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ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: **Vermont Yankee Nuclear Power Station**
Technical Specification Proposed Change No. 263
Extended Power Uprate – Regulatory Commitment
<u>Information Regarding Potential Adverse Flow Effects</u>

Reference:

1) Entergy letter to U.S. Nuclear Regulatory Commission, "Vermont Yankee Nuclear Power Station, License No. DPR-28 (Docket No. 50-271), Technical Specification Proposed Change No. 263, Extended Power Uprate," BVY 03-80, September 10, 2003

2) Entergy letter to U.S. Nuclear Regulatory Commission, "Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263 – Supplement No. 36, Extended Power Uprate – Response to NRC's Letter re: License Conditions," BVY 05-096, October 17, 2005

3) Entergy letter to U.S. Nuclear Regulatory Commission, "Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263 – Supplement No. 15, Extended Power Uprate – Response to Steam Dryer Action Item No. 2," BVY 04-100, September 23, 2004

This letter provides information pursuant to a regulatory commitment made in connection with the application by Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (Entergy) for a license amendment (Reference 1), as supplemented, to increase the maximum authorized power level of the Vermont Yankee Nuclear Power Station (VYNPS) from 1593 megawatts thermal (MWt) to 1912 MWt.

In Reference 2, Entergy proposed a license condition and made a regulatory commitment regarding potentially adverse flow effects on plant structures, systems, and components (SSCs) that might result from extended power uprate (EPU) operation. The subject regulatory commitment relates to actions required prior to exceeding 1593 MWt:

A001

With regard to [proposed] License Condition 3.M, "Potential Adverse Flow Effects," Entergy will provide information on plant data, evaluations, walkdowns, inspections, and procedures associated with the individual requirements of that license condition to the NRC staff prior to increasing power above 1593 MWt or each specified hold point, as applicable...

Data Collection and Evaluation

Entergy identified and evaluated piping and components that were potentially vulnerable to flow-induced vibration (FIV). Details regarding FIV were included in the VYNPS Power Uprate Safety Analysis Report (provided as part of Reference 1) and in response to requests for additional information from the NRC staff (including Reference 3). A summary of the FIV program (excluding the steam dryer) is provided in Attachment 1 to this letter. Upon request, additional details, such as plant-specific procedures and calculations, will be made available through NRC's resident inspector. Entergy plans to submit the Steam Dryer Monitoring Plan (SDMP) including information on procedures associated with the requirements of License Condition 3.M to the NRC staff in the near future as discussed below.

The VYNPS power ascension test plan for EPU will be the means for monitoring SSCs (including the steam dryer) for FIV during initial power ascension above current licensed thermal power (CLTP). Entergy has collected pre-EPU data from installed strain gauges and accelerometers on components potentially susceptible to FIV and will continue to record data through power ascension to full EPU implementation. These data will be supplemented by walkdowns and inspections where applicable and feasible during power operations. As described in Reference 3, FIV data obtained during power ascension testing will be evaluated relative to pre-determined acceptance criteria. The purpose of the evaluations will be to provide assurance that potentially affected components will perform acceptably at EPU conditions and the functions of SSCs will be maintained. Vibration data will be taken and evaluated at approximately 2.5% power increments between 100% and 120% of CLTP. Based on the data collected, engineering evaluations will determine the acceptability of vibrations at each 2.5% power step above 100% CLTP. If, during power ascension testing monitored parameters do not meet the acceptance criteria, the findings will be assessed and dispositioned in accordance with the VYNPS corrective action process. Corrective actions will include such actions as are necessary to preclude significant equipment degradation.

The EPU piping vibration monitoring program covers the FIV of the main steam and feedwater/condensate systems (including branch lines and cantilevered small bore lines) that will experience increased flow during EPU operating conditions. No other piping systems are expected to experience significantly increased flow rates at EPU conditions. As stated in Reference 3, the vibration monitoring program follows the guidance of ASME OM-S/G-2000 Code, Part 3, "Requirements for Preoperational and Initial Startup Vibration Testing of Nuclear Power Piping Systems."

The NRC staff has requested that Entergy provide the bases for the vibration acceptance criteria for piping systems and components. Because such bases are not normally included in test procedures, Attachment 1 to this letter includes a summary description of the bases for

those acceptance criteria. Further details can be made available to the NRC at the VYNPS site through NRC's resident inspector.

