# Enclosure 2

# MFN 14-052, Revision 1, Supplement 1

# GEH Revised Response to RAI 06.02.01.01.C-1

# ABWR DCD Revision 6 Markups

| | |
|---|---|
| Design flow rate | 954 $m^3/h$ |
| Total discharge head at design flow rate | 125m |
| Maximum bypass flow | 147.6 $m^3/h$ |
| Minimum total discharge head at maximum bypass flow rate | 220m Max<br>195m Min |
| Maximum runout flow | 1130 $m^3/h$ |
| Maximum pump brake horsepower | 550 kW |
| Net positive suction head (NPSH) at 1m above the pump floor setting | 2.4m |
| Process fluid temperature range | 10 to 182°C |

(2) Heat Exchangers

The RHR heat exchangers have three major functional requirements imposed upon them, as follows:

(a) **Post-LOCA Containment Cooling—**The RHR System limits the peak bulk suppression pool temperature to less than 97°C by direct pool cooling with two out of the three divisions.

(b) **Reactor Shutdown—**The RHR System removes enough residual heat (decay and sensible) from the reactor vessel water to cool it to 60°C within 24 hours after the control rods are inserted. This mode shall be manually activated after a blowdown to the main condenser reduces the reactor pressure to below 0.93 MPaG with all three divisions in operation.

(c) **Safe Shutdown—**The RHR System brings the reactor to a cold shutdown condition of less than 100°C within 36 hours of control rod insertion with two out of the three divisions in operation. The RHR System is manually activated into the shutdown cooling mode below a nominal vessel pressure of 0.93 MPaG.

safety

The RHR heat exchanger capacity is required to be sufficient to meet each of these functional requirements. The limiting function for the RHR heat exchanger capacity is post-LOCA containment cooling. The heat exchanger capacity, K, is $4.27 \times 10^5$ W/°C per RHR heat transfer loop. This K value well is flooded and the fuel pool gates are open, water is drawn from the reactor shutdown suction lines, pumped through the RHR heat exchangers and discharged through the reactor well distribution spargers. For 100% core removal, if necessary, water is drawn from the Fuel Pool Cooling (FPC) System skimmer surge tanks, pumped through the RHR heat exchangers and returned to the fuel pool via the FPC System cooling lines. These operations are initiated and shut down by operator action.

(7) Reactor Well and Equipment Pool Drain

The RHR System provides routing and connections for emptying the reactor well and equipment pool to the suppression pool after servicing. Water is pumped or drained by gravity through the FPC System return lines to the RHR shutdown suction lines and then to the suppression pool.

(8) AC-Independent Water Addition

The RHR System is provided with piping and valves which separately connect RHR loops B and C pump discharge piping to the Fire Protection System (FPS) and to the reactor building external fire truck pump hookups. These connections allow for addition of FPS water to the reactor pressure vessel, the drywell or wetwell spray header, or the spent fuel pool during events when AC power is unavailable from both onsite and offsite sources. Operation of the RHR System in the AC-independent water addition mode is entirely manual. All valves required to be opened or closed for operation are located adjacent to or within the respective loop ECCS valve room to provide ease of operation.

### 5.4.7.3 Performance Evaluation

RHR System performance depends on sizing its heat exchanger and pumping flow rate characteristics with enough capacity to satisfy the most limiting events. The worst case transient established the heat exchanger size, given the pumping flow of 954 $m^3$/h for each RHR loop. The shutdown cooling mode requirements were satisfied within the RHR characteristics ~~established by the worst case transient~~. as described in Appendix 5B.

#### 5.4.7.3.1 Shutdown with All Components Available

A typical curve is not included to show vessel cooldown temperatures versus time because of the infinite variety of such curves that is possible due to: (1) clean steam systems that may allow the main condenser to be used as the heat sink when nuclear steam pressure is insufficient to maintain steam air ejector performance; (2) the condition of fouling of the exchangers; (3) operator use of one or two cooling loops; (4) coolant water temperature; and (5) system flushing time. Since the exchangers are designed for the fouled condition with relatively high service water temperature, the units have excess capability to cool when first cut in at high vessel temperature. Total flow and mix temperature must be controlled to avoid exceeding a

55°C/hour cooldown rate. See Subsection 5.4.7.1.1.7 for minimum shutdown time to reach 100°C.

#### 5.4.7.3.2 Worst Case Transient

Several limiting events were considered for RHR heat exchanger sizing. Those events were:

(1) Feedwater line break (FWLB)

(2) Main steamline break

(3) Inadvertent opening of a relief valve

(4) Normal shutdown

(5) Emergency shutdown

(6) ATWS

The normal shutdown condition is used to establish the limiting heat exchanger capacity and is evaluated in Appendix 5B.3.

It was determined for post-LOCA suppression pool temperature control, that the FWLB is the most ~~limiting~~ event. The worst case conditions for the event assumes one RHR heat exchanger failure instead of one diesel generator failure. When one heat exchanger fails, the heat generated by the pump is still added to the containment, and also one additional pump flow carries the reactor decay heat more effectively to the suppression pool. Therefore, a single failure of a RHR heat exchanger is the most limiting single failure.

safety

The heat exchanger size ~~was established to limit the~~ suppression pool peak temperature to 97°C. This is acceptable to the ABWR for the following reasons:

evaluated in Appendix 5B.3 will also support the safety function of limiting

(1) The ABWR wetwell pressure becomes high, high enough to provide more than 11°C subcooling with 97°C pool temperature when the peak pool temperature occurs.

(2) ~~Because it takes 4 to 6 hours to reach the peak pool temperature, shutdown cooling will be initiated before the peak pool temperature. The energy release from the reactor will be controlled by the shutdown cooling system, and there is no need to release the reactor energy to the pool.~~

As shown in Figure 6.3-26 the RPV pressure decreases rapidly following a FWLB. As a result, operation of SRVs and RCIC will be very limited. The SRVs and RCIC are the main sources of long term energy release to the pool. When RPV pressure decreases to the point where LPCF begins initiating, cooling from the RHR Heat Exchangers will begin removing energy from the system and further energy release to the suppression pool will decrease.

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... ging the reactor to a cold shutdown condition within 36 hours following reactor shutdown with only offsite power or onsite power available, assuming the most limiting single failure.

Safety

## Table 5.4-4 RHR Heat Exchanger Design and Performance Data

| | |
|---|---|
| Number of units | 3 |
| Seismic | Category I design and analysis |
| Types of exchangers | Horizontal U-Tube/Shell |
| Maximum Pressure | |
| Primary side | 3.43 MPaG |
| Secondary side | 1.37 MPaG |
| Design Point Function | Post-LOCA Containment |
| Primary side (tube side) performance data | |
| (1) Flow | 954 $m^3/h$ |
| (2) Inlet temperature | 182°C maximum |
| (3) Allowable pressure drop (max) | 0.069 MPa |
| (4) Type water | Suppression Pool or Reactor Water |
| (5) Fouling factor | $2.446 \times 10^{-5} m^2 h°C/kJ$ |
| Secondary side (shell side) performance data | |
| (1) Flow | 1200 $m^3/h$ |
| (2) Inlet temperature | 37.8°C |
| (3) Allowable pressure drop maximum | 0.069 MPa |
| (4) Type water | Reactor Building Cooling |
| (5) Fouling factor | $2.446 \times 10^{-5} m^2 h°C/kJ$ |

Normal Design Point Function Normal Shutdown Condition

Editorial note - add the line above right above the Primary side (tube side) performance data