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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington DC 20555-0001

Attention: Theodore E. Quay, Director
Standardization Project Directorate

Subject: SBWR - Non-Proprietary Version of RAI Responses Submitted May 31, 1994

Reference:
1. Letter from Dino C. Scaletti (NRC) to Mr. James E.Quinn (GE), Request for Withholding Information From Public Disclosure, General Electric (GE) Responses to Request for Additional Information (RAI) Dated May 31, 1994, dated August 11, 1995.
2. Letter MFN 077-94 from P.W. Marriott (GE) to Richard W. Borchardt (NRC), NRC Requests for Additional Information (RAIs) on the Simplified Boiling Water Reactor (SBWR) Design, dated May 31, 1994.

In response to the NRC's Reference 1 request, GE is providing the attached non-proprietary version of Reference 2.

Sincerely,

James E. Quinn

cc:	P. A. Boehnert	(NRC/ACRS)	(2 paper copies plus E-Mail)
	I. Catton	(ACRS)	(1 paper copy plus E-Mail)
	A. Drozd	(NRC)	(1 paper copy plus E-Mail)
	S. Q. Ninh	(NRC)	(2 paper copies plus E-Mail)
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Purdue RAI Set 4

Question 1

Provide the dimensions for the inside diameter and the outside diameter of a steam separator and stand pipe (below the separator) in vessel.

GE Response:

The dimensions for the inside diameter and the outside diameter of a steam separator and stand pipe are provided in Reference 2.

Purdue RAI Set 4

Question 2

Provide the elevation and opening area of the pick-off rings in the steam separator where water from the pool surrounding the separators can drain back into the chimney region, as shown in attached Figures 2-2 and 2.1-16. Indicate which of the two designs shown in these figures represents the SBWR design. How many stages of separation are in a steam separator for the SBWR? If neither of these designs is applicable to the SBWR, provide a drawing of the SBWR design and list the elevation and opening area of the pick-off rings.

GE Response:

The requested elevations and opening areas of the pickoff rings can be determined using References 2 and 4. The SBWR steam separator is a three-stage steam separator.
Figure 2-2, attached to the Purdue questions, shows the SBWR separator design.