Recent Industry Operating Experience

Entergy has been active in reviewing applicable industry operating experience with respect to adverse flow effects at EPU conditions, including recent experience at Quad Cities Units 1 and 2. Entergy has also reviewed the operating experience regarding degradation of the electromatic relief valves (ERVs) and associated piping supports, thought to be caused by flow induced vibration at higher power levels. There was also experience at Quad Cities where a Target Rock safety/relief valve (SRV) was found to be inoperable during testing. The circumstances surrounding the degradations and the lessons learned from the failures of ERVs and the SRVs are important considerations in ensuring that FIV remains within acceptable limits at VYNPS under EPU conditions.

The staffs of Entergy and Exelon have been in communication regarding the extent of condition and contributing causes of both ERV and SRV degradations. VYNPS has no ERVs, but has Target Rock SRVs. The actuators on the VYNPS Target Rock SRVs are remotely mounted such that they are isolated from FIV forces. Entergy discussed potential root causes, as well as other lessons learned with the Exelon staff. Because Exelon's root cause evaluation efforts are continuing, additional information may develop which is relevant to VYNPS. Such information will be evaluated for applicability to VYNPS.

Steam Dryer

Upon issuance of the EPU license amendment, the provisions of License Condition 3.M and the associated regulatory commitment (Reference 2) will establish the principal requirements for monitoring and inspection of the steam dryer. The SDMP will implement the licensing requirements pertaining to the steam dryer through operating limits, required actions, and required surveillances.

Conclusion

The information contained herewith is provided in accordance with the cited regulatory commitment. To complete the regulatory commitment that pertains to the steam dryer and providing information associated with proposed License Condition 3.M, Entergy confirms that it will provide the NRC staff with the revised SDMP, including the steam dryer stress limit curve and the methodology for updating the limit curve prior to increasing power above 1593 MWt.

Entergy is giving due consideration to the potential for adverse flow effects that might result from EPU operation and remains confident that the VYNPS EPU can be implemented safely and reliably.

There are no new regulatory commitments contained in this submittal.

The information provided herewith is in partial fulfillment of a regulatory commitment and does not modify Entergy's application for a license amendment, does not change the scope or conclusions in the original application, nor does it change Entergy's determination of no significant hazards consideration.

If you have any questions or require additional information, please contact Mr. James DeVincentis at (802) 258-4236.

Sincerely,

Norman L. Rademacher
Director, Nuclear Safety Assurance
Vermont Yankee Nuclear Power Station

Attachment (1)

cc: Mr. Samuel J. Collins (w/o attachment)
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Mr. Richard B. Ennis, Project Manager
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Mr. David O'Brien, Commissioner
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Attachment 1

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263

Extended Power Uprate – Regulatory Commitment

Information Regarding Potential Adverse Flow Effects

Total number of pages in Attachment 1 (excluding this cover sheet) is 14.

Flow Induced Vibration of Piping Systems During EPU Power Ascension Testing

Background

References 1 and 2 conclude that certain flow rates in affected piping systems will increase by approximately 23% at extended power uprate (EPU) conditions. Engineering review shown that this flow rate increase could correspond to a 57% increase in flow induced steady state vibration levels. In addition, higher FIV level increases are possible if other FIV mechanisms are present (e.g., acoustic and/or structural resonances). The presence and results of these FIV mechanisms are not always possible to predict; therefore, an EPU power ascension vibration test program is utilized to evaluate the affected piping systems and vibration-sensitive branch lines.

Piping

The piping steady state vibration program follows the guidelines of the ASME OM-S/G-2000 Code, Part 3 (Reference 3) that defines analytical methodologies and corresponding acceptance criteria. The piping systems are classified into one of three vibration monitoring groups according to the criteria established in Reference 3. Meeting Reference 3 requirements will ensure that the piping systems do not experience high cycle fatigue associated with steady state flow vibration. Included in the piping program are branch lines and vibration sensitive small bore lines. Industry experience has identified numerous vibration fatigue failures of cantilevered small bore lines with socket-welded connections. Evaluations considered modification to the piping system, such as additional pipe supports or rerouting.

