Enclosure 2

M170209

ABWR DCD Markups for RAI Responses

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
4. continued c. The RHR pumps have sufficient NPSH.	4. continued c. Inspections, tests and analyses will be performed upon the as -built RHR System. ~~NPSH tests of the pumps will be performed in a test facility. The analyses will consider the effects of:~~Inspections of the as-built system will be performed to obtain piping system dimensions and other necessary information. The required NPSH of procured pumps will be determined by an inspection of the vendor specifications. The analysis will consider the effects of: – Pressure losses for pump inlet piping and components. – Suction from the suppression pool with water level at the minimum value. – ~~5O% blockage of pump suction strainers.~~Analytically derived values for blockage of pump suction strainers based upon the as-built system. – Design basis fluid temperature (100°C). – Containment at atmospheric pressure. – Confirm vertical and horizontal separation between the SRV Quencher and RHR Suction Strainer.	4. continued c. The available NPSH exceeds the required NPSH required by the pumps.

- Design basis debris loading of pumped fluid under conditions ranging from normal operating to design basis accident conditions.

Test result/report confirms that the RHR valves, RHR pumps and RHR heat exchangers perform their intended functions during post-LOCA operation for a minimum of 30 days.

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Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
3. continued g. The HPCF pumps have sufficient NPSH available at the pumps.	3. continued g. Inspections, tests and analyses will be performed upon the as-built system. ~~NPSH tests of the pumps will be performed in a test facility. The analyses will consider the effects of:~~ Inspections of the as-built system will be performed to obtain piping system dimensions and other necessary information. The required NPSH of procured pumps will be determined by an inspection of the vendor specifications. The analysis will consider the effects of: – Pressure losses for pump inlet piping and components. – Suction from the suppression pool with water level at the minimum value. – ~~50% minimum blockage of the pump suction strainers.~~ Analytically derived values for blockage of pump suction strainers based upon the as-built system. – Confirm vertical and horizontal separation between the SRV Quencher and HPCF Suction Strainer. – Design basis fluid temperature (100°C). – Containment at atmospheric pressure.	3. continued g. The available NPSH exceeds the required NPSH required by the pumps.

- Design basis debris loading of pumped fluid under conditions ranging from normal operating to design basis accident conditions.

Test result/report confirms that the HPCF valves and HPCF pumps perform their intended functions during post-LOCA operation for a minimum of 30 days.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
3. continued j. The RCIC System pump has sufficient NPSH.	3. continued j. Inspections, tests, and analyses will be performed based upon the as-built system. ~~NPSH tests of the pump will be performed at a test facility. The analyses will consider the effects of:~~Inspections of the as-built system will be performed to obtain piping system dimensions and other necessary information. The required NPSH of procured pumps will be determined by an inspection of the vendor specifications. The analysis will consider the effects of: (1) Pressure losses for pump inlet piping and components. (2) Suction from suppression pool with water level at the minimum value. (3) ~~50% blockage of pump suction strainers.~~Analytically derived values for blockage of pump suction strainers based upon the as-built system. (4) Design basis fluid temperature (77°C). (5) Containment at atmospheric pressure. (6) Confirm vertical and horizontal separation between the SRV Quencher and RCIC Suction Strainer.	3. continued j. The available NPSH exceeds the required NPSH required by the pump.

Test result/report confirms that the RCIC valves and RCIC pumps perform their intended functions during post-LOCA operation for a minimum of 12 hours.

- Design basis debris loading of pumped fluid under conditions ranging from normal operating to design basis accident conditions.

Table 1.6-1 Referenced Reports (Continued)

