNRC 10 CFR 50.46 Appendix K rule. The PARCH/REM computer code [10] is employed for the analyses. The heatup calculations are performed for the cases with a 0.028 ft^2 bleed path area and two HPSI pumps operating by varying the operator action time. As shown in Fig. IV-8, The PCTs are found not to exceed the fuel damage criterion of 2200 °F, even though the feed and bleed initiation is delayed up to 60 minutes after the PSV's lift. This demonstrates a sufficient margin provided by the first performance criterion.

3. TLOFW with Recovery (Design Option 2)

For design option 2, the operator action times for initiating the feed and bleed are investigated by varying the number of Sebim valves and high pressure safety injection (HPSI) pump. The various feed and bleed cases are analyzed according to the combinations of Sebim valves and HPSI pumps as described before in this section. Fig. IV-13 shows the summary of the analysis results where operator action times required to prevent core uncovery are presented for the various feed and bleed cases.

The system parameters for the various TLOFW cases using design option 2 are presented in Fig. IV-9 through Fig. IV-12. Especially, described herein is the feed and bleed case in which two Sebim valves opening with four HPSI pumps operating when the hot leg reaches saturation condition after about 2700 seconds. This feed and bleed procedure is the French practice discussed in section III.B. The transients of the system are identical to the TLOFW without recovery case until the safety valves (Sebim valves) lift. Soon after the bleed path is opened, the RCS pressure decreases rapidly, as shown in Fig. IV-9, and hence HPSI injection flow is initiated after 2746 seconds. Fig. IV-10 and Fig. IV-11 show the pressurizer level and bleed flow rates through two Sebim valves, respectively. The core mixture level increases again, as shown in Fig. IV-12, when the injected HPSI flow rate becomes higher than the bleed flow rate. Eventually, the continued decrease in RCS pressure results in increased HPSI flow, which causes the RCS inventory to rise. The CEFLASH-4AS/REM prediction in this case shows that the core mixture level is always maintained above the top of the core.

The analysis results show that the French feed and bleed practice is also applicable to the KNGR with three Sebim valves for the SDS. For the initiation of the feed and bleed, monitoring both hot leg saturation and steam generator inventory would be more reliable than relying on the opening of the PSV to minimize the probability of inadvertent opening of the bleed valves. This analysis indicates that the SDS design option 2 has enough capacity to extend the operator's action time to the time of hot leg saturation to initiate feed and bleed.

Let's examine the results of the analysis in terms of their conformance to EPRI requirements (section III.B). Fig. IV-13 shows that the case of the one Sebim valve opening with two HPSI pumps after 1290 seconds does not result in core uncovery, despite the slightly less bleeding capacity of the

Sebim valve compared to that of design option 1. This is because the Sebim valve opens quicker than the gate and glove valves used in design option 1. For the second EPRI criterion, it is shown that the operator delay time after the Sebim valve lift for the feed and bleed initiation can be extended to 45 minutes.

V. CONCLUSION

To investigate the feasibility of the two design approaches to be used in SDS design of the KNGR, the TLOFW events are simulated by the CEFLASH-4AS/REM computer code. The TLOFW events without operator recovery and TLOFW events with feed and bleed are analyzed. The use of bleed valves similar to those of ABB-CE's System 80+ is design option 1, while in design option 2, the French Sebim POSRV is considered to provide the combined function of overpressure protection and rapid depressurization.

For design option 1, the minimum analytical bleed area needed to prevent core uncovery is determined to be 0.028 ft^2 per bleed path, per EPRI performance requirements for the SDS. The analysis results demonstrate that the TLOFW event can be mitigated in a proper manner with a sufficient margin.

For design option 2, three Monobloc Sebim POSRVs are adopted for the bleed valves. The operator action times required to prevent core uncovery are investigated by varying the number of bleed valve openings in conjunction with available HPSI pumps. It is found that if operators open two of the three Sebim valves in conjunction with four HPSI pumps before hot leg temperature reaches saturation condition, the decay heat removal and core inventory make-up function can be successfully accomplished by the feed and bleed operation.

The results of the present investigation demonstrate the feasibility of the two design options considered in the design of KNGR SDS. However, since the Sebim valves have required functions of both overpressure protection and emergency bleed, the number of Sebim POSRVs required should be confirmed from the design basis overpressure transient analysis.

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Table III-1. Major KNGR Plant Parameters

Parameter	Design Value
Core power (MWt)	3914
RCS pressure (psia)	2250
RCS flowrate (lbm/sec)	$165.8*10^6$
Cold leg temperature (°F)	555.8
Hot leg temperature (°F)	615
steam generator pressure (psia)	1000
RCS Inventory (lbm)	624930
Primary side volume (ft^3)	15450
Pressurizer volume, liquid/total (ft^3)	1200/2400
Low steam generator level Rx trip setpoint (% WR)	40.7
SIAS setpoint (psia)	1825
HPSI pump shutoff head (psia)	1834.7
Number of PSV	4
PSV opening setpoint (psia)	2500
PSV capacity per valve (lbm/hr)	577500
(For Design Option 2)	
Number of Sebim valves	3
Sebim opening/blowdown setpoint (psia)	
first stage valve	2489.5/2406.5
second stage valve	2519.5/2436.5
third stage valve	2549.5/2466.5
Sebim valve area (ft^2)	0.024319

Table IV-1. Chronology of the TLOFW Event (Option 1)

	w/o Recovery	Feed and Bleed	
Bleed Area (ft^2)	0	0.028	0.056
Number HPSI pump	0	2	4
Event		Time (seconds)	
Total loss of feedwater	0	0	0
Reactor trip	30	30	30
RCP trip, manual	630	630	630
Steam generator dryout	1245	1245	1245
Safety valve open	1275	1275	1275
SDS bleed path(s) opens	N/A	1275	3675
HPSI flow on	N/A	1417	4360
Hot leg saturation	2811	1425	2811
Core uncovery begins	4975	N/A	N/A
or			
Minimum RV inventory, Mg		293520	186950
occurred at, sec		5385	4538

Table IV-2. Chronology of the TLOFW Event (Option 2)

	w/o Recovery	Feed and Bleed			
Bleed Area		1 Sebim	2 Sebims	2 Sebims	3 Sebims
Number HPSI pump	0	2	2	4	4
Event		Time (seconds)			
Total loss of feedwater	0	0	0	0	0
Reactor trip	30	30	30	30	30
RCP trip, manual	630	630	630	630	630
Steam generator dryou	1245	1245	1245	1245	1245
Safety valve open	1270	1270	1270	1270	1270
SDS bleed path(s) opens	N/A	1290	2200	2700	4200
HPSI flow on	N/A	1378	3382	2746	4543
Hot leg saturation	2704	1400	2210	2700	2704
Core uncovery begins	4894	N/A	N/A	N/A	N/A
or					
Minimum RV inventory, Mg		144100	120600	101400	107200
occurred at, sec		4200	3720	2835	4600

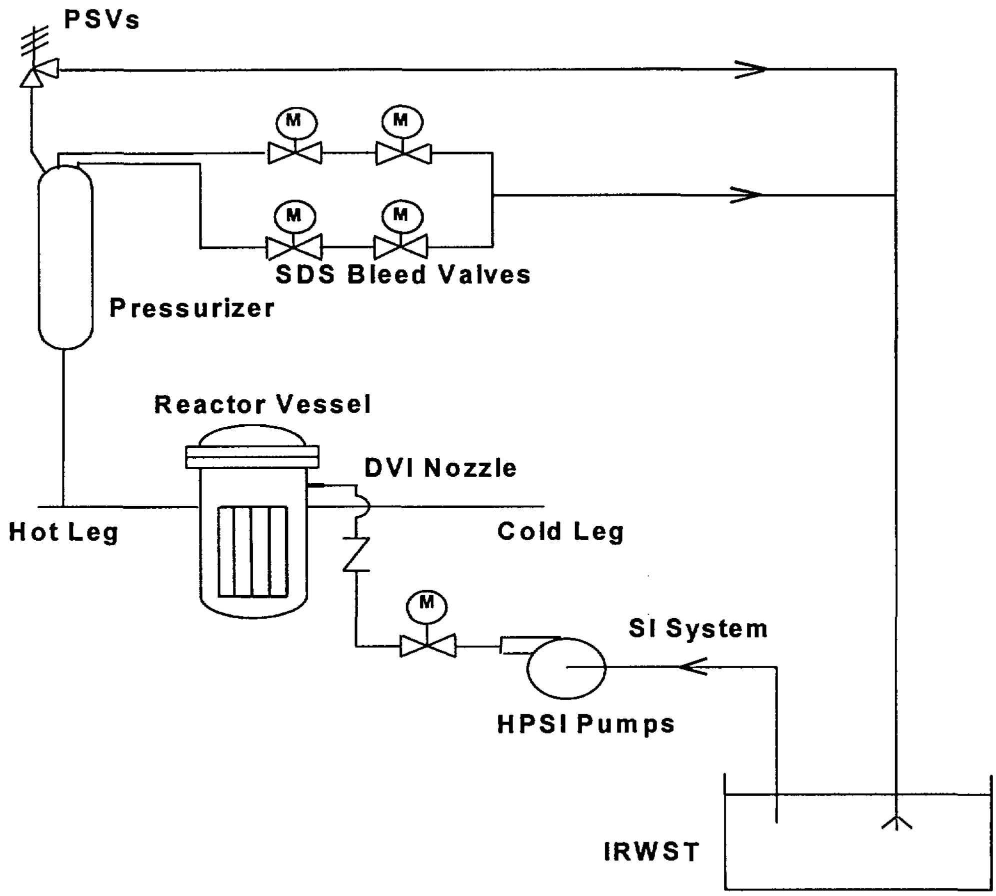


Fig. II-1. Schematic Diagram of KNGR SDS (Option 1)

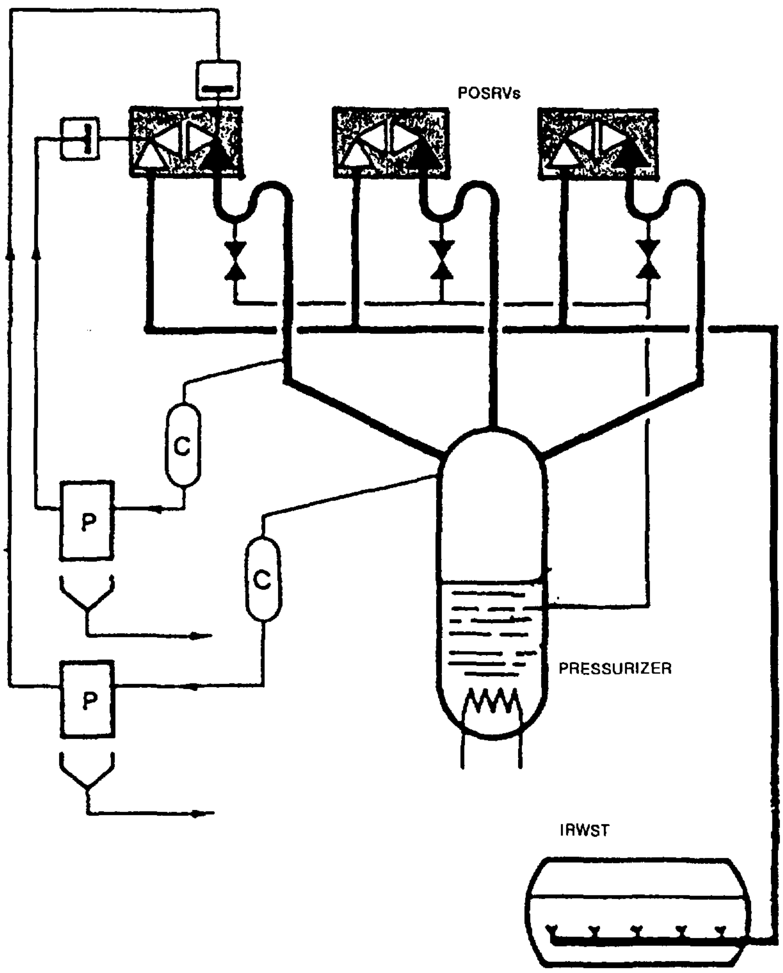


Fig. II-2. Schematic Diagram of KNGR SDS (Option 2)

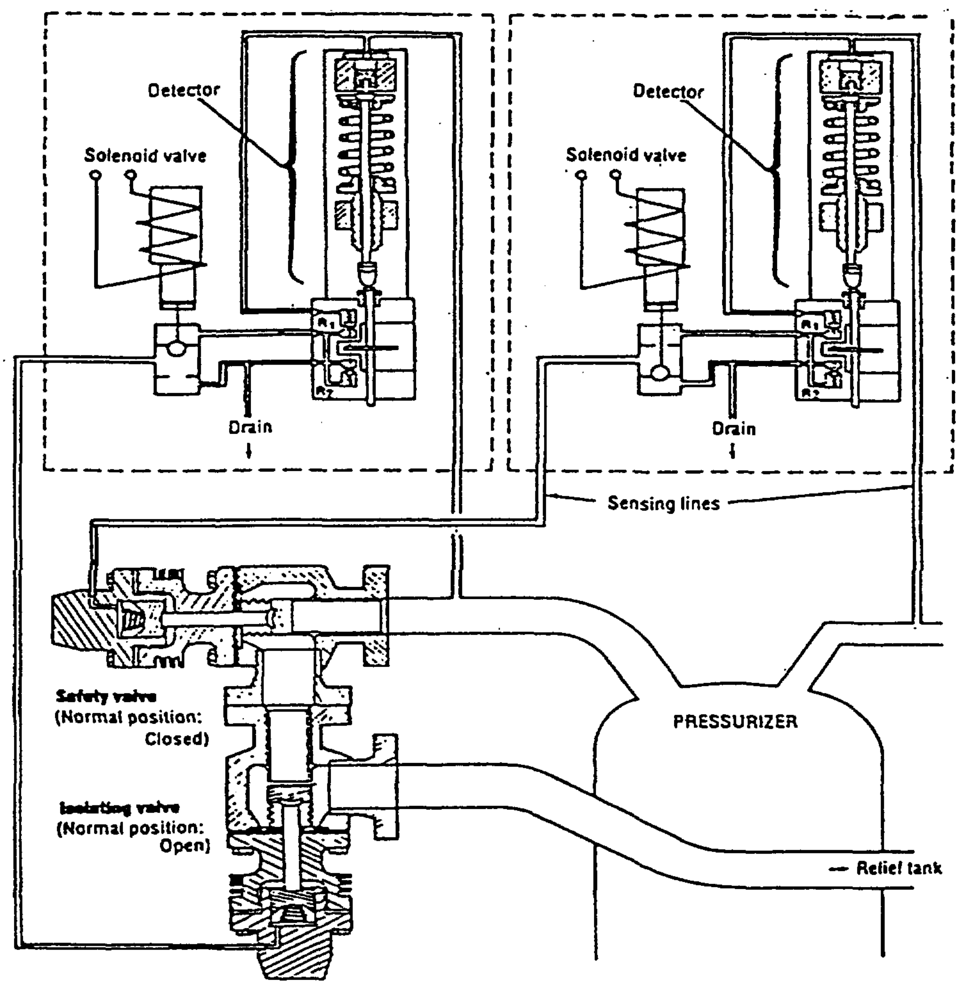


Fig. II-3. Installation of tandem of safety and associated pilot cabinets

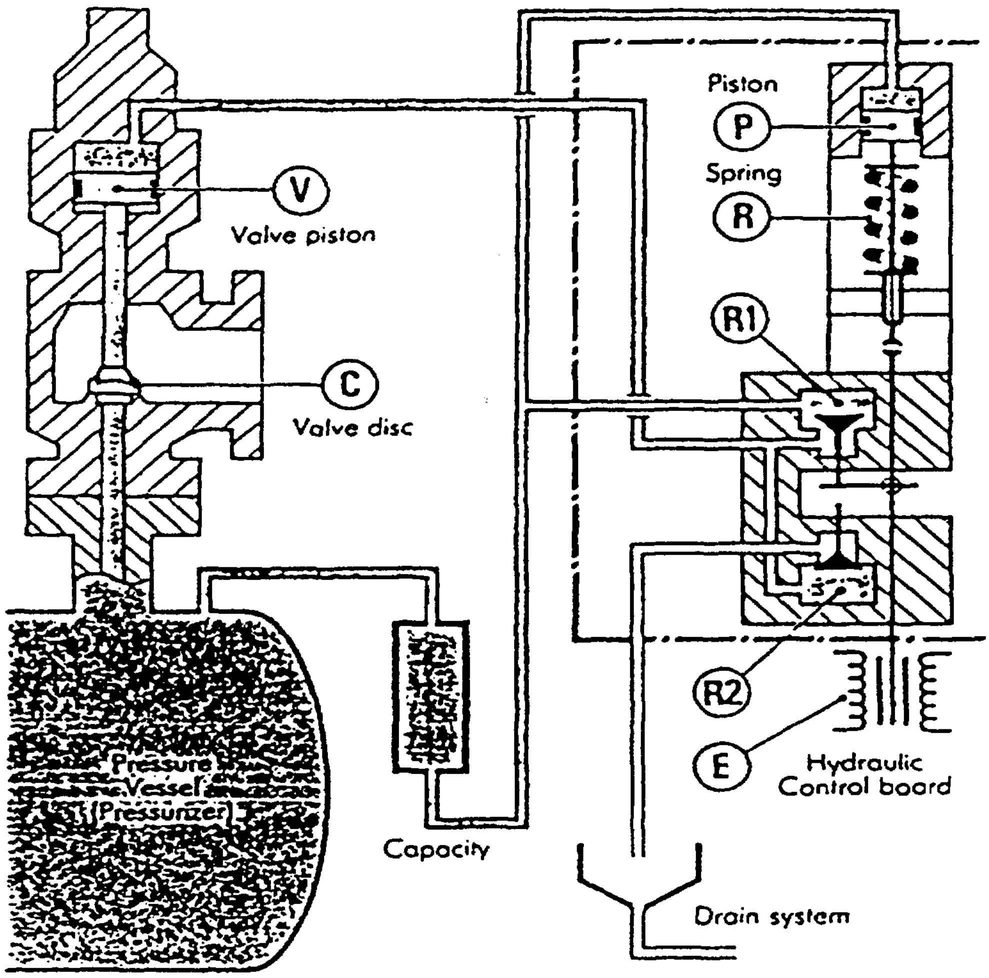
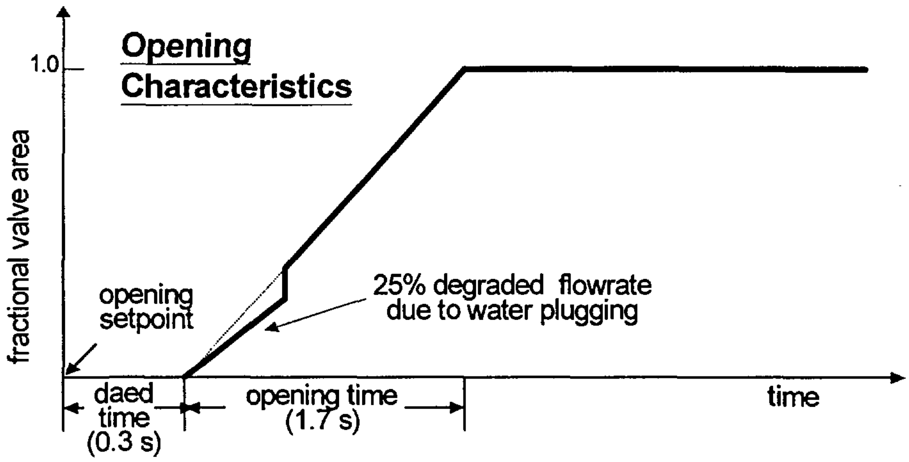


