Duke Power Company
P.O. Box 33198
Charlotte, N.C. 28242

Hal B. Tucker
Vice President
Nuclear Production
(704)373-4531

DUKE POWER

August 22, 1990

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Subject: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414
Response to Request for Additional Information
General Relief Request for Pump Vibration

This letter is in response to the NRC Request for Additional Information on the General Relief Request for Pump Vibration submitted by my letter dated March 15, 1990.

Each question in the Request for Additional Information deals with deviations between the Relief Request and the requirements of OM-6. Some confusion has resulted from the wording of the original relief request. It was not Duke Power's intent to adopt OM-6. The intent was to measure vibration velocity, as required by OM-6, because this provides a better measure of pump mechanical condition than vibration amplitude. Some parts of the relief request are based on OM-6, and as a result it was referenced when the relief request was originally submitted. The relief request does not specify compliance with OM-6 because there are fundamental problems with certain OM-6 requirements such as: 1) the vibration instrument accuracy statement is not clear or reasonable over the required frequency response range, 2) inaccessible vibration measurement points are specified, and 3) vibration acceptance criteria are to restrictive for smooth running pumps.

This letter also makes several changes to my original submittal. These changes are:

1) The accuracy specified in the relief request has been updated to reflect the use of a special National Institute of Standards and Technology (NIST) calibration and Computational Systems Incorporated newest data collector (CSI 2110). Per CSI the closed loop accuracy of the CSI 2110 is:

$$X = (9 + C^2 + K^2)^{.5}$$

Where: X = Closed loop accuracy (maximum error) in percent reading

C = Maximum error of the integrator. The signal is integrated once (converted from Gs to in/sec); therefore the maximum error of the integrator is +/-3%.

K = Maximum error of the sensor. This value is 5% of reading.

A001
1/1

Therefore, an accuracy of +/- 6.56% of "reading" instead of 6.56% of "full scale" is specified in the relief request.

2) An editorial change has been made to the table in the relief request that specifies the vibration ranges for smooth running pumps. The statement in the first column, second row, now reads "For All Pumps When Vr </= 0.075 in/sec". Some of this statement was inadvertently omitted in the original relief request.

3) The relief request has been changed to insure that data is taken over a range that encompasses all of the main potential noise contributors. It now specifies that vibration velocity will be measured over a range from 1/3 minimum pump shaft rotational speed to 1000 Hz.

Attachment I contains my reply to the NRC request for additional information. Attachment II contains the amended relief request.

Very truly yours,

H. B. Tucker

H. B. Tucker

MHH/60/td

cc: Mr. S. D. Ebneter
Regional Administrator, Region II
U. S. Nuclear Regulatory Commission
101 Marietta St., NW, Suite 2900
Atlanta, GA 30323

Mr. Herb Rockhold
EG&G Idaho, Inc.
Idaho National Engineering Laboratory
1520 Sawtelle Street
Idaho Falls, Idaho 83402

Dr. K. N. Jabbour
Office of Nuclear Regulation
U. S. Nuclear Regulatory Commission
One White Flint North
Mail Stop 14H25
Washington, DC 20555

Mr. W. T. Orders
NRC Resident Inspector
Catawba Nuclear Station

ATTACHMENT I

REPLY TO REQUEST FOR ADDITIONAL INFORMATION ON

CATAWBA GENERAL PUMP RELIEF REQUEST

1. OM-6 Section 4.6.4 Paragraph (d) states "... the reference points must be clearly identified on the pump to permit subsequent duplication in both location and plane." Does Catawba intend to mark the measurement locations, especially in the cases where there will be a deviation from OM-6 because the pump bearing housings are not accessible?

Answer:

Relief has not been requested from IWP-4160 which requires position sensitive instruments to be permanently mounted or provisions made to duplicate their position for each test. Therefore, all vibration measurement locations will be marked.

2. OM-6 Table 1 states Acceptable Instrument Accuracy for Vibration measurements to be +/- 5%. Using the total/absolute accuracy statement of +/- 7.3% uncertainty for the accelerometer and the data collector given in the relief request and applying it to the square root of the sum of the squares method to determine the total loop accuracy gives an overall maximum accuracy of +/- 10.32%, twice the allowed value from OM-6. While you have indicated that the proposed instrumentation is the best that can be reasonable obtained, there is a question whether this amount of error could mask a degraded pump or cause a good pump to be declared inoperable by stretching or compressing the envelope allowed. In view of the above, provide a basis for the proposed instrument accuracy addressing the need for the test to assess operational readiness and detect degradation. Also, address whether instrumentation that meets Code accuracy can be obtained at greater expense.

Answer:

An accuracy statement of +/- 6.56% of "reading" is in most cases more accurate than the vibration accuracy requirement of IWP. IWP requires vibration instrument accuracy to be +/- 5% of "full scale" and requires the full-scale range to be 3 times the reference value or less. Therefore IWP allows accuracy to be +/- 15% of "reading" at the reference value and greater than +/- 15% of "reading" at less than the reference value.

