16. TECHNICAL SPECIFICATIONS

16.1 Introduction and Regulatory Criteria

General Electric Hitachi Nuclear (GEH) modeled most of the generic technical specifications (TS) and generic TS bases for the economic simplified boiling-water reactor (ESBWR) after Revision 3 of NUREG-1434, "Standard Technical Specifications, General Electric Plants, BWR/6," dated June, 2004. In a few cases, such as containment systems, the applicant adapted TS requirements from Revision 3 of NUREG-1433, "Standard Technical Specifications, General Electric Plants, BWR/4," dated June 2004. The applicant developed these standard technical specifications (STS) from the results of the TS improvement program, in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.36, "Technical Specifications," and SECY-93-067, "Final Policy Statement on TS Improvements for Nuclear Power Reactors," dated July 22, 1993. As required by 10 CFR 52.47(a)(11), a standard design certification application must include proposed generic technical specifications (GTS) as a part of the final safety analysis report (FSAR). The GTS must be prepared in accordance with the requirements of 10 CFR 50.36 and 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors." The applicant states that the ESBWR GTS and GTS bases comply with 10 CFR 50.36(c)(2)(ii), which requires the TS to include a limiting condition for operation (LCO) for each item meeting one or more of the following four criteria:

Criterion 1—Installed instrumentation that is used to detect, and indicate in the control room (CR), a significant abnormal degradation of the reactor coolant pressure boundary

Criterion 2—A process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier

Criterion 3—A structure, system, or component (SSC) that is part of the primary success path and which functions or actuates to mitigate a design basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier

Criterion 4—An SSC shown by operating experience or a probabilistic safety assessment to be significant to public health and safety

The review of the GTS and bases by the staff of the U.S. Nuclear Regulatory Commission (NRC) concentrated on the differences between these documents and the STS and STS bases. Such differences result from the new passive systems design, structural differences from existing systems, and the advanced microprocessor-based instrumentation and control (I&C) system, as well as shutdown operations, including a new safe-shutdown operational mode.

During its review, the staff forwarded its comments on the proposed GTS and GTS bases to the applicant for resolution and incorporation into the final GTS and bases. The final GTS and bases, included in design control document (DCD), Tier 2, Chapters 16 and 16B, respectively, provide resolution of the staff's issues, described as appropriate in this safety evaluation report

(SER), and are certified to be accurate by the applicant. It should be noted that the GTS and the GTS bases are not Tier 1, Tier 2*, or Tier 2 information. However GTS Section 16.0 is Tier 2 information.

16.2 Staff Evaluation

16.2.0 General Considerations

The staff evaluated the GTS to confirm that they will preserve the validity of the plant design, as described in the ESBWR DCD, by ensuring that the plant will be operated (1) within the required conditions bounded by the ESBWR DCD and (2) with operable equipment that is essential to prevent ESBWR postulated design-basis events or mitigate their consequences.

Request for Additional Information (RAI) 16.0-1. The staff assessed the ESBWR GTS to confirm that the applicant had established an LCO for any aspect of the design that meets one or more of the four criteria outlined in 10 CFR 50.36(c)(2)(ii). The staff based this assessment partially on the applicant's response to the staff's request in RAI 16.0-1, which asked the applicant to explain how it formulated the LCOs for the ESBWR GTS and ensured that the GTS satisfied the requirements of 10 CFR 50.36. In its response dated August 8, 2006, the applicant stated that it had completed a "systematic and comprehensive evaluation of Revision 1 of the ESBWR DCD to determine the ESBWR process variables, design features, operating restrictions, and structures, systems, and components that meet one or more of the four criteria in 10 CFR 50.36(c)(2)(ii)." However, significant changes in the ESBWR design, as described in several subsequent revisions of the DCD, prompted the staff to ask the applicant to update its response. RA1 16.0-1 was being tracked as an open item in the SER with open items. In the update to its original response dated May 26, 2009, the applicant stated that it had continuously assessed how changes in the ESBWR design and responses to RAIs may have impacted the original response to RAI 16.0-1. The staff determined that, by carefully reviewing the change lists provided by GEH with each DCD revision, it was able to verify that the GTS include LCOs for all SSCs and parameters required by the four LCO criteria identified in 10 CFR 50.36. Therefore, RAI 16.0-1 is resolved.

The ESBWR design includes safety systems that are both innovative and simplified. It employs passive safety-related systems that rely on gravity and natural processes, such as convection, evaporation, and condensation. Although the applicant modeled the GTS after the STS to the maximum extent practical, it was necessary to develop GTS beyond those in the STS to account for the passive design features of the ESBWR. However, in most cases, the ESBWR system design functions are similar to those of existing boiling-water reactors (BWRs), even though the components and systems are new. The staff also requested that the applicant model the GTS after the equivalent STS safety functions. In those cases in which the staff believed deviation from the STS was appropriate to account for ESBWR design features, the required action completion times and surveillance requirement (SR) frequencies associated with the LCOs were maintained consistent with the STS provisions for the equivalent safety function.

The applicant determined that 10 CFR 50.36(c)(2)(ii) does not require establishing GTS LCOs for most active non-safety systems. However, following the guidance in SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs," dated March 28, 1994, the applicant proposed establishing an ESBWR availability controls manual (ACM), as described in Revision 6 of DCD, Tier 2, Chapter 19A. The applicant's evaluation of non-safety-related systems against the regulatory treatment of non-safety systems (RTNSS) significance criteria identified those non-safety-related SSCs which require high regulatory oversight in the form of GTS LCOs; those non-safety-related SSCs which require low regulatory oversight in the form of short-term availability controls (ACs), and which are included in the ACM; and those non-safety-related SSCs which require only the oversight imposed by 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" (referred to as the Maintenance Rule). Section 22.5 of this report provides the staff's evaluation of the ESBWR RTNSS.

In some instances, establishing the site-specific information to be included in the plant-specific TS (PTS) and PTS bases, which are issued with a combined license (COL), requires design details, equipment selections, instrumentation settings, or other information that cannot be provided during the design certification process. Locations in the GTS for the addition of this information are signified by square brackets to indicate that the COL applicant must provide plant-specific values or alternative text in the PTS and justify this information in the combined license application (COLA). GEH addressed this COLA requirement in the introduction to DCD Chapter 16, Revision 4, issued September 2007, by proposing COL Item 16.0-1, which stated the following:

> This set of generic technical specifications is provided as a guide for the development of plant specific technical specifications. Combined License applicants referencing the ESBWR will replace the preliminary information provided in "square brackets" ("[...]") with final plant specific information. The guidance of associated Reviewer's Notes included (typically in Chapter 16B) in the generic Technical Specifications is for information only and is deleted on completion of the COL Item.

<u>RAI 16.0-2</u>. The staff asked the applicant to consider how to avoid ambiguous use of brackets in the GTS and bases. In its response dated November 13, 2006, the applicant committed to use square brackets only when indicating information that a COL applicant would be expected to provide. Where necessary, GEH will add a reviewer's note to clarify what information is expected. For example, if the choice of information depends on whether conditions stated in a topical report are met, the DCD will provide a reviewer's note directing the COL applicant to address in its application how it satisfied those conditions. The applicant also stated in its response that, during the course of the design certification review, it will use curly brackets in any interim revisions of DCD Chapters 16 and 16B to denote information that must be finalized. The applicant stated that it would finalize such information by the completion of the ESBWR design certification review and remove the curly brackets. Revision 3 of DCD Chapter 16 reflected this commitment. Therefore, RAI 16.0-2 is resolved.

The staff was tracking RAI 16.0-2 as a confirmatory item (Confirmatory Item 16.0-2) to ensure that the applicant completed changes to DCD Chapters 16 and 16B based on its commitment to remove all curly brackets and limit the use of square brackets to information associated with COL Item 16.0-1. However, after receipt of DCD Revision 4, the staff decided that it would track the disposition of bracketed information under RAI 16.2-164, as discussed below. Therefore, Confirmatory Item 16.0-2 is considered complete.

RAI 16.2-164. In Revision 4 of the DCD, the applicant revised its intended use for curly brackets to denote only information that cannot be provided until after the COL is issued. The applicant stated it would propose a license condition requiring completion of such information in the PTS at an appropriate time interval before initial fuel load. In response, the staff sent the applicant RAI 16.2-164 in letter dated January 14, 2008, which states the following:

> In Revision 4 of the ESBWR DCD Chapter 16, GEH proposes to change the definition of a curly bracket from a value, parameter, or information that will be provided by the design certification applicant to a value, parameter, or information that will be provided by the combined license (COL) holder. This proposed change is unacceptable. All the curly brackets need to be removed during the design certification review unless the information is closely associated with design acceptance criteria (DAC) or is site specific. In the latter two cases, the brackets can be changed to square brackets. Please provide a schedule for revising the generic technical specifications (GTS) and Bases so they do not contain any curly brackets. For curly brackets associated with DAC, modify the DCD to include an appropriately worded proposed COL Item for the COL applicant or holder, depending on the wording of the DAC; and for curly brackets associated with site specific information please modify the DCD to include an appropriately worded proposed COL Item for the COL applicant.

In its response dated April 11, 2008, the applicant revised its proposed COL Item 16.0-1 by dividing it into two parts, as stated in the introduction to DCD Chapter 16, Revision 5:

> 16.0.1 COL Information
>
> 16.0-1-A COL Applicant Bracketed Items
> COL applicants referencing the ESBWR DCD will replace the preliminary information provided in brackets ("[...]"), and annotated with "16.0-1-A" labels, with final plant specific information.
>
> 16.0-2-H COL Holder Bracketed Items
> COL holders referencing the ESBWR DCD will replace the preliminary information provided in brackets ("[...]"), and annotated with "16.0-2-H" labels, with final plant specific information.

The introduction to DCD, Chapter 16, Revision 5, contained one table for applicant items and another table for holder items. Each table assigned a unique identifier to sets of related bracketed information, along with an associated reviewer's note explaining how to properly provide the bracketed information. The applicant also annotated each instance of bracketed information with its identifier in the GTS and bases; this served as a cross reference to the appropriate COL item table. As a part of its RAI response, the applicant included in the COL holder table a justification for each holder item explaining why resolution of the item would be delayed until after issuance of the COL. GEH would omit these justifications in the COL holder table included in the final DCD. The COL holder table included the following six justifications:

1) "The plant specific pressure/temperature limits will be prepared using actual reactor pressure vessel materials properties that will be submitted by the COL holder once the

reactor pressure vessel material properties are known, after shipment of the reactor pressure vessel." The following holder item was associated with this justification:

- 5.6.4-1 Pressure-temperature limits report listing of analytical methods used to determine the reactor coolant system (RCS) pressure and temperature limits

2) "ITAAC 2.2.2-7, #12 will require confirmation scram times and will be the appropriate test to determine the minimum scram accumulator pressure consistent with the ESBWR design (e.g., shorter core). The hydraulic conditions will provide a balance between meeting the maximum required scram times while at the same time assuring the drive does not insert so fast as to cause stress limits in the drive parts to be exceeded." The following holder items were associated with this justification:

- 3.1.5-1 Minimum and nominal scram accumulator pressure
- 3.9.5-1 Minimum scram accumulator pressure

3) "Determination of allowable values (AVs) for automatic instrumentation function trip settings is dependent on the instrumentation procured and final as-built information." The following holder items were associated with this justification:

- 3.1.7-1 AV for standby liquid control (SLC) system accumulator level instrumentation function

- 3.3.1.1-1 AVs for reactor protection system (RPS) instrumentation functions

- 3.3.1.4-1 AVs for neutron monitoring system (NMS) instrumentation functions

- 3.3.5.1-1 AVs for emergency core cooling system (ECCS) instrumentation functions

- 3.3.5.3-1 AVs for isolation condenser system (ICS) instrumentation functions

- 3.3.6.1-1 AVs for main steam isolation valve (MSIV) instrumentation functions

- 3.3.6.3-1 AVs for isolation instrumentation functions

- 3.3.7.1-1 AVs for the CR habitability area heating, ventilation, and air conditioning subsystem (CRHAVS) instrumentation functions

- 3.3.8.1-1 AVs for diverse protection system (DPS) instrumentation functions

- 3.7.1-1 AV for isolation condenser/passive containment cooling system (IC/PCCS) expansion pool-level instrumentation function

- 3.7.2-2 AV for CRHAVS main control room (MCR) temperature instrumentation function

- 3.7.6-2 AV for select control rod run-in/select rod insert (SCRRI/SRI) loss-of-feedwater-heating feedwater temperature instrumentation function

4) "Determination of startup range neutron monitor (SRNM) minimum count rate is dependent on the instrumentation procured and final as-built information." The following holder item was associated with this justification:

    - 3.3.1.6-1 Minimum SRNM count rate

5) "Requires design-specific information from battery manufacturer that is dependent on the battery procured." The following holder items were associated with this justification:

    - 3.8.1-1 Acceptance criteria for minimum duration of battery charger test
    - 3.8.1-2 Acceptance criteria for verification that battery is fully charged
    - 3.8.1-3 Use of a modified performance test to verify battery capacity
    - 3.8.1-4 Battery cell parameters
    - 3.8.1-5 Battery margin for aging factor and state of charge uncertainty
    - 3.8.3-1 Acceptance criteria for verification that battery is fully charged
    - 3.8.3-2 Use of a modified performance test to verify battery capacity
    - 3.8.3-3 Battery cell parameters
    - 3.8.3-4 Battery margin for aging factor and state of charge uncertainty

6) "Filter differential pressure acceptance criterion is dependent on the specific filter train procured." The following holder item was associated with this justification:

    - 5.5.13-1 Ventilation Filter Testing Program (VFTP) requirement for the CRHAVS emergency filter unit (EFU) differential pressure acceptance criteria.

The STS and STS bases contain reviewer's notes stating conditions that a COL applicant (or licensee) must satisfy in order to adopt a particular STS provision (e.g., incorporation of an NRC-approved methodology into a plant's licensing basis or a staff determination that a licensee's probabilistic risk assessment program is of adequate quality). Satisfying such conditions is integral to completing COL Item 16.0-1, as described previously. However, in DCD Revision 5, the applicant relocated all GTS reviewer notes to DCD Table 16.0-1-A, "COL—Applicant Open Items," and DCD Table 16.0-2-H, "COL—Holder Open Items." Because this presentation of reviewer notes is only an administrative difference between the GTS and the STS, the staff finds it acceptable.

In a letter (GEH letter MFN 09-139, dated February 24, 2009) regarding Interim Staff Guidance (ISG) DC/COL-ISG-8, "Necessary Content of Plant-Specific Technical Specifications," dated December 9, 2008, the applicant recharacterized each COL holder item as a COL applicant item. In accordance with the ISG, a COL applicant may address each of these items by providing the site-specific value, a useable bounding value, or an administrative control TS that requires determining the site-specific value using an NRC-approved methodology, with the value documented outside the PTS. Because the proposed GTS and bases no longer contain placeholders for the COL holder to address, therefore, RAI 16.2-164 is resolved.

RAI 16.0-3. The staff asked the applicant to list those STS generic changes (Technical Specifications Task Force (TSTF) travelers) that it is proposing for the GTS which are not included in STS Revision 3, including any proposed changes under review by the NRC staff. The staff also requested that the applicant explain any deviations from these travelers. In its response dated November 13, 2006, and in a subsequent letter dated February 26, 2009, the applicant listed the following travelers (this report addresses any special considerations related to their adoption where noted):

- TSTF-423-A, "Technical Specifications End States, NEDC-32988-A" (See discussion of RAI 16.0-7 in Section 16.2.0 of this report.) (The applicant withdrew this traveler from the GTS in DCD Revision 5.)

- TSTF-448-A, "Control Room Habitability" (See discussion of RAI 16.2-54 in Section 16.2.10 of this report.)

- TSTF-458-T, "Removing Restart of Shutdown Clock for Increasing Suppression Pool Temperature" (See Section 16.2.9 of this report.)

- TSTF-484-A, "Use of TS 3.10.1 for Scram Testing Activities" (See Sections 16.2.4 and 16.2.13 of this report.)

- TSTF-497-A, "Limit Inservice Testing Program SR 3.0.2 Application to Frequencies of 2 Years or Less" (See discussion of RAI 16.2-69 in Section 16.2.15 of this report.)

- TSTF-511-A, "Eliminate Working Hour Restrictions from TS 5.2.2 to Support Compliance with 10 CFR Part 26" (See Section 16.2.15 of this report.)

The following travelers have not been finalized, but upon NRC approval, the applicant stated that it may incorporate them in a future DCD revision. As of DCD Revision 7, the GTS had included provisions consistent with the current revisions of these travelers:

- TSTF-493, "Clarify Application of Setpoint Methodology for Limited Safety System Setting (LSSS) Functions," Revision 4, submitted to the NRC on July 31, 2009 (See discussion of RAIs 16.2-25, 16.2-146, 16.2-149, and 16.2-156 in Section 16.2.6 of this report.)

- TSTF-500, "DC Electrical Rewrite," Revision 2, submitted to the NRC on September 22, 2009 (See discussion of RAIs 16.2-55, 16.2-56, 16.2-57, 16.2-60, and 16.2-82 in Section 16.2.11 of this report.) (This traveler supersedes TSTF-360-A.)

Because the applicant provided a list of travelers that it had proposed to include in the GTS, therefore, RAI 16.0-3 is resolved.

The NRC staff notes that the ESBWR GTS and bases are based on STS Revision 3 as revised by the incorporation of the following approved travelers; together this is referred to as STS Revision 3.1, dated December 1, 2005. The staff verified that these travelers, with the exceptions noted, are properly incorporated in the GTS and bases.

- TSTF-369-A, “Removal of Monthly Operating Report and Occupational Radiation Exposure Report”
- TSTF-372-A, “Addition of LCO 3.0.8, Inoperability of Snubbers” (not included in GTS)
- TSTF-400-A, “Clarify SR on Bypass of diesel generator (DG) Automatic Trips” (not applicable to ESBWR)
- TSTF-439-A, “Eliminate Second Completion Times Limiting Time From Discovery of Failure To Meet an LCO”
- TSTF-479-A, "Changes to reflect Revisions of 10 CFR 50.55a"
- TSTF-482-A, “Correct LCO 3.0.6 Bases”
- TSTF-485-A, “Correct Example 1.4-1”

Excluding TSTF-372-A is acceptable because including STS LCO 3.0.8 could potentially be less restrictive on unit operation in the event of an inoperable snubber. Excluding TSTF-400-A is acceptable because it only applies to a SR for safety-related DGs. The ESBWR GTS do not specify this SR because 10 CFR 50.36(c)(2)(ii) does not require the ESBWR GTS to specify an LCO for the ESBWR DGs, which are not safety-related.

In Revision 1 of the DCD, the applicant proposed adopting TSTF-451-T, “Correct Battery Monitoring and Maintenance Program and the Bases for STS SR 3.8.4.2,” Revision 0, which would have affected GTS SR 3.8.1.2 and SR 3.8.1.3, as well as GTS 5.5.10. (Note that this “T-traveler” had not previously been submitted to the NRC.) The applicant withdrew the changes based on this traveler when it subsequently proposed to use valve-regulated lead acid (VRLA) batteries instead of vented lead acid (VLA) batteries. This was appropriate because the changes to the STS proposed by this traveler apply only to VLA batteries. However, in DCD Revision 6, GEH withdrew its proposal to use VRLA batteries. The staff compared the revised requirements for GTS SR 3.8.1.2, and its bases, and GTS 5.5.10.b and determined that only GTS 5.5.10.b differed from the changes proposed by TSTF-451-T. GTS 5.5.10.b did not replace “electrolyte level below the minimum established design limit” with “electrolyte level below the top of the plates.” The staff finds the difference in GTS 5.5.10.b acceptable because the minimum established design limit is understood to be at or above the top of the plates. Since GTS SR 3.8.1.2 and its bases and GTS 5.5.10.b are consistent with Institute of Electrical and Electronics Engineers (IEEE) Standard 450-2002, “IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications,” the staff concludes that they are acceptable. However, since GEH did not explicitly propose to adopt TSTF-451-T in the GTS, the staff did not perform a detailed evaluation of TSTF-451-T. The staff’s evaluation of GEH’s response to RAI 16.2-89 in Section 16.2.15 of this report provides further evaluation of GTS 5.5.10.

<u>RAI 16.0-5</u>. The staff requested that GEH justify its decision to exclude the following BWR/6 STS requirements from the GTS by demonstrating that they do not satisfy the LCO-establishment requirements of 10 CFR 50.36(c)(2)(ii):

- STS Section 3.7 requirements for the service water system and ultimate heat sink (cooling towers), the CR fresh air system, and the CR heating ventilation and air conditioning system;
- STS Section 3.9 requirements for the reactor water cleanup/shutdown cooling system; and
- STS Section 5.5 requirements for the ventilation filter test program (VFTP), and the diesel generator fuel oil testing program.

In its response dated November 13, 2006, the applicant referred to its responses to RAIs 16.0-1, 16.2-52, and 16.2-74 and concluded that ESBWR active systems analogous to the BWR/6 systems addressed by the listed STS requirements satisfy none of the criteria of 10 CFR 50.36(c)(2)(ii). The staff determined that, based on the responses to RAI 16.0-1, GEH had adequately determined which of the listed STS requirements belong as equivalent requirements in the GTS; these are requirements for the control room habitability area (CRHA) heating, ventilation, and air conditioning (HVAC) subsystem (CRHAVS), and the VFTP. This determination resolved RAI 16.0-5. However, the staff sent GEH two supplements to RAI 16.0-5 focusing on the proposed passive cooling design for the CRHA after an accident. Section 16.2.10 of this report discusses these supplemental RAIs.

RAI 16.0-7. In DCD Revision 1, the applicant proposed GTS action requirements with modified end states based on TSTF-423-A, Revision 0. When a particular required action to restore compliance with the associated LCO is not met within the specified completion time, the associated action requirements for most LCOs have mandated placing the unit outside the operational conditions during which the LCO is applicable (i.e., outside the specified applicability of the LCO—typically in Mode 5, cold shutdown). An LCO with a modified end state relaxation in the associated action requirements would only be required to place the unit in Mode 3, hot shutdown, or Mode 4, stable shutdown, rather than in Mode 5. In RAI 16.0-7, the staff asked the applicant to justify the proposed action requirements that specify modified end states. RAI 16.0-7 was being tracked as an open item in the SER with open items.

In its response dated March 11, 2008, the applicant withdrew its proposal to adapt TSTF-423-A to the GTS and stated the following:

> DCD Revision 5 will remove previously included “modified end state” Actions and corresponding Bases, including those applicable to TS 3.7.3. The Actions and associated Bases will be returned to appropriately match those in the BWR6 Standard Technical Specifications, NUREG-1434, Revision 3, without inclusion of TSTF-423-A end state changes.

The staff verified removal of all proposed modified end state changes in DCD Revision 5. Therefore, RAI 16.0-7 is resolved.

Sections 16.2.1 through 16.2.15 compare the GTS with the STS and evaluate the differences.

16.2. ESBWR GTS Section 1.0, “Use and Application”

GTS Section 1.1, “Definitions,” defines terms that correspond to those given in the STS, with appropriate differences. The staff finds these defined terms and their definitions to be acceptable because they are consistent with ESBWR design features and the STS.

The proposed definition of “dose equivalent I-131” differs from the STS definition by listing different source documents for the thyroid dose conversion factors used to calculate the dose equivalent I-131. The dose conversion factors from these source documents are acceptable because they are consistent with the ESBWR dose analysis, which uses the total effective dose equivalent methodology, and Regulatory Guide (RG) 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” issued July 2000. GTS 3.4.3, “RCS Specific Activity,” places a limit on dose equivalent I-131, in accordance with Criterion 2 of 10 CFR 50.36(c)(2)(ii). This limit will ensure that the doses resulting from a DBA, such as a main steam line break (MSLB), will be within the bounding values of the ESBWR accident analysis. Therefore, specifying different source documents for the thyroid dose conversion factors in the definition for dose equivalent I-131 is appropriate and is acceptable as proposed.

GTS Section 1.1 omits STS definitions for “average planar linear heat generation rate,” “end of cycle recirculation pump trip system response time,” and “maximum fraction of limiting power density.” The ESBWR GTS do not use these definitions. Therefore, their omission is acceptable.

<u>RAI 16.2-11</u>. The staff requested that the applicant explain why it had omitted the definition for “physics test” from GTS Section 1.1. In Part 1 of its response dated May 21, 2007, the applicant justified its decision to exclude the term “physics test” in the GTS by explaining that the performance of physics tests for the ESBWR will not require an exception to the normal GTS requirements because of ESBWR design characteristics. The prevalent design characteristics arise because the ESBWR uses natural circulation for core flow instead of relying on forced flow using recirculation pumps. Therefore, omission of the term “physics test” from the GTS is acceptable, and Part 1 of RAI 16.2-11 is resolved. Section 16.2.5 of this report discusses Part 2 of the applicant’s response to RAI 16.2-11 and the related RAI 16.2-24.

<u>RAI 16.2-12</u>. The staff requested that the applicant explain the difference between the proposed definition of “shutdown margin” (SDM) and the STS definition of SDM. In its response dated November 13, 2006, the applicant explained that specifying that the SDM determination assumes that “the control rod or control rod pair of highest reactivity worth” is fully withdrawn, instead of withdrawal of just the highest worth control rod, reflects an ESBWR design difference. The ESBWR uses fine motion control rod drives (FMCRDs) that, except for one control rod, group control rods in pairs. Therefore, the staff finds the difference in the SDM definition to be acceptable because of this difference in design. On the basis of this information, therefore, RAI 16.2-12 is resolved.

The ESBWR GTS contain an additional definition for ICS response time, which reflects the ICS design feature.

In GTS Table 1.1-1, “Modes,” the STS Mode 3 definition is replaced with new ESBWR definitions for Modes 3 and 4. The new Mode 3, “hot shutdown,” is defined as the combination of (1) reactor mode switch in the shutdown position, (2) average reactor coolant temperature greater than 215.6 degrees Celsius (C) (420 degrees Fahrenheit (F), and (3) all reactor vessel head closure bolts fully tensioned. This definition narrows the average reactor coolant temperature range of the STS Mode 3 definition. The new definition of Mode 4, "stable shutdown," captures the remaining part of the temperature range of the STS Mode 3 definition. The STS definitions for Mode 4, "cold shutdown," and Mode 5, "refueling," are adopted without change, but are renumbered Mode 5 and Mode 6, respectively, in the ESBWR GTS. The new Mode 4 is defined as the combination of (1) reactor mode switch in the shutdown position, (2) average reactor coolant temperature less than or equal to 215.6 degrees C (420 degrees F) and greater than 93.3 degrees C (200 degrees F), and (3) all reactor vessel head closure bolts fully tensioned. Use of this definition reflects the NRC's conclusion that plant temperatures below 215.6 degrees C (420 degrees F) are an acceptable stable, safe-shutdown condition in which the plant may be placed in the event that an LCO is not met under certain conditions, such as those addressed by TSTF-423-A. However, as discussed in Section 16.2.0 of this report, under RAI 16.0-7, the applicant withdrew its proposal to adapt TSTF-423-A to the GTS and adopt modified end states. Nevertheless, the revised mode definitions are not affected and will facilitate future adoption of modified end states by COL applicants or licensees referencing the ESBWR GTS.

ESBWR GTS Section 1.2, "Logical Connectors," which defines the use of "<u>OR</u>" and "<u>AND</u>" in GTS Sections 2.0, 3.0, and 3.1 through 3.10, is identical to the STS and is acceptable.

ESBWR GTS Section 1.3, "Completion Times," which defines the rules for applying required action completion times in GTS Sections 2.0, 3.0, and 3.1 through 3.10, differs from the STS to account for the differences between the ESBWR and the BWR/6 designs. For example, no safety systems in the ESBWR design rely on pumps, so GEH revised the STS Section 1.3 examples that discuss inoperable pumps to discuss inoperable valves in the ESBWR GTS. In addition, where appropriate, Mode 5 is used in place of Mode 4. Therefore, GTS Section 1.3 is acceptable.

<u>RAI 16.2-13</u> The staff requested that the applicant consider adding to GTS Section 1.3 an example to illustrate the use of the modified end state of Mode 3 for an LCO that is applicable in Modes 1, 2, 3, and 4, and, specifically, to make clear the implementation guidance (TSTF-IG-05-02) for the related TSTF-423-A, which limits the unit's stay in the modified end state to 7 days. In RAI 16.0-7, the staff had requested that GEH provide additional ESBWR-specific justification and implementation guidance. However, as discussed in Section 16.2.0 under RAI 16.0-7, the applicant withdrew its proposal to adapt TSTF-423-A to the GTS and adopt modified end states provisions, and did not submit the requested justification and implementation guidance. The staff evaluated the applicant's response to RAI 16.2-13 in a letter dated November 13, 2006, which stated that a new completion time example is not needed to ensure correct application of modified end state action requirements. In this evaluation, the staff assumed that an acceptable justification and implementation guidance had been provided. As discussed in Section 16.2.3 of this report, the staff believes that incorporating TSTF-423-A into the ESBWR GTS and bases would preclude unintentional misuse of modified end state provisions and ensure that an acceptable level of safety is maintained. Since the GTS bases would direct adherence to the established NRC-approved implementation guidance when utilizing NRC-approved modified end state TS action requirements, the staff concluded that no additional clarification of the guidance, such as an example in GTS Section 1.3, is warranted. Therefore, the staff finds the applicant's response to RAI 16.2-13 acceptable and considers this issue resolved.

ESBWR GTS Section 1.4, “Frequency,” which defines the rules for applying frequencies (test intervals) specified for performing SRs, is consistent with the STS, except for the use of the ESBWR GTS Mode 3 and Mode 4 definitions in place of the STS Mode 3 definition, and is therefore acceptable.

Based on the above, the staff finds GTS Section 1.0 acceptable.

16.2.2 ESBWR GTS Section 2.0, “Safety Limits”

Section 2.0 of the ESBWR GTS outlines the safety limit (SL) specifications, which are mostly consistent with the STS. The staff requested additional information to complete its review, as described below.

RAI 16.2-14 and RAI 16.2-52 (Related to RAI 15.0-16). The staff asked the applicant in RAI 16.2-14 to justify the omission of the minimum critical power ratio (MCPR) and its limiting numerical value in the statement of reactor core, SL 2.1.1.2. Instead, the applicant had proposed stating the SL with the following condition: “Greater than 99.9% of the fuel rods in the core would be expected to avoid boiling transition.” The staff considers that this condition is a criterion for an SL but is not itself an SL. The SL in this case should be a parameter, such as the MCPR or fuel rod peak centerline temperature, with a numerical value provided in brackets consistent with the BWR/6 STS SL 2.1.1.2. The staff also asked the applicant to explain the discrepancy between the bases for the proposed SL 2.1.1.2, which refers to the MCPR, and SL 2.1.1.2, which does not. RAI 16.2-14 was being tracked as an open item in the SER with open items.

In RAI 16.2-52, the staff referred to RAI 15.0-16 and requested that the applicant provide a basis for the proposed safety limit for minimum critical power ratio (SLMCPR) similar to that provided in the BWR/6 STS bases. RAI 16.2-52 and RAI 15.0-16 were being tracked as open items in the SER with Open Items.

In its response to RAI 16.2-14 in a letter dated November 13, 2006, the applicant stated that it would address this comment in its response to RAI 15.0-16. In RAI 15.0-16, the staff requested that the applicant revise SL 2.1.1.2 to specify an SLMCPR value and stated that the agency’s policy is to include a numerical value for the SLMCPR.

In its initial response to RAI 15.0-16 in a letter dated February 12, 2007, the applicant stated that it had changed the bases for SL 2.1.1.2, LCO 3.2.2, LCO 3.3.1.1, LCO 3.3.1.4, LCO 3.3.2.1, and LCO 3.7.3 by replacing “MCPR” and “MCPR safety limit” with “fuel cladding integrity safety limit (FCISL).” The applicant also revised the bases for LCO 3.3.2.1 by replacing “operating and safety limit MCPR and LHGR” with “operating limit MCPR, fuel cladding integrity safety limit and LHGR.” The applicant incorporated these bases changes into DCD Revision 2. However, GEH did not propose a numerical value for the SLMCPR.

In its response to RAI 16.2-52 in a letter dated May 16, 2007, the applicant referred to its initial response to RAI 15.0-16. However, in a supplement to RAI 15.0-16, the staff stated it had found the response unacceptable and that GEH should include a numerical value for the SLMCPR as a TS SL as is done in the BWR/6 STS. In its response to RAI 15.0-16, in letter dated September 14, 2007, the applicant stated that "the TRACG methodology directly establishes an Operating Limit Minimum Critical Power Ratio (OLMCPR), such that less than 0.1 percent of the fuel rods are expected to experience boiling transition, but does not establish a lower bound on the steady-state MCPR." In addition, GEH stated the following position:

> Although using the ESBWR TRACG FCISL Reactor Core Safety Limit terminology ensures protection of the fuel cladding for AOOs, it is recognized that a separate lower bound on the steady-state MCPR (i.e., SLMCPR) protects the fuel cladding when the MCPR is not within its LCO specification. A potential violation of the Reactor Core Safety Limit would only occur if the newly defined ESBWR SLMCPR is violated during steady-state operations, or if an AOO occurs when the MCPR is not within its LCO specification. For both of these situations, the process variable MCPR could be used. GEH proposes the following revised response to the original RAI 15.0-16 response.

In the revised response, GEH proposed that the ESBWR SLMCPR be included in the TS as determined by the ODYN methodology (NEDO-24154-A, Volumes 1 and 2, dated August 1986; NEDE-24154-P-A, Volume 3, dated August 1988, and NEDC-24154-P-A, Supplement 1, Volume 4, "Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors," dated February 2000). Chapter 15 of this report provides further evaluation of the details of the proposed SLMCPR. The applicant proposed the following changes to GTS SL 2.1.1.2 and the bases for GTS 2.1.1, "Reactor Core Safety Limits," and GTS 3.3.2.1, "Control Rod Block Instrumentation":

- The applicant revised SL 2.1.1.2 to state the following:

  > With the reactor steam dome pressure ≥ 5.412 MPaG (785 psig): Greater than 99.9% of the fuel rods in the core would be expected to avoid boiling transition. All MCPRs shall be greater than or equal to 1.18 during steady-state operation.

- The applicant revised the bases for GTS Section 2.1.1 as follows:

  – The following sentence was added to the end of the first paragraph in the applicable safety analysis section: "The Safety Limit MCPR (SLMCPR) is a lower bound on the steady-state MCPR that ensures greater than 99.9% of the fuel rods in the core would be expected to avoid boiling transition."

  – The title for the discussion of SL 2.1.1.2, in the applicable safety analysis section, was changed from "FCISL" to "FCISL and SLMCPR."

  - The following sentence was added to the end of the discussion of SL 2.1.1.2 in the applicable safety analysis section: "The Safety Limit MCPR (SLMCPR) is a lower bound on the steady-state MCPR. Details of the SLMCPR calculation process are given in Reference 5." In DCD Revision 7, Reference 5 of DCD Revision 4 became Reference 2: NEDC-33237P, GE14 for ESBWR - Critical Power Correlation, Uncertainty, and OLMCPR Development, Revision 4, July 2008. See below discussion of RAI 16.2-191.

- The applicant revised the bases for GTS Section 3.3.2.1 as follows:

  – The phrase, “the Fuel Cladding Integrity Safety Limit (FCISL),” was replaced with the phrase, “the Safety Limit MCPR (SLMCPR),” in the second sentence of the second paragraph of the background section.

  – The acronym “FCISL” was replaced with the acronym “SLMCPR” in the first sentence of the first paragraph of the applicable safety analyses, LCO, and applicability section.

The staff finds these changes appropriate because they are consistent with its position that the ESBWR TS should contain a numerical value for the SLMCPR. The staff verified that DCD Revision 5 incorporated these changes. Based on these changes, RAIs 15.0-16, 16.2-14 and 16.2-52 are resolved.

<u>RAI 16.2-159</u>. In Revision 4 of the GTS, GEH changed the RCS pressure SL (i.e., SL 2.1.2) from the following statement: “Reactor steam dome pressure shall be ≤ {9.211} MPaG ({1336} psig),” which is consistent with the STS presentation, to the following statement: “Reactor vessel bottom pressure shall be ≤ 9.481 MPaG (1375 psig).” GEH made this revision to ensure that the RCS pressure SL was consistent with the SL intent and the overpressure analysis acceptance criteria used in DCD Section 5.2.2.3.3. In RAI 16.2-159, the staff requested the applicant to provide additional justification for its decision to deviate from the STS. In its response dated February 20, 2008, GEH explained that the proposed presentation “eliminates a potential ambiguity in the application of the safety limit that could occur when the SL is specified for a location other than where the peak pressure would occur,” as is done in the STS. However, “application of the safety limit” in terms of vessel bottom pressure will always require evaluation of the monitored parameter—the steam dome pressure—to determine the maximum pressure reached at the reactor vessel bottom during an RCS pressure transient. The reactor vessel bottom pressure should be determined by adding to the reactor steam dome pressure the static pressure corresponding to the reactor vessel water level and density. Revision 4 of DCD, Tier 2, Table 15.2-5, “Results Summary of Anticipated Operational Occurrence Events,” lists for each analyzed event the calculated maximum reactor steam dome pressure and the calculated maximum reactor vessel bottom pressure. This table shows that the difference between these calculated pressures varies between 0.13 MPaG (19 psig) and 0.15 MPaG (22 psig), depending on the event. In the case of a pressure transient approaching the SL value, the licensee must determine whether the RCS pressure SL was exceeded. The staff expects the licensee to determine the peak reactor vessel bottom pressure, which occurs during the transient, by adding a conservative pressure difference to the maximum observed reactor steam dome pressure. A conservative pressure difference would derive from reactor vessel thermal-hydraulic conditions (e.g., coolant level, density, flow, temperature) that are bounding to the conditions observed during the transient.

The staff also requested that the applicant revise the GTS bases to be consistent with the level of detail (regarding the specific RPS instrumentation function) in the discussion of the applicable safety analyses (ASA) found in the STS SL 2.1.2 bases. The applicant justified the proposed level of detail in the GTS bases as follows:

> As indicated in DCD, Tier 2, Section 5.2.2, “Overpressure Protection,” and Section 5.2.2.3.1, “Method of Analysis,” the RCS overpressure analyses assume that peak pressure in the RPV during a plant transient is limited by the combination of the safety valves and a reactor trip. However, to allow for a potential failure in the RPS, the analysis assumes that the reactor trip is initiated by the second safety-grade signal from the RPS. DCD Section 5.2.2.3.1 indicates that the results of the overpressure analyses are acceptable when the reactor trip is [initiated] by main steam isolation valve position, neutron monitoring system flux, or RPS. The sequence in which these reactor trip signals are generated will vary depending on the transient. Therefore, DCD, Tier 2, Chapter 16B, Section B 2.1.2, uses the phrase “Reactor Protection System Scram settings” rather than stating that a specific reactor trip function is needed to protect the reactor pressure vessel safety limit.

By expressing the RCS pressure SL in terms of the “reactor vessel bottom pressure,” the applicant has improved the presentation of the proposed GTS SL 2.1.2 and the ASA discussion in the associated bases when compared to the STS because this parameter directly corresponds to the limiting location in the RCS. GTS SL 2.1.2 and the associated bases are acceptable because (1) the ASA discussion in the bases explicitly states that the reactor vessel bottom is “the lowest elevation of the RCS,” (2) the peak pressure reached at the reactor vessel bottom during a pressure transient may be readily determined, and (3) the RPS function that actuates to scram the reactor, which limits the rise in reactor vessel pressure, varies depending upon the event causing the pressure transient. Therefore, RAI 16.2-159 is resolved.

<u>RAI 16.2-191</u>. The staff asked that GEH revise the “Applicable Safety Analyses (ASA)” and “References” sections of the bases for GTS 2.1.1, regarding the reactor core SL of fuel cladding integrity, SL 2.1.1.1, by removing the reference to topical report NEDC-32851P-A, “GEXL14 Correlation for GE14 Fuel,” Revision 5, January 2008, for the critical power correlation, GE14. Although this reference is approved for currently operating BWRs that use 12-foot GE14 fuel, it does not directly apply to the ESBWR GE14E fuel. The staff asked GEH to replace this reference in the “ASA” section of the bases with the ESBWR-specific critical power correlation reference, topical report NEDC-33237P, “GE14 for ESBWR - Critical Power Correlation, Uncertainty, and OLMCPR Development,” Revision 4, July 2008. The “References” section of the bases for GTS 2.1.1 already lists NEDC-33237P as Reference 6. In its response dated December 9, 2009, GEH stated it will make the requested changes to the bases for GTS 2.1.1. In addition, GEH also stated it will remove NEDC-32851P-A from DCD, Tier 2, Table 1.6-1, “Referenced GE / GEH Reports.” The staff reviewed the markup of the affected pages in the DCD, which GEH included in its response letter, and found them to be acceptable. Therefore, the response is acceptable and RAI 16.2-191 is resolved.

Based on the resolution of the staff’s RAIs and the consistency with the STS, the staff finds that GTS Section 2.0 and bases are acceptable.

16.2.3 ESBWR GTS Section 3.0, “Limiting Condition for Operation Applicability and Surveillance Requirement Applicability”

Section 3.0 of the ESBWR GTS governs the general application of the LCOs and SRs. The specifications provided in Section 3.0, which correspond to the STS (LCOs 3.0.1 through 3.0.7

and SRs 3.0.1 through 3.0.4), are acceptable to the staff because they are consistent with the STS. In addition, the following RAIs have been successfully resolved.

RAIs 16.0-4 and 16.2-16. The difference between the ESBWR GTS statement of LCO 3.0.3 and the STS accommodates the introduction of the new definition of Mode 4 (stable shutdown). The staff requested the applicant, in RAI 16.2-16, to specify definite completion times in LCO 3.0.3 for reaching Mode 4 and Mode 5 (cold shutdown), consistent with the STS. In addition, the staff asked the applicant in RAI 16.0-4 to justify the proposed completion times for reaching lower modes of operation or other specified conditions in LCO 3.0.3 and all specifications with shutdown action requirements. In its response dated November 13, 2006, the applicant proposed that LCO 3.0.3 specify completion times of 25 hours to be in Mode 4 and 37 hours to be in Mode 5 and subsequently incorporated these changes to LCO 3.0.3 in DCD Chapter 16, Revision 1. These completion times, which are consistent with the STS, are acceptable because they are consistent with the capabilities of the ESBWR design and ensure that the required conditions can be reached from full-power conditions in an orderly manner without challenging safety systems. The completion times for shutdown actions in other specifications are acceptable because they are consistent with those specified for LCO 3.0.3. Therefore, RAIs 16.0-4 and 16.2-16 are resolved.

RAI 16.2-15. The staff requested that the applicant describe how modified end states (usually Mode 3 in LCOs with required actions that do not specify exiting the applicability of the LCO) may affect implementation of LCOs 3.0.3 and 3.0.4 and SRs 3.0.1 and 3.0.4. In its response dated November 13, 2006, the applicant addressed each of these specifications. However, as discussed in Section 16.2.0 of this report under the evaluation of the response to RAI 16.0-7, the applicant withdrew its proposal to adapt TSTF-423-A to the GTS and adopt modified end states. Therefore, RAI 16.2-15 is resolved.

RAI 16.2-17. The staff requested that the applicant discuss why it had not proposed an LCO similar to AP1000 LCO 3.0.8 that would apply during shutdown conditions (i.e., ESBWR GTS Modes 5 and 6) when the action requirements of an LCO are not met and no other action is specified or when none of the action requirements of an LCO address the plant condition. Such an LCO would function in the same way as LCO 3.0.3, except that it would not apply during operating modes (Modes 1, 2, 3, and 4) but would apply during cold shutdown and refueling. In its response dated November 13, 2006, the applicant stated that the STS have no such requirement and that the action requirements of the ESBWR specifications that are applicable during Modes 5 and 6, together with LCO 3.0.2, are equivalent to those provided by the first of the two AP1000 LCO 3.0.8 action requirements (i.e., 3.0.8.a, which requires action to be initiated to restore inoperable equipment to operable status), so a separate GTS requirement is unnecessary. The applicant also stated that the provisions of 10 CFR 50.65(a)(4) adequately address the second AP1000 LCO 3.0.8 action requirement (3.0.8.b, which requires action to be initiated to monitor safety system shutdown monitoring tree parameters), making it unnecessary as a TS requirement. The STS intentionally exclude requirements that are redundant to or duplicative of other STS requirements or regulations. Therefore, based on the preceding discussion, RAI 16.2-17 is resolved.

Based on the above, GTS Section 3.0 and bases are acceptable.

16.2.4 ESBWR GTS Section 3.1, "Reactivity Control Systems"

Section 3.1 of the ESBWR GTS governs reactivity control systems. The following specifications in Section 3.1 that correspond to those given in STS 3.1.1 through 3.1.7 are acceptable to the staff because they are consistent with the STS:

- 3.1.1, "Shutdown Margin (SDM)"
- 3.1.2, "Reactivity Anomalies"
- 3.1.3, "Control Rod Operability"
- 3.1.4, "Control Rod Scram Times"
- 3.1.5, "Control Rod Scram Accumulators"
- 3.1.6, "Rod Pattern Control"
- 3.1.7, "Standby Liquid Control (SLC) System"

The ESBWR design does not include scram discharge volumes (SDVs), so a GTS based on STS 3.1.8, "SDV Vent and Drain Valves," was not adopted. In addition, the following RAIs have been successfully resolved.

RAI 16.2-18. The staff requested that the applicant justify its decision not to include action requirements equivalent to STS 3.1.1, Required Actions D.4 and E.5, which both require initiating action to restore isolation capability in each required (i.e., secondary containment) penetration flow path which is not isolated within 1 hour of discovery that the SDM is outside the limits in Mode 4 and Mode 5, respectively. In its response dated November 13, 2006, the applicant explained that ESBWR GTS 3.1.1 contains action requirements implicitly equivalent to these STS action requirements and explicitly equivalent to STS 3.1.1, Required Actions D.2 and E.3, both of which require initiating action to restore secondary containment to operable status. In the ESBWR GTS, the reactor building specification is equivalent to both the STS secondary containment specification and the secondary containment isolation valve specification, since the ESBWR design does not have a secondary containment equivalent to that of the BWR/6 design. An operable reactor building requires isolation capability of all penetration flow paths. In DCD Revision 5, GEH made additional changes to Actions D and E, which now require that, upon discovery that the SDM is not within limits in Mode 5 and 6, GTS 3.1.1, Actions D and E, respectively, both call for immediately initiating action to either (1) isolate the reactor building refueling and pool area heating, ventilation, and air conditioning (HVAC) subsystem (REPAVS) and contaminated area HVAC subsystem (CONAVS) areas or (2) establish reactor building REPAVS and CONAVS area automatic isolation capability on respective exhaust high radiation signals. These are appropriate actions for SDM not within limits in Modes 5 and 6 and are consistent with the STS actions to restore secondary containment operability. Therefore, RAI 16.2-18 is resolved.

RAI 16.2-19. The staff requested that the applicant remove the word "each" from the Completion Time for Required Action A.3 of GTS 3.1.3, "Control Rod Operability," for the condition of "one withdrawn control rod stuck" because the action note allows separate condition entry for each control rod. Thus, the word "each" in the completion time of "24 hours from 'each' discovery of Condition A concurrent with thermal power greater than the low power setpoint" is unnecessary and potentially confusing. In its response dated November 13, 2006, the applicant stated that it would remove the word “each.” Revision 2 of DCD Chapter 16, dated December 22, 2006, includes this change. Therefore, RAI 16.2-19 is resolved.

RAI 16.2-20. The staff asked the applicant to explain why GTS SR 3.1.3.2 and SR 3.1.3.3 specify moving the control rod two notches instead of one notch, as specified in the STS. In its response dated November 13, 2006, the applicant stated that two notches for the ESBWR FMCRD is approximately the same distance as one notch for the typical BWR/6 control rod drive (CRD) and that insertion by at least two notches is compatible with the requirements of the ganged withdrawal sequence restrictions (GTS 3.1.6) and the rod control and information system (GTS 3.3.2.1). Therefore, SR 3.1.3.2 and SR 3.1.3.3 are acceptable, and RAI 16.2-20 is resolved.

RAI 16.2-21. The staff requested that the applicant address the omission of the phrase “control rod pair” in the GTS bases’ discussion of the note for the SRs of GTS 3.1.4. The note states, “During single or control rod pair scram time Surveillances, the CRD pumps shall be isolated from the associated scram accumulator.” In its response dated November 13, 2006, the applicant stated that it would correct this omission with the following sentences:

> All four SRs of this LCO are modified by a Note stating that during a single control rod or control rod pair scram time Surveillance, the CRD pumps shall be isolated from the associated scram accumulator. With the CRD pump isolated (i.e., charging valve closed) the influence of the CRD pump head does not affect the single control rod or control rod pair scram times.

Revision 2 of DCD Chapter 16B, dated December 22, 2006, includes this change. Therefore, RAI 16.2-21 is resolved.

RAIs 16.2-22 and 16.2-91. In RAI 16.2-22, the staff requested that the applicant add a discussion in the bases for GTS Table 3.1.4-1, “Control Rod Scram Times,” Footnote (c), which stated, “For reactor steam dome pressure < [6.550 MPaG (950 psig)], only the [60] percent insertion scram time limit applies.” Footnote (c) applied only to the table column for a reactor steam dome pressure of 0 MPaG (0 psig). In its response dated November 13, 2007, the applicant stated that the “insertion time limit at 0 psig is not necessary for the ESBWR” and that it would eliminate the 0 psig column and the associated note from Table 3.1.4-1, making the table and notes consistent with STS Table 3.1.4-1. Revision 2 of DCD Chapter 16B includes this change. In its response to a supplement to RAI 16.2-22 dated May 14, 2007, the applicant explained that Footnote (b) to Table 3.1.4-1 applies when performing scram insertion time testing when the reactor is depressurized (0 psig) up to a reactor vessel bottom pressure of 1,085 psig. Removing Footnote (c) in response to the initial question did not eliminate the requirement for a test at 0 psig. In addition, the scram times identified in the table match those stated in the accident analysis descriptions in DCD, Tier 2, Chapter 15. In RAI 16.2-91, the staff asked the applicant to explain the reactor pressure vessel (RPV) pressures associated with the identical scram time criteria in GTS Table 3.1.4-1 and DCD Tables 15.2-2 and 15.2-3. In its response dated January 18, 2007, GEH stated that it would verify that the RPV steam dome pressures in the GTS table are equivalent to the RPV bottom head pressures in the tables in DCD Chapter 15, once the pressure values were determined. DCD Revision 5, Tables 15.2-2 and 15.2-3, cite final pressures of 1,085 psig and 1,250 psig for the bottom head and 1,065 psig and 1,227 psig for the steam dome, respectively. The pressure differences between the bottom head and the steam dome of 20 psi and 23 psi appear reasonable, if the water is assumed to be saturated and if vessel water level is assumed to be the normal level of 20.72 meters above the vessel bottom. Because the pressures in the tables are equivalent and the scram time criteria match the values assumed in the accident analyses, the staff concludes that the proposed GTS Table 3.1.4-1 is acceptable. Therefore RAIs 16.2-22 and 16.2-91 are resolved.

