April 28, 2006

MEMORANDUM TO: Darrell J. Roberts, Chief
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

FROM: Kamal A. Manoly, Chief **/RA/**
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SUBJECT: STAFF TECHNICAL BASIS FOR CONTINUED POWER ASCENSION OF VERMONT YANKEE NUCLEAR POWER STATION UP TO 115% ORIGINAL LICENSED THERMAL POWER (TAC NO. MD0263)

Introduction

On March 2, 2006, the U.S. Nuclear Regulatory Commission (NRC) approved the request by Entergy Nuclear Operations, Inc. (Entergy) to increase the maximum authorized power level for Vermont Yankee Nuclear Power Station (Vermont Yankee) from 1593 Megawatts thermal (MWt) to 1912 MWt as an extended power uprate (EPU) equivalent to 120% of the original licensed thermal power (OLTP). During the initial power ascension at Vermont Yankee, plant instrumentation reached an administrative limit at 105% OLTP that required the licensee to evaluate the plant data before continuing the power ascension. As documented in a staff memorandum dated April 5, 2006, the licensee justified continued power ascension at Vermont Yankee. Upon achieving 112.5% OLTP (1791 MWt) on April 6 , Entergy informed the staff that plant instrumentation at Vermont Yankee had again reached an administrative limit that required evaluation. On April 20, Entergy submitted its evaluation to justify continued power ascension beyond 112.5% OLTP. On April 21, the staff informed Entergy that it did not object to the continued power ascension of Vermont Yankee up to 115% OLTP. A narrative of the NRC staff's review of the licensee's justification for continued power ascension at Vermont Yankee is provided below.

Background

Following receipt of the EPU license amendment, Entergy began to slowly increase reactor power at Vermont Yankee above OLTP on March 4, 2006, in accordance with its power ascension test procedure. The EPU amendment included a license condition that provides for monitoring and evaluating plant data at Vermont Yankee, and taking prompt action in response to potential adverse flow effects as a result of power uprate operation on structures, systems, and components (including verifying the continued structural integrity of the steam dryer).

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The Vermont Yankee power ascension procedure specifies that (1) the power ascension rate be no more than 16 MWt per hour; (2) steam dryer performance data be monitored hourly and compared to acceptance criteria; (3) power level be held for 4 hours at each 40 MWt step (2.5% OLTP) to obtain and evaluate additional plant performance data; and (4) power level be held for 96 hours at each 80 MWt plateau (5% OLTP) to conduct plant walkdowns and to perform steam dryer analysis whose results would be examined by the NRC staff. Entergy made a regulatory commitment to not increase power at Vermont Yankee if the NRC staff identified a safety concern during its evaluation of the plant data.

As part of the plant data evaluation, Entergy collects Main Steam Line (MSL) strain gage data to monitor pressure fluctuations within the main steam flow. The licensee inputs the MSL strain gage data into an acoustic circuit model (ACM) to calculate pressure loads on the steam dryer and the resulting stress in steam dryer components using a finite element model (FEM). The Vermont Yankee Steam Dryer Monitoring Plan (SDMP) establishes a Level 1 limit curve for the MSL strain versus frequency spectra based on the American Society of Mechanical Engineers (ASME) *Boiler & Pressure Vessel Code* (Code) fatigue stress limit of 13,600 pounds per square inch (psi), and a Level 2 limit curve based on 80% of that fatigue limit. If the Level 2 limit curve is reached, the SDMP specifies that power ascension be suspended until an engineering evaluation concludes that further power ascension is justified. If the Level 1 limit curve is reached, the licensee must reduce power until the curve is not exceeded.

On March 5, Entergy notified the NRC staff that the MSL strain gage data from the "A" MSL at Vermont Yankee had reached the Level 2 limit at 105% OLTP. On March 26, Entergy completed its engineering evaluation of the Vermont Yankee steam dryer and its justification for continued power ascension to 110% OLTP. Entergy verified that the stress in the Vermont Yankee steam dryer components remained significantly below the ASME Code fatigue stress limit of 13,600 psi at 105% OLTP. Based on its engineering evaluation, Entergy determined that continued power ascension to 110% OLTP would not cause stress exceedance in the steam dryer components that would challenge the structural integrity of the dryer. The NRC staff reviewed the licensee's justification for continued power ascension at Vermont Yankee beyond 105% OLTP. The NRC staff informed Entergy on March 31 that it did not have a safety concern with power ascension up to 110% OLTP, and documented its decision in a memorandum dated April 5, 2006. Subsequently, the licensee continued the power ascension at Vermont Yankee, and achieved 110% OLTP with the collected data remaining within the acceptance criteria. The staff reviewed the plant data, and did not object to continued power ascension up to 115% OLTP.

Licensee Justification for Power Ascension up to 115% OLTP

During further power ascension at Vermont Yankee, Entergy informed the NRC staff on April 6 that plant instrumentation at Vermont Yankee had reached an administrative limit at 112.5% OLTP that required evaluation. In particular, the licensee reported that the MSL strain gage data from the "A" MSL reached the Level 2 limit at a frequency resonance peak of 143 Hz. The licensee provided the specific plant data that supported its decision to remain at 112.5% OLTP while evaluating the data. The staff reviewed the plant data and held telephone discussions regarding the data with the licensee. Based on its review, the staff did not object to Vermont Yankee remaining at 112.5% OLTP while the licensee evaluated the plant data.