Report No.	Title	Tier 2 Section No.
NEDC-30851P-A	W. P. Sullivan, “Technical Specification Improvement Analyses for BWR Reactor Protection System,” March 1988.	19D.6
NEDE-31096-A	“GE Licensing Topical Report ATWS Response to NRC ATWS Rule 10CFR 50.62,” February 1987.	19B.2
NEDE-31152-P	“GE Bundle Designs,” December 1988.	4.2
NEDO-31331	Gerry Burnette, “BWR Owner’s Group Emergency Procedure Guidelines,” March 1987.	18A
NEDC-31336	Julie Leong, “General Electric Instrument Setpoint Methodology,” October 1986.	7.3
NEDC-31393	“ABWR Containment Horizontal Vent Confirmatory Test, Part I,” March 1987.	3B
NEDO-31439	C. VonDamm, “The Nuclear Measurement Analysis & Control Wide Range Neutron Monitoring System (NUMAC-WRNMS),” May 1987	20.3
NEDC-31858P	Louis Lee, “BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control System,” 1991	15.6
NEDE-31906-P	A. Chung, “Laguna Verde Unit I Reactor Internals Vibration Measurement,” January 1991.	7.4
NEDO-31960	Glen Watford, “BWR Owners’ Group Long-Term Stability Solutions Licensing Methodology,” June 1991.	4.4
NEDC-32084P-A Rev. 2	“TASC-03A - A Computer Program for Transient Analysis of a Single Channel,” July 2002.	6.3
NEDC-32267P	“ABWR Project Application Engineering Organization and Procedures Manual,” December 1993.	17.1
NEDO-32686-A	“Utility Resolution Guide for ECCS Suction Strainer Blockage,” October 1998.	6C
NEDC-32721P-A	“Application Methodology for the General Electric Stacked Disk ECCS Suction Strainer,” Rev. 2, March 2003 (using an updated head loss correlation).	6C
NEDO-33173 Supplement 4-A, Revision 1	“Implementation of PRIME Models and Data in Downstream Methods,” November 2012.	6.3
NEDE-33878P	“ABWR ECCS Suction Strainer Evaluation of Long-Term Recirculation Capability,” ~~Rev. 1, May 2017~~ (GEH Proprietary Information); NEDO-33878, “ABWR ECCS Suction Strainer Evaluation of Long-Term Recirculation Capability,” ~~Rev. 1, May 2017.~~	6C

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Table 1.8-20 NRC Regulatory Guides Applicable to ABWR (Continued)

RG No.	Regulatory Guide Title	Appl. Rev.	Issued Date	ABWR Applicable?	Comments
1.91	Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants	2	2/78	Yes	
[*1.92*	*Combining Modal Responses and Spatial Components in Seismic Response Analysis*	*1*	*2/76*	*Yes]*(1)	
1.93	Availability of Electric Power Sources	0	12/74	Yes	
1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of	---	---	---	See Table 17.0-1

ADD new line for RG 1.100 R3

RG No	Regulatory Guide Title	Appl Rev	Issued Date	ABWR Applicable?	Comments
[1.100	*Seismic Qualification of Electric Equipment for Nuclear Power Plants*	3	9/2009	yes]2	See Note 5

RG No.	Regulatory Guide Title	Appl. Rev.	Issued Date	ABWR Applicable?	Comments
	Control Systems for Boiling Water Reactor Nuclear Power Plants				
1.97	Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident	3	5/83	Yes	
1.98	Assumptions for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor	0	3/76	Yes	
1.99	Radiation Embrittlement of Reactor Vessel Materials	2	5/88	Yes	
[*1.100*	*Seismic Qualification of Electric Equipment for Nuclear Power Plants*	*2*	*6/88*	*Yes]*(2)	
1.101	Emergency Planning and Preparedness for Nuclear Power Reactors	3	8/92	Yes	
1.102	Flood Protection for Nuclear Power Plants	1	9/76	Yes	
[*1.105*	*Instrument Setpoints for Safety-Related Systems*	*2*	*2/86*	*Yes]*(3)	
1.106	Thermal Overload Protection for Electric Motors on Motor-Operated Valves	1	3/77	Yes	
1.107	Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures	1	2/77	Yes	

ADD in Comments Column for RG 1.100 R2: "See Note 5"

Sections 3.9 and

Table 1.8-20 Notes:

(1) See Subsection 3.9.1.7 for restriction of change to this revision. The change restriction to R.G 1.84 applies only in regard to Code Case N-420 (See DCD/Introduction, Table 7).

(2) See ~~Section~~ 3.10 for restriction of change to this revision.

(3) See Subsection 7.1.2.10.9 for restriction to change this revision.

(4) See Section 7A.1(1).

ADD New Note 5:

(5) RG 1.100 Rev 3 applies to endorsement of ASME QME 1 for qualification guidance of ECCS pumps and components under post LOCA conditions including design debris loading. RG 1.100 Rev 2 is applicable to all other scope.