RAI 16.2-75. By e-mail dated June 6, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML071580006 and ML071580007), the staff issued RAI 16.2-75, Supplement 1, requesting that the applicant add DCD references to the bases for GTS 3.1.1, “Shutdown Margin.” The “ASA” section of the bases for GTS 3.1.1 presents the control rod withdrawal (or removal) error (RWE) during refueling as the event basis for the LCO on SDM. The NRC staff asked the applicant to confirm whether RWE during refueling is more limiting than RWE at startup or low power. If RWE at startup or low power is more limiting, then the reference in the GTS bases should be changed to RWE during startup; that is, the applicant should change the DCD reference from Section 15.3.7 to Section 15.3.8. (See Section 15.3 of this report for a discussion of RAI 15.3-33 regarding analysis of the RWE event during power operation.) RAI 16.2-75 was being tracked as an open item in the SER with open items. In its response dated October 15, 2007, the applicant explained that RWE during refueling is more limiting than RWE during startup and power operation because only the analysis of RWE during refueling explicitly credits a subcriticality margin. Therefore, RAI 16.2-75 is resolved.

RAI 16.2-90. The staff requested that the applicant include in the bases for GTS 3.1.3 a discussion of the indications of a stuck control rod. In its response dated January 18, 2007, the applicant added the following statements to the ”Actions” section of the bases for GTS 3.1.3, Action A: “A control rod is stuck if it will not insert by either FMCRD motor torque or hydraulic scram pressure. A control rod is not made inoperable by a failure of the FMCRD motor if the rod is capable of hydraulic scram.” Therefore, RAI 16.2-90 is resolved.

RAI 16.2-93. The staff asked the applicant why it had not proposed to include STS SR 3.1.7.8 to verify the required flow through one SLC subsystem. In its response dated January 18, 2007, GEH stated that it had added SR 3.1.7.9, “Verify flow through one flow path on one SLC train from accumulator into reactor pressure vessel,” with a frequency of 24 months on a staggered test basis for each of the four flow paths—two flow paths per train. Since accumulators pressurized with nitrogen provide the driving force for SLC system flow, specifying a minimum flow rate is not a meaningful surveillance acceptance criterion. Once the capability to deliver the required volume in the specified time for each flow path is demonstrated during preoperational testing of the SLC system, it is sufficient to periodically verify that each flow path is not obstructed and that the accumulators contain the required volume of boric acid solution at the specified pressure. Based on the addition of this SR, RAI 16.2-93 is resolved.

RAI 16.2-104. The staff requested that GEH revise SR 3.1.3.5, “Verify each control rod does not go to the withdrawn overtravel position,” to include the frequency from the equivalent BWR/6 STS SR 3.1.3.5 of “Each time the control rod is withdrawn to ‘full out’ position.” In its response dated January 18, 2007, GEH stated that it would revise the frequency to include this frequency in addition to the frequency of “Prior to declaring control rod OPERABLE after work on control rod or CRD System that could affect coupling.” However, DCD Revision 3 did not reflect this change. In the list of changes between Revision 2 and Revision 3, Item 14 states that the “coupling check when the rod is full withdrawn is not required because the ESBWR design includes redundant instrumentation that provide immediate indication of an uncoupled rod." DCD Section 7.7.2.1.2 states that there are "dual redundant measurements of the absolute rod position during normal FMCRD conditions." The bases for SR 3.1.3.5 also state that the retained frequency is acceptable because of the mechanical integrity of the bayonet coupling design of the FMCRDs. For these reasons, the omission of the frequency of "Each time the control rod is withdrawn to 'full out' position" is acceptable. Therefore, RAI 16.2-104 is resolved.

RAI 16.2-109. The staff requested that GEH modify the GTS bases to be consistent with the resolution of RAI 4.6-23 regarding the treatment of the control rod drop accident (CRDA) in the ESBWR design, as described in the DCD. The staff noted that the bases for GTS 3.1.1 and GTS 3.1.3 do not discuss the CRDA, which is discussed in the STS bases. Furthermore, the bases for GTS 3.1.3, Required Actions A.1, A.2, A.3, and A.4, and GTS 3.1.6, 3.10.7, and 3.10.8 discuss the RWE analysis in place of the CRDA analysis, which is discussed in the STS bases. RAI 16.2-109 was being tracked as an open item in the SER with open items. In its response dated January 18, 2007, GEH stated that the GTS bases do not discuss the CRDA because it is not credible based on the design of the FMCRD and control rods used in the ESBWR. Since RAI 4.6-23 is resolved as described in Section 4.6 of this report, the CRDA is not deemed credible and the RWE event is the correct reference, the above differences from the STS bases are acceptable. Therefore, RAI 16.2-109 is resolved.

RAI 16.2-169. The staff asked the applicant to revise Action D of GTS 3.1.7 to require a unit shutdown. As written, Actions Condition D could mean that at least one accumulator is unavailable for ECCS injection. Since both accumulator volumes are necessary for successful mitigation of a loss-of-coolant accident (LOCA), this condition represents a loss of ECCS function; therefore, shutdown actions should be specified rather than an 8-hour completion time for restoring SLC system operability. In its response dated January 28, 2009, GEH combined Conditions D and E and deleted the action to restore SLC system operability in 8 hours. New Condition D corresponds to both a loss of capability to inject by one or both SLC trains and a failure to restore boron concentration to within limits in 72 hours (Action A), restore injection squib valve flow paths to operable status in 7 days (Action B), or restore accumulator isolation valves to operable status in 7 days (Action C). Action D requires a unit shutdown to Mode 5 in 36 hours, which is appropriate for the stated conditions. The applicant made appropriate conforming changes to the "Actions" section of the bases for GTS 3.1.7. With these changes, RAI 16.2-169 is resolved.

Based on the above evaluation and resolution of the RAIs, the staff concludes that GTS Section 3.1 and bases are acceptable.

16.2.5 ESBWR GTS Section 3.2, "Power Distribution Limits"

Section 3.2 of the ESBWR GTS governs core power distribution limits. Section 3.2 includes GTS 3.2.1, "Linear Heat Generation Rate (LHGR)," and GTS 3.2.2, "Minimum Critical Power Ratio (MCPR)," which correspond to STS 3.2.3 and STS 3.2.2, respectively. The staff finds these specifications acceptable based on their consistency with the STS and the resolution of the following RAIs.

RAIs 16.2-11 and 16.2-24. In RAI 16.2-24, the staff asked the applicant to explain why the ESBWR GTS do not include STS 3.2.1, "Average Planar Linear Heat Generation Rate

(APLHGR)," and STS 3.2.4, "Average Power Range Monitor (APRM) Gain and Setpoints." In its response dated April 13, 2007, the applicant stated that the limits on "average planar linear heat generation rate" (APLHGR) are not necessary for the ESBWR to meet the requirements of 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," regarding the limits for peak clad temperature and oxidation during a DBA LOCA because the RPV water level never falls below the top of the core during any ESBWR DBA. Based on this analysis result, the staff finds that the omission of TS for APLHGR and the APLHGR definition are acceptable. The applicant stated that it would address omission of STS 3.2.4 in its response to RAI 16.2-11.

RAI 16.2-11. The staff asked the applicant to justify its exclusion of the physics test definition of "maximum fraction of limiting power density" (MFLPD) from GTS Section 1.1. In Part 2 of its response to RAI 16.2-11 dated May 21, 2007, the applicant stated that STS Section 1.1 includes a definition for MFLPD and refers to MFLPD in STS 3.2.4, "Average Power Range Monitor (APRM) Gain and Setpoints (Optional)." In the STS, Specification 3.2.4 is optional for plants that must adjust either the flow-biased scram setpoints or average power range monitor (APRM) gain or limit power level to protect against the possibility of exceeding the thermal limits due to local power peaking at off-rated conditions. Similar to the approach used in the STS, the ESBWR core will maintain the required thermal limits in the core operating limits report (COLR), which will ensure that required thermal limits are met without the need for a TS equivalent to STS 3.2.4. Therefore, omission of the MFLPD definition and an LCO for APRM gain and setpoints is acceptable. Based on this, as well as the discussion in Part 1 of the applicant's response to RAI 16.2-11, as described in Section 16.2.1 of this report, RAIs 16.2-11 and 16.2-24 are resolved.

RAI 16.2-33. The staff requested that the applicant review the response to RAI 16.0-1 (which provided a systematic evaluation of the information in the DCD against the requirements of 10 CFR 50.36(c)(2)(ii)), considering the response to RAI 15.0-2 in which the staff asked the applicant to add a table in the DCD listing all of the non-safety grade related systems and components used for mitigating transients and accidents analyzed in DCD, Tier 2, Chapter 15. In its response dated January 18, 2007, the applicant stated that the response to RAI 15.0-2 addressed the non-safety-related systems used for mitigating transients (anticipated operational occurrences and infrequent events) and accidents. Furthermore, the applicant stated that it had considered this discussion in its response to RAI 16.0-1. In these responses, the applicant stated that it had evaluated the following non-safety-related systems:

- control rod drive (CRD) system—makeup water function
- fuel and auxiliary pool cooling system (FAPCS)—suppression pool cooling function
- feedwater control system (FWCS)
- rod control and information system (RC&IS)
- steam bypass and pressure control (SB&PC) system

GEH determined that the functions of the above systems are not in the primary success path for mitigating transients and accidents and are not risk significant, except as noted below.

The applicant stated that it had determined that the following non-safety-related-system functions are in the primary success path for mitigating transients:

- CRD system—selected control rod run-in (SCRRI) function (GTS 3.7.6)
- RC&IS—control rod block functions (GTS 3.3.2.1)
- SB&PC system—turbine bypass valve (TBV) opening function (GTS 3.7.4)

The staff finds the applicant's response acceptable except for the part concerning the FWCS. In a supplement to RAI 16.2-33, the staff asked GEH to clarify its response related to the role of the FWCS in mitigating the severity of transients (anticipated operational occurrences and infrequent events) by controlling RPV water level. RAI 16.2-33 was being tracked as an open item in the SER with open items. In its response dated October 7, 2008, GEH stated the following:

> The FWCS is a normally-operating, non-safety-related system that is assumed to continue functioning after Anticipated Operational Occurrences (AOOs) and Infrequent Events (IEs), except where the failure of the FWCS is the initiator of an AOO or IE. Therefore, the FWCS is not required in the primary success path of the applicable AOOs and IEs. In addition, the FWCS is not credited for mitigating the consequences of any Design Basis Accident (DBA)….for AOOs and IEs, there is no requirement to assume the failure of the normally-operating, non-safety-related systems and components coincident with or after initiation of the AOO or IE event….failure of [the] FWCS simultaneously with an Inadvertent Isolation Condenser Initiation (IICI) event is a detectable and non-consequential random, independent failure, and the automatic function of the FWCS is thus not in the primary success path for the mitigation of the consequences of an IICI event….Since failure of FWCS to automatically control feedwater flow, simultaneously with an IICI event is not deemed credible, only operation of the FWCS in manual control would prevent the automatic feedwater control that is assumed in response to an IICI event….[with FWCS in manual control] if an IICI event were to occur, it would be assumed that feedwater flow remains constant possibly impacting the MCPR resulting from the event….Since a basic assumption in the safety analysis for the IICI event is that the FWCS is in automatic control…in the calculation of the OLMCPR…operation of FWCS in manual mode would result in violating the requirements of Technical Specification 3.2.2, since the basic assumption of the OLMCPR as defined in the COLR would not be met…requiring restoration of automatic control of the FWCS [within 2 hours] or to reduce thermal power of the unit to less than 25% of rated thermal power [within 4 hours], as necessary.

The staff finds that the above information provides the requested clarification of the role of the FWCS in mitigating the severity of AOOs and IEs by controlling RPV water level, and concludes that the GTS do not need to include an LCO for the FWCS. However, the bases for GTS 3.2.2 did not specifically state that the MCPR operating limits specified in the COLR are not met whenever the unit is operating greater than or equal to 25 percent of the rated thermal power (RTP) in manual feedwater control. In a second supplement to RAI 16.2-33, the staff requested that GEH revise the bases to address this point. In its response dated May 4, 2009, GEH added the following statement to the "ASA" section of the bases for GTS 3.2.2: "The transient analyses assume that the feedwater control system is in automatic mode; therefore, if the feedwater control system is in manual mode, then the MCPR LCO is not met." If the MCPR LCO is not met, then the MCPR operating limits specified in the COLR are not met; the bases are clear that GTS 3.2.2, Action A, applies whenever the unit is operating at greater than or equal to 25 percent of the RTP in manual feedwater control. This is acceptable. Therefore, RAI 16.2-33 is resolved.

Based on consistency with the STS and the resolution of the above RAIs, the staff concludes that GTS Section 3.2 and bases are acceptable.

16.2.6 ESBWR GTS Section 3.3, "Instrumentation"

Section 3.3 of the GTS significantly differs from the instrumentation provisions in the STS. The use of microprocessor- or digital-based instrumentation systems in the ESBWR design is one source of the differences between the GTS and the STS. Another source of difference is the non-safety-related designation of a number of the active systems in the ESBWR design that correspond to safety-related systems in the STS. The applicant determined that the four criteria of 10 CFR 50.36(c)(2)(ii) do not require instrumentation TS LCOs for such non-safety-related systems. The resolution of RAI 16.0-1, regarding whether the process used by the applicant for the formulation of the ESBWR LCOs resulted in establishing LCOs meeting the requirements of 10 CFR 50.36(c)(2)(ii), supports this determination.

Section 3.3 of the ESBWR GTS contains the following instrumentation specifications and is generally based on the STS and the determinations made in response to RAI 16.0-1. Each of the following specifications contains LCO, action, and SRs for the associated instrumentation functions, consistent with 10 CFR 50.36, the design described in Revision 7 of Chapter 7 of DCD Tier 2, and the guidance provided in the STS:

- 3.3.1.1, "Reactor Protection System (RPS)"
- 3.3.1.2, "RPS Actuation"
- 3.3.1.3, "RPS Manual Actuation"
- 3.3.1.4, "Neutron Monitoring System (NMS) Instrumentation"
- 3.3.1.5, "NMS Automatic Actuation"
- 3.3.1.6, "SRNM Instrumentation"
- 3.3.2.1, "Control Rod Block (CRB) Instrumentation"
- 3.3.3.1, "Remote Shutdown System (RSS)"
- 3.3.3.2, "Post-Accident Monitoring (PAM) Instrumentation"
- 3.3.4.1, "Reactor Coolant System Leakage Detection (RCSLD) Instrumentation"
- 3.3.5.1, "Emergency Core Cooling System (ECCS) Instrumentation"
- 3.3.5.2, "ECCS Actuation"
- 3.3.5.3, "Isolation Condenser System (ICS) Instrumentation"
- 3.3.5.4, "ICS Actuation"
- 3.3.6.1, "Main Steam Isolation Valve (MSIV) Instrumentation"

- 3.3.6.2, “MSIV Actuation”
- 3.3.6.3, “Isolation Instrumentation”
- 3.3.6.4, “Isolation Actuation”
- 3.3.7.1, “Control Room Habitability Area (CRHA) Heating, Ventilation, and Air Conditioning (HVAC) Subsystem (CRHAVS)”
- 3.3.7.2, “CRHAVS Actuation”
- 3.3.8.1, “Diverse Protection System (DPS)”

Section 3.3 of the ESBWR GTS omits the following STS specifications. This is acceptable because each associated system either is not a part of the ESBWR design or is not safety related in the ESBWR design, as listed below.

Excluded STS instrumentation specifications associated with systems that are not a part of the ESBWR design are the following:

- 3.3.4.1, “End of Cycle Recirculation Pump Trip Instrumentation”
- 3.3.4.2, “Anticipated Transient Without Scram Recirculation Pump Trip Instrumentation”
- 3.3.5.2, “Reactor Core Isolation Cooling System Instrumentation”
- 3.3.6.4, “Suppression Pool Makeup System Instrumentation”
- 3.3.6.5, “Relief and Low-Low Set Instrumentation”
- 3.3.8.2, “RPS Electric Power Monitoring”

Excluded STS instrumentation specification associated with systems that are not safety related in the ESBWR design is the following:

- 3.3.6.3, “Residual Heat Removal Containment Spray System Instrumentation”

The following subsections describe the evaluation of the implementation of the requirements of 10 CFR 50.36(c) for LCOs, remedial actions (actions or required actions), and SRs in the specifications for ESBWR instrumentation.

16.2.6.1 *Limiting Conditions for Operation*

According to 10 CFR 50.36(c)(2)(i), LCOs are “the lowest functional capability or performance levels of equipment required for safe operation of the facility.” Accordingly, the proposed LCO for each instrumentation specification requires a corresponding minimum number of operable divisions or channels (as indicated below, depending on the specification) for each associated instrumentation function. For automatic functions, the minimum number is usually one more than the design requires to perform the safety function to account for a failure of the extra required division or channel. In the ESBWR design, the number of channels or divisions for a safety-related instrumentation function is typically one more than the LCO-specified minimum. See Chapter 7 of this report for an evaluation of the instrumentation design.

Generally, in the ESBWR GTS, an “instrumentation channel” refers to the process parameter sensor device and the circuit that carries the analog signal from the sensor to the analog-to-digital signal conversion device (e.g., a remote multiplexing unit (RMU) and a digital trip module (DTM), where the digitized analog signal is compared to the trip setpoint. An “actuation division” refers to the digital trip signal from the DTM to logic processing, which develops an actuation signal to the final device (e.g., a valve initiator). In the case of the RPS, an actuation division includes a trip logic unit (TLU), an output logic unit (OLU), and load drivers. Thus, the GTS contain both an “instrumentation” specification and an “actuation” specification for the RPS, NMS, ECCS (automatic depressurization system (ADS) and gravity-driven cooling system (GDCS)), ICS, MSIV [isolation], [containment] isolation, and CRHAVS.

The RPS trip logic and MSIV isolation functions of the reactor trip and isolation function (RTIF) platform use “de-energized-to-trip” and “failsafe” logic. For example, the RPS is able to scram the reactor if any two like and unbypassed parameters exceed their trip values.

The safety-related system logic and control/engineered safety feature (SSLC/ESF) trip logic uses “energized-to-trip” and “fail-as-is” logic. The isolated SSLC/ESF trip signal is transmitted via load drivers/discrete outputs to the actuators for protective action. The load drivers/discrete outputs are solid-state power switches, directing appropriate currents to devices such as the scram pilot valve solenoids, air-operated valves, and explosive-actuated squib valves.

Each required channel or division of a sensor or actuation function is supported by its own required division of the safety-related direct current (dc) and uninterruptible alternating current (ac) electrical power distribution system. An electrical power distribution division is required when it must be operable to meet LCO 3.8.6, “Distribution Systems—Operating,” or LCO 3.8.7, “Distribution Systems—Shutdown.”

For instrumentation functions that have four channels or divisions, the proposed LCOs require just three of the four channels or divisions to be operable. Any two channels or divisions are capable of performing the automatic safety function; requiring a third channel or division satisfies the single-failure criterion.

Some instrumentation functions have just two channels or divisions or the LCO requires just two channels or divisions to be operable. Except for the SRNM neutron flux monitoring function during spiral offloads or reloads in Mode 6, operability of these functions requires two channels or divisions to be operable. The following LCOs require two channels or divisions of instrumentation functions:

- 3.3.1.3, “RPS Manual Actuation” (two functions, two channels per function)
- 3.3.1.6, “SRNM Instrumentation” (one function, two channels; indication only)

3.3.2.1, “Control Rod Block (CRB) Instrumentation” (four functions, two channels per function)

- 3.3.3.1, “Remote Shutdown System (RSS)” (one function (manual scram), two divisions—Division 1 and Division 2 manual scram switches)

- 3.3.3.2, “Post-Accident Monitoring (PAM) Instrumentation” (multiple functions, two channels per function; indication only)

The instrumentation functions associated with these five LCOs, except for the SRNM, have just two channels or divisions, with each channel supported by its own safety-related electrical power distribution division—either Division 1 or Division 2. There are four SRNM channels (three detectors per channel), one channel for each division of electrical power. However, consistent with the STS; LCO 3.3.1.6 only requires two SRNM channels to be operable in Modes 3, 4, 5, and 6. In Mode 6 during certain refueling situations related to the location of fuel assemblies in the RPV, just one SRNM channel is required to be operable.

The remote shutdown system (RSS) consists of two redundant and independent panels located in the Division 1 and Division 2 quadrants of the reactor building. Division 1 and Division 2 and non-safety-related parameters displayed and controlled on the MCR video display units (VDUs) can also be displayed and controlled from either of the two RSS panels. Each RSS panel has the ability to operate all of the non-safety-related plant investment protection (PIP) equipment and the balance of plant equipment, either automatically or manually. However, the RSS instrumentation specification, GTS 3.3.3.1, only contains operability, action, and SRs for the Division 1 and Division 2 manual scram switches because manual scram is the only function that the operator needs to actuate to place and maintain the plant in hot shutdown (Mode 3) from a location other than the CR. The safety-related ICS is designed to automatically maintain the unit in Mode 3 and Mode 4 by removing decay heat following reactor shutdown with the RPV isolated. For example, RPV isolation would automatically occur on a reactor vessel water level—low, Level 2 signal. In addition, the LCO only requires that the manual scram function be operable at one of the two RSS panels. Based on the above, LCO 3.3.3.1 is acceptable.

Unlike the bases for STS 3.3.3.2, the bases for ESBWR GTS 3.3.3.1 do not list the instrumentation functions needed to maintain the unit in hot shutdown. This is appropriate because each ESBWR RSS panel allows operator access to all functions and controls that are available in the MCR, which include those for reactor scram, RCS decay heat removal (DHR), and RCS pressure control. Included controls are provided on PIP A and PIP B non-safety-related VDUs, which enable operator control of the reactor water cleanup/shutdown cooling (RWCU/SDC) system, CRD system, reactor closed-cooling water (RCCW) system, plant service water (PSW) system, non-safety-related electrical power distribution system, and the nuclear boiler system (NBS). These non-safety-related systems are not required by GTS LCO 3.3.3.1, but they are described in the appropriate section of the DCD, which is listed in the “References” section of the bases for GTS 3.3.3.1. Safety-related controls on the RSS panels include the LCO-required Division 1 and 2 manual scram switches, the Division 1 and 2 MSIV (and drain isolation valve) isolation switches, and the Division 1 and 2 VDUs. DCD Section 7.4.2.2 describes the RSS and the instrumentation and controls provided on each RSS panel. Therefore, the bases for LCO 3.3.3.1 are acceptable.

The RCSLD instrumentation specification, GTS 3.3.4.1, requires three separate RCS leak detection systems, in conformance with RG 1.45, Revision 0, “Reactor Coolant Pressure Boundary Leakage Detection Systems,” issued May 1973. These non-safety monitoring functions of the leak detection and isolation system (LD&IS) are performed in the non-safety-related distributed control and information system (N-DCIS) and provide indication and alarms to alert plant operators to increases in leakage, thereby supporting LCO 3.4.2, which specifies limits on RCS operational leakage. (See Section 16.2.6.3.4 of this report for the evaluation of GTS 3.3.4.1 action requirements and resolution of related RAIs.)

RAI 16.2-135. Equipment within an RPS division of trip actuators includes load drivers and controllers for automatic scram and air header dump (backup scram) initiation. LCO 3.3.1.2 addresses load drivers. The ESBWR GTS does not address operability requirements for the controllers. The staff asked the applicant to justify its decision to exclude controllers for automatic scram and air header dump (backup scram) initiation from the GTS. RAI 16.2-135 was being tracked as an open item in the SER with open items. In its response dated May 19, 2009, the applicant explained that the load drivers for the automatic scram function and the air header dump (backup scram) trip actuators (or "controllers" or "output contactors") both initiate a hydraulic scram by removing the instrument air pressure that keeps the scram valves shut. One air-operated scram valve is located on each hydraulic control unit scram accumulator; when the scram valve opens (i.e., when air pressure is exhausted), the associated control rods are hydraulically inserted into the core by the pressurized water in the scram accumulator. The applicant proposed to revise DCD Section 7.2.1.2.4.1 and the "Background" section of the bases for GTS 3.3.1.1 by clarifying the discussion of the divisions of trip actuators as follows:

> Equipment within a division of trip actuators includes load drivers for automatic primary scram and output contactors for the initiation of backup scram….When in a tripped state, the load drivers within a division interconnect with the Output Logic Unit (OLU) of all other divisions to form an arrangement (connected in series and in parallel in two separate groups) that results in two-out-of-four scram logic. Reactor scram occurs if load drivers associated with any two or more divisions receive trip signals from the OLUs….When in a tripped state, the output contactors cause the backup scram valve solenoids to energize. The output contactors of the backup scram are arranged in a two-out-of-four configuration similar to that…for the primary scram load drivers. Backup scram is diverse in power source and function to primary scram….OPERABILITY requirements for the [automatic primary scram] load drivers are addressed in LCO 3.3.1.2. OPERABILITY requirements for the backup scram [output contactors] are not addressed within the Technical Specifications.

In response to a manual or automatic scram signal (two-out-of-four logic) from the RPS, safety-related power is removed from each primary scram pilot valve solenoid, which positions each primary scram valve to exhaust air from the associated hydraulic control unit (HCU) scram valve air operator, allowing the HCU scram valve to open causing a hydraulic scram of the associated control rods by the pressurized water in the scram accumulators.

In response to a manual or automatic scram signal from the RPS (two-out-of-four logic), safety-related power is supplied to each backup scram valve solenoid, which positions each backup scram valve to isolate instrument air from the scram air header and exhaust air from the scram air header and the air operator of each HCU scram valve, allowing all HCU scram valves to open causing a hydraulic scram of all control rods by the pressurized water in the scram accumulators.

Further, as described in DCD, Tier 2, Section 7.2.1, “Reactor Protection System,” the backup scram valves are not safety related and the backup scram has a separate and independent power source and function from the primary scram. The staff concluded that the backup scram valves, including the solenoids and output contactors, do not satisfy any of the LCO criteria of 10 CFR 50.36 because they are not the primary means of initiating a hydraulic scram of the control rods in response to a scram signal from the RPS, and therefore need not be specified in a GTS LCO. Based on this conclusion, the design of the backup scram function, and the applicant’s response, RAI 16.2-135 is resolved.

<u>RAI 16.2-136</u>. The LCO for RPS manual actuation states that the Division 1 and 2 manual actuation channels and mode switch actuation channels must be operable. The staff asked the applicant to revise the LCO of GTS Section 3.3.1.3, “Reactor Protection System Manual Actuation,” to add the number of channels required to be operable for each manual actuation feature. RAI 16.2-136 was being tracked as an open item in the SER with open items. In its response dated October 15, 2007, GEH revised GTS 3.3.1.3 and associated bases to specify the number of channels required to be operable for each manual function by referencing new Table 3.3.1.3-1 in GTS LCO 3.3.1.1, which specifies the manual functions, their applicable modes, and the number of channels required operable. Specifically, two channels each of the manual scram function and reactor mode switch—shutdown position function are required to be operable in Modes 1 and 2 and in Mode 6 with any control rod withdrawn from a core cell containing one or more fuel assemblies. Because GEH made the requested changes to GTS 3.3.1.3 and bases to explicitly state the required number of operable channels for each RPS manual function, therefore, RAI 16.2-136 is resolved.

<u>RAI 16.2-139</u>. Instrumentation LCOs state the number of divisions required to be operable, whereas associated actions conditions refer to inoperable required channels. The staff asked the applicant to revise LCOs to state the number of channels required to be operable for each division. RAI 16.2-139 was being tracked as an open item in the SER with open items. In its response dated October 15, 2007, the applicant stated that it had revised GTS LCO 3.3.1.4, “Neutron Monitoring System (NMS) Instrumentation,” and Table 3.3.1.4-1 to explicitly state the required number of operable channels per required division for each function identified in Table 3.3.1.4-1 in Revision 4 of DCD Chapter 16. LCO 3.3.1.4 states the following:

> The NMS instrumentation channels of the three NMS instrumentation divisions associated with the DC and Uninterruptible AC Electrical Power Distribution Divisions required by LCO 3.8.6, “Distribution Systems—Operating,” and LCO 3.8.7, “Distribution Systems—Shutdown,” for each Function in Table 3.3.1.4-1 shall be OPERABLE.

In addition, Revision 5 to DCD Chapter 16 revised Action A of GTS 3.3.1.4 by adding “instrumentation” to Condition A for consistency with the LCO phrasing and to Required Action A.1 for clarity and consistency with the design, as follows:

Condition A	One or more Functions with instrumentation channel(s) inoperable in one required division.
Required Action A.1	Verify associated instrument channel in trip.
Completion Time	12 hours

These changes provided the requested clarification for LCO 3.3.1.4. The staff verified that Revision 5 to DCD Chapter 16 had also clarified the channels-per-division issue for the other LCOs in GTS Section 3.3. Therefore, RAI 16.2-139 is resolved.

RAI 16.2-186. The staff asked the applicant to correct an inconsistency between DCD, Tier 2, Revision 5, Section 4.6.1.2.6 and RPS Function 3 of GTS 3.3.1.1 and 3.3.2.1. Function 3 does not use "low low" and "hydraulic control unit" in its name, and GTS 3.3.2.1 does not specify the control rod block (CRB) function, "low pressure in the HCU accumulator charging water header." In its response dated May 1, 2009, GEH corrected the inconsistencies by revising DCD Tier 1 and DCD, Tier 2, Chapters 1, 4, 7, 15, 16, and 16B. Regarding RPS Function 3, the applicant replaced the terms "CRD accumulator" or "HCU accumulator" with the term "scram accumulator." GEH corrected the CRB function inconsistency by replacing various references to "[CRD][HCU] charging [water] header" with the reference "scram accumulator charging water header." In addition, GEH changed RPS Function 3 to "scram accumulator charging water header pressure—low-low," and the CRB function to "scram accumulator charging water header pressure—low." These nomenclature changes clarify the DCD description of these functions and the presentation of requirements in the GTS. Therefore, they are acceptable. GEH also stated that it had determined that the CRB function, "scram accumulator charging water header pressure—low," did not satisfy any of the criteria of 10 CFR 50.36(c)(2)(ii) because it is not credited in the "safety analyses and is not significant to public health and safety." Based on this determination and the correction of the noted inconsistencies, therefore, RAI 16.2-186 is resolved.

RAI 16.2-187. The staff asked the applicant to justify its decision not to specify several instrumentation functions, which are described in DCD Section 4.6.1.2.5, "Control Rod Drive System Operation." In its response dated May 1, 2009, GEH stated that all but one of the functions did not meet the criteria of 10 CFR 50.36(c)(2)(ii). The staff reviewed the justification provided in the response and found it to be acceptable. GEH referred to the response to RAI 21.6-103 in which it had concluded that the GTS should specify instrumentation and actuation functions for automatic stop of CRD pumps on coincident low level in two GDCS pools In DCD Revision 6, GEH added "GDCS Pool Water Level Low" (Function 14 of GTS 3.3.6.3) and "High Pressure Control Rod Drive Isolation" (Function 11 of GTS 3.3.6.4). Therefore, RAI 16.2-187 is resolved.

RAI 16.2-190. The standard technical specifications (STS) for boiling water reactors (BWRs) include a specification, STS 3.3.3.1, to govern post-accident monitoring (PAM) instrumentation which is based on RG 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," Revision 3, issued in 1983, and the May 9, 1988, T.E. Murley (NRC) to R. F. Janecek (BWR Owners' Group) letter, which presents the current NRC staff position regarding which accident monitoring instrumentation must be in TS. This letter is known as the "Split Report." The bases for STS 3.3.3.1, state:

PAM instrumentation that meets the definition of Type A in RG 1.97 satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii). Category 1, non-Type A, instrumentation is retained in the Technical Specifications because it is intended to assist operators in minimizing the consequences of accidents. Therefore, these Category 1, non-Type A variables are important for reducing public risk.

In addition, STS 3.3.3.1 contains a Reviewer's Note for applicants or licensees who propose to incorporate STS 3.3.3.1 into their plant's TS. The Note requires replacing the bracketed list of PAM functions in STS Table 3.3.3.1-1 with a list of all RG 1.97 Type A instruments, and the Category 1, non-Type A instruments specified in the plant's RG 1.97 Safety Evaluation Report. STS 3.3.3.1 and bases, and the STS Table 3.3.3.1-1 Reviewer's Note are consistent with the current staff position on accident monitoring instrumentation TS, which is articulated in the "Split Report."

The staff reviewed its current position regarding which accident monitoring instrumentation should be in the TS as compared to RG 1.97, Revision 4, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," issued June 2008. Based on that review, NRC staff concludes the following:

(1) Accident monitoring instrumentation Type A, as defined in RG 1.97, Revision 4, is similar to the Type A as defined in RG 1.97, Revision 3.

(2) Accident monitoring instrumentation Type B and Type C, as defined RG 1.97, Revision 4, are similar to the Category 1 type of accident monitoring instrumentation as defined in RG 1.97, Revision 3.

Therefore, the NRC staff concludes that TS should include (1) all RG 1.97, Revision 4, Type A instruments, and (2) all RG 1.97, Revision 4, Type B and Type C instruments. The staff notes that GEH has committed to following the guidance in RG 1.97, Revision 4, in its design certification application for the ESBWR.

Since STS for boiling water reactors (BWRs) include TS to govern PAM instrumentation, in RAI 16.2-190 the staff asked GEH to include requirements for PAM instrumentation in the ESBWR GTS. This would include removing the brackets from the entire GTS 3.3.3.2, as presented in DCD Revision 6, dated August 2009, and possibly a bracketed list of the potential Type A, Type B, and Type C PAM instrumentation functions in GTS Table 3.3.3.2-1.

Regardless of whether an ESBWR COL application references Revision 4 or Revision 3 of RG 1.97, the applicant would have to finalize the PAM instrumentation function list to complete GTS Table 3.3.3.2-1. However, if the COL applicant references Revision 4, finalizing the PAM instrumentation function list may not be possible before COL issuance. In RAI 16.2-190, the staff pointed out to the applicant that identification of Type A, Type B, and Type C accident monitoring instrumentation functions as defined in RG 1.97, Revision 4, depends on development of emergency operating procedures and abnormal operating procedures, which is a post-COL activity. Therefore COL applicants implementing RG 1.97, Revision 4, should use guidance from DC/COL-ISG-8, "Necessary Content of Plant-Specific Technical Specifications

When a Combined License Is Issued," issued December 2008, to finalize the list of PAM instrumentation functions in GTS Table 3.3.3.2-1.

In RAI 16.2-190, the staff suggested that GEH modify the GTS and bases, and DCD, Tier 2 Table 16.0-1-A to include a choice for the COL applicant to use Option 2 of DC/COL-ISG-8 to provide a site-specific bounding list of accident monitoring functions in GTS Table 3.3.3.2-1; or Option 3 of DC/COL-ISG-8 to remove GTS Table 3.3.3.2-1 and add a GTS programmatic requirement for identifying PAM functions in accordance with the NRC approved methodology endorsed by RG 1.97, Revision 4. Alternatively, the staff suggested that GEH consider modifying the GTS and bases, and DCD, Tier 2, Table 16.0-1-A to specify the programmatic option, so that ESBWR COL applications could incorporate it by reference. Finally, the staff requested that GEH also revise the actions of GTS 3.3.3.2 to be consistent with STS 3.3.3.1, as discussed in Section 16.2.6.3.3 of this report.

In its response dated October 27, 2009, GEH stated it will revise the GTS and bases, and DCD, Tier 2, Table 16.0-1-A to specify the programmatic option. The staff reviewed the markup of the affected pages in DCD, Tier 2, Section 16.0 and in the GTS and bases and found that they proposed all of the changes needed to incorporate the programmatic option suggested in the RAI. Therefore, GTS 3.3.3.2 and bases, GTS 5.5.14, and GTS 5.6.5 are acceptable. In addition, COL Items 3.3.3.2-1 and 5.6.5-1 in Revision 6 of DCD, Tier 2, Table 16.0-1-A are deleted. Based on these changes, therefore, RAI 16.2-190 is resolved. As discussed in Section 22.5.9 of this report, based on the changes associated with this RAI response, GEH also deleted Availability Control 3.3.4 from DCD, Tier 2, Chapter 19ACM.

The NRC staff compared the proposed instrumentation LCOs and associated bases to the instrumentation system design descriptions in DCD, Tier 2, Chapter 7, and the applicant's response to RAI 16.0-1 regarding compliance with 10 CFR 50.36(c)(2)(ii) criteria. The staff concludes that GEH has identified the instrumentation functions that are required to be the subject of LCOs in the GTS. The staff notes that several instrumentation functions are specified in GTS sections other than Section 3.3. This is an acceptable difference in presentation from that of the STS. Based on the preceding evaluations and the resolution of LCO-related RAIs, the staff concludes that the proposed instrumentation LCOs and associated bases sections regarding "Background," "ASA" and "LCO" are acceptable.

16.2.6.2 *Applicability*

The NRC staff verified that the reactor operating modes or other specified conditions stated in the applicability for each proposed instrumentation function are appropriate to ensure that the function's LCO will be met under plant conditions and evolutions for which the function is required by the ESBWR accident analyses or other governing regulatory requirements (such as for RSS and PAM instrumentation). Based on this and the resolution of the following RAI, the proposed applicability requirements for GTS Section 3.3 specifications are acceptable.

<u>RAI 16.2-141</u>. The staff asked the applicant to explain an apparent overlap of requirements for the SRNM instrumentation in Mode 6. GTS 3.3.1.6, "Startup Range Neutron Monitor Instrumentation," and 3.3.1.4, "Neutron Monitoring System (NMS) Instrumentation," require the SRNMs to be operable in Mode 6. The staff also asked the applicant to explain why SRNM channel calibration is required to be performed, in accordance with GTS 5.5.11, "Setpoint

Control Program (SCP)," in GTS 3.3.1.4 but not in GTS 3.3.1.6. RAI 16.2-141 was being tracked as an open item in the SER with open items.

In its response dated August 30, 2007, the applicant stated that the functional requirements for the SRNM instrumentation are not duplicated in LCO 3.3.1.4 and LCO 3.3.1.6. The SRNM subsystem Functions 3.3.1.4.1.a, "SRNM Neutron Flux—High," and 3.3.1.4.1.c, "SRNM Inop," are required to be operable in Mode 6 with any control rod withdrawn from a core cell containing one or more fuel assemblies to generate a scram trip signal to prevent fuel damage in the event of any abnormal positive reactivity insertion transients while operating in the startup power range. In contrast, LCO 3.3.1.6 specifies operability requirements only for the monitoring and indication functions of the SRNM instrumentation, which monitors reactivity changes during fuel or control rod movement to provide plant operators an early indication of unexpected subcritical multiplication that could be indicative of an approach to criticality. Since the SRNM monitoring and indication functions have no trip settings for generating a trip signal, the staff finds that the setpoint control program (SCP) does not apply to SR 3.3.1.6.5, which requires a channel calibration to verify the performance of the SRNM detectors and associated circuitry. Therefore, RAI 16.2-141 is resolved.

16.2.6.3 *Instrumentation Action Requirements*

According to 10 CFR 50.36(c)(2)(i), "when a limiting condition for operation of a nuclear reactor is not met, the licensee shall shut down the reactor or follow any remedial action permitted by the technical specifications until the condition can be met." Thus, for each function, each instrumentation specification includes remedial actions, consistent with the STS format, in the form of required actions that must be performed within specified completion times for various conditions of not meeting the LCO.

16.2.6.3.1 Separate Condition Entry

GTS Section 1.3 specifies that once an actions condition has been entered, subsequent divisions, subsystems, components, or variables expressed in the condition that are discovered to be concurrently inoperable or not within limits will not result in separate entry into the condition. Section 1.3 also specifies that required actions of the condition continue to apply for each additional failure, with completion times based on initial entry into the condition. However, separate condition entry (meaning a separate completion time for each subsequent condition entry) is acceptable when the actions provide appropriate compensatory measures for separate inoperable channels, divisions, or functions. The appropriate compensatory measure in such a loss of function condition is to immediately take the specified required actions that usually include shutting down the unit or declaring associated supported equipment or trains inoperable.

The actions for RPS, NMS, MSIV, Isolation, ECCS, ICS, CRHAVS, and DPS instrumentation specifications contain a note that allows separate condition entry for each channel, division, or function, as appropriate. Separate condition entry is appropriate because the required actions, as discussed below, provide appropriate compensatory measures for concurrently inoperable channels, divisions, or functions. Separate condition entry is permitted for each channel, division, or function, as follows:

Table 16-1
Summary of Basis for Separate Condition Entry into Instrumentation LCO Actions

Basis - channel, division, or function	LCO requirement
• RPS instrumentation channel	LCO 3.3.1.1 specifies 16 functions and requires three instrumentation channels to be operable for each function (one channel for each of three required electrical divisions).
• RPS automatic actuation division	LCO 3.3.1.2 specifies one function and requires three automatic trip actuation divisions to be operable (one division for each of three required electrical divisions).
• RPS manual actuation function	LCO 3.3.1.3 specifies two functions and requires two channels to be operable for each function (one channel for each of two required electrical divisions).
• NMS instrument channel	LCO 3.3.1.4 specifies seven functions and requires three or six channels to be operable for each function (one or two (Functions 1.a and 1.b) channels for each of three required electrical divisions).
• NMS automatic actuation division	LCO 3.3.1.5 specifies three functions and requires three automatic trip actuation divisions to be operable for each function (one division for each of three required electrical divisions).
• RSS function	LCO 3.3.3.1 specifies one function and requires two channels to be operable for that function (one channel for each of two required electrical divisions, Divisions 1 and 2). (RPS Divisions 1 and 2 manual scram switches located on one of the two RSS panels.)
• PAM function	LCO 3.3.3.2 specifies multiple functions (to be determined by the COL applicant) and requires two channels to be operable for each function (one channel for each of two required electrical divisions, Divisions 1 and 2).
• ECCS instrumentation channel	LCO 3.3.5.1 specifies three functions and requires three channels to be operable for each function (one channel for each of three required electrical divisions).
• ECCS actuation function	LCO 3.3.5.2 specifies four functions and requires three actuation divisions to be operable for each function (one actuation division for each of three required electrical divisions).

Basis - channel, division, or function	LCO requirement
• ICS instrumentation channel	LCO 3.3.5.3 specifies five functions and requires three channels to be operable for each function (one channel for each of three required electrical divisions).
• ICS actuation division	LCO 3.3.5.4 specifies one function and requires three actuation divisions to be operable for that function (one actuation division for each of three required electrical divisions).
• MSIV instrumentation channel	LCO 3.3.6.1 specifies seven functions and requires three channels to be operable for each function (one channel for each of three required electrical divisions).
• MSIV actuation division	LCO 3.3.6.2 specifies one function and requires three actuation divisions to be operable for that function (one actuation division for each of three required electrical divisions).
• Isolation instrumentation channel	LCO 3.3.6.3 specifies 14 functions and requires three channels to be operable for each function (one channel for each of three required electrical divisions).
• Isolation actuation division	LCO 3.3.6.4 specifies 11 functions and requires three actuation divisions to be operable for each function (one actuation division for each of three required electrical divisions).
• CRHAVS instrumentation channel	LCO 3.3.7.1 specifies four functions and requires three channels to be operable for each function (one channel for each of three required electrical divisions).
• DPS function	LCO 3.3.8.1 specifies three automatic instrument functions, one manual instrument function, and four actuation functions. Three non-safety, nondivisional load groups provide uninterruptible 120-volt ac electrical power to the required DPS functions.

The applicant did not propose an actions note allowing separate condition entry for the following instrumentation specifications:

- 3.3.1.6, “SRNM Instrumentation”
- 3.3.2.1, “Control Rod Block Instrumentation”
- 3.3.4.1, “Reactor Coolant System (RCS) Leakage Detection Instrumentation”
- 3.3.7.2, “CRHAVS Actuation”

RAIs 16.2-137 and 16.2-138. The staff asked the applicant in RAI 16.2-137 to revise the actions note of GTS 3.3.1.3, “Reactor Protection System Manual Actuation,” which permits separate condition entry for each function, to match the per-channel requirements in the LCO. In RAI 16.2-138, the staff requested that the applicant revise the actions of GTS 3.3.1.3 to require placing the unit in Mode 3 in 12 hours if both channels for one or both manual actuation functions are inoperable with the unit in Mode 1 or 2, or during refueling to initiate action to fully insert all insertable control rods in core cells containing one or more fuel assemblies. RAIs 16.2-137 and 16.2-138 were being tracked as open items in the SER with Open Items. In its responses dated October 15, 2007 and February 25, 2008, GEH revised the actions as requested, as well as the actions note, to allow separate condition entry for each manual function. The staff finds that these changes are acceptable because they are consistent with the response to RAI 16.2-136 (described previously) regarding the number of channels required to be operable for each RPS manual actuation function by LCO 3.3.1.3. Therefore, RAIs 16.2-137 and 16.2-138 are resolved.

16.2.6.3.2 Actions for Functions with Three Required Instrumentation Channels and Functions with Three Required Actuation Divisions

For functions designed with four instrumentation channels, or functions designed with four actuation divisions, three are sufficient to withstand a single failure. Therefore, the initial action requirement in each of the specifications for these functions addresses the condition of a loss of capability to withstand a single failure and still maintain functional capability. Subsequent action requirements address either failure to recover the capability to withstand a single failure or loss of functional capability altogether.

For the condition of one inoperable required instrumentation channel for one or more functions, the GTS actions require, depending on the specification, either restoring the required instrument channel (for all affected functions) to operable status within 12 hours or verifying that the inoperable required instrument channel (for all affected functions) is in trip within 12 hours.

For the condition of one inoperable required actuation division for one or more functions, the GTS actions require, depending on the specification, either restoring the required actuation division (for all affected functions, except for ECCS actuation functions) to operable status within 12 hours (except for an inoperable required isolation actuation division, which specifies 4 hours), or verifying that the inoperable required actuation division (for all affected functions) is in trip within 12 hours. GTS 3.3.5.2 allows separate condition entry for each of four ECCS actuation functions, instead of for each of the three required actuation divisions. Thus, Action A allows 12 hours to restore an inoperable division to operable status for each ECCS actuation function.

During the 12-hour or 4-hour completion time, the inoperable required instrumentation channel or actuation division may be placed in bypass, provided that the non-required instrumentation channel or actuation division is operable and not placed in bypass. Only one instrumentation channel or actuation division may be placed in bypass at a time. Also during the 12-hour or 4-hour completion time, the occurrence of a single failure could cause a complete loss of capability of the affected automatic safety function (loss of trip or actuation capability for that function).

16.2.6.3.2.1 Loss of Capability to Withstand a Single Failure—Action A

16.2.6.3.2.1.1 RPS, NMS, and MSIV Functions for Required Instrumentation Channels and Actuation Divisions

The condition of one inoperable required instrument channel or actuation division for one or more functions corresponds to an inability to sustain an additional failure in either of the remaining two required instrument channels (for the affected functions) or actuation divisions (for the affected actuation functions). The following table lists the GTS Revision 6 action requirements for this condition for the RPS, NMS, and MSIV functions; the staff added the italicized words to clarify the context of each condition and action. The completion time for each required action is 12 hours.

Table 16-2
Summary of Actions for Loss of Capability to Withstand a Single Failure for RPS, NMS, and MSIV Instrumentation and Actuation Functions

LCO	Condition A	Required Action A.1
3.1.1.1	One or more *RPS* functions with one required instrumentation channel inoperable.	Verify associated *RPS* instrument channel in trip.
3.3.1.2	One required RPS automatic actuation division inoperable.	Verify required *RPS automatic actuation* division in trip.
3.3.1.4	One or more *NMS* functions with instrumentation channel(s) inoperable in one required division.	Verify associated *NMS* instrument channel in trip.
3.3.1.5	One or more *NMS automatic actuation* functions with one required division inoperable.	Verify required *NMS automatic actuation* division in trip.
3.3.6.1	One or more *MSIV instrumentation* functions with one required channel inoperable.	Verify associated *MSIV* instrument channel in trip.
3.3.6.2	One required MSIV actuation division inoperable.	Verify required MSIV actuation division in trip.

By STS convention, restoring the inoperable instrument channel or actuation division to operable status within the specified completion time is also understood as an optional specified required action.

For the condition of one inoperable required instrument channel for more than one function, once the channel for one of the functions has been restored to operable status, the completion time is not reset, but continues from the time the channel for the first function was declared inoperable (from the time the condition was initially entered). The completion time may be extended if the function of the channel restored to operable status was the first function with the inoperable channel. The completion time may be extended for up to 12 hours provided this does not result in the same channel for any subsequent function being inoperable or not in trip for more than 12 hours. This extension is consistent with GTS Example 1.3-4 and is therefore, acceptable.

For the condition of one inoperable required actuation division for more than one actuation function, once the actuation division for one of the actuation functions has been restored to operable status, the completion time is not reset, but continues from the time the actuation division for the first actuation function was declared inoperable (from the time the condition was initially entered). The completion time may be extended if the actuation function of the actuation division that was restored to operable status was the first actuation function with the inoperable actuation division. The completion time may be extended for up to 12 hours provided this does not result in the same actuation division for any subsequent actuation function being inoperable or not in trip for more than 12 hours. This extension is consistent with GTS Example 1.3-4 and is therefore acceptable.

With one instrument channel or actuation division in trip, just one of the two remaining instrument channels or actuation divisions is needed to initiate an automatic safety actuation, such as reactor trip or main steam line isolation (MSLI). Also, an additional single failure affecting one of the two remaining instrument channels or actuation divisions would not defeat the automatic safety actuation. Therefore, continued operation is permitted without a time limit in this condition. However, the chance of a spurious trip or actuation is increased.

16.2.6.3.2.1.2 ECCS, ICS, Isolation, and CRHAVS Functions for Required Instrumentation Channels and Actuation Divisions

The condition of one inoperable required instrument channel or actuation division for one or more functions corresponds to an inability to sustain an additional failure in either of the remaining two required instrument channels or actuation divisions. The following table lists the GTS Revision 6 action requirements for this condition for the ECCS, ICS, isolation, and CRHAVS functions; the staff added the italicized words to clarify the context of each condition and action. In the following actions conditions, for the condition of one or more functions with one of the three required instrumentation channels or actuation divisions inoperable, the actions require that, within 12 hours, all inoperable functions in that channel or division be restored to operable status, with two exceptions. For the condition of one inoperable required isolation actuation division for one or more functions, the GTS 3.3.6.4 actions require restoring the required isolation actuation division (for all functions) to operable status within 4 hours. The 4-hour completion time is consistent with the action requirements of GTS 3.6.1.3, “Containment Isolation Valves.” The second exception stems from the allowance for separate condition entry for each ECCS actuation function in GTS 3.3.5.2.

