6.1 Engineered Safety Feature Materials

Materials used in the engineered safety feature (ESF) components have been evaluated to ensure that material interactions do not occur that can potentially impair operation of the ESF. Materials have been selected to withstand the environmental conditions encountered during normal operation and any postulated loss-of-coolant-accident (LOCA). Their compatibility with core and containment spray solutions has been considered, and the effects of radiolytic decomposition products have been evaluated.

Coatings used on exterior surfaces within the primary containment are suitable for the environmental conditions expected. Only metallic insulation is used inside the containment, except for duct and antisweat insulation. All nonmetallic thermal insulation employed is required to have the proper ratio of sodium silicate to leachable chloride plus fluoride ions (Regulatory Guide 1.36), in order to minimize the possible contribution to stress corrosion cracking of austenitic stainless steel.

6.1.1 Metallic Materials

6.1.1.1 Materials Selection and Fabrication

6.1.1.1.1 Material Specifications

Table 5.2-4 lists the principal pressure-retaining materials and the appropriate materials specifications for the reactor coolant pressure boundary (RCPB) components. Table 6.1-1 lists the principal pressure-retaining materials and the appropriate material specifications of the primary containment system, the Emergency Core Cooling System (ECCS) and their auxiliary systems and the Standby Liquid Control System (SLCS). The ESF materials selected satisfy Appendix I to Section III of the ASME Code and Parts A, B, and C of Section II of the Code.

6.1.1.1.2 Compatibility of Construction Materials with Core Cooling Water and Containment Sprays

All construction materials used in the essential portions of these systems are corrosion-resistant, both in the medium contained and the external environment. General corrosion of all materials, except carbon and low-alloy steel, is negligible. Conservative corrosion allowances are provided for all exposed surfaces of carbon and low-alloy steel. Special allowances are made for the SLCS, which contains sodium pentaborate solution.

Demineralized water, with no additives, is employed in BWR core cooling water and containment sprays (See Subsections 9.2.6 and 9.2.9 for a description of the water quality requirements). Leaching of chlorides from concrete and other substances is not significant. No detrimental effects occur on any of the ESF construction materials from allowable containment levels in the high-purity water. Thus, the materials are compatible with the post-LOCA environment.

6.1.1.1.3 Controls for Austenitic Stainless Steel

6.1.1.1.3.1 Control of the Use of Sensitized Stainless Steel

Controls to avoid severe sensitization are discussed in Subsection 5.2.3.4.1.1.

6.1.1.1.3.2 Process Controls to Minimize Exposure to Contaminants

Process controls for austenitic stainless steel are discussed in Subsection 5.2.3.4.1.2.

6.1.1.1.3.3 Use of Cold Worked Austenitic Stainless Steel

Austenitic stainless steels (300 series) are generally used in the solution heat treated condition. During bending and fabrication, the bend radius, the material hardness, and the surface finish of ground surfaces are controlled. Where the controls are not met, the material is required to be re-solution heat treated.

6.1.1.1.3.4 Thermal Insulation Requirements

Thermal insulation materials used on ESF systems shall be selected, procured, tested and stored in accordance with Regulatory Guides 1.36 and 1.82. Nonmetallic thermal insulation materials are required to have the proper ratio of leachable sodium plus silicate ions to leachable chloride plus fluoride ions as specified in Regulatory Guide 1.36. Insulation shall be tested to confirm that insulation debris resulting from a LOCA will not prevent the operation of the core cooling water and containment spray systems as specified in Regulatory Guide 1.82.

6.1.1.1.3.5 Avoidance of Hot Cracking of Stainless Steel

Process controls to avoid hot cracking are discussed in Subsection 5.2.3.4.2.1.

6.1.1.1.3.6 Not Used

6.1.1.2 Composition, Compatibility and Stability of Containment and Core Coolants

Demineralized water from the condensate storage tank or the suppression pool, with no additives, is employed in the core cooling water and containment sprays. One exception is that the sodium pentaborate liquid control solution, if used, enters through the core flooder system.

The post-LOCA ESF coolant, which is high-purity water, comes from one of two sources. Water in the 304L stainless steel-lined suppression pool is maintained at high purity (low corrosion attack) by the Suppression Pool Cleanup (SPCU) System (Subsection 9.5.9). Since the pH range (5.3 - 8.6) is maintained, corrosive attack on the pool liner (304L SS) will be insignificant over the life of the plant. ESF coolant may also be obtained from the condensate storage tank, if available (Subsection 9.2.6).