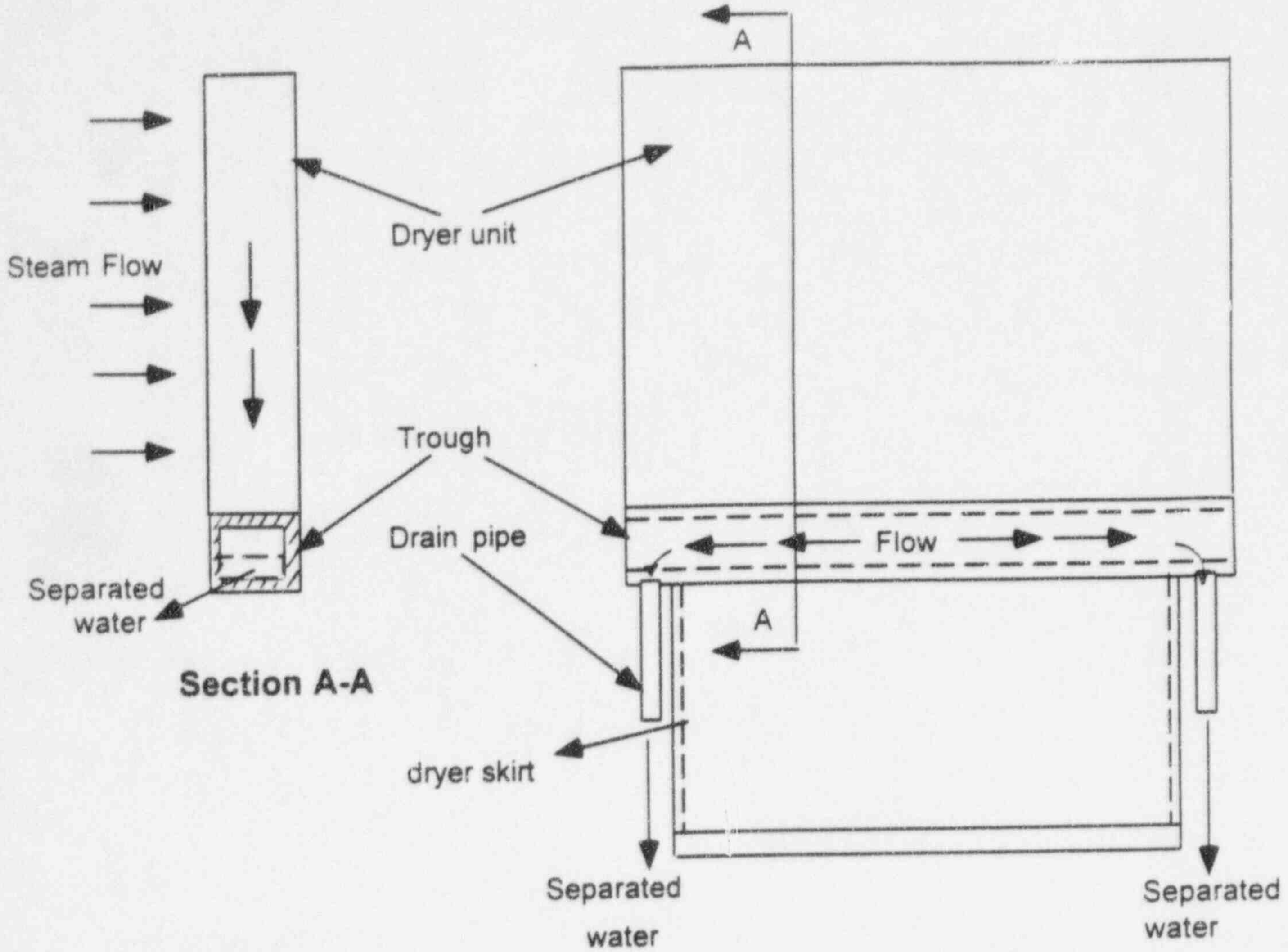
Purdue RAI Set 4

Question 3

Provide the dimensions for the inside diameter and the outside diameter of the dryer skirt and the corresponding elevations of the dryer. Provide a clear picture of the flow paths for water collected in the dryer troughs to return to the downcomer annulus through the pool surrounding the steam separators. What are the flow area and clearance in the annulus between the dryer skirt and vessel inner wall (at the elevation of a main steam line)?

GE Response:

The dryer skirt inside and outside diameters and the corresponding dryer elevations are provided in References 1 and 2. The attached figure titled, "Flow Path for Dryer" shows the flow path for water collected in the dryer troughs, for return to the downcomer annulus through the pool surrounding the steam separators. The flow area and clearance in the annulus between the dryer skirt and vessel inner wall, at the elevation of the main steam line, can be determined by using Reference 2.



Flow Path: Steam from the separators pass through the dryer units where dry steam is separated, and flows upward. The separated water is collected in the troughs, flows outward to the drain pipes, and down to downcomer region.

FLOW PATH FOR DRYER (SEE QUESTION # 3)

Purdue RAI Set 4

Question 4

There are several different values in the standard safety analysis report (SSAR) for the inside height of the reactor pressure vessel. Confirm whether the value is 24.447 m or 24.612 m, or provide the correct inside height dimension.

GE Response:

Reference 1, 107E6164, provides dimensions for the reactor pressure vessel.

Purdue RAI Set 4

Question 5

Provide the weight and material of the following reactor vessel internals (for estimating stored energy):

a. Lower core plate (with dimensions)
b. Core top guide plate (with dimensions)
c. Separators and stand pipes
d. Dryers
e. Control blades (with dimensions)
f. Control rod guide tubes (with dimensions)
g. Other lower plenum metal structure (with dimensions)

GE Response:

Reference 13 provides the weights of the Core Plate, Top Guide, Separators and Standpipes, Steam Dryer panels housing, support ring, water seal skirt, and lower ring, Control Rods, C.R. Guide Tubes, C.R. Drives & Thermal Sleeves, C.R. Drive Housings, In-Core Housings, and Reactor Vessel Bottom Head.

Lower core plate and core top guide plate dimensions are provided in References 2, 9 and 10. Lower core plate and Core top guide plate material is SA 240, TP 316L.