Fig. II-4. Sebim valve pilot cabinet operation



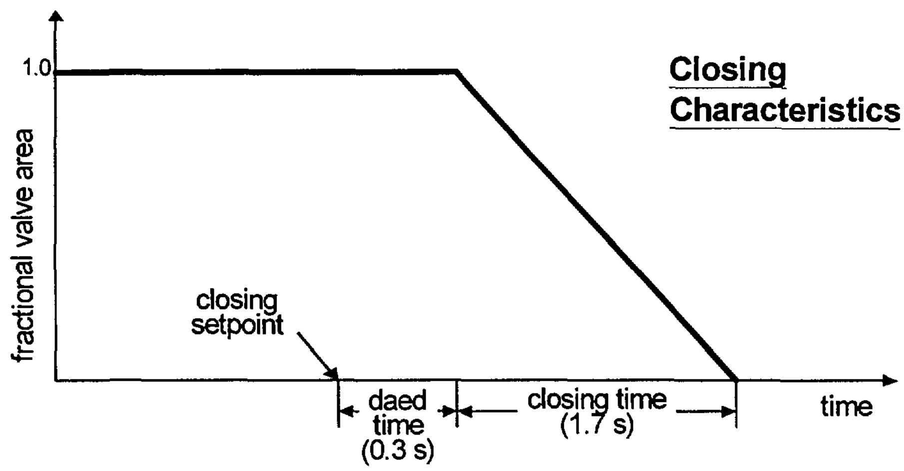


Fig. III-1. Characteristics of Sebim Valve (Option 2)

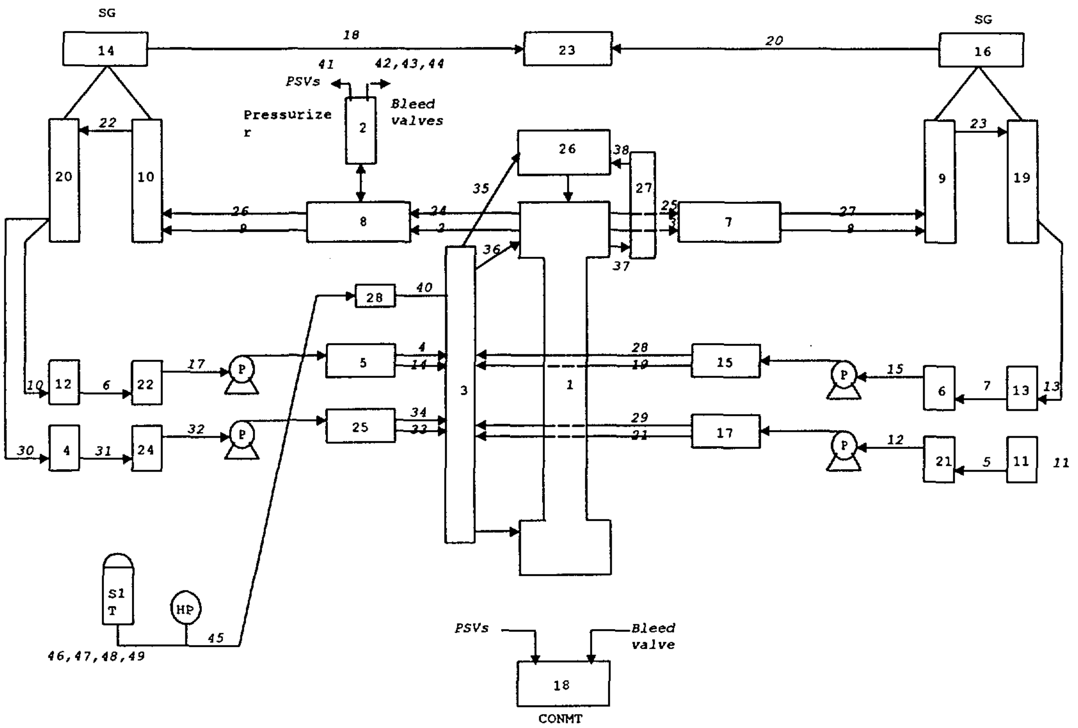


Fig. III-2. CEFLASH-4AS/REM Nodalization Scheme for TLOFW Analysis

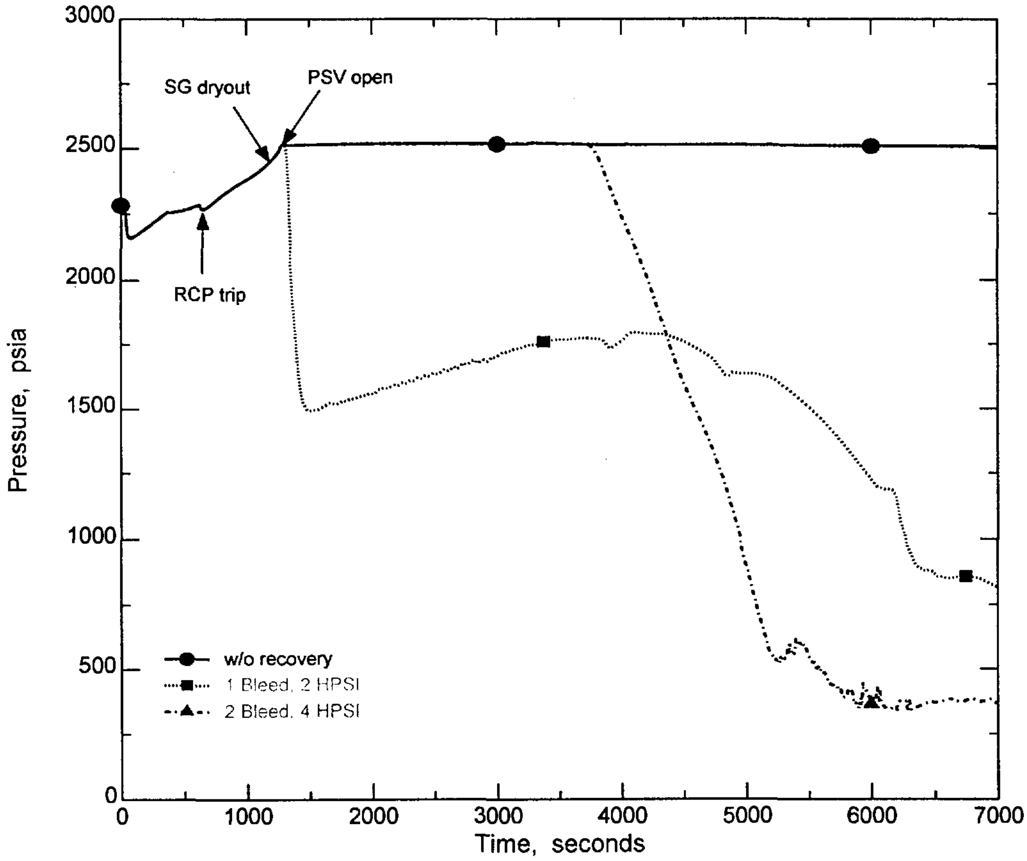


Fig. IV-1. RCS Pressure (Option 1)

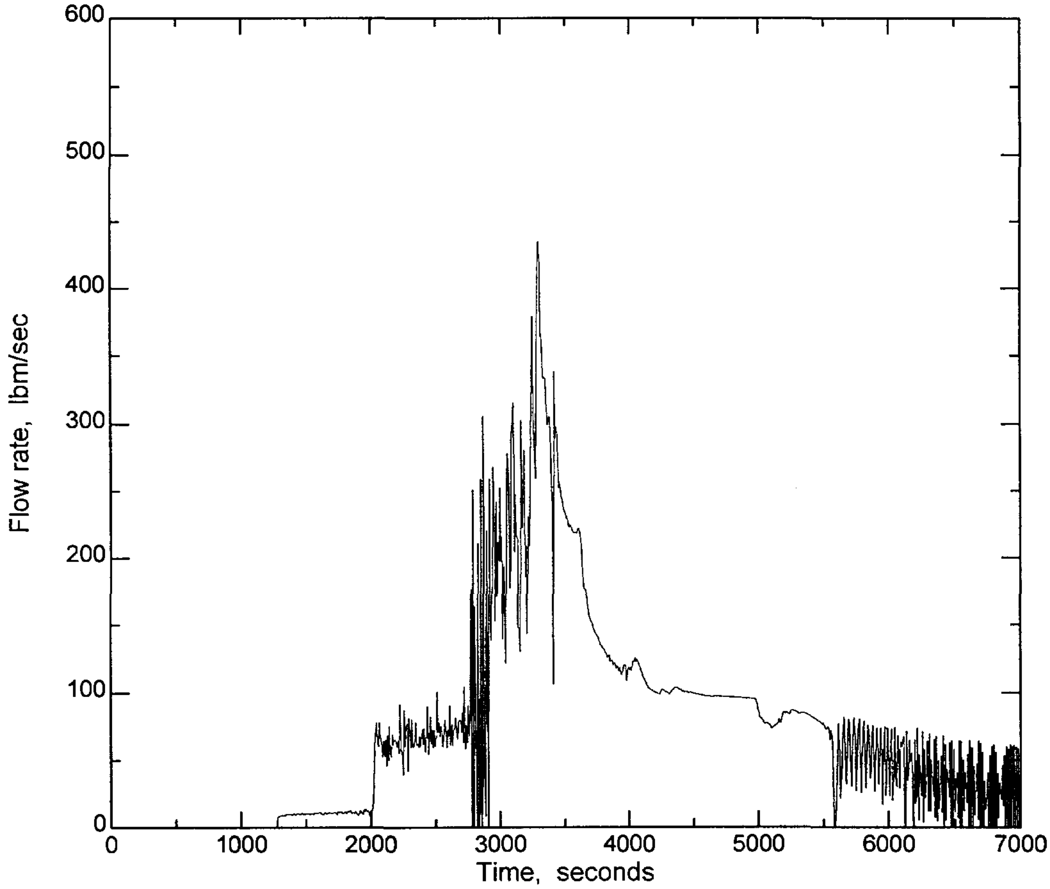


Fig. IV-2. PSV Flow Rates (Option 1)

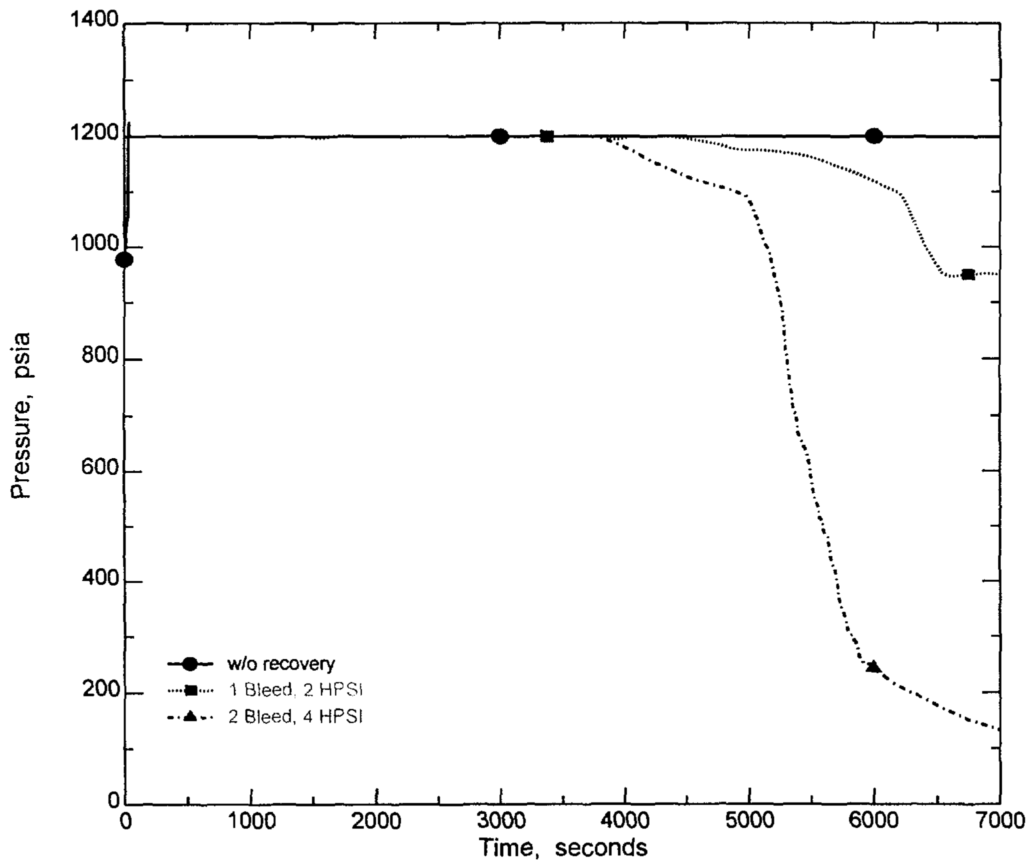


Fig. IV-3. Steam Generator Pressure (Option 1)

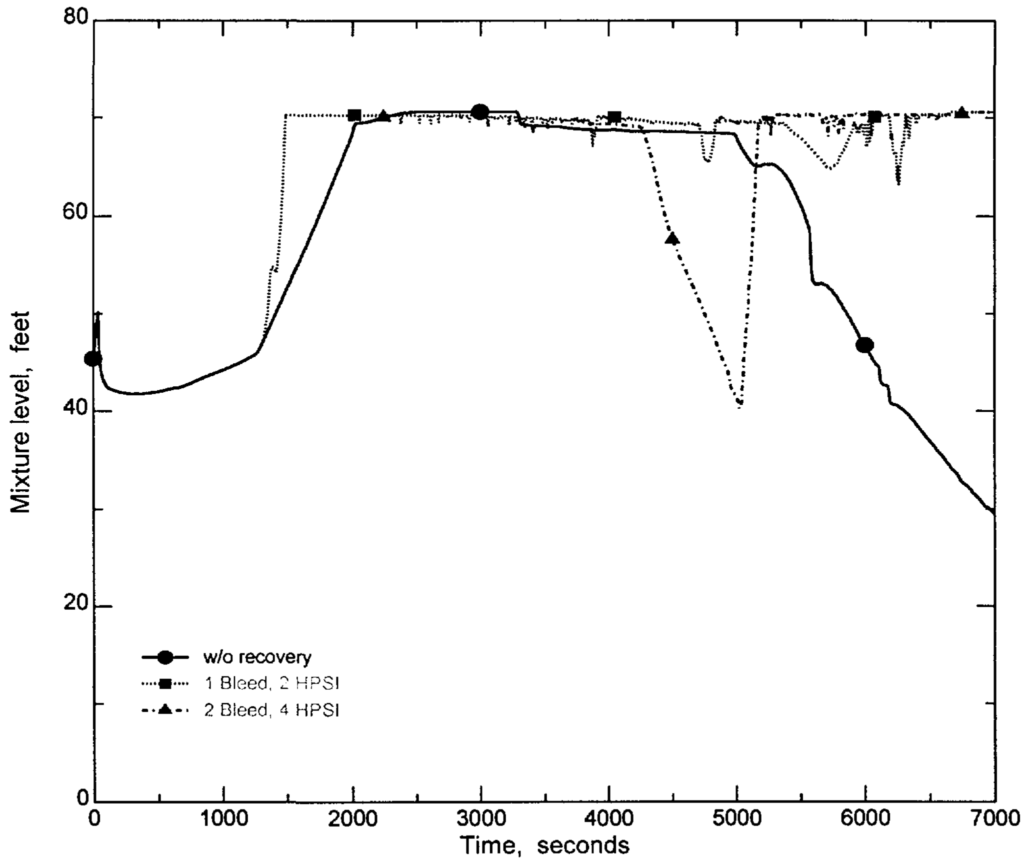


Fig. IV-4. Pressurizer Level (Option 1)

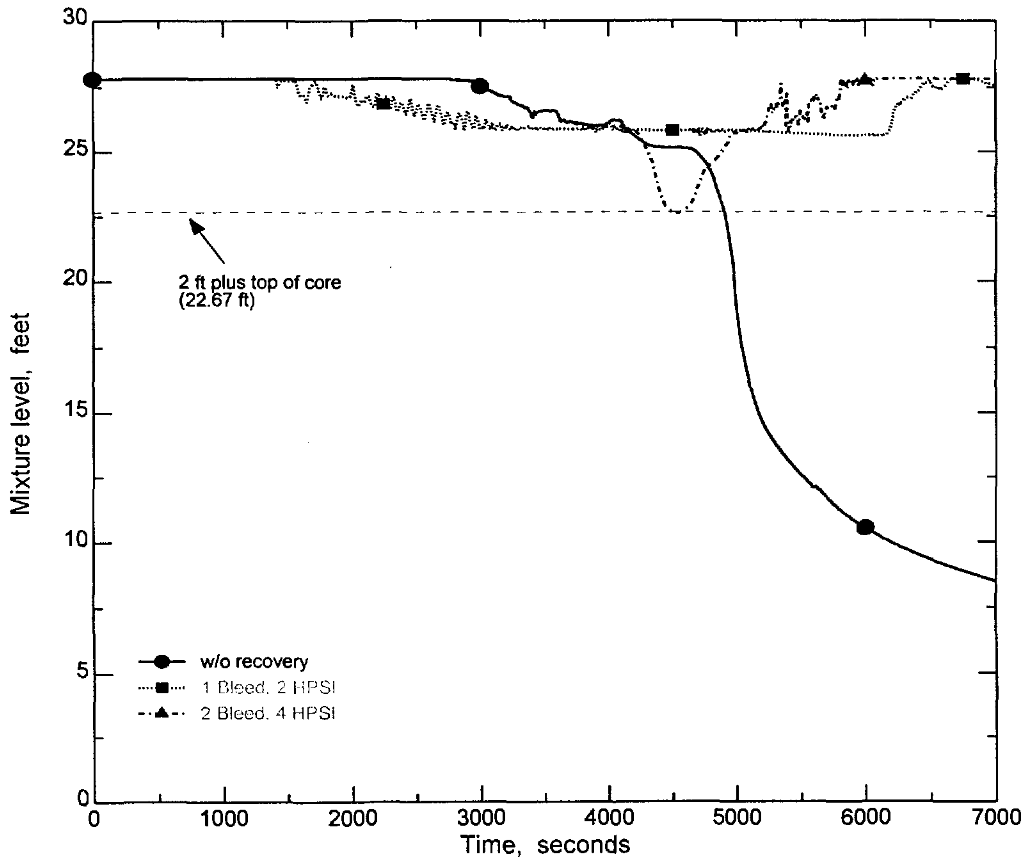


Fig. IV-5. Core Level (Option 1)

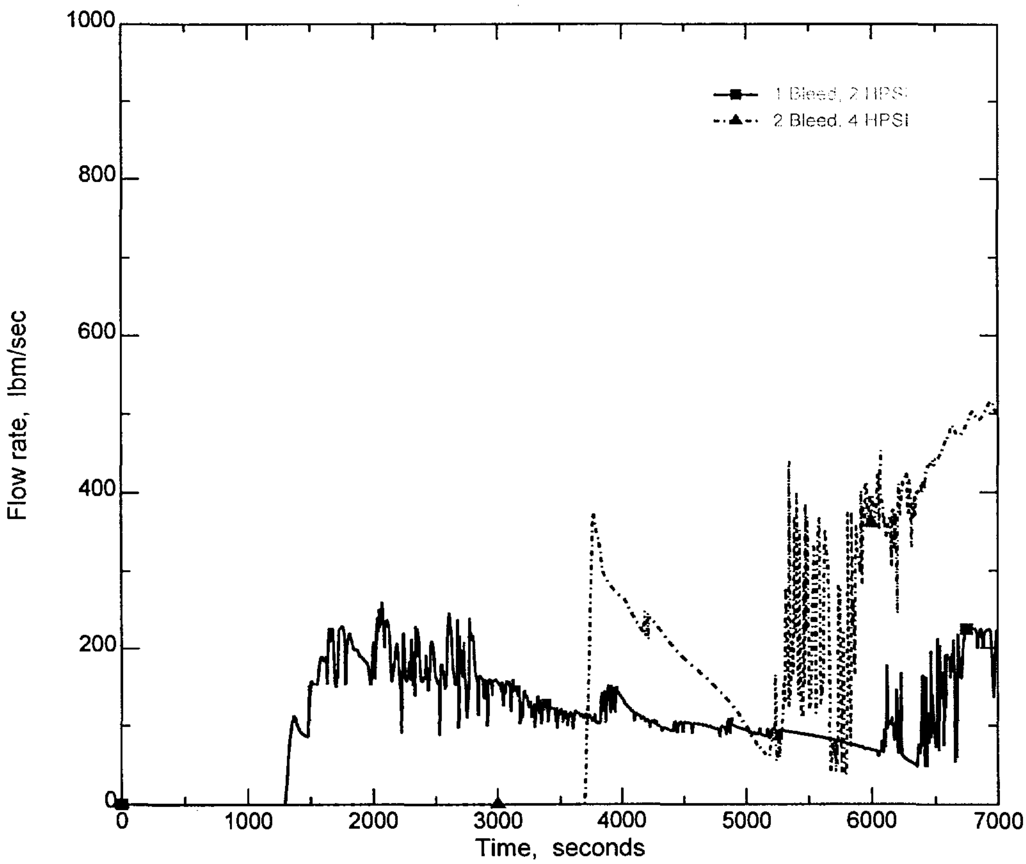


Fig. IV-6. Bleed Flow Rates (Option 1)