Table 16-3
Summary of Actions for Loss of Capability to Withstand a Single Failure for ECCS, ICS, Isolation, and CRHAVS Instrumentation and Actuation Functions

LCO	Condition A	Required Action A.1
3.3.5.1	One or more *ECCS* functions with one required *ECCS* instrumentation channel inoperable.	Restore required *ECCS instrument* channel to

LCO	Condition A	Required Action A.1
		OPERABLE status.
3.3.5.2	One or more *ECCS actuation* functions with one required *ECCS* actuation division inoperable.	Restore required *ECCS actuation* division to OPERABLE status.
3.3.5.3	One or more *ICS* functions with one required *ICS* instrumentation channel inoperable.	Restore required *ICS instrument* channel to OPERABLE status.
3.3.5.4	One required *ICS actuation logic* division inoperable.	Restore required *ICS actuation logic* division to OPERABLE status.
3.3.6.3	One or more *isolation* functions with one required *isolation* instrumentation channel inoperable.	Restore required *isolation instrument* channel to OPERABLE status.
3.3.6.4	One or more *isolation actuation* functions with one or more required isolation actuation divisions inoperable.	Restore required *isolation actuation* division(s) to OPERABLE status.
3.3.7.1	One or more *CRHAVS* functions with one required instrumentation channel inoperable.	Restore required *CRHAVS instrument* channel to OPERABLE status.
3.3.7.2	One required *CRHAVS* actuation division inoperable.	Restore required *CRHAVS actuation* division to OPERABLE status.

For the condition of one inoperable required instrument channel for more than one function, once the channel for one of the functions has been restored to operable status, the completion time is not reset, but continues from the time the channel for the first function was declared inoperable (from the time the condition was initially entered for that channel). The completion time may be extended if the function of the channel that was restored to operable status was the first function with the inoperable channel. The completion time may be extended for up to 12 hours provided this does not result in the same channel for any subsequent function being inoperable for more than 12 hours. This extension is consistent with GTS Example 1.3-4 and is therefore acceptable.

For the condition of one inoperable required actuation division for more than one function (except for an inoperable ECCS actuation division), once the actuation division for one of the functions has been restored to operable status, the completion time is not reset, but continues from the time the actuation division for the first function was declared inoperable (from the time the condition was initially entered for that actuation division). The completion time may be extended if the function of the actuation division that was restored to operable status was the first function with the inoperable actuation division. The completion time may be extended for up to 12 hours (4 hours for isolation actuation division) provided that this does not result in the same actuation division for any subsequent function being inoperable for more than 12 hours (4 hours). This extension is consistent with GTS Example 1.3-4 and is therefore acceptable.

GTS 3.3.5.2, Condition A for one inoperable required ECCS actuation division for more than one ECCS actuation function is equivalent to the condition of one inoperable required ECCS actuation division, regardless of how many functions are affected. This is because separate condition entry is allowed for each ECCS actuation function. If a second actuation division for the same function is determined to be inoperable, Action B requires the affected ECCS components to immediately be declared inoperable, which would require a unit shutdown. However, if the first inoperable actuation division is subsequently restored to operable status, Action B is exited, and the completion time for Action A continues from the time the restored actuation division for the affected function was declared inoperable (i.e., from the time of initial entry into Condition A). The completion time may be extended if the actuation division that was restored to operable status was the first inoperable actuation division. The completion time may be extended for up to 12 hours provided that this does not result in any subsequent actuation division for that function being inoperable for more than 12 hours. This extension is consistent with GTS Example 1.3-4 and is therefore acceptable.

During the 12-hour or 4-hour completion time, the inoperable required instrumentation channel, actuation division, or isolation actuation division may be placed in bypass, provided that the non-required instrumentation channel, actuation division, or isolation actuation division is operable and not placed in bypass. Only one instrumentation channel or actuation division may be placed in bypass at a time. The bypass feature affects all instrument functions for a given channel or all actuation functions for a given actuation division. In addition, during the 12-hour or 4-hour completion time, the occurrence of a single failure could cause a complete loss of capability of the affected automatic safety function (loss of trip or actuation capability for that function).

Placing the inoperable instrumentation channel or actuation division in trip is not specified for the ECCS, ICS, Isolation, and CRHAVS functions in order to minimize the chance of a spurious actuation of the ECCS, ICS, Isolation System and CRHAVS.

The 12-hour and 4-hour completion times are based on engineering judgment, considering the low probability of an event requiring actuation of the function during this interval and the capability of the automatic functions in the remaining required instrument channels or actuation divisions to initiate all safety functions assumed in the accident analysis. Therefore, Required Action A.1 for each of the listed conditions is acceptable.

16.2.6.3.2.2 Functional Capability Not Maintained or Required Action and Associated Completion Time of Condition A Not Met—Action B

16.2.6.3.2.2.1 RPS, NMS, MSIV, Isolation, and CRHAVS Functions for Required Instrumentation Channels; and NMS and Isolation Actuation Functions for Required Actuation Divisions

In the following specified conditions (either “Required Action and Associated Completion Time of Condition A not met,” or “one or more functions with trip (or actuation, or isolation, or isolation actuation) capability not maintained”), Required Action B.1 requires immediately entering the

Condition as listed in the associated table for the RPS, NMS, MSIV, Isolation, and CRHAVS instrumentation functions, and also for the NMS and Isolation actuation functions. The staff added the italicized words to clarify the context of each condition and action.

Required Action B.1 of GTS 3.3.1.4 and GTS 3.3.1.5, as noted in Table 16-4, requires entering the Condition referenced in Tables 3.3.1.4-1 and 3.3.1.5-1, respectively. For NMS instrument Function 3, "Oscillation Power Range Monitor—Upscale," and NMS actuation Function 3, "Oscillation Power Range Monitors," Actions E and C, respectively, both require within 12 hours initiating an alternate method to detect and suppress thermal hydraulic instability oscillations and within 120 days restoring required channels to operable status. The bases for GTS 3.3.1.4 and GTS 3.3.1.5 state the following:

> The 120-day Completion Time is considered adequate based on engineering judgment considering that with operation minimized in regions where oscillations may occur and implementation of the alternate methods, the likelihood of an instability event that could not be adequately handled by the alternate methods during this 120-day period was negligibly small.

This is consistent with Required Action J.1 of GTS 3.3.1.1 for the advanced boiling water reactor (ABWR) certified design, which requires, for the condition of failure to restore inoperable OPRM channels to operable status within the specified completion time, immediately initiating action to place the reactor power/flow relationship outside of the region of applicability shown in Figure 3.3.1.1-1, "Oscillation Power Range Function Conditions of Operability." The ABWR GTS bases state that, "The potential for power oscillations in a BWR is restricted to operation conditions with low core flow and relatively high power."

Table 16-4
Summary of Actions for the Condition of
Required Action and Associated Completion Time of Condition A Not Met or
Functional Capability Not Maintained for
RPS, NMS, MSIV, Isolation, and CRHAVS Instrumentation Functions, and
NMS and Isolation Actuation Functions

LCO	Condition B - Required Action and associated Completion Time of Condition A not met. <u>OR</u>	Required Action B.1 - Immediately enter the Condition referenced in:
3.3.1.1	One or more *RPS instrumentation* Functions with RPS trip capability not maintained.	Table 3.3.1.1-1 for the associated Function.
3.3.1.4	One or more *NMS instrumentation* Functions with NMS trip capability not maintained.	Table 3.3.1.4-1 for the associated Function.
3.3.1.5	One or more *NMS actuation* Functions with NMS actuation capability not maintained.	Table 3.3.1.5-1 for the associated actuation Function.

LCO	Condition B - Required Action and associated Completion Time of Condition A not met. <u>OR</u>	Required Action B.1 - Immediately enter the Condition referenced in:
3.3.6.1	One or more *MSIV instrumentation* functions with MSIV isolation capability not maintained.	Table 3.3.6.1-1 for the associated Function.
3.3.6.3	One or more *isolation instrumentation* functions with isolation capability not maintained.	Table 3.3.6.3-1 for the associated Function.
3.3.6.4	Isolation actuation capability not maintained.	Table 3.3.6.4-1 for the associated *actuation* Function.
3.3.7.1	One or more *CRHAVS instrumentation* Functions with CRHAVS actuation capability not maintained.	Table 3.3.7.1-1 for the associated Function.

Ensuring core flow is greater than 60 percent or that power is less than 30 percent RTP precludes power oscillations. Outside these limits, the OPRM is not required to be operable; therefore, continued operation outside the applicable region may continue indefinitely. However, in the ESBWR, core flow is achieved by natural circulation and cannot be increased by use of pumps, such as those provided in the ABWR and BWR/6 designs. Therefore, operation may not continue indefinitely with an inoperable OPRM-Upscale instrumentation or actuation function, but is limited to 120 days, provided that alternate methods have been implemented for detecting and suppressing thermal hydraulic instability oscillations. In addition, the ESBWR accident analyses do not assume the OPRM-Upscale function, and the ESBWR is designed to preclude operation in the power-flow region in which power oscillations can occur. For these reasons, the staff finds the 120-day operational restriction acceptable.

Required Action B.1 of GTS 3.3.7.1 requires entering Action C for CRHAVS instrumentation Function 1, “Control Room Air Intake Radiation—High,” and Function 2, “Extended Loss of AC Power.” Action C requires immediately isolating the CRHA boundary and placing the operable CRHAVS train in isolation mode, which accomplishes the objectives of the two inoperable functions; Action C alternatively requires declaring both CRHAVS trains inoperable. This is appropriate; GTS 3.7.2, Action D, would apply in Modes 1, 2, 3, and 4, and would require placing the unit in Mode 3 in 12 hours and Mode 5 in 36 hours. During operations with a potential for draining the reactor vessel (OPDRVs), Action E would apply and would require immediately initiating action to suspend OPDRVs. These actions are acceptable because they place the unit outside the GTS Applicability of the CRHAVS and supporting instrumentation.

Required Action B.1 of GTS 3.3.7.1 requires entering Action D for CRHAVS Function 3, “EFU Discharge Flow—Low (primary train), and Function 4, “EFU Outlet Radiation—High-High (primary train).” Required Action D.1 requires immediately declaring the standby CRHAVS train inoperable, which is appropriate because loss of Function 3 or 4 degrades or removes the standby automatic actuation capability of the standby train upon failure of the primary train filters or fans. This is also appropriate because GTS 3.7.2 Action C would apply and would require restoring the inoperable train to operable status in 7 days, which is consistent with STS 3.7.3 and therefore acceptable.

The conditions referenced by Required Action B.1 for the other listed LCOs (3.3.1.1, 3.3.6.1, 3.3.6.2, and 3.3.6.3) specify actions that are appropriate for the condition of the instrumentation and result in the unit being placed in an operating mode or condition in which the affected functions are not required or the associated system or component being declared inoperable. The times to perform these actions are the standard completion times used throughout the GTS and are consistent with STS guidance. GTS shutdown actions allow for shutting down the plant in a controlled and orderly manner and within the capability of systems used for unit shutdown and cooldown. Declaring a supported component inoperable is acceptable because the associated GTS Actions specify appropriate limitations on unit operation. Therefore, these actions are acceptable.

16.2.6.3.2.2.2 ECCS and ICS Functions for Required Instrumentation Channels and ECCS, ICS, and MSIV Functions for Required Actuation Divisions

In the following specified conditions (either "Required Action and Associated Completion Time of Condition A not met," "one or more functions with actuation capability not maintained," or "one or more functions with two or more actuation divisions inoperable"), Required Action B.1 requires immediately declaring inoperable the affected components, actuation devices, or trains, as appropriate, for the ECCS and ICS instrumentation functions, and for the ECCS, ICS, and MSIV actuation functions. The staff added the italicized words to clarify the context of each condition and action.

Table 16-5
Summary of Actions for the Condition of
Required Action and Associated Completion Time of Condition A Not Met,
Functional Capability Not Maintained, or Two or More Actuation Divisions Inoperable, for
ECCS and ICS Instrumentation Functions, and
ECCS, ICS, and MSIV Actuation Functions

LCO	Condition B—Required Action and associated Completion Time of Condition A not met. <u>OR</u>	Required Action B.1 and associated Completion Time
3.3.5.1	One or more *ECCS instrumentation* Functions with ECCS actuation capability not maintained.	Immediately declare affected ECCS components inoperable.
3.3.5.2	One or more ECCS *actuation* Functions with two or more required *ECCS* actuation divisions inoperable.	Immediately declare affected *ECCS* actuation device(s) inoperable.
3.3.5.3	One or more *ICS instrumentation* Functions with ICS actuation capability not maintained.	Immediately declare ICS trains inoperable.
3.3.5.4	ICS actuation capability not maintained.	Immediately declare affected *ICS* actuation device(s) inoperable.

LCO	Condition B—Required Action and associated Completion Time of Condition A not met. <u>OR</u>	Required Action B.1 and associated Completion Time
3.3.6.2	MSIV actuation capability not maintained.	Immediately declare affected *MSIV* actuation device(s) inoperable.

The actions for loss of ECCS, ICS, and MSIV actuation capability, and the action for an ECCS actuation function that has two or more required *ECCS* actuation divisions inoperable, are appropriate because declaring a supported component inoperable requires entering the associated GTS actions. These actions, which are specified by GTS 3.5.1, 3.5.2, 3.5.3, 3.5.4, and 3.6.1.3, provide appropriate limitations on unit operation. Therefore, Required Action B.1 for each of the listed conditions is acceptable.

16.2.6.3.2.2.3 RPS Functions for Required Actuation Divisions

GTS 3.3.1.2, "RPS Actuation," specifies an Action B with the unit in Mode 1 or 2 and an Action C with the unit in Mode 6, as follows:

Table 16-6
Summary of Actions for the Condition of
Required Action and Associated Completion Time of Condition A Not Met, or
Automatic Actuation Capability Not Maintained for
RPS Actuation Function

LCO	Condition	Required Action	Completion Time
3.3.1.2	B. Required Action and associated Completion Time of Condition A not met in Mode 1 or 2. <u>OR</u> RPS automatic actuation capability not maintained in Mode 1 or 2.	B.1 Be in Mode 3.	12 hours
3.3.1.2	C. Required Action and associated Completion Time of Condition A not met in Mode 6. <u>OR</u> RPS automatic actuation capability not maintained in Mode 6.	C.1 Initiate action to fully insert all insertable control rods in core cells containing one or more fuel assemblies.	Immediately

These actions for loss of RPS actuation capability are appropriate for the condition of the instrumentation and result in the unit being placed in an operating mode or condition in which the affected actuation function is not required. The times to perform these actions are the standard completion times used throughout the GTS and are consistent with STS guidance. GTS shutdown actions allow for shutting down the plant in a controlled and orderly manner within the capability of systems used for unit shutdown and cooldown. Therefore, Required Actions B.1 and C.1 for GTS 3.3.1.2 are acceptable.

16.2.6.3.2.2.4 CRHAVS Actuation Function for Required Actuation Divisions

GTS 3.3.7.2, "CRHAVS Actuation," specifies Action B for the condition of "Required Action and Associated Completion Time of Condition A not met" or "CRHAVS actuation capability not maintained." The associated required actions specify that either of the following actions should be taken immediately: (1) isolating the CRHA boundary (B.1.1), placing (running) the operable (standby) CRHAVS train in isolation mode (B.1.2), and declaring the remaining (primary) CRHAVS train inoperable (B.1.3) or (2) declaring affected actuation devices inoperable (B.2). These required actions are acceptable because they accomplish the required CRHAVS actuation and CRHA isolation and impose a 7-day limit on unit operation (GTS 3.7.2, Action C), or they result in the unit being placed in a condition in which GTS 3.3.7.2 does not apply, in accordance with GTS 3.7.2, Actions E or F. (See previous discussion of GTS 3.3.7.1, Action B).

16.2.6.3.3 Actions for Functions with Two Instrumentation Channels

The following five LCOs require just two instrumentation channels for each required function:

- 3.3.1.3, "RPS Manual Actuation"
- 3.3.1.6, "SRNM Instrumentation"
- 3.3.2.1, "Control Rod Block (CRB) Instrumentation"
- 3.3.3.1, "Remote Shutdown System (RSS)"
- 3.3.3.2, "Post-Accident Monitoring (PAM) Instrumentation"

<u>RAI 16.2-190</u>. The staff asked the applicant to revise the treatment of GTS 3.3.3.2 for PAM functions, so that GTS 3.3.3.2 is a required part of the GTS and not a COL action item, as described in Section 16.2.6.1 of this report. The staff also requested that the applicant revise the actions of GTS 3.3.3.2 to be consistent with the BWR/6 STS 3.3.3.1 actions, which require placing the unit in Mode 3 within 12 hours if two required channels of certain PAM functions are inoperable for more than 7 days. In its response dated October 27, 2009, GEH stated it will revise the actions of GTS 3.3.3.2 and associated bases to be consistent with the STS. The staff reviewed the markup of the affected pages in the GTS and bases and found them to be acceptable. Therefore, RAI 16.2-190 is resolved. Section 16.2.6.1 of this report describes the resolution of the balance of the issues in this RAI.

The specified actions for the listed LCOs are appropriate to the design of each function's instrumentation channels and are consistent with the STS actions for equivalent instrumentation systems. Therefore, the action requirements for functions with two channels are acceptable.

16.2.6.3.4 Actions for GTS 3.3.4.1, "Reactor Coolant System (RCS) Leakage Detection Instrumentation"

LCO 3.3.4.1 requires the following RCS leakage detection instrumentation to be operable in Modes 1, 2, 3, and 4:

- drywell floor drain high-conductivity waste (HCW) sump monitoring system
- particulate channel of the drywell fission product monitoring system
- drywell air coolers condensate flow monitoring system

This LCO is consistent with the corresponding STS LCO 3.4.7, "RCS Leakage Detection Instrumentation," except for the following differences:

- The STS specify a drywell floor drain sump monitoring system, not an "HCW" drywell floor drain sump monitoring system.
- The STS specify either a particulate channel or a gaseous channel of the drywell atmospheric monitoring system.
- The STS specify a drywell air cooler condensate flow rate monitoring system as optional.

The following addresses these differences and the associated LCO actions for RCSLD. GTS 3.3.4.1, "RCS Leakage Detection Instrumentation," and GTS 3.4.2, "RCS Operational Leakage," address Position C.9 of RG 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," issued May 1973. By letter dated August 3, 2006, the staff sent the applicant RAIs 16.2-1 and 16.2-4. In a letter dated August 21, 2006, the applicant responded to these RAIs.

RAI 16.2-1. In RAI 16.2-1, the staff stated that NRC Information Notice 2005-24, "Nonconservatism in Leakage Detection Sensitivity," dated August 3, 2005, indicated that the containment radiation gaseous monitors might not be able to detect RCS leakage of 1 gallon per minute (gpm) within 1 hour. This finding was based on the experiences of operating reactors using fuel with improved integrity. DCD Section 11.5.3.2.12 indicates that the gaseous radiation monitor, which is used as one of the two monitors for the drywell fission product monitoring system in LCO 3.3.4.1(b), is able to detect 1 gpm within 1 hour. In its response dated August 21, 2006, the applicant proposed to delete the gaseous radiation monitor from GTS 3.3.4.1. The airborne particulate radiation monitor remains as the drywell fission product monitoring system. Even without the gaseous radiation monitor, the ESBWR design satisfies RG 1.45, Regulatory Position C.3, by providing three RCS leakage detection methods—the drywell floor drain HCW sump monitoring system, the drywell fission product (particulate) monitoring system, and the drywell air coolers condensate flow monitoring system. The staff finds the applicant's response acceptable and confirmed that Revision 3 of GTS 3.3.4.1 included the changes.

In RAI 16.2-1, the staff also asked the applicant to address the procedures to convert the monitored parameters into a common leakage rate equivalent. RAI 5.2-4 also included this request. RAIs 16.2-1 and 5.2-4 were tracked as open items in the SER with Open Items. Revision 6 of DCD, Tier 2, Section 5.2.5.9, includes COL Information Item 5.2-2-A that states the following:

> The COL Applicant is responsible for the development of a procedure to convert

> different parameter indications for identified and unidentified leakage common leak rate equivalents (volumetric or mass flow) and leak rate rate-of-change values.

Based on this COL information item, this issue of RAI 16.2-1 is resolved. Therefore, based on resolution of RAIs 5.2-4 and 16.2-4, as well as the applicant's response to RAI 16.2-1, and the above statement in the DCD, RAI 16.2-1 is resolved.

<u>RAI 16.2-4</u>. The staff found that GTS LCO 3.4.2, "RCS Operational Leakage," did not specify a limit on the increase in unidentified leakage over a set time period. This is not consistent with STS LCO 3.4.5.d, which states that the increase in unidentified leakage within the previous 4-hour period in Mode 1 shall be less than or equal to 2 gpm.

Omitting this limit on the gpm increase per hour may not satisfy 10 CFR 50.36, which requires an LCO for installed instrumentation that is used to detect, and indicate in the CR, a significant abnormal degradation of the RCPB. The staff asked the applicant to justify omission of an LCO for an unidentified leakage rate-of-change from ESBWR GTS 3.4.2. RAI 16.2-4 was being tracked as an open item in the SER with open items. In its response dated August 21, 2006, the applicant provided the following justification:

> The STS LCO 3.4.5.d specifies a limit for an increase in unidentified leakage over a set time period; however, the printed statement of this requirement is bracketed in its entirety. The brackets indicate that incorporation of this LCO requirement is a plant-specific issue.
>
> This LCO requirement was prompted by Generic Letter (GL) 88-01, "NRC Position on Intergranular Stress Corrosion Cracking (IGSCC) in BWR Austenitic Stainless Steel Piping." GL 88-01 applies to all BWR piping made of austenitic stainless steel that is susceptible to intergranular stress corrosion cracking (IGSCC). According to DCD Section 5.2.3.4.1, the RCS piping is designed to avoid sensitization and susceptibility to IGSCC through the use of reduced carbon content material and process controls. During fabrication, solution heat treatment is used. During welding, heat input is controlled. Austenitic stainless steel is not used in the ESBWR design. Historically, good operator practice plays a role in the event of an anomaly in unidentified leakage. The operators regularly observe and record data, monitor trends in plant parameters and detect abnormal conditions during their shift. This provides a means to alert the plant staff to a condition that warrants further scrutiny and assessment. For example, if unidentified leakage is observed to be more than the normal expected leakage, yet less than the 5 gpm TS limit, the plant operators typically will be alerted to investigate, record, and track pertinent data, evaluate trends in the data and make an assessment of the cause for any change that could ultimately lead to a reactor shutdown to make a drywell entry to take further action to locate, assess and potentially repair the source of leakage.

Based on the applicant's justification that the ESBWR RCS piping is designed to avoid sensitization and susceptibility to IGSCC through the use of reduced carbon content material and process controls, the staff concludes that the requirement (from GL 88-01 relating to

IGSCC) for an unidentified leakage rate-of-change limit may no longer be needed as an LCO in the GTS for ESBWR. However, as a compensatory measure, the staff has determined that operating procedures for monitoring, recording, and trending of unidentified leakage and for responding to unidentified leakage rate-of-change alarms are needed to manage low-level RCS leakage. Therefore, to ensure implementation of such compensatory measures, the staff concluded that the ESBWR DCD needed a COL information item asking the COL applicant to develop unidentified leakage operating procedures. In response to this issue, the applicant established COL Item 5.2-2-A in DCD, Tier 2, Section 5.2.5.9 and Section 5.2.6 as the following:

> The COL Applicant is responsible for the development of procedures for monitoring, recording, trending, determining the source(s) of leakage, and evaluating potential corrective action plans. An unidentified leakage rate-of-change alarm provides operators an early alert to initiate response actions prior to reaching the Technical Specifications limit.

Based on the establishment of this COL item, the staff concludes that unidentified leakage will be adequately addressed through appropriate operating procedures. For this reason, and because ESBWR RCS piping is designed to avoid sensitization and susceptibility to IGSCC, omitting an LCO on unidentified leakage rate-of-change from GTS 3.3.4.1 is acceptable. Therefore, RAI 16.2-4 is resolved. The staff requested additional information regarding RCSLD as discussed below.

RAI 16.2-3. In RAI 16.2-3, the staff asked the applicant to state the instrumentation to be used to determine total RCS operational leakage and explain why GTS 3.3.4.1 did not include this instrumentation, as required by 10 CFR 50.36. In its response dated August 21, 2006, the applicant stated that RG 1.45, Regulatory Position 1, in part, requires that the source of leakage be identifiable to the extent practical. RCPB leak detection and collection systems should be selected and designed such that leakage from identified sources is collected or otherwise isolated so that the flow rates are monitored separately from unidentified leakage and the total flow rate can be established and monitored. DCD, Tier 2, Section 5.2.5, describes the systems for detecting both identified and unidentified RCS leakage. The total reactor coolant leakage rate consists of all identified and unidentified leakages that flow to the lower drywell floor drain and equipment drain sumps. The reactor coolant leakage rate limits for alarm annunciation are established at less than or equal to 95 liters per minute (L/m) (25 gpm) from identified sources and 19 L/m (5 gpm) from unidentified sources. The instrumentation is designed to measure leakage rates from unidentified sources of 3.8 L/m (1 gpm) in 1 hour. There is no specific instrument for determining total leakage, and the operator has procedures for converting the monitored parameters into a common leakage rate equivalent to assist in determining that the leakage rate is within specified limits. Based on these conditions, the staff finds that the applicant's method for monitoring RCS operational leakage is acceptable because it meets the requirements of 10 CFR 50.36. Therefore, on the basis of this information, RAI 16.2-3 is resolved.

RAI 16.2-5. Proposed GTS 3.3.4.1, Required Action A.1, requires restoring an inoperable drywell floor drain HCW sump monitoring system to operable status within 30 days. In RAI 16.2-5, the staff requested that the applicant explain how GTS SR 3.4.2.1, "Verify RCS unidentified and total LEAKAGE are within limits," can be performed when the drywell floor drain HCW sump monitoring system is inoperable. In its response dated August 21, 2006,, the applicant stated that alternative leak rate monitoring methods, such as manually pumping the drywell floor drain HCW sump or directly measuring the change in drywell floor drain HCW sump level, are available to quantitatively determine RCS unidentified leakage. The applicant considered manual leak rate measurements to be acceptable alternatives while the drain sump monitoring system is inoperable, provided that the alternative leak rate methodology is implemented using controlled procedures, has been demonstrated to be accurate, and can be inspected. Based on these conditions, the staff finds the applicant's alternative method to determine RCS leakage acceptable. Therefore, on the basis of this information, RAI 16.2-5 is resolved.

RAI 16.2-6. Proposed GTS 3.3.4.1, Required Action B.1, calls for the analysis of drywell atmosphere once every 12 hours when the drywell fission product monitoring system particulate channel is inoperable. Corresponding STS 3.4.7, Required Action B.1, also calls for analysis of grab samples of the drywell atmosphere every 12 hours, but Required Action B.2 requires restoration of the drywell atmospheric monitoring system to operable status within 30 days. In RAI 16.2-6, the staff requested that the applicant explain the omission of this required action to restore operability. In its response dated August 21, 2006, the applicant stated that the STS 30-day restoration time is a bracketed option based on having just one remaining automatic leak detection instrument operable (i.e., the analysis of grab samples of the drywell atmosphere is one of two remaining methods of leak detection; only the other method is automatic). The ESBWR design provides a third RCS leak detection instrument, the drywell air coolers condensate flow monitoring system. If both the drywell fission product monitoring system particulate channel and the drywell air coolers condensate flow monitoring system become inoperable, then Action D requires that one of these monitoring systems be restored to operable status within 30 days, provided that drywell atmosphere sampling continues every 12 hours and the drywell floor drain HCW sump monitoring system is operable. If the only method available is analysis of grab samples, Required Action E.1 mandates the placement of the plant in hot shutdown within 12 hours. Thus, the action requirements of GTS 3.3.4.1, including the 30-day completion time to restore the particulate channel and the allowance to continue plant operation indefinitely, while taking grab samples as long as the other two automatic detection methods are operable, are consistent with the STS and therefore acceptable. In summary, the staff concludes that the response to RAI 16.2-6 is acceptable. Therefore, RAI 16.2-6 is resolved.

RAI 16.2-7. The staff requested that the applicant provide technical justification for not entering Mode 5 when in GTS 3.3.4.1, Condition E, which states that the required action and associated completion time of Condition A, B, C, or D are not met. Proposed Action E requires placing the unit in Mode 3 within 12 hours. Equivalent STS LCO 3.4.7, Action E, specifies that the unit be in Mode 3 within 12 hours and Mode 5 within 36 hours. The staff also asked the applicant to justify why it omitted entering LCO 3.0.3, which would require being in Mode 5 within 37 hours when all the required leakage detection systems are inoperable. The applicant proposed a required action to be in Mode 3 within 12 hours; however, equivalent STS LCO 3.4.7, Action F, specifies entering LCO 3.0.3 when all required leakage detection systems are inoperable.

In its response dated August 21, 2006, the applicant referenced public meetings that discussed end-state relaxation of specific TS. The applicant's response to RAI 16.0-7 was to include the basis for the RCS leakage detection instrumentation required actions. In that letter, the applicant stated that GTS 3.3.4.1 presents an end-state relaxation (i.e., to Mode 3) that TSTF-423-A does not address. However, given that RCS leakage continues to be monitored to ensure that it is within limits, in accordance with LCO 3.4.2, “RCS Operational Leakage,” the risk of operation in Mode 3, in lieu of proceeding to Mode 5 (cold shutdown), is bounded by evaluations made with other risk-significant systems inoperable. As discussed in Section 16.2.0 of this report, under RAI 16.0-7, the applicant withdrew its proposal to adapt TSTF-423-A to the GTS and adopt modified end states, for which the staff had requested additional ESBWR-specific justification and implementation guidance. The applicant revised GTS 3.3.4.1, Action E, to require the unit to be placed in Mode 5 within 36 hours when either the required action and associated completion time of Condition A, B, C, or D are not met or all of the required leakage detection systems are inoperable. These changes are consistent with the STS. Therefore, RAI 16.2-7 is resolved.

Based on the above evaluation of responses to the staff’s RAIs, the actions for GTS 3.3.4.1 are acceptable.

16.2.6.3.5 Actions for GTS 3.3.8.1, “Diverse Protection System”

The ESBWR design includes a DPS to address concerns regarding common-cause failure of microprocessor- or digital-based instrumentation systems. The following discusses DPS functions and design, and the DPS LCO action requirements.

<u>DPS Functions</u>

The “Background” section of the bases for GTS 3.3.8.1 states, “DPS provides a set of initiation logics that provide a diverse means to initiate certain engineered safety feature (ESF) functions using sensors, hardware and software that are separate from, and independent of, the primary ESF systems.” The ESF functions include core cooling provided by the GDCS using injection valves and the ADS using safety/relief valves (SRVs) and depressurization valves (DPVs). The initiating logic is based on a signal of reactor pressure vessel level—low, Level 1, using two-out-of-four sensor logic and two-out-of-three processing logic. If the DPS ECCS initiation signal persists for 10 seconds, the logic seals in and a DPS ECCS start signal is initiated.

Manual initiation of ADS and GDCS requires operation of two switches, with each switch requiring two distinct operator actions. The manual initiation signal is based on two-out-of-two coincident logic processed by triply redundant processors.

The DPS also performs selected containment isolation functions as part of the diverse engineered safety feature (ESF) function using two-out-of-four sensor logic and two-out-of-three processing logic. The containment isolation functions performed by DPS include closure of the RWCU/SDC isolation valves on a signal of reactor water cleanup/shutdown cooling system differential mass flow—high.

The DPS also opens cross-connect valves between the equipment storage pool and the isolation condenser/passive containment cooling system (IC/PCCS) inner expansion pools when a low-level condition is detected in either of the IC/PCCS inner expansion pools.

<u>DPS Design</u>

The DPS is triply redundant and is powered by three non-safety-related 120–V ac uninterruptable power supply (UPS) load groups. Each DPS cabinet and the four DPS RMUs can perform their intended functions with power from just two of the three UPS load groups. The UPS are battery backed and have sufficient capacity to support the specified DPS functions. The DPS functions are based on four DPS sensors. For example, Functions 1.a and 2.a are based on four reactor vessel-level sensors. The analog signal from each sensor is measured independently by three separate analog-to-digital converters in a DPS RMU, which send three digital output signals to the triply redundant processors in the DPS cabinet. Each DPS processor takes the three digital signals associated with each sensor and produces a signal for comparison with the setpoint (in this case, reactor vessel level—low, Level 1). Each DPS processor performs a voting logic function. If at least two out of four signals satisfy the setpoint, the DPS processor outputs a trip signal to either two (for solenoid initiators) or three (for squib initiators) output logic devices (OLDs) in the RMUs. If the OLD receives at least two trip signals from the three DPS processors, it will actuate its associated load driver (discrete output switch), which is in a series actuation circuit, to power the end device initiator. All OLDs must actuate their associated discrete output switches to complete the circuit to power the end device initiator. The LCOs for the end devices address the operability, action, and SRs for the end device initiators (either a solenoid or a squib).

DPS Actions

GTS 3.3.8.1, Action A, allows 30 days to restore an inoperable required DPS function to operable status. A DPS function is inoperable if a sensor, any component in the RMU or DPS cabinet, or any discrete output switch is inoperable. Since it is possible for the instrumentation that implements a required DPS function to withstand some component failures without losing functional capability, Action A is conservative. In Condition A, design features intended to mitigate digital protection system common-mode failures may not be available. The 30-day completion time is acceptable because the required safety-related actuator initiators will actuate the minimum number of components required to respond to the design-basis LOCA concurrent with any additional single failure. If the inoperable DPS function is not restored to operable status within 30 days, Action B requires placing the unit outside the applicability of the LCO within standard completion times, consistent with the STS. Therefore, the actions for GTS 3.3.8.1 are acceptable.

16.2.6.3.6 Other Requests for Additional Information Regarding Actions

RAI 16.2-134. The reduced safety system capability described by the condition “capability not maintained” describes multiple SSC failures, representing a loss of two or three required channels or divisions of instrumentation out of four installed channels or divisions. This condition would permit the plant to operate for up to 1 hour with one or more accident prevention or mitigation functions of safety-related SSCs not operable. This is not an acceptable remedial action allowance because a loss-of-function condition should require immediate action to initiate a unit shutdown, consistent with the STS for similar instrumentation functions. For this specified plant condition, therefore, the staff will only accept a required action to immediately exit the GTS Applicability or immediately enter GTS LCO 3.0.3. The staff asked the applicant to revise the required action and completion time accordingly. The staff clarified this RAI in an e-mail dated June 26, 2007. RAI 16.2-134 was being tracked as an open item in the SER with open items.

In its responses dated October 15, 2007, and February 15, 2008, the applicant proposed to revise the GTS Section 3.3 required actions and completion times for conditions describing the "capability not maintained" condition by removing the 1-hour restoration time before requiring a unit shutdown. As previously noted, the staff considers that a unit shutdown is the appropriate action upon discovery of a loss-of-function condition. Therefore, RAI 16.2-134 is resolved.

RAI 16.2-138. In ESBWR GTS Section 3.3.1.3, "Reactor Protection System Manual Actuation," for the actions condition of "one or more channels inoperable," the reduced functional capability of the degraded condition described represents a loss of one or both required channels of instrumentation for one or both manual actuation items. This condition would permit the unit to operate for up to 12 hours with a loss of all required safety system RPS manual actuation instrumentation. Additional information is needed to justify that the loss of function condition is a credible condition for which a temporary relaxation of the required design basis should be approved. The staff asked the applicant to justify its decision to allow operation with more than one inoperable channel in either or both manual actuation functions. RAI 16.2-138 was being tracked as an open item in the SER with open items.

In its responses dated October 10, 2007 and February 26, 2008, the applicant revised the GTS 3.3.1.3 action requirements to allow separate condition entry for each manual actuation scram function, instead of for each channel. (Note: There are two channels for each of the two manual actuation scram functions; the two functions are "manual scram," which uses two scram push buttons, and the "reactor mode switch—shutdown position," which initiates a full scram when the reactor mode switch is placed in the shutdown position. Both channels in a function must be manually actuated for that function to initiate a scram.) This change enabled clarifications to the GTS 3.3.1.3 action requirements so that, in the event both functions are inoperable with one or more channels disabled, the operator must place the inoperable channels in trip immediately, which may cause a reactor scram. To avoid a reactor scram transient, if the unit is in Mode 1 or 2, the actions require the operator to shut down the unit to Mode 3 within 12 hours. If the unit is in Mode 6, the actions require the operator to immediately initiate action to fully insert all insertable control rods in core cells containing one or more fuel assemblies. The staff finds that these revised action requirements upon loss of manual scram capability are acceptable because they require placing the unit outside the applicability of the LCO in a timely manner, consistent with the STS. Therefore, RAI 16.2-138 is resolved.

RAI 16.2-142. The proposed end state for RCS leakage detection instrumentation LCO 3.3.4.1; LCO 3.3.6.3, Table 3.3.6.3-1, Function 13 (feedwater isolation instrumentation); and LCO 3.3.6.4, Table 3.3.6.4-1, Functions 14 (feedwater isolation valves) and 15 (feedwater pump breakers) is Mode 3; whereas, these functions are applicable in Modes 1, 2, 3, and 4. The staff requested that the applicant add required actions to place the plant in Mode 5 as the GTS required end state. RAI 16.2-142 was being tracked as an open item in the SER with open items. Revision 5 of DCD Chapters 16 and 16B included the requested changes. Therefore, RAI 16.2-142 is resolved.

RAI 16.2-143. The staff questioned the need for the actions table Note 1 in GTS 3.3.6.1 and 3.3.6.2 for the MSLI instrumentation channels and actuation divisions. This note states that "penetration flow paths may be unisolated intermittently under administrative controls." In its response dated July 23, 2007, the applicant proposed to remove the note and associated bases from GTS 3.3.6.1 and 3.3.6.2 because the actions of these specifications do not require isolating any penetration flow paths. This note is appropriate for GTS 3.6.1.3 because the actions specify isolating penetration flow paths, including MSL and main steam drain line containment penetrations. DCD Revision 4 incorporated these changes. Therefore, RAI 16.2-143 is resolved.

RAI 16.2-162. The staff requested that the applicant clarify the action requirements of DCD Revision 4, GTS 3.3.5.3, "Isolation Condenser System (ICS) Instrumentation," and 3.3.7.1, "CRHAVS Instrumentation." In its response dated March 3, 2008, GEH stated that it was changing Required Action A.1 for the condition of "one or more functions with one required instrumentation channel inoperable," from "verify instrumentation division in trip" to "restore required channel to operable status." The applicant stated the following:

> This change more accurately reflects the design function for SSLC/ESF instrument channels to fail "as-is" (i.e., not to the tripped state) and the SSLC/ESF design which does not provide a means to manually place an instrument division in trip [that is, a division of instrument channels in trip]. This will also provide consistency in use of "channel" in both the Condition and the associated Required Action.

GEH also stated that it was combining Condition B, "required action and associated completion time of Condition A not met," and Condition C, "one or more functions with ICS actuation capability not maintained," since they specify the same required action. The applicant revised Required Action B.1, which has a completion time of "immediately," from "declare associated ICS trains inoperable" to "declare ICS trains inoperable." GEH stated, "This change reflects the SSLC/ESF design where each divisional instrument channel supports the actuation logic in all divisionally actuated devices equally." The applicant revised the bases to make clear that all four required ICS trains are to be declared inoperable. This requires entering GTS 3.5.4, "ICS—Operating," Action B, which requires the unit to be placed in Mode 3 in 12 hours. GEH made similar changes to the action requirements of GTS 3.3.7.1, but superseded these changes in DCD Revision 6. Sections 16.2.6.3.2.1.2, 16.2.6.3.2.2.1, and 16.2.6.3.2.2.4 of this SER discuss the staff evaluation of the action requirements for CRHAVS instrumentation and actuation logic functions.

The applicant also changed the action requirements of GTS 3.3.5.4, "ICS Actuation," to state the following:

- Action A, for the condition of one required division inoperable, "restore required division to operable status."
- Action B, for the condition of ICS actuation capability not maintained, "declare affected actuation device(s) inoperable."

The applicant explained the proposed wording in Action B, as follows:

> Required Action B.1 requires the "affected actuation device(s)" rather than "associated ICS train" to be declared inoperable. The SSLC/ESF design does not initiate an ICS train with an associated actuation logic division. Rather, any two actuation divisions can actuate all ICS trains. Since actuation division load drivers (i.e., the individual mechanical component actuation "signals") are within the actuation logic, it is possible for their inoperability to be appropriately addressed by declaring only the associated actuated device inoperable. This change provides assurance that the affected actuated components in any train are declared inoperable, requiring entry into the appropriate mechanical system specification (GTS 3.5.4).

For the reasons stated, the staff finds these changes to GTS 3.3.5.4 acceptable. GEH proposed similar changes to GTS 3.3.7.2, "CRHAVS Actuation," but superseded these changes in DCD Revision 6 with the addition of two actuation functions for the standby CRHAVS train. Sections 16.2.6.3.2.1.2, 16.2.6.3.2.2.1, and 16.2.6.3.2.2.4 of this report discuss the staff evaluation of the action requirements for CRHAVS instrumentation and actuation logic functions. Based on the actions for these specifications as presented in DCD, Revision 6, RAI 16.2-162 is resolved.

16.2.6.3.7 Summary Conclusion Regarding Instrumentation Actions

The specified actions are appropriate to the design of each instrumentation function and are consistent with the STS actions for equivalent instrumentation systems. Therefore, they are acceptable.

16.2.6.4 *Instrumentation Surveillance Requirements*

According to 10 CFR 50.36(d)(3), the SRs are "requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met." For each instrumentation specification, and for each associated instrumentation function, appropriate SRs are to be performed within the specified frequency (test interval) and in accordance with SRs 3.0.1, 3.0.2, 3.0.3, and 3.0.4.

The following describes the five main types of SRs specified for instrumentation functions. Each type has an associated defined term, presented in all upper case letters in the GTS and bases.

16.2.6.4.1 Evaluation of Channel Check Surveillance Requirements

GTS Section 1.1 defines a channel check (Ch Chk) as follows:

> A CHANNEL CHECK shall be the qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and status to other indications or

status derived from independent instrument channels measuring the same parameter.

The following GTS SRs specify the channel check for the listed category of instrumentation functions:

- SR 3.3.1.1.1 RPS Instrumentation
- SR 3.3.1.4.1 NMS Instrumentation
- SR 3.3.1.6.1 SRNM Instrumentation
- SR 3.3.1.6.3 SRNM Instrumentation
- SR 3.3.3.2.1 PAM Instrumentation
- SR 3.3.4.1.1 RCSLD Instrumentation
- SR 3.3.5.1.1 ECCS Instrumentation
- SR 3.3.5.3.1 ICS Instrumentation
- SR 3.3.6.1.1 MSIV Instrumentation
- SR 3.3.6.3.1 Isolation Instrumentation
- SR 3.3.7.1.1 CRHAVS Instrumentation
- SR 3.3.8.1.1 Diverse Protection System (DPS)

The GTS specify a channel check only for suitable instrumentation functions. This is consistent with the STS and is acceptable. No channel check is specified for RSS instrumentation functions because the only RSS function required by LCO 3.3.3.1 is RPS manual trip, which is the only RSS function required for safe shutdown.

RAI 16.2-147. The staff requested that the applicant provide data to show that the self-test report meets the requirements of a channel check without performing the required comparison of the parameter. RAI 16.2-147 was being tracked as an open item in the SER with open items. In its response dated August 30, 2007, the applicant noted that the STS bases usually do not include details of methods for performing surveillances and proposed to remove from GTS bases all discussions of the online self-diagnostic design feature as a means of accomplishing a channel check. Removing these discussions removes this inconsistency with the STS; therefore, RAI 16.2-147 is resolved. However, removing from the GTS bases all discussions of the online self-diagnostic design feature as a means of accomplishing a channel check does not enable the NRC staff to complete its review of this feature within the scope of the ESBWR design certification.

In Revision 5 of the DCD (issued May 2008), the applicant proposed a 24-hour frequency for a channel check in place of the typical 12-hour frequency specified in the STS. The GTS bases appear to justify this relaxation by crediting the capabilities of the online self-diagnostic design feature to automatically detect instrumentation failures and presumably initiate alarms to alert the CR staff.

However, as noted in Section 16.2.6.5 of this report in the discussion of the GEH response to RAI 16.2-145, Supplement 1, GEH revised the channel check SR frequencies to be consistent with the BWR/6 STS and removed language from the bases for the channel check SRs that credited the online self-diagnostic design feature as a means of accomplishing a channel check. However, the GTS bases retained the online self-diagnostic design feature as part of the basis for the channel check SR frequencies. For example, the bases for SR 3.3.1.1.1 in draft DCD Revision 6 stated the following:

> The Frequency is based upon operating experience that demonstrates channel failure is rare and the self-diagnostic features that monitor the channels for proper operation. The Channel Checks every 12 hours supplement less formal, but more frequent, checks of channels during normal operational use of the displays associated with the channels required by the LCO.

Because the DCD includes insufficient design information for the staff to conclude that the capabilities of the self-diagnostic feature can be credited in the bases to help justify the 12-hour frequency, GEH removed the self-diagnostic feature capabilities from the bases for channel check SR frequencies. Section 16.2.6.4.2 of this report, regarding the resolution of RAI 16.2-145, Supplement 2, discusses this issue further. Therefore, because the GTS bases for channel check SR frequencies are identical to the STS bases, they are acceptable.

The staff considers the proposed channel check SRs acceptable because the GTS definition of channel check is the same as the STS definition. In addition, the proposed channel check SRs are specified for all suitable instrumentation functions at frequencies consistent with the STS.

16.2.6.4.2 Evaluation of Channel Functional Test Surveillance Requirements

GTS Section 1.1 defines a channel functional test (CFT) as the following:

> A CHANNEL FUNCTIONAL TEST shall be the injection of a simulated or actual signal into the channel as close to the sensor as practicable to verify OPERABILITY of all devices in the channel required for channel OPERABILITY. The CHANNEL FUNCTIONAL TEST may be performed by means of any series of sequential, overlapping, or total channel steps.

The bases for each instrumentation specification further describe what constitutes a CFT for the associated functions, and typically state, “A CHANNEL FUNCTIONAL TEST is performed on each required channel to ensure that the entire channel will perform the intended function.”

The following GTS SRs specify a CFT for the listed category of instrumentation functions:

- SR 3.3.1.1.2 RPS Instrumentation
- SR 3.3.1.3.1 RPS Manual Actuation—Manual Scram Function (7 days)
- SR 3.3.1.3.2 RPS Manual Actuation—Reactor Mode Switch—Shutdown Position Function (24 months)
- SR 3.3.1.4.3 NMS Instrumentation (7 days)
- SR 3.3.1.4.4 NMS Instrumentation
- SR 3.3.1.6.5 SRNM Instrumentation (7 days)

- SR 3.3.1.6.6 SRNM Instrumentation (31 days)
- SR 3.3.2.1.1 CRB Instrumentation
- SR 3.3.2.1.2 CRB Instrumentation
- SR 3.3.2.1.3 CRB Instrumentation
- SR 3.3.2.1.4 CRB Instrumentation
- SR 3.3.2.1.8 CRB Instrumentation
- SR 3.3.3.1.1 RSS
- SR 3.3.4.1.2 RCSLD Instrumentation
- SR 3.3.5.1.2 ECCS Instrumentation
- SR 3.3.5.3.2 ICS Instrumentation
- SR 3.3.6.1.2 MSIV Instrumentation
- SR 3.3.6.3.2 Isolation Instrumentation
- SR 3.3.7.1.2 CRHAVS Instrumentation
- SR 3.3.8.1.2 DPS

The staff considers the proposed CFT SRs acceptable because the GTS definition of CFT is the same as the STS definition, and they are specified for all suitable instrumentation functions.

The GTS contains two other CFT SRs that are required to be met during Mode 6, with a 7-day frequency. The associated bases for SR 3.9.1.1 (CFT for refueling equipment interlocks) and SR 3.9.2.2 (CFT for refuel position one-rod/rod-pair-out interlock), respectively, state the following:

> The 7 day Frequency for the refueling equipment interlocks is based on engineering judgment and is considered adequate in view of other indications of refueling interlocks and their associated input status that are available to plant operations personnel.
>
> The 7 day Frequency for the refuel position one-rod/rod-pair-out interlock is considered adequate because of demonstrated circuit reliability, procedural controls on control rod withdrawals, and visual and audible indications available in the CR to alert the operator of control rods not fully inserted.

The staff considers the bases for these CFT surveillance frequencies consistent with the STS for equivalent instrument functions. Therefore, they are acceptable. However, the staff requested additional information concerning CFT surveillances.

RAI 16.2-148. The staff requested that GEH provide data to demonstrate that the self-test report meets the requirements of a CFT without performing a test to inject a simulated or actual signal into the channel as close to the sensor as practicable to verify operability of all devices in the channel required for channel operability. RAI 16.2-148 was being tracked as an open item in the SER with open items. In its response dated August 30, 2007, GEH noted that the STS bases usually do not include details of methods for performing surveillances and proposed to remove from GTS bases all discussions of the online self-diagnostic design feature as a means of accomplishing a CFT. Removing these discussions removes this inconsistency with the STS. Therefore, RAI 16.2-148 is resolved.

However, removing from GTS bases all discussions of the online self-diagnostic design feature as a means of accomplishing a CFT does not enable the NRC staff to complete its review of this feature within the scope of the ESBWR design certification.

In Revision 5 of DCD Chapter 16, GTS Section 3.3, the applicant proposed a 24-month frequency for CFTs, in place of the typically shorter frequencies, (e.g., 7 days or 92 days as specified in the STS). The GTS bases appeared to justify this relaxation by crediting the capabilities of the online self-diagnostic design feature to automatically detect instrumentation failures and presumably initiate alarms to alert the CR staff. However, as noted in Section 16.2.6.5 of this report in the discussion of the GEH response to RAI 16.2-145, Supplement 1, GEH revised the CFT SR frequencies to be consistent with the BWR/6 STS and removed language from the bases for the CFT SRs that credited the online self-diagnostic design feature as a means of accomplishing a CFT. However, the bases retained the online self-diagnostic design feature as part of the basis for the CFT SR frequencies. For example, the bases for SR 3.3.1.1.2 stated that, “The Frequency of 92 days is based on the reliability of the channels and the self-diagnostic features that monitor the channels for proper operation.” Because of this, the staff requested additional information, as follows.

