calculate reactor thermal output. The Caldon system will measure FW mass flow to within plus or minus (±) 0.23% for Seabrook. This bounding FW mass flow uncertainty would be used to calculate a total power measurement uncertainty of 0.3%. On the basis of this, FPLE proposed to reduce the power measurement uncertainty required by 10 CFR, Part 50, Appendix K to 0.3%. The improved power measurement uncertainty would obviate the need for the 2% power margin originally required by 10 CFR, Part 50, Appendix K, thereby allowing an increase in the reactor power available for electrical generation by 1.7%.

This accuracy is supported by Caldon Topical Report ER-80P, "Improving Thermal Power Accuracy and Plant Safety While Increasing Operating Power Level Using the LEFM Check™ System," which, by safety evaluation report (SER) dated March 8, 1999 (Agencywide Documents and Management System (ADAMS) Accession Number 9903190065 (legacy library)), was approved by the NRC staff for use in justification of measurement uncertainty recapture (MUR) power uprates up to 1%. Subsequently, by Safety Evaluation (SE) dated December 20, 2001 (ADAMS Accession Number ML013540256), the NRC staff approved Caldon Topical Report ER-157P, "Basis for a Power Uprate With the LEFM Check™ or LEFM CheckPlus™ System," for use in justifying MUR power uprates up to 1.7%.

3.0 EVALUATION

3.1 Instrumentation and Controls (I&C)

3.1.1 Background

The NRC staff review in the area of I&C covers the proposed plant-specific implementation of the FW flow measurement technique and the power increase gained as a result of implementing this technique in accordance with the guidelines (A through H) provided in Section I of Attachment 1 to Regulatory Information Summary (RIS) 2002-03, "Guidance on the Content of Measurement Uncertainty Recapture Power Uprate Applications." The NRC staff review was conducted to confirm that the licensee's implementation of the proposed FW flow measurement device is consistent with the staff-approved Caldon Topical Reports ER-80P and ER-157P and adequately addresses the four additional criterion listed in the NRC staff SER of the Caldon Topical Reports ER-80P and ER-157P. The NRC staff also reviewed the power uncertainty calculations to ensure that the proposed uncertainty value of 0.3% correctly accounted for all uncertainties due to power level instrumentation errors, and that the calculations met the relevant requirements of Appendix K to 10 CFR Part 50 as described in Section 2.0 of this SE.

The neutron flux instrumentation is calibrated to the core thermal power, which is determined by an automatic or manual calculation of the energy balance around the plant's nuclear steam supply system (NSSS). This calculation is called a "secondary calorimetric" for a pressurized-water reactor (PWR). The accuracy of this calculation depends primarily upon the accuracy of FW flow and FW enthalpy measurements. FW flow uncertainty is the most significant contributor to the overall core thermal power uncertainty. An accurate measurement of this parameter will result in an accurate determination of core thermal power.

Currently, the instrumentation used for measuring FW flow rate at Seabrook is a venturi. This device generates a differential pressure proportional to the FW velocity in the pipe. Due to the high cost of calibration of the venturi and the need to improve flow instrumentation inoperable

inoperable LEFM and the effect on thermal power measurement and plant operation.

In response, FPLE stated that implementation of the MUR power uprate license amendment will include developing the necessary procedures and documents required for operation, maintenance, calibration, testing, and training with the new Caldon LEFM CheckPlus™ UFM system. These procedures will incorporate Caldon's maintenance and calibration requirements for the LEFM CheckPlus™ UFM system. The Caldon LEFM CheckPlus™ UFM system is designed and manufactured in accordance with Caldon's 10 CFR, Part 50, Appendix B, Quality Assurance Program and its Verification and Validation Program. Caldon's Verification and Validation Program fulfills the requirements of American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)-American Nuclear Society (ANS) Standard 7-4.3.2 and American Society of Mechnical Engineers Boiler and Pressure Vessel Code (ASME Code)-NQA-2a. In addition, the program is consistent with guidance for software verification and validation in Electric Power Research Institue (EPRI) TR-103291S. Specific examples of quality measures undertaken in the design, manufacture, and testing of the Caldon LEFM CheckPlus™ UFM system are provided in Caldon Topical Report ER-80P, Section 6.4 and Table 6-1.