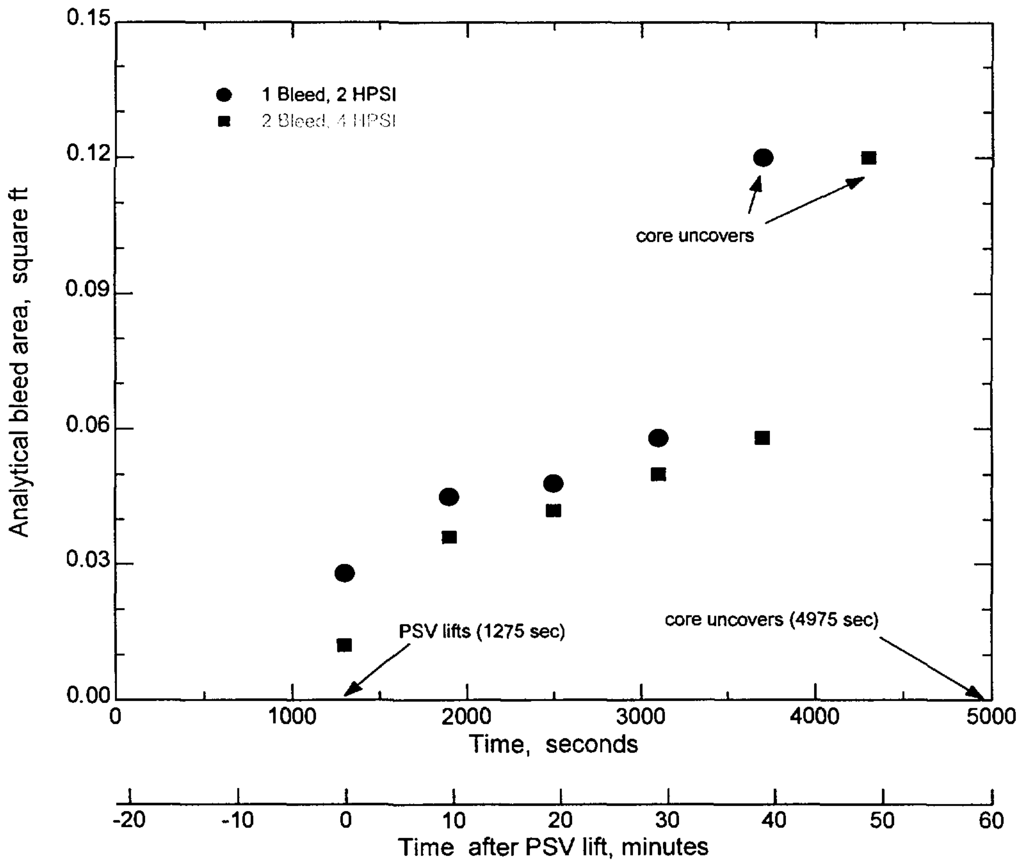


Fig. IV-7. Analytical Bleed Area Required to Prevent Core Uncovery for Various Operator Action Time (Option 1)

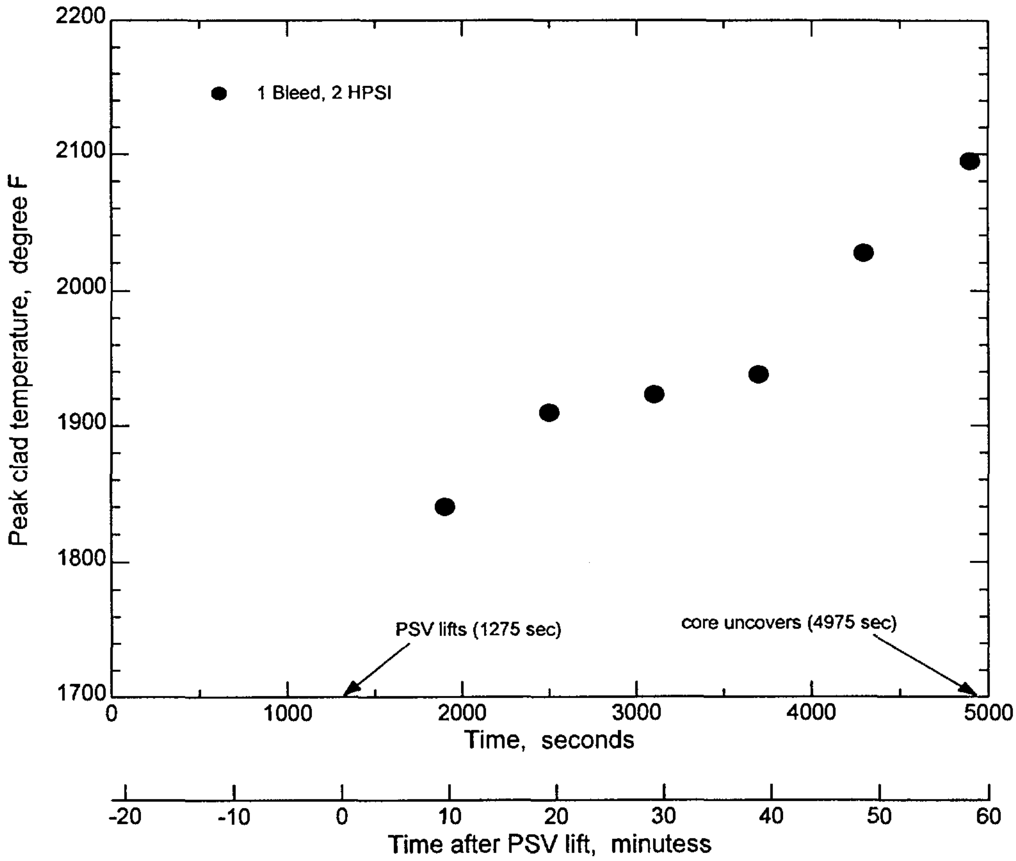


Fig. IV-8. Peak Cladding Temperature (Option 1)

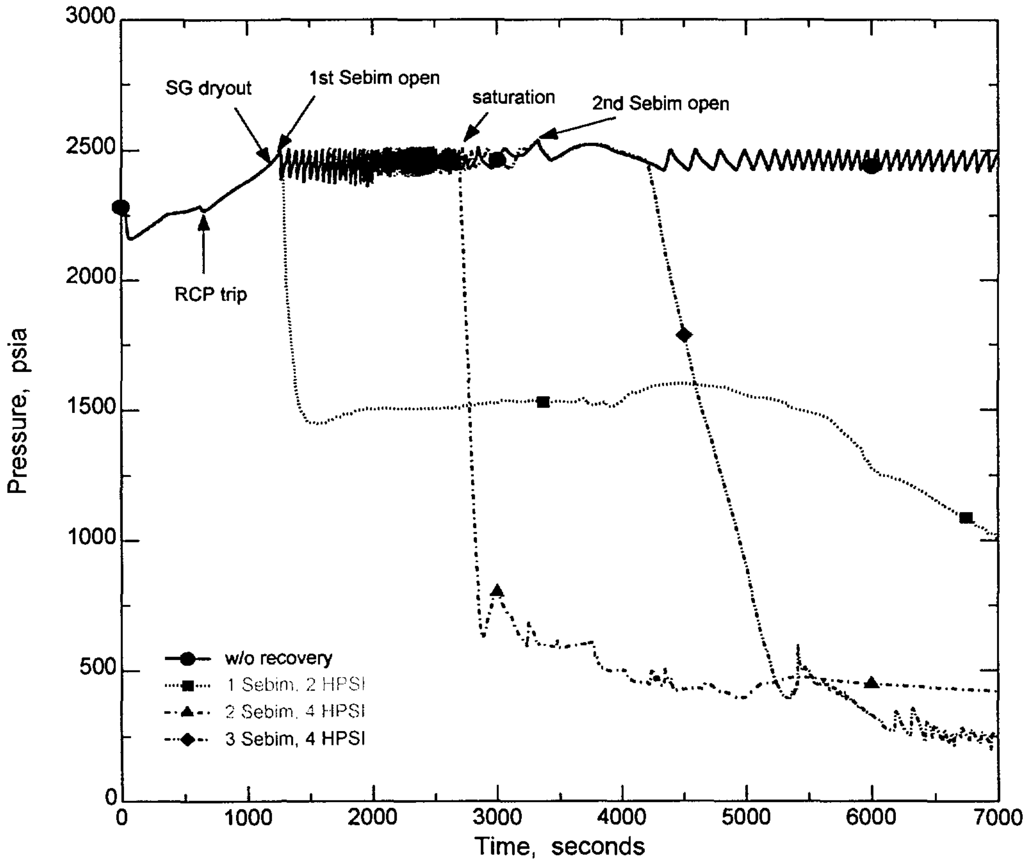


Fig. IV-9. RCS Pressure (Option 2)

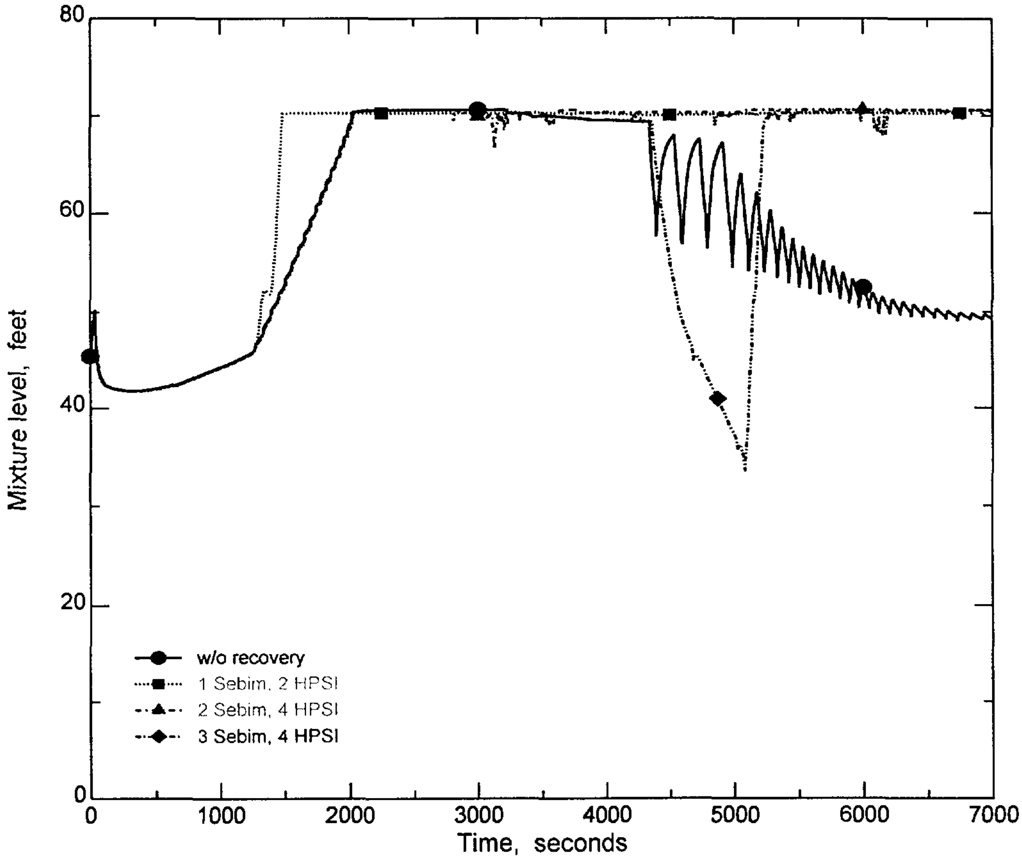


Fig. IV-10. Pressurizer Level (Option 2)

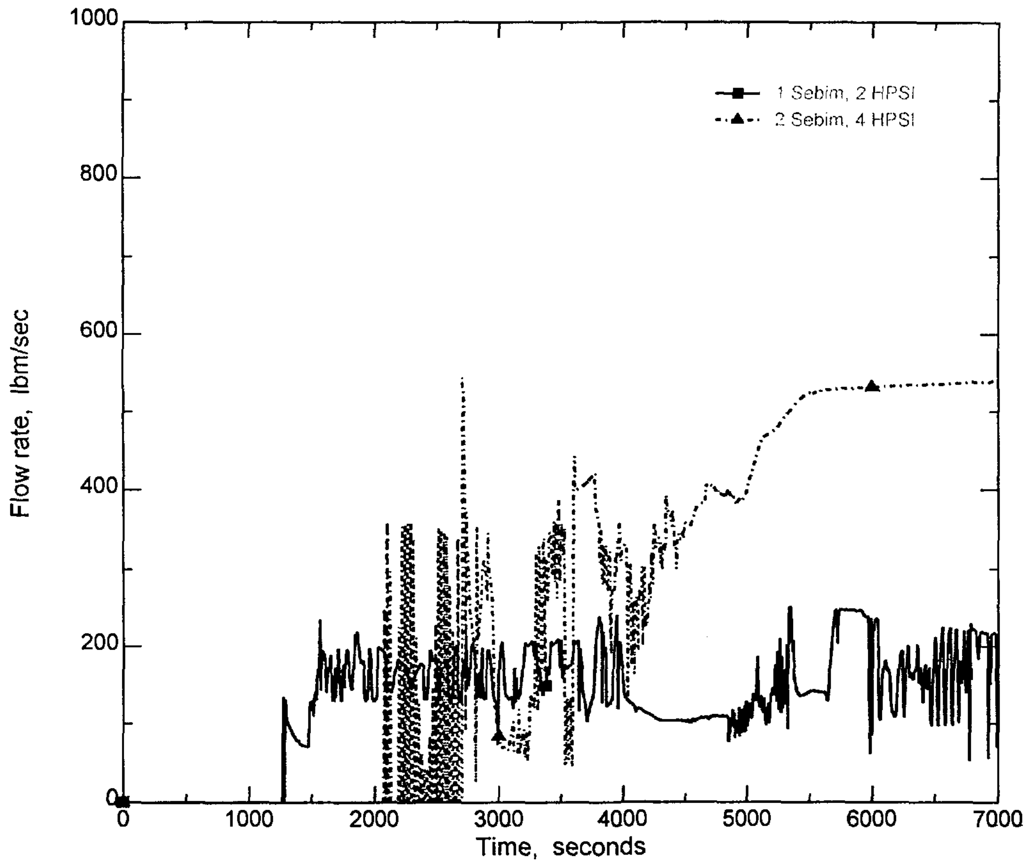


Fig. IV-11. Bleed Flow Rates (Option 2)

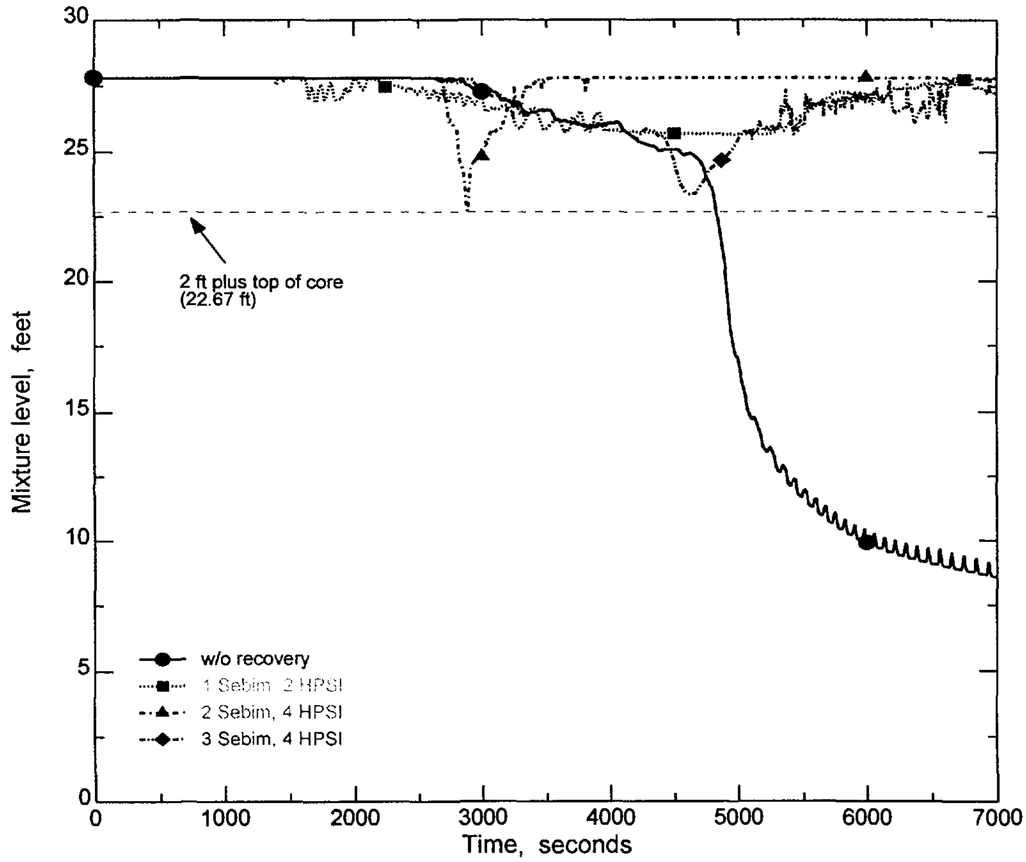


Fig. IV-12. Core Level (Option 2)

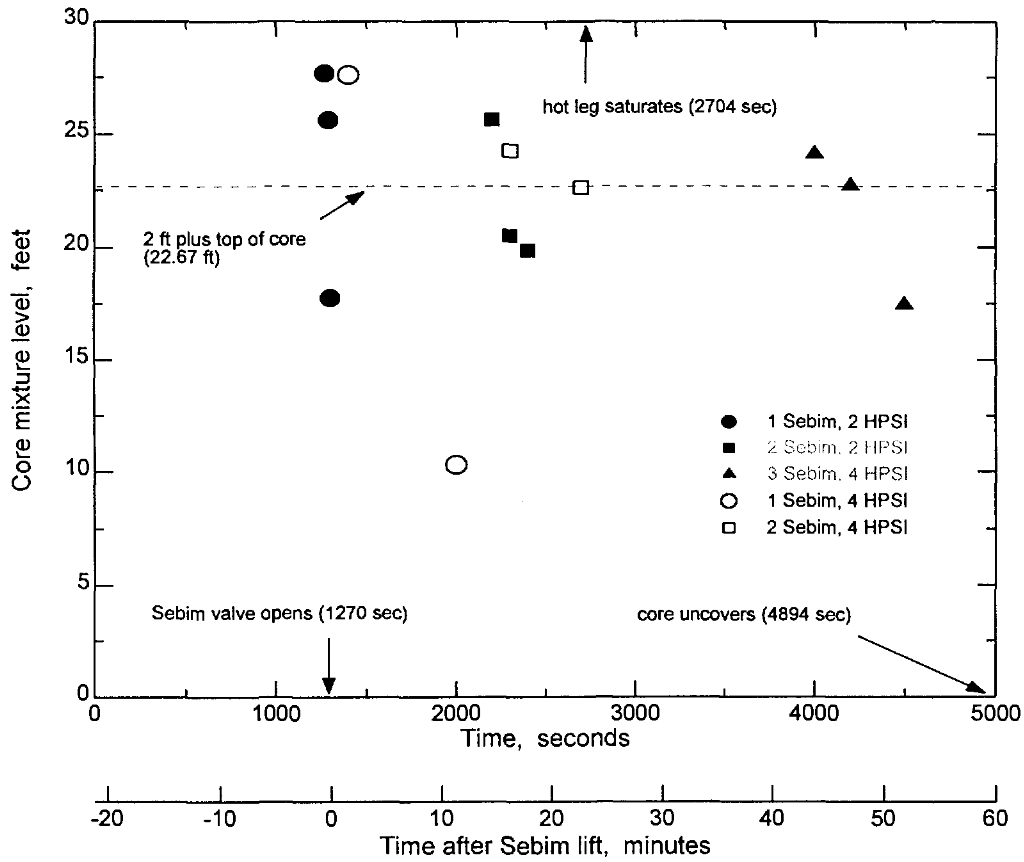


Fig. IV-13. Operator's Action Delay Time to Prevent Core Uncovery (Option 2)

