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

ACRSR-2260

June 22, 2007

Luis A. Reyes
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

SUBJECT: GENERAL ELECTRIC (GE) LICENSING TOPICAL REPORTS ON MAXIMUM EXTENDED LOAD LINE LIMIT ANALYSIS PLUS (MELLLA+) AND APPLICABILITY OF GE METHODS TO EXPANDED OPERATING DOMAINS

Dear Mr. Reyes:

During the 543rd meeting of the Advisory Committee on Reactor Safeguards, June 6-8, 2007, we reviewed the staff's Safety Evaluations for GE Licensing Topical Reports NEDC-33006P, Revision 2, "General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus," and NEDC-33173P, "Applicability of GE Methods to Expanded Operating Domains." Our Thermal-Hydraulic Phenomena Subcommittee also reviewed this matter on May 24-25, 2007. During these reviews, we had the benefit of presentations by and discussions with representatives of the NRC staff and General Electric. We also had the benefit of the documents referenced.

CONCLUSIONS

1. We concur with the staff's conclusion that application of the GE methods (documented in GE Licensing Topical Report NEDC-33173P) to extended power uprate (EPU) and the MELLLA+ operating domain, with the limitations imposed by the staff, is acceptable.

2. We concur with the staff's conclusion that application of the process (documented in GE Licensing Topical Report NEDC-33006P, Revision 2) for analysis of operation in the MELLLA+ region, with the limitations imposed by the staff including the modifications made by the staff during our discussions, is acceptable.

DISCUSSION

Boiling water reactors (BWRs) are licensed to operate within specific power and core flow conditions that are referred to as "operating domain" in a power-flow map. MELLLA+ expands the operating domain up to 120 percent of the originally licensed thermal power for core flow as low as 80 percent of the rated value. For core flows less than 80 percent of the rated value, the upper boundary of the expanded domain is approximately defined by a power-flow line that extends from 120 percent power at 80 percent flow down to less than the originally licensed power at 55 percent of the rated flow. The MELLLA+ expanded operating domain increases operating flexibility by allowing control of reactivity at maximum power by changing flow rather than rod insertion and withdrawal. GE Licensing Topical Report NEDC-33173P discusses the applicability of the GE methods proposed for safety analyses of both EPU and MELLLA+ operation. GE Licensing Topical Report, NEDC-33006P, Revision 2 addresses the impact of MELLLA+ operation as well as the scope of analyses that are needed to meet the safety and regulatory requirements for operation in the MELLLA+ domain.

A number of design developments enable operation in the MELLLA+ domain. The most important are: (1) fuel design features that accommodate operation at the higher power / lower flow conditions while maintaining acceptable fuel performance; and (2) a new detect and suppress system that provides protection against power and flow oscillations, which may arise more easily at higher powers and lower flows.

BWR fuel designs have evolved to 10 x 10 rod arrays. The 10 x 10 arrays provide sufficiently large heat transfer areas that can allow acceptable minimum critical power ratios (MCPRs) for both normal operating conditions and anticipated transients at EPU and MELLLA+ conditions. Additionally, such fuel designs lead to acceptable calculated peak clad temperatures during loss of coolant accidents (LOCAs). In order to minimize increases in the peak heat fluxes relative to current design levels, the fuel loading is adjusted to radially flatten the core power distribution. Part length fuel rods are introduced to provide better moderation in the core exit region and somewhat less peaked axial power profiles towards the end-of-fuel life. All this leads to peak heat fluxes that are within the range of experience even with 20 percent EPUs, although the average void fractions at the core exit are somewhat higher than those covered by current operating experience. Because of uncertainties associated with these higher void fractions and in the reactor physics calculations, as well as in the pressure drop and critical power ratio predictions, the staff has required additional margins in the MCPR safety limit and the MCPR operating limit. The staff has also imposed limits on bypass voiding. The additional margins that are required may be changed as more data become available to validate the reactor physics and the void fraction calculations. We agree with these requirements and would like the opportunity to review any changes that may be proposed in the future.

