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50.55a(a)(3)(ii)

NLS2003120
November 25, 2003

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Subject: Inservice Testing Program Relief Request RP-06, Revision 2
Cooper Nuclear Station, NRC Docket 50-298, DPR-46

References:
1. Nebraska Public Power District letter NLS2003059 to the Nuclear Regulatory Commission dated September 19, 2003, "Inservice Testing Program Relief Request RP-06, Revision 1"
2. Nuclear Regulatory Commission letter to Nebraska Public Power District dated October 10, 2003, "Request for Additional Information Regarding the Request for Relief From the Requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code Concerning Inservice Testing of Core Spray Pump CS-P-B as Required by ASME/ANSI OMa-1988, Part 6, Paragraphs 4.6.1.6 and 5.2.(d) (TAC No. MB6821)"

The purpose of this letter is to respond to a request for additional information (RAI) from the U.S. Nuclear Regulatory Commission (NRC) regarding Cooper Nuclear Station (CNS) Inservice Testing (IST) Program Relief Request, RP-06. RP-06 requests relief from certain American Society of Mechanical Engineers code requirements for IST Program testing of Core Spray Pump B at CNS. Nebraska Public Power District (NPPD) submitted RP-06 Revision 1 to the NRC by letter dated September 19, 2003 (Reference 1). The NRC transmitted the RAI to CNS by letter dated October 10, 2003 (Reference 2) based on their review of Reference 1. The response to the NRC RAI is provided in Attachment 1.

In response to Reference 2 and discussions with the NRC Staff during a telephone conference conducted on October 9, 2003, NPPD has revised RP-06 to request an increased alert range threshold for two vibration points on Core Spray Pump B. The revised relief request, RP-06, Revision 2, supercedes Revision 1 and is provided in Attachment 2. Revision bars in the margin

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indicate the location of revised text. No changes were made to the figures submitted with Revision 1. Those figures are not resubmitted with Revision 2. A summary of the changes made from RP-06, Revision 1 is provided as Attachment 3 to facilitate NRC Staff review of Revision 2.

NPPD requests NRC approval of this relief request by February 25, 2004. This date has been coordinated with the NRC Project Manager. NRC approval of this relief request will allow Core Spray Pump B to return to the normal testing interval. NPPD requests relief for the remainder of the Third Ten-year IST Program Interval (March 2006).

Should you have any questions concerning this matter, please contact Paul V. Fleming at (402) 825-2774.

Sincerely,

Stewart B. Minahan
Site Vice President

/rer
Attachments

cc: Regional Administrator w/ attachments
USNRC - Region IV

Senior Project Manager w/ attachments
USNRC - NRR Project Directorate IV-1

Senior Resident Inspector w/ attachments
USNRC

NPG Distribution w/o attachments

Records w/ attachments

Attachment 1

**Responses to NRC Request for Additional Information
Relief Request RP-06**

**Cooper Nuclear Station
Docket No. 50-298
(TAC No. MB6281)**

NRC RAI #1

The licensee and its pump experts have concluded that since initial installation of the core spray pump, the pump tests using the full-flow capabilities of the test line have not caused any damage to the pump, and the pump is operable. The staff finds that although no significant damage may have occurred based on the cumulative pump operating time during the quarterly tests (approximately 40 to 50 hours), the core spray pump is required to perform a safety function for an extended period of time following a LOCA. Therefore, the data collected from the pump tests are not sufficient to justify the long-term reliability of the pump.

With regard to the long-term reliability of the pump, the licensee states that the pump vendor (Byron-Jackson), in a letter dated February 16, 1973, indicated that "such low acceleration levels, along with the system acting as a rigid structure (between motor and pump), means that the motor and pump can operate with these levels of vibration with absolutely no impairment of operating life." (Ref. page 7 of Attachment 2).

The above statement, however, did not provide an adequate basis for its conclusion. In order to justify the long-term operability of the affected pump, the conclusion should be substantiated by analyses, operating history of similar pumps, or other technical bases appropriate to the pump. The staff requests that further justification or relevant documents demonstrating the pump's long-term reliability at these low-frequency vibration levels be submitted for staff review.

The licensee further argues that its alternative is similar or more conservative than that provided by the Sequoyah Nuclear Plant (SNP) in its alternative that was authorized by the staff. In the case of SNP, the licensee requested relief from the vibration that occurred only during the quarterly pump test using a mini-flow test line. During refueling outages, the pump test at SNP uses the normal post-LOCA flow path (full-flow line) and did not experience vibration problems. Consequently, SNP did not have to address the issue related to long-term operability of the affected pumps. SNP was requested only to justify that the mini-flow test had not caused damage or degradation to the pump, which in turn could be verified every two years by a full-flow test.

NPPD Response

The discussion in the RP-06, Rev. 1 relief request included a detailed historical synopsis of the events and evaluations that have lead up to the conclusion of the Nebraska Public Power District (NPPD) that the low frequency vibrations will not impact the long term reliability of Core Spray Pump B (CS-P-B) for Cooper Nuclear Station (CNS). The intent of providing the findings identified by Byron Jackson was to initiate the discussion on CS-P-B and to indicate when the piping-induced vibrations were first identified. NPPD did not intend that this information, by itself, would be the full justification for the long term reliability of CS-P-B. Rather, the analysis by Byron Jackson, the pump vendor, is only a portion of the information on which NPPD based its overall conclusion.

