3.0 DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

3.1 Conformance with NRC General Design Criteria

Section 3.1 of the Fermi 3 Combined License (COL) Final Safety Analysis Report (FSAR), Revision 7, incorporates by reference, with no departures or supplements, Section 3.1, "Conformance with NRC General Design Criteria," of Revision 10 of the Economic Simplified Boiling-Water Reactor (ESBWR) Design Control Document (DCD), referenced in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "License, Certification, and Approval for Nuclear Power Plants," Appendix E, "Design Certification Rule for the ESBWR Design." The U.S. Nuclear Regulatory Commission (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 confirms that 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 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to this section have been resolved.

3.2 Classification of Structures, Components, and Systems

3.2.1 Introduction

Nuclear power plant structures, systems, and components (SSCs) important to safety are designed to withstand the effects of earthquakes without loss of capabilities to perform their safety functions. SSCs important to safety are defined in 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants," as those SSCs that "provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public." These SSCs include safety-related SSCs whose functions ensure: (1) the integrity of the reactor coolant pressure boundary (RCPB); (2) the capability to shut down the reactor and maintain it in a safe shutdown condition; and (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures. These safety-related plant features are designed to sustain the safe shutdown earthquake (SSE). The SSE is based on an evaluation of the maximum earthquake potential for the site and is an earthquake that produces the maximum vibratory ground motion for which SSCs are designed to remain functional. The regulatory treatment of nonsafety systems (RTNSS) process is applied to define seismic requirements for SSCs that are nonsafety-related but perform risk significant functions.

Nuclear power plant SSCs important to safety are designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed. SSCs important to safety are those that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. Risk-significant nonsafety-related fluid systems that are important to safety are evaluated under the RTNSS process.

[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 COL application that references a design certification.

3.2.2 Summary of Application

Section 3.2 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.2 of the ESBWR DCD, Revision 10. Section 3.2 of the DCD includes Subsections 3.2.1, "Seismic Classification," and 3.2.2, "Quality Group Classification."

The system seismic and quality group classifications, discussed in the ESBWR DCD, address the requirement to design nuclear power plant SSCs important to safety to withstand the effects of earthquakes without a loss of capability to perform their safety functions – that means designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

This requirement is applicable to both pressure-retaining and non-pressure-retaining SSCs that are part of the RCPB, and to other systems important to safety, when reliance is placed on these systems to (1) prevent or mitigate the consequences of accidents and malfunctions originating within the RCPB, (2) permit a shutdown of the reactor and maintain it in a safe-shutdown condition, and (3) retain radioactive material. Regulatory Guide (RG) 1.29, Revision 4, "Seismic Design Classification," describes an acceptable method of identifying and classifying those plant features that should be designed to withstand the effects of SSEs. RG 1.26, Revision 4, "Quality Group Classification and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," provides the regulatory guidance for designing safety-related SSCs to quality standards. Risk-significant nonsafety-related SSCs that are important to safety are evaluated under the RTNSS process described in FSAR Chapter 19 and reviewed by the staff in Chapter 22, "Regulatory Treatment of Nonsafety Systems," of NUREG-1966, "Final Safety Evaluation Report Related to the Certification of the Economic Simplified Boiling-Water Reactor."

In addition, Fermi 3 COL FSAR, Section 1.9 includes the following information related to the applicable seismic classification and quality group:

- In FSAR Table 1.9-201, "Conformance with Standard Review Plan" (SRP), the applicant added a line stating that the Fermi 3 application conforms to Revision 2 of the SRP for Section 3.2.1. In this table, the applicant added another line stating that the Fermi 3 application conforms to Revision 2 of the SRP for Section 3.2.2.

- In FSAR Table 1.9-202, "Conformance with Regulatory Guides," the applicant added a line stating that the Fermi 3 application conforms to RG 1.29. This conformance is evaluated in Appendix 17AA, "Quality Assurance Program Description" (QAPD), Part IV. In this table, the applicant added another line stating that the Fermi 3 application conforms to RG 1.26. This conformance is evaluated in Appendix 17AA, QAPD, Part IV.

- In FSAR Table 1.9-203, "Conformance with the FSAR Content Guidance in RG 1.206," the applicant stated that the Fermi 3 application conforms to RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," Regulatory Position C.III.1 Subsection C.I.3.2.1, "Seismic Classification." The applicant also stated that there are no additional safety-related or RTNSS SSCs subject to seismic classification beyond those addressed in the DCD. There are no SSCs outside the referenced certified design that are required to be designed for an OBE. In this table, the applicant also stated that the Fermi 3 application conforms to RG 1.206, Position C.III.1, Subsection C.I.3.2.2, "System Quality Group Classification."

In addition, in Fermi 3 COL FSAR, Revision 7, Section 3.2, the applicant provides the following:

Conceptual Design Information

- STD CDI Classification Summary – RTNSS

    There are no site specific safety related or nonsafety-related RTNSS systems beyond the scope of the DCD.

- STD CDI Classification Summary – Hydrogen Water Chemistry System

    The site-specific plant design includes the HWCS.

- STD CDI Classification Summary – Zinc Injection System

    The site-specific plant design does not include the Zinc Injection System.

3.2.3 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 Commission regulations for the seismic classification and quality group classification, and the associated acceptance criteria are in Section 3.2.1 and Section 3.2.2 of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, (LWR Edition),” the SRP.

The applicable regulatory requirements for the seismic classification of SSCs are as follows:

10 CFR Part 50, Appendix A, General Design Criterion (GDC) 2, “Design bases for protection against natural phenomena,” which requires (in part) that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes.

The related acceptance criteria are as follows:

- RG 1.29 establishes an acceptable regulatory basis for meeting GDC 2 relative to seismic classification and classifies SSCs that are to be designed to withstand earthquakes.

- RG 1.206 states that the applicant should identify those SSCs important to safety that are outside the scope of the referenced certified design and that are designed to withstand the effects of earthquakes without loss of capabilities to perform their safety functions. The applicant should designate plant features that are outside the scope of the referenced certified design and that are designed to remain functional in the event of an SSE or a surface deformation as seismic Category I. The applicant should identify portions of SSCs outside the scope of the referenced certified design that are not required to continue to function, but whose failure could reduce the functioning of any seismic Category I plant feature to an unacceptable safety level or could result in a incapacitating injury to control room occupants. The design and construction of these SSCs should ensure that the SSE would not cause such failures. The applicant should also list or otherwise clearly identify all SSCs or portions thereof that are outside the scope of the referenced certified design and are intended to be designed for an Operating Basis Earthquake (OBE).

The applicable regulatory requirements for the quality group classification of SSCs are as follows:

- 10 CFR Part 50, Appendix A, GDC 1, "Quality standard and records," which requires (in part) that SSCs important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be supplemented or modified as necessary to assure a quality product consistent with the required safety function.

The related acceptance criteria are as follows:

- RG 1.26 establishes an acceptable regulatory basis for meeting GDC 1 relative to quality group classification. RG 1.26 also classifies fluid systems and their supports that are important to safety, which are to be designed to quality standards commensurate with their safety function.

- RG 1.206 states that the applicant should identify those fluid systems or portions thereof that are important to safety and outside of the certified design scope, as well as the applicable industry codes and standards for each pressure-retaining component.

3.2.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.2 of the ESBWR DCD. The staff reviewed Section 3.2 of the Fermi 3 COL FSAR, Revision 7, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 7, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

Section 1.2.3 of this safety evaluation report (SER) provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the design certification (DC) and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on standard content that were documented in the SER with open items issued for the North Anna Unit 3 application were equally applicable to the Fermi 3 COL application, the staff undertook the following reviews:

- The staff compared the North Anna 3 COL FSAR, Revision 1, to the Fermi 3 COL FSAR. In performing this comparison, the staff considered changes to the Fermi 3 COL FSAR (and other parts of the COL application, as applicable) resulting from

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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 COL application that references a design certification.

requests for additional information (RAIs) and open and confirmatory items identified in the North Anna SER with open items.

- The staff confirms that the applicant has endorsed all responses to the RAIs identified in the corresponding standard content (the North Anna SER) evaluation.

- The staff verified that the site-specific differences were not relevant to this section.

The staff has completed the review and found the evaluation performed for the North Anna Unit 3 standard content to be directly applicable to the Fermi 3 COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 7, as follows:

Conceptual Design Information

- STD CDI Classification Summary

The staff reviewed the additional information related to the seismic classification of safety-related SSCs included under Section 3.2.1 of the Fermi 3 COL FSAR, which states the following:

- There are no site-specific safety-related systems or nonsafety-related RTNSS systems beyond the scope of the DCD.

- The site-specific plant design includes the HWCS.

- The site-specific plant design does not include the Zinc Injection System.

Seismic Classification

The following portion of this technical evaluation section is reproduced from Subsection 3.2.1.4, "Technical Evaluation," of the North Anna Unit 3 SER (Agency wide Documents Access and Management System (ADAMS) Accession No. ML092010530):

Seismic Classification of Site Specific RTNSS SSCs

GDC 2 identifies, in part, that SSCs important to safety shall be designed to withstand the effects of earthquakes. FSAR Section 3.2.1 identifies no departures or supplements relative to the seismic classification of SSCs, and the standardization matrix identifies no site specific information that applies to Section 3.2. However, certain potential RTNSS-important SSCs, such as the plant service water system (PSWS) and makeup water system, are identified as site specific and makeup sources for the ultimate heat sink. Also, it is not clear whether there are any nonsafety-related SSCs outside of the DCD scope that may be important to safety.

The staff issued RAI 03.02.01-6, which requested the applicant to clarify whether there are any site specific, nonsafety-related SSCs outside of the DCD scope that are important to safety and, if so, to identify the appropriate seismic classification of those SSCs. For example, certain site specific defense in depth RTNSS SSCs, such as the PSWS and the intake structure, may be considered nonsafety-related but may *be important to safety and should be categorized as designed to withstand the effects of earthquakes. This seismic concern for RTNSS SSCs was also identified during the concurrent ESBWR design certification review. If the applicant decides to resolve this issue in the DCD rather than in the COL for all plant SSCs, including those that are site specific, the staff has asked the applicant to so advise the NRC. The applicant's response to the RAI stated that there are no nonsafety-related SSCs important to safety (RTNSS SSCs) that are outside of the DCD scope. This response also clarified that the seismic classification of RTNSS SSCs is within the DCD scope, and Appendix 19A of the DCD has undergone substantial changes in DCD Revision 5. The staff concurred that the seismic classification of site specific RTNSS SSCs can be evaluated in the DCD. Therefore, this COL concern is closed.*

<u>Seismic Classification of Other Site Specific SSCs</u>

Section 1 of the DCD identifies only limited site specific SSCs that are outside the scope of the DCD, and for which the COL applicant is expected to provide site specific information. COL application Table 1.9-203 indicates that there are no safety-related or RTNSS SSCs that are not included in the DCD. It is not clear, however, whether there are any other nonsafety-related SSCs that are considered important to safety but are not included in the DCD that will be addressed in the COL application.

The staff issued RAI 03.02.01-5 which requested the applicant to clarify whether there are any site specific SSCs outside of the DCD scope that are not included in DCD Table 3.2-1 and are to be seismically classified in the COL. For example, site specific structures such as the stack and miscellaneous items such as the reactor vessel insulation, which may or may not be site specific, are not included in the tables. If so, the RAI requested the applicant to identify the appropriate seismic classification of those SSCs or clarify when those SSCs will be classified. The applicant's response to the RAI stated that there are no nonsafety-related SSCs important to safety (RTNSS SSCs) outside of the DCD scope, and there are no site specific SSCs not in the DCD that are to be seismically classified. In regard to the stack (changed to three stacks in DCD Revision 5) and reactor vessel insulation, the applicant clarified that these SSCs are not site specific. Because no site specific SSCs will be classified in the COL, the staff concurred that this COL concern is closed.

<u>Quality Assurance for seismic Category II SSCs</u>

It is not clear in either the DCD or the FSAR how 10 CFR Part 50, Appendix B applies to seismic Category II SSCs, including those that may be site specific. FSAR Table 1.9-202 identifies conformance to RG 1.29. However, seismic Category II SSCs are not designated as QA Requirement B in either the DCD or the COL application. DCD Section 17.3 states that the COL applicant will address the QA Program, but it is not clear how the QA Program will include provisions for seismic Category II SSCs. The staff issued RAI 03.02.01-4, which requested the applicant to clarify the extent to which pertinent QA requirements of Appendix B to 10 CFR Part 50 in Regulatory Position C.4 of RG 1.29 apply to the activities affecting safety-related functions of those portions of SSCs covered under Regulatory Positions 2 and 3 of RG 1.29, including any site specific SSCs. This concern was also cited in an RAI for the ESBWR design certification review, and a special class was *designated for important nonsafety-related SSCs. But SSCs that are designated as a special class are not specified for review at this time. If the applicant decides to resolve this issue in the DCD rather than in the COL for all plant SSCs, including those that are site specific, the staff has asked the applicant to so advise the NRC. The applicant's response to the RAI stated that this issue will be resolved in the DCD, and General Electric-Hitachi (GEH) has included this information in DCD Section 3.2 and in DCD Appendix 19A for all SSCs, including those that are site specific. The staff concurred that this COL can be reviewed in the design certification, and therefore this RAI is closed.*

Consistency with Regulatory Guidance

FSAR Table 1.9-201 points out that the seismic classification conforms to SRP Section 3.2.1, Revision 2, and that SRP Section 3.2.1 references RG 1.29 (currently Revision 4) for seismic classification. SRP Section 3.2.1 identifies that the applicant should provide a list of SSCs that are necessary for continued safe operation that must remain functional without undue risk to the health and safety of the public and within applicable stress, strain, and deformation limits during and following an OBE, if the applicant has set the OBE ground motion to the value of one-third of the safe shutdown earthquake (SSE) ground motion. The list of SSCs may be addressed either in this section or in the operational programs for pre-earthquake planning in COL FSAR Section 3.7.4. Other than the three CDIs noted above, Section 3.2 of FSAR Revision 0 does not identify any departures or supplements relative to the seismic classification in the DCD and the conformance to RG 1.29 Revision 3 in the DCD.

The staff issued RAI 03.02.01-3, which requested the applicant to clarify the extent to which site specific seismic classifications of SSCs are consistent with RG 1.29, Revision 4. The applicant's response to the RAI clarified that the FSAR is incorrect. The classification of site specific SSCs is consistent with the DCD that references RG 1.29 Revision 3, and COL FSAR Table 1.9-202 will be revised accordingly. In addition, the staff has indicated to the applicant that there are no site specific SSCs requiring classification in the COL application or changes to the methodology. Therefore, the staff finds that use of RG 1.29, Revision 3 is acceptable.

However, in order to be consistent with SRP Section 3.2.1, Revision 2, the staff has indicated to the applicant that a list of SSCs necessary for continued operation when subjected to an OBE should be available for review if the applicant has set the OBE ground motion equal to one-third of the SSE ground motion. Since the COL applicant has not deviated from the DCD, which sets the OBE ground motion equal to one-third of the SSE ground motion, the applicant should submit a list of SSCs necessary for continued operation either in this section or in the operational programs for pre-earthquake planning in COL FSAR Section 3.7.4. Therefore, resolution of this issue is pending as Open Item 03.02.01-3.

List of SSCs Necessary for Continued Safe Operation During and Following an OBE

In RAI 03.02.01-7 for the previous R-COL applicant, the staff indicated to Dominion that, in order to be consistent with the requirements and guidance of 10 CFR Part 50, Appendix S, IV(a)(2)(I) and (3), RG 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," and NUREG-0800, SRP Section 3.2.1, Revision 2, a list of

SSCs necessary for continued operation when subjected to an OBE should be available for review if the applicant has set the OBE ground motion equal to one-third of the SSE ground motion. Dominion's RAI response indicated that there is no deviation from the DCD, which sets the OBE ground motion equal to one-third of the SSE ground motion. The staff requested Dominion to provide the list of SSCs necessary for continued safe operation that must remain functional without undue risk to the health and safety of the public and within applicable stress, strain, and deformation, during and following an OBE.

In a letter dated December 9, 2009 (ADAMS Accession No. ML093490251), Dominion responded to RAI 03.02.01-7 stating that as noted in 10 CFR Part 50, Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," Section IV(a)(2)(i)(A), if the OBE ground motion is set to one-third or less of the SSE, then the requirements associated with the OBE ground motion in 10 CFR Part 50, Appendix S, Section IV (a)(2)(i)(B)(I) can be satisfied without Dominion performing explicit response or design analyses. Since the ESBWR has set the OBE at one-third of the SSE (as discussed in ESBWR FSAR Tier 2, Section 3.7), no further explicit response is required in accordance with 10 CFR Part 50, Appendix S, Section IV(a)(2)(i)(A). Those SSCs that are designed to withstand an SSE are classified as seismic Category I and are given in ESBWR Tier 2, Table 3.2.2-1, "Classification Summary." This classification is in accordance with SRP Section 3.2.2-1. Based on Dominion's statement that the list is addressed through ESBWR DCD, Tier 2, Table 3.2.2-1 and the staff finding that the table is acceptable, the staff considers RAI 03.02.01-7 resolved.

Detroit Edison adopted Dominion's RAI response. After further examination, the staff finds that Open Item 03.02.01-3 is fully addressed within the scope of the ESBWR DCD as discussed above. Therefore, Open Item 03.02.01-3 is closed.

Important to Safety SSCs

DCD and COL FSAR Section 1 identify certain site-specific SSCs that are outside the scope of the DCD and the COL applicant is expected to provide site-specific information. FSAR Section 3.2 identifies only limited site-specific systems. FSAR Table 1.9-203 states that there are no safety-related or RTNSS SSCs not included in the DCD, but it was not clear if there are any unique plant-specific nonsafety-related SSCs that are considered important to safety and are not addressed in the DCD that are to be evaluated in the FSAR. Therefore, the staff issued RAI 03.02.01-2 requesting the applicant (Detroit Edison [DTE]) to provide additional information regarding site-specific SSCs, specifically, if there are any site specific SSCs that are nonsafety-related but are still considered to be important to safety that are not addressed in the DCD.

In a letter dated September 21, 2010 (ADAMS Accession No. ML102660141), the applicant states the following:

> FSAR Section 3.2 incorporates DCD Table 3.2-1 by reference with two changes. One change is the identification that the site-specific plant design includes the Hydrogen Water Chemistry System (HWCS). DCD Table 3.2-1 includes the classification information for the HWCS; thus, the only detail included in the FSAR is to identify that the HWCS is included in the site-specific plant design. As shown in DCD Table 3.2-1, the HWCS is nonsafety-related and non-seismic. The second change is the identification that the site-specific design does not include the Zinc Injection System.

DCD Appendix 19A demonstrates that the ESBWR design adequately addresses RTNSS issues. DCD Appendix 19A defines the criteria that are applied to the ESBWR design to determine the systems that are candidates for regulatory oversight. Based on the criteria, DCD Appendix 19A, Table 19A-2 identifies the RTNSS functions. DCD Appendix 19A Table 19A-3 identifies the structures housing the RTNSS functions identified in DCD Table 19A-2. There are no site-specific RTNSS functions or structures housing RTNSS functions outside the scope of the DCD. Additionally, there are no site-specific SSCs not in the DCD that are important to safety.

The staff finds that the applicant's response conforms to the guidance in RG 1.206 and the requirements in 10 CFR Part 50, Appendix A, GDC 1, and is therefore acceptable. Accordingly, Fermi 3 site-specific RAI 03.02.01-2 is closed.

The following portion of this technical evaluation section is reproduced from Subsection 3.2.1.4, "Technical Evaluation," of North Anna Unit 3 SER (ADAMS Accession No. ML092010530):

List of RTNSS SSCs

DCD Revision 5, Section 3.2.1 refers to Table 19A-1 for a list of RTNSS SSCs. However, Table 19A-1 in Revision 5 of the DCD has been deleted. It is not clear whether this list includes site specific SSCs. The staff issued RAI 03.02.01-2, which requested the applicant to identify the appropriate reference for the list of site specific RTNSS SSCs. The applicant's response to the RAI agrees that there is an inconsistency and has notified GEH accordingly. The correct reference for risk-significant RTNSS SSCs is in Table 3 of NEDO-33411, which documents the list of risk-significant RTNSS SSCs. NRC staff concurred that this list of RTNSS SSCs can be reviewed in the design certification for site specific SSCs, so this RAI is closed.

RTNSS SSCs Classified as Non-Seismic

DCD Revision 4 Table 3.2-1 identifies various nonsafety-related potential RTNSS SSCs as either Seismic II or non-seismic (NS). It is not clear whether any of these potential RTNSS SSCs are considered site specific. DCD Section 19A.8.3 classifies RTNSS Criterion B-SSCs, as a minimum, seismic Category II, and are qualified to the Institute of Electrical and Electronics Engineers (IEEE)-344-1987. These SSCs must be available following a seismic event. Relative to any site specific RTNSS-important SSCs that are required to withstand the effects of earthquakes and are qualified to the IEEE-344, NRC staff issued RAI 03.02.01-1, which requested the applicant to clarify the basis for the Seismic II or NS classification or identify an appropriate departure. The applicant's response to the RAI stated that there are no site specific, RTNSS-important SSCs beyond those identified in the DCD. Because there are no site specific, RTNSS-important SSCs included in the COL, the staff concurred that this concern can be reviewed in the design certification. Therefore, this RAI is closed.

Consistency with Regulatory Guides

The staff issued RAI 03.02.01-1 requesting the applicant to explain and justify why the seismic classification of site-specific SSCs in FSAR Table 1.9-202 uses Revision 3 of RG 1.29 rather than the current Revision 4. In a letter dated September 21, 2010 (ADAMS Accession No. ML102660141), the applicant states the following:

> ESBWR SSCs, including all site-specific SSCs, for Fermi 3 have been classified in the DCD in accordance with Revision 3 of Regulatory Guides [sic] 1.29 (refer to DCD Table 3.2-1). There are no additional site-specific SSCs beyond those listed in the DCD. Therefore, FSAR Revision 2, Table 1.9-202 takes exceptions to Revision 4 of RGs 1.29. The justification for these exceptions, as stated in FSAR Table 1.9-202, are that the requirements for the seismic classifications for systems and structures are defined by the DCD, which implements Revision 3 of RG 1.29.

In Detroit Edison's response to RAI 17.05-23, submitted in letter NRC3-10-0036, dated September 2, 2010 (ADAMS Accession No. ML102570700), the applicant provides a proposed markup for FSAR Table 1.9-202 to clarify that conformance with Revision 4 of RG 1.29 is limited to site-specific SSCs that are outside the scope of the DCD. The staff finds that the applicant's response conforms to the guidance in RG 1.29 and is therefore acceptable. Accordingly, Fermi 3 site-specific RAI 03.02.01-1 is closed.

Summary

Based on the above evaluation of the applicant's information related to seismic classification, the staff finds that the requirements of GDC 2 are met and the information is consistent with the guidance in RGs 1.29 and 1.206.

Quality Group Classification

The NRC staff's review of Subsection 1.1.1.7 of the Fermi 3 COL FSAR, Revision 7, finds that the applicant has incorporated by reference Subsection 3.2.2 of the ESBWR DCD, Revision 10. The review confirms that the information in the application and the information incorporated by reference address the required information relating to the quality group classification of SSCs.

NRC staff determined that the departures and supplements that include site-specific information related to the hydrogen water chemistry and zinc injection systems do not affect the quality group classifications.

There are no COL information items in Subsection 3.2.2 of the ESBWR DCD. DCD Section 1.10 states that the COL applicant is required to provide site-specific information.

The staff reviewed the COL applicant's information to determine whether the application contains sufficient information on the system quality group classification of site-specific SSCs that are outside of the DCD scope. Several RAIs were prepared to determine whether the scope of the SSCs that are considered site-specific is essentially complete, and whether sufficient information concerning the quality group classification of those SSCs is included in the application. The staff completed the review and found that the evaluation performed for the North Anna standard content is directly applicable to the Fermi COL application.

The following italicized portion of this technical evaluation section is reproduced from Subsection 3.2.2.4, "Technical Evaluation," of the North Anna Unit 3 SER (ADAMS Accession No. ML092010530):

Consistency with Regulatory Guidance

> *FSAR Table 1.9-201 shows that the seismic classification conforms to SRP Section 3.2.2, Revision 2 and that SRP Section 3.2.2 references RG 1.26 (currently Revision 4) for quality group classification. Section 3.2 of the FSAR Revision 0 does not identify any departures or supplements relative to the quality group classification identified in the DCD and compliance with RG 1.26 Revision 3 in the DCD. But FSAR Table 1.9-202 references conformance to Revision 4, dated March 2007. QA Program AR-NA-30 references Revision 4 to RG 1.26 with the DCD exception, but incorrectly references February 1976 rather than March 2007. NRC staff issued RAI 03.02.02-1, which requested the applicant to clarify whether classifications of site specific SSCs are consistent with RG 1.26 Revision 4.*

> *The applicant's response to the RAI clarified that the FSAR is incorrect. The classification of site specific SSCs is consistent with the DCD that references RG 1.26 Revision 3. COL FSAR Table 1.9-202 and Appendix 17BB will be revised accordingly. COL applicants should supplement generic DCD information on conformance to RGs to address those that were issued since the time the standard design was approved. There are no site specific SSCs classified in the COL application, so the effective RGs are appropriately referenced in the DCD. Therefore, this is Confirmatory Item 03.02.02-1.*

The staff tracked the verification that the next FSAR revision included this change. The staff verified that FSAR Revision 7 includes the proposed revisions. Therefore, Confirmatory Item 03.02.02-1 is resolved.

Fermi 3 FSAR, Revision 2, Subsection 3.2 did not identify any departures or supplements relative to the quality group classification in the ESBWR DCD, nor did it conform to RG 1.26, Revision 4. However, FSAR Table 1.9-202 identified an exception to Revision 4, dated March 2007, and cited conformance with RG 1.26, Revision 3 instead of Revision 4. In RG 1.206, Regulatory Position C.III.1, Subsection C.I.1.9.1 states that, for site-specific portions of the facility design that are not included in the referenced certified design, a COL applicant should address conformance with RGs in effect 6 months before the submittal date of the COL application. In RAI 03.02.02-1 the staff requested the applicant to explain and justify why the quality group classifications of any site-specific SSCs are based on RG 1.26, Revision 3 rather than the current Revision 4.

In the response to RAI 17.5-23 dated September 2, 2010 (ADAMS Accession No. ML102570700), the applicant states that ESBWR SSCs for Fermi 3, including all site-specific SSCs are classified in the DCD in accordance with Revision 3 of RG 1.26 (with a reference to DCD Table 3.2-1). There are no additional site-specific SSCs beyond those listed in the DCD. Therefore, FSAR Revision 2, Table 1.9-202 takes exceptions to Revision 4 of RG 1.26. The justification for these exceptions, as stated in FSAR Table 1.9-202, are that the requirements for the quality group classifications for systems and structures are defined by the DCD, which implements Revision 3 of RG 1.26. The response to RAI 17.05-23 also, provides a proposed markup for FSAR Table 1.9-202 to clarify that conformance with Revision 4 of RG 1.26 is limited to site specific SSCs that are outside the scope of the DCD. Confirmation that the FSAR has been updated is included in Chapter 17 of this SER.

The staff's review of the changes to the FSAR concludes that the application of the current version of RG 1.26 to any site-specific systems outside the scope of the DCD is consistent with the regulatory guidance and is therefore acceptable.

The following portion of this technical evaluation section is reproduced from Subsection 3.2.2.4, "Technical Evaluation," of the North Anna Unit 3 SER (ADAMS Accession No. ML092010530):

Codes and Standards

> *The NRC staff requirements memorandum (SRM) dated July 21,1993, concerning SECY-93-087, stated that the staff will review passive plant design applications using the newest codes and standards endorsed by the NRC, and unapproved revisions to the codes will be reviewed on a case-by-case basis. Editions of various codes and standards referenced in DCD Section 3.2.6 are not current, and newer codes and standards are not referenced in COL applicant Sections 3.2 or 1.8. The staff issued RAI 03.02.02-2, which requested the applicant to clarify the specific code editions the applicant has referenced that are currently endorsed by the NRC. The applicant was also asked to clarify whether current editions of codes and standards will be applied to the detailed design and procurement of ESBWR SSCs, so that these editions may be reviewed on a case-by-case basis. If the applicant decides to resolve this issue in the DCD rather than in the COL for all plant SSCs, including those that are site specific, the staff has asked the applicant to so advise the NRC.*
>
> *The applicant's response to the RAI stated that DCD Table 1.8-22 identifies industrial codes and standards and adjustments that have been made to these codes and standards. The applicant also indicated that questions regarding versions of codes and standards should be addressed to GEH. COL applicants should supplement generic DCD information on compliance with RGs to address those that have been issued since the time the standard design was approved.*
>
> *Although there are no site specific SSCs that are not classified in the DCD, effective regulatory guidance for site specific SSCs should be identified in the COL application rather than in the DCD, so that the effective RG revision is applied to site specific SSCs, including those added in the future. COL Table 1.9-204 identifies industrial codes and standards applicable to portions of the design that are beyond the scope of the DCD or SSAR, but the editions referenced in this list are different from the earlier editions referenced in Table 1.8-22 of the referenced DCD. In addition, the staff indicated that the applicant should more clearly identify which editions of industrial codes and standards are applicable to specific SSCs and whether those editions have been endorsed by the NRC. This is identified as Open Item 03.02.02-2.*

The Staff Requirements Memorandum (SRM) dated July 21, 1993, concerning SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," notes that the staff will review passive plant design applications using the newest codes and standards endorsed by the NRC and unapproved revisions to the codes will be reviewed on a case-by-case basis. RG 1.206, Regulatory Position CIII, states that COL applicants that referencing a certified design do not need to include additional information on codes and standards. However, if the applicant deviates from the DCD or there are site-specific SSCs, codes and standards would be expected to be identified. Editions of various codes and standards are referenced in FSAR Table 1.9-204, but it is not clear whether the list of codes and standards is a comprehensive list or applies only to site-specific SSCs. For example, the American Society of Mechanical Engineers (ASME) B31.1 Code, “Power Piping,” and supplemental standards used for the plant-specific fiberglass pressure pipe; and the applicable editions are not referenced in FSAR Table 1.9-204. In RAI 03.02.02-2, the staff requested the applicant to clarify which editions of codes and standards apply to any site-specific SSCs - such as fiberglass piping - and whether those editions are endorsed by the NRC or need to be reviewed on a case-by-case basis.

The applicant’s response to RAI 03.02.02-2 (ADAMS Accession No. ML102660141) states the following:

> The industrial codes and standards which are applicable to the design and procurement of ESBWR SSCs are provided in DCD Revision 7, Table 1.9-22. As described in FSAR Section 1.9.2, under Industrial Codes and Standards:
>
>> Table 1.9-204 identifies the Industrial Codes and Standards that are applicable to those portions of the Fermi 3 design that are beyond the scope of the DCD, and to the operational aspects of the facility.

Therefore, the codes and standards referenced in FSAR Table 1.9-204 apply to the portions of the Fermi 3 design beyond the scope of the DCD and to operational aspects of the facility, and are not a comprehensive list of all codes and standards applicable to Fermi 3.

As described in the supplemental response to RAI 09.02.01-3 submitted in Detroit Edison letter NRC3-10-0029, dated July 9, 2010 (ADAMS Accession No. ML101930518), Detroit Edison has elected not to pursue the use of fiberglass reinforced polyester piping for the Plant Service Water System (PSWS). Alternatively, Detroit Edison has selected carbon steel that meets ASTM standards for underground piping in the PSWS. As described in the response to RAI 09.02.01-3 quality and seismic requirements for the underground piping for the PSWS are dictated by DCD Table 3.2-1. The codes and standards for the underground carbon steel piping are included in DCD Table 1.9-22.

The staff finds that because no nonmetallic piping is used for the PSWS piping, there are no applicable augmented code requirements, and the industrial codes and standards identified in the FSAR are applicable to any site-specific SSCs not included in the DCD. Therefore, all issues related to codes and standards for site-specific systems are resolved and Open Item 03.02.02-2 associated with RAI 03.02.02-2 is closed.

Special Treatment for Risk-Significant SSCs

GDC 1 identifies (in part) that SSCs important to safety shall be designed, fabricated, erected and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. In RG 1.206, Regulatory Position C.III.1, Subsection C.I.3.2.2 states that the COL applicant will "identify those fluid systems or portions thereof that are important to safety and outside the scope of the certified design, as well as the applicable industry codes and standards for each pressure-retaining component." SRP Section 3.2.2 also specifically states that the staff reviews quality standards including the application of the Quality Assurance (QA) Program and the applicability of codes and standards. Supplemental quality standards and the QA Program applicable to passive SSCs used in nonsafety-related RTNSS that may be important to safety are not clearly defined in Subsection 3.2 of the COL application for site-specific SSCs. In RAI 03.02.02-3, the staff also requested the applicant to clarify in FSAR Section 3.2 or to include a reference to another FSAR chapter that defines which supplemental quality standards are applied to nonsafety-related site-specific SSCs that are important to safety to ensure that all SSCs important to safety are designed, fabricated, erected, and tested to quality standards commensurate with the safety function to be performed. For example, FSAR Subsection 9.2.1.5 states that fiberglass pressure pipe meeting ASME B31.1 and other supplemental standards will be applied, but it is not obvious which supplemental quality standards apply to site-specific SSCs, such as fiberglass piping, in either the DCD Tier 2, Section 3.2 tables or FSAR Section 3.2.

The applicant's response (ADAMS Accession No. ML102660141) states that FSAR Section 3.2 incorporates DCD Tier 2, Table 3.2-1 by reference with two changes. The first change includes the HWCS in the site-specific plant design. DCD Tier 2, Table 3.2-1 includes the classification information for the HWCS; thus, the only detail included in the FSAR is to identify that the HWCS is included in the site-specific plant design. As shown in DCD Table 3.2-1, the HWCS is nonsafety-related and non-seismic. The second change is not including the zinc injection system in the site-specific design. ESBWR DCD Tier 2, Table 3.2-1 specifies the extent to which the quality assurance requirements apply to nonsafety-related SSCs. General Electric-Hitachi (GEH) has included this information in DCD Tier 2, Section 3.2 and in Appendix 19A. These requirements are applied to all SSCs, including those that are site-specific. In addition, FSAR Table 1.9-203 states:

> There are no additional safety-related or RTNSS SSCs subject to seismic classification beyond those addressed in the DCD. There are no SSCs outside the referenced certified design that are required to be designed for an OBE.

There are no site-specific safety-related systems or nonsafety-related RTNSS systems beyond the scope of the DCD. Therefore, there is no need to define supplemental quality standards for site-specific SSCs.

As indicated above, in the supplemental response to RAI 09.02.01-3 (ADAMS Accession No. ML1019305180), Detroit Edison has elected not to pursue the use of fiberglass-reinforced polyester piping for the PSWS. Detroit Edison has selected carbon steel that meets ASTM standards for underground piping in the PSWS. Quality assurance and seismic requirements for the PSWS underground piping are dictated by DCD Tier 2, Table 3.2-1. The codes and standards for the underground carbon steel piping are included in DCD Tier 2, Table 1.9-22.

Because the applicant has revised FSAR Section 3.2 to state that there are no site-specific SSCs important to safety beyond the scope of the DCD and has elected not to use nonmetallic materials in the PSWS (a RTNSS Criterion C function) all issues associated with the special treatment for risk-significant site-specific systems are resolved. Therefore, RAI 03.02.02-3 is closed.

Summary

Based on the above evaluation of the applicant's information related to quality group classification, the staff finds that the requirements of GDC 1 are met and the information is consistent with the guidance in RG 1.26 and RG 1.206.

3.2.5 Post Combined License Activities

There are no post COL activities related to this section.

3.2.6 Conclusion

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the required information, 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 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

In addition, the staff compared the additional COL information in the application to the relevant NRC regulations, the guidance in Sections 3.2.1 and 3.2.2 of NUREG–0800, and the applicable RGs. The staff's review concludes that the applicant has adequately addressed the seismic and quality group classifications. The staff notes that these classifications meet the requirements of GDC 1 and GDC 2 and the guidance of RG 1.26, RG 1.29, and RG 1.206. Therefore the staff also finds that Fermi 3 COL FSAR, Revision 7, Subsections 3.2.1 and 3.2.2 are acceptable because they meet NRC regulatory requirements and acceptance criteria in Sections 3.2.1 and 3.2.2 of NUREG-0800.

3.3 Wind and Tornado Loadings

Section 3.3 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Section 3.3, "Wind and Tornado Loadings," of Revision 10 of the ESBWR DCD. 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 confirms that 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 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to the wind and tornado loadings have been resolved.

[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 COL application that references a design certification.

3.4 Water Level (Flood) Design

Section 3.4 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Section 3.4, “Water Level (Flood) Design,” of Revision 10 of the ESBWR DCD. 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 confirms that 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 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to the water level from floods have been resolved.

3.5 Missile Protection

3.5.1 Introduction

SSCs important to safety are analyzed for and designed to be protected from a wide spectrum of missiles, such as internally generated missiles from rotating equipment, high energy fluid systems, and gravitational missiles; externally generated missiles from tornado winds and extreme winds; and missiles from proximate site sources and aircraft hazards.