To protect against the increased susceptibility to flow and power oscillations in the MELLLA+ expanded operating domain, GE has developed the Detect and Suppress Solution-Confirmation Density (DSS-CD) system. The DSS-CD system uses a “detect and suppress” approach with a variety of indicators of increasing sensitivity to trigger its suppression function. The DSS-CD system is similar to the currently approved “Option III” detect and suppress solution, but it has a more sensitive detection capability. The DSS-CD system has been tested successfully. If the DSS-CD system is out of service, it is required that an automatic backup scram system be immediately armed. We agree with the staff that the DSS-CD system, in conjunction with the automatic backup scram system, will provide acceptable protection against power and flow oscillations.

Operation in the MELLLA+ domain could lead to conditions that are more difficult to manage during “special events,” such as an anticipated transient without scram (ATWS). The higher power could increase the peak reactor vessel pressure. The higher power / lower flow conditions and the closer proximity to stability boundaries could result in more rapid growth of oscillations during ATWS instability events. There are large uncertainties associated with the predictions of plant responses to ATWS, due to the difficulties in modeling such events and the paucity of data available to validate the calculational methods. These uncertainties are tempered to a large extent by the low frequency and the resulting low risk significance of these events. The staff is requiring plant-specific analyses for ATWS and additional mitigation measures. We agree with the staff that measures to deal with these events should not be approved on a generic basis at this time. Limitations related to ATWS instability developed as a result of our comments and those modified during our discussions with the staff are listed in the Attachment, and should be included in the final Safety Evaluation.

The Safety Evaluations were very demanding tasks for which the staff should be commended. The staff performed thorough evaluations and carried out convincing confirmatory analyses where tools were available, such as for the reactor physics and fuel related issues. Unfortunately, the staff did not have the thermal-hydraulic code capability that would have been needed to independently confirm some important parts of the evaluation such as ATWS instability. The TRACE thermal-hydraulic system analysis code has the capabilities needed to address such issues.

As recommended in our March 22, 2007 report, the TRACE code developmental work should be completed expeditiously to enable its incorporation into the regulatory process.

In conclusion, we find the methods and processes for enabling MELLLA+ operation proposed by GE to be acceptable with the inclusion of the limitations imposed by the staff. We would like to have the opportunity to review the first few plant-specific MELLLA+ applications. We would also like to have the opportunity to review any significant changes in the final Safety Evaluations including any changes to the limitations.

Sincerely

/RA/

William J. Shack
Chairman

References:

1. Memorandum dated May 1, 2007, from Jared Wermiel, Deputy Director, Division of Safety Systems, Office of Nuclear Reactor Regulation to Frank Gillespie, Executive Director, ACRS, Subject: General Electric (GE) Nuclear Energy (GENE) Licensing Topical Report (LTR) NEDC-33173P, “Applicability of GE Methods to Expanded Operating Domains.”

2. Memorandum dated May 3, 2007, from Michael Case, Director, Division of Policy and Rulemaking, Office of Nuclear Reactor Regulation to Frank Gillespie, Executive Director, ACRS, Subject: General Electric (GE) Nuclear Energy (GENE) Licensing Topical Report (LTR) NEDC-33006P, “Maximum Extended Load Line Limit Plus.”

3. GE Letter (MFN 05-141), NEDC-33006P, Revision 2, "General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus," November 28, 2005.

4. GE Letter (MFN 06-056), L. M. Quintana to NRC, GE Licensing Topical Report NEDC-33173P, “Applicability of GE Methods to Expanded Operating Domains,” February 10, 2006.

5. NEDC-33075P, Revision 5, MFN 05-145, “General Electric Boiling Water Reactor Detect and Suppress Solution - Confirmation Density,” December 1, 2005.

6. Letter, George Stramback (GE) to USNRC, CPR Margin – DSS-CD LTR NEDC-33075P, “Detect and Suppress Solution – Confirmation Density,” MFN 06-105, April 17, 2006.