In addition to the Byron Jackson analysis, the relief request discussed the modifications that have been made over the years to reduce the vibrations observed on CS-P-B, and follow-up analyses of CS-P-B by CNS staff and by Machinery Solutions, an independent, industry vibration expert. That discussion further supports the conclusion that the long term reliability of CS-P-B is not affected by these low frequency vibrations.

NPPD's conclusion that the low frequency vibrations will not impact the long term reliability of CS-P-B is based on the combination of the modifications made to reduce vibration, and the evaluations of the vibration performed by Byron Jackson, Machinery Solutions, and CNS personnel.

The last paragraph of RAI #1 was a discussion of the Sequoyah Nuclear Plant (SNP) relief request. NPPD understands the differences between the SNP and CNS relief requests and is not citing the SNP relief request as a precedent.

NRC RAI # 2

In lieu of meeting the Code requirements, the licensee proposes to filter out the low frequency vibration data at points 1H and 5H, and monitor them administratively for any anomaly or trend of high vibration. However, before the staff can evaluate the acceptability of monitoring low-frequency vibration administratively, (i.e., not in conjunction with ASME Code inservice testing requirements), the licensee is requested to demonstrate (1) that the excluded low-frequency vibration has no significant impact on the pump's long-term reliability (see RAI #1) and (2) the excluded vibration can be verified to stay within acceptable limits. To ensure that the vibration remains within acceptable levels, the proposed alternative should be revised to include an acceptable vibration limit for points 1H and 5H and required actions to be taken if these limits are exceeded. Any proposed alternative must be part of the inservice testing program, and administrative monitoring of the affected vibration parameters without specific acceptance criteria and corrective action will not be accepted.

NPPD Response

This RAI requests information needed by the Nuclear Regulatory Commission (NRC) Staff to approve the exclusion of the low frequency vibration from Inservice Testing (IST) Program test acceptance. During the discussion of this RAI on a telephone conference with NPPD conducted October 9, 2003, the NRC Staff indicated that requesting an increase in the alert limit for vibration would be more appropriate than requesting exclusion of the vibration occurring at frequencies between one-third and one-half pump rotational speed. Based on this telephone conference, NPPD is revising RP-06 to request an increased alert limit for monitoring the entire range of code required frequencies (one-third pump running speed to 1000 Hz) for the two points on CS-P-B that periodically experience increased vibration. The revised relief request, RP-06, Revision 2, is provided as part of this submittal.

To address NRC Staff concerns with administratively monitoring vibration between one-third and one-half pump running speed frequencies as proposed in RP-06 Revision 1, and associated long-term reliability of CS-P-B, NPPD will monitor the entire range of code required frequencies (one-third pump running speed to 1000 Hz) within the IST Program. In RP-06, Revision 2, NPPD is proposing an increased vibration alert range threshold of 0.400 in/s (increased from 0.325 in/s) for vibration points 1H and 5H. The basis for the proposed increased alert threshold is presented in the revised relief request.

Increasing the alert range threshold provides an alternative method that meets the intended IST function of monitoring the pump for degradation. The absolute required action threshold will remain unchanged at 0.7 in/s.

The information requested by this RAI is related to the administrative monitoring of vibration between one-third and one-half pump running speed proposed in RP-06, Revision 1. Because NPPD is revising RP-06 to request increased alert limits for vibration points 1H and 5H in lieu of the administrative monitoring, no additional information in response to this RAI is required.

NRC RAI #3

The licensee states (Reference page 5 of Attachment 2) that the forcing function in this case is caused by flow turbulence attributed in large part to the S-curve in the piping just off the pump discharge. The licensee is requested to address what actions have been taken to modify this portion of the piping in order to reduce vibration, especially when it became clear to the licensee that the primary source of high vibration was the flow turbulence in and around these areas.

NPPD Response

As stated in the relief request RP-06, Revision 1, NPPD submittal dated September 19, 2003, modifications to supports, hangers, and test line flow orifices have been completed, which improved the condition by reducing the vibration and piping deflections. However, NPPD has concluded that it would be impractical to modify the large, CS-P-B discharge piping. The basis for this decision is the conclusion by the multiple experts that the pump is not adversely affected by the low frequency vibrations. Modifying the discharge piping would be a significant modification. Since the evaluations concluded that there are no detrimental affects to the performance of CS-P-B due to the existing low frequency vibrations, CNS believes there is insufficient basis (i.e., need) for such a modification. If analyses had indicated that the pump reliability would be in question as a result of the vibration, additional modifications would have been proposed and implemented, as appropriate, to correct the condition.

Based on the above discussion, NPPD concludes that a relief request to address the impact of the low frequency vibration at two of the five vibration points on CS-P-B would be appropriate.

Attachment 2

Relief Request RP-06 (Revision 2)

Cooper Nuclear Station
Docket No. 50-298
(TAC No. MB6281)

NOTE: The figures discussed in this relief request were provided as Attachment 3 of RP-06, Revision 1, submitted to the Nuclear Regulatory Commission (NRC) by Nebraska Public Power District (NPPD) letter NLS2003059 dated September 19, 2003.

PUMP Core Spray, CS-P-B

CLASS ASME Code Class 2

FUNCTION The core spray pump has an active safety function to provide cooling spray water to the reactor vessel to mitigate the consequences of a Loss of Coolant Accident. The pump delivers water from the suppression pool to the spray spargers in the reactor vessel above the fuel to cool the core and limit cladding temperature. The pump must deliver a minimum of 4720 gpm at $\geq$ 113 psid to meet its safety function. Injection to the vessel occurs only after pressure has dropped below 436 psig, which allows the injection check valve to open.

