14.10 LOSS-OF-NON-EMERGENCY AC POWER

14.10.1 IDENTIFICATION OF EVENT AND CAUSE

The primary function of the AC power on the plant's ring bus is to provide power to the NSSS and the balance of plant electrical loads. Plant AC power goes to emergency and non-emergency AC power loads. Emergency power loads are classified as those loads that are essential to safely shut down the plant and maintain the plant in a safe shutdown condition.

Unit 1 and Unit 2 turbine-generators separately provide AC power to the plant ring bus which supplies AC power to the main grid and each of three service transformers. When the turbine-generators are off line, the main grid (i.e., offsite power) supplies power to all three plant service transformers. During normal operation, the service transformers supply AC power to all emergency and non-emergency AC loads. When a Unit's turbine-generator is off line during emergency conditions, and neither offsite nor station power is available, the emergency diesel generators supply AC emergency power to all of the plant's vital electrical loads. Non-vital electrical loads, such as RCPs and condensate pumps, are lost when there is a loss of all non-emergency AC power.

A Loss-of-Non-Emergency AC Power (LOAC) event is defined as a loss of the plant's 500 kV/13 kV service transformers. A loss of load to the plant's turbine-generator with offsite and plant power (i.e., other Unit's turbine-generator) unavailable would result in an LOAC event. In the following presentation, a LOOP will mean a loss of the main grid in conjunction with the loss of the other Unit's turbine-generator.

The most limiting LOAC event is a loss of turbine load at HFP with offsite AC power unavailable.

14.10.2 SEQUENCE OF EVENTS

An LOAC event can result in an approach to the DNBR and LHGR SAFDLs and the RCS Pressure Upset Limit. The action of the Low RCS Flow RPS Trip in conjunction with the steady-state margin ensured by the LCOs will prevent exceeding these limits.

The response of the RCS to an LOAC event during the first five seconds is identical to a Loss-of-Coolant Flow event. During this time interval, the secondary system (i.e., SG feedwater side) has not had enough time to affect the RCS due to the loop cycle time. Consequently, the analysis of the Loss of Flow event ensures the fuel SAFDLs will not be exceeded during an LOAC event.

Since the analysis of the Loss of Flow event ensures the fuel SAFDLs will not be exceeded, the analysis of LOAC event presented herein will address the approach to the RCS Pressure Upset Limit and the approach to the site boundary dose criteria in 10 CFR Part 100 guidelines.

An LOAC event is initiated at HFP by loss of turbine-generator load with offsite power unavailable. The immediate system response is similar to a simultaneous Loss of Load event, LOFW event, and Loss-of-Coolant Flow event. The loss of voltage to the 4 kV emergency busses generates an undervoltage signal initiating the starting of the diesel generator. The normal supply busses are automatically separated from the emergency and non-emergency busses. Once the diesel generator is up to speed, the load sequencer starts loading the emergency busses with the vital equipment in a sequential manner to avoid overloading the diesel generator.

With power lost to the RCP motors, the pumps start to coast down immediately. In the analysis, no credit is allowed for the loss of power to the CEA holding coils that would release the CEAs to shut down the reactor. A low RCS flow signal will be reached in less than one second, which will trip the reactor. In less than five seconds, the DNBR transient will be terminated (Section 14.9).

The SG response to the LOFW and the termination of the main steam flow to the turbine is an increase in SG pressure and temperature. The analysis assumes that the feedwater flow is instantaneously reduced to zero with the loss of the condensate system pumps, and that the steam flow to the turbine is instantaneously reduced to zero with the closure of the turbine stop valves upon initiation of turbine trip.

With the atmospheric steam dump and turbine bypass systems inoperable, the SG pressure will rapidly approach the MSSVs' opening pressures. The MSSVs will open as this is the only path for removal of decay heat (i.e., steam). With reactor power decreasing to decay heat levels, the RCS will continue to transfer heat to the SGs, thereby keeping the main steam safeties open.