Methods of protection must be provided for all SSCs that are necessary to perform functions required to attain and maintain a safe shutdown or to otherwise mitigate the consequences of an accident. These methods may consist of (1) locating the system or component in a missile-proof structure, (2) isolating redundant systems or components in the missile’s path or range, (3) providing local shields and barriers for SSCs, or (4) designing the equipment to withstand the impact of the most damaging missile.

The specific reactor site location determines the potential for missile hazards from nearby industrial sources and the hazards from aircraft operating in the region.

3.5.2 Summary of Application

Section 3.5 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.5 of the ESBWR DCD, Revision 10. In addition, in FSAR Sections 3.5, the applicant provides the following:

Supplemental Information

- STD SUP 3.5-1 — Site-Specific Missile Sources

In FSAR Subsection 3.5.1.5, the applicant states the following:

> Site-specific missile sources are addressed in Section 2.2..

- STD SUP 3.5-2 — Site-Specific Aircraft Analysis and the Site-Specific Critical Areas

In FSAR Subsection 3.5.1.6, the applicant states the following:

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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 COL application that references a design certification.

Site-specific aircraft hazard analysis and the site-specific critical areas are addressed in Section 2.2.

3.5.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is in NUREG–1966. In addition, the relevant guidance for compliance with the Commission regulations for missile protection, and the associated acceptance criteria, are in NUREG–0800, Subsection 3.5.1.3 for the turbine missile; Subsection 3.5.1.5 for the nearby site-generated missiles; and Subsection 3.5.1.6 for the aircraft hazards.

The applicable regulatory requirements for all missile protections are in:

10 CFR Part 50, Appendix A, GDC 4, "Environmental and dynamic effects design bases."

3.5.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.5 of the ESBWR DCD. The staff reviewed Section 3.5 of the Fermi 3 COL FSAR, Revision 7, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 7, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 7, as follows:

Supplemental Information

- STD SUP 3.5-1 — Site Specific Missile Sources (Site Proximity Missiles)

NRC staff reviewed STD SUP 3.5-1, which states that the site-specific missile sources are in Section 2.2 of the Fermi 3 FSAR.

The staff's technical evaluation of this portion of the application is limited to reviewing the supplemental information pertaining to STD SUP 3.5-1.

The staff reviewed the conformance of Section 3.5 of the Fermi 3 COL FSAR to the guidance in RG 1.206, Regulatory Position C.III.1, Subsection C.I.3.5.1.3, "Turbine Missiles". The staff finds that the FSAR appropriately incorporates by reference Subsection 3.5.1.1.1.2 of the ESBWR DCD, Tier 2, Revision 10.

The staff requested in RAI 03.05.01.05-1 that the applicant provide an assessment of the potential for the turbine missile generation from the existing Fermi 2 that may affect the safe operation of the proposed Fermi 3. The applicant's response to this RAI in a letter dated on January 27, 2010 (ADAMS Accession No. ML100290010) stated that based on strike angles

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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 COL application that references a design certification.

from the Fermi 2 site layout and beginning at the southeast corner of the Fermi 2 turbine building, there are no Fermi 3 essential systems within the strike zone. Therefore, the applicant concluded that because of the turbine orientation and offsets between the Fermi 2 turbine building to Fermi 3 targets, turbine missiles from Fermi 2 would not affect the safe operation of Fermi 3. The staff accepted the applicant's explanation as reasonable and concluded that the information in the FSAR and in the RAI response meets the requirements of GDC 4 and the guidance in Subsection 3.5.1.5 of NUREG-0800.

Based on the above, the staff concludes that the relevant information in the COL FSAR is acceptable and meets the requirements of GDC 4 of Appendix A to 10 CFR Part 50. The staff based this conclusion on the following:

STD SUP 3.5-1, "Site Proximity Missiles," is acceptable because the applicant has identified potential accidents related to the generation of site proximity missiles (except aircraft) in the site vicinity that could affect a nuclear power plant or plants of the specified type that might be constructed on the proposed site. The applicant has appropriately determined those potential accidents that should be considered as design-basis events and has demonstrated that the plant is adequately protected and can be operated with an acceptable degree of safety with regard to the design-basis accidents. The staff reviewed the information in the FSAR. For the reasons stated above, the staff concluded that the applicant has established that the construction and operation of Fermi 3 of the specified type on the proposed site location is acceptable and meets the requirements of 10 CFR 52.79(a)(1)(iv) and 10 CFR 52.79(a)(1)(vi) for compliance with respect to determining the acceptability of the site.

- STD SUP 3.5-2 Site-Specific Aircraft Analysis (Aircraft Hazards)

NRC staff reviewed STD SUP 3.5-2 which states that the site-specific aircraft analysis and site-specific critical areas are addressed in Section 2.2 of the Fermi 3 FSAR.

The staff's technical evaluation of this portion of the application is limited to reviewing the supplemental information pertaining to STD SUP 3.5-2.

The applicant performed the aircraft hazards evaluation in Fermi 3 FSAR, Subsection 2.2.3.1.3.1. The applicant addressed and evaluated potential aircraft hazards following the approach and methodology outlined in NUREG-0800, Subsection 3.5.1.6. The applicant simulated an aircraft crash into the effective plant areas of the safety-related structures on the site. The applicant determined the probability of aircraft accidents resulting in radiological consequences greater than the 10 CFR Part 100 exposure guidelines to be 2.3×10^{-7} per year from Mills Field Airport or Detroit Metropolitan Wayne County Airport.

The applicant addressed the evaluated airways in Fermi 3 FSAR, Subsection 2.2.3.1.3.2, and calculated the aircraft hazards probability for Airways V383 and V10-176-188. However, the applicant did not provide enough information with regard to the effective area used in the probability calculation. Therefore, the staff requested in RAI 03.05.01.06-1 that the applicant provide data, assumptions, annual flight operations and the effective area used in the calculation of the aircraft hazards probabilities. The applicant responded to this RAI in a letter dated January 27, 2010 (ADAMS Accession No. ML100290010) and provided information and revisions to the FSAR sections. The staff reviewed the applicant's information and performed confirmative probability calculations using annual average flight operations data from 2004 - 2009 within 8 kilometers (km) (5 miles) of the Fermi site obtained from the Federal Aviation Administration. Based on the review of the applicant's response and the confirmatory calculations, the staff concludes that the applicant's approach is reasonable and the conclusion is acceptable because the aircraft hazards probability is within the acceptable criterion of the magnitude on the order of 1×10^{-7} per year.

STD SUP 3.5-2, "Aircraft Hazards," is acceptable because the applicant has identified potential accidents related to the aircraft hazards in the site vicinity that could affect a nuclear power plant or plants of the specified type that might be constructed on the proposed site. The applicant has appropriately determined those potential accidents that should be considered as design-basis events and has demonstrated that the plant is adequately protected and can be operated with an acceptable degree of safety with regard to the design-basis accidents. The staff reviewed the information in the FSAR.

For the reasons stated above, the staff concludes that the applicant has established that the construction and operation of Fermi 3 on the proposed site location is acceptable and meets the requirements of 10 CFR 52.79(a)(1)(iv) and 10 CFR 52.79(a)(1)(vi) for compliance with respect to determining the acceptability of the site. Accordingly, RAI 03.05.01.05-1 and 03.05.01.06-1 are closed.

3.5.5 Post Combined License Activities

There are no post COL activities related to this section.

3.5.6 Conclusion

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the required information, 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 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to this section that were incorporated by reference have been resolved.

In addition, the staff compared the COL information in the application to the relevant NRC regulations, the guidance in Section 3.5 of NUREG–0800, and other NRC RGs. The staff's review concludes that the applicant has provided adequate information to satisfy the NRC requirements of GDC 4. Therefore, the staff finds that the relevant information in Section 3.5 of the Fermi 3 COL FSAR, Revision 7, is acceptable and meets the regulatory guidance in Sections 3.5 of NUREG-0800.

3.6 Protection against Dynamic Effects Associated with the Postulated Rupture of Piping

Section 3.6 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Section 3.6, "Protection against Dynamic Effects Associated with the Postulated Rupture of Piping," of Revision 10 of the ESBWR DCD. The staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review.[1] The staff's review confirms that no outstanding information is expected to be addressed in the COL FSAR related to this section. In Appendix 14.3A, "Design Acceptance

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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 COL application that references a design certification.

Criteria (DAC) ITAAC Closure Process," the applicant proposes two commitments, COM 3.10-003 and COM 14.3-001 regarding schedule for piping (including the pipe break analysis report) DAC ITAAC closure. In Section 14.3.4 and 14.3.5 of this safety evaluation, the staff reviewed these two commitments and finds them to be acceptable. Pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to the protection against dynamic effects associated with the postulated rupture of piping have been resolved.

3.7 Seismic Design

Safety-related systems, structures, and components (SSCs) are designed to withstand safe-shutdown earthquake (SSE) loads and other dynamic loads, including those due to reactor building vibration (RBV) caused by suppression pool dynamics. This section addresses seismic aspects of the design and analysis in accordance with RG 1.70, Revision 3, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)."

3.7.1 Seismic Design Parameters

Seismic Category I SSCs are designed to withstand the effects of the SSE event and to maintain the specified design functions. Seismic Category II and nonseismic (NS) structures are designed or physically arranged (or both) so that the SSE could not cause unacceptable structural interactions with or the failure of seismic Category I SSCs. The ESBWR standard plant SSE design ground motion is addressed in Section 3.7 of ESBWR DCD, Tier 2, Revision 10. The horizontal and vertical SSE design ground response spectra (for 5 percent damping), also termed certified seismic design response spectra (CSDRS) for the ESBWR design were developed based on enveloping RG 1.60, Revision 1, "Design Response Spectra for Seismic Design of Nuclear Power Plants," response spectra anchored to 0.3 g peak ground acceleration (PGA) and the high-frequency hard rock spectra anchored to 0.5g PGA. These spectra are shown in ESBWR DCD, Tier 2, Revision 10, Chapter 2.0, Figures 2.0-1 and 2.0-2 for horizontal and vertical directions, respectively. The CSDRS have been applied as the input ground motion at the building foundation level for the seismic design of the Category I structures included in the design document. For the reactor and fuel building (RB/FB) and the control building (CB), the input motion is the same as that shown in Figures 2.0-1 and 2.0-2. The input motion for the firewater service complex (FWSC) is 1.35 times the values shown in DCD Tier 2, Figures 2.0-1 and 2.0-2. The applicant has provided the seismic design parameters for the Fermi 3 site in this FSAR section, as documented below.

3.7.1.1 *Introduction*

This FSAR section addresses the design earthquake ground motion used for the seismic analysis and design of the Category I structures. The design earthquake ground motion is based on the seismic and geologic characteristics at the site and is established in terms of a set of idealized and smooth curves called the design response spectra. At the Fermi 3 site, the specific seismic design parameters include the design ground motion in terms of the foundation input response spectra (FIRS), design ground motion time histories, percentage of critical damping values, and the characteristics of the supporting media for Category I structures.

3.7.1.2 *Summary of Application*

Section 3.7.1 of the Fermi 3 COL FSAR, Revision 7 incorporates by reference Section 3.7.1 of the ESBWR DCD, Revision 10. In addition, in FSAR Section 3.7.1, the applicant provides the following:

<u>Supplemental Information</u>

- EF3 SUP 3.7-1 Site-Specific Design Ground Motion Response Spectra

In FSAR Section 3.7.1, the applicant provides the following:

1) The development of a comprehensive set of site-specific seismic inputs for the Fermi 3 site-specific soil-structure interaction (SSI) analyses of the RB/FB and the CB structures. Site-specific seismic inputs consist of performance-based surface response spectra (PBSRS), FIRS, site-specific ground motion time histories, and subsurface material profiles with corresponding dynamic properties used in the site-specific SSI analyses. The analyses also include the development of the FIRS for the FWSC structure.

2) The development of the damping ratios for the subsurface material profiles used in the site-specific SSI analyses of the RB/FB and the CB in FSAR Subsection 3.7.1.1.4.

3) The development of the dynamic properties of the subsurface material profiles used in the site-specific SSI analyses of the RB/FB and the CB in FSAR Subsection 3.7.1.1.4.

3.7.1.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG–1966. In addition, the relevant requirements of the Commission regulations for the seismic design, and the associated acceptance criteria, are in Section 3.7.1 of NUREG–0800. The specific requirements include the following:

- 10 CFR Part 50, Appendix A, GDC 2, as it relates to the seismic design basis to reflect the appropriate consideration of the most severe earthquakes historically reported for the site and surrounding area with a sufficient margin for the limited accuracy, quantity, and period of time in which historical data have been accumulated; and SSCs important to safety be designed to withstand the effects of earthquakes without a loss of capability to perform their intended safety functions.

- 10 CFR Part 50, Appendix S, “Earthquake Engineering Criteria for Nuclear Power Plants,” as it relates to the SSE ground motion in the free-field at the foundation level of the structures to be an appropriate response spectrum with a peak ground acceleration of at least 0.1g; and if the OBE is chosen to be less than or equal to one-third of the SSE ground motion, it will not be necessary to conduct explicit response or design analyses in accordance with Section IV.(2)(i)(A) of 10 CFR Part 50, Appendix S.

In addition, the acceptance criteria and regulatory guidance associated with the review of FSAR Section 3.7.1 include the following:

- SRP Section 3.7.1 for reviewing seismic design parameters to ensure that they are appropriate and contain a sufficient margin so that seismic analyses (reviewed under other SRP sections) accurately and/or conservatively represent the behavior of SSCs during postulated seismic events.

- RG 1.60, Revision 1, “Design Response Spectra for Seismic Design of Nuclear Power Plants,” to determine the acceptability of design response spectra for input into the seismic analysis of nuclear power plants.

- RG 1.61, Revision 1, “Damping Values for Seismic Design of Nuclear Power Plants,” to determine the acceptability of damping values used in the dynamic seismic analyses of seismic Category I SSCs.

- Design certification/COL–Interim Staff Guidance (DC/COL-ISG)-017, “Interim Staff Guidance on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analysis.”

- NUREG/CR–6728, “Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines,” to determine the acceptability of the site-specific FIRS used in the site-specific seismic analysis.

3.7.1.4 *Technical Evaluation*

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.7.1 of the ESBWR DCD. The staff reviewed Section 3.7.1 of the Fermi 3 COL FSAR and checked the referenced ESBWR DCD to ensure that the combination of the information in the COL FSAR and the information in the ESBWR DCD appropriately represents the complete scope of information relating to this review topic.[1] The staff’s review confirms that the information in the application and the information incorporated by reference address the required information relating to this section.

The staff reviewed the following information in the Fermi 3 COL FSAR, Revision 7:

<u>Supplemental Information</u>

- EF3 SUP 3.7-1 Site-Specific Design Ground Motion Response Spectra

[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 COL application that references a design certification.

Design Ground Motion

FSAR Figures 3.7.1-228, 3.7.1-229, and 3.7.1-238 show that the FIRS developed in FSAR Subsection 3.7.1.1.4 are enveloped by the ESBWR CSDRS in both horizontal and vertical directions for the RB/FB, CB, and FWSC. In addition, the Fermi 3 site-specific SSI analyses for the RB/FB and the CB were performed to address the following two Fermi 3 site-specific conditions:

- To confirm that the DCD standard plant design is applicable to the Fermi 3 site-specific conditions, where the RB/FB and the CB structures are partially embedded in the Bass Islands Group rock, with the engineered granular backfill surrounding the structures from the top of the rock to the grade level of the plant.

- To demonstrate that the standard plant design is applicable to the Fermi 3 site-specific conditions, even though the DCD requirements for the engineered granular backfill that surrounds the seismic Category I structures are not being met for the RB/FB and the CB structures. Specifically, the requirements in DCD Tier 2, Table 2.0-1 state that the minimum shear wave velocity of the material surrounding the embedded walls of these structures should be greater than 300 meters per second (m/s) (1000 feet [ft]/s).

FSAR Subsection 3.7.1.1 indicates that the FWSC is a surface-founded structure according to DCD Tier 2, Subsection 3.7.1.1, and there are no embedded walls for the FWSC. Therefore, the DCD requirements for the backfill surrounding seismic Category I structures are not applicable to the FWSC. As discussed in FSAR Section 2.5.4, the FWSC is founded on fill concrete that meets the DCD Tier 2, Table 2.0-1 requirements underneath seismic Category I structures. Therefore, no site-specific SSI analysis is performed for the FWSC. The staff's review of this issue is in Subsection 3.7.2.4 of this SER, where the staff concludes that no site-specific SSI analysis is needed for the FWSC.

The applicant developed seismic inputs for the site-specific SSI analysis to be consistent with the procedure described in DC/COL-ISG-017. The RB/FB and the CB design ground motions for the site-specific SSI analyses were based on the outcrop FIRS developed in FSAR Subsection 3.7.1.1.4 as the soil column outcrop response (SCOR). The SCOR was further enhanced to ensure that the PBSRS is enveloped at the ground surface. The SSE for Fermi 3 was then designated as the lower of the two enhanced SCOR FIRS for the RB/FB and the CB. The SSE is defined at the foundation level to be consistent with the definition used in the DCD. The applicant also stated that the OBE is one-third of the SSE

The staff found the applicant's specification of the SSE acceptable because it is defined as the lower of the two enhanced SCOR FIRS at the foundation level, which is consistent with the definition in the DCD. The staff's evaluation of the SCOR FIRS and the enhanced SCOR FIRS for the RB/FB and the CB, as well as the FIRS for the FWSC, is provided below under "Fermi 3 Site-Specific Ground Motions." The staff's evaluation of the site-specific RB/FB and CB SSI analysis is in Subsection 3.7.2.4 of this SER.

Fermi 3 Site-Specific Ground Motions

Development of Horizontal RB/FB SCOR FIRS, CB SCOR FIRS, and PBSRS

In the Fermi 3 site-specific SSI analyses in FSAR Section 3.7.2, the RB/FB and the CB are modeled as partially embedded structures within the Bass Islands Group rock. The site-specific SSI analyses did not consider the effect of the engineered granular backfill on the RB/FB and the CB. To confirm that the engineered granular backfill does not adversely impact seismic Category I structures, the applicant performed additional site-specific SSI analyses that included the engineered granular backfill above the top of the Bass Islands Group bedrock.

The applicant used the Nuclear Energy Institute (NEI) method described in Section 5.2.1 of DC/COL-ISG-017 to develop SCOR FIRS at the RB/FB and the CB foundation levels, as well as the PBSRS at the finished grade level. The SCOR FIRS were enhanced using the procedure described in Section 5.2.1 of DC/COL-ISG-017 to ensure hazard-consistent seismic inputs for the site-specific SSI analyses when compared to the PBSRS at the finished grade level. The staff found the applicant's process of developing the SCOR FIRS and enhanced SCOR FIRS acceptable, because the method and procedure used are consistent with the guidance in DC/COL-ISG-017.

The applicant developed three base case site response profiles to reflect the range in granular backfill material properties that may be used. These base case profiles are referred to as the lower-range (LR), intermediate range (IR), and upper-range (UR) profiles, and their properties are defined in FSAR Tables 3.7.1-201, 3.7.1-202, and 3.7.1-203, respectively (the staff notes that the LR, IR, and UR profiles are identical below the backfill in the rock portion, which is assumed to be linear). In addition, the applicant randomized the dynamic properties of the three base case profiles (i.e., shear-wave velocity and shear modulus reduction and damping) using the method described in FSAR Subsection 2.5.2.5.1.3. To develop the SCOR FIRS and PBSRS, the applicant used the same process that was used to develop its ground motion response spectrum (GMRS) in FSAR Subsections 2.5.2.5.3 and 2.5.2.6. According to the logic tree shown in FSAR Figure 3.7.1-210, the applicant assigned relative weights of 0.35, 0.50, and 0.15 to the respective UR, IR, and LR base case profiles in the development of the final amplification functions.

In RAI 02.05.02-20 and RAI 02.05.02-21, the staff requested the applicant to provide information related to the properties of the proposed engineered granular backfill—including a justification for the weighting factors developed for the LR, IR, and UR base case profiles. Based on the information in the response to both RAIs (ADAMS Accession Nos. ML13043A012 and ML13226A030, respectively), the staff performed a confirmatory site response analysis for the three individual base case profiles (LR, IR, and UR) without assigning any weighting factors.

The staff's analysis indicates that the envelope of the FIRS developed with the staff's confirmatory analysis and obtained from the three base cases without consideration of any weighting factors, is bounded by the enhanced SCOR FIRS used by the applicant in the site-specific SSI analysis. Furthermore, a comparison with the DCD CSDRS shows that significant margin exists between the CSDRS and the site-specific enhanced SCOR FIRS for both the RB/FB and the CB, as shown in the FSAR Figures 3.7.1-228 and 3.7.1-229. In addition, the envelope of the PBSRS obtained from the staff's site response analysis using the three backfill base cases, without consideration of any weighting factors, is bounded by the surface envelope of the response spectra computed from the SSI deterministic input and based on the three deterministic profiles used in the site-specific SSI analysis.

Based on the confirmatory analysis, the staff concludes that the PBSRS and the enhanced SCOR FIRS used by the applicant to develop the seismic input for the site-specific SSI analysis of the RB/FB and the CB are adequate for the Fermi 3 site.

Basis of the Assumption of One-Dimensional Versus Two-Dimensional Backfill Material Surrounding the Power Block

FSAR Figure 2.5.4-201 shows that the backfill material surrounding the power block structures extends to a perimeter diaphragm wall that is used to support the excavation of in situ material. Beyond the diaphragm wall, it appears that in situ soils will remain in place. Because the use of backfill material is limited in the lateral extent, the staff requested the applicant in RAI 03.07.01-5 to explain why it is appropriate to establish the PBSRS and FIRS for the RB/FB and the CB on the basis of a one-dimensional (1-D) site response analysis using a column of backfill/rock material.

In the response to RAI 03.07.01-5 (ADAMS Accession No. ML12086A091), the applicant demonstrated the appropriateness of defining the PBSRS and FIRS for the RB/FB and the CB on the basis of the 1-D column of backfill/rock material, by comparing the amplification functions obtained from the soil profiles inside and outside of the diaphragm wall support. Figures 5 through 7 of the response to RAI 03.07.01-5 provide the comparisons of the amplification functions for inside and outside of the diaphragm wall. The staff's review of these comparisons concludes that a 1-D representation of the backfill material is acceptable for establishing the PBSRS and FIRS for the RB/FB and the CB, because the shear wave velocity profiles for the conditions inside and outside of the perimeter diaphragm wall produce comparable SCOR amplification functions at the RB/FB and the CB foundation levels.

Meeting the Minimum Requirement of 10 CFR Part 50 Appendix S

10 CFR Part 50, Appendix S, requires that the horizontal component of the SSE ground motion in the free-field at the foundation levels of structures must be an appropriate response spectrum with a PGA of at least 0.1g. Therefore, in RAI 03.07.01-8, the staff requested the applicant to provide in the FSAR comparison plots of the RB/FB and the CB horizontal FIRS with the RG 1.60 horizontal spectrum anchored at 0.1g, which demonstrate that the RB/FB and the CB horizontal FIRS envelop the RG 1.60 spectrum anchored at 0.1g at all frequencies of interest.

FSAR Figures 3.7.1-226 and 3.7.1-227 provide the requested comparison plots of the RB/FB and the CB horizontal SCOR FIRS with the RG 1.60 horizontal spectrum anchored at 0.1g, respectively. The plots show that, the SCOR FIRS obtained from the site-response analysis for the RB/FB and the CB do not envelop the RG 1.60 shape scaled to a PGA of 0.1g in the frequency range of about 0.2 to 3 Hertz (Hz). To meet the requirements of the minimum horizontal ground motions specified in 10 CFR Part 50, Appendix S, the applicant modified the SCOR FIRS to ensure that these envelop the RG 1.60 spectrum scaled to a PGA of 0.1g. In addition, the applicant used the guidance specified in DC/COL-ISG-017 for ensuring performance-based seismic inputs for the site-specific SSI analysis. The staff notes that the initially enhanced FIRS as discussed above were further enhanced using the procedure described in Section 5.2.1 of DC/COL-ISG-017, thus ensuring performance-based seismic inputs for the site-specific SSI analyses when compared to the PBSRS at the finished grade level, as discussed above under "*Development of Horizontal RB/FB SCOR FIRS, CB SCOR FIRS, and PBSRS*."

The staff verified that the modified SCOR FIRS designated as "initially enhanced" FIRS in the FSAR enveloped the RG 1.60 spectrum scaled to a PGA of 0.1g as shown in FSAR Figures 3.7.1-226 and 3.7.1-227. The staff also verified that the final enhancements to the SCOR FIRS designated as the "enhanced SCOR FIRS" in the FSAR as shown in FSAR Figures 3.7.1-228 and 3.7.1-229 are developed using the guidance in DC/COL-ISG-017 and are bounded by the ESBWR CSDRS. On the above basis, the staff concludes that the site-specific enhanced SCOR FIRS meet the minimum requirement of 10 CFR Part 50, Appendix S and represent a performance-based seismic input acceptable for the site-specific SSI analysis

Development of Horizontal FWSC FIRS

According to FSAR Subsection 3.7.1.1.4.1, the FWSC is founded on 9.15 m (30 ft) of fill concrete, which overlies the Bass Islands Group rock. The FSAR states that because the FWSC is essentially a surface-founded structure, the FIRS for the FWSC was developed as a truncated soil column response (TSCR) in accordance with the NEI method described in DC/COL-ISG-017. FSAR Table 3.7.1-204 provides the site response analysis profile for both the fill concrete and the rock beneath the fill concrete used in the development of the FWSC FIRS. In addition, the applicant randomized the dynamic properties of the FWSC profile (i.e., shear-wave velocity and shear modulus reduction and damping) using the method described in FSAR Subsection 2.5.2.5.1.3. The applicant used a process similar to the process for developing the GMRS in FSAR Subsections 2.5.2.5.3 and 2.5.2.6 to compute the FWSC amplification functions and the FIRS.

The staff found the applicant's method for developing the FWSC FIRS acceptable, because the method is in accordance with the NEI method described in DC/COL-ISG017. In addition, the staff also performed a confirmatory analysis using the static and dynamic material properties in FSAR Subsection 3.7.1.1.4.1.1. To represent the input rock motions, the staff used the high- and low-frequency rock spectra associated with 10^{-4} exceedance probability, as well as the high- and low-frequency rock spectra associated with 10^{-5} exceedance probability. The staff's analysis confirms acceptability of the FIRS computed by the applicant because the results of the staff's analysis are comparable with that of the applicant's analysis used to establish the FIRS.

The FWSC FIRS is shown in FSAR Figure 3.7.1-238 and tabulated in FSAR Table 3.7.1-216. FSAR Figure 3.7.1-238 also shows the curve for FWSC CSDRS which is 1.35 times the ESBWR CSDRS as described in DCD Tier 2, Subsection 3.7.1.1. As shown in this Figure, the FWSC FIRS is enveloped by 1.35 times the ESBWR CSDRS by a significant margin. As such, the staff concludes that FWSC site-specific FIRS are bounded by the FWSC CSDRS and a site-specific SSI analysis for the FWSC is not needed.

Basis of the Assumption of One-Dimensional Versus Two-Dimensional Concrete Fill Material Underneath the FWSC

FSAR Figure 2.5.4-202 indicates that the lateral extent of the concrete fill material beneath the FWSC is limited to the footprint of the basemat. Because the concrete fill is limited in a lateral extent, the staff in RAI 03.07.01-3 requested the applicant to explain why it is appropriate to establish the FIRS for the FWSC on the basis of a 1-D site response analysis using a column of concrete fill/rock material, which presumes the concrete fill has infinite lateral extent.

In the response to RAI 03.07.01-3, dated March 13, 2012 (ADAMS Accession No. ML120730531), the applicant presented a methodology for developing the FIRS for the FWSC that takes into account 2-D site response analyses performed using the QUAD4MU program. In the 2-D analyses, the finite lateral extent of the concrete fill is explicitly taken into account; as well as the properties of the backfill from the LR, IR, and UR profiles. Following this methodology, the applicant established the 2-D versus the 1-D response spectral ratio envelopes at the FWSC foundation level. The 2-D versus the 1-D envelopes are shown in FSAR Figure 3.7.1-215 for the 10^{-4} and 10^{-5} exceedance probability levels of input ground motions. The plots indicate that the 2-D effect produces an increase in the mean site amplification functions above 5 Hz compared to the 1-D site response. The increase is generally greater for the 10^{-5} exceedance probability level than for the 10^{-4} exceedance level. FSAR Figure 3.7.1-216 shows the smoothed mean site amplification functions for the 10^{-4} and 10^{-5} exceedance probability levels at the FWSC foundation level for the 1-D site response compared with those incorporating the 2-D effects.

The FWSC FIRS shown in FSAR Figure 3.7.1-238 and tabulated in FSAR Table 3.7.1-216 are based on the mean site amplification functions that were modified by the 2-D versus the 1-D response spectral ratio envelopes shown in FSAR Figure 3.7.1-215 and illustrated in FSAR Figure 3.7.1-216.

Based on the above review, the staff concludes that the applicant's methodology for developing the FWSC FIRS adequately captures the 2-D effects resulting from the limited extent of the concrete fill beneath the FWSC basemat. The applicant's methodology is therefore acceptable.

Development of Vertical RB/FB SCOR FIRS, CB SCOR FIRS, FWSC FIRS, and PBSRS

The discussions above refer to the horizontal components of the SCOR FIRS for the RB/FB and CB, and the horizontal components of the FWSC FIRS and the PBSRS. To obtain the vertical component of the SCOR FIRS for the RB/FB and CB and the FWSC FIRS, FSAR Subsections 3.7.1.1.4.4 and 3.7.1.1.4.5 indicate that the applicant utilized the frequency-dependent vertical-to-horizontal (V/H) response spectral ratios for hard rock recommended by NUREG/CR–6728 for central and eastern United States (CEUS) bedrock sites (for 0.2 g ≤ PGA ≤ 0.5 g), which the staff finds acceptable because the RB/FB and the CB foundation levels are located within the bedrock. The staff noted that, unlike the RB/FB and the CB, the FWSC foundation level is located on concrete fill instead of the rock. The staff, however, finds the use of V/H response spectral ratios for hard rock recommended by NUREG/CR–6728 to be acceptable for the FWSC since the shear wave velocity for the concrete fill is comparable to that of the bedrock.

To obtain the vertical component of the PBSRS, the above approach is not entirely applicable because the full soil column for the PBSRS consists of a layer of backfill above the bedrock. Based on recent findings in the technical literature (FSAR References 3.7.1-213 and 3.7.1-215), FSAR Subsection 3.7.1.1.4.3.2 indicates that the applicant has modified the V/H ratios for hard rock by shifting the peak V/H ratio toward lower frequencies and slightly reducing the V/H ratios for frequencies below 9 Hz (a maximum reduction of approximately 15 percent).

The staff finds the above approach acceptable for the following reasons. First, the data in the references support the trend that (a) the peak V/H ratio is shifted to the lower frequencies, and (b) there is a slight reduction in the V/H ratios for low frequencies and for cases that compare soft rock relative to firm rock responses. Second, the full soil column for the PBSRS (which is closer to a shallow stiff soil site) is softer than the rock columns considered in the derivation of the V/H ratios recommended in NUREG/CR–6728 for CEUS bedrock sites; the staff thus expects a similar trend to apply. Third, a review of FSAR Figure 3.7.1-234 indicates that there is a sufficient margin between the vertical component of the PBSRS and the surface envelope of the vertical response spectra computed from the SSI deterministic inputs, based on the three deterministic profiles used in the site-specific SSI analysis. As a result of the above discussion, the staff concludes that the applicant has adequately addressed the effects of the variability in the modified V/H ratios on the SSI analysis.

FSAR Figure 3.7.1-220 shows the frequency-dependent V/H ratios for hard rock recommended by NUREG/CR–6728 for CEUS bedrock sites (for 0.2 g ≤ PGA ≤ 0.5 g) and the V/H ratios used to obtain the vertical component of the PBSRS.

The staff notes that the vertical components of the SCOR FIRS for the RB/FB and the CB were then enhanced following the procedure described in Section 5.2.1 of DC/COL-ISG-017. This procedure ensures hazard-consistent seismic inputs for the site-specific SSI analyses when compared to the PBSRS at the finished grade level, in the same manner as the horizontal components of the SCOR FIRS for the RB/FB and CB that the staff reviewed and accepted (see the discussion above under "*Development of Horizontal RB/FB SCOR FIRS, CB SCOR FIRS, and PBSRS*"). On the basis of this review, the staff concludes that the vertical components of the enhanced SCOR FIRS are acceptable for the RB/FB, the CB, the FWSC FIRS, and the PBSRS.

Deterministic Profiles for Site-Specific SSI Analyses

FSAR Subsection 3.7.1.1.4.3.3 describes the methodology used by the applicant to develop the following three deterministic profiles of subsurface material properties for site-specific SSI analyses: Best Estimate (BE), Lower Bound (LB), and Upper Bound (UB). The methodology follows the guidance in SRP Acceptance Criterion 3.7.2.II.4 and DC/COL-ISG-17. The methodology is based on the statistics of the strain-iterated soil properties obtained from the probabilistic site response analyses using the randomized full soil column profiles described in FSAR Subsection 3.7.1.1.4.1.1.3, which include the engineered granular backfill above the top of the Bass Islands Group bedrock. In the implementation of this methodology, the applicant addressed the following:

- The probabilistic site-response analyses took into consideration (a) the three base case profiles (LR, IR, and UR) to reflect the range of granular backfill material properties that may be used; (b) three alternate damping ratios for the bedrock (which was assumed to remain linear); and (c) 10^{-4} and 10^{-5} exceedance probability levels of high-frequency (HF) and low-frequency (LF) deaggregated earthquake (DE) of low, medium, and high seismic events. The logic tree is shown in FSAR Figure 3.7.1-210. As discussed in FSAR Subsection 3.7.1.1.4.1.1.3, randomized full soil column profiles and randomized modulus reduction and damping curves were utilized in the process.

- The BE profile was determined from the 50th percentile results of the strain-iterated soil properties. The LB and UB profiles were determined from the 16th and 84th percentile results, respectively.

- The UB and LB shear wave velocity profiles were adjusted where necessary to satisfy SRP Acceptance Criterion 3.7.2.II.4, which indicates that G_{UB} should be greater than or equal to G_{BE} x (1 + COV) and G_{LB} should be less than or equal to G_{BE} / (1 + COV), where G_{UB}, GL_B, and G_{BE} are the shear moduli for the UB, LB, and BE profiles; and COV represents the coefficient of variation. Since the in situ subsurface materials have been well investigated at the Fermi 3 site, a COV of 0.5 was used for the bedrock. However, for the backfill, a COV of 1.0 was used to be consistent with SRP

Acceptance Criterion 3.7.2.II.4 and to correspond with sites that are not well investigated.

- Damping ratios for the BE profile were determined from the 50th percentile results of the strain-iterated results. Damping ratios for the LB and UB profiles were determined from the 84th and 16th percentile results, respectively. Maximum damping ratios were below 15 percent in all cases and are thus consistent with SRP Acceptance Criterion 3.7.2.II.4.

- The compression wave velocity profiles were based on the corresponding shear wave velocity profiles and the site-specific Poisson's ratios identified in FSAR Table 2.5.4-202. In the layers of saturated backfill, the compression wave velocities were increased to the lower value of either 1,460 m/s (4,790 ft/s) or the compression wave velocity that resulted in a maximum Poisson's ratio of 0.48 for the corresponding LB, BE, and UB shear wave velocity. In the layers of bedrock below the groundwater table, the compression wave velocities exceeded 1,460 m/s (4,790 ft/s) in all cases and no adjustment was necessary.

FSAR Tables 3.7.1-206 through 3.7.1-211 and FSAR Figures 3.7.1-222 and 3.7.1-223 document the deterministic profiles of subsurface material properties used for site-specific SSI analyses, with and without engineered granular backfill above the top of the Bass Islands Group bedrock. The deterministic profiles without the backfill are the same as the deterministic profiles for the full soil column below the top of the Bass Islands Group bedrock.

The staff finds the above information acceptable because it was developed to adhere to the guidance in SRP Acceptance Criterion 3.7.2.II.4 and DC/COL-ISG-17.

<u>Site-Specific Design Ground Motion Time Histories</u>

FSAR Subsection 3.7.1.1.5 indicates that two sets of three orthogonal time histories (two horizontal and one vertical component) were generated to match the horizontal and vertical enhanced SCOR FIRS for the RB/FB and the CB, respectively, in accordance with SRP Acceptance Criterion 3.7.1.II.1.B, Option 1, Approach 2. The seed time histories used are those of the 1999 Chi-Chi Taiwan Earthquake, TAP078 recording, which was chosen from the CEUS record library in NUREG/CR–6728. Details of this record are in FSAR Table 3.7.1-217. Spectral matching was performed using the time-domain spectral matching technique described in FSAR References 3.7.1-219 and 3.7.1-220.

