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GE Nuclear Energy

ABWR

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NRC

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Subject PRA Input to ITAAC Item PRA-3
Common CAUSE FAILURE - Items C3, 05

Message
The two responses follow:
PRA Input to ITAAC: pg 1 + 4 tables
Sorry about the hand corrections
Common CAUSE FAILURE pg i, 1, 2, 3.

PRA INPUT TO ITAAC

19.X Tier 1 Treatment of Design Features Identified as Important by the PRA.

As the PRA was being finalized during NRC staff development of the Final Safety Evaluation Report, the PRA was reviewed to identify the most important PRA-related ABWR features. The judgement of several engineers was used to identify those features and capabilities which are most important in maintaining a low core damages frequency and in mitigating the consequences of an accident should one occur.

The results of this review are summarized in Table 19.X-1 through 4, divided into 4 major categories: Prevention of Core Damage, Avoidance of Suppression Pool Bypass, Maintenance of Containment Integrity, Minimize Threats from Floods and Fires. For each feature, reference is provided to the corresponding verifying ITAAC by indicating the system number followed by the entry number in the corresponding ITAAC table. In addition, key subsections of Chapter 19 are identified to allow a reviewer to appreciate the general significance of the feature beyond that identified here.

Table 19.X-1.
PRA INPUT TO ITAAC: PREVENTION OF CORE DAMAGE

General Capability	Specific Feature/Capability	Chapter 19 Subsection	(Notes For Now) ITAAC Reference
Redundant Systems	• Three separated divisions of ECCS and decay heat removal, ECCS pumps able to pump saturated water	19.1.2 19.6.5 19D.5.11.3	2.4.1(RHR) – 1, 2, 3, 8, 9, 18 2.4.2(HPCF) – 1, 2, 3, 4, 11, 10
	• RHR vessle injection valve which admits fire water to the RPV and drywell spray valve have handwheels for local manual operation without power.	19.J.3	2.4.1 (RHR) – 7
	• Automatic depressurization for transients and LOCAs	19.1.2	
Diversity	• RCIC capable of operation for several hours without AC power, and ability to override switchover to makeup water source from CST to suppression pool.	19.1.2, 19E.2.2.3	Number of hours not critical from PRA importance view (because of fire water) 2.4.4(RCIC) – 6 says isolation fails as is on loss of ac. Need to add switchover 2.12.12 (Direct current power supply) – later
	• Combustion Turbine Generator, connectable to at least one of three safety divisions to provide ~~RC~~ power		2.12.11 (CTG) – 1

ac

(which need not be seismically qualified)

Table 19.X-1.

PRA INPUT TO ITAAC: PREVENTION OF CORE DAMAGE (Continued)

General Capability	Specific Feature/Capability	Chapter 19 Subsection	(Notes For Now) ITAAC Reference
	• Seismically qualified ~~AC~~ dc independent water addition system, including dedicated diverse diesel and manually operable valves. Calculated flow rates: – for vessel injection, between ____ and ____ with RPV pressure at ____. – for drywell ~~or~~ spray, between ____ and ____ with drywell pressure at ____.	19.1.2	2.4.1(RHR) – 7 2.15.6 (FPWSS) – ~~later~~ 13
Minimize Potential for Failure to Shutdown	• Reactor Protection System – RPR please define this one	19.3.1.3	2.2.7 – later by RPR
	• Alternate rod insertion system (key features later, probably already covered)		Later by RPR
	• Standby liquid control system (key features later, probably already covered)	19.3.1.3	2.2.4(SLC) – by RPR

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Table 19.X-2.
PRA INPUT TO ITAAC: AVOIDANCE OF SUPPRESSION POOL BYPASS

General Capability	Specific Feature/Capabilit,	Chapter 19 Subsection	(Notes For Now) ITAAC Reference
Avoid Unisolatable RWCU Break	• Reactor water clean-up Isolation Valves must be "properly qualified (including seismic)" for expected duty	19.3.2.6	2.6.1(RWCU) – 3. See RWCU EQ entry in Table 3.0 of Tier 1 material.
Control Unisolatable RWCU Break	• Reactor water clean-up suction nozzle must be at least 5 feet above the planned elevation of the top of the active fuel.	19.3.2.6	2.6.1 (RWCU) – 4
Control Unisolatable RWCU Break	• Reactor water cleanup drain line tie in to the suction line must be at an elevation equal to or above the suction nozzle.	19.3.2.6	2.6.1 (RWCU) – 5
Avoid Unisolatable RHR Break	• Seismically qualified RHR isolation pool suction valve	19.6.3	See RHR EQ entry in Table 3.0 of Tier 1 material