Major Piping Program Steps:

The process of evaluating FIV-susceptible piping systems follows the following steps:

- Identify affected piping systems
- Classify piping systems into appropriate vibration monitoring groups
- Select monitoring methods – remote, hand-held, visual
- Select and install temporary remote instrumentation
- Perform baseline walkdown inspections of piping and pipe supports (piping component inspections performed concurrently)
- Collect pre-EPU baseline vibration data, evaluate and project to EPU levels
- Develop Acceptance Criteria and input to EPU power ascension test plan
- Collect data and perform walkdowns during EPU power ascension at 2.5% power increments between 100% and 120% current licensed thermal power (CLTP) levels and evaluate
- Compare monitoring measurements to acceptance criteria and track trending of visual observations. Evaluations will determine adequate margin to proceed to next power level or determine if corrective actions are required
- Implement corrective actions (if required)

Piping Components

The purpose of the piping components program is to identify and evaluate components and subcomponents (internal mechanisms) susceptible to flow induced vibration at EPU operating conditions. The component types are: in-line (e.g., sample probes) components, directly mounted to piping (e.g., valves and instruments) and any instrument lines attached to the mounted component. The evaluations considered modifications to the component(s) and/or ongoing monitoring to minimize the potential for flow induced vibration failures. As a result, Entergy proactively modified isokinetic probes and a main steam (MS) drain line sockolet weld.

Major Piping Component Program Steps:

The process of evaluating FIV-susceptible piping components follows the following steps:

- Evaluate plant-specific operating experience
- Evaluate industry operating experience
- Perform baseline walkdown inspections
- Evaluate identified susceptible components, subcomponents and instrument lines
- Select components for EPU power ascension testing
- Collect data during EPU power ascension at 2.5% power increments and evaluate
- Implement corrective actions (if required)

Discussion

Reference 2 identified the piping systems that are expected to experience significant flow increases during EPU operating conditions. Baseline walkdown inspections of piping (including attached small bore lines), pipe supports and mounted components were performed during refueling outage-24 (RFO-24) (spring 2004) to identify any vibration related damage/concerns. Walkdown checklists were utilized that included features to examine, such as insulation damage, damaged or bent pipe support members, and insufficient vibration clearance. The plant areas reviewed were the drywell, MS tunnel, heater bay, and the feedwater (FW) and condensate pump rooms. Overall no vibration damage or concerns were identified, with the exception of the two concerns which are identified below along with the associated corrective actions:

- MS low point drain lines (Reference 5 identifies a previous failure on another BWRs MS low point drain line) – Increased weld size at piping attachment weld and provided a 2:1 weld taper
- AOV air supply tubing – Replaced with flexible tubing (References 6 and 17)

As stated previously, the piping systems are classified into one of three vibration monitoring groups. In summary, Vibration Monitoring Group No. 1 (VMG-1) includes complex and inaccessible piping which should be quantitatively measured using remotely monitored instrumentation. VMG-2 includes accessible piping that, from industry or plant specific experience, may be vulnerable to vibration issues and should be quantitatively measured

using hand-held instrumentation. VMG-3 includes accessible piping that is not expected to experience vibration issues but should be visually monitored. Each group is discussed in greater detail below.

Vibration Monitoring Group No.1 (VMG-1)

- Systems:

VMG-1 consists of large bore MS and FW piping systems located in the drywell which are inaccessible during plant operation. Portions of piping from the reactor pressure vessel (RPV) nozzles to the inboard isolation valves are monitored. Portions of the MS and FW systems from the inboard isolation valves to the turbine building boundary (MS tunnel) are heavily supported and thereby do not experience any appreciable vibration (see below). In addition, MS piping located inside the heater bay and portions of FW piping located between the stage 1 high pressure FW heaters and the turbine building and MS tunnel building boundary are monitored.

- Monitoring Requirements

The VMG-1 piping is monitored for vibration levels utilizing remote accelerometers temporarily mounted to the piping that are hard wired to a remote, vibration digital acquisition computer system (DAC). Monitoring point locations were selected from free vibration modal analyses of the MS and FW piping systems. Location criteria also considered positions near flow altering equipment/devices, branch lines and valves. The analyses demonstrated that low vibration responses occur at the lower MS and FW drywell zones and inside the MS tunnel due to a significant pipe restraint design. Accelerometers were installed in other areas that could be subject to FIV effects (refer to References 7 and 11).

- Acceptance Criteria

Acceptance criteria were calculated based on Reference 3 allowable stresses. The design code for the MS and FW piping is the ANSI B31.1 power piping code.

