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DTE Energy

Proprietary Information – Withhold Under 10 CFR 2.390

10 CFR 50.46

February 13, 2017
NRC-17-0016

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

References: 1) Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

2) DTE Letter to NRC, "Submittal of Plant Specific Emergency Core Cooling System (ECCS) Evaluation Model Reanalysis," NRC-08-0046, dated June 23, 2008 (ML081830408)

3) DTE Letter to NRC, "Submittal of 2015 Safety Relief Valve Challenge Report, Main Steam Bypass Lines Report, and ECCS Cooling Performance Evaluation Model Changes or Errors Report," NRC-16-0026, dated April 27, 2016 (ML16119A439)

Subject: Submittal of Plant Specific Emergency Core Cooling System (ECCS) Evaluation Model Reanalysis

In accordance with 10 CFR 50.46(a)(3)(ii), DTE Electric Company (DTE) submits a reanalysis for the plant specific Emergency Core Cooling System (ECCS) evaluation for Fermi 2.

DTE submitted the previous reanalysis in Reference 2. Subsequently, in Reference 3, DTE identified all changes or errors in the ECCS cooling performance evaluation model since that submitted in Reference 2. In addition, Reference 3 identified that General Electric – Hitachi (GEH) had prepared a new reanalysis using SAFER/PRIME methodology and that DTE was in the process of developing documentation to officially adopt the results of this reanalysis into the plant design basis. DTE has now adopted this new reanalysis and is therefore submitting it to establish a new Licensing Basis Peak Clad Temperature (LBPCT) using the

**Enclosure 3 contains Proprietary Information – Withhold Under 10 CFR 2.390.
When separated from Enclosure 3, this document is decontrolled.**

SAFER/PRIME methodology for the GE14 fuel type. A summary of the current model assessment is provided in Enclosure 1.

The reanalysis (Enclosure 3) for Fermi 2 reveals that the small break LOCA is the limiting case for the GE14 fuel type with a LBPCT of 1980°F. Therefore, the reanalysis concludes that the Fermi 2 LBPCT is below the 2200°F limit for all loss of coolant accident (LOCA) events. As described in the enclosures, the other four 10 CFR 50.46 ECCS-LOCA analysis acceptance criteria are also well within the acceptable range. The reanalysis incorporates all evaluation model changes and error corrections documented in Reference 3.

Enclosure 3 contains proprietary information as defined by 10 CFR 2.390. GEH, as the owner of the proprietary information, has executed the affidavit in Enclosure 2, which identifies that the enclosed proprietary information has been handled and classified as proprietary, is customarily held in confidence, and has been withheld from public disclosure. A non-proprietary version of the documentation in Enclosure 3 is provided in Enclosure 4.

No new commitments are made in this letter.

Should you have any questions or require additional information, please contact Mr. Scott A. Maglio, Manager – Nuclear Licensing at (734) 586-5076.

Sincerely,

Keith J. Polson
Site Vice President

Enclosures:
1) Current LOCA Model Assessment for GE14 Fuel
2) GEH Affidavit for NEDC-33865P
3) NEDC-33865P – PROPRIETARY
4) NEDO-33865 – NON-PROPRIETARY

cc w/ all Enclosures:
NRC Project Manager
NRC Regional Administrator, Region III
NRC Resident Office
Reactor Projects Chief, Branch 5, Region III

cc w/o Enclosure 3:
Michigan Public Service Commission
Regulated Energy Division (kindschl@michigan.gov)

Enclosure 1 to
NRC-17-0016

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

Current LOCA Model Assessment for GE14 Fuel

Plant Name:	Fermi 2
ECCS Evaluation Model:	SAFER/PRIME-LOCA
New Analysis Approval Date:	January 20, 2017
Current Operating Cycle:	18

Analysis of Record

Evaluation Model:

1. NEDE-23785-1-PA, Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident, Volume III, SAFER/GESTR Application Methodology," October 1984.
2. NEDE-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants," October 1987.
3. NEDC-32950P, Rev. 1, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," July 2007.
4. NEDE-20566-P-A, "Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K," September 1986.
5. NEDC-32084P-A, Rev. 2, "TASC-03A A Computer Program for Transient Analysis of a Single Channel," July 2002.
6. NEDC-33256P-A, NEDC-33257P-A, NEDC-33258P-A, Rev. 1, "The PRIME Model for Analysis of Fuel Rod Thermal-Mechanical Performance," September 2010.
7. NEDO-33173 Supplement 4-A, Rev. 1, "Implementation of PRIME Models and Data in Downstream Methods," November 2012.

Calculation:

1. 000N1319-R0, "DTE Energy Enrico Fermi 2 SAFER/PRIME-LOCA Loss of Coolant Accident Analysis," dated March 2015.

Results:

- **Fuel Analyzed in Calculation:** GE14
- **Limiting Single Failure:** Division I Battery Power
- **Limiting Break Size and Location:** Small break in recirculation line
- **LBPCT:** 1980°F

Previous Analyses

- **LBPCT from Previous Analysis of Record (NRC-08-0046):** 1990°F
- **Net PCT from Previous Analyses of Changes/Corrections (NRC-16-0026):** 2112°F

Addendum/Errata

Following receipt of the reanalysis in March 2015 from GEH (Calculation #1 above), DTE identified an error in the design information provided to GEH regarding the Safety Relief Valves (SRVs). The input for the SRVs was corrected and provided to GEH for evaluation of the impact. The GEH evaluation in November 2016 (Evaluation #1 below) determined that there was no change in PCT since the incorrect SRV input was not credited in the analysis. Therefore, the LBPCT reported above remains valid and sufficient to stipulate compliance to the acceptance criteria of 10 CFR 50.46. The corrected SRV input is retained for future use. Following review of the addendum, the reanalysis was accepted and approved by DTE as the new analysis of record on January 20, 2017.

Evaluation:

1. 000N1319-R0 Addendum, "Fermi 2 Modelling for SRV and Low-Low Set in ECCS-LOCA Analysis," dated November 2016.

Enclosure 2 to
NRC-17-0016

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

GEH Affidavit for NEDC-33865P

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Lisa K. Schichlein, state as follows:

(1) I am a Senior Project Manager, NPP/Services Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC (GEH), and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in GEH proprietary report, NEDC-33865P, "DTE Energy Enrico Fermi 2 SAFER/PRIME-LOCA Loss-of-Coolant Accident Analysis," Revision 0, March 2015. GEH proprietary information in the text is identified by a dotted underline inside double square brackets [[This sentence is an example.{3}]] Figures and large objects containing GEH proprietary information are identified by double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, <u>Critical Mass Energy Project v. Nuclear Regulatory Commission,</u> 975F2d871 (DC Cir. 1992), and <u>Public Citizen Health Research Group v. FDA</u>, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GEH.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed information regarding the processes and methodology for application of SAFER/PRIME-LOCA to the performance of evaluations of LOCA events for GEH Boiling Water Reactors (BWRs). The development, testing, and documentation of the SAFER/PRIME-LOCA methodology were achieved at a significant cost to GEH.

The development of the SAFER/PRIME-LOCA methodology, along with the interpretation and application of the analytical results, is derived from the extensive experience database that constitutes a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 9th day of March 2015.

Lisa K. Schichlein

Lisa K. Schichlein
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Enclosure 4 to
NRC-17-0016

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

NEDO-33865 – NON-PROPRIETARY
DTE Energy Enrico Fermi 2 SAFER/PRIME-LOCA Loss-of-Coolant Accident Analysis

HITACHI

GE Hitachi Nuclear Energy

NEDO-33865
Revision 0
March 2015

Non-Proprietary Information – Class I (Public)

DTE ENERGY ENRICO FERMI 2
SAFER/PRIME-LOCA
LOSS-OF-COOLANT ACCIDENT ANALYSIS

INFORMATION NOTICE

This is a non-proprietary version of the document NEDC-33865P, Revision 0, which has the proprietary information removed. Portions of the document that have been removed are indicated by an open and closed bracket as shown here [[ ]].

