August 29, 2005

Mr. Michael R. Kansler, President
Entergy Nuclear Operations, Inc.
440 Hamilton Avenue
White Plains, NY 10601

SUBJECT: PILGRIM NUCLEAR POWER STATION - ENTERGY RELIEF REQUEST PR-03 HIGH-PRESSURE COOLANT INJECTION PUMP (TAC NO. MB8773)

Dear Mr. Kansler:

By letter dated February 24, 2005, as supplemented on May 24, 2005, Entergy Nuclear Operations, Inc. (Entergy), the licensee for Pilgrim Nuclear Power Station (PNPS), submitted a revision to the relief request dated December 6, 2002, as supplemented February 10, and June 2, 2004, for the high-pressure coolant injection pump (HPCI) comprehensive test for the PNPS. Entergy requested relief from certain requirements of the American Society of Mechanical Engineers (ASME) Code for Operation and Maintenance of Nuclear Power Plants (OM Code), specifically to the ASME OM Code1996 Edition, paragraph ISTB 5.2.3.

The Nuclear Regulatory Commission (NRC) staff has reviewed the proposed alternatives. The results of this review are provided in the enclosed Safety Evaluation. The NRC staff concludes that the proposed alternative, as specified in your relief request PR-03, is authorized pursuant to Title 10 of the *Code of Federal Regulations* Section 50.55a(a)(3)(i) for an interim period not to exceed two refueling cycles or three years on the basis that it provides an acceptable level of quality and safety. All other ASME OM Code requirements for which relief was not specifically requested and approved remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions regarding this approval, please contact the PNPS NRC Project Manager, James Shea, at 301-415-1388.

Sincerely,

/RA/

Darrell J. Roberts, Chief, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Reactor Regulation

Docket No. 50-293

Enclosure: As stated

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST PR-03 HIGH-PRESSURE COOLANT INJECTION PUMP

ENTERGY NUCLEAR OPERATIONS, INC

PILGRIM NUCLEAR POWER STATION

DOCKET NO. 50-293

1.0 INTRODUCTION

By letter dated February 24, 2005, as supplemented on May 24, 2005, Entergy Nuclear Operations, Inc. (Entergy or the licensee), the licensee for Pilgrim Nuclear Power Station (PNPS), submitted a revision to the relief request (RR) dated December 6, 2002, as supplemented February 10, and June 2, 2004, for its fourth 10-year interval inservice testing (IST) program, for PNPS. Entergy requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Code for Operation and Maintenance of Nuclear Power Plants (OM Code), specifically to the ASME OM Code, 1996 Edition, paragraph ISTB 5.2.3 for the high-pressure coolant injection pump (HPCI) comprehensive test.

The proposed RR PR-03 requested an expansion of the required acceptable pump vibration range and pump vibration alert range for the PNPS HPCI pump P-205.

2.0 REGULATORY EVALUATION

The *Code of Federal Regulations* (10 CFR) Section 50.55a, requires that IST of certain ASME Code Class 1, 2, and 3 pumps and valves be performed in accordance with the ASME OM Code and applicable addenda, except where alternatives have been authorized or relief has been requested by the licensee and granted by the Nuclear Regulatory Commission (NRC or the Commission) pursuant to Sections (a)(3)(i), (a)(3)(ii),or (f)(6)(i) of 10 CFR 50.55a.

In accordance with 10 CFR 50.55a(f)(4)(ii), licensees are required to comply with the requirements of the latest edition and addenda of the ASME Code incorporated by reference in the regulations 12 months prior to the start of subsequent 120-month IST program intervals. In proposing alternatives or requesting relief, the licensee must demonstrate that: (1) the proposed alternatives provide an acceptable level of quality and safety; (2) compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety; or (3) conformance is impractical for the facility. Section 50.55a of 10 CFR authorizes the Commission to approve alternatives and to grant relief from ASME Code requirements upon making necessary findings. NRC guidance contained in Generic Letter

(GL) 89-04, "Guidance on Developing Acceptable Inservice Testing Programs," provides alternatives to ASME Code requirements which are acceptable. Further guidance is given in GL 89-04, Supplement 1, and NUREG-1482, "Guidance for Inservice Testing at Nuclear Power Plants."

