14.5 LOSS OF LOAD EVENT

14.5.1 IDENTIFICATION OF EVENT AND CAUSE

The primary function of the turbine stop valves (throttle valves on Unit 2) are to quickly shut off steam flow to the high pressure turbine. There are four valves in parallel off a common header which are located upstream of the turbine control valves (governor valves on Unit 2) and downstream of the MSIVs. The quick closure of the stop valves prevents overspeeding the turbine when there is a turbine trip. A turbine trip can be the result of a reactor trip, loss of electrical load, loss of condenser vacuum, low oil pressure, etc.

A Loss of Load event is defined as any event that results in a reduction in the SGs heat removal capacity through the loss of secondary steam flow. Closure of all MSIVs, turbine stop valves, or turbine control valves will cause a Loss of Load event. Of the three types of valves in the steam lines between the SG and the high pressure turbine, the turbine stop valves have the quickest closure time.

The most limiting Loss of Load event for primary system overpressure is a turbine trip without a concurrent reactor trip or an inadvertent closure of the turbine stop valves at HFP. A turbine trip would result in the closure of the turbine stop valves.

14.5.2 SEQUENCE OF EVENTS

A Loss of Load event can result in an approach to the DNBR and LHGR SAFDLs and the RCS Pressure Upset Limit. The action of the TM/LP, the Variable High Power, or the High Pressurizer Pressure Trip will prevent exceeding these limits. Since no fuel pin failures are postulated to occur, the site boundary dose criteria in the 10 CFR 50.67 guidelines will not be approached.

The most limiting criteria for the Loss of Load event are the RCS and Secondary Pressure Upset Limit of 110% of design. Normally the non-safety grade turbine trip would initiate a reactor trip and lessen the peak pressure. In analyzing this event, no credit is allowed for this trip (Section 7.2.3.8).

A Loss of Load event is initiated at HFP by the termination of steam flow to the turbine. The immediate system response is a rapid increase in SG pressure and temperature with the RCS adding heat and without any steam being extracted from the SG. To maximize the pressure and temperature increase, no credit is allowed for the Steam Dump and Bypass System (SDBS) which would reduce the pressure transient. With the SDBS inoperable, the secondary pressure will rapidly reach the SG safety valve analysis setpoints.

With the inability of the SG to remove the heat from the RCS, the RCS temperature will rapidly begin to increase. The pressurizer pressure and level will increase with the increasing RCS temperature. To maximize RCS pressure no credit is taken for the pressurizer pressure and level control system. Consequently, the pressure will rapidly approach the PORV analysis setpoint and the High Pressurizer Pressure Analysis Trip setpoint. To maximize the peak RCS pressure, no credit is taken for the action of the PORVs.

To maximize secondary peak pressure, credit is taken for the pressurizer pressure control system. This will delay the high pressurizer pressure trip and thus add more energy to the secondary system.

The analysis assumes a positive MTC which will add positive reactivity with the increasing RCS temperature. The MTC is normally negative at HFP. The core power and core average heat flux will increase and further increase the rate of the primary system pressurization.

A High Pressurizer Pressure Trip will be initiated when the pressure reaches the analysis setpoint. The reactor trip will terminate the core power increase after some delay reflecting RPS response, CEA holding coil, and CEA insertion time intervals. The core power will then rapidly decrease to the decay power level. The core average heat flux will follow the core power but will lag the core power due to the fuel time constant.

After the reactor trip, the pressurizer pressure will continue to increase and approach the PSVs' opening pressure analysis setpoint. This is caused by the above-mentioned delays and the core heat flux lagging behind the core power, which results in additional heat being added to the coolant.

The pressurizer pressure will peak and then start to rapidly decrease once the heat flux decays as the SGs begin removing heat through the MSSVs. Consequently, PSVs that opened will close.

The RCS temperatures will slowly decrease and approach the saturation temperature corresponding to the lowest MSSV pressure analysis setpoint.

14.5.3 CORE AND SYSTEM PERFORMANCE

14.5.3.1 Mathematical Models

The NSSS response to the Loss of Load event was simulated using the S-RELAP5 computer code described in Section 14.1.4.2.

