Entergy

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March 17, 2003

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket 50-293
License No. DPR-35

Response to NRC Request for Additional Information
Appendix K Measurement Uncertainty Recovery – Power Uprate Request

REFERENCE: 1. ENO letter to the NRC, License Amendment Appendix K Measurement Uncertainty Recovery-Power Uprate Request, dated July 5, 2002

LETTER NUMBER: 2.03.027

Dear Sir or Madam:

Discussions with the NRC indicated that additional information was needed to complete their review of the reference submittal. Attached is the additional information requested.

Note that the report identified as Attachment 3, Westinghouse Electric Company LLC draft calculation, "Determination of Uncertainty in Pilgrim Station's "Core Thermal Power Evaluation" with Revised Crossflow Ultrasonic Feedwater Flow Measurement," is proprietary. An affidavit signed by an authorized representative of Westinghouse is provided in the front of the document, pursuant to 10 CFR 2.790. It is requested that this proprietary information be withheld from public disclosure.

This response does not change the no significant hazard conclusions previously submitted in Entergy Letter 2.02.048, dated July 5, 2002.

Should you have any questions or comments concerning this submittal, please contact Bryan Ford at (508) 830-8403.

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I declare under penalty of perjury that the foregoing is true and correct. Executed on the 17th day of March 2003.

Sincerely,

Robert M. Bellamy

JRH/dd

Attachments:
1. Response to NRC Request for Additional Information (3 pages)
2. Basis for The Core Thermal Power Uncertainty at Pilgrim Nuclear Power Station (2 pages)
3. Westinghouse Electric Company LLC **PROPRIETARY** draft uncertainty calculation (152 pages)
4. ANALOGIC Vendor Manual Information (4 pages)
5. Response to NRC Request for Additional Information on Equipment Qualification (1 page)
6. Response to NRC Request for Additional Information on Radiological Calculations (1 page)

cc:

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ATTACHMENT 1

LETTER NUMBER 2.03.027

Response to NRC Request for Additional Information
Appendix K Measurement Uncertainty Recovery-Power Uprate Request

NRC Request 1:
Please provide a plant-specific calculation of the total power measurement uncertainty in accordance with RIS 2002-03, Item I.1.E, for the uncertainty in the feedwater flow measurement itself and for the thermal power uncertainty. Please include a description of the thermal power assessment computation in detail to support the calculation.

Response:
Pilgrim provided the equations used in the existing Power Measurement Uncertainty Calculation based on current licensed thermal power in section 4.2.5 in Entergy letter 2.02.048, "License Amendment Request Appendix K Measurement Uncertainty Recovery – Power Uprate Request," dated July 5, 2002. As requested, Attachment 2 describes the basis that will be used to finalize the uncertainty in the feedwater flow measurement calculation. Attachment 3 is the Westinghouse Electric Company LLC proprietary draft calculation that Pilgrim has used to conclude that the core thermal power uncertainty will be less than 0.5%. This draft calculation shows an uncertainty of 0.42% for core thermal power. The final uncertainty will be calculated before exceeding the current licensed thermal power of 1998 MWt.

NRC Request 2:
The justification provided for the 14-day allowed outage time (AOT) is based upon experience with a type of UFM (Crossbeam) described to be similar to the units to be used in connection with measurement uncertainty recapture (Crossflow). Even if the Crossbeam UFM were deemed sufficiently similar to the Crossflow units, it is not clear that the Crossbeam data would be suitable to justify the AOT with the proposed power uprate. For example, if the data are too widely spaced in time, they might not reflect the effects of the build-up and then rapid removal of fouling materials on the venturi: the venturi performance would look constant despite a possibly sizable transient condition. Also, there is no provision for early termination of the AOT in the event of rapid power change or other event which might render the correction factor non-conservative (such as by resulting in defouling of a venturi to which a correction factor has already been applied). Please provide justification of the AOT considering these factors.

Response:
In Entergy Letter 2.02.112, it was discussed that the existing Crossbeam system would be used when the redundant Crossflow systems were out of service, in support of the 14 day AOT. However, since that submittal, it has been decided not to retain Crossbeam as a backup system. Since Crossbeam will not be available, Entergy is requesting a 24-hour AOT in the unlikely event that both Crossflow systems are out of service. When both Crossflow systems are out of service, reactor thermal power would be lowered to 1998 MWt within 24 hours utilizing plant procedures. Should a rapid power change occur or some other event which might render the current correction factor non-conservative (such as rapid defouling of a venturi to which a correction factor has already been applied), the correction factor will be evaluated and power will be lowered to a value where an appropriate correction factor can be applied. When a valid correction factor cannot be determined, the core thermal power will be lowered to 1998 MWt within 24 hours.

