August 22, 2000

Mr. Charles H. Cruse
Vice President - Nuclear Energy
Calvert Cliffs Nuclear Power Plant, Inc.
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

SUBJECT: SAFETY EVALUATION OF RELIEF REQUESTS FOR THE THIRD 10-YEAR PUMP AND VALVE IN-SERVICE TESTING PROGRAM CALVERT CLIFFS NUCLEAR POWER PLANT UNITS 1 AND 2 (TAC NOS. MA7848 AND MA7849)

Dear Mr. Cruse:

By letter dated December 30, 1999, as supplemented May 19, 2000, Baltimore Gas and Electric Company, licensee for the Calvert Cliffs Nuclear Power Plant; Unit Nos. 1 and 2, submitted three relief requests related to their third 10-year interval inservice testing program for pumps and valves. Relief Request PR-05 was granted on an interim basis in the staff's Safety Evaluation dated February 11, 1998, for a period of 1 year (note: the licensee submitted their revised relief request 10 months after the interim period expired). In addition, the licensee has submitted two new Relief Requests, PR-11 and VR-14. The NRC staff has reviewed the proposed alternative testing methods in these relief requests against the requirements of the American Society of Mechanical Engineers Section XI Code which references Operations and Maintenance (OM) Standards Part 6 for pumps and Part 10 for valves.

The staff finds proposed alternatives PR-05 and PR-11 may be authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the determination that compliance with the specified requirements results in a hardship without a compensating increase in the level of quality and safety. The proposed alternative VR-14 may be authorized pursuant to 10 CFR 50.55a(a)(3)(i) based on the determination that the proposed alternative testing provides an acceptable level of quality and safety.

Sincerely,

/RA/

Marsha Gamberoni, Chief, Section I
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-317 and 50-318

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE INSERVICE TESTING PROGRAM THIRD 10-YEAR INTERVAL

CALVERT CLIFFS NUCLEAR POWER PLANT, INC.

CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NOS. 1 AND 2

DOCKET NUMBERS 50-317 AND 50-318

1.0 INTRODUCTION

The *Code of Federal Regulations*, 10 CFR 50.55a, requires that inservice testing (IST) of certain American Society of Mechanical Engineers (ASME) Code Class 1, 2, and 3 pumps and valves be performed in accordance with Section XI of the ASME *Boiler and Pressure Vessel Code* (the Code) and applicable addenda, except where alternatives have been authorized or relief has been requested by the licensee and granted by the Commission pursuant to paragraphs (a)(3)(i), (a)(3)(ii), or (f)(6)(i) of 10 CFR 50.55a. 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 its facility. Section 50.55a authorizes the Commission to approve alternatives and to grant relief from ASME code requirements upon making the necessary findings. NRC guidance contained in Generic Letter (GL) 89-04, "Guidance on Developing Acceptable Inservice Testing Programs," provides alternatives to the Code requirements which are acceptable. Further guidance is given in GL 89-04, Supplement 1, and NUREG-1482, "Guidelines for Inservice Testing at Nuclear Power Plants."

By letter dated December 30, 1999, as supplemented May 19, 2000, Calvert Cliffs Nuclear Power Plant, Inc., the licensee, submitted three relief requests for the third 10-year interval of the IST program for pumps and valves for Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2. The third 10-year interval began on January 15, 1998, and is scheduled to end January 14, 2008. The IST program was developed in accordance with the requirements of the 1989 Edition of the ASME Section XI Code which reference ASME/ANSI *Operations and Maintenance (OM) Standards* Part 6 and Part 10 (OM-6, and OM-10) for IST of pumps and valves respectively.

The NRC's findings with respect to authorizing alternatives and granting or denying the IST program relief requests are given below.

Enclosure

2.0 PUMP RELIEF REQUESTS

2.1 Relief Request PR-05

The licensee has requested relief from the frequency response range requirements of vibration measurement of OM-6, Paragraph 4.6.1.6, for the instrumentation used to measure the vibration of the reactor coolant charging pumps. The licensee has proposed to use instrumentation with a frequency response range minimum of 3 Hz as opposed to 1.16 Hz which is required by the Code. The 3 Hz minimum is below the running speed of the pump which is approximately 3.48 Hz.