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

The design, engineering, and other information contained in this document are furnished for the purposes of supporting DTE Electric Company (DTE) in proceedings before the U.S. Nuclear Regulatory Commission (NRC). The only undertakings of GEH with respect to information in this document are contained in the contract between GEH and DTE, and nothing contained in this document shall be construed as changing that contract. The use of this information by anyone for any purpose other than that for which it is intended, is not authorized; and with respect to any unauthorized use, GEH makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
ADS	Automatic Depressurization System
ANS	American Nuclear Society
BWR	Boiling Water Reactor
CFR	Code of Federal Regulations
CLTP	Current Licensed Thermal Power
CS	Core Spray
DBA	Design Basis Accident
DEG	Double-Ended Guillotine
D/G	Diesel Generator
Div. I	Division I Battery
Div. II	Division II Battery
DTE	DTE Electric Company
ECCS	Emergency Core Cooling System
FFWTR	Final Feedwater Temperature Reduction
FWHOOS	Feedwater Heater Out Of Service
FWLB	Feedwater Line Break
FWTR	Feedwater Temperature Reduction
GEH	GE-Hitachi Nuclear Energy Americas LLC
HEM	Homogeneous Equilibrium Model
HPCI	High Pressure Coolant Injection
ICF	Increased Core Flow
IMLTR	Interim Methods Licensing Topical Report
LBPCT	Licensing Basis Peak Cladding Temperature
LHGR	Linear Heat Generation Rate
LOCA	Loss-of-Coolant Accident
LPCI	Low Pressure Coolant Injection
LPCIIV	Low Pressure Coolant Injection Isolation Valve
LPCS	Low Pressure Core Spray
LTR	Licensing Topical Report
MAPLHGR	Maximum Average Planar Linear Heat Generation Rate
MCPR	Minimum Critical Power Ratio
MELLLA	Maximum Extended Load Line Limit Analysis
MFB	Minimum Flow Bypass
MSIV	Main Steam Isolation Valve
MUR	Measurement Uncertainty Recapture (Thermal Power Optimization)
NA	Not Applicable
NFWT	Normal Feedwater Temperature
NRC	Nuclear Regulatory Commission
OPL	Operating Parameters List
PCT	Peak Cladding Temperature
PLHGR	Peak Linear Heat Generation Rate
RCIC	Reactor Core Isolation Cooling

Acronym	Definition
RPV	Reactor Pressure Vessel
SBA	Small Break Analysis
SER	Safety Evaluation Report
SLO	Single Loop Operation
SRV	Safety Relief Valve
TAF	Top of Active Fuel
TS	Technical Specification(s)
UBPCT	Upper Bound Peak Cladding Temperature

SUMMARY

An emergency core cooling system (ECCS) performance analysis has been performed for Fermi 2. The ECCS performance responses to a wide spectrum of loss-of-coolant accidents (LOCAs) are evaluated using the SAFER/PRIME-LOCA analytical model and methodology. The results show a Fermi 2 plant-specific licensing basis peak cladding temperature (PCT) is less than 1,980°F. This PCT is well below the 10 CFR 50.46 limit of 2,200°F. All other 10 CFR 50.46 acceptance criteria and NRC compliance for SAFER/PRIME methodology have also been met.

The analysis was performed using the SAFER/PRIME-LOCA application methodology at the thermal power level of 3,499 MWt, which bounds the current licensed thermal power (CLTP) of 3,486 MWt including licensed measurement uncertainty and rated core flow of 100 Mlbm/hr, which is the current rated thermal power level and core flow, and a maximum extended operating domain rod line defined in Reference 1. For future fuel reload cycles with new fuel designs, the application of the results of this evaluation will be confirmed by fuel reload licensing analyses.

ECCS-LOCA results incorporate all evaluation model changes and error corrections documented through Notification Letter 2014-04.

1.0 INTRODUCTION

As a license condition for operation, NRC regulations require nuclear power plants to have an installed ECCS capable of providing sufficient cooling following a postulated LOCA to meet prescribed criteria which are calculated to provide a measure of protection of the health and safety of the public. The ECCS must be demonstrated to be effective by application of approved analytical tools over a range of accidents up to the complete double-ended rupture of the largest pipe of the reactor coolant system, defined for purposes of the regulation as the design basis accident (DBA). Historically, the analysis of the large break LOCA had been performed on a very conservative basis. This was done partly as a result of the restrictions imposed by the requirements of 10 Code of Federal Regulations (CFR) 50.46 and 10 CFR 50 Appendix K and partly to compensate for uncertainties inherent in the simplified models. However, after years of research with large-scale experiments and the development of the best estimate codes, improved and more realistic boiling water reactor (BWR) licensing models (i.e., SAFER/PRIME-LOCA) have been approved by the NRC. These models calculate more realistic PCTs to relieve unnecessary plant operating and licensing restrictions. More realistic analyses also predict actual plant response during postulated accidents and can be used as a basis for more appropriate operator actions. The LOCA analysis for Fermi 2 uses these models and this licensing methodology.

The SAFER/PRIME-LOCA application methodology was based on the generic studies presented in References 2, 3, and 4. The SAFER and PRIME-LOCA models are coupled mechanistic, reactor system thermal-hydraulic, and fuel rod thermal-mechanical evaluation models (PRIME-LOCA replaces the earlier GESTR-LOCA model for fuel rod input). These models are based on realistic correlations and inputs.

An analysis was performed for Fermi 2 and presented in this report using the SAFER/PRIME-LOCA application methodology. The analysis was based on the thermal power level of 3,499 MWt, which bounds the CLTP of 3,486 MWt including licensed measurement uncertainty and rated core flow of 100 Mlbm/hr, which is the current rated thermal power level and core flow, and a maximum extended operating domain rod line defined in Reference 1, consistent with Reference 5. This LOCA analysis was performed in accordance with NRC requirements to demonstrate conformance with the ECCS acceptance criteria of 10 CFR 50.46. A key objective of the LOCA analysis is to provide assurance that the most limiting combination of break size, break location and single failure has been considered for Fermi 2. References 2 and 3 document the requirements and the approved methodology to satisfy these requirements.

2.0 DESCRIPTION OF MODELS

Four GEH computer models were used to determine the LOCA response for the Fermi 2 ECCS-LOCA analysis. These models are LAMB, TASC, SAFER and PRIME-LOCA. Together, these models evaluate the short-term and long-term reactor vessel blowdown response to a pipe rupture, the subsequent core flooding by ECCS, and the coincident fuel rod heat-up. Figure 2-1 is a flow diagram of these computer models, indicating the major code functions and the transfer of major parameters. The purpose of each model is described in the following subsections.

2.1 Short-Term Thermal Hydraulic Model (LAMB)

The LAMB model (Reference 6) analyzes the short-term blowdown phenomena for postulated large pipe breaks in which nucleate boiling is lost before the water level drops sufficiently to uncover the active fuel. The LAMB output (most importantly, core flow as a function of time) is used in the TASC model for calculating blowdown heat transfer and fuel dryout time.

2.2 Transient Critical Power Model (TASC)

The TASC model (Reference 7) evaluates the short-term thermal-hydraulic response of the coolant in a single bundle during a postulated LOCA. TASC receives input from LAMB and is used to analyze the convective heat transfer process in the thermally limiting fuel bundle and predict the time and location of boiling transition and dryout time. The calculated fuel dryout time is an input to the long-term thermal-hydraulic transient model, SAFER.