Process steps:

1. Run dynamic response spectrum piping analysis with 1g flat spectra in 3 directions over a frequency range of 0 to 200 Hz.
2. SRSS acceleration and stress output in each direction and list for each node point.
3. Select the maximum stress value and calculate the ratio of this value to the ASME O&M allowable alternating stress value.
4. Multiply the acceleration values for the monitored node points by this ratio to obtain the acceleration acceptance values.

This method is conservative because a flat response spectrum level is specified at every frequency from 0-200 Hz in all 3 directions simultaneously. Typically the maximum stress levels in a piping system result from the response of a small number of predominant modes. A flat acceleration loading applied for all modes and all directions results in a high value for

the maximum pipe stress and correspondingly low conservative value for acceptance criteria.

The development of the acceptance criteria is documented in References 18 and 19 using as input the piping analyses performed in References 15 and 16. The acceptance criteria values were input to the EPU power ascension test procedure.

- Testing/Monitoring Plan (includes precautions, pre-test requirements/conditions, holdpoints)

Pre-EPU baseline acceleration measurements were performed during RFO24 start-up. Test requirements were provided in References 8 and 10. Measurements were taken at 80, 90, 92, 95, 97 and 100% CLTP. EPU power ascension measurements will be taken at 2.5% power level increments above CLTP.

- Instrumentation

A detailed description of the accelerometers, charge converters, wiring, acquisition system, installation, diagnostics and calibration is provided in Vermont Yankee Temporary Modification 2003-022 (Reference 8).

- Measurements/Observation/Evaluations

<u>Pre-EPU Baseline Measurements</u>

RFO24 start-up measurements taken at 80, 90, 92, 95, 97 and 100% CLTP levels are documented in Reference 10. Data reduction, evaluations and trend plots to 120% CLTP power levels are documented in Reference 11.

The maximum root mean squared (RMS) acceleration recorded was 0.083 grms and the maximum peak-to-peak displacement recorded was less than 0.00245" at the 100% power level. The projected MS and FW piping accelerations at the 120% EPU power level are estimated to be very low acceleration levels for piping systems (Reference 11).

<u>EPU Measurements</u>

At each 2.5% power level increment above CLTP, accelerometer measurements will be taken and compared to the acceptance limits. Measurements and acceptance criteria will be documented in the EPU power ascension test procedure. Any measurements determined to be approaching the acceptance limit and/or higher than the trend plots values in Reference 11 will result in the initiation of a Condition Report, and the data will be evaluated for acceptability prior to sign-off for continued power ascension.

- Data Handling/Storage

Data is stored on the DAC hard disk and transferred to a personal computer for analysis.

- System Restoration

With the exception of the MS accelerometers in the drywell, after completion of 120% CLTP power level testing and evaluations, it is anticipated that the accelerometers and associated equipment will be removed during the following refueling outage. The MS accelerometers in the drywell will remain in place as part of the steam dryer FIV monitoring system.

Vibration Monitoring Group No. 2 (VMG-2)

- Piping Systems

The piping to be monitored includes FW piping downstream of the reactor feed pumps in the FW pump room and the heater bay. Two locations on the FW piping are monitored in the FW pump room: at the FW flow control valves and at a location on the FW discharge header. Several small-bore attached cantilevered lines with two valves were also selected for monitoring in the FW pump room and in the heater bay. Additionally, cantilevered branch lines just downstream of the condensate pumps were chosen as monitoring points. The monitoring point selection is documented in Reference 12.

- Monitoring Requirements

Monitoring of the piping is performed with a hand-held vibration meter which records displacement at each location. Monitoring points were located at accessible portions of the FW flow control valves and on the FW discharge header and the cantilevered concentrated mass (valve) location on the cantilevered branch lines. These points will serve as benchmarks for the remainder of the piping to gauge any increase in vibration levels at each power level increment.

- Acceptance Criteria

The acceptance limit analyses are documented in Reference 12. The methodology used to develop the acceptance criteria for the main FW piping was similar to the method used for the VMG-1 group piping except that the measured quantity used is displacement levels instead of accelerations.

A dynamic response spectrum piping analysis of the FW piping was performed with 1g flat spectra in 3 directions over a frequency range of 0 to 200 Hz. Calculated displacements at the locations to be monitored were multiplied by the ratio of OM-3 allowable stress to maximum model stress and to obtain the conservatively low acceptance criteria. Acceptance criteria (displacements) for cantilevered small bore branch lines were also based on OM-3 allowable stress criteria.