Due to the inability of the SGs to remove all of the generated heat, the RCS temperature, and then the pressure, will almost immediately start increasing. For a short period of time after the CEAs are inserted into the core, the RCS pressure will continue to increase and approach the PSVs' analysis setpoints. The pressurizer pressure and level control systems and the pressurizer PORVs would partially mitigate the pressure transient. For the analysis, no credit is allowed for these systems or for the PORVs. The opening of the MSSVs in conjunction with only decay heat being generated will result in the RCS pressure peaking and then decreasing. In one to two minutes, the RCPs will have completely coasted down and the RCS will be in natural circulation.

The SG liquid inventory will slowly deplete due to the steam blowdown through MSSVs and the LOFW to the SG. As the SG liquid inventory decreases and temperature increases, the SG heat transfer capability will be reduced. The reduction in heat transfer to the SG will prevent the RCS from cooling down. The combination of decay heat, natural circulation, and degraded SG heat transfer will then cause the core average temperature to increase.

Once the core decay heat rate equals the SG heat removal rate, the core average temperature will start slowly decreasing. After approximately 200 seconds, the decay heat rate will remain relatively constant. The RCS average temperature will approach the saturation temperature corresponding to the MSSV opening analysis setpoint.

At 600 seconds (10 minutes), the analysis assumes the operator initiates AFW via remote-manual operation from the Control Room. The present AFW System automatically initiates AFW flow in less than 180 seconds following a low SG level signal initiated by the ESFAS during a loss of AC power.

The subcooled AFW decreases the SG temperature and starts to cool down the RCS. At 900 seconds (15 minutes), the analysis assumes the operator, by remote-manual operation of the atmospheric dump valves, initiates plant cooldown.

14.10.3 CORE AND SYSTEM PERFORMANCE

14.10.3.1 <u>Mathematical Models</u>

The NSSS response to the LOAC event was simulated using the CESEC computer code described in Section 14.1.4.1. The site boundary dose was calculated as described in Section 14.1.4.3.

14.10.3.2 Input Parameters and Initial Conditions

The input parameters and initial conditions used in the analysis are listed in Table 14.10-1 for the present cycles of Unit 1 and Unit 2. Those parameters which are unique to the analysis are discussed below.

To maximize the power increase with the increasing core temperatures, a positive MTC is assumed.

Of the key input parameters, only primary and secondary coolant activity, in principle, is burnup dependent. However, the analysis assumed conservative values for the primary and secondary coolant activities.

14.10.3.3 Results

Table 14.10-2 contains the sequence of events for the LOAC event at HFP. Figures 14.10-1 through 14.10-5 present the transient behavior of the core power, core average heat flux, RCS temperatures, RCS pressure, and SG pressure.

The sequence of events and NSSS response plots are based on the OSG plant configuration. These trends are representative of the RSG plant configuration.

Table 14.10-3 presents the radiological assumptions and the 0-2 hour site boundary dose for the event. The results show that the thyroid and WBD is 0.04 and 0.0006 REM compared to the 10 CFR Part 100 guidelines of 300 and 25 REM, respectively.

14.10.4 CONCLUSION

The analysis of the LOAC event demonstrates that the action of the RPS and LCOs prevent exceeding the fuel SAFDLs. The action of the low RCS flow trip in conjunction with the MSSVs ensures the integrity of the RCS. The radiological consequences of opening the MSSVs during the event and cooling down through the atmospheric dump valves is a site boundary dose which is negligible in comparison to the 10 CFR Part 100 guidelines.

The Technical Specification limits on primary and secondary activities will bound the effects of extended burnup.

This event is not affected by the transition to Advanced CE-14 HTP™ fuel because the key parameters for this event are plant related system responses which are unchanged from, or bounded by, the current analysis.