Appendix

Table A-1. Modofication of Subroutine LEAKST.F for SEBIM-Model

```
      SUBROUTINE LEAKST                                                   LEAKST    2
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                                 apollo
C                                                                         LEAKT     3
C PRELIMINARY CALCULATIONS FOR TYPE 7 LEAK FLOW PATHS BEFORE CALLING     LEAKT     4
C LEAK  THEN CALLS LEAK                                                   LEAKT     5
C                                                                         LEAKT     6
      INCLUDE 'COMDB.i'                                                   APOLL     3
C                                                                         LEAKS     8
      INCLUDE 'COMDD.i'                                                   APOLLO    5
C                                                                         LEAKST   10
      INCLUDE 'COMDBK.i'                                                  APOLLO    8
C                                                                         RE88030  130
c     REAL  CCRIT(4)                                                      RE88030  131
      DIMENSION  CCRIT(4)                                                 RE88030a 131
      DIMENSION  OTIMESB(3),FTIMESB(3),CTIMESB(3),ASVPSB(3)               SEBIM
      DIMENSION  KOINGSB(3),KODTTSB(3),KCINGSB(3),KCDTTSB(3)              SEBIM
      DIMENSION  PSETSB(3),PBLDSB(3),KPLUGSB(3)                           SEBIM
      CHARACTER*6 LSR                                                     apollo
      SAVE                                                                SEBIM
c     DATA LSR/6HLEAKST/                                                  RE81223   14
      DATA LSR/'LEAKST'/                                                  RE81223a  14
C                                                                         LEAKST   12
C                                                                         LEAKST   13
      J = JCHECK                                                          LEAKST   14
      JSB = J-41                                                          SEBIM
      KSU = NUP(J)                                                        AF81232    1
      KSD = NDOWN(J)                                                      AF81232    2
      JJ = NWJ(J)                                                         AF82327  208
      JT = ILEAKA(JJ)                                                     AF82327  209
      IF (JT .GE. 1) GO TO 32                                             AF82327  210
C                                                                         RE81223   16
C CONSTANT LEAK AREA                                                      RE81223   17
C                                                                         RE81223   18
      AR9(J) = 0.0                                                        AF82320  191
      IF (TAU .LT. TRUP) RETURN                                           LEAKST   15
      IF (FTR .GE. 1.0) GO TO 10                                          LEAKST   16
      IF (TPN .GT. 0.0) GO TO 20                                          LEAKST   17
   10 CONTINUE                                                            LEAKST   18
      FTR = 1.0                                                           LEAKST   19
      GO TO 30                                                            LEAKST   20
   20 CONTINUE                                                            LEAKST   21
      FTR = (TAU - TRUP) / TPN                                            LEAKST   22
c     FTR = AMIN1(FTR, 1.0)                                               LEAKST   23
c     FTR = AMAX1(FTR, 0.0)                                               LEAKST   24
      FTR =  MIN (FTR, 1.0)                                               LEAKSTa  23
      FTR =  MAX (FTR, 0.0)                                               LEAKSTa  24
```

```
   30 CONTINUE                                                          LEAKST  25
      TAR = FTR * TA(J)                                                 LEAKST  28
      IF (TAU .GT. SHUTLK(J)) TAR = 0.0                                 LEAKST  29
      GO TO 33                                                          RE81223 19
   32 CONTINUE                                                          RE81223 20

CCC  ---- SEBIM VALVE MODEL BY YOUNGMIN KWON AT 9/13/1996  ----         SEBIM

c    opening and closing setpoin; SEBIM path number should be 42,43,44  SEBIM
c    SHUTLK(J)=Time for locked open of SEBIM valves                     SEBIM
c                                                                       SEBIM
       ISB=1                                                            SEBIM
       PSETSB(ISB)=2489.5                                               SEBIM
       PSETSB(ISB+1)=2519.5                                             SEBIM
       PSETSB(ISB+2)=2549.5                                             SEBIM

       PBLDSB(ISB)=2406.5                                               SEBIM
       PBLDSB(ISB+1)=2436.5                                             SEBIM
       PBLDSB(ISB+2)=2466.5                                             SEBIM

c    characteristic value of SEBIM valve                                SEBIM
       TAR=0.0                                                          SEBIM
       DTOSB=0.3                                                        SEBIM
       PDTOSB=0.25                                                      SEBIM
       OTSB=1.7                                                         SEBIM
       DTCSB=0.3                                                        SEBIM
       CTSB=1.7                                                         SEBIM

       IF(TAU .GT. SHUTLK(J)) GO TO 81                                  SEBIM
       IF(P(KSU) .LT. PSETSB(JSB)) GO TO 87                             SEBIM
 81      IF(KOINGSB(JSB) .EQ. 1) GO TO 83                               SEBIM

            IF(KODTTSB(JSB) .EQ. 0) THEN                                SEBIM
                OTIMESB(JSB)=TAU+DTOSB                                  SEBIM
                KODTTSB(JSB)=1                                          SEBIM
                FTIMESB(JSB)=OTIMESB(JSB)+PDTOSB                        SEBIM
                GO TO 150                                               SEBIM
            ENDIF                                                       SEBIM

         IF(TAU .LT. OTIMESB(JSB)) GO TO 150                            SEBIM
             KODTTSB(JSB)=0                                             SEBIM
             KOINGSB(JSB)=1                                             SEBIM

 83     ASVPSB(JSB)=ASVPSB(JSB)+DELT/OTSB                               SEBIM
        ASVPSB(JSB)=AMIN1(ASVPSB(JSB),1.0)                              SEBIM

        IF(TAU .GT. FTIMESB(JSB) .OR. KPLUGSB(JSB) .EQ.1) THEN          SEBIM
            KPLUGSB(JSB)=1                                              SEBIM
            GO TO 96                                                    SEBIM
        ENDIF                                                           SEBIM
```

```
      IF(TAU .GT. OTIMESB(JSB)+OTSB) ASVPSB(JSB)=1.0                   SEBIM
      TAR=ASVPSB(JSB)*TA(J)*0.75                                       SEBIM
      GOTO 150


 87   IF(ASVPSB(JSB) .EQ. 0.) GO TO 150                                SEBIM

        IF(P(KSU) .GT. PBLDSB(JSB)) THEN                               SEBIM
              IF(KOINGSB(JSB) .EQ. 1) THEN                             SEBIM
                GO TO 83                                               SEBIM
              ELSE                                                     SEBIM
                GO TO 93                                               SEBIM
              ENDIF                                                    SEBIM
        ENDIF                                                          SEBIM

          IF(KCINGSB(JSB) .EQ. 1) GO TO 93                             SEBIM
            IF(KCDTTSB(JSB) .EQ. 0) THEN                               SEBIM
              CTIMESB(JSB)=TAU+DTCSB                                   SEBIM
              KCDTTSB(JSB)=1                                           SEBIM
              GO TO 96                                                 SEBIM
            ENDIF                                                      SEBIM

      IF(TAU .LT. CTIMESB(JSB)) GO TO 96                               SEBIM
        KCDTTSB(JSB)=0                                                 SEBIM
        KCINGSB(JSB)=1                                                 SEBIM
           KOINGSB(JSB)=0                                              SEBIM

 93   ASVPSB(JSB)=ASVPSB(JSB)-DELT/CTSB                                SEBIM
      ASVPSB(JSB)=AMAX1(0.0,ASVPSB(JSB))                               SEBIM
      IF(TAU .GT. CTIMESB(JSB)+CTSB) ASVPSB(JSB)=0.0                   SEBIM
      IF(ASVPSB(JSB) .EQ. 0.) KCINGSB(JSB)=0                           SEBIM

 96   TAR=ASVPSB(JSB)*TA(J)                                            SEBIM
 150   AR9(J)=TAR                                                      SEBIM
       GO TO 33                                                        SEBIM

CCC -----  END OF MAIN MODEL OF SEBIM VALVE  -----                     SEBIM

C                                                                      RE81223     21
C AREA VERSUS TIME LEAK AREA                                           RE81223     22
C                                                                      RE81223     24
      TAR = POLATE(WFT(1,JT), TAU, NFT(JT), LSR)                       AF82327    211
      AR9(J) = TAR                                                     AF82320    192
   33 CONTINUE                                                         RE81223     25
C                                                                      RE88030    132
C==========================================================            RE88030    133
C     ***DEFINITION OF LEAK PRESSSURE AND ENTHALPY                     RE88030    134
C                                                                      RE88030    135
      TDZ1 = ZM(KSU) - ZOUT(J)                                         RE88030    136
c     TDZ1 = AMAX1(TDZ1, 0.0)                                          RE88030    137
      TDZ1 =  MAX (TDZ1, 0.0)                                          RE88030a   137
```

```
      TDZ1 = TDZ1 * WIN(KSU) / 144.0                                RE88030   138
      TDZ2 = ZIN(J) - ZM(KSD)                                       RE88030   139
c     TDZ2 = AMIN1(TDZ2, 0.0)                                       RE88030   140
      TDZ2 =  MIN (TDZ2, 0.0)                                       RE88030a  140
      TDZ2 = TDZ2 * WIN(KSD) / 144.0                                RE88030   141
      PK2 = P(KSD) - TDZ2                                           RE88030   142
      PLK = P(KSU) + TDZ1                                           RE88030   143
      PLEAK  =  PLK                                                 RE88030   144
C                                                                   RE88030   145
C                                                                   RE86270    32
      HLEAK  =  H(J)                                                RE88030   146
      IF (TX(KSU) .LE. 0.) THEN                                     RE88060   375
        XLIQ  = 0.                                                  RE88060   376
      ELSEIF (TX(KSU) .GE. 1.) THEN                                 RE88060   377
        XLIQ  = 0.                                                  RE88060   378
      ELSE                                                          RE88060   379
        IF (WH(KSU) .GE. HLIQ(KSU)) THEN                            RE88060   380
          XLIQ  = 0.                                                RE88060   381
        ELSE                                                        RE88060   382
          XLIQ  = (WH(KSU)-HLIQ(KSU)) / (HSTM(KSU)-HLIQ(KSU))       RE88060   383
        ENDIF                                                       RE88060   384
      ENDIF                                                         RE88060   385
      IF (X(J) .GT. 0.) THEN                                        RE88030   149
        XLEAK  =  X(J)                                              RE88030   150
      ELSE                                                          RE88030   151
        XLEAK  = (H(J)-HFNODE(KSU)) / (HGNODE(KSU)-HFNODE(KSU))     RE88030   152
c       XLEAK   =  AMIN1(XLEAK, 0.)                                 RE88060   386
        XLEAK   =   MIN (XLEAK, 0.)                                 RE88060a  386
      ENDIF                                                         RE88030   153
C                                                                   RE88030   154
C===========================================================        RE88030   155
C     ***BREAK FLOW MULTIPLIERS                                     RE88030   156
C                                                                   RE88030   157
      CCRIT(1)  =  CC1(J)                                           RE88030   158
      CCRIT(2)  =  CC2(J)                                           RE88030   159
      CCRIT(3)  =  CC3(J)                                           RE88030   160
      CCRIT(4)  =  CC4(J)                                           RE88030   161
C                                                                   RE88030   162
C==========================================================         RE88030   163
C                                                                   RE88030   164
      CALL LEAK (PLEAK, PK2, HLEAK,XLEAK, XLIQ,                     RE88030   165
     .            CCRIT, TAR, W(J), PTHR(J),                        RE88030   166
     A            ESUBK(J), JCHECK, IFCRIT(J))                      AF82226   168
C                                                                   RE88030   167
C==========================================================         RE88030   168
C                                                                   RE88030   169
c   PRINT FOR DEBUGGING                                             SEBIM
      IF(TAU .GT. 4000 .and.  TAU. LT. 5000) WRITE(49,250)          SEBIM
     & TAU,J,DELT,P(KSU),                                           SEBIM
     & ASVPSB(JSB),TAR,KOINGSB(JSB),KODTTSB(JSB),KCINGSB(JSB),      SEBIM
     & KCDTTSB(JSB), W(J)                                           SEBIM
```

```
250   FORMAT(3X,F12.2,I6,4F12.6,4I5,F12.6)                          SEBIM

      RETURN                                                        LEAKST   43
      END                                                           LEAKST   44
```

Table A-2. CEFLASH-4AS input for TLOFW without recovery (Design Option 2)

```
KNGR    TLOFW AND FEED/BLEED TRANSIENTS (BASE CASE) using SEBIM valve
        *
        ** kbase2.inp : PSV open, SG dryout and Core Uncover times
        *
        * NO ECCS FLOW, REACTOR TRIP AT 29.91 SEC
        * W/O CHARGING FLOW
        ************************************************************************
        *  KNGR TLOFW and FEED/BLEED Transients Analyses for determing  *
        *  min. SDS bleed valve capacity (Cal. Sheet :KNGR-SS-CA002,Rev.0)  *
        *                                                                   *
        *  Systems Safety Analysis Dept.                                    *
        *  Prepared by Hong-Sik Lim, December 1995.                         *
        ************************************************************************
        *
        *  TLOFW ANALYSIS USING SEBIM VALVE
        *   September 16, 1996 young min kwon (*8688)
        *   sbase1.inp
        ************************************************************************
        ** RESTART
        101, 1,0
        102, SBASE2,200.0
        103, SBASE2,3,AAAA
        *
        ** GENERAL TIME AND REM OPTION
        *
        1001, 7000.,0.0,0.02,1000000,30000,0,3,2,1,1,1,1
        1021, 30000.0
        1031, 0.0001
        *
        **INNER VESSEL GEOMETRY AND REM OPTION
        *
        1101, 1,12,3,1,1,1,1,1,1,1,3.48,10
        1102, 0,1,1,3,1,1,1,0.0
        1106, 1,1,0.0
        *
        ** EDIT, TIME STEP AND PUNCH INFORMATION
        2001,     30.,    5., 0, 0, 0, 0
        2002,    100.,   10., 0, 0, 0, 0
        2003,    250.,   50., 0, 0, 0, 0
        2004,   1200.,  250., 0, 0, 0, 0
        2005,   2600.,  250., 0, 0, 0, 0
        2006,   4200.,  500., 0, 0, 0, 0
        2007,  10000.,  500., 0, 0, 0, 0
```

```
*
2201, 0.0001, 0.2
2202, 0.0001, 0.2
2203, 0.0001, 0.2
2204, 0.0001, 0.2
2205, 0.00001, 0.1
2206, 0.00001, 0.1
2207, 0.0001, 0.2
*
2401, 0.02, 0.00005, 0.1, 0.1, 0.1, 0.5
2501, 3, 1, 8, 2, 1, 1
*
* Reactor Trip at 29.91 sec & after 10 min RCP Trip
*
** PUMP RUNNING TIME
2601, 1.0, 629.91
*
** NODAL CONTROL VOLUMES
*
*                                            *****    ****
*     AREA    HEIGHT  EXIT    INLET   BOT     PRESS      ENTH    LEV
3001, 87.685 ,27.813 ,24.125 , 3.058 , 0.0    ,2282.514, 634.998, 0.0
3002, 34.961 ,70.58  ,27.715 ,27.715 ,27.615 ,2250.0  ,    0.0  ,36.256
3003, 33.428 ,34.615 , 3.058 ,24.665 , 2.958 ,2317.344, 554.41 , 0.0
3004, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
3005, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
3006,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
3007,192.943 , 3.5   ,25.865 ,24.125 ,24.115 ,2262.77 , 634.998, 0.0
3008,192.943 , 3.5   ,25.865 ,24.125 ,24.115 ,2262.77 , 634.998, 0.0
3009, 24.364 ,35.741 ,57.909 ,34.97  ,34.87  ,2231.124, 580.852, 0.0
3010, 24.364 ,35.741 ,57.909 ,34.97  ,34.87  ,2231.124, 580.852, 0.0
3011, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
3012, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
3013, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
2ry SG 3014,105.302 ,130.368,97.088 ,37.474 ,34.87  , 978.0  ,    0.0  ,40.36
3015, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
2ry SG 3016,105.302 ,130.368,97.088 ,37.474 ,34.87  , 978.0  ,    0.0  ,40.36
3017, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
3018,15000.0 ,200.0  ,98.195 ,98.195 , 0.0   ,   14.7  ,    0.0  , 1.-9
3019, 24.364 ,35.741 ,34.97  ,57.909 ,34.87  ,2215.233, 553.779, 0.0
3020, 24.364 ,35.741 ,34.97  ,57.909 ,34.87  ,2215.233, 553.779, 0.0
3021,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
3022,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
3023,  1.+10 ,1000.0 ,97.088 ,97.088 , 0.0   ,   14.7  ,    0.0  , 1.-9
3024,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
3025, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
3026,111.726 ,17.597 ,28.246 ,28.246 ,28.146 ,2277.454, 602.984, 0.0
3027,  7.8   , 5.75  ,28.046 ,22.496, 22.396 ,2282.81 , 634.998, 0.0
3028,  5.184 , 0.708 ,32.459 ,32.459 ,32.409 ,2315.904, 554.41 , 0.0
*
** HORIZONTAL CYLINDRICAL NODES
```

```
*
3081, 7,1, 8,1, 5,1, 15,1, 17,1, 25,1, 28,1
*
** SECTIONALIZED NODE
*
3100, 1, 12, 2, 11
*
** DETAILED INNER VESSEL GEOMETRY
*
3101,102.28489, 8.17325
3102, 60.8, 1.25
3103, 60.8, 1.25
3104, 60.8, 1.25
3105, 60.8, 1.25, 60.8, 1.25
3106, 60.8, 1.25, 60.8, 1.25
3107, 60.8, 1.25
3108, 60.8, 1.25
3109, 60.8, 1.25
3110,118.04461, 7.13925
*
* PRESSURIZER DETAIL GEOMETARY
**
3111,  3.3393,20.2258, 21.5504, 2.0287
3112, 45.5287, 1.4121, 50.2382,10.8681
3113, 50.2382,10.8681, 50.2382,10.8681
3114, 50.2382,10.8681, 48.9727, 0.3977
3115, 44.1784, 1.0144, 31.2481, 1.0144
3116, 11.8527, 1.0144
*
* SEGMENTED NODE (LOOP SEAL MODEL)
**
3202,  6, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3203, 21, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3204, 22, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3205, 24, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3206,  4, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
3207, 11, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
3208, 12, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
3209, 13, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
*
** BUBBLE RISE MODEL
*
3401,  -1, -1., 1.
3402,  -2, -1., 1.
3403,  -3, -1., 2.
3404,  -4, -1., 1.
3405,  -5, -1., 1.
3406,  -6, -1., 1.
3407,  -7, -1., 1.
3408,  -8, -1., 1.
3409,  -9, -1., 1.
```

```
3410, -10, -1., 1.
3411, -11, -1., 1.
3412, -12, -1., 1.
3413, -13, -1., 1.
3414, -14, -1., 1.
3415, -15, -1., 1.
3416, -16, -1., 1.
3417, -17, -1., 1.
3418, -18, -1., 1.
3419, -19, -1., 1.
3420, -20, -1., 1.
3421, -21, -1., 1.
3422, -22, -1., 1.
3423, -23, -1., 1.
3424, -24, -1., 1.
3425, -25, -1., 1.
3426, -26, -1., 1.
3427, -27, -1., 1.
3428, -28, -1., 1.
*
** BUBBLE CONVECTION AND DISENGAGEMENT
*
3491, 3, 1
*
** NODAL NON-EQUILIBRIUM OPTIONS
*
3501,  3,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3502,  5,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3503, 15,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3504, 17,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3505, 25,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3506,  4,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3507,  6,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3508, 11,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3509, 12,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3510, 13,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3511, 21,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3512, 22,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3513, 24,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3514,  1,  2, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3515, 26,  2, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3516, 27,  2, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3517,  7,  2, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3518,  8,  2, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3519,  9, -1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3520, 10, -1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3521, 19, -1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3522, 20, -1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3523,  2,  2, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
3524, 28,  1, 0, 50.0, 50.0,   50.0, .5,  0,  0,  0, 0,  0.0
*
```

```
        ** GENERAL NON-EQUILIBRIUM OPTIONS
        *
        3551, 0.0, 1.0+6, 0, 0.05
        *
        ** PROPORTIONAL HEATER TABLE
        *
        3581, 379.2,0.0, 379.2,2225., 0.,2275., 0.,1.E+9
        *
        ** ON/OFF HEATER
        *
        3591, 2200.0,  2225.0,  1896.0,  1.0
        *
        ** CONTAINMENT NODE
        *
        3801, 18
        *
        ** PZR SWITCH -  NOT USED IN THE REM
        *
        3803, 0.0
        *
        ** LIQUID ENTRAINMENT (path 41=PSV, path 42,43,44= sebim v/v)
        *
        3811, 8, 16, 24, 2, 41, 42, 0.1, 0.69, 0.6
        3812, 2, 41, 16, 0, 42, 41, 0.1, 0.69, 0.6
        3813, 2, 42, 16, 0, 41, 42, 0.1, 0.69, 0.6
SEBIM   3814, 2, 43, 16, 0, 41, 43, 0.1, 0.69, 0.6
SEBIM   3815, 2, 44, 16, 0, 41, 44, 0.1, 0.69, 0.6
        ** NODE MASS SUMMATIONS
        *
        3851,  4, 1,3,26,27
        3852, 24, 1,2,3,4,5,6,7,8,9,10,11,12,13,15,17,19,20,21,22,24,25,26,27,28
        3853,  1, 16
        3854,  1, 2
        3855,  1, 26
        3856,  2, 9, 19
        3857,  1, 7
        3858,  1, 15
        3859,  2, 6, 13
        *
        ** FLOW PATH SUMMATION
        *
SEBIM   3871, 5, 45,46,47,48,49
SEBIM   3872, 4, 41,42,43,44
        3873, 1, 18
        *
        ** WALL HEAT  :  1-D SLAB
        *
        *                  MCP          UA        BOT       TOP
        3901,  1, 1, 25278.501, 455.732,  0.001,  8.172, 0.
        3902, 27, 2,  3403.282, 760.354, 22.397, 28.145, 0.
        3903, 26, 2, 14750.449,4716.879, 28.147, 45.741, 0.
```

```
3904, 26, 2,  1699.479, 476.053, 28.147, 41.843, 0.
3905,  6, 2, 12074.262,  30.547, 15.916, 27.114, 0.
3906, 21, 2, 12074.262,  30.547, 15.916, 27.114, 0.
3907, 22, 2, 12074.262,  30.547, 15.916, 27.114, 0.
3908, 24, 2, 12074.262,  30.547, 15.916, 27.114, 0.
3909,  4, 2,  3009.043,  11.992, 15.916, 28.223, 0.
3910, 11, 2,  3009.043,  11.992, 15.916, 28.223, 0.
3911, 12, 2,  3009.043,  11.992, 15.916, 28.223, 0.
3912, 13, 2,  3009.043,  11.992, 15.916, 28.223, 0.
3913,  4, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3914, 11, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3915, 12, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3916, 13, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3917,  7, 2, 20974.537,1333.488, 24.116, 27.614, 0.
3918,  8, 2, 20974.537,1333.488, 24.116, 27.614, 0.
3919, 14, 2,133011.813, 905.938, 34.871, 97.087, 0.
3920, 16, 2,133011.813, 905.938, 34.871, 97.087, 0.
3921,  2, 2,  2626.088,  24.062, 27.616, 47.84 , 0.
*
** WALL HEAT TO STEAM (HEAT TRANSFER AREA)
*
3956, 1,3672.68, 2,2495.64, 3,7357.9, 4,600.0, 5,258.14, 6,258.14
3957, 7,258.14, 8,258.14, 9,137.67, 10,137.67, 11,137.67, 12,137.67
3958, 13,2235.46, 14,2235.46, 15,2235.46, 16,2235.46, 17,4416.76
3959, 18,4416.76, 19,5810.23, 20,5810.23, 21,300.0, 22,219.95
3960, 23,219.95, 24,361.75, 25,361.75, 26,361.75, 27,361.75, 28,20.74
*
** WALL HEAT : 1-D CYLINDRICAL
*
*               MCP         UA
3961,  7,  2, 7392.351,20.272,  0.0
3962,  8,  2, 7392.351,20.272,  0.0
3963,  5,  2,15807.372, 40.27,  0.0
3964, 15,  2,15807.372, 40.27,  0.0
3965, 17,  2,15807.372, 40.27,  0.0
3966, 25,  2,15807.372, 40.27,  0.0
3967, 28,  2,   195.98 , 3.803,  0.0
*
** DETAILED 2 D SLAB WALL HEAT
*
*          AREA      K     ALPHA
3971,  3, 1594.555,21.679, 0.333 , -1.,-1.,-1.,-1.,-1.
3972,  1, 4018.9  ,11.425, 0.175 , -1.,-1.,-1.,-1.,-1.
3973, 26, 1204.1  ,11.425, 0.175 , -1.,-1.,-1.,-1.,-1.
3974,  3, 1351.166,11.129, 0.172 , -1.,-1.,-1.,-1.,-1.
3975,  2, 1339.836,21.441, 0.322 , -1.,-1.,-1.,-1.,-1.
*
*      BOT     TOP
3981,  2.959,  37.572
3982, 22.397,  27.811
3983, 28.147,  45.741
```

```
3984,  6.344,  37.572
3985, 47.877,  98.194
*
*    THICK
3991, 1.007
3992, 0.032
3993, 0.456
3994, 0.267
3995, 0.427
*
** FLOW PATHS
*
*    TY  FR  TO      FLOW        L/A      AREA       DH
4001, 8,  3,  1, 45202.78,  0.602 , 60.8    , 0.0403,  1.0, 1.0
4002, 8,  1,  8, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4003, 8,  1,  7, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4004, 8,  5,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4005, 8, 11, 21, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4006, 8, 12, 22, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4007, 8, 13,  6, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4008, 8,  7,  9, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4009, 8,  8, 10, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4010, 8, 20, 12, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4011, 8, 19, 11, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4012, 2, 21, 17, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4013, 8, 19, 13, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4014, 8,  5,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4015, 2,  6, 15, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4016, 5,  2,  8,      0.0 , 200.438,  0.559 , 0.844 ,  1.0, 1.0
4017, 2, 22,  5, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4018, 9, 14, 23,      0.0 ,  1.0   ,  1.0   , 1.0    ,  1.0, 1.0
4019, 8, 15,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4020, 9, 16, 23,      0.0 ,  1.0   ,  1.0   , 1.0    ,  1.0, 1.0
4021, 8, 17,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4022, 8, 10, 20, 23027.78,  1.166 , 27.39   , 0.0555,  1.0, 1.0
4023, 8,  9, 19, 23027.78,  1.166 , 27.39   , 0.0555,  1.0, 1.0
4024, 8,  1,  8, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4025, 8,  1,  7, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4026, 8,  8, 10, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4027, 8,  7,  9, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4028, 8, 15,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4029, 8, 17,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4030, 8, 20,  4, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4031, 8,  4, 24, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4032, 2, 24, 25, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4033, 8, 25,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4034, 8, 25,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4035, 8,  3, 26,    241.67, 24.314 ,  0.106 , 0.3678,  1.0, 1.0
4036, 8,  3,  1,    611.11,  7.059 ,  0.106 , 0.3678,  1.0, 1.0
4037, 8,  1, 27,    366.67,  0.369 ,  0.369 , 0.6857,  1.0, 1.0
4038, 8, 27, 26,    366.67,  0.751 ,  7.779 , 3.1471,  1.0, 1.0
```

