14.7 EXCESS FEEDWATER HEAT REMOVAL EVENT

14.7.1 INTRODUCTION

The condensate and feedwater system is designed to provide a means for transferring the condensate from the condenser hotwells to the SGs (while at the same time raising the temperature and pressure) and providing a means for controlling the quantity of feedwater into the SGs (Section 10.2).

Condensate from the three condenser hotwells is pumped first through the two lowest pressure feedwater heating stages (three heaters per stage), and then through two parallel sets of three low pressure feedwater heaters to the SG feed pumps. The feedwater is then pumped through two parallel feedwater heaters to the SGs. Steam generator level is modulated by the feedwater regulating valves, the feedwater regulating bypass valves, and the associated control systems.

An Excess Feedwater Heat Removal event is defined as a reduction in SG feedwater temperature without a corresponding reduction in steam flow from the SGs. This could be caused by the loss of one or more of the feedwater heaters, or due to a feedwater controller malfunction at steady-state power that causes an increase in feedwater flow.

Proposed General Design Criterion 6, Reactor Core Design, requires that the reactor core function without exceeding fuel damage limits under all normal operating conditions and plant transients. This transient, the Excess Feedwater Heat Removal event, was analyzed to ensure the DNB and LHR SAFDLs are not exceeded. The computer models and methods used in this analysis are those described in Section 14.1.4, specifically S-RELAP5 and XCOBRA-IIIC. As discussed in the following sections, during the core and system response to the Excess Feedwater Heat Removal event, the SAFDLs are within the required limits and the proposed General Design Criterion is met.

14.7.2 PHYSICAL DESCRIPTION OF EVENT

The most limiting Excess Feedwater Heat Removal event is postulated to occur at HFP and is caused by the assumed loss of both high pressure feedwater heaters. This is modeled by a reduction in SG feedwater enthalpy. The immediate system response to this malfunction is a decrease in feedwater temperature to the SGs. The cooler water entering the SGs causes the SG temperature and pressure to slowly decrease, and more heat is extracted from the RCS. In response, the RCS temperature and pressure will decrease and cause pressurizer level to decrease.

When there is a negative MTC, a positive reactivity feedback occurs in the core in response to the decreasing core average temperature. This increases core power. The core average heat flux will also increase and partially offset the RCS temperature decrease resulting from the feedwater temperature decrease, and the reactor reaches a new (higher) steady-state power. Although the VHPT is approached, no reactor trip on nuclear instrument power occurs due to the temperature shadowing of the excore detectors. The delta T portion of the VHPT and the TM/LP trip are not credited. The plant remains at the steady-state power until operators manually trip the plant. Table 14.7-2 depicts the sequence of events for the Excess Feedwater Heat Removal event.

An increase in feedwater flow rate to 155% of rated full power flow has also been analyzed. However, the results of the increased feedwater flow transient were bounded by the results of the loss of feedwater heater transient.

14.7.3 METHODOLOGY

The NSSS response to the Excess Feedwater Heat Removal event was simulated using S-RELAP5. The S-RELAP5 results were subsequently used as input to the XCOBRA-IIIC code to evaluate the DNB response. Fuel centerline melt is bounded by that calculated for an Excess Load event initiated at HFP.

14.7.4 INPUTS AND ASSUMPTIONS

Initial Conditions

Steam and main feedwater flow are initially assumed equal. The remaining initial plant conditions for the Excess Feedwater Heat Removal event were selected to maximize the NSSS cooldown and the core power increase to ensure the SAFDLs are maintained. Key inputs such as power, T_{in}, RCS pressure, core mass flow rate, MTC, and the feedwater enthalpy were selected to achieve these conditions (Table 14.7-1).

Concurrent Events/Single Failures

There are no concurrent events or single failures assumed in the analysis.

Automatic RPS/ESFAS Functions

No RPS actuations occurred. No ESFAS equipment is actuated during this event.

Other Equipment Safety Functions

The pressurizer pressure and level control systems are not credited. Since this is an overcooling event and the RCS/SG pressure upset limits are not approached, the PSVs, PORVs, and MSSVs are not actuated. In addition, the AFW system is not actuated.

Operator Actions

The analysis assumed that operator actions mitigate the event (i.e., manually trip the plant) at 1800 seconds in accordance with applicable plant procedures.

Status of Non-safety Related Control Systems

The steam dump and bypass system is not actuated.

14.7.5 RESULTS

Figures 14.7-1 through 14.7-6 present, as a function of time, the transient core power, core average heat flux, RCS temperatures, RCS pressure, SG pressure, and SG temperature. These results support the determination that the DNB and FCM SAFDLs are not exceeded.

Results of all cases show that this event is bounded by the Excess Load event for all criteria.

14.7.6 CONCLUSIONS

The loss of both high pressure feedwater heaters is the most limiting HFP Excess Feedwater Heat Removal event (i.e., results in higher core power and lower RCS temperature and pressure). The analysis demonstrates that the SAFDLs (DNB and FCM) are not exceeded. Since this is an overcooling event, the RCS pressure upset limit is not approached. In addition, since there are no fuel failures, the radiological consequences of the Excess Feedwater Heat Removal event are negligible.

TABLE 14.7-1

INITIAL CONDITIONS AND INPUT PARAMETERS FOR THE EXCESS FEEDWATER HEAT REMOVAL EVENT

PARAMETER	UNITS	HFP VALUE
Initial Core Power	MWt	2754
Initial Core Inlet Temperature	°F	548
Initial RCS Pressure	psia	2250
Initial Vessel Flow Rate	gpm	370,000
Effective MTC	pcm/°F	-33
EOC Kinetics, β_{eff}	---	0.005237
ASI for MDNBR (Limiting Design Axial Profile)	---	-0.3
Doppler Coefficient	pcm/°F	-1.11
Integrated Radial Peak Factor (F_r)	---	1.65
Maximum Feedwater Temperature Decrease	°F	100.0

TABLE 14.7-2

SEQUENCE OF EVENTS FOR THE EXCESS FEEDWATER HEAT REMOVAL EVENT

TIME (sec)	EVENT	SETPOINT OR VALUE
0.0	Loss of Both High Pressure Feedwater Heaters	---
160.2	Secondary Pressure Reaches a Minimum Value	815.0 psia
161.4	RCS Pressure Reaches a Minimum Value	2228.5 psia
162.6	Core Power Reaches a Peak Value	3208 MW 117.2% of 2737 MWt
162.6	Minimum DNBR is Reached	> MDNBR SAFDL
163.6- 169.4	Core Inlet Temperature Reaches a Minimum Value	540.0°F
167.6	Core Average Heat Flux Reaches a Maximum Value	3205.53 MW 117.1% of 2737 MWt
1800	Operator Action Mitigates the Event	---