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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

VERMONT YANKEE NUCLEAR POWER CORPORATION

VERMONT YANKEE NUCLEAR POWER STATION

DOCKET NO. 50-271

1.0 INTRODUCTION

By letter dated October 31, 1995 (Reference 1), as supplemented on November 3, 1995, Vermont Yankee Nuclear Power Corporation (Vermont Yankee) submitted a validation report, YAEC-1926, "Method for Power/Flow Exclusion Region Calculation Using the LAPUR5 Computer Code," which is Yankee Atomic Electric Company's (Yankee Atomic's) application of the Boiling Water Reactor Owners Group (BWROG) stability exclusion region methodology for implementation of stability long-term solution Option 1-D at Vermont Yankee Nuclear Power Station (VYNPS). Vermont Yankee submitted YAEC-1926 to establish an NRC-approved methodology for calculating the power/flow exclusion region at VYNPS each operating cycle. The purpose of establishing YAEC-1926 as an approved methodology for VYNPS is to satisfy one of the two conditions stated in a March 30, 1995, safety evaluation (SE) (Reference 2) to complete the implementation of Option I-D at VYNPS. The other condition stated in the March 30, 1995, safety evaluation is the implementation of power distribution controls (i.e., a stability monitor) to ensure that operating conditions will remain within the assumptions used for the power/flow exclusion region calculations. To satisfy this condition, VYNPS has implemented the SOLOMON stability monitor, a software system designed by General Electric. Although the NRC staff has generically reviewed the SOLOMON stability monitor, its formal acceptance is pending. Nevertheless, the NRC staff has completed its review of Vermont Yankee's plant-specific implementation of the SOLOMON stability monitor at VYNPS, as described in this SE.

Oak Ridge National Laboratory (ORNL) assisted the NRC staff in the review of YAEC-1926 and prepared a technical evaluation report (TER) which is attached to this SE. Appendix A to this TER contains the report of an audit conducted by the NRC staff and ORNL at VYNPS and the Headquarters of Yankee Atomic on May 30 and 31, 1996. This audit reviewed the implementation of Option I-D and the SOLOMON stability monitor at VYNPS.

2.0 BACKGROUND

A long-term solution to the stability problem is required to prevent the violation of specified acceptable fuel design limits (SAFDL) in the event of out-of-phase instabilities or core-wide instabilities with large local power peaking. Under these events, the reactor protection system (specifically, the high average power range monitor (APRM) scram, or the flow-biased thermal-power scram) may not provide sufficient margin to prevent SAFDL violations under all postulated operating conditions in all BWRs.

A number of long-term solutions were proposed by General Electric in NEDO-31960 and NEDO-31960 Supplement 1, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology." By letter to L.A. England of the BWROG dated July 12, 1993, the NRC documented its acceptance for BWR licensees to reference these topical reports. The approved long-term solution chosen by Atomic Yankee and Vermont Yankee for VYNPS is Option I-D, which requires establishing an administratively controlled power/flow exclusion region, supported by plant-specific calculations. These calculations must show low likelihood for out-of-phase oscillations and protection against core-wide mode oscillations by the unfiltered flow-biased scram. Vermont Yankee performed these calculations and documented them in topical report GENE-637-018-0793, DRF A00-04021, "Application of the Regional Exclusion with Flow-Biased APRM Neutron Flux Scram Stability Solution (Option I-D) to the Vermont Yankee Nuclear Power Plant." The NRC approved this topical report and the implementation of Option I-D at VYNPS with two conditions in a March 30, 1995, SE (Reference 2). These conditions were to establish an NRC-approved stability monitor and plant-specific calculation methodology to determine the excluded area of the power/flow map for each fuel cycle. The NRC staff's review of Yankee Atomic's implementation of the SOLOMON stability monitor to satisfy the first condition and its proposal to satisfy the second condition is the subject of this SE.

Vermont Yankee also previously proposed Option I-D related changes to the VYNPS technical specifications. These TS changes were approved by the NRC in Amendment No. 146 on August 9, 1995. Specifically, TS 3.6.J, "Thermal Hydraulic Stability," and TS 6.7.A.4, "Core Operating Limits Report (COLR)," were revised to remove the power/flow exclusion region map entitled "Stability Power and Flow Exclusion Region" from TS 3.6.J and place it in the COLR. TS 6.7.A.4 was also revised by adding NEDO-31960, and its supplement, to the list of NRC-approved analytical methods used to determine the core operating limits. These references were added because they had been used to verify the continued validity of the current power/flow exclusion region map that was moved to the COLR.

3.0 EVALUATION

Vermont Yankee proposed to satisfy one of the two conditions for implementing Option I-D by submitting YAEC-1926 (Reference 1) to establish an NRC-approved methodology to recompute the exclusion region for every new fuel cycle reload. YAEC-1926 documents the method for power/flow exclusion region calculation implemented by Yankee Atomic for VYNPS using the LAPUR5 computer code.

The LAPUR code was developed by the NRC in the late 1970's and has been widely used both nationally and internationally over the years. Version 5 of LAPUR was benchmarked against both core-wide and out-of-phase instabilities in a published report ORNL/NRC/LTR-90/6, where it was concluded that the error in decay ratios calculated by LAPUR is less than ±0.2.

