

April 5, 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  
110% 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 subsequent power ascension at Vermont Yankee, plant instrumentation reached an initial administrative limit that required the licensee to evaluate the plant data before continuing the power ascension. On March 26, Entergy submitted its justification for continued power ascension at Vermont Yankee up to 110% OLTP. The NRC staff has reviewed the licensee's justification for continued power ascension at Vermont Yankee. Entergy will need to justify power ascension beyond 110% OLTP based on its review of plant data collected up to that power level. 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 above OLTP on March 4, 2006, at Vermont Yankee in accordance with its power ascension test procedure. The EPU amendment included a license condition that provides for monitoring, evaluating, 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) at Vermont Yankee.

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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 with NRC staff review. Entergy has made a regulatory commitment to not increase power at Vermont Yankee if the NRC staff identifies 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. Entergy's evaluation of the MSL strain gage and accelerometer data concluded that it was acceptable to maintain plant operation at 105% OLTP while the engineering evaluation was performed. The NRC staff independently evaluated the 105% OLTP data, and concluded that continued plant operation at 105% OLTP was reasonable and acceptable.

#### Licensee Justification for Power Ascension up to 110% OLTP

On March 26, 2006, Entergy completed its engineering evaluation of the Vermont Yankee steam dryer and its justification for continued power ascension to 110% OLTP. The engineering evaluation used (1) an improved ACM that is more bounding of actual steam dryer loads with reduced uncertainty; (2) an updated FEM that refines the assessment of the gusset shoe area that was of concern in a similar steam dryer at the Dresden nuclear power plant; (3) a more precise MSL strain gage data acquisition system designed to reduce the measurement uncertainty in the acoustic signals; and (4) MSL strain gage data collected at 105% OLTP.

Entergy verified that the stress in the Vermont Yankee steam dryer components remains significantly below the ASME Code fatigue stress limit of 13,600 psi at 105% OLTP. Further, the reduced uncertainty in the ACM and the MSL strain gage data acquisition system allowed Entergy to raise the limit curve for the MSL strain gage measurements while maintaining the resulting stress in the steam dryer below the ASME Code fatigue stress limit. The new limit curve has been incorporated into a revision of the Vermont Yankee SDMP.

Based on its engineering evaluation, Entergy has determined that continued power ascension to 110% OLTP will 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, has reviewed Entergy's engineering evaluation consisting of multiple analyses, data, and figures. The staff's review of the licensee's generic application of uncertainty assumptions for the revised ACM and improved MSL strain gage instrumentation is continuing. At this time, the staff has evaluated the licensee's basis for continued power ascension at Vermont Yankee up to 110% OLTP, including the calculation of the stresses on the steam dryer components at 105% OLTP and the establishment of new limit curves for MSL strain gage data in support of operation up to 110% 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 105% OLTP is calculated to be 2321 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 9866 psi. This stress is about 40% 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 established for initial power ascension to the new limit curves based on the revised ACM and more accurate MSL strain gage data. Although the new limit curves permit a higher MSL strain gage signal than the initial curves, the allowed MSL strain levels continue to be low. Higher strain peaks at the resonance frequencies experienced at 105% OLTP were acceptable to be included in the limit curve based on their insignificant contribution to the total resulting stress. Since the only instrumented steam dryer among the operating U.S. boiling water reactors is that at Quad Cities Unit 2 and the original steam dryers at Quad Cities were the only dryers at U.S. plants that have experienced severe damage under EPU conditions, the revised Level 1 limit curve for Vermont Yankee was compared to the MSL data measured at Quad Cities Unit 2. The comparison indicated that the Vermont Yankee revised Level 1 limit was significantly below the MSL data measured at Quad Cities Unit 2. 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 where the Vermont Yankee Level 1 limit curve is above the measured Quad Cities Unit 2 MSL data.

The NRC staff is reviewing the recently identified cracking in the skirt region of the steam dryer at Quad Cities Unit 2. The Quad Cities licensee has initiated an extensive effort to determine the cause of the cracking. Prior to the current outage, Quad Cities Unit 2 operated at up to 117% of the original licensed power for about 6 months with substantial high-frequency acoustic loads on the steam dryer. Entergy has evaluated the applicability of the Quad Cities Unit 2 information to Vermont Yankee. The staff reviewed Entergy's evaluation of the applicability of the Quad Cities Unit 2 steam dryer cracking to Vermont Yankee. Entergy applied a more conservative damping assumption in its assessment of the steam dryer skirt at Vermont Yankee than that used at Quad Cities. Even with this more conservative damping assumption, the stress in the skirt region of the Vermont Yankee steam dryer is calculated to be less than 1000 psi at 105% OLTP. Therefore, there is considerable margin in the stress analysis for the skirt region at Vermont Yankee to account for damping and other assumptions. The staff does not consider the cracking in the skirt region of the Quad Cities Unit 2 steam dryer to raise a safety concern with power ascension at Vermont Yankee up to 110% OLTP.

### Conclusion

Based on its review of the Entergy's engineering evaluation, the NRC staff concludes that the licensee has provided a reasonable basis for continuing power ascension up to 110% OLTP at Vermont Yankee, including (1) plant performance limit curves that maintain MSL strain gage data far lower than the Quad Cities data in the high-frequency acoustic range; (2) frequent monitoring of plant performance data, including hourly collection of the MSL strain gage data; and (3) plant procedures that 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 March 31, 2006, the NRC staff informed Entergy that the staff did not object to the continued power ascension process at Vermont Yankee up to 110% OLTP. The staff will continue to discuss the steam dryer analysis and its assumptions with Entergy as part of the review of the revised ACM for generic use at Vermont Yankee and other nuclear power plants. 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 this next power ascension step.

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