REQUIRED TEST OMa-1988, Part 6, Table 3a, specifies alert range absolute limits for vibrational parameters associated with centrifugal pumps as follows:

Alert Range: > 0.325 in/s

This is for a range of frequencies from one-third minimum pump shaft rotational speed to at least 1000Hz per Paragraph 4.6.1.6 of OMa-1988, Part 6.

BASIS FOR RELIEF A. Summary of Basis for Relief

NPPD submits this relief request for NRC review and approval in accordance with 10CFR50.55a (a)(3)(ii). Compliance with the specified requirement results in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The Inservice Testing (IST) Program has consistently required that CS-P-B be tested on an increased frequency due to vibrational values at points 1H and 5H, as shown in Figure 1 of Attachment 3 from RP-06, Revision 1, periodically being in the alert range. Relief is requested from OM-6, Table 3 requirements to test the pump on an increased periodicity due to vibration levels for points 1H and/or 5H exceeding the OM-6 alert range absolute limit. This request is based on analysis of vibration and pump differential pressure data indicating that no pump degradation is taking place. Cooper Nuclear Station (CNS) is proposing to use alternative vibration alert range limits for vibration points 1H and 5H. This provides an alternative method that continues to meet the intended function of monitoring the pump for degradation over time while keeping the required action level unchanged.

B. Pump Testing Methodology

Core Spray (CS) pump B (CS-P-B) at CNS is tested using a full flow recirculation test line back to the suppression pool each quarter. CS-P-B has a minimum flow line which is used only to protect the pump from overheating when pumping against a closed discharge valve. The mini-flow line isolation valve for CS-P-B is initially open when the pump is started and flow is initially recirculated through the mini-flow line back to the suppression pool. Then, the full flow test line isolation valve is throttled open to establish flow through the full flow recirculation test line. The mini-flow line is then isolated automatically and all flow remains through the full flow test line for the IST test.

The B train of the CS system is operated in the same manner and under the same conditions for each test of CS-P-B, regardless of whether CNS is operating or shut down. Consequently, the pump will experience the same potential for flow-induced, low frequency vibration whenever it is tested, whether CNS is operating or shut down. As a result, this relief is needed for all testing of CS-P-B.

CNS considers full flow testing to be preferable to mini-flow testing due to the ability to evaluate overall pump performance at post-accident flow design conditions. Mini-flow testing would provide only limited information about the pump.

C. NRC Staff Document NUREG/CP-0152

NRC Staff document NUREG/CP-0152, entitled "Proceedings of the Fourth NRC/ASME Symposium on Valve and Pump Testing," dated July 15-18, 1996, included a paper entitled Nuclear Power Plant Safety Related Pump Issues, by Joseph Colaccino of the NRC staff. That paper presented four key components that should be addressed in a relief request of this type to streamline the review process. These four key components are as follows:

I. The licensee should have sufficient vibration history from inservice testing which verifies that the pump has operated at this vibration level for a significant amount of time, with any "spikes" in the data justified.

II. The licensee should have consulted with the pump manufacturer or vibration expert about the level of vibration the pump is experiencing to determine if pump operation is acceptable.

III. The licensee should describe attempts to lower the vibration below the defined Code absolute levels through modifications to the pump.

IV. The licensee should perform a spectral analysis of the pump-driver system to identify all contributors to the vibration levels.

The following is a discussion of how these four key components are addressed for this relief request.

I. Vibration History (Key Component No. 1)

A. Testing Methods and Code Requirements

Inconsistent higher vibrations on CS-P-B have been a condition that has existed since original installation of this pump in 1973. During the construction and preoperational testing, vibrations were measured in "mils" at the top and side of the motor outboard (furthest from the pump), the side of the motor inboard (nearest the pump), and pump inboard (nearest the motor). The vibration signals were tape recorded along with the dynamic pressure pulsations in the suction and discharge of the pump as the flow was varied. The intention was to see if hydraulic disturbances were responsible for the observed phenomena. Observation of the vibration signals on the oscilloscope showed conclusively that the motor was vibrating with randomly distributed bursts of energy at the natural frequency of the total system. Therefore, it was determined that the hydraulic disturbances found in the piping was the source of the energy. Pipe restraints were added that reduced the piping system vibrations.

The monitoring of multiple vibration points over the years had not been a requirement of Section XI of the ASME Code until the adoption of the O&M Standards/Codes. Therefore, at CNS, the first and second ten-year interval IST code requirements did not include the monitoring of multiple vibration points. The CNS second interval IST Program was committed to the 1980 Edition, Winter 1981 Addenda, of Section XI. Paragraph IWP-4510 of this code required that "at least one displacement vibration amplitude shall be read during each inservice test." This code was in effect at CNS until the start of the current third ten-year interval, which began on March 1, 1996. The CNS third interval IST Program is committed to the 1989 Edition of Section XI, which requires multiple vibration points to be recorded during IST pump testing in accordance with the ANSI/ASME Operations and Maintenance Standard, Part 6, 1987 Edition with the 1988 Addenda. However, CNS proactively began monitoring vibration on pumps in the IST Program in velocity units (inches per second) at multiple vibration points in 1990 in accordance with an approved relief request. Therefore, data exists for vibration points 1H and 5H from April 1990 to the present. This data is included in the figures provided in Attachment 3 of RP-06, Revision 1. In April 1990, an analog velocity meter was utilized to begin measuring five different points in units of velocity. These are the same points measured today. Further technological advances resulted in the utilization of more reliable vibration meters beginning in late 1996.