QME-1 2007 Qualification of Active Mechanical Equipment Used in Nuclear Power Plants (10)

Table 1.8-21 Industrial Codes and Standards* Applicable to ABWR (Continued)

Code or Standard Number	Year	Title
N510†	1989	Testing of Nuclear Air-Cleaning Systems
NOG-1	2004	Rules for Construction of Overhead and Gantry Cranes
NQA-1†	1983	Quality Assurance Program Requirements for Nuclear Facilities
NQA-1a†	1983	Addenda to ANSI/ASME NQA-1-1983
[NQA-2a†	*1990*	*Quality Assurance Requirements of Computer Software for Nuclear Facility Application]*(3)(4)
OMa	1988	Operation and Maintenance of Nuclear Power Plants (Addenda to OM-1987)
Sec II	1989	BPVC Section II, Material Specifications
[*Sec III*	*1989*	*BPVC Section III, Rules for Construction of Nuclear Power Plant Components*](6)(8)
Sec VIII	1989	BPVC Section VIII, Rules for Construction of Pressure Vessel
Sec IX	1989	BPVC Section IX, Qualification Standard for Welding and Brazing Procedures Welder, Brazers and Welding and Brazing Operators
Sec XI	1989	BPVC Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components
American Society for Testing and Materials (ASTM)		
[*C776*	*1979*	*Sintered Uranium Dioxide Pellets*](2)
[*C934*	*1980*	*Design and Quality Assurance Practices for Nuclear Fuel Rods*](2)
E84 REV. A	1991	Methods of Test of Surface Burning Characteristics of Building Materials
E119	1988	Standard Test Methods for Fire Tests of Building Construction and Materials
E152	1981	Standard Methods of Fire Tests of Door Assemblies
		(See ASME BPVC Section III for ASTM Material Specifications)
American Welding Society (AWS)		
A4.2†	1986	Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite content of Anstenitic Stainless Steel Weld Metal
D1.1†	1986	Steel Structural Welding Code
D14.1†	1985	Welding of Industrial and Mill Cranes and other Material Handling Equipment
American Water Works Association (AWWA)		
D100†	1984	Welded Steel Tanks for Water Storage

Table 1.8-21 Industrial Codes and Standards* Applicable to ABWR (Continued)

Code or Standard Number	Year	Title
NEI 12-01	2012	Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities
NEI 12-02	2012	Industry Guidance for Compliance with NRC Order EA-12-051, “To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation”
~~NEI 12-06 R0~~	~~2012~~	~~Diverse and Flexible Coping Strategies (FLEX) Implementation Guide~~
NEI 14-01 R0	2014	Emergency Response Procedures and Guidelines for Beyond Design Basis Events and Severe Accidents
NEI 91-04 R1	1994	Severe Accident Issue Closure Guidelines
OSHA 1910.179	1990	Overhead and Gantry Cranes
TEMA C	1978	Standards of Tubular Exchanger Manufacturers Association
UL-44	1983	Rubber-Insulated Wires and Cables
UL-489	1991	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
UL-845	1988	Standard for Safety Motor Control Centers - Low Voltage Circuit Breakers
--	--	Crane Manufacturers Association of America, Specification No. 70
--	--	Aluminum Construction Manual by Aluminum Association
NCIG-01	Rev. 2	Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants
UBC	1991	Uniform Building Code

* The listing of a code or standard does not necessarily mean that it is applicable in its entirety.

† Also an ANSI code (i.e. ANSI/ASME, ANSI/ANS, ANSI/IEEE etc.).

‡ ANSI, ANSI/ANS, ANSI/ASME, and ANSI/IEEE codes are included here. Other codes that approved by ANSI and another organization are listed under the latter.

ƒ As modified by NRC accepted alternate positions to the related Regulatory Guide and identified in Table 2-1 of Reference 1 to Chapter 17.

Notes:

(1) See Subsection 3.8.3.2 for restriction to use of these.

(2) See Subsection 4.2.

(3) See section 7A.1(1).

(4) See Section 7A.1(2).

(5) See Section 18E.1 for required use of this document.

(6) See Subsection 3.8.1.1.1 for specific restriction of change to this edition.

(7) See Section 3.10 for restriction of change to this revision.

(8) See Subsection 3.9.1.7 for specific restriction of change to this edition in application to piping design. See Table 3.2-3 for the restricted Subsections of this Code as applied to piping design only.

(9) See Subsection 7.1.1.2.

(10) See Subsection 3.9.6.1 for restrictions to use of these.