14.5.3.2 Input Parameters and Initial Conditions

The input parameters and initial conditions used in the analysis to maximize peak RCS pressure are listed in Table 14.5-1 for the present cycles of Unit 1 and Unit 2. The input parameters and initial conditions used in the analysis to maximize peak secondary pressure are listed in Table 14.5-3. Those parameters, which are unique to the analysis, are discussed below.

The most positive MTC was assumed. This MTC, in conjunction with the increasing coolant temperatures, maximizes the rate of change of heat flux and the pressure at the time of reactor trip. A FTC corresponding to BOC conditions was used in the analysis. This FTC causes the least amount of negative reactivity feedback to mitigate the transient increases in both the core heat flux and the pressure. The uncertainty on the FTC used in the analyses is shown in Table 14.5-1. Sensitivity studies were performed to determine the most limiting set of initial conditions, provided in Tables 14.5-1 (RCS Pressure) and 14.5-3 (Secondary Peak Pressure). Pressurizer pressure and level, SG level, RCS inlet temperature and RCS flow rate were ranged, one parameter at a time. The most limiting set of initial conditions is provided in the Tables. The lower limit on initial RCS pressure is used to maximize the rate of change of pressure, and thus peak pressure, following trips. For the case to maximize RCS peak pressure, the lower limit on T_{in} is assumed, which results in a lower initial second pressure, delays the opening of MSSVs, and maximizes RCS pressure.

14.5.3.3 Results

The Loss of Load event has been analyzed to ensure that the significant pressure increase experienced during the event remains below 110% of design. Table 14.5-2 contains the sequence of events to calculate maximum RCS pressure. Figures 14.5-1 through 14.5-6 present the transient core power, core average heat flux, RCS pressure, RCS temperature behavior, SG pressure, and pressurizer water volume.

Table 14.5-4 contains the sequence of events for the maximum peak secondary pressure analysis. No additional parameter plots for this case are provided as they are very similar to Figures 14.5-1 through 14.5-6.

The results show the peak RCS pressure and peak secondary pressure remain below 110% of design. Due to the prominent pressure spike combined with the limited power increase, the minimum DNBR and peak LHR will not challenge the SAFDLs. As such, no explicit calculations are included for this event. Cases were analyzed to verify the applicability of the MSSV out-of-service power levels as stated in the Technical Specifications and to determine the peak pressurizer level following a Loss of Load. The radiological consequences of opening the MSSVs during the most adverse Loss of Load event are less adverse than the LOAC event.

14.5.4 CONCLUSIONS

The analysis of the Loss of Load event demonstrates that the action of the High Pressurizer Pressure Trip, PSVs, and MSSVs is sufficient to ensure that the integrity of the RCS and Main Steam System are maintained without any credit for the SDBS and the pressurizer PORVs. The radiological consequence of opening the MSSVs during the event is a site boundary dose which is negligible compared to the 10 CFR 50.67 guidelines.

TABLE 14.5-1

INITIAL CONDITIONS AND INPUT PARAMETERS FOR THE LOSS OF LOAD EVENT TO CALCULATE MAXIMUM RCS PRESSURE

PARAMETER	UNITS	VALUE
Initial Core Power Level	MWt	2754[b]
Initial Core Inlet Coolant Temperature	°F	546
Vessel Flow Rate	gpm	412,000
Initial PZR Pressure	psia	2164[a]
Initial Pressurizer Liquid Level	---	67.2% span
Initial SG Pressure	psia	N/A
Initial SG Level	%NR	69
MTC	X 10^{-4} $\Delta\rho$/°F	+0.15
Doppler Coefficient	X 10^{-4} $\Delta\rho$/°F	-0.08[e]
Doppler Coefficient Uncertainty	%	N/A
Number of Plugged SG Tubes	%	10
Axial Shape Index	---	N/A
CEA Worth at Trip	% $\Delta\rho$	-5.0
Time to 90% Insertion of SCRAM Rods	sec	3.1
RRS	Operating Mode	Manual
SDBS	Operating Mode	Inoperative
MSSV Opening Pressure	psia	1029.25
Pressurizer Pressure Control System	Operating Mode	Manual
Pressurizer Level Control System	Operating Mode	Manual
Turbine Stop Valve Stroke Time	Sec	0.0[d]

(a) Corresponds to Technical Specification minimum indicated pressure of 2200 psia. The value includes an uncertainty on indicated pressurizer pressure.