RAI 16.2-145, Supplement 2. Because of insufficient design information, the staff is unable to conclude that the capabilities of the self-diagnostic design feature can be credited in the bases to help justify the CFT and channel check SR frequencies. The staff also cannot conclude that, based solely on instrument reliability, the ESBWR instrumentation can use the BWR/6 CFT SR frequencies, since BWR/6 instrumentation channel reliability is supported by NRC-approved topical reports, which only apply to analog instrumentation systems used in BWR/6 and earlier BWR plant designs. For these reasons, the staff requested GEH to take the following actions:

- Remove references taking credit for the online self-diagnostic design feature from the bases for instrumentation SR frequencies for all channel checks and CFTs. The staff stated that it will accept a channel check SR frequency of 12 hours and a CFT SR frequency of 7 days based solely on the reliability of the ESBWR instrumentation channels.
- Revise the CFT SR frequencies of 92 days to 31 days, which the staff will accept based solely on the reliability of the ESBWR instrumentation channels.

In its response dated August 3, 2009, GEH proposed to revise the CFT SR frequencies to 31 days and to remove the language describing the online self-diagnostic design feature from the bases for channel checks and CFTs. DCD Revision 6 incorporated these changes. Therefore, RAI 16.2-145, Supplement 2, is resolved.

Based on consistency with the STS and resolution of the CFT-related RAIs, the staff finds the proposed CFT SRs acceptable.

16.2.6.4.3 Evaluation of Channel Calibration Surveillance Requirements

GTS Section 1.1 defines channel calibration (Ch Cal) as the following:

> A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel output such that it responds within the necessary range and accuracy to known values of the parameter that the channel monitors. The CHANNEL CALIBRATION shall encompass all devices in the channel required for channel OPERABILITY and the CHANNEL FUNCTIONAL TEST. Calibration of instrument channels with resistance temperature detector (RTD) or thermocouple sensors may consist of an in place qualitative assessment of sensor behavior and normal calibration of the remaining adjustable devices in the channel. The CHANNEL CALIBRATION may be performed by means of any series of sequential, overlapping, or total channel steps.

This definition is identical to the STS definition and is acceptable. The GTS require performing a channel calibration on each required channel, consistent with Specification 5.5.11, “Setpoint Control Program (SCP),” except for instrumentation having no trip settings to initiate automatic actuation of safety systems. The channel calibration surveillances for such instrumentation are the following:

- SR 3.3.1.6.7 SRNM (used only for neutron monitoring in Modes 3, 4, 5, and 6)
- SR 3.3.3.2.2 PAM (CR indication of parameters used for assessing postaccident conditions)
- SR 3.3.4.1.3 RCS leakage detection

The GTS bases for each instrumentation channel calibration SR typically describe what constitutes a channel calibration for the associated instrumentation functions as follows, where $NTSP_F$ is the nominal trip setpoint as defined in the NRC-approved setpoint methodology, which is specified by the SCP:

> A CHANNEL CALIBRATION is a complete check of the instrument loop and the sensor. This test verifies the required channel responds to the measured parameter within the necessary range and accuracy. CHANNEL CALIBRATION leaves the required channel adjusted to the $NTSP_F$ within the “as-left” tolerance to account for instrument drifts between successive calibrations consistent with the methods and assumptions required by the SCP.

The bases for RCS leakage detection instrumentation also state, “the calibration verifies the accuracy of the instrument string, including the instruments located inside the drywell.”

All channel calibration SRs specify a frequency of 24 months. The GTS bases for each instrumentation channel calibration SR justify this frequency as follows:

1) The bases for the following SRs state that “The [24-month] Frequency is based upon the assumption of a 24-month calibration interval in the determination of the magnitude of equipment drift in the setpoint analysis.”

    - SR 3.1.7.8 SLC accumulator level instrumentation channels
    - SR 3.3.1.1.3 RPS instrumentation channels
    - SR 3.3.1.4.6 NMS instrumentation channels
    - SR 3.3.5.1.3 ECCS instrumentation channels
    - SR 3.3.5.3.3 ICS instrumentation channels
    - SR 3.3.6.1.3 MSIV instrumentation channels
    - SR 3.3.6.3.3 Isolation instrumentation channels
    - SR 3.3.7.1.3 CRHAVS instrumentation channels
    - SR 3.3.8.1.3 DPS instrumentation channels
    - SR 3.7.1.9 IC/PCCS inner expansion pool level instrumentation channels (that support automatic opening of the inner expansion pool-to-equipment pool squib and pneumatic cross connect valves on a low level in either inner expansion pool)
    - SR 3.7.2.6 MCR temperature instrumentation channels
    - SR 3.7.6.6 Loss-of-feedwater-heating instrumentation channels

2) The bases for the following SR state that, “The 24-month Frequency considers the unit conditions required to perform the test, the ease of performing the test, and the likelihood of a change in the system or component status.”

    - SR 3.3.1.6.7 SRNM instrumentation channels (neutron monitoring only)

3) The bases for the following SR state that, “The 24-month Frequency is based on operating experience and consistency with the typical industry refueling cycles.”

    - SR 3.3.3.2.2 PAM instrumentation channels

4) The bases for the following SR state that, “The Frequency of 24 months is a typical refueling cycle and considers channel reliability. Operating experience has proven this Frequency is acceptable.”

    - SR 3.3.4.1.3 RCS leakage detection instrumentation channels

5) The bases for the following SR state that, “The 24 month Frequency was developed to coincide with the 24 month refueling interval because access to the vacuum breakers is required to perform the SR.” See discussion of RAI 16.2-47 in Section 16.2.9 of this report for further evaluation of the 24-month frequency for this SR.

    - SR 3.6.1.6.4 Wetwell-to-drywell vacuum breaker flow path isolation function instrumentation channels

The staff considers the frequencies and the bases for the frequencies of the various channel calibration surveillances to be consistent with the STS for equivalent instrument functions, and therefore, they are acceptable.

<u>RAI 16.2-163</u>. In the list of changes for DCD Chapter 16 between DCD Revision 3 and Revision 4, Item 92, in GTS 3.7.6, “Selected Control Rod Run-In (SCRRI) and Selected Rod Insert (SRI) Functions,” the applicant added a channel calibration SR for the SCRRI and SRI instrumentation functions; however, the LCO did not explicitly state these functions. The staff asked the applicant to explain why the LCO does not specify these instrumentation functions. In its response dated February 20, 2008, the applicant stated “support functions (e.g., instrumentation functions) are not required to be specified in the LCO to adequately address the necessary operability requirement.” The applicant proposed bases changes to clarify [that] the SCRRI and SRI function is connected with the loss-of-feedwater-heating initiation signal (i.e., instrumentation function) and to “clearly define that the channel calibration is associated with the loss-of-feedwater-heating initiation signal (eliminating use of “function” for the initiation signal)….” In DCD Revision 5, the applicant revised SR 3.7.6.6 and bases to explicitly require the performance of a channel calibration of the “loss-of-feedwater-heating instrumentation channels.” These changes provided the requested clarifications to SR 3.7.6.6 and associated bases. Therefore, RAI 16.2-163 is resolved.

16.2.6.4.4 Evaluation of Response Time Surveillance Requirements

GTS Section 1.1 specifies the five response time (Resp Time) definitions identified below. The bases for each instrumentation specification further describe what constitutes a response time test for the associated functions. An excerpt from each associated bases follows each definition.

16.2.6.4.4.1 ECCS Response Time

<u>Definition</u>: “The ECCS RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its ECCS initiation setpoint at the channel sensor until the ECCS equipment is capable of performing its safety function (i.e., the valves travel to their required positions, etc.). The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured. In lieu of measurement, response time may be verified for selected components provided that the components and methodology

for verification have been previously reviewed and approved by the NRC."

SR Bases: ECCS instrumentation and actuation response time testing "ensures that the individual required channel (or actuation division) response times are less than or equal to the maximum values assumed in the accident analysis. The ECCS RESPONSE TIME acceptance criteria are included in DCD Section 15.2." The tests required by instrumentation SR 3.3.5.1.4 and actuation SR 3.3.5.2.2 overlap to ensure complete testing of instrument channels and actuation circuitry.

RAI 16.2-97. In its response to RAI 16.2-97 in a letter dated January 18, 2007, the applicant stated that it had added response time testing of the ECCS actuation logic with SR 3.3.5.2.2, "Verify the ECCS RESPONSE TIME of each required division is within limits." In a supplement to this RAI, the staff stated that it did not concur with the applicant's position that the GTS implicitly includes ADS and DPV timers because the bases for the ECCS response time surveillance do not clearly state that the surveillance includes testing of the timers. RAI 16.2-97 was being tracked as an open item in the SER with open items. In its response dated October 15, 2007, GEH stated that, in DCD Revision 4, it had revised the bases for the ECCS response time surveillance to clarify that the scope of the surveillance includes timers. With this change, therefore, RAI 16.2-97 is resolved.

The proposed ECCS response time SRs are acceptable because of the resolution of RAI 16.2-97 and because they are consistent with the STS.

16.2.6.4.4.2 Isolation Condenser System Response Time

Definition: "The ISOLATION CONDENSER SYSTEM (ICS) RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its ICS initiation setpoint at the channel sensor until the ICS equipment is capable of performing its safety function (i.e., the valves travel to their required positions, etc.). The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured. In lieu of measurement, response time may be verified for selected components provided that the components and methodology for verification have been previously reviewed and approved by the NRC."

SR Bases: ICS instrumentation and response time testing "ensures that the individual required channel (or actuation division) response times are less than or equal to the maximum values assumed in the accident analysis. The ICS RESPONSE TIME acceptance criteria are included in DCD Section 15.2." The tests required by instrumentation SR 3.3.5.3.4 and actuation SR 3.3.5.4.2 overlap to ensure complete testing of instrument channels and actuation circuitry.

The proposed ICS response time SRs are acceptable because they are consistent with the STS.

16.2.6.4.4.3 Isolation System Response Time

Definition: "The ISOLATION SYSTEM RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its isolation initiation setpoint at the channel sensor until the isolation valves travel to their required positions. The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured. In lieu of measurement, response time may be verified for selected components provided that the components and methodology for verification have been previously reviewed and approved by the NRC."

SR Bases: Response time testing for MSIV instrumentation channels and actuation circuitry and isolation system instrumentation channels and actuation circuitry "ensures that the individual required channel (or actuation division) response times are less than or equal to the maximum values assumed in the accident analysis. The ISOLATION SYSTEM RESPONSE TIME acceptance criteria are included in DCD Section 15.2." The tests required by the following pairs of instrumentation and actuation SRs, respectively, overlap to ensure complete testing of instrumentation channels and actuation circuitry:

- SR 3.3.6.1.4 and SR 3.3.6.2.2
- SR 3.3.6.3.4 and SR 3.3.6.4.2

The instrument response times must be added to the associated isolation valve closure times to obtain the isolation system response time.

The proposed isolation system response time SRs are acceptable because they are consistent with the STS.

16.2.6.4.4.4 Reactor Protection System Response Time

Definition: "The REACTOR PROTECTION SYSTEM (RPS) RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its RPS trip setpoint at the channel sensor until de-energization of the scram pilot valve solenoids. The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured. In lieu of measurement, response time may be verified for selected components provided that the components and methodology for verification have been previously reviewed and approved by the NRC."

SR Bases: Response time testing for RPS instrumentation and actuation and NMS instrumentation and actuation "ensures that the individual required channel (or actuation division) response times are less than or equal to the maximum values assumed in the accident analysis. The RPS RESPONSE TIME acceptance criteria are included in DCD Section 15.2." The tests required by the following pairs of instrumentation and actuation SRs, respectively, overlap to ensure complete testing of instrument channels and actuation circuitry:

- SR 3.3.1.1.4 and SR 3.3.1.2.2
- SR 3.3.1.4.8 and SR 3.3.1.5.2

The proposed RPS response time SRs are acceptable because they are consistent with the STS.

16.2.6.4.4.5 Control Room Habitability Area Heating, Ventilation, and Air Conditioning Subsystem Response Time

Definition: “The CONTROL ROOM HABITABILITY AREA (CRHA) HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SUBSYSTEM (CRHAVS) RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its CRHAVS initiation setpoint at the channel sensor until the CRHAVS equipment is capable of performing its safety function (i.e., the dampers travel to their required positions, fans start, etc). The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured. In lieu of measurement, response time may be verified for selected components provided that the components and methodology for verification have been previously reviewed and approved by the NRC.”

SR Bases: “This SR ensures that the individual required division response times are less than or equal to the maximum values assumed in the accident analysis. The instrument response times must be added to the associated closure times to obtain the CRHAVS RESPONSE TIME. CRHAVS RESPONSE TIME acceptance criteria are included in DCD Section 15.2.” The testing required by instrumentation SR 3.3.7.1.4 and actuation SR 3.3.7.2.2 overlap to ensure complete testing of instrumentation channels and actuation divisions.

The proposed CRHAVS response time SRs are acceptable because they are consistent with the STS.

16.2.6.4.4.6 Combined License Item to Omit Response Time Testing for Selected Components

RAI 16.2-157. In Revision 4 of DCD Chapter 16B, the GTS bases for the RPS, ECCS, and isolation system instrumentation response time testing SRs describe conditions for exempting selected components from response time testing. Furthermore, the bases refer to two topical reports, which are enclosed in brackets: NEDO-32291-A, “System Analyses for the Elimination of Selected Response Time Testing Requirements,” issued October 1995, and NEDO-32291-A, Supplement 1, “System Analyses for the Elimination of Selected Response Time Testing Requirements,” issued October 1999. RAI 16.2-157 was being tracked as an open item in the SER with open items. In its response dated March 25, 2008, GEH indicated that the topical reports were intended as examples to support elimination of certain response time tests in the ESBWR by a COL applicant or holder. In place of these examples, GEH provided a bracketed discussion and a reviewer’s note in the bases. DCD Revision 5 moved all reviewers’ notes in the GTS and bases to DCD Table 16.0-1-A and established a reviewer’s note for every COL item. For each COL item regarding an optional allowance to exclude from response time testing (1) certain sensors or other instrumentation components or (2) certain portions of the actuation circuitry, Table 16.0-1-A provides the following reviewer’s note:

> Applicants or Licensees may remove brackets and adopt this provision by application of Specification 5.5.7, “Bases Control Program,” after appropriate assessment and incorporation into the plant licensing basis of an NRC approved methodology evaluating sensor and instrumentation loop response time requirements. All implementation requirements of the NRC Safety Evaluation Report for the methodology must be addressed. This allowance is provided as a template for potential future assessments.

The bracketed discussions in the GTS bases for response time testing SRs for instrumentation sensor channels and actuation divisions, respectively, typically state the following:

> [However, some sensors for Functions are allowed to be excluded from specific RPS RESPONSE TIME measurement if the conditions of Reference XX are satisfied. If these conditions are satisfied, sensor response time may be allocated based on either assumed design sensor response time or the manufacturer's stated design response time. When the requirements of Reference XX are not satisfied, sensor response time must be measured. Furthermore, measurement of the instrument loops response times is not required if the conditions of Reference XX are satisfied.]
>
> [However, some portions of the RPS actuation circuitry are allowed to be excluded from specific RPS RESPONSE TIME measurement if the conditions of Reference XX are satisfied. Furthermore, measurement of the instrument loops response times is not required if the conditions of Reference XX are satisfied.]

The above changes resolved RAI 16.2-157 because they clearly explain that NRC approval is required to exclude some sensor and actuation components from response time testing for those COL applicants or holders choosing to implement this option in accordance with DCD Tier 2, Table 16.0-1-A, COL Applicant Open Items 3.3.1.1-2, 3.3.1.2-1, 3.3.1.4-2, 3.3.1.5-2, 3.3.5.1-2, 3.3.5.2-1, 3.3.5.3-2, 3.3.5.4-1, 3.3.6.1-2, 3.3.6.2-1, 3.3.6.3-2, 3.3.6.4-1, 3.3.7.1-3, and 3.3.7.2-2.

16.2.6.4.4.7 Response Time Test Acceptance Criteria

<u>RAI 16.2-158</u>. The staff requested GEH to revise the bases for RPS, ECCS, and isolation system response time SRs by stating the actual reference to the document containing the required response time limits. RAI 16.2-158 was being tracked as an open item in the SER with open items. In it response dated March 25, 2008, GEH revised the bases with the correct reference—DCD Section 15.2. DCD Table 15.2-23, "Instrument Response Time Limits for RPS, ECCS, MSIV, ICS, CRHAVS and Isolation Functions," states the actual response time limit values. Because GEH made the requested changes to the bases for RPS, ECCS, and isolation system response time SRs, therefore, RAI 16.2-158 is resolved.

16.2.6.4.4.8 Response Time Test Surveillance Requirement Frequency

The response time test SR frequency of 24 months on a staggered test basis, for three channels or divisions, which applies to the RPS, ECCS, MSIV, ICS, CRHAVS, and isolation system functions, is consistent with the STS for equivalent instrument functions. The GTS bases for these sensor and actuation SRs typically state that the frequency of 24 months on a staggered test basis ensures that the required [sensor] channels associated with each division are alternately tested and that each required [actuation] division is alternately tested. Specifically, the bases state, "The 24-month test Frequency is consistent with the refueling cycle and with operating experience that shows that random failures of instrumentation components causing serious response time degradation, but not channel failure, are infrequent." On this basis, the proposed response time test SR frequency of 24 months on a staggered test basis is acceptable.

16.2.6.4.5 Evaluation of Logic System Functional Test Surveillance Requirements

GTS Section 1.1 provides the following definition of a logic system functional test (LSFT):

> A LOGIC SYSTEM FUNCTIONAL TEST shall be a test of all logic components required for OPERABILITY of a logic circuit, from as close to the sensor as practicable up to, but not including, the actuated device, to verify OPERABILITY. The LOGIC SYSTEM FUNCTIONAL TEST may be performed by means of any series of sequential, overlapping, or total system steps so that the entire logic system is tested.

This is consistent with the STS and is acceptable. The bases for each instrumentation actuation LSFT SR, as listed below, further describe what constitutes a LSFT for the associated functions, as follows:

> The LOGIC SYSTEM FUNCTIONAL TEST demonstrates the OPERABILITY of the
>
> - RPS Actuation divisions, including the two-out-of-four function of the Trip Logic Unit (TLU), Output Logic Unit (OLU), and Load Drivers (LDs) for a specific division. (bases for SR 3.3.1.2.1)
> - NMS automatic actuation divisions. (bases for SR 3.3.1.5.1)
> - required ECCS logic for a specific division. (bases for SR 3.3.5.2.1)
> - required ICS logic for a specific division. (bases for SR 3.3.5.4.1)
> - MSIV actuation divisions, including the two-out-of-four function of the Trip Logic Unit (TLU), Output Logic Unit (OLU), and Load Drivers (LDs) for a specific division. (bases for SR 3.3.6.2.1)
> - isolation actuation divisions. (bases for SR 3.3.6.4.1)
> - required CRHAVS logic for a specific division. (bases for SR 3.3.7.2.1)
> - DPS logic. (bases for SR 3.3.8.1.4)
> - required actuation logic for the IC/PCCS expansion pool-to-equipment pool cross-connect valves for a specific division. (bases for SR 3.7.1.12)

The bases also state that the "24-month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the Surveillance when performed at the 24 month Frequency." The bases for the frequency of 24 months for the RPS, NMS, ECCS, ICS, MSIV, isolation, and CRHAVS actuation LSFT SRs are consistent with the STS bases for equivalent instrument actuation functions. Therefore, the proposed LSFT SRs, frequency, and bases are acceptable.

16.2.6.4.6 Evaluation of Instrumentation Surveillance Requirements Performed on a Staggered Test Basis

Certain SRs, such as response time testing, are performed on a staggered test basis, which GTS Section 1.1 defines as the following:

> A STAGGERED TEST BASIS shall consist of the testing of one of the systems, subsystems, channels, or other designated components during the interval specified by the Surveillance Frequency, so that all systems, subsystems, channels, or other designated components are tested during n Surveillance Frequency intervals, where n is the total number of systems, subsystems, channels, or other designated components in the associated function.

This is consistent with the STS definition and is acceptable.

<u>RAIs 16.2-29, 16.2-150, and 16.2-151</u>. In RAI 16.2-29, the staff requested that the applicant identify all GTS Section 3.3 required actions that allow indefinite continued operation with an inoperable instrumentation function channel, provided the action requirements are met. (This is permitted when the inoperable instrument channel or actuation division is placed in trip; see Section 16.2.6.3.2 of this report.) The staff asked the applicant to revise its original response in a letter dated August 21, 2006, to account for the replacement of the emergency breathing air system with the CRHAVS, as well as any other changes to the proposed instrumentation GTS made since August 2006. RAI 16.2-29 was being tracked as an open item in the SER with Opens Items. The staff considers this item to be related also to the “N−2” proposal for instrumentation LCOs, which requires one division less than specified in the design, provided that the design contains four divisions and just two are necessary to maintain function. The staff prefers that the LCO require all four divisions to be operable and that the actions specify no restriction on continued operation when just one division is inoperable. The staff prefers this approach because it applies explicit TS control of the status and testing of all four divisions, even though TS would impose no operational restriction when only one of four divisions is inoperable. Subsequent changes to instrumentation action requirements culminating in DCD Revision 6 clarified the functions for which a channel or division may be placed in trip.
RAIs 16.2-150 and 16.2-151 also address the issue concerning the number of instrumentation channels or actuation divisions that LCOs should require to be operable. In these RAIs, the staff requested that the applicant base the staggered test surveillance frequencies for response time testing and actuation instrumentation LSFTs, respectively, on the number of divisions required to be operable by the LCO (three) instead of the number in the design (four). In its responses to RAIs 16.2-150 and 151 in a letter dated July 23, 2007, the applicant stated its preference of requiring four divisions to avoid testing multiple divisions in a single test interval. RAIs 16.2-150 and 16.2-151 were being tracked as Open Item 16.2-150 in the SER with Open Items (RAI 16.2-151 being included in RAI 16.2-150 for tracking purposes). In a supplement to RAI 16.2-150, the staff stated its position that the application of the staggered testing definition should define the number of divisions to be tested as the number required to be operable by the associated LCO, and not the number in the design, and that this definition should be based on 10 CFR 50.36(d)(3) (i.e., “SRs are requirements to assure…that LCOs will be met”). In its response to RAI 16.2-150, Supplement 1, in a letter dated December 4, 2007, the applicant stated that it would revise the LSFT and response time testing surveillance frequencies by deleting the phrase “for four channels.” Because this change will ensure that staggered testing

intervals for each channel or division will be determined by the number of channels or divisions required by the LCO, the staff finds the change acceptable. Therefore, RAIs 16.2-150 and 16.2-151 are resolved.

In DCD Revision 6, GEH removed the allowance for staggered testing from the 24-month SR frequency for LSFT SRs because it lacked a technical basis. Since this change will require more frequent performance of the LSFT on each actuation division, the staff finds it acceptable.

Based on the above evaluation of instrumentation SRs, the staff finds the SRs for instrumentation and actuation functions acceptable. Table 16-7 lists the specified SRs and associated frequencies for each instrumentation function, as stated in Revision 6 of the GTS.

Table 16-7 Summary of Instrumentation Surveillances

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	Ch Chk	CFT	Ch Cal	*Response Time	LSFT	Other SR
3.1.7 Standby Liquid Control (SLC) System						
SLC System accumulator level instrumentation			24 m			
3.3.1.1 RPS Instrumentation						
1. NMS Input—SRNM	12 h	31 d				
2. NMS Input—APRM/OPRM	12 h	31 d				
3. Scram Accumulator Charging Water Header Pressure—Low-Low	12 h	31 d	24 m			
4. Reactor Vessel Steam Dome Pressure—High	12 h	31 d	24 m	24 m		
5. Reactor Vessel Water Level—Low, Level 3	12 h	31 d	24 m	24 m		
6. Reactor Vessel Water Level—High, Level 8	12 h	31 d	24 m	24 m		
7 MSIV—Closure (Per Steam Line)		31 d	24 m	24 m		
8. Drywell Pressure—High	12 h	31 d	24 m	24 m		
9. Suppression Pool Temperature—High	12 h	31 d	24 m	24 m		
10. Turbine Stop Valve Closure Trip		31 d	24 m	24 m		
11. Turbine Control Valve Fast Closure Trip Oil Pressure—Low	12 h	31 d	24 m	24 m		
12. Main Condenser Pressure—High	12 h	31 d	24 m	24 m		
13. Power Generation Bus Loss	12 h	31 d	24 m	24 m		
14. Feedwater Temperature Biased Simulated Thermal Power—High	12 h	31 d	24 m			
15 Simulated Thermal Power Biased Feedwater Temperature—High	12 h	31 d	24 m			

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	**Ch Chk**	**CFT**	**Ch Cal**	***Response Time**	**LSFT**	**Other SR**
16 Simulated Thermal Power Biased Feedwater Temperature—Low	12 h	31 d	24 m			
3.3.1.2 RPS Actuation						
RPS Automatic Actuation				24 m	24 m	
3.3.1.3 RPS Manual Actuation						
1. Manual Scram		7 d				
2. Reactor Mode Switch—Shutdown Position		24 m				
3.3.1.4 NMS Instrumentation						
1.a. SRNM—Neutron Flux—Short Period	12 h	7 d	24 m	24 m		
1.b. SRNM—Inop		7 d				
2.a. APRM—Fixed Neutron Flux—High, Setdown	12 h	7 d	24 m	24 m		
# average core exposure	SR 3.3.1.4.5, Calibrate LPRM					# 750 MWD/T
2.b. APRM—APRM Simulated Thermal Power—High	12 h	31 d	24 m	24 m		
# average core exposure	SR 3.3.1.4.2, Calorimetric SR 3.3.1.4.5, Calibrate LPRM SR 3.3.1.4.7, Verify time constant within limit					7 d # 750 MWD/T 24 m
2.c. APRM—Fixed Neutron Flux—High	12 h	31 d	24 m	24 m		
# average core exposure	SR 3.3.1.4.2, Calorimetric SR 3.3.1.4.5, Calibrate LPRM					7 d # 750 MWD/T
2.d. APRM—Inop		31 d				
3. OPRM—Upscale		31 d	24 m	24 m		
	SR 3.3.1.4.9, Verify OPRM is not bypassed when thermal power is ≥ 25% RTP					24 m
3.3.1.5 NMS Automatic Actuation						
1. SRNM				24 m	24 m	
2. APRM				24 m	24 m	
3. OPRM				24 m	24 m	
3.3.1.6 SRNM Instrumentation (monitoring and indication functions only)						
1. SRNM Modes 3, 4, 5	24 h	31 d	24 m			
**during Core Alterations	SR 3.3.1.6.4, Verify count rate is ≥ 3.0 cps					12 h** and 24 h

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	**Ch Chk**	**CFT**	**Ch Cal**	***Response Time**	**LSFT**	**Other SR**
1. SRNM Mode 6 (may substitute movable detectors)	12 h	7 d	24 m			
**during Core Alterations	SR 3.3.1.6.2, Verify SRNM location SR 3.3.1.6.4, Verify count rate is ≥ 3.0 cps					12 h 12 h** and 24 h
3.3.2.1 Control Rod Block (CRB) Instrumentation						
1.a. Rod Control and Information System (RC&IS)—Automated Thermal Limit Monitor (ATLM)		^31 d				
^ SR 3.3.2.1.1 Note: Not required to be performed until one hour after Thermal Power is ≥ 30% RTP.	SR 3.3.2.1.6, Verify required ATLM channels are not bypassed when Thermal Power is ≥ 30% RTP					24 m
1.b. RC&IS—Rod Worth Minimizer (RWM)		^31 d **31 d				
^ SR 3.3.2.1.2 Note: Not required to be performed until one hour after any control rod is withdrawn in Mode 2. ** SR 3.3.2.1.4 Note: Not required to be performed until one hour after Thermal Power is ≤ 10% RTP.	SR 3.3.2.1.5, Verify required RWM channels are not bypassed when Thermal Power is ≤ 10% RTP. SR 3.3.2.1.9, Verify the bypassing and movement of control rods required to be bypassed in the Rod Action Control Subsystem (RACS) cabinets by a second licensed operator or other qualified member of the technical staff.					24 m Prior to and during the movement of control rods bypassed in RACS
1.c. Multi-Channel Rod Block Monitor (MRBM)		^31 d				
^ SR 3.3.2.1.4 Note: Not required to be performed until one hour after Thermal Power is ≥ 30% RTP.	SR 3.3.2.1.7, Verify required MRBM channels are not bypassed when Thermal Power is ≥ 30% RTP.					24 m
2. Reactor Mode Switch—Shutdown Position ^ SR 3.3.2.1.8 Note: Not required to be performed until one hour after reactor mode switch is in shutdown position.		^24 m				
3.3.3.1 Remote Shutdown System (RSS)						
RPS Division 1 & 2 Manual Scram Switches		24 m				
3.3.3.2 Post-Accident Monitoring (PAM) Instrumentation						
Each Type A, B, and C PAM Instrumentation Function	31 d		24 m			
3.3.4.1 Reactor Coolant System (RCS) Leakage Detection Instrumentation						

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	**Ch Chk**	**CFT**	**Ch Cal**	***Response Time**	**LSFT**	**Other SR**
a. Drywell Floor Drain HCW Sump Monitoring System	12 h	31 d	24 m			
b. Particulate Channel of the Drywell Fission Product Monitoring System	12 h	31 d	24 m			
c. Drywell Air Coolers Condensate Flow Monitoring System	12 h	31 d	24 m			
3.3.5.1 ECCS Instrumentation						
1. Reactor Vessel Water Level—Low, Level 1	12 h	31 d	24 m	24 m		
2. Reactor Vessel Water Level—Low, Level 0.5	12 h	31 d	24 m	24 m		
3. Drywell Pressure—High	12 h	31 d	24 m	24 m		
3.3.5.2 ECCS Actuation						
1. ADS				24 m	24 m	
2. GDCS Injection Lines				24 m	24 m	
3. GDCS Equalizing Lines				24 m	24 m	
4. Standby Liquid Control (SLC)				24 m	24 m	
3.3.5.3 ICS Instrumentation						
1. Reactor Vessel Steam Dome Pressure—High	12 h	31 d	24 m	24 m		
2. Reactor Vessel Water Level—Low, Level 2	12 h	31 d	24 m	24 m		
3. Reactor Vessel Water Level—Low, Level 1	12 h	31 d	24 m	24 m		
4. MSIV—Closure	12 h	31 d	24 m	24 m		
5. Power Generation Bus Loss	12 h	31 d	24 m	24 m		
3.3.5.4 ICS Actuation						
ICS Actuation Logic				24 m	24 m	
3.3.6.1 MSIV Instrumentation						
1. Reactor Vessel Water Level—Low, Level 2	12 h	31 d	24 m	24 m		
2. Reactor Vessel Water Level—Low, Level 1	12 h	31 d	24 m	24 m		
3. Main Steam Line Pressure—Low	12 h	31 d	24 m	24 m		
4. Main Steam Line Flow—High (Per Steam Line)	12 h	31 d	24 m	24 m		
5. Condenser Pressure—High (Per Condenser)	12 h	31 d	24 m	24 m		
6. Main Steam Tunnel Ambient Temperature—High	12 h	31 d	24 m	24 m		
7. Main Steam Turbine Area Ambient Temperature—High	12 h	31 d	24 m	24 m		

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	**Ch Chk**	**CFT**	**Ch Cal**	***Response Time**	**LSFT**	**Other SR**
3.3.6.2 MSIV Actuation						
MSIV [isolation] actuation				24 m	24 m	
3.3.6.3 Isolation Instrumentation						
1. Reactor Vessel Water Level—Low, Level 2	12 h	31 d	24 m	24 m		
2. Reactor Vessel Water Level—Low, Level 1	12 h	31 d	24 m	24 m		
3. Drywell Pressure—High	12 h	31 d	24 m	24 m		
4. Main Steam Tunnel Ambient Temperature—High	12 h	31 d	24 m	24 m		
5. RWCU/SDC Differential Mass Flow—High (Per Subsystem)	12 h	31 d	24 m	24 m		
6. Isolation Condenser Steam Line Flow—High (Per Isolation Condenser)	12 h	31 d	24 m	24 m		
7. Isolation Condenser Condensate Return Line Flow—High (Per Isolation Condenser)	12 h	31 d	24 m	24 m		
8. Isolation Condenser Pool Vent Discharge Radiation—High (Per Isolation Condenser)	12 h	31 d	24 m	24 m		
9. Feedwater Line Differential Pressure—High	12 h	31 d	24 m	24 m		
10. Reactor Building Exhaust Radiation—High	12 h	31 d	24 m	24 m		
11. Drywell Water Level—High	12 h	31 d	24 m	24 m		
12. Reactor Vessel Water Level Low—Level 0.5	12 h	31 d	24 m	24 m		
13. Drywell Pressure—High-High	12 h	31 d	24 m	24 m		
14. GDCS Pool Water Level—Low	12 h	31 d	24 m	24 m		
3.3.6.4 Isolation Actuation						
1. Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) System Isolation (Modes 1, 2, 3, 4, 5, 6)				24 m	24 m	
1. RWCU/SDC Isolation (Modes 5, 6)	SR 3.3.6.4.3, Perform a system functional test					24 m
2. ICS Isolation				24 m	24 m	
3. Process Radiation Monitoring System Isolation				24 m	24 m	
4. Equipment and Floor Drain System Isolation				24 m	24 m	
5. Containment Inerting System Isolation				24 m	24 m	
6. Chilled Water System Isolation				24 m	24 m	

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	**Ch Chk**	**CFT**	**Ch Cal**	***Response Time**	**LSFT**	**Other SR**
7. Fuel and Auxiliary Pools Cooling System Process Isolation				24 m	24 m	
8. Reactor Building Heating, Ventilation and Air Conditioning System Isolation				24 m	24 m	
9. High Pressure Nitrogen Gas Supply System Isolation				24 m	24 m	
10. Feedwater Isolation Valves Isolation				24 m	24 m	
	SR 3.3.6.4.3, Perform a system functional test					24 m
11. High Pressure Control Rod Drive Isolation				24 m	24 m	
	SR 3.3.6.4.3, Perform a system functional test					24 m
3.3.7.1 CRHAVS Instrumentation						
1. CR Air Intake Radiation—High-High	12 h	31 d	24 m	24 m		
2. Extended Loss of AC Power	12 h	31 d	24 m	24 m		
3. Emergency Filter Unit (EFU Discharge Flow—Low (primary train)	12 h	31 d	24 m	24 m		
4. EFU Outlet Radiation—High-High (primary train)	12 h	31 d	24 m	24 m		
3.3.7.2 CRHAVS Actuation						
CRHAVS Actuation				24 m	24 m	
3.3.8.1 Diverse Protection System (DPS)						
1.a ADS—Actuation, Reactor Vessel Level—Low, Level 1	12 h	31 d	24 m		24 m	
1.b ADS—Actuation, Drywell Pressure—High (Manual Actuation)	12 h	31 d	24 m		24 m	
2.a GDCS Injection Lines—Actuation, Reactor Vessel Level—Low, Level1	12 h	31 d	24 m		24 m	
2.b GDCS Injection Lines—Actuation, Drywell Pressure—High (Manual Actuation)	12 h	31 d	24 m		24 m	
3.a RWCU/SDC System Lines—Isolation, RWCU/SDC System Differential Mass Flow—High	12 h	31 d	24 m		24 m	
4.a Isolation Condenser/Passive Containment Cooling System (IC/PCCS) Expansion Pool-to-Equipment Pool Cross-Connect—Actuation, IC/PCCS Pool Level—Low	12 h	31 d	24 m		24 m	

GTS Specification	Surveillance Requirement Frequencies *Staggered Test Basis h—hours, d—days, m—months					
Function	**Ch Chk**	**CFT**	**Ch Cal**	***Response Time**	**LSFT**	**Other SR**
3.6.1.6 Wetwell-to-Drywell Vacuum Breakers						
Vacuum breaker flow path isolation function			24 m			
	SR 3.6.1.6.5, Perform a system functional test					24 m
3.7.1 Isolation Condenser/Passive Containment Cooling System (IC/PCCS) Pools						
IC/PCCS expansion pool level instrumentation channels	12 h	31 d	24 m			
IC/PCCS expansion pool-to-equipment pool cross-connect actuation logic divisions					24 m	
3.7.2 CRHAVS						
MCR temperature instrumentation channels			24 m			
3.7.6 Selected Control Rod Run-In (SCRRI) and Select Rod Insert (SRI) Functions						
Loss of feedwater-heating instrumentation channels			24 m			
	SR 3.7.6.3. Perform system functional test for the SCRRI function					24 m
	SR 3.7.6.4. Perform system functional test for the SRI function					24 m
3.9.1 Refueling Equipment Interlocks						
a. All-rods-in		7 d				
b. Refueling machine position		7 d				
c. Refueling machine fuel grapple hoist, fuel loaded		7 d				
d. Refueling machine auxiliary hoist, fuel loaded		7 d				
3.9.2 Refuel Position One-Rod/Rod-Pair-Out Interlock						
Mode switch refuel position one-rod/rod-pair-out interlock ^ SR 3.9.2.2 Note: Not required to be performed until one hour after any control rod is withdrawn.		^7 d				

16.2.6.5 *Setpoint Methodology*

DCD, Tier 2, Section 7.1.3.1.3, "Q-DCIS Setpoint Methodology," describes the considerations for determining instrumentation settings; these considerations are reflected in the setpoint methodology for ESBWR instrumentation settings. GEH submitted this methodology for NRC staff review and approval as part of the ESBWR design certification in NEDE-33304P, "GEH

ABWR/ESBWR Setpoint Methodology," issued October 2007. This was an update to NEDC-31336P-A, "General Electric Instrument Setpoint Methodology," issued September 1996, to address conformance with Regulatory Issue Summary (RIS) 2006-17, "NRC Staff Position on the Requirements of 10 CFR 50.36, 'Technical Specifications,' Regarding Limiting Safety System Settings During Periodic Testing and Calibration of Instrument Channels." GEH submitted Revision 1 to NEDE-33304P on November 25, 2008, to incorporate changes based on the GEH responses in a letter dated September 10, 2008, to staff comments in RAI 7.1-86 and its supplement, as well as the GEH response in a letter dated October 17, 2008, to staff comments in RAI 7.1-102. See Section 7.1.4 of this report for a discussion of the staff's review of the ESBWR instrumentation setpoint methodology and the resolution of related RAIs 7.1-86 and 7.1-102.

Following is a summary of how issues related to the setpoint methodology affected the review of GTS channel calibration SRs and the presentation of instrumentation limiting safety system settings (LSSS) in the GTS to satisfy the requirements of 10 CFR 50.36(c)(1)(ii)(A).

In RAI 7.2-36, the staff requested that GEH clarify that the analytical limits, from which the instrumentation trip settings are determined, are based on the ESBWR accident analysis, and not on "typical analytical limits," as implied by Tables 7.2-2 and 7.2-3 of DCD, Tier 2, Revision 1. In its response dated February 12, 2007, and in DCD Revision 3 GEH provided the requested clarification. As described below, the staff subsequently sent GEH a supplement to this RAI.

<u>RAI 16.2-25</u>. The staff asked GEH to revise Revision 1 of the GTS instrumentation TS to adopt the NRC-approved version of TSTF-493, "Clarify Application of Setpoint Methodology for LSSS Functions." Once the NRC staff approves this STS generic change, it will provide resolution of regulatory and technical issues regarding LSSS during periodic testing and calibration of instrument channels. In its response dated, November 13, 2006, GEH committed to address incorporation of TSTF-493 to the extent practicable, based on the ESBWR design and setpoint methodology, in a future revision of DCD Chapters 16 and 16B, following approval of TSTF-493 by the NRC. Based on this commitment, therefore, RAI 16.2-25 is resolved.

In Revision 2 of the DCD, GEH proposed to add a SCP specification to GTS Section 5.5 that would require use of an NRC-approved setpoint methodology to determine the various instrumentation setting acceptance criteria, which must be satisfied to meet channel calibration SRs, and which would be maintained in a licensee-controlled document outside the TS. The proposed SCP specification also contained the technical content of STS instrumentation function table footnotes, which had been included in TSTF-493 to address performance of channel calibration SRs. In conjunction with the addition of a SCP specification, GEH revised the GTS instrumentation function tables to identify the instrumentation function analytical limits or design limits under the heading "setting basis," instead of stating the allowable values. In addition, GEH revised the channel calibration SRs to reference the SCP specification (this also included channel calibration SRs in GTS sections other than Section 3.3). These changes reflected ongoing discussions between the NRC and the TSTF regarding TSTF-493; DCD Revision 3 retained these changes.

Before receipt of DCD Revision 2, however, the staff had sent GEH a supplement to RAI 7.2-36 which requested that GEH provide the following information for each instrumentation function:

1. Documentation, with example calculations, of the methodology for determining the limiting and nominal trip setpoints (LTSP and NTSP), acceptable as-found and as-left settings, and the analytical limit or other limiting design values, including the sources of these values.

2. A statement as to whether the instrumentation setting is for a variable on which a safety limit (SL) has been placed (SL-related settings).

3. A description of whether and how GEH will adopt in the ESBWR GTS the setpoint-related TS provisions for SL-related instrumentation functions, contained in a letter from the NRC to the Nuclear Energy Institute (NEI) dated September 7, 2005 (ADAMS Accession No. ML052500004); this includes a description of how as-found settings will be evaluated during surveillances, and the controls to ensure that the instrument as-left setting at the conclusion of the surveillance is consistent with the setpoint methodology.

4. For non-SL-related instrumentation, a description of the measures to be taken to ensure that the instrument channel is capable of performing its specified safety functions in accordance with applicable design requirements and associated analyses; this will include a description of the controls to ensure that the instrument as-left setting at the conclusion of the surveillance is consistent with the setpoint methodology and the corrective action process for restoring channels to operable status.

In its response dated May 15, 2007, GEH (1) stated that ESBWR setpoints are calculated by NEDC-31336P-A, the latest NRC-approved General Electric setpoint methodology, and described its use, with sample calculations; (2) identified all SL-related instrumentation functions; (3) committed to adopt the latest NRC guidance regarding the additional TS provisions for instrumentation settings; and (4) provided the information requested regarding non-SL-related instrumentation functions. As noted above, GEH proposed an updated setpoint methodology in October 2007 in NEDE-33304P. Therefore, regarding the response to Item (1), the staff concluded that GEH intends to calculate instrumentation settings using NEDE-33304P, once approved by the NRC staff, and not NEDC-31336P-A. Therefore, RAI 7.2-36 is resolved based on the information in the applicant’s responses. In addition, the staff transferred resolution tracking of SCP specification issues to RAI 16.2-156 and setpoint methodology issues to RAI 7.1-102.

In its response to Supplement 1 to RAI 7.2-36 in letter dated May 15, 2007, GEH also stated that it would specify the AV in the GTS for each instrumentation function and remove the proposed SCP specification. DCD Revision 4 (issued September 2007), however, did not include these changes.

In DCD Revision 5, GEH replaced the “setting basis” with the AV in the GTS for each instrumentation function according to its followup response to RAI 7.2-36, Supplement 1 in a letter dated January 16, 2008. However, GEH retained the SCP specification (with changes based on its response to RAI 16.2-156, Supplement 1) to satisfy the provisions of 10 CFR 50.36(c)(1)(ii)(A). Stating AVs in the TS is potentially less burdensome than stating NTSPs because AVs are anticipated to change much less frequently than NTSPs and consequently could result in fewer setpoint-related license amendments over the life of the facility. However, the staff took the position in RIS 2006-17 that the NTSP (equivalent to

ESBWR $NTSP_F$) values are the LSSS required to be included in the TS by 10 CFR 50.36(c)(1)(ii)(A). If a SCP specification is written with suitable compliance language so that it has sufficient regulatory force, then the staff may conclude that the GTS satisfy 10 CFR 50.36(c)(1)(ii)(A), even though the LSSS values (NTSP values) would be maintained in a licensee-controlled document outside the TS.

RAI 16.2-156. In RAI Letter 134, dated January 14, 2008 (based on DCD Revision 4), the staff requested GEH to revise the GTS LCO instrumentation function tables to include the type of instrumentation setting values that are consistent with the ABWR/ESBWR setpoint methodology. RAI 16.2-156 was being tracked as an open item in the SER with open items. In its response dated February 8, 2008, GEH stated that it had previously changed the GTS to state the AVs in its followup response to RAI 7.2-36, Supplement 1 in letter dated January 16, 2008.

The staff decided that 10 CFR 50.36(c)(1)(ii)(A) could allow the $NTSP_F$ values to be maintained in a licensee-controlled document outside the TS, provided the SCP specification contained provisions ensuring adequate TS control of those values. Subsequently, the staff sent GEH Supplement 1 to RAI 16.2-156 that described the necessary program provisions and included an example of a SCP specification acceptable to the NRC staff. (Note: RAI 16.2-156, Supplement 1, superseded RAI 7.2-36 regarding SCP specification issues.)

IIn response to RAI 16.2-156, Supplement 1, GEH had moved some of the provisions in the staff's example SCP specification to a reviewer's note in DCD Section 16.0. A reviewer's note states any necessary conditions for site-specific implementation of a bracketed TS provision. As noted in Section 16.2.0 of this report, GEH provided a reviewer's note in DCD Table 16.0-1-A for every COL item in the GTS and bases. The FSAR associated with a COL will not retain the reviewer's notes, as well as the listing of COL items. Because of this, the staff considered the applicant's decision to place some of the provisions of the proposed SCP in a reviewer's note to be unacceptable.

In RAI 16.2-156, Supplement 2 the staff requested that GEH revise its proposed SCP specification to conform to a second example SCP specification, in which the staff had incorporated some but not all of the GEH suggestions. In its response dated October 31, 2008, GEH incorporated all of the provisions in the staff's second example SCP, except for those previously relegated to the reviewer's note.

In a third supplement to RAI 16.2-156, the staff proposed that (1) the contested provisions be retained as bracketed items in the SCP specification and (2) the reviewer's note state that a COL applicant may choose to either remove the brackets or incorporate the bracketed information in the NRC-approved setpoint methodology document. The staff also insisted that the licensee trend as-found settings for each instrument channel regardless of whether they are less conservative than the predetermined as-found tolerance (AFT). In its response dated February 3, 2009, GEH adopted the staff's proposal except for the creation of two COL items. The applicant's proposal retained the provision regarding the comparison of the as-found setting with the $NTSP_F$ in the reviewer's note for GTS 5.5.11, which specifies that this provision be incorporated into the NRC-approved setpoint methodology. This is acceptable to the staff because the SCP specification requires (1) calculating the AFT and the as-left tolerance (ALT) in conformance with the NRC-approved setpoint methodology and (2) comparing the as-found setting with the previous as-left setting or the $NTSP_F$ during channel calibration surveillance. The applicant's proposal also moved the provision regarding trending and evaluating the difference between the as-found setting and the previous as-left setting or the $NTSP_F$ from the reviewer's note to the SCP specification. The staff finds this is acceptable because specifying this provision in GTS 5.5.11 will ensure that the instrument channel is functioning in accordance with its design basis. With these revisions, the staff concludes that GTS 5.5.11 satisfies the LSSS requirements of 10 CFR 50.36(c)(1)(ii)(A). Therefore, RAI 16.2-156 is resolved.

DC/COL-ISG-8. In its letter dated February 24, 2009, regarding DC/COL-ISG-8, GEH proposed deleting all GTS references to AVs because AVs would be determined and maintained in a document outside the TS in accordance with the SCP specification. (See Section 16.2.0 of this report for additional information concerning completion of COL information.) Based on the resolution of RAI 16.2-156, this change is acceptable because the SCP specification will ensure adequate TS control of the AVs, as well as the other instrumentation setting criteria.

RAI 16.2-145. In this RAI, the staff stated that instrumentation channel operability that is based on AVs, predefined AFT bands, and ALT bands, as specified in the GTS for the ESBWR, is applicable only to analog protection systems using bistables. For the ESBWR digital protection systems, setpoints are controlled in the GTS. The GTS require that the NTSP, embedded in the digital protection system, be equal to or conservative with respect to the LSSS. The staff requested that GEH provide documentation to show that the GTS will require surveillances to verify operability of the critical functions using (1) internal diagnostic methods that can monitor the "health" of different processors/memory boards and perform software checks to ensure that the proper software is executing and (2) power-up tests (e.g., RAM, EPROM) and error checking on the data links, as well as tests by a transmitting channel, to ascertain that the transmitted signal has been properly received by the receiving channels during the CFT. The staff requested this information to understand how the proposed SCP specification will ensure that the requirements of 10 CFR 50.36(c)(1)(ii)(A) are met. RAI 16.2-145 was being tracked as an open item in the SER with open items.

In its response dated April 21, 2008, GEH proposed changes to DCD, Tier 2, Chapter 7, information regarding the distributed control and information system (DCIS), specifically in DCD Sections 7.1.3.4, "Q-DCIS Testing and Inspection Requirements," and 7.1.5.4, "N-DCIS Testing and Inspection Requirements." These changes included adding references to specific Q-DCIS hardware platforms (e.g., NUMAC, TRICON); descriptions of DCIS online self-diagnostic features; descriptions of the N-DCIS technical specifications monitor (TSM); and descriptions of Q-DCIS SRs for frequent monitoring for gross channel failure (channel checks), periodic confirmation of actuation settings (channel calibrations), and the overall functioning of all the devices in the system (CFT, LSFT, response time test). In its response, GEH stated that, "The basic [instrumentation] operability requirements and objectives of the Limiting Safety System Settings (LSSS) are not unique to digital protection systems compared to analog protection systems using bistables." The staff found that the additional information clarified the overall approach to Q-DCIS testing, but was insufficient to determine the acceptability of using self-diagnostic features to meet SRs because it did not include digital platform-specific operational experience and test data to support using self-diagnostic features to meet SRs .

In its response to RAI 16.2-145, GEH also proposed relaxing surveillance frequencies for Q-DCIS instrumentation channel checks to 24 hours and CFTs to 24 months based on the capabilities of the online self-diagnostic features to continually support the objectives of these surveillances. However, the staff determined that it had insufficient design information regarding the online self-diagnostic features to accept the proposed surveillance frequency relaxations based on the use of online self diagnostics to meet channel check and CFT SRs. In a supplement to RAI 16.2-145, the staff requested that GEH revise these surveillance frequencies to be consistent with the BWR/6 STS.

In its response to RAI 16.2-145, Supplement 1, in a letter dated February 3, 2009, GEH proposed to revise the surveillance frequencies for channel checks and CFTs for Q-DCIS instrumentation functions to be consistent with the BWR/6 STS. These changes are acceptable because the SR frequencies for channel checks and CFTs are consistent with the STS frequencies for equivalent instrumentation functions. Table 16-7 lists these frequencies for each instrumentation function, which are discussed in Sections 16.2.6.4.1 and 16.2.6.4.2 of this report.

GEH also proposed the following changes:

- Replace specific references to Q-DCIS hardware platforms with “safety-related platforms” in DCD Section 7.1.3.4.

- Revise the description of the scope of a CFT contained in DCD Section 7.1.3.4 and the bases for GTS Section 3.3 to include the “sensor input through the digital trip module (DTM) function,” but not the logic output contact.

