10.0 STEAM AND POWER CONVERSION SYSTEM

This chapter introduces the principle design features, systems and components of the steam and power conversion system. The components of this system are designed to produce electric power using the steam generated by the reactor, condense the steam into water, and return water to the reactor as heated feedwater (FW), with a major portion of its gaseous, dissolved, and particulate impurities removed to maintain reactor water quality.

The steam and power conversion system includes the turbine main steam system (TMSS), main turbine generator, main condenser, main condenser evacuation system, turbine gland seal system (TGSS), turbine bypass system (TBS), condensate purification system, condensate and feedwater system (CFS), and circulating water system. The majority of the steam and power conversion system piping and components are located in the turbine building.

10.1 <u>Summary Description</u>

Section 10.1 of the Fermi 3 Combined License (COL) Application (COLA) Final Safety Analysis Report (FSAR), Revision 4, incorporates by reference, with no departures or supplements, Section 10.1, "Summary Description," of Revision 9 of the economic simplified boiling-water reactor (ESBWR) design certification document (DCD), which is itself incorporated by reference into Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Appendix [X]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review.[1] The NRC staff's review confirmed that there is no outstanding issue related to this section. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to summary description that were incorporated by reference have been resolved.

10.2 <u>Turbine Generator</u>

10.2.1 Introduction

This section of the Fermi 3 COLA FSAR, Revision 4, describes the turbine generator equipment design and design bases, including programs to ensure turbine rotor integrity to minimize potential impacts on safety-related structures, systems and components (SSCs).

10.2.2 Summary of Application

Section 10.2 of the Fermi 3 COLA FSAR, Revision 4, incorporates by reference Section 10.2 of the ESBWR DCD, Revision 9. In addition, in FSAR Section 10.2, the applicant provides the following:

<u>COL Items</u>

- STD COL 10.2-1-A Turbine Maintenance and Inspection Program

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1 See *"Finality of Referenced NRC Approvals"* in SER Section 1.2.2 for a discussion on the staff's review related to verification of the scope of information to be included in a COLA that references a design certification.

The applicant addressed COL Item 10.2-1-A, "Turbine Maintenance and Inspection Program," in FSAR Subsections 10.2.2.4, 10.2.2.7, 10.2.3.6, and 10.2.3.7. In Subsection 10.2.3.6, the applicant stated that the turbine maintenance and inspection program that supports the original equipment manufacturer's (OEM's) turbine missile generation probability calculation is described in DCD Subsections 10.2.2.7, 10.2.3.5, 10.2.3.6, and in General Electric (GE) ST-56834/P, "ESBWR Steam Turbine – Low Pressure Rotor Missile Generation Probability Analysis," Revision 4, October 18, 2011. ST-56834/P, Revision 4, is a bounding missile probability calculation that contains the associated maintenance and inspection recommendations.

The applicant further addressed COL Item 10.2-1-A in FSAR Subsection 10.2.3.7. This section states that inspection of all valves of one functional type or size will be conducted if a detrimental unusual condition is discovered during the inspection of any single valve. It also states that the description of the valve inspection program, including valve and control system maintenance, inspections, testing, and associated frequencies, is provided in the bounding missile probability analysis (ST-56834/P, Revision 4).

In FSAR Subsections 10.2.2.4 and 10.2.2.7, the applicant described how the information in Subsections 10.2.3.6 and 10.2.3.7 applies to the turbine overspeed protection system and nonreturn valve inspection and testing.

- STD COL 10.2-2-A Turbine Missile Probability Analysis

In FSAR Subsection 10.2.3.8, the applicant provided information to address COL Item 10.2-2-A, "Turbine Missile Probability Analysis," by stating that the probability of turbine missile generation is based on bounding material property values in ST-56834/P. Since the applicant relies on ST-56834/P, Revision 4, to address the COL information items described above, the staff reviewed this report as part of its technical evaluation of the Fermi 3 COLA.

Supplemental Information

- STD SUP 10.2-1 Turbine Design

In FSAR Subsection 10.2.3.4, the applicant identified the turbine model as N3R-6F52 from the GE nuclear steam turbine series.

10.2.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is in NUREG-1966, the Final Safety Evaluation Report (FSER) related to the certified ESBWR DCD. In addition, the relevant requirements of the Commission's regulations for the turbine generator and the associated acceptance criteria are given in Section 10.2 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition."

The applicable regulatory requirements and associated guidance for the turbine generator are as follows:

- General Design Criterion (GDC) 4, "Environmental and Dynamic Effects Design Bases," of Appendix A to 10 CFR Part 50 as it relates to structures, systems, and components important to safety being appropriately protected against the effects of missiles that may result from turbine rotor failure.

- Regulatory Guide (RG) 1.115, “Protection Against Low-Trajectory Turbine Missiles,”
- NUREG-0800 Sections 3.5.1.3 and 10.2.3

10.2.4 Technical Evaluation

As documented in NUREG–1966, the NRC staff reviewed and approved Section 10.2 of the certified ESBWR DCD. The staff reviewed Section 10.2 of the Fermi 3 COLA FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the DCD and information in the COL FSAR represents the complete scope of information relating to this review topic.[1] The staff’s review confirmed that information in the application and information incorporated by reference address the required information related to the turbine generator.

The staff review of the information contained in the Fermi 3 COLA FSAR, Revision 4, is given below:

COL Items

- STD COL 10.2-1-A Turbine Maintenance and Inspection Program

DCD COL 10.2-1-A requires the COL applicant to provide a description of the plant-specific turbine maintenance and inspection program required to satisfy the OEM’s turbine missile generation probability calculation, including each of the criteria identified in Section II of SRP 3.5.1.3, and to address any valve and control system maintenance, inspections, and tests needed.

STD COL 10.2-1-A is distributed over four subsections of Revision 3 of the COLA FSAR: 10.2.2.4 (“Turbine Overspeed Protection System”), 10.2.2.7 (“Testing”), 10.2.3.6 (“Inservice Maintenance and Inspection of Turbine Rotors”), and 10.2.3.7 (“Inservice Inspection of Turbine Valves”). These subsection numbers and titles correspond to subsections in the DCD.

Subsection 10.2.2.4 states that inspection programs required by the turbine missile probability analysis and implementation of the inspection, maintenance, and testing programs discussed in Subsection 10.2.3.6 and 10.2.3.7 ensure operability. Subsection 10.2.2.7 states that nonreturn valves are inspected and tested in accordance with vendor recommendations, as discussed in Subsection 10.2.3.7. The description of the valve inservice inspection requirement in Subsection 10.2.3.7 is consistent with the DCD, and it refers to the bounding missile probability analysis (ST-56834/P) for the valve and control system maintenance, inspections, testing, and associated frequencies. The staff confirmed that ST-56834/P (Section 10.2) provides this information and, therefore, finds that the portion of STD COL 10.2-1-A provided in FSAR Subsection 10.2.2.4 is acceptable.