The PNPS fourth 10-year IST interval is from December 7, 2002, through December 7, 2012. The licensee's IST program for PNPS was developed in accordance with the 1995 Edition including 1996 Addenda of the ASME OM Code. Subsection ISTB provides the requirements for IST of pumps and Subsection ISTC provides the requirements for IST of valves.

3.0 TECHNICAL EVALUATION

3.1 Code Requirements for which Relief is Requested

ASME OM Code, paragraph ISTB 5.2.3(d) requires that vibration (displacement or velocity) shall be determined and compared with corresponding reference values. Vibration measurements are to be broad-band (unfiltered). If velocity measurements are used, they shall be peak. If displacement amplitudes are used, they shall be peak-to-peak.

ISTB 5.2.3(e) requires that all deviations from the reference values shall be compared with the range of Tables ISTB 5.2.1-1 and ISTB 5.2.3-1 and corrective action taken as specified in paragraph ISTB 6.2. The vibration measurements shall be compared to the relative and absolute criteria shown in the Alert and Required Action Range of Table ISTB 5.2.1-1. For example, if vibration exceeds either 6 V_r, or 0.7 inch/second, the pump is in the Required Action Range.

3.2 Entergy ASME Code RR

Entergy requested relief from the ASME Code requirements of paragraphs ISTB 5.2.3 (d) and ISTB 5.2.3(e) for the PNPS HPCI main pump/booster pump P-205.

Specifically, Entergy proposes to expand the acceptable pump vibration range and pump vibration alert range identified in Table ISTB 5.2.1 during comprehensive pump testing. In addition, the resonance peaks will be evaluated and filtered during each test.

3.3 PNPS Component for which Relief is Requested

The PNPS component affected by this RR is the HPCI pump designated as P-205. This pump is classified as an ASME Code Class 2, Group B pump. The HPCI pump contains a main pump and a booster pump. The HPCI pump is driven by a turbine.

The HPCI main pump P-205 has the safety function to operate in series with the booster pump 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.

3.4 Basis for Relief

Entergy's relief from the referenced ASME Code requirements is based on the following:

> Historical testing and analysis performed on the HPCI System by PNPS (and the pump manufacturer) have consistently revealed characteristic pump vibration levels that exceed the acceptance criteria stated in [ASME OM Code] Table ISTB 5.2.1-1. High vibration appears on the Main Pump bearing housings at approximately 2x RPM [revolutions per minute] in the horizontal direction, which is caused by Booster Pump excitation (at 4x RPM of the booster pump). Under normal circumstances at 4000 RPM, the vibration amplitude at the Main Pump bearings in the horizontal direction exceeds the [ASME] OM Code absolute vibration Required Action Range of > 0.7 in./sec. Also, under the same [operating] conditions, all of the remaining HPCI Main and Booster Pump vibration monitoring points, except for one, typically exceed the [ASME] OM Code absolute acceptable range upper value of 0.325 in/sec.
>
> The vibration characteristics of the HPCI pump are predominantly a function of the pump design and can be identified as such rather than attributed to pump degradation. The high vibration has been present in the same order of magnitude since the pump was new. Although existing vibration levels of the HPCI pump are higher than the acceptance criteria provided in Table ISTB 5.2.1-1, they reflect the unique operating characteristics of the HPCI pump design configuration. There are no vibration concerns that would result in pump degradation or would prevent the HPCI pump from performing its design safety function for an extended period of operation.
>
> The purpose of the [AMSE] Code-required [vibration] testing is to demonstrate operational readiness of the HPCI pump by monitoring pump vibration for degradation and taking corrective actions when vibration levels exceed the [AMSE] Code-specified values. The [AMSE] Code states in the last paragraph of ISTB 4.3(g) Footnote 1, "the reference vibration measurements should be representative of the pump and that the measured vibration will not prevent the pump from fulfilling its function." Accordingly, Pilgrim is proposing an alternative testing to demonstrate the operational readiness by taking into consideration the vibration measurements representative of the as-built configuration of the HPCI pump.

