

June 20, 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/*  
Engineering Mechanics Branch  
Division of Engineering  
Office of Nuclear Reactor Regulation

SUBJECT: STAFF TECHNICAL BASIS FOR CONTINUED POWER ASCENSION  
OF VERMONT YANKEE NUCLEAR POWER STATION TO FULL  
EXTENDED POWER UPRATE CONDITIONS OF 120% 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 power ascension at Vermont Yankee, plant instrumentation reached an administrative limit at 105% OLTP (1673 MWt) and 112.5% OLTP (1791 MWt) that required the licensee to evaluate the plant data before continuing the power ascension. In memoranda dated April 5 and 28, 2006, the NRC staff documented its review of the licensee's justification for continued power ascension at Vermont Yankee from 105% and 112.5% OLTP, respectively.

Upon achieving 117.5% OLTP (1872 MWt) on April 28, Entergy informed the NRC staff that plant instrumentation at Vermont Yankee had again reached administrative limits that required evaluation. On May 1, Entergy made available for NRC review its evaluation to justify continued power ascension beyond 117.5% OLTP up to full EPU conditions of 120% OLTP (1912 MWt). The licensee submitted this information to the NRC in a letter dated May 4, 2006. Subsequently, the NRC staff informed Entergy on May 4 that it did not object to the continued power ascension of Vermont Yankee up to full EPU conditions (120% OLTP). A narrative of the NRC staff's review of the licensee's justification for continued power ascension at Vermont Yankee is provided.

CONTACT: Thomas G. Scarbrough, NRR/DCI/CPTB  
(301) 415-2794

## 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).

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 to the next lower power hold point when the limit curve was 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, and informed Entergy on March 31 that it did not have a safety concern with power ascension up to 110% OLTP. The staff 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.

On April 6, Entergy reported that the MSL strain gage data from the "A" MSL at Vermont Yankee reached the Level 2 limit at a frequency resonance peak of 143 Hz at 112.5% OLTP. On April 20, Entergy submitted its evaluation of the plant data to justify continued power ascension beyond 112.5% OLTP. The licensee verified that the stress in the Vermont Yankee steam dryer components remained significantly below the ASME Code fatigue stress limit of 13,600 psi. 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. The NRC staff reviewed the licensee's justification for continued power ascension at Vermont Yankee beyond 112.5% OLTP, and informed Entergy on April 21 that it did not have a safety concern with power ascension up to 115% OLTP. The staff documented its decision in a memorandum dated April 28, 2006. Subsequently, the licensee continued the power ascension at Vermont Yankee, and achieved 115% OLTP on April 22, 2006. The data collected at 115% OLTP remained within the acceptance criteria. The staff reviewed the plant data, and did not object to continued power ascension beyond 115% OLTP on April 26, 2006.

#### Licensee Justification for Power Ascension up to Full EPU Conditions (120% OLTP)

During continued power ascension at Vermont Yankee, Entergy informed the NRC staff on April 28 that plant instrumentation had reached an administrative limit at 117.5% OLTP that required evaluation. In particular, the licensee reported that the upper and lower sets of MSL strain gages on the "A" MSL reached the Level 2 limit at a resonant peak frequency of 143 Hz. Plant chemistry measurements also indicated that the Level 2 limit of 0.1% for moisture carryover was exceeded at 117.5% OLTP. The licensee provided specific plant data that supported its decision to remain at 117.5% 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 117.5% OLTP while the licensee evaluated the plant data.

On May 1, Entergy made available for NRC review its evaluation of the plant data in justifying continued power ascension at Vermont Yankee beyond 117.5% OLTP. Rather than applying the acoustic circuit model (ACM) at this intermediate power step, the licensee calculated the stress on the most limiting component (hood gusset shoe) of the Vermont Yankee steam dryer based on the combination of resulting stresses in the dryer that are derived using the measured MSL strain gage data at peak resonant frequencies during the power ascension. As a result, the licensee calculated that the steam dryer gusset shoe had a maximum stress of 3599 psi from acoustic loading. The stress from steam dryer loading calculated by the computational fluid dynamics (CFD) analysis remained at 599 psi. The licensee then recalculated the Level 1 and Level 2 limit curves for the MSL strain gage data using the plant data from 117.5% OLTP and the trend analysis. The licensee incorporated the new limit curves into a revision of the Vermont Yankee SDMP submitted on May 4, 2006.

With respect to moisture carryover, Entergy initiated increased monitoring of plant data in response to the Level 2 limit of 0.1% being exceeded. The increased monitoring found the moisture carryover values to remain about 0.11%. Entergy predicted that the moisture carryover would trend up to about 0.15% as power was increased to 120% OLTP.