B. Review of Vibration History Data

Beginning in April 1990, five vibration points (1V, 1H, 2H, 3H, 5H) were recorded for CS-P-B. However, the pump was tested at 4720 gpm from April 1990 to April 1992, then at 4800 gpm from April 1992 through December 1994, and finally at 5000 gpm from January 1995 to the present. The January 1995 test was also a post-maintenance test following the work that replaced the restricting orifice in the test return line. The last re-baseline occurred on November 6, 1996 due to the implementation of a new vibration meter with new instrument settings. Therefore, it would be appropriate to review the data from this date forward to track for degradation. This would be over six and one-half years of data at the same reference points.

CS-P-B IST vibration trend graphs (Figures 2a, 3a, 4a, 5a, and 6a in Attachment 3 of RP-06, Revision 1), which include data from November 6, 1996 to the present, show essentially flat or slightly downward trends, indicating that CS-P-B vibrations are not increasing in magnitude. These trends also show that points 1H and 5H occasionally exceed the alert range criteria (Figures 2a and 3a). Figure 12 illustrates the trend for CS-P-B differential pressure (D/P) readings from January 1995 (re-baselined pump at 5000 gpm) to the present. This represents nearly nine years of data for pump differential pressure with the testing at 5000 gpm. As can be seen from Figure 12, essentially no degradation in pump D/P has occurred.

Trend graphs 2b, 3b, 4b, 5b, and 6b illustrate vibration data dating back to April 1990 for all vibration points. The data prior to 1996 represents data taken with analog, less reliable vibration instruments and as discussed previously, at differing flows. This data should not be directly compared to data from November 1996 to the present, but it does clearly indicate that the piping induced vibrations for vibration points 1H and 5H were present in the early 1990s. This condition was also documented in the 1980s. In July 1985, CNS work item #85-2497 documented high vibration readings on the horizontal motor position. A pipe resonance problem was suspected at that time. Vibrational readings varied between 0.3 and 0.5 in/sec with spikes to 0.7 in/sec every few seconds. This 1985 documentation, available vibration data since 1990, along with the testing performed during the preoperational time period, substantiates that the piping induced vibrations have been in existence since the pump was installed. These graphs indicate that the vibration point trends since April 1990 are essentially flat or slightly downward. Therefore, based on the available data at CNS, this pump has experienced essentially no degradation in vibration levels for the last thirteen years or in D/P for nearly the last nine years.

C. Review of "Spikes" in Vibration Data

In reviewing the trend data for vibration points 1H (Figures 2a, 2b) and 5H (Figures 3a, 3b), which includes the Code required frequency ranges (one-third pump running speed to 1000 Hz.), random spikes were observed throughout the data that resulted in values above the alert range. These spikes are best described in a 2001 report by Machinery Solutions, an industry expert on vibrations, as follows:

> Most of the vibration that is measured on the motor casing is due to excitation of the structural resonances of the motor/pump by turbulent flow. These structural resonances are poorly damped and can be easily excited. Most vertical pumps have similar types of behavior and it is not necessary problematic by itself. A problem occurs when a pump has a continuous forcing function whose frequency coincides with a resonance (i.e., running speed). The forcing function in this case is flow turbulence caused in large part by the S-curve in the piping just off the pump discharge. The flow through this area generates lateral broadband forces, due to elbow effects, that excite the resonances in a noncontinuous fashion. This is why the amplitude swings so dramatically on the motor case [the location of vibration points 1H and 5H]. The system goes from brief periods of excitation to brief periods of no excitation. The discharge riser is also moving side to side from the same forces. Although the discharge piping configuration is both non standard and less than optimum for this application, it poses no threat to the long term reliability of either the pump or the motor. The only negative impact is on vibration levels relative to a generic standard.

As illustrated previously, there have been no degrading trends associated with vibration data for the last thirteen years (Figures 2b and 3b). Since June 2002, filtered data (removal of one-third pump running speed to one-half pump running speed frequencies) has been recorded in addition to the current code required values for vibration points 1H and 5H (reference Figures 2c and 3c). In reviewing this data, the trends are lower in value, steady, and without the spikes that the code required data contains. This further supports the fact that the spikes in the original code data are due to the piping induced, non-detrimental vibration occurring at the one-third to one-half pump running speed.

II. Consultation With Pump Manufacturer or Vibration Expert (Key Component No. 2)

A. Pump Manufacturer Evaluation of CS-P-B Vibrations

Byron Jackson is the pump vendor for CS-P-B. The pump is a 8 x 14 x 30 DVSS, vertical mount, single stage centrifugal pump. The pump impeller is mounted on the pump motor's extended shaft. As outlined in the Core Spray System Summary of Preoperational Test, the data obtained for the B Core Spray Pump indicated high vibration. The high vibration had been recognized early in the construction testing phase and Byron Jackson, the pump manufacturer, sent a representative to the site to investigate. In a letter dated February 16, 1973, the Byron Jackson representative indicated the following:

1. Tests indicated that the natural frequency of the pump was 940 rpm (approximately one-half pump speed) in the direction of the piping and 720 rpm (between one-third and one-half of pump speed) in the direction perpendicular to the piping.

2. Observation of the test signals on the oscilloscope showed very conclusively that the motor was vibrating with randomly distributed bursts of energy, the frequency of which matched the natural frequency of the total system. This can only mean that the energy is coming from the hydraulic disturbances found in the piping.

3. Whenever large flows are carried in piping, there is usually considerable turbulence associated with the elbows, tees, etc. of the piping configuration, all of which results in piping reactions and motion. Apparently, the vibrating piping was in turn vibrating the pump.