TABLE 14.10-1

INITIAL CONDITIONS AND INPUT PARAMETERS FOR LOSS-OF-NON-EMERGENCY AC POWER EVENT

PARAMETER	UNITS	UNIT 1[a,b]	UNIT 2[a,b]
Initial Core Power Level	MWt	102% of 2700	102% of 2700
Core Inlet Temperature	°F	552	552
Vessel Flow Rate	gpm	370,000	370,000
RCS Pressure	psia	2200	2200
SG Pressure	psia	875	875
Low RCS Flow Trip Response	sec	0.65[d]	0.65[d]
MTC	10^{-4} $\Delta\rho$/°F	+0.5	+0.5
Doppler Coefficient Uncertainty	%	15	15
CEA Worth on Trip	10^{-2} $\Delta\rho$	-5.14	-5.14
AFW System Response	---	Manual[e]	Manual[e]

(a) These values represent inputs to the limiting transient scenario analyzed for each unit. In general, a range of initial conditions and input parameters, including uncertainties, were evaluated to determine the limiting case.

(b) For the RSG configuration, an evaluation was performed to determine the effects of RSGs on the consequences of the event. The evaluation concluded that any impact on the reported dose consequences associated with the RSGs (i.e., changes in liquid volume and metal mass) was more than compensated by the use of a RCS activity of 2.5 μCi/gm versus the Technical Specification limit of 0.5 μCi/gm.

(d) Present Technical Specification limit is 0.50 second.

(e) While the Technical Specification response time for AFAS is ≤ 180 seconds, this analysis assumes manual actuation of AFW after 10 minutes.

TABLE 14.10-2

SEQUENCE OF EVENTS FOR LOSS-OF-NON-EMERGENCY AC POWER EVENT

TIME (sec)	EVENT	ANALYSIS SETPOINT OR VALUE
0.0	Loss of All Non-Emergency AC Power	---
1.00	Low Flow Trip Analysis Setpoint is Reached	93%[a,b]
1.65	Trip Breakers Open	---
2.15	CEAs Begin to Drop Into Core	--
3.8	SG Safety Valves Start to Open	1000 psia
8.5	Maximum SG Pressure	1041 psia
12.0	Maximum RCS Pressure	2493 psia
602.4	AFW Flow Initiated	---
618.5	SG Safety Valves Close	---
900.0	Operator Activates the Remotely-Operated Atmospheric Steam Dump Valves and Initiates Plant Cooldown	---
10,236.0	SDC Initiated	300 psia

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[a] Percent of initial 4-RCP Flow.

[b] An evaluation has been performed to determine the effects of the RSG configuration on the consequences of the event. The evaluation found that the current analysis is still bounding.

TABLE 14.10-3

RADIOLOGICAL ASSUMPTIONS AND RESULTS FOR LOSS-OF-NON-EMERGENCY AC POWER EVENT

PARAMETER		UNITS	UNIT 1	UNIT 2
Primary to Secondary Leak Rate		gpm	1[a]	1[a]
RCS Volume		ft^3	10,400	10,400
RCS Maximum allowable concentration (DEQ I-131)		μCi/gm	2.5[b]	2.5[b]
Secondary Maximum allowable concentration (DEQ I-131)		μCi/gm	0.1[a]	0.1[a]
RCS Maximum allowable concentration of Noble Gases (DEQ Xe-133)		μCi/gm	102.5/E[c]	102.5/E[c]
RCS Cooldown Rate		°F/hr	100	100
Steam Required to Drive AFW Pump Turbines		lbs/hr	26,555	26,555
SG Partition Factor		---	0.01	0.01
Atmospheric Dispersion Coefficient		sec/m^3	$1.8x10^{-4}$	$1.8x10^{-4}$[d]
Breathing Rate		m^3/sec	$3.47x10^{-4}$	$3.47x10^{-4}$
Dose Conversion Factor (I-131)		REM/Ci	$1.48x10^6$	$1.48x10^6$
Dose Conversion Factor (Xe-133)		$REM/MeV/m^3$	$1.33x10^{-11}$	$1.33x10^{-11}$
Site Boundary Dose:	Thyroid	REM	0.04	0.04
(0-2 hrs)	Whole Body	REM	0.0006	0.0006

(a) Technical Specification Limit.

(b) Present Technical Specification Limit is 0.5 μCi/gm.

(c) Present Technical Specification Limit is 100/E - μCi/gm.

(d) This X/Q is very conservative (actual X/Q = $1.3x10^{-4}$ sec/m^3) and is a compensatory measure for an error in the decay heat model of CESEC.