6.3 Emergency Core Cooling Systems

The information in this section of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departures and supplements.

STD DEP Admin

STD DEP T1 2.4-1

STD DEP T1 2.4-3

STD DEP 7.3-11 (Figure 6.3-7)

STD DEP 6C-1 (Table 6.3-8, Table 6.3-9, Figure 6.3-1)

As required by Section IV.A.3 of the ABWR Design Certification Rule, the plant-specific DCD must physically include the proprietary and safeguards information referenced in the ABWR DCD. Section 6.3 in the reference ABWR DCD references proprietary information. That proprietary information is provided below, has finality in accordance with Section VI.B.2 of the ABWR Design Certification Rule, and does not constitute a supplement to or departure from the reference ABWR DCD.

6.3.2.2.3 Reactor Core Isolation Cooling System (RCIC)

STD DEP T1 2.4-3

The RCIC System consists of a steam-driven turbine ~~which drives a~~ integral with a *pump assembly. The system also includes piping, valves, and instrumentation necessary to implement several flow paths. The RCIC steam supply line branches off one of the main steamlines (leaving the reactor pressure vessel) and goes to the RCIC turbine with drainage provision to the main condenser. The turbine exhausts to the suppression pool with vacuum breaking protection. Makeup water is supplied from the CST and the suppression pool with the preferred source being the CST. RCIC pump discharge lines include the main discharge line to the feedwater line, a test return line to the suppression pool, a minimum flow bypass line to the ~~pool~~*suppression pool*~~, and a cooling water supply line to auxiliary equipment~~. The piping configuration and instrumentation is shown in Figure 5.4-8. The process diagram is given in Figure. 5.4-9.*

6.3.2.2.4 Residual Heat Removal System (RHR)

STD DEP T1 2.4-1

In the shutdown cooling mode, with the pump suction being taken from the reactor pressure vessel (via the shutdown cooling lines), the pump discharge within these loops provides a flow path back to the reactor vessel via the core cooling discharge return lines, and feedwater line, or to the upper reactor well via the fuel cooling system ~~(on two loops only)~~.

With the pump suction being taken from the skimmer surge tanks of the fuel pool cooling system, the pump discharge is returned to the fuel pool ~~on two loops only~~.

For each loop, a minimum flow bypass line is also provided to return water to the suppression pool to prevent pump damage due to overheating when the injection valves on the main discharge lines are closed. The bypass line connects to the main discharge lines between the main pump and the discharge check valve. A motor-operated valve on the bypass line automatically closes when flow in the main discharge line is sufficient to provide the required pump cooling. A flow element in the main discharge line measures system flow rate during LOCA and test conditions and automatically controls the motor-operated valve on the bypass lines. The motor-operated valve does not receive an *automatic signal~~s~~* to open *unless the associate pump indicates a high discharge pressure.*

6.3.3.2 Acceptance Criteria for ECCS Performance

STD DEP Admin

Criterion 2: Maximum Cladding Oxidation

"The calculated total local oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation." Conformance to Criterion 2 is shown in ~~Figure 6.3-10 (Break Spectrum) and~~ Table 6.3-4 (Summary of LOCA Analysis Results) for the system response analysis. This limit will be assured for the limiting break. See Subsection 6.3.6 for COL license information.

Criterion 4: Coolable Geometry

"Calculated changes in core geometry shall be such that the core remains amenable to cooling." As described in Reference ~~6.2-1~~ 6.3-1*, Section III.A, conformance to Criterion 4 is demonstrated by conformance to Criteria 1 and 2.*

Criterion 5: Long-Term Cooling

"After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core." Conformance to Criterion 5 is demonstrated generically for GE BWRs in Reference ~~6.2-1~~ 6.3-1*, Section III.A. Briefly summarized, for any LOCA, the water level can be restored to a level above the top of the core and maintained there indefinitely.*

6.3.3.10 Severe Accident Considerations

STD DEP Admin

If the LPFL is not initiated in time to prevent core damage, LPFL injection is still beneficial *by enhancing cooling and preventing radioactive heating from the core debris. If injection is initiated prior to vessel failure, melt progression may be arrested in-vessel. However, if vessel failure occurs, debris will relocate from the vessel breach* *into the lower drywell. Water flowing into the lower drywell will cover the core debris and enhance debris cooling.*

6.3.6 COL License Information

6.3.6.1 ECCS Performance Results

The following site-specific supplement addresses COL License Information Item 6.6.

The exposure-dependent MAPLHGR, peak cladding temperature, and oxidation fraction for each initial core bundle design based on the limiting break size will be provided as an amendment to the FSAR in accordance with 10 CFR 50.71(e) at least one year prior to fuel load. The analysis will reflect the final fuel design for the initial core loading. (COM 6.3-1)

6.3.6.2 ECCS Testing Requirements

The following site-specific supplement addresses COL License Information Item 6.7.

In accordance with the Technical Specifications, a test will be performed every refueling outage in which each ECCS subsystem is actuated through the emergency operating sequence. The test procedure will be developed consistent with the plant operating procedure development plan~~, which was provided to the NRC in ABWR Licensing Topical Report NEDO-33297, "Advanced Boiling Water Reactor (ABWR)Procedures Development Plan," dated January 2007. This will be developed and available for NRC review prior to fuel receipt.~~in Section 13.5. (COM 6.3-2)

6.3.6.3 Limiting Break Results

The following site-specific supplement addresses COL License Information Item 6.7a.