The staff verified the following aspects of the spectrally matched time histories:

- The correlation coefficients between the three components are less than 0.16, as listed in FSAR Table 3.7.1-218, which indicates statistical independence.

- The strong motion durations as defined in SRP Acceptance Criterion 3.7.1.II.1.B are listed in FSAR Table 3.7.1-219 and are in the order of 25 to 31 seconds, thus exceeding the minimum requirement of 6 seconds.

- The 5-percent damped response spectra of the time histories were compared with the enhanced SCOR FIRS at 301 spectral frequency points (or 100 frequencies per spectral frequency decade) in FSAR Figures 3.7.1-239 through 3.7.1-244. The comparison indicates that the response spectra are within 90 percent to 130 percent of the enhanced SCOR FIRS for the frequency range between 0.1 and 50 Hz.

- The time step and duration of the time histories are 0.005 seconds and 80 seconds, respectively, which correspond to an acceptable Nyquist frequency of 100 Hz.

On the basis of the above verifications, the staff finds the spectrally matched time histories to be acceptable per SRP Acceptance Criterion 3.7.1.II.1.B, Option 1, Approach 2. FSAR Figures 3.7.1-245 through 3.7.1-250 show that the spectrally matched time histories are compatible with the enhanced SCOR FIRS for the RB/FB and CB at the foundation levels.

The values of the parameter peak ground velocity (PGV)/PGA shown in FSAR Table 3.7.1-219 are consistent with the characteristic values reported in NUREG/CR–6728; however, the values of PGA x peak ground displacement (PGD)/PGV^2 are larger. This difference is acceptable because the time histories are spectrally matched to the enhanced SCOR FIRS, which represent a combination of hazards from both large, distant earthquakes and smaller, closer earthquakes. In this situation, a parameter such as PGA x PGD/PGV^2 may not necessarily match the characteristic values reported in NUREG/CR–6728 because the latter correspond to individual events and not combinations of events.

The applicant performed an additional verification to demonstrate that there are no significant gaps in power for the spectrally matched time histories. To do this, power spectral densities (PSDs) were calculated for the frequency range of 0.3 to 50 Hz per the guidance in Appendices A and B of SRP Section 3.7.1.

The staff notes that the spectrally matched time histories have a very long total duration (approximately 80 seconds) and clearly show non-stationary characteristics, with the high-frequency content decreasing significantly after about 45 to 50 seconds. These characteristics were inherited from the seed records corresponding to the 1999 Chi-Chi Taiwan event that were used to generate the time histories. As a consequence of the non-stationary characteristics, the PSD computations are sensitive to the definition and duration of the strong motion window used to define the PSD per the SRP guidance. To account for this sensitivity, several strong motion windows were addressed as shown in FSAR Figure 3.7.1-251.

The PSD plots are shown in FSAR Figures 3.7.1-252 through 3.7.1-255. The only appreciable dips in energy content are observed to occur below 1 Hz and above 25 Hz, for the shorter strong motion windows (the staff notes that the dips become attenuated as the durations of the windows increase). The reason for the dips is the energy content at these frequencies that occurs outside of the corresponding window used to define the PSD and thus cannot be represented in the plots. This is a limitation of the methodology for computing the PSD, which presumes stationary characteristics and does not necessarily reflect a deficiency in the energy content of the time histories. The staff concludes that the spectrally matched time histories are acceptable because the calculated PSD does not show significant gaps in power for the frequency range of 0.3 to 50 Hz, which is the frequency range of interest for the SSI analysis and is consistent with SRP Acceptance Criterion 3.7.1.II.1.B.ii.

Based on the NEI method described in DC/COL-ISG-017, the applicant developed in-column motions at the foundation levels of the RB/FB and the CB using the spectrally matched time histories defined as outcrop motions at the foundation levels and the deterministic subsurface profiles (BE, LB, and UB with and without backfill). These in-column motions are used as inputs into the Fermi 3 site-specific SSI analyses described in FSAR Section 3.7.2. This approach is acceptable to the staff because it is consistent with the NEI method described in DC/COL-ISG-17.

<u>Percentage of Critical Damping Values</u>

In FSAR Subsection 3.7.1.2, the applicant summarizes the damping ratios for the subsurface material profiles used in the site-specific SSI analyses of the RB/FB and CB, which were described in detail in FSAR Subsection 3.7.1.1.4. The staff's review of this information is discussed above in this SER under "*Deterministic Profiles for Site-Specific SSI Analyses.*" Maximum damping ratios were below 15 percent in all cases and are therefore acceptable per the guidance in SRP Acceptance Criterion 3.7.2.II.4.

<u>Supporting Media for Category I Structures</u>

In FSAR Subsection 3.7.1.3, the applicant summarizes the dynamic properties of the subsurface material profiles used in the site-specific SSI analyses of the RB/FB and CB, which were described in FSAR Subsection 3.7.1.1.4. The staff's review of this information is discussed above in this SER under "*Deterministic Profiles for Site-Specific SSI Analyses.*"

The applicant provides the site plans and profiles of the supporting media for the Category I and Category II structures in FSAR Figures 2.5.4-201 through 2.5.4-204. The staff determined that this information together with the standard plant structural data in the ESBWR DCD, Revision 10, is sufficient per SRP Acceptance Criterion 3.7.1.II.3. The staff's evaluation of the site-specific seismic analysis of the RB/FB using the site characteristics described in FSAR Subsection 3.7.1.3 is discussed in Section 3.7.2 of this SER.

3.7.1.5 *Post Combined License Activities*

There are no post COL activities related to this section.

3.7.1.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the Fermi 3 FSAR related to this section. All nuclear safety issues relating to the seismic design parameters that were incorporated by reference have been resolved.

The staff compared the supplemental information in the COL application to the relevant NRC regulations, the guidance in Section 3.7.1 of NUREG–0800, other NRC RGs, and the Interim Staff Guidance. The staff finds that the applicant has addressed seismic design parameters in accordance with the acceptance criteria delineated in these guidance documents. On this basis, the staff concludes that the applicant has satisfied the relevant requirements of the regulations delineated in Subsection 3.7.1.3 of this SER.

3.7.2 Seismic System Analysis

3.7.2.1 *Introduction*

This FSAR section addresses the seismic analysis methods and acceptance criteria used for the ESBWR seismic Category I structures. Seismic Category I structures are designed to withstand the effects of the SSE event and to maintain the specified design functions. This section applies to building structures that constitute primary structural systems. The reactor pressure vessel (RPV) is not a primary structural component; but it is considered as another part of the primary system of the RB for the purpose of dynamic analysis because of its dynamic interaction with the supporting structure. Seismic Category II and NS structures are designed or physically arranged (or both) to prevent the SSE from causing unacceptable structural interactions with or the failure of seismic Category I SSCs. The ESBWR method for a standard plant seismic analysis of the Category I structures is in Section 3.7.2 of ESBWR DCD, Tier 2, Revision 10.

3.7.2.2 *Summary of Application*

Section 3.7.2 and Appendices 3A and 3C of the Fermi 3 COL FSAR, Revision 7, incorporate by reference Section 3.7.2 and Appendices 3A and 3C of ESBWR DCD, Revision 10. In addition, in FSAR Section 3.7.2 and Appendices 3A and 3C, the applicant provides the following:

<u>*Supplemental Information*</u>

- EF3 SUP 3.7-4 Soil-Structure Interaction

In FSAR Subsection 3.7.2.4, the applicant presents the site-specific SSI analyses for the RB/FB and the CB performed for the Fermi 3 site conditions. The SSI analyses considered site conditions with and without the engineered granular backfill placed above the top of the Bass Islands Group rock. The FSAR includes a comprehensive set of the SSI analysis results (e.g., enveloping structural loads, maximum vertical accelerations, and floor response spectra) and their comparisons against corresponding DCD values.

- EF3 SUP 3.7-5 Interaction of Non-Category I Structures with Seismic Category I Structures

In FSAR Subsection 3.7.2.8, the applicant addresses the requirements for site-specific analyses of Non-Category I structures both within and outside the scope of the DCD and including the turbine building (TB), service building (SB), ancillary diesel building (ADB), and radwaste building (RWB).

In FSAR Subsection 3.7.2.14, the applicant indicates that the "site-specific stability evaluation against overturning" is in FSAR Section 3.8.5.

- EF3 SUP 3A.5-1 Soil Structure Interaction Analysis Method

In FSAR Appendix 3A Section 3A.5.3, the applicant indicates that the SASSI2010 computer program was used for all site-specific SSI and structure-soil-structure interaction (SSSI) analyses using the direct method (DM) or the modified subtraction method (MSM) of analysis described in FSAR Subsection 3.7.2.4.1.3. The staff reviewed the computer programs used in the site-specific analysis along with the review of the FSAR Section 3.7.2.

- EF3 SUP 3C-1 Site Specific Soil-Structure Interaction

In FSAR Appendix 3C, the applicant describes the computer codes used in the Fermi 3 site-specific SSI analysis—including the computer code SASSI2010. The staff reviewed the computer programs used in the site-specific analysis along with a review of FSAR Section 3.7.2.

Conceptual Design Information

- EF3 CDI ESBWR Standard Plant Site Plan

The applicant indicates in FSAR Section 3A.1 that FSAR Chapter 2 describes site-specific geotechnical data, which are compatible with the site enveloping parameters considered in the standard design. The staff reviewed this information as it relates to the site-specific SSI analysis along with the review of the FSAR Section 3.7.2.

The applicant indicates in FSAR Section 3A.2 that FSAR Figure 2.1-204 depicts the site plan. The staff used this information in reviewing the FSAR Section 3.7.2.

3.7.2.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG–1966. In addition, the relevant requirements of the Commission regulations for the seismic system analysis, and the associated acceptance criteria, are in Section 3.7.2 of NUREG–0800. The specific requirements include the following:

- 10 CFR Part 50, Appendix A, GDC 2, as it relates to the seismic design basis to reflect appropriate consideration of the most severe earthquakes historically reported for the site and surrounding area with a sufficient margin for the limited accuracy, quantity, and period of time in which historical data have been accumulated. In addition, SSCs important to safety should be designed to withstand the effects of earthquakes without losing the capability to perform their intended safety functions.

- 10 CFR Part 50, Appendix S, as it relates to the SSE ground motion in the free-field at the foundation level of the structures to be an appropriate response spectrum with a peak ground acceleration of at least 0.1g; and if the OBE is chosen to be less than or equal to one-third of the SSE ground motion, it is not necessary to conduct explicit response or design analyses in accordance with Section IV.(2)(i)(A) of 10 CFR Part 50, Appendix S, and the requirement of taking into account SSI effects.

In addition, the acceptance criteria and regulatory guidance associated with the review of FSAR Section 3.7.2 include the following:

- SRP Section 3.7.2 guidance to review methods for site-specific seismic analysis and modeling of structures to ensure that they accurately and/or conservatively represent the behavior of SSCs during postulated seismic events.

- DC/COL-ISG-1, “Interim Staff Guidance on Seismic Issues of High Frequency Ground Motion,” and DC/COL-ISG-017 in reviewing the seismic input and the SSI dynamic model acceptability for the Fermi 3 site.

- RG 1.61 to determine the acceptability of the damping values used in the structural model.

3.7.2.4 *Technical Evaluation*

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.7.2 and Appendices 3A and 3C of the ESBWR DCD. The staff reviewed Section 3.7.2 and Appendices 3A and 3C of the Fermi 3 COL FSAR, Revision 7, and checked the referenced ESBWR DCD to ensure that the combination of the information in the COL FSAR and the information in the ESBWR DCD appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the required information relating to this section.

The staff reviewed the following information in the Fermi 3 COL FSAR:

Supplemental Information

- EF3 SUP 3.7-4 Soil-Structure Interaction
- EF3 SUP 3A.5-1 Soil-Structure Interaction Analysis Method
- EF3 SUP 3C-1 Site Specific Soil-Structure Interaction

Conceptual Design Information

- EF3 CDI ESBWR Standard Plant Site Plan

Soil-Structure Interaction

Site-Specific SSI Analysis

SRP Section 3.7.2 provides the guidance on the review of the seismic analysis of seismic Category I structures. Specifically, the NRC staff's review includes an assessment of the methods used in the seismic analysis to account for SSI effects, including the validation of the computer programs used in the analysis.

As indicated in FSAR Section 2.5.4 and Figures 2.5.4-201 through 2.5.4-204, the RB/FB and the CB structures at the Fermi 3 site are partially embedded in the Bass Islands Group rock. Therefore, the underlying soil media are in fact rock media. In the case of the FWSC, the structure is supported on a block of concrete fill that bears on the Bass Islands Group rock. A block of concrete fill is also located in the gap between the RB/FB and the CB.

Engineered granular backfill is used to fill the site excavation surrounding the power block structures. This backfill is placed above the top of the Bass Islands Group rock up to the plant grade level and is depicted in FSAR Figures 2.5.4-201, 2.5.4-202, and 2.5.4-203. FSAR

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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 COL application that references a design certification.

Subsection 2.5.4.5.4.2 describes the material properties and specifications of the engineered granular backfill.

Site-specific SSI analyses for the RB/FB and the CB were performed for the site conditions with and without the presence of the engineered granular backfill. These analyses are documented in FSAR Subsection 3.7.2.4 and in Sargent & Lundy Reports SL-011864 Revision 1, "Licensing Basis SSI Analyses of Reactor Building/Fuel Building and Control Building Summary Report," (ADAMS Accession No. ML13210A144); and SL-011956, Revision 1, "SSI Analyses of Reactor Building/Fuel Building and Control Building with Engineered Backfill Summary Report," (ADAMS Accession No. ML13360A176).

Site-specific SSI analyses were also performed to account for the SSSI effect of the RB/FB and FWSC on the CB, considering the presence of the engineered granular backfill. These analyses are documented in Sargent & Lundy Report SL-011960,Revision 0, "SSSI Sensitivity Studies of CB and FWSC with Engineered Backfill Summary Report," (ADAMS Accession No. ML13232A006).

The staff reviewed calculations pertinent to the site-specific SSI and SSSI analyses during the onsite audit on November 18 through 22, 2013 (ADAMS Accession No. ML14028A245). The staff also reviewed calculations pertaining to the validation and verification of the computer program used in the site-specific SSI and SSSI analyses during the onsite audit on March 19 through 21, 2013, (ADAMS Accession No. ML13149A515). This program is further discussed later in this section under "Computer Programs Verification and Validation Issues."

The site-specific SSI and SSSI analyses for the RB/FB and the CB structures were performed by the applicant to address the following site-specific issues:

- To confirm that the ESBWR DCD standard plant design is applicable to the Fermi 3 site-specific conditions where the RB/FB and the CB structures are partially embedded in the Bass Islands Group rock, with engineered granular backfill surrounding the structures from the top of the rock to the plant grade level. These site-specific conditions deviate from the soil cases considered in the SSI analyses described in ESBWR DCD, Tier 2, Appendix 3A.

- To demonstrate that the standard plant design is applicable to the Fermi 3 site-specific conditions, even though the ESBWR DCD requirements for the engineered granular backfill that surrounds the seismic Category I structures are not being met for the RB/FB and the CB structures. Specifically, ESBWR DCD, Tier 2, Table 2.0-1 states that the minimum shear wave velocity of the material surrounding the embedded walls of these structures should be greater than 300 m/s (1000 ft/s). In accordance with Footnote (16) to ESBWR DCD, Tier 2, Table 2.0-1; ESBWR DCD, Tier 1, Section 5.0, "Site Parameters"; and Footnote (6) to ESBWR DCD, Tier 1, Table 5.1-1; site-specific SSI analyses are required to demonstrate the adequacy of the standard plant design for sites not meeting the ESBWR DCD soil parameter requirements.

Site-specific SSI analyses for the FWSC structure were not performed by the applicant. The staff finds this acceptable because the two issues identified above are not applicable to the FWSC. First, because the FWSC at the Fermi site is supported on a block of concrete fill that bears on the Bass Islands Group rock, the FWSC is therefore not partially embedded in the Bass Islands Group rock. Second, as described in ESBWR DCD, Tier 2, Subsection 3.7.1.1, the FWSC is essentially a surface-founded structure (embedded 2.35 m [7.7 ft]) with no embedded walls. Therefore, the requirement in ESBWR DCD, Tier 2, Table 2.0-1 for material surrounding the embedded walls is not applicable to the FWSC. Because the site-specific FIRS for the FWSC is bounded by the ESBWR CSDRS, and all other requirements in ESBWR DCD, Tier 2, Table 2.0-1 are met, the staff concludes that the standard plant design for the FWSC is applicable to the Fermi 3 site without further site-specific SSI analyses.

The various SSI and SSSI case analyses performed by the applicant are summarized in Table 3.7.2-1 and Table 3.7.2-2 of this SER. In these tables, DM and MSM refer to the "Direct Method" and "Modified Subtraction Method" of the SASSI2010 program, respectively. (See the discussion below under "*SSI Analysis Method.*") BE, LB and UB refer to the "Best Estimate"; "Lower Bound" and "Upper Bound" subsurface material profiles, respectively. (See the discussion below under "*Strain Compatible Dynamic Subsurface Material Properties.*")

Strain Compatible Dynamic Subsurface Material Properties

The site-specific SSI analyses considered the three site-specific subsurface material profiles that are documented in FSAR Tables 3.7.1-206 through 3.7.1-211. The staff finds these profiles acceptable because they account for the effects of the potential variability in the properties of the soils and rocks at the site and are consistent with SRP Acceptance Criterion 3.7.2.II.4. The three profiles are designated as BE, LB, and UB. For the LB and UB profiles, the SSI analyses considered separate cases with and without the engineered granular backfill surrounding the structures. For the BE profile, the SSI analyses considered only the case without the backfill.

The staff's review of the above information is in Subsection 3.7.1.4 of this SER. The staff notes that the subsurface material profiles documented in FSAR Tables 3.7.1-206 through 3.7.1-211 were slightly adjusted in the SSI analyses to ensure that layer thicknesses and mesh dimensions would match the characteristics of the embedded portions of the structures, as well as to address finite element aspect ratios and model passing frequencies (see the discussion below under "*SSI Analyses of Structural Models*"). During the onsite audit on November 18 through 22, 2013, (ADAMS Accession No. ML14028A245) the staff confirms that the effect of these adjustments on the SSI analyses was negligible, and the SSI analyses are therefore acceptable.

The subsurface material profiles used in the SSI analyses—with the adjustments described above—are documented in Sargent & Lundy Reports SL-011864, Revision 1 (ADAMS Accession No. ML13210A144) and SL-011956, Revision 1 (ADAMS Accession No. ML13360A176).

FIRS Compatible Ground Motion Time History

The site-specific SSI analyses considered three orthogonal components (two horizontal and one vertical) of ground motion time histories described in FSAR Subsection 3.7.1.1.5. These time histories were developed to be in-column motions at the bottom of the RB/FB and the CB basemat elevations and are compatible with the site-specific FIRS of the RB/FB and the CB (designated as "enhanced SCOR FIRS") described in FSAR Section 3.7.1. The staff finds that these ground motion time histories are acceptable control motions for the site-specific SSI analyses performed by the applicant.

The staff's review of the above information is in Subsection 3.7.1.4 of this SER.

SSI Analysis Method

The applicant performed site-specific SSI analyses following the methodology in ESBWR DCD, Tier 2, Appendices 3A.5 and 3A.5.2, which is based on the frequency domain complex response approach using the SASSI 2000 program. Structural responses were computed in terms of maximum absolute accelerations, maximum forces and moments, and floor response spectra (FRS) at the key locations in the structures identified in ESBWR DCD, Tier 2, Appendix 3A, as well as seismic lateral soil pressures acting on below-grade exterior walls (seismic soil pressures are reviewed in Subsection 3.8.4.4 of this SER). The above methodology is acceptable to the staff because it is the same methodology applied in the ESBWR DCD and is consistent with SRP Acceptance Criterion 3.7.2.II.4.

However, the applicant used the SASSI2010 program instead of the SASSI2000 program in the site-specific SSI analyses. To ensure the acceptability of the SASSI2010 program for use in the site-specific SSI analyses at Fermi 3, the applicant performed validation and verification analyses. The staff's review of this validation and verification effort is described below under "Computer Programs Verification and Validation Issues," where the staff concludes that the SASSI2010 program is acceptable for the site-specific SSI analyses at the Fermi 3 site.

To perform the SSI analysis of embedded structures such as the RB/FB and the CB, the SASSI2010 program may use the DM (also known as the "Flexible Volume Method"), the MSM, or the SM ("Subtraction Method"). The DM is the most accurate but also the most computationally intensive method. If not implemented properly, the SM could potentially result in erroneous and non-conservative SSI responses when compared to the DM.

FSAR Subsection 3.7.2.4.1.3 indicates that the site-specific SSI analyses were performed using either the DM or the MSM, but not the SM. Current staff guidance regarding the use of the DM versus the MSM is in SRP Section 3.7.2, Revision 4, SRP Acceptance Criterion 3.7.2.II.4. Although the guidance states that the DM should be used to the extent practical, the MSM is also identified as an alternative for very large computer models where it is not feasible to use the DM. The guidance recommends the use of reduced-size computer models (e.g., quarter models) to perform direct comparisons between the MSM and the DM solutions and to draw conclusions that can be extrapolated to the full-size models.

In accordance with the above guidance, the applicant performed additional benchmark studies for those SSI case analyses that required the use of the MSM in SASSI2010 because of the computational limitations with the size of the computer models (SSI analyses of cases RBFB2UB-MSM and RBFB2LB-MSM for the RB/FB and CB4-FWSC1UB-MSM and CB4-FWSC1LB-MSM for the CB).

The benchmark studies discussed below used reduced-size models and the same site-specific subsurface material profiles (UB with backfill considered) and input motions as the full-size models. The benchmark studies performed were as follows:

- Direct DM versus the MSM comparison of a quarter-size model of the RB/FB determined that two layers of interaction nodes were necessary in the implementation of the MSM to obtain essentially identical results as the DM for the frequency range of interest. The two layers of interaction nodes were located at the plant grade elevation of +4.65 m (15.26 ft) and at the elevation of -2.025 m (-6.644 ft), in the portion of the SSI model known as the "excavated volume."

- Direct DM versus the MSM comparison of a full-size model of the CB determined that two layers of interaction nodes were necessary in the implementation of the MSM to obtain essentially identical results as the DM for the frequency range of interest. The two layers of interaction nodes were located at the plant grade elevation of +4.50 m (14.76 ft) and at the elevation of -2.00 m (6.56 ft).

- Direct DM versus the MSM comparison of a half-size model of the FWSC determined that a single layer of interaction nodes was required in the implementation of the MSM to obtain essentially identical results as the DM for the frequency range of interest. The layer of interaction nodes was located at the plant grade elevation of +4.50 m (14.76 ft).

The results of these benchmark studies are documented in Sargent & Lundy Reports SL-011814, Revision 0, "Modified Subtraction Method (MSM) Reactor Building/Fuel Building Benchmark Summary Report," (ADAMS Accession No. ML13127A034); SL-011874 Revision 0, "Modified Subtraction Method (MSM) Control Building Benchmark Summary Report," (ADAMS Accession No. ML13175A263); and SL-011863 Revision 0, "Modified Subtraction Method (MSM) Firewater Service Complex Benchmark Summary Report," (ADAMS Accession No. ML13175A264). The benchmark studies were reviewed by the staff during the onsite audit on November 18 through 22, 2013, (ADAMS Accession No. ML14028A245). The staff notes that the benchmark studies of the CB and the FWSC were necessary for the SSSI analyses discussed below under "*SSSI Analysis*."

The staff reviewed the reduced-size models used in the benchmark studies to ensure that they were representative of the full-size models in terms of dynamic characteristics, foundation width-to-depth ratio, embedment depth, subsurface material profiles, and input motions. The staff also reviewed the DM versus the MSM comparisons of structural responses in terms of transfer functions, maximum absolute accelerations, maximum forces and moments, FRS at the key locations in the structures identified in ESBWR DCD, Tier 2, Appendix 3A, and the seismic lateral soil pressures acting on below-grade exterior walls. The staff confirmed that the results are essentially identical for the frequency range of interest to the Fermi 3 site conditions.

On the basis of the benchmark studies performed using reduced-size computer models and the staff guidance discussed above, the staff concludes that the applicant's implementation of the MSM in SASSI2010 is acceptable because the full-size models used the same number of layers of interaction nodes identified in the benchmark studies. The staff's review of the SSI and SSSI analyses is documented in Sargent & Lundy Reports SL-011956, Revision 1 (SSI analyses with engineered granular backfill) and SL-011960 Revision 0 (SSSI analyses with engineered granular backfill), respectively. The review confirms the acceptability of the applicant's implementation of the MSM and thus resolved the issue.

SSI Analyses of Structural Models

The site-specific SSI models of the RB/FB and the CB consist of (a) lumped-mass stick models that consider shear, bending, torsion, and axial deformations of the buildings; (b) single-degree-of-freedom (SDOF) oscillators connected to the stick models and used to represent the out-of-plane seismic response of flexible slabs in the buildings; (c) plate finite elements arranged in a uniform mesh that was used to represent the exterior walls below grade and the basemats; (d) brick finite elements arranged in a uniform mesh that was used to model the portion of the subsurface backfill/rock medium where the structures are embedded (known as the "excavated volume"); and (e) horizontal layers of infinite extension used to represent the subsurface profile of the backfill/rock medium. It should be noted that the exterior walls below grade and the basemats match the lateral perimeter and bottom boundary of the excavated volume.

FSAR Subsection 3.7.2.4.1.4 indicates that the site-specific SSI model configurations are the same as those in ESBWR DCD, Tier 2, Figures 3A.7-8 through 3A.7-10 for the RB/FB and DCD Figures 3A.7-11 through 3A.7-13 for the CB, except that the vertical and horizontal spacing of the excavated soil volume nodes and boundary—items (c) and (d) above—are adjusted to closely match the site-specific subsurface profile layers and to address model passing frequencies. The staff finds this model configuration acceptable, as discussed below.

The site-specific SSI model configurations are depicted in FSAR Figures 3.7.2-201 through 3.7.2-203 (the RB/FB model without backfill and designated as model RBFB1 in SER Table 3.7.2-1 below); FSAR Figures 3.7.2-203a through 3.7.2-203c (the RB/FB model with backfill and designated as model RBFB2 in SER Table 3.7.2-1 below); FSAR Figures 3.7.2-204 through 3.7.2-206 (the CB model without backfill and designated as model CB1 in SER Table 3.7.2-2 below); and FSAR Figures 3.7.2-206a through 3.7.2-206c (the CB model with backfill and designated as model CB2 in SER Table 3.7.2-2 below).

FSAR Subsection 3.7.2.4.1.4 indicates that the stick models and the SDOF oscillators for the RB/FB and the CB—items (a) and (b) above—are the same as those described in ESBWR DCD, Tier 2, Section 3A.7, “Analysis Models,” and depicted in DCD Figure 3A.7-4 (RB/FB) and Figure 3A.7-6 (CB). The stick models and the SDOF oscillators used in the site-specific SSI models are therefore acceptable because they are the same as those used in the ESBWR DCD for the same purpose, and they are consistent with SRP Acceptance Criterion 3.7.2.II.3.C.

To ensure that the dynamic response of the site-specific SSI models is adequate for the frequency range of interest, the uniform finite element meshes used to represent the excavated soil volumes and their boundaries—items (c) and (d) above—should be sufficiently refined to address criteria (1) the horizontal dimensions (both East-West and North-South directions) should not exceed 20 percent of the shear wavelength of the corresponding layer at the passing frequency of the model; (2) the vertical dimension should not exceed 20 percent of the shear wavelength of the corresponding layer at the passing frequency of the model; and (3) the aspect ratio of the plate and brick finite elements used in the mesh should not exceed 1:3, as identified by the applicant in the validation and verification study for the SASSI2010 program, which is discussed later in this section under “Computer Programs Verification and Validation Issues.” Per the Interim Staff Guidance DC/COL-ISG-1, the passing frequency of the SSI models should be at least 50 Hz.

The staff reviewed the finite element meshes of the corresponding excavated volumes depicted in FSAR Figures 3.7.2-201 through 3.7.2-203, FSAR Figures 3.7.2-203a through 3.7.2-203c, FSAR Figures 3.7.2-204 through 3.7.2-206, and FSAR Figures 3.7.2-206a through 3.7.2-206c. The staff concluded that the mesh sizes meet the criteria identified above except for the SSI analyses of cases RBFB2LB-MSM and CB2LB-DM (the LB subsurface profile with backfill considered). For these cases, the staff concluded that the passing frequency of the SSI models is approximately 19 Hz and thus deviates from the guidance in DC/COL-ISG-1.

The staff reviewed the horizontal layers of the infinite extension used to represent the subsurface profiles of the backfill/rock medium—item (e) above—as documented in Sargent & Lundy Reports SL-011956, Revision 1 (SSI analyses with engineered granular backfill) and SL-011960, Revision 0 (SSSI analyses with engineered granular backfill). The staff concluded that the thickness of the rock layers in the models satisfies the limiting criterion of 20 percent of the shear wavelength at the passing frequency of the model. However, the SSI analyses of cases RBFB2LB-MSM and CB2LB-DM (the LB subsurface profile with backfill considered), the thickness of the backfill layers did not satisfy the criterion and resulted in a passing frequency of approximately 19 Hz, which is consistent with the staff's finding for the finite element meshes of the excavated volumes.

The staff's assessment concluded that the deviation from the guidance identified above is not a technical concern for the following reasons. First, the site-specific seismic responses computed for the UB subsurface profile with and without considering the backfill are more sensitive to the frequency content of input motions above 19 Hz. These are accurately captured in the analyses because they are based on SSI models that have the required 50 Hz passing frequency. Second, the reduced passing frequency for the SSI analyses of cases RBFB2LB-MSM and CB2LB-DM reflects an insufficient mesh/layer refinement in the backfill portions of the models only—the mesh/layer dimensions in the rock portions are adequate. Third, a review of site-specific seismic responses in the structures computed for SSI analyses of cases RBFB2LB-MSM and CB2LB-DM indicates that these cases are generally almost always bounded by the other case analyses that have the required 50 Hz passing frequency. This is because SSI effects at the Fermi 3 site are dominated by the interaction between the structures and the rock in which they are embedded. Fourth, the reduced passing frequency for the SSI analyses of cases RBFB2LB-MSM and CB2LB-DM does not affect the seismic lateral soil pressures computed for these cases because these are mainly due to low frequency responses (i.e., below 19 Hz).

On the basis of these considerations for items (a) through (e) identified above, the staff finds that the site-specific SSI models documented in FSAR Subsection 3.7.2.4.1.4 meet SRP Acceptance Criteria 3.7.2.II.3 and 3.7.2.II.4 and are therefore acceptable. ESBWR DCD, Tier 2, Table 3A.6-1 identifies several modifications to the basic stick models of the RB/FB and the CB for purposes of evaluating the effects of parameter variations on the seismic responses. FSAR Subsection 3.7.2.4.1 indicates that in the site-specific SSI analyses, the basic stick models designated as "base" were used. These base models considered the concrete to be "uncracked," which is represented by assuming the full value of the concrete modulus of elasticity.

In the supplemental response to RAI 03.07.02-9 Item 4 (Attachment 15 to DTE Letter NRC3-13-0036, ADAMS Accession No. ML13354B536), the applicant further clarified that OBE damping ratios were used for the structural elements in all SSI and SSSI analyses. In the RB/FB models, OBE damping values of 4 percent and 3 percent were used for reinforced concrete elements and welded steel elements, respectively. In the CB models, OBE damping values of 4 percent were used for the reinforced concrete elements.

The staff finds the above modeling assumptions acceptable given the overall moderate magnitude of the site-specific stress levels induced throughout the RB/FB and the CB structures. As discussed below under "*SSI Analysis Results—Enveloping Maximum Structural Loads*," and "*SSI Analysis Results—Enveloping Single-Degree-of-Freedom Oscillator Response,*" the site-specific seismic loads are bounded by the seismic loads considered in the standard design—in some cases by a significant margin. Therefore, per SRP Acceptance Criterion 3.7.1.II.2 and RG 1.61 guidance, the use of uncracked section properties and OBE damping is conservative and are thus acceptable.

SSI Case Analyses

The various SSI case analyses performed by the applicant are summarized in SER Tables 3.7.2-1 and 3.7.2-2. Site-specific SSSI analyses of cases are also included in these tables for completeness. SSSI analyses are discussed below under "*SSSI Analysis*."

The three site-specific subsurface material profiles BE, LB, and UB account for the variability in the subsurface material properties at the Fermi 3 site, as discussed earlier in Subsection 3.7.1.4 of this SER. For the LB and UB profiles, the SSI analyses considered separate cases with and without the backfill surrounding the structures. For the BE profile, the SSI analyses considered only the case without the backfill. The staff finds this acceptable because the dynamic properties of the LB and UB profiles with backfill effectively bound the corresponding properties of the BE profile with the backfill. The staff concludes that the SSI and SSSI cases summarized in SER Tables 3.7.2-1 and 3.7.2-2 provide sufficient information for the staff to determine the acceptability of the ESBWR standard plant design at the Fermi 3 site.

SSI Analysis Results—Transfer Functions

Sargent & Lundy Reports SL-011864, Revision 1 (SSI analyses without engineered granular backfill) and SL-011956, Revision 1 (SSI analyses with engineered granular backfill) document the transfer functions computed for the site-specific SSI case analyses. These reports present results for the following key locations identified in DCD Appendix 3A:

- RB/FB: top of basemat, refueling floor, reinforced concrete containment vessel (RCCV) top slab, top of vent wall, top of reactor shield wall (RSW), top of RPV.

- CB: top of basemat and top of roof slab.

The staff reviewed the transfer function plots and found them to be generally smooth, with a sufficient density of calculated frequency points in the frequency range of interest. Although some isolated sharp spikes were noted in a few of the plots because of the interpolation scheme used by the SASSI2010 program, these spikes had no observable impact on the seismic response or the FRS.

Therefore, the staff concludes that the site-specific SSI analyses performed by the applicant with the SASSI2010 program were implemented in a manner consistent with the frequency domain complex response method described in ESBWR DCD, Tier 2, Appendix 3A.

SSI Analysis Results—Enveloping Maximum Structural Loads

FSAR Tables 3.7.2-203a through 3.7.2-203e document the envelope of the maximum seismic forces and moments in the different stick models of the RB/FB complex obtained from the site-specific SSI case analyses and compare these to the corresponding values in ESBWR DCD, Tier 2, Tables 3A.9-1a through 3.A.9-1e. The comparisons are as follows:

- RB/FB stick (FSAR Table 3.7.2-203a and DCD Table 3A.9-1a): maximum ratio of site-specific seismic loads to corresponding DCD values is approximately 67 percent.

- RCCV stick (FSAR Table 3.7.2-203b and DCD Table 3A.9-1b): maximum ratio of site-specific seismic loads to corresponding DCD values is approximately 68 percent.

- Vent Wall/Pedestal stick (FSAR Table 3.7.2-203c and DCD Table 3A.9-1c): maximum ratio of site-specific seismic loads to corresponding DCD values is approximately 51percent.

- RSW stick (FSAR Table 3.7.2-203d and DCD Table 3A.9-1d): maximum ratio of site-specific seismic loads to corresponding DCD values is approximately 60 percent.

- RPV stick (FSAR Table 3.7.2-203e and DCD Table 3A.9-1e): maximum ratio of site-specific seismic loads to corresponding DCD values is approximately 86 percent.

FSAR Table 3.7.2-204 documents the envelope of the maximum seismic forces and moments in the CB obtained from the site-specific SSI case analyses and compares these to the corresponding values in ESBWR DCD, Tier 2, Table 3A.9-1f. The comparison is as follows:

- CB stick (FSAR Table 3.7.2-204 and DCD Table 3A.9-1f): maximum ratio of site-specific seismic loads to corresponding DCD values is approximately 72 percent.

FSAR Tables 3.7.2-205a through 3.7.2-205d document the envelope of the maximum absolute vertical accelerations in the different stick models of the RB/FB complex obtained from the site-specific SSI case analyses and compare these to the corresponding values in ESBWR DCD, Tier 2, Tables 3A.9-3a through 3.A.9-3d. The comparisons are as follows:

- RB/FB stick (FSAR Table 3.7.2-205a and DCD Table 3A.9-3a): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 46 percent.

- RCCV stick (FSAR Table 3.7.2-205b and DCD Table 3A.9-3b): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 41 percent.

- Vent Wall/Pedestal stick (FSAR Table 3.7.2-205c and DCD Table 3A.9-3c): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 44 percent.

- RSW stick (FSAR Table 3.7.2-205d and DCD Table 3A.9-3d): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 45 percent.

FSAR Table 3.7.2-206 documents the envelope of the maximum absolute vertical accelerations in the CB obtained from the site-specific SSI case analyses and compares these to the corresponding values in ESBWR DCD, Tier 2, Table 3A.9-3g. The comparison is as follows:

- CB stick (FSAR Table 3.7.2-206 and DCD Table 3A.9-3g): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 41 percent.

Based on the above comparisons, the staff concludes that the site-specific envelope of maximum seismic forces and moments and maximum absolute vertical accelerations in the different stick models of the RB/FB and the CB are bounded by the corresponding values in ESBWR DCD, Tier 2, Section 3A.9.1. This finding is acceptable and indicates that the standard plant design is applicable to the RB/FB and the CB at the Fermi 3 site.