2.1.1 Licensee's Basis for Requesting Relief

The licensee states:

> The rotational shaft speed of the charging pumps is 209 rpm relating to a rotational frequency of approximately 3.48 Hz. In order to satisfy the requirements of paragraph 4.6.1.6, a vibration measurement system capable of measuring vibration to a lower limiting frequency of 1.16 Hz would be required.
>
> The instruments currently being used at Calvert Cliffs have a lower frequency limit for reliable, accurate measurement of 3 Hz. This instrumentation is "state-of-the-art" industrial grade, high quality equipment. Satisfying the Code requirements with respect to frequency response would require special calibration by off-site vendors which would involve extra expense. Because calibration of the instrument would require sending it off-site, and because of the extra expense of this special calibration, the use of this instrumentation would have to be restricted to monitoring charging pump vibration only in order to minimize the potential for damage to the instrument. Since this special calibration would require sending the instrument off-site, additional analyzers that were used solely for monitoring the charging pumps would be required in order to ensure at least two (one primary and one backup) were always in calibration and available on-site.
>
> According to Table 6.0, "Illustrated Vibration Diagnostic Chart," contained in "Predictive Maintenance and Vibration Signature Analysis I," by J. E. Berry, Technical Associates of Charlotte, Inc., the anomaly which would normally be expected to produce only sub-harmonic vibrations is oil whip/whirl. Other conditions that could result in low frequency vibration (less than shaft speed) would normally also be detectable at shaft running speed, and harmonic and non-harmonic frequencies. Therefore, monitoring lower frequencies (less than rotational speed) is performed primarily for the purpose of detecting oil whirl or whip in journal bearings. However, the main bearings in Calvert Cliffs' charging pumps are oil-mist lubricated tapered roller bearings that are not susceptible to the oil whip or whirl phenomena. Calibrating the instruments down to 3 Hz will include some sub-harmonic frequencies. Additionally, although the instrumentation used by Calvert Cliffs will only be calibrated down to 3 Hz which is slightly less than pump running speed (approximately *85%),* it will remain capable of detecting vibrations at frequencies as low as 1 Hz. This means we would still expect to detect any developing sub-harmonic vibrations which could still at least be qualitatively evaluated.

Seal rub and bearing looseness are two other conditions which may be detected at sub-harmonic frequencies. The primary indicator for seal rub is a truncation of the waveform observed through time-domain waveform analysis. Bearing looseness can also be identified through waveform analysis. Normally, harmonics of shaft speed would also be detectable in order to confirm this condition.

In addition to the American Society of Mechanical Engineers pump testing, Calvert Cliffs has implemented a "Rotating Machinery Vibration Monitoring Program" that includes periodic vibration monitoring of the charging pumps. This program is inclusive and encompasses a wider range of vibration analyses and frequencies, including time-domain waveform analysis, phase analysis, and spectral analysis, at various critical pump and motor locations. The data derived from this expanded program along with the Inservice Test vibration data will provide a high degree of assurance that the anomalies of concern can be identified and significant pump degradation will not go undiscovered.

Based on: (1) the fact that Calvert Cliffs' charging pumps are not susceptible to oil whip/whirl which is the major anomaly which would normally be expected to produce only sub-harmonic vibrations, (2) the low probability of any other anomalies producing vibrations at only sub-harmonic frequencies and not at running speed or harmonic and/or non-harmonic frequencies, and (3) Calvert Cliffs' "Rotating Machinery Vibration Monitoring Program," the added expense of the special calibration and additional test equipment necessary outweighs their benefit.

2.1.2 Alternate Testing

The licensee proposes:

The instruments used for measuring vibration on the reactor charging water pumps will have a frequency response calibrated range that extends to a lower limiting frequency of 3 Hz.

The charging pumps will be included in the Calvert Cliffs' "Rotating Machinery Vibration Monitoring Program" that includes periodic vibration monitoring and analysis of each pump.

2.1.3 Evaluation

The Code requires that the frequency response range for vibration instrumentation be from a minimum of 1/3 running speed to at least 1000 Hz. The reactor coolant charging pumps have a rotational speed of approximately 209 revolutions per minute (rpm) corresponding to a frequency of 3.48 Hz. Therefore, for these pumps, the Code would require that the frequency response range be from a minimum of 1.16 Hz to at least 1000 Hz.