- Hand-Held Instrumentation

Hand-held vibration meter – Vibration Analyzer CSI Model 2115 or equivalent

- Measurements/Observations/Evaluations

Pre-EPU baseline displacement measurements were taken at 100% CLTP. These are documented in Reference 12. During EPU, at each 2.5% power level increment above CLTP, displacement measurements will be taken and compared to the acceptance limits.

Measurements and acceptance criteria will be documented in the EPU PATP. Any measurements determined to be approaching the acceptance limit will result in a the initiation of a Condition Report, and the data will be evaluated for acceptability prior to sign-off for continued power ascension.

- Data Handling/Storage

Hand held meter data will be transferred to a computer disk.

- System Restoration

None is required.

Vibration Monitoring Group No. 3 (VMG-3)

- Piping Systems

Included in this group are FW, condensate, extraction steam, heater drains located in the FW pump room and heater bay, and the condensate piping located in the condensate pump room. Included in this group is small-bore attached piping, especially cantilevered lines with large valves and/or two valves.

- Monitoring Requirements

Because no pre-EPU issues were identified, the baseline and EPU power ascension monitoring will be visual. Monitoring locations for main piping were determined by observation. Any noticeable level of vibration which is judged to be of potential concern will be measured with the hand-held vibration meter. The baseline observations were documented in Reference 12. The walkdown team includes engineers with expertise in piping design and analysis.

- Acceptance Criteria

The acceptance criteria are based on Reference 3. For main piping, if the level of vibration is too small to be perceived, and the possibility of fatigue issues is judged to be minimal, the piping system is acceptable. Any observed vibration levels judged by walkdown personnel to be a potential concern will be monitored utilizing simplified VMG-2 methods. The acceptance criteria for these locations will be established as described for VMG-2 piping.

- Measurements/Observations/Evaluations

Pre-EPU baseline walkdowns were performed at 100% CLTP. These are documented in Reference 12. During EPU, at each 2.5% power level increment above CLTP, system walkdowns will be performed and the results documented in the EPU PATP. Any observation determined to be approaching the acceptance limit will result in the initiation of a Condition Report, and the data will be evaluated for acceptability, prior to sign-off for continued power ascension.

- System Restoration

None required.

Piping Components

As described above, the piping component program identified and evaluated piping components susceptible to flow induced vibration at EPU conditions. The component types were also described above. The basis for selection of potentially FIV-vulnerable components for monitoring includes:

- Plant-specific operating experience
- Industry operating experience
- Identification of FIV through plant inspections
- Additional evaluation of components potentially susceptible to FIV at increased system flow

Plant-Specific Operating Experience Evaluation

In addition to plant-specific walkdowns and the monitoring of structures, systems and components during CLTP conditions and during EPU power ascension, industry events that were attributable to EPU were reviewed. Industry EPU operating experience indicates that power uprate may exacerbate existing FIV vulnerabilities, rather than introduce new ones. In order to identify any existing VYNPS vulnerabilities, a review was conducted of plant maintenance records and corrective action event and condition reports for components with failures or wear degradation attributed to vibration. Interviews were conducted with Entergy system engineers and maintenance personnel at VYNPS to identify component FIV vulnerabilities reflected in periodic corrective maintenance or in the VYNPS preventive maintenance (PM) program. The following components with the potential for vibration wear were identified for evaluation, although system and component evaluations would not indicate exacerbation because of EPU:

Reactor water cleanup (RWCU) pump – excessive vibration caused by reduction in system flow to improve thermal efficiency. System flow was subsequently restored to previous rates. This was determined to be a one time event. RWCU will not have increased flow at EPU operating conditions. Therefore, this component has not been selected for FIV monitoring.

Service water pressure indicator – this pressure indicator is attached to an instrument line that experiences some limited steam flashing in the summer due to high service water temperatures. The flashing results in vibration of the pressure indicator. The pressure indicator is now isolated except when readings are being taken. Isolating the gage eliminates the pressure indicator cycling. There is no flow increase in service water under normal EPU conditions. A supplemental monitoring plan has been developed for the SW system for EPU conditions.

Condensate minimum flow recirculation valve – this valve is used during low power operation to recirculate condensate flow to the condenser, maintaining minimum condensate system flow rate. The valve experiences cavitation due to the large differential between condensate system operating pressure and condenser pressure (vacuum). The cavitation causes vibration of the valve which results in accelerated wear in the valve and attached fittings. This valve will not be in service at EPU operating condition. Therefore, this component has not been selected for FIV monitoring.