NRC Question 3:
Item 2 of the attachment to the December 30, 2002, supplement implies that the Cross*beam* UFMs may play a part in uprated reactor operation if the Cross*flow* UFMs are unavailable. Item 1 of the letter implies that the licensee has been using the Crossbeam UFM to modify the

calibration of the FW flow venturi. The Crossbeam UFM has never been submitted for NRC evaluation, and the Staff has no assurance that the Crossbeam instrument as applied at Pilgrim provides Feedwater Flow measurements within the Appendix K allowance. Therefore, the staff has no independent basis for recognizing the suitability of the Crossbeam UFM for service in support of uprated power or even in support of the pre-uprate power level. Please provide clarification of the past and intended future use of the Crossbeam UFMs, and of the influence that they might have had over venturi calibration/correction.

Response:
As stated in the response for Question 2, the redundant Crossflow UFM will be the only instrumentation used to provide a correction factor to the installed feedwater flow venturis in support of the Appendix K Measurement Uncertainty Recapture.

As is typical at many utilities, Pilgrim has used an ultrasonic flow measurement system to calibrate the feedwater flow venturis and to obtain more accurate feedwater flow information that is used in calculating thermal power. Pilgrim has used the existing system for the past four years and it has demonstrated stability and accuracy. The existing system uses the same technology as the Crossflow system.

The Crossflow system will sample a larger cross section of the flow which will provide higher statistical accuracy. In addition, Crossflow uses both temperature and pressure compensation. The Crossflow system will have an initial in-situ calibration and will have improved data collection capability. The Crossflow will interface with the plant computer and provide automatic correction factor updates, whereas the existing system required manual addition of the correction factor. The existing system will not be used for the Appendix K Measurement Uncertainty Recapture.

NRC Question 4:
In the November 6, 2002 supplement, Attachment 1, Item 4a, the licensee asserts that computer points are self-checking and therefore do not need to be calibrated. Self-checking relies upon some reference standard(s) contained within the system. Please explain why the reference standard(s) do not need to be verified periodically.

Response:
The Pilgrim feedwater flow instrumentation data acquisition system has an analog to digital converter that contains a precision voltage reference system. This circuit uses two references that are continuously compared to detect excessive drift or a shift in either reference. In addition, this data is compared with the separate and diverse data from the Crossflow system to detect excessive drift or shift. This reference system ensures high accuracy in the feedwater flow measurement. Therefore, no periodic calibration is required.

Discussions were held with the vendor supplying the Crossflow reference module. The vendor does not recommend periodic calibration since the design includes frequent self-checking. Attachment 4 provides vendor manual information from ANALOGIC concerning the self-test (Section 3.2.6), Analog Input Specifications regarding measurement accuracy (Section 3.2.8.5), and a description of the calibrator (Section 3.2.9.2.12).

NRC Question 5:
Section 4.2.2 of attachment 1 to July 5, 2002, application states, "There will be automatic detection of non-conservative readings due to rapid defouling or component failure." This assertion should be explained. What provides this detection, and how does it discriminate among possible causes for the conditions that it detects?

Response:
Section 4.4.2 of Attachment 1 to the July 5, 2002 letter states, "There will be online detection of non-conservative readings..."

Pilgrim has multiple means of identifying events such as defouling that could make the correction factors less accurate. The modifications being implemented will include new alarms that will be generated by the Crossflow system and others that are completely independent of Crossflow. Whenever Crossflow indicates loss of a good quality correction factor, loss of communications or detects rapid defouling, a new control room annunciator window will alarm. To detect defouling, the Crossflow system compares the average of a series of instantaneous correction factors stored in a long buffer with a similar average from a short buffer. A rapid divergence in these correction factor average readings is indicative of rapid defouling.

In addition, the Pilgrim plant computer (EPIC) is being modified so that deviations in both the steam flow to feedwater flow and first stage turbine pressure with feedwater flow relationships are detected and alarmed in the overhead annunciator.

The operator is ultimately responsible for discriminating among the possible causes for defouling or other flow reading mismatches. There are alternate indications such as the APRMs as well as existing PNPS procedures, which allow the operator to independently evaluate reactor power. In the unlikely event of a rapid defouling event, resin intrusion and other chemistry parameters (ph, conductivity etc.) are monitored to assist in discriminating among the likely causes.

NRC Question 6:
Section 10.4 (p10-5), Attachment 2 of July 5, 2002, application indicates that a ±3 inch water level change and a 3 psi step change in pressure setpoint are to be used in testing the FW/level control system, but it does not indicate the basis for these numbers. Please explain the basis for these numbers.