The staff granted interim relief in a safety evaluation (SE) dated February 11, 1998, because the licensee did not provide sufficient information on the hardship or unusual difficulty associated with complying with the Code and the proposed lower frequency response range of 4 Hz did not bound the pump running speed of 3.48 Hz. An additional commitment by the licensee to include these pumps in their rotating machinery vibration monitoring program was

recognized but could not be assessed because specific information was not provided about the program.

The licensee now states that the minimum frequency response range is 3 Hz which does bound the running speed. In addition, these pumps have tapered roller bearings which are not susceptible to oil whip or oil whirl phenomenon as are journal bearings. The licensee has also described that their Rotating Machinery Vibration Monitoring Program includes spectral analysis, which is not currently required by the Code, to identify potential vibration sources. Therefore, it would be a hardship for the licensee to procure additional equipment to meet the Code requirements when the existing vibration instrumentation is able to adequately detect degradation in the reactor charging pumps. The proposed alternative testing provides a reasonable assurance of operational readiness because of the reasons stated above.

2.1.4 Conclusion

The proposed alternative to the Code frequency response lower range requirement of OM Part 6, Paragraph 4.6.1.6, for the reactor coolant charging pumps is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the determination that compliance with the specified requirements results in a hardship without a compensating increase in the level of quality and safety.

2.2 Relief Request PR-11

The licensee has requested relief from the vibration alert range absolute acceptance criteria requirements of 0.325 inches per second (ips) as specified in OM-6, Table 3a, for several measured vibration directions of each of the four low-pressure safety injection (LPSI) pumps (two pumps per unit). The relief is requested for the quarterly testing of these pumps only. Flow testing at cold shutdowns and refueling outages is performed at substantial flow rates [3000 gallons per minute (gpm)]. The licensee has proposed new alert range absolute acceptance criteria for measured directions which have an average reference value greater than or equal to 0.26 ips.

2.2.1 Licensee's Basis for Requesting Relief

The licensee states:

> The LPSI Pumps are tested quarterly using the minimum recirculation flow path from each pump through the minimum recirculation piping associated with each pump to the minimum recirculation flow common header and back to the refueling water tank. The common header is instrumented with an ultrasonic flow meter. During the quarterly test, the pumps are operated one at a time. After the required stabilization period, flow rate and differential pressure are measured, recorded, and compared to acceptance criteria developed in accordance with the hydraulic acceptance criteria requirements specified in Table 3b. However, as discussed in Calvert Cliffs Nuclear Power Plant (CCNPP) Pump Relief (PR)-01 Request, flow is not throttled during the quarterly test to eliminate the potential for pump overheating and damage should flow inadvertently be throttled below that required to ensure adequate pump cooling.

As further discussed in PR-01, the LPSI pumps are tested at a substantial flow rate (approximately 3000 gpm) during every refueling outage, as well as during planned and unplanned cold shutdown periods when plant conditions and circumstances permit. These tests are known at CCNPP as "Large Flow Rate" tests. Calvert Cliffs Nuclear Power Plant's PR-01 Request was previously approved in the Safety Evaluation Report for CCNPP's Third 10-Year Inservice Test (IST) Interval provided by the Nuclear Regulatory Commission, dated February 11, 1998.

During refueling outages and cold shutdown periods, the LPSI pumps are used for shutdown cooling. However, during the normal operating cycle, the LPSI pumps generally are operated only for quarterly minimum recirculation flow IST pump testing, quarterly Engineered Safety Feature Actuation System testing, and to support quarterly IST testing of the High Pressure Safety Injection (HPSI) Header Loop Isolation Check Valves.

During the Second 10-Year IST Interval, Article IWP requirements did not permit measuring and recording vibration in terms of velocity. Therefore, historically, the surveillance procedures used to perform these tests required vibration measurements to be recorded in terms of displacement (mils), not velocity. In recognition of the better indications provided by vibration measurements in terms of velocity, and as now permitted by OM-6, CCNPP is converting the vibration testing in the surveillance procedures to utilize velocity. However, CCNPP long ago recognized the benefit of velocity over displacement for analyzing pump vibrations and has included such measurements in the CCNPP Rotating Machinery Vibration Monitoring Program, which conducts periodic vibration monitoring and analysis of numerous pumps and motors (including the LPSI pumps) beyond that required for the IST Program. The CCNPP Rotating Machinery Vibration Monitoring Program includes spectral analysis of the vibration measurements.

