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From: Stephen Alexander
To: Dale Thatcher; Evangelos Marinos; Gregory Cwalina; Iqbal Ahmed; Jose Calvo; Steven Arndt
Date: Thu, Sep 25, 2003 10:34 AM
Subject: Re: 2003-03 & 07 CI Concerns Compilation

Upon further review, we have concluded that the characterization of the VPCF calibration curve as a "4-point least-squares fit" is a description that is too specific and not necessarily that of the CI. What the NP topical cites is ARL data taken at Reynolds numbers ranging from 0.8E6 to 7E6, without specifying four data points. I have edited the concern accordingly.

>>> Evangelos Marinos 09/25/03 09:06AM >>>
We have reviewed the list of the CI's concerns and understand the technical points made that you believe need to be addressed by NRC. However, we are extremely concerned with the CI's knowledge of protected proprietary information, of another licensee, that this CI has obtained and cites, in formulating Concern 2 in the list you provided. We, therefore, believe that such breach of confidentiality must be referred to IG and OI for investigation, to determine how this CI obtained such information.

>>> Stephen Alexander 09/23/03 10:58AM >>>
My apologies to all concerned. I regret that this document was released yesterday prematurely before some editorial corrections were made. Please delete the previous version and use this one.

Reference documents received from CI:

ER-262 (NP)

Apparent Contradictions and Errors in NRC Review of Caldon Engineering Report ER-262 (P)

ER-356, Rev 0, Evidence Summary of Crossflow Calibration Errors in the Field-Case Studies (P)

Caldon/NRC Meeting Regarding January 28, 2003, SER, Rev P, April 27, 2003 (Proposed Staff Meeting Notes) (P)

PR399, Rev 8, Caldon/NRC Meeting to Discuss January 28, 2003, SER Proposed Staff Meeting Slides, March 2003 (P)

ER-365, Rev 0 and Rev 1, June 2003, A Tabulation of Errors and Misleading Statements in WCAP 15689, *Evaluation of Transit Time and Cross Correlation Ultrasonic Flow Measurement Experience with Nuclear Plant Feedwater Flow Measurement, Rev 1, September 2002* (P)

Additional Questions Raised by public documents (including TB-03-6) related to the feed flow issue at Byron and Braidwood.

The following is a compilation of the principal concerns expressed in the above documents and in conversations with the CI. Refer to the cited documents if more detail is desired.

1. The discrepancies in indicated feedwater flow between SONGS-2 and 3 may be due in part to some kind of bias or systematic error in the Crossflow equipment coupled with the random uncertainty that WEC/AMAG have not accounted for and that the equipment is not able to detect and compensate for.

2. The calibration of the Crossflow UFM at ARL that was used to create the VPCF calibration curve is based on ARL data taken at Reynolds numbers ranging from 0.8E6 to 7E6, yet the ARL stated uncertainty of 0.25% is carried as the uncertainty of that curve without additional uncertainty for extrapolation to bounding plant flow conditions with Reynolds numbers around 30E6. WEC goes on to assert in CENPD-397-NP-A, Rev. 1, Section 4.2, "Profile Validation at Higher Reynolds Numbers," and Section 4.3,

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"Conclusions," that the calibration can be extrapolated to the higher Reynolds numbers found in plants, and that the uncertainty need only be that of the original ARL uncertainty, by citing standard practice for venturis. However, cross-correlation meters do not have the same physics or operational history as venturis. Further, in the case of venturis, the individual meters are calibrated and then the calibration is extrapolated to the operating conditions, but with the Crossflow UFM, the calibration curve was developed with one meter and it was then generalized for all of the meters.

3. The VPCF calibration curve is based on the performance of a particular single Crossflow UFM. There is inadequate justification of the applicability of this instrument response curve to all other Crossflow UFMs with zero additional uncertainty being carried to bound the effects of all the credible differences. Since there are no conclusive, repeatable comparisons with the performance of other Crossflow UFMs under the same laboratory conditions, and against NIST-traceable standards, or even against other independent instruments that are inherently more accurate than (or even as accurate as) the Crossflow UFM, how can identical, repeatable performance be assumed (noting exceptions taken to the plant confirmatory data)?

4. The calibration curve is based on the performance of a Crossflow UFM under a set of laboratory conditions. In order to demonstrate applicability of that testing to all other conditions that may be encountered in actual plant installations, all the credible differences would need to be accounted for. The Crossflow UFM total uncertainty would be expected to account for some kinds of credible differences by adding uncertainty in the correction factors for electronics, limited piping configuration variance based on laboratory testing, transducer spacing, time delay measurement, and the accuracy of flow area determination. How are these correction factors extrapolated to plant Reynolds numbers without carrying additional uncertainty such that they can be assured to bound the effects of all the credible differences under actual plant conditions when they were determined in the laboratory? The effects of specific plant conditions, such as flow velocity or upstream perturbations need to be modeled or measured and correction factors developed. The correction factors are applied, but the uncertainties of the corrections are not included, only the uncertainty of the original calibration. Without these uncertainties being evaluated and accounted for, the calibration is only traceable to the particular instrument calibrated in the certified laboratory and for the conditions examined at that laboratory.

