14.26 <u>FEEDLINE BREAK EVENT</u>

14.26.1 IDENTIFICATION OF EVENT AND CAUSE

A Feedline Break (FLB) may occur as a result of thermal stress or cracking in the main feedline. The guillotine-type break assumed in the Safety Analysis is the most adverse transient scenario and its probability of occurrence is extremely low. Installation of a safety-grade AFAS forced the inclusion of this event into the scope of DBEs.

The safety-grade AFAS consists of two components.

a. Automatic initiation of AFW to both SGs is based on a low level signal from either one of the SGs. This signal is generated when the water level in either SG decreases below a nominal analysis setpoint value based on wide range level indication.

b. Isolation logic identifies and isolates a ruptured SG. A SG with lower pressure (in comparison to the other SG) is identified as being ruptured and is isolated when the SG differential pressure (i.e., P^{SG}[A] - P^{SG}[B]) exceeds the analysis setpoint value. The safety analysis was performed by including appropriate uncertainties to the nominal analysis setpoint.

The FLB event is analyzed to demonstrate that the RCS pressure limit of 2750 psia is not exceeded and that the site boundary doses do not exceed 10 CFR 50.67 guidelines. The event was analyzed with Loss of AC Power on turbine trip for primary system overpressure and without Loss of AC Power on turbine trip for secondary system overpressure and decay heat removal by AFW. A spectrum of break sizes were considered in the primary system overpressure analysis and the results of the limiting break size are presented here.

14.26.2 SEQUENCE OF EVENTS

The FLB event is initiated by a break in the MFW System piping. Depending on the break size and location and the response of the MFW System, the effects of a break can vary from a rapid heatup to a rapid cooldown of the RCS. In order to discuss the possible effects, breaks are categorized as small if the associated discharge flow is within the excess capacity of the MFW System, and as large if otherwise. Break locations are identified with respect to the feedwater line reverse flow check valve. The reverse flow check valve of concern is located between the SG feedwater nozzle and the containment penetration. Closure of the check valve, to prevent reverse flow from the SG, maintains the heat removal capability of that SG in the presence of a break upstream of the check valve.

Feedwater line breaks upstream of the reverse flow check valve can initiate one of the following transients. A break of any size, with MFW System unavailable, will result in a LOFW Flow event. A small pipe break with MFW System available will result in no reduction in feedwater flow. Depending on the break size, a large break with MFW System available will result in either a partial or a total LOFW Flow event. Since FLBs upstream of the reverse flow check valve result in transients no more severe than a LOFW Flow event, these FLBs were not analyzed.

In addition to the possibility of partial or total LOFW flow, FLBs downstream of the check valve have the potential to establish reverse flow from the affected SG back to the break. Reverse flow occurs whenever the MFW System is not operating subsequent to a pipe break, or when the MFW System is operating, but without sufficient capacity to maintain pressure at the break above the SG pressure. Feedline Breaks which develop reverse flow through the break are limiting with respect to RCS overpressure. Thus, only these FLBs were considered in the analysis.

Feedline Breaks downstream of the check valve with reverse flow may result in either an RCS heatup or an RCS cooldown event, depending on the enthalpy of the reverse flow and the heat transfer characteristics of the affected SG. However, excessive heat removal through the feedwater line break is not considered in the analysis because the cooldown potential is less than that for the SLB event. This occurs because SLBs have a greater potential for discharging high enthalpy fluid because the steam piping is located above the feedwater piping within a SG.

Unlike SLBs, FLBs cause a decrease in feedwater flow, resulting in lower SG liquid inventory that reduces the heat removal capacity. The reduced heat transfer capability results in a rapid RCS overpressurization and, thus, it is the heatup potential of an FLB which was analyzed.

A general description of the FLB event downstream of the check valves, with the MFW System unavailable and with low enthalpy break discharge, is given below. The loss of subcooled feedwater flow to both SGs causes increasing SG temperatures, decreasing liquid inventories and decreasing water levels. The rising secondary temperature reduces the primary-to-secondary heat transfer, which results in a heatup and pressurization of the RCS. The heatup becomes more severe as the affected SG experiences a further reduction in its heat transfer capability due to decreasing liquid inventory. The heatup of the RCS and the depletion of liquid inventory in the SG will initiate a reactor trip on either high pressurizer pressure or SG low water level. The RCS heatup can continue even after a reactor trip, due to a total loss of heat transfer in the affected SG as the liquid inventory is completely depleted. The rise in RCS pressure causes the PSVs to open. The rise in secondary pressure is limited by the opening of the MSSVs. The opening of the PSVs and the MSSVs, in conjunction with the reactor trip (which reduces core power to decay level), mitigates the RCS overpressurization.