Selected I&C personnel will be trained and qualified per FPLE's Institute for Nuclear Power Operations-accredited training program before maintenance or calibration is performed and prior to increasing power above 3587 MWt. This training will include lessons learned from industry experience. Initially, formal training by Caldon will be provided to Seabrook personnel. Corrective action involving maintenance will be performed by personnel qualified in accordance with FPLE's Instrumentation and Calibration Training Program and formally trained on the LEFM CheckPlus™ UFM system. The Seabrook LEFM CheckPlus™ UFM system will be included in Caldon's Verification and Validation Program, and procedures will be maintained for user notification of important deficiencies in accordance with 10 CFR Part 21 reporting requirements.

The LEFM CheckPlus™ UFM system is assumed to be inoperable if one or more paths is lost. The proposed allowed outage time (AOT) for operation at any power level in excess of the current licensed core power level (3587 MWt) with the LEFM CheckPlus™ UFM system out of service is 48 hours provided steady-state conditions persist (i.e., no power changes in excess of 10%) throughout the 48-hour period.

For the LEFM CheckPlus™ UFM system out-of-service condition, the 48-hour AOT will start at the time of the failure and this failure will be annunciated in the control room. FPLE stated that the plant operating procedures will be revised to state that if the inoperable LEFM CheckPlus™ UFM system is not restored to an operable status or the plant experiences a power change of greater than 10% during the 48-hour period, then the permitted maximum power level will be reduced to the current licensed core thermal power level of 3587 MWt.

Additionally, FPLE stated that there are alternate plant instruments (FW venturies and main steam flow) available to be used if the LEFM CheckPlus™ UFM system is out of service. The alternate instrumentation and the LEFM CheckPlus™ UFM system calorimetric are completely separate, and the calculations of core thermal power are performed independently by the main plant computer. The preferred alternate method is the main steam flow instruments normalized to the LEFM CheckPlus™ UFM system flow. The

steam flow normalization is performed by taking the ratio of total steam flow measured by the alternate instrumentation to the FW flow measured by the LEFM CheckPlus™ UFM system. The calorimetric flow input can be provided by the feedwater venturis, the main steam flow meters normalized to the feedwater venturis or the main steam flow meters normalized to the LEMF CheckPlus™ UFM system. All three methods are bounded by the 2% uncertainty for a core power level of 3587 MWt. The accuracy of the FW venturies and the main steam flow instrumentation will gradually degrade over time as a result of nozzle fouling and transmitter drift. The values of this drift, however, are typically in the range of tenths of a percent of the calibrated span over 18 to 24 months or more. This typical drift value will not result in any significant drift for the instrumentation associated with the calorimetric measurements over a 48-hour period.

A main plant computer system failure will be treated as a loss of both the Caldon LEFM CheckPlus™ UFM system and the ability to obtain a corrected calorimetric power using alternate plant instrumentation. Thus, operation at the MUR core power level of 3648 MWt may continue until the next required nuclear instrumentation heat balance adjustment which could be up to 24 hours. The main plant computer system failure will then result in reducing core thermal power to the current licensed core power level of 3587 MWt, as needed, to support the manual calorimetric measurement. The 48-hour time period will not apply in this specific case, as a manual calorimetric will be required.

(2) For plants that currently have LEFMs installed, the licensee should provide an evaluation of the operational and maintenance history of the installation and confirm that the installed instrumentation is representative of the LEFM system and bounds the analysis and assumptions set forth in topical report ER-80P.

In response, FPLE stated that Seabrook currently has flow measurement venturies on the FW system, and differential pressure instrumentation on the main steam system. The FW system flow venturies and the main steam differential pressure instrumentation will serve as backup inputs to the calorimetric to be used when the LEFM CheckPlus™ UFM system is not available. The new LEFM CheckPlus™ UFM system will be independent of the FW system venturies, the main steam system flow instrumentation, and the Caldon 2-path chordal devices. Thus, operational and maintenance history associated with the Caldon 2-path chordal devices is not applicable to the new LEFM CheckPlus™ UFM system.

