

February 12, 1999

Mr. Gregory A. Maret  
Director of Operations  
Vermont Yankee Nuclear Power Corporation  
185 Old Ferry Road  
Brattleboro, VT 05301

SUBJECT: REQUEST FOR ALTERNATIVE TESTING REGARDING THE INSERVICE TESTING (IST) PROGRAM AT VERMONT YANKEE NUCLEAR POWER STATION (TAC NO. MA4273)

Dear Mr. Maret:

By letter dated November 20, 1998, you requested NRC authorization to perform alternative testing to that specified by the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, and ASME/ANSI, "Code for Operation and Maintenance of Nuclear Power Plants." The testing involves vibration testing of the high pressure coolant injection and reactor core isolation cooling pumps. By letter dated January 14, 1999, we authorized your request.

Your letter dated February 5, 1999, identified several corrections and clarifications of an editorial nature in our safety evaluation (SE) dated January 14, 1999, on this subject. We have reviewed the corrections and clarification you identified. We agree that the SE needs revision, and replacement pages for the January 14, 1999, SE are enclosed. The corrections and clarifications do not change the conclusions reached in the SE and letter dated January 14, 1999. Please replace pages 2, 4, 6, 9, 10, and 11 of the SE with the enclosed pages.

Sincerely,  
original signed by:  
William M. Dean, Director  
Project Directorate I-2  
Division of Reactor Projects - I/II  
Office of Nuclear Reactor Regulation

Docket No. 50-271  
Enclosure: Safety Evaluation replacement pages  
cc w/encl: See next page

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UNITED STATES  
NUCLEAR REGULATORY COMMISSION

WASHINGTON, D.C. 20555-0001  
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Sincerely,

A handwritten signature in cursive script, appearing to read "William M. Dean".

William M. Dean, Director  
Project Directorate I-2  
Division of Reactor Projects - I/II  
Office of Nuclear Reactor Regulation

Docket No. 50-271

Enclosure: Safety Evaluation replacement pages

cc w/encl: See next page

G. Maret

cc:

Regional Administrator, Region I  
U. S. Nuclear Regulatory Commission  
475 Allendale Road  
King of Prussia, PA 19406

Mr. David R. Lewis  
Shaw, Pittman, Potts & Trowbridge  
2300 N Street, N.W.  
Washington, DC 20037-1128

Mr. Richard P. Sedano, Commissioner  
Vermont Department of Public Service  
120 State Street, 3rd Floor  
Montpelier, VT 05602

Public Service Board  
State of Vermont  
120 State Street  
Montpelier, VT 05602

Chairman, Board of Selectmen  
Town of Vernon  
P.O. Box 116  
Vernon, VT 05354-0116

Mr. Richard E. McCullough  
Operating Experience Coordinator  
Vermont Yankee Nuclear Power Station  
P.O. Box 157  
Governor Hunt Road  
Vernon, VT 05354

G. Dana Bisbee, Esq.  
Deputy Attorney General  
33 Capitol Street  
Concord, NH 03301-6937

Chief, Safety Unit  
Office of the Attorney General  
One Ashburton Place, 19th Floor  
Boston, MA 02108

Ms. Deborah B. Katz  
Box 83  
Shelburne Falls, MA 01370

Vermont Yankee Nuclear Power Station

Mr. Raymond N. McCandless  
Vermont Division of Occupational  
and Radiological Health  
Administration Building  
Montpelier, VT 05602

Mr. Gautam Sen  
Licensing Manager  
Vermont Yankee Nuclear Power  
Corporation  
185 Old Ferry Road  
Brattleboro, VT 05301

Resident Inspector  
Vermont Yankee Nuclear Power Station  
U. S. Nuclear Regulatory Commission  
P.O. Box 176  
Vernon, VT 05354

Mr. Peter LaPorte, Director  
ATTN: James Muckerheide  
Massachusetts Emergency Management  
Agency  
400 Worcester Rd.  
P.O. Box 1496  
Framingham, MA 01701-0317

Jonathan M. Block, Esq.  
Main Street  
P. O. Box 566  
Putney, VT 05346-0566

Mr. Michael J. Daley  
Trustee and Legislative Representative  
New England Coalition on Nuclear  
Pollution, Inc.  
Box 545  
Brattleboro, VT 05301

Power Plants." Specifically, each requests the use of an "alert range" that is less restrictive than that prescribed by OM-6 (at specified vibration data points) but commits to the use of full spectrum vibration analysis in lieu of the broad band vibration monitoring allowed by the Code.