2.3 Fuel Rod Thermal Performance Model (PRIME-LOCA)

The PRIME-LOCA model (References 4 and 8) has been developed to produce best estimate predictions of the thermal performance of GEH fuel rods experiencing variable power histories. For ECCS analyses, the PRIME-LOCA model provides the parameters to initialize the fuel stored energy and fuel rod fission gas inventory at the onset of a postulated LOCA for input to SAFER. PRIME-LOCA also establishes the initial transient pellet-cladding gap conductance for input to both SAFER and TASC. This PRIME-LOCA model has replaced the earlier GESTR-LOCA model (Reference 2). Use of PRIME-LOCA captures the physical phenomenon of fuel pellet conductivity degradation with pellet exposure.

2.4 Long-Term Thermal Hydraulic Model (SAFER)

This SAFER model (References 2, 3, and 9) calculates the long-term system response of the reactor over a complete spectrum of hypothetical break sizes and locations. SAFER is compatible with the PRIME-LOCA fuel rod model for gap conductance and fission gas release. SAFER calculates the core and vessel water levels, system pressure response, ECCS performance, and other primary thermal-hydraulic phenomena occurring in the reactor as a function of time. SAFER realistically models all regimes of heat transfer that occur inside the core, and provides the PCT and the heat transfer coefficients (which determine the severity of the temperature change) as a function of time. The SAFER code receives input from PRIME-LOCA, LAMB and TASC.

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Figure 2-1. Flow Diagram of LOCA Analysis Using SAFER/PRIME

3.0 ANALYSIS PROCEDURE

3.1 Licensing Criteria

10 CFR 50.46 outlines the acceptance criteria for ECCS analysis. A summary of the acceptance criteria is provided below:

Criterion 1 – Peak Cladding Temperature: The calculated maximum fuel element cladding temperature shall not exceed 2,200°F.

Criterion 2 – Maximum Cladding Oxidation: The calculated total local oxidation shall not exceed 0.17 times the total cladding thickness before oxidation.

Criterion 3 – Maximum Hydrogen Generation: The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all the metal in the cladding cylinder surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react.

Criterion 4 – Coolable Geometry: Calculated changes in core geometry shall be such that the core remains amenable to cooling.

Criterion 5 – Long-Term Cooling: After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

The conformance with Criteria 1 through 3 for Fermi 2 is presented in this report. As discussed in Reference 6, conformance with Criterion 4 is demonstrated by conformance to Criteria 1 and 2. The bases and demonstration of compliance with Criterion 5 are documented in References 6 and 10 and remain unchanged by application of SAFER/PRIME-LOCA.

3.2 SAFER/PRIME-LOCA Licensing Methodology

The SAFER/PRIME-LOCA licensing methodology as approved by the NRC in References 2 and 4 allows the plant-specific break spectrum to be defined using the Nominal input assumptions. However, the calculation of the limiting PCT to demonstrate conformance with the requirements of 10 CFR 50.46 must include specific inputs and models documented in Appendix K.

More recently, in Reference 11, the methodology was amended. In response to a request by the NRC, GEH agreed to alter the methodology to assure a bounding result would be obtained for all possible operating conditions by surveying the plant-specific break spectrum on the basis of calculations applying conservatisms consistent with Appendix K to 10 CFR 50. The limiting PCT demonstration for conformance, or licensing basis PCT (LBPCT), would then be determined consistent with that highest Appendix K PCT. The calculation of a Nominal PCT coincident with that operation statepoint, single failure assumption and break size and location would then be used for comparison and complying with the original uncertainty basis of the model approval (95% probability at a 95% confidence level that PCT would be bound by the indicated Nominal PCT plus uncertainty term).

The LBPCT is based on the most limiting LOCA result (highest Appendix K PCT) and is defined as:

[[

]]

The plant variable uncertainty term accounts statistically for the uncertainty in parameters which are not specifically addressed by 10 CFR 50 Appendix K.

To conform with 10 CFR 50.46 and the NRC safety evaluation report (SER) requirements for use of the licensing methodology, the LBPCT must be less than 2,200°F.

Conformance evaluation of the Nominal PCT is also required through the use of a statistical Upper Bound PCT (UBPCT) as defined in the NRC SER documented in Reference 2. The UBPCT is a function of the limiting break Nominal PCT, modeling bias, and plant variable uncertainty. The UBPCT is defined as:

[[ ]]

where:

[[

]]

The SAFER/PRIME-LOCA application is used for ECCS-LOCA analysis across a wide range of power and flow options available to the plant. The SAFER analyses consist of analyses for the recirculation line break spectrum, non-recirculation line breaks, alternate operating modes (such as maximum extended load line limit analysis (MELLLA) and single loop operation (SLO)), and the UBPCT and LBPCT calculations. The SAFER/PRIME-LOCA application has been adapted to present a conservative, realistic, calculation of LBPCT across the span of operating domains licensed for a plant. Flexibility has been included in the process to assure compliance to the acceptance criterion across all power and flow combinations and determination of a single bounding LBPCT. The NRC has approved the applicability of GEH methods to expanded operating domains in Reference 11.

The UBPCT is required to be bounded by the LBPCT. This ensures that the LBPCT is, in all cases, greater than the 95th percentile of the PCT distribution for the limiting case LOCA, and for all LOCAs within the design basis. GEH demonstrated that this criterion was satisfied generically for the BWR/3-4 class of plants in Reference 2. For Fermi 2, fuel and plant-specific evaluations were performed to demonstrate conformance to these acceptance criteria, as documented in this report.

3.3 BWR/3-4 Generic Analysis

The break spectrum response is determined by the ECCS network design and is common to all BWRs. There are two limiting points on the break spectrum; the full sized recirculation line break, and the worst small break with failure of the high pressure ECCS or the minimum number of automatic depressurization system (ADS) valves. For the BWR/3-4 product lines, to which Fermi 2 belongs, a generic conformance calculation was performed for the limiting hypothetical LOCA as described in Reference 2. For BWR/3-4 plants, it is anticipated that the battery failure will be limiting. Historically, the limiting LOCA was determined from the Nominal break spectrum to be a recirculation line break and ECCS component failure combination that yielded the highest Nominal PCT. The Appendix K calculation was then performed to establish the basis for licensing evaluation. The DBA recirculation suction line break with battery failure was found to be the limiting break in the Nominal break spectrum for BWR/3-4 product lines. As a result, this case was used to perform the Appendix K calculation. The LBPCT for BWR/3-4 was then calculated by combining the Nominal PCT with the adder described earlier. This generic evaluation demonstrated that a PCT margin in excess of [[ ]] existed from the UBPCT to the LBPCT.

SAFER/PRIME-LOCA has been applied to expanded operating domains as discussed in References 3 and 11. The SAFER/PRIME-LOCA application methodology will continue to be based on a best estimate approach where best-estimate modeling and Nominal input values and assumptions are used to evaluate the LOCA response. The reported LBPCT results will be demonstrated to be sufficiently conservative by comparison with the results of a 95th percentile UBPCT evaluation.

3.4 Fermi 2 Plant-Specific Analysis

The specific analysis performed for Fermi 2 consisted of cases for break sizes ranging from 0.05 ft^2 to the maximum DBA recirculation suction line break of 4.13 ft^2. Different single failure assumptions were investigated in order to identify the limiting case. Non-recirculation line breaks were also evaluated.

The SAFER/PRIME-LOCA analysis methodology to evaluate the LBPCT for Fermi 2 was used such that the break spectrum analysis identified the limiting single failure, fuel type, break size, axial power shape and break location using both Appendix K and Nominal assumptions. The most limiting PCT based on the Appendix K assumptions is identified as the basis for LBPCT and the most limiting PCT based on the Nominal assumptions is identified as the basis for UBPCT. The analysis was performed using analysis assumptions for Appendix K calculations (Table 3-1) and for Nominal calculations (Table 3-2) at rated core flow condition. The MELLLA, feedwater temperature reduction (FWTR) (final feedwater temperature reduction (FFWTR) / feedwater heater out-of-service (FWHOOS)), increased core flow (ICF) were analyzed as sensitivity studies compared to the rated conditions. The UBPCT and the LBPCT are calculated at the most limiting operating point. The Fermi 2 Nominal and Appendix K (specified models) PCT results were compared to assure that the PCT trends, as a function of break size, were similar to one another and to those of the generic BWR/3-4 (described in Section 3.3) break spectrum curves as documented in Reference 2.