According to Criterion 4 of SRP Section 3.5.1.3, an applicant obtaining the turbine from a manufacturer with an NRC-approved missile probability analysis is required to meet the probabilities listed in Table 3.5.1.3-1. This includes the probability of a turbine failure resulting

[1] See *“Finality of Referenced NRC Approvals”* in SER Section 1.2.2 for a discussion on the staff’s review related to verification of the scope of information to be included in a COLA that references a design certification

in the ejection of turbine rotor fragments through the turbine casing, P_1, of less than 10^{-4} per year for loading a favorably oriented turbine and bringing the system on line. For the ESBWR, Subsection 10.2.1 of the DCD states that a more conservative P_1 value of less than 10^{-5} per year will be used if the recommended inspections and tests are conducted at the recommended frequencies. Criterion 4 of SRP Section 3.5.1.3 also states that the turbine manufacturer should provide applicants with the relationship between probability and time that can be used to establish the inservice inspection and valve testing intervals that meet the missile probability criterion. Since the applicant for Fermi Unit 3 submitted a missile probability analysis from the manufacturer for NRC approval as part of the COLA, the inspection and valve testing intervals are also expected to be provided by the manufacturer. In the case of Fermi Unit 3, the applicant stated in Subsections 10.2.3.6 and 10.2.3.7 of the COLA FSAR, Revision 3, as part of STD COL 10.2-1-A, that this information is described in DCD Subsections 10.2.2.7, 10.2.3.5, and 10.2.3.6. The staff previously reviewed these DCD subsections and determined that additional information is required from a COL applicant (i.e., COL 10.2-1-A and 10.2-2-A).

The staff determined that by only listing DCD subsections as the basis for the inspection and maintenance program, the applicant was not providing new information from the manufacturer as required by COL 10.2-1-A. Specifically, the turbine missile probability analysis recommended rotor dovetail and extraction nonreturn valve testing that is not included in the DCD. Therefore, in RAI 10.02.03-19, the staff requested that the applicant include a requirement for these inspections in the COLA FSAR. In a response dated October 28, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML11305A214), the applicant proposed revising Subsection 10.2.3.6 of the FSAR as follows, with the revised portion identified by underlined text:

> The turbine maintenance and inspection program that supports the Original Equipment Manufacturer's turbine missile generation probability calculation is described in DCD Subsections 10.2.2.7, 10.2.3.5, and 10.2.3.6, and in GE-ST, "ESBWR Steam Turbine – Low Pressure Rotor Missile Generation Probability Analysis," ST-56834/P, Revision 4.

The staff finds this acceptable because referencing ST-56834/P provides additional maintenance and inspection information to supplement the DCD requirements and thereby satisfies the OEM's missile probability calculation, as required by COL 10.2-1-A. The staff confirmed that the applicant made this change in Revision 4 of the COLA FSAR; therefore, this issue is resolved.

The staff reviewed the entire turbine missile probability analysis, ST-56834/P, as discussed below in the technical evaluation of STD COL 10.2-2-A. ST-56834/P addresses maintenance and inspection of rotors in Section 10.1 and inspection of turbine valves in 10.2. Section 10.1 is divided into Subsections 10.1.1 ("In-service Volumetric Rotor Inspections") and 10.1.2 ("Rotor Dovetail Inspections"), and it includes the following types of inspection:

- visual, magnetic particle, and ultrasonic examination of all accessible surfaces of the rotors

- visual and magnetic particle or liquid penetrant examination of all turbine blades

- visual and magnetic particle examination of couplings and coupling bolts

- rotor dovetail inspections

The first three inspections are also listed in the DCD in Subsection 10.2.3.6. The description of the maintenance and inspection program in Section 10.1 of ST-56834/P is consistent with the DCD. In addition, for all of these inspections, ST-56843/P recommends an interval of no more than 12 years. This recommendation applies to the surfaces of both high-pressure and low-pressure rotors and rotor dovetails. The inspection interval and the rotor dovetail inspections are not identified in the DCD; therefore, the staff reviewed this as new information provided by the applicant as part of STD COL 10.2-1-A.

For the rotors, the inservice inspections consist of visual, surface, and volumetric examinations, as described above. Subsection 10.1.1 of ST-56843/P also states that it is not possible to perform volumetric examination of 100 percent of the rotor because of the outside surface geometry and features. The report states that this inspection is not essential for meeting the missile probability requirements because the growth of an internal flaw to the critical crack size is never the most probable missile generation mechanism. Since a 100-percent inservice volumetric examination is not possible, GE uses controls on rotor metallurgy, manufacturing, and preservice inspection to limit undetected flaws in the rotor. Subsection 3.1.3 of ST-56843/P describes preservice inspection and testing, which includes 100 percent volumetric examination and 100 percent surface examination (including the bore surface of bored rotors).

As discussed in ST-56843/P, the probability of missile generation is dominated by turbine overspeed in the first 15 to 20 years of operation and by stress corrosion cracking (SCC) in an axial-entry dovetail slot bottom thereafter. Subsection 10.1.2 of ST-56843/P addresses the rotor dovetail inspections and recommends the following:

- magnetic particle surface examination of axial entry wheel dovetail faces
- ultrasonic examination of axial entry dovetail bottoms
- inspection of tangential entry dovetails (Stages 1 through 4) using a technique such as phased array ultrasonic examination
- engineering disposition of flaw indications (and possible removal of buckets for additional surface examination)
- inservice inspection measurements are used to recalculate missile probability and determine subsequent inspection intervals, if necessary (e.g., if cracks are found))

The applicant's bounding missile probability analysis (ST-56843/P) showed that the criterion of 10^{-5} annual missile generation probability is met for both bored and solid rotors for a period longer than the proposed 12-year inspection interval. Since the applicant's proposed rotor inspection program, including the 12-year inspection interval, is consistent with the DCD and meets the missile probability requirement in SRP 3.5.1.3 for bounding materials properties, the staff finds the program acceptable. This finding is based, in part, on the staff's detailed review of STD COL 10.2-2-A, the missile probability analysis.

Section 10.2 of ST-56843/P describes the recommended inservice inspection of valves. This supplements the following statement in FSAR Subsection 10.2.3.7 (based on the DCD):

Inspection of all valves of one functional type or size (i.e., stop, control, intercept, nonreturn) are conducted for any detrimental unusual condition (as defined by the turbine valve inspection program) if one is discovered during the inspection of any single valve.

In the response to RAI 10.02.03-19, the applicant also proposed a revision to Subsection 10.2.3.7 of the FSAR to address the valve testing requirements in COL 10.2-1-A as follows, with additions (underline) and deletions (strike-through) shown:

> The turbine valve inspection program, including ~~Associated~~ valve and control system maintenance, inspections, testing, and associated frequencies, is described ~~and test frequencies are established in the bounding missile probability analysis~~ in GE-ST, “ESBWR Steam Turbine – Low Pressure Rotor Missile Generation Probability Analysis,” ST-56834/P, Revision 4 ~~2, submitted in Reference 10.2-201~~.

In the same response, the applicant proposed deleting FSAR Subsection 10.2.6 (“References”), which contained ST-56834/P as the only entry, and correcting the revision number of ST-56834/P to Revision 4 in four places. The staff finds these changes acceptable because Revision 4 of ST-56834/P is the latest revision reviewed by the staff, and the FSAR Subsections 10.2.3.6 and 10.2.3.7 provide the reference information (making Section 10.2.6 unnecessary). The staff confirmed that the applicant made these changes in Revision 4 of the Fermi 3 COLA FSAR; therefore, this issue is resolved.

The staff finds that the information provided in Section 10.2 of the COLA FSAR describes the turbine maintenance and inspection program required to satisfy the manufacturer’s turbine missile generation probability calculation. This is based on the information being consistent with the corresponding information in the DCD and meeting the criteria in SRP Section 3.5.1.3 related to periodic inspection and testing. Therefore, the staff determined that STD COL 10.2-1-A is acceptable with respect to providing the valve testing requirements and frequencies. The staff also evaluated these requirements and frequencies as part of the review of COL 10.2-2-A, the missile probability analysis, which is described below.