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4039, 8, 26,  1,    608.33,  0.432 ,  1.571 , 1.4143,  1.0, 1.0
4040, 8, 28,  3,       0.0 ,  5.912 ,  0.394 , 0.7083,  1.0, 1.0
4041, 9,  2, 18,       0.0 ,  1.0   ,  1.0   , 1.0   ,  1.0, 1.0
*
****
*     KF     KGF     KGR     M  C    AREA      L        HT
4101, 0.0 ,19.0929,21.0913, 0, 1, 37.97    , 0.0 , 2.7979, 1
4102, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 3
4103, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 3
4104, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4105, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4106, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4107, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4108, 0.0 , 5.5723, 1.7409, 0, 1,  4.811   , 0.0 , 0.87  , 3
4109, 0.0 , 5.5723, 1.7409, 0, 1,  4.811   , 0.0 , 0.87  , 3
4110, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4111, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4112, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4113, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4114, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4115, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4116,1.725, 2.7549, 2.7549, 0, 1,  0.5595 ,124.52,0.1   , 1
4117, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4118, 1.0 ,  1.0  ,  1.0  , 0, 1,  1.0     , 1.0 , 1.0   , 1
4119, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4120, 1.0 ,  1.0  ,  1.0  , 0, 1,  1.00    , 1.0 , 1.0   , 1
4121, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4122, 0.0 , 0.2580, 0.2580, 0, 1, 27.3904 , 0.0 ,12.6013, 1
4123, 0.0 , 0.2580, 0.2580, 0, 1, 27.3904 , 0.0 ,12.6013, 1
4124, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 2
4125, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 2
4126, 0.0 , 5.5723, 1.7409, 0, 1,  4.811   , 0.0 , 0.87  , 2
4127, 0.0 , 5.5723, 1.7409, 0, 1,  4.811   , 0.0 , 0.87  , 2
4128, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4129, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4130, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4131, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4132, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4133, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4134, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4135, 0.0 , 2.8074, 2.8074, 0, 1,  0.1063 , 0.0 , 0.1   , 1
4136, 0.0 , 0.4472, 0.4472, 0, 1,  0.1063 , 0.0 , 3.5   , 1
4137, 0.0 , 3.5130, 2.8363, 0, 1,  0.3693 , 0.0 , 0.1   , 1
4138, 0.0 , 1.2965, 0.7554, 0, 1,  7.779   , 0.0 , 0.1   , 1
4139, 0.0 , 0.6493, 0.6494, 0, 1,  1.571   , 0.0 , 0.1   , 1
4140, 1.0 ,  1.0  ,  1.0  , 0, 1,  0.3941 , 2.33, 0.6483, 1
4141, 1.0 ,  1.0  ,  1.0  , 0, 1,  1.0     , 1.0 , 0.5124, 1
***********************************************************
*
** UPPER PLENUM FRICTIONAL LOSS
*
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```
        4180, 1, 22.597, 24.114, 0.92466, 1.39526, 20.61
        *
        ** LEAK PATH (PATH 42) : bleed v/v
        *
SEBIM 4242, 7, 2, 18, 2.0, 0.024319, 0.9,0.9,0.9,1.0, 0.207, 1,1.0+6, 1
SEBIM 4243, 7, 2, 18, 2.0, 0.024319, 0.9,0.9,0.9,1.0, 0.207, 1,1.0+6, 1
SEBIM 4244, 7, 2, 18, 2.0, 0.024319, 0.9,0.9,0.9,1.0, 0.207, 1,1.0+6, 1
        ** FILL PUMP FLOW PATHS
        *
        ** HPSI (14.7 PSIA,120 deg F)
SEBIM 4445, 6, 1, 28, 1.0, 0.0, 87.97, 0.0, 1, 1
        *
        ** CHARGING PUMP (path 44,45 : before/after operator action)
        * (NOT USED)
SEBIM *4446, 6, 2, 15, 1.0 , 0.0, 459.11, 0.019595, 2, 2
SEBIM *4447, 6, 3, 15, 1.0 , 0.0, 87.97,      0.0, 3, 3
        *
        ** SIT TANKS (NOT USED)
        4546, 11,1,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
        4547, 11,2,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
        4548, 11,3,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
        4549, 11,4,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
        *
        ** SIT INFORMATION (REM MODEL)
        4571, 0.0 ,0
        4572, 0.0 ,0
        4573, 0.0 ,0
        4574, 0.0 ,0
        *
        ** VARIABLE AREA VS. PRESSURE
        *
        ** SG SAFETY VALVE FLOW PATH
        4801, 18, 1, 0.0, 0.0, 0.0, 0.0, 0.0
        4802, 20, 1, 0.0, 0.0, 0.0, 0.0, 0.0
        *
        ** PZR SAFETY VALVE FLOW PATH
        4803, 41, 2, 0.0, 0.0, 0.0, 0.0, 0.0
        *
        ** MSSV VALVES FLOW PATH
        4811,    0.0,   0.0,   0.0   , 1200.0
        4812, 0.5177, 1201.0,  0.5177, 1235.0, 1.0342, 1236.0
        4813, 1.0342, 1260.0,  2.581 , 1261.0, 2.581 , 1.0+9
        *
        ** PRESSURIZER SAFETY VALVES
SEBIM 4821, 0.0,0.0, 0.0,1.0+9
        *
        ** MODIFICATION OF UPSTREAM AND DOWNSTREAM ELEVATION
        *
        *    PATH    UP      DOWN
        4901, 16, 27.715 , 27.505
        4902, 24, 25.865 , 25.865
```