Interim Methods Licensing Topical Report (IMLTR) SER Limitation and Condition 9.7 (Reference 11) was imposed by the NRC for expanded operating domains to consider both top and mid peaked power shapes for both large and small break LOCA to demonstrate the bounding power shape. IMLTR SER Limitation and Condition 9.8 (Reference 11) required that ECCS-LOCA should be performed for all statepoints in the upper boundary of the expanded operating domain. Therefore, for Fermi 2 the analysis was performed at both rated and MELLLA flow conditions with limiting axial power shapes for both large and small break LOCA.

The Fermi 2 SAFER/PRIME-LOCA analysis was performed with many of the plant and ECCS parameters conservatively relaxed relative to the design and actual performance of the ECC systems as well as the system performance assumed in the BWR/3-4 generic analysis and the determination of the statistical upper bound. This was done to provide a bounding evaluation for potential system degradation and future Technical Specification (TS) improvements. Inputs used in the analysis are given in Section 4.

Table 3-1. Analysis Assumptions for Appendix K Calculations

1.	Decay Heat	1971 American Nuclear Society (ANS) + 20%
2.	Transition Boiling Temperature	Transition boiling allowed during blowdown only until cladding superheat exceeds 300°F
3.	Break Flow	Moody Slip Flow Model with discharge coefficients of 1.0, 0.8 and 0.6
4.	Metal-Water Reaction	Baker–Just metal-water reaction rate
5.	Core Power	3,499 MWt[(a)]
6.	Peak Linear Heat Generation Rate (PLHGR)	[[ ]]
7.	Bypass Leakage Coefficients	Nominal Values
8.	Initial Operating Minimum Critical Power Ratio (MCPR)	1.25/1.02[(b)]
9.	ECCS Water Temperature	88 Btu/lbm (120°F)
10.	ECCS Initiation Signals	Drywell Trip+ Injection Valve Open + Delay
11.	ADS	120 seconds delay time
12.	ECCS Available	Systems remaining after worst single failure
13.	Stored Energy	Best Estimate PRIME-LOCA
14.	Fuel Exposure	Limiting fuel exposure which maximizes PCT

a 102% of pre-measurement uncertainty recapture (MUR) CLTP core power (1.02 x 3,430 MWt). This value is consistent with a plant-specific power uncertainty for Fermi 2.

b Operating initial MCPR, which conservatively bounds the TS MCPR limit.

Table 3-2. Analysis Assumptions for Nominal Calculations

1.	Decay Heat	1979 ANS
2.	Transition Boiling Temperature	Iloeje Correlation
3.	Break Flow	1.25 HEM[a] (Subcooled) 1.0 HEM (Saturated)
4.	Metal-Water Reaction	EPRI Coefficients
5.	Core Power	3,488 MWt [b]
6.	PLHGR	[[ ]]
7.	Bypass Leakage Coefficients	Nominal Values
8.	Initial Operating MCPR	1.25
9.	ECCS Water Temperature	88 Btu/lbm (120°F)
10.	ECCS Initiation Signals	Drywell Trip+ Injection Valve Open + Delay
11.	ADS	120 seconds delay time
12.	ECCS Available	Systems remaining after worst single failure
13.	Stored Energy	Best Estimate PRIME-LOCA
14.	Fuel Exposure	Limiting fuel exposure which maximizes PCT

a HEM: Homogeneous Equilibrium Model.

b The Nominal thermal power corresponds to Fermi 2 MUR project licensed thermal power of 3,486 MWt plus a small margin.

4.0 INPUT TO ANALYSIS

4.1 Plant Inputs

The significant plant input parameters for the Fermi 2 ECCS-LOCA analysis are presented in Tables 4-1, 4-2 and 4-3. Table 4-1 shows the plant operating conditions, Table 4-2 shows the fuel parameters, and Table 4-3 identifies the ECCS parameters. Table 4-4 identifies the combinations of single-failures and available systems specifically analyzed for the Fermi 2 ECCS configuration (Figure 4-1). Fermi 2 ECCS-LOCA analysis does not credit the reactor core isolation cooling (RCIC) system.

4.2 Fuel Parameters

The SAFER/PRIME-LOCA analyses were performed with conservative maximum average planar linear heat generation rate (MAPLHGR) at the most limiting combination of power and exposure (Table 4-2). The most limiting power/exposure combination was determined by performing generic sensitivity studies along the peak power/exposure envelope used for fuel thermal-mechanical design. The fuel evaluated for this analysis is GE14. This analysis is valid for all GE14 fuels for the PLHGR curve documented in Table 4-2.

The limiting exposure for the GE14 fuel type occurs at the first "knee" of the PLHGR curve (Table 4-2). The axial power shape was varied for each analyzed power/flow condition to place the hot bundle on the PLHGR limit while the bundle power is on the MCPR limit.

4.3 ECCS Parameters

The ECCS is designed to provide protection against postulated LOCAs caused by ruptures in primary system piping. The Fermi 2 SAFER/PRIME-LOCA analysis incorporates conservative values for most ECCS performance requirements relative to the current TS or expected equipment performance. The intent is to perform the break spectrum analyses in a conservative manner relative to the expected equipment performance to allow for degraded performances and subsequent improvements in TS. The specific ECCS performance input parameters utilized in the evaluation are presented in Table 4-3.

Table 4-1. Plant Operational Parameters Used in the Fermi 2 SAFER/PRIME-LOCA Analysis

Plant Parameters	Nominal	Appendix K
Core Thermal Power (MWt)[a]	3,488	3,499
Corresponding Power (% of 3,430 MWt)	101.7	102.0[b]
Vessel Steam Flow (Mlbm/hr)	15.152	15.213
Vessel Steam Flow (% rated)	100	100.4
Core Flow (Mlbm/hr)[c]	100.0	100.0
Core Flow (% rated)	100	100
Vessel Steam Dome Pressure (psia)	1,045.0	1,063.0
Maximum Recirculation Line Break Area (ft^2)	4.13	4.13
Bottom Head Drain Line Break Area (ft^2)	0.016	0.016

a The Nominal thermal power (3,488 MWt) corresponds to Fermi 2 MUR project licensed thermal power of 3,486 MWt plus a small margin. The pre-MUR power was 3,430 MWt. A conservative core thermal power of 3,499 MWt, which corresponds to 102% of pre-MUR power was used for the Appendix K evaluation.

b This value corresponds to 102% of pre-MUR power.

c Limiting LOCA cases analyses were performed as described in Section 5 from 83.1 to 105 Mlbm/hr (83.1% to 105% rated core flow) at 3,488 MWt core power.

Table 4-2. Fuel Parameters Used in the Fermi 2 SAFER/PRIME-LOCA Analysis

Fuel Parameter		Analysis Value
		GE14
PLHGR (kW/ft)	– Appendix K – Nominal	[[ ]]
MAPLHGR (kW/ft)	– Appendix K – Nominal	12.82 [[
Pellet Exposure for ECCS Evaluation[a] (MWd/MTU)		
PLHGR-Exposure Limit Curve Used in the LOCA Analysis (kW/ft vs. MWd/MTU)		]]
MAPLHGR-Exposure Limit Curve Used in the LOCA Analysis (kW/m vs. MWd/MTU) (kW/ft vs. MWd/MTU)		12.82/0 12.82/16,000 12.82/21,100 8.0/63,500 5.0/70,000
Initial Operating MCPR – LOCA Analysis Limit	– Appendix K – Nominal	1.25 [[
R-Factor		]]
Number of Fuel Rods per Bundle		92

a This is the exposure at the knee in the PLHGR curve. It represents the limiting exposure point resulting in the maximum calculated PCT at any time during the fuel bundle life.