The separator and stand pipe material is SA 312, TP 316L. The dryer material is SA 240, TP316L.

Dimensions for control blades, control rod guide tubes and other lower plenum metal structures are provided in References 7 & 12. The control blade sheathing material is SA 240, TP 316L and the material for the tubes inside the sheathing is SA 351, TP 316L. The control rod guide tube and the control rod drive housing material is SA 312, TP 316L. The control rod guide tube base coupling material is Type XM-19 stainless steel.

The shroud material is SA-240, TP 316L. The shroud bracket material is SB-168 or SB-166.

Purdue RAI Set 4

Question 6

Provide hydraulic diameter for the following:

a. Core (namely, fuel assembly section and core bypass section, with and without control blades inserted)

b. Lower core plate

c. Core top guide plate

d. Stand pipe section (Enclosure)

e. Separator section

f. Downcomer in each of the separator/stand pipe section, chimney section, and core section

g. Lower plenum

GE Response:

PROPRIETARY - Provided by Reference 2*

*Refers to Reference 2 of the transmittal letter to this non-proprietary version of the RAI response.

Purdue RAI Set 4

Question 7

Provide the elevation and material for the following fuel assembly components:

a. Fuel support casting

b. Lower tie plate coolant slots (with dimensions)

c. Upper tie plate (with dimensions and its position within the core top guide plate)

d. Five fuel rod spacers

GE Response:

PROPRIETARY - Provided by Reference 2*

*Refers to Reference 2 of the transmittal letter to this non-proprietary version of the RAI response.

Purdue RAI Set 4

Question 8

Provide a drawing showing the 8x8 fuel rods in a channel box and the location and dimension of water rods.

GE Response:

Reference 19 provides a drawing showing the 8x8 fuel rods in a channel box and the location and dimension of water rods.

Purdue RAI Set 4

Question 9

Provide the free volume in the core region between the top of the lower core plate to the top of the core top guide plate.

GE Response:

The free volume in the core region between the top of the lower core plate to the top of the core top guide plate is provided in Reference 13, Figure 1 Regions E, F, G, H.

Purdue RAI Set 4

Question 10

Referring to attached Figure 5.3-3, provide the following:

a. Diameter of core top guide plate (between the top of the active fuel and the chimney)

b. Diameter of the steam separator support plate (between the steam separator assembly and top of the chimney)

c. Diameter of the steam dryer support plate.

GE Response:

The requested information is provided in Reference 2.

Purdue RAI Set 4

Question 11

Provide a drawing showing how a 3-inch bypass line connects to the 8-inch vessel suction line of the Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) System. Also, show how these two lines connect to the bottom drain line. Provide the total break flow area in a double-ended bottom drain line break accident (namely, 2-inch break flow at the vessel bottom "plus" another break flow leaving the vessel downcomer through a RWCU/SDC System line.)

GE Response:

Reference 15 shows the 3 inch bypass line connections to the 8 inch suction line, and the 8 inch suction line connection to the bottom drain line. The valve positions during normal operation are also shown in Reference 15.

The break flow areas for a double-ended bottom drain line break are provided below:

2" break area = 0.0218 ft^2 leaving the vessel bottom
3" break area = 0.0491 ft^2 leaving the vessel downcomer through the RWCU/SDC line

Purdue RAI Set 4

Question 12

Is there a flow resistor on the 8-inch vessel suction line of the Reactor Water Cleanup/Shutdown Cooling System or at the reactor pressure vessel penetration of the Isolation Condenser System steam line?

GE Response:

There are no flow restrictors on the 8 inch RWCU/SDC suction line or the Isolation condenser system steam line nozzle. (Reference 1 shows the RPV nozzles.)

Reference 14 shows the flow restrictors in the Isolation Condenser (IC) steam pipe near the inlets to the IC horizontal headers. After exiting the primary containment, the IC steam supply pipe branches into four pipes which feed the two horizontal headers of the IC. Each of these four pipes has a built-in flow restrictor.