Because of the methods described above (coolant storage provisions, insulation materials requirements, and the like), as well as the fact that the containment has no significant stored quantities of acidic or basic materials, the post-LOCA aqueous phase pH in all areas of

containment will have a flat time history. In other words, the liquid coolant will remain at its design basis pH throughout the event.

6.1.2 Organic Materials

6.1.2.1 Protective Coatings

The use of organic protective coatings within the containment has been kept to a minimum. The major use of such coatings is on the carbon steel containment liner, internal steel structures, and equipment inside the drywell and wetwell.

The epoxy coatings are specified to meet the requirements of Regulatory Guide 1.54 and are qualified using the standard ANSI tests, including ANSI N101.2. However, because of the impracticability of using these special coatings on all equipment, certain exemptions (e.g., electronic/electrical trim, covers, face plates and valve handles) are allowed. The exemptions are restricted to small-size equipment where, in case of a LOCA, the paint debris is not a safety hazard. Other than these minor exemptions, all coatings within the containment are qualified to Regulatory Guide 1.54. See Subsection 6.1.3.1 for COL license information.

6.1.2.2 Other Organic Materials

Materials used in or on the ESF equipment have been reviewed and evaluated in respect to radiolytic and pyrolytic decomposition and attendant effects on safe operation of the system. For example, fluorocarbon plastic (Teflon) is not permitted in environments that attain temperatures greater than 148.8°C, or radiation exposures above 100 gray. The 10 reactor internal pump motors each contain less than 4.54 kg of polyacrylic and polyethylene motor winding insulation. This material has a design life of 20 years in the environment of less than $6x10^5$ gray at 60°C maximum.

Other organic materials in the containment are qualified to environmental conditions in the containment. See Subsection 6.1.3.1 for COL license information.

6.1.2.3 Safety Analysis

For each application the materials have been specified to withstand an appropriate radiation dose for their design life, without suffering any significant radiation-induced damage. The specified integrated radiation doses are consistent with those listed in Section 3.11. The various suppliers have indicated their compliance with these requirements.

In addition, since the containment post-accident environment consists of hot water, air and steam, no significant chemical degradation of these materials is expected because of strict applications of inspection and testing. No significant amount of solid debris is expected to be generated from these materials.

6.1.3 COL License Information

6.1.3.1 Protective Coatings and Organic Materials

The COL applicant shall:

(1) Indicate the total amount of protective coatings and organic materials used inside the containment that do not meet the requirements of ANSI N101.2 and Regulatory Guide 1.54.

(2) Evaluate the generation rate as a function of time of combustible gases that can be formed from organic materials under DBA conditions.

(3) Provide the technical basis and assumptions used for this evaluation (Subsection 6.1.2.1 and 6.1.2.2).

Table 6.1-1 Engineered Safety Features Component Materials*

Component	Form	Material	Specification (ASTM/ASME)
RHR Heat Exchanger			
Shell, Head and Channel	Plate	Carbon Steel	SA-516 Gr 70
Tube Sheet	Plate	Carbon Steel	SA-516 Gr 70
Nozzles and Flanges	Forging	Carbon Steel	SA-350 Gr LF2
Tubes	Tube	Stainless Steel	SA-249 Type 304L
Nuts and Bolts	Bar	Low Alloy Steel	SA-194 Gr 7, SA-193 Gr B7
RHR Pumps and HPCF Pumps			
Bowl Assembly	Casting	Carbon Steel	SA-352 Gr LCB
Discharge Head Shell/Cover	Plate/Forging	Carbon Steel	SA-516 Gr 70/SA-350 Gr LF2
Suction Barrel Shell & Disked Head	Plate	Carbon Steel	SA-516 Gr 70
Flanges	Forging	Carbon Steel	SA-350 Gr LF2
Pipe	Pipe	Carbon Steel	SA-333 Gr 6
Shaft	Bar	Stainless Steel	SA-479 Type 410 (Q&T or N&T)
Impellers	Casting	Stainless Steel	SA-487 Gr CA6NM
Studs & Nuts	Bar	Low Alloy Steel	SA-193 Gr B7/SA-194 Gr 7
RHR			
A—High and Low Pressure Primary Piping (Class 1 or 2)			
Piping	Seamless Pipe Welded Pipe	Carbon Steel Carbon Steel	SA-333 Gr 6 SA-672 Gr C70
Fittings	Forging	Carbon Steel	SA-350 Gr LF2 or SA-420 Gr WPL6
Flanges	Forging	Carbon Steel	SA-350 Gr LF2
Valves (Gate, Globe, Check)	Forging Casting	Carbon Steel Carbon Steel	SA-350 Gr LF2 SA-352 Gr LCB
Bolting	Bar	Low Alloy Steel	SA-193 Gr B7
Nuts	Bar	Low Alloy Steel	SA-194 Gr 7