(b) Value does not include 17 MWt of pump heat.

(c) Deleted.

(d) A faster turbine stop valve stroke time results in higher peak primary pressure.

(e) The Doppler reactivity feedback includes an uncertainty of 10%.

TABLE 14.5-2

SEQUENCE OF EVENTS FOR LOSS OF LOAD EVENT TO MAXIMIZE CALCULATED RCS PEAK PRESSURE

TIME (sec)	EVENT	SETPOINT OR VALUE
0.0	Event Initiation	---
5.2, 5.5	MSSVs Open	---
6.17	High Pressurizer Pressure Trip Setpoint	2420 psia
7.55	Peak Reactor Power	102.5% RTP
7.58	CEAs Begin to Insert	---
8.10	PSV RC-200 Opens	---
8.87	PSV RC-201 Opens	---
8.75	Peak RCS Pressure	2706.6 psia
9.2	Peak Secondary Pressure	1094.8 psia
10.8	PSVs RC-201 Closes	---
11.25	Peak Pressurizer Level	75.32% span
11.6	PSVs RC-200 Closes	---
14.55	Peak Reactor Vessel Inlet Temperature	565.9

TABLE 14.5-3

INITIAL CONDITIONS AND INPUT PARAMETERS FOR THE LOSS OF LOAD EVENT TO CALCULATE MAXIMUM SECONDARY PRESSURE

PARAMETER	UNITS	VALUE
Initial Core Power Level	MWt	2754[b]
Initial Core Inlet Coolant Temperature	°F	550
Vessel Flow Rate	gpm	370,000
Initial PZR Pressure	psia	2164[a]
Initial Pressurizer Liquid Level	---	32.2% span
Initial SG Pressure	psia	N/A
MTC	$X\ 10^{-4}\ \Delta\rho/°F$	+0.15
Doppler Coefficient	$X\ 10^{-4}\ \Delta\rho/°F$	-0.08[d]
CEA Worth at Trip	$\%\ \Delta\rho$	-5.0
Number of Plugged SG Tubes	%	0
Time to 90% Insertion of SCRAM Rods	sec	3.1
RRS	Operating Mode	Manual
SDBS	Operating Mode	Inoperative
MSSV Opening Pressure	psia	1029.25
Pressurizer Pressure Control System	Operating Mode	Auto
Pressurizer Level Control System	Operating Mode	Auto
Turbine Stop Valve Stroke Time	sec	0.15-2[c]

(a) Corresponds to Technical Specification minimum indicated pressure of 2200 psia. The value includes an uncertainty on indicated pressurizer pressure.

(b) Value does not include 17 MWt of pump heat.

(c) A range of turbine stop valve stroke times between 0.15 seconds and 2 seconds has been analyzed.

(d) The Doppler reactivity feedback includes an uncertainty of 10%.

TABLE 14.5-4

SEQUENCE OF EVENTS FOR LOSS OF LOAD EVENT TO MAXIMIZE CALCULATED SECONDARY PEAK PRESSURE

TIME(sec)	EVENT	SETPOINT OF VALUE
0.0	Event Initiation	---
8.2	SG Safety Valves Begin to Open	1029.35 psia
15.4	High Pressurizer Pressure Trip Setpoint	2420 psia
16.2	Peak Reactor Power	102.8% RTP
16.3	Trip Breakers Open	Setpoint + 0.9 sec
16.8	CEA Insertion Begins	Breakers open + 0.5 sec
18.6	Peak RCS Pressure[a]	2517.2 psia
19.8	Peak Pressurizer Level	44.1% span
22.6	Peak Secondary Pressure[a]	1101.8 psia
24.6	Peak Reactor Vessel Inlet Temperature	568.8

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[a] Peak Pressure includes elevation head.