SSI Analysis Results—Enveloping Single-Degree-of-Freedom Oscillator Response

FSAR Table 3.7.2-205e documents the envelope of the maximum absolute vertical accelerations for the SDOF flexible slab oscillators in the RB/FB obtained from the site-specific SSI case analyses and compares these to the corresponding values in ESBWR DCD, Tier 2, Table 3.A.9-3e. The comparison is as follows:

- RB/FB (FSAR Table 3.7.2-205e and DCD Table 3A.9-3e): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 75 percent.

FSAR Table 3.7.2-206 documents the envelope of the maximum absolute vertical accelerations for the SDOF flexible slab oscillators in the CB obtained from the site-specific SSI case analyses and compares these to the corresponding values in ESBWR DCD Table 3A.9-3g. The comparisons are as follows:

- CB (FSAR Table 3.7.2-206 and DCD Table 3A.9-3g): maximum ratio of site-specific vertical accelerations to corresponding DCD values is approximately 75 percent.

Based on the above comparisons, the staff concludes that the site-specific envelope of maximum absolute vertical accelerations for the SDOF flexible slab oscillators in the RB/FB and the CB are bounded by the corresponding values in ESBWR DCD, Tier 2, Section 3A.9.1. This is acceptable and indicates that the standard plant design is applicable to the RB/FB and the CB at the Fermi 3 site.

SSI Analysis Results—Enveloping Floor Response Spectra

FSAR Figures 3.7.2-207a through 3.7.2-209f present the envelopes of the 5-percent damped FRS at the key locations in the RB/FB (top of basemat, refueling floor, RCCV top slab, top of vent wall, top of RSW, top of RPV) obtained from the site-specific SSI case analyses and compare these to the corresponding enveloping FRS in ESBWR DCD, Tier 2, Section 3A.9.2.

FSAR Figures 3.7.2-210a through 3.7.2-212b present the envelopes of the 5-percent damped FRS at the key locations in the CB (top of basemat and top of roof slab) obtained from the site-specific SSI case analyses and compare these to the corresponding enveloping FRS in ESBWR DCD, Tier 2, Section, 3A.9.2.

Based on the above comparisons, the staff concludes that the site-specific FRS at the key locations in the RB/FB and the CB are bounded by the corresponding enveloping FRS in ESBWR DCD, Tier 2, Section 3A.9.2, by a substantial margin. This finding is acceptable and indicates that the standard plant design is applicable to the RB/FB and the CB at the Fermi 3 site.

SSSI Analysis

To evaluate the SSSI effect of the RB/FB and the FWSC on the CB, the applicant performed site-specific SSSI analyses that adhered to the same methodologies described in ESBWR DCD, Tier 2, Section 3A.8.11. These analyses are documented in the Sargent & Lundy Report SL-011960, Revision 0 (SSSI analyses with engineered granular backfill).

The staff notes that the RB/FB is considerably more massive than the CB is, so the SSSI effect of the RB/FB on the CB is thus more significant than the effect of the CB on the RB/FB. On this basis, the applicant did not evaluate the SSSI effect of the CB on the RB/FB. The staff reviewed the ESBWR DCD and determined that the basis provided by the applicant for neglecting the SSSI effect of the CB on the RB/FB is consistent with the seismic analysis methodology described in ESBWR DCD, Tier 2, Section 3A.8.11 and is therefore acceptable.

To evaluate the SSSI effect of the RB/FB on the CB, the applicant performed the SSSI analyses denoted as CB3UB-DM and CB3LB-DM in SER Table 3.7.2-2 below. These analyses considered the presence of the backfill above the rock and were performed in two steps. In the first step, the ground motion responses at the center of the CB basemat location in the free-field were obtained from the SSI analyses of the RB/FB with backfill considered (SSI analyses of cases RBFB2UB-MSM and RBFB2LB-MSM). In the second step, the ground motion responses computed in the first step were used as input motions to SSI analyses of the CB, thus capturing the SSSI effect of the RB/FB on the CB. This method is the same as the one described in ESBWR DCD, Tier 2, Section 3A.8.11.

To evaluate the SSSI effect of the FWSC on the CB, the applicant performed the SSSI analyses denoted as CB4-FWSC1UB-MSM and CB4-FWSC1LB-MSM in SER Table 3.7.2-2, below. These analyses considered the presence of the backfill above the rock and used fully coupled models in which both the CB and the FWSC were represented together with the subsurface material. The input motions applied to the coupled CB4-FWSC1 models were the in-column motions corresponding to the SSI FIRS for the CB applied at the bottom of the CB basemat. This method is the same as the one described in ESBWR DCD, Tier 2, Section 3A.8.11.

The site-specific SSSI analyses described above used the same model representation of the RB/FB and the CB structures and the UB and LB subsurface profiles used in the other SSI case analyses, which the staff reviewed and accepted as discussed above under *"SSI Analyses of Structural Models."* The passing frequency of the models used for SSSI analyses of cases CB3LB-DM and CB4-FWSC1LB-MSM is approximately 19 Hz, which deviates from the guidance in DCD/COL-ISG-1. The staff concluded that this deviation is not a safety concern for several reasons discussed above under *"SSI Analyses of Structural Models*," which are also applicable to the SSSI analyses of the models.

For the site-specific SSSI analyses, the model representation of the FWSC structure consisted of a lumped-mass stick model, with plate finite elements used to represent the basemat described in ESBWR DCD, Tier 2, Section 3A.7. The excavated volume for the FWSC extended from the bottom of the concrete fill under the basemat up to plant grade elevation. The concrete fill under the basemat was modeled with brick finite elements and was considered part of the structure. The staff finds the model representation of the FWSC acceptable because it uses the same stick model as the one used in the EBSWR DCD for the same purpose; and the finite element mesh used to represent the concrete fill satisfies the acceptance criteria for the aspect ratio and the passing frequency discussed above under *"SSI Analyses of Structural Models,"* which are consistent with SRP Acceptance Criterion 3.7.2.II.3.C.

The staff reviewed the structural responses computed from the site-specific SSSI analyses in terms of transfer functions, maximum absolute accelerations, maximum forces and moments, and the 5-percent damped FRS at the key locations in the CB identified in ESBWR DCD, Tier 2, Appendix 3A. These results are documented in the Sargent & Lundy Report SL-011960, Revision 0 (ADAMS Accession No. ML13232A006). In reviewing the results, the staff observed the following:

The maximum ratio of site-specific seismic loads to corresponding ESBWR DCD values in the CB stick is approximately 65 percent (envelope of SSSI analyses of cases CB3UB-DM and CB3LB-DM) and 60 percent (envelope of SSSI analyses of cases CB4-FWSC1UB-MSM and CB4-FWSC1LB-MSM) compared to 72 percent obtained for the other SSI case analyses.

The maximum ratio of site-specific vertical accelerations to corresponding ESBWR DCD values in the CB stick is approximately 40 percent (envelope of SSSI analyses of cases CB3UB-DM and CB3LB-DM) and 39 percent (envelope of SSSI analyses of cases CB4-FWSC1UB-MSM and CB4-FWSC1LB-MSM) compared to 41 percent obtained for the other SSI case analyses.

The maximum ratio of site-specific vertical accelerations to corresponding ESBWR DCD values for the SDOF flexible slab oscillators in the CB is approximately 62 percent (envelope of SSSI analyses of cases CB3UB-DM and CB3LB-DM) and 61 percent (envelope of SSSI analyses of cases CB4-FWSC1UB-MSM and CB4-FWSC1LB-MSM), compared to 75 percent obtained for the other SSI case analyses.

A comparison of 5-percent damped FRS at the key locations in the CB (top of basemat and top of roof slab) obtained from the various site-specific SSSI case analyses to the corresponding enveloping FRS in ESBWR DCD, Tier 2, Section 3A.9.2 indicates that the latter bound the former by a significant margin.

Based on the above observation, the staff concludes that (a) at the Fermi 3 site, the SSSI effects on the CB are relatively minor; and (b) the structural responses computed from the site-specific SSSI analyses in terms of maximum absolute accelerations, maximum forces and moments, and the 5-percent damped FRS at the key locations in the CB identified in ESBWR DCD, Tier 2, Appendix 3A are bounded by the corresponding values considered in the EBSWR DCD. Therefore, the standard plant design for the Fermi 3 site is acceptable.

The seismic lateral soil pressures acting on below-grade exterior walls of the CB and computed from the site-specific SSSI analyses discussed above were incorporated into the applicant's evaluations of the design of below-grade exterior walls of the CB. This issue was reviewed by the staff under Subsection 3.8.4.4 of this SER.

Supplemental Information

- EF3 SUP 3.7-5 Interaction of Non-Category I Structures with Seismic Category I Structures

Interaction of Non-Category I Structures with Seismic Category I Structures

FSAR Subsection 3.7.2.8 indicates that site-specific Non-Category I structures (outside the scope of the ESBWR DCD) are separated from seismic Category I structures by at least a distance equal to their height above grade. Therefore, the collapse of any site-specific Non-Category I structure will not cause the Non-Category I structure to strike a seismic Category I structure. The locations of structures are depicted in FSAR Figure 2.1-204. The staff concludes that this is consistent with SRP Acceptance Criterion 3.7.2.II.8.A and is therefore acceptable.

FSAR Subsection 3.7.2.8 indicates that the design and analysis of the seismic Category II structures (TB; SB; and ADB) and the seismic Category NS RWB identified in ESBWR DCD, Tier 2, Subsection 3.7.2.8 will be completed as part of the detailed design phase for the ESBWR standard plant design, per DCD Tier 2, Subsection 3.7.2.8.1 for the TB, Subsection 3.7.2.8.2 for the RWB, Subsection 3.7.2.8.3 for the SB, and Subsection 3.7.2.8.4 for the ADB; and DCD Tier 1, ITAAC Tables 2.16.8-1 for the TB, 2.16.9-1 for the RWB, 2.16.10-1 for the SB, and 2.16.11-1 for the ADB.

In addition, for the TB, RWB, SB, and ADB structures, FSAR Subsection 3.7.2.8 and Fermi 3 COL application Part 10 identify site-specific ITAAC and corresponding acceptance criteria that indicate the following:

- If the Fermi 3 soil properties do not meet the site parameters specified in the ESBWR DCD, Tier 1, Table 5.1-1 and ESBWR DCD, Tier 2, Table 2.0-1 (e.g., for the engineered granular backfill surrounding the embedded walls of these structures), then Fermi 3 site-specific SSI and SSSI analyses using the Fermi 3 site properties will be performed for the TB, RWB, SB, and ADB structures adhering to the same methodology specified in ESBWR DCD, Tier 2, Appendix 3A; ESBWR DCD, Tier 2, Subsections 3.7.2.8.1 for the TB, 3.7.2.8.2 for the RWB, 3.7.2.8.3 for the SB, and 3.7.2.8.4 for the ADB; and ESBWR DCD, Tier 1 ITAAC Tables 2.16.8-1 for the TB, 2.16.9-1 for the RWB, 2.16.10-1 for the SB, and 2.16.11-1 for the ADB.

- The acceptance criteria consist of comparing the results of the site-specific SSI and SSSI analyses for the TB, RWB, SB, and ADB structures to the corresponding SSI and SSSI analyses performed for the standard plant design under the DCD and confirming that the standard plant design is adequate for the site-specific conditions at Fermi 3.

The site-specific ITAAC are in Fermi 3 COL application Part 10 Tables 2.4.15-1 (TB), 2.4.16-1 (RWB), 2.4.17-1 (SB), and 2.4.18-1 (ADB).

The staff believes that the applicant’s intent was to provide a site-specific ITAAC that will ensure that site-specific SSI and SSSI analyses are performed if necessary to demonstrate that the standard plant design for the TB, SB, ADB, and RWB is adequate for the site-specific conditions at the Fermi 3 site. However, the language in FSAR Subsection 3.7.2.8 and in Part 10 of the COL application was not clear. Therefore, the staff proposed modifications to the ITAAC for better clarity with respect to the expectations of these analyses. The proposed modifications were discussed with the applicant during an open items call held on May 8, 2014 (ADAMS Accession No. ML14140A531). On the same day the applicant submitted a revised FSAR markup (ADAMS Accession No. ML14129A360) that documented the revisions to the ITAAC. The staff is tracking these revisions to FSAR Subsection 3.7.2.8 and Fermi 3 COL application Part 10, Tables 2.4.15-1 (TB), 2.4.16-1 (RWB), 2.4.17-1 (SB), and 2.4.18-1 (ADB) as Confirmatory Item 3.7.2-1. The staff tracked the verification that the next FSAR revision included this change. Therefore, Confirmatory Item 3.7.2-1 is resolved.

Determination of Seismic Overturning Moments and Sliding Forces for Seismic Category I Structures

In FSAR Subsection 3.7.2.14, the applicant indicates that the site-specific stability evaluation against overturning is in FSAR Section 3.8.5. The staff’s evaluation of FSAR Section 3.8.5 is in Subsection 3.8.5.4 of this SER.

Computer Programs Verification and Validation Issues

The applicant performed a verification and validation study of the SASSI2010 program to ensure the numerical accuracy, stability, and consistency of the results obtained using SASSI2010. In this study, the applicant implemented a set of 47 SSI test problems for which the solutions obtained using SASSI2010 were verified and validated against (a) analytical or numerical solutions available in the technical literature; (b) solutions obtained using SASSI2000 and accepted by the staff for the SSI analyses documented in the ESBWR DCD; and (c) solutions obtained using other computer codes. Although most of the test problems were generic, the applicant did consider several test problems that incorporated subsurface profiles and input motions that were representative of the Fermi 3 site; as well as the frequency range of interest to the Fermi 3 site-specific SSI and SSSI analyses.

The staff reviewed selected portions of the applicant's validation and verification calculations during the onsite audits on March 19 through 21, 2013 (ADAMS Accession No. ML13149A515) and November 18 through 22, 2013 (ADAMS Accession No. ML14028A245). Two test problems that incorporated subsurface profiles representative of the Fermi 3 site conditions and frequency range of interest are documented in the supplemental response to RAI 03.07.02-11, (Attachment 1 to DTE Letter NRC3-13-0023, ADAMS Accession No. ML13192A302).

The staff reviewed test problems performed using the DM of analysis in SASSI2010, which were considered relevant to the Fermi 3 site conditions. Additional benchmarking study of the MSM relative to the DM of analysis in SASSI2010 is separately discussed in this report under "*SSI Analysis Method*."

The staff's review yielded the following conclusions:

- For test problems with subsurface profiles representative of the Fermi 3 site conditions and passing frequencies up to 50 Hz, comparisons of impedance functions computed with SASSI2010 and those computed using an alternative program or published solutions were found to be acceptable for approximately 50 Hz for the LB rock profile.

- Test problems with subsurface profiles representative of the Fermi 3 site conditions and passing frequencies up to 50 Hz confirmed the numerical stability of the SASSI2010 solutions to the upper limit of Poisson's ratio of 0.48, which is of interest at the Fermi 3 site.

- Several test problems indicated that the aspect ratio of both plate and brick finite elements used to model the excavated volume of partially embedded structures needs to be limited to 1:3 in the horizontal and vertical directions.

Based on the above discussion and staff's on-site audits mentioned above, the staff concludes that the SASSI2010 program is acceptable for the specific conditions at the Fermi 3 site because the applicant has demonstrated the applicability of SASSI2010 at the Fermi 3 site up to a frequency of 50 Hz. The staff also confirms that the aspect ratio limitation for plate and brick finite elements was implemented in the SSI and SSI analyses as discussed earlier in this SER.

Table 3.7.2-1 Summary of the Applicant's SSI Analyses for the RB/FB

Building	Case ID	DCD Model	Analysis Case	SASSI2010 Method of Analysis	Control Motion	Soil/Rock Profile		
						LB	BE	UB
RB/FB	RBFB1UB-DM	"Base" (*)	SSI without engineered backfill	DM	FIRS			X
	RBFB1BE-DM		SSI without engineered backfill	DM			X	
	RBFB1LB-DM		SSI without engineered backfill	DM		X		
	RBFB2UB-MSM		SSI with engineered backfill	MSM				X
	RBFB2LB-MSM		SSI with engineered backfill	MSM		X		

SSI = soil-structure interaction; RB/FB = reactor building/fuel building; LB = lower bound; BE= best estimate; UB = upper bound; DM = direct method; FIRS = foundation input response spectra; MSM = modified subtraction method.

Note: (*) DCD "Base" model refers to the structural model described in DCD Table 3A.6-1.

Table 3.7.2-2 Summary of the Applicant's SSI Analyses for the CB

Building	Case ID	DCD Model	Analysis Case	SASSI2010 Method of Analysis	Control Motion	Subsurface Profile		
						LB	BE	UB
CB	CB1UB-DM	"Base" (*)	SSI without engineered backfill	DM	FIRS			X
	CB1BE-DM		SSI without engineered backfill	DM			X	
	CB1LB-DM		SSI without engineered backfill	DM		X		
	CB2UB-DM		SSI with engineered backfill	DM				X
	CB2LB-DM		SSI with engineered backfill	DM		X		
	CB3UB-DM		SSSI with engineered backfill	DM	Modified FIRS (**)			X
	CB3LB-DM		SSSI with engineered backfill	DM		X		
	CB4-FWSC1UB-MSM		SSSI with engineered backfill	MSM	FIRS			X
	CB4-FWSC1LB-MSM		SSSI with engineered backfill	MSM		X		

SSI = soil-structure interaction; CB = control building; LB = lower bound; BE= best estimate; UB = upper bound; DM = direct method; FIRS = foundation input response spectra; SSSI = structure-soil-structure interaction; MSM = modified subtraction method.

Notes:

(*) DCD "Base" model refers to the structural model described in DCD Table 3A.6-1.

(**) Modified FIRS refers to control motion based on FIRS, but modified to account for SSSI between the RB/FB and the CB.

3.7.2.5 *Post Combined License Activities*

Site-specific ITAAC and corresponding acceptance criteria for Non-Category I structures within the scope of the DCD are described in Fermi 3 COL application Part 10 ,Tables 2.4.15-1, 2.4.16-1, 2.4.17-1, and 2.4.18-1. The review of these site-specific ITAAC is in Subsection 3.7.2.4 of this SER under "Interaction of Non-Category I Structures with seismic Category I Structures."

3.7.2.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the Fermi 3 FSAR related to this section. All nuclear safety issues relating to the seismic system analysis that were incorporated by reference have been resolved.

The staff compared the supplemental information in the COL application to the relevant NRC regulations, the guidance in Section 3.7.2 of NUREG–0800, other NRC RGs, and the Interim Staff Guidance. The staff finds that the applicant has adequately addressed the seismic system analysis, in accordance with the acceptance criteria delineated in these guidance documents. On this basis, the staff concludes that the applicant has satisfied the relevant requirements of the regulations delineated in Subsection 3.7.2.3 of this SER.

3.7.3 Seismic Subsystem Analysis

Section 3.7.3 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Sections 3.7.3, "Seismic Subsystem Analysis," of the ESBWR DCD, Revision 10. 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 confirms that no outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to the seismic subsystem analysis have been resolved.

3.7.4 Seismic Instrumentation

3.7.4.1 *Introduction*

This FSAR section describes the seismic instrumentation systems as they relate to the capabilities and performance of the instruments to adequately measure the effects of earthquakes. The seismic instrumentation and associated equipment used to measure the plant responses to earthquake motion includes:

- One triaxial time-history accelerograph (THA) installed in the free-field; three THAs in the RB and two THAs in the CB.
- Recording and playback equipment

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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 COL application that references a design certification.

- Annunciators in the main control room.

3.7.4.2 *Summary of Application*

Section 3.7.4 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.7.4 of the ESBWR DCD, Revision 10. In addition, in Section 3.7.4, the applicant provides the following:

Supplemental Information

- EF3 SUP 3.7-6 Seismic Instrumentation

In FSAR Section 3.7.4, the applicant adds the following commitment (COM 3.7-001):

> The seismic monitoring program described in this subsection, including the necessary test and operating procedures, will be implemented prior to receipt of fuel on site.

3.7.4.3 *Regulatory Requirements*

The regulatory basis of the information incorporated by reference is in NUREG–1966. In addition, the relevant requirements of the Commission regulations for the seismic instrumentation, and the associated acceptance criteria, are in Section 3.7.4 of NUREG–0800. The specific requirements include the following:

- 10 CFR Part 50, Appendix S, requires instrumentation to be provided so that the seismic response of safety-related nuclear plant features can be evaluated promptly after an earthquake.

- 10 CFR Part 50.55a, “Codes and standards.”

In addition, the acceptance criteria and regulatory guidance associated with the review of FSAR Section 3.7.4 is documented below:

- RG 1.12, Revision 2, “Nuclear Power Plant Instrumentation for Earthquakes”

- EPRI Report NP-6695, “Guidelines for Nuclear Plant Response to an Earthquake”

- EPRI Report NP-5930, “A Criterion for Determining Exceedance of the Operating Basis Earthquake”

- EPRI Technical Report TR-100082, “Standardization of the Cumulative Absolute Velocity,” as permitted by RG 1.166

- RG 1.166, “Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions”

- RG 1.167, “Restart of a Nuclear Power Plant Shut Down by a Seismic Event”

3.7.4.4 *Technical Evaluation*

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.7.4 of the ESBWR DCD. The staff reviewed Section 3.7.4 of the Fermi 3 COL FSAR and checked the referenced ESBWR DCD to ensure that the combination of the information in the COL FSAR and the information in the ESBWR DCD appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the required information relating to this section.

The staff reviewed the following information in the Fermi 3 COL FSAR:

<u>*Supplemental Information*</u>

- EF3 SUP 3.7-6 Seismic Instrumentation

The applicant adds the following commitment (COM 3.7-001) in FSAR Section 3.7.4:

> The seismic monitoring program described in this subsection, including the necessary test and operating procedures, will be implemented prior to receipt of fuel on site.

Based on the compliance of the proposed resolution with the general operability guidance for seismic equipment in RG 1.12, RG 1.166, and RG 1.167, the staff finds that the timing of the Commitment (COM 3.7-001) is appropriately scheduled before the initial fuel loading.

3.7.4.5 *Post Combined License Activities*

The applicant identifies the following commitment:

- Commitment (COM 3.7-001) – Implement the seismic monitoring program described in this subsection [ESBWR DCD Subsection 3.7.4.5], including the necessary test and operating procedures, before the receipt of fuel onsite.

3.7.4.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG–1966. NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the Fermi 3 FSAR related to this section. There are no unresolved nuclear safety issues relating to the seismic instrumentation that were incorporated by reference.

The staff compared the supplemental information in the COL application to the relevant NRC regulations, the guidance in Section 3.7.4 of NUREG–0800, and other NRC RGs. The staff finds that the applicant has addressed seismic instrumentation in accordance with the acceptance criteria delineated in these guidance documents. On this basis, the staff concludes

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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 COL application that references a design certification.

that the applicant has satisfied the relevant requirements of the regulations delineated in Subsection 3.7.4.3 of this SER.

3.8 Seismic Category I Structures

3.8.1 Concrete Containment

Section 3.8.1 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Section 3.8.1, "Concrete Containment," of the ESBWR DCD, Revision 10. 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 confirms that no outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to the concrete containment have been resolved.

3.8.2 Steel Components of the Reinforced Concrete Containment

Section 3.8.2 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Section 3.8.2, "Steel Components of the Reinforced Concrete Containment," of the ESBWR DCD, Revision 10. 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 confirms that no outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to the steel components of the reinforced concrete containment have been resolved.

3.8.3 Concrete and Steel Internal Structures of the Concrete Containment

Section 3.8.3 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Section 3.8.3, "Concrete and Steel Internal Structures of the Concrete Containment," of the ESBWR DCD, Revision 10. 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 confirms that no outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to the concrete and steel internal structures of the concrete containment have been resolved.

3.8.4 Other Seismic Category I Structures

3.8.4.1 *Introduction*

This FSAR section describes the RB, CB, FB, and FWSC as other seismic Category I structures that are not inside the containment and that constitute the ESBWR standard plant design. In addition, this section describes the Non-Category I structures that could interact with these structures and with other structures important to safety.

3.8.4.2 *Summary of Application*

Section 3.8.4 and Appendix 3G of the Fermi 3 COL FSAR, Revision 7, incorporate by reference Section 3.8.4 and Appendix 3G of the ESBWR DCD, Revision 10. In addition, in FSAR Section 3.8.4, the applicant provides the following:

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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 COL application that references a design certification.

Supplemental Information

- EF3 SUP 3.8-1 Foundation Stability

In FSAR Subsection 3.8.4.5.6, the applicant provides supplemental information addressing the site-specific evaluation of the seismic lateral soil pressures acting on exterior walls of the RB/FB complex and the CB that are below grade and embedded in the soil media. This subsection also evaluates the design of these exterior walls for the seismic lateral soil pressures.

3.8.4.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG–1966, and NUREG-1966, Supplement 1 (ADAMS Accession No. ML14265A084). In addition, the relevant requirements of the Commission regulations for other seismic Category I structures, and the associated acceptance criteria, are in Section 3.8.4 of NUREG–0800. The specific requirements include the following:

- 10 CFR 50.55a and 10 CFR Part 50, Appendix A, GDC 1 as they relate to safety-related structures being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

- 10 CFR Part 50, Appendix A, GDC 2, as it relates to the design of the safety-related structures that are capable of withstanding the most severe natural phenomena such as wind, tornadoes, hurricanes, floods, and earthquakes and the appropriate combination of all loads.

- 10 CFR Part 50, Appendix A, GDC 4, “Environmental and dynamic effects design bases,” as it relates to appropriately protecting safety-related structures against dynamic effects—including the effects of missiles, pipe whipping, and discharging fluids—that may result from equipment failures and from events and conditions outside the nuclear power unit.

- 10 CFR Part 50, Appendix A, GDC 5, “Sharing of structures, systems, and components,” as it relates to not sharing safety-related structures among nuclear power units, unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

- 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” as it relates to the quality assurance criteria for nuclear power plants.

- 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act, and the Commission’s rules and regulations.

In addition, the acceptance criteria and regulatory guidance associated with the review of FSAR Section 3.8.4 include the following:

- SRP Section 3.8.4, to evaluate the combination of the incorporated information together with the supplementary information in this section to meet the relevant requirements of 10 CFR 50.55a; GDC 1, 2, 4, and 5 of Appendix A to 10 CFR Part 50; and Appendix B to 10 CFR Part 50.

- RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants."

3.8.4.4 *Technical Evaluation*

As documented in NUREG–1966, and NUREG-1966, Supplement 1, the supplemental FSER (ADAMS Accession No. ML14265A084) related to the certified ESBWR DCD, NRC staff reviewed and approved Section 3.8.4 of the ESBWR DCD. The staff reviewed Section 3.8.4 of the Fermi 3 COL FSAR and checked the referenced ESBWR DCD to ensure that the combination of the information in the COL FSAR and the information in the ESBWR DCD appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the required information relating to this section.

The staff reviewed the following information in the COL FSAR:

Supplemental Information

- EF3 SUP 3.8-1 Foundation Stability

Structural Acceptance Criteria

Exterior Wall Design

SRP Section 3.8.4 provides guidelines for the staff's review. Specifically, the staff's review includes an assessment of the wall design for the site-specific seismic lateral soil pressures acting on seismic Category I exterior walls that are below grade and embedded in the soil media.

The review of seismic Category I exterior walls that are above grade, which are thus not subjected to seismic lateral soil pressures, is in Subsection 3.7.2.4 of this SER as part of the review of the overall site-specific seismic response of seismic Category I structures. As indicated in FSAR Section 2.5.4, Figures 2.5.4-201 through 2.5.4-204 depict that the RB/FB and CB are partially embedded in the Bass Islands Group rock. Therefore, the underlying soil media are in fact rock media. In the case of the FWSC, the structure is supported on a block of concrete fill, which bears on the Bass Islands Group rock. A block of concrete fill is also located in the gap between the RB/FB and CB.

Engineered granular backfill is used to fill the site excavation surrounding the power block structures. This backfill is placed above the top of the Bass Islands Group rock up to the plant grade level, as shown in FSAR Figures 2.5.4-201, 2.5.4-202, and 2.5.4-203. FSAR Subsection 2.5.4.5.4.2 describes the material properties and specifications of the engineered granular backfill.

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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 COL application that references a design certification.

Therefore, below-grade exterior walls of the RB/FB and the CB bear against rock or concrete fill below the top of rock elevation and against the engineered granular backfill above this elevation. The FWSC has no below-grade walls, so seismic lateral soil pressures are not considered for the FWSC.

As shown in ESBWR DCD, Tier 2, Figures 3G.1-6 and 3G.1-7, the RB/FB has three stories below grade. The walls of the RB/FB that are subjected to lateral soil pressures vertically span between elevations of +3.65 m (11.98 ft) and -1.00 m (-3.28 ft) (top span), -2.00 m (6.56 ft) and -6.40 m (-21 ft) (middle span), and -7.40 m (-24.28 ft) and -11.50 m (-37.73 ft) (bottom span). Stiff floor slabs and the basemat provide lateral support for these walls typically between elevations of +4.65 m (15.26 ft) and +3.65 m (11.98 ft) (floor slab), -1.00 m (-3.28 ft) and -2.00 m (-6.56 ft) (floor slab), -6.40 m (-21 ft) and -7.40 m (-24.28 ft) (floor slab), and -11.50 m (-37.73 ft) and -15.50 m (-50.85 ft) (basemat).

As shown in ESBWR DCD, Tier 2, Figure 3G.2-3, the CB has two stories below grade. The walls of the CB that are subjected to lateral soil pressures vertically span between elevations of +4.15 m (13.61 ft) and -2.00 m (6.56 ft) (top span) and -2.50 m (-8.20 ft) and -7.40 m (-24.28 ft) (bottom span). Stiff floor slabs and the basemat provide lateral support for these walls, typically between elevations of +4.65 m (15.26 ft) and +4.15 m (13.61 ft) (floor slab), -2.00 m (6.56 ft) and -2.50 m (-8.20 ft) (floor slab), and -7.40 m (-24.28 ft) and -10.40 m (-34.12 ft) (basemat).

As indicated above, below-grade exterior walls of the RB/FB and the CB bear against rock or concrete fill below the top of rock elevation (approximately 11.40 m [37.40 ft] below the plant grade) and against the engineered granular backfill above this elevation. Because of the large discontinuity in stiffness between the rock/concrete and the granular backfill media in which the walls are embedded, standard methods for evaluating seismic lateral soil pressures—such as the method described in Subsection 3.5.3.2 of ASCE 4-98, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary”—are not directly applicable to the Fermi 3 site because such methods are based on the assumption that the walls are embedded in a homogeneous soil medium. Therefore, the staff conducted a case-by-case review of the applicant's site-specific evaluations as discussed below.

The applicant's site-specific evaluations of seismic lateral soil pressures acting on below-grade exterior walls of the RB/FB and the CB are documented in FSAR Subsection 3.8.4.5.6 and with more details in the Sargent & Lundy Report SL-012018 Revision 1, “Evaluation of Reactor Building/Fuel Building and Control Building Dynamic Bearing Capacity, Foundation Stability, and Wall Seismic Soil Pressures Summary Report,” (ADMAS Accession No. ML13360A177). In these site-specific evaluations, the applicant used the results of the SSI and SSSI analyses described in FSAR Section 3.7.2, which are also documented in the Sargent & Lundy Reports SL-011864, Revision 1 (ADAMS Accession No. ML13210A144), SL-011956, Revision 1 (ADAMS Accession No. ML13360A176), and SL-011960, Revision 0 (ADAMS Accession No. ML13232A006).

The seismic lateral soil pressures were obtained from the resulting forces in the spring elements connected to the appropriate below-grade nodes of the various SSI and SSSI analysis models, which were specifically added to capture the lateral soil pressures from the SSI and SSSI analyses. The staff considers this to be an acceptable methodology for the Fermi 3 site conditions because it takes into account (a) the site-specific SSI and SSSI effects, and (b) the differences in stiffness between the rock and the granular backfill media in which the structures are embedded. The staff also notes that this SSI analysis-based methodology is consistent with the way the seismic design pressures were developed in the standard design, as described in DCD Tier 2, Sections 3G.1.5.2.1.13 and 3G.2.5.2.1.7.

The seismic lateral soil pressures obtained from the site-specific SSI and SSSI analyses are documented in FSAR Figures 3.8.4-201a through 3.8.4-201h for the RB/FB, FSAR Figures 3.8.4-202a through 3.8.4-202d for the CB (without SSSI effects), and FSAR Figures 3.8.4-203a and 3.8.4-203b for the CB (with SSSI effects). In these figures, the pressures exhibit a sharp peak at the elevation of the top of the rock, which reflects the stiffness discontinuity between the rock and the granular backfill media in which the walls are embedded. In the figures that correspond to SSI analyses without the granular backfill (FSAR Figures 3.8.4-201a, 3.8.4-201e, 3.8.4-202a, and 3.8.4-202c), there are no pressures above the elevation of the top of the rock because the granular backfill was not considered in the analysis of the models. However, these cases exhibit the largest pressure peaks at the elevation of the top of the rock.

In the figures for the RB/FB, the site-specific seismic lateral soil pressures are compared to the two pressure profiles considered in the standard design, which are: (a) seismic design pressures (DCD Tier 2, Subsection 3G.1.5.2.1.13), and (b) wall capacity passive pressures (DCD Tier 2, Subsection 3G.1.5.5). The staff notes that in the standard design, the wall capacity passive pressures are added to the at-rest soil pressures for the wall design so that the above comparison is appropriate. In the figures for the CB, the site-specific pressures are only compared to the seismic design pressures considered in the standard design (DCD Tier 2, Subsection 3G.2.5.2.1.7). The results of these comparisons indicate that the site-specific pressures for the RB/FB and the CB exceed the corresponding pressures considered in the standard design at some locations at elevations near the top of the rock.

To address this issue, the applicant performed additional evaluations to determine the impact of these exceedances on the design of below-grade exterior walls. These additional evaluations are documented in the Sargent & Lundy Report SL-012018, Revision 1 (ADAMS Accession No. ML13360A177). The applicant computed the maximum induced, out-of-plane bending moments and shear forces in the walls due to the site-specific seismic lateral soil pressures and compared them to the corresponding induced moments and shears in the walls due to the pressure profiles considered in the standard design. In all cases, the applicant determined that the Fermi 3 analyses were bounded by the analyses in the ESBWR DCD. The critical cases for the RB/FB were identified as (a) walls RA and RG (see DCD Tier 2, Figures 3G.1-1 and 3G.1-2 for the location of these walls); and (b) the bottom span (between elevations -7.40 m [-24.28 ft] and -11.50 m [-37.73 ft]), where the site-specific induced moments and shears range between 79 percent and 99 percent of the corresponding values resulting from the wall capacity passive pressure profiles considered in the standard design. The critical cases for the CB were identified as walls C1, C5, CA, and CD (see DCD Tier 2, Figures 3G.2-1 and 3G.2-2 for the location of these walls); and the bottom span (between elevations -2.50 m [-8.20 ft] and -7.40 m [-24.28 ft]), where the site-specific induced moments and shears range between 32 percent and 51 percent of the corresponding values resulting from the seismic design pressure profiles considered in the standard design.

The staff reviewed these evaluations and noted that at some locations, the site-specific seismic lateral soil pressures acting on below-grade exterior walls exceed the corresponding pressures considered in the standard design. However, the staff finds the standard design to be acceptable at the Fermi 3 site, because the site-specific member forces (moments and shears) induced in the walls by these pressures are bounded by the corresponding member forces considered in the standard design. The applicant's site-specific evaluation of the below-grade exterior walls design is therefore acceptable per SRP Acceptance Criterion 3.8.4.II.4.H.

Other Review Topics

Design for Hurricane Missiles for RTNSS Related Structures

Based on RG 1.221, the staff requested in RAI 02.03.01-20 that the applicant update the site characteristic values in the Fermi 3 FSAR. As a related matter, the staff also requested the applicant to explain whether the loads from site-specific hurricane winds and hurricane-generated missiles per RG 1.221 were bounded by the loads generally considered in the ESBWR DCD and in particular, the loads for the site-specific hurricane missiles considered in the design for the RTNSS and RTNSS-related structures identified in ESBWR DCD, Tier 2, Appendix 19A.

The staff noted that in ESBWR DCD, Tier 2, Tables 19A-3 and 19A-4 and ESBWR DCD, Tier 2, Table 2.0-1, Footnote (3) indicates that the tornado missile design criterion is not applicable to seismic Category NS and seismic Category II buildings. However, for seismic Category NS and seismic Category II buildings that house RTNSS equipment, a hurricane missile criterion is specified so that barriers are designed for the impact from missiles generated by Category 5 hurricanes (a 3-second gust wind speed of 313.76 kilometers per hour (kph) [195 miles per hour (mph)]). The missile spectrum and missile velocities are in accordance with SRP Subsection 3.5.1.4, Revision 2, where the tornado wind speed replaced the hurricane wind speed.