Table 6.1-1 Engineered Safety Features Component Materials* (Continued)

Component	Form	Material	Specification (ASTM/ASME)
B—Low Pressure Spray Equipment Inside Wetwell (Class 3)			
Piping	Pipe	Carbon Steel	SA-106 Gr B SA- 672 Gr C60/C70
Fittings	Forging	Carbon Steel	SA-105 SA-234 Gr WPB
Flanges	Forging	Carbon Steel	SA-105
Valves (Gate, Globe, Check)	Forging Casting	Carbon Steel Carbon Steel	SA-105 SA-216 Gr WCB
Bolting (same as A above)			
Nuts (same as A above)			
C—Interface to Fuel Pool Piping (Class 3)			
Piping	Pipe	Stainless Steel	SA-376 Type 316L SA-312 Type 316L SA-358 Type 316L
Valves (Gate, Globe, Check)	Forging	Stainless Steel	SA-182 Gr F316L SA-351 Gr CF3
Fittings	Forging	Stainless Steel	SA-182 Gr F316L or SA-403 Gr WP316L/W
Flanges	Forging	Stainless Steel	SA-182 Gr F316L SA-351 Gr CF3
Bolting (same as A above)			
Nuts (same as A above)			
HPCF			
Same as RHR-A above			
RCIC Turbine-Pump			
Casing	Casting	Stainless Steel	SA-487 CA6NM Class A
Shaft	Bar	Stainless Steel	A-276 S42000
Impeller	Casting	Stainless Steel	SA-487 CA6NM Class A
Same as RHR-A above			
Standby Liquid Control Pump (No welding)			
Fluid Cylinder	Forging	Stainless Steel	SA-182 F304
Cylinder Head, Valve Cover, and Stuffing Box Flange Plate	Plate	Stainless Steel	SA-240 Type 304

Table 6.1-1 Engineered Safety Features Component Materials* (Continued)

Component	Form	Material	Specification (ASTM/ASME)
Cylinder Head Extension, Valve Stop, and Stuffing Box	Bar	Stainless Steel	SA-479 Type 304
Stuffing Box Gland and Plungers	Bar	Stainless Steel	SA-564 Type 630 (H 1100)
Studs	Bar	Alloy Steel	SA-193 Grade B7
Nuts	Forging	Alloy Steel	SA-194 Grade 7
Standby Liquid Storage Tank			
Tank	Plate	Stainless Steel	SA-240 Type 304
Fittings	Forgings	Stainless Steel	SA-183 Gr F304
Pipe	Pipe	Stainless Steel	SA-312 Type 304
Welds	Filler	Stainless Steel	SFA 5.4 & 5.9, Types 308, 308L, 316L
Containment Vessel	Plate Plate	Carbon Steel Stainless Steel	SA-516 Gr 70 SA-240 Type 304L
Penetrations	Forging Forging	Carbon Steel Stainless Steel	SA-350 Gr LF 1 or 2 SA-182/F304L
Structural Steel	Shapes	Carbon Steel	A36
HVAC Emergency Cooling Water System			
Heat Exchanger	Plate Tube	Carbon Steel Copper Alloy	SA-283 Gr A SB75-C12200
Pump	Casting Casting	Carbon Steel Stainless Steel	SA-216 Gr WCB SA-351 Gr CF8
Valves	Casting Forging	Carbon Steel Carbon Steel	SA-216 Gr WCB SA-105
Piping	Seamless Pipe Welded Pipe	Carbon Steel Carbon Steel	SA-106 Gr A SA-672 Gr B60
Reactor Building Cooling Water System			
Heat Exchanger†	Plate Tubes		
Pump	Casting Casting	Carbon Steel Stainless Steel	SA-216 Gr WCC SA-351 Gr CF8
Valves	Casting Forging	Carbon Steel Carbon Steel	SA-216 Gr WCB SA-105
Piping	Seamless Pipe Welded Pipe	Carbon Steel Carbon Steel	SA-106 Gr A SA-672 Gr B60

Table 6.1-1 Engineered Safety Features Component Materials* (Continued)

Component	Form	Material	Specification (ASTM/ASME)
Reactor Service Water System†			
Pump	Casting		
Valves	Casting		
	Casting		
	Casting		
	Forging		
Piping	Seamless Pipe		
	Welded Pipe		

* Carbon content for wrought austenitic stainless steels will be limited to 0.020% for service temperatures above 93.3°C.

† Materials are site dependent.