A comparison between the accuracy specified in the relief request and OM-6 is not as straightforward as the above. The relief request specifies accuracy as percent of "reading". OM-6 does not specify that its +/- 5% accuracy statement is relative to "readings" or "full scale". Therefore, comparisons between the accuracy specified in OM-6 and the relief request can not be clearly made.

The basis for the proposed instrument accuracy is that large changes in vibration levels are the best indicator of pump degradation. For most pumps vibration will have increased at least 250% to enter the Alert Range (>2.5V_r to 6V_r) or 600% to enter the Required Action Range (>6V_r). Since such high percent changes in vibration usually occur before a pump enters the Alert or Required Action Range, a +/-6.56% of reading accuracy statement is insignificant.

Some pumps may enter the Alert or Required Action Range based on the fixed vibration limits of >0.325 in/sec to 0.70 in/sec for the Alert Range, and >0.70 in/sec for the Required Action Range. These fixed vibration units were extracted from vibration severity charts. While the charts are in general agreement, there is not agreement on specific numbers. The fixed units in the Relief Request are the units required by OM-6. These fixed units are necessary because for a pump with a high V_r an alert range of 2.5 V_r to 6 V_r and a required action range of 6 V_r is not acceptable.

The accuracy statement in OM-6 could probably be met if unlimited resources were available. However, any improvement in vibration instrument accuracy would have a negligible positive impact on the effectiveness of vibration monitoring. As stated above, a +/- 6.56% accuracy statement is insignificant; therefore, any small improvements in accuracy are even more insignificant. Instrumentation changes would be expensive and would disrupt the well established and effective vibration monitoring program in place. Following are examples of how better accuracy statements would be obtained.

- More accurate and more expensive accelerometers could be used, however, due to limited frequency response ranges measurements would probably have to be taken with two different accelerometers at each monitoring point. This would increase monitoring times as well as radiation exposure and manpower needs. It would also require data splicing to get an overall reading.

- Expensive and very accurate laser vibrometers could be used. They must be totally isolated from vibration sources; however, so they are not suitable for field applications.

3. OM-6 Table 3 shows "Acceptable", "Alert", and "Required Action" ranges based on the reference value for vibration velocity. Catawba proposed assigning absolute vibration velocity "Alert" and "Required Action" limits for their smoothly running pumps (those pumps with vibration velocity reference values less than 0.075 in/sec). This deviation from OM-6 may not be conservative for every pump in this classification since it could allow a large change in vibration velocity measurements, from the reference value, prior to reaching the assigned limits. Alternate methods such as using different absolute values of acceptance criteria or setting minimum reference values should be adequately justified.

Answer:

Fixed acceptance limits have been assigned for smooth running pumps to insure that they do not fall into the alert or required action range while still running smoothly. The alert and required action ranges in OM-6 are relative to reference values; therefore, smooth running pumps could fall into the alert or required action range. For example, when V_r = .005 in./sec, action is required at .031 in/sec. This is inappropriate since pump vibrations of .031 in/sec are of no concern. Also, any corrective actions taken could possibly increase vibration levels.

The fixed acceptance limits that have been assigned for smooth running pumps are acceptable because they are conservative. Vibration levels within the limits are acceptable for all pumps and any change up to the limits are considered acceptable.

The limits were established, in part, by substituting 0.075 in/sec into the relative acceptance criteria of OM-6. Therefore, "very smooth" running pumps (V_r < 0.075 in/sec) will have the same alert and action limits that OM-6 establishes for "moderately smooth" running pumps (V_r = 0.075).

It should be noted that IWP-3210 allows alternate acceptance criteria to established and used.

4. OM-6 recommends measuring pump vibration displacement for low speed pumps (i.e., <600 rpm). Clarify how this relief request addresses the OM recommendation to measure displacement for low speed pumps.

Answer:

None of the pumps in the Catawba Inservice Testing Program operate at less than 600 rpm; therefore, there is no need for the relief request to address the OM-6 recommendation to measure vibration displacements for pumps that operate at less than 600 rpm.

5. OM-6 Section 4.6.1.6 states that the frequency response range "...shall be from 1/3 minimum pump shaft rotational speed to at least 1000 Hz." Provide justification to assure that pump degradation of low speed pumps will be observed with the proposed instrumentation. Address this issue for the low speed pumps at Catawba in terms of likely degradation mechanisms with responses at less than RPM frequencies. Also, address whether instrumentation that meets Code accuracy can be obtained at greater expense.

Answer:

The slowest speed pumps in the Catawba Inservice Testing Program are the Nuclear Service Water Pumps and the Control Area Chilled Water Pumps. They run at 715 and 1770 rpm respectively. 1/3 pump speed for these pumps corresponds to 3.95 and 9.83 Hz respectively. The relief request specifies that vibration instrumentation will be calibrated from 10 to 1000 Hz. Therefore, the nuclear service Water Pumps are the only pumps that will be monitored significantly below the range instruments are calibrated over.