- STD COL 10.2-2-A Turbine Missile Probability Analysis

DCD COL 10.2-2-A requires the COL applicant to provide an evaluation of the probability of turbine missile generation using criteria in accordance with NRC requirements (based, if necessary, on bounding material property values until the actual material specimens are available.)

The staff reviewed the STD COL information item 10.2-2-A, related to providing the turbine missile probability analysis using the criteria in RG 1.115 and the guidance in SRP Sections 3.5.1.3 and 10.2.3. Beginning with Revision 3 of the COLA FSAR, the applicant addressed this COL information by reference to a bounding analysis in GE-ST Report ST-56834/P, “ESBWR Steam Turbine – Low Pressure Rotor Missile Generation Probability Analysis.” Revision 2 of the FSAR referenced Revision 1 of ST-56834/P, dated July 2009. The staff’s review of the turbine missile probability analysis included sequential requests for additional information, which resulted in corresponding changes to the missile analysis report and the FSAR (summarized in the following paragraph). This process culminated with

Revision 4 of the FSAR (February 2012) referencing Revision 4 of ST-56834/P, dated October 28, 2011. The review is described in detail below.

Due to the response dated October 5, 2010, to RAIs 10.02.03-1 through 10.02.03-11 (ML102800185), the response dated July 29, 2011, to RAIs 10.02.03-12 through 10.02.03-16 (ML112140345); and the response dated October 28, 2011, to RAIs 10.02.03-17 through 10.02.03-19 (ML113050573), the applicant submitted a revised turbine missile analysis, ST-56834/P Revision 4 in aletter, dated October 28, 2011.The staff finds the revision to the analysis addressed the staff's concerns as described below and is acceptable. In addition, the staff notes that Revision 4 of the Fermi COL FSAR was revised to reference the updated Revision 4 of ST-56834/P as the applicant's turbine missile probability analysis for the GE model number N3R-6F52 turbine generator. The staff finds this acceptable since the updated analysis was found to be acceptable as discussed below, and is applicable to the Fermi 3 turbine generator.

ST-56834/P provides the turbine missile analysis for the probability of generating missiles for the GE model number N3R-6F52 turbine generator specified by the COL applicant in STD SUP 10.2-1. Revision 4 provides the methodology, assumptions, and results of the turbine missile generation probability, along with the manufacturer's recommendations for inservice testing and inspections. The methodology is consistent with the GE report entitled, "Probability of Missile Generation in General Electric Nuclear Turbines," issued January 1984, as approved by the NRC in NUREG-1048, "Safety Evaluation Report Related to the Operation of Hope Creek Generating Station," Supplement 6, Appendix U, "Probability of Missile Generation in General Electric Nuclear Turbines," issued July 1986. ST-56834/P, Revision 4, also provides updated data, such as valve failure rates, to demonstrate that the destructive overspeed analysis is conservative. The methodology used consists of calculating the probability of turbine overspeed in conjunction with the probability of rotor burst and the probability of a turbine rotor fragment penetrating the turbine casing. The failure modes assumed in the analysis include ductile burst (destructive overspeed), brittle fracture of a missed internal flaw growing to critical size due to cyclic fatigue and SCC at the rotor dovetails.

The material used for the rotor forgings is nickel-chromium-molybdenum-vanadium (NiCrMoV) alloy. The staff first reviewed the detailed material requirements in Revision 2 of ST-56834/P, which stated in Section 3.1 that the rotor material would be produced in accordance with GE material specification B50A373B8. The staff determined that ST-56834/P, Revision 2, did not provide enough detail about the material properties, including chemistry, as required by the ESBWR DCD. In addition, the staff's safety evaluation report (SER) for the ESBWR DCD, Subsection 10.2.3.2.3 stated that the COL applicant would provide the material properties (e.g., sulfur and phosphorus content) as part of the turbine missile analysis. In the October 5, 2010, response to RAI 10.02.03-4, and the July 29, 2011, response to RAI 10.02.03-12, the applicant stated that the rotors for the subject turbine use the GE material specification B50A373B8 or equivalent specification with more restrictive chemistry, and that this material has been used since the 1980s for numerous integral (nonbored) rotors with no rotor failures. The applicant also stated that the geometry of the buckets has been modified since the 1980s to reduce the stresses, and the use of shot peening applies compressive forces on the surfaces of the rotor to mitigate SCC.

However, the staff requested the applicant to provide the material specification for staff review to ensure the material specification, including chemistry, is adequate to meet the guidance in SRP Section 10.2.3 concerning chemistry and processing to ensure adequate fracture toughness, etc., for the turbine rotor. The July 29, 2011, response to RAI 10.02.03-12 clarified that the GE material specification B50A373B8 was revised to GE material specification B50A373B12. The only change in this Revision (B12) was to restrict the nickel range required to achieve the desired material properties in nuclear nonbored monoblock rotor forgings. The staff conducted an audit of the GE material specification, as documented in an NRC memorandum dated September 26, 2011 (ML112640028), which confirmed that the material has been used since the 1980s for turbine rotors and was only revised to restrict the nickel range. The staff also confirmed that the material is a vacuum-treated NiCrMoV alloy, with the amounts of alloying impurity elements in the range of typical modern nuclear turbines, which is consistent with Subsection 10.2.3.1 of the ESBWR DCD and SRP Section 10.2.3. Therefore, the staff finds that the material composition, which was included in Revision 4 of the ST-56834/P, is acceptable and will be used for the procurement of the Fermi 3 turbine rotor.

Concerning the use of the bounding material properties, the applicant stated in the October 28, 2011, response to RAI 10.02.03-17, that Revision 4 of ST-56834/P was updated to include the bounding assumption of the minimum tensile strength in the material specification. The bounding fracture appearance transition temperature (FATT) value of +30 degrees Fahrenheit (ºF) described in the ESBWR DCD and the applicable GE material specification B50A373B12 was also used in Revision 4 of the analysis, as discussed in the July 29, 2011, response to RAI 10.02.03-13. As stated in the October 5, 2010, response to RAI 10.02.03-5, this FATT value of +30ºF will be determined on the site-specific rotor forgings using a deep-seated impact specimens machined from radial trepans between the rotor wheels to ensure that the specified FATT value in the internal rotor region is met. In addition, the October 5, 2010, response to RAI 10.02.03-6 and 10.02.03-7 shows that 11 nuclear turbine rotor forgings in the past 20 years were tested and were well within the FATT value of -+30ºF throughout the rotor forgings. Statistically, the forging data resulted in a mean FATT value of -34F, with a plus two-sigma value of +11 F, which demonstrates that these large monoblock forgings can achieve the required FATT value of +30F. Therefore, the staff finds that the bounding material properties of the turbine rotor were used in the analysis.

In addition, in the October 28, 2011, response to RAI 10.02.03-18, the applicant clarified that the analysis used design overspeed stresses based on the postulated conditions and events in Chapter 7 of ST-56834/P. The design overspeed was clarified to be 120 percent of rated speed in the October 5, 2010, response to RAI 10.02.03-3, and is consistent with the ESBWR design overspeed. In the July 29, 2011, response to RAI 10.02.03-15, the applicant discussed that the tangential stresses at the slot bottoms of axial entry dovetails are lower than the previous shrunk-on-wheel keyways, and therefore the use of the shrunk-on-wheel crack initiation and growth characteristics is conservative. Also, this response provided information that shot-peening the rotor imparts compressive stresses to remove tensile residual stresses on the surface, thereby reducing the occurrence of SCC. Therefore, based on the above, the staff finds that the analysis used conservative and appropriate stresses in the turbine rotor.