On April 20, Entergy submitted its evaluation of the plant data to justify continued power ascension at Vermont Yankee beyond 112.5% OLTP. The licensee recalculated the stress on the steam dryer using the plant data from 112.5% OLTP and its current version of the ACM. As part of its analysis, the licensee adjusted the uncertainty associated with the ability of the ACM to match the frequency spectra from 15% to 25%. The licensee then recalculated the Level 1 and Level 2 limit curves for the MSL strain gage data using plant data from 112.5% OLTP and the updated uncertainty values. The licensee incorporated the new limit curves into a revision of the Vermont Yankee SDMP. Based on its engineering evaluation, Entergy determined that continued power ascension to 115% OLTP would not cause stress exceedance in the steam dryer components that would challenge the structural integrity of the dryer.

NRC Staff Evaluation

The NRC staff, with support from its consultants from Argonne National Laboratory, reviewed Entergy's engineering evaluation consisting of multiple analyses, data, and figures. The staff's evaluation focused on the licensee's basis for continued power ascension at Vermont Yankee up to 115% OLTP. For example, the staff reviewed the calculation of the stresses on the steam dryer components at 112.5% OLTP, and the establishment of new limit curves for MSL strain gage data in support of operation up to 115% OLTP.

The Vermont Yankee steam dryer analysis indicates that the steam dryer gusset shoe area is the most limiting stress location on the Vermont Yankee steam dryer for EPU operation. The stress on this component at 112.5% OLTP was calculated to be 2688 psi from the ACM and 599 psi from the Computational Fluid Dynamics (CFD) analyses. If the MSL strain gage measurements increase up to the new Level 1 limit curve in all four steam lines, the stress at this location is projected to be 9514 psi. This stress is about 30% less than the ASME Code fatigue limit of 13,600 psi. The Vermont Yankee SDMP provides additional margin in that power ascension must be halted and the collected data evaluated if any portion of the measured MSL strain-frequency spectra reaches the Level 2 limit (80% of the 13,600 psi limit) for any of the four steam lines.

As part of its review, the staff compared the Vermont Yankee MSL strain gage limit curves from 105% OLTP to the new limit curves established at 112.5% OLTP. The 112.5% limit curves have a lower baseline limit resulting from the increased ACM uncertainty, but permit higher MSL strain gage signals at the resonance frequencies experienced at 112.5% OLTP. The higher resonance peaks are allowed to be included in the new limit curve based on their small contribution to the total resulting stress on the steam dryer. Also, the Vermont Yankee Level 1 limit remains below the MSL data measured in the high-frequency range of interest at Quad Cities Unit 2, which experienced severe steam dryer damage under EPU conditions. Further, the Vermont Yankee SDMP will require the licensee to halt power ascension if any acoustic signal from the Vermont Yankee MSL strain gage data in any MSL reaches the Level 2 limit curve, which is 80% of the Level 1 limit curve. With respect to the low-frequency regions of MSL strain gage data, the staff will ensure that Entergy closely monitors those low frequency areas during future power ascension.

Conclusion

Based on its review of the Entergy's engineering evaluation, the NRC staff concluded that the licensee provided a reasonable basis for continuing power ascension up to 115% OLTP at Vermont Yankee. The staff's conclusion is based on: (1) the calculated stress on the most limiting component of the Vermont Yankee steam dryer at 112.5% OLTP is significantly below the ASME Code fatigue limit; (2) plant performance limit curves maintain MSL strain gage data lower than the Quad Cities data in the high-frequency acoustic range; (3) frequent monitoring of plant performance data, including hourly collection of the MSL strain gage data, during power ascension; and (4) plant procedures halt power ascension if any portion of the measured MSL strain vs. frequency spectra reach the Level 2 limit curve for any Vermont Yankee MSL. On April 21, 2006, the NRC staff informed Entergy that the staff did not object to the continued power ascension process at Vermont Yankee up to 115% OLTP. The staff will ensure that Entergy closely monitors the MSL strain gage data for any increases toward the limit curves during the power ascension at Vermont Yankee. The staff will review Entergy's justification for continued power uprate operation, including further power ascension, based on the plant data collected during the next power ascension step. Further, the staff notes that a license condition requires that Entergy resolve the steam dryer analysis uncertainties within 90 days of issuance of the EPU license amendment.

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Based on its review of the Entergy's engineering evaluation, the NRC staff concluded that the licensee provided a reasonable basis for continuing power ascension up to 115% OLTP at Vermont Yankee. The staff's conclusion is based on: (1) the calculated stress on the most limiting component of the Vermont Yankee steam dryer at 112.5% OLTP is significantly below the ASME Code fatigue limit; (2) plant performance limit curves maintain MSL strain gage data lower than the Quad Cities data in the high-frequency acoustic range; (3) frequent monitoring of plant performance data, including hourly collection of the MSL strain gage data, during power ascension; and (4) plant procedures halt power ascension if any portion of the measured MSL strain vs. frequency spectra reach the Level 2 limit curve for any Vermont Yankee MSL. On April 21, 2006, the NRC staff informed Entergy that the staff did not object to the continued power ascension process at Vermont Yankee up to 115% OLTP. The staff will ensure that Entergy closely monitors the MSL strain gage data for any increases toward the limit curves during the power ascension at Vermont Yankee. The staff will review Entergy's justification for continued power uprate operation, including further power ascension, based on the plant data collected during the next power ascension step. Further, the staff notes that a license condition requires that Entergy resolve the steam dryer analysis uncertainties within 90 days of issuance of the EPU license amendment.

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