5. The other way that the effects on flow of different plant conditions are addressed is to determine in the laboratory, where they can be measured to an accuracy greater than the claimed UFM accuracy, what the bounding conditions are and the limitations on these effects. Then install the UFM in locations beyond the reach of those effects. When the UFM cannot be installed beyond the reach of accuracy degrading effects, the so-called "in-situ" calibrations are performed. It is recognized that when this practice is employed, the uncertainties of the individual UFMs are combined using the RSS method. However, again it appears that the accuracy of one Crossflow UFM is being confirmed by the accuracy of others, and there is inadequate traceability under those conditions to standards that are even as accurate as the instrument being calibrated. In addition, WEC/AMAG have determined that 15 diameters was the point at which the velocity profile correction factor is no longer a function of upstream disturbances. This was reportedly done using a 90-degree planar bend. How are more complicated piping configurations accounted for such as one or two non-planar bends?

6. The eight (8) plant confirmatory data has significant data scatter, but the uncertainty bounds are not given. They were taken over a range of Reynolds numbers from 11,000,000 up to 25,000,000 at different plants with different instruments whose accuracy was determined with varying degrees of rigor. For example, the highest value at Re=25E6 was taken from a recently calibrated venturi, while others around 20,000,000 for example were taken with "defouled" venturis. The fact that a few diverse raw data points happen to agree within some given value to the VPCF curve value for the corresponding Reynolds number during a given plant test does not mean they necessarily and repeatably agree, but only that there exist some data that happen to agree. Where there is relatively close agreement, it could simply be a fortunate superposition of errors. This sort of comparison is not valid empirically. It does not prove that the curve is accurate under all conditions to the claimed +/-0.25% (the ARL uncertainty). This is because (1) the uncertainty of the comparison instruments has not been taken into account, (2) that uncertainty, when taken into account, will be, at best, 0.6% when, as prescribed in ASME Std PTC-6, the flow nozzle (and presumably the same DP cell as well) is cleaned, calibrated at the lab, reinstalled, tested promptly,

and then sent back to the lab for re-checking the calibration. Not all these provisions were met in all the tests. Therefore, using these data for confirmation of claimed accuracy of the VPCF calibration curve is trying to demonstrate an accuracy of 0.25% by comparison to a few data from instruments of lesser accuracy, i.e., 0.6% at best at plant-comparable Reynolds numbers. Other data of ostensibly higher accuracy, again was a lower Reynolds number (e.g., tracer data at Re=11E6). Finally, there is an insufficient number of comparable raw data points to perform a meaningful statistical analysis.

7. The laboratory testing to determine the VPCF used long, straight, very smooth (plastic) pipe to minimize hydraulic anomalies, especially pipe wall roughness, to achieve classic "fully developed" flow. The corresponding flow velocity distribution or profile has a finite amount of curvature that, according to theory is a function of Reynolds number. This forms the fundamental characteristic programmed response of the Crossflow UFM to flow of varying Reynolds number. However, aside from the metrology concerns about the accuracy and repeatability of this curve, there is data [obtained by the CI] that indicates that there can be distortions to the flow velocity profile that (1) are flatter than classic fully developed flow (non-conservative), (2) asymmetrical, (3) that persist out to at least 45 L/D, (4) that change over time, independent of changes in plant configuration or readily recognizable events (Note: I think WEC has addressed this specific one to some extent). One of the principle phenomenon of concern is swirl which can create tangential velocity vectors with magnitudes as much as 20% of the axial velocity and can vary significantly over time. It is not clear from the WEC/AMAG documents how the Crossflow UFM can adequately detect and properly correct for all those conditions that appear to be outside its design basis. What data does WEC/AMAG have that support the assumption that their smooth pipe assumption is always conservative? Has WEC/AMAG done any experiments to see for themselves if this can occur?

8. The CI has been following the Byron and Braidwood feed flow issue. The CI previously brought up the question of unaccounted for error sources from noise in TP 28 (submitted to the NRC prior to the March 2000 public meeting) and again in ER-365. It is not clear from existing WEC documentation (including recent information pertaining to Byron and Braidwood) how the Crossflow UFM, even when operated in accordance with WEC guidelines, can recognize acoustic anomalies (noise or "signal contamination") that may develop over time and that may bias it and degrade its accuracy. CI contends that the UFM issue at Byron and Braidwood is an example of the noise error problem he brought up previously.

Note that due to various circumstances, EEIB has received this list for review three days late. That means that there are three fewer days of the nine working days allotted to the proprietary review by the ARB. In order to allow EEIB its full nine days for this review, beginning, Tuesday, September 23, we will need to take other steps to regain the schedule. If EEIB is not able to complete its review in six days, i.e., by September 30, we may ask the CI to complete the review to confirm completeness and accuracy of the distillation of concerns in a shorter time than its allotted "one week" in order to catch up to the schedule for review and closeout of this allegation.

Note also that the CI's concerns with WCAP 15689 are detailed in ER-365 which I have forwarded to EEIB previously. Please let me know if you need another copy for later. You shouldn't need it for the proprietary review as it is a CI document to begin with.

CC: Theodore Quay