Based on its engineering evaluation, Entergy determined that continued power ascension from 117.5% OLTP to full EPU conditions (120% 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 from 117.5% up to full EPU conditions (120% OLTP). For example, the staff reviewed the calculation of the stresses on the steam dryer components at 117.5% OLTP, and the establishment of new limit curves for MSL strain gage data in support of operation up to 120% OLTP. The NRC license amendment for Vermont Yankee EPU operation dated March 2, 2006, specifies that, after reaching 120% OLTP, the licensee shall obtain measurements from the MSL strain gages, establish the steam dryer flow-induced vibration load fatigue margin, update the steam dryer stress report, and re-establish the SDMP limit curve with the updated ACM load definition; and shall resolve the steam dryer analysis uncertainties within 90 days of issuance of the EPU license amendment. The staff will review the continued operation of Vermont Yankee at EPU conditions upon submittal of the EPU plant data and the licensee's analysis to support long-term EPU operation.

For continued power ascension at Vermont Yankee from 117.5% OLTP to full EPU conditions (120% OLTP), the NRC staff reviewed the licensee's trend analysis of the MSL strain gage data used in calculating the stress in the steam dryer gusset shoe of 3599 psi from the acoustic loads at 117.5% OLTP for Vermont Yankee. The stress on the steam dryer gusset shoe from CFD loads continued to be calculated as 599 psi. When combined, the resulting stress on the steam dryer gusset shoe remains significantly below the ASME Code fatigue limit of 13,600 psi. To support the reliability of MSL strain gage trend analysis for the power increase from 1872 to 1912 MWt, the licensee showed that the Level 1 limit curve calculated by the MSL strain gage data trend analysis compared closely to the Level 1 limit curve calculated using the ACM analysis at 1792 MWt.

Based on its trend analysis of the MSL strain gage data, Entergy developed new limit curves for the continued power ascension up to 120% OLTP at Vermont Yankee. If the MSL strain gage measurements increase up to the new Level 1 limit curve in all four steam lines, the licensee projected that the stress in the steam dryer gusset shoe would be 9529 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 NRC staff compared the previous Vermont Yankee MSL strain gage limit curves to the new limit curves established at 117.5% OLTP. The 117.5% OLTP limit curves have a lower baseline limit, but permit higher MSL strain gage signals at the resonance frequencies experienced at 117.5% 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 previous MSL data measured in the high-frequency range of interest at Quad Cities Unit 2, which experienced

severe steam dryer damage under EPU conditions at that time. 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.

The NRC staff is continuing to monitor the licensee's response to the increased values of moisture carryover with power ascension at Vermont Yankee. The moisture carryover values of about 0.11% at 117.5% OLTP are significantly below the Level 1 limit of 0.35%. Moisture carryover also remained steady with the more frequent data collection initiated with the Level 2 limit being exceeded. The predicted trend of moisture carryover to about 0.15% with additional power ascension is not unexpected with the reduced efficiency of the steam dryer during increased steam flow conditions.

### 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 full EPU power (120% 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 117.5% OLTP is significantly below the ASME Code fatigue limit; (2) plant performance limit curves maintain MSL strain gage data lower than previous Quad Cities data in the high-frequency acoustic range; (3) frequent monitoring of plant performance data, including MSL strain gage data and moisture carryover, 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 May 4, 2006, the NRC staff informed Entergy that the staff did not object to the continued power ascension process at Vermont Yankee up to full EPU power level (120% OLTP). The staff will review Entergy's justification for long-term power uprate operation, based on the plant data collected during the power ascension to full EPU conditions.

severe steam dryer damage under EPU conditions at that time. 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.

The NRC staff is continuing to monitor the licensee's response to the increased values of moisture carryover with power ascension at Vermont Yankee. The moisture carryover values of about 0.11% at 117.5% OLTP are significantly below the Level 1 limit of 0.35%. Moisture carryover also remained steady with the more frequent data collection initiated with the Level 2 limit being exceeded. The predicted trend of moisture carryover to about 0.15% with additional power ascension is not unexpected with the reduced efficiency of the steam dryer during increased steam flow conditions.

### 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 full EPU power (120% 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 117.5% OLTP is significantly below the ASME Code fatigue limit; (2) plant performance limit curves maintain MSL strain gage data lower than previous Quad Cities data in the high-frequency acoustic range; (3) frequent monitoring of plant performance data, including MSL strain gage data and moisture carryover, 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 May 4, 2006, the NRC staff informed Entergy that the staff did not object to the continued power ascension process at Vermont Yankee up to full EPU power level (120% OLTP). The staff will review Entergy's justification for long-term power uprate operation, based on the plant data collected during the power ascension to full EPU conditions.

### **DISTRIBUTION:**

DCI r/f

MMayfield

GImbro

**ADAMS Accession No.: ML061720389**

<b>OFFICE</b>	NRR/DCI/CPTB	NRR/DE/EEMB	NRR/DE/EEMB
<b>NAME</b>	TScarbrough	CWu	KManoly
<b>DATE</b>	06/19/2006	06/19/2006	06/20/2006

**OFFICIAL RECORD COPY**