The long-term vibration trend (1995 through present) during quarterly testing of the LPSI pumps using the minimum recirculation flow path shows consistent results and stable performance with no unexplainable significant changes. The quarterly tests are performed at approximately 40-50 gpm which is between approximately 1.3%-1.6% of the LPSI pumps' "Best Efficiency Flow Rate." The Best Efficiency Flow Rate is based on the original Vendor Pump Curve. It is used instead of the system 5 design flow rate because the onset of pump internal recirculation and cavitation is a function of the pump's performance characteristics, not the system's design requirements.

As discussed in Attachment 1 [of letter dated December 30, 1999,] "Effect of Pump Operation at Low Flow Rates," operating the LPSI pumps at these low flow rates results in a variety of effects (e.g., internal recirculation, cavitation, and force imbalance on the impeller) which contribute to increased vibration. Spectral analysis of the LPSI pump vibration measurements reveals: (1) a general increase in the broadband noise levels which is indicative of internal recirculation and cavitation, and (2) discrete spikes at frequencies corresponding to the blade pass frequency which is indicative of force imbalances acting on the impeller. (References: "Centrifugal Pump Clinic," 2nd edition, by Igor Karassik, Published by Marcel Dekker Inc., 1989, and "Predictive Maintenance and Vibration Signature Analysis I," by J. E. Berry, Technical Associates of Charlotte, Inc., Table 6.0, "Illustrated Vibration Diagnostic Chart.")

The “Large Flow Rate" tests for the LPSI pumps have been in use at CCNPP since approximately 1991. At a minimum, each pump has been tested during each refueling outage since these tests were implemented. Vibration data (in both displacement and velocity) was collected during these tests via the surveillance tests themselves and the CCNPP Rotating Machinery Vibration Monitoring Program. The vibration data recorded during these large flow tests show the overall vibration levels drop significantly, as expected. Furthermore, spectral analysis of these results show the general broadband noise and spikes at discrete frequencies caused by the blade passing are significantly reduced.

The following factors lead to the conclusion that the current vibration levels recorded during LPSI minimum recirculation flow testing are acceptable and are not indicative of any pump mechanical problems or degradation, and, therefore, that the LPSI pumps are operating acceptably.

(1) The long-term stability of the vibration trend based on data from the surveillance tests and CCNPP Rotating Machinery Vibration Monitoring Program obtained during quarterly minimum recirculation flow testing.

(2) Spectral analysis confirmed the major contributor to the overall vibration levels recorded during quarterly minimum recirculation flow testing is consistent with phenomena which are well known to be associated with operation of a centrifugal pump at low flow rates and also well known to cause higher vibrations at these low flow rates.

(3) The overall vibration levels recorded during large flow testing of the LPSI pumps are significantly reduced compared to the levels recorded during the quarterly minimum recirculation flow tests and are consistent with vibration levels experienced while testing centrifugal pumps at substantial flow rates in other Systems and applications.

(4) Spectral analysis confirmed that the major contributors to the overall vibration levels observed during quarterly minimum recirculation flow testing which are associated with operation of a centrifugal pump at low flow rates are significantly reduced during large flow testing of the LPSI pumps.

(5) Similar vibration patterns have been observed for the other standby Emergency Core Cooling System pumps, although the effects are not as pronounced as they are for the LPSI pump because the LPSI pumps are the pumps which are tested at the lowest flow condition relative to their Best Efficiency Flow Rate.

(6) The LPSI pumps have no history of mechanical failures nor have they required significant maintenance on a regular basis.

The overall vibration levels observed during quarterly LPSI pump minimum recirculation flow testing, augmented by spectral analysis, are not sufficiently high as to prevent detection of increases in the LPSI pump vibration levels which would be indicative of mechanical degradation. Furthermore, the vibration monitoring during less frequent LPSI pump large flow testing, also augmented by spectral analysis, provides even

greater opportunities to detect increases in the LPSI pump vibration levels which would be indicative of mechanical degradation. Calvert Cliffs Nuclear Power Plant's experience has shown that spectral analysis of the vibration measurements obtained during quarterly minimum recirculation flow testing is sufficiently sensitive to changes in the pumps' mechanical condition and provides reasonable assurance that mechanical degradation can be detected early.