3.4.1 Proposed Alternative Testing

The licensee's proposed alternative testing is as follows:

> A. The alternative testing proposes to remove the 4x Booster Pump RPM frequency component (discrete peak) from the vibration spectrum of the Main Pump since its amplitude is not related to the physical condition or rotating dynamics of the Main Pump rotor or bearing system. The Main Pump vibration spectrum, with this single 4x Booster Pump RPM frequency component removed, has been shown to be stable and more useful for monitoring actual pump condition. When the vibration frequency component at 4x Booster Pump RPM is subtracted from

the Main Pump vibration spectrum, the remaining vibration, which is attributed to the Main Pump, is below the [ASME] OM Code-Required Action Range. This corrected vibration level provides a more representative measurement of the pump condition to be used for trending.

B. All other discrete vibration peaks observed at the main pump horizontal vibration points will be evaluated during each Comprehensive test, and will have an Acceptable Range upper limit of 1.05 V_r and an Alert Range upper limit of 1.3 V_r. These reviews of the frequency spectrum data ensure that any significant change in the vibration signature will be noted regardless of whether the severity causes the overall level to exceed its criteria. For example, if the overall vibration level is acceptable, but the 1x RPM component has increased to greater than 1.3 times the reference value overall level (V_r), then the pump will be placed in the vibration Required Action Range (> 0.7in/sec).

Pilgrim will increase the ASME OMa-1996, ISTB 5.2.3 required frequency for vibration monitoring (that is part of the comprehensive testing) from once/2 years to once/year. The [ASME] Code-required comprehensive test for flow rates [hydraulic degradation] would continue to be once/2 years. Given that the vibration will normally be within the Alert Range (> 0.325 in./sec), the once/year frequency will typically be doubled to twice/year. The normal practice will be to monitor vibration in the same manner during each of the Quarterly Group B Hydraulic Tests. Thus, vibration monitoring will be performed up to 8 times in 2 years as part of the Group B Hydraulic Tests, instead of once/2 years as part of the comprehensive test.

C. Pilgrim will continue current HPCI pump and turbine [condition] monitoring and maintenance activities, with changes as conditions warrant, as follows:

- Quarterly pump and valve operability tests will be performed to ensure the HPCI pump and turbine function for their intended safety function[s].

- Quarterly lubrication oil sampling and laboratory analysis for the pressure-fed bearings on the Turbine, Main Pump, and Gear Reducer and once/cycle (2 years) for the non-pressure fed Booster Pump will be performed. Lubrication oil analysis currently performed includes [determination of] viscosity, acidity, residue, water content, metals by A.E. spectrometry, and ferrogram readings. This type of monitoring will detect degradation of the turbine or pump bearings due to accelerated wear, fretting, surface fatigue, or oil contamination.

- HPCI pump and turbine lube oil system is serviced as-needed weekly. HPCI gland seal condenser hot well pump and motor bearings and HPCI auxiliary lube oil pump and motor bearings will be serviced semiannually for lubrication.

- HPCI Turbine/Main Pump, Main Pump/Reducer, and Reducer/Booster Pump gear-type shaft couplings will be cleaned, examined, and grease-lubricated every 2 years. These examinations will detect excessive wear, fretting, heating, or fatigue due to any unusual loading conditions.

The past third IST interval [testing program] and all previous monitoring and maintenance activities have shown no evidence or observations of degradation in the HPCI Turbine, Main Pump, Gear Reducer, or Booster Pump. Thus, the continuation of the above periodic monitoring and maintenance activities will ensure that the HPCI pump remains in a high level of operational readiness and that any degradation of HPCI pump mechanical condition, reliability, or performance will be detected and corrected in a timely manner.

3.4.2 Technical Justification for Alternative

Entergy provides the following technical justification for their proposed alternative:

PNPS has conducted an evaluation of the HPCI pump vibration characteristics. An important conclusion of the PNPS evaluation is that the mechanical condition of the Main Pump can be monitored satisfactorily by disregarding the single frequency component caused by the excitation at 4x Booster Pump RPM. The four-vane impeller of the Booster Pump generates the excitation force hydraulically. This small pressure pulsation force exists at the vane passing frequency (number of vanes times RPM) for all centrifugal pumps and is usually seen as a significant but not particularly troublesome component on the frequency spectrum for vibration measurements taken at the bearing housings. For the HPCI pump, this vane passing frequency is a problem because it coincides with a hydraulic standing wave resonance in the cross-over piping from the Booster Pump to the Main Pump when the machine is operating at the rated speed of 4000 RPM. There is an acoustic pressure standing wave pattern, at the 4x RPM frequency, whose wavelength in water is equal to an even fraction (¼ or ½) of the dimensional length inside the cross-over pipe. This is the same principle on which an organ pipe generates a pure tone pneumatic pressure standing wave.