The analysis results for the limiting break for each bundle design will be provided as an amendment to the FSAR in accordance with 10 CFR 50.71(e) at least one year prior to fuel load. The analysis will reflect the final fuel design for the initial core loading. (COM 6.3-3)

[s4]

Table 6.3-6 Plant Variables with Nominal and Sensitivity Study Values

[redacted]

COMPETITIVE ADVANTAGE

{e4}

Table 6.3-8 Design Parameters for HPCF System Components

(1) Main Pumps (C001)

NPSH Required	~~2.2m~~ 1.7m

Table 6.3-9 Design Parameters for RHR System Components

(1) Main Pumps (C001)

NPSH Required	~~2.4m~~ 2.0m

[s4]

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-1 Minimum Water Level Outside Shroud Versus Break Area

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-11 Normalized Core Power Versus Time for Loss-of-Coolant Accident Analysis

COMPETITIVE ADVANTAGE

Figure 6.3-12 Normalized Core Flow Following a Main Steamline Break Inside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-13 Minimum Critical Power Ratio Following a Main Steamline Break Inside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-14 Water Level in Fuel Channels Following a Main Steamline Break inside Containment, HPCF, Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-15 Water Level Inside Shroud Following a Main Steamline Break Inside Containment, HPCF, Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-16 Water Level Outside Shroud Following a Main Steamline Break Inside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-17 Vessel Pressure Following a Main Steamline Break Inside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-18 Flow Out of Vessel Following a Main Steamline Break Inside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-19 Flow Into Vessel Following a Main Steamline Break Inside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-20 Peak Cladding Temperature Following a Main Steamline Break Inside Containment Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-21 Normalized Core Flow Following a Feedwater Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-22 Minimum Critical Power Ratio Following a Feedwater Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-23 Water Level in Fuel Channels Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-24 Water Level Inside Shroud Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-25 Water Level Outside Shroud Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-26 Vessel Pressure Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-27 Flow Out of Vessel Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-28 Flow Into Vessel Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-29 Peak Cladding Temperature Following a Feedwater Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-30 Water Level in Fuel Channels Following an RHR Shutdown Suction Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-31 Water Level Inside Shroud Following an RHR Shutdown Suction Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-32 Water Level Outside Shroud Following an RHR Shutdown Suction Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-33 Vessel Pressure Following an RHR Shutdown Suction Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-34 Flow Out of Vessel Following an RHR Shutdown Suction Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-35 Flow Into Vessel Following an RHR Shutdown Suction Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-36 Peak Cladding Temperature Following an RHR Shutdown Suction Line, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-37 Water Level in Fuel Channels Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-38 Water Level Inside Shroud Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-39 Water Level Outside Shroud Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-40 Vessel Pressure Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-41 Flow Out of Vessel Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-42 Flow into Vessel Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-43 Peak Cladding Temperature Following an RHR/LPFL Injection Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-44 Normalized Core Flow Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-45 Minimum Critical Power Ratio Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-46 Water Level in Fuel Channels Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-47 Water Level Inside Shroud Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-48 Water Level Outside Shroud Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-49 Vessel Pressure Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-50 Flow Out of Vessel Following a Core Flooder Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-51 Flow Into Vessel Following a Core Flooder Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-52 Peak Cladding Temperature Following a Core Flooder Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-53 Water Level in Fuel Channels Following a Bottom Drain Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-54 Water Level Inside Shroud Following a Bottom Drain Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-55 Water Level Outside Shroud Following a Bottom Drain Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-56 Vessel Pressure Following A Bottom Drain Line Break, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-57 Flow out of Vessel Following a Bottom Drain Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-58 Flow Into Vessel Following A Bottom Drain Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-59 Peak Cladding Temperature Following a Bottom Drain Line Break, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-60 Water Level in Fuel Channels Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-61 Water Level Inside Shroud Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-62 Water Level Outside Shroud Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-63 Vessel Pressure Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-64 Flow Out of Vessel Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-65 Flow Into Vessel Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-66 Peak Cladding Temperature Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure

COMPETITIVE ADVANTAGE

Figure 6.3-67 Normalized Core Flow Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-68 Minimum Critical Power Ratio Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

[redacted]

COMPETITIVE ADVANTAGE

Figure 6.3-69 Water Level in Fuel Channels Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

COMPETITIVE ADVANTAGE

Figure 6.3-70 Water Level Inside Shroud Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on 95% Probability Value)

COMPETITIVE ADVANTAGE

Figure 6.3-71 Water Level Outside Shroud Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

COMPETITIVE ADVANTAGE

Figure 6.3-72 Vessel Pressure Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

COMPETITIVE ADVANTAGE

Figure 6.3-73 Flow Out of Vessel Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

COMPETITIVE ADVANTAGE

Figure 6.3-74 Vessel Pressure Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

COMPETITIVE ADVANTAGE

Figure 6.3-75 Flow Out of Vessel Following a Main Steamline Break Outside Containment, HPCF Diesel Generator Failure (Based on Bounding Values)

COMPETITIVE ADVANTAGE

Figure 6.3-76 Peak Cladding Temperature Versus Break Area with 1 RHR/LPFL + 5 ADS Available

COMPETITIVE ADVANTAGE

Figure 6.3-77 Vessel Level Inside Shroud Versus Bottom Head Maximum Drainline Break 1 RHR/LPFL + 5 ADS Available

GE Company Proprietary

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Figure 6.3-78 Vessel Pressure Time Bottom Head Maximum Drainline Break 1 RHR/LPFL + 5 ADS Available

COMPETITIVE ADVANTAGE

Figure 6.3-79 Peak Cladding Temperature Versus Time Bottom Head Maximum Drainline Break 1 RHR/LPFL + 5 ADS Available

[e4]