Table 19.X-3.
PRA INPUT TO ITAAC: MAINTENANCE OF CONTAINMENT INTEGRITY

General Capability	Specific Feature/Capability	Chapter 19 Subsection	(Notes For Now) ITAAC Reference
Avoid Hydrogen Related Threats	• Provisions to provide inerted containment	19.6.6 19.6.8	2.14.6 (ACS) – 1
Avoid Containment Structural Failure	• Containment over pressure protection system with rupture disk set-point established at 90 psig and nominal flow rate of XXX when containment pressure is YYY. (XXX, YYY, later from CEB).	19.2.4.3	2.14.6 (ACS) –5, –6, –8 R.D. Setpoint may change.
Minimize Challenge to Containment	• Passive Flooder system: – N (number) valves which open when lower drywell temperature exceeds 500°F – YYY nominal flow rate per valve – N, YYY later from CEB		No ITAAC section yet.
Maintenance of Suppression Pool Integrity	• RHR heat exchanger seismic capacity	19.J.3	

Table 19.X-4.

PRA INPUT TO ITAAC: MINIMIZE THREATS FROM INTERNAL FLOODS AND FIRES

General Capability	Specific Feature/Capability	Chapter 19 Subsection	(Notes For Now) ITAAC Reference
Flooding	• Normally closed watertight door between turbine building and service building tunnel.	19Q. later	Later by McSherry, Ehbert
	• Control building lower floor level sensors which alarm at 0.15 meter and trip RSW pumps and close RSW isolation values in affected division at 0.8 meter.	19Q. later	Later by McSherry, Ehbert
	• ECCS rooms have water tight doors which open into corridor	19Q. later	Later by McSherry, Ehbert
	• Reactor building corridor (Floor XXX) volume sufficiently large (YYY cubic meters) to contain largest flood source	19Q. later	Later, by McSherry , Ehbert
Fire	Later by Maxwell, Raftery		

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Avoid Containment Structural Failure	• Containment over pressure protection system with rupture disk set-point established at 90 psig and nominal flow rate of XXX when containment pressure is YYY. (XXX, YYY, later from CEB).	19.2.4.3	2.14.6 (ACS) –5, –6, –8 R.D. Setpoint may change.
Minimize Challenge to Containment	• Passive Flooder system: – ~~24~~ N (number) valves which open when lower drywell temperature exceeds 500°F – YYY nominal flow rate per valve – N, YYY later from CEB		No ITAAC section yet.
Maintenance of Suppression Pool Integrity	• RHR heat exchanger seismic capacity	19.J.3	

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Fire	Later by Maxwell, Raftery		

May 28, 19[illegible]

J.D. Duncan
M/C 754

Enclosed is our response to the NRC comments C-3 and O-5 on the treatment of common-cause failures in the ABWR PRA.

The response consists of reevaluating core damage frequency with the addition of common-cause failures at the component level in the four system fault trees that use redundant divisions or trains. The CDF of the CCF run is 19.2% higher than the CDF of the (revised) base run. This increase is not very significant. The major contributors to the increase in CDF are inter-division CCFs of the reactor building cooling water system, particularly due to their affect on HPCF and RHR (core flooding mode).

L.G. Frederick
M/C 489

cc: R.P. Raftery

Response to NRC Outstanding Items C-3 and O-5

Outstanding Items C-3 and O-5 requested further analysis of equipment common-cause failures at the component level. In discussions with the NRC, it was agreed that an acceptable approach at this time is to perform the updated PRA Level 1 requantification without addressing CCF (with no additional common-cause failures), then requantify with component-level CCFs added to see the effect on core damage frequency.

CCFs that were already included in the **base** quantification are:

ESF logic	backup scram relays
transmission network (MUX)	pressure sensors
sensor and transmitter miscalibration	APRMs
output logic unit	diesel generators
digital trip unit	batteries
trip logic unit	offsite power source
main scram load drivers	safety relief valves

These CCFs were retained in the base run.

