UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

April 20, 2015

Mr. Mark A. Satorius
Office of Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: TOPICAL REPORT NEDC-33766P, "GEH SIMPLIFIED STABILITY SOLUTION (GS3)"

Dear Mr. Satorius:

During the 623rd meeting of the Advisory Committee on Reactor Safeguards (ACRS), April 9-11, 2015, we completed our review of the General Electric-Hitachi (GEH) Topical Report, NEDC-33766P, "GEH Simplified Stability Solution (GS3)," and the final Safety Evaluation prepared by the NRC staff. Our Thermal-Hydraulic Phenomena Subcommittee reviewed this matter during a meeting on March 20, 2015. During these reviews, we had the benefit of discussions with representatives of the NRC staff, their consultants, and GEH. We also had the benefit of the documents referenced.

CONCLUSION

We concur with the staff's finding that Topical Report NEDC-33766P, documenting the GEH Simplified Stability Solution (GS3), is acceptable for BWR/2-6 licensing applications to the extent specified and under the limitations and conditions delineated in the Topical Report and in the staff's Safety Evaluation.

BACKGROUND

Boiling water reactors (BWRs) are licensed to operate within specific power and core flow conditions that are referred to as their "operating domains" on a power/flow map. Within these domains, certain conditions may cause instabilities characterized by periodic variations in power and flow as a result of two-phase density waves sweeping through the reactor core. The power-flow oscillations can be core-wide, where all channels oscillate in-phase; regional, where half the channels oscillate out-of-phase with the other half; local, where different quadrants of the core oscillate out-of-phase; or even single channel, with flow but little power oscillation. If the flow and power oscillations become large enough, the safety limit minimum critical power ratio (SLMCPR) may be violated. Following a 1988 instability event at LaSalle, it was found that the protection system scram from high average power range monitor (APRM) signals might not be adequate to deal with out-of-phase oscillations. To maintain margin to the SLMCPR, three long-term solution options were proposed and approved.

Option I defines an exclusion region outside of which instabilities are very unlikely. If power and flow measurements indicate the reactor is entering this exclusion region, an automatic protective action is initiated. In Option I-A, the protection action is either a scram or select-rod insertion. In Option I-D, which may be applied to small-core plants with tight inlet orifices that have reduced likelihood of out-of-phase instabilities, a high APRM scram provides adequate protection and is initiated. Also, administrative controls to maintain the reactor outside the exclusion region are established.

In Option II, the reactor scrams on high quadrant-based APRM signals. For BWR-2s, the quadrant-based APRM is capable of detecting in-phase and out-of-phase oscillations with sufficient sensitivity to protect safety margins.

In Option III, the reactor scrams on a high signal from local power range monitors, which are analyzed online for oscillations using a period-based detection algorithm (PBDA), with an amplitude-based algorithm and growth rate algorithm being set to have defense-in-depth functions. If any of these detect instability, automatic protective action is taken to suppress the oscillation before safety margins are compromised. The setpoints for the PBDA are based on a combination of successive confirmation counts of power oscillations and oscillation amplitude.

Option I-A is preventive in nature, whereas the other options all rely on detection and suppression of oscillations. In the “detect and suppress” type solutions (Options I-D, II, and III), reactor operation in the entire licensed domain is allowed. If growing power oscillations occur, it may take some time for them to grow to levels that require suppression. Operators may, therefore, have time to take actions to move out of the instability regions before a scram initiates, which is desirable as scrams can challenge safety systems and adversely impact aging.

The current implementation of the detect and suppress options is based on the DIVOM (Delta over Initial MCPR Versus Oscillation Magnitude) methodology to calculate the setpoints such that SLMCPRs are not compromised during instability events. The DIVOM methodology is based on a conservative correlation for estimating the change in critical power ratio as a function of oscillation amplitude. Plant and cycle-specific DIVOM correlations for the detect and suppress solutions are currently used to select the scram setpoints, which as a result are set conservatively low. The setpoints for scram may, in some cases, have to be set at values so low that reactor noise or some operational maneuvers may trigger them, as evidenced by recent spurious scrams at Hope Creek, Perry, and Dresden, all of which operated with Option III. In addition, more realistic evaluation of trip setpoints and associated safety margins have become urgent because of recent power uprates, expanded operating domains, and incorporation of advanced BWR fuel designs along with higher fuel burnup.