- Revise the description of the scope of the LSFT contained in DCD Section 7.1.3.4 and the bases for GTS Section 3.3 to include “all logic components required for operability of a logic circuit, from as close to the sensor as practicable up to, but not including, the actuated device.”

- Replace “instrument” with “logic processor or logic function” to describe self-diagnostics, internal clocks, and cycle in the discussion of response time testing in DCD Section 7.1.3.4.

In summary, logic portions of the Q-DCIS are tested in accordance with SRs for response time tests and LSFTs, which are included in “actuation” specifications. Instrumentation portions (sensor channels) of the Q-DCIS are tested in accordance with SRs for channel checks, CFTs, and channel calibrations, which are included in “instrumentation” specifications. Response time testing is also specified for sensor channel functions, where appropriate. The staff finds that these changes are acceptable because they are consistent with the definitions of instrumentation surveillances, which are specified in GTS Section 1.1 and the DCIS design, as described in DCD, Tier 2, Section 7. GEH also proposed other changes to the GTS Section 3.3 SRs as follows:

- Add SR 3.3.1.6.3, channel check of required SRNM channels during operation in Modes 3, 4, and 5 once per 24 hours, to be consistent with the equivalent STS SR 3.3.1.2.3, which also has a 24-hour frequency and applies during operation in equivalent BWR/6 Modes 3 and 4.

- Remove channel check from GTS 3.3.2.1 because the equivalent STS 3.3.2.1 does not specify a channel check for control rod block instrumentation.

- Revise SR 3.3.1.3.1 to require a CFT only for manual scram function channels, with a 7-day frequency, consistent with the equivalent STS SR 3.3.1.1.5.

- Add SR 3.3.1.3.2 to require a CFT for the reactor mode switch—shutdown position function with a frequency of 24 months, consistent with the equivalent STS SR 3.3.1.1.10.

- Add SR 3.3.1.4.4 to require a CFT once every 92 days for NMS instrumentation Functions 2.b, 2.c, 2.d, and 3, consistent with the equivalent STS SR 3.3.1.1.7. Note: The frequency was changed to 31 days in DCD Revision 6 based on the response to Supplement 2 of RAI 16.2-145.

- Add SR 3.3.1.6.6 to require a CFT once every 31 days for SRNM channels during operation in Modes 3, 4, and 5, consistent with the equivalent STS SR 3.3.1.2.6 which also has a 31-day frequency and applies during operation in the equivalent BWR/6 Modes 3 and 4.

These changes are acceptable because they are consistent with the equivalent STS SRs, as noted.

The staff noted that the discussions in DCD Chapter 7 concerning Q-DCIS testing and the discussions in the GTS Section 3.3 bases regarding CFTs appeared to imply that use of online self-diagnostics of the safety-related platforms would be required in the performance of SRs on Q-DCIS instrumentation. The staff concluded that this is not an issue for the following reasons, based on information included in the DCD:

- Inspection, Test, Analysis, and Acceptance Criterion (ITAAC) Item 13.a in DCD, Tier 1, Revision 6, Table 2.2.15-2, "ITAAC For IEEE Std. 603 Compliance Confirmation," addresses IEEE Standard 603, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations—Description," Criterion 5.10, "Repair," and states the following:

    > The software projects have self-diagnostic features that facilitate the timely recognition, location, replacement, repair, and adjustment of malfunctioning equipment.

    The acceptance criterion for this item states the following:

    > The software project design phase summary baseline review records (BRR) confirm that the software project self-diagnostic functions locate failure to the component level. {{Design Acceptance Criteria}}

    The staff notes that completion of ITAAC Item 13.a will involve verification of the implementation of Branch Technical Position 7-17, "Guidance on Self-Test and

Surveillance Test Provisions," which will enable the staff to determine the acceptability of using the self-diagnostic feature of the digital instrumentation platforms, which have been chosen by the ESBWR COL holder, as a tool for performing channel checks and CFTs on ESBWR PTS-required instrumentation functions. In order for a COL applicant to revise the FSAR and GTS bases to permit use of self-diagnostic features it must first obtain NRC approval of an exemption from the ESBWR design certification rule. The staff finds that this change process will ensure that an adequate technical basis is established before self-diagnostic features are allowed to be credited as a tool for performing channel checks and CFTs.

- Chapter 7 and the GTS bases in the DCD, and Chapter 7 and the PTS bases in a plant-specific FSAR will not allow crediting the self-diagnostic feature of the digital instrumentation platforms as a tool for performing channel checks and CFTs on ESBWR TS-required instrumentation functions, without first departing from the design certification rule or revising the licensing basis as previously described.

- The PTS definitions of channel check and CFT for an ESBWR COL are expected to match the ESBWR GTS definitions, which match the definitions in the BWR/6 STS. These definitions do not describe the tools used to perform these surveillances.

Based on the evaluation of the applicant's response to RAI 16.2-145, Supplement 2, in Section 16.2.6.4.2 of this report, as well as the above information, RAI 16.2-145 is resolved.

RAIs 16.2-152, 16.2-153, and 16.2-154. The staff requested GEH to do the following because the GTS bases appeared to lack sufficiently detailed information:

- Add information to GTS bases for instrumentation requirements to identify all devices in the channel required to be tested by a CFT for each GTS instrument function.

- Add information to GTS bases for instrumentation requirements to define logic circuit and identify the logic circuit devices tested by LSFT.

- Identify all ESBWR instrumentation devices in DCD Tier 2 that GTS require to be operable to ensure the LCO-specified safety function can be met.

- Show that ESBWR GTS-required testing and calibration will ensure the necessary quality of instrumentation devices is maintained.

RAIs 16.2-152, 16.2-153, and 16.2-154 were being tracked as open items in the SER with Open Items.

In its response to these RAIs in a letter dated April 21, 2008, GEH did not propose adding details to the bases for GTS Section 3.3 to identify all devices in the channel tested by a CFT, all logic circuit devices tested by a LSFT, and all instrumentation devices necessary for the LCO-specified safety function. The requested level of detail is contained in the DCD and its addition to the bases would result in a greater level of detail than that contained in the bases for STS Section 3.3. GEH also stated that the changes to the information in DCD, Tier 2, Chapter 7, regarding the Q-DCIS in DCD Section 7.1.3.4, "Q-DCIS Testing and Inspection Requirements," and associated changes to the bases for GTS Section 3.3, which were made in response to RAI 16.2-145, indicate that testing and calibration, in accordance with the TS, will maintain the necessary quality of instrumentation devices. Based on the resolution of RAI 16.2-145, the staff concurs with these statements and finds the GEH responses to these RAIs acceptable. Therefore, RAIs 16.2-152, 16.2-153, and 16.2-154 are resolved.

RAI 16.2-146. The staff requested that GEH define the terms "nominal trip setpoint," "allowable value," "as-found tolerance band," and "leave alone tolerance band," which proposed GTS 5.5.11, "Setpoint Control Program (SCP)," requires establishing and documenting using a specified setpoint methodology for TS-required automatic protection instrumentation functions. The staff noted that channel calibration tests for such instrumentation functions must evaluate the channel to verify that it is functioning as required before returning it to service when the as-found channel setting is found to be conservative with respect to the AV, but outside its predefined AFT band. The staff also requested that GEH (1) justify why it chose these setpoint methodology terms for establishing digital protection channel operability during a channel calibration and (2) explain qualitatively what is meant by a leave alone tolerance band for a digital protection channel. The staff requested this information to understand how the proposed SCP will ensure that the requirements of 10 CFR 50.36(c)(1)(ii)(A) are met. RAI 16.2-146 was being tracked as an open item in the SER with open items.

In its response dated November 12, 2007, the applicant revised its proposed SCP specification to require documentation of the $NTSP_F$, AV, AFT, and ALT for each TS-required automatic protection instrumentation function in the GTS and to require that they be calculated in accordance with the NRC-approved setpoint methodology. The staff reviewed the proposed setpoint methodology presented in NEDE-33304P, Revision 1, "GEH ABWR/ESBWR Setpoint Methodology," issued November 2008, as a part of the ESBWR design certification. Because the staff's review of the setpoint methodology is being tracked under RAI 7.1-102, and the review of the SCP specification is being tracked under RAI 16.2-156, the staff considers RAI 16.2-146 to be resolved.

RAI 16.2-149. The staff requested that GEH provide an analysis to show that elements of the proposed SCP specification are sufficient to ensure that the requirements of 10 CFR 50.36(c)(3) will be met, including an appropriate basis for the setpoint design basis (setting basis) for each instrumentation function with a specified instrument calibration performed in accordance with the SCP. RAI 16.2-149 was being tracked as an open item in the SER with open items. In its response dated November 12, 2007, the applicant revised its proposed SCP specification and setpoint methodology (NEDE-33304P), which it stated contains the requested analysis. The applicant also highlighted ITAAC #10 in DCD, Tier 1, Table 2.2.15-2, which requires the performance of inspections, tests, and analyses to verify that the instrumentation settings for safety-related functions are defined, determined, and implemented based on the approved setpoint methodology. As stated in the discussion of RAI 16.2-146, the staff's review of the setpoint methodology is being tracked under RAI 7.1-102, and the review of the SCP specification is being tracked under RAI 16.2-156. Therefore, RAI 16.2-149 is resolved.

16.2.6.6 Summary Conclusion for Instrumentation Specifications

Section 3.3 of the ESBWR GTS regarding safety-related instrumentation systems implements modified versions of the STS associated with the equivalent safety functions. These specifications conform to the format and usage rules of the STS and are functionally equivalent to those in the STS. As explained previously, the staff finds that the ESBWR design differences justify GEH's decision not to specify LCOs for the STS instrumentation system functions noted above. The NRC staff considers the ESBWR instrumentation GTS and bases to be acceptable because the specifications will ensure that the designated instrumentation systems are capable of performing their intended safety functions, as assumed in the safety analyses, in the event of a DBA or transient.

16.2.7 ESBWR GTS Section 3.4, "Reactor Coolant System"

The ESBWR RCS specifications correspond to those in the STS, as follows:

STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.4.1*	None	(*Recirculation Loops Operating)
3.4.2*	None	(*Flow Control Valves)
3.4.3*	None	(*Jet Pumps)
3.4.4*	3.4.1	Safety Relief Valves (*Safety/Relief Valves)
3.4.5*	3.4.2	RCS Operational Leakage (*same)
3.4.6*	None	(*RCS Pressure Isolation Valve Leakage)
3.4.7*	3.3.4.1	RCS Leakage Detection Instrumentation (*same)
3.4.8*	3.4.3	RCS Specific Activity (*same)
3.4.9*	None	(*Residual Heat Removal Shutdown Cooling System—Hot Shutdown)
3.4.10*	None	(*Residual Heat Removal Shutdown Cooling System—Cold Shutdown)
3.4.11*	3.4.4	RCS Pressure and Temperature (P/T) Limits (*same)
3.4.12	3.4.5	Reactor Steam Dome Pressure (*same)

Section 3.4 in the ESBWR GTS is similar to the corresponding STS for the RCS for SRVs, RCS operational leakage, RCS leakage detection instrumentation, RCS specific activity, RCS pressure and temperature (P/T) limits, and reactor steam dome pressure. The ESBWR design does not include certain systems associated with previous BWRs, and the following paragraphs discuss these deviations and exclusions from the STS.

The ESBWR design has no recirculation loops with recirculation pumps, flow control valves, or jet pumps; hence, the GTS contain no LCOs for these BWR/6 systems.

The ESBWR GTS do not include an LCO corresponding to STS 3.4.6 for RCS pressure isolation valve (PIV) leakage. RCS PIVs are defined as any two normally closed valves in series within the RCPB. The function of RCS PIVs is to separate the high-pressure RCS from an attached low-pressure system to protect the RCS pressure boundary. As discussed in DCD, Tier 2, Chapter 3, Appendix 3K, "Resolution of Intersystem Loss of Coolant Accident," the periodic surveillance and leak rate testing requirements for high-pressure to low-pressure isolation valves is not applicable to the ESBWR because the design does not contain a PIV between the RCPB and a low-pressure piping system.

The ESBWR GTS do not contain an LCO for the dual purpose RWCU/SDC system. This system most resembles the BWR/6 residual heat removal shutdown cooling system but is not designated as safety related and satisfies none of the four criteria of 10 CFR 50.36(c)(2)(ii). The combination of the ICS, the GDCS, and the passive containment cooling system (PCCS) performs the safety-related DHR functions in the ESBWR design.

RAI 16.2-119. The staff asked the applicant to provide an analysis that explicitly assumes that just one SRV functions in order for the GTS LCO 3.4.1 to require just two SRVs to be operable. In its response to RAI 21.6-91, the applicant stated, "Changes to DCD, Tier 2, Figure 5.2-4 will be made in response to this RAI. Figure 5.2-4 will be updated based on the result of a TRACG analysis that uses the following input files: MSIVF_EOC_NOFW.INP and SCRAM_PRESS_8GROUPS.TDT."

In a supplement to this RAI (sent by e-mail dated July 3, 2007), the staff stated that, since the applicant proposes in GTS LCO 3.4.1 to rely on only one SRV for overpressure protection, it should verify that the input files used to generate Figure 5.2-4 credit only one SRV. In addition, the staff asked the applicant to correct the apparent discrepancy between the last sentence of the first paragraph of DCD, Tier 2, Section 5.2.2.3.3, where it states that the [full open] flow through three SRVs (not one) is needed to mitigate the MSIV closure with high neutron flux scram event. RAI 16.2-119 was being tracked as an open item in the SER with open items.

In its response dated March 31, 2008, GEH stated the following:

> The TRACG analysis that credits the capacity of only 1 SRV for over pressure protection has been performed with the input file MSIVF_EOC_NOFW.INP and kinetics file SCRAM_PRESS_8GROUPS.TDT. The input file was modified to simulate the SRV capacity change from approximately 3 SRVs to that of 1 SRV. A replacement for Figure 5.2-4 has been generated for inclusion in the DCD, but has been changed to Figure 15.5-11 as the analysis for the MSIV closure with flux scram event is now described in Section 15.5.1.1 of the DCD. The analysis resulted in no change in the maximum reactor vessel pressure and demonstrates that 1 SRV is sufficient to mitigate the reactor vessel pressure response.

The staff verified that DCD Revision 6 incorporated the described changes to the Chapter 15 analyses. Based on the applicant's response and changes to the DCD, RAI 16.2-119 is resolved.

RAI 16.2-2. The staff requested that the applicant provide a technical justification for relaxing the 8-hour frequency of STS SR 3.4.2.1, which calls for verifying RCS unidentified and total leakage, to a 12-hour frequency in GTS SR 3.4.2.1. In its response dated August 21, 2006, the applicant referenced the guidance provided in GL 88-01, Supplement 1, "NRC Position on Intergranular Stress Corrosion Cracking (IGSCC) in BWR Austenitic Stainless Steel Piping," dated February 4, 1992, which states that monitoring RCS leakage every 4 hours creates an unnecessary administrative hardship for plant operators. The proposed 12-hour frequency of ESBWR SR 3.4.2.1 is acceptable based on guidance in GL 88-01, Supplement 1, which allows RCS leakage measurements to be taken once per shift, not to exceed 12 hours. Therefore, RAI 16.2-2 is resolved.

RAI 16.2-121. The NRC staff noted that ESBWR GTS 3.4.3 for RCS specific activity conforms to STS 3.4.8, except that it does not specify an option for placing the plant in hot shutdown within 12 hours and cold shutdown (or stable shutdown) within 36 hours in lieu of isolating all MSLs within 12 hours. Failure to include this option in ESBWR GTS 3.4.3 reduces the operational flexibility for removing decay heat under conditions requiring MSLI with a substantial previous power history. The bases for the equivalent STS 3.4.8 allow the option of placing the plant in Mode 3 within 12 hours and Mode 4 within 36 hours for those instances in which MSLI is not desired (e.g., because of the decay heat loads). In STS Mode 4, cold shutdown, the requirements of the LCO are no longer applicable. ESBWR GTS 3.4.3 should include the option of being in Mode 3 within 12 hours and in Mode 5 within 36 hours. If the option will not be used, the staff asked the applicant to discuss the anticipated DHR methodology (i.e., ICS, FAPCS) in the event the MSLs are isolated and a substantial previous power history exists. The staff presented this issue to the applicant in RAI 16.2-121. In its response dated July 23, 2007, the applicant committed to revise GTS 3.4.3, Action B, to include the option of placing the unit in Mode 5. In DCD Revision 4, shutdown actions were added to Action B of GTS 3.4.3 as an option to isolating all MSLs. Therefore, RAI 16.2-121 is resolved. However, in DCD Revision 5, GEH revised (1) the applicability of GTS 3.4.3 by removing the condition "with any main steam line not isolated" and (2) Action B of GTS 3.4.3 by removing the action to "isolate all main steam lines," leaving only the actions to be in Mode 3 within 12 hours and Mode 4 within 36 hours, while determining the Dose Equivalent Iodine-131 once every 4 hours. In the table entitled, "Chapter 16 Changes from Revision 4 to Revision 5," which GEH submitted with DCD Revision 5, the applicant stated in Items 210 and 211 that these changes were made for "consistency with DCD dose consequences results." With these changes, GTS 3.4.3 will be applicable in Modes 1, 2, 3, and 4, regardless of the isolation state of any MSL, and will require a unit shutdown to Mode 5 in the event Dose Equivalent Iodine-131 is not restored to within 0.2 µCi/gm within the specified Completion Time of 48 hours or exceeds 4.0 µCi/gm. Since these provisions are more restrictive on unit operation, the staff finds them acceptable.

ESBWR GTS 3.4.4, for the RCS P/T limits, in conjunction with GTS 5.6.4, "RCS Pressure and Temperature Limits Report (PTLR)," conforms to STS 3.4.11 and STS 5.6.6, except that the SRs associated with recirculation pumps are omitted since these pumps are not in the ESBWR design. The P/T limits are not derived from DBA analyses, but are prescribed during normal operation to avoid encountering pressure, temperature, and temperature rate of change conditions that might cause undetected flaws to propagate and cause nonductile failure of the RCPB. In operating BWR designs, the determination that reactor recirculation loop and vessel component differential temperatures are within the applicable Pressure and Temperature Limits Report (PTLR) limits before changing reactor recirculation flow ensures that thermal stresses will not exceed design allowances. The ESBWR design is similar to that of the operating BWRs, except that the design does not include recirculation pumps and associated piping. Reactor coolant circulation through the ESBWR core is accomplished by means of natural circulation, and flow is dependent on the difference in water density between the downcomer region and the core region. Therefore, the ESBWR GTS 3.4.4 does not require surveillances associated with starting recirculation pumps or unisolating reactor recirculation loops and is acceptable.

ESBWR GTS 3.4.5, for reactor steam dome pressure, conforms to STS 3.4.12 and is therefore acceptable.

The ESBWR GTS for the RCS implement modified versions of the STS for the RCS. The staff finds that these specifications are essentially equivalent to those in the STS for the applicable RCS functions. For cases in which the applicant has not included GTS requirements equivalent to STS requirements, ESBWR design differences provide sufficient justification for such omissions. Therefore, based on the resolution of the RCS-related RAIs and the preceding evaluations, the GTS and bases for the RCS are acceptable.

16.2.8 ESBWR GTS Section 3.5, "Emergency Core Cooling Systems (ECCSs)"

The ESBWR uses a passive ECCS rather than the pump-driven, active ECCS of currently operating plants, which is the basis for the STS ECCS requirements. The safety-related ECCS is designed to perform emergency core cooling and DHR, reactor coolant emergency makeup, and safety injection. The ECCS consists of the ADS, the GDCS, and the ICS. The GTS for the ESBWR ECCS generally correspond to the STS for the ECCS, as follows:

STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.5.1*	3.5.1	ADS (*ECCS—Operating)
3.5.1*	3.5.2	GDCS—Operating (*ECCS—Operating)
3.5.2*	3.5.3	GDCS—Shutdown (*ECCS—Shutdown)
3.5.1*	3.5.4	ICS—Operating (*ECCS—Operating)
3.5.2*	3.5.5	ICS—Shutdown (*ECCS—Shutdown)
3.5.3*	None	(*Reactor Core Isolation Cooling (RCIC) System)

The ESBWR design does not include an active system corresponding to the reactor core isolation cooling (RCIC) system. The ESBWR design does not include a safety-related high-pressure ECCS. Instead, the design provides redundant systems and makeup water supplies to depressurize and reflood the reactor vessel following a LOCA. The ICS is designed to passively remove decay heat with the RCS pressurized.

A combination of the GDCS, the ADS, the SLC system, and the ICS provides the ECCS function. The ECCS is designed to flood the core and provide core cooling following a LOCA. By providing core cooling following a LOCA, the ECCS, in conjunction with the containment, limits the release of radioactive materials to the environment. The functional requirements (e.g., coolant delivery rates) are such that the system performance under all LOCA conditions postulated in the design satisfies the requirements of 10 CFR 50.46. The ECCS is designed to provide protection for any primary system line break up to and including the double-ended break of the largest line; require no operator action until 72 hours after an accident; and ensure a sufficient water source, including the necessary piping and other hardware, such that the containment and reactor core can be flooded for core DHR following a LOCA.

Automatic Depressurization System

The ADS provides reactor depressurization capability in the event of a pipe break. The depressurization function is accomplished through the use of SRVs and DPVs. The ADS is an integral part of the ECCS because GDCS flow to the RPV requires the RPV to be close to containment pressure. The ADS is designed to depressurize the RPV following indication of a LOCA. The ADS consists of 8 squib-actuated DPVs and 10 SRVs that are configured to function as ADS valves (relief mode) in addition to functioning as spring-loaded safety valves (safety mode) to satisfy LCO 3.4.1. The 10 dual-function SRVs are pneumatically actuated when functioning as ADS valves using energy stored in nitrogen accumulators. (Note: The eight SVs are not required to be operable by any LCO.)

Gravity-Driven Cooling System

The GDCS provides flow to the annulus region of the reactor through dedicated nozzles. It provides gravity-driven flow from three separate water pools located within the drywell at an elevation above the active core region. It also provides water flow from the suppression pool to meet long-term, post-LOCA core cooling requirements. The system provides these flows by gravity forces alone (without reliance on active pumps) once the reactor pressure is reduced to near containment drywell pressure.

The three subsystems of the GDCS are the GDCS short-term cooling (injection subsystem); the GDCS long-term cooling (equalizing subsystem); and the GDCS deluge subsystem. Three GDCS pools, located above the wetwell at an elevation above the reactor core, contain the water that supports all four GDCS trains for the injection, equalizing, and deluge subsystems. The GDCS injection subsystem is capable of refilling the RPV following a LOCA after the RPV is depressurized by the ADS. The GDCS equalizing subsystem provides long-term, post-LOCA water makeup by connecting the annulus region of the reactor to the suppression pool. The GDCS deluge subsystem is used to dump water from the GDCS pools to the lower drywell in the event of a severe accident. The Availability Control Manual (ACM) in Section 19A of the DCD addresses the availability requirements for the GDCS deluge subsystem, which is not included in the GDCS LCO. Section 22.5 of this report evaluates the RTNSS controls of the ACM.

GDCS injection and equalizing subsystems are required to be operable in Modes 1, 2, 3, and 4 when there is considerable energy in the reactor core and core cooling may be required to prevent fuel damage following a LOCA. GDCS operability requires eight branch lines of the injection subsystem (i.e., all four injection trains) and four trains of the equalizing subsystem. Operability of the squib-actuated GDCS valves requires electrical continuity of redundant explosive charge firing circuits to each valve. However, one squib charge firing circuit may be bypassed intermittently for required testing or maintenance. Operability of each GDCS branch line requires that the water level in the associated GDCS pool be within specified limits. All GDCS RPV block valves, GDCS pool block valves, and suppression pool block valves must be locked open.

Two GDCS trains are required to be operable in Modes 5 and 6 to provide additional water inventory inside the containment to respond to a loss of non-safety-related DHR capability or a loss of reactor coolant inventory. Loss of DHR capability could result from a loss of RWCU/SDC, a loss of reactor component cooling water, a loss of plant service water, or a loss of preferred power. Loss of reactor coolant inventory could result from pipe breaks in the RCS associated with maintenance or refueling, misalignment of systems connected to the RCS, or leakage during replacement of CRD assemblies.

Isolation Condenser System

The ICS provides additional liquid inventory upon opening of the condensate return valves and initiating system operation. The ICS actuates automatically following RPV isolation and transfers sufficient heat from the RPV to the IC/PCCS pool to prevent SRV actuation. The ICS is designed to remove sufficient decay heat following RPV isolation to cool the reactor to safe-shutdown conditions within 36 hours and maintain the reactor in a safe condition for an additional 36 hours with minimal loss of RCS inventory. The ICS also provides water inventory to the RPV at the start of a LOCA and provides the initial RPV depressurization following a loss of feedwater, which allows ADS initiation to be delayed. The ICS is also assumed available to respond to a station blackout (SBO) and an anticipated transient without scram (ATWS).

The ICS consists of four independent trains. Each ICS train includes a heat exchanger (i.e., the isolation condenser (IC)), a steam supply line that connects the top of the IC to the RPV, a condensate return line that connects the bottom of the IC to the RPV, a high-point purge line, and vent lines from both the upper and lower headers of the IC. The ICs are located above the containment and are submerged in a large pool of water (the IC/PCCS pool) that is at atmospheric pressure. Steam produced in IC/PCCS pools by boiling around the IC is vented to the atmosphere.

The two IC/PCCS inner expansion pools, the equipment pool, and the reactor well pool supply makeup water. The equipment pool and reactor well pool are normally isolated from the inner expansion pools because the equipment pool and reactor well are maintained at a higher water level than the inner expansion pools. The equipment pool is connected to each inner expansion pool by redundant flow paths—one containing a squib valve and one containing a pneumatic valve—that open automatically when there is a low level in either inner expansion pool. The equipment pool is connected to the reactor well pool through the reactor well gate, which is not installed during normal plant operation. By connecting the equipment pool and reactor well pool to the inner expansion pools, the volume of water available to the ICS and PCCS subcompartments is sufficient to support DHR for 72 hours without operator action or the need to replenish the water in the inner expansion pools.

Four ICS trains are required to be operable in Modes 1 and 2 and in Modes 3 and 4 when less than 2 hours have passed since the reactor was critical to remove reactor decay heat or provide additional RCS inventory following a LOCA, a loss of feedwater, or a reactor shutdown with isolation. In addition, in Modes 1 and 2, the ICS is required to be operable to prevent unnecessary automatic reactor depressurization or SRV actuation following RPV isolation or low RPV water level events. Operation of three of the four ICS trains will limit RCS pressure enough to prevent SRV actuation. By conserving reactor water inventory following the RPV isolation, the ICS minimizes the need for automatic reactor depressurization that would be required to gain additional water inventory from low-pressure sources.

Two ICS trains are required to be operable to provide an automatic backup DHR method in Modes 3 and 4, when more than 2 hours have elapsed since the reactor was critical, and in Mode 5. Although various methods of active DHR using feed and bleed may be available, operability of two ICS trains is intended to ensure the availability of at least one highly reliable and passive automatic alternative to the RWCU/SDC system for DHR. If the normal method of

DHR is lost when in Mode 5, the two required ICS trains will automatically remove decay heat following RCS heatup and pressurization.

RAIs 16.2-32, 16.2-98, 16.2-107, and 16.2-108. In RAI 16.2-32, the staff requested that the applicant provide action requirements addressing the combinations of inoperable ADS, SRV, DPV, and GDCS, or justify not addressing these combinations. RAI 16.2-32 was being tracked as an open item in the SER with open items. In its response dated November 13, 2006, the applicant proposed to enclose the conditions, required actions, and completion times for LCOs 3.5.1 and 3.5.2 in brackets, indicating that additional analysis or justification is required before approval, until the DCD changes that provide the required justification are approved. The applicant subsequently removed the brackets from LCOs 3.5.1 and 3.5.2, Actions A through E, and proposed to base the ECCS required actions and completion times on a pending ECCS N−2 topical report, which the bases for GTS 3.5.1 and 3.5.2 would reference. In RAI 16.2-108, the staff requested that GEH submit the ECCS N−2 topical report. In RAI 16.2-98, the staff also asked GEH to clarify the bases for the actions of GTS 3.5.2. RAI 16.2-98 was being tracked as an open item in the SER with open items. In its response to RAI 16.2-98 dated August 24, 2007, GEH stated that it would bracket the actions of GTS 3.5.2 until supporting analysis is completed.

Because the scope of RAI 16.2-32 includes a request to clarify the bases for GTS 3.5.2, resolution of RAI 16.2-32 also resolves RAI 16.2-98. In RAI 16.2-107, the staff asked the applicant to explain why the action requirements of GTS 3.5.1 in DCD Revision 1 did not require reducing reactor steam dome pressure when two or more ADS SRVs or two or more DPVs are inoperable. Subsequent changes to the action requirements of GTS 3.5.1, as described in the resolution of RAIs 16.0-7, 16.2-32, and 16.2-98, removed the basis for this request and removed any reference to an ECCS N−2 topical report, as well. With these changes, RAIs 16.2-107 and 16.2-108 are resolved.

In a letter supplementing its response to RAI 16.2-32 dated May 5, 2008, the applicant proposed new action requirements, without brackets, for ADS, GDCS—Operating, and ICS—Operating and incorporated these changes into DCD Revision 5. GEH stated the following in its response:

> In DCD Revision 5, GEH is revising LCO 3.5.1, LCO 3.5.2, and LCO 3.5.4 and the supporting Bases to Required Actions based on the existing analyses described in DCD, Tier 2, Revision 4, Table 6.3-6, “Single Failure Evaluation.” This change establishes Actions and Completion Times (CTs) that require the plant be placed outside the Applicability when more than one ADS valve, more than one GDCS injection branch line, more than one GDCS equalizing train, or more than one ICS train is inoperable. Additionally, LCO 3.5.1, LCO 3.5.2, and LCO 3.5.4 are revised to require the operability of ECCS actuation by the Diverse Protection System (DPS) and add Actions when a DPS actuator is not operable. [Note; DPS actuator operability to satisfy LCO 3.5.4 for ICS was subsequently removed, as described below in the discussion of RAI 16.2-174.] Finally, the SRs for periodic verification of squib continuity were expanded to include both squib actuators and solenoid actuators and include verification that the actuators are associated with electrical divisions that are required to be operable by LCO

3.8.6, “Distribution Systems—Operating,” to assure continuity with the corresponding instrumentation support systems.

In conjunction with these changes, GEH is revising the Bases to clarify requirements for the actuators (i.e., squib initiators and solenoid valves) needed to support ECCS valve operability. Each ECCS valve has four actuators—three that are initiated by Safety System Logic and Control/Engineered Safety Features (SSLC/ESF) instrumentation and one that is initiated by the DPS. Any one of the four actuators is capable of actuating the ECCS valve. Because only three of the four safety-related electrical and instrumentation actuation divisions are required to be operable, two of the three SSLC/ESF actuators are required for ECCS valve operability. Two SSLC/ESF actuators are necessary to ensure the minimum requirements for ECCS specified in Table 6.3-6 are met if a single failure occurs in one of the three required electrical or instrumentation actuation divisions. Because all ECCS valves will still actuate when a required electrical or instrumentation division fails, minimum ECCS requirements are met even when an individual ECCS valve fails concurrently with the failure of a required electrical or instrumentation actuation division. A 14 day Completion Time for restoration of
an inoperable ADS valve, GDCS injection line, GDCS equalizing train, or ICS

train is proposed based on engineering judgment considering the low probability of the failure of a required electrical or instrumentation actuation division concurrent with a design basis event during this period.

The staff finds the above described changes to the required actions (and bases) for restoration of an inoperable ADS valve, GDCS injection line, GDCS equalizing train, or ICS train to operable status acceptable for the reasons stated in the applicant's response, and because each of these conditions corresponds to or is bounded by the worst single failure following a LOCA as shown in DCD, Tier 2, Table 6.3-6. In these conditions, minimum ECCS requirements are still satisfied even with the additional failure of a required electrical division or instrumentation actuation division. The staff finds this capability to be a sufficient basis to accept the 14-day completion time to restore an inoperable ADS valve, GDCS injection line, GDCS equalizing train, or ICS train to operable status during unit operation in Modes 1, 2, 3, and 4.

The staff finds the proposed actions, related to loss of common-mode failure protection, for the four conditions of one ADS valve with DPS initiator inoperable, two or more ADS valves with DPS initiator inoperable, one or more GDCS subsystems with one DPS initiator inoperable, and one or more GDCS subsystems with two or more DPS initiators inoperable, are acceptable for the reasons described below in the discussion of RAI 16.2-174.

In the conditions of two or more ADS valves inoperable, two or more branch lines of the GDCS injection subsystems inoperable, and two or more GDCS equalizing trains inoperable, for reasons other than inoperable DPS initiators, the minimum ECCS requirements may not be satisfied. The staff finds the proposed actions for these conditions in LCOs 3.5.1 and 3.5.2 acceptable because they require placing the unit outside the applicability of the associated LCO in a time period consistent with the capability of the unit to be placed in Mode 5 using normal shutdown procedures and without challenging safety systems.

The staff also finds the above described changes to the SRs acceptable because the proposed SRs will assure that the necessary quality of all ADS, GDCS, and ICS components is maintained, and that the associated LCOs will be met. The staff also finds the squib-valve SRs acceptable as described below in the discussions of RAI 16.2-35 and RAI 16.2-173.

However, the response failed to justify the applicant's decision not to include a condition for an inoperable injection branch line concurrent with an inoperable equalizing train in the action requirements of GTS 3.5.2 and 3.5.3. In a supplement to RAI 16.2-32, the staff asked the applicant to propose this condition and restoration actions with a 24-hour completion time, with accompanying changes to the bases. Since this issue was common to both RAIs 16.2-98 and 16.2-32, RAI 16.2-98 is considered resolved. In its response dated August 19, 2009, GEH explained that the function of the GDCS injection branch lines and the function of the GDCS equalizing trains are not impacted by degradation in the other subsystem. Since the injection and equalizing subsystem functions are designed to meet short term and long term emergency cooling needs, respectively, the staff finds that the applicant's response is accurate. Based on this, the staff concludes that no additional action requirement to address the condition of one branch line and one equalizing train concurrently inoperable is warranted. Therefore, RAI 16.2-32 is resolved.

However, in its response to RAI 16.2-32, GEH also proposed additional action requirements to address the condition of one or more ADS, GDCS, or ICS valves with DPS actuator inoperable during unit operation in Modes 1, 2, 3, and 4. The staff requested that the applicant address these additional action requirements in RAI 16.2-174.

GTS 3.5.3, "GDCS-Shutdown," is applicable during Mode 5, and during Mode 6 except with the buffer pool gate removed and water level greater than or equal to 23.0 feet over the top of the reactor pressure vessel flange. The staff finds the proposed action requirements acceptable as described in the following:

- Action A: Similar to GTS 3.5.1 and 3.5.2, a completion time of 14 days is specified (Action A) for restoring one of the six required GDCS injection branch lines, one of the two required GDCS equalizing trains, or one required ADS valve to operable status. The staff finds this completion time acceptable because the remaining operable required branch lines, required equalizing train, and required ADS valves provide sufficient RPV flooding capability to recover from a loss of decay heat removal capability, LOCA, or inadvertent vessel draindown. The 14-day completion time is also acceptable because of the low probability of an event requiring GDCS injection occurring concurrent with another failure of a GDCS branch line or equalizing train, or an ADS valve while in this condition during this time.

- Action B: In the condition of two or more of the six required branch lines inoperable, the volume from one, two, or three of the GDCS pools may be unavailable for event mitigation. Required Action B.1 proposes to permit operation for up to the 14-day completion time of Action A (plus 24 hours as permitted under the conditions described in GTS Section 1.3), provided that within 4 hours the unit ensures the capability of two methods of injecting a combined water volume equivalent to the required GDCS pool volume. The DCD shows that possible available methods include RPV injection using the CRD system from the condensate storage tank, and the FAPCS system from the suppression pool. In Modes 5 and 6 both trains of the FAPCS system are required to be available by the Availability Controls Manual (ACM) for the suppression pool cooling, alternate shutdown cooling, and low pressure coolant injection functions; each train has a separate ACM-required standby diesel generator ac power source. The 4-hour completion time is acceptable because it provides sufficient time to verify the capability of the two alternate methods of RPV makeup, and because of the low probability of an event requiring GDCS injection occurring while in this condition during this time.

- Action C: In the condition of both required branch equalizing subsystem trains inoperable, the volume from one, two, or three of the GDCS pools may be unavailable for event mitigation. Required Action C.1 proposes to permit operation for up to the 14-day completion time of Action A (plus 24 hours as permitted under the conditions described in GTS Section 1.3), provided that within 4 hours the unit ensures the capability of two methods of injecting a combined water volume equivalent to the required suppression pool volume. The DCD shows that possible available methods include RPV injection using the CRD system from the condensate storage tank, and the FAPCS system from the suppression pool. In Modes 5 and 6 both trains of the FAPCS system are required to be available by the ACM for the suppression pool cooling, alternate shutdown cooling and low pressure coolant injection functions; each train has a separate ACM-required standby diesel generator ac power source. The 4-hour completion time is acceptable because it provides sufficient time to verify the capability of the two alternate methods of RPV makeup, and because of the low probability of an event requiring GDCS injection occurring while in this condition during this time.

- Action D: In the condition of GDCS inoperable due to two or more required ADS valves inoperable, RPV venting capacity may not be sufficient to allow GDCS injection. Required Action D.2 proposes to permit operation in this condition for up to 72 hours, provided that within 4 hours RCS vent path(s) with relief capacity equivalent to the required number of ADS valves (equivalent to six DPVs) is established, which would restore capability for GDCS injection (Required Action D.1.1). Alternately, Required Action D.2 proposes to permit operation in this condition for up to 72 hours, provided that within 4 hours the unit ensures the capability of two methods of injecting a combined water volume greater than or equal to the required GDCS and suppression pool volumes (Required Action D.1.2). The DCD shows that possible available methods include RPV injection using the CRD system from the condensate storage tank, and the FAPCS system from the suppression pool. In Modes 5 and 6 both trains of the FAPCS system are required to be available by the ACM for the suppression pool cooling, alternate shutdown cooling and low pressure coolant injection functions; each train has a separate ACM-required standby diesel generator ac power source. The 4-hour completion time is acceptable because it provides sufficient time to either restore required RPV vent capacity or verify the capability of two alternate methods of RPV makeup, and because the probability of an event occurring in this condition during this time is low. The 72-hour completion time to restore the GDCS to operable status as required by LCO 3.5.3 (by restoring the required number of ADS valves to operable status) is acceptable because of the compensatory measures to either restore the GDCS injection functional capability or establish two alternate methods of RPV makeup, and because of the low probability of an event requiring GDCS injection occurring while in this condition during this time.

- Action E: In the condition of GDCS inoperable “for reasons other than Condition A, B, or C,” other reasons include insufficient water volume in one or more GDCS pools or in the suppression pool. The condition is written to capture any instances of failure to meet LCO 3.5.3 that are not addressed by Conditions A, B, and C that renders either or both of the GDCS injection and equalizing subsystems inoperable. Required Action E.2 proposes to permit operation in this condition for up to 72 hours, provided that within 4 hours the unit ensures the capability of two methods of injecting a combined water volume greater than or equal to the required GDCS and suppression pool volumes (Required Action E.1). The DCD shows that possible available methods include RPV injection using the CRD system from the condensate storage tank, and the FAPCS system from the suppression pool. In Modes 5 and 6 both trains of the FAPCS system are required to be available by the ACM for the suppression pool cooling, alternate shutdown cooling, and low pressure coolant injection functions; each train has a separate ACM-required standby diesel generator ac power source. The 4-hour completion time is acceptable because it provides sufficient time to verify the capability of two alternate methods of RPV makeup, and because the probability of an event occurring in this condition during this time is low. The 72-hour completion time to restore the GDCS to operable status as required by LCO 3.5.3 is acceptable because of the compensatory measure to establish two alternate methods of RPV makeup, and because of the low probability of an event requiring GDCS injection occurring while in this condition during this time.

- Action F: Failure to successfully accomplish any of the required actions of Conditions A, B, C, D, or E before expiration of the associated completion time is a condition in which the water inventory available for RPV injection may not be sufficient to successfully respond to a loss of decay heat removal capability, LOCA, or inadvertent vessel draindown. Required Action F.1, to immediately initiate action to suspend operations with a potential for draining the reactor vessel, is an appropriate action because it minimizes the chance of a vessel drain down event. Required Actions F.2.1 and F.2.2 are also appropriate compensatory measures because they require immediately initiating action to ensure that the reactor building refueling and pool area HVAC subsystem (REPAVS) and contaminated area HVAC subsystem (CONAVS) area isolation boundaries are, or will automatically be, established in the event of a loss of decay heat removal capability, LOCA, or inadvertent vessel draindown without sufficient vessel makeup capability. Isolation of REPAVS and CONAVS area boundaries will mitigate the potential radiological consequences of these events. Because these actions are appropriate for the reasons stated, the staff finds them acceptable.

Based on the above evaluation, the staff finds that the action requirements of GTS 3.5.3 are acceptable. The staff finds that the applicability of GTS 3.5.3 is also acceptable because with the buffer pool gate removed and water level greater than or equal to 23.0 feet over the top of the reactor pressure vessel flange, there is adequate coolant inventory and sufficient heat removal capability for the irradiated fuel in the core in response to a loss of decay heat removal capability, a LOCA, or an inadvertent draindown of the RPV. The adequacy of the water inventory in this condition was addressed by GEH in its response to RAI 16.2-73, which is described below.

<u>RAI 16.2-174</u>. The staff noted that, in DCD Revision 5, GEH proposed action requirements that would allow operation with all ADS, GDCS, and ICS valve DPS actuators inoperable for an entire operating cycle, which would be inconsistent with the actions of GTS 3.3.8.1, which specify a 30-day completion time to restore a DPS instrumentation function to operable status. An inoperable DPS instrumentation function would affect all automatic valves associated with that function, which could include ADS valves, GDCS valves, IC valves, containment isolation valves, and IC/PCCS expansion pool-to-equipment pool cross-connect valves that have TS-required DPS actuators. In its response, GEH proposed action requirements to permit just one valve (per subsystem for GDCS—one of eight valves in the injection subsystem, one of four valves in the equalizing subsystem) in each of these systems, except for the ICS, to have an inoperable DPS actuator until the end of the operating cycle. Two or more valves with the DPS actuator inoperable in each of these systems (per subsystem for GDCS) would require restoring all DPS actuators to operable status within 30 days. In its response dated February 3, 2009, GEH stated the following:

> Operation in the [conditions, as described below, that require restoring the DPS actuator(s) to operable status with a] Completion Time of "prior to entering MODE 2 or 4 from MODE 5" is acceptable because, with the restrictions being added as described below, sufficient DPS actuators remain OPERABLE to mitigate the possibility of digital protection system common mode failures. As

such, the remaining DPS actuators will actuate the safety-related functions required to respond to the design basis LOCA concurrent with any additional single failure, including digital protection system common mode failures.

- For ADS, the Specification and associated Bases for TS 3.5.1, Action A, will be revised to limit the number of inoperable DPS actuators to only one ADS valve with the Completion Time of “prior to entering MODE 2 or 4 from MODE 5.” Operation in Action A with one DPS actuator inoperable continues to provide the minimum number of DPS actuated ADS valves that are required to mitigate analyzed accidents concurrent with digital protection system common mode failures. A new Action B and associated Bases will be added to address two or more ADS valves with the DPS actuator inoperable. The new Action B will provide a Completion Time of 30 days, consistent with TS 3.3.8.1 for inoperability of the DPS ADS actuation function.

- For GDCS, the Specification and associated Bases for TS 3.5.2, Action A, will be revised to limit the number of inoperable DPS actuators to only one valve per GDCS subsystem (injection and/or equalizing subsystem) with the Completion Time of “prior to entering MODE 2 or 4 from MODE 5.” Operation in Action A, with one DPS actuator inoperable on one or both GDCS subsystems, continues to provide the necessary DPS actuated GDCS valves to mitigate analyzed accidents with the possibility of digital protection system common mode failures. A new Action B and associated Bases will be added to address two or more valves per GDCS subsystem with the DPS actuator inoperable. The new Action B will provide a Completion Time of 30 days, consistent with TS 3.3.8.1 for inoperability of the DPS GDCS actuation function.

- For reactor water cleanup/shutdown cooling system (RWCU/SDC) containment isolation valves (CIVs), the Specification and associated Bases for TS 3.6.1.3 Action A will be revised to limit the Completion Time to 30 days. Because the ESBWR design for RWCU/SDC isolation from DPS is currently not sufficiently detailed defining whether one or both RWCU/SDC CIVs will be equipped with DPS actuators, Action A and associated Bases will be revised to conservatively provide a Completion Time of 30 days [for the condition of one or more RWCU/SDC penetration flow path CIV DPS actuator(s) inoperable], consistent with TS 3.3.8.1 for inoperability of the DPS RWCU/SDC actuation function.

- For the isolation condenser/passive containment cooling system (IC/PCCS) expansion pool-to-equipment pool cross-connect valves, the Specification and associated bases for GTS 3.7.1 Action A will be revised to address only one inoperable IC/PCCS DPS actuator in the expansion pool-to-equipment pool cross-connect valves between one or both expansion pools and the equipment pool. Operation in Action A continues to provide one operable DPS actuator in at least one connection line for each expansion pool to mitigate the possibility of digital protection system common mode failures. A new Action B will be added to address one or both IC/PCCS expansion pools with both expansion pool-to-equipment pool cross-connect valve DPS actuators inoperable. The new Action B will be provided a Completion Time of 30 days, consistent with GTS 3.3.8.1 for inoperability of the DPS IC/PCCS expansion pool-to-equipment pool cross-connect actuation function.

- The DPS actuators for the isolation condenser system (ICS) did not meet criteria for high regulatory oversight. The basis for this is found in DCD Sections 19A.8.1 and 19A.8.4, which describe the results of the regulatory oversight evaluation for DPS. While DPS actuators were not included in Revision 5 of GTS 3.5.4, they are included in Revision 5 of DCD Section 19ACM, "Availability Controls Manual," specifically in Availability Control (AC) 3.3.[4] "Diverse Protection System (DPS)."

The staff finds the proposed actions to address valves with inoperable DPS actuators acceptable for the reasons stated in the applicant's response. Therefore, RAI 16.2-174 is resolved.

<u>RAI 16.2-34</u>. Based on DCD Revision 1, the staff requested that the applicant provide additional justification for allowing operation to continue for 14 days with just three operable non-ADS SRVs (safety mode), as proposed in GTS 3.4.1, and eight operable ADS-SRVs and six operable DPVs, as proposed in GTS 3.5.1. In its response dated November 13, 2006, the applicant described the three functions performed by the ESBWR SRVs as follows:

- Overpressure protection (addressed in LCO 3.4.1).
- ATWS overpressure protection (addressed by plant configuration management and corrective action programs; not in TS).
- Automatic depressurization of the RPV to support ECCS (addressed by LCO 3.5.1).

As described in DCD, Tier 2, Section 5.2.2 and the bases for LCOs 3.4.1 and 3.5.1, the ten ADS-SRVs are equipped with auxiliary actuating devices allowing them to function as both auxiliary-operated ADS valves and spring-lift SRVs. Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Articles NB 7510, "Safety, Safety Relief, and Relief Valves," NB 7520, "Pilot Operated Pressure Relief Valves," and NB 7540, "Safety Valves or Pilot Operated Pressure Relief Valves with Auxiliary Actuating Devices" ensure that a malfunction of the auxiliary actuating device does not compromise the spring-lift mode SRV function.

In its response to RAI 5.2-27 dated June 16, 2006, the applicant explained that that "only one of 18 SRVs is required to open to prevent exceeding the ASME limit in the ASME overpressure protection event. The other 17 SRVs are needed for the ATWS event." The applicant included this information in Section 5.2.2.3.2 of DCD Revision 3, issued February 2007. Therefore, Revision 3 of GTS 3.4.1 required the safety mode of just two SRVs (which can be any two of the 18 SRVs) to be operable and allowed one required SRV to be inoperable for 14 days. In addition, DCD Revision 3 addressed separately the ADS and GDCS in LCO 3.5.1 and LCO 3.5.2, respectively. DCD Revision 1 had previously addressed both of these systems in

LCO 3.5.1. GTS 3.5.1 proposed to allow one ADS-SRV and one DPV to be concurrently inoperable until the next entry into Mode 2 or 4 from Mode 5, and, as in DCD Revision 1, two ADS-SRVs and two DPVs to be concurrently inoperable for 14 days.

In a supplement to RAI 16.2-34, the staff asked the applicant to provide the following information:

(1) Justify the change from four to two SRVs with an operable safety mode required by LCO 3.4.1.

(2) Explain the methodology for periodic testing of the non-ADS SRVs, including a discussion of why the testing is not included in a TS SR.

(3) Correct an apparent error in Revision 3 of DCD, Tier 2, Table 5.2-2, in which Note (1) indicates that "The SRVs also perform the automatic depressurization function." The non-ADS SRVs do not perform an automatic depressurization function. The superscript "(1)" should be deleted from the "Number of Valves" heading. This superscript should be relocated following "ADS SRV" and "DPV," since only the ADS SRVs and DPVs perform the automatic depressurization function, and should state, "(1) The ADS SRVs and DPVs also perform the automatic depressurization function."

RAI 16.2-34 was being tracked as an open item in the SER with open items.

In its response dated November 10, 2007, GEH clarified the terminology, which it had introduced in DCD Revision 4, of the various safety valves and ADS valves in the ESBWR design, as follows:

Previous Name	New Name	LCO	Number Required
ADS-SRV	SRV	3.4.1 (safety mode)	2
Non-ADS SRV	SV	none	8
ADS-SRV	SRV	3.5.1 (ADS function)	10
DPV	DPV	3.5.1 (ADS function)	8

This change simplified LCO 3.4.1 by clearly requiring the safety mode of two of the ten SRVs to be operable, to maintain function in case a single failure renders the safety mode of one required SRV inoperable, and specifically not requiring operability of the eight SVs, so that the associated SRs for the safety mode lift settings of the SRVs are not required for the SVs. The safety mode lift settings for the SVs are maintained in accordance with the inservice testing (IST) program, which is acceptable. Based on DCD, Tier 2, Revision 4, Section 5.2.2.3, the most severe overpressurization event for the ESBWR is the MSIV closure, with scram occurring on high flux, (i.e., MSIV closure with flux scram (MSIVF) special event). The evaluation of the MSIVF event shows that only one SRV is required to open to prevent exceeding the ASME limit, as stated in DCD Section 5.2.2.3.2. Therefore, to satisfy the design-basis overpressure event (and to account for single failure), TS 3.4.1 requires the safety mode of two SRVs to be operable. LCO 3.4.1 does not require the relief mode (ADS mode) of the SRVs, as discussed in the response to RAI 5.2-19, which explains why the ESBWR design does not include the automatic power-actuated pressure relief function, which is incorporated in the BWR/6 STS 3.4.4 requirements for SRVs (seven SRVs in safety mode and seven other SRVs in relief mode must be operable). Therefore, LCO 3.4.1 is acceptable. The 14-day completion time to restore an inoperable required SRV to operable status is consistent with the BWR/6 STS 3.4.4 actions. Therefore, GTS 3.4.1 is acceptable. Based on the above, Parts 1 and 2 of RAI 16.2-34, Supplement 1, are resolved. The applicant resolved Part 3 by removing the note in question as unnecessary detail and by changing the nomenclature to SRV and SV. The discussion of RAI 16.2-32 addresses the resolution of the action requirement issue for ADS valves (SRVs and DPVs). Therefore, RAI 16.2-34 is resolved.