The Main Pump pedestal has a horizontal structural rocking mode of the pump pedestal at the same frequency when the Main Pump is operating at the rated speed of 4000 RPM. The vibration mode is the second fundamental rocking mode, which is a torsional or twisting mode where the two end bearings move 180 degrees out of phase horizontally. The result of these coincident acoustic and structural resonances is that the Main Pump exhibits high vibration in the horizontal direction at the 4x Booster Pump RPM frequency. This is solely due to the excitation from the Booster Pump being amplified by the coincident resonances. This level of vibration at 4x Booster Pump RPM would be seen on the Main Pump bearing housings even if the Main Pump was not actually running (which is not possible as both pumps are on the same drive train).

The resonant vibration condition at the 4000 RPM operating speed is not detrimental and will not prevent the HPCI Pump from fulfilling its function. At the 134 Hz frequency of the resonant vibration on the Main Pump, caused by the excitation at 4x Booster Pump RPM, the actual displacement amplitude at 0.7 in./sec. peak velocity amplitude is 0.0017 inches peak-to-peak. This displacement imposes negligible alternating stresses on the pump pedestal, housings, and connected piping. The peak-to-peak displacement is also less than the Main Pump fluid film journal bearing clearances and would impose negligible loading to these bearings.

The purpose of the ASME OM Code for pump testing is to monitor pumps for degradation. The concept of vibration monitoring is to establish baseline values for vibration when the pump is known to be in good working condition, such as after a maintenance overhaul. From that reference point, trending is performed to monitor for degradation based on the ratio of subsequent vibration levels relative to the reference values. The [AMSE] OM Code also establishes absolute vibration level criteria for Alert (> 0.325 in/sec) and Required Action (> 0.7 in/sec). In doing so, it is recognized that absolute vibration level limits (as opposed to relative change or ratio limits) are not always quantitatively linked directly with pump physical condition and the following remarks are stated in the ASME OMa Code-1996 [ISTB 4.3(g) Footnote 1]:

> "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. "

An important conclusion of the PNPS HPCI vibration evaluation is that the mechanical condition of the Main Pump can be monitored satisfactorily by disregarding the single frequency component caused by the excitation at 4x Booster Pump RPM. A single peak frequency component can be effectively deleted from a vibration spectrum using the mean-squared subtraction method, that is, the discrete component amplitude (in/sec peak) is squared and subtracted from the spectrum overall level squared, then the square root of that difference represents the overall vibration level that exists without the energy contributed by the deleted component. It has been found that when this method is used, the remaining vibration overall level is much more consistent, stable, and trendable.

This method of vibration level correction was applied to historical spectrums. The 4x booster pump RPM component was taken out of the calculation for the main pump overall vibration level. This data shows that when the 4x booster pump RPM component is deleted from the main pump vibration, the level is below the Required Action Range

(> 0.7 in./sec.) but still within the Alert Range (> 0.325 in./sec). It was also shown that the potential effects from the dynamic alignment of pump shaft couplings (at 2x Main Pump RPM) can still be monitored effectively.

3.4.3 Impact of Potential Modifications

Entergy has provided the following impact of potential modifications:

> For the HPCI Main and Booster Pumps, it has been determined that the vibration is indeed foundation and piping dependent. To reduce the HPCI Main and Booster Pump vibration down to levels that meet acceptable [AMSE] OM Code vibration criteria requires modifications to the HPCI Pump, mounting components, foundation and/or cross-over (interconnecting) piping. As suggested in a Byron Jackson [the HPCI pump vendor] Tech Note [provided with the submittal], this vibration may be improved by modifying the interconnecting piping and the Main Pump mounting pedestal. The alternative modification changes the Booster Pump impeller from four to five vanes to alter the forcing function of the standing wave resonance.
>
> The proposed Byron Jackson modifications, other than replacing the Booster Pump impeller, are generally very difficult to implement successfully. Altering the natural frequency of a large pump installation requires either considerable additions of stiffening components or substantial additions of mass. Often the results of such design changes are unsuccessful or unfavorable due to the variable speed operation requirements.
>
> Modification of the HPCI Booster [pump] would require replacing the current four-vane impeller with an upgraded five-vane impeller. The impeller modification, although yielding predictable results, requires extensive work to the HPCI pump at a time when such a major rebuild of this pump is not otherwise necessary or desired. The expected result would be a modest decrease in the vibration caused on the Main Pump at 4000 RPM, although the vibration would remain above the 0.325 in./sec. Alert Range criteria. A small decrease in hydraulic performance is also expected when changing from a four to five vane impeller. The proposed major modification would cost approximately $500,000 without a compensating decrease in the pump vibration to bring it from the Action Required Range to the Acceptable Range. Accordingly, the proposed modification would not serve the underlying objective of the [ASME] Code required testing for monitoring degradation or in existing pump operational readiness.
>
> PNPS has also concluded that none of the possible modifications that could be performed on the HPCI pump, mounting pedestal, or cross-over piping are necessary. This is primarily due to the nature of the HPCI Pump service profile. The Byron Jackson Tech Note describes the following consideration in the Technical Discussion:
>
>> "Pumping systems in which the vane passing pressure pulsations form standing waves in the attached piping are not unusual, especially if the pumps have a variable speed driver. Standing waves are highly dependent upon water temperature. Thus, measured vibration amplitudes often vary from test to test."
>
> The HPCI Pump service is such that the pump runs for short periods of time at highly variable speeds. The pump inservice testing at PNPS is performed with the pump

operating at or close to its rated speed (4000 RPM) and flow conditions (4250 GPM) that are unique to PNPS. For this particular pump configuration, this pump speed corresponds to the point where the acoustic resonant vibration is typically most pronounced. In actual service for high pressure coolant injection to the reactor, the pump will operate at the speed that the flow controller requires to maintain reactor water level. The flow rate of 4250 GPM is the maximum makeup flow rate for which the HPCI system was intended to be capable of maintaining reactor water level. This flow rate is far in excess of the decay heat makeup water requirements for the reactor in the isolated condition in the absence of a major leak. The pump speed required is also dependent on reactor pressure with the required speed decreasing along with reactor pressure.

The same general HPCI pump configuration is used at other plants but often with different rated speeds and flows such that the vibration characteristics at the inservice testing point are markedly different for that reason. The vibration monitoring performed (including a frequency spectral review) to date under the IST program and the PNPS pump vibration monitoring program has shown that there has not been degradation of these HPCI Pump components.

Inservice Testing can be successfully performed for the PNPS HPCI Pump using the methods proposed in this relief request, along with monitoring and maintenance activities currently in practice. Any significant degradation of the HPCI Pump components will be readily identified using the vibration spectral analysis methods and monitoring activities described in the relief request. Therefore, Entergy beleives that the proposed alternative testing and monitoring for the PNPS HPCI pump will provide an acceptable level of quality and safety in accordance with 10 CFR 50.55a(a)(3)(i).

3.4.4 Alternative Testing Acceptance Criteria

Entergy has provided the following alternative testing acceptance criteria in support RR PR-03:

To allow for practicable monitoring of vibration levels on the HPCI pump, alternate vibration acceptance criteria are necessary. A full spectrum review will be performed for all IST vibration points during each proposed comprehensive test, utilizing the following criteria.

The table below provides the acceptance criteria that are applied to the overall vibration level for the Main Pump. The note explains that for the horizontal Main Pump points, the discrete frequency components at 4x Booster Pump RPM will be removed from the overall value using the mean-squared subtraction method.

MAIN PUMP*

Test Parameter	Vibration Point	Acceptable Range	Alert Range	Required Action Range
v	Main Pump * Horizontal Inboard & Outboard (P3H & P4H)	# 2.5 V_r but not > 0.325 in/sec	> 2.5 V_r to 6 V_r or > 0.325 to 0.70 in/sec	> 6 V_r or > 0.70 in/sec
v	Main Pump Vertical Inboard & Outboard (P3V & P4V) Axial Inboard (P3A)	# 2.5 V_r but not > 0.325 in/sec	> 2.5 V_r to 6 V_r or > 0.325 to 0.70 in/sec	> 6 V_r or > 0.70 in/sec
General Note: The subscript v denotes vibration velocity reference and subscript r denotes reference value.				