```
      4903,  25,  25.865 , 25.865
      4904,  26,  26.735 , 35.84
      4905,  27,  26.735 , 35.84
      4906,   4,  25.865 , 25.865
      4907,  28,  25.865 , 25.865
      4908,  29,  25.865 , 25.865
      4909,  34,  25.865 , 25.865
      4910,  35,  37.373 , 37.373
      4911,  36,  24.115 , 24.115
      4912,  37,  22.496 , 22.496
      4913,  38,  28.046 , 28.246
      4914,  39,  28.246 , 27.712
      4915,  40,  32.459 , 32.459
      4916,  41,  96.489 , 96.489
SEBIM 4917,  42,  97.686 , 97.686
SEBIM 4918,  43,  97.686 , 97.686
SEBIM 4919,  44,  97.686 , 97.686
      *
      ** LOOP SEAL VOIDING MODEL
      4951,  4, 31, 0
      4952, 24, 31, 0
      4953, 12,  6, 0
      4954, 22,  6, 0
      4955, 13,  7, 0
      4956,  6,  7, 0
      4957, 11,  5, 0
      4958, 21,  5, 0
      *
      ** LOOP SEAL SEQUENCING MODEL
      4959, 0, 5.0
      *
      ** VARIABLE AREA VS TIME TABLE (BLEED PATH FOR BASE CASE)
SEBIM *   (dummy for SEBIM MODEL)
SEBIM 4971, 0.0, 0.0,  0.0, 1.0+9
      *
      ** REACTOR CORE PARAMETERS
      *
      5001,1711.88,12.5,0.04029,188211.651,70958.0,1.,1.,1.,1.,1.,60.8
      *
      ** AXIAL POWER SHAPE
      *
      5191, 0.285, 0.550, 0.655, 0.720, 0.795, 0.925
      5192, 1.100, 1.355, 1.620, 1.600, 0.760
      *
      ** GENERAL CORE INFORMATION
      *
      5201, 2, 1, 1, 1, 2, 1.0, 0.01383, 0.00208, 1.0, 643.945,5.0
      5202, 20000.0, 1.0, 1, 1, 0, 0, 0, 0.0, 100.0, 0, 8.0
      *
      ** LYONOS THERMAL CONDUCTIVITY FOR UO2
      *
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5211, 0.0, 4009.416, 692.32, 6.1185-12,   0.0 , 0.0, 0.0
*
** FUEL ROD GAP MATERIAL PROPERTIES
*
5221, 3, 0.0, 0.424
*
** FUEL ROD MATERIAL REGION INFORMATION
*
5301, 1, 7, 1.0, 0.01356
5302, 3, 1, 0.0, 0.01383
5303, 2, 1, 0.0, 0.01592
*
** SCRAM PARAMETERS
6001, 1.0, 1.E+9, 1825.0, 1.15, 29.91, 3.0, 1.E+9, 2, 2, 1
*
** KINETIC PARAMETERS
*
6002, 3.03E-5, 1.0, 0.01, 1.0, 1.0, 2
*
** REACTIVITY VS TIME
*
6021,  .0000 , 0.00,  .00000, 0.50, -.00088, 1.21
6022, -.0021 , 1.58, -.00340, 1.92, -.00590, 2.22
6023, -.0081 , 2.55, -.01220, 2.86, -.01910, 3.20
6024, -.0324 , 3.60, -.05283, 4.00, -.10000, 4.67
6025, -.1000 , 1.+9
*
** DELAYED NEUTRON FRACTIONS
*
6031, 0.000255, 0.001512, 0.001388, 0.003054, 0.001096, 0.000261
*
** DECAY CONSTANTS OF DELAYED NEUTRONS
*
6041, 0.0127, 0.0317,  0.1181, 0.318, 1.403, 3.925
*
** 1979 ANS + 0 SIGMA CURVE (YGN 3,4 SPECIFIC FROM Y34-FE-0021)
*
6101,0.06967,    0.0, 0.06638,    1.0, 0.06215,    2.0
6102,0.05755,    4.0, 0.05454,    6.0, 0.05233,    8.0
6103,0.05063,   10.0, 0.04535,   20.0, 0.04235,   30.0
6104,0.04023,   40.0, 0.03862,   50.0, 0.03732,   60.0
6105,0.03623,   70.0, 0.03530,   80.0, 0.03449,   90.0
6106,0.03378,  100.0, 0.03259,  120.0, 0.03162,  140.0
6107,0.03080,  160.0, 0.03011,  180.0, 0.02950,  200.0
6108,0.02826,  250.0, 0.02729,  300.0, 0.02649,  350.0
6109,0.02580,  400.0, 0.02520,  450.0, 0.02465,  500.0
6110,0.02371,  600.0, 0.02291,  700.0, 0.02220,  800.0
6111,0.02157,  900.0, 0.02100,1000.0, 0.02001,1200.0
6112,0.01917,1400.0, 0.01844,1600.0, 0.01779,1800.0
6113,0.01722,2000.0, 0.01513,3000.0, 0.01378,4000.0
6114,0.01283,5000.0, 0.01157,7000.0, 0.01044,10000.
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6115,0.00999,14000., 0.00912,20000., 0.00721,50000.0
*
** STEAM GENERATORS SHUTDOWN PARAMETERS
*
7011, 1.0, 1.E+9, 1.0, 1.E+9,  0.02, 3.0, 1.E+9, 14, 2
7012, 1.0, 1.E+9, 1.0, 1.E+9, 29.91, 3.0, 1.E+9, 14, 2
7013, 1.0, 1.E+9, 1.0, 1.E+9,  0.02, 3.0, 1.E+9, 16, 2
7014, 1.0, 1.E+9, 1.0, 1.E+9, 29.91, 3.0, 1.E+9, 16, 2
*
** STEAM GENERATOR PARAMETERS
*
7041, 1, 1, 0, 0.0, 1, 0, 1
*
** SECONDARY NODE INFORMATION
*
7101, 14, 2453.56, 0.0625, 0.0555, 42.46, 0.082, 0
7102, 16, 2453.56, 0.0625, 0.0555, 42.46, 0.082, 0
*
** PRIMARY NODE INFORMATION
*
7105, 10, 1246866.7, 1.0, 70675.762, 31.95, 22, 14929.87
7106, 20,  623433.4, 1.0, 70675.762, 31.95, 22, 14929.87
7108,  9, 1246866.7, 1.0, 70675.762, 31.95, 23, 14929.87
7109, 19,  623433.4, 1.0, 70675.762, 31.95, 23, 14929.87
*
** SG LOCAL HEAT TRANSFER COEFFICIENTS
*
7301, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
*
** U-TUBE THERMAL CONDUCTIVITY
*
7321, -1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
*
** SG OPERATION VS TIME (HEAT LOAD AND ENTHALPY)
** SG 1
7401,   0.0,1.0, 1.0,430.62
7402, 1.0+6,1.0, 1.0,430.62
*
7421,   0.0,1.0, 1.0,430.62
7422,  0.02,1.0, 0.0,430.62
7423,  1.+6,1.0, 0.0,430.62
*
7441,  0.0 ,1.0, 0.0,430.62
7442,  0.30,0.0, 0.0,430.62
7443,  1.+6,0.0, 0.0,430.62
*
** SG2
7461,   0.0,1.0, 1.0,430.62
7462, 1.0+6,1.0, 1.0,430.62
*
7481,   0.0,1.0, 1.0,430.62
```

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7482,  0.02,1.0, 0.0,430.62
7483,  1.+6,1.0, 0.0,430.62
*
7501,  0.0 ,1.0, 0.0,430.62
7502,  0.30,0.0, 0.0,430.62
7503,  1.+6,0.0, 0.0,430.62
*
**  COUNTER-CURRENT FLOODING IN SG AND HOT LEG
*
7570,  0.725, -0.7, 0.7, 0.00308
*
** RCS PUMPS CONDITIONS
*
8000, 1.0, 0, 1.0, 0, 1.0, 0, 1.0, 0
*
** RATED PUMP CONDITIONS
*
8001, 124.757, 369.07, 46.5, 45321.951, 147401.0, 0.0
8002, 0.0, 0.962659, 1.001102, 1.033150
*
** PUMP SHUTDOWN PARAMETERS
8011, 1825.0, 1.E+9, 629.91, 3.0, 1.0+9, 2, 1
*
** PUMP HOMOLOGOUS CURVES
*
** TORQUE
*
8021,   .68,   .71,   .73,   .76,   .80,   .83
8022,   .86,   .89,   .92,   .96,  1.00
8031,  -.82,  -.58,  -.40,  -.24,  -.08,   .08
8032,   .26,   .44,   .62,   .80,  1.00
8041,   .68,   .82,   1.0,  1.23,  1.48,  1.76
8042,  2.06,  2.34,  2.66,  2.98,  3.32
8051,  1.78,  1.99,  2.12,  2.19,  2.20,  2.24
8052,  2.39,  2.58,  2.80,  3.04,  3.32
8061, -1.34, -1.14,  -.95,  -.74,  -.54,  -.37
8062,  -.20,  -.02,   .16,   .34,   .52
8071,  1.78,  1.58,  1.42,  1.30,  1.20,  1.12
8072,  1.06,   .86,   .84,   .70,   .52
8141, -1.34, -1.54, -1.82, -2.09, -2.42, -2.70
8142, -3.03, -3.36, -3.74, -4.10, -4.51
8151,  -.82, -1.07, -1.38, -1.68, -2.00, -2.33
8152, -2.70, -3.07, -3.50, -3.97, -4.51
*
** HEAD
*
8081,  1.30,  1.30,  1.29,  1.28,  1.27,  1.24
8082,  1.21,  1.17,  1.12,  1.08,  1.00
8091, -1.08,  -.92,  -.75,  -.56,  -.36,  -.17
8092,   .06,   .27,   .50,   .76,  1.00
8101,  1.30,  1.38,  1.56,  1.75,  1.98,  2.24
```

```
8102,  2.52,  2.80,  3.10,  3.40,  3.72
8111,  1.77,  1.94,  2.08,  2.16,  2.24,  2.32
8112,  2.40,  2.52,  2.70,  3.30,  3.72
8121,   .29,   .30,   .31,   .34,   .35,   .40
8122,   .48,   .58,   .69,   .87,  1.08
8131,  1.77,  1.58,  1.40,  1.26,  1.19,  1.14
8132,  1.09,  1.07,  1.05,  1.06,  1.08
8161,   .29,   .28,   .26,   .20,   .13,  0.0
8162,  -.168, -.41,  -.60, -.907, -1.207
8171, -1.08, -1.18, -1.26, -1.32, -1.34, -1.35
8172, -1.36, -1.35, -1.31, -1.26, -1.207
*
** TWO-PHASE PUMP HEAD DEGRADATION MULTIPLIER
*
8201, 0.0,0.0, -0.06,0.07, -0.06,0.12, 0.07,0.2, 0.361,0.3
8202, 0.564,0.4, 0.734,0.5, 0.883,0.6, 0.995,0.7, 0.995,0.8
8203, 0.775,0.9,  0.52,0.95, 0.0,1.0
8221, 0.0,0.0, 0.6,0.1, 1.0,0.2, 0.985,0.25, 0.815,0.4
8222, 0.745,0.5, 0.685,0.6, 0.59,0.7, 0.463,0.8, 0.31,0.9
8223, 0.0,1.0
*
** RCP ON/OFF CONTROL VS TIME
*
8251, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
8261, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
8271, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
8281, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
*
** ELECTRICAL TORQUE VS PUMP SPEED
*
8311,  87251.8 ,-50.27,  99497.67, 62.83, 119397.2 , 87.96
8312, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8313, 179095.8 ,119.38, 147715.77,121.89,  45922.0 ,124.62
8314,        0.0 ,125.66
8315, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
8316,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
8317,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
*
8321,  87251.8 ,-50.27,  99497.67, 62.83, 119397.2 , 87.96
8322, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8323, 179095.8 ,119.38, 147715.77,121.89,  45922.0 ,124.62
8324,        0.0 ,125.66
8325, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
8326,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
8327,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
*
8331,  87251.8 ,-50.27,  99497.67, 62.83, 119397.2 , 87.96
8332, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8333, 179095.8 ,119.38, 147715.77,121.89,  45922.0 ,124.62
8334,        0.0 ,125.66
8335, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
```

```
        8336,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
        8337,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
        *
        8341,  87251.8 ,-50.27,  99497.67, 62.83, 119397.2 , 87.96
        8342, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
        8343, 179095.8 ,119.38, 147715.77,121.89,  45922.0 ,124.62
        8344,       0.0 ,125.66
        8345, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
        8346,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
        8347,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
        *
        ** TWO-PHASE PUMP DIFFERENCE HOMOLOGOUS CURVES (HEAD)
        *
        8401,  1.08 ,    1.048,  1.008,  0.971,  0.925,  0.906
        8402,  0.871,    0.875,  0.889,  0.890,  0.834
        8411,  0.034,    0.087,  0.147,  0.237,  0.400,  0.419
        8412,  0.370,    0.356,  0.490,  0.669,  0.834
        8421,  1.08 ,   -1.611, -1.634, -1.651, -1.669, -1.68
        8422, -1.709,   -1.749, -1.754, -1.726, -1.68
        8431, -0.445,   -0.421, -0.423, -0.571, -0.686, -0.817
        8432, -0.96 ,   -1.109, -1.28 , -1.44 , -1.68
        8441,  0.001,    0.001,  0.001,  0.001,  0.001,  0.001
        8442,  0.001,    0.001,  0.001,  0.001,  0.001
        8451,  -.445,    -.445,  0.001,  0.001,  0.001,  0.001
        8452,  0.001,    0.001,  0.001,  0.001,  0.001
        8461,  0.001,    0.001,  0.001,  0.001,  0.001,  0.001
        8462,  0.001,    0.001,  0.001,  0.001,  0.001
        8471,  0.034,    0.001,  0.001,  0.001,  0.001,  0.001
        8472,  0.001,    0.001,  0.001,  0.001,  0.001
        *
        ** FILL SYSTEM ACTUATION PARAMETERS
        *
        10001, 0.1, 1825.0, 2, 2, 100.0, 100.0
SEBIM   *10002, 0.1,  1.E+9, 2, 2, 100.0, 100.0
SEBIM   *10003, 0.1,  1.E+9, 2, 2, 100.0, 100.0
        *
        ** FILL SYSTEM TIME DELAYS
        *
        10011, 1.0+9, 40.0, 1.0+9
SEBIM   *10012, 1.0+9, 1.+9, 0.01
SEBIM   *10013, 1.0+9, 1.+9, 0.01
        *
        ** FILL SYSTEM PUMP CHARACTERISTICS
        *
        * HPSI (pump #1)
        10021, 1104.0 ,   34.7, 1098.0 ,  54.7
        10022, 1094.0 ,   74.7, 1090.0 ,  94.7, 1086.0 ,  114.7
        10023, 1082.0 ,  134.7, 1072.0 , 154.7, 1067.97,  174.7
        10024, 1064.44,  189.7, 1056.0 , 214.7, 1050.95,  229.7
        10025, 1047.9 ,  244.7, 1029.0 , 314.7, 1004.0 ,  414.7
        10026,  914.0 ,  614.7,  818.67, 814.7,  769.0 ,  914.7
```

```
        10027,  716.0 , 1014.7,  604.0 ,1214.7,  477.33, 1414.7
        10028,  373.18, 1514.7,  330.74,1553.7,  266.0 , 1614.7
        10029,     0.0 , 1834.7,     0.0 , 1.E+9
        *
        * CHARGING PUMP (BEFORE OPERATOR INTERVENTION : pump #2)
SEBIM   *10031, 120.0, 0.0, 120.0, 1.E+9
        *
        * CHARGING PUMP (AFTER OPERATOR INTERVENTION  : pump #3)
SEBIM   *10041, 120.0, 0.0, 120.0, 1.E+9
        *
        ** FILL FLOW MULTIPLIERS (for base case)
        *
        10101, 0.0, 0.0,  0.0, 1.0+9
SEBIM   *10111, 0.0, 0.0,  0.0, 1.0+9
SEBIM   *10121, 0.0, 0.0,  0.0, 1.0+
        *
        ** MODREATOR DENSITY REACTIVITY TABLE
        *
        11001, 0.0, 0.0,  0.0,  100.0
        *
        ** DOPPLER REACTIVITY TABLE
        *
        11011, 0.0148, 100.0, 0.0131, 200.0, 0.0115, 300.0, 0.0100, 400.0
        11012, 0.0085, 500.0, 0.0079, 550.0, 0.0072, 600.0, 0.0059, 700.0
        11013, 0.0046, 800.0, 0.0033, 900.0, 0.0020,1000.0, 0.0009,1100.0
        11014, -.0002,1200.0, -.0035,1500.0, -.0083,2000.0, -.0128,2500.0
        11015, -.0175,3000.0, -.0221,3500.0, -.0267,4000.0, -.0359,5000.0
        *
        *
        .
       0.1
KNGR FEED/BLEED W/SEBIM (BASE CASE)
F&B FOR TLOFW W/O ECC  SBASE2
        0          0          1
        1
 POWER NODE 1
0.20     6.0      0.0            1
 600.0   5.0      0.0
        3
 PRESSURE NODE  1
500.0    6.0       0.0           1
 600.0   5.0      0.0
 PRESSURE NODE  2
500.0    6.0       0.0           2
 PRESSURE NODE 14
250.0    6.0       0.0           14
       20
 FLOW RATE PATH  1
10000.   6.0     -10000.0        1
 FLOW RATE PATH 12
3000.    6.0      -3000.0        12
```

```
FLOW RATE PATH 16
300.0     6.0       -900.0        16
FLOW RATE PATH 18
300.0     6.0       -900.0        18
FLOW RATE PATH 42
100.0     6.0       -50.0         42
FLOW RATE PATH 43
50.00     6.0       -50.0         43
FLOW RATE PATH 44
50.00     6.0       -50.0         44
FLOW RATE PATH 46
50.00     6.0       -50.0         46
FLOW RATE PATH 2
3000.     6.0       -3000.0       2
FLOW RATE PATH 24
3000.     6.0       -3000.0       24
FLOW RATE PATH 9
3000.     6.0       -3000.0       9
FLOW RATE PATH 26
3000.     6.0       -3000.0       26
FLOW RATE PATH 14
1500.     6.0       -1500.0       14
FLOW RATE PATH 4
1500.     6.0       -1500.0       4
FLOW RATE PATH 10
3000.     6.0       -3000.0       10
FLOW RATE PATH 6
3000.     6.0       -3000.0       6
FLOW RATE PATH 35
 100.     6.0       -100.0        35
FLOW RATE PATH 36
 150.     6.0       -150.0        36
FLOW RATE PATH 37
 100.     6.0       -100.0        37
FLOW RATE PATH 39
150.0     6.0       -150.0        39
       15
MIX. LEVEL NODE 1
10.0      6.0       0.0           1
COL. LEVEL NODE 1
10.0      6.0       0.0           -1
SUB. LEVEL NODE 1
10.0      6.0       0.0           101
MIX. LEVEL NODE 14
10.0      6.0       0.0           14
MIX. LEVEL NODE 2
10.0      6.0       0.0           2
COL. LEVEL NODE 2
10.0      6.0       0.0           -2
MIX. LEVEL NODE 3
10.0      6.0       0.0           3
```

```
MIX. LEVEL NODE 5
 1.0       6.0       0.0               5
MIX. LEVEL NODE 8
 1.0       6.0       0.0               8
MIX. LEVEL NODE 10
10.0       6.0       0.0              10
MIX. LEVEL NODE 20
10.0       6.0       0.0              20
MIX. LEVEL NODE 12
5.0        6.0       0.0              12
MIX. LEVEL NODE 22
5.0        6.0       0.0              22
MIX. LEVEL NODE 26
5.0        6.0       0.0              26
MIX. LEVEL NODE 27
2.0        6.0       0.0              27
        0
        4
COOLANT TEMP NODE 1
50.0       6.0       400.0             1
SUBCOOL TEMP NODE 1
50.0       6.0       400.0            -1
COOLANT TEMP NODE 2
50.0       6.0       400.0             2
COOLANT TEMP NOD 14
50.0       6.0       400.0            14
      4
QUALITY NODE  1
.2         6.0       -0.2              1
QUALITY NODE  2
.2         6.0       -0.2              2
QUALITY NODE  5
.2         6.0       -0.2              5
QUALITY NODE  8
.2         6.0       -0.2              8
      5
QUALITY PATH 16
.2         6.0       -0.2             16
QUALITY PATH 41
.2         6.0       -0.2             41
QUALITY PATH 42
.2         6.0       -0.2             42
QUALITY PATH 43
.2         6.0       -0.2             43
QUALITY PATH 44
.2         6.0       -0.2             44
      9
REACTOR VESSEL MASS
 50.0       6.0       0.0       -1          1
PRIMARY SYSTEM MASS
 150.0      6.0       0.0       -2          1
```

STEAM GENERATOR 2RY MASS

50.0	6.0	0.0	-3	1

PRESSURIZER MASS

50.0	6.0	0.0	-4	1

RV UPPER HEAD MASS

50.0	6.0	0.0	-5	1

SG U-TUBES MASS

50.0	6.0	0.0	-6	1

INTEGRAL ECCS MASS

200.0	6.0	-200.0	-1	13

INTEGRAL OUTLET FLOW

200.0	6.0	-200.0	-2	13

INTEGRAL MSSV FLOW

200.0	6.0	-200.0	-3	13

1

TIME STEPS

0.1	6.0	-0.1	1

Table A-3. CEFLASH-4AS input for TLOFW with Feed and Bleed (Design Option 2)

```
KNGR    TLOFW AND FEED/BLEED TRANSIENTS (SINGLE FAILURE CASE)
        *
        ** ksf0_028.inp : One BV, Two HPSI Trains, 0 min delay
        * B.A.=0.028 ft2 (modify CARDS 4971&10101)
        * REACTOR TRIP AT 29.91 SEC, PSV LIFT TIME = 1275.32 SEC
        * STROKE TIME OF GATE VALVE(BV)=25 SEC, GLOBE VALVE=67 SEC
        *
        ********************************************************************
        *  KNGR TLOFW and FEED/BLEED Transients Analyses for determing       *
        *  min. SDS bleed valve capacity (Cal. Sheet :KNGR-SS-CA002,Rev.0)  *
        *                                                                   *
        *  Systems Safety Analysis Dept.                                    *
        *  Prepared by Hong-Sik Lim, December 1995.                         *
        ********************************************************************
        *
        *  TLOFW ANALYSIS USING SEBIM VALVE
        *   September 16, 1996 young min kwon (*8688)
        *    2 SEBIM, 2 HPSI at 2200 sec. (sf2f.inp)
        ********************************************************************
        *
        ** RESTART
        101, 1,0
        102, SF0001,500.0
        103, SF0001,1,AAAA
        *
        ** GENERAL TIME AND REM OPTION
        *
        1001, 8000.,0.0,0.02,1000000,30000,0,3,2,1,1,1,1
        1021, 90000.0
        1031, 0.0001
        *
        **INNER VESSEL GEOMETRY AND REM OPTION
        *
        1101, 1,12,3,1,1,1,1,1,1,1,3.48,10
        1102, 0,1,1,3,1,1,1,0.0
        1106, 1,1,0.0
        *
        ** EDIT, TIME STEP AND PUNCH INFORMATION
        2001,  1250., 250., 0, 0, 0, 0
        2002,  1350., 100., 0, 0, 0, 0
        2003,  1500., 150., 0, 0, 0, 0
        2004, 10000., 500., 0, 0, 0, 0
        *
        2201, 0.00001, 0.1
        2202, 0.00001, 0.05
```

```
        2203, 0.00001, 0.01
        2204, 0.00001, 0.1
        *
        2401, 0.02, 0.00005, 0.1, 0.1, 0.1, 0.5
        2501, 3, 1, 8, 2, 1, 1
        *
        * Reactor Trip at 29.91 sec & after 10 min RCP Trip
        *
        ** PUMP RUNNING TIME
        2601, 1.0, 629.91
        *
        ** NODAL CONTROL VOLUMES
        *
        *                                          *****     ****
        *  AREA HEIGHT EXIT INLET BOT PRESS ENTH  LEV
        3001, 87.685 ,27.813 ,24.125 , 3.058 , 0.0   ,2282.514, 634.998, 0.0
        3002, 34.961 ,70.58  ,27.715 ,27.715 ,27.615 ,2250.0  ,   0.0  ,36.256
        3003, 33.428 ,34.615 , 3.058 ,24.665 , 2.958 ,2317.344, 554.41 , 0.0
        3004, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
        3005, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
        3006,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
        3007,192.943 , 3.5   ,25.865 ,24.125 ,24.115 ,2262.77 , 634.998, 0.0
        3008,192.943 , 3.5   ,25.865 ,24.125 ,24.115 ,2262.77 , 634.998, 0.0
        3009, 24.364 ,35.741 ,57.909 ,34.97  ,34.87  ,2231.124, 580.852, 0.0
        3010, 24.364 ,35.741 ,57.909 ,34.97  ,34.87  ,2231.124, 580.852, 0.0
        3011, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
        3012, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
        3013, 17.157 ,18.955 ,16.015 ,34.67  ,15.915 ,2215.019, 553.779, 0.0
2ry SG  3014,105.302 ,130.368,97.088 ,37.474 ,34.87  , 978.0  ,   0.0  ,40.36
        3015, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
2ry SG  3016,105.302 ,130.368,97.088 ,37.474 ,34.87  , 978.0  ,   0.0  ,40.36
        3017, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
        3018,15000.0 ,200.0  ,98.195 ,98.195 , 0.0   ,  14.7  ,   0.0  , 1.-9
        3019, 24.364 ,35.741 ,34.97  ,57.909 ,34.87  ,2215.233, 553.779, 0.0
        3020, 24.364 ,35.741 ,34.97  ,57.909 ,34.87  ,2215.233, 553.779, 0.0
        3021,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
        3022,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
        3023,  1.+10 ,1000.0 ,97.088 ,97.088 , 0.0   ,  14.7  ,   0.0  , 1.-9
        3024,  6.422 ,11.2   ,24.665 ,16.015 ,15.915 ,2213.178, 553.779, 0.0
        3025, 90.471 , 2.5   ,24.665 ,24.665 ,24.615 ,2333.636, 554.41 , 0.0
        3026,111.726 ,17.597 ,28.246 ,28.246 ,28.146 ,2277.454, 602.984, 0.0
        3027,  7.8   , 5.75  ,28.046 ,22.496, 22.396 ,2282.81 , 634.998, 0.0
        3028,  5.184 , 0.708 ,32.459 ,32.459 ,32.409 ,2315.904, 554.41 , 0.0
        *
        ** HORIZONTAL CYLINDRICAL NODES
        *
        3081, 7,1, 8,1, 5,1, 15,1, 17,1, 25,1, 28,1
        *
        ** SECTIONALIZED NODE
        *
        3100, 1, 12, 2, 11
```

```
*
** DETAILED INNER VESSEL GEOMETRY
*
3101,102.28489, 8.17325
3102, 60.8, 1.25
3103, 60.8, 1.25
3104, 60.8, 1.25
3105, 60.8, 1.25, 60.8, 1.25
3106, 60.8, 1.25, 60.8, 1.25
3107, 60.8, 1.25
3108, 60.8, 1.25
3109, 60.8, 1.25
3110,118.04461, 7.13925
*
* PRESSURIZER DETAIL GEOMETARY
**
3111,  3.3393,20.2258, 21.5504, 2.0287
3112, 45.5287, 1.4121, 50.2382,10.8681
3113, 50.2382,10.8681, 50.2382,10.8681
3114, 50.2382,10.8681, 48.9727, 0.3977
3115, 44.1784, 1.0144, 31.2481, 1.0144
3116, 11.8527, 1.0144
*
* SEGMENTED NODE (LOOP SEAL MODEL)
**
3202,  6, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3203, 21, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3204, 22, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3205, 24, 2,11.69031, 2.5, 4.90874, 8.7,  0.0, 0.0
3206,  4, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
3207, 11, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
3208, 12, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
3209, 13, 3,10.49258, 2.5, 4.90874, 9.84925, 37.94091, 6.60575
*
** BUBBLE RISE MODEL
*
3401,  -1, -1., 1.
3402,  -2, -1., 1.
3403,  -3, -1., 2.
3404,  -4, -1., 1.
3405,  -5, -1., 1.
3406,  -6, -1., 1.
3407,  -7, -1., 1.
3408,  -8, -1., 1.
3409,  -9, -1., 1.
3410, -10, -1., 1.
3411, -11, -1., 1.
3412, -12, -1., 1.
3413, -13, -1., 1.
3414, -14, -1., 1.
3415, -15, -1., 1.
```