Purdue RAI Set 4

Question 13

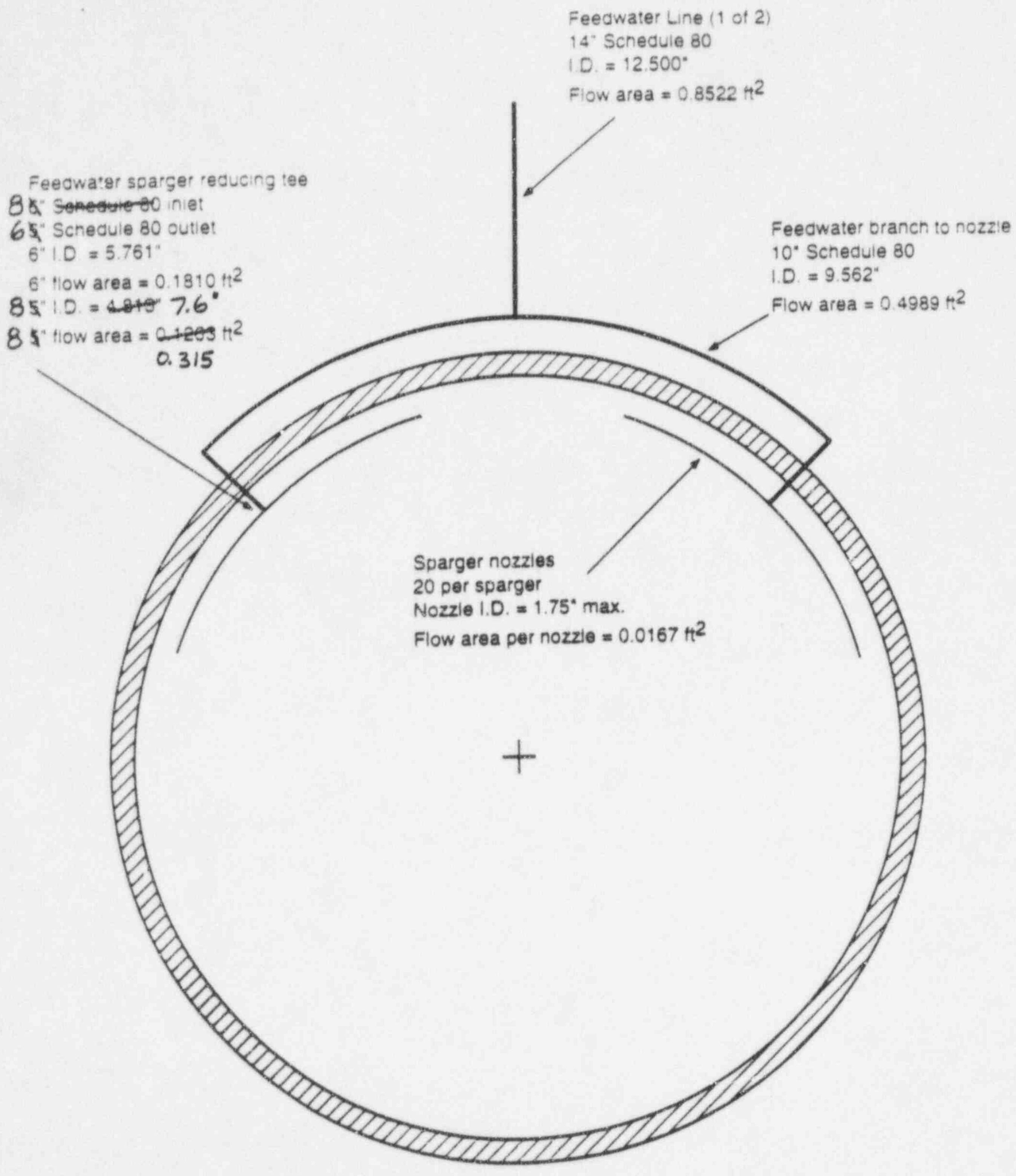
On page 6.3-20 of the SSAR, the feedwater line break size was listed as 8.9 in (inside diameter equivalent nozzle size). However, the pipe at the reactor pressure vessel penetration is a 10-inch Schedule 80 pipe with an inside diameter of 9.5 in. What is the correct break size for the feedwater line break?

GE Response:

The feedwater sparger details were previously provided in the response to question 1a of the first set of Purdue Questions. In order to reduce the fatigue stresses at the feedwater nozzle thermal sleeve, the design of the thermal sleeve and sparger has been revised. The figure that was included in the responses to the Set 1 questions has been revised and it is included with these Set 4 responses.