Cyclic propagation of an assumed internal forging defect due to tangential stresses from mechanical and thermal loading was performed in the analysis. As stated in the October 28, 2011, response to RAI 10.02.03-18, the loading was determined based on both normal and abnormal turbine speed, with assumed annual cyclic loading due to starts, stops, and load swings of the turbine. These stresses were derived using finite element analysis based on the geometry for the N3R-6F52 rotor using corresponding startup transient thermal loadings, as stated by the applicant in its October 5, 2010, response to RAI 10.02.03-9.

The report includes analysis of rupture of the turbine rotor due to SCC in the slot bottoms of the rotor dovetails for the axial entry dovetails. The crack growth rate of shrunk-on-wheel keyways was used as a conservative basis, due to the higher stresses at these keyways from past operating experience when compared to the current monoblock forgings. The tangential stress of the dovetail slots in the monoblock forgings are much less than in the previous shrunk-on-wheel keyways, as illustrated in the October 5, 2010, response to RAI 10.02.03-10. Also, shot-peening of the turbine rotor surfaces reduces residual stresses and adds compressive stresses to mitigate the occurrence of SCC, as discussed in the July 29, 2011, response to RAI 10.02.03-15. The analysis demonstrated that the critical crack size in the dovetail slots would be reached in approximately 40 years, and that the crack size is well within the nondestructive inspection capabilities, as discussed in the July 29, 2011, response to RAI 10.02.03-13.

The ductile tensile burst of the rotor was analyzed using the average tangential stress of each rotor stage and the corresponding tensile strength of the material. . The minimum ultimate tensile strength of the material specification was used in order to be a bounding analysis.

These three failure modes—cyclic fatigue, SSC, and ductile tensile burst—were used to calculate the probability of rupturing the rotor, and were then combined to achieve a single probability of rupturing a turbine rotor. This was conducted for various scenarios and turbine speeds and these probabilities of rupturing a rotor, combined with the probability of the ruptured rotor fragment penetrating the turbine casing resulted in a final probability of generating a turbine missile. The result of the annual probability of generating a turbine missile is presented in Figures 9-1 and 9-2 of ST-56834/P.

These annual probability results in Figures 9-1 and 9-2 of ST-56834/P demonstrate that the probability of generating turbine missiles is less than 10^{-5} for an inspection interval greater than 12 years. Therefore, the proposed inspection interval of 12 years, as stated in Section 10.1 of the ST-56834/P, Revision 4, meets the criteria in RG 1.115. Section 10.1 of the ST-56834/P, Revision 4, also provides the turbine manufacturer recommendations for the inspection and maintenance program description on the turbine rotors, which includes the following:

- visual, magnetic particle, and ultrasonic examination of all accessible rotor surfaces
- visual and magnetic particle or liquid penetrant examination of all turbine blades
- visual and magnetic particle examination of couplings and coupling bolts

These inspection methods are consistent with the ESBWR DCD, Subsection 10.2.3.6.
As clarified in the October 28, 2011, response to RAI 10.02.03-19, the turbine manufacturer also recommends that rotor dovetail inspections, detailed in Subsection 10.1.2 of the ST-56834/P, Revision 4, be performed within a 12-year interval since GE determined in Section 9 of the ST-56834/P, Revision 4, that SCC in dovetail slot bottoms controls the probability of generating a turbine missile after 20 years of operation. The staff finds that the proposed description of the inspection program and inspection interval of 12 years acceptable since it meets the criteria of RG 1.115 and is consistent with the guidelines of SRP Section 10.2.3 to ensure that the turbine rotor integrity is maintained to preclude the generation of a missile.

As clarified by the October 5, 2010, response to RAI 10.02.03-2, a MARK VIe turbine generator control system (TGCS) is used for the ESBWR turbine generator at Fermi 3. This TGCS has the same functional design and component requirements of previous GE turbine generators, with improvements made based on operating experience. Some of the improvements, as detailed in the October 5, 2010, response to RAI 10.02.03-11, include the use of direct mechanical connections to the valve stem to reduce the number of moving parts and eliminate potential linkage binding on the control and intercept steam valves. These direct linkages have also been used in current operating plants on the main stop valve and intercept stop valves. In addition, the October 5, 2010, response to RAI 10.02.03-11 provided the steam valve failure rates based on failure assessment data reports collected in 1993 and 2008 and were used in the ST-56834/P for the main stop and control valves and the intermediate stop and intercept valves. As stated in the July 29, 2011, response to RAI 10.02.03-16, the improvements made after 1984 were effective in reducing the probability of failures, with the failure rates listed in Section 5 of ST-56834/P, Revision 4.

Subsection 5.4.1 provided the hydraulic system reliability model based on the following common failure modes: water contamination caused by leaking oil coolers and corrosion of non-stainless steel mechanical and/or electrical hydraulic trip valves. After 1984, GE improved the designs and material in current operating plants, such as titanium hydraulic oil coolers and new hydraulic fluid conditioning equipment that resolved these common failure modes. However, the analysis used the pre-1984 hydraulic failure rate model as a conservative assumption, which bounds the improved hydraulic system proposed for the ESBWR turbine. The overspeed probability from valve failures was performed for valve test intervals of 90 and 120 days, resulting in similar annual missile probabilities, which were provided in the July 29, 2011, response to RAI 10.02.03-16. The overspeed probability for a valve test interval of 120 days was well within the criteria of 10^{-5} per year specified in RG 1.115 and the guidance in SRP Section 3.5.1.3. Therefore, the staff finds the 120-day test interval acceptable since it meets the annual missile probability criteria of 10^{-5} per year in RG 1.115 and as specified in the guidelines in SRP Sections 3.5.1.3 and 10.2.3 to ensure that the turbine rotor integrity is maintained to preclude the generation of missiles.

The staff finds the applicant's referenced turbine missile probability analysis, ST-56834/P, Revision 4, provides an acceptable analysis that substantiates the turbine manufacturer's recommendations for inspecting and testing the turbine rotor and associated valves using the criteria in RG 1.115. In addition, the applicant's description of the turbine maintenance and inspection program, which includes the turbine manufacturer's recommendations for inspecting and testing the turbine rotor and associated valves, is consistent with the guidance in SRP Section 10.2.3, and Subsection 10.2.3 of the ESBWR DCD. Therefore, the staff determined that STD COL 10.2-2-A is acceptable with respect to providing an evaluation of the probability of turbine missile generation using criteria in accordance with NRC requirements.

With respect to the review of STD COL 10.2-1-A and STD COL 10.2-2-A, the staff has determined that RAIs 10.02.03-1 through 10.02.03-19 are resolved..

Supplemental Information:

- STD SUP 10.2-1 Turbine Design

In FSAR Subsection 10.2.3.4, "Turbine Design," the applicant states that GE will manufacture the turbine and generator for the Fermi 3 site. The applicant selected the N3R-6F52 turbine model, which is one of GE's N series nuclear steam turbines. The staff finds this acceptable, because GE provided an acceptable turbine missile analysis for this model, as discussed above in the evaluation of STD COL 10.2-2-A.

10.2.5 Combined License Activities

There are no post COL activities related to this section.

10.2.6 Conclusion

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. The NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information relating to the turbine generator, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to the turbine generator that were incorporated by reference have been resolved.