*Note: For the Main Pump horizontal vibration points P3H and P4H, a frequency spectrum analysis will be performed for each comprehensive pump test and the discrete peak at 4x booster pump RPM will be removed (using the mean-squared subtraction method) from the vibration [main pump] spectrum overall value. In addition, all other vibration spectrum discrete peaks will be evaluated during each test and will have an Acceptable Range upper limit of 1.05 V_r and an Alert Range upper limit of 1.3 V_r.

3.5 NRC Staff Evaluation

ASME OM Code, paragraph ISTB 5.2.3(d) states: “Vibration (displacement or velocity) shall be determined and compared with corresponding reference values. Vibration measurements are to be broad band (unfiltered). If velocity measurements are used, they shall be peak. If displacement amplitudes are used, they shall be peak-to-peak.”

Paragraph ISTB 5.2.3(e) states: “All deviation from the reference values shall be compared with the range of Tables ISTB 5.2.1-1 and ISTB 5.2.3-1 and corrective action taken as specified in paragraph ISTB 6.2. The vibration measurements shall be compared to the relative and absolute criteria shown in the Alert and Required Action Range of Table ISTB 5.2.1-1. For example, if vibration exceeds either 6 V_r or 0.7 in./sec., the pump is in the required action range.”

Paragraph ISTB-4.7.4 requires that on centrifugal pumps vibration measurements be taken in a plane approximately perpendicular to the rotating shaft in two orthogonal directions on each accessible pump bearing housing. The ASME Code further states that vibration measurements shall be taken in the axial direction on each accessible pump thrust bearing housing.

The licensee measured vibrations at the following points on the HPCI main pump:

P3H - HPCI Main Pump Turbine-End Horizontal (inboard)
P3V - HPCI Main Pump Turbine-End Vertical (inboard)
P3A - HPCI Main Pump Turbine-End Axial (inboard)
P4H - HPCI Main Pump Gear-End Horizontal (outboard)
P4V - HPCI Main Pump Gear-End Vertical (outboard)

The HPCI main pump vibration measurements provided by the licensee at points P3H and P4H are greater than the alert or required action range of Table ISTB 5.2.1-1 of the ASME OM Code as identified in the following table:

HPCI Main Pump Vibration Velocity Inch/Second			Remark	
Date	Location Point		Table ISTB 5.2.1-1	
	P3H	P4H	Alert Range (in/sec)	Required Action Range (in/sec)
29-Jul-1992	0.984	0.665	> 0.325 to 0.7	> 0.7
24-Nov-1992	0.712	0.577	> 0.325 to 0.7	> 0.7
30-May-1993	0.817	0.751	> 0.325 to 0.7	> 0.7
01-Jul-1993	1.050	0.762	> 0.325 to 0.7.	> 0.7
30-Sep-1993	0.889	0.667	> 0.325 to 0.7.	> 0.7
06-Jan-1994	0.782	0.439	> 0.325 to 0.7	> 0.7
09-Mar-1994	0.708	0.512	> 0.325 to 0.7	> 0.7
25-May-1994	0.848	0.681	> 0.325 to 0.7	> 0.7
20-Nov-1995	0.663	0.475	> 0.325 to 0.7	> 0.7
06-May-1996	0.820	0.600	> 0.325 to 0.7	> 0.7
17-Dec-1997	0.661	0.515	> 0.325 to 0.7	> 0.7
24-Aug-2004	0.933	0.642	> 0.325 to 0.7	> 0.7
24-Nov-2004	0.792	0.671	> 0.325 to 0.7.	> 0.7
Note: The licensee states that all the vibration velocity values at the other HPCI main pump points (P3V, P3A, and P4V) are below Action Range.				

The licensee states that under normal operating conditions (4000 RPM), the vibration amplitude at the main pump bearing in the horizontal direction exceeds the ASME OM Code absolute vibration required action range of > 0.7 in./sec. Also, under the same conditions, all the remaining HPCI main and booster pump vibration monitoring points typically exceed the ASME OM Code absolute acceptable range value of 0.325 inch/second.

