December 4, 1998

MEMORANDUM TO: Docket File

FROM: Jacob I. Zimmerman, Project Manager Original signed by:
Project Directorate II-2
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

SUBJECT: FARLEY UNITS 1 AND 2 - PLACEMENT OF A DOCUMENT IN THE PUBLIC DOCUMENT ROOM

The attached message was faxed today to Mark Ajluni of the Southern Nuclear Operating Company, Inc. (SNC). The sole purpose of the message is to prepare SNC personnel for a conference call. The message itself does not constitute a formal request for information or represent a formal NRC staff position.

Docket Nos. 50-348 and 50-364

Attachment: As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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REQUEST FOR ADDITIONAL INFORMATION WCAP-14750

RCS FLOW VERIFICATION USING ELBOW TAPS AT WESTINGHOUSE 3-LOOP PWRS

(TAC NOs. M97325 and M97326)

1. Section 4.2, Elbow Tap Flow Measurement Procedure, defines the baseline elbow tap flow coefficient (B), and future cycle elbow tap flow coefficient (K) as the elbow tap ΔP (inches water) multiplied by the cold leg water specific volume (v).

(a) The use of the terminology "flow coefficient" to define the ΔP measurement values is confusing because the elbow tap "flow coefficient" normally refers to the constant (C) in the elbow tap equation $Q = C (\Delta P)^{1/2}$, whereas ΔP is a variable as a function of flow rate. Why not use an alternate terminology, other than "flow coefficient," for "$\Delta P \times v$?"

(b) Discuss the reasons for not directly using the equation $Q = C (\Delta P)^{1/2}$ for measuring reactor coolant system (RCS) flow rate with elbow tap meters, where the flow coefficient, C, should have a constant value for an elbow tap installation, and the elbow tap ΔP readings would be proportional to the square of the cold leg flow rates, independent of the plant hydraulic changes such as pump impeller smoothing, steam generator tube plugging, and fuel design change.

(c) The definition in Equations 1 and 2 that B (or K) = $\Delta P \times v$ (where ΔP is in inches H_2O, and B and K are in inches $H_2O * ft^3/lb$) is not consistent with the basic elbow tap flow equation volumetric flow rate $Q = C \times (\Delta P)^{1/2}$.

Explain why B and K are defined as they are. Please examine Equations 1 and 2 for whether B and K are defined correctly.

2. In the elbow tap flow measurement procedure in Section 4.2, the future cycle RCS flow rate will be calculated from the baseline calorimetric-measured RCS flow multiplied by the "ratio of future cycle flow," R, which is defined in Equation 3 to be the square root of the ratio of the average ΔP (times specific volume) of all elbow tap from the future cycle to that of the baseline cycle, i.e. $(K/B)^{1/2}$.

(a) Because of the variations in the elbow tap flow coefficients (note that the flow coefficient here is C in the basic elbow tap equation, not B or K as defined in Equations 1 and 2 of your report) and the ΔPs for different elbow taps in the cold legs, what is the mathematical basis for the use of the average ΔP of all elbow taps in defining the ratio of future cycle flow, R? Provide the mathematical derivation to show correctness of "R," "B," and "K" as defined in Section 4.2 using the average ΔPs.

(b) As the flow coefficient (C) for each elbow tap should remain constant, the volumetric flow ratio should be equal to the square root of the ΔP ratio between two cycles, which should be anticipated to be the same for all elbow taps. Would it be more appropriate, mathematically, to use the average value of the flow ratios (i.e., square root of ΔP ratios) between the future cycle and the baseline cycle of all elbow taps to define the "ratio of future cycle flow," R? If not, why not?

(c) FSAR Section 4.4.1.1 indicates there is to be at least a 95 percent probability at a 95 percent confidence level that departure from nuclear boiling (DNB) will not occur on the limiting fuel rods during normal operation and anticipated operational occurrences. Technical Specification 3.4.1 requires measurement of the DNB parameter of total RCS flow rate.

To provide a 95/95 probability/confidence of the value of R, would it be more appropriate to adjust the "future cycle flow ratio," R, by taking into to account the uncertainty distribution of the ΔP ratios among the elbow taps as in the equation below? If not, why not?

$$R = R_{avg} - K(95,95,N)\ \sigma$$

where,

$R_{avg} = \Sigma\ R_i\ /N$

$R_i = (\Delta P_F\ /\ \Delta P_B)_i^{1/2}, \quad I = 1,2,....N$

(Note that ΔPs are in inch of water. If ΔPs are in psi, then it will be multiplied by the specific volume of water)

N = total number of elbow taps = 3 x number of cold legs

σ = standard deviation of R_is

K(95,95,N) = factor for one-sided tolerance limit for 95% probability at 95% confidence level for a sample size of N.

