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Response to an RAI on Topical Report ANP-10262(P), Revision 0, "Enhanced Option III Long Term Stability Solution" and BAW-10255(P), Revision 2, "Cycle-Specific DIVOM Methodology Using the RAMONDA5-FA Code"

Ref. 1: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of ANP-10262(P) Revision 0, 'Enhanced Option III Long Term Stability Solution'," NRC:06:002, January 31, 2006.

Ref. 2: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of BAW-10255(P), Revision 2, 'Cycle-Specific DIVOM Methodology using the RAMONA5-FA Code'," NRC:06:001, January 30, 2006.

Ref. 3: Letter, Holly D. Cruz (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Request for Additional Information Re: U.S. Nuclear Regulatory Commission (NRC) Advisory Committee on Reactor Safeguards (ACRS) Review of Draft Safety Evaluations for AREVA NP Inc. (AREVA) Topical Report (TR) ANP-10262(P), Revision 0, 'Enhanced Option III Long Term Stability Solutions,' (TAC No. MC9766) and AREVA TR BAW-10255(P), Revision 2, 'Cycle-Specific DIVOM Methodology Using the RAMONA5-FA Code,' (TAC No. MC9767)," January 29, 2008.

AREVA NP Inc. (AREVA NP) requested the NRC's review and approval of the topical report ANP-10262(P) Revision 0 in Reference 1 and BAW-10255(P) Revision 2 in Reference 2.

The NRC provided a Request for Additional Information (RAI) regarding these topical reports in Reference 3. The response to RAI Question Number 2 is provided in Attachment A enclosed with this letter. The responses to the remaining questions will be submitted to the NRC in accordance with the schedule provided in Reference 3.

If you have any questions related to this submittal, please contact Ms. Gayle F. Elliott, Product Licensing Manager. She may be reached by telephone at 434-832-3347 or by e-mail at gayle.elliott@areva.com.

Sincerely,

Ronnie L. Gardner, Manager
Site Operations and Corporate Regulatory Affairs
AREVA NP Inc.

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NRR

Enclosure

cc: H.D. Cruz
Project 728

Attachment A

Question 2: *ADDITIONAL JUSTIFICATION FOR THE 5 PERCENT HOT CHANNEL OSCILLATION MAGNITUDE (HCOM) PENALTY*

Please provide an expansion of Section 1.2 of TR ANP-10262(P) with a summary of the approved HCOM methodology (NEDO-32465-A). Provide a clear definition of what HCOM is, including the effect that higher decay ratios could have on the delta-critical power ratio (CPR) because of the delay on reactor shutdown after scram initiation.

Figure 3-6 of TR ANP-10262(P) shows that a biasing factor of 1.3 in the HCOM decay ratio (DR) probability distribution results in an amplitude setpoint change from 1.10 to 1.095 (i.e., 0.5 percent). Please describe how this result translates to a 5 percent HCOM penalty.

Note: the PBDA algorithm will trip the reactor when the DR becomes greater than 1.0. Under MELLLA+ conditions, a two-pump trip followed by the associated subcooling transient will result in a final DR significantly larger than under OLTP conditions, but the PBDA will scram the reactor at an earlier time (i.e., when the DR is approximately 1.0). With this argument in mind, please justify why a biasing factor of 1.3 conservatively represents the DR values that could be expected under MELLLA+ conditions at the time of scram (not the final DR).

Response 2:

HCOM is an acronym for "Hot Channel Oscillation Magnitude" where the hot channel is not necessarily the bundle with the highest power but more appropriately the one with the largest power swing so that its transient change in CPR defines the limiting response of the core. The oscillation magnitude refers to the relative bundle power, and is defined as the peak bundle power (P) minus the preceding minimum bundle power (M) for a given oscillation cycle divided by the average power (A) over that oscillation period. Thus, HCOM = (P-M)/A.

The HCOM methodology refers to the analysis of the relationship between the hot channel oscillation magnitude (HCOM) and the trip amplitude setpoint S_P. The amplitude setpoint, S_P, is defined as the peak-to-average ratio of the OPRM signal at which a trip command is issued by the trip channel containing this OPRM. The HCOM analysis results in a few tabulated data pairs (normally 3 pairs) of HCOM versus S_P. Although not necessarily linear by definition, the relationship between S_P and HCOM obtained from actual analysis is almost exactly linear. Thus,

$$S_P = 1 + \xi \quad \text{HCOM} \tag{2.1}$$

where ξ is constant. Notice that the fractional part of S_P (not S_P itself) is proportional to HCOM because of their respective definitions. The HCOM analysis is effectively reduced to the methodology for determining the constant proportionality parameter, ξ.

In the idealized case where the detector response is measuring the power of a single bundle and the scram occurs immediately upon reaching the amplitude setpoint, the proportionality parameter $\xi = 0.5$ is obtained. However, the real system includes a plurality of OPRM detectors where each is made up of several LPRM detectors at different elevations, and each LPRM detector is driven by the nearest four bundles instead of a single bundle. This reduces the proportionality parameter to $\xi \approx 0.3$ (exact value is plant-specific).

