CR-PLP-2007-04614 CA-00002 (Level C)

Perform Disposition Review of RIS 2007-24

EVENT DESCRIPTION

On September 27, 2007, the NRC issued Regulatory Issue Summary (RIS) 2007-24, "NRC Staff Position on Use of the Westinghouse CROSSFLOW Ultrasonic Flow Meter for Power Uprate or Power Recovery." The RIS identifies concerns with Westinghouse Topical Report CENPD-397-P, Revision 01-P. The NRC is suspending its March 20, 2000 approval of this report for new and future applications. This RIS does not transmit any new requirements and does not require any specific action or written response.

Topical Report CENPD-397-P was the basis for the NRC's approval for the 10 CFR 50 Appendix K Measurement Uncertainty Recovery (MUR) for Palisades, which was issued as NRC License Amendment 216 on June 23, 2004. The NRC has not suspended the use of CROSSFLOW for existing users primarily due to the small effect on the consequences of postulated licensing basis accident and transient analyses, and the low safety significance of the issue.

The NRC has suspended approval of the CROSSFLOW topical report for future submittals based on the following weaknesses identified;

1) The topical report assumes that the UFM laboratory calibration is transferable to in-plant configurations without additional in-plant calibration, without a complete uncertainty evaluation, and without traceability to a national standard. The NRC does not concur with this assumption. Alternatively, if in-plant calibration is used to eliminate this assumption, the weaknesses of in-plant calibration without a complete uncertainty evaluation and without traceability to a national standard may remain.
2) The treatment of the impact of acoustic noise on the CROSSFLOW system is a weakness.
3) There is a lack of required periodic in-plant calibrations using an instrument traceable to a national standard and a lack of assurance that CROSSFLOW operation remains within claimed uncertainty.
4) There is a lack of specific restrictions over a range of acceptable flows and plant configurations that define where CROSSFLOW is considered valid.
5) There is inadequate description of installation and use of CROSSFLOW consistent with the actual calibration and commissioning practices.

CROSSFLOW is an ultrasonic flow meter (UFM) developed by Advanced Measurement and Analysis Group (AMAG) and originally marketed by ABB Combustion Engineering Nuclear Power, Inc. (ABB-CE), which is now incorporated into Westinghouse Electric Company LLC, (Westinghouse).

The RIS notes that Westinghouse failed to demonstrate adequately its CROSSFLOW meter can consistently achieve its stated levels of accuracy. Although the RIS does not require any specific action from current users of CROSSFLOW, the NRC suggests that current users should review the new information in the RIS and consider actions, as appropriate, to assure that CROSSFLOW continues to function consistent with all the requirements in the plant licensing basis.

CONDITION EVALUATION

Palisades utilizes the CROSSFLOW UFM system to 1) compensate for fouling of the feedwater venturis, which would otherwise result in plant operation below rated thermal power, and 2) implement the MUR power uprate license amendment to operate at higher rated power.

Background Information

Palisades has a relatively simple CROSSFLOW installation with the UFM instrumentation permanently installed on both the A and B feedwater loops inside containment. The CROSSFLOW system at Palisades does not have an interface with the plant computer. The system is used in the manual mode for monthly calibrations of feedwater flow by calculation of correction factors. The CROSSFLOW system remains in service between calibrations collecting data. This data is trended per Engineering Manual procedure EM-04-51, "Reactor Engineering Monitoring Guidelines".

Palisades has evaluated numerous OE issues related to CROSSFLOW as specified in the partial list below.

Notice	Disposition
• TB-02-4: Effect of Pipe Insulation on CROSSFLOW Ultrasonic Flow Measurement System	• Evaluated as low risk for Palisades due to different operating and system installation differences relative to Hope Creek. However, vendor was brought in for system inspection. (CE001827)
• TB-03-6: CROSSFLOW Ultrasonic Flow Measurement System Signal Issues	• DIAGNOSE determined no signal contamination on existing installations. Scheduled DIAGNOSE for before and after 1.4% power uprate. (CE007099). Minor power dependency in B loop lead to installation of 2 additional meters in 2004 refueling outage. (CA026774)
• NSAL-03-12: CROSSFLOW Ultrasonic Flow Measurement System Flow Signal Interference Issue	• Procedure enhancements as recommended by NSAL to calibration procedure and monitoring procedure. (CA021516)
• TB-04-4: Information Regarding Recent CROSSFLOW Ultrasonic Flow Measurement System Performance Observations	• Procedure revision to Operations procedure and additional procedure revision to calibration procedure. (CE009266)