Table 4-3. Fermi 2 SAFER/PRIME-LOCA Analysis ECCS Parameters

1. Low Pressure Coolant Injection (LPCI) System

	Variable	Units	Analysis Value
a.	Maximum vessel pressure at which flow may commence	psid (vessel to drywell)	264
b.	Minimum rated flow inside the vessel per division at vessel pressure of Two LPCI pumps injecting into one recirculation loop Three LPCI pumps injecting into one recirculation loop Four LPCI pumps injecting into one recirculation loop	psid (vessel to drywell) gpm gpm gpm	20 21,850 26,260 27,625
c.	Initiating signals • Low water level (Level 1) or • High drywell pressure	inches above vessel zero psig	378.51 2
d.	Pressure permissive at which injection valve may open	psig	350
e.	Injection valve stroke time	sec	30
f.	Maximum allowable time from initiating signal to pump at rated speed and ready to inject flow to vessel with emergency power	sec	77
g.	Minimum detectable break size for loop selection logic	ft^2	0.15

Table 4-3. Fermi 2 SAFER/PRIME-LOCA Analysis ECCS Parameters (Continued)

2. Low Pressure Core Spray (LPCS) System

	Variable	Units	Analysis Value
a.	Maximum vessel pressure at which flow may commence	psid (vessel to drywell)	280
b.	Minimum rated flow inside the vessel per division at vessel pressure of One Loop Two Loop	psid (vessel to drywell) gpm gpm	100 5,625 11,250
c.	Initiating signals • Low water level (Level 1) or • High drywell pressure	inches above vessel zero psig	378.51 2
d.	Pressure permissive at which injection valve may open	psig	350
e.	Injection valve stroke time	sec	15
f.	Maximum allowable time from initiating signal to pump at rated speed and ready to inject flow to vessel with emergency power	sec	47

Table 4-3. Fermi 2 SAFER/PRIME-LOCA Analysis ECCS Parameters (Continued)

3. High Pressure Coolant Injection (HPCI) System

	Variable	Units	Analysis Value
a.	Maximum vessel pressure at which pump can inject flow	psia	1,135
b.	Minimum flow into reactor vessel at vessel pressure of	psia gpm	1,135 to 165 5,000
c.	Initiating signals • Low water level (Level 2) or • High drywell pressure	inches above vessel zero psig	457.51 2
d.	Maximum allowable time delay from initiating signal to rated flow available and injection valve fully open	sec	60.0

4. ADS

	Variable	Units	Analysis Value
a.	Total number of relief valves installed with ADS function		5
b.	Total number of relief valves with ADS function assumed in analysis		4
c.	Total minimum flow capacity of any 4 valves At vessel pressure	Mlbm/hr psig	3.48 1,090
d.	Initiating signals • Low water level (Level 1) and • High drywell pressure	inches above vessel zero psig	378.51 2
e.	ADS timer delay from initiating signal completed to the time valves are opened	sec	120

The table below shows combinations of the ADS, HPCI system, LPCI system and LPCS system remaining operable following assumed single active failures. In performing the SAFER/PRIME-LOCA analysis, it was assumed that no postulated single active component failure will result in less than the minimum combinations of systems remaining operable as identified below. Therefore, it is only necessary to consider each of these single failures in the ECCS performance analyses.

Table 4-4. Fermi 2 Single-Failure Evaluation

Assumed Failure[(a)]	Systems Remaining[(b)]
Division I DC Power Source (Div. I Battery)	HPCI, 2 LPCI, 1 LPCS
Division II DC Power Source (Div. II Battery)	4 ADS, 2 LPCI, 1 LPCS[(c)(d)]
LPCI Injection Isolation Valve (LPCIIV)	4 ADS, HPCI, 2 LPCS[(c)]
Diesel Generator (D/G)	4 ADS, HPCI, 2 LPCI, 1 LPCS [(c)]
HPCI	4 ADS, 4 LPCI, 2 LPCS[(c) (d)]
One ADS Valve	4 ADS, 4 LPCI, HPCI, 2 LPCS

a Other postulated failures are not specifically considered because they all result in at least as much ECCS capacity as one of the assumed single failures listed above.

b Systems remaining, as identified in this table, are applicable to all non-ECCS line breaks. For a LOCA from an ECCS line break, the systems remaining are those listed, less the ECCS system in which the break is assumed.

c The analysis conservatively assumes 4 ADS valves available.

d The HPCI failure small break analysis (SBA) case is analyzed with 4 ADS valves available.