In addition, the staff concludes that the relevant information presented within this section of the COL FSAR is acceptable and meets the requirements of GDC 4. The staff evaluated STD COL 10.2-1-A and STD COL 10.2-2-A according to the relevant NRC regulations and acceptance criteria defined in NUREG–0800, Sections 3.5.1.3 and 10.2.3. The staff finds the applicant has satisfactorily addressed DCD COL Item 10.2-1-A because the proposed maintenance and inspection program is consistent with the corresponding information in the DCD and meets the criteria in SRP Section 3.5.1.3 related to periodic inspection and testing. The staff finds the applicant has satisfactorily addressed DCD COL Item 10.2-2-A because the turbine missile probability analysis, ST-56834/P, provides the turbine manufacturer's recommendations for inspecting and testing the turbine rotor and associated valves using the criteria in RG 1.115. Additionally, the staff reviewed STD SUP 10.2-1, which provides the turbine model number, and found this supplemental information acceptable, because the applicant provided an acceptable turbine missile analysis for this model, as discussed in the evaluation of STD COL 10.2-2-A.

10.3 Turbine Main Steam Supply System

Section 10.3 of the Fermi 3 COLA FSAR, Revision 4, incorporates by reference, with no departures or supplements, Section 10.3, "Turbine Main Steam Supply System," of Revision 9 of the ESBWR DCD, which is itself incorporated by reference into 10 CFR Part 52, Appendix [X]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review.[1] The NRC staff's review confirmed that there is no outstanding issue related to this section. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to turbine main steam supply system that were incorporated by reference have been resolved.

10.4 Other Features of Steam and Power Conversion System

This section describes other features of the steam and power conversion system:

- Subsection 10.4.1: The main condenser system functions as the steam cycle heat sink in receiving, condensing, and deaerating steam from the main turbine and other vents and drains in the steam cycle system.
- Subsection 10.4.2: The main condenser evacuation system establishes and maintains the main steam condenser vacuum and removes noncondensable gases and air from the main condenser.

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[1] See *"Finality of Referenced NRC Approvals"* in SER Section 1.2.2 for a discussion on the staff's review related to verification of the scope of information to be included in a COLA that references a design certification.

- Subsection 10.4.3: The turbine gland seal system prevents air leakage into and steam out of the annulus space between the turbine and steam valve shafts.
- Subsection 10.4.4: The turbine bypass system enables a system to allow some main steam flow directly to the main condensers, bypassing the turbine.
- Subsection 10.4.5: The circulating water system (CWS) provides a continuous supply of cooling water to the main condenser.
- Subsection 10.4.6: The condensate purification system (CPS) purifies the condensate and minimizes corrosion/erosion products in the power conversion cycle.
- Subsection 10.4.7: The condensate and feedwater system supplies high-purity feedwater to the reactor at the required flow rate, pressure, and temperature.
- Subsection 10.4.8: The steam generator blowdown system for pressure-water reactors (PWRs) is not applicable to the ESBWR design.
- Subsection 10.4.9: The auxiliary feedwater system for PWRs is not applicable to the ESBWR design.

10.4.1 Main Condenser

Subsection 10.4.1 of the Fermi 3 COLA FSAR, Revision 4, incorporates by reference, with no departures or supplements, Subsection 10.4.1, "Main Condenser," of Revision 9 of the ESBWR DCD, which is itself incorporated by reference into 10 CFR Part 52, Appendix [X]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this subsection remained for review.[1] The NRC staff's review confirmed that there is no outstanding issue related to this subsection. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to main condenser that were incorporated by reference have been resolved.

10.4.2 Main Condenser Evacuation System

Subsection 10.4.2 of the Fermi 3 COLA FSAR, Revision 4, incorporates by reference, with no departures or supplements, Subsection 10.4.2, "Main Condenser Evacuation System," of Revision 9 of the ESBWR DCD, which is itself incorporated by reference into 10 CFR Part 52, Appendix [X]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this subsection remaining for review.[1] The NRC staff's review confirmed that there is no outstanding issue related to this subsection. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to main condenser evacuation system that were incorporated by reference have been resolved.

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[1] See *"Finality of Referenced NRC Approvals"* in SER Section 1.2.2 for a discussion on the staff's review related to verification of the scope of information to be included in a COLA that references a design certification.

10.4.3 Turbine Gland Seal System

Subsection 10.4.3 of the Fermi 3 COLA, Revision 4, incorporates by reference, with no departures or supplements, Subsection 10.4.3, "Turbine Gland Seal System," of Revision 9 of the ESBWR DCD, which is itself incorporated by reference into 10 CFR Part 52, Appendix [X]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue related to this subsection remained for review.[1] The NRC staff's review confirmed that there is no outstanding issue related to this subsection. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to turbine gland seal system that were incorporated by reference have been resolved.

10.4.4 Turbine Bypass System

Subsection 10.4.4 of the Fermi 3 COLA, Revision 4, incorporates by reference, with no departures or supplements, Subsection 10.4.4, "Turbine Bypass System," of Revision 9 of the ESBWR DCD, which is itself incorporated by reference into 10 CFR Part 52, Appendix [X]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue related to this subsection remained for review.[1] The NRC staff's review confirmed that there is no outstanding issue related to this subsection. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to turbine bypass system that were incorporated by reference have been resolved.

10.4.5 Circulating Water System

10.4.5.1 *Introduction*

The CWS provides cooling water for removal of the power cycle heat from the main condensers and transfers this heat to the normal power heat sink.

10.4.5.2 *Summary of Application*

Subsection 10.4.5 of the Fermi 3 COLA FSAR, Revision 4, incorporates by reference Subsection 10.4.5, "Circulating Water System," of the ESBWR DCD, Revision 9. In addition, in FSAR Subsection 10.4.5, the applicant provides the following conceptual design information (CDI):

Site-Specific Information Replacing Conceptual Design Information

The applicant replaced the CDI provided in the DCD with a detailed description of the site-specific system for Fermi 3 as follows:

- EF3 CDI – FSAR Subsection 10.4.5.2.1, "General Description"

The applicant described the CWS by replacing the design information provided in the DCD with a more detailed general description of the site-specific system proposed for Fermi 3.

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1 See *"Finality of Referenced NRC Approvals"* in SER Section 1.2.2 for a discussion on the staff's review related to verification of the scope of information to be included in a COLA that references a design certification

- EF3 CDI – FSAR Subsection 10.4.5.2.2, “Component Description”

In FSAR Table 10.4-3R, the applicant provided site-specific parameters to replace the values given in ESBWR DCD Table 10.4-3, “Circulating Water System.”

- EF3 CDI – FSAR Subsection 10.4.5.2.2.1, “CIRC Chemical Injection”

In FSAR Subsection 10.4.5.2.2.1 the applicant provided information on the CWS chemical injection system and water chemistry that is not included in the DCD.

- EF3 CDI – FSAR Subsection 10.4.5.2.3, “System Operation”

In FSAR Subsection 10.4.5.2.3, “System Operation,” the applicant provided supplemental information to the referenced DCD describing the Fermi 3 site-specific CWS operation.

- EF3 CDI – FSAR Subsection 10.4.5.5, “Instrumentation Applications”

In FSAR Subsection 10.4.5.5, the applicant provided the additional instrumentation and test practice to those in the ESBWR DCD, Revision 9.

- EF3 CDI – FSAR Subsections 10.4.5.6, “Flood Protection,” and 10.4.5.8, “Normal Power Heat Sink”

In FSAR Subsections 10.4.5.6 and 10.4.5.8 the applicant described the Fermi 3 site-specific cooling tower failure analysis related to flood protection and the normal power heat sink consisting of one hyperbolic natural draft cooling tower (NDCT).