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Details of the inservice testing program, including test schedules and frequencies, will be reported in the inservice inspection and testing plan to be provided by the applicant referencing the ABWR design. The plan will integrate the applicable test requirements for safety-related pumps and valves, including those listed in the technical specifications, Chapter 16, and the containment isolation system, Subsection 6.2.4. For example, the periodic leak testing of the reactor coolant pressure isolation valves (See Appendix 3M for design changes made to prevent intersystem LOCAs) in Table 3.9-9 will be performed in accordance with Chapter 16 Surveillance Requirement SR 3.6.1.5.10. This plan will include baseline pre-service testing to support the periodic inservice testing of the components. Depending on the test results, the plan will provide a commitment to disassemble and inspect the safety-related pumps and valves when limits of the OM Code are exceeded, as described in the following paragraphs. The primary elements of this plan, including the requirements of Generic Letter 89-10 for motor operated valves, are delineated in the subsections to follow. (See Subsection 3.9.7.3 for COL license information requirements.)

3.9.6.1 Testing of Safety-Related Pumps

For each pump, the design basis and required operating conditions (including tests) under which the pump will be required to function will be established. These designs (design basis and required operating) conditions include flow rate and corresponding head for each system mode of pump operation and the required operating time for each mode, acceptable bearing vibration levels, seismic/dynamic loads, fluid temperature, ambient temperature, and pump motor minimum voltage.

The COL applicant will establish the following design and qualification requirements and will provide acceptance criteria for these requirements. For each size, type, and model the COL applicant will perform testing encompassing design conditions that demonstrate acceptable flow rate and corresponding head, bearing vibration levels, and pump internals wear rates for the operating time specified for each system mode of pump operation. From these tests the COL applicant will also develop baseline (reference) hydraulic and vibration data for evaluating the acceptability of the pump after installation. The COL applicant will ensure that the pump specified for each application is not susceptible to inadequate minimum flow rate and inadequate thrust bearing capacity. With respect to minimum flow pump operation, the sizing of each minimum recirculation flow path is evaluated to assure that its use under all analyzed conditions will not result in degradation of the pump. The flow rate through minimum recirculation flow paths can also be periodically measured to verify that flow is in accordance with the design specification.

The ABWR safety-related pumps and piping configurations accommodate in-service testing at a flow rate at least as large as the maximum design flow for the pump application. The safety-related pumps are provided with instrumentation to verify that the net positive suction head (NPSH) is greater than or equal to the NPSH required during all modes of pump operation. These pumps can be disassembled for evaluation when Part 6 testing results in a deviation which falls within the “required action range.” The Code provides criteria limits for the test

It is demonstrated that the ECCS pumps (including mechanical seal) can perform specified functions under all design basis conditions including post-LOCA debris loading conditions. Demonstration of acceptable performance for as-built ECCS pumps is validated under QME-1 2007, Qualification of Active Mechanical Equipment Used in Nuclear Power Plants as endorsed by RG 1.100 Revision 3.

parameters identified in Table 3.9-8. A program will be developed by the COL applicant to establish the frequency and the extent of disassembly and inspection based on suspected degradation of all safety-related pumps, including the basis for the frequency and the extent of each disassembly. The program may be revised throughout the plant life to minimize disassembly based on past disassembly experience. (See Subsection 3.9.7.3(1) for COL license information requirements.)

3.9.6.2 Testing of Safety-Related Valves

3.9.6.2.1 Check Valves

(1) Design and Qualification

For each check valve with an active safety-related function, the design basis and required operating conditions (including testing) under which the check valve will be required to perform will be established.

The COL applicant will establish the following design and qualification requirements and will provide acceptance criteria for these requirements. By testing each size, type, and model the COL applicant will ensure the design adequacy of the check valve under design (design basis and required operating) conditions. These design conditions include all the required system operating cycles to be experienced by the valve (numbers of each type of cycle and duration of each type cycle), environmental conditions under which the valve will be required to function, severe transient loadings expected during the life of the valve such as waterhammer or pipe break, life-time expectation between major refurbishments, sealing and leakage requirements, corrosion requirements, operating medium with flow and velocity definition, operating medium temperature and gradients, maintenance requirements, vibratory loading, planned testing and methods, test frequency and periods of idle operation. The design conditions may include other requirements as identified during detailed design of the plant systems. This testing of each size, type and model shall include test data from the manufacturer, field test data for dedication by the COL applicant, empirical data supported by test, or test (such as prototype) of similar valves that support qualification of the required valve where similarity must be justified by technical data. The COL applicant will ensure proper check valve application including selection of the valve size and type based on the system flow conditions, installed location of the valve with respect to sources of turbulence, and correct orientation of the valve in the piping (i.e., vertical vs horizontal) as recommended or required by the manufacturer. The COL applicant will ensure that valve design features, material, and surface finish will accommodate non-intrusive diagnostic testing methods available in the industry or as specified. The COL applicant will also ensure that flow through the valve is determinable from installed instrumentation and that the valve disk positions are determinable without disassembly such as by use of non-intrusive diagnostic methods. Valve internal parts