RAI 16.2-35. The staff requested that the applicant describe how squib valve explosive charge actuation testing will be ensured during plant operation. In its response dated November 21, 2006, the applicant stated that SLC, ADS, and GDCS squib valves must meet the requirements of 10 CFR 50.55a, "Codes and Standards." Specifically, 10 CFR 50.55a requires that these valves be subject to an IST program performed in accordance with the latest approved version of American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) Operations and Maintenance Standards, Part 10 (OM-10), "Inservice Testing of Valves in Light-Water Reactor Power Plants." Revision 3 of DCD, Tier 2, Table 3.9-8, "In-Service Testing," provides the details for implementing the squib valve IST program. GEH has also revised Revision 3 of DCD, Tier 2, Section 16B, to remove brackets around the IST program for SRs 3.5.1.5 and 3.5.2.4. The IST program, in conjunction with TS SRs to verify squib valve firing circuit continuity every 31 days, provides an acceptable means for ensuring that squib valve operability is maintained during plant operation. Therefore, RAI 16.2-35 is resolved.

RAI 16.2-36. GTS SR 3.5.3.1 (Modes 5 and 6) requires the combined water volume of required GDCS pools to be verified every 24 hours. The GTS bases state that SR 3.5.3.1 will verify that the water level in each of the GDCS pools is greater than or equal to the specified limit for operability. In RAI 16.2-36, the staff asked the applicant to clarify the differing requirements (i.e., combined GDCS pool water volume versus GDCS pool water level) between SR 3.5.3.1 and the associated bases. In its response dated November 13, 2006, the applicant proposed revising the bases for SR 3.5.3.1 to reflect the GDCS pool operability requirements as specified in the surveillance. The change to the bases, which state, "this SR requires verification every 24 hours that the combined water volume in GDCS pools associated with Operable GDCS injection branch lines is greater than or equal to the specific limit," is acceptable. Therefore, RAI 16.2-36 is resolved. DCD Revision 5 changed the bases of the corresponding SR 3.5.3.2 to state, "this SR requires verification that the water level in each of the GDCS pools is within the specified limit." DCD Revision 5 also changed the bases of LCO 3.5.3 to state, "this LCO requires two injection subsystem branch lines associated with each of the three GDCS pools (i.e., six injection subsystem branch lines) and two equalizing lines." For the reasons described in the evaluation of RAI 16.2-94, these changes are acceptable.

RAI 16.2-37. The staff asked the applicant to justify the different acceptance criteria for GDCS pools in SR 3.5.2.1 for Modes 1, 2, 3, and 4 and in SR 3.5.3.1 for Modes 5 and 6. Specifically, SR 3.5.2.1 requires that each GDCS "pool water level" be verified every 12 hours, and SR 3.5.3.1 requires that the "combined water volume of required GDCS pools" be verified every 24 hours. In its response dated November 13, 2006, the applicant stated that the GDCS pool water level is verified in GTS SR 3.5.2.1 to ensure that the volume of water assumed in the accident analysis for Modes 1, 2, 3, or 4 is met. The minimum combined water volume specified in GTS SR 3.5.3.1 is equal to the volume of the two smaller GDCS pools when each is filled to the normal operating level. This minimum volume, therefore, provides sufficient combined water inventory to fulfill makeup requirements for Modes 5 or 6, while still allowing any one of the three GDCS pools to be drained for maintenance or inspection. This is acceptable since GDCS pool operability is based on maintaining a combined water inventory, as assumed in the accident analysis. Thus, the criteria may be based on either minimum pool water level or minimum pool volume. Therefore, RAI 16.2-37 is resolved. For the reasons described in the evaluation of RAI 16.2-94, DCD Revision 5 changed the corresponding SR 3.5.3.2 and LCO 3.5.3.a to require all three GDCS pools to maintain a level in each pool of greater than or equal to 6.5 m (21.3 ft).

RAI 16.2-38. The staff requested that the applicant provide a detailed explanation for GDCS pool operability in the bases for GTS 3.5.2, including factors such as air space communication with the drywell, pool debris, and water chemistry. In its response, dated November 13, 2006, the applicant proposed revising the bases for GTS 3.5.2 to include the statement, "OPERABILITY of each GDCS injection branch line requires that the water level in the associated GDCS pool be within the limit specified by GTS SR 3.5.2.1." The applicant also stated that it did not include GDCS pool airspace-to-drywell communication as a GTS requirement since no mechanism exists for isolating this connection. GDCS pool water chemistry verification is not included as a GTS requirement since it does not meet any criteria in 10 CFR 50.36. GDCS pool debris and protective coatings are controlled consistent with specific guidance, as referenced in the DCD. The staff considers the bases changes acceptable. Therefore, RAI 16.2-38 is resolved.

RAI 16.2-39. The staff asked the applicant to provide a detailed explanation of the meaning of "required GDCS pools" in GTS SR 3.5.3.1. In its response dated November 13, 2006, the applicant stated that LCO 3.5.3, "Gravity-Driven Cooling System (GDCS)—Shutdown," and GTS SR 3.5.3.1 credit the minimum number of GDCS branch lines and combined GDCS pool volume that can be injected to ensure GDCS operability. The applicant revised GTS LCO 3.5.3 and SR 3.5.3.1 and bases to reflect this response. In DCD Revision 4, the applicant further clarified this surveillance, which was renumbered as SR 3.5.3.2, to explicitly state the combined GDCS pool water volume required to be available for injection through the four associated GDCS injection branch lines that are required to be operable by LCO 3.5.3. For reasons described in the evaluation of RAI 16.2-94, DCD Revision 5 changed the corresponding SR 3.5.3.2 and LCO 3.5.3.a to require six injection branch lines—two from each GDCS pool—and all three GDCS pools to maintain a level in each pool of greater than or equal to 6.5 meters (21.3 feet). These changes, along with the associated changes to the bases for LCO 3.5.3 and SR 3.5.3.2, as described in the discussion of RAI 16.2-36, are acceptable. Therefore, RAI 16.2-39 is resolved.

RAI 16.2-40. The staff requested that the applicant justify its decision not to specify a GDCS pool operability temperature limit in GTS 3.5.2. The ESBWR accident analysis for peak containment pressure assumes that the initial GDCS water and gas space temperatures are in equilibrium with the drywell air temperature. In its response dated November 13, 2006, the applicant stated that the analysis assumed an initial temperature of 46.1 ºC (115 ºF) for both the drywell gases and the GDCS pool water. In addition, GTS 3.6.1.5 ensures that drywell air temperature is maintained less than or equal to this limit. The applicant further stated that the drywell air temperature limits GDCS pool temperature because there is no mechanism that could cause GDCS pool temperature to rise above drywell air temperature.

In a supplement to RAI 16.2-40, the staff asked that the applicant explain in further detail how the GDCS pool temperature is to be adequately determined to be less than or equal to 46.1 ºC (115 °F) by referencing an equilibrium with average drywell air temperature, because temperatures in the upper levels of the drywell (i.e., in the space surrounding the GDCS pool walls and air space) may be potentially and consistently greater than 115 °F, although the drywell average temperature is below this value. RAI 16.2-40 was being tracked as an open item in the SER with open items. In its response dated May 21, 2008, GEH stated that "the normal operating containment ventilation design utilizes upper and lower drywell air handling units, which minimizes thermal stratification and the general uncertainties associated with severe temperature gradients. Therefore, it is not necessary to measure separately the GDCS pool water or air temperatures, to ensure the critical initial conditions of the containment and ECCS performance analyses are being maintained." GEH also stated that analyses performed in response to RAI 6.2-64 show that "initial GDCS pool water temperature does not have a significant impact on the containment and ECCS performance analyses. Therefore, there is no required GDCS pool water temperature band necessary to ensure that the acceptance criteria of the containment and ECCS performance analyses are met. As such, 10 CFR 50.36(c)(2)(ii)(B), Criterion 2, is not applicable to this variable, and there is no requirement for a technical specification to monitor GDCS pool water temperature."

DCD Revision 4 revised LCO 3.6.1.5 to require drywell temperature be less than or equal to 135 °F, instead of less than or equal to 115 °F. And, in DCD Revision 5, GEH revised LCO 3.6.1.5 again to require the drywell temperature be less than or equal to 150 ºF. In a second supplement to RAI 16.2-40, the staff asked GEH to provide a SR for GDCS pool temperature in GTS 3.5.2 that is consistent with the highest and lowest initial temperatures and pressures in the drywell and temperatures in the GDCS pools assumed in the analyses of design-basis events. The staff stated that, although an initial drywell temperature of 150 °F is consistent with the DCD Revision 5 analysis assumptions, specifying a temperature limit of 150 °F in GTS LCO 3.6.1.5 implies that this is an acceptable temperature for normal operation. The staff asked GEH to explain why the TS should not require taking action to deal with degraded drywell cooling at drywell temperatures much lower than this. In its response dated April 30, 2009, GEH stated that the "expected steady state GDCS pool temperature is expected to be less than 135 °F due to the drywell cooling system (DCD, Tier 2, Table 9.4-12) maintaining drywell temperature at or less than 135 °F with a maximum of 150 °F (DCD, Tier 2, Table 6.2-2). Maintaining a lower drywell temperature would provide an unwanted load on the drywell cooling system and lower the operating efficiency of the plant." In addition, GEH stated that "using TRACG for the limiting cases in DCD, Tier 2, Sections 6.2 (MSLB) and 6.3 (ICS drain line break) demonstrate that higher initial GDCS pool water temperatures do not have a significant impact on the containment and ECCS performance." GEH also added the following to the "Background" section of the bases for GTS 3.5.2 and DCD Section 6.3.2.8.3, "Safety Evaluation," of the ADS:

> Although the nominal and bounding containment performance analyses are performed at an initial condition of 115 °F for the GDCS pool water temperature, additional analyses assuming GDCS pool water temperature as high as 150 °F were performed. These analyses demonstrate the relative insensitivity of the calculated peak containment pressure and temperature and reactor pressure

vessel long-term water level after a DBA for increased GDCS pool water initial temperature.

Based on the stated analysis results, GEH concluded that monitoring the GDCS pool temperature is not required. RAI 16.2-40 is resolved based on the GEH responses, the results of the additional analyses, and changes to DCD Section 6.3.2.8.3 and the “Background” section of the bases for GTS 3.5.2.

<u>RAI 16.2-41</u>. The staff requested that the applicant justify its decision not to include limits on the ICS subcompartment pool water level and temperature in GTS 3.5.4, “Isolation Condenser System (ICS)—Operating.” In its response dated March 26, 2007, the applicant explained that GTS 3.5.4 does not include a surveillance to verify IC subcompartment level and temperature because GTS 3.5.4 and 3.7.1, “IC/PCCS Pools,” together specify adequate surveillances to ensure that there is sufficient water in the IC/PCCS pools, with average temperature at or below the required limit, to provide the required 72-hour heat sink. As specified in DCD Revision 6, and as revised by the applicant’s response to RAI 16.2-189, these surveillances include the following:

- SR 3.5.4.4, to verify once every 24 months that each ICS subcompartment manual isolation valve is locked open, including each manual isolation valve between an ICS sub-compartment and its associated inner expansion pool;
- SR 3.7.1.1, to perform once every 12 hours a channel check on each required IC/PCCS expansion pool level instrumentation channel;
- SR 3.7.1.2, to verify once every 24 hours the required level in the IC/PCCS inner expansion pools;
- SR 3.7.1.3, to verify once every 24 hours the required level in the equipment pool and reactor well (the equipment pool and reactor well are connected through the opening for the reactor well-to-equipment pool gate);
- SR 3.7.1.4, to verify once every 24 hours that the average water temperature in available IC/PCCS pools (which include the IC/PCCS inner expansion pools, the ICS and PCCS sub-compartments, the equipment pool, and the reactor well) is within limit;
- SR 3.7.1.5, to verify once every 31 days that supply pressure to each IC/PCCS inner expansion pool-to-equipment pool cross-connect valve accumulator is within limit;
- SR 3.7.1.6, to verify once every 31 days continuity of the DPS initiator and two [required] safety-related initiators on each IC/PCCS inner expansion pool-to-equipment pool cross-connect valve;
- SR 3.7.1.7, to perform once every 31 days a channel functional test on each required IC/PCCS expansion pool level instrumentation channel;
- SR 3.7.1.8, to verify once every 24 months that each manual isolation valve between the partitions in each IC/PCCS inner expansion pool is locked open;
- SR 3.7.1.8, to verify once every 24 months that each manual isolation valve on each inner expansion pool-to-equipment pool line is locked open;

- SR 3.7.1.9, to verify once every 24 months that the reactor well-to-equipment pool gate is not installed;
- SR 3.7.1.10 to verify once every 24 months that each IC/PCCS inner expansion pool-to-equipment pool cross-connect valve actuates on an actual or simulated automatic initiation signal;
- SR 3.7.1.11, to perform once every 24 months a channel calibration on each required IC/PCCS inner expansion pool level instrumentation channel consistent with Specification 5.5.11, "Setpoint Control Program (SCP)";
- SR 3.7.1.12, to perform once every 24 months a LSFT on each required division of the IC/PCCS inner expansion pool-to-equipment pool cross-connect actuation logic;
- SR 3.7.1.13, to verify once every 10 years that each IC/PCCS pool subcompartment has an unobstructed path through the moisture separator to the atmosphere.

Verifying IC/PCCS inner expansion pool level ensures proper level in each ICS and PCCS condenser subcompartment because each subcompartment is connected to its inner expansion pool by means of a locked open manual isolation valve located near the bottom of the subcompartment.

Regarding the lack of limits on ICS subcompartment water temperature in GTS 3.5.4, the applicant indicated that no limits are required to be specified because initial ICS subcompartment temperature does not affect the analysis results for the postulated design-basis events of a LOCA, SBO, and RPV isolation. However, the IC/PCCS pool average temperature is an assumption in the safety analysis; therefore it is limited by GTS 3.7.1 in SR 3.7.1.4. The staff concludes that the GTS requirements for the IC/PCCS pools will provide adequate assurance of the operability of the heat sink to support ICS and PCCS operability. Therefore, RAI 16.2-41 is resolved.

<u>RAI 16.2-42</u>. The staff asked the applicant to justify why it did not include in GTS 3.5.4, “Isolation Condenser System (ICS)—Operating,” a SR similar to the approved Dresden TS SR 3.5.3.4, which requires verifying every 60 months that the ICS is capable of removing design heat load. In its response dated April 13, 2007, the applicant stated that Revision 3 of GTS 3.5.4, “Isolation Condenser System (ICS)–Operating,” added a SR to verify the heat removal capability of each IC train. The associated GTS bases state that this surveillance will demonstrate the heat removal capability of each IC train to satisfy the design requirements specified in DCD, Tier 2, Chapter 5. The surveillance frequency for the IC heat capacity testing is “Prior to exceeding 25% RTP if not performed in the previous 24 months on a staggered test basis.” This frequency will ensure timely identification of any degradation in ICS performance by testing one IC train every 24 months, so that each IC train is tested once every 8 years. The staff finds this frequency acceptable. In DCD Revision 3, the surveillance frequency was enclosed in brackets, pending supporting changes to DCD Section 5.4.6.4, which the applicant proposed in response to RAI 5.4-52. In Revision 4 to GTS 3.5.4, the applicant removed the brackets from the frequency for this SR, coincident with associated changes to DCD Section 5.4.6.4. With the addition of SR 3.5.4.6 and associated bases, RAI 16.2-42 is resolved.

<u>RAI 16.2-73</u>. The staff requested that the applicant justify limiting the applicability of ESBWR GTS 3.5.3, “GDCS—Shutdown,” to Mode 6, except with the buffer pool gate removed and the

water level greater than or equal to 7.01 meters (23.0 feet) over the top of the RPV flange. In its response, the applicant indicated that the RWCU/SDC system provides adequate decay heat removal (DHR) capability, with the FAPCS providing backup DHR. During an unlikely event, such as a loss of inventory coincident with loss of the RWCU/SDC system, the water volume above the top of active fuel (TAF) but below the vessel flange provides adequate time to align makeup water from the CRD, FAPCS, firewater, or condensate pumps. The applicant relies heavily on the RWCU/SDC system and FAPCS to support shutdown DHR. The staff questioned why there are no ACs on the RWCU/SDC system and the referenced alternate makeup systems because these systems share dependencies on support systems, such as non-safety electrical power. The diesel firewater pump is not dependent on electrical power, but it is unclear to the staff how makeup water from this system would reach the reactor vessel without an intact refueling cavity.

In a supplement to RAI 16.2-73, the staff recommended establishing short-term ACs for the RWCU/SDC system, expanding the operability requirement for the GDCS to include Mode 6 for all refueling cavity water levels, or providing analysis demonstrating that sufficient water inventory would remain above TAF following a shutdown LOCA for greater than 72 hours. In a teleconference between the NRC staff and the applicant on September 6, 2007, the staff asked the applicant to pursue the recommended analysis.

In a second supplement to RAI 16.2-73, the staff replaced its request for an analysis with a request for a detailed description of the proposed makeup water transfers and a corresponding markup of the FAPCS ACs. RAI 16.2-73 was being tracked as an open item in the SER with open items. In its response dated March 25, 2008, GEH stated that it had performed an analysis of the passive DHR from the RPV during the onset of a refueling outage. The following were among the assumptions used in the analysis:

- Analysis begins 24 hours after shutdown.
- All fuel is kept in the RPV (none in the buffer pool deep pit).
- Available water is limited to the RPV, reactor cavity, and shallow buffer pool.

GEH stated that the "analysis shows that the water above the core will heat up and begin to boil if forced cooling is lost. After 72 hours under the most limiting heat load, there is still sufficient water to keep the core covered and maintain an adequate level of shielding." Based on the stated results of this analysis, the staff concludes that, in Mode 6 with the reactor cavity flooded up, sufficient water inventory exists to passively provide DHR and protect the fuel until active non-safety systems become available to perform the DHR function and provide RPV inventory makeup. Therefore, RAI 16.2-73 is resolved.

<u>RAI 16.2-74</u>. The staff requested that the applicant clarify the basis for not including an operability requirement for a DHR method in the refueling mode with the head fully detensioned or removed. In its response dated January 19, 2007, the applicant stated that the non-safety-related RWCU/SDC system provides the normal method of DHR in Modes 5 and 6, but that the criteria of 10 CFR 50.36(c)(2)(ii) did not require establishing an LCO for this system. The applicant further stated that, in Mode 6 with a water level less than or equal to 7.01 meters (23.0 feet) over the top of the RPV flange (low water level), the GDCS provides the safety-related backup DHR method. Furthermore, the GDCS requires adequate reactor vessel venting to maintain its operability. The RPV must remain depressurized following a loss of DHR in order

for the GDCS to inject cooling water into the vessel. When in Mode 6 with the water level greater than 7.01 meters (23.0 feet) over the top of the RPV flange (high water level) and the new fuel pool gate removed (i.e., with the RPV flooded), the large amount of water stored above the core provides the safety-related backup DHR capability.

In contrast, the bases of STS 3.9.8, “RHR—High Water Level,” and 3.9.9, “RHR—Low Water Level,” describe the safety-related residual heat removal (RHR) system as the primary DHR method in Mode 6. At a high water level, the large coolant inventory provides a heat sink as backup to the RHR system. In addition, the bases for STS 3.5.2, “ECCS-Shutdown,” describe the injection capability of the large volume of water above the vessel as providing sufficient coolant inventory in Mode 6 to allow time for operators to take action to terminate the coolant inventory loss before uncovering the fuel in the event of an inadvertent RPV draindown.

From its review of the applicant’s response, the staff concluded that the GTS did not explicitly specify an adequate RPV vent path in either Mode 5 or in Mode 6 before removal of the vessel head. The staff believes that the GTS should explicitly require an adequate RPV vent path; simply describing this GDCS operability requirement in the bases for GTS 3.5.3 will not ensure GDCS operability in Mode 5 and in Mode 6 before removal of the vessel head.

In Supplement 1 to RAI 16.2-74, the staff requested that the applicant provide a GTS requirement for a RPV vent path as part of GDCS operability with the unit in Mode 5 and in Mode 6 before removal of the vessel head. In addition, the staff requested that the applicant provide an AC for the RWCU/SDC system. In its response dated May 14, 2007, the applicant proposed a new SR for GTS 3.5.3 to “verify availability of RPV venting capacity sufficient to allow GDCS injection following loss of decay heat removal capability,” with a frequency of once every 24 hours, which was less restrictive than the frequency of the corresponding surveillance in the STS (see NUREG-1431, Revision 3.0, “Standard Technical Specifications—Westinghouse Plants,” issued June 2004, and specifically, SR 3.4.12.5, “Verify required RCS vent ≥ [2.07] square inches open,” with a frequency of “12 hours for unlocked open vent valve(s) AND 31 days for other vent path(s)”). The applicant did not propose an AC for the RWCU/SDC function.

The NRC staff and the applicant discussed the proposed SR in a teleconference on September 6, 2007. The staff suggested that the SR was actually an indirect expansion of the ADS LCO 3.5.1 applicability to include Modes 5 and 6 when ADS is needed to support GDCS operability in the event of a loss of DHR. This is because meeting the proposed SR in Mode 5 or 6 (without an adequate vent path) would require making the ADS operable to provide the necessary vent path. The staff preferred revising the applicability of the ADS LCO to the applicant’s proposal of a new SR in the shutdown GDCS specification. The staff also pointed out that other GTS changes would be needed, such as changing ECCS instrumentation ADS function applicability.

The staff included these comments in Supplement 2 to RAI 16.2-74, which was being tracked as an open item in the SER with open items. In its response to Supplement 2 dated January 17, 2008, the applicant proposed revising GTS SR 3.5.3.1 to “verify operability of sufficient ADS capacity to support assumed GDCS injection following loss of DHR capability,” and adding a GTS 3.5.3 action requirement for an inoperable GDCS due to insufficient venting capacity (i.e., due to the inoperability of a required ADS support function). The applicant also proposed to revise GTS 3.3.5.2, "ECCS Actuation," to require operability of the ADS actuation instrumentation function in Mode 5 and in Mode 6 with the RPV head in place.

In Supplement 3 to RAI 16.2-74, the staff asked how an operator would determine the number of required SRVs and DPVs as a function of the decay heat load in order to meet the proposed GTS 3.5.3 action requirement for insufficient vent capacity and the proposed surveillance to verify sufficient vent capacity. In its response dated April 18, 2008, GEH proposed to revise the action requirement to state, "Establish RCS vent path(s) with relief capacity equivalent to required ADS valves," in 4 hours, and the surveillance to state, "Perform applicable LCO 3.5.1, 'Automatic depressurization system (ADS)—Operating,' SRs for ADS valves required for relief capacity equivalent to 4 depressurization valves (DPVs)," with a frequency of "In accordance with applicable SRs." Subsequently, in DCD Revision 5, the applicant increased the number of required DPVs to six in SR 3.5.3.1 to provide an allowance for DPV failures. The staff finds that this change is acceptable because it will ensure that sufficient ADS valves are operable to support GDCS operability as required by GTS 3.5.3 even in the event of a failure of one of the required ADS valves. In DCD Revision 6, this SR was combined with the verification in GTS SR 3.5.3.5 that each required GDCS valve and ADS valve actuates on an actual or simulated automatic initiation signal. This change in presentation did not alter the proposed requirement for verifying reactor vessel relief capacity in Modes 5 and 6, and is acceptable because it is only an administrative change.

GTS 3.5.3 requires operability of two injection system branch lines for each of the three GDCS pools (which must have specified minimum volume), two equalizing subsystem trains (which must have specified minimum suppression pool volume), and ADS valves with relief capacity equivalent to six DPVs. Even in the event of any single failure, these requirements will ensure that sufficient water will be automatically injected into the RPV following a loss of DHR capability or a loss of RPV inventory (a LOCA or an inadvertent vessel draindown event) while in Mode 5, Mode 6 with the RPV head in place, or Mode 6 with water level less than 23.0 feet above the top of the RPV flange. Therefore, GTS LCO 3.5.3 is acceptable and RAI 16.2-74 is resolved. In RAI 16.2-173, discussed below, the staff noted an additional concern regarding the SR to verify reactor vessel relief capacity in Modes 5 and 6.

<u>RAI 16.2-94</u>. In response to the staff's request, GEH confirmed that the level of 6.5 meters (21.3 feet) in each GDCS pool, specified in SRs 3.5.2.1 and 3.5.3.2, is equivalent to the minimum total drainable inventory of 1,636 m^3 (57,775 ft^3), as stated in Revision 5 of DCD, Tier 2, Table 6.3-2 for three GDCS pools at low water level (i.e., 6.5 m (21.3 ft)). In DCD Revision 5, GEH revised GTS 3.5.3 to also require the minimum total drainable inventory for three GDCS pools at low water level (i.e., 6.5 m (21.3 ft)). DCD Revision 5 superseded the GEH response to a supplement to RAI 16.2-94 dated May 21, 2007, in which SR 3.5.3.2 was to specify just the combined drainable inventory in the two smaller GDCS pools corresponding to a water level of 6.5 meters and volume of 986.8 m^3 (34,848 ft^3). The applicant based the changes it made to the GTS 3.5.3 LCO (to require two injection subsystem branch lines associated with each GDCS pool and two equalizing subsystem trains) and actions (to ensure capability of two methods of injecting a combined water volume equivalent to required GDCS pool volume and required suppression pool volume within 4 hours) in DCD Revision 5 on achieving consistency with DCD, Tier 2, Section 15.2.2.9, "Loss of Shutdown Cooling Function of RWCU/SDC," and the GEH response to RAI 19.1-96, Supplement 1. Based on these changes and confirmation that the specified minimum levels in the three GDCS pools are correct, RAI 16.2-94 is resolved.

RAI 16.2-95. The staff requested that the applicant add a system flow test surveillance to GTS 3.5.2, “GDCS—Operating,” as a part of a system-level operability test program, such as that specified in the AP1000 design certification GTS for the core makeup tanks and the in-containment refueling water storage tank with a 10-year frequency. In its response dated April 19, 2007, GEH stated that such a system-level operability test program for the GDCS is not warranted for the following reasons:

- Preoperational testing and completion of ITAAC for the GDCS will verify that the injection subsystem and the equalizing subsystem are capable of providing sufficient flow to maintain reactor vessel water level one meter above top of active fuel (TAF) for 72 hours following a design basis LOCA. (See Section 6.3 of this report for discussions of responses to RAI 6.3-57 and RAI 6.3-18, Supplement 1 regarding GDCS ITAAC listed in DCD, Tier 1, Table 2.4.2-3.)

- Cleanliness controls will be implemented in accordance with RG 1.39, “Housekeeping Requirements for Water-Cooled Nuclear power Plants,” and will prevent degradation of GDCS performance due to accumulation of debris during normal operation and maintenance, to ensure that each GDCS injection and equalizing line has a flow loss coefficient that is less than that modeled in the TRACG code.

- GTS 3.5.2 was revised with the addition of SR 3.5.2.4 to “Verify the flow path for each GDCS injection branch line and equalizing line is not obstructed” on a 10-year Frequency. This surveillance is consistent with the testing listed in DCD, Tier 2, Table 6.3-3, “Inservice Testing and Maintenance,” which uses flow through the system test lines to open and close the GDCS check valves and to show that there is no obstruction of the RPV nozzles. DCD, Tier 2, Table 3.9-8, “Inservice Testing,” states that the 8 GDCS injection branch line check valves and 4 equalizing line check valves are tested every 24 months (refueling outage frequency). Table 6.3-3 also states that flushing will be performed using test connections during each refueling outage to (1) functionally test the 8 injection branch line check valves and 4 equalizing line check valves, (2) remove any possible plugging of the 4 injection lines, 8 injection branch lines, and the venturis within each GDCS-RPV nozzle, and (3) prevent crud build up in the deluge lines.

Based on the above, RAI 16.2-95 is resolved.

RAI 16.2-96. The staff requested that GEH add SRs to GTS 3.5.2 corresponding to the test items listed in DCD, Tier 2, Table 6.3-3, or explain why it did not propose such surveillances. These items include (1) functional testing of GDCS check valves, (2) explosive testing for GDCS squib valve initiators, (3) flushing of GDCS injection lines to remove possible plugging, (4) flushing of the GDCS injection nozzles, and (5) flushing of the deluge lines. In its response dated April 19, 2007, GEH stated that the IST program requires functional testing of the check valves and testing of squib valve initiators. The provisions of 10 CFR 50.55a and GTS 5.5.5

require the IST program. Tests required by the IST program must be met to establish component and system operability, unless a technical evaluation by the licensee has determined that the component is degraded but operable (see RIS 2006-17), and need not be specified again as TS SRs. GEH also stated that “requirements for system flushing, unless used explicitly for removing obstructions that could interfere with system performance, are cleanliness controls.” The staff considers that the flushing requirements listed in Table 6.3-3 are preventive maintenance requirements and, therefore, need not be specified as TS SRs. However, failure to perform this maintenance during a refueling outage would require a system operability assessment (see RIS 2006-17) to verify that SR 3.5.2.4 for the injection and equalizing lines and availability SR (ACSR) 3.5.1.6 for the deluge lines are still met. For the reasons stated, the staff concludes that the test items listed in Table 6.3-3 need not be GTS SRs. Therefore, RAI 16.2-96 is resolved. In DCD Revision 4, GEH changed the title of Table 6.3-3 from “Surveillance Requirements” to “Inservice Testing and Maintenance” to clarify the nature of the items listed in the table.

RAI 16.2-173. In DCD Revision 5, SR 3.5.3.1 stated, “Perform applicable LCO 3.5.1, ‘Automatic Depressurization System (ADS)—Operating,’ SRs for ADS valves required for relief capacity equivalent to 6 depressurization valves (DPVs).” The staff asked GEH to clarify this SR by explaining which GTS 3.5.1 SRs would be applicable. In its response, GEH added explicit SRs to GTS 3.5.3 corresponding to the “applicable” SRs in GTS 3.5.1. As presented in DCD Revision 6, these SRs include the following:

- SR 3.5.3.3, verification that SRV accumulator supply pressure is ≥ 2.41 MPaG (350 psig) once per 31 days (equivalent of SR 3.5.1.1)

- SR 3.5.3.4, verification that continuity of two initiators associated with DC and Uninterruptible AC Electrical Power Distribution Divisions required by LCO 3.8.7, ‘Distribution Systems—Shutdown,’ for each required GDCS valve and for ADS valves required to support relief capacity equivalent to 6 DPVs once per 31 days (equivalent of SR 3.5.1.2)

- SR 3.5.3.5, verification that each required GDCS valve and ADS valve required to support relief capacity equivalent to 6 DPVs actuates on an actual or simulated automatic initiation signal once per 24 months (equivalent to SRs 3.5.1.3 and 3.5.1.4)

These SRs superseded the previous SR for verifying RCS relief capacity. The applicant also made conforming changes to the bases for GTS 3.5.3. The above changes to the SRs for GTS 3.5.3 provided the requested clarification to the previous SR for verifying RCS relief capacity. Therefore, RAI 16.2-173 is resolved.

RAI 16.2-188. The staff requested that GEH strengthen Action A of GTS 3.5.5 for the condition of one or more required ICS trains inoperable. As written in DCD Revision 5, Action A would permit all required ICS trains to be inoperable indefinitely, provided two methods of DHR are available. The staff pointed out that LCO 3.5.5 thus provided no meaningful requirement to keep two ICS trains operable in Mode 5 as the safety-related method of DHR, which would be needed if normal DHR was lost (i.e., loss of the RWCU/SDC system). In its response dated June 8, 2009, GEH changed Action A to be more consistent with the STS residual heat removal system action requirements and removed the allowance to operate indefinitely with no operable ICS trains by requiring the following four actions:

- Required Action A.1 ("immediately initiate action to restore required ICS trains to operable status") removed the allowance to operate indefinitely with no operable ICS trains.

- Required Action A.2 ("within 1 hour and once per 24 hours thereafter, verify an alternate method of DHR is available for each inoperable required ICS train") ensures that alternate methods of DHR are ready in case the RWCU/SDC system is lost.

- Required Action A.3 ("within 1 hour and once per 12 hours thereafter, verify at least one method of DHR is in operation") and Required Action A.4 ("once per hour monitor reactor coolant temperature and pressure") ensures effective control of reactor coolant temperature and pressure.

The revised action requirements are acceptable for the reasons stated. Therefore, RAI 16.2-188 is resolved.

The ESBWR ECCS GTS implement modified versions of the STS for ECCSs. The staff finds that these GTS are essentially equivalent to the STS for ECCS functions. For those cases in which the applicant has not included a GTS corresponding to a STS, ESBWR design differences provide sufficient justification for such an omission. Therefore, the ESBWR ECCS GTS and bases are acceptable.

16.2.9 ESBWR GTS Section 3.6, "Containment Systems"

The ESBWR containment boundary is formed by the inside surfaces of the following:

- lower drywell floor and wall, which is beneath the RPV

- upper drywell floor, including beneath the lower boundary of the drywell-to-suppression pool vent wall structure and the lower boundary of the wetwell (an enclosed space containing the suppression pool)

- upper drywell wall (which includes the outer wall of the wetwell and the outer walls of the GDCS pools)

- upper drywell ceiling, which includes the removable drywell head

- PCCS condenser, which is a closed loop extension of the containment pressure boundary

The GDCS pools are inside the drywell and are connected to the drywell by vents through the pools' inside walls above the normal water level of the pools. The ESBWR suppression pool in the wetwell is connected to the upper drywell through horizontal vents to perform a pressure suppression function similar to the BWR/6 design. The ESBWR wetwell ceiling penetrations, each containing a drywell-to-wetwell vacuum breaker, connect the wetwell airspace above the suppression pool to the upper drywell.

In DCD Revision 4, GEH withdrew its intention (as stated in its response to RAI 16.0-1) to establish a GTS SR to test the float valves (which function as check valves) for the lower drywell spillover pipes because they were replaced with a passive design using spillover pipes without float valves, as described in Section 7.3 of licensing topical report (LTR) NEDE-33261P, Revision 1, dated October 2007. On page 7-2 of this LTR, GEH states, "the twelve lower drywell spillover pipes have been replaced with small pipes directly connected to the main vents above the pool water line." This new design for the spillover pipes does not require any float valves, obviating the need for a SR. GEH also removed language from Revision 3 of DCD Section 6.2.1.1.2 regarding the previous spillover pipe design to reflect the new simplified design. The staff finds that a SR for the lower drywell spillover pipes is not necessary to ensure that they are capable of supporting containment operability because of the simplicity of their modified design.

The ESBWR GTS 3.6.1.1 through 3.6.1.5 are essentially identical to the corresponding STS requirements for primary containment, containment air locks, primary containment isolation valves (CIVs), and primary containment pressure and air temperature because the designs are functionally very similar. Major differences exist, however, between the ESBWR containment design and the BWR/6 Mark III containment design. These differences in the ESBWR design include the following:

- A PCCS is used instead of active systems, such as the BWR/6 RHR containment spray system and RHR suppression pool cooling system.

- An enclosing reactor building is used instead of a secondary containment with a standby gas treatment system.

- The drywell boundary forms most of the containment boundary, unlike the BWR/6 Mark III primary containment design in which the drywell boundary is not part of the primary containment boundary. For this reason, the ESBWR GTS do not contain LCOs corresponding to the STS for the drywell.

These differences are reflected in the ESBWR GTS Section 3.6 containment system specifications which correspond to the STS as follows:

STS # BWR/4 STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.6.1.1*	3.6.1.1	Containment (*Primary Containment)
3.6.1.2*	3.6.1.2	Containment Air Lock (*Primary Containment Air Locks)
3.6.1.3*	3.6.1.3	Containment Isolation Valves (*Primary Containment Isolation Valves)
3.6.1.4*	3.6.1.4	Drywell Pressure (*Primary Containment Pressure)
3.6.1.5*	3.6.1.5	Drywell Air Temperature (*Primary Containment Air Temperature)
3.6.1.6*	None	(*Low-Low Set Valves)

STS # BWR/4 STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.6.1.7*	None	(*Residual Heat Removal Containment Spray System)
3.6.1.7*#	None	(*Reactor Building-to-Suppression Chamber Vacuum Breakers)
3.6.1.8*#	3.6.1.6	Wetwell-to-Drywell Vacuum Breakers (*Suppression Chamber-to-Drywell Vacuum Breakers)
None	3.6.1.7	Passive Containment Cooling System (PCCS)
3.6.1.8*	None	(*Penetration Valve Leakage Control System)
3.6.1.9*	None	(*Main Steam Isolation Valve Leakage Control System)
3.6.2.1*	3.6.2.1	Suppression Pool Average Temperature (*same)
3.6.2.2*	3.6.2.2	Suppression Pool Water Level (*same)
3.6.2.3*	None	(*Residual Heat Removal Suppression Pool Cooling)
3.6.2.4*	None	(*Suppression Pool Makeup System)
3.6.2.5*#	None	(*Drywell-to-Suppression Chamber Differential Pressure)
3.6.3.1*	None	(*Primary Containment and Drywell Hydrogen Ignitors)
3.6.3.2*	None	(*[Drywell Purge System])
3.6.3.2*#	3.6.1.8	Containment Oxygen Concentration (*Primary Containment Oxygen Concentration)
3.6.3.3*#	None	(*Containment Atmosphere Dilution System)
3.6.4.1*	3.6.3.1	Reactor Building (*[Secondary Containment])
3.6.4.2*	3.6.3.1	Reactor Building (*Secondary Containment Isolation Valves)
3.6.4.3*	None	(*Standby Gas Treatment System)
3.6.5.1*	None	(*Drywell)
3.6.5.2*	None	(*Drywell Air Lock)
3.6.5.3*	None	(*Drywell Isolation Valve[s])
3.6.5.4*	None	(*Drywell Pressure)
3.6.5.5*	None	(*Drywell Air Temperature)
3.6.5.6*	None	(*Drywell Vacuum Relief System)

The ESBWR design does not include a system corresponding to the BWR/4 containment atmosphere dilution system or the following BWR/6 systems:

- low-low set valve system
- penetration valve leakage control system
- MSIV leakage control system
- primary containment and drywell hydrogen igniters
- drywell
- drywell purge system
- standby gas treatment system
- drywell isolation valves
- drywell vacuum relief system

Accordingly, the GTS contain no LCOs for these systems. The GTS also contain no LCOs corresponding to the BWR/4 STS for the drywell-to-suppression chamber differential pressure. However, the ESBWR does include a CONAVS that includes redundant reactor building HVAC exhaust filtration trains for mitigating and controlling gaseous effluents from the reactor building. It also includes passive autocatalytic recombiners in the upper and lower drywell to reduce the hydrogen concentration in containment. These non-safety-related accident mitigation features are the subject of short-term ACs in the ACM (AC 3.7.4 and AC 3.6.2, respectively), as described in Section 22.5.9 of this report.

The GTS do not include an LCO for the drywell spray system, which is part of the non-safety-related FAPCS. Unlike the BWR/6 RHR containment spray system, which is specified in STS 3.6.1.7, "RHR Containment Spray System," the ESBWR drywell spray system is not credited in any DBA analysis and is not assumed to function during the initial 72-hour period following a design-basis event. Drywell spray is a mode of FAPCS operation that is expected to be available for use following the initial 72-hour period after a LOCA to assist in postaccident recovery. During this mode of operation, to reduce the containment pressure, the FAPCS draws and cools water from the suppression pool and then sprays the cooled water into the drywell air space through a discharge line and ring header with spray nozzles mounted on the header. To prevent drywell spray actuation from reducing drywell pressure too much, a flow-restricting orifice limits the flow. Using an orifice instead of a throttle valve for this purpose reduces the need to specify, subsequent to initial system testing following construction, a GTS surveillance to periodically verify that the flow is limited as required. Therefore, omission of an LCO for the drywell spray system is acceptable.

The PCCS is designed to transfer heat from the containment drywell to the IC/PCCS pools following a LOCA. The PCCS consists of six independent condensers. Each condenser is a heat exchanger that is an integral part of the containment pressure boundary. The condensers are located above the containment and are submerged in a large pool of water (IC/PCCS pool) that is at atmospheric pressure. Steam produced in IC/PCCS pools by boiling around the PCCS condensers is vented to the atmosphere. GTS 3.7.1, "Isolation Condenser (IC)/Passive Containment Cooling System (IC/PCCS) Pools," supports the PCCS in removing sufficient post-LOCA decay heat from the containment to maintain containment pressure and temperature within design limits for a minimum of 72 hours, without operator action.

Each of the six PCCS condensers consists of two identical modules. A single central steam supply pipe, open to the drywell at its lower end, directs steam from the drywell to the horizontal upper header in each module. Steam is condensed inside banks of vertical tubes that connect the upper and lower header in each module. The condensate collects in each module's lower header and drain volume and then returns by gravity flow to the GDCS pools. By being returned to the GDCS pools, the condensate is available to be returned to the RPV by way of the GDCS injection lines. Noncondensable gases that collect in the condensers during operation are purged to the suppression pool via vent lines. A loop seal in the GDCS drain line prevents backflow from the GDCS pool to the suppression pool.

During a LOCA, drywell pressure rises above the pressure in the wetwell (suppression pool). This differential pressure initially directs the high-energy blowdown fluids from the RCS break in the drywell through both the pressure suppression pool and through the PCCS condensers. As the flow passes through the PCCS condensers, heat is rejected to the IC/PCCS pool, thus cooling the containment.

The PCCS does not have instrumentation, control logic, or power-actuated valves, and the system does not need or use electrical power for its operation. This configuration makes the PCCS fully passive. Long-term effectiveness of the PCCS (beyond 72 hours) is supported by vent fans that are connected to each PCCS vent line and exhaust to the GDCS pool. The PCCS vent fans aid in the long-term removal of noncondensable gas from the PCCS for continued condenser efficiency. A GTS Section 3.6 LCO does not specify that the PCCS vent fans are to be operable because they do not meet any of the criteria in 10 CFR 50.36(c)(2)(ii). However, the ACM (AC 3.6.3) includes these fans, as described in Section 22.5.9 of this report.

The capabilities of the PCCS to condense steam from the drywell, drain the resulting condensate to the GDCS pools, and vent the noncondensable gases to the suppression pool are assured based on full-scale height testing during the development of the containment design for the simplified boiling-water reactor (SBWR). As discussed in Section 6.2 of this report, the NRC staff previously reviewed the test reports and found the SBWR containment cooling design to be effective and acceptable. Consequently, the ESBWR design certification applicant proposed no periodic testing requirements in the GTS to physically demonstrate these capabilities because such testing was unnecessary and impractical. To ensure that the PCCS condensers, vent lines, and drain lines remain clear, GTS SR 3.6.1.7.3 requires verifying that both modules in each PCCS condenser have an unobstructed path from the drywell inlet through the condenser tubes to both the GDCS pool through the drain line and to the suppression pool through the vent line, every 24 months on a staggered test basis (i.e., each PCCS condenser and associated drain and vent lines will be verified to be unobstructed once every 12 years).

RAI 16.2-112. In DCD Revision 0, SR 3.6.1.1.2 states the following:

> Verify drywell to suppression chamber differential pressure does not decrease at a rate greater than [6 mm water (0.25 inches water)] per minute tested over a [10] minute period at an initial differential pressure of [6.9 kPa (1 psi)].

This is consistent with BWR/4 STS SR 3.6.1.1.2, which states the following:

> Verify drywell to suppression chamber differential pressure does not decrease at a rate > [0.25] inch water gauge per minute tested over a [10] minute period at an initial differential pressure of [1] psid.

In DCD Revision 1, the applicant revised SR 3.6.1.1.2 to state, "Verify drywell to wetwell bypass leakage is less than 1 cm^2 ($A/\sqrt{K}$)."

In DCD Revision 3, the applicant added SR 3.6.1.1.2 to verify that the feedwater flow isolation valve in-leakage is "< { lpm (gpm)} when tested at ≥ { kPad (psid)}." The applicant renumbered the drywell-to-wetwell bypass leakage test as SR 3.6.1.1.3. In addition, GEH made a significant change in DCD Revision 3 to the drywell-to-wetwell bypass leakage test. Instead of measuring overall drywell-to-wetwell bypass area, the applicant proposed to measure only the leakage area through vacuum breaker lines. GEH revised SR 3.6.1.1.3 to state, "Verify the combined leakage rate through all vacuum breaker lines is ≤ 0.1 cm^2 (1.0×10^{-4} ft^2) (A/√K) when tested at ≥ { kPaD (psid)}."

The staff noted that this is inconsistent with the BWR/4 STS SR 3.6.1.1.2, quoted above, and BWR/6 STS SR 3.6.5.1.1, which states the following:

> Verify bypass leakage is less than or equal to the bypass leakage limit. However, during the first unit startup following bypass leakage testing performed in accordance with this SR, the acceptance criterion is ≤ [10%] of the drywell bypass leakage limit.

In DCD Revision 3, the drywell-to-wetwell bypass leakage test only requires determining leakage through the vacuum breaker lines. But the BWR/4 and BWR/6 STS equivalent SRs require determining the total bypass leakage between drywell and wetwell (suppression chamber). Total bypass leakage is an assumption in the peak containment pressure calculation in Revision 3 of DCD, Tier 2, Section 6.2. In RAI 16.2-112, the staff asked the applicant to explain how it would ensure that the assumed total bypass leakage between the drywell and wetwell will not be exceeded during operation of the reactor. RAI 16.2-112 was being tracked as an open item in the SER with open items.

The staff also noted that SR 3.6.1.1.3 in DCD Revision 3 was not self-consistent because the side to the left of the less than or equal symbol (≤) refers to a "leakage rate" (e.g., liters per minute), while the side to the right of the symbol has dimensions of area. In RAI 16.2-112, the staff asked the applicant to resolve the inconsistency.

In DCD Revision 4, the applicant revised SR 3.6.1.1.3 to state, "Verify the combined leakage rate through all vacuum breaker lines is less than or equal to the maximum established design A/√K." However, this did not address the staff's concern about not testing for the overall suppression pool bypass leakage. In its response dated April 3, 2008 to RAI 16.2-112, GEH resolved the noted inconsistency by explaining how, in industry practice, leakage is expressed in terms of area. The applicant also replaced SR 3.6.1.1.3 with the following three surveillances:

> 3.6.1.1.3 Verify each wetwell-to-drywell vacuum breaker and vacuum breaker isolation valve leakage is ≤ 15% of design basis A/√K.
>
> 3.6.1.1.4 Verify total wetwell-to-drywell vacuum breaker and vacuum breaker isolation valve pathway leakage is ≤ 35% of design basis A/√K.
>
> 3.6.1.1.5 Verify overall suppression pool bypass leakage is ≤ 50% of design basis A/√K.

GEH stated that satisfactory performance of these SRs would ensure that the rate of suppression pool bypass leakage would remain below the maximum allowable suppression pool bypass leakage assumed in the analysis, thus ensuring that the containment design pressure will not be exceeded.

GEH stated that the maximum allowable suppression pool bypass leakage area is 2.0 square centimeters (cm^2). In SR 3.6.1.1.5, the 50-percent criterion therefore corresponds to an area of 1.0 cm^2. GEH proposed to perform this overall bypass leakage test in conjunction with, and at the frequency of, the containment integrated leak rate test (ILRT). As discussed in Section 6.2.1.1.3 of this report, in RAI 6.2-145, the staff questioned the proposed acceptance criterion and the test frequency. Based on the results of suppression pool bypass leakage surveillances at operating BWR facilities with Mark II and Mark III containments, the staff concluded that the 50-percent criterion for SR 3.6.1.1.5 is acceptable. However, the staff did not find the test history a sufficient basis for a 10-year test interval for the overall bypass leakage test. Because the staff had previously required plant-specific data to support such frequency relaxations at operating plants, the staff requested that GEH provide additional justification for the proposed frequency for the ESBWR test. In its response dated April 27, 2009, GEH proposed a 24-month frequency for the overall suppression pool bypass leakage test. The staff found this frequency acceptable because it is consistent with the frequency in the STS and for currently operating plants that have not gone to a longer test interval.

The staff reviewed the proposed acceptance criteria and frequencies of SR 3.6.1.1.3 for each wetwell-to-drywell vacuum breaker and vacuum breaker isolation valve leakage. The staff also reviewed the proposed criteria and frequencies of SR 3.6.1.1.4 for the total wetwell-to-drywell vacuum breaker and vacuum breaker isolation valve leakage. The staff found the acceptance criteria for these SRs to be acceptable because they are consistent with DCD Section 6.2. The staff found the 24-month frequency for these SRs acceptable because it is consistent with the frequency in the STS and the need to perform these surveillances under conditions that apply during a plant outage.

The staff concludes that the proposed SRs will ensure that drywell-to-wetwell bypass leakage will be maintained below the leakage assumed in the safety analysis and will support the conclusion that containment design pressure will not be exceeded following a design-basis event. They are therefore acceptable and RAI 16.2-112 is resolved.

Combustible Gas Control

The NRC revised 10 CFR 50.44, “Combustible Gas Control System in Light-Water-Cooled Power Reactors,” 10 CFR 50.34, “Contents of Applications; Technical Information,” and 10 CFR 52.47, “Contents of Applications,” and created a new rule, 10 CFR 50.46a, “Acceptance Criteria for Reactor Coolant System Venting Systems” (see Volume 67, Page 50374, of the Federal Register; August 2, 2002). These changes were meant to risk-inform the combustible gas control requirements and constituted significant relaxations of the requirements. The proposed rule changes became effective on October 16, 2003. The ESBWR DCD was written to be consistent with these rule changes.

The applicant states in DCD Section 6.2.5.1 that 10 CFR 50.44(c)(2) establishes for future water-cooled reactor applicants and licensees that “all containments must have an inerted atmosphere, or must limit hydrogen concentrations in containment during and following an accident….” The applicant then states, “The design of the ESBWR provides for an inerted containment and, as a result, no system to limit hydrogen concentration is required.”

