5.3 Reactor Vessel

The information in this section of the reference ABWR DCD, including all subsections and figures, is incorporated by reference with the following departures and supplements.

STD DEP T1 2.1-2

STD DEP 5.3-1

STD DEP Vendor

STD DEP Admin

5.3.1.2 Special Procedures Used for Manufacturing and Fabrication

STD DEP Vendor

*All fabrication of the RPV is performed in accordance with ~~GE~~*Vendor*-approved drawings, fabrication procedures, and test procedures. The shells and vessel heads are made from formed plates or forgings, and the flanges and nozzles from forgings. Welding performed to join these vessel components is in accordance with procedures qualified per ASME Code Section III and IX requirements. Weld test samples are required for each procedure for major vessel full-penetration welds. Tensile and impact tests are performed to determine the properties of the base metal, heat-affected zone, and weld metal.*

5.3.1.6.1 Compliance with Reactor Vessel Material Surveillance Program Requirements

STD DEP 5.3-1

STD DEP Admin

The materials surveillance program monitors changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region resulting from exposure to neutron irradiation and thermal environment.

*Reactor vessel materials surveillance specimens are provided in accordance with requirements of ASTM E-185 and 10~~CRF~~*CFR *50 Appendix H. Materials for the program are selected to represent materials used in the reactor beltline region. Charpy V-notch and tensile specimens are manufactured from the material actually used in the reactor beltline region. To represent those, if any, RPV pressure boundary welds that are in the beltline region (or are exposed to the predicted maximum neutron fluence (E>1.60E-13J) at the end of the design lifetime exceeding* $1x10^{17}$ *neutron/cm*^{2} *at the inside surface of the reactor vessel), Charpy V-notch specimens of weld metal and HAZ material, and tensile specimens of weld metal are manufactured from the sample welds. The same ~~hat~~*heat *of weld wire and lot of flux (if applicable) and the same welding practice as used for the beltline weld are utilized to make the sample welds. The specimen capsules are provided, each containing* a minimum of

12 Charpy V-notch and tensile specimens of the beltline material along with ~~*and*~~*temperature monitors. Additionally, if required, the specimens identified to represent the welds requiring surveillance are also loaded in the same numbers. The surveillance specimen holders having brackets welded to the vessel cladding in the core beltline region are provided to hold the specimen capsules and a neutron dosimeter. Since reactor vessel specifications require that all low-alloy steel pressure vessel boundary materials be produced to fine-grain practice, the bracket welding does not pose a concern of underclad cracking. A set of out-of-reactor baseline Charpy V-notch specimens, tensile specimens, and archive material are provided with the surveillance test specimens. The neutron dosimeter and temperature monitors will be located as required by ASTM E-185.*

Four surveillance capsules are provided. The predicted end of the adjusted reference nil ductility temperature of the reactor vessel steel is less than 38°C.

The following proposed withdrawal schedule is extrapolated from ASTM E-185.

- *First Capsule: After 6 effective full-power years.*
- *Second Capsule: After 20 effective full-power years.*
- *Third Capsule: With an exposure not to exceed the peak EOL fluence.*
- *Fourth Capsule: Schedule determined based on results of first two capsules per ASTM E-185, Paragraph 7.6.2 (see Section 5.3.4.2 for additional capsule requirements). Fracture toughness testing of irradiated capsule specimens will be in accordance with requirements of ASTM E-185 as called out for by 10CFR50 Appendix H.*

5.3.1.6.4 Position of Surveillance Capsules and Methods of Attachment Appendix H.II B (2)

STD DEP 5.3-1

The surveillance specimen holders, described in Subsections 5.3.1.6.1 and 3.9.5.1.2.10, are located at different azimuths at common elevation in the core beltline region. The locations are selected to produce lead factor ~~*of approximately 1.2*~~ greater than 1 and less than or equal *to 1.5 for the inserted specimen capsules. A positive spring-loaded locking device is provided to retain the capsules in position throughout any anticipated event during the lifetime of the vessel. The capsules can be removed from and reinserted into the surveillance specimen holders. See Subsection 5.3.4.2 for COL license information requirements pertaining to the surveillance material, lead factors, withdrawal schedule and neutron fluence levels.*

In areas where brackets (such as the surveillance specimen holder brackets) are located, additional nondestructive examinations are performed on the vessel base metal and stainless steel weld-deposited cladding or weld-buildup pads during vessel manufacture. The base metal is ultrasonically examined by straight-beam techniques to a depth at least equal to the thickness of the bracket being joined. The area

examined is the area of width equal to at least half the thickness of the part joined. The required stainless steel weld-deposited cladding is similarly examined. The full penetration welds are liquid-penetrant examined. Cladding thickness is required to be at least 3.2 mm. These requirements have been successfully applied to a variety of bracket designs which are attached to weld-deposited stainless steel cladding or weld buildups in many operating BWR reactor pressure vessels.

5.3.1.6.5 Time and Number of Dosimetry Measurements

STD DEP Vendor

~~*GE provides a*~~ A *separate neutron dosimeter* is provided *so that fluence measurements may be made at the vessel ID during the first fuel cycle to verify the predicted fluence at an early date in plant operation. This measurement is made over this short period to avoid saturation of the dosimeters now available. Once the fluence-to-thermal power output is verified, no further dosimetry is considered necessary because of the linear relationship between fluence and power output. It will be possible, however, to install a new dosimeter, if required, during succeeding fuel cycles.*

5.3.3 Reactor Vessel Integrity

STD DEP Vendor

The reactor vessel material, equipment, and services associated with the reactor vessels and appurtenances would conform to the requirements of the subject purchase documents. Measures to ensure conformance included provisions for source evaluation and selection, objective evidence of quality furnished, inspection at the vendor source and examination of the completed reactor vessels.