The reduction of liquid inventory in the unaffected SG in conjunction with low level SG signal initiates AFW flow to the unaffected SG. Automatic initiation of AFW in combination with operator action at 10 minutes to increase AFW flow is sufficient to provide a continued heat sink for the removal of decay heat.

14.26.3 CORE AND SYSTEM PERFORMANCE

14.26.3.1 Mathematical Models

The FLB event is simulated using the S-RELAP5 computer code described in Section 14.1.4.2. The simulation includes the effects of tripping the RCPs on Loss of AC Power. The automatic actuation of AFAS is credited, together with operator action after 10 minutes.

14.26.3.2 Input Parameters and Initial Conditions

The following is a discussion of the conservative assumptions and initial conditions chosen to maximize RCS pressure:

Blowdown of the SG nearest the feedwater line break is modeled using the Moody critical flow model with homogeneous flow and a sudden expansion loss coefficient. The break is conservatively modeled from below the feedwater ring in the SG downcomer. These modeling choices generate conservative break flow and primary-to-secondary heat transfer, and thus a conservative RCS overpressurization.

For smaller break sizes credit is only required for the High Pressurizer Pressure Trip. As the break size is increased, credit is required for the SG Low Pressure Trip. No credit was taken for the High Containment Pressure Trip or the Low SG Level Trip.

Table 14.26-1 presents the initial conditions chosen to maximize the RCS pressure. An MTC value corresponding to BOC conditions is assumed. The MTC, in conjunction with increasing coolant temperatures, adds positive reactivity, and, thus, maximizes the rate of change of heat flux and pressure at the time of trip. An FTC corresponding to BOC conditions is used in the analysis. This FTC causes the least amount of negative reactivity feedback, allowing higher increases in both the heat flux and RCS pressure. An uncertainty factor of 10% is applied to the FTC used in the analysis.

A minimum initial RCS pressure is used in the analysis to maximize the rate of change of pressure at time of trip and, thus, the peak pressure obtained following a reactor trip.

The SDBS, the PPCS, the PLCS and the PORVs are assumed to be in the manual mode of operation. This assumption enhances the RCS pressure increase, since the automatic operation of these systems mitigates the RCS pressure increase.

This analysis credited the automatic initiation of AFW on low SG level. At 10 minutes after reactor trip, operator action was credited to control AFW flow to maintain SG level.

The assumptions made to maximize the boundary site dose are given in Table 14.26-2. During the event, two sources of radioactivity contribute to the site boundary dose: (1) the initial activity in the SG, and (2) the activity associated with primary-to-secondary leakage. The leakage through the SG tubes is assumed to be 1.0 gpm. The initial primary and secondary activities are assumed to be at the Technical Specification limits of 0.5 μCi/gm (DEQ I-131) and 0.1 μCi/gm (DEQ I-131), respectively. The analysis assumes that all of the initial activity in the SGs and the primary activity due to the tube leakage are released to the atmosphere with a decontamination factor of 1.0, resulting in the maximum site boundary dose.

14.26.3.3 Results

The FLB event with Loss of AC (LOAC) power on reactor trip results in the maximum RCS pressure. This occurs because the LOAC power causes the RCPs to coast down. The reduced core flow decreases the rate of heat removal and, thus, maximizes the primary heatup and overpressurization. Thus, only the results of the FLB event with LOAC power on reactor trip are presented here.

Figure 14.26-1 shows the peak RCS pressure as a function of break size for the initial conditions and input parameters specified in Table 14.26-2. The peak RCS pressure occurred for a break size of 0.02 ft^2. The transient progression for key parameters can be observed on Figures 14.26-2 through 14.26-10 and the sequence of events for the limiting break size is included in Table 14.26-3. The limiting break size is so small that the damaged steam generator does not depressurize sufficiently to signal closure of the MSIVs and the differential pressures between the two steam generators does not reach the setpoint to automatically isolate the AFW to the damaged steam generator.