The fact that instruments will not be calibrated below 10 Hz does not mean that meaningful measurements can not be taken over the range from 3.95 to 10 Hz. The vibration instruments used are repeatable in this range. Also, the instrument manufacturers specify that their accuracy statements are valid over this range under certain conditions (this can not be verified due to instrument limitations).

The range from 3.95 to 10 Hz constitutes less than 1% of the range over which measurements will be taken; therefore, any additional inaccuracy over this range will have an insignificant impact on overall vibration measurements. Hence the lack of an accuracy statement over this range is insignificant.

The discussion of the available instrumentation in response 2 also applies here.

ATTACHMENT II

DUKE POWER COMPANY
Catawba Nuclear Station
General Relief Request

PUMPS: All pumps included in the IST program.

TEST REQUIREMENTS: IWP-3100 and IWP-3300 require vibration amplitude to be measured. IWP-3210 specifies the allowable ranges of vibration amplitude measurements. IWP-4110 requires the accuracy of vibration amplitude measurements to be +/- 5% of full scale. IWP-4120 requires the full-scale range of vibration instrumentation to be three times the reference value or less. IWP-4510 requires displacement vibration amplitude to be read at one specific location during each test. IWP4520(b) requires the frequency response range of vibration instrumentation to be from one-half minimum speed to at least maximum pump shaft speed.

BASIS FOR RELIEF: Experience has shown that measuring vibration as required by IWP is not the most effective way to determine the mechanical condition of a pump. In order to better determine the mechanical condition of pumps, multiple vibration velocity measurements will be obtained/evaluated and supplemented, when necessary, with acceleration/displacement measurements and spectral analysis. In order to facilitate this testing, digital vibration instrumentation will be used.

IWP does not provide adequate guidance/requirements for performing the better/alternate testing.

ALTERNATIVE TESTING: In lieu of the vibration requirements of IWP-3100 and IWP-3300, peak vibration velocity will be measured. In most cases, vibration velocity gives the best indication of machine mechanical condition.

In lieu of IWP-4520(b) vibration instrumentation will be calibrated over a range of 10 to 1000 Hz. This is the range that the state of the art instrumentation used can be adequately calibrated over. In lieu of IWP-4520(b) vibration velocity will be measured over a range from 1/3 minimum pump shaft rotational speed to 1000 Hz.

(Measurements at other frequencies will be taken as necessary.) This range will encompass most potential noise contributors.

In lieu of the vibration instrument accuracy requirements of IWP-4110, the loop accuracy of vibration instruments will be +/- 6.56% of reading. This accuracy will be used because IWP does not specify an accuracy for vibration velocity. This accuracy is the best that can be reasonably obtained from the state of the art instrumentation used. (The requirements of IWP allow vibration inaccuracies of greater than +/- 15% of reading.)

In lieu of the range requirements imposed on vibration instrumentation by IWP-4120, there will be no vibration instrumentation range requirement (digital vibration instrumentation is auto-ranging). It is not necessary to have a range requirement because the accuracy stated above and the readability of a digital gauge are not dependent upon instrument range.

In lieu of the vibration ranges specified in IWP-3210, the following ranges shall be used. These ranges will be used because IWP does not specify ranges for vibration velocity. These ranges are based on current vibration standards (vibration severity charts).

	Acceptable Range	Alert Range	Required Action Range
For All Pumps When V_r </=0.075 in/sec	0 to 0.19 in/sec	>0.19 to 0.45 in/sec	>0.45 in/sec
For Centrifugal Pumps When V_r >0.075 in/sec	</=2.5V_r	>2.5V_r to 6V_r or >0.325 to 0.70 in/sec	>6V_r or >0.70 in/sec
For Reciprocating Pumps When V_r >0.075 in/sec	</=2.5V_r	>2.5V_r to 6V_r	>6V_r

In lieu of IWP-4510, peak vibration velocity measurements shall be taken during each test.

- On centrifugal pumps, measurements shall be taken in a plane approximately perpendicular to the rotating shaft in two orthogonal directions. These measurements shall be taken on each accessible pump bearing housing. If no pump bearing housings are accessible, these measurements shall be taken at the accessible location that gives the best indication of lateral pump vibration. This location shall be one of the following.

    Pump casing
    Motor bearing housing

Measurements also shall be taken in the axial direction. This measurement shall be taken on each accessible pump thrust bearing housing. If no pump thrust bearing housings are accessible, this measurements shall be taken at the accessible location that gives the best indication of axial pump vibration. This location shall be one of the following.

    Pump casing
    Motor thrust bearing housing
    Motor casing

- On reciprocating pumps, a measurement shall be taken on the bearing housing of the crankshaft, approximately perpendicular to both the crankshaft and the line of plunger travel.