Toshiba ~~*GE*~~ *provides inspection surveillance of the reactor vessel fabricator in-process manufacturing, fabrication, and testing operations in accordance with* ~~*the GE*~~their *quality assurance program and approved inspection procedures. The reactor vessel fabricator is responsible for the first level inspection of manufacturing, fabrication, and testing activities, and* Toshiba ~~*GE*~~ *is responsible for the first level of audit and surveillance inspection.*

5.3.3.1.1.1 Reactor Vessel

STD DEP T1 2.1-2

The cylindrical shell and top and bottom heads of the reactor vessel are fabricated of low-alloy steel, the interior of which is clad with stainless steel weld overlay except for the top head, and *all nozzles but the steam outlet nozzles ~~and the reactor internal pump casings~~. The bottom head is clad with Ni-Cr-Fe alloy. The reactor internal pump penetrations are clad with Ni-Cr-Fe alloy, or alternatively stainless steel.* The reactor internal pump motor casings are clad with stainless steel only in the stretch tube region and around the bottom of the reactor internal pump motor casings where they interface with the motor cover closures.

5.3.3.3 Fabrication Methods

STD DEP Vendor

STD DEP Admin

*The reactor pressure vessel is a vertical cylindrical pressure vessel of welded construction fabricated in accordance with ASME Code Section III, Class 1, requirements. All fabrication of the reactor pressure vessel ~~was~~*is *performed in accordance with ~~GE~~*Vendor*-approved drawings, fabrication procedures, and test procedures. The shell and vessel head ~~were~~*are *made from formed low-alloy steel plates or forgings and the flanges and nozzles from low-alloy steel forgings. Welding performed to join these vessel components ~~was~~*is *in accordance with procedures qualified to ASME Section III and IX requirements. Weld test samples ~~were~~*are *required for each procedure for major-vessel full-penetration welds.*

5.3.4 COL License Information

5.3.4.1 Fracture Toughness Data

The following site-specific supplement addresses COL License Information Item 5.4.

Fracture toughness data based on the limiting reactor vessel actual materials will be provided in an amendment to the FSAR in accordance with 10 CFR 50.71(e) that occurs one year after the on-site acceptance of the reactor vessel. The data will be based on test results from the actual materials used in the RPV. (COM 5.3-1)

The evaluation methods will be in accordance with 10 CFR 50 Appendices G and H, Regulatory Guide 1.99 Rev. 2, and Reference 5.3-4.

5.3.4.2 Materials and Surveillance Capsule

The following site-specific supplement addresses COL License Information Item 5.5.

The site-specific information of the materials and surveillance program for STP 3 & 4 is as follows:

(1) Specific materials in each surveillance capsule

The surveillance specimens are fabricated from extra portions of vessel forging material from the core regions. The vessel material is low alloy steel, ASME SA-508 Class 3. Surveillance specimens are fabricated by sectioning a weldment made from the extra forging material. Surveillance specimens are taken from the base metal, weld metal and the heat affected zone of the weldment.

(2) Capsule lead factor

The lead factor of each capsule is approximately 1.1.

(3) Withdrawal schedule for each surveillance capsule

The capsule withdrawal schedule is in accordance with ABWR DCD Tier 2 Section 5.3.1.6.1.

(4) Neutron fluence to be received by each capsule at the time of its withdrawal

The neutron fluence to be received by each capsule is as follows:

(a) First capsule: 5.2×10^{16} n/cm^2

(b) Second capsule: 1.7×10^{17} n/cm^2

(c) Third capsule: not to exceed 5.0×10^{17} n/cm^2

(d) Fourth Capsule: will be based on the results of the first two capsules

(5) Vessel end-of life peak neutron fluence

The vessel end-of-life neutron fluence is approximately 5.0×10^{17} n/cm^2.

The materials and surveillance capsule program for STP 3 & 4 are in accordance with Reference 5.3-3.

The Final Safety Analysis Report will be updated prior to receipt of fuel on site to identify the specific materials in each surveillance capsule and provide a plant-specific replacement for the Pressure-Temperature limits. The data will be based on test results from the actual materials used in the RPV. (COM 5.3-2)

5.3.4.3 Plant-Specific Pressure-Temperature Information

The following site-specific supplement addresses COL License Information Item 5.6.

Plant-specific calculations of RT_{NDT}, stress intensity factors, and pressure-temperature curves similar to those in Regulatory Guide 1.99 and SRP Section 5.3.2 will be provided in an amendment to the FSAR in accordance with 10 CFR 50.71(e) prior to receipt of fuel on site. The data will be based on test results from the actual materials used in the RPV. (COM 5.3-3)

The evaluation methods will be in accordance with 10 CFR 50 Appendices G and H, Regulatory Guide 1.99 Rev. 2, and Reference 5.3-4.

5.3.5 References

~~*5.3-2 "Transient Pressure Rises Affecting Fracture Toughness Requirements for Boiling Water Reactors", January1979 (NEDO-21778-A).*~~

5.3-3 "Reactor Pressure Vessel Material Surveillance Program", Toshiba Corporation, April 2009 (UTLR-0003, Rev. 0).

5.3-4 SIR-05-044-A, "Pressure-Temperature Limits Report Methodology for Boiling Water Reactors," April 2007