The details of the application of LAPUR5 to exclusion region methodology are summarized in YAEC-1926 (Reference 1). The deviations from the standard vendor procedure are identified in Table 3.1 of YAEC-1926. Specifically, the estimated gap conductance value in Yankee Atomic's FROSSTEY-2 code, used for input to exclusion region calculations, is larger than the value in vendor licensing models (GESTAR code). Because the higher gap conductance values used by Yankee Atomic for VYNPS result in a conservative decay ratio and a larger exclusion region, its use is acceptable in both LAPUR5 and in SOLOMON on-line calculations.

During the NRC staff's review of YAEC-1926 (Reference 1), the NRC staff and ORNL conducted an audit to review the implementation of Option I-D and the SOLOMON stability monitor at VYNPS. During the SOLOMON demonstration at the plant, the audit team expressed some concern that the decay ratio calculated by SOLOMON appeared to be too high for the operating conditions at the time. Yankee Atomic representatives stated that they were aware of this condition and it was most likely caused by the very-conservative value of fuel gap conductance used in the SOLOMON calculations. To resolve this issue, Yankee Atomic agreed to collect noise data to perform a benchmark stability test. These data were collected on September 6, 1996, during a scheduled shutdown, and were provided to ORNL for analysis. The ORNL analysis indicates that the decay ratio during the September 6, 1996, tests was of the order of 0.23 ± 0.07, with an oscillation frequency of 0.50 ± 0.08 Hz. Using the conservative values for fuel gap conductance (~4000 BTU/hr/F/ft^2), VYNPS's implementation of the SOLOMON stability monitor predicts a decay ratio of 0.48. A sensitivity analysis conducted by ORNL using the LAPUR5 code indicates that the calculated decay ratio would be in agreement with the measured data if a fuel gap conductance value of ~1000 BTU/hr/F/ft^2 were used. Gap conductance values in the range of 800 to 1500 have been commonly used to benchmark other stability tests, where the operating power is ~50% of nominal. Because SOLOMON is used as an on-line monitoring system, accuracy (as opposed to conservatism) is desirable to maintain operator confidence in the system. Thus, the use of an overly-conservative fuel gap conductance value, while acceptable, is not required and more realistic input values of gap conductance are also acceptable.

Based on the review of the subject submittal (Reference 1) and the results of the implementation audit, and the results of the September 6, 1996, stability benchmark, the staff has found that (1) the LAPUR5 methodology proposed by Yankee Atomic in YAEC-1926 to calculate exclusion regions for application to long-term solution Option I-D and (2) the implementation of the SOLOMON stability monitor for power distribution control are acceptable. Therefore, the conditions specified in the March 30, 1995, SE (Reference 2) for full implementation of Option I-D at VYNPS are satisfied.

4.0 CONCLUSIONS

On the basis of its review in conjunction with the attached TER by ORNL, the NRC staff concludes that:

1. Yankee Atomic's Implementation of LAPUR5 as described in YAEC-1926 is technically adequate. This implementation is defined as the LAPUR5 code itself (which is under Yankee Atomic's configuration control) and the associated codes, procedures, and guidelines used to generate the LAPUR5 input for an exclusion region calculation.

2. Based on the benchmark data presented in YAEC-1926, we conclude that the accuracy of Yankee Atomic's implementation of LAPUR5 code results in a decay ratio error of ±0.2. With this accuracy, core and channel decay ratios estimated using Yankee Atomic's LAPUR5 implementation can be used to define an Exclusion Region based on the standard BWROG acceptance criteria that is defined in NEDO-31960 and NEDO-31960 Supplement 1.

3. The deviations from the standard BWROG methodology to define the Exclusion Region that are documented in Table 3.1 of YAEC-1926 are acceptable.

4. The present VYNPS implementation of the SOLOMON stability monitor, which includes a very conservative fuel gap conductance value, is an acceptable methodology to satisfy the power distribution control requirement set forth in the Reference 2.

5. Based on the results of September 6, 1996, stability benchmark, the use of a more realistic fuel gap conductance value in the SOLOMON on-line calculations is also acceptable.

In summary, the NRC staff concludes that Vermont Yankee has met the two conditions specified in Reference 2 for implementing the stability long-term solution Option I-D. Therefore, based on the review of topical report YAEC-1926 and the implementation audit at Yankee Atomic and VYNPS, it is acceptable for Vermont Yankee to implement Option I-D as proposed. However, prior to incorporating a power/flow exclusion region calculated by the methodology described in YAEC-1926 (Reference 1) into the VYNPS COLR, this approved methodology should be referenced in TS 6.7.A.4.

Attachment: Technical Evaluation Report by Oak Ridge National Laboratory (ORNL/NRC/LTR-96/21)

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REFERENCES

1. Letter from J. J. Duffy (VYNPC) to USNRC, submittal of YAEC-1926 "Method for Power/Flow Exclusion Region Calculation Using the LAPUR5 Computer Code", Yankee Atomic Electric Company Application of BWROG Stability Exclusion Region Methodology for Implementation of Long-Term Solution Option 1-D at Vermont Yankee Nuclear Power Station, BVY95-115, October 31, 1995.

2. Letter from D. H. Dorman (USNRC) to D. A. Reid (VYNPC), dated March 30, 1995, SER (TAC No. M87091) on "Regional Exclusion with Flow-Biased APRM Neutron Flux Scram" Stability Solution (Option I-D) to the Vermont Yankee Nuclear Power Plant, GENE-637-018-0793, General Electric Nuclear Energy, July 1993.