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6C Containment Debris Protection for ECCS Strainers

6C.1 Background

NRC Bulletin No. 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers," references NRC guidance and highlights the need to adequately accommodate suppression pool debris in design by focusing on an incident at the Perry Nuclear Plant. Similar concerns were later identified throughout the industry and documented by subsequent bulletins and generic letters including NRC Bulletin 95-02, NRC Bulletin 96-03, Generic Letter 97-04, and Generic Letter 98-04. GEH reviewed the concerns addressed by these bulletins/letters and has determined that the ABWR design satisfactorily accommodates suppression pool debris for a number of reasons as discussed in the following:

The ultimate concern raised by the Perry incident was the deleterious effect of debris in the suppression pool and how it could impact the ability to draw water from the suppression pool during an accident. To address this concern, the ABWR design has committed to following the guidance provided in Regulatory Guide 1.82 as well as NEDO-32686-A (Utility Resolution Guide for ECCS Suction Strainer Blockage), and additional guidance as described below.

The ABWR is designed to inhibit debris generated during a LOCA from preventing operation of the Residual Heat Removal (RHR), Reactor Core Isolation Cooling (RCIC) and High Pressure Core Flooder (HPCF) systems.

6C.2 ABWR Mitigating Features

The ABWR has substantially reduced the amount of piping in the drywell relative to earlier designs and consequently the quantity of insulation required. Furthermore, there is no equipment in the wetwell spaces that requires insulation or other fibrous materials. The ABWR design conforms with the guidance provided by the NRC for maintaining the ability for long-term recirculation cooling of the reactor and containment following a LOCA.

The Perry incident was not the result of a LOCA but rather debris entering the Suppression Pool during normal operation. The arrangement of the drywell and wetwell/wetwell airspace on a Mark III containment (Perry) is significantly different from that utilized in the ABWR design. In the Mark III containment, the areas above the suppression pool water surface (wetwell airspace) are substantially covered by grating with significant quantities of equipment installed in these areas. Access to the wetwell airspace (containment) of a Mark III is allowed during power operations. In contrast, on the ABWR the only connections to the suppression pool are the 10 drywell connecting vents (DCVs), and access to the wetwell or drywell during power operations is prohibited. The DCVs will have horizontal steel plates located above the openings that will prevent any material falling in the drywell from directly entering the vertical leg of the DCVs. This arrangement is similar to that used with the Mark II connecting vent pipes. Vertically oriented trash rack construction will be installed around the periphery of the horizontal steel plate to intercept debris. The trash rack design shall allow for adequate flow

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from the drywell to wetwell. In order for debris to enter the DCV it would have to travel horizontally through the trash rack prior to falling into the vertical leg of the connecting vents. Thus the ABWR is resistant to the transport of debris from the drywell to the wetwell.

In the Perry incident, the insulation material acted as a septa to filter suspended solids from the suppression pool water. The Mark I, II, and III containments have all used carbon steel in their suppression pool liners. This results in the buildup of corrosion products in the suppression pool which settle out at the bottom of the pool until they are stirred up and re-suspended in the water following some event (SRV lifting). In contrast, the ABWR liner of the suppression pool is fabricated from stainless steel which significantly lowers the amount of corrosion products which can accumulate at the bottom of the pool.

A further mitigating feature for the ABWR is that the insulation installed on the ASME Section III, Class 1 piping greater than 80 mm in the drywell, i.e., the large bore piping, is reflective metal type (RMI). Use of RMI minimizes the fibrous insulation source term from the upper drywell used in the suction strainer design. This use of RMI is a significant factor in design that reduces the potential suction strainer debris load and further reduces the potential for suction strainer clogging.