The ESBWR containment inerting system can be used under postaccident conditions for containment atmosphere dilution to maintain the containment in an inerted condition by a controlled purge of the containment atmosphere with nitrogen to prevent reaching a combustible gas condition. Thus, the applicant did not propose a specification similar to BWR/4 STS 3.6.3.3 for the containment atmosphere dilution system for design-basis hydrogen control.

RAI 16.2-110. The staff asked the applicant to add a GTS to limit containment oxygen concentration to less than 4 percent by volume, based on BWR/4 STS 3.6.3.2. RAI 16.2-110 was being tracked as an open item in the SER with open items. In its response dated June 29, 2007, the applicant proposed establishing ACs for containment oxygen concentration. In a followup question, the staff stated the following:

> The regulatory limit proposed by the applicant, based on the future design certification rulemaking for ESBWR, will be too far removed from the day-to-day operation of a plant to provide sufficient control of and attention to the containment oxygen concentration limit. It adds little to the requirements already present in 10 CFR 50.44. Further, using the applicant's suggested Availability Control also lacks sufficient regulatory force. The staff's position is that a GTS limiting condition for operation must be established for an inerted containment to meet 10 CFR 50.36(c)(2)(ii)(D). The structure is the inerted containment. The NRC has determined that combustible gases produced by beyond design-basis accidents involving both fuel-cladding oxidation and core-concrete interaction would be risk-significant for plants with inerted containments, if not for the inerted containment atmosphere. It is essential to have a regulatory limit on containment oxygen concentration in each ESBWR plant license, meaning a GTS LCO. Provide a GTS of this type in DCD Chapter 16.

Section 6.2.5 of this report contains the staff's evaluation of combustible gas control for the ESBWR design.

In its response dated January 16, 2008 to the staff's followup question to RAI 16.2-110, the applicant proposed establishing a GTS for containment oxygen concentration—GTS 3.6.1.8, "Containment Oxygen Concentration." The proposed GTS is consistent with STS 3.6.3.2, "Primary Containment Oxygen Concentration," in NUREG-1433, "STS General Electric Plants, BWR/4." Therefore, the staff finds GTS 3.6.1.8 acceptable.

In its response to the staff's followup question to RAI 16.2-110, the applicant also proposed a new special operations GTS to allow suspension of LCO 3.6.1.8 during the initial 120 effective full power days (EFPD) of operation to avoid the personnel hazard of an oxygen deficient containment atmosphere during startup testing, which requires containment entries to inspect components following the performance of some tests. This special operations GTS is consistent with TS 3/4.10.5, "Oxygen Concentration," of NUREG-0123, Revision 2, "Standard Technical Specifications General Electric Boiling Water Reactors," issued in 1979. Therefore, the staff finds GTS 3.10.9, "Oxygen Concentration—Startup Test Program," acceptable.

Based on the proposed GTS for containment oxygen concentration, RAI 16.2-110 is resolved.

RAI 16.2-45. The staff requested that the applicant further justify omitting GTS requirements for CIV instrumentation functions in Mode 5. RAI 16.2-45 was being tracked as an open item in the SER with open items. In its response dated January 19, 2007, the applicant discussed the CIV and other system isolation instrumentation functions in the BWR/6 STS that are required when the plant is in hot shutdown, cold shutdown, and refueling. The applicant determined that no CIV instrumentation functions were required in cold shutdown and refueling to limit fission product release during and after postulated DBAs for the ESBWR because the fuel-handling accident does not assume containment isolation. Based on the applicant's determination, the staff finds that the GTS do not need to require CIV instrumentation functions to be operable in Mode 5 or during movement of irradiated fuel.

However, the applicant did not justify excluding CIV operability during OPDRVs. Rather, the applicant stated that it had determined that the instrumentation function to close the RWCU/SDC system containment penetrations upon detection of a leak from the RWCU/SDC system is required in Modes 5 and 6 to isolate the RPV to minimize loss of RCS inventory for core protection. Accordingly, the applicant proposed to add TS requirements for this isolation function in GTS Section 3.4. However, in DCD Revision 3, Chapters 16 and 16B, the applicant revised the location for specifying the RWCU/SDC isolation function in Modes 5 and 6 to GTS 3.3.6.3, "Isolation Instrumentation," and 3.3.6.4, "Isolation Actuation." As discussed below in Supplement 2 to RAI 16.2-45, the staff requested additional information regarding this change.

In Supplement 1 to RAI 16.2-45, the staff requested that the applicant consider revising the GTS to require CIVs and associated instrumentation functions to be operable during OPDRVs and irradiated fuel movement for the purpose of defense in depth. In its response dated November 9, 2008, the applicant explained that the "condition of OPDRVs in the BWR/6 STS requires mitigative features that essentially ensure capability of establishing a secondary containment boundary." The staff concurred with this statement. In its response, the applicant also stated the following:

> For the ESBWR, NEDO-33201, "ESBWR Certification Probabilistic Risk Assessment," dated September 2006, Section 16, "Shutdown Risk," evaluates drain down of the reactor pressure vessel (RPV) or Loss of Coolant Accidents (LOCAs) during shutdown. This evaluation concludes that closure of both lower drywell hatches provides the appropriate mitigative response for the shutdown LOCA below top of active fuel (TAF) event initiators during Modes 5 and 6.

Based on this conclusion, the applicant proposed to provide an AC "that will assure the ability to immediately close the lower drywell hatches during OPDRVs." In DCD, Tier 2, Revision 4, Section 19A.8.4, the applicant identified the lower drywell hatches as important non-safety equipment and recommended regulatory oversight of their capability for timely closure to isolate the lower drywell to provide a "boundary for recovering vessel level following a Shutdown LOCA below top of fuel event." Section 22.5.5, "Evaluation of Adverse Systems Interactions," of this report lists the ability to close the drywell hatches during shutdown conditions as meeting RTNSS Criterion 3 described in SECY 94-084, which states the following:

> Structure, system, or component functions relied upon under power-operating and shutdown conditions to meet the Commission's safety goal guidelines of a

core damage frequency (CDF) of less than $1x10^{-4}$ per reactor year, and a large release frequency (LRF) of less than $1x10^{-6}$ per reactor year.

The applicant established an AC for drywell hatches requiring the lower drywell personnel air lock and lower drywell equipment hatch to be available for closure in Modes 5 and 6. This applicability does not need to include “during OPDRVs” because the equipment hatches to the lower drywell would not be opened in other modes. See Section 22.5.9 of this report for an evaluation of ACs. Based on this AC, the staff determined that not requiring CIV operability during OPDRVs is acceptable.

In Supplement 2 to RAI 16.2-45, the staff asked the applicant to explain how the GTS address operability and SRs for the automatic isolation valves for the RWCU/SDC system, associated with the following proposed isolation instrumentation functions in GTS 3.3.6.3 (the function numbers and titles, which changed subsequent to Supplement 2, are those given by DCD Revision 5):

- Function 1, “Reactor Vessel Water Level—Low, Level 2”
- Function 2, “Reactor Vessel Water Level—Low, Level 1”
- Function 5, “RWCU/SDC System Differential Mass Flow—High (Per Subsystem)”

The staff also asked for a similar explanation concerning the isolation actuation function in GTS 3.3.6.4—Function 1, “RWCU/SDC System Isolation.”

In its response dated November 9, 2007, GEH stated that GTS 3.6.1.3 requires the automatic isolation valves for the RWCU/SDC system because they have a containment isolation function in Modes 1, 2, 3, and 4. Specifically, SR 3.6.1.3.7 requires periodic verification that each automatic CIV will actuate to its isolation position on a containment isolation signal. The bases for SR 3.6.1.3.7 state that the LSFTs in LCOs 3.3.6.2, 3.3.6.4, and 3.3.8.1 overlap this SR to provide complete testing of the safety function. The bases for SR 3.3.6.4.3, “Perform a [RWCU/SDC Isolation] system functional test,” state that “The LSFT in SR 3.3.6.4.1 and LCO 3.3.8.1 (for RWCU/SDC isolation valves) overlaps SR 3.3.6.4.3 to provide complete testing of the safety function.”

In Modes 5 and 6, the RWCU/SDC CIVs are not required to perform a containment isolation function, but are required to isolate the RWCU/SDC system from the RPV in case of a line break in the RWCU/SDC system.

In addition, the bases for GTS 3.3.6.4, isolation actuation Function 1, state the following:

> The RWCU/SDC System Isolation actuation divisions receive input in Modes 1, 2, 3, and 4 from the following isolation instrumentation specified in GTS 3.3.6.3:
>
> - Function 1, “Reactor Vessel Water Level—Low, Level 2”
> - Function 2, “Reactor Vessel Water Level—Low, Level 1”
> - Function 4, “Main Steam Tunnel Ambient Temperature—High”
> - Function 5, “Reactor Water Cleanup/Shutdown Cooling System Differential Mass Flow—High (per RWCU/SDC subsystem)”

In MODES 5 and 6, the RWCU/SDC System Isolation actuation divisions only receive input from GTS 3.3.6.3 isolation instrumentation Function 1 and Function 5.

Based on the information provided in the applicant's responses, the bases for GTS 3.3.6.3, 3.3.6.4, 3.3.8.1, and 3.6.1.3 in DCD Revision 5, and the above conclusions about not requiring CIVs during movement of irradiated fuel or during OPDRVs, RAI 16.2-45 is resolved.

RAI 16.2-47. The staff asked the applicant to provide additional justification for the 24-month surveillance frequency of SR 3.6.1.6.3 to verify that each wetwell-to-drywell vacuum breaker fully opens at the specified minimum differential pressure. In its response to RAI 16.2-47 dated November 13, 2006, the applicant stated it had previously addressed this question in response to RAI 3.9-1, dated June 16, 2006, by providing reference documents containing information regarding vacuum breaker testing in support of the SBWR design. Specifically, the applicant stated the following:

> As stated in DCD, Tier 2, Subsection 6.2.1.1.5.3.2, the ESBWR vacuum breakers are not equipped with an air actuated cylinder. Testing for freedom of movement requires access to the vacuum breakers; therefore, this SR can only be performed with the plant in a shutdown condition. In addition to the changes in vacuum breaker configuration discussed in DCD Subsection 6.2.1.1.5.3.2, the reliability studies referenced by MFN 06-127 showed the ESBWR vacuum breakers to be highly reliable. Therefore, GE has determined that a 24-month Frequency is appropriate.

Based on the stated reasons, the 24-month frequency is acceptable, and RAI 16.2-47 is resolved.

RAI 16.2-48. The staff requested that the applicant provide an acceptable differential pressure value in place of the curly brackets in SR 3.6.1.6.3, "Verify each required vacuum breaker opens at ≤ { } kPaD." In DCD Revision 5, the applicant provided an acceptable maximum differential pressure value of 3.07 kPaD (0.445 psid) in SR 3.6.1.6.3, consistent with the vacuum breaker opening pressure in DCD Section 6.2.1.1.2, Table 6.2-1. Therefore, RAI 16.2-48 is resolved.

RAI 16.2-49. The staff requested that the applicant justify the omission of a surveillance to test wetwell-to-drywell vacuum breaker butterfly valves and their solenoid valves. In its response dated November 13, 2006, the applicant reiterated its commitment "to include the drywell-to-wetwell vacuum breaker proximity switch and downstream isolation valve testing in the GTS," which it made in response to RAI 16.0-1. The applicant met this commitment with SR 3.6.1.6.4, which requires the performance of a channel calibration, and SR 3.6.1.6.5, which requires the performance of a system functional test, for each vacuum breaker flow path isolation function on a 24-month frequency. Therefore, RAI 16.2-49 is resolved.

RAI 16.2-50. The staff asked that the applicant describe how it anticipates performing SR 3.6.3.1.4 to verify that the reactor building exfiltration rate is within limits and to justify the 60-month frequency. In its response, dated January 19, 2007, the applicant indicated that the 60-month frequency was adequate to ensure that the leak rate assumptions remain valid because of "general building integrity inspections." However, the associated GTS bases for

SR 3.6.3.1.4 state that the 60-month frequency is based on engineering judgment, but does not say why it is acceptable. The staff requested that the applicant provide clearer justification for the 60-month frequency in the GTS bases for SR 3.6.3.1.4.

In a supplement to RAI 16.2-50, the staff requested that the applicant respond to the original question to the extent permitted by currently available information, even though “construction-level-design details” are not currently available. The applicant’s response, dated June 27, 2007 referenced the response to related RAI 15.4-26, which described the reactor building flow paths to be isolated and the method to be used to verify the reactor building leak rate. The staff verified that the applicant updated the DCD to reflect changes proposed in the response to RAI 15.4-26. See Section 15.4 of this report for the evaluation of RAI 15.4-26. However, neither response offered further justification for the 60-month frequency.

In a second supplement to RAI 16.2-50, the staff requested that the applicant provide additional justification for the 60-month frequency or revise it to 24 months. In addition, the staff asked the applicant to revise the bases for this frequency to be consistent with the bases for the frequency for the secondary containment boundary integrity verification SRs, such as BWR/6 STS SR 3.6.4.1.5. In its response dated October 15, 2009, GEH stated it will revise the Frequency for GTS SR 3.6.3.1.5 to 24 months and make conforming changes to the associated bases, consistent with the STS bases for STS SR 3.6.4.1.5. The staff reviewed the markup of the affected GTS pages, which had been provided in the response letter, and found them to be acceptable. Therefore, RAI 16.2-50 is resolved.

<u>RAI 16.0-3</u>. The staff asked the applicant to list the STS generic changes (TSTF travelers) that it is proposing for the GTS, which are not included in STS Revision 3, including any proposed changes under review by the NRC staff. The staff also requested that the applicant explain any deviations from these travelers. In its response dated November 13, 2006, the applicant listed unapproved TSTF-458-T, Revision 0, “Removing Restart of Shutdown Clock for Increasing Suppression Pool Temperature,” as being incorporated in the GTS. The NRC staff’s evaluation of this TSTF follows.

TSTF-458-T makes the following changes to STS 3.6.2.1, “Suppression Pool Average Temperature,” to remove a potential ambiguity between Actions D and E:

- Condition D applies when the suppression pool average temperature exceeds 110 ºF regardless of how high the suppression pool average temperature rises, instead of just up to 120 ºF, so that regardless of any temperature increase above 120 ºF, the 36-hour completion time clock of Required Action D.3, to be in cold shutdown, will not reset.

- Required Action D.2 changes from “verify suppression pool average temperature ≤ 120 ºF every 30 minutes” to “determine suppression pool average temperature every 30 minutes,” to ensure timely detection of temperature changes.

- For the condition of suppression pool average temperature above 120 ºF, Action E changes with the removal of Required Action E.2, to be in cold shutdown in 36 hours, which leaves only Required Action E.1 to depressurize the reactor vessel to less than 200 psig within 12 hours (i.e., to be in hot shutdown; 200 psig saturated steam corresponds to an RCS temperature of approximately 375 ºF).

Resetting the shutdown completion time clock of Required Action D.3 when the suppression pool average temperature exceeds 120 ºF is not the intended requirement. When the suppression pool average temperature exceeds and stays above 110 ºF, the intent of STS 3.6.2.1 Actions D and E, is to require placing the unit in cold shutdown in 36 hours, regardless of how high the temperature rises. The clarification of these ambiguous action requirements is consistent with this intent and is an administrative change. Therefore, TSTF-458-T is acceptable.

In a supplement to RAI 16.0-3, the staff noted that proposed ESBWR TS 3.6.2.1, "Suppression Pool Average Temperature," differed significantly from TSTF-458-T in the following ways:

- Required Action D.2 still requires "verifying" instead of "determining" temperature.
- STS Required Action D.3, to be in cold shutdown within 36 hours of entering Condition D, is deleted.
- Required Action E.2, to be in cold shutdown within 36 hours of entering Condition E, is not deleted.
- Condition D applies when the suppression pool average temperature exceeds 120 ºF, instead of the STS value of 110 ºF, and Condition E applies when the suppression pool average temperature exceeds 130 ºF, instead of the STS value of 120 ºF.

In its response dated July 16, 2007, the applicant committed to change Revision 3 of DCD Chapters 16 and 16B to incorporate without deviation TSTF-458-T, but to use the higher temperatures appropriate to the ESBWR suppression pool design. Staff review of the proposed pool temperature limits depended on the GEH response to RAI 6.2-159. The applicant provided additional information in its response to RAI 6.2-159, dated December 21, 2007 to support the higher suppression pool temperatures for the ESBWR. Based on this information, the staff concluded that the higher suppression pool temperatures proposed for the ESBWR design are acceptable. The staff verified that the proposed changes had been incorporated into GTS 3.6.2.1 and bases. Therefore, this part of RAI 16.0-3 is resolved.

The ESBWR GTS for containment systems implement modified versions of the STS for containment systems. The staff finds that the GTS for containment systems have been constructed to be essentially equivalent to the STS for the containment cooling and isolation functions. For those cases in which STS for containment systems have not been included, ESBWR design differences provide sufficient justification for such omissions. Therefore, the staff finds the ESBWR GTS and bases for containment systems acceptable.

16.2.10 ESBWR GTS Section 3.7, "Plant Systems"

The ESBWR GTS for plant systems correspond to the STS as follows:

STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.7.1*	None	(*Standby Service Water System and Ultimate Heat Sink (UHS))

STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.7.2*	None	(*High Pressure Core Spray Service Water System)
3.7.1*	3.7.1	Isolation Condenser/Passive Containment Cooling System (IC/PCCS) Pools (*Standby Service Water System and Ultimate Heat Sink (UHS))
3.7.3*	3.7.2	CRHAVS (*Control Room Fresh Air System)
3.7.4*	none	(*Control Room Air Conditioning System)
3.7.5*	3.7.3	Main Condenser Offgas (*same)
3.7.6*	3.7.4	Main Turbine Bypass System (*same)
3.7.7*	3.7.5	Fuel Pool Water Level and Temperature(*Fuel Pool Water Level)
none	3.7.6	Selected Control Rod Run-In (SCRRI) and Select Rod Insert (SRI) Functions

The GTS contain no specification for the plant service water system (PSWS) in conjunction with the ultimate heat sink (UHS) analogous to STS 3.7.1. The PSWS does not perform any safety-related function. There is no interface with any safety-related component. Omission of specifications for the PSWS in conjunction with the non-safety UHS system (e.g., cooling tower) is acceptable because these systems do not perform safety-related functions and do not satisfy any of the criteria in 10 CFR 50.36(c)(2)(ii).

16.2.10.1 *Plant Service Water System*

The PSWS consists of two independent and 100-percent redundant trains that continuously circulate water through the reactor component cooling water system (RCCWS) and turbine component cooling water system (TCCWS) heat exchangers. It has functions related to the RTNSS to provide post-72-hour cooling to the RCCWS and TCCWS. Section 22.5.9 of this report addresses these short-term ACs. The PSWS is designed so that neither a single active nor single passive component failure results in a complete loss of nuclear island cooling and/or plant dependence on any safety-related system. This is achieved by redundant components, automatic valves, and piping cross-connects for increased reliability.

16.2.10.2 *Isolation Condenser/Passive Containment Cooling System Pools*

The water volume of the IC/PCCS pools provides the safety-related UHS function through evaporation. The ICS and the PCCS provide safety-related heat removal for design-basis events. The ICS and PCCS pools are safety related and contain sufficient water volume to act as the UHS, through evaporation, for a period of 72 hours after a DBA without replenishment; after that, operators must manually replenish the IC/PCCS pools using the fire water system, which is subject to short-term ACs. LCOs 3.5.4, 3.5.5, 3.6.1.7, and 3.7.1 require the ICS, PCCS, and the IC/PCCS pools to be operable.

RAI 16.2-78. The staff requested that the applicant describe the surveillance (including IST) and action requirements that would apply to the valves in the makeup water transfer line from the fire protection water system and the offsite water supply sources to the FAPCS. The availability of these flow paths and water sources is necessary to extend the passive cooling by the IC and PCCS beyond the initial 72 hours following a design-basis event and to replenish any water lost through evaporation from the spent fuel pool. In its response dated November 13, 2006, the applicant stated that it had enhanced the makeup water capability by replacing the single isolation valve with two isolation valves in parallel in the design of the water supply line from the fire protection system to the FAPCS. The applicant also stated that it would apply short-term ACs under RTNSS, and these controls would include appropriate testing requirements to ensure the availability of makeup water for the IC/PCCS pools and the spent fuel pools. The staff verified that the ACM contains the proposed ACs, and concluded that they are acceptable. Therefore, RAI 16.2-78 is resolved.

RAI 16.2-182. The staff requested that GEH revise the actions and surveillances of GTS 3.7.1 to address the following items. The GEH response dated January 28, 2009, is described with each item.

- The staff asked GEH whether the IC/PCCS pool temperature could be kept within its limit of 43.3 ºC (110 ºF), with drywell temperature at its limit of 65.6 ºC (150 ºF), because the IC/PCCS pools are located above and outside the containment boundary, directly above the drywell top slab. GEH stated that the drywell air space temperature is not expected to challenge the ability of the FAPCS to maintain the IC/PCCS pool temperature because the drywell air space must transfer heat through the floor of the IC/PCCS pool. The staff finds this response acceptable.

- The staff asked GEH to clarify the bases description of the connections between the IC/PCCS subcompartment pools and inner expansion pools. GEH clarified the bases upon which the following summary is based. Each IC/PCCS subcompartment pool is connected to one of two inner expansion pools by locked open manual valves, which are verified to be open to support operability of each ICS train (SRs 3.5.4.4 and 3.5.5.4) and each PCCS condenser (SR 3.6.1.7.2). Each inner expansion pool consists of three connected partitions, with a normally locked open manual valve in each connection. Each inner expansion pool is connected to the common (i.e., single) equipment pool by two piping connections. One connection to each expansion pool contains a squib-actuated pool cross-connect valve. The other connection to each expansion pool contains one fail-as-is double-acting pneumatic piston cross-connect valve. The pool cross-connect valves open automatically on inner expansion pool low level. Four level instrument channels monitor each IC/PCCS inner expansion pool and initiate an opening signal to all four of the expansion pool-to-equipment pool cross-connect valves on low level in either inner expansion pool. Opening one pool cross-connect valve from the equipment pool to each inner expansion pool provides the required makeup from the equipment pool to the inner expansion pools. Each inner expansion pool-to-equipment pool connection also includes a manually operated valve, which is normally locked open. The manual isolation valve on each of the four inner expansion pool-to-equipment pool lines and between each of the inner expansion pool partitions is verified to be locked open (SR 3.7.1.6) to support operability of the IC/PCCS pools. Operability of the IC/PCCS pools also requires that the reactor well gate not be installed (SR 3.7.1.7). By connecting the equipment pool and reactor well pool to the inner expansion pools, the volume of water available to the ICS and PCCS subcompartments is sufficient to support DHR for 72 hours without operator action or the need to replenish the water in the inner expansion pools. The staff concluded that Revision 6 of the bases for GTS 3.7.1

provides a clear description of connections between the IC/PCCS subcompartment pools and inner expansion pools and between the inner expansion pools and the equipment pool and the reactor well.

- The staff asked GEH how SR 3.7.1.3, "Verify average water temperature in IC/PCCS pools is ≤ 43.3 °C (110 °F)," can be met if one or more IC/PCCS pools are not available or isolated from the expansion pool or equipment pool, because only the temperature of the water in each of the available pools should be used to determine the average temperature. The applicant revised the SR to indicate that the average water temperature is determined by the volume and temperature of the water in the "available" IC/PCCS pools. This is acceptable.

- The staff asked GEH to clarify that SR 3.7.1.5, which requires verification of the continuity of DPS initiator and one safety related initiator, applies to each of the four expansion pool-to-equipment pool valves (one valve in each of the two connection lines on each expansion pool). GEH stated that the presentation in the SR and bases needed no clarification. This is acceptable because it matches the level of detail typically found in the STS for similar SRs.

- The staff requested that GEH revise the scope of Actions C and D by removing conditions corresponding to a loss of capability to open at least one connection between each expansion pool and the equipment pool (i.e., makeup available to both expansion pools through equipment pool connections). GEH deleted Action C, which had proposed allowing 7 days for the condition of just one operable connection to one expansion pool. The applicant relabeled Action D as Action C and retained the allowance of 8 hours to restore IC/PCCS pools to operable status when an IC/PCCS pool is inoperable for reasons other than Condition A, B, or C. GEH stated that this completion time was acceptable because (1) it was consistent with Action C of the AP1000 generic TS 3.6.6, "Passive Containment Cooling System (PCCS)," which specifies 8 hours to restore PCCS water storage tank parameters (temperature and volume) to within limits, (2) even with all equipment pool connections isolated, the IC/PCCS subcompartment and expansion pools still provide heat removal capability, and (3) there are alternate methods of providing makeup to the IC/PCCS pools (e.g., the bases state that the FAPCS includes flow paths for postaccident makeup water transfer from the fire protection system and off-site water supply sources to the IC/PCCS pools). The revised action requirements are therefore acceptable.

The staff verified that the applicant incorporated the changes proposed to GTS 3.7.1 in DCD Revision 6. Therefore, RAI 16.2-182 is resolved.

<u>RAI 16.2-189</u>. GTS SR 3.7.1.8 verifies actuation of each of the four IC/PCCS pool inner expansion pool-to-equipment pool cross-connect valves on an actual or simulated automatic initiation signal. The bases of SR 3.7.1.8 state that this SR overlaps the LSFT required by GTS SR 3.3.8.1.4 for DPS Function 4.a, "IC/PCCS Pool Expansion Pool to Equipment Pool Cross-Connect—Actuation, IC/PCC System Pool Level—Low," to provide complete testing of the assumed safety function. However, the GTS included no LCO or LSFT SR for the safety-related actuation logic function associated with the safety-related initiators on the cross-connect valves. Also, SR 3.5.4.5, which overlaps the LSFT of SR 3.3.5.4.1, does not appear to address

the safety-related initiators for opening the cross-connect valves. Consequently, the staff asked GEH to revise the GTS as described in the following discussions. GEH's response dated October 27, 2009, is described in each discussion.

- The staff asked GEH to add an LCO to explicitly require operability of (1) the safety-related IC/PCCS inner expansion pool level—low instrumentation function channels, and (2) the safety-related actuation logic function divisions that actuate to open the IC/PCCS pool inner expansion pool-to-equipment pool cross-connect valves on low level in at least one inner expansion pool.

  In its response, GEH stated it will revise GTS LCO 3.7.1 and the associated bases to explicitly require operability of the instrumentation channels, actuation logic divisions, and valve initiators associated with the IC/PCCS expansion pool-to-equipment pool cross-connect function. GEH also stated it will add SR 3.7.1.1 and SR 3.7.1.7 and associated bases to require performance of channel checks and channel functional tests of the IC/PCCS expansion pool level instrumentation. Along with the revised LCO and SRs, GEH also stated it will revise DCD, Tier 2 Section 7.4.4.3 and the bases for GTS 3.3.8.1, "Diverse Protection System (DPS)," to clarify the number of initiators on each of the cross-connect valves; e.g., "Each valve has four initiators (three divisional initiators and one DPS initiator)."

- The staff asked GEH to revise the GTS and bases by adding (1) a LSFT SR for these safety-related actuation logic function divisions, (2) appropriate action requirements for both the inner expansion pool level instrument channels and expansion pool-to-equipment pool cross-connect actuation divisions, and (3) appropriate bases for the LCO, actions, and SRs, including the overlap of the LSFT with tests of the valve initiators on an actual or simulated automatic initiation signal.

  In its response, GEH stated it will add SR 3.7.1.12 and associated bases to require a LSFT of the logic associated with the IC/PCCS expansion pool-to-equipment pool cross-connect function. The LSFT will test the safety-related logic associated with the safety-related valve initiators.

  GEH also stated it will add Required Action D.1 and Required Action E.1 to GTS 3.7.1 and bases to address the inoperability of a required instrument channel or actuation logic division, respectively. GTS 3.7.1 will specify a Completion Time of 20 hours for Required Actions D.1 and E.1 to restore the required instrument channel or actuation logic division to operable status. This Completion Time is consistent with the GTS Section 3.3 required action completion times because it includes (1) the typical 12-hour allowance to restore an ESBWR instrumentation channel/actuation division to operable status, followed by immediately declaring the supported component inoperable; and (2) the typical 8-hour allowance to restore the affected IC/PCCS pool to operable status. Failing that, GTS 3.7.1 (renumbered) Action G will require a unit shutdown.

  Finally, GEH stated it will revise the bases for SR 3.7.1.10 (previously SR 3.7.1.8) to state that SR 3.7.1.10, which verifies actuation of each of the four IC/PCCS pool inner expansion pool-to-equipment pool cross-connect valves on an actual or simulated automatic initiation signal, overlaps the LSFT of SR 3.7.1.12.

- GEH also confirmed the staff's observation about SR 3.5.4.5 by stating that "SR 3.5.4.5 does not test any feature of the IC/PCCS expansion pool-to-equipment pool cross-connect function. The cross-connect function safety-related initiators are fully tested via existing SR 3.7.1.10 (previously SR 3.7.1.8), which overlaps with newly created SR 3.7.1.12."

The staff reviewed the markup of the DCD pages, which were affected by the above described changes and included in the response letter, and found them to be acceptable. These changes result in acceptable GTS operability, action, and SRs for the IC/PCCS expansion pool-to-equipment pool cross-connect instrumentation and actuation functions. Therefore, RAI 16.2-189 is resolved.

GTS 3.7.1 requires the IC/PCCS pools to be operable and provides appropriate action and SRs. Therefore, GTS 3.7.1 and bases are acceptable.

16.2.10.3 *Control Room Habitability Area Heating, Ventilation, and Air Conditioning Subsystem*

CRHAVS is designed to automatically provide safety-related ventilation and radiation protection to keep the CRHA habitable following a design-basis event. Each redundant train is electrically independent and capable of performing the specified safety function. GTS LCO 3.7.2 requires two CRAHVS trains to be operable in Modes 1, 2, 3, and 4, and during OPDRVs. To automatically maintain a safe environment in the CRHA following a design-basis event, the CRHAVS relies on (1) ventilation dampers to isolate normal nonfiltered air intakes and exhaust ducts, (2) emergency filtration units and supply fans to supply and filter outside air, which may contain radioactivity, to the CRHA, and (3) the thermal design of the CRHA boundary, along with the CRHAVS filtered air supply, to maintain CRHA air temperature within acceptable limits.

The CRHAVS does not rely on air conditioning units for temperature control following isolation of CRHA nonfiltered air intakes and exhaust ducts as does the BWR/6 STS CR fresh air and control room air conditioning systems (CRACS). The STS require an operable CRACS. The bases for GTS 3.7.2 state that, following a DBA, the CRHAVS air-handling units, which provide air conditioning, are assumed to initially operate with power from non-safety-related uninterruptible ac sources, for up to 2 hours, to remove heat from non-safety loads within the CRHA to maintain temperature less than or equal to 78 ºF(this was changed to 74 º F in DCD Revision 7). After 2 hours, these non-safety loads are tripped and passive heat transfer from the CRHA to the CRHA boundary, which functions as a passive heat sink, limits the CRHA temperature increase to 15 ºF until ac power is restored no later than 72 hours after the start of the event.

<u>RAI 16.0-5, Supplements 1 and 2; RAI 16.2-118; and RAI 16.2-183</u>. The staff requested additional information to either justify the proposed GTS 3.7.2 LCO, action, and SRs and associated bases, for the CRHAVS or to revise these requirements to ensure that acceptable temperatures are maintained in the CRHA following a design-basis event. The applicant responded to the staff's questions as follows.

In RAI 16.0-5, Supplement 1, the staff asked GEH to justify its decision not to include an LCO for the CRHA filtered ventilation and cooling subsystem and a programmatic specification for ventilation filter testing. GEH stated in its response dated January 23, 2007, that the intent of the application of the 10 CFR 50.36(c)(2)(ii) LCO criteria is limited to the protective and mitigative features that are credited in the primary success path during the first 72 hours following the start of a postulated event. Referring to its response to RAI 16.0-1, GEH determined that the CRHA filtered ventilation and cooling subsystem did not meet the LCO criteria. At that time, the emergency bottled air system (EBAS) was the safety-related CRHA habitability system in the ESBWR design, which was intended to meet General Design Criterion 19, "Control Room" (see Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50). GEH indicated that it had not completed its assessment of non-safety systems for regulatory treatment in the form of short-term ACs, which would include consideration of the CRHA filtered ventilation and cooling subsystem. GEH requested that staff questions about the RTNSS be addressed in response to the NRC review of DCD Chapter 19A.

In RAI 16.0-5, Supplement 2, following the design change to replace the EBAS with the CRHAVS, the staff asked the applicant to establish an ITAAC to demonstrate the claimed postaccident temperature behavior of the CRHA and passive heat sink (i.e., the CRHA temperature increase limited to 15 ºF until ac power is restored no later than 72 hours after the start of the event). The staff also questioned the 72-hour allowance of GTS 3.7.2, Action A, to restore CRHA temperature to less than or equal to 78 ºF (this was changed to 74 º F in DCD Revision 7). RAI 16.0-5 was being tracked as an open item in the SER with open items. In its response dated April 17, 2008, GEH pointed out an ITAAC (see DCD, Tier 1, Revision 4, Section 2.16.2.2, "Control Building HVAC System," Item 4, and Table 2.16.2-4) related to verification of the CRHA passive cooling capability. GEH stated the following:

> ITAAC ensure that the Control Room Habitability Area (CRHA) temperature increase will be < 8.3 °C (15 °F) during the 72 hours following loss of normal cooling by passively dissipating heat to CRHA heat sinks. This ITAAC confirms that the non-safety-related air conditioning units are not required to limit the increase in CRHA temperature consistent with design commitments in DCD, Tier 2, Section 9.4.1 and DCD, Tier 2, Section 6.4.

In Revision 7 of the DCD, GEH revised ITAAC item 4 in Tier 1, Table 2.16.2-4 as a result of RAI 6.2-24 S01. The staff's evaluation of the resolution of RAI 6.2-24 S01 and the revised ITAAC are discussed in Sections 6.4 of this report.

GEH also made changes to the DCD "to ensure that the DCD fully describes the CRHA heat sink and that Technical Specification Surveillance Requirements verify that CRHA heat sink analysis initial conditions and assumptions are met." The applicant incorporated the following changes in DCD Revision 5

- Revised DCD Sections 6.4 and 9.4.1 to more completely describe the CRHA heat sinks and temperature limits assumed in the CRHA temperature analysis.

- Revised GTS 3.7.2, "CRHAVS," and bases to expand the requirements of SR 3.7.2.1 to define the CRHA heat sinks and establish acceptance criteria consistent with the changes to DCD Sections 6.4 and 9.4.1. This SR requires verifying once every 24 hours that the average temperature for each CRHA heat sink is within established design limits (DCD, Tier 1, Section 3H).

- Revised actions of GTS 3.7.2 to limit the duration of a heat sink temperature excursion when air temperatures in the CRHA or adjacent spaces are not being maintained within SR 3.7.2.1 limits. Specifically, GEH reduced the completion time for restoration of the CRHA heat sink temperature to within the SR 3.7.2.1 limit from 72 hours to 24 hours, as long as the heat sink temperature stays below a specified value. The applicant justified these changes by stating, "These Actions will ensure that CRHA heat sink temperatures are restored, or reactor shutdown initiated, before there is a substantial degradation of the CRHA heat sinks."

In RAI 16.2-118, the staff asked GEH to address several items about the CRHA heat sink requirements of GTS 3.7.2 in DCD Revision 3, including (1) correction of a typographical error in the bases, (2) additional justification for the 72-hour completion time for Required Action A.1 to restore CRHA temperature to within the limit, and (3) recommendation to require an operable AHU for the associated CRHAVS subsystem train to be operable, with appropriate action and SRs for the AHUs with supporting auxiliary cooling units, which provide active cooling of the CRHA. RAI 16.2-118 was being tracked as an open Item in the SER with open items. In its response, dated April 17, 2008, GEH corrected the typographical error by revising the fourth sentence of the "ASA" section of the bases for GTS 3.7.2 to state, "No single active or passive failure will cause the loss of outside air to the CRHA." This clarification corrected the error so that the bases are consistent with the DCD Section 6.4 description of the CRHAVS subsystem. Therefore it is acceptable. In its response to RAI 16.2-118, GEH also referred to its response to RAI 16.0-5, Supplement 2, regarding the reduced completion time of 24 hours to restore the CRHA heat sink temperature to less than or equal to 78 ºF (this was changed to 74 º F in DCD Revision 7) and its decision not to include an LCO for CRHA air conditioning. The response to RAI 16.2-118 provided no additional justification for not specifying the AHUs with supporting auxiliary cooling units in LCO 3.7.2 beyond that given by its response to RAI 16.0-5 Supplement 2.

In RAI 16.2-183, the staff requested that the applicant respond to the following items regarding GTS 3.7.2 in DCD Revision 5. Each item describes the associated GEH response in a letter dated March 25, 2009. The staff's conclusions are provided with each item.

- The staff asked GEH to add action and SRs for CRHA air temperature to be less than or equal to 78 degrees F (this was changed to 74 º F in DCD Revision 7)at all measured locations in the CRHA (i.e., no areas above this limit). GEH replied that the requested action and SRs are not necessary because monitoring the heat sink air temperature ensures that the bulk heat sink temperatures are within limits consistent with the analysis assumptions. For clarification, GEH revised Condition A to state, "One or more CRHA heat sink(s) with average temperature not within limit." The staff concludes that the response to this item is acceptable because the design of the CRHAVS subsystem (described in DCD Sections 6.4 and 9.4.1) ensures adequate mixing of air in the CRHA so that during normal operation the average air temperature associated with each CRHA heat sink will be representative of the bulk heat sink temperature.

- The staff questioned the adequacy of GTS 3.7.2, Required Action A.1, which requires verifying every 8 hours that each CRHA average heat sink temperature is less than or equal to 8.0 degrees F above the specified limit of 78 degrees F(this was changed to 74 º F in DCD Revision 7). The staff asked that GEH provide additional information to demonstrate that acceptable CRHA air temperatures will be maintained should a design-basis event occur with the average temperatures for all CRHA heat sinks at 86 degrees F. In response, GEH revised Required Action A.1 to require that each CRHA heat sink average air temperature be restored to within limits within 8 hours. The 8-hour completion time is intended to allow the operator time to evaluate and repair any discovered inoperable SSCs related to the high CRHA air temperature while minimizing risk. GEH stated that restoring the CRHA heat sink average air temperatures to within limits within 8 hours controls the temperature excursion of the CRHA heat sink structure because the temperature response of the CRHA heat sink area materials is slower than the response of the average air temperature on increasing temperature (i.e., a loss of normal cooling). The bases state that restoring the CRHA heat sink to within limits within 24 hours (Required Action A.2) can be performed by either administrative evaluation, considering the length of time and extent of the average air temperature excursion and the known thermodynamic properties of the structural materials, or by direct measurement of the temperature of the structural materials. Based on this rationale, the staff finds that Action A is acceptable.

- The staff asked GEH to describe how CRHA heat sink temperatures are measured. GEH stated that details of how the heat sink structure temperatures and heat sink average air temperatures are measured are procedural details beyond the scope of the DCD and the GTS bases. The staff recognizes that procedural details for measuring heat sink temperature may not be appropriate for inclusion in the DCD or GTS bases, but asked the question to better understand how GEH envisions plant operation using passive cooling in the CRHA for 72 hours after an event. Monitoring heat sink capacity by monitoring average air temperature provides a rapid conservative indication of degradation of heat sink capacity. Room air temperature responds to ventilation changes more quickly than the materials in the heat sink (notably concrete). Therefore, this approach is conservative. The staff finds the response to this item acceptable because in the event of a loss of normal cooling in the CRHA and a rise in temperature above the limit, GTS 3.7.2 requires restoring air temperature to within the limit within a short time of 8 hours and likely before significant temperature changes can occur in the passive heat sink itself.

- The staff asked GEH to (1) explicitly state in SR 3.7.2.1 that Table B 3.7.2-1 identifies the established CRHA heat sink design temperatures and (2) revise the bases to reference the location of these design temperatures in the DCD. GEH revised the bases for SR 3.7.2.1 to provide the location of the design limits by adding "(Ref. 4)," which is DCD Section 3H. The staff finds the response to this item acceptable because it is consistent with the STS conventions for writing SRs and because the bases now include a needed reference to the DCD.

- The staff requested that GEH clarify the ventilation damper alignment requirements for an operable CRHAVS train. GEH revised the LCO section of the bases for GTS 3.7.2 to clarify that, during normal operation, with the EFUs not in operation, the boundary isolation dampers associated with each EFU train are closed. During operation of an EFU fan, only the isolation dampers associated with the running EFU fan are open. The isolation dampers associated with the nonrunning EFU fans remain closed. The staff finds that the change to the bases provides the requested clarification. Therefore, the response to this item acceptable.

As described in the preceding evaluation of RAIs 16.0-5, 16.2-118, and 16.2-183, the staff finds the changes that the applicant made to GTS 3.7.2 and its bases to be acceptable. Therefore, RAIs 16.0-5, 16.2-118, and 16.2-183 are resolved.

RAI 16.2-54. The staff requested that the applicant adopt TSTF-448-A. In DCD Revision 3, the applicant changed the plant design to make CR ventilation safety related and accordingly added GTS 3.3.7.1, 3.3.7.2, and 3.7.2 for the CRHA instrumentation, actuation, and HVAC, respectively. The applicant also added GTS 5.5.13, “Ventilation Filter Testing Program (VFTP),” for the CRHAVS EFUs. The staff verified that the applicant had proposed GTS 3.7.2 and its bases and GTS 5.5.12, “CRHA Boundary Program,” in accordance with the STS changes stipulated in TSTF-448-A, with no significant deviations. Therefore, RAI 16.2-54 is resolved.

Based on the above evaluation and RAI resolutions, the staff concludes that GTS 3.7.2 and bases are acceptable.

16.2.10.4 *Main Condenser Offgas and Spent Fuel Pool Water Level and Temperature*

GTS 3.7.3 for main condenser offgas and GTS 3.7.5 for spent fuel pool water level are essentially the same as the corresponding STS 3.7.5 and 3.7.7, respectively, and are therefore acceptable. See Section 16.2.12 of this report under the discussion of RAI 16.2-76 regarding the addition of a fuel pool temperature limit to GTS 3.7.5.

16.2.10.5 *Main Turbine Bypass System*

GTS 3.7.4 for the main turbine bypass system is essentially the same as the corresponding STS 3.7.6. The main turbine bypass system satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii) because it is assumed to function as part of the primary success path during transient events that could increase reactor pressure, as described in DCD, Tier 2, Section 15.2.2. However, neither the STS nor the GTS include explicit requirements for instrumentation sensors and logic that support the steam bypass function of the SB&PC system.

DCD, Tier 2, Section 7.7.5.2.4 states that the “SB&PC system has no safety setpoints because it is not a safety-related system. Actual operational setpoints are determined during startup testing….The steam bypass function controls reactor pressure by responding to the bypass flow demand signal. It modulates the regulating bypass valves, which are automatically operated. This control mode is assumed…during plant load rejection and turbine/generator trips.”

DCD, Tier 2, Section 7.7.5, describes the SB&PC system, but does not discuss response time testing for the turbine bypass system. However, SR 3.7.4.3 specifies response time testing. GTS Section 1.1 provides the following definition of “turbine bypass system response time,” which is identical to that of the STS:

The TURBINE BYPASS SYSTEM RESPONSE TIME consists of two components:

a. The time for initial movement of the main turbine stop valve or control valve until 80% of the turbine bypass capacity is established; and

b. The time for initial movement of the main turbine stop valve or control valve until initial movement of the turbine bypass valve (TBV).

The response time may be measured by means of any series of sequential, overlapping, or total steps such that the entire response time is measured.

The bases for SR 3.7.4.3 states that the response time testing for the main turbine bypass system ensures that the response time complies with the assumptions of the "appropriate safety analysis." In DCD Revision 6, the applicant revised the bases for SR 3.7.4.3 by adding the sentence, "The response time limits are specified in Reference 4." The applicant revised the "References" section of the bases to include Reference 4, which is "Chapter 15, Table 15.2-1, 'Input Parameters, Initial Conditions and Assumptions Used in AOO and Infrequent Event Analyses.'" This table contains the turbine bypass system response time values assumed in the accident analysis. The two components of the response time are listed as follows:

- Total Delay Time from TSV or TCV to 80% of Total Bypass Valve Capacity, 0.17 seconds.

- Total Delay Time from TSV or TCV to the start of bypass valve Main Disc Motion, 0.02 seconds.

The 24-month frequency for the turbine bypass system response time testing is consistent with the STS. Therefore, the staff finds SR 3.7.4.3 and its bases acceptable.

RAI 16.2-53. The staff asked the applicant to specify a 31-day frequency for the surveillance to cycle the turbine bypass valve and describe in the bases the conditions for relaxing this frequency from 31 to 92 days, for optional use by a COL applicant. In its response dated November 13, 2006, the applicant committed to revise the surveillance frequency to 31 days in GTS SR 3.7.4.1 and to describe the option to extend the frequency to 92 days in the GTS bases. DCD Revision 3 incorporated these changes. Therefore, RAI 16.2-53 is resolved.

Based upon the above, GTS 3.7.5 and bases are acceptable.

16.2.10.6 *Selected Control Rod Run-In and Select Rod Insert Functions*

The applicant proposed GTS 3.7.6, "Selected Control Rod Run-In (SCRRI) and Select Rod Insert (SRI) Functions," to specify operability of the SCRRI function and the SRI function. The bases state that the SCRRI and SRI functions are required to be operable to limit the decrease in MCPR to within acceptable limits such that the FCISL is not exceeded during events that could result in a decrease in core coolant temperature or an increase in reactor pressure and cause a rapid increase in core reactivity. These events are loss of feedwater heating, generator load rejection with turbine bypass, and turbine trip with turbine bypass. The SCRRI function provides for electrical insertion of selected control rods using the FMCRD. The SRI function provides for hydraulic scram insertion of selected control rods. This specification addresses the operability and SRs for the following:

- SCRRI/SRI signal from the DPS to the RC&IS
- SCRRI function logic in the RC&IS
- SCRRI/SRI signal from the automated thermal limit monitor control rod block instrumentation function to the RC&IS
- FMCRD induction motor controller logic and emergency rod insertion panels
- SRI function logic in the DPS
- automatic SRI command signals to the scram timing test panel from the—
  - DPS
  - hard-wired turbine trip and load reject signals from the turbine control system
- control rods associated with the SCRRI and SRI functions
- electrical power to each FMCRD associated with the SCRRI function
- HCU solenoid return line switches for SRI function selected control rods
- loss-of-feedwater-heating instrumentation channels

The actions allow just 2 hours to restore the SCRRI and SRI functions to operable status; otherwise, the unit must be brought to below 25-percent RTP within the next 4 hours. The 2-hour completion time is reasonable because it provides an appropriate length of time to repair the component causing the SCRRI or SRI function to be inoperable and there is a low probability of an event occurring during this period requiring the SCRRI and SRI functions. The 4-hour completion time is reasonable based on operating experience and allows sufficient time to reach the required unit condition from full-power conditions in an orderly manner and without challenging unit systems.

The staff finds GTS 3.7.6 and associated bases to be consistent with STS style conventions. It is also technically consistent with the ESBWR design. Therefore GTS 3.7.6 and bases are acceptable.

Section 3.7 of the GTS implements modified versions of the STS for plant systems. The staff finds that the GTS for plant systems are essentially equivalent to the STS for plant systems. For those cases in which the GTS do not include STS for plant systems, ESBWR design differences provide sufficient justification for such omissions. Therefore, the staff finds that the GTS and bases for plant systems are acceptable.

16.2.11 ESBWR GTS Section 3.8, "Electrical Power Systems"

During the first 72 hours following the occurrence of a design-basis event, the ESBWR design relies only on dc electrical power sources (dc sources) for mitigating accident consequences and achieving a safe-shutdown condition of at least hot shutdown, Mode 3, or stable shutdown, Mode 4. (The definition of safe shutdown in DCD, Tier 1, Section 1.2.1, includes the operational conditions of hot shutdown, stable shutdown, and cold shutdown.) Consequently, the applicant did not propose a GTS for ac sources corresponding to STS 3.8.1, "AC Sources—Operating," STS 3.8.2, "AC Sources—Shutdown," and STS 3.8.3, "Diesel Fuel Oil, Lube Oil, and Starting Air." The ESBWR design designates ac sources and associated ac electrical power distribution circuits (ac distribution) as non-safety-related systems. However, after the initial 72-hour period, the design does require the availability of an ac source for maintaining a safe-shutdown condition. In addition, placing the plant in cold shutdown, Mode 5, is not possible without the availability of an ac source. Because an ac source is necessary for maintaining the plant in a safe-shutdown condition beyond 72 hours, the onsite ac sources (standby and ancillary diesel generators),offsite ac sources, and associated ac electrical power distribution circuits (ac distribution) are important from an RTNSS perspective and should be included in short-term ACs. Section 22.5.9 of this report addresses the ACs for onsite ac sources.

The dc sources supply emergency power to associated safety-related inverters, which convert 250-V dc power to 120-V ac power and provide uninterruptible 120-V ac power during all modes of operation. Uninterruptible 120-V ac power supplies all safety-related loads, including the safety-related DCIS and the control power for safety-related systems. The dc sources are designed to have sufficient capacity, independence, redundancy, and testing capability to perform their safety functions when any three of the four divisions are available, assuming a single failure of one of the three required divisions.

Each of the two safety-related inverters in each division receives power from an associated rectifier, or battery and battery charger. Both the battery charger and the rectifier are supplied with 480-V ac power by the associated division's isolation power center (IPC) bus. The battery charger and rectifier both convert 480-V ac power to 250-V dc power. If the battery charger and rectifier both lose ac power from the IPC bus, the associated safety-related 250-V battery will automatically supply the inverter by means of the 250-V dc bus. The output diodes for battery chargers and safety-related rectifiers isolate the output of each required battery from an associated 480 V ac IPC bus that is de-energized or has degraded voltage.

The ESBWR GTS for electrical power systems correspond to STS for electrical power systems as follows:

STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.8.4*	3.8.1	DC Sources—Operating (*same)
3.8.5*	3.8.2	DC Sources—Shutdown (*same)
3.8.6*	3.8.3	Battery Parameters (*same)
3.8.7*	3.8.4	Inverters—Operating (*same)

STS	ESBWR TS	ESBWR TS TITLE (*STS TITLE)
3.8.8*	3.8.5	Inverters—Shutdown (*same)
3.8.9*	3.8.6	Distribution Systems—Operating (*same)
3.8.10*	3.8.7	Distribution Systems—Shutdown (*same)

GTS 3.8.1, which is applicable in Modes 1, 2, 3, and 4, requires dc sources to be operable to support the three divisions of dc electrical power distribution and the three divisions of uninterruptible ac electrical power distribution required by GTS LCO 3.8.6. GTS LCO 3.8.1 and LCO 3.8.6 are acceptable because three operable divisions of the dc electrical power distribution and three operable divisions of the uninterruptible ac electrical power distribution represent the lowest functional capability of the electrical power distribution system required for safe operation of the facility, assuming a design-basis event with a loss of all offsite and onsite ac sources and a single failure that results in the loss of one of the three electrical power distribution divisions. An operable division requires two operable dc sources. An operable dc source requires a 250-V battery, an associated battery charger, and all associated control equipment and interconnecting cable. The staff has concluded that the actions of GTS 3.8.1 and 3.8.6 are acceptable, as described below in the evaluation of RAI 16.2-82. The SRs are consistent with those in STS 3.8.4 and 3.8.9. Since the LCO, action, and SRs of GTS 3.8.1 are consistent with the STS and the ESBWR design, GTS 3.8.1 and 3.8.6 are acceptable.