4. When jacks were installed between the top of the pump and the bottom of the motor flange in an effort to stiffen the motor pump system, the motor vibrations went up due to more energy being transmitted from the pipe-pump system into the motor.

5. Testing was performed to determine any weaknesses in the pump-motor mechanical system. The vibration amplitude using the IRD instrument, with the filter set at operating speed, sampled many points vertically along the pump-motor structure. Plots of the data (along with phase angle determined by means of the strobe light) showed very clearly that the total structure was vibrating as a rigid assembly from the floor mounting. Examination of the high amplitude vibration signals showed them to be at the extremely low system natural frequencies as determined earlier.

6. Such low acceleration levels, along with the system acting as a rigid structure (between motor and pump), means that the motor and pump can operate with these levels of vibration with absolutely no impairment of operating life. This is the picture that seems very clearly described by the data obtained during these tests. There is absolutely no reason to restrict the operation of these pumps in any way.

Although the vibration was found to be acceptable, CNS took actions to install new pipe supports as an attempt to reduce these piping-induced vibrations. This action was successful as will be discussed in a later section of this relief request.

B. CNS Expert Analysis of CS-P-B Vibrations

As the Vibration Monitoring Program expanded in the early 1990s, it became evident that the low frequency piping-induced vibrations still remained in CS-P-B. Design Change (DC) 94-046 resulted in the replacement of the orifices in the test return line. A March 16, 1995 memo to the CNS IST Engineer from the CNS Lead Civil/Structural Engineer discussed the CS-P-B vibration measurements obtained during DC 94-046 acceptance testing. The vibration data was collected using peak velocity measuring instrumentation as required for the performance of the IST test, and with instrumentation that provides displacement and velocity versus frequency data. It was observed that the significant vibrations in the 1H direction were occurring around 700 cycles per minute (cpm), while the pump speed is at 1780 cpm (i.e., rpm). Given the piping movement of the system, and the knowledge that piping vibrations can commonly occur in the 700 cpm (12 Hz) range, CNS concluded that the pump vibrations were piping dependent.

The CNS Lead Civil/Structural Engineer concluded that the significant pump vibrations are occurring at less than one-half of the pump operating speed. The pumps are rigidly mounted at their bases, and any impeller induced vibrations would occur at the pump running speed or at the vane passing frequency. Therefore, the sub-synchronous pump vibrations are clearly piping induced, non detrimental to pump/motor service or reliability, and should not be used as a basis for pump degradation. This is because the purpose of pump in-service testing is to diagnose and trend internal pump degradation.

The memo further states that the vibration data collection requirement specified in the IST procedure consists of peak velocity recordings, which may be masked by piping induced vibrations, negating internal pump degradation diagnosis and trending. Based on the historical trending data for both Core Spray pumps, the vibration has remained at a consistent amplitude, trending neither upward nor downward, indicating that the induced vibrations are not impairing pump operability, nor capable of preventing the pump from fulfilling its safety function. The piping vibration is present when flow is present through the test return line. It was visually observed during DC 94-046 acceptance testing that piping vibrations were minimal when flow was directed through the minimum flow line.

Following the DC 94-046 testing, CNS noted that the deflections observed in the discharge piping were significantly reduced. Based on these results, it was determined by the Nuclear Engineering Department, Civil/Structural Group, that the CS Loop B piping vibration stresses are less than the endurance limit of the piping.

On October 17, 2002, a Plant Engineering Supervisor at CNS, knowledgeable in the area of pump vibration analysis, issued a memo to the CNS Risk & Regulatory Affairs Manager, discussing the low frequency vibration issue with the "B" Core Spray Pump. In the memo, it is stated that the pipe is vibrating as a reaction to flow turbulence, which in turn is causing the pump to vibrate. The memo documents the basis for why the low frequency vibration (less than one-half pump running speed) experienced during CS-P-B operation is not indicative of degrading pump performance, and is not expected to adversely impact pump operability. To summarize, in the area of pump performance, aside from the randomness of the low frequency peaks, the spectral data shows no degrading trend in performance over several years of data. The low frequency piping induced vibrations are not expected to adversely impact pump operability.

C. Independent Industry Vibration Expert Evaluation of CS-P-B

In 2001, Machinery Solutions, Inc. was retained to perform an independent study of the CS-P-B vibrations. The following discussion was obtained from their report, issued in September of 2001. Machinery Solutions utilized seven transducers and acquired data from CS-P-B continuously while it was operating, and data was stored every 3 seconds. Orbit plots, spectrum plots, bode and polar plots, cascade/waterfall plots, overall amplitude plots, trend plots, XY graph plots and tabular lists were utilized to analyze the data. The data obtained by Machinery Solutions indicated that the vibration amplitudes during the run were much higher at the top of the motor than they were at the bottom of the motor. The amplitudes decreased even further on the pump. The spectrum plots showed that most of the vibration was occurring below running speed. They also showed that the low frequency vibration is a different frequency in each direction. The predominant peaks occur at approximately 870 cpm (less than one-half pump running speed) in line with discharge and at approximately 630 cpm (less than one-half pump running speed) perpendicular to discharge. The amplitude of each of these peaks varied significantly from second to second. The natural frequency of the pump-motor-piping structure was determined via impact testing prior to starting the pump. The natural frequencies were determined to be approximately 830 cpm in line with discharge and 670 cpm perpendicular to discharge. Such a vibration response is typical for vertical pumps.