K(95,95,9) = 3.031

(d) Alternatively, provide (1) statistical calculations that show that the 95/95 probability and confidence level can be met for RCS flow rate using your proposed measurement method utilizing the elbow tap flow meters, or (2) a justification for measures used to achieve an acceptable accuracy that bounds the 95/95 criteria such as by use of margins, conservative data, etc.

3. The best-estimate flow confirmation procedure described in Section 4.2 sets the upper bound of the future cycle RCS flow in accordance with Equation 6 by comparing the measured flow ratio to the flow ratio of best-estimate hydraulic calculations, which is indicated in Section 5.1 to have been developed and confirmed by numerous component flow resistance tests and analyses to be accurate to plus or minus 2 percent. The multiplier in Equation 6 is said to be an allowance for elbow tap flow measurement repeatability. It is indicated that since the elbow tap flow measurement uncertainty includes this repeatability allowance, the measured flow ratio can be 0.4 percent higher than the estimated flow ratio and still define a conservative flow.

Section 4.1 discusses the elbow tap flow measurement repeatability with comparisons at the Prairie Island plant to the measurements of leading edge flow meter (LEFM), which is shown (in Section 5.2) to have an accuracy of plus or minus 0.67 percent established by a calibration test at the Alden Laboratories. An average difference of less than 0.3 percent is shown in Table 4-1 between the elbow tap meter and the LEFM measurements on the RCS loop flows at full power and the flow ratios with one- and two-pump operations.

(a) Provide the definition of the terms "repeatability," "accuracy," and "uncertainty" as applied to the indicated RCS flow rate obtained by the elbow tap flow meters.

(b) Provide the elbow tap measurement repeatability value, and describe how it is related to the data provided in Table 4-1, and explain how the elbow tap flow measurement uncertainty described in Appendix A of the report includes the repeatability allowance.

(c) Describe or reference the best-estimate hydraulic calculation methodology used by Farley and other 3-loop plants, and describe how the plus or minus 2 percent accuracy of the hydraulic calculation is obtained and will be assured in the future hydraulic calculations.

(d) The comparisons provided in Figures 6-1 and 6-2 of the RCS flows from the calorimetric measurements, elbow taps measurements, and best-estimate hydraulic calculations, show a difference of less than 0.5 percent between the elbow tap flow meter measured flow rates and the hydraulic calculation RCS flow rates. Explain how the use of Equation 6 defines a conservative flow, considering the hydraulic calculation accuracy, the elbow tap flow measurement repeatability and uncertainty.

4. Tables 6-1 and 6-2 provide calorimetric flow rates of all three loops for various cycles and baseline flow rates for Farley Units 1 and 2, respectively. The baseline flow rates for both units, which are shown to be the average of the loop flow rates of earlier cycles (before the transition to low leakage fuel core loading patterns) with hydraulic corrections and roundoff, are shown to be higher than any individual value from the three early cycles from which the baseline flow rates are obtained.

(a) With pump impeller smoothing, which was indicated by the Prairie Island LEFM data to cause a reduction of the RCS flow by 0.6 to 0.8 percent, and why are the baseline RCS flow rates higher than the first cycle flow rate? Provide the calculations to show how these baseline value flow rates are obtained and why they are higher than any individual value.

(b) In addition to the reasons provided in Sections 6.1 and 6.2 for excluding data of several cycles from Tables 6-1 and 6-2 for Farley 1 and 2, respectively, provide the criteria and bases for the criteria that are used for Farley and will be used for other 3-loop plants such as V. C. Summer, Turkey Point 3 and 4, for excluding data from being used in deriving the baseline flow.

5. Tables A-4 and A-5, respectively, provide the cold leg elbow tap flow uncertainty for the process computer and low flow reactor trip. Are the instrumentation uncertainty values sufficient to bound the uncertainties of the elbow tap measurement instrument, including the larger drift effects, caused by the absence of current normalization of elbow tap measurement against the precision heat balance measurement at the beginning of each cycle? Provide corrected uncertainty values, if necessary, and the basis for the uncertainty values.