Notice	Disposition
• INPO SER 3-04	• SER evaluated, no additional corrective actions in addition to actions taken per Tech Bulletins (CE010557)

Response to specific NRC staff concerns:

1) *The topical report assumes that the UFM laboratory calibration is transferable to in-plant configurations without additional in-plant calibration, without a complete uncertainty evaluation, and without traceability to a national standard. The NRC does not concur with this assumption. Alternatively, if in-plant calibration is used to eliminate this assumption, the weaknesses of in-plant calibration without a complete uncertainty evaluation and without traceability to a national standard may remain.*

Palisades, as well as most of the current CROSSFLOW users, commissioned the UFM system based upon transfer of the UFM laboratory calibration without additional in-plant calibration. The Palisades installation was considered a standard installation in accordance with the Topical Report.

Palisades is a participant in the PWR Owners Group – CROSSFLOW Task Force (PWROG – CTF). The CTF will meet in early November to address RIS 2007-04 an issue of a letter to the industry regarding the RIS. The CTF is expected to recommend that reasonable assurance of CROSSFLOW accuracy may be achieved through detailed comparison with available plant indications such as a Thermal-hydraulic plant model. A corrective action will be created to document the CTF's recommendations within CR-PLP-2007-04614.

An independent and traceable calibration of the CROSSFLOW system could be achieved by replacement of the original feedwater flow elements. This would require a significant plant modification that would need to be performed during a refueling outage. A corrective action will be created to initiate a "Funding Justification" to perform study of available options to remove existing feedwater flow venturis and replace with new design that can be routinely calibrated to NIST, and/or pursue implementation of available plant process instrumentation model to validate accuracy of UFM.

The baseline case for comparison will be replacement of FE-0701 and FE-0703 in containment with flanged ASME flow sections that meet the requirements of ASME PTC 6. The study phase will determine 1) if this level of accuracy is necessary for UFM validation, and 2) whether acceptable results can be obtained with other options, possibly installed outside containment. Note that the only straight runs of feedwater piping long enough to meet PTC 6 requirements are located in containment.

Other calibration methods including chemical tracer testing, could be pursued. Thermal-hydraulic plant and instrumentation models (thermal kits) are available in the industry that could be used to validate the UFM calculated feedwater flow rate, although this would not be a calibration to a national standard as recommended in the RIS.

2) *The treatment of the impact of acoustic noise on the CROSSFLOW system is a weakness.*

Palisades has evaluated numerous operating experience issues including acoustic noise events, specifically associated with Technical Bulletin (TB) 03-6 and ISAL-03-12.

Sensitivity to power changes (a.k.a. a power dependency) is a potential symptom of acoustic signal contamination. As discussed in ACE003333, a slight power dependency was observed in the original Loop B UFM meter. The apparent cause of the minor power dependency in the B feedwater loop was that the UFM meter located only 9.84 pipe diameters (generally referred to as "Lower D's") from the first upstream elbow. While this is acceptable for qualified "standard" installation of the CROSSFLOW system, it is at the lower end of the acceptable range.

The elbow correction term is a complex exponential function that goes to zero at an L/D value of 14.94. The 9.84 L/D value for loop B results in a relatively large elbow correction of 0.0268 which is approximately five times the correction that is applied to the A loop with its L/D value of 13.17.

To further investigate this power dependency, two new CROSSFLOW UFM meters were installed on feedwater loop B during the September 2004 refueling outage (per TM-2004-010 and Purchase Order P804159). The two new meters are located downstream of the original meter approximately 20 L/D & 25 L/D respectively downstream of the 90 degree elbow.

AMAG-REP-EN-064-00, "Palisades CROSSFLOW/Plant Startup Data Analysis Report" evaluated CROSSFLOW performance at different power levels using data collected in December 2004 and following a January 2005 forced outage. The data was analyzed by comparing the ratio of the CROSSFLOW readings to the plant instrumentation readings (Fufm/Fventuri). This ratio (Cf = Fu/Fv) is then compared at the different power levels to verify the repeatability. The repeatability of the ratio (or "Cf" venturi correction factor) is an indication of a stable flow profile.