Machinery Solutions concluded the following:

1. Most of the vibration that is measured on the motor casing is due to excitation of the structural resonances of the motor/pump by turbulent flow. These structural resonances are poorly damped and can be easily excited. Most vertical pumps have similar types of behavior and it is not necessarily problematic by itself. A problem occurs when a pump has a continuous forcing function whose frequency coincides with a resonance (i.e., running speed). The forcing function in this case is flow turbulence caused in large part by the S-curve in the piping just off the pump discharge. The flow through this area generates lateral broadband forces, due to elbow effects, that excite the resonances in a noncontinuous fashion. This is why the amplitude swings so dramatically on the motor case [the location of vibration points 1H and 5H]. The system goes from brief periods of excitation to brief periods of no excitation. The discharge riser is also moving side to side from the same forces. Although the discharge piping configuration is both non standard and less than optimum for this application, it poses no threat to the long term reliability of either the pump or the motor. The only negative impact is on vibration levels relative to a generic standard.

2. The balance condition of the motor and pump are acceptable with no corrective action required at this time.

3. The shaft alignment between the motor and the pump is acceptable for long term operation.

4. There is no evidence of motor bearing wear.

Machinery Solutions recommended the following actions:

1. Create a new IST vibration data point configuration within the data collector database to use an overall level that is generated from spectral data above 950 cpm. This will eliminate the energy from the resonances from the data set and still allow for protection from bearing degradation, impeller degradation and motor malfunctions. The only potential failure mode that could occur within this excluded frequency range would be a fundamental train pass frequency generated by a rolling element bearing. This frequency only occurs with increased bearing clearance. On vertical machines, this increased bearing clearance causes increased bearing compliance and the 1X component will become larger. The 1X change will be evident in the monitored data set.

2. Continue to acquire the old data points with the low frequency data "for information only" to verify that the system response does not change.

III. Attempts to Lower Vibration (Key Component No. 3)

CNS installed additional pipe restraints during the preoperational period in order to reduce piping-induced vibrations. Testing on October 26 and 27, 1973, following the installation of these new supports, demonstrated significantly reduced vibrations.

Low frequency piping-induced vibrations continued, but with reduced amplitude following the installation of the pipe restraints. However, the issue resurfaced in the early 1990s when additional vibration points were recorded, more strict acceptance criteria were adopted for vibrations, and new technology was incorporated into the CNS vibration program. These new points were more influenced by the low-frequency piping-induced vibrations than the one or two points recorded in the 1980s. It was evident that the piping-induced vibrations were still prevalent with the CS-P-B pump.

In 1993, a deficiency report was written to address increased frequency IST testing of CS-P-B due to vibration. It was suspected that the pump vibrations were piping-induced. Preliminary investigation of the vibration issue concluded that cavitation at the Core Spray test return line throttle valve and/or restriction orifices was likely causing the elevated piping vibration in both Core Spray System loops. Vibration testing of the Core Spray piping confirmed this conclusion.

To reduce these flow-induced vibrations, DC 94-046 was developed to replace the existing simple, single-stage orifices on both Core Spray subsystem test return lines with multi-stage orifices. Post-installation testing with these multi-stage orifices demonstrated lower vibration levels on CS-P-A, but higher vibration levels on CS-P-B. A multi-hole single-stage orifice was fabricated and installed in the CS-P-B test return line (and later in the CS-P-A test return line) with significantly improved results. Visual observation and vibration data collected during acceptance testing determined that CS-P-B pump vibrations had been reduced, but one direction (location 1H in Figure 1) still demonstrated peak velocity reading in the alert range. The pump vibrations in the 1H direction were occurring at frequencies much lower than the pump operating speed. The major vibration peaks were occurring at approximately 700 cycles per minute (cpm), while the pump speed is at 1780 cpm, indicating that the vibration was piping induced. It was also observed during acceptance testing that vibrations were minimal during operation in the minimum flow condition.

IV. Spectral Analysis (Key Component No. 4)

Figures 7 through 11 in Attachment 3 of RP-06, Revision 1, show spectrum plots for CS-P-B, as well as spectrum trends. Markers drawn on these plots show that the peak energy spikes for points 1H and 5H remain below one-half pump running speed and that the pump vibration signature remains fairly uniform. Figure 12 shows that pump differential pressure is consistently acceptable. This data validates the analysis performed by Machinery Solutions, Inc., and the earlier conclusions that the elevated vibrations are piping-induced, and not indicative of degraded pump performance. No pump or motor faults and/or degradation are evident in the spectral analysis for this pump. This test data also shows that the vibrations experienced remain in the region of the CS-P-B pump-motor-piping system natural frequency, at less than half the pump's operating speed.

Vibrations occurring at these low frequencies are not expected to be detrimental to the long term reliability of either the pump or the motor. Typical pump faults, i.e., impeller wear, bearing problems, alignment problems, shaft bow, etc., would result in measurable vibration response in frequencies equal to or greater than one-half of pump running speed. Such faults would also be evident in pump trends. However, the vibrations are being experienced below one-half pump operating speed, have existed since initial operation, and are not trending higher. Visual inspection by Machinery Solutions in 2001 of the pump baseplate, soleplate, and grout identified no visible cracks or degradation. Further, they concluded that the balance condition and shaft alignment of the pump and motor were acceptable, and detected no evidence of motor bearing wear.