It is clear from Equation (2.1) that modification of the analysis assumptions in order to account for different stability conditions would alter the value of the parameter ξ. A reduction of ξ by 5% results in a reduction of the fractional part of the setpoint, $S_P - 1$, by the same 5% in order to protect the same HCOM. Equivalently, an existing analysis with the associated value of ξ unchanged can be used with a penalty of 5% applied to the HCOM value itself, with the same effect on the amplitude setpoint reduction.

The actual oscillation suppression due to the reactor scram lags the trip signal issued upon reaching the amplitude setpoint. Thus, the relationship between HCOM and S_P depends on the particular organization of the LPRM detector assignments to OPRM cells, and is also affected by the possibility of detectors out-of-service. The Detect & Suppress methodology as described in the topical report (NEDO-32465-A) requires a plant-specific statistical methodology for calculating a tabulated relationship between HCOM and S_P. This plant-specific HCOM methodology is described briefly below.

The HCOM statistical methodology applies a Monte Carlo technique to sample many cases to obtain the conservative 95% probability with 95% confidence value of the hot channel oscillation magnitude HCOM at the time of oscillation suppression for a given amplitude setpoint S_P. To characterize an oscillation for each case, the oscillation decay ratio (or more appropriately growth ratio) and the oscillation period are sampled from probability distributions shown in Figures (4.4) and (4.5) of NEDO-32465-A, and the first oscillation peak that exceeds the amplitude setpoint is positioned randomly such that the setpoint is anywhere between that peak and the preceding one. In the worst case, a signal peak is very slightly below the setpoint and the overshoot peak of the subsequent cycle would have the highest possible value of $1+(S_P-1)\times GR$ where GR is the growth ratio for this particular instability. The suppression time delay is smaller than a full oscillation period, which makes the limiting oscillation peak the one occurring in the opposite side of the core a half period later, with an amplitude a factor of $\sqrt{GR}$ greater. Thus the amplitude of a signal at the time of oscillation suppression, S, is obtained in the range

$$1+(S_P-1)\times GR^{0.5} < S < 1+(S_P-1)\times GR^{1.5} \qquad (2.2)$$

The hot channel oscillation magnitude, HCOM, is higher than the OPRM signal magnitude, S, because the latter is a combination of detector responses at several neighboring bundles. However, the maximum signal amplitude and the HCOM are similarly affected by the growth ratio. This explains the need to apply a penalty to the setpoint (or equivalently the HCOM) when an existing HCOM analysis is used for conditions associated with anticipated higher growth ratios compared with the conditions associated with the original analysis.

Following a two-pump-trip, the reactor is brought to natural circulation and power is reduced. The core remains stable until the feedwater heaters respond to the decreased steam flow and the inlet subcooling gradually increases which combined with the resulting power increase bring the core gradually to less stable conditions. The rate of the destabilization depends on the balance of plant (feedwater heaters) not on the operating domain itself. However, operating under extended flow windows (MELLLA+) makes it possible for the final decay ratio to be higher. However, the detection system operates on OPRM signals in the range when coherent signals start (Decay Ratio ≈ 1) to higher growth ratios when the signal amplitude exceeds the setpoint. The growth ratio at the time of detection, not the maximum growth ratio, influences the relationship between HCOM and the amplitude setpoint as discussed above. It should be noted that the Enhanced Option III solution single channel instability exclusion limits the maximum growth ratio of the signals processed by the detection system. For an exclusion region boundary that crosses the natural circulation line at or below the MELLLA line, no increase in growth ratio is expected and the HCOM versus S_P relationship is not affected by MELLLA+ operation, where the higher growth ratios are anticipated after the operating point crosses into the exclusion region and a scram is initiated.

The proposed 5% HCOM penalty is used to allow the use of existing HCOM analysis, while also allowing the possibility to place the exclusion region boundary at or above the MELLLA natural circulation corner. A conservative accounting of the increase in growth ratio is made by biasing the growth ratio probability distribution such that the most likely growth ratio in excess of unity is increased by a factor of ~1.3; in this way for the original probability distribution with a most likely growth ratio of 1.07 the biased distribution would be peaked at a growth ratio of 1.09. Thus biased, the probability of a highly unstable oscillation with a growth ratio of 1.2 is increased by a factor >2 which signifies the high level of conservatism applied due to the probability distribution biasing.

In conclusion, the proposed 5% penalty on existing HCOM versus S_P relationship for application to EO-III is justified as a very conservative approach allowing the single channel instability exclusion region boundary to cross the natural circulation line at or above the MELLLA line. For applications where the single channel instability exclusion region boundary crosses the natural circulation line at a lower power level due to the application of layers of conservatisms in its determination, the 5% HCOM penalty is no longer required.