With the new design, the limiting feedwater line break area is 0.630 ft^2. For further details, refer to the attached figure titled, "Feedwater Line Break Area Calculation".

SSAR Chapter 6 will be revised to provide the results for a feedwater line break analysis based on the new thermal sleeve and sparger design.



Feedwater Line Break Area Calculation (*Response No. 13*)

(Response No. 13)

Feedwater Line Break Area Calculation Summation

14" feedwater line	1 line	0.852 ft^2
10" feedwater branch to nozzle	2 lines	1.00 ft^2
8 ~~6~~" Tee inlet	2 lines	0.630 ~~0.362~~ ft^2
6 ~~5~~" Tee outlet	4 lines	0.724 ~~0.504~~ ft^2
Sparger nozzles	40 total	0.668 ft^2

Conclusion - Limiting break area = 0.630 ~~0.362~~ ft^2

file: 3.2.4

Purdue RAI Set 4

Question 14

Describe the control logic for controlling the control rod drive (CRD) flow during a loss-of-coolant accident (LOCA). What is the CRD flow rate as a function of time and its injection location during a LOCA?

GE Response:

CRD flow is initiated by the Level 2 water level setpoint and terminated by the Level 8 water level. The high pressure injection mode of CRD has a flow design requirement of 105 cubic meters/ hour, at a 8.619 MPa differential pressure between the water source and the reactor. The pumps are multiple stage centrifical pumps. Fifty percent (50%) of design flowrate is achieved within 10 seconds, and full flow within 25 seconds of initiation.

Purdue RAI Set 4

Question 15

Provide free volume as a function of elevation in the lower drywell. The attached Figure 3 (taken from "Design Specification, FMF SBWR, MPL Item No. A11-5299, Preliminary Issue DMH-4126 February 12, 1991") suggests that there is a brick layer of about 1 m in thickness at the bottom of the lower drywell which precludes water from filling that location. Does this 1-meter-thick brick layer exist?

GE Response:

Reference 3, sheets 9 and 35, provide the lower drywell free volume as a function of elevation. The 1M thick brick layer that is shown on sheet 35, is going to be replaced with a 1M thick layer of concrete.

Purdue RAI Set 4

Question 16

Provide a description of the steam dryer (not the dryer in the reactor pressure vessel) in the gas space of the Isolation Condenser System pool. (The steam will pass through this dryer before it exits to the atmosphere.) Provide the design pressure drop across this dryer, design pressure (i.e., expected pressure of operation), and K value for the dryer.

GE Response:

The steam dryer will be a single-hook moisture separator with an 8" vane length. There is not sufficient room to fit the dryer directly above the Isolation Condenser (IC) pool, therefore the dryer will be located just downstream of the 3 square meter opening from the IC pool.

- The design pressure drop across the dryer = 1.6" water
- The expected pressure of operation= 16 psia
- The k value for the dryer can be calculated using the following data:
  - steam dryer(face) area= 6.44 square meters
  - flow rate through dryer=29.4 feet per second

Purdue RAI Set 4

Question 17

Explain whether the water level predictions in SSAR Sections 6.2 and 6.3 are for collapsed level or for two-phase mixture level.

GE Response:

The plots in SSAR chapter 6.2 and 6.3 graph the interface of a potentially two-phase mixture, not a collapsed level.

Purdue RAI Set 4

Question 18

The SSAR does not clearly define the LOCA scenarios (i.e., timing of the event). Provide the scenarios and control logic to initiate the main steam line break, bottom drain line break, stub line break, and feedwater line break.

GE Response:

The attached scenario describes system operation during a LOCA for cases with AC, with only on-site, diesel generated AC power, and with only inverters supplied AC power. Because the scenario is symptom based it is common to both large and small, liquid and steam breaks. The initiation time can be determined by correlating the initiating condition against the plots in the SAR.

LOCA Sequence of Events

Initiating event: Double ended guillotine rupture in GDCS injection line (limiting for core water level and clad temperature), or Main Steam line (limiting for containment pressure and temperature)

Three scenarios are developed: 1) without AC power, 2) with diesel generators available, 3) with offsite AC power.