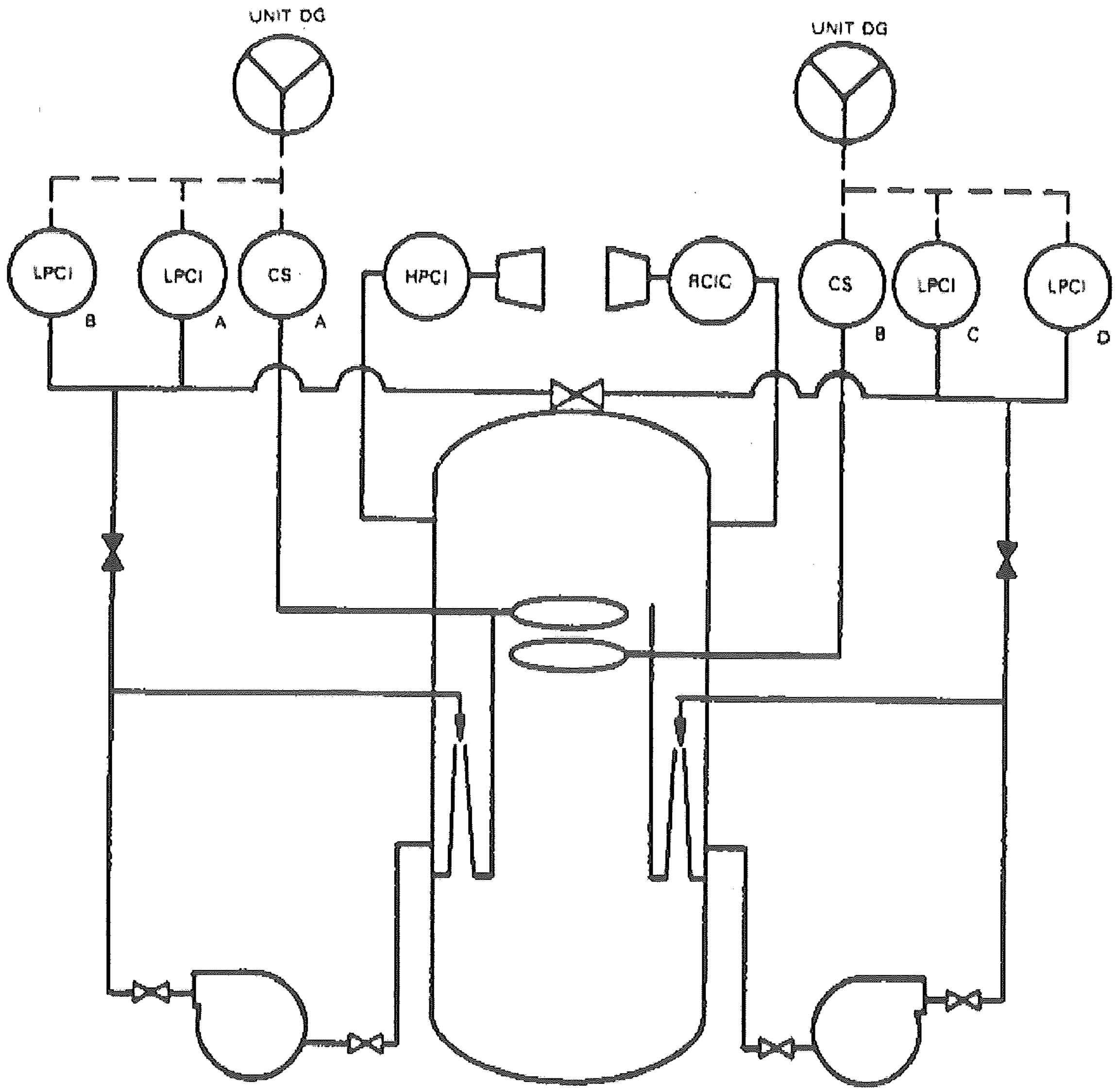

Figure 4-1. Fermi 2 ECCS Configuration

5.0 RESULTS

5.1 Break Spectrum Calculations

The Fermi 2 break spectrum response is determined by the ECCS network design and is common to all BWRs. There are two limiting points on the break spectrum; the full sized recirculation line break, and the worst small break with failure of the high pressure ECCS or the minimum number of ADS valves. The PCT for the limiting large break LOCA is determined primarily by the hot bundle power; the hot bundle is assumed to be operating at the thermal limits (MCPR, MAPLHGR, and linear heat generation rate (LHGR)).

A sufficient number of recirculation suction line break sizes and ECCS failure combinations were analyzed using Nominal and Appendix K inputs at rated flow so that the shape of the PCT versus break area curve (break spectrum) could be determined. This ensures that the limiting combination of break size and single failure have been determined. Fermi 2 specific design with Division I, Division II battery and LPCIIV failure combinations have been explicitly considered in this evaluation. The results of single failure analyses provided in Tables 5-1 and 5-2 confirm that for large break the Division II battery failure is limiting while for small break it is the Division I battery failure. The resulting Appendix K and Nominal breaks spectrum for break sizes ranging from 0.05 ft^2 to the double-ended guillotine (DEG), also referred to as DBA, recirculation suction line break of 4.13 ft^2, based on rated flow condition with limiting single failure, is shown in Figure 5-1 and in Tables 5-1 and 5-2.

Both mid-peaked and top-peaked axial power shapes are considered for this analysis. The evaluation confirms that the [[ ]] axial power shape yields the limiting PCT for large breaks (Table 5-1) and the [[ ]] axial power shape yields the limiting PCT for small breaks (Table 5-2).

The limiting Appendix K assumptions case occurs at the recirculation suction line break with break size of [[ ]] with Division I single failure at the MELLLA condition. The limiting Nominal assumptions case occurs at the recirculation suction line break with break size of [[ ]] with Division I single failure at rated flow.

5.1.1 Large Recirculation Line Breaks

The limiting large break LOCA event for Fermi 2 is the DBA recirculation suction line break. Several large recirculation suction line breaks were analyzed for GE14 fuel with Nominal and Appendix K assumptions across the operating domain to confirm the limiting break and single failure combination. These analyses include dryout times from LAMB/TASC calculations that determined early boiling transition. The results of these analyses are given in Table 5-1 and Figures A-1 through A-4. These results show that the limiting break and single failure combination is the DBA recirculation suction line break with Division II battery for both Nominal and Appendix K assumptions at the MELLLA condition. The calculated PCTs for these cases are [[ ]] and [[ ]], respectively.

[[

]]

Results of the large break [[ ]] and provided in this analysis to satisfy IMLTR Limitation and Condition 9.8 (Reference 11). The results of Nominal and Appendix K at rated flow are given in Table 5-1 and in Figures A-3 and A-4. Two large break sizes (60%, 80%) were also performed with Appendix K input assumptions for the limiting single failure at rated flow to satisfy the Appendix K requirements for using the Moody Slip Flow Model with three discharge coefficients between 0.6 and 1.0 (rated case). The results of these cases are given in Table 5-1 and Figure 5-1. An additional [[ ]] to confirm the adequacy of the break spectrum. The result of this case is given in Table 5-1 and Figure 5-1.

5.1.2 Small Recirculation Line Breaks

Fermi 2 specific design with Division I battery, Division II battery and LPCIIV failure assumptions has been explicitly considered in this evaluation. The most limiting single failure for small recirculation line breaks is the Division I battery as shown in Table 5-2. The small break cases were analyzed for GE14 fuel with Nominal and Appendix K assumptions to determine the small break with the highest PCT. The results of these analyses are given in Table 5-2. From this analysis, it was concluded that the most limiting small break is the [[ ]] recirculation line break with Nominal assumptions at 100% core flow (rated) and the [[ ]] recirculation line break with Appendix K assumptions at 83.1% core flow (MELLLA). The calculated PCTs for these cases are [[ ]] and [[ ]], respectively. The limiting Nominal and Appendix K small recirculation break PCTs are higher than the limiting large recirculation line break PCTs. These results confirm that the recirculation suction line small break is the limiting LOCA event for Fermi 2.

For the [[ ]] recirculation line break case with Division I battery and Nominal assumptions at rated flow, scram is assumed to occur at the start of the event on high drywell pressure. [[

]] A two-phase level is rapidly recovered in the bundle and terminates the bundle heat up (Figures B-3c and B-3d).

The accident progression for the [[ ]] recirculation line break case with Division I battery and Appendix K assumptions at MELLLA flow is similar to the Nominal case. [[

]] A two-phase level is rapidly recovered in the bundle and terminates the bundle heat up (Figures B-2c and B-2d).

Results of the limiting Nominal small break of [[ ]] at MELLLA flow are given in Table 5-2 and Figures B-1a to B-1e. Results of the Appendix K small break [[ ]] at rated flow are given in Table 5-2 and Figures B-4a to B-4e. These results are provided to satisfy IMLTR Limitation and Condition 9.8 (Reference 11).

5.1.3 Non-Recirculation Line Breaks

The non-recirculation line breaks are typically less limiting than the recirculation line break because the break location is well above the top of the core. A sufficient number of non-recirculation line breaks were analyzed to demonstrate that these postulated breaks are less limiting than the postulated recirculation line breaks.

For BWR/4s with HPCI, the HPCI injects through the feedwater line; thus, it is possible for HPCI to be effectively disabled as a consequence of the break (i.e., not in association with a single failure), if it is postulated to occur in the line associated with HPCI injection. For Fermi 2, the assumed [[

]]. This FWLB analysis credits manual operator action to depressurize the reactor. The manual operator action to perform emergency depressurization was assumed to occur when the reactor water level reached the minimum water level requiring emergency depressurization, which is defined as 42 inches below top of active fuel (TAF). The limiting analysis demonstrates that at least [[
]] are required to maintain calculated PCT values that are below the 2,200°F licensing limit. The PCT of this case remains below the 2,200°F licensing limit as shown in Table 5-3. The action to perform emergency depressurization occurs at approximately [[ ]] into the accident.

5.2 Compliance Evaluations

5.2.1 Licensing Basis PCT Evaluation

The Appendix K results confirm that the limiting break is the [[ ]] recirculation suction line break with Division I battery failure (Tables 5-1 and 5-2). The LBPCT for Fermi 2 is calculated for GE14 fuel based on the above Appendix K PCT and using the SAFER/PRIME-LOCA licensing methodology approved by the NRC in References 2 and 4. Fermi 2 unique variable uncertainties, including [[ ]] were evaluated specifically for GE14 fuel to determine plant-specific adders. The calculated LBPCT is less than the UBPCT. Because the LBPCT must bound the UBPCT, the LBPCT is set to 1,980°F.