During the onsite audit on April 23 through 27, 2012 (ADAMS Accession No. ML12207A471), the applicant explained that a response to RAI 02.03.01-20 was submitted on April 3, 2012 (ADAMS Accession No. ML12095A283). The staff reviewed the response and found that it did not address the issue of site-specific hurricane missiles considered in the design of RTNSS and RTNSS-related structures.

The applicant explained that for the hurricane missile design, consistent with the guidance in SRP Subsection 3.5.1.4, Revision 2, the missile velocities associated with the three missile types (1,800-kilogram [kg] [3,968-pound] automobile, 125-kg [275.57-pound] pipe, and the 2.54–centimeter (cm) [1-inch] diameter solid sphere) are taken as 35 percent of the assumed 313.76-kph (195-mph) hurricane wind, which is 109.4 kph (68 mph) (i.e., 0.35 x 195 mph = 68 mph). This information is specified in a GEH internal document that the staff reviewed and identified in the staff's audit report (ADAMS Accession No. ML12207A471).

The applicant also explained that by assuming the most conservative estimate of the RG 1.221 design-basis hurricane wind speed at the Fermi site of 209.2 kph (130 mph), missile velocities associated with the three missile types in RG 1.221 are 106.2 kph (66 mph) for the 1,800-kg [3,968-pound] automobile; 78.84 kph (49 mph) for the 125-kg (275.57-pound) pipe; and 67.58 kph (42 mph) for the 2.54-cm (1-inch) diameter solid sphere.

Because conservative estimates of site-specific missile velocities computed in accordance with RG 1.221 are bounded by the corresponding DCD hurricane missile criterion (i.e., 109.4 kph [68 mph]), the staff concludes that the DCD hurricane missile criterion bounds the Fermi 3 site for the seismic Category NS and seismic Category II buildings that house RTNSS equipment.

3.8.4.5 *Post Combined License Activities*

There are no post COL activities related to this section.

3.8.4.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG–1966, and NUREG-1966, Supplement 1. NRC staff reviewed the application and checked the referenced ESBWR DCD. The staff's review confirms that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to the other seismic Category I structures have been resolved.

The staff compared the supplemental information in the COL application to the relevant NRC regulations, the guidance in Section 3.8.4 of NUREG–0800, and other NRC RGs. The staff finds that the applicant has adequately addressed the site-specific issues related to the design of other seismic Category I structures consistent with the acceptance criteria delineated in these guidance documents. On this basis, the staff concludes that the applicant has satisfied the relevant requirements of the regulations delineated in Subsection 3.8.4.3 of this SER.

3.8.5 Foundations

3.8.5.1 *Introduction*

This FSAR section addresses the foundations for all seismic Category I Structures. The ESBWR design employs separate reinforced-concrete mat foundations for major seismic Category I Structures. The RB including the containment and the FB are built on a common foundation mat. The foundations of the CB and the FWSC are separate from each other and from the RB and FB foundations.

3.8.5.2 *Summary of Application*

Section 3.8.5 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.8.5 of the ESBWR DCD, Revision 10. In addition, in FSAR Section 3.8.5, the applicant provides the following:

Supplemental Information

- EF3 SUP 3.8-1 Foundation Stability

In FSAR Subsection 3.8.5.5.1, the applicant provides the following:

- Site-specific evaluations of foundation stability for the RB/FB and the CB.
- Site-specific evaluations of sliding stability for the block of concrete fill under the FWSC.
- Site-specific dynamic bearing pressure demands for the RB/FB and the CB against the corresponding DCD values and site-specific dynamic bearing pressure capacities reported in FSAR Section 2.5.4.

3.8.5.3 *Regulatory Basis*

The regulatory basis of the information incorporated by reference is in NUREG–1966 and NUREG-1966, Supplement 1. In addition, the relevant requirements of the Commission regulations for the review of the foundation, and the associated acceptance criteria, are in Section 3.8.5 of NUREG–0800. The specific requirements include the following:

- 10 CFR 50.55a and 10 CFR Part 50, Appendix A, GDC 1, as they relate to safety-related foundations being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

- 10 CFR Part 50, GDC 2, as it relates to the design of the safety-related foundations that are capable of withstanding the most severe natural phenomena such as wind, tornadoes, hurricanes, floods, and earthquakes and the appropriate combination of all loads.

- 10 CFR Part 50, GDC 4, as it relates to appropriately protecting safety-related foundations against dynamic effects; including the effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures and from events and conditions outside the nuclear power unit.

- 10 CFR Part 50, GDC 5, as it relates to not sharing safety-related foundations among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

- 10 CFR Part 50, Appendix B, as it relates to quality assurance criteria for nuclear power plants.

- 10 CFR 52.80(a), which requires a COL application to contain the proposed inspections, tests, and analyses—including those applicable to emergency planning—that the licensee shall perform; and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that if the inspections, tests, and analyses are performed and the acceptance criteria are met, the facility has been constructed and will operate in conformity with the COL; the provisions of the Atomic Energy Act; and Commission rules and regulations.

3.8.5.4 *Technical Evaluation*

As documented in NUREG–1966 and NUREG-1966, Supplement 1, the supplemental FSER related to the certified ESBWR DCD, NRC staff reviewed and approved Section 3.8.5 of the ESBWR DCD. The staff reviewed Section 3.8.5 of the Fermi 3 COL FSAR and checked the referenced ESBWR DCD to ensure that the combination of the information in the COL FSAR and the information in the ESBWR DCD appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the required information relating to this section.

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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 COL application that references a design certification.

The staff reviewed the following information in the COL FSAR:

Supplemental Information

- EF3 SUP 3.8-1 Foundation Stability

Structural Acceptance Criteria

Foundation Stability

SRP Section 3.8.5 provides guidelines to the staff for reviewing foundations of seismic Category I structures. Specifically, the staff's review includes an evaluation of the stability of the foundation against overturning, sliding, and flotation to ensure adequate safety margins.

The RB/FB complex foundation consists of a reinforced concrete basemat 4.0-m (13.12-ft) thick with plan dimensions of 70 m by 49 m (229.7 by 160.8 ft) (ESBWR DCD, Tier 2, Figures 3G.1-1, 3G.1-6, and 3G.1-7). The CB foundation consists of a 3.0-m (9.84-ft) thick reinforced concrete basemat with plan dimensions of 30.3 m by 23.8 m (99.41 by 72.54 ft) (ESBWR DCD, Tier 2, Figure 3G.2-1). The FWSC foundation consists of a 2.5-m (8.20-ft) thick reinforced concrete basemat with plan dimensions of 52 m by 20 m (170.6 by 65.62 ft) (ESBWR DCD, Tier 2, Figure 3G.4-1). Other key dimensions of the foundations are in ESBWR DCD, Tier 2, Table 3.8-13.

As indicated in FSAR Section 2.5.4, Figures 2.5.4-201 through 2.5.4-204, the RB/FB and the CB structures at the Fermi 3 site are partially embedded in the Bass Islands Group rock. Therefore, the underlying soil media are in fact rock media. In the case of the FWSC, the structure is supported on a block of concrete fill that bears on the Bass Islands Group rock. A block of concrete fill is also located in the gap between the RB/FB and the CB.

Engineered granular backfill is used to fill the site excavation surrounding the power block structures. This backfill is placed above the top of the Bass Islands Group rock up to the plant grade level, as shown in FSAR Figures 2.5.4-201, 2.5.4-202, and 2.5.4-203. FSAR Subsection 2.5.4.5.4.2 describes the material properties and specifications of the engineered granular backfill.

The applicant's site-specific evaluations of foundation stability for the RB/FB and the CB are in FSAR Subsection 3.8.5.5.1, FSAR Tables 3.8.5-201 and 3.8.5-202, and with more details in the Sargent & Lundy Report SL-012018, Revision 1 (ADAMS Accession No. ML13360A177). In these site-specific evaluations, the applicant used the results of the SSI analyses described in FSAR Section 3.7.2, which are documented in the Sargent & Lundy Reports SL-011864, Revision 1 (ADAMS Accession No. ML13210A144) and SL-011956, Revision 1 (ADAMS Accession No. ML13360A176).

The staff reviewed selected portions of the applicant's foundation stability calculations for the RB/FB and the CB during the onsite audit on November 18 through 22, 2013 (ADAMS Accession No. ML14028A245).

Sliding Stability of the RB/FB and CB

To calculate the minimum factor of safety (FS) against sliding due to site-specific seismic loads, the applicant followed the method described in ESBWR DCD, Tier 2, Subsection 3.8.5.5, which was accepted by the staff during the review of the ESBWR DCD and is therefore acceptable for the site-specific evaluation.

In this method, the FS is evaluated as the ratio of the total horizontal frictional resistance force to the horizontal seismic load. The FS was evaluated as a function of time, and the values reported in the FSAR correspond to a time instant that yields the lowest FS. The evaluation was performed separately in the two orthogonal horizontal directions.

The applicant considered a static friction coefficient of 0.7 to evaluate the frictional resistance along the sliding plane located at the bottom of the basemat shear keys, which is consistent with ESBWR DCD, Tier 2, Subsection 3.8.5.5 and is the major contributor to the total horizontal frictional resistance force. The staff finds this value of 0.7 acceptable because it corresponds to an equivalent angle of internal friction of 35 degrees, which is lower (i.e., more conservative) than the site-specific equivalent Mohr-Coulomb angle of internal friction parameters reported for the Bass Islands Group rock in FSAR Table 2.5.4-208. These site-specific parameters are 53 degrees (upper bound), 48 degrees (mean), and 42 degrees (lower bound)—all greater than 35 degrees. In addition, FSAR Subsection 2.5.4.10.1 indicates that the angle of internal friction representative of the Bass Islands Group rock is 52 degrees, which is also greater than 35 degrees.

The applicant conservatively ignored the following three forces that would contribute to the total horizontal resisting force: (a) skin friction resistance provided by the basemat sides parallel to the direction of motion; (b) skin friction resistance provided by the outside vertical surface of shear keys parallel to the direction of motion; and (c) lateral bearing resistance acting against the shear keys opposite to the direction of motion. The applicant conservatively ignored any contribution from the engineered granular backfill placed above the rock.

In the case of the RB/FB, the applicant also conservatively ignored the lateral bearing resistance acting against the basemat opposite from the direction of motion. In other words, the only horizontal resistance force considered in the evaluation of the RB/FB results from friction along the sliding plane located at the bottom of the basemat shear keys.

In the case of the CB, for the SSI analyses without the engineered granular backfill (the SSI analyses denoted as CB1LB-DM, RBFB1BE-DM, and RBFB1UB-DM and listed in Tables 3.7.2-1 and 3.7.2-2 of this SER), a certain amount of lateral bearing resistance against the basemat opposite from the direction of motion was necessary to obtain an acceptable FS of 1.1. The staff reviewed the applicant's calculations, which are summarized in the Sargent & Lundy Report SL-012018, Revision 1. The staff determined that the allowable lateral bearing strength of the rock and concrete fill that surrounds the CB basemat substantially exceeds the lateral bearing force necessary for an FS of 1.1. The staff's conclusion is based on comparisons of (1) the necessary bearing force to the site-specific allowable bearing capacity of the rock reported in FSAR Table 2.5.4-227 (for dynamic loading conditions), and (2) the compressive strength of the concrete fill specified in FSAR Subsection 2.5.4.5.4.2. The applicant also determined that in this condition, the block of concrete fill between the RB/FB and the CB will not slide relative to the underlying rock (the staff estimated an FS in excess of 3.0 for the block against sliding). Therefore, the staff concludes that there is no transfer of horizontal seismic load from the CB to the RB/FB through the block of concrete.

The applicant determined that the minimum FS against sliding for the RB/FB is 1.22 (for the SSI analysis of case RBFB1BE-DM in the North-South direction without the engineered granular backfill; other SSI case analyses yield a higher FS). Similarly, the applicant determined that the minimum FS against sliding for the CB is 1.1 (for SSI analyses of cases CB1LB-DM, CB1BE-DM, and CB11UB-DM in East-West and North-South directions without the engineered granular backfill; other SSI case analyses yield a higher FS). All SSI analyses without the engineered granular backfill yield a lower FS than the corresponding SSI analyses with the engineered granular backfill.

The staff concludes that the reported FS were conservatively estimated using acceptable methodologies, and all are greater than or equal to the required minimum FS of 1.1 specified in SRP Acceptance Criterion 3.8.5.II.5. The reported FS are therefore acceptable.

Overturning Stability of the RB/FB and CB

To calculate the minimum FS against overturning due to site-specific seismic loads, the applicant followed the energy method described in DCD Tier 2, Subsection 3.7.2.14. This method was accepted by the staff during the review of the DCD and is therefore acceptable for the site-specific evaluation.

This method evaluates the FS as the ratio of the potential energy required to overturn the structure to the maximum kinetic energy imparted to the structure by the site-specific seismic motions. To compute the maximum kinetic energy, the applicant used the maximum absolute velocities obtained from the site-specific SSI analyses. The applicant conservatively assumed that the maximum absolute velocities at all mass degrees-of-freedom in both the horizontal and vertical directions occur at the same time instant. To compute the potential energy required to overturn the structure, the applicant conservatively ignored the potential energy caused by the effect of embedment.

The applicant determined that the minimum FS against overturning for the RB/FB is 2,262 (for SSI analysis of case RBFB1UB-DM in East-West direction, without the engineered granular backfill; other SSI analysis cases yield higher FS). Similarly, the applicant determined that the minimum FS against overturning for the CB is 1,733 (SSI analysis of case CB1BE-DM in East-West direction, without the engineered granular backfill; other SSI case analyses yield higher FS). All SSI analyses without the engineered granular backfill yield a lower FS than the corresponding SSI analyses with the engineered granular backfill.

The staff concludes that the reported FS were conservatively estimated using methodologies accepted by the staff during the review of the DCD, and all are greater than or equal to the required minimum FS of 1.1 specified in SRP Acceptance Criterion 3.8.5.II.5. Therefore, the reported FS are acceptable.

Flotation Stability of the RB/FB and CB

To calculate the minimum FS against flotation due to site-specific flooding, the applicant followed the method described in DCD Tier 2, Subsection 3.8.5.5 that was accepted by the staff during the review of the DCD. This method is therefore acceptable for the site-specific evaluation. This method evaluates the FS as the ratio of the sustained downward forces (i.e., dead load) to the sustained upward forces (i.e., buoyancy).

The site-specific evaluation considered the design-basis flood level to be 0.30 m (1 ft) below plant grade, which is higher than the maximum site-specific flood level of 1.20 m (4 ft) below grade reported in FSAR Table 2.0-201 and is therefore conservative.

The applicant determined that the minimum FS against flotation are 3.50 and 1.86 for the RB/FB and the CB, respectively. The staff concludes that the reported FS were conservatively estimated using methodologies accepted by the staff during the review of the DCD, and all are greater than or equal to the required minimum FS of 1.1 specified in SRP Acceptance Criterion 3.8.5.II.5. The reported FS are therefore acceptable.

Sliding Stability of the Block of Concrete Fill Below the FWSC

Although site-specific seismic SSI analyses of the FWSC were not required (see Subsection 3.7.2.4 of this SER), the applicant performed an evaluation of the sliding stability of the block of concrete fill under the FWSC basemat because this was not considered in the standard plant design. This evaluation is documented in FSAR Subsection 3.8.5.5.1.

The applicant followed the method described in DCD Tier 2, Subsection 3.8.5.5, which was accepted by the staff during the review of the DCD and is therefore acceptable for the site-specific evaluation. In this method, the minimum FS against sliding is evaluated as the ratio of the total horizontal frictional resistance force to the horizontal seismic load.

The horizontal seismic load was conservatively evaluated from the results of the SSI analyses reported in the DCD, because site-specific seismic SSI analyses of the FWSC were not performed. This approach is acceptable because the seismic loads considered in the DCD are based on the FWSC CSDRS, which bounds the site-specific FWSC FIRS and is explained in Subsection 3.7.1.4 of this SER.

The applicant determined that the minimum horizontal frictional resistance force in the concrete fill corresponds to the shear resistance on a shear plane below the FWSC basemat shear keys. To ensure that a minimum FS of at least 1.1 is obtained for this shear plane, the FSAR indicates that a shear-friction reinforcement will be placed in the concrete fill. The specific amount of reinforcement will be selected during the detailed design phase with a minimum design margin of 10 percent. The staff finds this reinforcement acceptable because it results in a minimum sliding FS of 1.1 for any shear plane in the concrete fill below the FWSC basemat shear keys and is consistent with SRP Acceptance Criterion 3.8.5.II.5.

Soil Bearing Pressures

SRP Section 3.8.5 provides guidelines for the staff to review issues related to the foundations of seismic Category I structures. Specifically, the staff's review includes an assessment of the foundations for their capability to receive loads from the structures and transmit these loads to the soil media with appropriate safety margins.

The applicant performed SSI analyses with and without considering the effects of the engineered granular backfill. All SSI analyses without the engineered granular backfill yield greater bearing pressures than the corresponding SSI analyses with the engineered granular backfill.

The applicant's site-specific evaluations of maximum dynamic soil-bearing pressures (i.e., maximum toe pressures under worst-case static plus seismic loads) for the RB/FB complex and the CB are in FSAR Subsection 3.8.5.5.2, FSAR Table 3.8.5-203, and with more details in the Sargent & Lundy Report SL-012018, Revision 1 (ADAMS Accession No. ML13360A177). In these site-specific evaluations, the applicant used the results of the SSI analyses described in FSAR Section 3.7.2, which are documented in the Sargent & Lundy Reports SL-011864, Revision 1 (ADAMS Accession No. ML13354B536) and SL-011956, Revision 1 (ADAMS Accession No. ML13360A176).

The staff reviewed selected portions of the applicant's dynamic soil-bearing pressure calculations for the RB/FB and the CB during the onsite audit on November 18 through 22, 2013 (ADAMS Accession No. ML14028A245).

To calculate the site-specific dynamic soil-bearing pressures, the applicant followed the "Modified Energy Balance" (MEB) method (ESBWR DCD, Tier 2, Reference 3G.1-2). This is the same method referenced in ESBWR DCD, Tier 2, Subsections 3G.1.5.5 and 3G.2.5.5, which was accepted by the staff during the review of the DCD and is therefore acceptable for the site-specific evaluation. The staff notes that the ESBWR DCD refers to this method as the "Energy Balance" method. The response to ESBWR RAI Letter Number 363—RAI 3.8-94, Supplement 05— (ADAMS Accession No. ML092430127) clarified that the MEB method was used in all ESBWR DCD evaluations.

To account for additional uplift pressures from the rotation of the basemat around the two horizontal axes, the applicant followed a conservative approach to evaluate and envelope two cases for the (a) potential uplift in the X direction together with a full contact length in the Y direction; and (b) potential uplift in the Y direction together with a full contact length in the X direction. This is the same approach accepted by the staff during the review of the DCD and is therefore found acceptable by the staff for the site-specific evaluation.

The applicant determined that the maximum site-specific dynamic pressure exerted by the RB/FB on the underlying rock is 2.05 megapascal (MPa) (297.31 pounds per square inch [psi]) (FSAR Table 3.8.5-203), which corresponding to the SSI analysis of case RBFB1UB-DM without the engineered granular backfill (other SSI case analyses yield lower bearing pressures). This value is greater than the value of 1.10 MPa (159.53 psi) value reported in ESBWR DCD, Tier 2, Tables 2.0-1 and 3G.1-58 for the "hard" site condition, but less than 2.70 MPa (391.58 psi) value for the "medium" site condition.

Similarly, the applicant determined that the maximum site-specific dynamic pressure exerted by the CB on the underlying rock is 0.85 MPa (123.28 psi) (FSAR Table 3.8.5-203), corresponding to the SSI analysis of case CB1UB-DM without the engineered granular backfill (other SSI case analyses yield lower bearing pressures). This value is greater than the 0.42 MPa (60.91 psi) value reported in ESBWR DCD, Tier 2, Tables 2.0-1 and 3G.2-27 for the "hard" site condition, but less than the 2.20 MPa (319.07 psi) value for the "medium" site condition.

As indicated above, the site-specific maximum dynamic soil-bearing pressures for the RB/FB and the CB exceed the values reported in the ESBWR DCD for the "hard" site condition, which is the DCD condition that most resembles the underlying rock at the Fermi 3 site. The staff finds this acceptable because the site-specific maximum dynamic soil-bearing pressures are bounded by the site-specific allowable dynamic bearing capacities of the underlying rock, which are reported in FSAR Tables 2.0-201 and 2.5.4-227 as 5.98 MPa (867.28 psi) for the RB/FB and 18.70 MPa (2712.1 psi) for the CB. The staff concludes that the maximum toe pressures exerted by the RB/FB and the CB structures, under worst-case static plus seismic loads, do not exceed the allowable dynamic bearing capacities of the underlying rock at the Fermi 3 site and therefore the dynamic pressures meet the guidance in SRP Acceptance Criterion 3.8.5.II.4.

Because the site-specific maximum dynamic soil-bearing pressures exceed the values reported in the ESBWR DCD, the staff evaluated whether the site-specific stresses induced in the RB/FB and CB basemats from load combinations that include seismic loads, also exceed the stresses considered in the standard design. The staff concluded that site-specific stresses induced in the RB/FB and CB basemats are bounded by the stresses considered in the standard design, as discussed below.

In the standard design described in ESBWR DCD, Tier 2, Sections 3G.1.4, 3G.1.5, 3G.2.4, and 3G.2.5, three-dimensional linear-elastic finite element models of the RB/FB and the CB are used to analyze and design the basemats. In these DCD models, the underlying soil media are represented by elastic springs connected to the nodes at the bottom of the basemats. The stiffness of these springs corresponds to the "soft" site condition (see DCD Tier 2, Subsection 3G.1.4.2 and Table 3G.1-1 for the RB/FB and DCD Tier 2, Subsection 3G.2.4.2 and Table 3G.2-1 for the CB). The seismic loads (seismic shears, moments, and vertical accelerations) applied to the DCD models are shown in DCD Tier 2, Figures 3G.1-24, 3G.1-25, 3G.1-26, and Table 3G.1-9 for the RB/FB; and DCD Tier 2, Figure 3G.2-14 and Table 3G.2-5 for the CB.

ESBWR DCD, Tier 2, Subsection 3.8.5.4 indicates that basemat deformations and stresses for the "soft" site condition were compared to the corresponding values obtained assuming a "hard" site condition. The "soft" site condition was found to control the standard design of the basemats.

The staff compared the seismic loads applied to the ESBWR DCD models of the RB/FB and the CB to the corresponding site-specific seismic loads reported in Tables 3 through 15 of the supplemental response to RAI 03.07.02-9 dated December 13, 2013 (ADAMS Accession No. ML13354B536). The staff concluded that the site-specific seismic loads are bounded by the seismic loads applied to the DCD models by a significant margin.

Based on the above considerations, as well as considering the linearity of the ESBWR DCD analysis models, the staff concludes that if the site-specific seismic loads were to be applied to the DCD models of the RB/FB and the CB with a soil spring stiffness representative of the underlying rock at the Fermi 3 site, the site-specific stresses induced in the RB/FB and CB basemats would be bounded by the stresses considered in the standard design by a substantial margin and are therefore consistent with SRP Acceptance Criterion 3.8.5.II.4.

<u>Other Review Topics</u>

Prevention of Alkali-Silica Reaction-Induced Concrete Degradation

Per SRP Section 3.8.5, the staff's review includes an assessment of the materials and quality control programs for concrete used in foundations and other elements of seismic Category I structures in view of NRC Information Notice (IN) 2011-20, "Concrete Degradation by Alkali-Silica Reaction."

NRC IN 2011-20 (ADAMS Accession No. ML112241029) informs the licensees about the potential occurrence of alkali-silica reaction (ASR)-induced concrete degradation of a seismic Category I structure that occurred at the Seabrook Station Nuclear Power Plant. The IN indicates that the tests described in ASTM C227, "Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)," and ASTM C289, "Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)," may not accurately predict aggregate reactivity when dealing with late or slow-expanding aggregates containing strained quartz or micro-crystalline quartz. More appropriate in this regard are the updated testing standards in ASTM C1260, “Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method),” and ASTM C1293, “Standard Test Method for Determination of Length of Change of Concrete Due to Alkali-Silica Reaction.”

Neither Revision 4 of the FSAR nor the DCD referenced the updated testing standards of ASTM C1260 and C1293, either directly or by reference to ACI 349-01, “Code Requirements for Nuclear Safety Related Concrete Structures,” or the ASME Code (2004 Edition). During the onsite audit on April 23 through 27, 2012 (ADAMS Accession No. ML12207A471), the staff requested the applicant to explain the measures implemented in the FSAR to prevent the problems that IN 2011-20 describes. In particular, whether testing in accordance with the updated ASTM C1260 and C1293 will be performed during construction.

To address the staff's concerns, the applicant submitted markups to FSAR Table 1.9-204 and FSAR Subsection 2.5.4.12 (Attachment 1 to DTE Letter NRC3-12-0012, ADAMS Accession No. ML12097A556) that identify and specify the testing of the concrete aggregate for seismic Category I and RTNSS structures in accordance with the testing standards in ASTM C1260-07 and ASTM 1293-08b. The staff finds the applicant’s information acceptable because, as indicated above, updated testing standards in ASTM C1260 and C1293 have been better predictors of aggregate reactivity. The staff subsequently confirmed that these changes were incorporated into Revision 5 of the FSAR, which resolves this issue.

3.8.5.5 *Post Combined License Activities*

There are no post COL activities related to this section.

3.8.5.6 *Conclusion*

The NRC staff's finding related to information incorporated by reference is in NUREG-1966 and NUREG-1966, Supplement 1. NRC staff reviewed the application and checked the referenced ESBWR DCD. The staff’s review confirms that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to seismic Category I foundations that were incorporated by reference have been resolved.

The staff compared the supplemental information in the COL application to the relevant NRC regulations, the guidance in Section 3.8.5 of NUREG–0800, and other NRC RGs. The staff finds that the applicant has adequately addressed the site-specific issues related to the design of the foundations for Category I structures consistent with the acceptance criteria delineated in these guidance documents. On this basis, the staff concludes that the applicant has satisfied the relevant requirements of the regulations delineated in Subsection 3.8.5.3 of this SER.

3.8.6 Special Topics

Sections 3.8.6 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference, with no departures or supplements, Sections 3.8.6,” Special Topics,” of the ESBWR DCD, Revision 10. 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 confirms that no

[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 COL application that references a design certification.

outstanding information is expected to be addressed in the COL FSAR related to this section. All nuclear safety issues relating to this section have been resolved.

3.9 Mechanical Systems and Components

3.9.1 Introduction

Section 3.9 of the Fermi 3 COL FSAR addresses the structural integrity and functional capability of mechanical SSCs and incorporates by reference Section 3.9 of the ESBWR DCD, Revision 10. Following the issuance of the ESBWR FSER on March 9, 2011, the (NRC staff identified issues applicable to the ESBWR steam dryer structural analysis based on information obtained during the NRC review of a license amendment request for a power uprate at an operating boiling-water reactor nuclear power plant. As a result of resolving those issues, General Electric–Hitachi (GEH) revised the DCD to withdraw the licensing topical reports (LTRs) addressing the ESBWR steam dryer structural evaluation, and to reference new engineering reports that describe the updated ESBWR steam dryer analysis methodology. The staff reviewed the revised DCD sections, the new GEH engineering reports, and the RAI responses. NUREG-1966, Supplement 1, the Supplemental FSER related to the certified ESBWR DCD, Tier 2, Section 3.9.5 replaces in its entirety Section 3.9.5, “Reactor Pressure Vessel Internals,” of the DCD FSER issued on March 9, 2011. Information related to ESBWR reactor pressure vessel (RPV) internals other than the steam dryer (such as core support structures) was copied from the FSER and placed in the Supplemental FSER to provide the description of the staff’s review of all ESBWR RPV internals in one location.

3.9.2 Summary of Application

Section 3.9 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.9 of the ESBWR DCD, Revision 10. In addition, in Fermi 3 COL FSAR, the applicant provides the following:

COL Items

- EF3 COL 3.9.9-1-A — Reactor Internals Vibration Analysis, Measurement and Inspection Program

To address COL Item 3.9.9-1-A, the Fermi 3 COL applicant provides the following supplemental information in FSAR Subsection 3.9.2.4:

> For reactor internals other than the steam dryer, the vibration assessment program, as specified in Regulatory Guide (RG) 1.20, is provided in DCD Appendix 3L and the following referenced GEH Report:
>
> - NEDE-33259P-A, “Reactor Internals Flow Induced Vibration Program”
>
> The classification of the Fermi 3 reactor internals in accordance with RG 1.20 is dependent on ESBWR status, i.e., if Fermi 3 is the initial ESBWR to perform testing of the reactor internals, or if testing is performed at another reactor prior to Fermi 3 testing. There are two different scenarios:

1. A valid prototype for the Fermi 3 reactor internals does not exist. Under this scenario, Fermi 3 reactor internals classification is a prototype per RG 1.20.

2. A valid prototype for Fermi 3 reactor internals does exist. If the prototype testing is performed outside the United States, the guidance in RG 1.20, Revision 3, Regulatory Position 1.2, would need to be satisfied in order for this reactor to be considered a “valid prototype.” Assuming that Fermi 3 reactor internals are substantially similar to the valid prototype and that the valid prototype does not experience inservice problems that result in component or operational modifications, Fermi 3 reactor internals will be classified as non-prototype Category I. If a change to classification for Fermi 3 reactor internals is later determined to be necessary, the classification change will be addressed at the time the change is proposed with proper evaluation/justification and documented in a revision to the FSAR.

Specific to the steam dryer, the comprehensive vibration assessment program, as specified in RG 1.20, is provided in DCD Appendix 3L and the following referenced GEH reports:

- NEDE-33312P, “ESBWR Steam Dryer Acoustic Load Definition”

- NEDE-33313P, “ESBWR Steam Dryer Structural Evaluation”

- NEDE-33408P, “ESBWR Steam Dryer- Plant Based Load Evaluation Methodology, PBLE01 Model Description”

Unlike the overall classification for the reactor internals described above, the steam dryer is definitively classified as a prototype according to RG 1.20, Revision 3. Section 10.2 of NEDE-33313P provides four elements of a steam dryer Comprehensive Vibration Assessment Program that must be addressed. The following describes the approach for the steam dryer Comprehensive Vibration Assessment Program elements, consistent with RG 1.20 and Section 10.2 of NEDE-33313P:

1. The ESBWR steam dryer Comprehensive Vibration Assessment Program is described in DCD Section 3.9, DCD Appendix 3L, and NEDE-33313P, Section 10.0, which includes a description for preparing and submitting to the NRC a Steam Dryer Monitoring Plan no later than 90 days before startup.

2. The detailed design of the steam dryer will follow the methodology described in DCD Appendix 3L and the incorporated engineering reports. As described in NEDE-33313P, Section 10.2(b), an example of a steam dryer predicted analysis that concludes the steam dryer will not exceed stress limits with applicable bias and uncertainties and the minimum alternating stress ratio of 2.0 is provided in NEDE-33408P. The final detailed design of the ESBWR steam dryer has not yet been completed. Therefore, the example of an as-designed steam dryer that has been subject to the predicted analysis process and successful startup testing

described in NEDE-33408P serves as the design analysis report for the steam dryer and provides sufficient information for licensing. The post licensing commitments in ITAAC and license conditions confirm the acceptability of the ESBWR steam dryer design.

3. The startup program and associated license conditions that include appropriate notification points during power ascension, providing data to the NRC at certain hold points and at full power, and providing to the NRC a full stress analysis report and evaluation within 90 days of reaching the full power level, are established in accordance with NEDE-33313P, Section 10.2(c).

4. Periodic steam dryer inspection during refueling outages is as described in NEDE-33313P, Section 10.2(d), and associated license conditions.

In addition, in FSAR Subsection 3.9.2.4, the applicant identifies two commitments—COM 3.9-001 and COM 3.9-006—related to the development of a comprehensive vibration assessment and the associated reports. These commitments are listed later in this section.

- STD COL 3.9.9-2-A ASME Class 2 or 3 or Quality Group D Components with 60-Year Design Life

To address COL 3.9.9-2-A, the Fermi 3 COL applicant adds the following two commitments in FSAR Subsection 3.9.3.1:

Commitment (COM 3.9-002):

The equipment stress reports identified in this DCD section will be completed within six months of completion of DCD ITAAC Table 3.1-1.

Commitment (COM 3.9-004):

The FSAR will be revised as necessary in a subsequent update to address the results of this analysis.

- STD COL 3.9.9-3-A Inservice Testing Programs

To address COL Item 3.9.9-3-A, the Fermi 3 COL applicant specifies FSAR provisions to supplement ESBWR DCD, Tier 2, Section 3.9.6, "Inservice Testing of Pumps and Valves." For example, the Fermi 3 FSAR specifies that in addition to the provisions in ESBWR DCD, Tier 2, Section 3.9.6, milestones for implementing the ASME *Code for Operation and Maintenance of Nuclear Power Plants* (OM Code) preservice and inservice testing programs are defined in FSAR Section 13.4. In addition to the provisions in ESBWR DCD, Tier 2, Subsection 3.9.6.1, "Inservice Testing of Valves," the Fermi 3 FSAR specifies that valves are subject to preservice testing. In addition to the provisions in ESBWR DCD, Tier 2, Subsection 3.9.6.1.4, "Valve Testing," the Fermi 3 FSAR provides additional provisions for valve exercise tests. The Fermi 3 FSAR also specifies additional provisions for the design and qualification process for explosively actuated valves. In addition to the power-operated valve test provisions in ESBWR DCD, Tier 2, Subsection 3.9.6.1.5, "Specific Valve Test Requirements," the Fermi 3 FSAR refers to Subsection 3.9.6.8 for additional (non-Code) testing of power-operated valves as discussed in Regulatory Issue Summary (RIS) 2000-03, "Resolution of Generic Safety Issue 158:

Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions." In addition to the check valve exercise test provisions in ESBWR DCD, Tier 2, Subsection 3.9.6.1.5, the Fermi 3 FSAR specifies that check valve testing includes verification that obturator movement is in the direction required for the valve to perform its safety function. The Fermi 3 FSAR also includes additional check valve test provisions for (1) acceptance criteria, (2) a disassembly examination program where test methods are impractical, (3) nonintrusive diagnostic techniques, (4) post-maintenance testing, (5) preoperational testing, and (6) data collection for testing and inspections. In addition to the provisions in ESBWR DCD, Tier 2, Subsection 3.9.6.5, "Valve Replacement, Repair and Maintenance," the Fermi 3 FSAR provides additional provisions for determining new reference values. In addition to the provisions in ESBWR DCD, Tier 2, Subsection 3.9.6.8, "Non-Code Testing of Power-Operated Valves," the Fermi 3 FSAR provides additional provisions for performing periodic tests of power-operated valves that are consistent with the guidance in NRC RIS 2000-03.

- STD COL 3.9.9-4-A Snubber Inspection and Test Program

To address COL Item 3.9.9-4-A, the Fermi 3 COL applicant specifies FSAR provisions that will supplement ESBWR DCD, Tier 2, Subsection 3.9.3.7.1(3)e, "Snubber Preservice and Inservice Examination and Testing." For example, the Fermi 3 FSAR provides additional provisions to supplement the provisions for preservice examination and testing, and inservice examination and testing, of snubbers in ESBWR DCD, Tier 2, Subsection 3.9.3.7.1(3)e. In addition, the Fermi 3 FSAR provides additional provisions for listing snubber information to supplement ESBWR DCD, Tier 2, Subsection 3.9.3.7.1(3)f, "Snubber Support Data."

In addition, in FSAR Subsection 3.9.3.7.1(3)f, the applicant identifies two commitments (COM 3.9-003 and COM 3.9-005) for preparing a piping and components plant-specific table that will include snubber information and the scheduled update of the FSAR to include snubber information. These commitments are listed later in this section.

Supplemental Information

- STD SUP 3.9-1 10 CFR 50.55a Relief Requests and Code Cases

The Fermi 3 FSAR supplements ESBWR DCD, Tier 2, Subsection 3.9.6.6, "10 CFR 50.55a Relief Requests and Code Cases," by specifying that no relief from or alternative to the ASME OM Code is being requested.

- STD SUP 3.9-2 Risk-Informed Inservice Testing

The Fermi 3 FSAR supplements ESBWR DCD, Tier 2, Section 3.9.7, "Risk-Informed Inservice Testing," by specifying that risk informed inservice testing is not being utilized.

- STD SUP 3.9-3 Risk-Informed Inservice Inspection of Piping

The Fermi 3 FSAR supplements ESBWR DCD, Tier 2, Section 3.9.8, "Risk-Informed Inservice Inspection of Piping," by stating that "risk informed inservice inspection is not being utilized."

Commitments

Fermi 3 FSAR Section 3.9 includes the following commitments for specific components:

Commitment (COM 3.9-001):

Fermi 3 FSAR Section 3.9.2.4: For reactor internals other than the steam dryer, the comprehensive vibration assessment program will be developed and implemented as described in DCD Appendix 3L with no departures. The vibration measurement and inspection programs will comply with the guidance specified in RG 1.20, Revision 3, consistent with the Fermi 3 reactor internals classification. A summary of the vibration analysis program and description of the vibration measurement (including measurement locations and analysis predictions) and inspection phases of the comprehensive vibration inspection program will be submitted to the NRC six months prior to implementation.