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3416, -16, -1., 1.
3417, -17, -1., 1.
3418, -18, -1., 1.
3419, -19, -1., 1.
3420, -20, -1., 1.
3421, -21, -1., 1.
3422, -22, -1., 1.
3423, -23, -1., 1.
3424, -24, -1., 1.
3425, -25, -1., 1.
3426, -26, -1., 1.
3427, -27, -1., 1.
3428, -28, -1., 1.
*
** BUBBLE CONVECTION AND DISENGAGEMENT
*
3491, 3, 1
*
** NODAL NON-EQUILIBRIUM OPTIONS
*
3501,  3,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3502,  5,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3503, 15,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3504, 17,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3505, 25,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3506,  4,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3507,  6,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3508, 11,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3509, 12,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3510, 13,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3511, 21,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3512, 22,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3513, 24,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3514,  1,  2, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3515, 26,  2, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3516, 27,  2, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3517,  7,  2, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3518,  8,  2, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3519,  9, -1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3520, 10, -1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3521, 19, -1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3522, 20, -1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3523,  2,  2, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
3524, 28,  1, 0, 50.0, 50.0,  50.0, .5,  0,  0,  0, 0,  0.0
*
** GENERAL NON-EQUILIBRIUM OPTIONS
*
3551, 0.0, 1.0+6, 0, 0.05
*
** PROPORTIONAL HEATER TABLE
*
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```
        3581, 379.2,0.0, 379.2,2225., 0.,2275., 0.,1.E+9
        *
        ** ON/OFF HEATER
        *
        3591, 2200.0,  2225.0,  1896.0,  1.0
        *
        ** CONTAINMENT NODE
        *
        3801, 18
        *
        ** PZR SWITCH -  NOT USED IN THE REM
        *
        3803, 0.0
        *
        ** LIQUID ENTRAINMENT (path 41=PSV, path 42= B.V)
        *
        3811, 8, 16, 24, 2, 41, 42, 0.1, 0.69, 0.6
        3812, 2, 41, 16, 0, 42, 41, 0.1, 0.69, 0.6
        3813, 2, 42, 16, 0, 41, 42, 0.1, 0.69, 0.6
        3814, 2, 43, 16, 0, 41, 43, 0.1, 0.69, 0.6
        3815, 2, 44, 16, 0, 41, 44, 0.1, 0.69, 0.6
        *
        ** NODE MASS SUMMATIONS
        *
        3851,  4, 1,3,26,27
        3852, 24, 1,2,3,4,5,6,7,8,9,10,11,12,13,15,17,19,20,21,22,24,25,26,27,28
        3853,  1, 16
        3854,  1, 2
        3855,  1, 26
        3856,  2, 9, 19
        3857,  1, 7
        3858,  1, 15
        3859,  2, 6, 13
        *
        ** FLOW PATH SUMMATION
        *
SEBIM 3871, 5, 45,46,47,48,49
SEBIM 3872, 4, 41,42,43,44
        3873, 1, 18
        *
        ** WALL HEAT  :  1-D SLAB
        *
        *                    MCP          UA        BOT       TOP
        3901,  1, 1, 25278.501, 455.732,  0.001,  8.172, 0.
        3902, 27, 2,  3403.282, 760.354, 22.397, 28.145, 0.
        3903, 26, 2, 14750.449,4716.879, 28.147, 45.741, 0.
        3904, 26, 2,  1699.479, 476.053, 28.147, 41.843, 0.
        3905,  6, 2, 12074.262,  30.547, 15.916, 27.114, 0.
        3906, 21, 2, 12074.262,  30.547, 15.916, 27.114, 0.
        3907, 22, 2, 12074.262,  30.547, 15.916, 27.114, 0.
        3908, 24, 2, 12074.262,  30.547, 15.916, 27.114, 0.
```

```
3909,  4, 2,  3009.043,   11.992, 15.916, 28.223, 0.
3910, 11, 2,  3009.043,   11.992, 15.916, 28.223, 0.
3911, 12, 2,  3009.043,   11.992, 15.916, 28.223, 0.
3912, 13, 2,  3009.043,   11.992, 15.916, 28.223, 0.
3913,  4, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3914, 11, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3915, 12, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3916, 13, 2, 10706.623, 643.633, 22.025, 34.869, 0.
3917,  7, 2, 20974.537,1333.488, 24.116, 27.614, 0.
3918,  8, 2, 20974.537,1333.488, 24.116, 27.614, 0.
3919, 14, 2,133011.813, 905.938, 34.871, 97.087, 0.
3920, 16, 2,133011.813, 905.938, 34.871, 97.087, 0.
3921,  2, 2,  2626.088,   24.062, 27.616, 47.84 , 0.
*
** WALL HEAT TO STEAM (HEAT TRANSFER AREA)
*
3956, 1,3672.68, 2,2495.64, 3,7357.9, 4,600.0, 5,258.14, 6,258.14
3957, 7,258.14, 8,258.14, 9,137.67, 10,137.67, 11,137.67, 12,137.67
3958, 13,2235.46, 14,2235.46, 15,2235.46, 16,2235.46, 17,4416.76
3959, 18,4416.76, 19,5810.23, 20,5810.23, 21,300.0, 22,219.95
3960, 23,219.95, 24,361.75, 25,361.75, 26,361.75, 27,361.75, 28,20.74
*
** WALL HEAT : 1-D CYLINDRICAL
*
*                MCP          UA
3961,  7,   2, 7392.351,20.272,   0.0
3962,  8,   2, 7392.351,20.272,   0.0
3963,  5,   2,15807.372, 40.27,   0.0
3964, 15,   2,15807.372, 40.27,   0.0
3965, 17,   2,15807.372, 40.27,   0.0
3966, 25,   2,15807.372, 40.27,   0.0
3967, 28,   2,   195.98 , 3.803,   0.0
*
** DETAILED 2 D SLAB WALL HEAT
*
*          AREA       K      ALPHA
3971,  3, 1594.555,21.679, 0.333 , -1.,-1.,-1.,-1.,-1.
3972,  1, 4018.9   ,11.425, 0.175 , -1.,-1.,-1.,-1.,-1.
3973, 26, 1204.1   ,11.425, 0.175 , -1.,-1.,-1.,-1.,-1.
3974,  3, 1351.166,11.129, 0.172 , -1.,-1.,-1.,-1.,-1.
3975,  2, 1339.836,21.441, 0.322 , -1.,-1.,-1.,-1.,-1.
*
*      BOT      TOP
3981,  2.959,  37.572
3982, 22.397,  27.811
3983, 28.147,  45.741
3984,  6.344,  37.572
3985, 47.877,  98.194
*
*   THICK
3991, 1.007
```

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3992, 0.032
3993, 0.456
3994, 0.267
3995, 0.427
*
** FLOW PATHS
*
*   TY  FR  TO     FLOW       L/A      AREA      DH
4001, 8,  3,  1, 45202.78,  0.602 , 60.8    , 0.0403,  1.0, 1.0
4002, 8,  1,  8, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4003, 8,  1,  7, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4004, 8,  5,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4005, 8, 11, 21, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4006, 8, 12, 22, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4007, 8, 13,  6, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4008, 8,  7,  9, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4009, 8,  8, 10, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4010, 8, 20, 12, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4011, 8, 19, 11, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4012, 2, 21, 17, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4013, 8, 19, 13, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4014, 8,  5,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4015, 2,  6, 15, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4016, 5,  2,  8,      0.0 , 200.438,  0.559 , 0.844 ,  1.0, 1.0
4017, 2, 22,  5, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4018, 9, 14, 23,      0.0 ,  1.0   ,  1.0   , 1.0   ,  1.0, 1.0
4019, 8, 15,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4020, 9, 16, 23,      0.0 ,  1.0   ,  1.0   , 1.0   ,  1.0, 1.0
4021, 8, 17,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4022, 8, 10, 20, 23027.78,  1.166 , 27.39   , 0.0555,  1.0, 1.0
4023, 8,  9, 19, 23027.78,  1.166 , 27.39   , 0.0555,  1.0, 1.0
4024, 8,  1,  8, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4025, 8,  1,  7, 11513.89,  3.123 , 15.2    , 0.0403,  1.0, 1.0
4026, 8,  8, 10, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4027, 8,  7,  9, 11513.89,  3.453 , 13.695 , 0.0555,  1.0, 1.0
4028, 8, 15,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4029, 8, 17,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4030, 8, 20,  4, 11513.89,  3.497 , 13.695 , 0.0555,  1.0, 1.0
4031, 8,  4, 24, 11513.89,  2.289 ,  4.909 , 2.5    ,  1.0, 1.0
4032, 2, 24, 25, 11513.89,  4.977 ,  4.909 , 2.5    ,  1.0, 1.0
4033, 8, 25,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4034, 8, 25,  3,  5756.94,  6.395 ,  2.454 , 2.5    ,  1.0, 1.0
4035, 8,  3, 26,   241.67, 24.314 ,  0.106 , 0.3678,  1.0, 1.0
4036, 8,  3,  1,   611.11,  7.059 ,  0.106 , 0.3678,  1.0, 1.0
4037, 8,  1, 27,   366.67,  0.369 ,  0.369 , 0.6857,  1.0, 1.0
4038, 8, 27, 26,   366.67,  0.751 ,  7.779 , 3.1471,  1.0, 1.0
4039, 8, 26,  1,   608.33,  0.432 ,  1.571 , 1.4143,  1.0, 1.0
4040, 8, 28,  3,      0.0 ,  5.912 ,  0.394 , 0.7083,  1.0, 1.0
4041, 9,  2, 18,      0.0 ,  1.0   ,  1.0   , 1.0   ,  1.0, 1.0
*
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*     KF    KGF   KGR M C AREA      L    HT
4101, 0.0 ,19.0929,21.0913, 0, 1, 37.97   , 0.0 , 2.7979, 1
4102, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 3
4103, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 3
4104, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4105, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4106, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4107, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4108, 0.0 , 5.5723, 1.7409, 0, 1,  4.811  , 0.0 , 0.87  , 3
4109, 0.0 , 5.5723, 1.7409, 0, 1,  4.811  , 0.0 , 0.87  , 3
4110, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4111, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4112, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4113, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4114, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4115, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4116,1.725, 2.7549, 2.7549, 0, 1,  0.5595 ,124.52,0.1   , 1
4117, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4118, 1.0 ,  1.0  ,  1.0  , 0, 1,  1.0    , 1.0 , 1.0   , 1
4119, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4120, 1.0 ,  1.0  ,  1.0  , 0, 1,  1.00   , 1.0 , 1.0   , 1
4121, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4122, 0.0 , 0.2580, 0.2580, 0, 1, 27.3904 , 0.0 ,12.6013, 1
4123, 0.0 , 0.2580, 0.2580, 0, 1, 27.3904 , 0.0 ,12.6013, 1
4124, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 2
4125, 0.0 ,10.5019,15.4453, 0, 1,  4.8106 , 0.0 , 1.74  , 2
4126, 0.0 , 5.5723, 1.7409, 0, 1,  4.811  , 0.0 , 0.87  , 2
4127, 0.0 , 5.5723, 1.7409, 0, 1,  4.811  , 0.0 , 0.87  , 2
4128, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4129, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4130, 0.0 , 2.2179, 7.9949, 0, 1,  4.9087 , 0.0 , 0.1   , 1
4131, 0.0 , 0.2679, 0.2679, 0, 1,  4.9087 , 0.0 , 2.3   , 1
4132, 0.0 , 0.1014, 0.1014, 0, 1,  4.9087 , 0.0 , 2.44  , 1
4133, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.2   , 3
4134, 0.0 , 0.9241, 0.982 , 0, 1,  2.4544 , 0.0 , 1.24  , 2
4135, 0.0 , 2.8074, 2.8074, 0, 1,  0.1063 , 0.0 , 0.1   , 1
4136, 0.0 , 0.4472, 0.4472, 0, 1,  0.1063 , 0.0 , 3.5   , 1
4137, 0.0 , 3.5130, 2.8363, 0, 1,  0.3693 , 0.0 , 0.1   , 1
4138, 0.0 , 1.2965, 0.7554, 0, 1,  7.779  , 0.0 , 0.1   , 1
4139, 0.0 , 0.6493, 0.6494, 0, 1,  1.571  , 0.0 , 0.1   , 1
4140, 1.0 ,  1.0  ,  1.0  , 0, 1,  0.3941 , 2.33, 0.6483, 1
4141, 1.0 ,  1.0  ,  1.0  , 0, 1,  1.0    , 1.0 , 0.5124, 1
**************************************************************
*
** UPPER PLENUM FRICTIONAL LOSS
*
4180, 1, 22.597, 24.114, 0.92466, 1.39526, 20.61
*
** LEAK PATH (PATH 42) : bleed v/v
SEBIM 4242, 7, 2, 18, 2.0, 0.024319, 0.9,0.9,0.9,1.0, 0.207, 1,2200.0, 1
SEBIM 4243, 7, 2, 18, 2.0, 0.024319, 0.9,0.9,0.9,1.0, 0.207, 1,2200.0, 1
```

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SEBIM 4244, 7, 2, 18, 2.0, 0.024319, 0.9,0.9,0.9,1.0, 0.207, 1,1.0+6, 1
       *
       *
       ** FILL PUMP FLOW PATHS
       *
       ** HPSI (14.7 PSIA,120 deg F)
SEBIM 4445, 6, 1, 28, 1.0, 0.0, 87.97, 0.0, 1, 1
       *
       ** CHARGING PUMP (path 44,45 : before/after operator action)
       * (NOT USED)
SEBIM *4446, 6, 2, 15, 1.0 , 0.0, 459.11, 0.019595, 2, 2
SEBIM *4447, 6, 3, 15, 1.0 , 0.0, 87.97,     0.0, 3, 3
       *
       ** FOUR SIT TANKS ARE MODELED TO ONE (NOT USED)
       4546, 11,1,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
       4547, 11,2,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
       4548, 11,3,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
       4549, 11,4,28,87.97,0.6827,4.5,0.01617,642.5,1763.5,10.737, 0.01, 1.4
       *
       ** SIT INFORMATION (REM MODEL)
       4571, 0.0 ,0
       4572, 0.0 ,0
       4573, 0.0 ,0
       4574, 0.0 ,0
       *
       ** VARIABLE AREA VS. PRESSURE
       *
       ** SG SAFETY VALVE FLOW PATH
       4801, 18, 1, 0.0, 0.0, 0.0, 0.0, 0.0
       4802, 20, 1, 0.0, 0.0, 0.0, 0.0, 0.0
       *
       ** PZR SAFETY VALVE FLOW PATH
       4803, 41, 2, 0.0, 0.0, 0.0, 0.0, 0.0
       *
       ** MSSV VALVES FLOW PATH
       4811,    0.0,   0.0,   0.0   , 1200.0
       4812, 0.5177, 1201.0,  0.5177, 1235.0, 1.0342, 1236.0
       4813, 1.0342, 1260.0,  2.581 , 1261.0, 2.581 , 1.0+9
       *
       ** PRESSURIZER SAFETY VALVES
SEBIM 4821, 0.0,0.0, 0.0,1.0+9
       *
       ** MODIFICATION OF UPSTREAM AND DOWNSTREAM ELEVATION
       *
       *    PATH    UP      DOWN
       4901,  16,  27.715 , 27.505
       4902,  24,  25.865 , 25.865
       4903,  25,  25.865 , 25.865
       4904,  26,  26.735 , 35.84
       4905,  27,  26.735 , 35.84
       4906,   4,  25.865 , 25.865
```

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        4907,  28,  25.865 , 25.865
        4908,  29,  25.865 , 25.865
        4909,  34,  25.865 , 25.865
        4910,  35,  37.373 , 37.373
        4911,  36,  24.115 , 24.115
        4912,  37,  22.496 , 22.496
        4913,  38,  28.046 , 28.246
        4914,  39,  28.246 , 27.712
        4915,  40,  32.459 , 32.459
        4916,  41,  96.489 , 96.489
SEBIM 4917,  42,  97.686 , 97.686
SEBIM 4918,  43,  97.686 , 97.686
SEBIM 4919,  44,  97.686 , 97.686
        *
        ** LOOP SEAL VOIDING MODEL
        4951,  4, 31, 0
        4952, 24, 31, 0
        4953, 12,  6, 0
        4954, 22,  6, 0
        4955, 13,  7, 0
        4956,  6,  7, 0
        4957, 11,  5, 0
        4958, 21,  5, 0
        *
        ** LOOP SEAL SEQUENCING MODEL
        4959, 0, 5.0
        *
        ** VARIABLE AREA VS TIME TABLE (BLEED PATH FOR SINGLE FAILURE)
SEBIM *   (dummy for SEBIM MODEL)
SEBIM 4971, 0.0, 0.0,  0.0, 1.0+9
        *
        ** REACTOR CORE PARAMETERS
        *
        5001,1711.88,12.5,0.04029,188211.651,70958.0,1.,1.,1.,1.,1.,60.8
        *
        ** AXIAL POWER SHAPE
        *
        5191, 0.285, 0.550, 0.655, 0.720, 0.795, 0.925
        5192, 1.100, 1.355, 1.620, 1.600, 0.760
        *
        ** GENERAL CORE INFORMATION
        *
        5201, 2, 1, 1, 1, 2, 1.0, 0.01383, 0.00208, 1.0, 643.945,5.0
        5202, 20000.0, 1.0, 1, 1, 0, 0, 0, 0.0, 100.0, 0, 8.0
        *
        ** LYONOS THERMAL CONDUCTIVITY FOR UO2
        *
        5211, 0.0, 4009.416, 692.32, 6.1185-12,   0.0 , 0.0, 0.0
        *
        ** FUEL ROD GAP MATERIAL PROPERTIES
        *
```

```
5221, 3, 0.0, 0.424
*
** FUEL ROD MATERIAL REGION INFORMATION
*
5301, 1, 7, 1.0, 0.01356
5302, 3, 1, 0.0, 0.01383
5303, 2, 1, 0.0, 0.01592
*
** SCRAM PARAMETERS
6001, 1.0, 1.E+9, 1825.0, 1.15, 29.91, 3.0, 1.E+9, 2, 2, 1
*
** KINETIC PARAMETERS
*
6002, 3.03E-5, 1.0, 0.01, 1.0, 1.0, 2
*
** REACTIVITY VS TIME
*
6021,  .0000 , 0.00,  .00000, 0.50, -.00088, 1.21
6022, -.0021 , 1.58, -.00340, 1.92, -.00590, 2.22
6023, -.0081 , 2.55, -.01220, 2.86, -.01910, 3.20
6024, -.0324 , 3.60, -.05283, 4.00, -.10000, 4.67
6025, -.1000 , 1.+9
*
** DELAYED NEUTRON FRACTIONS
*
6031, 0.000255, 0.001512, 0.001388, 0.003054, 0.001096, 0.000261
*
** DECAY CONSTANTS OF DELAYED NEUTRONS
*
6041, 0.0127, 0.0317,  0.1181, 0.318, 1.403, 3.925
*
** 1979 ANS + 0 SIGMA CURVE (YGN 3,4 SPECIFIC FROM Y34-FE-0021)
*
6101,0.06967,    0.0, 0.06638,    1.0, 0.06215,    2.0
6102,0.05755,    4.0, 0.05454,    6.0, 0.05233,    8.0
6103,0.05063,   10.0, 0.04535,   20.0, 0.04235,   30.0
6104,0.04023,   40.0, 0.03862,   50.0, 0.03732,   60.0
6105,0.03623,   70.0, 0.03530,   80.0, 0.03449,   90.0
6106,0.03378,  100.0, 0.03259,  120.0, 0.03162,  140.0
6107,0.03080,  160.0, 0.03011,  180.0, 0.02950,  200.0
6108,0.02826,  250.0, 0.02729,  300.0, 0.02649,  350.0
6109,0.02580,  400.0, 0.02520,  450.0, 0.02465,  500.0
6110,0.02371,  600.0, 0.02291,  700.0, 0.02220,  800.0
6111,0.02157,  900.0, 0.02100,1000.0, 0.02001,1200.0
6112,0.01917,1400.0, 0.01844,1600.0, 0.01779,1800.0
6113,0.01722,2000.0, 0.01513,3000.0, 0.01378,4000.0
6114,0.01283,5000.0, 0.01157,7000.0, 0.01044,10000.
6115,0.00999,14000., 0.00912,20000., 0.00721,50000.0
*
** STEAM GENERATORS SHUTDOWN PARAMETERS
*
```

```
7011, 1.0, 1.E+9, 1.0, 1.E+9,  0.02, 3.0, 1.E+9, 14, 2
7012, 1.0, 1.E+9, 1.0, 1.E+9, 29.91, 3.0, 1.E+9, 14, 2
7013, 1.0, 1.E+9, 1.0, 1.E+9,  0.02, 3.0, 1.E+9, 16, 2
7014, 1.0, 1.E+9, 1.0, 1.E+9, 29.91, 3.0, 1.E+9, 16, 2
*
** STEAM GENERATOR PARAMETERS
*
7041, 1, 1, 0, 0.0, 1, 0, 1
*
** SECONDARY NODE INFORMATION
*
7101, 14, 2453.56, 0.0625, 0.0555, 42.46, 0.082, 0
7102, 16, 2453.56, 0.0625, 0.0555, 42.46, 0.082, 0
*
** PRIMARY NODE INFORMATION
*
7105, 10, 1246866.7, 1.0, 70675.762, 31.95, 22, 14929.87
7106, 20,  623433.4, 1.0, 70675.762, 31.95, 22, 14929.87
7108,  9, 1246866.7, 1.0, 70675.762, 31.95, 23, 14929.87
7109, 19,  623433.4, 1.0, 70675.762, 31.95, 23, 14929.87
*
** SG LOCAL HEAT TRANSFER COEFFICIENTS
*
7301, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
*
** U-TUBE THERMAL CONDUCTIVITY
*
7321, -1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
*
** SG OPERATION VS TIME (HEAT LOAD AND ENTHALPY)
** SG 1
7401,    0.0,1.0, 1.0,430.62
7402, 1.0+6,1.0, 1.0,430.62
*
7421,    0.0,1.0, 1.0,430.62
7422,  0.02,1.0, 0.0,430.62
7423,  1.+6,1.0, 0.0,430.62
*
7441,  0.0 ,1.0, 0.0,430.62
7442,  0.30,0.0, 0.0,430.62
7443,  1.+6,0.0, 0.0,430.62
*
** SG2
7461,    0.0,1.0, 1.0,430.62
7462, 1.0+6,1.0, 1.0,430.62
*
7481,    0.0,1.0, 1.0,430.62
7482,  0.02,1.0, 0.0,430.62
7483,  1.+6,1.0, 0.0,430.62
*
7501,  0.0 ,1.0, 0.0,430.62
```