10.4.5.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG-1966, the FSER related to the certified ESBWR DCD. In addition, the relevant requirements of the Commission regulations for the circulating water system (CWS) and the associated acceptance criteria are in Section 10.4.5 of NUREG-0800.

The applicable regulatory requirements and associated guidance for the CWS are as follows:

- GDC 4, as it relates to design provisions provided to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS.

10.4.5.4 *Technical Evaluation*

As documented in NUREG–1966, the NRC staff reviewed and approved Subsection 10.4.5 of the certified ESBWR DCD. The staff reviewed Subsection 10.4.5 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the DCD and information in the COL FSAR represents the complete scope of information relating to this review topic.[1] The staff’s review confirmed that information in the

[1] See *“Finality of Referenced NRC Approvals”* in SER Section 1.2.2 for a discussion on the staff’s review related to verification of the scope of information to be included in a COLA that references a design certification.

application and information incorporated by reference address the required information related to the CWS.

The staff reviewed the relevant information in the COL FSAR as follows:

Site-Specific Information Replacing Conceptual Design Information:

- EF3 CDI – FSAR Section 10.4.5.2.1, "General Description"

In FSAR Section 10.4.5.2.1the applicant described the CWS by replacing the design information provided in the DCD with a more detailed general description of the site-specific system proposed for Fermi 3. The supplemental information that the applicant provided included the design and arrangement of the CWS, which consists of: one hyperbolic NDCT, four 25-percent capacity circulating water pumps, condenser water boxes, piping, and valves, water box drain subsystem, and condenser tube cleaning equipment. The system configuration for the Fermi 3 CWS is depicted in FSAR Figures 10.4-201 and 10.4-202, which replace the conceptual diagram in Figure 10.4-1 of the DCD. The staff reviewed the design information provided in FSAR Section 10.4.5.2.1 and finds that the applicant addressed the final configuration of the Fermi 3 CWS, as specified in Section 10.4.5.2.1, of the ESBWR DCD, Revision 9. Also, the staff finds that the system configuration and piping and valve arrangement of the CWS are in agreement with the conceptual design, as recommended in the DCD, and is therefore acceptable.

Further, the CWS design includes vents to help fill in and remove air and other gases from the condenser water boxes during startup and normal operations. The system includes design features, such as slow-stroke, motor-operated valves; air- and vacuum-release valves; and control and interlock features that ensure proper valve lineup and open and close with pump startup and stop signals. These provisions will minimize pressure transients during startup and normal operations of the system. The staff finds that these vents, air releases, and vacuum-relief valve provisions in the CWS adequately address the requirements of GDC 4, as it relates to the design features to accommodate the effects of discharging water and to prevent water hammer and subsequent CWS piping or component failures from occurring at pump startup from initial system depressurization.

- EF3 CDI – FSAR Section 10.4.5.2.2, "Component Description"

In FSAR Table 10.4-3R, the applicant provided site-specific parameters to replace the values given in ESBWR DCD Table 10.4-3, "Circulating Water System." The staff finds that the operating temperatures and circulating water pump information given in Table 10.4-3R of the Fermi 3 application are acceptable because they are bounded by the values in the ESBWR DCD.

- EF3 CDI – FSAR Section 10.4.5.2.2.1, "CIRC (CWS) Chemical Injection"

FSAR Section 10.4.5.2.2.1 provides information on the CWS chemical injection system and water chemistry that is not included in the ESBWR DCD. The proposed chemical injection maintains a noncorrosive, nonscale forming condition. This ensures that biological film growth that may affect the condenser heat transfer rate does not occur. This section also provides the chemicals used, as specified by plant chemistry, to control the circulating water chemistry.
It further states that chemicals selected are compatible with selected materials or components used in the CWS.

The staff reviewed the information provided in the FSAR. Based upon its review, the staff finds that the applicant has identified the chemicals to be used for chemical treatment of the CWS materials and has specified criteria to ensure compatibility with the system materials. Further, the types of chemicals identified perform the appropriate functions to minimize fouling of heat transfer surfaces and corrosion of the CWS. Although there are no specific regulatory criteria for the CWS materials and chemistry, the use of materials that are corrosion-resistant in the environment and water treatment chemicals that are compatible with the system materials ensures that corrosion and biological film growth will not affect the condenser heat transfer rate.

- EF3 CDI – FSAR Section 10.4.5.2.3, "System Operation"

In FSAR Section 10.4.5.2.3, "System Operation," the applicant provided supplemental information to the referenced DCD describing the Fermi 3 site-specific CWS operation. The applicant stated that leakage from the main condenser into the CWS through a condenser tube leak is not likely to occur during power operation, since the CWS normally operates at a greater pressure than the shell (condensate) side of the condenser. This prevents radioactive releases into the circulating water, and therefore the staff finds the applicant's discussion of CWS operation acceptable.

Further, the applicant noted that analysis of routine cooling tower grab samples will detect events that could lead to unmonitored, uncontrolled radioactive releases to the environment. The applicant further noted that this provides the action that NRC Inspection and Enforcement Bulletin (IEB) No. 80-10 requires. In FSAR Sections 11.2 ("Liquid Waste Management Systems") and 11.4 ("Solid Waste Management Systems"), consistent with IEB 80-10, the applicant committed to addressing the issue of preventing and monitoring for cross-contamination of systems not normally radioactive that could become contaminated through interaction with the operating conditions in radioactive systems. Sections 11.2 and 11.4 of this report provide the staff's evaluation on this issue.

- EF3 CDI – FSAR Section 10.4.5.5, "Instrumentation Applications"

The applicant provided the following additional instrumentation and test practice to those in the ESBWR DCD, Revision 9: a) level instrumentation provided in the circulating water pump pit controls makeup flow from station water system to the NDCT basin and provides alarms in the main control room on abnormally low or high water level, b) pressure indications on the CWS pump discharge and differential pressure instrumentation across the inlet and outlet to the condenser to determine the frequency of operating the condenser tube-cleaning system, and c) local grab samples used to periodically test the circulating water quality. The staff finds this addition of new instrumentation acceptable because it enhances the design and operational capability of the CWS.

- EF3 CDI – FSAR Section 10.4.5.6, "Flood Protection," and Section 10.4.5.8, "Normal Power Heat Sink"

In FSAR Section 10.4.5.8, "Normal Power Heat Sink," the applicant described the Fermi 3 site-specific normal power heat sink consisting of one NDCT. The applicant stated that the NDCT would be located at least a distance equal to its height away from Seismic Category 1 and 2 structures, and therefore, there is no potential for the cooling tower to fall and damage safety-related structures or components. Further, the NDCT is made of noncombustible material.

The staff reviewed the information the applicant provided in Revision 0 of the FSAR Section 10.4.5.8 and could not find further details on the location of the NDCT. The staff also could not find any design features to prevent or control the flooding effects in case of a cooling tower failure on the nearby safety-related areas or the safety-related SSCs, as they relate to the requirements of GDC 4 criteria. In addition, no information was provided in the FSAR with respect to Section 10.4.5.6, "Flood Protection," of the ESBWR DCD, Revision 9. In accordance with SRP Section 10.4.5, "Circulating Water System," Item II.1, design provisions need to be provided to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS. Therefore, in RAI 10.04.05-1, the staff requested the applicant to provide additional information about its cooling tower failure analysis or the provisions that are incorporated in the Fermi 3 CWS design to prevent unacceptable flooding of areas containing safety-related equipment or to mitigate the consequences of flooding.