Based on plant-specific operating experience, no specific components were identified as being currently vulnerable to FIV at EPU conditions. Therefore, no specific components were selected for FIV monitoring.

Component susceptibility at EPU operating conditions will be monitored on a long-term basis via the VYNPS PM program.

Industry Operating Experience Evaluation

Entergy reviewed industry BWR EPU operating experience information pertaining to FIV for applicability to VYNPS and potential vulnerabilities. The BWROG EPU Committee has reviewed the Institute for Nuclear Power Operations (INPO) Power Uprate and Cycle Events database to identify BWR EPU events attributed to FIV. Entergy also reviewed each of these FIV events and dispositioned their applicability to VYNPS. The following Table 1 summarizes the disposition results. As a result of the industry EPU FIV operating experience evaluation, Entergy made proactive modifications and will monitor the following components:

- MS safety/relief valves (SRVs) – via accelerometers on MS piping
- MS low point drain lines – via visual walkdowns and accelerometers
- FW heater level control valves – via inspection/walkdowns
- FW isokinetic probes – removed/replaced

A Quad Cities 3-stage Target Rock SRV had its as-found pressure setpoint out of specification in 2004. The cause was determined to be pilot valve bellows cap wear resulting from flow induced vibration of the MS piping. VYNPS has an aggressive SRV inspection and preventive maintenance program, which meets ASME code requirements. VYNPS has eight SRVs; four in service and four being readied for operation during the next cycle. All four SRVs are removed from service at the end of each operating cycle and shipped to an experienced valve maintenance vendor, with certified Target Rock technicians. All four valves have their as-found pressure settings tested for compliance with VYNPS Technical Specifications. In accordance with a prescribed schedule and VYNPS-specific tolerances, two of the SRVs are disassembled, inspected and rebuilt. All four SRVs have their as-left pressure settings tested. Inspection results, including any abnormal findings such as indications of wear, are documented and reported to Entergy. Entergy's preventative maintenance program ensures that all four SRVs currently in-service will be inspected for wear at the end of the current operating cycle at which time it is expected that the valves will have experienced approximately one year at EPU service conditions.

Entergy implements an operating experience (OE) program that reviews industry events and assesses applicability to VYNPS. The VYNPS OE program has been flagging events identified as being caused by power uprate. Applicable events have been, and will continue to be, evaluated for potential vulnerabilities, including FIV.

System/Component Inspection/Walkdown Evaluation

Entergy has performed rated CLTP baseline inspections/walkdowns of the condensate, FW and MS systems to identify systems and components with elevated vibration and to provide a documented general FIV baseline (Reference 12). The baseline will be used for comparison during EPU power ascension testing to identify components experiencing increased vibration levels. Results of the inspections/walkdowns performed during EPU power ascension testing, along with available vibration measurement data, will be compared to baseline results at pre-EPU rated power conditions. Components identified as having significant increases in FIV will be entered into the corrective action program and evaluated for acceptability and additional action.

Component evaluations may also conclude that additional surveillance is necessary or the preventive maintenance of the component should be increased in frequency and/or enhanced.

The baseline walkdown in the heater bay conducted during RFO24 identified air supply tubing to FW system air-operated valves (AOVs) vulnerabilities. Failure of this tubing occurred at another BWR during power uprate conditions when pipe vibration produced excessive relative movements between an AOV and the tubing anchor point. Similar configurations at VYNPS were found and the affected tubing was replaced with flexible tubing to ensure no flow induced vibration concerns will be present at EPU operating conditions (Reference 6 and 17).

Additional Evaluations of Components

Isokinetic probes in the condensate and FW systems were evaluated by Reference 9. The evaluation identified four probes which were potentially vulnerable to structural failure under higher EPU system flow conditions. The probes were replaced during RFO25 with a new shorter design which is adequate for EPU flow conditions (Reference 20).