(3) The licensee should confirm that the methodology used to calculate the uncertainty of the LEFM in comparison to the current feedwater instrumentation is based on accepted plant setpoint methodology (with regard to the development of instrument uncertainty). If an alternate methodology is used, the application should be justified and applied to both venturi and ultrasonic flow measurement instrumentation installation for comparison.

In response, FPLE stated that the total power calorimetric accuracy using the LEFM CheckPlus™ UFM system is determined by evaluating the reactor thermal power sensitivity to deviations in the process parameters used to calculate reactor thermal power. Uncertainties for parameters that are not statistically independent are arithmetically summed to produce groups that are independent of each other, which can be statistically combined. Then all independent

To address Item E of RIS 2002-03, FPLE provided a summary of the Seabrook core thermal power measurement uncertainty in a table format listing uncertainty values from the Caldon Engineering Report ER-482P which provides a detailed calculation of the uncertainties. FPLE stated that the values in the uncertainty column of the table and the total power uncertainty determination are bounding values. The staff audit of ER-482P found that the calculations determined individual measurement uncertainties of all parameters contributing to the core thermal power measurement uncertainty and those uncertainties were then combined using square root of sum of squares methodology, as described in Regulatory Guide (RG) 1.105 and Instrument Society of America S67.04.

Upon review of the submitted information, the NRC staff finds that the licensee has provided calculations of the total power measurement uncertainty at the plant, explicitly identifying all parameters and their individual contribution to the power uncertainty and, therefore, has adequately addressed the guidance in Item E of Section I of Attachment 1 to RIS 2002-03.

To address the five aspects contained in Item F of RIS 2002-03 as applicable to the LEFM CheckPlus™ UFM system, FPLE provided detailed information in their response to Criterion 1 of the NRC staff SER on ER-80P. To address these five aspects applicable to all other instruments that affect the power calorimetric and the main plant computer, FPLE listed all those process inputs and stated that the process inputs are obtained from analog instrumentation channels that are maintained and calibrated in accordance with required periodic calibration procedures. Additionally, FPLE stated that the configuration of the hardware associated with these process inputs is maintained in accordance with the Seabrook change control process. FPLE further stated that the maintenance and calibration of the main plant computer inputs is performed in accordance with the Seabrook periodic maintenance program, and the software and hardware configuration is maintained in accordance with the Seabrook change control process, which includes verification and validation of changes to software and hardware configuration.

Based on the information provided by FPLE, the NRC staff finds that FPLE has addressed the calibration and maintenance aspects of the LEFM CheckPlus™ UFM system and all other instruments affecting power calorimetric and, thus, complied with the guidance in item F of Section I of Attachment 1 to RIS 2002-03.

3.1.4 Summary

The NRC staff reviewed the licensee's proposed plant-specific implementation of the FW flow measurement device and the power uncertainty calculations and determined that the licensee's proposed use of Topical Report ER-80P, and its supplement ER-157P, is consistent with the staff's approval of the topical reports. The NRC staff has also determined that the licensee adequately accounted for instrumentation uncertainties in the reactor thermal power measurement uncertainty calculations and demonstrated that the calculations meet the relevant requirements of 10 CFR Part 50, Appendix K as described in Section 2 of this SE. Therefore, the NRC staff finds the I&C aspect of the proposed MUR power uprate acceptable.

The licensee re-analyzed the Updated Final Safety Analysis Report (UFSAR) Chapter 15 LOCA and non-LOCA transients and accidents in support of the Seabrook 5.2% SPU. The licensee used NRC-approved computer codes and methodologies for each accident and transient analysis. These analyses were performed at a rated core power of 3587 MWt using plant parameter values for those operating conditions plus a 2% initial conditions uncertainty. Thus, the analyzed core power level of 3659 MWt is 2% greater than the current licensed core power level of 3587 MWt and 0.3% greater than the proposed MUR core power level of 3648 MWt. The staff reviewed and approved the licensee's transient and accident analyses at 3659 MWt conditions assumed by the SPU, confirming that the acceptance criteria were still met under these conditions. The results of this review are summarized in Table 3.2 below.