The LBPCT is calculated based on the most limiting recirculation suction line break with Appendix K assumptions under Division I battery failure. This evaluation demonstrated that the licensing acceptance criteria and the NRC SER requirements are met for all the operating points.

5.2.2 Upper Bound PCT Evaluation

The NRC SER approving the original SAFER/GESTR-LOCA application methodology (described in Reference 2) placed a restriction of 1,600°F on the UBPCT calculation. The 1,600°F restriction on the UBPCT was later eliminated (Reference 12). The elimination of the restriction on the UBPCT is applicable to all plants using the SAFER/PRIME-LOCA application methodology described in References 2 and 4, including Fermi 2. The primary purpose of the UBPCT calculation is to demonstrate that the LBPCT is sufficiently conservative by showing that the UBPCT is bounded by the LBPCT. The NRC SER in Reference 12 required confirmation that the plant-specific operating parameters have been conservatively bounded by the models and inputs used in the generic calculations. The NRC SER also required confirmation that the plant-specific ECCS configuration is consistent with the referenced plant class ECCS configuration for the purpose of applying the generic UBPCT calculations from the licensing topical report (LTR) to the plant-specific analysis. Because of the wide variation in plant-specific operating parameters and ECCS performance parameters within the BWR product lines, it is difficult to judge whether an individual plant is bounded by the generic calculations. Therefore, the practice has been to calculate the UBPCT on a plant-specific basis rather than rely on the generic UBPCT calculations in order to demonstrate that the LBPCT is sufficiently conservative.

As described in Section 4.0, the Fermi 2 analysis was performed with many of the plant and ECCS parameters conservatively established relative to the design and actual performance of the ECCS at Fermi 2, and the ECCS performance parameters assumed in the generic determination of the statistical upper bound. This was done to accommodate potential system degradation and future improvements to the plant without requiring extensive reanalysis. Even with these conservative plant and system parameters, the UBPCT is calculated at 1,980°F based on the limiting recirculation suction line break with Nominal assumptions under Division I single failure. Based on these results the UBPCT value is assigned as the LBPCT. The LBPCT is below the 10 CFR 50.46 limit of 2,200°F. Therefore, 10 CFR 50.46 acceptance criteria (Section 3.1) and the NRC SER requirements for the SAFER/PRIME-LOCA methodology are met for all the operating conditions.

5.3 Alternate Operating Mode Considerations

The limiting large break, the DBA recirculation suction line break, was considered for the MELLLA, FWTR, ICF and SLO operating modes. The MELLLA and FWTR analyses are also considered for Fermi 2 small breaks as the small break is the limiting break.

5.3.1 Maximum Extended Load Line Limit Analysis (MELLLA)

Per IMLTR Limitation and Condition 9.8 (Reference 11), the ECCS-LOCA analysis should be performed for all statepoints in the upper boundary of the expanded operating domain. SAFER calculations for the MELLLA condition at 100% of assumed rated power (3,488 MWt) and 83.1% of rated flow with Nominal assumptions and Appendix K assumptions are shown in Tables 5-1 and 5-2. These calculations show that the results for the case at MELLLA conditions are limiting for both large and small breaks with Appendix K assumptions; therefore, these results are considered for LBPCT and UBPCT calculations.

5.3.2 Feedwater Temperature Reduction (FFWTR/FWHOOS)

SAFER calculations for FWTR (FFWTR/FWHOOS), based on a [[ ]] reduction in the initial feedwater temperature, with Appendix K assumptions are shown in Tables 5-1 and 5-2. These calculations show that the results for the case at rated power/MELLLA flow conditions at normal feedwater temperature (NFWT) are still bounding.

5.3.3 Increased Core Flow

The effect of ICF operation (up to 105% of rated core flow) on the ECCS-LOCA analysis is a slight delay in the onset of early boiling transition for the axial nodes in the upper part of the bundle. This results in a lower calculated PCT for these nodes. However, [[ ]]. Therefore, the effect of ICF operation on the ECCS-LOCA analysis results [[ ]]. Thus, the PCTs for the limiting large break cases given in Section 5.1 are applicable to the ICF condition.

5.3.4 Single Loop Opeation

The SLO analysis (66.1% of rated CLTP and 48% of rated core flow) conservatively assumes [[ ]].

With the SLO multipliers of 0.8 on LHGR and MAPLHGR shown in Table 6-2, the SLO analysis results in Table 5-1 [[ ]]. With Appendix K assumptions the PCT remains below the 2,200°F licensing limit.

5.3.5 Out-of-Service Equipment

The Fermi 2 plant TS allow various equipment components to be out-of-service. For example, ADS valve out-of-service and several SRVs can be inoperable without requiring a plant shutdown. The effect of these conditions on the SAFER/PRIME-LOCA analysis was examined (Table 5-2). Because the out-of-service equipment is evaluated to give Fermi 2 an option to operate without requiring a plant shutdown, the results of these options are not considered in the calculated LBPCT.

5.4 MAPLHGR Limits

Current GEH BWR MAPLHGR limits (as a function of exposure) are based on the most limiting value of either the MAPLHGR determined from ECCS limits (PCT) or the MAPLHGR determined from fuel thermal-mechanical design analysis limits.

The bounding MAPLHGR used in the Fermi 2 SAFER/PRIME-LOCA analysis (i.e., 12.82 kW/ft for the GE14 fuel type) is higher than the thermal-mechanical MAPLHGRs for this fuel design. Therefore, this analysis establishes that for the GE14 fuel design at Fermi 2, the MAPLHGR is not limited by ECCS-LOCA considerations.

Table 5-1. Summary of Large Recirculation Line Break Results [a]

Power/Flow Condition, Break Location and Break Size [b]	Failure [c]	Nominal PCT		Appendix K PCT	
		First Peak (°F)	Second Peak (°F)	First Peak (°F)	Second Peak (°F)
[[					
					]]

[[

]]

Table 5-2. Summary of Small Recirculation Line Break Results [a]

Power/Flow Condition and Break Location[b]	Break Area (ft^2)	Failure[c]	Nominal PCT (^oF) [d]	Appendix K PCT (^oF)
[[				
				]]

[[

]]

Table 5-3. Summary of Feedwater Line Break Results [a]

Power/Flow Condition and Break Location	Break Area (ft^2)[b]	Failure[c]	Nominal PCT (^oF)	Appendix K PCT (^oF)
[[				]]

[[

]]

[[

]]

Figure 5-1. Appendix K and Nominal LOCA Break Spectrum Analysis Results

6.0 CONCLUSIONS

LOCA analyses have been performed for Fermi 2 utilizing the GEH SAFER/PRIME-LOCA application methodology approved by the NRC. These analyses were performed in accordance with the NRC SER for the use of the SAFER/PRIME-LOCA analysis methodology and demonstrate conformance with 10 CFR 50.46 and 10 CFR 50 Appendix K and thus establish a licensing basis for Fermi 2 with the GEH SAFER/PRIME-LOCA methodology.

The Fermi 2 SAFER/PRIME-LOCA results presented in Section 5 demonstrate that a sufficient number of plant-specific PCT points have been evaluated to establish the Appendix K PCTs for all possible break locations. Based on this evaluation, the small recirculation line break was used to establish the limiting LBPCT.

Table 6-1 summarizes the key SAFER/PRIME licensing results. The analyses presented are performed in accordance with NRC requirements and demonstrate conformance with the ECCS acceptance criteria of 10 CFR 50.46. Therefore, the results documented in this report may be used to provide a LOCA licensing basis for Fermi 2 and can be used for updating the safety analysis report and in support of future TS changes for the plant. The results are valid for fuel designs with comparable geometry to the GE14 fuel type analyzed and for MAPLHGR and PLHGR values less than or equal to those shown in Table 4-2.