Component CCFs for the following systems were identified, evaluated and included in the CCF run (in addition to those above):

- HPCF (2/2 trains) (14 components)
- RHR Core Flooding Mode (3/3 trains) (24 components)
- RHR SP Cooling Mode (3/3 trains) (25 components)
- RBCW (internal to each division) (4 components)
- RBCW (between Divisions A & B) (6 components)
- RBCW (between Divisions A & C) (6 components)
- RBCW (between Divisions B & C) (6 components)
- RBCW (between Divisions A, B & C) (6 components)

These are the systems where component common-cause failures might have a significant effect. RPS, CRD, Electrical, and Instrumentation and Control Systems already include component CCFs in the base analysis.

The component CCFs that have been added to the system analysis include pumps, pump auxiliary equipment, manual valves, motor-operated valves, check valves, room air conditioners, spargers, strainers, circuit breakers, flow transmitters, heat exchangers, and temperature elements.

For the RBCW CCFs internal within each division of RBCW, the component CCFs were added at appropriate places within the fault tree structures. For all other cases (inter-divisional or between trains), the individual component CCFs were summed and added-in at the top as a CCF module. The RBCW interdivisional CCFs were added-in at the top of the fault trees for all systems that use RBCW.

Component CCFs were identified wherever redundancy occurs in the fault trees (generally, for every "and" gate). The component CCFs were quantified using the "multiple Greek letter" method, and using the CCF factors given in the EPRI ALWR Requirements Document. Where common-cause factors were not given for specific component types, the recommended

"generic" factors were used. For those cases, the results should be considered as "bounding" and are probably conservative.

The numerical results of the analysis in terms of CCFs are given below:

HPCF CCFs (2/2 loops)	2.46E-3
RHR Core Flooding CCFs (3/3 loopr)	1.00E-3
RHR SP Cooling CCFs (3/3 loops)	9.78E-4
RBCW CCFs within a division (1/2 pumps)	1.52E-5
RBCW CCFs between Div. A and B (2/2)	6.48E-6
RBCW CCFs between Div. A and C (2/2)	6.48E-6
RBCW CCFs between Div. B and C (2/2)	6.48E-6
RBCW CCFs between Div. A,B and C (3/3)	5.93E-6

The numerical results of this analysis also can be viewed from two different perspectives: the effect on system unavailability and the effect on core damage frequency. Effect on system unavailability:

System	Base $\bar{\lambda}$	$\bar{\lambda}$ with CCFs*	% Increase
HPCF	2.33E-3	4.79E-3	105
RHR (flood)	9.65E-5	1.10E-3	1040
RHR (cool)	2.72E-4	1.25E-3	360
RBCW Div. A	3.09E-4	3.24E-4	4.85
RBCW Div. B	3.09E-4	3.24E-4	4.85
RBCW Div. C	3.09E-4	3.24E-4	4.85

*CCFs within that system

The effects of component CCFs on system unavailability are significant. The most significant effect is on the core flooding mode of RHR, where the system unavailability with component CCFs is over 11 times the system unavailability without component CCFs. The largest contributors to RHR CCF are common-cause failure of the RHR pumps to start, and common-cause failure of the pump room air conditioners. Common-cause failure of the injection valves to open is also a significant contributor to RHR CCF.

For the HPCF system, the most significant CCF contributors are common-cause failure of the pumps to start, and mispositioning (closed) of manual valve F005. The reason for the large CCF of the manual valve is because of a very high assigned random failure probability (1.0E-2) as taken from WASH 1400. This is an unreasonably conservative value.

The individual divisions of the RBCW system were not significantly affected by component CCFs. However, the interdivisional CCFs have a measureable effect on core damage frequency, as discussed below.

Effect on CDF:

System	CDF Increase	% Increase
HPCF	5.6E-9/yr	3.6
RHR (flood)	4.9E-9/yr	3.1
RHR (cool)	5.4E-10/yr	0.3
RBCW A,B,& C	1.90E-8/yr	12.2
TOTAL	3.00E-8/yr	19.2

The most significant effect on CDF is due to the CCFs between all 3 divisions of RBCW. This is primarily due to the failure of both HPCF and RHR Core Flooding, given loss of all RBCW divisions. All other CCFs have very little effect on CDF.

The common-cause failure of all three divisions of RBCW is balanced among common-cause failure of heat exchangers and common-cause failure of pumps (failing to run). Plugged strainers and temperature control valves failing closed also contribute to the RBCW interdivisional CCFs.