Commitment (COM 3.9-002):

Fermi 3 FSAR Section 3.9.3.1: The equipment stress reports identified in this DCD section will be completed within six months of completion of DCD ITAAC Table 3.1-1.

Commitment (COM 3.9-003):

Fermi 3 FSAR Section 3.9.3.7.1(3)f: For the ASME Class 1, 2, and 3 systems listed in DCD Tier 1, Section 3.1, that contain snubbers, a plant-specific table will be prepared in conjunction with the closure of the system-specific ITAAC for piping and component design and will include specific snubber information.

Commitment (COM 3.9-004):

Fermi 3 FSAR Section 3.9.3.1 on stress analysis: The FSAR will be revised as necessary in a subsequent update to address the results of this analysis.

Commitment (COM 3.9-005):

Fermi 3 FSAR Section 3.9.3.7.1(3)f on specific snubber information: This information will be included in the FSAR as part of a subsequent FSAR update.

Commitment (COM 3.9-006):

Fermi 3 FSAR Section 3.9.2.4: For reactor internals other than the steam dryer, the preliminary and final reports (as necessary), which together summarize the results of the vibration analysis, measurement and inspection programs will be submitted to the NRC within 60 and 180 days, respectively, following the completion of the programs.

License Conditions

Part 10 of the Fermi 3 COL application specifies proposed license conditions in such technical areas as the steam dryer, explosively actuated valves, initial test program, and the operational program implementation schedule.

3.9.3 Regulatory Basis

The regulatory basis of the design-related information incorporated by reference is in NUREG-1966 and NUREG-1966, Supplement 1. In addition, the relevant requirements of the Commission regulations for the mechanical systems and components, and the associated acceptance criteria, are listed in Section 3.9 of NUREG-0800 and include the following:

- The guidance associated with the reactor internals startup testing is provided in RG 1.20, (Revision 3), "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing."

- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," GDC 1, "Quality standards and records," which requires (in part) that components important to safety be designed, fabricated, erected, and, tested to quality standards commensurate with the importance of the safety functions to be performed.

- GDC 2, "Design bases for protection against natural phenomena," which requires (in part) that components important to safety be designed to withstand seismic events without a loss of capability to perform their safety functions.

- GDC 4, "Environmental and dynamic effects design bases," which requires that SSCs important to safety be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operations, maintenance, testing, and postulated pipe ruptures including loss-of-coolant accidents.

- GDC 14, "Reactor coolant pressure boundary," which requires that the RCPB be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage; rapidly propagating failures; and gross ruptures.

- GDC 15, "Reactor coolant system design," which requires that the reactor coolant system and associated auxiliary, control, and protection systems be designed with sufficient margins to assure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including anticipated operational occurrences.

- 10 CFR Part 50, Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," as it relates to the suitability of the plant design bases for mechanical components established in consideration of site seismic characteristics.

The regulatory basis for the staff's review of the Fermi 3 FSAR is provided by 10 CFR Parts 50 and 52. Specifically, the NRC regulations in 10 CFR 52.79(a)(11) require that a COL application provide a description of the programs and their implementation necessary to ensure that the systems and components meet the requirements of the ASME Boiler and Pressure Vessel Code (BPV Code) and the ASME OM Code, in accordance with 10 CFR 50.55a. As discussed in the ESBWR DCD FSER, GDC 1, 2, 4, 14, 15, 37, "Testing of emergency core cooling system"; 40, "Testing of containment heat removal system"; 43, "Testing of containment atmospheric cleanup system"; 46, "Testing of cooling water system"; and 54, "Piping systems penetrating containment"; in Appendix A to 10 CFR Part 50 establish the necessary design, fabrication, construction, testing, and performance requirements for SSCs that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. The quality assurance (QA) criteria in 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," provide assurance that the design, tests, and documentation related to functional design, qualification, and inservice testing (IST) programs for pumps, valves, and dynamic restraints will comply with established standards and criteria; thereby ensuring that such equipment will be capable of performing the intended functions.

RG 1.206 provides guidance for a COL applicant in preparing and submitting the COL application in accordance with NRC regulations. For example, Section C.IV.4 in RG 1.206 discusses the requirement in 10 CFR 52.79(a) that descriptions of operational programs need to be included in the FSAR for a COL application to allow reasonable assurance for a finding of acceptability. In particular, a COL applicant should fully describe the IST and other operational programs defined in Commission Paper SECY-05-0197, "Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria," to avoid the need for ITAAC for operational programs. The term "fully described" for an operational program should be understood to mean that the program is clearly and sufficiently described in terms of scope and level of detail to allow a reasonable assurance finding. Further, operational programs should be described at a functional level with an increasing level of detail, where implementation choices could materially and negatively affect the program's effectiveness and acceptability. In the SRM for SECY-05-0197 dated February 22, 2006, the Commission approved the SECY—including the use of a license condition for operational program implementation milestones that are fully described or referenced in the FSAR.

The staff's review of the Fermi 3 COL application followed the applicable guidance in SRP Section 3.9. Fermi 3 FSAR Table 1.9-201, "Conformance with Standard Review Plan," specifies that the COL application conform to the subsections in SRP Section 3.9. The staff also compared the Fermi 3 FSAR information with the guidance in RG 1.206, as listed in Fermi 3 FSAR Table 1.9-203, "Conformance with the FSAR Content Guidance in RG 1.206."

3.9.4 Technical Evaluation

As documented in NUREG–1966 and in NUREG-1966, Supplement 1, the NRC staff reviewed and approved Section 3.9 of the ESBWR DCD. The staff reviewed Section 3.9 of the Fermi 3 COL FSAR and checked the referenced ESBWR DCD to ensure that the combination of the information in the COL FSAR and the information in the ESBWR DCD appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

The staff reviewed the information in the Fermi 3 COL FSAR as follows:

<u>COL Items</u>

- EF3 COL 3.9.9-1-A — Reactor Internals Vibration Analysis, Measurement and Inspection Program

DCD COL Item 3.9.9-1-A in Section 3.9.9 of the ESBWR DCD states that the COL applicant will perform the following:

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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 COL application that references a design certification.

(1) For the reactor internals, other than steam dryer, classify its reactor per the guidance in RG 1.20 and provide a milestone for submitting a description of the inspection and measurement programs to be performed (including measurement locations and analysis predictions) and the results of the vibration analysis, measurement and test program (Subsection 3.9.2.4).

(2) For the steam dryer, which is classified as a prototype per the guidance in RG 1.20, (a) provide a milestone of no later than 90 days before startup to prepare and provide to the NRC a Steam Dryer Monitoring Plan as described in NEDE-33313P, Section 10; (b) submit or reference a steam dryer predicted analysis (for the plant-specific or a sample steam dryer) that concludes the steam dryer will not exceed stress limits with applicable bias and uncertainties and the minimum alternating stress ratio (MASR) of 2.0; (c) describe startup program (with proposed license conditions) that includes appropriate notification points during power ascension, and submittal of the completed analysis of steam dryer data within 90 days following completion of the power ascension testing and monitoring of the steam dryer; and (d) specify periodic steam dryer inspections during refueling outages (Subsection 3.9.2.4).

To address COL Item 3.9.9-1-A, the applicant states in FSAR Subsection 3.9.2.4 that the vibration assessment program for reactor internals other than the steam dryer, as specified in RG 1.20, is provided in ESBWR DCD Appendix 3L and NEDE-33259P-A ADAMS Accession No. ML091660432 (non-public proprietary version), ADAMS Accession No. ML091660433 (transmittal letter), and ADAMS Accession No. ML091660434 (public version). In addition, the classification of the Fermi 3 reactor internals in accordance with RG 1.20 is dependent on the ESBWR status (i.e., whether Fermi 3 or another reactor before Fermi 3 is the initial ESBWR to test the reactor internals).

Specific to the steam dryer, the comprehensive vibration assessment program, as specified in RG 1.20 is provided in ESBWR DCD Appendix 3L, NEDE-33312P (ADAMS Accession No. ML13344B163), NEDE-33313P (ADAMS Accession No. ML13344B164), and NEDE-33408P (ADAMS Accession No. ML13344B176).

The steam dryer is classified as a prototype according to RG 1.20, Revision 3, and the applicant presents an approach that is consistent with RG 1.20 and Section 10.2 of NEDE-33313P, including four elements of a steam dryer Comprehensive Vibration Assessment Program (CVAP) that must be addressed.

The staff reviewed the classification of the Fermi 3 reactor internals. The Fermi 3 classification of the reactor internals has two scenarios. In the first scenario, the Fermi 3 reactor internals are classified as the ESBWR prototype for testing the reactor internals. In the second scenario, should a CVAP for an ESBWR unit other than Fermi 3 be completed and approved by the NRC as a valid prototype before the initiation of startup testing at Fermi 3, the Fermi 3 reactor internals will be classified as non-prototype Category I. As described in NUREG-1966, Supplement 1, the Supplemental FSER related to the certified ESBWR DCD, Tier 2, Section 3.9.5, the steam dryer will be classified as a prototype regardless of the presence of another ESBWR unit. The staff finds the classification approach for the Fermi 3 reactor internals to be acceptable because the classification of the reactor internals for Fermi 3 is consistent with RG 1.20, and the classification of the steam dryer as a prototype regardless of the presence of another ESBWR unit is conservative.

For reactor internals (other than the steam dryer) to be installed in Fermi 3, the staff finds the review and acceptance of the CVAP specified in the ESBWR DCD to be acceptable as described in NUREG-1966, Supplement 1, the supplemental FSER related to the certified ESBWR DCD, Tier 2, Section 3.9.5. Therefore, the staff finds the portion of COL Item 3.9.9-1-A related to the reactor internals (other than the steam dryer) for Fermi 3 to be satisfied.

For the steam dryer, a description of the staff's review and acceptance of the ESBWR steam dryer evaluation methodology is in NUREG-1966, Supplement 1, the Supplemental FSER related to the certified ESBWR DCD, Tier 2, Section 3.9.5. The Fermi 3 FSAR specifies the COL applicant's actions that are necessary to satisfy the portion of COL Item 3.9.9-1-A related to the steam dryer. For the Fermi 3 steam dryer —Item (a) of COL Item 3.9.9-1-A— the CVAP to be applied is described in ESBWR DCD, Tier 2, Section 3.9 and Appendix 3L and in NEDE-33313P, Section 10.0. The CVAP includes preparing and submitting to the NRC a Steam Dryer Monitoring Plan (SDMP) no later than 90 days before startup. For Item (b) of COL Item 3.9.9-1-A, the detailed design of the Fermi 3 steam dryer will follow the methodology described in DCD Appendix 3L and in the incorporated engineering reports. As described in NEDE-33313P, Section 10.2(b), an example of a steam dryer predictive analysis that concludes the steam dryer will not exceed stress limits with the applicable bias and uncertainties and the minimum alternating stress ratio of 2.0 is provided in NEDE-33408P. The example of an as-designed steam dryer that was subject to the predictive analysis process and successful startup testing described in NEDE-33408P serves as the design analysis report for the steam dryer and provides sufficient information for licensing. For Item (c) of COL Item 3.9.9-1-A, the Fermi 3 startup program is based on NEDE-33313P, Section 10.2(c), which includes (1) providing appropriate notification points during power ascension; (2) providing data to the NRC at certain hold points and at full power; and (3) providing a full stress analysis report and evaluation to the NRC within 90 days of reaching the full power level. For Item (d) of COL Item 3.9.9-1-A, the periodic steam dryer inspection program for Fermi 3 during refueling outages is described in NEDE-33313P, Section 10.2(d). Part 10 of the Fermi 3 COL application provides a proposed license condition for the steam dryer startup program and the periodic inspection program.

The NRC staff has reviewed the actions specified in the Fermi 3 FSAR for each of the individual portions of COL Item 3.9.9-1-A regarding the steam dryer. The staff determined that the Fermi 3 FSAR actions related to the steam dryer satisfy the provisions in ESBWR DCD, Tier 2 and NEDE-33312P, NEDE-33313P, and NEDE-33408P incorporated in the ESBWR DCD as accepted in NUREG-1966, Supplement 1 on ESBWR DCD, Tier 2, Section 3.9.5. These Fermi 3 actions include application of the CVAP for the steam dryer described in the ESBWR DCD, Tier 2 and NEDE-33313P, reference of the example steam dryer predictive analysis in NEDE-33408P, preparation of a Fermi 3 startup program that incorporates the steam dryer monitoring plan in NEDE-33313P, and specification of a periodic steam dryer inspection program consistent with NEDE-33313P. The Fermi 3 steam dryer monitoring and inspection program will be verified by the license condition specified later in this SER section. The staff notes that the license condition proposed in this SER, as compared to the model condition proposed in NEDE-33313P, has been reformatted to better conform with standard license condition format and has been rewritten for clarity and to remove redundancy. Some of these changes resulted in minor changes in substance, such as more clearly specifying power levels for steam dryer monitoring and methods for informing the NRC of the results of monitoring. The staff reviewed and accepted the ESBWR DCD and its referenced engineering reports on the steam dryer as part of the NRC review of the ESBWR design certification application. Therefore, the staff finds that the actions specified by the Fermi 3 COL applicant satisfy the steam dryer portion of COL Item 3.9.9-1-A.

The NRC staff notes that the ESBWR DCD identifies specific portions of the information on the structural integrity and functional capability of mechanical systems and components to be Tier 2* information. As part of this identification of Tier 2* information, the ESBWR DCD identifies Tier 2, Section 3.9.2.3 as well as the GEH engineering reports NEDE-33312P, NEDE-33313P, and NEDE-33408P on the ESBWR steam dryer incorporated by reference in the DCD as Tier 2* in their entirety. Therefore, the Fermi 3 steam dryer evaluation methodology will be implemented as Tier 2* information in accordance with the ESBWR design certification.

In FSAR Subsection 3.9.2.4, the Fermi 3 COL applicant identifies two commitments—COM 3.9-001 and COM 3.9-006—related to the development of a comprehensive vibration assessment and the associated reports. The NRC staff finds that the commitments are consistent with the provisions in the ESBWR DCD as accepted by the NRC as part of its ESBWR design certification review. These commitments provide an additional mechanism for additional licensee tracking of activities related to the comprehensive vibration assessment program. The NRC staff has reviewed and approved this program under the ESBWR DCD; in addition, license conditions exist for the most critical elements of the program related to the steam dryer, and license conditions and NRC inspections are already planned in conjunction with the initial test program (ITP). Therefore, the use of a commitment to track completion of these activities is acceptable.

Based on the review described above, the staff finds that the Fermi 3 COL applicant has satisfied the provisions in COL Item COL 3.9.9-1-A. The staff discusses the applicable license conditions related to reactor internals for Fermi 3 later in this SER section. The staff finds that the information related to reactor internals classification and testing adequately meets RG 1.20 guidance and NRC regulatory requirements and is thus acceptable.

- STD COL 3.9.9-2-A — ASME Class 2 or 3 or Quality Group D Components with 60-Year Design Life

DCD COL Item 3.9.9-2-A in Section 3.9.9 of the ESBWR DCD states the following:

> The COL Applicant will provide a milestone for completing the required equipment stress reports, per ASME BPV Code, Subsection NB, for equipment segments that are subject to loadings that could result in thermal or dynamic fatigue and for updating the FSAR, as necessary, to address the results of the analysis (Subsection 3.9.3.1).

Fermi 3 COL FSAR, Revision 7, Subsection 3.9.3.1, “Loading Combinations, Design Transients and Stress Limits,” states that the required equipment stress reports will be completed within 6 months of the completion of DCD ITAAC Table 3.1-1 (Commitment 3.9-002). In addition, the Fermi 3 FSAR specifies that the FSAR will be revised as necessary in a subsequent update to address the results of this analysis in Commitment 3.9-004. The staff observes that in order to complete the referenced ITAAC related to the pipe break analyses listed in DCD Tier 1, Table 3.1-1, the applicant will first perform equipment and piping stress analyses that support the determination of pipe break locations. Additional ITAAC related to the completion of component and piping stress analyses in accordance with ASME BPV Code requirements are in DCD Tier 1. Furthermore, in both a public teleconference on February 20, 2014 (ADAMS Accession No. ML14078A005), and a letter dated February 28, 2014 (ADAMS Accession No. ML14064A283), the applicant clarified that there are currently no non-Class 1 components subjected to cyclic loadings of a magnitude and/or duration so severe that the 60-year design life cannot be assured. Therefore, the staff finds that no supplemental information that provides an analysis or design per the Tier 2* provisions of ESBWR DCD, Tier 2, Subsection 3.9.3.1, is necessary at this time. The staff also observes that the original basis for including these requirements in the ESBWR DCD related to the NRC staff's concerns regarding environmentally assisted fatigue, which have been resolved through the final staff position in RG 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due To the Effects of the Light-Water Reactor Environment for New Reactors," which is committed to in ESBWR DCD, Tier 2, Section 3.9.1. Therefore, the applicant has provided an acceptable milestone related to the development of the required equipment stress reports, as requested in the COL item. The use of Commitments 3.9-002 and 3.9-004 to track these activities is acceptable to the staff, as they address one detail of the overall stress analysis that will be confirmed through completion of ITAAC related to ASME BPV Code requirements, as well as periodic FSAR updates required by the regulations. Licensing and inspection processes are already in place to provide final verification of these overall activities. Based on the provision of a reasonable milestone in response to the COL item and the associated ITAAC, the staff thus finds the applicant's response to COL Item 3.9.9-2-A acceptable.

- STD COL 3.9.9-3-A Inservice Testing Programs

This COL item is related to the functional design, qualification, and IST Programs for pumps, valves, and dynamic restraints. The NRC staff reviewed the Fermi 3 COL application and the applicable sections in the ESBWR DCD incorporated by reference in the Fermi 3 FSAR for the functional design, qualification, and IST Programs for safety-related pumps, valves, and dynamic restraints to determine whether the Fermi 3 COL application meets the regulatory requirements to provide reasonable assurance that the applicable safety-related components at Fermi 3 will be capable of performing their safety functions. In response to RAIs on the ESBWR design certification (DC) application, GEH revised the ESBWR DCD to specify provisions for the IST Programs to support COL applications referencing the ESBWR design. Detroit Edison notified the NRC in letters dated February 16, 2009; July 19, 2010; and September 21, 2010 (ADAMS Accession Nos. ML102660145, ML090620123, and ML102660145, respectively), that Detroit Edison had assumed the role of the reference COL (R-COL) application for the ESBWR design and adopted the RAI responses related to FSAR Section 3.9.6 provided by Dominion Power for the previous R-COL application plant. The staff's review of the description of the IST Programs for Fermi 3 is as follows:

COL Item 3.9.9-3-A in Section 3.9.9 of the ESBWR DCD states the following:

> The COL Applicant shall provide a full description of the IST Program and a milestone for full program implementation as identified in Subsection 3.9.6.1.

The staff reviewed Section 3.9.6 of the ESBWR DCD. The staff's technical evaluation included the information incorporated by reference related to the functional design, qualification, and IST Programs for safety-related pumps, valves, and dynamic restraints. The evaluation is documented in NUREG-1966, the staff's FSER for the ESBWR DC application. ESBWR DCD, Tier 2, Section 3.9.6 provides a general description of the IST Operational Programs to be developed for an ESBWR plant.

ESBWR DCD Subsection 3.9.3.5, "Valve Operability Assurance," describes the process for the functional design and qualification of valves to be used in the ESBWR. Subsection 3.9.3.5 in ESBWR DCD, Tier 2 specifies that valve designs not previously qualified will meet the requirements of ASME Standard QME-1-2007, "Qualification of Active Mechanical Equipment

Used in Nuclear Power Plants." For valve designs previously qualified to standards other than ASME QME-1-2007, ESBWR DCD, Tier 2, Subsection 3.9.3.5 specifies an approach for valve qualification that follows the key principles of ASME QME-1-2007. The Fermi 3 FSAR incorporates by reference this section of the ESBWR DCD without supplemental information. The NRC issued Revision 3 to RG 1.100, "Seismic Qualification of Electric and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," which accepts the use of ASME QME-1-2007 for the functional design and qualification of pumps, valves, and dynamic restraints, with certain conditions. Based on the lessons learned from valve research and operating experience incorporated in ASME QME-1-2007 as accepted in Revision 3 to RG 1.100, the staff found the provisions in the ESBWR DCD for the functional design and qualification of safety-related valves to be acceptable.

ESBWR DCD, Tier 2, Section 3.9.6, "Inservice Testing of Pumps and Valves," provides a general description of the IST Program to be developed for an ESBWR plant. DCD Tier 2, Table 1.9-22 specifies that the ASME OM Code (2001 Edition through the 2003 Addenda) is the basis for the IST Program to be described in COL applications referencing the ESBWR design. ESBWR DCD, Tier 2, Table 3.9-8, "Inservice Testing," provides a list of the valves and other information to be included in the IST Program for an ESBWR plant, such as the valve number; quantity; description; valve and actuator type; ASME Code Class and category; valve function; normal, safety, and fail-safe positions; containment isolation function; and test parameters and frequencies. The ESBWR does not include safety-related, motor-operated valves (MOVs).

As part of the response to COL Item 3.9.9.3-A, the applicant provides supplemental information in the Fermi 3 FSAR on the IST Program for Fermi 3. For example, the Fermi 3 FSAR describes the overall IST Program, preservice testing, power-operated valve testing, and check valve testing. The Fermi 3 COL FSAR does not identify any additional plant-specific valves to be included in the IST Program beyond those listed in ESBWR DCD, Tier 2, Table 3.9-8. ESBWR DCD, Tier 2, Subsection 3.9.6.1.4, "Valve Testing," references NUREG–1482 (Revision 1), "Guidelines for Inservice Testing at Nuclear Power Plants." Following the issuance of the Fermi 3 COL, the guidance in NUREG–1482, (Revision 2 issued in October 2013) can be used to develop the IST Program for Fermi 3, including the specific information to be included in IST Program documentation and tables for NRC inspection.

The staff reviewed the description of the ASME OM Code requirements in the Fermi 3 FSAR on the IST Program that supplements the provisions in the ESBWR DCD. For example, Fermi 3 FSAR Subsection 3.9.6.1 describes the IST provisions for the (a) establishment of reference values; (b) prohibition of preconditioning that undermines the purpose of IST activities; (c) comparisons of stroke time to the reference value, except for fast-acting valves assigned a stroke time limit of 2 seconds; (d) testing of solenoid-operated valves; (e) preoperational testing of check valves; (f) acceptance criteria for check valve tests; (g) use of nonintrusive techniques for check valve tests; (h) test conditions for the check valve tests; (i) post-maintenance testing for the check valves; (j) check valve disassembly and testing; (k) re-establishment of reference values following maintenance; and (l) valve replacement, repair, and maintenance. The staff finds the Fermi 3 FSAR to be consistent with Subsection ISTC, "Inservice Testing of Valves in Light-Water Reactor Nuclear Power Plants," of the ASME OM Code incorporated by reference in 10 CFR 50.55a, and therefore, the FSAR description of the use of ASME OM Code, Subsection ISTC, is acceptable.

ESBWR DCD, Tier 2, Section 3.9.6 specifies that the IST of the applicable ASME BPV Code, Section III, Class 1, 2, and 3 pumps and valves will be performed in accordance with the ASME

OM Code required by 10 CFR 50.55a(f), including limitations and modifications set forth in 10 CFR 50.55a. ESBWR DCD, Tier 2, Section 3.9.10, “References,” specifies the application of the 2001 Edition with the 2003 Addenda of the ASME OM Code for use in the ESBWR design. The Fermi 3 FSAR incorporates these provisions by reference in the ESBWR DCD.

Supplemental Information STD SUP 3.9-1 to Fermi 3 FSAR Subsection 3.9.6.6 specifies that no relief from or alternative to the ASME OM Code is being requested beyond what is identified in the DCD. The ASME OM Code (2001 Edition through 2003 Addenda) is incorporated by reference in 10 CFR 50.55a of the NRC regulations with certain limitations and modifications. Therefore, the staff considers the application of the ASME OM Code, 2001 Edition through 2003 Addenda, as specified in the NRC regulations with applicable limitations and modifications, to be acceptable for the Fermi 3 IST Program description. As specified in 10 CFR 50.55a, a COL licensee is required to incorporate in the IST Program the latest edition and addenda of the ASME OM Code approved in 10 CFR 50.55a(f), on the date 12 months before initial fuel load.

The ESBWR DCD specifies that the ESBWR reactor design does not require the use of pumps to mitigate the consequences of design-basis accidents or to achieve or maintain a safe-shutdown condition. Therefore, the IST Program for the ESBWR design does not include any pumps. As indicated in a GEH response to RAI 3.9-152 (MFN 06-489) dated November 30, 2006 (ADAMS Accession No. ML063460294), post-accident long-term decay heat removal for the ESBWR is performed by nonsafety-related systems as accepted in Commission paper SECY-94-084, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-safety Systems [RTNSS] in Passive Plant Designs.” The availability of systems relied on after 72 hours that is addressed under the RTNSS Program is discussed in Chapter 19.0, “Probabilistic Risk Assessment and Severe Accidents,” of the Fermi 3 SER.

In RAI 03.09.06-1 for the previous R-COL application plant, the staff requested Dominion to discuss the process for implementing the provisions specified in ESBWR DCD, Tier 2, Subsection 3.9.3.5 for the functional design and qualification of valves and dynamic restraints. In a letter dated February 16, 2009 (ADAMS Accession No. ML090620123), Detroit Edison adopted Dominion’s RAI response dated September 11, 2008, specifying that GEH is responsible for the design and qualification of mechanical equipment including valves and dynamic restraints. In July 2009, the staff conducted an audit of the design and procurement specifications for valves and environmental qualification (EQ) at the GEH office in Wilmington, NC. The purpose of the audit was to confirm the implementation of the ESBWR DCD provisions for the design and qualification of applicable pumps, valves, and dynamic restraints and to support the full description of the IST and EQ operational programs provided by COL applicants. As discussed in an NRC memorandum dated September 1, 2009 (ADAMS Accession No. ML092390403) documenting the results of the July 2009 audit, the staff reviewed ESBWR DCD IST Table 3.9-8 and several design and purchase specifications for various valve types. The audit identified specific provisions of the ESBWR DCD IST Table and component specifications that needed to be clarified regarding aspects such as the valve types identified in the IST Program Table and the consideration of lessons learned from valve operating experience. In the response to the audit follow-up items in a letter dated September 21, 2009 (ADAMS Accession Number ML092650083), GEH indicated that the ESBWR DCD IST Table and component specifications would be revised to incorporate the necessary clarifications identified during the audit. In a letter dated November 12, 2009 (ADAMS Accession No. ML093170020), GEH discussed its review of Revision 3 to RG 1.100 for any necessary modifications to its valve specifications that reference the application of ASME Standard QME-1-2007. As indicated in the GEH response to the audit follow-up actions, GEH revised the ESBWR DCD (beginning with Revision 6) to include the necessary clarifications to the DCD IST

Table identified during the audit. On March 19, 2010, the staff conducted a follow-up audit at the GEH office in Washington, DC, to review the implementation of the actions specified by GEH in the letter dated September 21, 2009. Based on that GEH letter and the NRC follow-up audit conducted on March 19, 2010, the staff considers that GEH has resolved the audit follow-up actions related to the functional design and qualification of valves in support of the ESBWR DCD. The staff finds that the ESBWR DCD provisions for the functional design and qualification of valves are being implemented in the component specifications in an adequate manner to support the Fermi 3 COL application. Therefore, RAI 03.09.06-1 is resolved.

In RAI 03.09.06-2 for the previous R-COL application plant, the staff requested Dominion to clarify the ASME OM Code edition and addenda that are the basis for the IST Program described in the COL application. In a letter dated February 16, 2009 (ADAMS Accession No. ML090620123), Detroit Edison adopted Dominion's RAI response dated September 11, 2008, which indicates that the ASME OM Code, 2001 Edition with the 2003 Addenda, is the basis for the IST Program for the R-COL application plant. The staff finds that the RAI response clarifies the specific ASME OM Code edition and addenda to be used in describing the IST Program for the Fermi 3 COL application. Therefore, RAI 03.09.06-2 is resolved.

RAI 03.09.06-3 for the previous R-COL application plant requested Dominion to discuss (1) the provisions in the FSAR for the periodic verification of air-operated valve (AOV) capability; (2) the application of lessons learned from valve performance to power-operated valves (POVs) other than AOVs; and (3) the basis for the statement in FSAR Section 3.9.6 that post-maintenance procedures are applied where high-risk valve performance could be affected. In a letter dated February 16, 2009 (ADAMS Accession No. ML090620123), Detroit Edison adopted Dominion's RAI response dated September 11, 2008, which discussed the IST Program for AOVs and other POVs (with the exception of safety-related MOVs, which are not used in the ESBWR design). As a result, Fermi 3 FSAR Section 3.9.6 describes the incorporation of lessons learned from valve experience at operating nuclear power plants into the AOV IST Program for Fermi 3. The Fermi 3 FSAR supplements the ESBWR DCD with a description of the testing program for POVs to be used at Fermi 3. For example, the AOV program will include the key elements of the Joint Owners Group AOV Program discussed in RIS 2000-03, which also references the staff's comments on the program. Among the key lessons learned in the AOV Program, the Fermi 3 FSAR specifies that periodic dynamic testing of AOVs will be performed (if necessary) to re-verify the capability of the valve to perform its required functions based on valve qualification or operating experience. The Fermi 3 FSAR states that the attributes of the AOV Testing Program are applied to other POVs to the extent that they apply to and can be implemented for those valves. The Fermi 3 FSAR also clarifies that post-maintenance procedures ensure that baseline testing is re-performed as necessary, when maintenance on the valve (such as valve repair or replacement) has the potential to affect valve functional performance. The staff finds that the provisions included in the Fermi 3 FSAR to supplement the ESBWR DCD are sufficient to apply the lessons learned from valve testing to the POV Testing Program at Fermi 3. Therefore, RAI 03.09.06-3 is resolved.

ESBWR DCD, Tier 2, Subsection 3.9.3.7, "Component Supports," discusses piping supports; spring hangers; struts; and snubbers (dynamic restraints). To address COL Item 3.9.9-4 A, the Fermi 3 FSAR provides supplemental information on the snubber Inservice Examination and Testing Program. In particular, the Fermi 3 FSAR specifies that the program will satisfy ASME OM Code, Subsection ISTD, and provides specific examples of the program content to supplement the ESBWR DCD.

ESBWR DCD, Tier 2, Subsection 3.9.3.7.1, "Piping Supports," specifies provisions for snubber design, testing, installation, and preservice examination and testing. For example, ESBWR DCD, Tier 2, Subsection 3.9.3.7.1 states in paragraph c, "Snubber Design and Testing," that the codes and standards used for snubber qualification and production testing are the ASME BPV Code (Section III and Subsection NF); the ASME OM Code (Subsection ISTD); and the ASME Standard QME-1-2007 (Subsection QDR). ESBWR DCD, Tier 2, Subsection 3.9.3.7.1 states in paragraph e, "Snubber Pre-service and In-service Examination and Testing," that the COL applicant will provide a full description of the snubber IST Program. In ESBWR DCD, Tier 2, Section 3.9.9, COL Item STD COL 3.9.9-4-A specifies that the COL applicant shall provide a full description of the snubber preservice and inservice inspection and testing programs and a milestone for program implementation, including development of a data table identified in Subsection 3.9.3.7.1(3)f. Fermi 3 FSAR Section 3.9.9 states that COL Item STD COL 3.9.9-4-A is discussed in Subsections 3.9.3.7.1(3)e and f. Table 1.9-203 in the Fermi 3 FSAR states that the COL application conforms to paragraph C.III.1.3.9.6.4 of RG 1.206, with the exception that a plant-specific snubber table will be prepared in conjunction with the closure of ITAAC Table 3.1-1. Section 3.9 in the Fermi 3 FSAR describes the snubber Inservice Examination and Testing Program. This description specifies that the program will satisfy ASME OM Code, Subsection ISTD, and includes specific examples of the program content to supplement the ESBWR DCD. The staff reviewed the description of the IST Program for dynamic restraints in comparison to ASME OM Code, Subsection ISTD. As discussed below regarding COL Item 3.9.9-4-A, the staff has reviewed the description of the snubber Inservice Examination and Testing Program provided in the Fermi 3 FSAR and the referenced provisions in the ESBWR DCD. The staff determined that the description of the Fermi 3 snubber Inservice Examination and Testing Program is consistent with the ASME OM Code, Subsection ISTD, as incorporated by reference in 10 CFR 50.55a. Therefore, the staff finds that the Fermi 3 FSAR and the ESBWR DCD provide an acceptable description of the Operational Program for Dynamic Restraints at Fermi 3 in support of the Fermi 3 COL application.

In RAI 03.09.06-4 for the previous R-COL application plant, the staff requested Dominion to clarify the reference to ASME BPV Code, Section XI, with respect to snubbers that are described in paragraph 3(b) of ESBWR DCD, Tier 2, Subsection 3.9.3.7.1. In a letter dated February 16, 2009 (ADAMS Accession No. ML090620123), Detroit Edison adopted Dominion's RAI response dated September 11, 2008, which referenced an RAI response from GEH indicating that the specifications referring to ASME BPV Code, Section XI, would be deleted from this section in ESBWR DCD, Tier 2. Subsequently, the staff found that the revised ESBWR DCD, Tier 2 is consistent with the RAI response. Therefore, RAI 03.09.06-4 is resolved.

Fermi 3 FSAR Section 13.4 indicates that FSAR Table 13.4-201, "Operational Programs Required by NRC Regulations," lists each operational program; the regulatory source for the program; the associated implementation milestones; and the FSAR section that fully describes the operational program (as discussed in RG 1.206). FSAR Table 13.4-201 specifies the implementation milestone for the IST Program as "after generator online on nuclear heat." The implementation milestone for the Preservice Testing (PST) Program is specified as "prior to fuel load." A note in FSAR Table 13.4-201 specifies that the "snubber inservice examination is initially performed not less than two months after attaining 5 % reactor power operation and will be completed within 12 calendar months after attaining 5 % reactor power."

In RAI 03.09.06-5 for the previous R-COL application plant, the staff requested Dominion to discuss the commencement of the PST Program. In a letter dated February 16, 2009 (ADAMS Accession No. ML090620123), Detroit Edison adopted Dominion's RAI response dated

September 11, 2008, which states that the COL will contain a license condition that requires the licensee to submit to the NRC a schedule that supports planning for and conducting NRC inspections of operational programs (including the PST Program). The schedule will be submitted 12 months after the issuance of the COL and will be updated every 6 months until 12 months before the scheduled fuel loading, and every month thereafter until either the operational programs listed in FSAR Table 13.4-201 are fully implemented or the plant is placed in commercial service—whichever comes first. According to the RAI response, commencement of PST will be concurrent with the operational status of the equipment and the readiness to support PST, with completion of the PST before fuel load as indicated in FSAR Table 13.4-201. This provision is indicated to mean, for example, that the installation of the valves in the piping system must be complete—along with most of the piping system—when the valve power and controls are in place to support valve operation. Further, any post-installation construction testing and valve setup activities (such as setting torque or limit switches; lubricating the valve; packing installation; or adjustment) must be complete. The accomplishment of these activities will depend on the plant construction and turnover schedules. The staff finds that the RAI response clarifies the commencement of the PST Program. As discussed later in this SER section, the licensee will submit a schedule that supports planning and conducting NRC inspections of operational programs, including the PST Program listed in Fermi 3 FSAR Table 13.4-201. Based on this license condition (License Condition 03.09-01), the staff will be aware of the commencement of the PST Program in preparation for NRC inspection activities. Therefore, RAI 03.09.06-5 is resolved.