7. LTR NEDE-33147P, Revision 1, (GE Letter MFN 06-153), "DSS-CD TRACG Application," May 23, 2006.

8. Report dated March 22, 2007, from William J. Shack, Chairman, ACRS to Dale E. Klein, Chairman, NRC, Subject: Development of the TRACE Thermal-Hydraulic System Analysis Code.

9. Memorandum dated May 23, 2007, from Jared Wermiel, Deputy Director, Division of Safety Systems, Office of Nuclear Reactor Regulation to Frank Gillespie, Executive Director, ACRS, Subject: Revised Limitations Associated with the Draft SER Approving General Electric (GE) Nuclear Energy (GENE) Licensing Topical Report (LTR) NEDC-33006P, A Maximum Extended Load Line Limit Plus.”

LIMITATIONS RELATED TO ATWS INSTABILITY DEVELOPED AS A RESULT OF ACRS COMMENTS AND THOSE MODIFIED BY THE STAFF DURING DISCUSSIONS WITH THE ACRS

Plant-Specific ATWS Instability Limitation

Until such time that NRC approves a generic solution for ATWS instability calculations for MELLLA+ operation, each plant-specific MELLLA+ application must provide ATWS instability analysis that satisfies the ATWS acceptance criteria listed in SRP 15.8. The plant-specific ATWS Instability calculation must: (1) be based on the peak-reactivity exposure conditions, (2) model the plant-specific configuration important to ATWS Instability response including mixed core, if applicable, and (3) use the regional-mode nodalization scheme.

In order to improve the fidelity of the analyses, the plant-specific calculations should be based on latest NRC-approved neutronic and thermal-hydraulic codes such as TGBLA06/PANAC11 and TRACG04.

Generic ATWS Instability Limitation

Once the generic solution is approved, the plant-specific applications must provide confirmation that the generic instability analyses are relevant and applicable to their plant.

Applicability confirmation includes review of any differences in plant design or operation that will result in significantly lower stability margins during ATWS such as:

1. turbine bypass capacity,
2. fraction of steam-driven feedwater pumps,
3. any changes in plant design or operation that will significantly increase core inlet subcooling during ATWS events,
4. significant differences in radial and axial power distributions,
5. hot-channel power-to-flow ratio,
6. fuel design changes beyond GE14.

ATWS Limitation 12.15

- For plants that do not achieve hot shutdown prior to reaching the heat capacity temperature limit (HCTL) based on the licensing ODYN code calculation, plant-specific MELLLA+ implementations must perform best-estimate TRACG calculations on a plant-specific basis. The TRACG analysis will account for all plant parameters, including water-level control strategy and all plant-specific emergency operating procedure (EOP) actions.

- The TRACG calculation is not required if the plant increases the boron-10 concentration/enrichment so that the integrated heat load to containment calculated by the licensing ODYN calculation does not change with respect to a reference OLTP/75 percent flow ODYN calculation.

Attachment

- Peak cladding temperature (PCT) for both phases of the transient (initial overpressure and emergency depressurization) must be evaluated on a plant-specific basis with the TRACG ATWS calculation.

- For key input parameters, systems and engineering safety features that are important to simulating the ATWS analysis and are specified in the Technical Specification (TS) (e.g. SLCS parameters and ATWS RPT), the calculation assumptions must be consistent with the allowed TS values, and allowed plant configuration. If the analyses deviate from the allowed TS configuration for long-term (beyond the TS LCO) equipment out of service, the plant-specific application will specify and justify the deviation. In addition, the licensee must ensure that all operability requirements (e.g., NPSH) by equipment assumed operable in the calculations are met.

- Nominal input parameters can be used in the ATWS analyses provided the uncertainty treatment and selection of the values of these input parameters are consistent with the input methods used in the original GE ATWS analyses in NEDE-24222. Treatment of key input parameters in terms of uncertainties applied or plant-specific TS value used can differ from the original NEDE-24222 approach, provided the manner in which it is used yields more conservative ATWS results.

- The plant-specific application will include tabulation and discussion of the key input parameters and the associated uncertainty treatment.