Table 3.2
Pressurized Water Reactor Systems - Summary of Staff Review

Topic	LAR 05-04 Section	UFSAR Section(s)	Bounding Analysis (Including Reference)	NRC Approved
Large-Break LOCA	Table 3.1-1, Row 3.1	15.6.5	Seabrook LAR 04-03, Attachment 1, Section 6.1.1	Yes
Small-Break LOCA	Table 3.1-1, Row 3.2	15.6.5	Seabrook LAR 04-03, Attachment 1, Section 6.1.2	Yes
Post-LOCA Long-Term Cooling	Table 3.1-1, Row 3.3	15.6.5	Seabrook LAR 04-03, Attachment 1, Section 6.1.3	Yes
Excessive Heat Removal Due to FW System Malfunctions	Table 3.1-1, Row 3.9	15.1.1, 15.1.2	Seabrook LAR 04-03, Attachment 1, Section 6.3.2.1	Yes
Excessive Increase in Steam Flow	Table 3.1-1, Row 3.10	15.1.3	Seabrook LAR 04-03, Attachment 1, Section 6.3.2.2	Yes
Inadvertent Opening of a Steam Generator Dump, Relief, or Safety Valve	Table 3.1-1, Row 3.11	15.1.4	Seabrook LAR 04-03, Attachment 1, Section 6.3.2.3	Yes
Steam System Piping Failure	Table 3.1-1, Row 3.12	15.1.5	Seabrook LAR 04-03, Attachment 1, Section 6.3.2.4	Yes

Loss of External Load / Turbine Trip	Table 3.1-1, Row 3.13	15.2.2, 15.2.3	Seabrook LAR 04-03, Attachment 1, Section 6.3.3.1	Yes
Loss of Normal FW Flow	Table 3.1-1, Row 3.14	15.2.7	Seabrook LAR 04-03, Attachment 1, Section 6.3.3.2	Yes
Loss of Offsite Power (LOOP)	Table 3.1-1, Row 3.15	15.2.6	Seabrook LAR 04-03, Attachment 1, Section 6.3.3.3	Yes
FW System Pipe Breaks	Table 3.1-1, Row 3.16	15.2.8	Seabrook LAR 04-03, Attachment 1, Section 6.3.3.4	Yes
Total Loss of Forced Reactor Coolant Flow	Table 3.1-1, Row 3.18	15.3.2	Seabrook LAR 04-03, Attachment 1, Section 6.3.4.1.2	Yes
Single Reactor Coolant Pump Locked Rotor / Shaft Break	Table 3.1-1, Row 3.19	15.3.3, 15.3.4, 15.3.5	Seabrook LAR 04-03, Attachment 1, Section 6.3.4.2	Yes
Uncontrolled Rod Cluster Control Assembly (RCCA) Withdrawal from Subcritical	Table 3.1-1, Row 3.20	15.4.1	Seabrook LAR 04-03, Attachment 1, Section 6.3.5.1	Yes
Uncontrolled RCCA Withdrawal at Power	Table 3.1-1, Row 3.21	15.4.2	Seabrook LAR 04-03, Attachment 1, Section 6.3.5.2	Yes
RCCA Misoperation	Table 3.1-1, Row 3.22	15.4.3	Seabrook LAR 04-03, Attachment 1, Section 6.3.5.3	Yes
Startup of an Inactive Reactor Coolant Pump	Table 3.1-1, Row 3.23	15.4.4	Three-loop operation is not allowed per Seabrook Technical Specifications	N/A
Inadvertent Boron Dilution	Table 3.1-1, Row 3.24	15.4.6	Seabrook LAR 04-03, Attachment 1, Section 6.3.5.5	Yes

> Station at the end of license is less than 100 °F. Per reference 5.1-8[1], these end of license transition temperature shift values would require three capsules to be withdrawn from Seabrook Station, while the original withdrawal schedule in Reference 5.1-9[2] called for four capsules. Therefore, the current surveillance capsule withdrawal schedule remains acceptable for the SPU.