In RAI 03.09.06-6 for the previous R-COL application plant, the staff requested Dominion to describe the planned implementation of the program to address potential adverse flow effects on safety-related valves and dynamic restraints within the IST Program in the reactor coolant, steam and feedwater systems from hydraulic loading and acoustic resonance during plant operation. In a letter dated February 16, 2009 (ADAMS Accession No. ML090620123), Detroit Edison adopted Dominion’s RAI response dated September 11, 2008, (ADAMS Accession No. ML082730754) stating the intent to use the overall ITP (including preoperational and startup testing) to address potential adverse flow effects on safety-related valves and dynamic restraints. As discussed in the RAI response, the objective of the program is to confirm the attributes of the component design as indicated in the ESBWR DCD, with implementation described in FSAR Section 14.2 and Table 13.4-201. ESBWR DCD, Tier 2, Section 3.9.2, “Dynamic Testing and Analysis of Systems, Components, and Equipment,” addresses criteria; testing procedures; and dynamic analyses employed to ensure the structural and functional integrity of piping systems, mechanical equipment, reactor internals, and their supports under vibratory loadings. ESBWR DCD, Tier 2, Subsection 3.9.2.1, “Piping Vibration, Thermal Expansion and Dynamic Effects,” states that the overall testing program is divided into the preoperational test phase and the initial startup test phase where piping vibration, thermal expansion, and dynamic effects testing are performed during both phases, as described in ESBWR DCD, Tier 2, Chapter 14. ESBWR DCD, Tier 2, Subsection 3.9.2.1.1, “Vibration and Dynamic Effects Testing,” states that the purpose of these tests is to confirm that the piping, components, restraints, and supports of specified high and moderate energy systems have been designed to withstand the dynamic effects of steady-state flow-induced vibration (FIV) and anticipated operational transient conditions. The DCD specifies that vibration testing will be performed in accordance with ANSI/ASME OM-S/G-1990, Part 3, “Requirements for Preoperational and Initial Start-up Vibration Testing of Nuclear Power Plant Piping Systems.” ESBWR DCD, Tier 2, Subsection 3.9.3.5 requires valve specifications to incorporate lessons learned from nuclear power plant operations and research programs—including applicable load combinations. ESBWR DCD, Tier 2, Subsections 3.9.3.7 and 3.9.3.8 require analyses or tests for component supports to assure that their structural capability will withstand seismic and other dynamic excitations. ESBWR DCD, Tier 2, Section 3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment," addresses methods of testing and analyses employed to ensure the operability of mechanical and electrical equipment under the full range of normal and accident loadings, to ensure conformance with NRC regulations. ESBWR DCD, Tier 2, Subsection 14.2.8.1.42, "Expansion, Vibration and Dynamic Effects Preoperational Test," states that its objective is to verify that critical components and piping runs are properly installed and supported, so that expected steady-state and transient vibration and movement due to thermal expansion do not result in excessive stress or fatigue to safety-related plant systems and equipment. ESBWR DCD, Tier 2, Subsection 14.2.8.2.10, "System Vibration Test," describes the applicable preoperational and startup tests for plant systems.

Based on the above information, the staff finds that the ESBWR DCD includes provisions to address potential adverse flow effects for safety-related valves and dynamic restraints at Fermi 3 that reflect nuclear power plant operating experience. The staff reviewed the qualification provisions for potential adverse flow effects as part of the audit of ESBWR design and procurement specifications discussed in this SER section. In Part 10, "ITAAC," of the Fermi 3 COL application, the Fermi 3 COL applicant in Section 3.2, "License Conditions for Initial Test Program," specifies a detailed license condition related to the startup administrative manual, preoperational and startup test procedures, power ascension test phase reports, and test changes. In Chapter 14.0, "Initial Test Program," of this SER, the staff describes its review of the Fermi 3 ITP including the proposed license conditions in Part 10 of the Fermi 3 COL application. The Fermi 3 COL applicant's use of the ITP to address potential adverse flow effects on plant components through implementation of the provisions in ESBWR DCD, Tier 2, Chapter 14 will be verified as part of future NRC inspections at Fermi 3. Therefore, RAI 03.09.06-6 is resolved.

Subsection ISTC-5260, "Explosively Actuated Valves," in the ASME OM Code specifies that at least 20 percent of the charges in explosively actuated (i.e., squib) valves shall be fired and replaced at least once every 2 years. If a charge fails to fire, the ASME OM Code states that all charges with the same batch number shall be removed, discarded, and replaced with charges from a different batch. In light of the updated design and safety significance of squib valves in new reactors, the need for improved surveillance activities for squib valves is being considered by the nuclear industry; ASME; and U.S. and international nuclear regulators. In RAI 03.09.06-1 for the Fermi 3 COL application, the staff requested Detroit Edison to describe its plans for addressing the surveillance of squib valves that will provide reasonable assurance of the operational readiness of those valves to perform their safety functions in support of the Fermi 3 COL application. In a letter dated November 9, 2010 (ADAMS Accession No. ML103140611), Detroit Edison submitted a planned revision to Fermi 3 COL FSAR Section 3.9.6 to specify that industry and regulatory guidance will be considered in the development of the IST Program for squib valves. Detroit Edison indicated that the FSAR would also state that the IST Program for squib valves will incorporate lessons learned from the design and qualification process for these valves, such that surveillance activities provide reasonable assurance of the operational readiness of squib valves to perform their safety functions. The staff found that the planned changes to the Fermi 3 COL FSAR are sufficient to describe the IST Program for squib valves for incorporating the lessons learned from the design and qualification process in developing surveillance activities that will provide reasonable assurance of the operational readiness for squib valves to perform their safety functions. In Fermi 3 COL FSAR (Revision 3 through Revision 7), Subsection 3.9.6.1.4, "Valve Testing"; Item (4), "Special Tests," includes the provisions for surveillance of squib valves as specified in the RAI response. Therefore, RAI 03.09.06-1 is closed.

As discussed later in this SER section, the staff has prepared License Condition 03.09-2 directing the implementation of a surveillance program for squib valves in the gravity-driven cooling system and the automatic depressurization system at Fermi 3 prior to fuel load to supplement the IST requirements in the ASME OM Code, consistent with the licensing of other passive design new reactors. The staff considers the application of the ASME OM Code as incorporated by reference in 10 CFR 50.55a prior to startup of Fermi 3 to be sufficient for squib valves in the standby liquid control (SLC) system at Fermi 3, without the additional provisions of License Condition 03.09-2 that are necessary for the gravity driven cooling system and automatic depressurization system, based on operating experience with SLC squib valves in current boiling-water reactor nuclear power plants.

- STD COL 3.9.9-4-A Snubber Inspection and Test Program

DCD COL Item 3.9.9-4-A in Section 3.9.9 of the ESBWR DCD states the following:

> The COL Applicant shall provide a full description of the snubber preservice and inservice inspection and testing programs, and a milestone for program implementation, including development of a data table identified in Subsection 3.9.3.7.1(3)f (Subsection 3.9.3.7.1(3)e).

The staff reviewed the applicant's information related to the snubber preservice and inservice examination and testing programs included under Subsection 3.9.3.7.1(3)e of the Fermi 3 COL FSAR, which states the following:

> A preservice thermal movement examination is also performed; during initial system heatup and cooldown, for systems whose design operating temperature exceeds 121°C (250°F), snubber thermal movement is verified.
>
> Additionally, preservice operational readiness testing is performed on all snubbers. The operational readiness test is performed to verify the parameters of ISTD-5120. Snubbers that fail the preservice operational readiness test are evaluated to determine the cause of failure, and are retested following completion of corrective action(s).
>
> Snubbers that are installed incorrectly or otherwise fail preservice testing requirements are re-installed correctly, adjusted, modified, repaired or replaced, as required. Preservice examination and testing is re-performed on installation-corrected, adjusted, modified, repaired or replaced snubbers as required.
>
> Inservice examination and testing of all safety-related snubbers is conducted in accordance with the requirements of the ASME OM Code, Subsection ISTD. Inservice examination is initially performed not less than two months after attaining 5 percent reactor power operation and will be completed within 12 calendar months after attaining 5 percent reactor power. Subsequent examinations are performed at intervals defined by ISTD-4252 and Table ISTD-4252-1. Examination intervals, subsequent to the third interval, are adjusted based on the number of unacceptable snubbers identified in the then current interval.
>
> An inservice visual examination is performed on all snubbers to identify physical damage, leakage, corrosion, degradation, indication of binding, misalignment or

deformation and potential defects generic to a particular design. Snubbers that do not meet visual examination requirements are evaluated to determine the root cause of the unacceptability, and appropriate corrective actions (e.g., snubber is adjusted, repaired, modified, or replaced) are taken. Snubbers evaluated as unacceptable during visual examination may be accepted for continued service by successful completion of an operational readiness test.

Snubbers are tested inservice to determine operational readiness during each fuel cycle, beginning no sooner than 60 days before the scheduled start of the applicable refueling outage. Snubber operational readiness tests are conducted with the snubber in the as-found condition, to the extent practical, either in place or on a test bench, to verify the test parameters of ISTD-5210. When an in-place test or bench test cannot be performed, snubber subcomponents that control the parameters to be verified are examined and tested. Preservice examinations are performed on snubbers after reinstallation when bench testing is used (ISTD-5224), or on snubbers where individual subcomponents are reinstalled after examination (ISTD-5225).

Defined test plan groups (DTPG) are established and the snubbers of each DTPG are tested according to an established sampling plan each fuel cycle. Sample plan size and composition are determined as required for the selected sample plan, with additional sampling as may be required for that sample plan based on test failures and failure modes identified. Snubbers that do not meet test requirements are evaluated to determine root cause of the failure, and are assigned to failure mode groups (FMG) based on the evaluation, unless the failure is considered unexplained or isolated. The number of unexplained snubber failures not assigned to an FMG determines the additional testing sample. Isolated failures do not require additional testing. For unacceptable snubbers, additional testing is conducted for the DTPG or FMG until the appropriate sample plan completion criteria are satisfied.

Unacceptable snubbers are adjusted, repaired, modified, or replaced. Replacement snubbers meet the requirements of ISTD-1600. Post-maintenance examination and testing, and examination and testing of repaired snubbers, is done to ensure that test parameters that may have been affected by the repair or maintenance activity are verified acceptable.

Service life for snubbers is established, monitored and adjusted as required by ISTD-6000 and the guidance of ASME OM Code, Non-mandatory Appendix F.

In Commitment 3.9-003, the Fermi 3 applicant specifies in the Fermi 3 FSAR that for the ASME Class 1, 2, and 3 systems listed in DCD Tier 1, Section 3.1, that contain snubbers, a plant-specific table will be prepared in conjunction with the closure of the system-specific ITAAC for piping and component design and will include specific snubber information.

In Commitment 3.9-005, the Fermi 3 applicant specifies in the Fermi 3 FSAR that this information will be included in the FSAR as part of a subsequent FSAR update.

The staff finds that the provisions specified in the Fermi 3 FSAR on the snubber inspection and test program together with the ESBWR DCD provisions incorporated by reference in the Fermi 3 FSAR adequately describe the snubber inspection and test program as consistent with the

ASME OM Code provisions in accordance with Commission policy to review a description of the operational programs (including the snubber IST program) in support of the COL application review. As indicated in License Condition 03.09-01 specified later in this SER section, the licensee will submit a schedule that supports planning and conducting NRC inspections of operational programs. During inspections of the Fermi 3 operational programs, the staff will confirm that the PST and IST Operational Programs (including the snubber program) have been established consistent with the Fermi 3 FSAR and this SER section, including completion of the applicable commitments specified in the Fermi 3 FSAR. Therefore, COL Item 3.9.9-4-A is satisfied.

Supplemental Information

The Fermi 3 COL application also provides three instances of standard supplemental information in Section 3.9. In Section 3.9.6.6, STD SUP 3.9-1 states that no relief from or alternative to the ASME OM Code is being requested. In Section 3.9.7, STD SUP 3.9-2 states that risk-informed IST is not being utilized, replacing a statement in the ESBWR DCD that risk-informed IST initiatives, if any, are included in IST Program implementation plans. Similarly, in Section 3.9.8, STD SUP 3.9-3 states that risk-informed inservice inspection is not being utilized, replacing a statement in the ESBWR DCD that initiatives for risk-informed inservice inspection of piping, if any, are included in inservice inspection implementation plans. All three of these supplemental statements confirm that the Fermi 3 applicant intends to follow the processes for ASME OM Code implementation, IST Program implementation, and inservice inspection implementation described in the ESBWR DCD, as supplemented in the Fermi 3 COL application and evaluated as described in this SER section. Therefore, the staff finds this supplemental information acceptable.

Interfaces for Standard Design

ESBWR DCD, Tier 2, Section 1.8, "Interfaces with Standard Design," identifies site-specific interfaces with the standard ESBWR design. DCD Table 1.8-1, "Matrix of NSSS Interfaces," references Section 3.9 for the supporting interface areas of mechanical SSCs. The staff reviewed the Fermi 3 COL application for interface requirements with the ESBWR standard design regarding the functional design, qualification, and IST Programs for safety-related valves and dynamic restraints using the review procedures described in SRP Section 3.9.6. The staff finds that the applicant's consideration of design interface items is acceptable based on compliance with NRC regulations discussed in this SER section.

License Conditions

The staff's review of the Fermi 3 COL application determined the need for three license conditions related to mechanical systems and components described in Fermi 3 FSAR Section 3.9. These conditions are listed in Section 3.9.5, "Post Combined License Activities," of this SER.

3.9.5 Post Combined License Activities

License Conditions

The staff's review of the Fermi 3 COL application determined the need for the following three license conditions related to mechanical systems and components described in Fermi 3 FSAR Section 3.9:

License Condition 03.09-01: FSAR Section 13.4 indicates that FSAR Table 13.4-201 lists each operational program, the regulatory source for the program, the associated implementation milestones, and the FSAR section where the operational program is fully described, as discussed in RG 1.206. RG 1.206, Regulatory Position Section C.IV.4.3 states that the COL will contain a license condition that requires the licensee to submit to the NRC a schedule that supports planning and conducting NRC inspections of operational programs. The schedule must be submitted 12 months after the NRC issues the COL. The schedule will be updated every 6 months, until 12 months before scheduled fuel loading, and every month thereafter until either the operational programs in FSAR Table 13.4-201 have been fully implemented or the plant has been placed in commercial service, whichever comes first.

License Condition 03.09-02: Consistent with the licensing of other passive design new reactors, the NRC staff has prepared a license condition directing the implementation of a surveillance program for squib valves in the gravity driven cooling system (GDS) and the automatic depressurization system (ADS) at Fermi 3 prior to fuel load to supplement the IST requirements in the ASME OM Code. The license condition is as follows:

Before initial fuel load, the licensee shall implement a surveillance program for explosively actuated valves (squib valves) in the GDS and the ADS at Fermi 3 that includes the following provisions in addition to the requirements specified in the ASME *Code for Operation and Maintenance of Nuclear Power Plants* (OM Code) as incorporated by reference in 10 CFR 50.55a.

a. Preservice Testing

All explosively actuated valves shall be preservice tested by verifying the operational readiness of the actuation logic and associated electrical circuits for each explosively actuated valve with its pyrotechnic charge removed from the valve. This must include confirmation that sufficient electrical parameters (voltage, current, resistance) are available at the explosively actuated valve from each circuit that is relied upon to actuate the valve. In addition, a sample of at least 20 percent of the pyrotechnic charges in all explosively actuated valves shall be tested in the valve or a qualified test fixture to confirm the capability of each sampled pyrotechnic charge to provide the necessary motive force to operate the valve to perform its intended function without damage to the valve body or connected piping. The sampling must select at least one explosively actuated valve from each redundant safety train. Corrective action shall be taken to resolve any deficiencies identified in the operational readiness of the actuation logic or associated electrical circuits, or the capability of a pyrotechnic charge. If a charge fails to fire or its capability is not confirmed, all charges with the same batch number shall be removed, discarded, and replaced with charges from a different batch number that has demonstrated successful 20 percent sampling of the charges.

b. Operational Surveillance

Explosively actuated valves shall be subject to the following surveillance activities after commencing plant operation:

(1) At least once every 2 years, each explosively actuated valve shall undergo visual external examination and remote internal examination (including evaluation and

removal of fluids or contaminants that may interfere with operation of the valve) to verify the operational readiness of the valve and its actuator. This examination shall also verify the appropriate position of the internal actuating mechanism and proper operation of remote position indicators. Corrective action shall be taken to resolve any deficiencies identified during the examination with post-maintenance testing conducted that satisfies the PST requirements.

(2) At least once every 10 years, each explosively actuated valve shall be disassembled for internal examination of the valve and actuator to verify the operational readiness of the valve assembly and the integrity of individual components and to remove any foreign material, fluid, or corrosion. The examination schedule shall provide for each valve design used for explosively actuated valves at the facility to be included among the explosively actuated valves to be disassembled and examined every 2 years. Corrective action shall be taken to resolve any deficiencies identified during the examination with post-maintenance testing conducted that satisfies the PST requirements.

(3) For explosively actuated valves selected for test sampling every 2 years in accordance with the ASME OM Code, the operational readiness of the actuation logic and associated electrical circuits shall be verified for each sampled explosively actuated valve following removal of its charge. This must include confirmation that sufficient electrical parameters (voltage, current, resistance) are available for each valve actuation circuit. Corrective action shall be taken to resolve any deficiencies identified in the actuation logic or associated electrical circuits.

(4) For explosively actuated valves selected for test sampling every 2 years in accordance with the ASME OM Code, the sampling must select at least one explosively actuated valve from each redundant safety train. Each sampled pyrotechnic charge shall be tested in the valve or a qualified test fixture to confirm the capability of the charge to provide the necessary motive force to operate the valve to perform its intended function without damage to the valve body or connected piping. Corrective action shall be taken to resolve any deficiencies identified in the capability of a pyrotechnic charge in accordance with the PST requirements.

This license condition shall expire upon (1) incorporation of the above surveillance provisions for explosively actuated valves into the facility's inservice testing program, or (2) incorporation of inservice testing requirements for explosively actuated valves in new reactors (i.e., plants receiving a construction permit, or COL for construction and operation, after January 1, 2000) to be specified in a future edition of the ASME OM Code as incorporated by reference in 10 CFR 50.55a, including any conditions imposed by the NRC, into the facility's inservice testing program.

This license condition supplements the current requirements in the ASME OM Code for explosively actuated valves, and sets forth requirements for both pre-service testing and operational surveillance, as well as any necessary corrective action. The license condition will expire when either (1) the license condition is incorporated into the Fermi 3 IST program; or (2) the updated ASME OM Code requirements for squib valves in new reactors, as accepted by the NRC in 10 CFR 50.55a, are incorporated into the Fermi 3 IST program. For the purpose of satisfying the license condition, the licensee retains the option of including in its IST program either the requirements stated in this condition, or including updated ASME Code requirements.

<u>License Condition 03.09-03</u>: Steam Dryer Monitoring Plan

1. The licensee shall prepare a Steam Dryer Monitoring Plan (SDMP) and submit the SDMP to the NRC no later than 90 days before the scheduled date for initial fuel loading.

2. The licensee shall provide Power Ascension Test (PAT) procedures for steam dryer monitoring to the NRC resident inspectors at least 10 days before the scheduled date for initial fuel loading. The PAT procedures must include the following:

    - Level 1 and Level 2 acceptance limits, as defined in Report NEDE-33313P (Revision 5, December 2013), for on-dryer strain gage and on-dryer accelerometer measurements to be used up to 100 percent power;
    - The power levels at which the steam dryer will be monitored (subject to Conditions 3 and 4) during power ascension, and the duration of monitoring at each power level;
    - A description of activities to be accomplished during monitoring at each power level;
    - Plant parameters to be monitored;
    - A description of the actions to be taken if acceptance criteria are not satisfied; and
    - A description of the process for verification of the completion of commitments and planned actions specified in the PAT procedures.

3. The licensee shall complete the actions specified in Item 2 of the model license condition specified in paragraph (c) of Section 10.2, "Comprehensive Vibration Program Elements for a COL Applicant," in NEDE-33313P (Revision 5) between 65 and 75 percent thermal power.

4.. DTE shall measure, record, and evaluate pressures, strains, and accelerations from the steam dryer instrumentation at power levels approximately 5 percent higher than the previous power level at which DTE measured, recorded, and evaluated such parameters until 100 percent thermal power is reached. DTE shall generate data trending and a projection of strain levels for each successive power level, including full power. DTE shall use data trending analysis to assess whether the Level 1 or Level 2 acceptance limits would be exceeded at the next higher power level for which the PAT specifies monitoring. DTE shall provide the data trending results and revised limit curves to the NRC project manager by facsimile or electronic transmission.

5. At each power level for which Conditions 3 and 4 require steam dryer monitoring, DTE shall measure and record pressure, strain, and acceleration responses over a range of plant conditions sufficient to confirm that loading and fatigue effects from

normal variations in plant conditions at power levels up to and including 100 percent thermal power will not adversely affect the life of the dryer. DTE shall include its evaluation of steam dryer performance during such variations in plant conditions, including during Power Maneuvering in the Feedwater Temperature Operating Domain testing, in the dryer structural response as part of the full stress analysis report described in Condition 9 below.

6. If a flow-induced resonance is identified at any power level at which Conditions 3 and 4 require steam dryer monitoring, and the strains or vibrations exceed the pre-determined Level 1 or Level 2 limit curve, DTE shall cease power ascension until completing the actions specified in Item 5 of the model license condition specified in paragraph (c) of Section 10.2 in NEDE-33313P (Revision 5) and the following:

   a. If a Level 1 limit curve is exceeded, DTE shall reduce power to the last power level at which DTE performed steam dryer monitoring pursuant to Conditions 3 and 4 and at which the Level 1 limit curve was not exceeded. DTE shall perform a stress analysis to develop a new Level 1 limit curve before increasing power to the next level at which Conditions 4 requires steam dryer monitoring.

   b. If a Level 2 limit curve is exceeded, or if data trending indicates that a Level 1 limit curve may be challenged before the next power level at which Conditions 4 requires steam dryer monitoring is reached, DTE shall evaluate the Level 1 and Level 2 limit curves and perform a stress analysis that demonstrates that the stress acceptance limits are satisfied at the higher power level before power is increased.

7. DTE shall determine end-to-end bias and uncertainties by comparing the predicted and measured strain or acceleration on the steam dryer at each power level at which DTE performs steam dryer monitoring pursuant to Conditions 3 and 4 and confirm the conservatism of the predicted dryer stress field. At each such power level, DTE shall adjust the predicted strain and acceleration responses using the frequency-dependent end-to-end bias errors and uncertainty values. If any of the measured sensor data at that power level exceeds the adjusted predictions, DTE shall either (A) modify the bias errors and uncertainty values and limit curves and ensure measured sensor responses do not exceed the adjusted predictions, or (B) quantitatively evaluate the effect on fatigue life.

8. At the initial power level at which Condition 3 requires steam dryer monitoring and at approximately 85 and 95 percent power, DTE shall provide the steam dryer data analysis and results to the NRC project manager by facsimile or electronic transmission; and shall not exceed the power level at which it performed the steam dryer monitoring for at least 72 hours after the NRC project manager has confirmed receipt of the transmission.

9.. DTE shall provide data collected from the steam dryer monitoring required by Condition 4 at 100 percent power to the NRC project manager by facsimile or electronic transmission within 72 hours of completing the collection of that data, with receipt confirmation from the NRC project manager. DTE shall submit a full stress analysis report and evaluation to the NRC document control desk in accordance with 10 CFR 52.4 within 90 days of first reaching 100 percent thermal power. The report must include the minimum stress ratio and the final dryer load definition using steam dryer data, and associated bias errors and uncertainties, and must demonstrate that the steam dryer will maintain its structural integrity over its design life considering variations in plant parameters, including, but not limited to, reactor pressure and core flow rate. If the structural integrity of the steam dryer for the full plant life is not demonstrated by the stress analysis, DTE shall describe its compensatory actions, such as future dryer replacement, in the stress analysis report.

10. The licensee shall implement a periodic steam dryer inspection program as follows:

    a. During the first two refueling outages after first reaching 100 percent thermal power, DTE shall perform a visual inspection of all accessible areas and susceptible locations of the steam dryer in accordance with industry guidance on steam dryer inspections in the latest NRC staff-approved version of BWRVIP-139-A, "BWR Vessel and Internals Project, Steam Dryer Inspection and Flaw Evaluation Guidelines," with any conditions or limitations specified in the NRC staff approval. The results of these baseline inspections shall be submitted to the NRC within 60 days following startup after each outage.

    b. At the end of the second refueling outage after reaching 100 percent thermal power, DTE shall update the Steam Dryer Monitoring Program to include a long-term inspection plan based on plant-specific and industry operating experience, and shall submit the updated program to the NRC within 180 days following startup from the second refueling outage.

In addition to the above three license conditions, the NRC staff notes that, as discussed earlier in this SER section, Part 10 of the Fermi 3 COL application lists a detailed license condition for the ITP that includes activities to address COL Item STD COL 14.2.3-A, "Preoperational and Startup Test Procedures." This license condition will ensure that the COL licensee implements the ITP, which includes the reactor internals initial start-up FIV testing.

Commitments

In Section 3.9 of the Fermi 3 FSAR, the applicant specifies the following commitments:

- Commitment (COM 3.9-001) – For reactor internals other than the steam dryer, the comprehensive vibration assessment program will be developed and implemented as described in DCD Appendix 3L with no departures. The vibration measurement and inspection programs will comply with the guidance specified in RG 1.20, Revision 3, consistent with the Fermi 3 reactor internals classification. A summary of the vibration analysis program and description of the vibration measurement (including measurement locations and analysis predictions) and inspection phases of the comprehensive vibration inspection program will be submitted to the NRC six months prior to implementation.

- Commitment (COM 3.9-002) – The equipment stress reports identified in this DCD section will be completed within six months of completion of DCD ITAAC Table 3.1-1.

- Commitment (COM 3.9-003) – For the ASME Class 1, 2, and 3 systems listed in DCD, Tier 1, Section 3.1, that contain snubbers, a plant-specific table will be prepared in conjunction with the closure of the system-specific ITAAC for piping and component design and will include the following specific snubber information.

- Commitment (COM 3.9-004) – The FSAR will be revised as necessary in a subsequent update to address the results of this analysis.

- Commitment (COM 3.9-005) – This information will be included in the FSAR as part of a subsequent FSAR update.

- Commitment (COM 3.9-006) – For reactor internals other than the steam dryer, the preliminary and final reports (as necessary), which together summarize the results of the vibration analysis, measurement and inspection programs will be submitted to the NRC within 60 and 180 days, respectively, following the completion of the programs.

<u>*ITAAC*</u>

ESBWR DCD, Tier 1 includes numerous ITAAC to verify the acceptability of the as-built mechanical systems and components at Fermi 3. A sample of the ITAAC related to the Fermi 3 steam dryer includes the following:

ESBWR DCD, Tier 1, Table 2.1.1-3, "ITAAC for the Reactor Pressure Vessel and Internals"

ITAAC Item 8b. The RPV internal structures listed in Table 2.1.1-1 (chimney and partitions, chimney head and steam separators assembly, and steam dryer assembly) meet the requirements of ASME BPV Code, Subsection NG-3000, except for the weld quality and fatigue factors for secondary structural non-load bearing welds.

ITAAC Item 12. The number and locations of pressure sensors installed on the steam dryer for startup testing ensure accurate pressure predictions at critical locations.

ITAAC Item 13. The number and locations of strain gages and accelerometers installed on the steam dryer for startup testing are capable of monitoring the most highly stressed components, considering accessibility and avoiding discontinuities in the components.

ITAAC Item 14. The number and locations of accelerometers installed on the steam dryer for startup testing are capable of identifying potential rocking and of measuring the accelerations resulting from support and vessel movements.

ITAAC Item 16. The as-built steam dryer predicted peak stress is below the fatigue limitation.
ESBWR DCD, Tier 1, Table 2.1.2-3, "ITAAC for the Nuclear Boiler System"

ITAAC Item 36. The main steam line and SRV/SV [safety relief valve/safety valve] branch piping geometry precludes first and second shear layer wave acoustic resonance conditions from occurring and avoids pressure loads on the steam dryer at plant normal operating conditions.

With respect to the ESBWR steam dryer, NEDE-33313P specifies Tier 2* provisions for the COL licensee to complete the design and construction of the steam dryer for an ESBWR nuclear power plant. For example, Section 9.1, "Instrumentation for Monitoring Steam Dryer Response," in NEDE-33313P describes the process to meet ITAAC Items 12, 13, and 14 in DCD Tier 1, Table 2.1.1-3, for the installation of pressure sensors; strain gages; and accelerometers on the as-built steam dryer to monitor its performance during power ascension. Section 10.1.1, "Steam Dryer Design Analysis Report," in NEDE-33313P specifies the elements for the as-designed ESBWR steam dryer analysis report. Section 10.1.2, "Steam Dryer As-Built

Analysis Report," in NEDE-33313P specifies the process to satisfy ITAAC Item 16 in DCD Tier 1, Table 2.1.1-3, for verifying that the as-built steam dryer fatigue analysis provides at least a minimum alternating stress ratio (MASR) of 2.0 to the allowable alternating stress intensity of 93.7 MPa (13,600 psi). Appendix A, "ITAAC for Reactor Pressure Vessel Internals," to NEDE-33313P describes the process to meet ITAAC Item 8b in DCD Tier 1, Table 2.1.1-3, so as to provide assurance that the reactor internal structures will meet the provisions of ASME BPV Code, Subsection NG-3000, except for the weld quality and fatigue factors for secondary structural non-load bearing welds. Appendix B, "ITAAC for Main Steam Line and SRV/Safety Valve Branch Piping Acoustic Resonance," to NEDE-33313P describes the process to meet ITAAC 36 in DCD Tier 1, Table 2.1.2-3, to provide assurance that the main steam line and SRV/SV branch piping geometry will preclude first and second shear layer wave acoustic resonance conditions from occurring and avoids excessive pressure loads on the steam dryer at plant normal operating conditions. These post COL activities for the ESBWR steam dryer will be performed by the COL licensee for Fermi 3, as described by the Tier 2* provisions in the ESBWR DCD and its referenced engineering reports, unless the COL licensee obtains regulatory approval for an alternative process.

3.9.6 Conclusion

The NRC staff reviewed Fermi 3 FSAR Section 3.9 and the provisions specified in ESBWR DCD, Tier 2, Section 3.9 that are incorporated by reference in the Fermi 3 FSAR for structural integrity and functional capability of mechanical systems and components for the Fermi 3 nuclear power plant. The staff review of the information provided in Section 3.9 of the ESBWR DCD, Tier 2 is provided in the FSER on the ESBWR design certification applicant as modified by NUREG-1966, Supplement 1 on Section 3.9.5 of the ESBWR DCD, Tier 2. Based on its review, the staff concludes that the Fermi 3 COL applicant has provided reasonable assurance that mechanical systems and components to be installed in Fermi 3 will have the structural integrity and functional capability to perform their design functions for the safe operation of the Fermi 3 nuclear power plant.

3.10 Seismic and Dynamic Qualification of Mechanical and Electrical Equipment

3.10.1 Introduction

Seismic and dynamic qualification of seismic Category I equipment include the following types:

- Safety-related active mechanical equipment that performs a mechanical motion while accomplishing a system safety-related function. Examples include pumps, valves, and valve operators.
- Safety-related, non-active mechanical equipment whose mechanical motion is not required while accomplishing a system safety-related function, but whose structural integrity must be maintained in order to fulfill its design safety-related function.
- Safety-related instrumentation and electrical equipment and certain monitoring equipment.

Mechanical and electrical equipment (including instrumentation and controls and where applicable, their supports) classified as seismic Category I must demonstrate that they are capable of performing their intended safety-related functions under the full range of normal and accident (including seismic) loadings. This equipment includes devices associated with systems that are essential to safe shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing a significant release of radioactive material into the environment or in mitigating the consequences of accidents.

The criteria for the seismic and dynamic qualification include the following considerations:

- Adequacy of seismic and dynamic qualification input motions.
- Methods and procedures for qualifying electrical equipment, instrumentation, and mechanical components.
- Methods and procedures for qualifying supports of electrical equipment, instrumentation, and mechanical components.
- Documentation.

3.10.2 Summary of Application

Section 3.10 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.10 of the ESBWR DCD, Revision 10. In addition, in FSAR Section 3.10, the applicant provided the following:

COL Items

- STD COL 3.10.4-1-A — Dynamic Qualification Report

In FSAR Subsection 3.10.1.4, the applicant adds Commitment (COM 3.10-001), Commitment (COM 3.10-002), and Commitment (COM 3.10-003) to develop the dynamic qualification report ITAAC and an implementation schedule for the ITAAC.

Supplemental Information

- STD SUP 3.10-1 — Quality Assurance Program for Equipment Qualification

In FSAR Subsection 3.10.1.4, the applicant states that the Fermi 3 QA Program is in FSAR Section 17.5, including requirements for handling safety-related quality records; control of purchased material, equipment, and services; test control; and other quality related processes.

3.10.3 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 seismic and dynamic qualification of mechanical and electrical equipment, and the associated acceptance criteria are in Section 3.10 of NUREG-0800. Specific requirements include the following:

- GDC 1 and GDC 30, "Quality of reactor coolant pressure boundary," as they relate to qualifying equipment to appropriate quality standards commensurate with the importance of the safety functions to be performed.

- GDC 2 and Appendix S to 10 CFR Part 50, as they relate to designing equipment to withstand the effects of natural phenomena such as earthquakes.

- GDC 4 as it relates to qualifying equipment as capable of withstanding the dynamic effects associated with external missiles and internally generated missiles, pipe whip, and jet impingement forces.

- GDC 14, "Reactor coolant pressure boundary," as it relates to qualifying equipment associated with the reactor coolant boundary so that there is an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

- 10 CFR Part 50, Appendix B, as it relates to qualifying equipment using the quality assurance criteria.

- 10 CFR Part 50, Appendix B, Criterion III, as it relates to verifying and checking the adequacy of a design by the performance of a suitable test program (among other options), which specifically requires that a test program used to verify the adequacy of a specific design feature shall include suitable qualification testing of a prototype unit under the most adverse design conditions.

- 10 CFR 52.80(a), which requires that a COL application to contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act, and NRC's regulations.

3.10.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.10 of the certified ESBWR DCD. The staff reviewed Section 3.10 of the Fermi 3 COL FSAR, Revision 7, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 7, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

Section 1.2.3 of this SER provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on the standard content that were documented in the SER with open items issued for the North Anna Unit 3

[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 COL application that references a design certification.

application were equally applicable to the Fermi 3 COL application, the staff undertook the following reviews:

- The staff compared the North Anna 3 COL FSAR, Revision 1, to the Fermi 3 COL FSAR. In performing this comparison, the staff considered changes to the Fermi 3 COL FSAR (and other parts of the COL application, as applicable) resulting from RAIs and open and confirmatory items identified in the North Anna SER with open items.

- The staff confirmed that the applicant has endorsed all responses to the RAIs identified in the corresponding standard content (the North Anna SER) evaluation.

- The staff verified that the site-specific differences were not relevant to this section.

The staff has completed the review and found the evaluation performed for the North Anna Unit 3standard content to be directly applicable to the Fermi 3 COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting.

The staff reviewed the information in the Fermi 3 COL FSAR, Revision 7, as follows:

COL Items

- STD COL 3.10.4-1-A Dynamic Qualification Report

The staff reviewed the applicant's information related to the dynamic qualification report that was included under Subsection 3.10.1.4 of the Fermi 3 COL FSAR. In this subsection, the applicant adds the following commitments:

- **Commitment (COM 3.10-003**) Detroit Edison shall submit to the NRC, no later than 1 year after issuance of the combined license or at the start of construction as defined in 10 CFR 50.10(a), whichever is later, its implementation schedules for completing of the following ITAACs. Detroit Edison shall submit updates to the ITAAC schedules every 6 months thereafter and, within 1 year of its scheduled date for initial loading of fuel, and shall submit updates to the ITAAC schedules every 30 days until the final notification is provided to the NRC under paragraph (c)(1) of this section [10 CFR 52.99].

- **Commitment (COM 3.10-001)** The Dynamic Qualification Report and documentation that describe the seismic and dynamic qualification methods will be made available for NRC staff review, inspection, and audit. Information that verifies the seismic and dynamic qualification will be made available to the NRC to facilitate reviews, inspections, and audits throughout the process.

- **Commitment (COM 3.10-002)** FSAR information will be revised, as necessary, as part of a subsequent FSAR update.

The staff's review finds that the applicant's response adequately addresses COL Item STD COL 3.10.4-1-A per the guidance in RG 1.206.

Supplemental Information

- STD SUP 3.10-1 — Quality Assurance Program for Equipment Qualification

The staff reviewed the applicant's information related to the QA Program for equipment qualification included under FSAR Subsection 3.10.1.4, which states the following:

> Section 17.5 defines the Quality Assurance Program requirements that are applied to equipment qualification files, including requirements for handling safety-related quality records, control of purchased material, equipment and services, test control, and other quality related processes.

The following portion of this technical evaluation section is reproduced from Subsection 3.10.4, "Technical Evaluation," of the North Anna Unit 3 SER (ADAMS Accession No. ML091730304):

> *The staff reviewed the conformance of Section 3.10 of the North Anna COL FSAR to the guidance in RG 1.206, Chapter 3, Sections C.I.3.10 and C.III.1.3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment." The staff's review of Section 3.10 of the North Anna COL FSAR found that the applicant has appropriately incorporated by reference Section 3.10 of the ESBWR DCD, Revision 5 except that the standard COL item described above is not acceptable in accordance with the guidance in Section C.I.3.10.4 of RG 1.206. RG 1.206 Sections C.I.3.10.4 and C.III.3.10.4 state that the applicant should provide the results of tests and analyses to demonstrate adequate seismic qualification of equipment. However, RG 1.206 acknowledges that this level of detail may not be available and provides an alternative provision for an implementation plan that includes milestones and completion dates.*
>
> *The staff reviewed the North Anna COL FSAR and found that it does not provide either the results of qualification or an implementation plan. This information is necessary for the staff to make a reasonable assurance safety finding for licensing (i.e., to find that the design is in accordance with the regulations). The information included with this plan should address those planning details not addressed in the DCD. Those details include, for example, a listing of the equipment to be qualified, the method of qualification, who will be performing the qualification, the timing, etc. The expectation is that all information for the phases would be completed before procurement would be available for review prior to licensing. For example, the list of equipment and qualification method can be provided now with wording for a license condition which will require provision of the name of the organization qualifying the equipment and details on timing post procurement six months before the qualification process is expected to be completed. It is expected that this information would be available to be audited by the NRC Staff prior to equipment installation. In* ***RAI 3.10-1****, the NRC requested the applicant to provide an implementation plan that includes the level of detail that will be completed prior to procurement and the plan for completing equipment qualification as called for in RG 1.206 and the example described above.*

As indicated above in Fermi 3 COL FSAR, Section 3.10, the applicant provides Commitments COM 3.10-001, COM 3.10-002, and COM 3.10-003 that meet the alternative provision for an implementation plan that includes milestones and completion dates as described in RG 1.206.