Since the debris in the Perry incident was created by roughing filters on the containment cooling units a comparison of the key design features of the ABWR is necessary. In the Mark III design more than 1/2 of the containment cooling units are effectively located in the wetwell airspace. For the ABWR there are no cooling fan units in the wetwell air space. Furthermore the design of the ABWR Drywell Cooling Systems does not utilize roughing filters on the intake of the containment cooling units during plant operation.

In the event debris enters the suppression pool and does not settle on the pool bottom, the Suppression Pool Cleanup System (SPCU) will remove the suspended debris during normal plant and SPCU operation. The SPCU is described in Section 9.5.9 and shown in Figure 9.5-1. The SPCU is designed to provide a continuous cleanup flow of 250 m^3/h. This flow rate is sufficiently large to effectively maintain the suppression pool water at the required purity. The SPCU system is intended for continuous operation and the suction pressure of the pump is monitored and an alarm is provided on low pressure. Early indication of any deterioration of the suppression pool water quality will be provided if significant quantities of debris were to enter the suppression pool and cause the strainer to become plugged resulting in a low suction pressure alarm.

The suction strainers design at Perry preceded and did not meet the current regulatory requirements. The ABWR ECCS suction strainers are patented GE optimized stacked disk design in accordance with NEDC-32721P-A Rev.2. This strainer design was developed in response to NRC Bulletin 96-03 as a replacement of existing ECCS strainers with a large capacity passive strainer design. This strainer design utilizes disks whose internal radius and thickness vary over the height of the strainer. The selected variation in these parameters achieves an increased surface area compared to existing strainers of the same size to provide a

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higher capacity for debris capture. The ABWR strainer will perform with a minimum head loss for the range of possible amounts of debris while fitting in the required volume. To avoid debris clogging the flow restrictions downstream of the strainers, the size of the holes in the perforated sheets is chosen by considering specific flow paths of ECCS equipment and piping (for example, the containment spray nozzle and the ECCS pump seal cooling flow orifices). The strainers will have holes no larger than 3.175 mm (0.125 inch).

The ABWR design also has additional features not utilized in earlier designs that could be used in the highly improbable event that all suppression pool suction strainers were to become plugged. The alternate Alternating Current independent water addition (ACIWA) mode of RHR allows water from the Fire Protection System to be pumped to the vessel and sprayed in the wetwell and drywell from diverse water sources to maintain cooling of the fuel and containment. The wetwell can also be vented at low pressures to assist in cooling the containment.

6C.3 Design Considerations

6C.3.1 RG 1.82 Improvement

All ECCS strainers will at a minimum be sized to conform with the guidance provided in Reg Guide 1.82 for the most severe of all postulated breaks.

The following clarifying assumptions will also be applied and will take precedence:

(1) The debris generation model ~~shall be consistent with Methods 1, 2, or 3 from the zone of influence approach in~~utilizes spherical zones of influence (ZOI) in accordance with the Utility Resolution Guidance, Reference 6C-3.

(2) Of the debris generated, the amount that is transported to the suppression pool shall be determined in accordance with Reference 6C-3 based on similarity of the Mark III upper drywell design. This approach is conservative due to the ABWR containment improvements over the Mark III as discussed in Section 6C.2.

(3) The debris in the suppression pool will be assumed to remain suspended until it is captured on the surface of a strainer.

Suction Strainer sizing is based on satisfying NPSH requirements at runout flow~~, plus margin,~~ with the design basis debris in the suppression pool accumulated on the suction strainers.

The sizing of the suction strainers assumes that the insulation debris in the suppression pool is ~~proportionally~~ distributed to the pump suctions based on the maximum debris load fraction assuming flow rates of the operating systems at limiting runout conditions. The strainers assumed available for capturing insulation debris for the limiting design condition are ~~two~~one RHR ~~suction strainers and a single~~loop, one HPCF loop, and the~~or~~ RCIC system~~suction strainer~~.

6C.3.2 Chemical Effects

~~The chemical effects of the post-LOCA environment on debris shall be evaluated to assess the extent to which chemical reaction products contribute to blockage of the ECCS strainers. The evaluation shall be submitted by the COL Applicant and shall demonstrate that the effects of chemical reaction products from post-LOCA debris shall not prevent long-term cooling of the core (COL 6.12).~~The ABWR design has been reviewed for the potential generation of chemical precipitates which may contribute to strainer head loss following a LOCA. In general, the ABWR design features preclude the materials and environmental conditions which are most problematic for generation of chemical precipitate debris that may contribute to blockage and head loss.