Table 1 – Applicability of Industry FIV Events to VYNPS

INPO EVENT #	PLANT	EVENT	CAUSE	VYNPS APPLICABILITY
237-031009	DRESDEN 2 October 2003 DRESDEN 3 December 2003	FW sample probes lost in the Condensate and FW Systems were found during fall and winter 2003 outages. One probe was found to have damaged a FW sparger, another was found in the condensate booster pump casing. NRC IN 2004-06 was written to address. Similar probe failures have occurred at Perry, Braidwood, Browns Ferry and Grand Gulf.	Vibration. FW sample probe design was susceptible to transgranular stress corrosion cracking and fatigue failure from flow induced vibration. FW sample probe failures had occurred prior to EPU at Quad Cities (INPO Event # 254-940909) and Browns Ferry 3 (INPO Event #296-920723).	Four Condensate and FW Isokinetic Sample Probes were identified as vulnerable to EPU flow conditions (VYC-2422 Rev. 0). These probes were replaced by a new robust design by Reference 20 Design Change.
333-030319	FITZPATRICK Weld failure occurred 3/19/03	Socket weld failure on zinc injection skid connected to FW line. The failure occurred on an unisolable section of the FW supply line, requiring plant shutdown within 24 hours to repair. Connection isolation valve stem failure had occurred one month prior. Stem failure was not recognized as a precursor	Vibration. Stress was high at the valve-to-pipe joint due to highly rigid piping and high valve mass creating a fixed-end cantilever condition, combined with piping resonant vibration in the FW pump 5X vane pass frequency.	Entergy has identified condensate, FW and MS piping for cantilevered piping configurations potentially susceptible to FIV. Susceptible components were evaluated for expected EPU vibration levels and will be monitored during power ascension testing, with follow-on actions taken as appropriate.
352-000402	LIMERICK	Broken extraction steam line plate leads to tube failures in FW heater	Vibration. Failure of the plate was due to a weld seam design flaw and poor quality welds, combined with increased extraction steam flow induced vibration.	The four VYNPS high pressure FW heaters were replaced during the spring 2004 refueling outage with higher capacity heaters designed to provide adequate EPU operating margin. Design of the new VYNPS FW heaters took into account higher EPU extraction steam flow rates and

Table 1 – Applicability of Industry FIV Events to VYNPS

INPO EVENT #	PLANT	EVENT	CAUSE	VYNPS APPLICABILITY
				provide adequate design margin. The six LP heaters were replaced prior to EPU. All these heaters were replaced with units that included larger shell diameters to reduce steam inlet velocities, flash chambers to separate steam and drain flows, stainless and chrome-moly material to minimize erosion, and heavy steam impingement plates to minimize the potential for plate failures. These changes provided ample design margin for the LP heaters under EPU operation.
374-020422	LASALLE	Multiple FW heater tube leaks	Vibration. Failure of the tubes was attributed to marginal heater design and excessive shell side velocity as a result of a stretch power uprate.	The four VYNPS high pressure FW heaters were replaced in spring 2004 with higher capacity heaters designed to provide adequate EPU operating margin. Design of the new VY FW heaters took into account higher EPU extraction steam flow rates and provided adequate design margin.
333-981028	FITZPATRICK	Degraded FW heater system level control valves	Vibration. FW heater level control valves experienced positioner failures and were found to have vibration induced failures including broken air lines, valve yokes and valve internal welds.	Entergy evaluated VY FW heater level control valve vibration susceptibility. As a result, nine level control AOVs were modified by replacing the air supply rigid tubing with flex hose. FW heater level control valves will be monitored for vibration during EPU power ascension testing.
341-931226	FERMI 2	Failure of Reactor Recirc Pump "B" discharge valve to close.	Vibration. Recirculation pump operating speed created a vibration harmonic coincident with the discharge valve yoke and control wire bundle natural	Recirculation pump speeds will not increase beyond the currently evaluated speed as a result of EPU.