The licensee states that historically the HPCI pump vibration level consistently exceeds the acceptance criteria of Table ISTB 5.2.1-1, and that PNPS has conducted an evaluation of the HPCI pump vibration data and characteristics which were obtained by performing spectrum analysis. A typical spectrum analysis provides a graphic display of vibration in the frequency domain with the vibration amplitude (displacement, velocity or acceleration) on the Y-axis and frequency on the X-axis (cycles per second or Hz). The licensee provided a spectrum analysis for the HPCI main pump which shows that vibration at horizontal direction points P3H (inboard) and P4H (outboard) spikes at a frequency corresponding to 2x RPM of the main pump, which coincides with 4x RPM of the booster pump. The licensee believes that high vibration (peak) on the main pump bearing housings at approximate 2x RPM in the horizontal direction, is caused by the booster pump excitation (4x RPM of the booster pump). The licensee states that the peak vibration amplitude is not related to the physical condition or rotating dynamics of the main pump rotor or bearing system. Therefore, the licensee is proposing to remove (filter) the peak values from the measured vibration values of the HPCI main pump, such that the filtered vibration values meet the ASME Code requirements.

The licensee proposes to use the acceptance criteria specified in the ASME OM Code Table ISTB 5.2.1-1 for the main pump turbine side (inboard) vertical and axial vibration points P3V and P3A and main pump gearbox side (outboard) vertical vibration point P4V. For the main pump horizontal vibration points P3H and P4H, a frequency spectrum analysis will be performed and the discrete peak at 4x booster pump RPM will be removed (using mean-squared subtraction method) from the main pump spectrum overall value. In addition, all other discrete peaks will be evaluated during each test and will have an Acceptable Range upper limit of 1.05 V_r and an Alert Range upper limit 1.3 V_r.

The licensee states that they will perform HPCI main pump condition monitoring and maintenance activities, with changes as conditions warrant, as follows:

A. Quarterly pump and valve operability tests will be performed to ensure the HPCI pump and turbine function for the intended safety function(s).

B. Quarterly lubrication oil sampling and laboratory analysis will be performed for the pressure-fed bearings on the turbine, main pump, and gear reducer and once/cycle (2 years) for the non-pressure fed booster pump. Lubrication oil analysis currently performed includes determination of viscosity, acidity, residue, water content, metals by spectrometry, and ferrogram readings. This type of monitoring will detect degradation of the turbine or pump bearings due to accelerated wear, fretting, surface fatigue, or oil contamination.

C. HPCI pump and turbine lube oil system is serviced as-needed weekly. HPCI gland seal condenser hotwell pump and motor bearings and HPCI auxiliary lube oil pump and motor bearings are serviced semiannually for lubrication.

D. HPCI turbine/main pump, main pump/reducer, and reducer/booster pump gear type shaft couplings are cleaned, examined, and grease-lubricated every 2 years. These examinations will detect excessive wear, fretting, heating, or fatigue due to any unusual loading conditions.

E. Vibration monitoring will be performed quarterly as part of Group B hydraulic tests, and spectrum analysis as part of the vibration monitoring will also be performed quarterly.

The NRC staff is aware that HPCI pumps at various nuclear plants have a history of vibration issues, which are referenced in Attachment 2, HPCI Pump IST Vibration Evaluation, of the licensee's RAI response dated February 10, 2004. Byron Jackson performed a study of HPCI pump vibration at various nuclear plants, including PNPS, and issued their finding as Technical Note No. 9112-80-018. Byron Jackson's Technical Note states that "If bearing housing vibration exceeds the Alert limits in the ASME Section XI Code (now OM Code), the following actions are recommended: (i) verify correct dynamic alignment of all shaft couplings; (ii) verify acoustic resonant condition from measured flow, RPM, water temperature, and vibration frequency; and (iii) replace four vane booster pump impeller with a staggered five vane impeller.

The licensee states that "the proposed Byron Jackson modifications, other than replacing the Booster Pump impeller, are generally very difficult to implement successfully. Altering the natural frequency of a large pump installation requires either considerable additions of stiffening components or substantial additions of mass. Often the results of such design changes are unsuccessful or unfavorable due to the variable speed operation requirements."

Further, the licensee states that the impeller modification (from four vanes to five vanes), although yielding predictable results, requires extensive work to the HPCI pump at a time when such a major rebuild of this pump is not otherwise necessary or desired.