The primary containment will not contain reactive materials such as aluminum, phosphates, or calcium silicate, and minimizes zinc by prohibiting it except for a small amount in galvanized steel and inorganic primers. Inorganic zinc primers are top coated with an epoxy layer that prevents exposure to the LOCA environment. Coatings are qualified as described in Subsection 6.1.2. The debris load described in Table 6C-1 accounts for coatings that are destroyed during a LOCA.

An important consideration in the generation of corrosion products is the post-LOCA environment which, for some plant designs, can be of an acidic nature due to the use of boric acid in the primary coolant. The ABWR does not utilize boric acid. The Standby Liquid Control System is capable of injecting a sodium pentaborate solution, however this system is not used during a LOCA. Standby Liquid Control is only used to mitigate ATWS events as described in Appendix 15E. Consequently, the post-LOCA environment inside containment is relatively pH neutral with a flat time history throughout the event as described in Section 6.1.1.2.

6C.3.3 Downstream Effects

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The effects of debris ~~passing through the strainers shall be~~being transported from the suppression pool are evaluated for interactions with downstream components such as pumps, valves, and heat exchangers and also for the potential blockage of coolant flow at the entrance to the fuel assemblies. NEDE-33878P, ABWR ECCS Suction Strainer Evaluation of Long-Term Recirculation Capability, ~~Rev. 0,~~ (Reference 6C-5) evaluated the impact of debris downstream of the ECCS strainers causing blockage or wear and abrasion. The three areas of concern evaluated are (1) blockage of system flow paths at narrow flow passages (e.g., ECCS sparger spray nozzles), (2) wear and abrasion of surfaces (e.g., pump running surfaces and heat exchanger tubes and orifices), and (3) blockage of flow paths through fuel assemblies.~~The evaluation shall be submitted by the COL Applicant and shall demonstrate that the effects of debris bypass of the strainer shall not prevent long-term cooling of the core (COL 6.12).~~

This assessment concludes that ECCS flow paths and components downstream of the strainers, including fuel assemblies, are not susceptible to failure from debris blockage, particulate ingestion, abrasive effects and long term degradation and can perform required safety functions during the required mission time. The ABWR design includes several mitigating features that reduce the likelihood of such adverse debris interactions. These include:

- Minimal opportunity for debris generation in the wetwell. High energy breaks are restricted to the drywell, and debris generated there must pass through trash racks and vertical/horizontal vents before reaching the suppression pool.
- Diverse ECCS delivery locations, which include injection both inside and outside the core shroud.
- Bypass flow paths which exist around the debris filters of the fuel assemblies.
- The Suppression Pool Cleanup System will minimize the quantity of latent debris in the suppression pool. A suppression pool cleanliness program will be developed (Subsection 6.2.7.3) to minimize the quantity of latent debris.

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The assessment includes the effects of debris settling in instrument lines and components, blockage and binding of tight clearance valves (such as throttle and check valves) and wear of ECCS components (pumps and heat exchangers).

The assessment credited the configuration of ECCS instrument line taps in the process piping. ECCS instrument lines in service during post-LOCA operation are installed above the horizontal plane of the process piping. No settling of debris in an instrument line with this orientation is expected.

The assessment used the listed ECCS valve positions for post-LOCA system alignment:

* Table 1, Valve Position Chart, DCD Figure 5.4-11, Reactor Heat Removal System PFD (sheet 2 of 2)
* Table 1, Valve Position Chart, DCD Figure 6.3-1, High Pressure Core Flooder System PFD (sheet 2 of 2)
* Table 1, Valve Position Chart, DCD Figure 5.4-9, Reactor Core Isolation Cooling System PFD (sheet 2 of 2)

ECCS pump and component performance qualification will be validated using the guidance of QME-1, Qualification of Active Mechanical Equipment Used in Nuclear Power Plants.

suction pressure can provide early indication of debris present in the suppression pool and permit the plant operator to take appropriate corrective action.

(5) The equipment installed in the drywell and wetwell minimize the potential for generation of debris.

(6) The ECCS suction strainers meet the current regulatory requirements.