Table 1 – Applicability of Industry FIV Events to VYNPS

INPO EVENT #	PLANT	EVENT	CAUSE	VYNPS APPLICABILITY
			frequency. This resulted in a fatigue failure of some valve limit switch wires.	
265-020402	QUAD CITIES 2	MS piping low point drain line failed due to vibration related to EPU	Vibration. Increased steam flow and change in turbine control valve position resulted in higher FIV. The drain line had been modified three weeks prior (during an outage) by removing supports. The plant EPU monitoring program did not include this drain line.	The VYNPS MS piping low point drain lines have been modified during RFO25 as recommended by the OEM to provide an enhanced fatigue resistant weld joint configuration at the socket weld connection between the main run pipe and the branch connection (Reference 21). The attachment weld for this line was increased to ½" and 2:1 taper during RFO25 to increase fatigue resistance for EPU conditions by the Reference 21 Design Change.
INPO Event Number Not Yet Assigned	QUAD CITIES 2	SRV as-found pressure setpoint exceeded Tech Spec allowed value and ASME Code requirements.	Vibration. FIV caused bellows cap material grooving. This resulted in spring interference requiring additional force to actuate the SRV.	VYNPS has 3-stage Target Rock SRVs. These have been identified as potentially susceptible to FIV. Piping in the vicinity of the SRVs will be monitored for FIV during power ascension testing using pipe-mounted accelerometers and defined piping acceptance criteria.
388-940621	SUSQUEHANNA 2	Recirc Pump vibration following stretch uprate implementation (GE SIL 600)	Vibration. Increase in recirculation pump flow for a stretch uprate resulted in increased noise and vibration as identified in GE SIL 600.	VYNPS is currently licensed for ICF up to 107% of rated core flow. Recirculation pump speeds will not increase beyond the currently evaluated speed as a result of EPU.
265-020329	QUAD CITIES 2	Turbine Control Valve EHC accumulator leaks caused unplanned shutdown	Vibration. Leaks in the turbine control valve EHC accumulator were caused by fatigue failure resulting from high frequency FIV of the accumulator assemblies. The design was	VYNPS does not have EHC accumulators that could experience FIV and fatigue. The VYNPS turbine control system is a mechanical hydraulic control (MHC) design.

Table 1 – Applicability of Industry FIV Events to VYNPS

INPO EVENT #	PLANT	EVENT	CAUSE	VYNPS APPLICABILITY
			inadequate for handling the higher vibration experienced at EPU operating conditions.	
INPO Event Number Not Yet Assigned	QUAD CITIES 1 & 2	Dresser Electromatic Relief Valve Actuator Failure	Vibration (root cause evaluation pending). Wear on actuator components resulting from vibration caused by acoustic resonance of piping at EPU conditions.	VY does not have any of these valves installed at the plant. The actuators on the VY Target Rock SRVs are remotely mounted such that they are isolated from FIV forces.

References

1. GE Feasibility Study, Section 3.7
2. GE Project Task T0318 Report, "Piping Flow Induced Vibration," Rev. 0
3. ASME OM-S/G-2000 Code, "Standards and Guides for Operation and Maintenance of Nuclear Power Plants," Part 3, "Requirements for Pre-Operational Testing of Nuclear Power Plant Piping"
4. EPRI Report TR-104534-V1, V2, V3, "Fatigue Management Handbook," dated December, 1994
5. OE14373, Quad Cities Unit 2, April 2, 2002, "Fatigue Failure of a Main Steam Line Low Point Drain Line During Power Uprate Conditions"
6. Technical Evaluation No. 2004-049, "Mechanical/Structural Engineering Evaluation Identification of AOV Rigid Tubing to be Replaced with Flexible Hose"
7. VYC-2346, CCN 01, "MS & FW Piping Accelerometer Locations for EPU Flow Induced Vibration Monitoring"
8. TMOD 2003-022, "Vibration Monitoring Equipment Installation on MS & FW Piping for EPU"
9. VYC-2422 Revision 0, "Flow Induced Vibration of Sample Probes"
10. STP 2003-0004, "Power Ascension Test Procedure"
11. VYC-2459 Revision 0, "Main Steam and Feedwater System Vibration Data Reduction" (SIA Calculation No. VY-13Q-301 Revision 1)
12. VYC-2330 Revision 0, "Piping Vibration Acceptance Criteria for EPU"
13. ANSI B31.1 Power Piping-1977
14. ASME Boiler and Pressure Code 1986 Edition
15. VYC-2390 Revision 0, "Evaluation of Feedwater Piping to Support Flow Induced Vibration Program"
16. VYC-2378 Revision 0, "Evaluation of Main Steam Piping to Support Flow Induced Vibration Program"
17. Work Order Support Evaluation (WOSE) 2004-033, "Valve Flexible Air Supply Connection for EPU Increased Flow Vibration"
18. VYC-2409 Revision 0, "Main Steam Line Piping Vibration Acceptance Criteria (SIA Calc No. VY-13Q-304)"
19. VYC-2410 Revision 0, "Feedwater Line Piping Vibration Acceptance Criteria (SIA Calc No. VY-13Q-303)"
20. Engineering Request Response (Nuclear Change) ER 05-0731, "Replacement of FW Isokinetic Sample Probes"
21. Engineering Request Response (Nuclear Change) ER 04-1267, "Reinforced Weld Detail for MSL Low Point Drain Connection"