1. Scenario without offsite power & diesels (no AC except from battery powered inverters). This is the scenario analyzed in Chapter 6 of the SAR, except as noted.

Symptom	Action(s)
Loss of Offsite Power	Generator trips, causing turbine valve closure scram, bypass valves close after 6 seconds. No credit for this scram or the bypass heat sink is taken in the SAR Chapter 6 analysis.
	Feedwater coastdown
	(diesel generators fail to start)
	Fuel pool cooling lost
	Chilled water lost
	DW coolers lost
	CRD pumps trip
Hi Stem Flow (Large Main Steam break)	Isolates MSIV (Main steam break only, not GDC break)

Symptom	Action(s)
Hi Drywell pressure	Scram
	CACS (Cont. Atm. Control Sys) purge & vent isolates
	FAPCS (Fuel & Aux. Pool Cooling Sys.) isolation
	PCC condensation begins
	PCC pool boil down begins, HX tubes remain covered >72 hr.
	Isolate High & Low conductivity sumps, fission product sampling, Reactor building HVAC exhaust
Low water level L2	IC drain valve opens (MSIV closure also initiates)
	Isolate High & Low conductivity sumps, fission product sampling, Reactor building HVAC exhaust
	DW coolers isolate
L1 low water level	ADS/GDCS initiation, timed sequential opening of: 4 SRVs/4 SRVs/2 DPVs/2 DPVs/6 GDC injection valves
	DW coolers isolate
	Same equipment which isolated L2 received redundant isolation signal.
P rpv< GDC pool head	Injection flow begins
(Level<TAF+1m) + (30 min. after GDCS initiation)	GDC Equalization valves fire
Post LOCA radiolytic H2 & O2	PAR's (Passive Autocatalytic Recombiners) function. (PAR's are not simulated in fuel peak temperature and minimum water level calculations)
P dw<P ww +0.5 psi	Vacuum breakers open

2. Scenarios without offsite power. Additional systems functional with diesel generations, without offsite AC.

Symptom	Action(s)
Loss of normal AC	Diesel Generator starts
	FMCRD run-in backs up hydraulic scram
L2, low water level	CRD initiates in high pressure injection mode
Above actions are automatic, no operator action necessary	
L3 low water level	FPACS LPCI mode, injection through FW system
High pool temperature	FAPCS Pool cooling mode, if adequate core cooling. (Operator action required because system had auto-isolated)
P cont.>14.2 psig	FAPCS DW & WW spray
T dw>ADS qual. temp	FAPCS DW spray
P rpv> hi P scram	RWCU/SDC
~L1 per EPG	Firewater (requires local insertion of spool-piece)
Containment pressure hi or T dw>Tech Spec. LCO	DW cooler (marginal credit high DW density may overload motors)
GDC pool level<NWL-0.5M (2 of 3 GDC pools)	Trip CRD pumps
2 days post LOCA	PCC vent fan

3. Scenario with offsite power with diesels generators. Additional systems functional with offsite AC.

Symptom	Action(s)
L3 low water level	FW & Condensate injection
Pressure > Normal setpt.	Bypass valves

Purdue RAI Set 4

Question 19

Provide the firing sequence of six depressurization valves.

GE Response:

The SRV and DPV firing sequence is provided below:

Time	Action
0.0	Low setpoint SRV's, 2 on each MSL
10.0	High setpoint SRV's, 2 on each MSL
55.0	2 DPV's on MSL
100.0	1 DPV on dedicated stub line, 1 DPV on IC line
145.0	2 DPV's on IC lines

(Time is delay in seconds after confirmed L1 (L1 + seconds))

Purdue RAI Set 4

Question 20

Provide the feedwater pump coastdown curve after the pump is tripped. Provide the control logic that initiates a feedwater pump trip. Explain how the feedwater controller behaves as the vessel water level decreases during a LOCA.

GE Response:

RAI's 950.14 and .15 (attached) provide a feedwater coastdown curve for LOCA and a nominal coastdown time. The only control logic which initiates a FW flow reduction is an ATWS condition: neutron monitors not downscale and [pressure high or level 2]. There is no FW isolation on LOCA signal as in most PWR's.