7502, 0.30,0.0, 0.0,430.62
7503, 1.+6,0.0, 0.0,430.62
*
** COUNTER-CURRENT FLOODING IN SG AND HOT LEG
*
7570, 0.725, -0.7, 0.7, 0.00308
*
** RCS PUMPS CONDITIONS
*
8000, 1.0, 0, 1.0, 0, 1.0, 0, 1.0, 0
*
** RATED PUMP CONDITIONS
*
8001, 124.757, 369.07, 46.5, 45321.951, 147401.0, 0.0
8002, 0.0, 0.962659, 1.001102, 1.033150
*
** PUMP SHUTDOWN PARAMETERS
8011, 1825.0, 1.E+9, 629.91, 3.0, 1.0+9, 2, 1
*
** PUMP HOMOLOGOUS CURVES
*
** TORQUE
*
8021, .68, .71, .73, .76, .80, .83
8022, .86, .89, .92, .96, 1.00
8031, -.82, -.58, -.40, -.24, -.08, .08
8032, .26, .44, .62, .80, 1.00
8041, .68, .82, 1.0, 1.23, 1.48, 1.76
8042, 2.06, 2.34, 2.66, 2.98, 3.32
8051, 1.78, 1.99, 2.12, 2.19, 2.20, 2.24
8052, 2.39, 2.58, 2.80, 3.04, 3.32
8061, -1.34, -1.14, -.95, -.74, -.54, -.37
8062, -.20, -.02, .16, .34, .52
8071, 1.78, 1.58, 1.42, 1.30, 1.20, 1.12
8072, 1.06, .86, .84, .70, .52
8141, -1.34, -1.54, -1.82, -2.09, -2.42, -2.70
8142, -3.03, -3.36, -3.74, -4.10, -4.51
8151, -.82, -1.07, -1.38, -1.68, -2.00, -2.33
8152, -2.70, -3.07, -3.50, -3.97, -4.51
*
** HEAD
*
8081, 1.30, 1.30, 1.29, 1.28, 1.27, 1.24
8082, 1.21, 1.17, 1.12, 1.08, 1.00
8091, -1.08, -.92, -.75, -.56, -.36, -.17
8092, .06, .27, .50, .76, 1.00
8101, 1.30, 1.38, 1.56, 1.75, 1.98, 2.24
8102, 2.52, 2.80, 3.10, 3.40, 3.72
8111, 1.77, 1.94, 2.08, 2.16, 2.24, 2.32
8112, 2.40, 2.52, 2.70, 3.30, 3.72
8121, .29, .30, .31, .34, .35, .40

8122, .48, .58, .69, .87, 1.08
8131, 1.77, 1.58, 1.40, 1.26, 1.19, 1.14
8132, 1.09, 1.07, 1.05, 1.06, 1.08
8161, .29, .28, .26, .20, .13, 0.0
8162, -.168, -.41, -.60, -.907, -1.207
8171, -1.08, -1.18, -1.26, -1.32, -1.34, -1.35
8172, -1.36, -1.35, -1.31, -1.26, -1.207
*
** TWO-PHASE PUMP HEAD DEGRADATION MULTIPLIER
*
8201, 0.0,0.0, -0.06,0.07, -0.06,0.12, 0.07,0.2, 0.361,0.3
8202, 0.564,0.4, 0.734,0.5, 0.883,0.6, 0.995,0.7, 0.995,0.8
8203, 0.775,0.9, 0.52,0.95, 0.0,1.0
8221, 0.0,0.0, 0.6,0.1, 1.0,0.2, 0.985,0.25, 0.815,0.4
8222, 0.745,0.5, 0.685,0.6, 0.59,0.7, 0.463,0.8, 0.31,0.9
8223, 0.0,1.0
*
** RCP ON/OFF CONTROL VS TIME
*
8251, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
8261, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
8271, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
8281, 1.0, 0.0, 1.0, 629.91, 0.0, 629.91, 0.0,1.0+9
*
** ELECTRICAL TORQUE VS PUMP SPEED
*
8311, 87251.8 ,-50.27, 99497.67, 62.83, 119397.2 , 87.96
8312, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8313, 179095.8 ,119.38, 147715.77,121.89, 45922.0 ,124.62
8314, 0.0 ,125.66
8315, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
8316,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
8317,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
*
8321, 87251.8 ,-50.27, 99497.67, 62.83, 119397.2 , 87.96
8322, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8323, 179095.8 ,119.38, 147715.77,121.89, 45922.0 ,124.62
8324, 0.0 ,125.66
8325, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
8326,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
8327,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
*
8331, 87251.8 ,-50.27, 99497.67, 62.83, 119397.2 , 87.96
8332, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8333, 179095.8 ,119.38, 147715.77,121.89, 45922.0 ,124.62
8334, 0.0 ,125.66
8335, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
8336,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
8337,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
*
8341, 87251.8 ,-50.27, 99497.67, 62.83, 119397.2 , 87.96

```
8342, 177565.07,113.1 , 184453.37,115.61, 187514.83,117.37
8343, 179095.8 ,119.38, 147715.77,121.89,  45922.0 ,124.62
8344,       0.0 ,125.66
8345, -45922.0 ,126.71,-147715.77,129.43,-179095.8 ,131.95
8346,-187514.83,133.96,-184453.37,135.72,-177565.07,138.23
8347,-119397.2 ,163.36, -99497.67,188.5 , -87251.8 ,301.59
*
** TWO-PHASE PUMP DIFFERENCE HOMOLOGOUS CURVES (HEAD)
*
8401,  1.08 ,   1.048,  1.008,  0.971,  0.925,  0.906
8402,  0.871,   0.875,  0.889,  0.890,  0.834
8411,  0.034,   0.087,  0.147,  0.237,  0.400,  0.419
8412,  0.370,   0.356,  0.490,  0.669,  0.834
8421,  1.08 ,  -1.611, -1.634, -1.651, -1.669, -1.68
8422, -1.709,  -1.749, -1.754, -1.726, -1.68
8431, -0.445,  -0.421, -0.423, -0.571, -0.686, -0.817
8432, -0.96 ,  -1.109, -1.28 , -1.44 , -1.68
8441,  0.001,   0.001,  0.001,  0.001,  0.001,  0.001
8442,  0.001,   0.001,  0.001,  0.001,  0.001
8451,  -.445,   -.445,  0.001,  0.001,  0.001,  0.001
8452,  0.001,   0.001,  0.001,  0.001,  0.001
8461,  0.001,   0.001,  0.001,  0.001,  0.001,  0.001
8462,  0.001,   0.001,  0.001,  0.001,  0.001
8471,  0.034,   0.001,  0.001,  0.001,  0.001,  0.001
8472,  0.001,   0.001,  0.001,  0.001,  0.001
*
** FILL SYSTEM ACTUATION PARAMETERS
*
      10001, 0.1, 1825.0, 2, 2, 100.0, 100.0
SEBIM *10002, 0.1,  1.E+9, 2, 2, 100.0, 100.0
SEBIM *10003, 0.1,  1.E+9, 2, 2, 100.0, 100.0
*
** FILL SYSTEM TIME DELAYS
*
      10011, 1.0+9, 40.0, 1.0+9
SEBIM *10012, 1.0+9, 1.+9, 0.01
SEBIM *10013, 1.0+9, 1.+9, 0.01
*
** FILL SYSTEM PUMP CHARACTERISTICS
*
* HPSI (pump #1)
10021, 1104.0 ,    34.7, 1098.0 ,   54.7
10022, 1094.0 ,    74.7, 1090.0 ,   94.7, 1086.0 ,  114.7
10023, 1082.0 ,   134.7, 1072.0 , 154.7, 1067.97,  174.7
10024, 1064.44,   189.7, 1056.0 , 214.7, 1050.95,  229.7
10025, 1047.9 ,   244.7, 1029.0 , 314.7, 1004.0 ,  414.7
10026,  914.0 ,   614.7,  818.67, 814.7,  769.0 ,  914.7
10027,  716.0 ,  1014.7,  604.0 ,1214.7,  477.33, 1414.7
10028,  373.18,  1514.7,  330.74,1553.7,  266.0 , 1614.7
10029,    0.0 ,  1834.7,    0.0 , 1.E+9
*
```

```
       * CHARGING PUMP (BEFORE OPERATOR INTERVENTION : pump #2)
SEBIM *10031, 120.0, 0.0, 120.0, 1.E+9
       *
       * CHARGING PUMP (AFTER OPERATOR INTERVENTION  : pump #3)
SEBIM   *10041, 120.0, 0.0, 120.0, 1.E+9
       *
       ** FILL FLOW MULTIPLIERS (single failure)
       *
       10101, 2.0, 0.0,  2.0, 1.0+9
SEBIM *10111, 0.0, 0.0,  0.0, 1.0+9
SEBIM *10121, 0.0, 0.0,  0.0, 1.0+
       *
       ** MODREATOR DENSITY REACTIVITY TABLE
       *
       11001, 0.0, 0.0,  0.0,  100.0
       *
       ** DOPPLER REACTIVITY TABLE
       *
       11011, 0.0148, 100.0, 0.0131, 200.0, 0.0115, 300.0, 0.0100, 400.0
       11012, 0.0085, 500.0, 0.0079, 550.0, 0.0072, 600.0, 0.0059, 700.0
       11013, 0.0046, 800.0, 0.0033, 900.0, 0.0020,1000.0, 0.0009,1100.0
       11014, -.0002,1200.0, -.0035,1500.0, -.0083,2000.0, -.0128,2500.0
       11015, -.0175,3000.0, -.0221,3500.0, -.0267,4000.0, -.0359,5000.0
       *
       .
      0.1
KNGR FEED/BLEED TRANSIENT (SINGLE FAILURE)
TLOFW F&B ANALYSIS  SF0001
        0          0           0
        1
 POWER NODE 1
 0.20      6.0       0.0               1
  600.0    5.0       0.0
        3
 PRESSURE NODE  1
 500.0     6.0         0.0             1
  600.0    5.0       0.0
 PRESSURE NODE  2
 500.0     6.0         0.0             2
 PRESSURE NODE 14
 250.0     6.0         0.0             14
       20
 FLOW RATE PATH  1
 10000.    6.0      -10000.0           1
 FLOW RATE PATH 12
 3000.     6.0       -3000.0           12
 FLOW RATE PATH 16
 300.0     6.0       -900.0            16
 FLOW RATE PATH 18
 300.0     6.0       -900.0            18
 FLOW RATE PATH 42
```

100.0 6.0 -50.0 42
FLOW RATE PATH 43
50.00 6.0 -50.0 43
FLOW RATE PATH 44
50.00 6.0 -50.0 44
FLOW RATE PATH 45
50.00 6.0 -50.0 45
FLOW RATE PATH 2
3000. 6.0 -3000.0 2
FLOW RATE PATH 24
3000. 6.0 -3000.0 24
FLOW RATE PATH 9
3000. 6.0 -3000.0 9
FLOW RATE PATH 26
3000. 6.0 -3000.0 26
FLOW RATE PATH 14
1500. 6.0 -1500.0 14
FLOW RATE PATH 4
1500. 6.0 -1500.0 4
FLOW RATE PATH 10
3000. 6.0 -3000.0 10
FLOW RATE PATH 6
3000. 6.0 -3000.0 6
FLOW RATE PATH 35
100. 6.0 -100.0 35
FLOW RATE PATH 36
150. 6.0 -150.0 36
FLOW RATE PATH 37
100. 6.0 -100.0 37
FLOW RATE PATH 39
150.0 6.0 -150.0 39
15
MIX. LEVEL NODE 1
10.0 6.0 0.0 1
COL. LEVEL NODE 1
10.0 6.0 0.0 -1
SUB. LEVEL NODE 1
10.0 6.0 0.0 101
MIX. LEVEL NODE 14
10.0 6.0 0.0 14
MIX. LEVEL NODE 2
10.0 6.0 0.0 2
COL. LEVEL NODE 2
10.0 6.0 0.0 -2
MIX. LEVEL NODE 3
10.0 6.0 0.0 3
MIX. LEVEL NODE 5
1.0 6.0 0.0 5
MIX. LEVEL NODE 8
1.0 6.0 0.0 8
MIX. LEVEL NODE 10

```
10.0      6.0       0.0                 10
MIX. LEVEL NODE 20
10.0      6.0       0.0                 20
MIX. LEVEL NODE 12
5.0       6.0       0.0                 12
MIX. LEVEL NODE 22
5.0       6.0       0.0                 22
MIX. LEVEL NODE 26
5.0       6.0       0.0                 26
MIX. LEVEL NODE 27
2.0       6.0       0.0                 27
      0
      4
COOLANT TEMP NODE 1
50.0      6.0       400.0                1
SUBCOOL TEMP NODE 1
50.0      6.0       400.0               -1
COOLANT TEMP NODE 2
50.0      6.0       400.0                2
COOLANT TEMP NOD 14
50.0      6.0       400.0               14
     4
QUALITY NODE  1
.2        6.0      -0.2                  1
QUALITY NODE  2
.2        6.0      -0.2                  2
QUALITY NODE  5
.2        6.0      -0.2                  5
QUALITY NODE  8
.2        6.0      -0.2                  8
     5
QUALITY PATH 16
.2        6.0      -0.2                 16
QUALITY PATH 41
.2        6.0      -0.2                 41
QUALITY PATH 42
.2        6.0      -0.2                 42
QUALITY PATH 43
.2        6.0      -0.2                 43
QUALITY PATH 44
.2        6.0      -0.2                 44
     9
REACTOR VESSEL MASS
 50.0      6.0       0.0        -1        1
PRIMARY SYSTEM MASS
 150.0     6.0       0.0        -2        1
STEAM GENERATOR 2RY MASS
 50.0      6.0       0.0        -3        1
PRESSURIZER MASS
 50.0      6.0       0.0        -4        1
RV UPPER HEAD MASS
```

50.0	6.0	0.0	-5	1

SG U-TUBES MASS

50.0	6.0	0.0	-6	1

INTEGRAL ECCS MASS

200.0	6.0	-200.0	-1	13

INTEGRAL OUTLET FLOW

200.0	6.0	-200.0	-2	13

INTEGRAL MSSV FLOW

200.0	6.0	-200.0	-3	13

1

TIME STEPS

0.1	6.0	-0.1	1

서 지 정 보 양 식

수행기관보고서번호	위탁기관보고서번호	표준보고서번호	INIS 주제코드
KAERI/TR-1233/99			

제목 / 부제	차세대원자로 안전감압계통의 POSRV 채택에 관한 타당성 연구
연구책임자 및 부서명 (AR,TR일 경우 주저자)	권영민 (차세대원자로 기술개발 계통안전해석)
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초록 (15-20줄내외)

한국형 차세대원자로 (KNGR)는 완전급수상실사고 (TLOFW)나 중대사고와 같은 설계기준초과사고시 RCS를 급격히 감압하기 위하여 안전감압계통(SDS)을 설계에서 채택하고 있다. KNGR SDS에는 SYSTEM 80+ 형태의 방출밸브를 사용하는 경우와 POSRV를 사용하는 경우 두 가지 설계 방안이 검토되고 있다. 두번째 방안은 Power Operated Safety Relief Valve (POSRV)를 사용하여 급속감압과 과압방지 두 기능을 함께 수행하는 설계이다.

본 보고서의 목적은 KNGR SDS에 프랑스식 세빔 POSRVs의 채택 가능성을 검토하는 것이다. 세빔밸브를 사용하는 경우의 TLOFW 해석방법론 및 최적설계코드인 CEFLASH-4AS/REM 전산코드를 사용하여 TLOFW 사고와 충전/유출 운전 (Feed & Bleed)을 모의한 결과에 대하여 논의하였다. 방출밸브로서 3개의 Monobloc Sebim POSRV를 사용하였을 때, 고온관이 포화온도에 도달하기 전에 운전원이 두 개의 밸브와 네 대의 HPSI 펌프를 동시에 작동시켜서 충전-유출 운전을 시작하면, 붕괴열 제거와 노심의 냉각재 보충이 성공적으로 수행되었다. 해석결과에 의하면 양쪽 SDS 설계방안 모두 TLOFW 사고시 충분한 여유도를 확보하고 있음을 알 수 있었다. 따라서 POSRV를 한국형 차세대 원자로의 안전감압계통 설계에 채택하는 방안의 가능성이 입증되었다. 그러나 Sebim POSRV는 급속감압과 과압방지 기능을 함께 수행하는 장치이므로 과압 설계기준사고 측면에서 사용 타당성이 검증되어야 한다.

주제명키워드 (10단어내외)	안전감압계통, 완전급수상실사고, 차세대원자로, CEFLASH-4AS/REM, 충전 및 유출운전

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Abstract (15-20 Lines)

The Korean Next Generation Reactor (KNGR) adopted an advanced design feature of safety depressurization system (SDS) to rapidly depressurize the reactor coolant system (RCS) in case of beyond design basis events of severe accidents, or a highly unlikely event of a total loss of feedwater (TLOFW) to both steam generators. Two design approaches were considered for the KNGR SDS design. The use of bleed valves similar to those of ABB-CE's System 80+ is design option 1, while in design option 2, the Power Operated Safety Relief Valve (POSRV) is considered to provide the combined function of overpressure protection and rapid depressurization.

The purpose of this report is to investigate the feasibility of adoption of French Sebim POSRVs for KNGR SDS (design option 2). This report provides the methodology to analyze the TLOFW event with Sebim valves and presents the results of thermal hydraulic analyses using a best-estimate version of CEFLASH-4AS/REM for the TLOFW event with feed and bleed. The analyses were performed using a preliminary KNGR design data. For design option 2, if the operator opens two out of the three Sebim valves in conjunction with the four HPSI pumps before a hot leg saturation condition, the decay heat removal and core inventory make-up function can be successfully accomplished. The results of the present investigation demonstrate that the two design options are both feasible to mitigate the consequences of the TLOFW event with a sufficient margin.

Subject Keywords	Total loss of feedwater, Safety Depressurization System, POSRV, CEFLASH-4AS/REM, Feed and Bleed,