GTS 3.8.2, which is applicable in Modes 5 and 6, requires dc sources to be operable to support the divisions of dc electrical power distribution and divisions of uninterruptible ac electrical power distribution required by LCO 3.8.7. GTS LCO 3.8.2 and LCO 3.8.7 are acceptable because they will ensure the availability of sufficient 250-V dc power sources and portions of the dc electrical power distribution and the uninterruptible ac electrical power distribution to operate the unit safely and to mitigate the consequences of postulated events during shutdown (e.g., inadvertent reactor vessel draindown). The fuel-handling accident analysis (DCD, Tier 2, Section 15.4.1) does not credit the mitigation function provided by the CRHAVS charcoal filters. CR ventilation is assumed to operate in normal operation mode for the duration of the event. GTS 3.8.2 and 3.8.7 omit the applicability condition of “during movement of recently irradiated fuel” and the required action to immediately “suspend movement of recently irradiated fuel assemblies in the containment” when one or more required dc sources are inoperable, or one or more required electrical power distribution divisions are inoperable, respectively. The staff concludes that the actions of GTS 3.8.2 and 3.8.7 are acceptable as described below in the evaluation of RAI 16.2-82. The staff also concludes that the LCO, action, SRs of GTS 3.8.2 and 3.8.7 are consistent with STS 3.8.5 and 3.8.10. Since the LCO, action, and SRs of GTS 3.8.2 and 3.8.7 are consistent with the STS and the ESBWR design, GTS 3.8.2 and 3.8.7, and bases are acceptable.

Staff review of GTS 3.8.3, “Battery Parameters,” focused on differences associated with the proposed use of the VRLA battery type and resulted in the RAIs discussed below. These issues were resolved; however, when GEH changed to the VLA battery type, the applicant adopted action and SRs consistent with the STS and IEEE Standard 450-2002. Since the LCO, action, and SRs of GTS 3.8.3 are consistent with STS 3.8.6 and the ESBWR design, GTS 3.8.3 and bases are acceptable.

GTS 3.8.4, which is applicable in Modes 1, 2, 3, and 4, requires inverters to be operable to support the three divisions of uninterruptible ac electrical power distribution required by GTS LCO 3.8.6. The staff has concluded that the actions of GTS 3.8.4 are acceptable as described below in the evaluation of RAI 16.2-82. The staff also concludes that the LCO, action, and SRs of GTS 3.8.4 are consistent with STS 3.8.7 and the ESBWR design. Therefore, GTS 3.8.4 and bases are acceptable.

GTS 3.8.5, which is applicable in Modes 5 and 6, requires inverters to be operable to support the uninterruptible ac electrical power distribution divisions required by GTS LCO 3.8.7. The staff has concluded that the actions of GTS 3.8.5 are acceptable as described below in the evaluation of RAI 16.2-82. The staff also concludes that the LCO, action, and SRs of GTS 3.8.5 are consistent with STS 3.8.8 and the ESBWR design. Therefore, GTS 3.8.5 and bases are acceptable.

RAI 16.2-55. The staff asked the applicant to justify its proposal to use float current monitoring to determine battery state of charge (SOC), instead of a SR for measuring battery cell electrolyte specific gravity. RAI 16.2-55 was being tracked as an open item in the SER with open items. In its response dated November 13, 2006, the applicant committed to propose, upon final resolution of the staff's concerns with TSTF-360, a surveillance that conforms to the STS to the extent practicable and consistent with the ESBWR design. TSTF-360 is to be replaced with TSTF-500, "DC Electrical Rewrite—Update to TSTF-360," which was scheduled to be submitted by July 2007. Subsequent to its response, the applicant issued DCD Revision 3. This revision proposed that specific gravity measurements be replaced with float current monitoring to determine the battery SOC. To accept this proposal, the staff needed confirmation from the VRLA battery manufacturer that float current monitoring can accurately indicate the battery SOC during steady-state and discharge conditions. If float current monitoring does not indicate 100-percent SOC, the staff would have requested that the COL applicant commit to additional design margins in the battery sizing calculations to compensate for measurement uncertainty, and that the GTS bases specify these design margins. In DCD Revision 6, and in response to RAI 8.3-62 dated April, 2009, the applicant changed the type of battery to VLA and retained the proposed SR for float current measurements consistent with the STS. In addition, the applicant revised GTS 5.5.10, "Battery Monitoring and Maintenance Program," to address specific gravity. This specification states, "The following programs shall be established, implemented, and maintained….This program provides for battery restoration and maintenance, which includes the following:….A requirement to obtain specific gravity readings of all cells at each discharge test, consistent with manufacturer recommendations." This provision is consistent with staff comments that were subsequently incorporated into TSTF-500, Revision 2, which was submitted for staff review by the industry owners group TSTF by letter dated September 22, 2009. COL Information Items, such as item 3.8.1-4 in DCD Table 16.0-1-A, stipulate that use of battery float current instead of battery cell specific gravity to indicate that the battery is fully charged is acceptable "provided the battery manufacturer has confirmed the acceptability and acceptance criteria, and that battery capacity includes margin for state of charge uncertainty." The staff finds that the battery-parameter-related COL items listed in DCD Table 16.0-1-A will ensure that use of battery float current to indicate battery state of charge is adequately justified. The staff also finds that the battery monitoring and maintenance program specification will ensure that battery cell electrolyte specific gravity measurements will be obtained as recommended by the battery manufacturer to confirm battery state of charge during a battery discharge test. Therefore, RAI 16.2-55 is resolved.

RAIs 16.2-57, 16.2-87, and 16.2-184. The staff asked the applicant to include a value for the minimum acceptable pilot cell temperature. In its response dated November 13, 2006, the applicant committed to propose, upon final resolution of the staff's concerns with TSTF-360, a surveillance that conforms to the STS to the extent practicable and consistent with the ESBWR design. TSTF-360 is being replaced by TSTF-500, which was issued for NRC staff review in July 2007. Subsequent to its response, the applicant issued DCD Revision 3. This revision replaced the requirements in Required Action 3.8.3.D.1 and SR 3.8.3.4 for pilot cell temperature with battery room temperature. The revised DCD did not justify using battery room temperature and did not state whether the design includes continuous monitoring of the battery room temperature with high and low alarms in the MCR. Since battery cell temperature could change for reasons other than ambient conditions (e.g., power flow, resistivity issues/internal shorts), the staff determined that new SRs should be specified for the battery pilot cells and connected cells. The staff also noted that the surveillance frequency should specify taking temperature measurements at the negative post of battery pilot cells every 31 days and at the negative post of connected cells every 92 days. The issues in RAI 16.2-87 (response provided in a letter dated March 27, 2007) and RAI 16.2-184 (response provided in a letter dated February 2, 2009) are similar to the issue in RAI 16.2-57. Therefore, the staff considered RAIs 16.2-87 and 16.2-184 to be resolved for tracking purposes. RAI 16.2-57 was being tracked as an open item in the SER with open items. In DCD Revision 6, and in its response to RAI 8.3-62 dated April 17, 2009, GEH changed the type of battery to VLA and revised the actions and SRs of GTS 3.8.3, as well as the affected bases sections. GEH also changed GTS 5.5.10, "Battery Monitoring and Maintenance Program," to be consistent with the changes proposed in TSTF-500, Revision 1, which was submitted for staff review on November 5, 2008. See Section 8.3 of this report for additional evaluation of the VLA battery-related changes addressed by the response to RAI 8.3-62 and incorporated in DCD Revision 6. Based on the resolution of RAI 8.3-62, RAI 16.2-57 is resolved.

RAI 16.2-122. GTS 3.8.3 includes required actions and SRs for battery room temperature. The staff asked the applicant to explain the basis for battery room temperature and why the DCD or GTS bases do not require continuous monitoring of the battery room temperature with alarms in the MCR when room temperature is below or above established design limits. The staff pointed out that battery cell temperature could change for reasons other than ambient conditions (e.g., power flow, resistivity issues/internal shorts), and for this reason, requested that the applicant specify a new LCO for the battery pilot cells and connected cells. The surveillance frequency associated with these LCOs should specify that the battery pilot cell temperature at the negative post be measured every 31 days and at the negative post of connected cells every 92 days. In DCD Revision 6, and in response to RAI 8.3-62, the applicant changed the type of battery to VLA and revised GTS 3.8.3 to include a SR for battery pilot cells and connected cells consistent with the STS. Therefore, RAI 16.2-122 is resolved.

RAI 16.2-123. The staff asked the applicant to explain how battery room temperature will be maintained during loss of ac power. Battery performance is dependent on battery temperature. The applicant should provide assurance that the battery will perform its intended function without ac power to the battery room ventilation and air conditioning systems. The staff asked the applicant to discuss battery margins (i.e., aging margin, design margin, temperature correction factor, and float current monitoring uncertainty for 100-percent SOC) and the potential for thermal runaway. In DCD Revision 6, and in response to RAI 8.3-62, the applicant changed the type of battery to VLA. Accordingly, the applicant revised GTS 3.8.3 to include SRs consistent with the STS for (1) battery pilot cell electrolyte temperature and float voltage, and (2) connected cell electrolyte level and float voltage. The applicant also removed the previously proposed SR on battery room temperature. Therefore, RAI 16.2-123 is resolved.

RAI 16.2-124. Based on DCD Revision 4, the staff requested that GEH justify its decision to not follow IEEE Standard 1188-2005, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications," in proposed GTS SR 3.8.3.6. The proposed SR required battery capacity verification every 60 months and every 12 months when the battery showed degradation or reached 85 percent of expected life. IEEE Standard 1188-2005, however, recommends that the performance test interval should not be greater than 25 percent of the expected service life or 2 years, whichever is less. In its response dated June 4, 2007, the applicant proposed to revise the SR 3.8.3.6 frequency to "24 months and 12 months when battery shows degradation or has reached 85% of the expected life." This frequency is consistent with IEEE Standard 1188-2005. Should the VRLA battery service life be found to be less than 8 years, for example from testing, then the 24-month frequency would need to be reduced.

In a followup question to the applicant's response to RAI 16.2-124, the staff pointed out that the proposed minimum battery capacity of 80 percent in SR 3.8.3.6 is applicable to VLA batteries, not VRLA batteries. The staff requested that the applicant revise SR 3.8.3.6 to state, "Verify each required battery capacity is greater than or equal to 90% of the manufacturer's rating when subjected to a performance discharge test {or a modified performance discharge test}." This is consistent with the proposed bases and Section 6.3 of IEEE Standard 1188-2005. In a telephone conference between the applicant and the NRC staff on July 27, 2007, the staff proposed that the COL applicant provide documentation to justify the use of the modified performance discharge test for VRLA batteries in SR 3.8.3.6 and that the 80-percent battery capacity limit for the performance discharge test be bracketed in SR 3.8.3.6 as an item for the COL applicant to determine based on battery sizing.

However, in DCD Revision 6, GEH changed the battery type from VRLA to VLA, referenced IEEE Standard 450-2002, removed the option to perform a modified performance discharge test, and revised SR 3.8.3.6 to be consistent with STS SR 3.8.6.6, including the associated frequencies. On the basis of the changes made in DCD Revision 6, RAI 16.2-124 is resolved.

RAI 16.2-126. DCD Revision 4, GTS 3.8.1, Required Action A.2, states that, if one or both required battery chargers are inoperable on one required division, the associated battery must be returned to the fully charged condition. The bases specify a fully charged condition as either three consecutive hourly current readings with a change of "less than {0.5} amps" or a float current of "less than {2} amps." The staff stated that GTS 3.8.1, not the bases, must define the fully charged condition. In addition, the staff noted that the applicant gave no technical justification for three consecutive hourly readings with a change of "less than {0.5} amps" in lieu of a float current of "less than {2} amps." RAI 16.2-126 was being tracked as an open item in the SER with open items.

In its response dated December 4, 2007, GEH described two methods for determining battery SOC and stated that these methods are based on current monitoring because monitoring the electrolyte specific gravity of VRLA batteries is not feasible, and referenced IEEE

Standard 1188-2005. GEH also stated that a third method for determining SOC is monitoring the float current, which is specifically designed for a battery being maintained in standby service at float voltage and consistent with the STS, which are based on the use of VLA batteries. GEH reasoned that this third method could be applied to VRLA batteries and noted that chemical changes occur within the VRLA battery, as they do in the VLA battery, as a result of the aging process. These chemical changes will cause the float current for a fully charged VRLA battery to increase with battery age. Therefore, unless the float current acceptance criterion is periodically increased, this method could result in a conservative but incorrect determination that a fully charged ESBWR VRLA battery is inoperable. Because of this, in DCD Revision 6, GEH revised two reviewer's notes associated with proposed COL Items 3.8.1-2 and 3.8.3-1 (both entitled, "Acceptance criteria for verification that battery is fully charged." in DCD Table 16.0-1-A) by adding the following statement, denoted by underlining:

> Provide acceptance criteria for verification that battery is fully charged consistent with battery manufacturer recommendations. <u>Use of float current monitoring option requires that battery manufacturer confirm acceptability and acceptance criteria and that battery capacity includes margin for state of charge uncertainty</u>.

However, in Revision 6 of the DCD, GEH changed the battery type from VRLA to VLA and changed DCD Revision 5 by replacing GTS 3.8.1, Action A, and changing GTS 3.8.3, Required Action B.2 from "Verify battery is fully charged" to "Restore battery [float current < 30 amps]." (See discussion of RAI 16.2-82 in this section of this report.) These changes are consistent with the equivalent requirements in STS 3.8.4, Required Action A.2, and STS 3.8.6, Required Action B.2. The applicant also made conforming changes to the bases. Based on the applicant incorporating these changes in DCD Revision 6, RAI 16.2-126 is resolved.

<u>RAI 16.2-129</u>. The bases for LCO 3.8.1, "DC Sources," state that all safety-related Class 1E loads are isolated from the IPC buses by diodes on the output of both the non-safety-related rectifiers and the 250-V dc bus associated with the dc sources. The staff asked the applicant to explain why there are no SRs to periodically verify that the blocking diodes are operable. RAI 16.2-129 was being tracked as an open item in the SER with open items. In its response dated December 4, 2007, GEH committed to add SR 3.8.1.4 and associated bases to require verification every 24 months that the output diodes for the battery chargers and safety-related rectifiers do not allow current to flow from the dc source to an IPC bus that is deenergized or has degraded voltage. GEH stated that SR 3.8.1.4 will periodically verify that the output diodes for the battery chargers and safety-related rectifiers function to prevent degradation of the safety-related DC power system by the non-safety-related ac power system, as described in DCD Section 8.1.5.2. GEH also committed to revise SR 3.8.2.1 and the associated bases to require compliance with SR 3.8.1.4 for required battery chargers and associated safety-related rectifiers in Modes 5 and 6. GEH also committed to make conforming changes to DCD, Tier 1, Sections 2.13.3 and 2.13.5 to establish, in Table 2.13.5-2, ITAAC requirements to verify that the output diodes for the safety-related rectifiers prevent degradation of the safety-related DC power system by the non-safety-related ac power system. Specifically, SR 3.8.1.4 states, "Verify the output diode for each required battery charger and safety-related rectifier connected to the Isolation Power Center bus prevents reverse current flow" and has a 24-month frequency. The staff finds the proposed changes acceptable and verified their incorporation in DCD Revision 5. Therefore, RAI 16.2-129 is resolved.

RAIs 16.2-56 and 16.2-86. The staff asked the applicant to provide a value for the minimum acceptable pilot cell voltage in SR 3.8.3.2. RAI 16.2-86 is related to the minimum acceptable pilot cell float voltage. The minimum acceptable pilot cell float voltage is a bracketed value, and it is the responsibility of the COL applicant to ensure that the PTS specify the minimum acceptable voltage. RAI 16.2-56 is related to the pilot cell selection criteria. According to Revision 3 of DCD Chapter 16B, the bases for SRs 3.8.3.2 and 3.8.3.5 state that the cell selection criterion is the lowest cell voltage in the series string following the quarterly surveillance. The quarterly surveillance verifies that the float voltage of each connected cell of each required battery is greater than or equal to the minimum acceptable voltage. This selection criterion for the pilot cell will provide reasonable assurance that no cell voltage is less than the minimum acceptable voltage between quarterly surveillances. Based on the preceding discussion, the staff finds the response acceptable. Therefore, RAIs 16.2-56 and 16.2-86 are resolved.

RAIs 16.2-60 and 16.2-82. Based on its review of DCD Revision 1, the staff requested that the applicant explain and justify the action requirements for Condition A of GTS 3.8.1, "24-hour DC Sources—Operating." (This request also applied to the action requirements for Condition A of GTS 3.8.2, "72-hour DC Sources—Operating.") Specifically, RAI 16.2-60 stated the following:

> DCD, Tier 2, Revision 1, Chapter 16, Bases, Section 3.8.1, Required Action A.3, page B 3.8.1-5, should specify the power supply requirements for the alternate means of restoring battery terminal voltage. Explain whether the alternate means of restoring battery terminal voltage should rely on a power source that is independent of offsite power in order to justify the 7 day completion time.

The applicant's response to RAI 16.2-60 dated November 13, 2006, pointed out that the staff's concern was similar to Staff Concern 1 contained in NRC's letter to the operating reactor owners' group Technical Specifications Task Force, dated April 11, 2006, "Request for Public Meeting to Discuss Enclosed Document Electrical Engineering Branch Concerns with Technical Specifications Task Force (TSTF)-360, Revision 1 DC Electrical Rewrite" (ADAMS Accession Nos. ML061020636 and ML061100185). The applicant stated, "Upon final resolution of the staff concerns with TSTF-360, the ESBWR [design certification application] will address any agreed to changes to NUREG-1434." The staff notes that the industry's latest proposal to resolve issues with TSTF-360 is provided in TSTF-500, Revision 1, "DC Electrical Rewrite—Update to TSTF-360," dated November 5, 2008. In DCD Revision 2, Chapters 16 and 16B, dated December 15, 2006, the applicant revised the dc sources specifications and bases by eliminating 24-hour safety-related dc sources and requiring just three of the four divisions of dc sources to be operable in Modes 1, 2, 3 and 4, since three is the minimum number to meet the single failure criterion. GEH also reduced the 7-day completion time for an inoperable dc source battery charger (equivalent to the condition of one or both required battery chargers inoperable on one required division (i.e., one dc source division) to 72 hours. However, DCD Revision 2 did not resolve the concern about whether the alternate means of restoring battery terminal voltage (Required Action A.1) should rely on a power source that is independent of offsite power. In DCD Revisions 2 and 3, the bases for Required Action A.1 stated the following (emphasis added):

> Required Action A.1 requires that the battery terminal voltage be restored to greater than or equal to the minimum established float voltage within 2 hours.

> This time provides for returning the inoperable charger to OPERABLE status *or providing an alternate means of restoring battery terminal voltage* to greater than or equal to the minimum established float voltage.

The staff finds that this basis is acceptable because the only practical “alternate means” in the ESBWR design would be the backup battery charger. In addition, the shortened completion time of 72 hours to restore one battery charger in one division (GTS 3.8.1, Required Action A.3, in DCD Revision 6) is reasonable considering that the affected division can still supply all of its loads with just one battery or one battery charger supplying one dc bus and one inverter. Further, in DCD Revision 6, for the condition of “DC Sources associated with two DC Electrical power distribution buses on one required division inoperable,” GTS 3.8.1, Required Action B.1, requires restoring the required dc sources on one dc electrical power distribution bus to operable status within 8 hours. This is also reasonable, since the two remaining operable divisions are capable of initiating actuation of all safety functions assumed in the FSAR Chapter 15 analyses of design-basis events and accidents. Therefore, the staff considers RAI 16.2-60 to be resolved based on these reasons and the resolution of RAI 16.2-82.

In RAI 16.2-82, the staff requested that the applicant provide the basis for the proposed required action completion times in DCD Revision 1 for GTS 3.8.1, Action B, and GTS 3.8.5, Action A. This request was also relevant to GTS 3.8.2, Action B. These actions stated the following:

GTS 3.8.1,“24-hour DC Sources—Operating” (Modes 1, 2, 3, 4) (Divisions 1, 2, 3, and 4)

- Condition B. — One 24-hour DC Source battery inoperable.
- Required Action B.1 — Restore 24-hour battery to OPERABLE status.
- Completion Time — 48 hours

GTS 3.8.2,“72-hour DC Sources – Operating” (Modes 1 and 2) (Divisions 1 and 2)

- Condition B. — One 72-hour DC Source Division inoperable for reasons other than Condition A (One required 72-hour DC Source battery charger inoperable.)
- Required Action B.1 — Restore 72-hour DC Source Division to OPERABLE status.
- Completion Time — 30 days

GTS 3.8.5, “Inverters – Operating” (MODES 1 and 2; MODES 3 and 4, except the 72-hour inverters are not required to be OPERABLE.)

- Condition A. — One inverter inoperable.
- Required Action A.1 — Restore inverter to OPERABLE status.
- Completion Time — 24 hours for 24-hour inverter AND 30 days for 72-hour inverter

In its response dated January 26, 2007, subsequent to submission of DCD Revision 2, the applicant stated the following:

> The ESBWR design consists of four divisions with two 72-hour batteries per division for a total of eight safety-related batteries. The ESBWR no longer includes 24-hour batteries. The ESBWR design ensures single failure tolerance is maintained when any three of the four divisions of DC and uninterruptible AC electrical power sources are operable and the associated distribution systems are energized. The design described is reflected in Revision 2 of DCD, Tier 2, Chapter 16, "Technical Specifications," which requires operability of only three of the four DC and uninterruptible AC electrical divisions.

The applicant noted that DCD Revision 1 actions were also changed. The corresponding actions in DCD Revisions 2 and 3 stated the following:

GTS 3.8.1, "DC Sources—Operating" (Modes 1, 2, 3, 4) (Three Divisions)

- Condition B. — One or more DC Sources inoperable on one required division for reasons other than Condition A (one or both required battery chargers inoperable on one required division).
- Required Action B.1 — Restore DC Sources to OPERABLE status.
- Completion Time — 24 hours

GTS 3.8.4, "Inverters—Operating" (MODES 1, 2, 3, and 4) (Three Divisions)

- Condition A. — One required division inoperable.
- Required Action A.1 — Restore required division to OPERABLE status.
- Completion Time — 24 hours

Note that in DCD Revision 3, GTS 3.8.1 replaced the two previous specifications for dc sources—operating. Also note that in the renumbered inverter specification, GTS 3.8.4, Condition A addressed both inverters in a division being inoperable and noted that both must be restored to operable status in order to exit the condition. The applicant justified the proposed dc source completion time based on the enhanced design of the dc sources and the electrical power distribution in the ESBWR as compared to the BWR/6. The applicant justified the inverter division completion time based on the similarity of the BWR/6 and ESBWR inverter designs in that both assume that the ac bus is powered via the non-safety-related constant voltage transformer from an offsite or onsite ac source. Subsequent to DCD Revision 5, however, the applicant removed the constant voltage transformer from the ESBWR design.

In a supplement to RAI 16.2-82, the staff asked the following of GEH:

1. Explain in greater detail the design differences between BWR/6 and ESBWR that justify the 24-hour completion time in GTS 3.8.1, Action B, for restoring ESBWR dc sources in one required division to operable status or change it to a shorter completion time that the design difference can justify.

2. Provide additional justification for the 24-hour completion time in GTS 3.8.4, Action A, for restoring the required division to operable status or change it to an 8-hour completion time, which is consistent with the 8-hour completion time of Action B of GTS 3.8.6 for restoring one required division of uninterruptible ac electrical power distribution to operable status.

3. Revise required action completion times in GTS 3.8.6 for restoring electrical power distribution buses to operable status to be consistent with the completion times in GTS 3.8.1 and 3.8.4, if shorter completion times are proposed in response to Items 1 and 2 above.

4. Provide additional justification for the periodic 24-hour completion time for GTS 3.8.1, Required Action A.2, to verify that the battery is in a fully charged condition or propose and justify a periodic completion time much shorter than 24 hours.

Following subsequent conference calls between GEH and the NRC staff, GEH responded in a letter dated August 4, 2009 to RAI 16.2-82, Supplement 1, by proposing action requirements for GTS 3.8.1, 3.8.2, 3.8.4, 3.8.5, 3.8.6, and 3.8.7 consistent with the following descriptions:

- Specify a condition in which just one half of one division is inoperable with a 72-hour completion time to restore the division to operable status in Modes 1, 2, 3, 4, 5 and 6.

- Specify a condition in which both halves of one division are inoperable with an 8-hour completion time to restore half of the division to operable status, for Modes 1, 2, 3, and 4, and a completion time of immediately to declare affected (or associated supported) features inoperable (or stop core alterations and operations with a potential for draining the reactor vessel and initiate action to restore required features—dc sources, inverters, dc buses, or uninterruptible ac buses to operable status) for Modes 5 and 6.

The proposed action requirements for half of one required division being inoperable in Modes 1, 2, 3, 4, 5 and 6 are reasonable because the degraded division is still capable of powering its supported safety systems, although in some cases for less than the designed 72-hour period following a design-basis event, but for greater than 36 hours. Hence following a design-basis event in this condition, safety-related electrical power can withstand an additional active failure and still perform its intended support functions for a significant fraction of the 72-hour period. It is customary in standard TS to allow 72 hours for a loss of redundancy in a safety system consisting of two 100-percent capacity subsystems because of the low probability of a design-basis event occurring during the specified time to restore the redundant subsystem to operable status. Since the ESBWR design offers additional capability over that assumed for a similar condition in the BWR/6 design, the staff finds the 72-hour completion time to restore the inoperable half of one required division acceptable.

The proposed action requirements for a complete loss of redundancy (both halves of one required division are inoperable) in Modes 1, 2, 3, and 4, which require restoring at least half of the inoperable division to operable status within 8 hours, are reasonable considering the capability of the remaining two operable divisions to ensure a reactor scram and automatic actuation of all safety systems (ADS, GDCS, ICS, main steam and containment isolation, SLC, and CRHAVS), should a design-basis event occur. This capability exceeds that of the BWR/6 which would only retain half its safety system actuation capability in a similar condition. The proposed 8-hour time allowed to restore half of the inoperable division to operable status is acceptable because of the low probability that a design-basis event will occur during this time.

The proposed action requirements for a complete loss of redundancy in Modes 5 and 6, which require immediately declaring supported features inoperable, or suspending core alterations, suspending operations with a potential for draining the reactor vessel, and initiating action to restore the inoperable required features to operable status, are consistent with the BWR/6 STS. These action requirements will ensure that effective remedial measures will be taken to either minimize the chance of a shutdown event (e.g., drop of an irradiated fuel assembly) occurring while the unit is vulnerable to another failure, which could result in a loss of a safety function, or to prevent a shutdown event from occurring at all. Therefore, these actions are acceptable.

The staff also requested that the applicant provide additional justification for the periodic 24-hour completion time for GTS 3.8.1, Required Action A.2, to verify that the battery is in a fully charged condition or to propose and justify a periodic completion time much shorter than 24 hours. In its response to RAI 16.2-82, Supplement 1, the applicant proposed to remove GTS 3.8.1, Action A, since the revised action requirements adequately addressed the condition of an inoperable battery charger dc source. In addition, the applicant proposed to replace Action B in GTS 3.8.3, "Battery Parameters," with two actions—one for the condition of one battery on one required division with "[float current > 30 amps]," and the other for the condition of both batteries on one required division with "[float current > 30 amps]." Similar to the resolution of the action requirements for dc sources, inverters, and distribution buses, GEH proposed that for one battery on one required division with "[float current > 30 amps]," that 24 hours be allowed to restore the battery "[float current < 30 amps]." This time is reasonable since the affected division retains the capability to initiate actuation of all its supported safety systems because half of the division remains operable, although for less than the design 72-hour period, and the remaining two divisions can initiate actuation of all safety systems. This completion time is also consistent with a reviewer's note in the BWR/6 STS 3.8.6 bases concerning the completion time to restore a discharged battery to a fully charged state, as indicated by the battery's float current. For these reasons the proposed 24-hour completion time is acceptable.

For the condition of two batteries with "[float current > 30 amps]" on one required division, GEH proposed that 8 hours be allowed to restore one battery "[float current < 30 amps]." This time is reasonable since the remaining two divisions can initiate actuation of all safety systems. Also, it is unlikely that the second battery in a required division will be significantly discharged because of testing (i.e., a service discharge test). Therefore, 8 hours is expected to afford sufficient time to recharge the partially discharged battery, so that battery "[float current < 30 amps]." For these reasons, the staff finds the 8-hour completion time acceptable.

Based on the above evaluation of the GEH response and proposed action requirements for electrical power system specifications, RAI 16.2-82 is resolved.

The GTS for electrical power systems implement modified versions of the STS for the dc and vital ac electrical power systems. The staff finds that the GTS for electrical power systems are essentially equivalent to the STS for the corresponding electrical power system functions. For those cases in which the GTS do not include STS for electrical power systems, ESBWR design differences provide sufficient justification for such omissions. Therefore, the staff finds the GTS and bases for electrical power systems acceptable.

16.2.12 ESBWR GTS Section 3.9, "Refueling Operations"

The ESBWR GTS for refueling operations compare closely to the corresponding STS provisions, with only a few exceptions. The correspondence between Section 3.9 of the ESBWR GTS and Section 3.9 of the STS is as follows:

STS	GTS	GTS TITLE (*STS TITLE)
3.9.1*	3.9.1	Refueling Equipment Interlocks (*same)
3.9.2*	3.9.2	Refuel Position One-Rod/Rod-Pair-Out Interlock (*Refuel Position One-Rod-Out Interlock)
3.9.3*	3.9.3	Control Rod Position (*same)
3.9.4*	3.9.4	Control Rod Position Indication (*same)
3.9.5*	3.9.5	Control Rod OPERABILITY—Refueling (*same)
3.9.6*	3.9.6	Reactor Pressure Vessel (RPV) Water Level (*[RPV] Water Level—[Irradiated Fuel])
None	3.9.7	Decay Time
3.9.7*	None	(*[RPV] Water Level—[New Fuel])
3.9.8*	None	(*RHR—High Water Level)
3.9.9*	None	(*RHR—Low Water Level)

The GTS for refueling equipment interlocks, refuel position one-rod/rod-pair-out interlock, control rod position, control rod position indication, control rod operability—refueling, and RPV water level contain no significant differences from the corresponding STS requirements. Therefore, GTS 3.9.1, 3.9.2, 3.9.3, 3.9.4, 3.9.5, and 3.9.6, and bases are acceptable.

The GTS do not include a specification for the non-safety-related normal SDC system, which corresponds to the RHR system specified in the STS. The ESBWR employs passive safety-related methods for removing decay heat when the plant is in the refueling mode. (One such method is feed-and-bleed from the GDCS pool. If this method is not used, then decay heat may be removed by refueling cavity boiling if the refueling canal is full and the RPV upper internals are removed.) Because the accident analyses do not assume that the SDC system will function in a loss-of-cooling event during refueling shutdown conditions, the SDC system does not satisfy the criteria of 10 CFR 50.36(c)(2)(ii). Therefore, omitting specifications corresponding to the STS RHR requirements during refueling operations is acceptable.

The time interval between when the reactor was last critical and the initial movement of an irradiated fuel assembly from the reactor core is a key assumption in the dose consequence estimates of an ESBWR design-basis fuel-handling accident analysis, as well as in the spent fuel pool cooling requirements. As such, this decay time satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii) and must be included in an LCO in the ESBWR GTS, preferably in GTS

Section 3.9. The applicant proposed a decay time specification in ESBWR GTS 3.9.7, “Decay Time.” This specification provides a decay time limit and associated action and SRs consistent with the ESBWR fuel-handling accident analysis, STS format, and requirements of 10 CFR 50.36. Therefore, GTS 3.9.7 and bases are acceptable.

RAI 16.2-76. In its response to the supplement to this RAI dated August 13, 2007, the applicant proposed to establish RTNSS short-term ACs for spent fuel pool water level (AC 3.7.3, “SFP Water Level”) and the fire protection water supply system emergency makeup to the spent fuel pool (AC 3.7.1, “Emergency Makeup Water”). The applicant proposed to add these ACs to the ACM in appendix 19A to DCD Tier 2. Subsequently as discussed in Section 9.1.3 of this report, the applicant removed the AC for spent fuel pool water level and revised GTS 3.7.5 to require spent fuel pool level to be 9.20m (30.2ft) above the top of irradiated fuel assemblies and that pool water temperature be ≤ 60 °C (140 °F). These level and temperature limits apply to both the fuel building spent fuel storage pool and the deep pit area of the reactor building buffer pool. The applicant also added appropriate action and surveillance requirements for pool temperature. The staff finds the revised GTS 3.7.5 requirements and associated bases changes to be acceptable because they are consistent with the boil- off analysis assumptions, as discussed in Section 9.1.3 of this report, and will ensure that in the event of a loss of FAPCS cooling, the level in the spent fuel pool and buffer pool will remain above the top of the irradiated fuel assemblies for 72 hours without makeup.. Therefore, RAI 16.2-76 is resolved.

RAI 16.2-77. The staff asked the applicant to describe how the GTS include an LCO for a makeup water system for the reactor building buffer pool. The staff asserted that such a system satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii) as the primary success path to mitigate a loss of coolant inventory caused by a failure of the refueling seal around the reactor vessel or a failure of the inclined fuel transfer system (IFTS) interlocks. In its response dated May 16, 2007, GEH stated that the refueling bellows seal is designed to seismic Category I requirements; therefore, a rapid loss of coolant through this seal is not credible. GEH also stated that the IFTS is designed with sufficient redundancy and diversity to ensure that there are no modes of operation that will allow simultaneous opening of any set of valves that could cause draining of the water from the upper (buffer) pool in an uncontrolled manner. Since these events are not deemed credible, and are therefore not postulated in the safety analysis in DCD Chapter 15, GEH concludes that an LCO is not required for the FAPCS, which is designed to supply the makeup water to the buffer pool. However, AC 3.7.1, “Emergency Makeup Water,” requires the availability of FAPCS makeup capability. GEH revised DCD, Tier 2, Table 3.2-1 and Section 6.2.1.1.2, to show that the refueling bellows is a part of the containment system and is designed to seismic Category I. In addition, GEH removed “refueling bellows” from the list of refueling equipment in DCD Table 9.1-4. Based on the applicant’s response, RAI 16.2-77 is resolved.

RAI 16.2-99. The staff asked GEH why the third paragraph in the “Background” section of the bases for STS 3.9.2, “Refuel Position One-Rod-Out Interlock,” was replaced with another paragraph in the bases for GTS 3.9.2, “Refuel Position One-Rod/Rod-Pair-Out Interlock.” This STS paragraph states, “This specification ensures that the performance of the refuel position one-rod-out interlock in the event of a DBA meets the assumptions used in the safety analysis of FSAR Section [15.4.1.1].” In DCD Revision 5, the first sentence of the GTS paragraph states, “The refuel position one-rod/rod-pair-out interlock prevents the selection of a second control rod for movement when any other control rod or control rod pair is not fully inserted ([DCD] Section 7.7.2)." In its response, dated January 18, 2007, GEH stated that the control rod withdrawal error during refueling (DCD, Tier 2, Section 15.3.7) is categorized for the ESBWR as an infrequent incident, but not a DBA, as it is for the BWR/6 design. Since the proposed paragraph is consistent with the ESBWR design and safety analysis, it is acceptable and RAI 16.2-99 is resolved. The staff notes that this RAI was mistakenly associated with the resolution of RAI 4.6-23 regarding the CRDA, which Revision 5 of DCD, Tier 2, Section 15.4.6.3, discusses.

RAI 16.2-101. The NRC staff requested that the applicant adopt STS 3.9.7, "RPV Water Level—New Fuel or Control Rods," to ensure that new fuel assemblies or control rods are not moved over irradiated fuel assemblies seated within the RPV unless the water above the top of the irradiated fuel assemblies seated within the RPV is sufficient to retain iodine fission product activity in the water in the event of a fuel-handling accident resulting in the release of fission product activity from irradiated fuel assemblies. RAI 16.2-101 was being tracked as an open item with the SER with Open Items. In its response dated January 18, 2007, the applicant stated that dropping a new fuel assembly and dropping a control rod onto irradiated fuel are not DBAs for the ESBWR. Therefore, an LCO for RPV level in Mode 6 while moving new fuel or control rods does not meet Criterion 2 of 10 CFR 50.36(c)(2)(ii). In a supplement to this RAI, the staff requested that GEH add to GTS 3.9.6 the following applicability condition: "During movement of new fuel assemblies or handling of control rods within the RPV, when irradiated fuel assemblies are seated within the RPV." The staff also asked the applicant to make corresponding bases changes, consistent with BWR/6 STS 3.9.6, its bases, and the STS reviewer's note which states that "LCO 3.9.6 is written to cover new fuel and control rods as well as irradiated fuel." The staff made this request because there appeared to be no ESBWR design-specific reason to deviate from the BWR/6 STS 3.9.6. In its response dated May 27, 2009, GEH agreed to restore consistency with the STS by adding the above applicability condition to GTS 3.9.6 and making conforming bases changes. Therefore, RAI 16.2-101 is resolved.

The GTS for refueling operations implement modified versions of the STS for refueling operations. The staff finds that the GTS for refueling operations are essentially equivalent to the STS for the corresponding refueling constraints. For those cases in which the GTS does not include STS for refueling operations, ESBWR design differences provide sufficient justification for such omissions. Therefore, the staff finds the GTS and bases for refueling operations acceptable.

16.2.13 ESBWR GTS Section 3.10, "Special Operations"

The GTS associated with special operations correspond to the STS as follows:

STS	GTS	GTS TITLE (*STS TITLE)
3.10.1*	3.10.1	Inservice Leak and Hydrostatic Testing Operation (*same)
3.10.2*	3.10.2	Reactor Mode Switch Interlock Testing (*same)
3.10.3*	3.10.3	Control Rod Withdrawal—Shutdown (*Single Control Rod Withdrawal—Hot Shutdown)

STS	GTS	GTS TITLE (*STS TITLE)
3.10.4*	3.10.4	Control Rod Withdrawal—Cold Shutdown (*Single Control Rod Withdrawal—Cold Shutdown)
3.10.5*	3.10.5	Control Rod Drive Removal—Refueling (*Single Control Rod Drive Removal—Refueling)
3.10.6*	3.10.6	Multiple Control Rod Withdrawal—Refueling (*same)
3.10.7*	3.10.7	Control Rod Testing—Operating (*same)
3.10.8*	3.10.8	SHUTDOWN MARGIN (SDM) Test—Refueling (*same)
3.10.9*	None	(*Recirculation Loops—Testing)
None	3.10.9	Oxygen Concentration—Startup Test Program
None	3.10.10	Oscillation Power Range Monitor (OPRM)—Initial Cycle

The GTS associated with special operations implement modified versions of the STS for special operations. The staff finds that these specifications are essentially equivalent to the STS for the corresponding testing constraints and format and usage rules. The staff finds that for those cases in which a GTS provision differs from the equivalent STS provision or a GTS corresponding to the STS has not been included, the ESBWR design provides sufficient justification for such differences.

RAI 16.2-65. The staff identified inconsistent action requirements related to GTS 3.10.1, "Inservice Leak and Hydrostatic Testing Operation," and GTS 3.6.3.1, "Reactor Building," as compared to the actions described in STS LCOs 3.6.1 and 3.3.6.2. Specifically, the STS require immediate suspension of testing, restoration of secondary containment and secondary containment isolation valve operability, and cooldown to less than 93.3 ºC (200 º F) within 36 hours, if operability cannot be restored. In RAI 16.2-65, the staff requested that the applicant provide technical justification for allowing scram time testing in Mode 5, with the reactor coolant temperature greater than 93.3 ºC (200ºF) and with the reactor building inoperable for an extended time. In its response, dated November 13, 2006, the applicant revised the note to GTS 3.10.1, Required Action A.1, to state that "Required Actions to be in MODE 3 include reducing average reactor coolant temperature to ≤ 93.3 °C (200 °F) within 36 hours." Activities that could further increase reactor coolant temperature or pressure are suspended immediately in accordance with Required Action A.1, and the reactor coolant temperature is reduced to establish normal Mode 5 requirements. The allowed completion time of 24 hours for Required Action A.2 is based on engineering judgment and provides sufficient time to reduce the average reactor coolant temperature. The staff considers this change acceptable for ensuring that reactor coolant temperature will be reduced to less than 93.3 º C (200 º F) within 36 hours, consistent with the actions described in the STS. Therefore, RAI 16.2-65 is resolved.

The staff concludes that the constraints specified for testing under special operations will protect the fuel cladding and the RCS pressure boundary. Therefore, the staff finds the GTS and bases for special operations to be acceptable.

16.2.14 ESBWR GTS Section 4.0, "Design Features"

The GTS design features correspond to, and are consistent with, those specified in the STS.

In response to RAI 9.1-129 dated December 4, 2009, GEH stated it will:

- Change the value of k-infinity shown in GTS 4.3.1.1.a and GTS 4.3.1.2.a from "1.35" to "1.32" to be consistent with NEDC-33374P, "Safety Analysis Report for Fuel Storage Racks Criticality Analysis for ESBWR Plants."

- Delete the adjective "beginning-of-life (BOL)" from the phrase "maximum beginning-of-life (BOL) lattice k-infinity" in GTS 4.3.1.2.a to be consistent with NEDE-33374P and the STS.

- Add a requirement equivalent to STS 4.3.1.2.c regarding the center-to-center storage spacing distance for fuel assemblies placed in the new fuel storage racks in the reactor building buffer pool. GEH stated that two values will be provided since the center-to-center storage spacing is dependent upon whether the assemblies are within the same or differing rows of a given fuel storage rack. Since the new fuel storage racks do not contain neutron poison material, GEH stated that GTS 4.3.1.2.c will not contain a reference to neutron poison material.

These changes are acceptable for the reasons stated in the evaluation of the response to this RAI in Section 9.1 of this report.

<u>RAI 16.2-80</u>. The staff asked GEH to clarify GTS 4.3.2, "Drainage," regarding the minimum elevation used for spent fuel storage pool drainage prevention features. In its response dated May 14, 2007, GEH resolved this RAI by revising GTS 4.3.2 to state the following:

> 4.3.2 <u>Drainage</u>
>
> 4.3.2.1 The Fuel Building spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below an elevation of 14.3 m (46.9 ft) above the floor of the pool.
>
> 4.3.2.2 The Reactor Building buffer pool deep pit is designed and shall be maintained to prevent inadvertent draining of the pool below an elevation of 16.2 m (53.1 ft.) above the floor of the deep pit area.

Based on consistency with the STS, the ESBWR DCD, and the resolution of RAI 16.2-80 and RAI 9.1-129, the staff concludes that GTS Section 4.0 is acceptable.

16.2.15 ESBWR GTS Section 5.0, "Administrative Controls"

The GTS administrative controls correspond to, and are consistent with, those specified in the STS.

The applicant proposed (GEH letter MFN 09-149, dated February 26, 2009) to incorporate TSTF-511-A, "Eliminate Working Hour Restrictions from TS 5.2.2 to Support Compliance with 10 CFR Part 26." The revised regulations (Volume 73, Page 16966, of the *Federal Register;* March 31, 2008) in Subpart I, "Managing Fatigue," of 10 CFR Part 26, "Fitness for Duty Programs," superseded the previously proposed working hour restrictions of GTS 5.2.2.d, which is deleted. This change is consistent with the STS convention that TS do not repeat requirements specifically contained in regulations. It is also consistent with the changes contained in TSTF-511-A. Therefore this change is acceptable.

The staff requested additional information regarding the Section 5.0 specifications, as described in the following RAIs.

<u>RAI 16.2-68</u>. The staff asked the applicant to justify excluding STS 5.5.3, "Post Accident Sampling," from ESBWR GTS Section 5.5. The STS program contains a reviewer's note which states, "This program may be eliminated based on the implementation of NEDO-32991, Revision 0, 'Regulatory Relaxation for BWR Post Accident Sampling Stations (PASS),' and the associated NRC Safety Evaluation dated June 12, 2001." In its response dated November 13, 2006, and in accordance with the reviewer's note, the applicant stated that it planned to implement the guidance of NEDO-32991 and the associated NRC safety evaluation by revising the ESBWR DCD Appendix 1A and DCD Sections 7.5.2, 7.5.3, 9.3.2, 11.5, and others as necessary. The staff verified that GEH had incorporated the guidance into the appropriate DCD sections and noted that DCD Section 9.3.2.1 states that the process sampling system "design provides the capability to meet the requirements of NEDO-32991-A, 'Regulatory Relaxation for BWR Post-Accident Sampling Stations (PASS).'" Therefore, RAI 16.2-68 is resolved.

<u>RAI 16.2-69</u>. At the staff's request, the applicant incorporated TSTF-497-A, "Limit Inservice Testing Program SR 3.0.2 Application to Frequencies of 2 Years or Less," into GTS 5.5.5, "Inservice Testing (IST) Program," without deviation. This is acceptable because it is consistent with the staff's position on limiting IST interval extensions. Therefore, RAI 16.2-69 is resolved.

<u>RAI 16.2-89</u>. The staff requested that the applicant verify that proposed GTS 5.5.10, "Battery Monitoring and Maintenance Program," references the appropriate IEEE standard and includes all essential maintenance parameters. In its response dated March 27, 2007, the applicant stated that it had replaced its program proposal, as of Revision 3 to the DCD, to state the following:

> This Program provides for battery restoration and maintenance, based on the recommendations of IEEE Standard 1188-2005, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications," or of the battery manufacturer of the following:
>
> a. Actions to restore battery cells with float voltage < 2.18 V, and
>
> b. Actions to determine the cause and correct when cell temperatures deviate more than 3 °C (5 °F) from each other.

In a followup question, the staff stated that it had not yet endorsed IEEE Standard 1188-2005 and asked the applicant to revise the program to state the following:

> This Program provides for battery restoration and maintenance which includes the following:
>
> a. Actions to restore battery cells with float voltage < 2.18 V, and
>
> b. Actions to determine the cause and correct when cell temperatures deviate more than 3 °C (5 °F) from each other.
>
> c. Actions to verify that remaining cells are ≥ 2.14 VDC when a cell or cells have been found to be < 2.18 VDC.

RAI 16.2-89 was being tracked as an open Item in SER with Open Items.

In its response, dated December 4, 2007, GEH revised GTS 5.5.10 to be consistent with the above recommendation by the staff, but combined proposed Item (c) with Item (a) since it is related to the same condition of discovering one or more battery cells less than 2.18 V. GEH also added a reference to SR 3.8.3.5, "Verify each required battery connected cell float voltage is ≥ [2.09] V," to Item (a), since this surveillance provides a more direct connection to the appropriate actions if a cell is discovered to be less than 2.14 V (i.e., Action A of Specification 3.8.3). The staff finds these changes acceptable.

As described in the evaluation of RAI 8.3-62 in Section 8.3 of this report, in DCD Revision 6 GEH changed its type of battery to VLA and replaced Item (b) with three additional items such that GTS 5.5.10 states the following:

> This Program provides for battery restoration and maintenance, which includes the following:
>
> a. With battery cell float voltage [< 2.13] V, actions to restore cell(s) to [≥ 2.13] V and perform SR 3.8.3.5;
>
> b. Actions to equalize and test battery cells that had been discovered with electrolyte level below the minimum established design limit;
>
> c. Limits on average electrolyte temperature, battery connection resistance, and battery terminal voltage; and
>
> d. A requirement to obtain specific gravity readings of all cells at each discharge test, consistent with manufacturer recommendations.

The staff finds the proposed program elements acceptable because they are more conservative than those provided in the STS. Therefore, GTS 5.5.10 is acceptable and RAI 16.2-89 is resolved.

Based upon the above evaluations, the RAI resolutions, and consistency with the STS, the staff concludes that GTS Section 5.0 is acceptable.

16.2.16 Consideration of Generic Communications

Chapter 20 of this report lists generic communications. Those related to the TS and their dispositions are as follows:

Generic Letters	Disposition
82-021, "Technical Specifications for Fire Protection Audits," October 6, 1982	Not applicable; no longer in TS
82-023, "Inconsistency Between Requirements of 10 CFR 73.40(D) and Standard Technical Specifications for Performing Audits of Safeguards Contingency Plans," October 30, 1982	Not applicable; no longer in TS
87-009, "Sections 3.0 and 4/0 of the Standard Technical Specifications on the Applicability of Limiting Conditions for Operation and Surveillance Requirements," June 4, 1987	Superseded by STS
88-016, "Removal of Cycle-Specific Parameter Limits from Technical Specifications," October 3, 1988	DCD Table 16.0-1-A , COL Item 5.6.3-1 for bracketed information—COLR
89-014, "Line-Item Improvements in Technical Specifications—Removal of the 3.25 Limit on Extending Surveillance Intervals," August 2, 1989	Superseded by STS generic change process (TSTF travelers)
91-004, "Changes in Technical Specification Surveillance Intervals to Accommodate a 24-Month Fuel Cycle," April 2, 1991	Adopted in ESBWR GTS
93-005, "Line-Item Technical Specification Improvements to Reduce Surveillance Requirements for Testing During Power Operation," September 27, 1993	Superseded by STS
96-003, "Relocation of the Pressure Temperature Limit Curves and Low Temperature Overpressure Protection System Limits," January 31, 1996	DCD Table 16.0-1-A, COL Items 1.1-1 and 5.6.4-1 for bracketed information—PTLR
03-001, "Control Room Habitability," June 12, 2003	Closed based on adoption of TSTF-448-A

New Generic Issues	Disposition
78, "Monitoring of Fatigue Transient Limits for Reactor Coolant System"	The staff's evaluation of issue 78 is described in Section 3.12 of this report.

The above listed generic items are resolved for ESBWR based on the disposition listed above.

16.3 <u>Conclusions</u>

Based on its review of the proposed ESBWR GTS and GTS bases, the staff concludes that the proposed GTS and GTS bases are consistent with the regulatory guidance contained in the STS and STS bases. The proposed GTS and GTS bases contain design-specific parameters and additional requirements considered appropriate by the staff. The staff concludes that the proposed GTS and GTS bases comply with the requirements of 10 CFR 50.34, 10 CFR 50.36 and 10 CFR 50.36a and that they are therefore acceptable.