Noise analysis was performed utilizing the Time Domain Analysis (TDA) technique with the DIAGNOSE software package. This testing provided proof that the slight power dependency of the original Loop B UFM installation was not the result of noise, supporting the apparent cause of ACE003333 that the

power dependency was the result of the original meter's close proximity to an upstream 90 degree elbow.

Some noise contamination is present on the two new loop B meters. The effect of this noise was determined by TDA and a correction factor is applied to the UFM measured flow to negate this effect. The noise-corrected Cf variation for both new meters is less than 0.1% for the range of 95% to 100% power, well within the acceptable range of variation. DIAGNOSE is run following each refueling outage or major maintenance on the feedwater system prior to placing the UFM system back in service. DIAGNOSE was also run as part of the implementation of the MUR uprate.

3) *There is a lack of required periodic in-plant calibrations using an instrument traceable to a national standard and a lack of assurance that CROSSFLOW operation remains within claimed uncertainty.*

If the study phase of item 1 above determines that calibration of the UFM meters is warranted, then periodic in-plant re-calibration of the meters will also be addressed. The frequency of re-calibration will be determined with input from the CTF and industry. The study phase of the project will also look at the need to periodically recalibrate the reference flow elements that will be used to validate CROSSFLOW.

4) *There is a lack of specific restrictions over a range of acceptable flows and plant configurations that define where CROSSFLOW is considered valid.*

Acceptable plant configurations were reviewed as part of Palisades response to TB-04-4 (CE009266) Palisades restricts use of the UFM correction to power levels above 95% as this is the power level and feedwater flow range that the system was initially evaluated and commissioned upon. The correction factors are removed (set to 1.000) if power is reduced below 95%. The plant procedure that performs the calibration, MT-15, "UFM Data Collection, Analysis, and Implementation" requires that the plant be at stable, near full power conditions in order to set correction factors. The procedure performs system checks and has specific data quality acceptance criteria.

Palisades has only two main feed pumps so both pumps must be in operation at the power levels where the UFM correction factor is applicable. Similarly, removal of a heater drain pump from service requires a power reduction to less than 90% power. The correction factors are set to 1.000 since power is less than 95%.

Bypass and isolation of a high pressure feedwater heater has not occurred since implementation of the CROSSFLOW system at Palisades, however procedure SOP-10, "Extraction and Heater Drain System" has been revised

to add the requirement to reset correction factors to 1.000 prior to removing a high pressure feedwater heater from service.

5) *There is inadequate description of installation and use of CROSSFLOW consistent with the actual calibration and commissioning practices.*

Palisades installed and commissioned the CROSSFLOW system based on approved procedures via the engineering modification process.

The CTF has published the CROSSFLOW Users' Guidelines which provides a fairly detailed description of installation and use of CROSSFLOW system. The Users' Guidelines were used as the basis of a Self Assessment (SA-0101-800) performed on the use of the CROSSFLOW system at Palisades.

The self assessment raised a question regarding the effect of a 15 degree, 5 radius bend approximately 24 feet upstream of the A Loop UFM meter. This piping configuration is expected to result in a low magnitude swirl which would bias the UFM meter in the conservative direction. Power dependency testing performed at Palisades has shown no observable variation in UFM correction factor on the A loop meter. This evidence supports that swirl induced bias, if any, is negligible.

This issue was previously discussed with vendor personnel who concurred that the Palisades configuration would be expected to result in only a low magnitude swirl which would cause a small conservative bias. This bais may be too small to be observable. Palisades requested written documentation to support this conclusion. An evaluation was provided in a letter dated April 27, 2007. This letter confirmed that the effect would be less than 0.2 percent, but recommended further evaluation.

To further evaluate the effect of the 15 degree bend, a Computational Fluid Dynamics (CFD) analysis should be performed. A corrective action will be created to perform CFD analysis of the Palisades feedwater piping configuration relative to the UFM meter locations.