Item 1 (ECCS-LOCA Power Shape)

For applications requesting implementation of EPU or expanded operating domains, including MELLLA+, the small and large break ECCS-LOCA analyses will include top-peaked and mid-peaked power shape in establishing the MAPLHGR and determining the PCT. This limitation is applicable to both the licensing bases PCT and the upper bound PCT. The plant-specific applications will report the limiting small and large break licensing basis and upper bound PCTs.

Item 2 (Related LTR Limitations)

The limitations and conditions specified in the NRC Staff SERs approving NEDC-33173P (ADAMS Accession No. ML63440002); NEDC33075P (ADAMS Accession No. ML062640346); and NEDC-33147(ADAMS Accession No. ML070810308) apply to the review and approval of NEDC-33006P, “General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus.” Plant-specific applications using NEDC-33006P must comply with all the limitations and be consistent with the purpose and content covered in the staff SERs approving these licensing topical reports. Any subsequent revisions to the staff SERs approving these topical reports that lead to changes in specific limitations also apply as revised.

Item 3 TS Limitations

TS changes:

a) The licensee will amend the TS Limiting Condition for Operation (LCO) for any equipment out-of-service (SLO) or operating flexibilities prohibited in the plant-specific MELLLA+ application.

b) For operating flexibility such as feedwater heater out-of- service (FWHOOS) that is prohibited in the MELLLA+ plant-specific application but is not included in the TS LCO, a license will propose and implement a license condition.

c) The power flow map is not specified in the TS, however it is an important licensed operating domain. Licensees may elect to be licensed and operate under plant-specific expanded domain that is bounded by the MELLLA+ upper boundary. Plant-specific applications approved for operation within the MELLLA+ domain will include the plant-unique power/flow map specifying the licensed domain in the Core Operating Limit Report.

The Safety Evaluations were very demanding tasks for which the staff should be commended. The staff performed thorough evaluations and carried out convincing confirmatory analyses where tools were available, such as for the reactor physics and fuel related issues. Unfortunately, the staff did not have the thermal-hydraulic code capability that would have been needed to independently confirm some important parts of the evaluation such as ATWS instability. The TRACE thermal-hydraulic system analysis code has the capabilities needed to address such issues. As recommended in our March 22, 2007 report, the TRACE code developmental work should be completed expeditiously to enable its incorporation into the regulatory process.

In conclusion, we find the methods and processes for enabling MELLLA+ operation proposed by GE to be acceptable with the inclusion of the limitations imposed by the staff. We would like to have the opportunity to review the first few plant-specific MELLLA+ applications. We would also like to have the opportunity to review any significant changes in the final Safety Evaluations including any changes to the limitations.

Sincerely

/RA/

William J. Shack
Chairman

References:

1. Memorandum dated May 1, 2007, from Jared Wermiel, Deputy Director, Division of Safety Systems, Office of Nuclear Reactor Regulation to Frank Gillespie, Executive Director, ACRS, Subject: General Electric (GE) Nuclear Energy (GENE) Licensing Topical Report (LTR) NEDC-33173P, “Applicability of GE Methods to Expanded Operating Domains.”

2. Memorandum dated May 3, 2007, from Michael Case, Director, Division of Policy and Rulemaking, Office of Nuclear Reactor Regulation to Frank Gillespie, Executive Director, ACRS, Subject: General Electric (GE) Nuclear Energy (GENE) Licensing Topical Report (LTR) NEDC-33006P, “Maximum Extended Load Line Limit Plus.”

3. GE Letter (MFN 05-141), NEDC-33006P, Revision 2, "General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus," November 28, 2005

4. GE Letter (MFN 06-056), L. M. Quintana to NRC, GE Licensing Topical Report NEDC-33173P, “Applicability of GE Methods to Expanded Operating Domains,” February 10, 2006.

DOCUMENT NAME:C:\FileNet\ML071760346.wpd

OFC	ACRS	ACRS	ACRS	ACRS
NAME	HNourbakhsh	CSantos	FGillespie	JMG For WJS
DATE	6/22 /07	6/22 /07	6 / 22 /07	6/ 22 /07

OFFICIAL RECORD COPY