The licensee states that the main pump pedestal has a horizontal structure rocking mode when the main pump is operating. The vibration mode is the second fundamental rocking mode, which is torsional or twisting where the two end bearings move 180 degrees out of phase horizontally. The results of these coincident acoustic and structure resonances is that the main pump exhibits high vibration in the horizontal direction at the 4x booster pump RPM frequency. This is solely due to the excitation from the booster pump being amplified by the coincident resonances. This level of vibration at 4x booster pump RPM would be seen on the main pump bearing housing even if the main pump was not running, which is not possible, because the main pump and booster pump are on same drive. The level of vibration will be above the Acceptable Range and Alert Range, and may result in pump damage.

As discussed above, the licensee proposed that peak vibration amplitude is not related to the physical condition or rotating dynamics of the main pump rotor or bearing system. Therefore, PNPS is proposing to filter the measured vibration values of the HPCI main pump, such that filtered vibration values meet the ASME Code requirements. The AMSE OM Code, paragraph ISTB 5.2.3(d) requires that vibration measurements be broad band (unfiltered). A typical spectrum analysis is a means to reveal information as to the source of a potential vibration problem. The licensee-proposed alternative to filter the peak vibration values will not correct the elevated vibration levels at the pump. The proposal masks the potential elevated vibration levels by removing them from consideration. Therefore, the NRC staff does not agree with the licensee's proposed filtering of the peak values, which is not allowed by the ASME OM Code.

In its evaluation of the above points of discussion, the NRC staff finds the proposed alternative does not provide an acceptable level of quality and safety in the long term because the alternative does not provide reasonable assurance of the long-term operational readiness of the HPCI pump. For long-term assessment of the operational readiness of the HPCI pump, it is necessary that pump vibration meet the ASME OM Code requirements as specified in Table ISTB 5.2.1-1.

In addition, the licensee did not demonstrate that compliance with ASME Code requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Although the need to implement the Byron Jackson recommended modifications at an estimated cost of about $500,000 may be a hardship, the modification would likely lower the actual vibration levels of the HPCI pump. Also, the licensee did not demonstrate that meeting the ASME Code vibration acceptance criteria is impractical. The NRC staff is aware of some licensees who have performed the design modification per Byron Jackson recommendations, and who were able to reduce the HPCI pump vibration levels.

However, the staff has considered the licensee’s proposed enhanced HPCI main pump monitoring and maintenance activities as described above, and the fact that evaluation of the HPCI pump vibration measurements as provided in the above table shows that vibration measurements are consistent even though they exceed the ASME Code values using the current test methodology. Therefore, the staff finds that the licensee’s alternative provides sufficient assurance of operational readiness of the HPCI pump to authorize the alternative for an interim period to allow time for the licensee to reevaluate its proposed alternative testing and technical justification. The proposed alternative provides sufficient assurance of operation readiness during the interim period because of vibration measurement, lubrication analysis and vibration spectrum analysis will be performed quarterly instead of every 2 years, and because the licensee has not identified any maintenance or testing issues associated with these pumps. Considering that plant modification would require time and planning as well as plant shutdown, and that the proposed alternative would provide reasonable assurance of pump operability without major degradation, RR PR-03 is authorized for an interim period not to exceed two refueling cycles or 3 years.

During the interim period, the licensee should reevaluate its proposed alternative to meet the ASME OM Code vibration requirements. This may entail a more detailed analysis of the IST data, a possible design modification based on the previous vendor’s recommendation, and/or consultation with the pump manufacturer, as appropriate.

4.0 CONCLUSION

The licensee’s proposed alternative to the ASME Code requirements of Table ISTB 5.2.1-1 for HPCI pump P-205, described RR PR-03, is authorized for an interim period not to exceed two refueling cycles or 3 years, pursuant to 10 CFR 50.55a(a)(3)(i) on the basis that the proposed alternative provides an acceptable level of quality and safety. This ASME Code relief would be invalid if any significant changes to the licensee conditioning monitoring and maintenance program as described in the submittal are implemented during the interim period. The licensee should reevaluate its proposed alternative to meet the ASME OM Code vibration requirements during this interim period.

All other ASME OM Code requirements for which relief was not specifically requested and approved remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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