15.9 MISCELLANEOUS

15.9.1 MODERATE FREQUENCY INCIDENTS

15.9.1.1 Asymmetric Steam Generator Transient

15.9.1.1.1 Identification of Causes and Frequency Classification

The transients resulting from the malfunction of one steam generator are analyzed to determine the initial margins that must be maintained by the technical specifications limiting conditions for operation (LCOs) such that in conjuction with the RPS (CPC high differential cold leg temperature reactor trip) the DNBR and Fuel Centerline Melt (CTM) limits are not exceeded.

The four events which affect a single steam generator are identified below:

a) Loss of Load to One Steam Generator (LL/1SG)

b) Excess Load to One Steam Generator (EL/1SG)

c) Loss of Feedwater to One Steam Generator (LF/1SG)

d) Excess Feedwater to One Steam Generator (EF/1SG)

→(DRN 05-543, R14; 06-1062, R15; EC-8458, R307; LBDCR 15-039, R309)

Of the four events described above, it has been determined that the Loss of Load to One Steam Generator (LL/1SG) Event is the limiting asymmetric event. The LL/1SG is an event of moderate frequency. Results of the evaluation presented in this section are valid for up to 10% of the steam generator tubes plugged for the Replacement Steam Generators. The results presented in this section are based on an evaluation using the revised SCRAM curve times presented in Table 15.0-5.

←(DRN 05-543, R14; 06-1062, R15; EC-8458, R307; LBDCR 15-039, R309)

15.9.1.1.2 Sequence of Events and Systems Operation

The event is initiated by the inadvertent closure of a Single Main Steam Isolation Valve (MSIV), which results in a loss of load to the affected steam generator. Upon the loss of load to the single steam generator, its pressure and temperature increase to the opening pressure of the secondary safety valves. The core inlet temperature of the loop with the affected steam generator increases resulting in a temperature tilt across the core. The steam flow from the unaffected steam generator increases to "pick up" the lost load causing a decrease in its temperature and pressure. This causes the unaffected steam generator loop core inlet temperature to decrease, thereby enhancing the temperature tilt at the core inlet. In the presence of a negative moderator temperature coefficient, the radial power peak increases in the cold side of the core, resulting in a condition which potentially could cause an approach to DNBR and CTM limits. The CPC high differential cold leg temperature trip serves as the primary means of mitigating this transient. Additional protection is provided by the steam generator low level trip. Table 15.9-1 presents the sequence of events.

15.9.1.1.3 Core and System Performance

15.9.1.1.3.1 Mathematical Model

→(DRN 05-1201, R14; EC-8458, R307)

The NSSS response is generated with the CENTS code. The CENTS code provides necessary data including the difference in Cold Leg Temperature, which can be combined with physics data for the maximum radial distortion factor to determine the asymmetric power peaking. The power peaking can then be incorporated in the CETOP code with information from the CENTS code to determine the resultant changes in DNBR.

←(DRN 05-1201, R14; EC-8458, R307)

→(DRN 05-543, R14)

The transient thermal margin and DNBR are calculated with the CETOP code using an interface file generated by CENTS. The important physical effect driving DNBR degradation is the core power tilt developed by the asymmetry in the core inlet temperature and the MTC. The most negative MTC is used to model this radial power tilt. In combination with this, the NSSS response from the least negative MTC is used to minimize any core wide decreases in power from the asymmetry. The transient is also analyzed for symmetric and asymmetric steam generator tube plugging (SGTP).

←(DRN 05-543, R14)

15.9.1.1.3.2 Input Parameters and Initial Conditions

The initial conditions used for the LL/1SG analysis are presented in Table 15.9-2. A parametric study on axial shape index was done to determine the maximum initial margin needed to ensure the DNBR and CTM limits are not violated. The most negative value of the moderator temperature coefficient is assumed to maximize the calculated severity of the associated power peaking.

15.9.1.1.3.3 Results

→(DRN 02-1479, R12; 05-1021, R14; EC-8458, R307; LBDCR 15-039, R309)

Figures 15.9-1 to 15.9-6 show the NSSS response for core power, core heat flux, RCS temperatures, RCS pressure, and steam generator pressures and DNBR. A reactor trip is generated by the CPCs at 5.33 seconds based on high differential cold leg temperature between the cold legs associated with the steam generators. The minimum transient DNBR calculated for the LL/1SG Event is greater than the DNBR limit. A linear heat rate of 21.0 kw/ft (which corresponds to the onset of fuel centerline melting), is not exceeded during this transient. This amount of margin is assured by setting the linear heat rate LCO based on the limiting allowable linear heat rate for LOCA. The required margin for this event is less than that required for the CEA drop event as discussed in Subsection 15.4.1.4.

←(DRN 02-1479, R12; 05-1201, R14; EC-8458, R307; LBDCR 15-039, R309)

15.9.1.1.4 Barrier Performance

This section is not applicable because there are no significant releases from this event. Moreover, as explained in paragraph 15.9.1.1.1, the sole purpose for analyzing this transient is to ensure that the initial margin maintained by the LCOs is sufficient to prevent the DNBR and CTM limits from being exceeded.

15.9.1.1.5 Radiological Consequences

The radiological consequences due to steam releases from the secondary system are less severe than the consequences of the inadvertent opening of an atmospheric dump valve discussed in Subsection 15.1.2.4.

Table 15.9-1 Revision 309 (06/16)

→(DRN 05-543, R14; EC-13881, R304; EC-8458, R307)

Sequence of Events for the ASGT Event

Time (sec)	Event	Setpoint or Value
0.0	Initiate Closure of a Single Main Steam Isolation Valve (MSIV)	---
0.1	MSIV on Affected Steam Generator is Fully Closed	---
0.1	Steam Flow from Unaffected Steam Generator Increases to Maintain Turbine Power	---
4.8	MSSVs open	1117 psia
5.33	CPC Delta-T Setpoint Reached (Differential Cold leg Temperature)	11°F
5.73	Trip breakers open	---
6.33	CEAS begin to drop	---
→(LBDCR15-039, R309) 7.7	Minimum WSSV-T / ABB-NV DNBR	≥1.24
9.2	Maximum RCS Pressure	< 2750 psia
10.9 ←(LBDCR15-039, R309)	Maximum Steam Generator Pressure	< 1210 psia

←(DRN 05-543, R14; EC-13881, R304; EC-8458, R307)

Table 15.9-2 Revision 309 (06/16)

→ (DRN 05-543, R14; 06-1062, R15; EC-8458, R307)

Assumptions for the ASGT Event

Parameter	Assumptions
Initial Core Power, MWt – (97% including uncertainty)	3605
Core Inlet Coolant Temperature, °F	552
Reactor Coolant system Flowrate, lbm/hr	$148 * 10^6$
Reactor Coolant System Pressure, psia	2250
Pressurizer Level, %	67.5
→(LBDCR15-039, R309) Steam Generator Pressure, psia ←(LBDCR15-039, R309)	908
SG Level, %NR	64.4
Moderator Temperature Coefficient, 10^{-4} Δρ/°F	-3.9 *
Doppler Coefficient Multiplier	1.30
CEA Worth for trip, x 10^{-2} Δρ	-5.0
Radial distortion factor for a 20 °F core inlet temperature asymmetry	1.22
Asymmetry in number of tubes plugged in two SGs	0

* The most negative value of MTC is used for quantifying the primary DNBR degradation mechanism. It is used in the combination with a $-0.179 * 10^{-4}$ Δρ/°F MTC in the transient simulation.

← (DRN 05-543, R14; 06-1062, R15; EC-8458, R307; EC-8458, R307)