The resultant site boundary and Control Room doses calculated with the assumptions given in Table 14.26-2 are:

Exclusion Area Boundary	0.4 rem TEDE
Low Population Zone	0.01 rem TEDE
Control Room	1.10 rem TEDE

14.26.4 CONCLUSION

The results of the FLB event with LOAC power on turbine trip show that the peak pressure does not exceed the pressure upset limit of 2750 psia and that the site boundary doses are within 10 CFR 50.67 guidelines. The downward trend of the long-term RCS pressure and temperatures and increasing intact SG level show plant recovery.

14.26.5 REFERENCES

1. Not used.
2. Federal Guidance Report (FGR) 11, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” September 1988
3. Federal Guidance Report (FGR) 12, “External Exposure to Radionuclides in Air, Water, and Soil,” September 1993

TABLE 14.26-1

INITIAL CONDITIONS AND INPUT PARAMETERS ASSUMED IN THE FEEDWATER LINE BREAK EVENT

PARAMETER	UNITS	VALUE[a]
Initial Core Power Level	MWt	2754[b]
Initial Core Inlet Coolant Temperature	°F	535[e]
Vessel Flow Rate	gpm	412,000
Initial Pressurizer Pressure	psia	2164
Initial Pressurizer Liquid Level	% span	32.2
Effective MTC	$x10^{-4}\ \Delta\rho/°F$	+0.15
Doppler Reactivity Feedback	---	Minimum
High Pressurizer Pressure Trip Setpoint[c]	psia	2470
AFAS setpoint inches below normal water level	inches BNWL	265.2
CEA Worth at Trip	% $\Delta\rho$	-5.0
RRS	Operating Mode	Manual[d]
SDBS	Operating Mode	Manual[d]
Pressurizer Pressure Control System	Operating Mode	Manual[d]
Pressurizer Level Control System	Operating Mode	Manual[d]

(a) These values represent inputs to the limiting transient scenario analyzed for Unit 1. A range of selected parameters, including uncertainties, were evaluated to determine the most limiting set of initial conditions.

(b) Value does include approximately 17 MWt of pump heat calculated by S-RELAP5.

(c) The trip credited is dependent upon the break size. The limiting break size presented is associated with a small break size. Larger breaks are protected by the Low SG Pressure trip.

(d) These modes of control system operation maximize the peak RCS pressure.

(e) Minimum including EOC temperature coastdown conditions.

TABLE 14.26-2

ASSUMPTIONS FOR THE RADIOLOGICAL EVALUATION FOR THE FEEDLINE BREAK EVENT

PARAMETER	UNITS	VALUE
RCS Maximum Allowable Concentration (DEQ I-131)[(a)]	μCi/gm	0.5
Secondary Maximum Allowable Concentration (DEQ I-131)[(a)]	μCi/gm	0.1
Partition Factor Assumed for All Doses	---	1.0
Atmosphere Dispersion Coefficient[(b)]	sec/m^3	1.44E-04
Breathing Rate	m^3/sec	3.50E-4
Dose Conversion Factors per References 2 and 3		

(a) Technical Specification Limits.

(b) 0-2 hour accident condition at EAB.

TABLE 14.26-3

SEQUENCE OF EVENTS FOR FEEDWATER LINE BREAK WITH LOAC FOLLOWING REACTOR TRIP

TIME (sec)	EVENT	SETPOINT OR VALUE
0.0	Event Initiation	0.02 ft^2
44.1	Low-Low SG level AFAS	----
57.8	High Pressurizer Pressure Trip Setpoint	2470.0 psia
58.7	Reactor and Turbine Trip	---
59.2	Scram Rods Fall	---
60.7	PSV RC-200 Opens	2575 psia
61.2	PSV RC-201 Opens	2601 psia
61.9	Peak RCS Pressure[(a)]	2730.7 psia
63.4	MSSVs Open	---
65.9	PSV RC-200 Closes	2497.0 psia
68.3	PSV RC-201 Closes	2472.2 psia
79.1	SG Blowdown Isolation	---

(a) Peak pressure includes elevation head.