D. Maintenance History

The maintenance history for CS-P-B reflects that there have been no significant work items applicable to CS-P-B due to the low frequency vibrations that have been experienced since the construction phase of the plant. A review of maintenance history for the CS-P-B pump and motor was performed. The search consisted of a historical review of CS-P-B pump and motor maintenance in addition to a more general search of CS System vibrational issues. This search identified that the pump and motor installed in the plant today is the same combination that was installed during the construction phase of the plant. Some of the key items reviewed are summarized below:

1. 1973: Additional supports installed on "B" Core Spray System during pre-operational stage. As discussed previously, this resulted in lowering CS-P-B vibrations.

2. January 1977: Vibration eliminator on "B" Core Spray test line, CS-VE7, required tightening of wall plate bolts per Maintenance Work Request (MWR) 77-1-10. Bolts in pipe clamp were replaced and clamp was realigned. Design was determined to be adequate, but lock washers should be used to prevent recurrence of the problem. MWR 77-1-262 completed this action.

3. April 1989 (Work Item [WI] 89-0269); November 1991 (WI 91-1507), February 1993 (MWR #92-2876): CS-P-B stator end turn bracing brackets inspected for stress corrosion cracking or unusual conditions such as loose bolts or bending. No cracks, loose bolts, or other unusual conditions were observed.

4. March 1993: A magnetic particle examination of CS-P-B support attachment weld revealed an indication at Lug #5 of the pump support. The indication was ground out, repaired, and retested satisfactorily. The indication was very small and would not have affected the overall stiffness of the pump. In 2003, no recurrence of this indication was identified.

5. April 1993: Work order #93-1631 was initiated due to mechanical seal leakage. A complete inspection of the pump/motor was also completed. The pump was found with the keyway not properly aligned with the mechanical seal, causing the leakage. The impeller was found to have minor pitting at the base of the wear ring area. The pump casing and cover had minor erosion and pitting. No significant problems with the pump or motor were noted.

6. July 1994: Bolt torque checked for lower end bell and lower bearing housing on CS-P-B motor due to a loose bolt found on the "A" RHR pump motor. No movement on lower bearing housing bolts. Movement of lower end bell bolts were as follows: 1/16 flat on #1, 3, 4, and 5 and no movement on #2, 6, 7, and 8. These were very minor adjustments.

7. Late 1994: DC 94-046 installs new orifices in CS-P-B test line. As previously discussed, this reduced piping deflections in the test line.

8. Oil Samples (Dates: 09-22-95, 10-22-95, 11-24-95, 02-28-97, 03-26-98, 04-05-99, 01-24-00, 12-26-00, 10-28-02): Periodic Oil Sample Analysis of the upper and lower motor bearings in accordance with Preventive Maintenance Program. Results of CS-P-B Motor oil analysis were satisfactory with no corrective actions required.

9. Numerous Visual Motor Inspections completed satisfactory (i.e. January of 2002): Visual motor inspection satisfactory per work order #4199724.

10. February 2003: Notification #10225272 identified an indication approximately 3/8" on a CS-P-B integral attachment (CS-PB-A1). The indication is at the top of one of the small gusset supports where the gusset is welded to the cast pump bowl extension (different spot than the 1993 indication). Within engineering evaluation 03-030, the indication was determined to be on the gusset side of the weld and appears to be an incomplete fusion of the weld and not a service load induced flaw. Poor

accessibility was the most likely cause. Calculation NEDC 03-007 demonstrated that, even if the five minor gusset plates were ignored, the pump support is still qualified under the most severe design loads.

This search of the maintenance history, covering a time period of approximately thirty years, identified no significant maintenance or corrective actions that had to be implemented for the "B" Core Spray pump and motor due to the piping induced vibrations. Only minor indications were noted on the pump impeller and casing during the last significant motor/pump disassembly in 1993. No other documentation of pump/motor disassembly inspection results was found during this review. Oil analyses of the CS-P-B lower and upper motor bearing housings were found to be satisfactory for all the results documented since 1995 to the present. Wear metals, contaminants, additives, etc. were all at acceptable levels. The addition of pipe supports in 1973 and new orifices in the test lines were necessary modifications and were previously discussed. Other than these modifications, only minor corrections have been made with pipe and/or pump supports (tightening bolts, minor indication, etc.), none of which were found to be significant. Therefore, the maintenance history supports the basis of this relief request in that the piping induced vibrations occurring on CS-P-B have not degraded the pump or motor in any way.

E. Basis for Code Alternative Alert Values for Points 1H and 5H

By this relief request NPPD is proposing to increase the absolute alert limit for vibration points 1H and 5H from 0.325 in/s to 0.400 in/s. The piping-induced vibration, which occurs at low frequencies, occasionally causes the overall vibration value for these two points to exceed 0.325 in/s, resulting in CS-P-B being on an increased test frequency. However, several expert analyses and maintenance history reviews have shown that this piping-induced vibration has not resulted in degradation to the pump. Additionally, the overall vibration levels have remained steady over the last 13 years. Therefore, it has been demonstrated that doubling the test frequency under the current conditions does not provide additional assurance as to the condition of the pump and its ability to perform its safety function. Approval of the proposed new alert values for vibration points 1H and 5H would allow the removal of CS-P-B from increased frequency testing.

These new values are reasonable as they represent an alternative method that still meets the intended function of monitoring the pump for degradation over time while keeping the required action level unchanged. The proposed values encompass the majority of the historical values, but not all of them (reference figures 2a, 2b, 3a, 3b). With these new values, a reading above 0.400 in/s would require NPPD to place the pump on an increased testing frequency and to evaluate the pump performance to determine the cause of the reading. It is expected that a small amount of degradation occurring in the pump or a slight increase in the piping induced vibration would be quickly identified with these new parameters.