The Vermont Yankee Nuclear Power Station IST program for the third 10-year interval began on September 1, 1993, and is scheduled to expire on August 31, 2003. The Vermont Yankee Nuclear Power Station IST program was developed to the 1989 Edition of Section XI, Division 1, of the ASME Boiler and Pressure Vessel Code. The 1989 Edition of the Code specifies that the rules for the inservice testing of pumps and valves are stated in the ASME/ANSI Operations and Maintenance (OM) Standards, Part 6, "Inservice Testing of Pumps in Light-Water Reactor Power Plants," Part 10, "Inservice Testing of Valves in Light-Water Reactor Power Plants," and OMa-1988 Addenda to the OM-1987 Edition. [Reference VY third 10-year IST program submittal dated November 30, 1992, and NRC SE dated September 3, 1993.]

### 3.0 HIGH PRESSURE COOLANT INJECTION PUMP RELIEF REQUEST RR-P04, REVISION 1

RR-P04 pertains to the Safety Class 2 High Pressure Coolant Injection (HPCI) main (high pressure) pump at Vermont Yankee Nuclear Power Station (P44-1A). The main pump has the safety function to operate in series with the booster pump (P44-1B) to provide: 1) adequate core cooling and reactor vessel depressurization following a small break loss of coolant accident, and 2) reactor pressure control during reactor shutdown and isolation.

The licensee requests relief from Section 5.2(d) of OM-6 for the HPCI pump. This section of the ASME Code requires that "Pressure, flow rate, and vibration (displacement or velocity) shall be determined and compared with corresponding reference values. All deviations from the reference values shall be compared with the limits given in Table 3 and corrective action taken as specified in para. 6.1."

Specifically, the licensee requests relief from the vibration velocity ( $V_v$ ) acceptance criteria specified in Table 3 at the Main Pump Turbine Side Horizontal and Vertical Vibration Points I-3, O-3 and Main Pump Gearbox Side Horizontal Vibration Point I-4. The remaining HP and Booster pump vibration points will be evaluated using OM-6 acceptance criteria. Relief request RR-P04 was previously approved by NRC in a safety evaluation dated September 3, 1993, in a format that could be interpreted to apply to all HP pump vibration points. The licensee now proposes to perform vibration spectrum monitoring quarterly, to delete the spectral resonance alarm criteria of 1.05 and 1.3 times the overall peak reference value (committed to in Rev. 0 of RR-P04), and lower the overall peak value acceptable range limit from 0.675 in/sec (approved in Rev. 0 of RR-P04) to 0.575 in/sec.

#### 3.1 Licensee's Basis for Request

The licensee provided the following basis for the relief request:

Relief is requested on the basis that the proposed alternatives would provide an acceptable level of quality and safety.

### 3.2 Proposed Alternate Testing

The licensee proposed the following:

To allow for practicable vibration monitoring of the HPCI HP pump, alternate vibration acceptance criteria are required specifically for vibration points I-3, O-3 and I-4. Full spectrum analysis will be performed during each quarterly test and the following criteria will be used:

Test Parameter	Acceptable Range	Alert Range	Required Action Range
$V_v$	$\leq 2.5 V_r$ but not $> 0.575$ in/sec	$> 2.5 V_r$ , to and including $6 V_r$ but not $> 0.70$ in/sec	$> 6 V_r$ or $> 0.70$ in/sec

The remaining HPCI HP and Booster pump vibration points are evaluated using OM-6 acceptance criteria.

### 3.3 Evaluation

Section 4.6.4 of OM-6 requires that "On centrifugal pumps, measurements shall be taken in a plane approximately perpendicular to the rotating shaft in two orthogonal directions on each accessible pump bearing housing. Measurement also shall be taken in the axial direction on each accessible pump thrust bearing housing." The licensee proposes to use the acceptance criteria specified in the table below for the Main Pump Turbine Side Horizontal and Vertical Vibration Points I-3, O-3 and Main Pump Gearbox Side Horizontal Vibration Point I-4. The remaining HPCI HP and Booster pump vibration points will be evaluated using OM-6 acceptance criteria.

components. The spectrum analysis allows a more comprehensive evaluation of pump condition than the Code required wide range vibration measurements. Therefore, the proposal provides an acceptable level of quality and safety.

Deletion of the commitment to have an additional Alert Range of 1.05 V, to 1.3 V, and an additional Required Action Range of > 1.3 V, for the resonance peaks will not decrease the effectiveness of the licensee's pump vibration monitoring program in terms of its ability to detect pump degradation. This additional commitment could cause an unnecessary burden on the licensee particularly when "resonance peaks" are interpreted to be the largest peak on the spectrum even though resonance only occurs when a natural frequency and forced frequency coincide.

### 3.4 Conclusion

The licensee's proposed alternative to the Code requirement, described in Revision 1 to pump relief request RR-P04, is authorized pursuant to 50.55a(a)(3)(i) based on the determination that the proposed alternative provides an acceptable level of quality and safety.