In a LOCA with AC power available at the FW pumps, the post scram water level shrink will cause the level error to dominate in 3 element control, causing the flow demand signal to integrate to it's maximum limit. Flow will increase to 155 to 180% of rated. After level has been recovered, the control system will ramp flow down to equilibrate with break flow. Eventually when the water source in the hotwell is exhausted, pumps will trip on low suction pressure.

Purdue RAI Set 4

Question 21

Provide current information on the operation of three vacuum breakers (between the drywell and suppression pool gas space).

GE Response:

Reference 5 specifies the test acceptance criteria for the vacuum breaker valve. Reference 6 provides a detail drawing of the vacuum breaker valve.

Purdue RAI Set 4

Question 22

Provide the response of the turbine during a LOCA such as main steam line break, bottom drain line break, Gravity-Driven Cooling System line break, and feedwater line break. Provide the description and set point for the components that regulate the turbine response.

GE Response:

The are no turbine control actions specific to LOCA, or a scram. The turbine/pressure controller will attempt to maintain a constant reactor dome pressure. This will cause the turbine valves to close following a scram caused by low water level or high drywell pressure. The valves will open following a MSIV closure if the break is not large enough to cause vessel depressurization. If off-site AC power connections are lost coincident with the LOCA the turbine valves will be closed by the turbine overspeed protection logic, and the reactor will immediately scram.

For example, in a small liquid break with feedwater available, flow would continue through the turbine and bypass valves. In a large main steam line break, the MSIVs will isolate the reactor on high flow and flow through the turbine will stop. For an intermediate steam break size, depressurization from the break causes controller to close the turbine valves prior to MSIV isolation.

References:

1. "Reactor Assembly" GE Drawing No. 107E6164, Rev. 1 markup

2. "Reactor Data" GE Information Doc. No. 213A8843, Rev. B markup

3. "Containment Configuration Data Book" GE Doc. No. 25A5044, Rev. 2 markup, only Sh. 9 & 35

4. "Steam Separator Assembly" Draft GE Drawing

5. "Drywell to Wetwell Vacuum Breaker" GE Test Spec. No. 25A5445, Rev. 1

6. "SBWR Vacuum Breaker Valve General Assembly", FIAT Drawing No. 2T137684

7. "Reactor Core Interface" GE Drawing No. 107E5159, Rev. B

8. "SBWR - Internals Chimney" FIAT Drawing No. 2T136472, Rev. 1 (SBW-5100-DMNF-M011-001 Rev. 1)

9. "SBWR - Internals Top Guide" FIAT Drawing No. 2T136965, Rev. 1 (SBW-5100-DMNF-M012-001 Rev. 1)

10. "SBWR - Internals Core Plate" FIAT Drawing No. 2T136966, Rev. 1 (SBW 5100-DMNF-M013-001 Rev. 1)

11. "SBWR - Internals Shroud" FIAT Drawing No. 2T137061, Rev. 1 (SBW-5100-DMNF-M014-001 Rev. 1)

12. "SBWR - Internals Shroud/Support Bracket Preliminary Design" FIAT Drawing No. 2Q136664, Rev. 0

(Note: If any dimensions on References 8 through [illegible] agree with References 1 and 2, the Reference 1 and 2 dimensions govern.)

13. "Reactor Weight and Volume" GE Doc. No. 23A6998, Rev. 1

14. "Isolation Condenser General Arrangement" Ansaldo Drawing No. SBW-5280-DMNX-1101, Rev. 0

15. "Reactor Water Cleanup/Shutdown Cooling System" P&ID GE Drawing No. 107E6277, Rev. 1, only Sh. 1 & 2

References: (Continued)

16. Response to RAI No. 950.38, provided in Letter from P. W. Marriott to USNRC Document Control Desk, "NRC Requests for Additional Information (RAIs) Regarding the Simplified Boiling Water Reactor (SBWR) Design", April 29, 1994, MFN No. 062-94, Docket STN 52-004

17. "Reactor Pressure Vessel" Equipment Requirements Spec., GE Doc. No. 25A5001, Rev. 1, only Sh. 25 and 26.

18. "Reactor System Heat Balance" Design Specification, GE Doc. No. 23A6929, Rev. 1

19. "Fuel Design Bases and Criteria" Data book for GE8-SBWR fuel, preliminary GE report