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6C.5 Strainer Sizing Analysis Summary

A preliminary analysis was performed to assure that the above requirements could be satisfied using strainers compatible with the suppression pool design as shown by Figure 1.2-13i.

Each loop of an ECCS system utilizes a single stacked disk suction strainer. The strainer design conforms to the methodology defined in Reference 6C-4. The strainer has a central core of varying radius such that the flow through the entire central region is maintained at constant velocity. The constant velocity core minimizes head loss where velocities are the greatest. A number of perforated disks of varying internal diameter and whose thickness may vary with radius surround the central core.

All of the debris is assumed to deposit on the strainers. The debris load is characterized by the methods in Reference 6C-3, and quantities are summarized in Table 6C-1. The distribution of debris volume to the strainer regions was determined as a fraction of the proportional loop flow splits. The strainer sizing is calculated based on the strainer flow rate and debris load. The head loss is calculated by a method based upon Reference 6C-4 which uses empirical correlations to test data. The methodology considers losses through a clean strainer and factors in the effects of the debris bed taking into account the thickness of the bed, and the type of debris (fiber, RMI, sludge, etc.). Consideration is given to whether the quantity of debris is sufficient to fully engulf the gaps between the strainer disks, as this has an influence on the head loss correlation.

By making realistic assumptions, the following additional conservatisms are likely to occur, but they were not applied in the analysis. No credit in water inventory was taken for water additions from feedwater flow or flow from the condensate storage tank as injected by RCIC or HPCF. Also, for the long term cooling condition, when suppression pool cooling is used instead of the low pressure flooder mode (LPFL), the RHR flow rate decreases from runout (1130 m3/h) to rated flow (954 m3/h), which reduces the pressure drop across the debris.

Based on these considerations, the ABWR ECCS suction strainers are the GE stacked disk strainer design analyzed for the sizing methodology in NEDC-32721 P-A (Ref. 6C-4). The ABWR selected strainer design utilizes sizing for the RHR service for each of the strainers. The ABWR ECCS suction strainer configuration is as follows:

- Type: GE stacked disk passive suction strainer.
- Flow Area: Each strainer has perforated area 36 m^2 with 20 disks, which provides a combined surface area of 216 m^2 for three (3) RHR, two (2) HPCF and one (1) RCIC strainer(s).
- Hole Size: 3.2 mm diameter.
- Flow Rate Sizing: 2180 m^3/hr.

The ABWR ECCS suction strainer classification information is provided in Table 3.2-1, Classification Summary.

6C.6 COL License Information

6C.6.1 ~~Debris Evaluation for ECCS Suction Strainer~~Deleted

~~An evaluation shall be submitted by the COL Applicant that demonstrates that chemical effects and the effect of debris bypass of the strainers does not prevent long-term cooling of the core (COL 6.12). The evaluation shall be based on the research and recommendations of the BWR Owner's Group GSI-191 committee.~~

6C.7 References

6.C-1 Debris Plugging of Emergency Core Cooling Suction Strainers, USNRC Bulletin No. 93-02, May 11, 1993.

6.C-2 Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident, USNRC Reg. Guide 1.82 Rev. ~~3~~4.

6.C-3 Utility Resolution Guidance for ECCS Suction Strainer Blockage, NEDO-32686-A, October, 1998.

6.C-4 Application Methodology for the General Electric Stacked Disk ECCS Suction Strainer, NEDC-32721P-A, March 2003 (using an updated head loss correlation).

6.C-5 NEDE-33878P, "ABWR ECCS Suction Strainer Evaluation of Long-Term Recirculation Capability," ~~Rev. 1, May 2017~~ (GEH Proprietary Information); NEDO-33878, "ABWR ECCS Suction Strainer Evaluation of Long-Term Recirculation Capability," ~~Rev. 1, May 2017.~~

Rev. 2, August 2017

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Table 6C-1 ECCS Strainer Debris Load

Debris Type	Strainer Load
Sludge / corrosion prod.	90.7 kg (200 lbm)
Inorganic Zinc (IOZ)	21.3 kg (47 lbm)
Epoxy Coated IOZ	38.6 kg (85 lbm)
Rust Flakes	22.7 kg (50 lbm)
Dust / Dirt	68.0 kg (150 lbm)
Reflective Metal Insulation	35.8 m^2 (385 ft^2)
Nukon Fiber Insulation	23.4 kg (51.6 lbm)