### 4.0 REACTOR CORE ISOLATION COOLING PUMP RELIEF REQUEST RR-P10, REVISION 2

RR-P10, Revision 2 pertains to the Safety Class 2 Reactor Core Isolation Cooling (RCIC) pump at Vermont Yankee Nuclear Power Station (P47-1A). The RCIC pump is powered by a steam driven turbine and has a safety function to operate to provide makeup water to the reactor vessel during shutdown and isolation in order to prevent the release of radioactive materials to the environment as a result of inadequate core cooling. The system is designed to receive steam from the reactor vessel and function without AC power from normal supplies or the emergency diesel generators. The pump is a horizontal, multistage, centrifugal, double volute pump having five stages with four vanes on the first stage impeller and five vanes on the remaining four impellers, designed to provide a constant flow of 416 gpm at rated speed. The bearings are antifriction, rolling element type. The RCIC system at VY is designed and qualified for at least 12 hours of continuous or intermittent operation in support of core cooling following transient or accident events. Other plants using this pump design are Quad Cities, Monticello, and Pilgrim.

The licensee requests relief from Section 5.2(d) of OM-6 for the RCIC pump. This section of the ASME Code requires that "Pressure, flow rate, and vibration (displacement or velocity) shall be determined and compared with corresponding reference values. All deviations from the reference values shall be compared with the limits given in Table 3 and corrective action taken as specified in para. 6.1."

Specifically, the licensee requests relief from the Vibration Velocity ( $V_v$ ) acceptance criteria specified in Table 3 for the Pump Outboard Bearing, Vertical Vibration Point O-4. The remaining RCIC pump vibration points (i.e., the pump inboard bearing horizontal/vertical and the outboard bearing horizontal/axial points) will be evaluated using OM-6 acceptance criteria.

Although existing vibration levels in the RCIC pump outboard bearing vertical direction are at the high end of standard acceptance criteria, they are acceptable and reflect the unique operating characteristics of the VY RCIC pump. It has been concluded that there are no vibration concerns of a magnitude that would indicate pump degradation or prevent the pump from performing its intended function.

#### 4.2 Proposed Alternate Testing

The licensee proposed the following:

To allow for practicable vibration monitoring of the RCIC pump, alternate vibration acceptance criteria are required. Full spectrum vibration monitoring will be performed during each quarterly test and the following criteria will be used for RCIC pump vibration point O-4:

Test Parameter	Acceptable Range	Alert Range	Required Action Range
$V_v$	$\leq 2.5 V_r$ , but not $> 0.575$ in/sec	$> 2.5 V_r$ , to and including $6 V_r$ , but not $> 0.70$ in/sec.	$> 6 V_r$ , or $> 0.70$ in/sec

#### 4.3 Evaluation

The licensee stated that use of the vibration acceptance criteria contained in OM-6 has caused, and continues to cause, frequent entry into the Alert Range, requiring increased frequency testing for vibration point O-4.

Section 4.6.4 of OM-6 requires that "On centrifugal pumps, measurements shall be taken in a plane approximately perpendicular to the rotating shaft in two orthogonal directions on each accessible pump bearing housing. Measurement also shall be taken in the axial direction on each accessible pump thrust bearing housing." Table 3a of OM-6 requires those pumps with vibration levels between 0.325 in/sec and 0.700 in/sec be classified in the "alert" range and that the testing frequency be doubled (from quarterly to every 6 weeks) until the cause of the vibration is determined and the condition corrected.

While not implemented by the licensee, the staff approved interim use of relaxed alert range (0.50 in/sec to 0.70 in/sec) in a safety evaluation to the licensee dated May 26, 1995. In that safety evaluation the staff stated that "During the interim period, the licensee should investigate methods to reduce current pump vibration levels; confirm that an analysis has been performed which demonstrates the pump is capable of continued operation at higher vibration levels (including contact with the pump manufacturer); and evaluate data on how the revised alert limit was derived. ...If the licensee has implemented a program for spectral analysis of the vibration signature of the pump, it would be beneficial to include such information in the alternative

testing section of the revised relief request." As discussed below, the licensee's revised relief request RR-P10, Rev. 2 is responsive to the concerns raised by the staff in the May 26, 1995, safety evaluation.

The licensee now proposes to use the acceptance criteria specified in the table below for the Pump Outboard Bearing, Vertical Vibration Point O-4 (vibration levels between 0.575 in/sec and 0.700 in/sec will be classified in the "alert" range for this one vibration data point). The remaining RCIC pump vibration points (i.e., the pump inboard bearing horizontal/vertical and the outboard bearing horizontal/axial points) will be evaluated using OM-6 acceptance criteria.