Therefore, RAI 3.10-1 is closed. Based on the above evaluation above, the staff finds the information in Supplemental Information Item STD SUP 3.10-1 acceptable.

3.10.5 Post Combined License Activities

The applicant identifies the following commitments:

- **Commitment (COM 3.10-003)** Detroit Edison shall submit to the NRC, no later than 1 year after issuance of the combined license or at the start of construction as defined in 10 CFR 50.10(a), whichever is later, its implementation schedules for completing of the following ITAACs. Detroit Edison shall submit updates to the ITAAC schedules every 6 months thereafter and, within 1 year of its scheduled date for initial loading of fuel, and shall submit updates to the ITAAC schedules every 30 days until the final notification is provided to the NRC under paragraph (c)(1) of this section [10 CFR 52.99].

- **Commitment (COM 3.10-001)** The Dynamic Qualification Report and documentation that describe the seismic and dynamic qualification methods will be made available for NRC staff review, inspection, and audit. Information that verifies the seismic and dynamic qualification will be made available to the NRC to facilitate reviews, inspections, and audits throughout the process.

- **Commitment (COM 3.10-002)** FSAR information will be revised, as necessary, as part of a subsequent FSAR update.

3.10.6 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 NRC staff's review confirms that the applicant has addressed the required information, 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 10 CFR Part 52, Appendix E ,Section VI.B.1, all nuclear safety issues relating to the seismic and dynamic qualification of mechanical and electrical equipment that were incorporated by reference have been resolved.

In addition, the staff compared the additional COL information in the application to the relevant NRC regulations, the guidance in Section 3.10 of NUREG–0800, and other NRC RGs. The staff's review concluded that the applicant has adequately addressed COL Item STD COL 3.10.4-1-A and Supplemental Item STD SUP 3.10-1. Therefore, the staff finds that Fermi 3 COL FSAR, Revision 7, Section 3.10, is acceptable and meets the NRC regulatory requirements and acceptance criteria in Section 3.10 of NUREG-0800 and RG 1.206 including GDC 1, GDC 2, GDC 4, GDC 14 and GDC 30; Appendix S to 10 CFR Part 50, 10 CFR Part 50, Appendix B, Criterion III, and 10 CFR 52.80(a).

3.11 <u>Environmental Qualification of Mechanical and Electrical Equipment</u>

3.11.1 Introduction

This FSAR section describes the EQ Program to be used at Fermi 3 for the electrical and mechanical equipment important to safety. The objective of the EQ Program is to reduce the potential for common failures resulting from specified environmental events and to demonstrate that the equipment within the scope of the EQ Program is capable of performing its intended design function under all conditions, including environmental stresses resulting from design-basis events. During plant operation, the COL licensee implements the EQ Program, which specifies the replacement frequencies of affected safety-related equipment in harsh environments. The EQ Program also addresses nonsafety-related equipment failures under the postulated environmental conditions that could prevent the satisfactory performance of the safety functions of the safety-related equipment, and certain post-accident monitoring equipment.

The equipment important to safety must perform its safety functions under all normal environmental conditions, abnormal operational occurrences, design-basis events, post-design-basis events, and containment test conditions. This capability is demonstrated through qualification testing and analysis of similar equipment under the temperature, pressure, humidity, chemical effects, radiation, and submergence conditions in which the equipment will be expected to operate. The qualification information shall include identification of the equipment required to be environmentally qualified. Each component shall have onsite and in an auditable form, the designated functional requirements; the definition of the applicable environmental parameters; the periodic maintenance to support the qualified life; the accident that the component is required to mitigate; the required operation time; and the documentation of the qualification process employed to demonstrate the required environmental capability. This information shall be maintained and remain current.

3.11.2 Summary of Application

Section 3.11 of the Fermi 3 COL FSAR, Revision 7, incorporates by reference Section 3.11 of the ESBWR DCD, Revision 10. In addition, in FSAR Section 3.11 the applicant provides the following:

COL Items

- STD COL 3.11-1-A Environmental Qualification Documentation

In FSAR Subsection 3.11.4.4 the applicant provides additional information to address COL Item 3.11-1-A. The applicant states that a description of the EQ Program is in ESBWR DCD, Tier 2, Section 3.11. The Fermi 3 FSAR also specifies that the implementation of the EQ Program, including the development of the Environmental Qualification Document (EQD), will be in accordance with the milestone schedule in FSAR Section 13.4, “Operational Program Implementation.”

3.11.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is discussed in NUREG–1966.

The relevant requirements of the Commission regulations for the EQ operational program and EQD and the associated acceptance criteria are in Section 3.11 of NUREG-0800.

The applicable regulatory requirements for the EQD are as follows:

- 10 CFR 50.49, “Environmental qualification of electrical equipment important to safety for nuclear plants,” requires an applicant for a nuclear power plant license to establish a program that qualifies electrical equipment for environmental effects.

- GDC 1 requires components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

- GDC 2 requires components important to safety be designed to withstand the effects of natural phenomena without loss of capability to perform their safety function.

- GDC 4 requires components important to safety be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss of coolant accidents.

- GDC 23, “Protection system failure modes,” requires protection systems to be designed to fail in a safe state, or in a state demonstrated to be acceptable on some other defined basis, if conditions such as postulated adverse environments occur (e.g., extreme heat or cold, pressure, steam, water, or radiation).

- 10 CFR Part 50, Appendix B, Criterion III, “Design Control,” requires measures to be established to ensure that applicable regulatory requirements and the associated design bases are correctly translated into specifications, drawings, procedures, and instructions. These measures should include provisions to ensure that appropriate quality standards are included in design documents and deviations from established standards are controlled. A process should also be established to determine the suitability of equipment that is essential to safety-related functions and to identify, control, and coordinate design interfaces between participating design organizations. Where a testing program is used to verify the adequacy of a specific design feature, the test shall include suitable qualification testing of a prototype unit under the most adverse design conditions.

- 10 CFR Part 50, Appendix B, Criterion XI, “Test Control,” requires a test control plan to be established to ensure that all tests needed to demonstrate a component's performance capability are identified in accordance with required procedures and acceptance limits in the applicable design documents.

- 10 CFR Part 50, Appendix B, Criterion XVII, “Quality Assurance Records,” requires sufficient records to be maintained to furnish evidence of activities affecting quality. The records must include inspections, tests, audits, work performance monitoring, and materials analyses. Records must be identifiable and retrievable.

The related acceptance criteria are as follows:

- In accordance with SECY-05-0197, “Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria,” as accepted in the Commission’s SRM dated February 22, 2006, equipment qualification is an Operational Program that will be reviewed in the COL application. The staff reviews this program to make a reasonable assurance finding on the program. A COL applicant should fully describe the EQ and other

Operational Programs as defined in SECY-05-0197 to avoid the need for ITAAC to implement those programs. The term "fully described" for an operational program should be understood to mean that the program is clearly and sufficiently described in terms for scope and level of detail to allow a reasonable assurance finding of acceptability. Further, Operational Programs should be described at a functional level and an increasing level of detail where implementation choices could materially and negatively affect the program effectiveness and acceptability. The Commission approved the use of a license condition for operational program implementation milestones that are fully described or referenced in the FSAR as discussed in the SRM for SECY-05-0197, dated February 22, 2006.

3.11.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Section 3.11 of the certified ESBWR DCD. The staff reviewed Section 3.11 of the Fermi 3 COL FSAR, Revision 7, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 7, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

The NRC staff reviewed the Fermi 3 COL application and the applicable sections in the ESBWR DCD incorporated by reference into the Fermi 3 FSAR for the description of the EQ Program for mechanical and electrical equipment to determine whether the Fermi 3 COL application meets the regulatory requirements to provide reasonable assurance that the applicable equipment at Fermi 3 will be capable of performing their intended functions. In letters dated February 16, 2009, July 19, 2010, and September 21, 2010, Detroit Edison notified the NRC that it had assumed the role of the referenced COL (R-COL) application for the ESBWR design. Detroit Edison also adopted the RAI responses related to FSAR Section 3.11 that Dominion Power had provided for the previous R-COL plant. The staff's review of the description of the EQ Program for Fermi 3 appears below in this SER section.

The staff reviewed the following information in the Fermi 3 COL FSAR as follows:

COL Items

- STD COL 3.11-1-A Environmental Qualification Documentation

NRC staff reviewed the additional information related to the environmental qualification documentation under Subsection 3.11.7 of the Fermi 3 COL FSAR, Revision 7, which states the following:

> This COL item is addressed in Subsection 3.11.4.4.

In ESBWR DCD, Tier 2, Subsection 3.11.7, COL Item 3.11-1-A states that the COL applicant will provide a full description and a milestone for implementing the EQ Program that will include completion of the plant-specific EQD per Subsection 3.11.4.4, "Environmental Qualification

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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 COL application that references a design certification.

Documentation." In FSAR Subsection 3.11.4.4, the applicant states that a description of the EQ Program is provided in ESBWR DCD, Tier 2, Section 3.11. The applicant also states that the implementation of the EQ Program, including the development of the EQD will be in accordance with the milestone schedule in FSAR Section 13.4. The NRC staff reviewed the applicant's resolution to ESBWR COL Item 3.11-1-A in FSAR Subsection 3.11.4.4. In addition to reviewing the Fermi 3 COL application, the staff reviewed the information in the ESBWR DCD. Provisions in the ESBWR DCD support the Fermi 3 COL application by fully describing the EQ Operational Program for Fermi 3.

Fermi 3 FSAR Section 3.11 incorporates by reference ESBWR DCD, Tier 2, Section 3.11 with supplemental information. In RAI 03.11-1 for the previous R-COL plant, the staff requested Dominion to provide or reference certain information related to the EQ Program for safety-related mechanical equipment - or indicate the status of and schedule for its availability. Detroit Edison adopted Dominion's RAI response dated September 11, 2008 (ADAMS Accession No. ML082730754), which noted that ESBWR DCD, Tier 2, Section 3.11 had been revised to provide substantial additional information. For example, ESBWR DCD, Tier 2, Table 3.11-1, "Electrical and Mechanical Equipment for Environmental Qualification," identifies the environment in which a component within the scope of the EQ Program will be located. The RAI response stated that no site-specific, safety-related equipment will be used beyond that described in the ESBWR DCD. Subsection 3.11.4.1, "Harsh Environment Qualification," in ESBWR DCD, Tier 2, indicates that the qualification of mechanical equipment includes materials that are sensitive to environmental effects (e.g., seals, gaskets, lubricants, and fluids for hydraulic systems). The RAI response stated that the completion of the plant-specific EQD will be accomplished as specified in FSAR Subsection 3.11.4.4. Furthermore, the RAI response indicated that the completion of the EQ Program for plant equipment will be confirmed by the close-out of the ITAAC, which is specified in ESBWR DCD, Tier 1, Table 3.8-1, "ITAAC for Environmental Qualification of Mechanical and Electrical Equipment." As noted in Section 3.9.4 of this SER, GEH is responsible for the design and qualification of mechanical equipment, and the GEH procurement specifications and processes were made available for NRC to review.

In July 2009, the staff conducted an audit of the design and procurement specifications for valves and the EQ (ADAMS Accession No. ML092390403) at the GEH office in Wilmington, North Carolina. The purpose of the audit was to confirm the implementation of the ESBWR DCD provisions for the design and qualification of applicable pumps, valves, and dynamic restraints; and to support the full description of the IST and EQ operational programs by COL applicants. As discussed in an NRC memorandum dated September 1, 2009 (ADAMS Accession No. ML092390403), the staff reviewed ESBWR DCD IST Table 3.9-8, and several design and purchase specifications. In the response to the audit follow-up items in a letter dated September 21, 2009 (ADAMS Accession No. ML092650083), GEH indicated that the ESBWR DCD IST table and component specifications would be revised to incorporate the necessary clarifications identified during the audit. On March 19, 2010, the staff conducted a follow-up audit at the GEH office in Washington, DC, to review the implementation of the actions specified by GEH in a letter dated September 21, 2009 (ADAMS Accession No. ML092650083). During the follow-up audit, the staff found that GEH had issued the design specification for the EQ of mechanical and electrical equipment. Based on the GEH letter dated September 21, 2009, and the NRC follow-up audit on March 19, 2010, the staff noted that GEH had resolved the audit follow-up actions related to the EQ of mechanical equipment in support of the ESBWR DCD (ADAMS Accession No. ML100890011). The staff finds that the ESBWR DCD provisions for the EQ of mechanical equipment are being implemented in the design specifications in an adequate manner to support the Fermi 3 COL application. Therefore, RAI 03.11-1 is resolved.

ESBWR DCD, Tier 2, Subsection 3.11.4.1 states that active EQ safety-related mechanical equipment will be qualified using the qualification methods of IEEE Standard (Std.) 323-1974, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations." ESBWR DCD, Tier 2, Subsection 3.11.4.2, states that the environmental design bases will be specified in the design and purchase specifications to assure that EQ safety-related equipment located in a mild environment meet their safety-related functional requirements during normal environmental conditions and anticipated operational occurrences. For EQ safety-related equipment (except for computer-based instrumentation and control systems), a Certificate of Conformance from the vendor of the safety-related equipment that will be located in a mild environment will certify performance to the environmental design basis for normal environmental conditions and anticipated operational occurrences, at the equipment location for the amount of time that the safety-related function will be required.

In RAI 03.11-2 for the previous R-COLA plant, the staff requested Dominion to discuss the implementation of the EQ approach. Detroit Edison adopted Dominion's RAI response dated September 11, 2008 (ADAMS Accession No. ML082730754), which referenced ESBWR DCD, Tier 2, Section 3.11 for more detailed provisions of the EQ Program. The RAI response also noted that the qualification of safety-related mechanical equipment will be performed by GEH, and the qualification processes will be available for NRC to audit.

As discussed above, the staff conducted an audit to determine the acceptability of specific aspects of the EQ program. The scope of the audit included the concerns expressed in RAI 03.11-2 as well as RAI 03.11-1 and noted above. The audit report (ADAMS Accession No. ML092390403) concludes that the GEH approach to EQ as documented in the ESBWR DCD is adequately being implemented in the design specifications to support the Fermi 3 COL application. Therefore, RAI 03.11-2 is resolved.

In RAI 03.11-3 for the previous R-COL plant, the staff requested Dominion to clarify whether the FSAR would be updated to include additional equipment not identified in ESBWR DCD, Tier 2, Table 3.11-1. Detroit Edison adopted Dominion's RAI response dated September 11, 2008, that there is no safety-related equipment or safe shutdown equipment outside the scope of the ESBWR design. As a result, there is no additional equipment covered by the EQ Program that is not identified in DCD Table 3.11-1. Therefore, RAI 03.11-3 is resolved.

ESBWR DCD, Tier 2, Section 3.11 references the NRC-approved proprietary licensing Topical Report NEDE-24326-1-P, "General Electric Environmental Qualification Program." In a letter dated November 19, 2007 (MFN 07-174, Supplement 2) (ADAMS Accession No. ML073380043), GEH stated that the staff's review of NEDE-24326-1-P was addressed in NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design." On page 3-90 of NUREG-1503, NRC staff found that the topical report conforms to 10 CFR 50.49 and its associated standards, except for the position on the time margin. In RAI 03.11-4 for the previous R-COL plant, the staff requested Dominion to describe the implementation of NEDE-24326-1-P for the EQ of safety-related mechanical equipment, including the exception to its acceptance indicated in NUREG-1503. Detroit Edison adopted Dominion's RAI response dated September 11, 2008, which stated that the ESBWR DCD had been revised to incorporate the provisions of NEDE-24326-1-P and to address the time margin issue. The staff reviewed ESBWR DCD, Revision 10 and found that the time margin issue was acceptably addressed and conformed to 10 CFR 50.49 requirements. Therefore, RAI 03.11-4 is resolved.

ESBWR DCD, Tier 2, Section 3.10, addresses the methods of testing and analysis employed to ensure the capability of mechanical and electrical equipment under the full range of normal and accidental loadings to ensure conformance with NRC regulations. Operating experience from nuclear power plants has revealed the potential for adverse flow effects during normal plant operation that can impact safety-related components (such as safety relief valves). As a result, EQ programs need to address these adverse flow effects to provide confidence that safety-related equipment will be capable of performing their safety functions.

In RAI 03.11-5 for the previous R-COL plant, the NRC staff requested Dominion to describe the consideration of FIV in the qualification of safety-related mechanical equipment, including acoustic resonance and hydraulic loading. Detroit Edison adopted Dominion's RAI response dated September 11, 2008, which stated that ESBWR DCD, Tier 2, Subsection 3.9.3.5 requires the ESBWR general valve requirement specification to include requirements related to the design and functional qualification of safety-related valves that incorporate lessons learned from nuclear power plant operations and research programs. ESBWR DCD, Tier 2, Section 3.10 addresses methods of testing and analysis employed to ensure the capability of mechanical and electrical equipment under the full range of normal and accident loadings. The RAI response indicated that testing, as described in ESBWR DCD, Tier 2, Section 3.9.2 and FSAR Section 14.2, will provide confidence in the capability of safety-related equipment to perform their safety functions. For example, ESBWR DCD, Tier 2, Section 3.9.2.1.1 discusses vibration and dynamic effects testing that will be performed during the ITP, as described in DCD Subsections 14.2.8.1.42 and 14.2.8.2.10. The objective of these tests will be to confirm that the piping, components, restraints, and supports of specified high and moderate-energy systems were designed to withstand the dynamic effects of steady-state FIV and anticipated operational transient conditions. The staff considers that the actions specified in the ESBWR DCD will address potential adverse flow effects on safety-related valves and dynamic restraints including the consideration of lessons learned from nuclear power plant operating experience. Therefore, RAI 03.11-5 is resolved.

Fermi 3 FSAR Section 13.4, "Operational Program Implementation," includes FSAR Table 13.4-201, "Operational Programs Required by NRC Regulations," which lists each Operational Program, the regulatory source for the program, the FSAR section where the Operational Program is described, and the associated implementation milestones. FSAR Table 13.4-201 specifies the implementation milestone for the EQ Program as "prior to fuel load." In RAI 03.11-6 for the previous R-COL plant, the staff requested Dominion to clarify the commencement of the EQ Program and its transition into an operating reactor program. Detroit Edison adopted Dominion's RAI response dated September 11, 2008, stating that the COL application will contain a license condition that will require the COL licensee to submit a schedule to the NRC 12 months after the issuance of the COL, which will support planning and conducting NRC inspections of Operational Programs including the EQ Program, with periodic updating of the schedule. This schedule will address additional program implementation details, such as commencement of the EQ Program. The transition of the EQ Program into an operating program will occur as part of the plant turnover process. The staff finds that the RAI response clarified plans for the implementation and turnover of the EQ Program during plant construction and startup. Therefore, RAI 03.11-6 is resolved.

ESBWR DCD, Tier 1, Revision 4, Section 3.8, "Environmental Qualification of Mechanical and Electrical Equipment," specifies the EQ ITAAC for safety-related mechanical and electrical equipment in Table 3.8-2. The inspections, tests, and analyses for safety-related or RTNSS mechanical equipment located in a harsh environment state that type tests, or a combination of type tests and analyses will be performed. In RAI 03.11-7 for the previous R-COL plant, the staff requested Dominion to describe the plan for the implementation of the ITAAC for safety-related mechanical equipment located in a harsh environment, as specified in ESBWR DCD, Tier 1. Detroit Edison adopted Dominion's RAI response dated September 11, 2008, stating that ESBWR DCD, Tier 1, Subsection 1.1.2.2 provides a general plan description of ITAAC implementation. Part 10 of the Fermi 3 COL application incorporates the DCD ITAAC by reference. With respect to specific ITAAC implementation, the NRC regulations in 10 CFR 52.99, "Inspection during construction," require the licensee to submit a schedule for completing the inspections, tests, or analyses in the ITAAC, no later than 1 year after COL issuance or the start of construction as defined in 10 CFR 50.10(b) - whichever is later - with subsequent updates to the ITAAC schedule. The RAI response stated that plans and schedules for implementing the ITAAC will be provided in accordance with 10 CFR 52.99. The staff finds that these provisions for addressing the EQ ITAAC are consistent with the regulations and are thus acceptable. Therefore, RAI 03.11-7 is resolved.

ESBWR DCD, Tier 2, Section 3.11 describes the program for the initial EQ of electrical and mechanical equipment within the EQ Program for nuclear power plants applying the ESBWR reactor design. An NRC audit at the GEH office in Wilmington, NC, in July 2009, found that the ESBWR DCD does not address the transition from the initial EQ program to the operational aspects of the EQ Program. As discussed in RG 1.206 and Commission Paper SECY-05-0197, COL applicants must fully describe their operational programs to avoid the need for ITAAC regarding those programs. Therefore, the staff requested in RAI 03.11-8 for the previous R-COL plant that Dominion address the operational aspects of the EQ Program in the FSAR. Detroit Edison adopted Dominion's RAI response dated February 4, 2010 (ADAMS Accession No. ML100470588), which provided a proposed revision to the FSAR to enhance the EQ Program description and to address the operational aspects of the program. The staff found that the planned revision to the COL FSAR would provide an acceptable description of the transition from the initial EQ Program to the operational aspects of the EQ Program. In the SER with open items, this issue was tracked as Confirmatory Item 03.11-8 for incorporation of the Fermi 3 FSAR changes. Subsequently, Revision 3 (and Revision 4) to Fermi 3 FSAR in Subsection 3.11.4.4 incorporates the provisions for the EQ Operational Program as specified in the RAI response. For example, the FSAR specifies that the documentation necessary to support the continued qualification of the equipment installed in the plant that is within the EQ Program scope will be available in accordance with 10 CFR Part 50, Appendix A. The FSAR also describes the EQ Master Equipment List (EQMEL) that identifies the electrical and mechanical equipment that must be environmentally qualified for use in a harsh environment. The FSAR describes the control of revisions to the EQ files and the EQMEL. The FSAR specifies that the operational aspect of the EQ Program will include: (1) evaluation of EQ results for design life to establish activities to support continued EQ; (2) determination of surveillance and preventive maintenance activities based on EQ results; (3) consideration of EQ maintenance recommendations from equipment vendors; (4) evaluation of operating experience in developing surveillance and preventive maintenance activities for specific equipment; (5) development of plant procedures that specify individual equipment identification, appropriate references, installation requirements, surveillance and maintenance requirements, post-maintenance testing requirements, condition monitoring requirements, replacement part identification, and applicable design changes and modifications; (6) development of plant procedures for reviewing equipment performance and EQ operational activities, and for trending the results to incorporate lessons learned through appropriate modifications to the EQ operational program; and (7) development of plant procedures for the control and maintenance of EQ records. Therefore, Confirmatory Item 03.11-8 is closed. Based on the above evaluation, the staff finds that the applicant has adequately addressed COL Item STD COL 3.11-1-A, and it is therefore acceptable.

Interfaces for Standard Design

ESBWR DCD, Tier 2, Section 1.8, "Interfaces with Standard Design," identifies site-specific interfaces with the standard ESBWR design. DCD Table 1.8-1, "Matrix of NSSS Interfaces," references Section 3.11 for the supporting interface area of the environmental design of mechanical and electrical equipment. The staff reviewed the Fermi 3 COL application for interfacing requirements with the ESBWR standard design regarding the EQ of mechanical and electrical equipment using the review procedures described in SRP Section 3.11. The NRC staff finds the applicant's consideration of design interface items to be acceptable based on compliance with 10 CFR 50.49 as discussed above.

License Conditions

- Part 10, License Condition 3.5

The applicant proposed a license condition providing the implementation milestone for the EQ Program.

- Part 10, License Condition 3.6

The applicant proposed a license condition to provide a schedule to support the NRC's inspection of operational programs, including the EQ Program.

These license conditions are consistent with the policy established in SECY-05-0197 and are, thus, acceptable.

3.11.5 Post Combined License Activities

The following items were identified as the responsibility of the COL licensee:

License Condition 3.5, "Operational Program Implementation," in Part 10 of the Fermi 3 COL application includes a Proposed License Condition in 3.5.7 related to the EQ Program. This license condition will require the EQ Program to be implemented prior to initial fuel load. License Condition 3.6, "Operational Program Readiness," in Part 10 of the Fermi COL application will require the licensee to develop a schedule that supports planning for and conduct of NRC inspection of the operational programs listed in Fermi 3 COL FSAR Table 13.4-201, "Operational Program Required by NRC Regulations." This schedule must be available to the NRC staff no later than 12 months after issuance of the COL. The condition will also require that the schedule be updated every 6 months until 12 months before scheduled fuel load, and every month thereafter until the operational programs listed in the Fermi 3 COL FSAR Table 13.4-201 have been fully implemented or the plant has been placed in commercial service, whichever comes first.

3.11.6 Conclusion

The NRC staff's finding related to information incorporated by reference is in NUREG-1966. The staff reviewed the application and checked the referenced DCD. The NRC staff's review confirms that the applicant has addressed the required information 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 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to the EQ of the mechanical and electrical equipment that were incorporated by reference have been resolved.

In addition, the staff compared the supplemental information in the COL application to the relevant NRC regulations, the guidance in Section 3.11 of NUREG-0800, and other NRC RGs. The staff's review concluded that the applicant has provided sufficient information to satisfy the NRC requirements. Therefore, the staff concludes that the Fermi 3 COL FSAR, with the incorporation by reference of the ESBWR DCD, provides an acceptable description of the EQ of electrical and mechanical equipment to be used at Fermi 3, which provides reasonable assurance that the electrical and mechanical equipment within the scope of the Fermi 3 EQ Program will be capable of performing their safety functions in accordance with NRC regulations.

3.12 Piping Design Review

3.12.1 Introduction

This FSAR section covers the design of the metallic piping system and piping support for seismic Category I, Category II, and nonsafety systems. The discussion also includes the adequacy of the structural integrity, and the functional capability of the safety-related piping system, piping components, and their associated supports. The design of the piping systems should ensure that they perform their safety-related functions under all postulated combinations of normal operating conditions, system operating transients, postulated pipe breaks, and seismic events. This includes pressure retaining piping components and their supports, buried piping, instrumentation lines, and the interaction of NS Category I piping and associated supports with seismic Category I piping and associated supports. This section also covers the design transients and resulting loads and load combinations with appropriate specified design and service limits for seismic Category I piping and piping supports - including those designated as ASME Code Class 1, 2, and 3.

3.12.2 Summary of Application

Section 3.12 of the Fermi 3 COL FSAR, Revision 7, references the related sections of Chapter 3 and Chapter 5 of the ESBWR DCD, Revision 10 for the information on seismic Category I and II and NS piping analyses. In addition in FSAR Section 3.12, the applicant provides the following:

Supplemental Information

- STD SUP 3.12-1 Piping Design Review

In Section 3.12, the applicant states the following:

> Information on seismic Category I and II, and non-seismic piping analysis and their associated supports is presented in DCD Sections 3.7, 3.9, 3D, 3K, 5.2 and 5.4.

3.12.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is in NUREG–1966.

In addition, the relevant requirements of the Commission regulations for the piping and support design, and the associated acceptance criteria, are in Section 3.12 of NUREG-0800.

3.12.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Chapters 3 and 5 of the ESBWR DCD. The staff reviewed Section 3.12 of the Fermi 3 COL FSAR, Revision 7, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 7, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

The staff reviewed the following information in the Fermi 3 COL FSAR:

Supplemental Information

- STD SUP 3.12-1 Piping Design Review

The staff reviewed Supplemental Information STD SUP 3.12-1. The ESBWR DCD does not have Section 3.12. Therefore, this supplemental information is being considered as an editorial change to provide a map for the piping design information. The staff finds this change acceptable.

The staff also reviewed COL application FSAR Section 3.7 to verify that the site-specific structural response spectra are enveloped by the response spectra of the ESBWR DCD. This evaluation is documented in Section 3.7.2 of this SER. On the basis that site-specific response spectra are enveloped by the ESBWR DCD response spectra, the staff finds the ESBWR standard plant design acceptable at the Fermi 3 site.

In addition to the piping DAC ITAAC in ESBWR DCD, Tier 1, the staff also reviewed COL Item STD COL 14.3A-1-1 which provides a schedule for completing the piping DAC ITAAC. On the basis that the applicant's proposed DAC are sufficient to provide reasonable assurance in meeting the requirements of 10 CFR 52.80(a), the staff finds this acceptable.

3.12.5 Post Combined License Activities

The following activities will be implemented following issuance of the COL:

- Piping DAC
  - The ASME Code piping and support design reports are completed on a system-by-system basis for applicable systems in order to support closure of the DAC ITACC.
  - Reconciliation of the as-built piping.

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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 COL application that references a design certification.

3.12.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the relevant information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional COL information in the application to the relevant NRC regulations and the guidance in Section 3.12 of NUREG-0800. The staff's review concludes that the applicant is in compliance with NRC regulations. The applicant has adequately addressed the COL information item involving the completion of the piping DAC ASME Design Reports. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Part 52 requirements by providing reasonable assurance that the piping system will be designed and built in accordance with the certified ESBWR design.

3.13 Threaded Fasteners – ASME BPV Code Class 1, 2 and 3

3.13.1 Introduction

This FSAR section covers the selection of the materials and design, and the inspecting and testing for threaded fasteners before initial service and during service and is limited to threaded fasteners in the ASME Boiler and Pressure Vessel Code Class 1, 2 or 3 systems.

ESBWR DCD, Revision 10 does not contain Section 3.13 because the DCD application was submitted before the new SRP Section 3.13 was issued in March 2007. However, ESBWR DCD, Tier 2, Subsection 3.9.3.9, "Threaded Fasteners - ASME B&PV Code Class 1, 2 and 3," provides sufficient information for the staff to conclude that the selection of the materials and design, and inspecting and testing for threaded fasteners before initial service and during service are acceptable. Therefore, Fermi 3 FSAR, Revision 7, Section 3.13 provides supplemental information that references ESBWR DCD, Tier 2, Subsection 3.9.3.9.

3.13.2 Summary of Application

Section 3.13 of the Fermi 3 FSAR, Revision 7, references Subsection 3.9.3.9 of the ESBWR DCD, Revision 10. Section 3.9 of Fermi 3 FSAR, Revision 7, incorporates by reference Subsection 3.9.3.9 of the ESBWR DCD, Revision 10. In addition, in FSAR Section 3.13 the applicant provides the following:

Supplemental Information

- STD SUP 3.13-1 Threaded Fasteners – ASME Code Class 1, 2, and 3

In Section 3.13, the applicant states the following:

> Criteria applied to the selection of materials, design, inspection and testing of threaded fasteners (i.e., threaded bolts, studs, etc.) are presented in DCD Section 3.9.3.9, with supporting information in DCD Sections 4.5.1, 5.2.3, and 6.1.1.

3.13.3 Regulatory Basis

The relevant requirements of the Commission regulations for the piping and support design, and the associated acceptance criteria, are in Section 3.13 of NUREG–0800. Specific requirements include the following:

- 10 CFR Part 50, Appendix A, GDC 1 and 30, as they relate to the requirement that SSCs important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

- GDC 4, as it relates to the compatibility of components with environmental conditions.

- GDC 14, as it relates to the requirement that the RCPB be designed, fabricated, erected, and tested in a manner that provides assurance of an extremely low probability of abnormal leakage, rapidly propagating failure, or gross rupture.

- GDC 31, "Fracture prevention of reactor coolant pressure boundary," as it relates to the requirement that the RCPB be designed with a sufficient margin to ensure that when stressed under operating, maintenance, testing, and postulated accident conditions the boundary behaves in a non-brittle manner and the probability of rapidly propagating fracture is minimized.

- 10 CFR Part 50, Appendix B, as it relates to controlling the cleaning of material and equipment to prevent damage or deterioration.

- 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements," as it relates to materials testing and acceptance criteria for fracture toughness of reactor pressure boundary components.

- 10 CFR 50.55a incorporates by reference the design criteria of ASME BPV Code, Section III, Class 1, 2, and 3 components. The selection of materials, design, testing, fabrication, installation and inspection of threaded fasteners and mechanical joints are acceptable if they meet the criteria of ASME BPV Code, Section III Class 1, 2, and 3 components. However, 10 CFR 50.55a(b)(4) permits the use of code cases that have been adopted by the staff in RG 1.84 in lieu of applicable criteria in ASME BPV Code, Section III, Class 1, 2, and 3 component.

- 10 CFR 52.47(b)(1), which requires a DC application to contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC's regulations.

- 10 CFR 52.80(a), which requires that a COL application to contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act, and the NRC's regulations.

3.13.4 Technical Evaluation

As documented in NUREG–1966, NRC staff reviewed and approved Subsection 3.9.3.9 of the certified ESBWR DCD. The staff reviewed Section 3.13 of the Fermi 3 COL FSAR, Revision 7, which references ESBWR Subsection 3.9.3.9, and checked the referenced ESBWR DCD to ensure that the combination of the information in the ESBWR DCD and the information in the Fermi 3 COL FSAR, Revision 7, appropriately represents the complete scope of information relating to this review topic.[1] The staff's review confirms that the information in the application and the information incorporated by reference address the relevant information related to this section.

Section 1.2.3 of this SER provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on the standard content that were documented in the SER with open items issued for the North Anna Unit 3 application were equally applicable to the Fermi 3 COL application, the staff undertook the following reviews:

- The staff compared the North Anna 3 COL FSAR, Revision 1, to the Fermi COL FSAR. In performing this comparison, the staff considered changes to the Fermi 3 COL FSAR (and other parts of the COL application, as applicable) resulting from (RAIs) and open and confirmatory items identified in the North Anna SER with open items.
- The staff confirmed that the applicant has endorsed all responses to the RAIs identified in the corresponding standard content (the North Anna SER) evaluation.
- The staff verified that the site-specific differences were not relevant to this section.

The staff has completed the review and found the evaluation performed for the North Anna standard content to be directly applicable to the Fermi COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting.

The staff reviewed the following information in the Fermi 3 COL FSAR:

Supplemental Information

- STD SUP 3.13-1 Threaded Fasteners – ASME Code Class 1, 2, and 3

The staff reviewed the applicant's information related to threaded fasteners and included under Section 3.13 of the Fermi 3 COL FSAR, which states the following:

> Criteria applied to the selection of materials, design, inspection and testing of threaded fasteners (i.e., threaded bolts, studs, etc.) are presented in DCD Section 3.9.3.9, with supporting information in DCD Sections 4.5.1, 5.2.3, and 6.1.1.

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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 COL application that references a design certification.

The following portion of this technical evaluation section is reproduced from Subsection 3.13.4, “Technical Evaluation,” of the North Anna Unit 3 SER (ADAMS Accession No. ML092010530):

> *NRC staff reviewed STD SUP 3.13-1 related to the criteria for the selection of materials, design, inspection, and testing of threaded fasteners included under Section 3.13 of the North Anna 3 COL FSAR. STD SUP 3.13-1 points to ESBWR DCD Tier 2, Sections 4.5.1, 5.2.3, and 6.1.1. Those sections provide additional and specific requirements concerning threaded fasteners used in reactor internals, the reactor coolant system, and other engineered safety features. The staff found that STD SUP 3.13-1 appropriately points out the DCD sections that identify the specific use of threaded fasteners in reactor internals, the reactor coolant system, and other engineered safety features.*
>
> *The staff reviewed the conformance of Section 3.13 of the North Anna 3 COL FSAR to the guidance of RG 1.206, Section C.III.1, Chapter 3, C.I.3.13, “Threaded Fasteners.” The staff’s review of Section 3.13 of the North Anna 3 COL FSAR found that the applicant has appropriately incorporated by reference Section 3.9.3.9 of ESBWR DCD, Revision 5.*

The staff considers the applicant’s Supplemental Information Item STD SUP 3.13-1 to adequately address threaded fasteners.

3.13.5 Post Combined License Activities

There are no post COL activities related to this section.

3.13.6 Conclusion

NRC staff reviewed the application and checked the referenced DCD. The staff’s review confirms that the applicant has addressed the relevant information, and no outstanding information is expected to be addressed in the COL FSAR related to this section.

In addition, the staff compared the additional COL information in the application to the relevant NRC regulations, the guidance in Section 3.12 of NUREG-0800, and other NRC RGs. The staff’s review concludes that the information in Fermi 3 COL FSAR, Section 3.13 is within the scope of the design certification and adequately incorporates by reference Subsection 3.9.3.9 of the ESBWR DCD, which addresses SRP Section 3.13. The information is thus acceptable and meets the NRC regulations.