DISCUSSION

To address the need for a solution with less conservative setpoints, GEH developed GS3, which uses a best estimate plus uncertainty approach to calculate the onset and growth of power oscillations. The critical output variable is the minimum critical power ratio (MCPR) including

uncertainty, which is obtained for a given setpoint. Reasonably limiting transients that may lead to instability are analyzed for each plant for both rated and single loop operation. The margin to the safety limit for a given setpoint is obtained with less conservatism than using the DIVOM methodology. As a result, setpoints can be adjusted to higher values while preserving adequate margin. GS3 does not require any hardware or software changes for plants licensed with Options I-D, II, or III stability solutions. Application of the methodology is limited to these solutions for operating domains up to and including the maximum extended load line limit analysis (MELLLA) domain.

The best estimate plus uncertainty methodology is analogous to that used to meet acceptance criteria for loss of coolant accidents (LOCAs) and uses the code scaling applicability and uncertainty approach. Its application here is based on TRACG to simulate core oscillations as well as determining local and single channel behavior including limiting channels. A three dimensional kinetics module consistent with the PANAC11 steady state simulator is incorporated. TRACG has been accepted for best estimate instability calculations in the more demanding MELLLA+ expanded operating domain. Much of what has been learned in applying TRACG has been carried over to developing the GS3 methodology, including sufficiently fine nodalization and explicit integration to limit numerical diffusion which tends to dampen the growth of oscillations. The calculations have been validated adequately against separate effects, integral, and plant data, to allow acceptance of the methodology for the GS3 application.

With regard to the estimation of MCPR uncertainties, the use of nonparametric order statistics is acceptable, with such methods having been intensively reviewed and accepted for LOCA calculations. A defensible basis has also been presented for the selection of uncertainty parameters for Monte Carlo analyses.

We endorse the use of Monte Carlo analyses and nonparametric order statistics in future applications of the best estimate plus uncertainty methodology. Submissions should contain careful consideration of the selection of sample parameters and their possible correlation, as well as development of the distributions and database for the parameter values.

Based on these considerations, we concur with the staff's finding that the GEH GS3 is acceptable for BWR/2-6 applications to the extent specified and under the limitations and conditions delineated in the Topical Report and in the staff's Safety Evaluation.

Sincerely,

/RA/

John W. Stetkar
Chairman

REFERENCES

1. U.S. NRC, “Safety Evaluation for GE-Hitachi Nuclear Energy Americas LLC Simplified Stability Solution (TAC MF 2730),” February 18, 2015 (ML15049A650)

2. GE Hitachi Nuclear Energy, NEDE-33766P, Revision 0, “GEH Simplified Stability Solution (GS3),” September 2013 (ML13254A137)

3. U.S. NRC, “Audit Report - GEH Simplified Stability Solution (GS3) Reactor Systems Branch Audit Including the Developed Bounding Envelope,” August 18, 2014 (ML14217A046)

4. GE Hitachi Nuclear Energy, “Response to Request for Additional Information Re: GEH Licensing Topical Report NEDE-33766P,” September 19, 2014 (ML14262A445)

5. GE Nuclear Energy, NEDO-31960-A, “BWR Owners' Group Long-Term Stability Solutions Licensing Methodology,” November 1995 (ML14093A212)

6. GE Nuclear Energy, NEDO-31960-A, Supplement 1, “BWR Owners' Group Long-Term Stability Solutions Licensing Methodology,” November 1995 (ML14093A211)

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1. U.S. NRC, "Safety Evaluation for GE-Hitachi Nuclear Energy Americas LLC Simplified Stability Solution (TAC MF 2730)," February 18, 2015 (ML15049A650)

2. GE Hitachi Nuclear Energy, NEDE-33766P, Revision 0, "GEH Simplified Stability Solution (GS3)," September 2013 (ML13254A137)

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