Test Parameter	Acceptable Range	Alert Range	Required Action Range
OM-6, $V_v$ ( $\geq 600$ rpm)	$\leq 2.5 V_r$	$> 2.5 V_r$ to $6 V_r$ , or $> 0.325$ in/sec	$> 6 V_r$ or $> 0.70$ in/sec
RR-P10, Rev. 2 Proposed $V_v$	$\leq 2.5 V_r$ but not $> 0.575$ in/sec	$> 2.5 V_r$ to and including $6 V_r$ , but not $> 0.70$ in/sec	$> 6 V_r$ or $> 0.70$ in/sec

The licensee states that "Past testing and analysis performed on the RCIC System by VY and independent vibration consultants in 1988 and 1997 confirms characteristic pump vibration levels in the outboard bearing vertical direction, at the high end of the acceptance range criteria stated in Table 3 of Part 6 of the Code. This testing and analysis meets the intent of Paragraph 4.3 and footnote 1 of Part 6 of the Code." Footnote 1 to Paragraph 4.3, "Reference Values" states:

Vibration measurements of pumps may be foundation, driver, and piping dependent. Therefore, if initial vibration readings are high and have no obvious relationship to the pump, then vibration measurements should be taken at the driver, at the foundation, and on the piping and analyzed to ensure that the reference vibration measurements are representative of the pump and that the measured vibration levels will not prevent the pump from fulfilling its function.

The licensee has performed extensive analysis of this pump installation and determined that the root cause of the high vibration levels are due to:

- a) Excitement in the outboard bearing support in the vertical direction at or near the fourth and fifth orders (vane pass frequency),
- b) The presence of a natural frequency at 320 Hz. (19,200 cycles per minute) in the outboard bearing vertical direction.

An analysis performed by a vibration consultant in 1988 documented that the 4th order peak value of 0.511 in/sec at 4500 rpm dropped to 0.177 in/sec when speed was decreased to



4342 rpm. The recommendation at that time was to reduce the speed for surveillance testing. A second analysis performed by the same vibration consultant in 1997 documented the relationship of the natural frequency to the 4th and 5th order vane pass frequency using improved vibration technology. The excitement in the bearing support was also documented. The vibration consultant's recommendation was again to reduce the speed for surveillance testing if possible. If a speed reduction was not possible then changing the number of 1st stage impeller vanes and modifications to the outboard bearing support was recommended. With only one vertical direction vibration point exceeding the OM-6 vibration criteria the licensee determined that to pursue 1st stage impeller replacement or to perform the analysis to qualify a bearing support modification would result in a hardship without a compensating increase in quality and safety of the plant.

Spectrum analysis of the latest surveillance test data shows that the primary source of the vibration continues to coincide with vane pass frequency of the pump. Vane pass frequency is inherent in all pumps and normally does not present a problem unless it happens to excite resonant frequencies. The vane pass frequencies do not coincide exactly with the natural frequency; therefore, full resonance (and hence potentially damaging) condition does not exist in this instance. The identified vane pass frequencies are on the periphery of resonance excitement, thereby causing higher than expected vibration in the outboard vertical direction. This condition on the outboard bearing, in one direction, is not of a magnitude that would prevent the RCIC pump from performing its intended safety function. This condition is design related and has existed since initial pump installation. Surveillance test documentation collected over a number of years demonstrates that no appreciable degradation has taken place.

The licensee stated that the pump vendor has certified, in a September 14, 1998, memorandum, that the pump could be run at 0.575 in/sec and would not be expected to exhibit reduced reliability given the intermittent and short duration (< 24 hours) operation in support of core cooling following transient or accident events. The licensee contacted BWR licensees with similar RCIC pumps and identified that vibration levels of  $\leq 0.2$  in/sec are routinely experienced; however, they noted that these other licensee's pump pedestals are approximately 1'-3" high while the VY RCIC pump pedestal is 3'-0" in height. Therefore, the licensee states that a direct comparison between plants cannot be made since the foundation is dissimilar and natural frequencies are unique for each component and combination of components.

The licensee's proposal to perform pump vibration spectrum analysis quarterly with a higher vibration acceptance criteria (as certified to be acceptable by the RCIC pump vendor) should result in corrective action being taken on a pump with significant degradation. A spectrum analysis measures a narrow vibration band width over a wide frequency range and indicates the frequency and magnitude of vibration peaks, which permits identification of specific problems with bearings and other pump mechanical components. The spectrum analysis allows a more comprehensive evaluation of pump condition than the Code required wide range vibration measurements. Therefore, the proposal provides an acceptable level of quality and safety.