Conservative Margin

EA-BWB-96-01, "Heat Balance Calculation Using the Ultrasonic Flow Measurement Device" describes several conservative assumptions used in the heat balance calculation. Conservative constant values are used for various input variables such that an approximate 0.99 MWth (0.04%) conservatism exists for the bounding constant value relative to the value obtained using nominal operating parameters.

Additionally, the Feedwater pressure at the UFM instruments is assumed to be equal to the respective feedwater pump discharge pressure. Actual feedwater pressure at the UFM instruments is estimated to be 120 - 150 psia lower than the values used in the Correction Factor calculation. The effect of this assumption is that the UFM mass flow rate measurement is biased high approximately 0.08% to 0.11%. This bias is conservative for the heat balance calculation.

Plant procedure MT-15, "UFM Data Collection, Analysis, and Implementation" includes at least 0.1% power conservatism when the UFM Correction Factors are established for use in the plant heat balance calculation. This is implemented in Attachment 2 of MT-15 through the addition of 0.001 to the calculated UFM Correction Factors for each Loop. Additional margin may be added at the discretion of the Engineer based upon review of trend data.

Per EA-ELEC08-000 , "Uncertainty Calculation for the Secondary Calorimetric Heat Balance", the secondary heat balance (with UFM correction) has a random uncertainty of ±0.5238% power with an enthalpy bias term of - 0.032% power. Thus the total uncertainty total +0.49% to -0.56% power. As the MUR uprate was for just 1.4% rather than the 1.51% theoretically possible from this uncertainty calculation, a conservative margin of 0.11% exist.

Combination of the above conservatisms indicate that at least:

0.04% + 0.08% + 0.1% +0.11% = 0.33% conservate margin exist.

DISPOSITION

In Summary, the NRC has suspended its previous approval of the CROSSFLOW topical report for new a future use. Palisades previously relied upon the TR for licensing of the 1.4% MUR power uprate. The suspension is based on NRC concerns and sited weaknesses in the methodology and application of the UFM technology.

None of the weaknesses have been directly attributable to Palisades such that a known error exists in the CROSSFLOW technology or the application of CROSSFLOW at Palisades. However, the five weaknesses identified above should be addressed in a timely fashion.

The NRC has not suspended the use of CROSSFLOW for existing users primarily due to the small effect on the consequences of postulated licensing basis accident and transient analyses, and the low safety significance of the issue.

Additional actions to address the recommendations of the RIS will be performed as described below. It is not necessary to suspend use of CROSSFLOW at Palisades in the interium as Palisades has reasonable assurance that CROSSFLOW is operating within the design basis.

CORRECTIVE ACTIONS

1. Evaluate recommendations from the Westinghouse PWR Owners Group (PWROG) CROSSFLOW Task Force (CTF) relative to RIS 2007-24 as they apply to Palisades and document this evaluation within CR-PLP-2007-04614.

2. Initiate a "Funding Justification" to perform study of available options to remove existing feedwater flow venturis and replace with new design that can be routinely calibrated to NIST, and/or pursue implementation of available plant process instrumentation model to validate accuracy of UFM.

3. Perform Computational Fluid Dynamics (CFD) analysis of the Palisades feedwater piping configuration relative to the UFM meter locations.

REFERENCES

Technical Bulletin, TB-03-6, "CROSSFLOW Ultrasonic Flow Measurement System Signal Issues", dated September 5, 2003

Nuclear Safety Advisory Letter, NSAL-03-12, "CROSSFLOW Ultrasonic Flow Measurement System Flow Signal Interference Issues", dated December 5, 2003

Technical Bulletin TB-04-4, "Information Regarding Recent CROSSFLOW Ultrasonic Flow Measurement System Performance Observations", dated February 12, 2004

SC-97-028, "Installation of UFM devices to measure feedwater flow to steam generator"

EA-BWB-96-01, "Heat Balance Calculation Using the Ultrasonic Flow Measurement Device" Revision 5

EA-ELEC08-0001, "Uncertainty Calculation for the Secondary Calorimetric Heat Balance"

EM-04-51, "Reactor Engineering Monitoring Guidelines".

MT-15, "UFM Data Collection, Analysis, and Implementation"

SOP-10, "Extraction and Heater Drain System"