The applicant responded to the above RAI on November 20, 2009, (ML093280179) and on January 29, 2010 (ML100331450), and stated that failure of a pipe or component in the NDCT or elsewhere in the CWS would not have an adverse impact on the design functions of safety-related SSCs. The applicant further described that for the NDCT, the largest components are the CWS discharge piping. The four CWS pumps are arranged in parallel, and the discharge lines combine into two parallel main circulating water supply lines to the main condenser. A pipe break in the combined line would be a limiting pipe break scenario. The CWS pipes, for the most part, are routed below grade. A postulated rupture of one of the CWS pipes above grade would result in water flow in the area of the yard near the NDCT. However, the NDCT is located at an elevation lower than the power block area, where Category I structures are located. Also, in Revision 2 of the FSAR, the applicant provided supplemental information to Section 10.4.5.6 of the DCD to reflect the above response, in which the applicant stated that the grade elevation where Category I structures are located is raised to more than 2.1 meters (7 feet) above the current elevation. The NDCT is not located in the area that is being raised. Therefore, the applicant stated that the water discharged from the postulated break in the CWS line above grade would flow away from the power block. Further, FSAR Figures 2.1-204 and 2.4-215 provide the relative location of the NDCT with respect to power block structure and the extent of the area that is raised.

In addition, in its RAI response, the applicant stated that the pipe failures of the above ground bounds other failures of piping and components in the CWS since the underground and smaller-diameter components would have lower flow rates than a postulated failure of the above ground, large-bore CWS pipe. The discharge water from such a failure would flow away from any safety-related structures and not cause any flooding to these structures. Also, the applicant considered failure of the NDCT basin and stated that such a failure would have no effect on safety-related structures since the NDCT is lower than the grade elevation of the power block and the basin water level elevation in the basin is lower than those in the surrounding areas.

Based on the above discussions, the staff finds that the applicant's response to RAI 10.04.05-1 is acceptable in providing design provisions to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS. Therefore, the staff has determined that RAI 10.04.05-1 is closed. In addition, the staff finds that the conclusions in the ESBWR DCD SER regarding the requirements of GDC 4, with respect to effects of discharging water that may result from a failure of a component or piping in the CWS, remain valid.

10.4.5.5 *Post Combined Operating License Activities*

There are no post COL activities related to this subsection.

10.4.5.6 *Conclusion*

The staff's finding related to information incorporated by reference is in NUREG 1966.
The NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information relating to the circulating water system, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to the circulating water system that were incorporated by reference have been resolved.

In addition, the staff concludes that the site-specific conceptual design information for the CWS presented in this subsection of the Fermi 3 COLA FSAR is acceptable and does not change the conclusions of the ESBWR DCD. The staff finds that the EF3 CDI for the CWS meets the relevant NRC regulations and acceptance criteria defined in NUREG–0800, Section 10.4.5. The staff also concludes that the relevant information presented for the EF3 CDI within this subsection is acceptable and meets the requirements of GDC 4.

10.4.6 Condensate Purification System

10.4.6.1 *Introduction*

This subsection of the Fermi 3 COL FSAR, Revision 4, addresses the CPS, which includes information related to purification and treatment of condensate required to maintain reactor feedwater purity. The CPS uses filtration to remove suspended solids, including corrosion products, and ion exchange to remove dissolved solids and other impurities.

10.4.6.2 *Summary of Application*

Subsection 10.4.6 of the Fermi 3 COL FSAR, Revision 4, incorporates by reference Subsection 10.4.6 of the ESBWR DCD, Revision 9. In addition, the application provides the following in FSAR Subsection 10.4.6:

<u>COL Item</u>

- STD COL 10.4-1-A Leakage (of Circulating Water Into the Condenser)

In STD COL 10.4-1-A, the COL applicant added information to FSAR Section 10.4.6 about the chemistry parameters in the condensate purification system. The applicant provided a table summarizing the manufacturer's recommended threshold values of the chemistry parameters and the operator actions associated with it. These parameters enable the operation of the system within the guidelines of the Electric Power Research Institute (EPRI) Report NP-4947-SR, "BWR Water Chemistry Guidelines," 1987 Revision.

Supplemental Information

- EF3 SUP 10.4-1

The applicant provided plant-specific supplemental information that added a sentence stating that the CPS condensate filters and demineralizers are capable of accommodating 100 percent of the feedwater flow.

10.4.6.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG-1966, the FSER related to the certified ESBWR DCD. In addition, the relevant requirements of the Commission regulations for the CPS and the associated acceptance criteria are in Section 10.4.6 of NUREG-0800.

The applicable regulatory requirements and associated guidance for the CPS are as follows:

- GDC 14, "Reactor Coolant Pressure Boundary," of 10 CFR Part 50, as it relates to the reactor coolant pressure boundary being designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture

- EPRI Report NP-4947-SR, 1987 Revision

10.4.6.4 *Technical Evaluation*

As documented in NUREG–1966, the staff reviewed and approved Subsection 10.4.6 of the certified ESBWR DCD. The staff reviewed Subsection 10.4.6 of the Fermi 3 COL FSAR, Revision 4 and checked the referenced ESBWR DCD to ensure that the combination of the information in the DCD and information in the COL FSAR represents the complete scope of information relating to this review topic.[1] The staff's review confirmed that information in the application and information incorporated by reference address the required information related to the CPS.

The staff reviewed the information in the COL FSAR as follows:

COL Item:

- STD COL 10.4-1-A Leakage (of Circulating Water Into the Condenser)

In STD COL 10.4-1-A, the COL applicant added information to FSAR Section 10.4.6 about the chemistry parameters in the condensate purification system. The applicant provided a table summarizing the manufacturer's recommended threshold values of the chemistry parameters and the operator actions associated with it. These parameters enable the operation of the system within the guidelines of EPRI's chemistry guidelines. The staff finds that STD COL 10.4-1-A is acceptable because the chemistry parameters meet the recommendations of SRP 10.4.6 and EPRI's BWR water chemistry guidelines, and the requirements of GDC 14.

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1 See *"Finality of Referenced NRC Approvals"* in SER Section 1.2.2 for a discussion on the staff's review related to verification of the scope of information to be included in a COLA that references a design certification

Supplemental Information

- EF3 SUP 10.4-1

The applicant added a sentence stating that the CPS condensate filters and demineralizers are capable of accommodating 100 percent of the feedwater flow. The staff finds this statement acceptable because it gives the system the capabilities to operate in a cascading configuration while accommodating 100 percent of the feedwater flow.

10.4.6.5 *Post Combined License Activities*

There are no post COL activities related to this section.

10.4.6.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG-1966. The NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information relating to the condensate purification system, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to the condensate purification system that were incorporated by reference have been resolved.

In addition, the staff concludes that the relevant information presented within this subsection of the Fermi 3 COLA FSAR is acceptable and meets the requirements of GDC 14 and the NRC endorsed EPRI guidelines. The staff evaluated STD COL 10.4-1-A and EF3 SUP 10.4-1 for this subsection, according to the relevant NRC regulations and acceptance criteria defined in NUREG–0800, Section 10.4.6, and finds that the applicant has satisfactorily addressed these items.

10.4.7 Condensate and Feedwater System

10.4.7.1 *Introduction*

This subsection of the Fermi 3 COL FSAR, Revision 4, addressed the condensate and feedwater system (C&FS), which receives condensate from the condenser hotwell, supplies condensate to the condensate purification system, and delivers high-purity feedwater to the reactor, at the required flow rate, pressure, and temperature. The C&FS does not serve or support any safety function and has no safety-design basis. Failure of this system will not compromise any safety-related system or prevent safe shutdown.