The new alert limits will still allow for early detection of pump degradation or piping-induced vibration increases prior to component failure, while the required action absolute limit will remain at the code value of 0.700 in/s. Therefore, the intent of the code will be maintained.

Conclusions

Several expert evaluations have documented that no internal pump or motor degradation is occurring due to the piping induced vibration, which has been present since the pre-operational testing time period. The available vibration data over the last thirteen years and differential pressure data over nearly the last nine years supports this fact as essentially no degradation has been indicated. A maintenance history review and review of oil analyses results further supports these conclusions.

Based on this information, CNS concludes that CS-P-B has been tested on an increased frequency, unnecessarily, for many years. Doubling the test frequency does not provide additional information nor additional assurance as to the condition of the pump and its ability to perform its safety function. Testing of this pump on an increased frequency places an unnecessary burden on CNS resources.

All four key components discussed in NUREG/CP-0152 have been addressed in detail, supporting the alternative testing recommended in this relief request.

CNS concludes that CS-P-B is operating acceptably and will perform its safety function as required during normal and accident conditions. The increased alert limits proposed for vibration points 1H and 5H in this relief request will continue to assure long-term reliability of CS-P-B.

ALTERNATE TEST

During the performance of CS-P-B inservice testing, pump vibration shall be monitored in accordance with OMa-1988, Part 6, Paragraphs 4.6.1.6 and 4.6.4(a). The acceptance criteria for vibration points 2H, 3H, and 1V will follow the criteria specified in Table 3a of OMa-1988, Part 6. The acceptance criteria of vibration points 1H and 5H will have increased absolute alert limit values of 0.400 in/s. The absolute required action limits for all points will continue to be 0.700 in/s in accordance with Table 3a of OMa-1988, Part 6. The absolute alert and required action limits for all vibration points associated with CS-P-B are summarized in Table 1, below. The duration of this alternate testing is until the end of the current 10-year interval (March 2006).

Table 1: Absolute Vibration Acceptance Criteria for CS-P-B:

Vibration Parameter	Acceptable Range	Alert Range	Required Action Range
1H	≤0.400 in./sec.	> 0.400 in./sec.	> 0.700 in./sec.
5H	≤0.400 in./sec.	> 0.400 in./sec.	> 0.700 in./sec.
1V	≤0.325 in./sec.	> 0.325 in./sec.	> 0.700 in./sec.
2H	≤0.325 in./sec.	> 0.325 in./sec.	> 0.700 in./sec.
3H	≤0.325 in./sec.	> 0.325 in./sec.	> 0.700 in./sec.

Attachment 3

Summary of Changes From Revision 1 to Revision 2 of RP-06

Section(s)	Description of Change(s)
Required Test	Replaced reference to OMa-1988, Part 6 code requirements of frequency response range and unfiltered vibration measurements (Revision 1 approach) with reference to code requirements for vibration absolute alert limits for centrifugal pumps (Revision 2 approach).
Basis for Relief: A. Summary of Basis for Request	Replaced the discussion of filtering out the low frequency piping-induced vibration and administratively monitoring the entire range (Revision 1 approach) with discussion of using alternative alert limits on vibration points 1H and 5H (Revision 2 approach).
Basis for Relief: B. Pump Testing Methodology	Deleted the discussion of monitoring pump performance (last two sentences of the third paragraph) as it does not apply to increased alert limits (Revision 2 approach.)
I. Vibration History (Key Component No. 1): C. Review of "Spikes" in Vibration Data	Deleted the discussion of filtering out vibration from one-third to one-half pump running speed frequencies in paragraph three (Revision 1 approach.)
II. Consultation With Pump Manufacturer or Vibration Expert (Key Component No. 2) B. CNS Expert Analysis of CS-P-B Vibrations	Deleted the discussion of pump failure modes that exhibit vibration in the range of one-third to one-half pump running speed and monitoring the vibration in this range administratively (Revision 1 approach.)
IV. Spectral Analysis (Key Component No. 4)	Deleted discussion of failure modes at low frequency (Revision 1 approach).
E. Basis for Code Alternative Alert Values for Points 1H, 5H	New section presenting the basis for increasing the alert limits for vibration points 1H and 4H to 0.400 in/s (Revision 2 approach).
Conclusions	Replaced the discussion of filtering out vibration in the range of one-third to one-half pump running speed and monitoring it administratively (Revision 1 approach) with discussion in support of increasing the alert range for vibration points 1H and 5H (Revision 2 approach.)
Alternate Test	Replaced the discussion of filtering out vibration in the range of one-third to one-half pump running speed and monitoring it administratively (Revision 1approach) with discussion in support of increasing the alert range for vibration points 1H and 5H; added Table 1 with summary of acceptance criteria (Revision 2 approach.)

ATTACHMENT 3 LIST OF REGULATORY COMMITMENTS©

Correspondence Number: NLS2003120

The following table identifies those actions committed to by Nebraska Public Power District (NPPD) in this document. Any other actions discussed in the submittal represent intended or planned actions by NPPD. They are described for information only and are not regulatory commitments. Please notify the Licensing & Regulatory Affairs Manager at Cooper Nuclear Station of any questions regarding this document or any associated regulatory commitments.

COMMITMENT	COMMITTED DATE OR OUTAGE
NPPD will conduct inservice testing on Core Spray Pump B using 0.400 in/second as the alert limit for vibration points 1H and 5H in accordance with Relief Request RP-06.	30 days after NRC approval of RP-06, Revision 2