Because the LBPCT for Fermi 2 bounds the UBPCT (95th percentile), the level of safety and conservatism of this analysis meets the NRC approved criteria. Therefore, the requirements of Appendix K are satisfied.

The thermal limits applied to the GE14 fuel in the ECCS-LOCA evaluation are summarized in Table 6-2.

Table 6-1. SAFER/PRIME-LOCA Licensing Results for Fermi 2

	Parameters	Results	Acceptance Criteria
1.	Fuel Type	GE14 Fuel	
2.	Limiting Break	Recirculation Suction Small Break	
3.	Limiting Failure	Division I DC Power (Battery)	
4.	PCT (Licensing Basis)	< 1,980°F	≤ 2,200°F
5.	Estimated UBPCT (95% Probability PCT)	< 1,980°F	≤ LBPCT
6.	Maximum Local Oxidation	< 4 %	≤ 17 %
7.	Core-Wide Metal-Water Reaction	< 0.1 %	≤ 1.0 %
8.	Coolable Geometry	Items 4 and 6	PCT<2200°F and Maximum Local Oxidation <17%
9.	Long Term Cooling	Core flooded above TAF	Core temperature acceptably low and long-term decay heat removed

Table 6-2. Thermal Limits for GE14

Fuel Parameter	**Analysis Limit**	
LHGR - Exposure Limit Curve (Peak Pellet Exposure)	**MWd/MTU**	**kW/ft**
	[[	
		]]
MAPLHGR - Exposure Limit Curve (Lattice Exposure)	**MWd/MTU**	**kW/ft**
	0	12.82
	16,000	12.82
	21,100	12.82
	63,500	8.0
	70,000	5.0
Initial Operating MCPR	1.25	
R-Factor	[[ ]]	
SLO Multiplier on LHGR & MAPLHGR	0.80	
Initial Operating MCPR - LOCA Analysis Limit -Appendix K -Nominal	1.25 [[ ]]	

7.0 REFERENCES

1. GE Nuclear Energy, "Maximum Extended Operating Domain Analysis for Detroit Edison Company Enrico Fermi Energy Center Unit 2," NEDC-31843P, July 1990.

2. General Electric Company, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident, Volume III, SAFER/GESTR Application Methodology," NEDE-23785-1-PA, Revision 1, October 1984.

3. GE Nuclear Energy, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," NEDC-32950P, Revision 1, July 2007.

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5. GE Nuclear Energy, "Fermi-2 SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis," NEDC-31982P, July 1991.

6. General Electric Company, "Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K," NEDE-20566-P-A, September 1986.

7. GE Nuclear Energy, "TASC-03A A Computer Program for Transient Analysis of a Single Channel," NEDC-32084P-A, Revision 2, July 2002.

8. GE Hitachi Nuclear Energy, "The PRIME Model for Analysis of Fuel Rod Thermal-Mechanical Performance," NEDC-33256P-A, NEDC-33257P-A, NEDC-33258P-A, Revision 1, September 2010.

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11. GE Hitachi Nuclear Energy, "Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P-A, Revision 4, November 2012.

12. GE Nuclear Energy, "GESTR-LOCA and SAFER Models for Evaluation of Loss-of-Coolant Accident, Volume III, Supplement 1 – Additional Information for Upper Bound PCT Calculation," NEDE-23785P-A, Supplement 1, Revision 1, March 2002.

APPENDIX A. - System Response Curves for Large Line Breaks

Included in this appendix are the system response curves for Fermi 2. Table A-1 contains the figure numbering sequence for the limiting Nominal and Appendix K large line breaks cases.

Table A-1. Large Line Breaks Figure Summary

	Limiting DBA Recirculation Line Suction Break, MELLLA (Nominal)	**Limiting DBA Recirculation Line Suction Break, MELLLA (Appendix K)**	**DBA Recirculation Line Suction Break with Rated Flow (Nominal)**	**DBA Recirculation Line Suction Break with Rated Flow (Appendix K)**
Water Level in Hot and Average Channels	A-1a	A-2a	A-3a	A-4a
Reactor Vessel Pressure	A-1b	A-2b	A-3b	A-4b
PCT	A-1c	A-2c	A-3c	A-4c
Heat Transfer Coefficients	A-1d	A-2d	A-3d	A-4d
ECCS Flows	A-1e	A-2e	A-3e	A-4e

[[

]]

Figure A-1a. Water Level in Hot and Average Channels. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-1b. Reactor Vessel Pressure. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-1c. Peak Cladding Temperature. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-1d. Heat Transfer Coefficients. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-1e. ECCS Flows. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-2a. Water Level in Hot and Average Channels. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-2b. Reactor Vessel Pressure. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-2c. Peak Cladding Temperature. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-2d. Heat Transfer Coefficients. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-2e. ECCS Flows. Limiting DBA Recirculation Line Suction Break, Division II Battery, MELLLA (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-3a. Water Level in Hot and Average Channels. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-3b. Reactor Vessel Pressure. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-3c. Peak Cladding Temperature. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-3d. Heat Transfer Coefficients. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-3e. ECCS Flows. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Nominal Assumptions]

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Figure A-4a. Water Level in Hot and Average Channels. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-4b. Reactor Vessel Pressure. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-4c. Peak Cladding Temperature. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-4d. Heat Transfer Coefficients. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

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Figure A-4e. ECCS Flows. Recirculation Line Suction Break, Division II Battery with Rated Flow (2 LPCI + 1 LPCS + 4 ADS Available) [Appendix K Assumptions]

APPENDIX B. - System Response Curves for Small Line Breaks

Included in this appendix are the system response curves for Fermi 2. Table B-1 contains the figure numbering sequence for the limiting Nominal and Appendix K Small line breaks cases.

Table B-1. Small Line Breaks Figure Summary

	Small Recirculation Line Suction Break ([[ ]], MELLLA Flow) (Nominal)	**Limiting Small Recirculation Line Suction Break ([[ ]], MELLLA Flow) (Appendix K)**	**Limiting Small Recirculation Line Suction Break ([[ ]], Rated Flow) (Nominal)**	**Small Recirculation Line Suction Break ([[ ]], Rated Flow) (Appendix K)**
Water Level in Hot and Average Channels	B-1a	B-2a	B-3a	B-4a
Reactor Vessel Pressure	B-1b	B-2b	B-3b	B-4b
Peak Cladding Temperature	B-1c	B-2c	B-3c	B-4c
Heat Transfer Coefficients	B-1d	B-2d	B-3d	B-4d
ECCS Flows	B-1e	B-2e	B-3e	B-4e

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Figure B-1a. Water Level in Hot and Average Channels. Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-1b. Reactor Vessel Pressure. Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-1c. Peak Cladding Temperature. Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-1d. Heat Transfer Coefficients. Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-1e. ECCS Flows. Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-2a. Water Level in Hot and Average Channels. Limiting Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-2b. Reactor Vessel Pressure. Limiting Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-2c. Peak Cladding Temperature. Limiting Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-2d. Heat Transfer Coefficients. Limiting Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-2e. ECCS Flows. Limiting Small Recirculation Line Break [[ ]], Division I Battery, MELLLA (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-3a. Water Level in Hot and Average Channels. Limiting Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-3b. Reactor Vessel Pressure. Limiting Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-3c. Peak Cladding Temperature. Limiting Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-3d. Heat Transfer Coefficients. Limiting Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-3e. ECCS Flows. Limiting Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Nominal Assumptions]

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Figure B-4a. Water Level in Hot and Average Channels. Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-4b. Reactor Vessel Pressure. Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-4c. Peak Cladding Temperature. Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-4d. Heat Transfer Coefficients. Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]

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Figure B-4e. ECCS Flows. Small Recirculation Line Break [[ ]], Division I Battery with Rated Flow (2 LPCI + 1 LPCS + HPCI Available) [Appendix K Assumptions]