10.4.7.2 *Summary of Application*

Subsection 10.4.7 of the the Fermi 3 COL FSAR, Revision 4, incorporates by reference Subsection 10.4.7 of the ESBWR DCD, Revision 9. In addition, in FSAR Subsection 10.4.7 the applicant provides the following:

Supplemental Information

- EF3 SUP 10.4-2

The applicant provided supplemental information that added a sentence stating that the C&FS components can accommodate 100 percent feedwater flow to support a cascading feedwater configuration.

10.4.7.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG-1966, the FSER related to the certified ESBWR DCD. In addition, the relevant requirements of the Commission regulations for the C&FS and the associated acceptance criteria are in Section 10.4.7 of NUREG-0800.

10.4.7.4 *Technical Evaluation*

As documented in NUREG–1966, the NRC staff reviewed and approved Subsection 10.4.7 of the certified ESBWR DCD. The staff reviewed Subsection 10.4.7 of the Fermi 3 COL FSAR, Revision 4, and checked the referenced ESBWR DCD to ensure that the combination of the information in the DCD and information in the COL FSAR represents the complete scope of information relating to this review topic.[1] The staff's review confirmed that information in the application and information incorporated by reference address the required information related to the C&FS.

The staff reviewed the information in the COL FSAR as follows:

Supplemental Information

- EF3 SUP 10.4-2

With respect to the Fermi 3 COL FSAR, Revision 3, Section 10.4.7 did not include any departures, COL items, supplemental information, or standard content. However, in response to RAI question 12.02-7, dated August 5, 2011 (ML11221A075), the applicant proposed to add new supplemental information in Subsection 10.4.7.2.1 of the application, by adding a sentence stating, "The C&FS components can accommodate 100 percent feedwater flow to support a cascading feedwater configuration."

The staff reviewed the proposed change to Tier 2 Section 10.4.7.1 and found that in the ESBWR DCD, the steam and power conversion system design and the balance of plant heat balance were based on the C&FS operating in a pumped forward configuration. While the staff's review of the DCD information did indicate that the C&FS is capable of being configured to operate in a cascade configuration, the staff found that the DCD does not discuss system operation in the cascade mode, nor does it directly identify a system configuration to route 100 percent of the feedwater flow through the CPS, as stated in the supplemental information proposed to be added to the Fermi 3 COLA. Therefore, the staff issued RAI 10.04.07-1 requesting that the applicant clarify whether the proposed change to the COLA constitutes a

[1] See *"Finality of Referenced NRC Approvals"* in SER Section 1.2.2 for a discussion on the staff's review related to verification of the scope of information to be included in a COLA that references a design certification

departure, and to provide appropriate justification for the applicant's determination on the classification of the information added, along with supporting information to specify how the operation in the cascade mode is bounded by relevant evaluation included in the ESBWR DCD.

The applicant responded to RAI 10.04.07-1 in a letter dated December 14, 2011 (ML11350A200), and indicated that the information added to the COL pertaining to operation of the C&FS in a cascade configuration does not represent a deviation from the design information in the DCD and, therefore, is not considered a departure. In support of that determination, the applicant provided the following:

- The supplemental information added to Chapter 10 of the FSAR ensures sufficient capacity in the C&FS and CPS to allow full feedwater flow to pass through the CPS.

- The ESBWR feedwater heater drain systems are normally operated in a pumped forward configuration. The Fermi 3 FSAR does not modify the ESBWR DCD description of normal plant operation; i.e., Detroit Edison intends to operate Fermi 3, as described in the DCD, in a pumped forward configuration.

- The ESBWR DCD safety analyses and anticipated operational occurrences analyses are not impacted by operation in the cascade configuration because feedwater temperature must be maintained within the feedwater temperature operating domain. If necessary, Feedwater Heater No. 7 can be placed into service to ensure that feedwater system temperature is maintained within the operating domain.

- When operating in a cascade configuration, feedwater heaters will remain in service. Feedwater flow will continue to be controlled and regulated by ESBWR control systems. ESBWR setpoints and controls maintain feedwater within the feedwater temperature operating domain throughout evolutions of balance of plant (BOP) system configurations. Thus, reactor safety is unaffected by operation in a cascade configuration. Cascade configuration does not impact safety-related functions or components.

- The FSAR and DCD describe the design bases, design features, and system functional requirements that are implemented during detailed design and procurement for construction of the plant. The BOP system capacity, identified in the Fermi 3 FSAR supplements, will be applied during detailed design activities by implementing the design requirements of the ESBWR DCD. For example, codes and standards referenced by the ESBWR DCD will be implemented as described by the DCD. DCD Chapter 3, "Design of Structures, Components, Equipment, and Systems," describes ESBWR design criteria, including classification, flood protection, protection against dynamic effects associated with the postulated rupture of piping, and seismic design requirements, among others.

- The DCD, C&FS, and CPS systems will have sufficient capacity and control stability to accommodate normally anticipated step and ramp changes in reactor power.

The staff reviewed the information provided in the applicant's response to RAI 10.04.07-1, relevant to the supplemental information proposed to be added to FSAR Subsection 10.4.7. The RAI response indicates that the C&FS normally will be operated in the pumped forward configuration, but may at times be run in a cascade configuration, based on operational conditions and reactor water iodine concentrations, if necessary to control reactor water iodine concentrations.

The staff reviewed the information the applicant provided on why the ESBWR safety analyses and anticipated operational occurrences analyses are not impacted by operation of the C&FS in cascade configuration. The applicant clarified that when operating in the cascade configuration, the feedwater temperature can be maintained within the feedwater temperature operating domain by placing Feedwater Heater No. 7 into service, if necessary. The staff agrees that the C&FS in the ESBWR DCD bounds the Fermi 3 C&FS operation in the cascade configuration. In addition, the design features and system functional requirements that are in operation during detailed design and procurement will provide for equipment selection that supports the 100 percent feedwater flow through the entire C&FS.

Based on the above review, the staff finds the addition of the supplemental information to Section 10.4.7.1, EF3 SUP 10.4-2, to be acceptable because the evaluations of the C&FS in the ESBWR DCD bounds the C&FS cascade configuration operation that the applicant proposed to be added to Section 10.4.7.21 of the Fermi 3 COLA. In addition, the staff verified that this information has been provided in Revision 4 of the FSAR and therefore, the staff has determined that RAI 10.04.07-1 is resolved.

10.4.7.5 *Post Combined License Activities*

There are no post COL activities related to this section.

10.4.7.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG-1966. The NRC staff reviewed the application and checked the referenced DCD. The staff's review confirmed that the applicant has addressed the required information relating to the condensate and feedwater system, and no outstanding information is expected to be addressed in the COL FSAR related to this section. Pursuant to 10 CFR 52.63(a)(5) and Part 52, Appendix [X], Section VI.B.1, all nuclear safety issues relating to the condensate and feedwater system that were incorporated by reference have been resolved.

The staff evaluated EF3 SUP 10.4-2 for this subsection according to the relevant NRC regulations and acceptance criteria defined in NUREG–0800, Section 10.4.7, and finds that the applicant has satisfactorily addressed this item. In addition, since the ESBWR DCD bounds C&FS system operation in the cascade configuration, the proposed operation of the C&FS is acceptable since it does not change the conclusions arrived at in NUREG–1966.

10.4.8 Steam Generator Blowdown System (PWR)

As stated in the ESBWR DCD, this section is not applicable to the ESBWR design.

10.4.9 Auxiliary Feedwater System (PWR)

As stated in the ESBWR DCD, this section is not applicable to the ESBWR design.