FPLE's calculation confirmed that the maximum EOL transition temperature shift using SPU fluence will remain less than 100 °F. Per the ASTM Standard Practice E185-82, these EOL transition temperature shift values would require three capsules to be withdrawn from Seabrook, while the original withdrawal schedule called for four capsules. Since the transition temperature shift using SPU fluence is less than 100 °F, the third capsule needs to be withdrawn at not less than once or greater than twice the peak EOL fluence. The licensee has already withdrawn two capsules (U and Y). Capsule V is planned to be removed when the capsule fluence reaches 6.58 x 10^{19} n/cm^2 (E>1.0 MeV), which occurs at 11.1 effective full power years. The peak vessel EOL fluence using SPU is 2.2 x 10^{19} n/cm^2 (E>1.0 MeV). Hence, FPLE's plan for the withdrawal of Capsule V is within the acceptable limit of not less than once or greater than twice the peak EOL fluence. Therefore, there is no impact of capsule withdrawal schedules because of the SPU. It follows that, because the SPU fluence bounds the MUR power uprate fluence, there is no impact on withdrawal schedules due to implementation of the MUR power uprate.

Regarding the Seabrook PTS analyses for the Seabrook RV, FPLE provided RT_{PTS} values for the beltline materials of the Seabrook vessel in LAR 04-03 and a supplement to the LAR dated October 12, 2004, concluding:

> The pressurized thermal shock calculations were performed for the Seabrook Station beltline materials using the latest procedures required by the NRC in 10 CFR 50.61. To evaluate the effects of the SPU, the pressurized thermal shock values for the beltline region materials from Seabrook Station were re-evaluated using the SPU fluences. Based on this evaluation, the reference temperature - pressurized thermal shock values will remain below the Nuclear Regulatory Commission screening criteria values using the projected SPU fluence values through end of license for 40 Effective Full Power Years for Seabrook Station and thus meet the requirements of 10 CFR 50.61.

The NRC staff evaluated the information provided by FPLE as well as the information contained in the NRC staff's Reactor Vessel Integrity Database. Using this data, and based on the fact that the SPU fluence bounds the MUR fluence, the NRC staff independently confirmed that the Seabrook RPV materials would continue to meet the PTS screening criteria requirements of 10 CFR 50.61 following implementation of the MUR power uprate.

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[1]American Society for Testing and Materials (ASTM) E185-82, Annual Book of ASTM Standards, Section 12, Volume 12.02, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels."

[2]Singer, L.R., "Public Service Company of New Hampshire Seabrook Station Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-10110, March 1983.

Power/Steam Systems				
Main Steam System and Steam Dump System	Table 7.1-1, Row 7.1	10.4.4	Seabrook LAR 04-03, Attachment 1, Sections 4.3.2 and 8.4.1	Yes
Condensate and FW Systems	Table 7.1-1, Row 7.5	10.4.7	Seabrook LAR 04-03, Attachment 1, Section 8.4.3	Yes[3]
Emergency FW System and Condensate Storage System	Table 7.1-1, Row 7.6	9.2.6	Seabrook LAR 04-03, Attachment 1, Section 8.4.4	Yes
FW Heaters and Drains	Table 7.1-1, Row 7.10	10.4.7	Seabrook LAR 04-03, Attachment 1, Section 8.4.8	Yes
Main Condenser Evacuation System	Table 7.1-1, Row 7.8	10.4.2	Seabrook LAR 04-03, Attachment 1, Section 8.4.6	Yes
Main Condenser and Circulating Water System	Table 7.1-1, Row 7.9	10.4.5	Seabrook LAR 04-03, Attachment 1, Section 8.4.7	Yes
SG Blowdown System	Table 7.1-1, Row 7.7	10.4.8	Seabrook LAR 04-03, Attachment 1, Section 8.4.5	Yes
Extraction Steam	Table 7.1-1, Row 7.2	10.2.2.3	Seabrook LAR 04-03, Attachment 1, Section 8.4.2	Yes
Turbine System and Auxiliaries	Table 7.1-1, Rows 7.3 and 7.4	10.4.11	Seabrook LAR 04-03, Attachment 1, Section 8.3.1	Yes
Ultimate Heat Sink	Table 7.1-1, Row 7.13	9.2.5	Seabrook LAR 04-03, Attachment 1, Section 8.4.11	Yes

[3] Modifications to the FW pump turbines will not affect FW system performance as previously evaluated.