Response:
The water level change of ± 3" and the 3 psi step change in pressure are consistent with the original startup tests performed by GE and with the GE Nuclear Energy "Generic Guidelines and Evaluations for General Electric Boiling Water Reactor Thermal Power Optimization" (TLTR), Licensing Topical Report NEDC-32938P, Class III (Proprietary), July 2000. These are the same tests that have been performed at other GE plants to support more significant power uprate applications. These tests are performed to demonstrate that small operational disturbances will not introduce unacceptable harmonic responses in the control systems at the increased power levels.

ATTACHMENT 2

LETTER NUMBER 2.03.027

Basis for The Core Thermal Power Uncertainty at Pilgrim Nuclear Power Station

BASIS FOR THE CORE THERMAL POWER UNCERTAINTY
AT
PILGRIM NUCLEAR POWER STATION

Core Thermal Power (CTP) is defined by the following equation for a boiling water reactor:

$$CTP = Q_{fw} + Q_{cr} + Q_{cu} + Q_{rad} - Q_p$$

Where: Q_{fw} = the thermal power transferred from the core to the feedwater

Q_{cr} = the thermal power transferred to the control rod flow

Q_{cu} = the thermal power transferred to the cleanup system

Q_{rad} = the thermal power loss to radiation

Q_p = The thermal power added to the system by the recirculation pumps

A review of these thermal power components will reveal that the dominant term is Q_{fw}, which is defined as the product of feedwater mass flow times the change in enthalpy as shown in the following equation:

$$Q_{fw} = W_{fw} (hg - mh_{fg} - h_{fw})$$

where: W_{fw} = The feedwater flow

h_g = The enthalpy of saturated steam

m = The moisture being carried over from the reactor vessel to the turbine

h_{fg} = The heat of vaporization

h_{fw} = The enthalpy of the feedwater entering the reactor vessel

Based on a preliminary and conservative uncertainty analysis (Reference 1), it was shown that the 2-sigma uncertainty for the core thermal power is 0.42%. Q_{fw} accounts for an uncertainty of 0.41% itself, leaving 0.01% for the remaining terms. If one further analyzes the individual terms in this equation, it will be seen that the most important parameter is the accuracy of the feedwater flow. If this term is removed, the remaining components, steam enthalpy, heat of vaporization, feedwater enthalpy and moisture carryover only contribute an additional 0.06%. The remaining 0.35% is contributed by the uncertainty of the feedwater flow measurement. Hence, the uncertainty of the feedwater is the most important parameter in reducing the overall uncertainty of the core thermal power measurement.

In order to reduce the uncertainty of the feedwater flow measurement at Pilgrim, it was decided that an in-situ calibration would be used, during system startup, to calibrate the redundant CROSSFLOW meters. This will be done by installing temporary CROSSFLOW meters on the two long individual loops downstream of the common header and using the sum of these measurements to establish the calibration factor for the CROSSFLOW meters on the common header.

For the preliminary uncertainty analysis, it was conservatively assumed that the accuracy of each of the in-situ calibration meters would only meet the warranted accuracy of 0.5%. Making this assumption and taking credit for the statistical combination of the temporary CROSSFLOW units, it is believed an effective accuracy of approximately 0.35% can be achieved.

In conclusion, it can confidently be stated that with the planned instrument upgrades in conjunction with an in-situ calibration of the CROSSFLOW meters on the common header, a core thermal power uncertainty of 0.5% or better will be achieved at Pilgrim. The key parameter in achieving this level of accuracy is the conservative assumption of a 0.5% CROSSFLOW accuracy for each of the in-situ calibration meters. This confidence is further assured by the NRC, which has carefully reviewed the CROSSFLOW technology documented in the Westinghouse topical report CENPD-397-P-A (Reference 2) and has stated in their SER (Reference 3), that the CROSSFLOW meter is capable of achieving a flow measurement accuracy of 0.5% or better.

Reference 1: Determination of Uncertainty in Pilgrim Station's Core Thermal Power Evaluation With Revised Crossflow Ultrasonic Feedwater Flow Measurement.

Reference 2: Topical Report Submitted to NRC: CENPD-397-P-A, Rev. 1; Improved Flow Measurement Accuracy Using Crossflow Ultrasonic Flow Measurement Technology, CE Nuclear Power LLC (Westinghouse).

Reference 3: Safety Evaluation for ANN Combustion Engineering Nuclear Power Topical Report CENPD-397-P-A, Rev. 1; Improved Flow Measurement Accuracy Using Crossflow Ultrasonic Flow Measurement Technology.