Performing pump testing at double the normal quarterly frequency when vibration levels exceed the acceptance criteria specified in Table 3a is physically possible, i.e., it is practicable. However, based on the discussions contained in Attachment (1), "Effect of Pump Operation at Low Flow Rates," such increased frequency testing will potentially reduce LPSI pump reliability and increase the probability of LPSI pump degradation, damage, or failure. Therefore, such testing is considered impractical because, though it is possible to perform such increased frequency testing, the potential reduction in LPSI pump reliability and potential increase in the probability of LPSI pump degradation, damage, or failure is a result which is contrary to the intent of the IST Program.

The running time of these pumps during the operating cycle is very limited since operation at low flow rates is detrimental to the pumps. Performing increased frequency testing on a regular basis during the operating cycle would increase the run time of these pumps by as much as approximately 30%. Title 10 Code of Federal Regulations 50.55a(a)(3)(i) and (ii) address alternatives when the Code requirement would result in either a use of resources or a hardship/burden with no commensurate increase in the level of quality or safety. Not only would increased frequency testing of the LPSI pumps be both a waste of resources and a hardship/burden with no commensurate increase in the level of quality or safety, but such unnecessary testing will actually result in a very real potential to reduce the level of quality and safety and, therefore, should be considered impractical.

2.2.2 Alternative Testing

The licensee proposes:

Table 3a specifies the value defining the upper limit of the acceptable range and the lower limit of the alert range shall be 2.5 times the reference value, not to exceed 0.325 ips. This means that up to a reference value of 0.13 ips, a 250% margin is allowed between the reference value and the "alert limit."

Clearly, relief is required for any vibration measurement with a reference value which is greater than the absolute alert limit of 0.325 ips specified by OM-6. However, there are also several vibration measurements which are "close" to the limit of 0.325 ips but do not exceed it. For these velocity measurements, relatively small increases in the overall vibration level which would normally be considered acceptable will cause them to exceed 0.325 ips, thus reducing the benefit and effectiveness of this relief request. Therefore, the following criteria is intended to allow a minimum of a 25% margin between each vibration reference value and the respective alert limit.

However, in no case shall the alert limit exceed 90% of the maximum vibration level allowed by the Code [0.700 ips for the LPSI pump] (i.e., the "action limit"). This

corresponds to a maximum allowable alert limit of 0.630 ips (90% X 0.700 ips). Based on the vibration instrumentation accuracy requirements in OM-6, this level is sufficient to ensure that a reading in the acceptable range cannot actually be greater than the action limit of 0.700 ips due to instrument accuracy/uncertainty. Attachment (2) [of letter dated December 30, 1999,] provides a detailed discussion regarding the manner in which the reference values were developed and evaluated, and also includes the specific reference values and alert/action limits to be used at this time for information.

Reference Value (V_R) inches per second (ips)	Acceptable Range	Alert Range	Action Range
$V_R \leq 0.11$	$V \leq 2.5\ V_R$	$2.5\ V_R < V \leq 6\ V_R$	$6\ V_R < V$
$0.11 < V_R \leq 0.13$	$V \leq 2.5\ V_R$	$2.5\ V_R < V \leq 6\ V_R$	$0.700 < V$
$0.13 < V_R < 0.26$	$V \leq 0.325$	$0.325 < V < 0.700$	$0.700 < V$
$0.26 \leq V_R \leq 0.50$	$V \leq 1.25\ V_R$	$1.25\ V_R < V \leq 0.700$	$0.700 < V$
$0.50 \leq V_R$	$V \leq .630$	$0.630 < V \leq 0.700$	$0.700 < V$

Calvert Cliffs Nuclear Power Plant believes this approach provides greater flexibility than does seeking approval of specific values. This flexibility will permit CCNPP to revise the alert limits (within the guidelines contained in this relief request) should the need arise, such as following maintenance, after the necessary technical evaluation without using significant additional CCNPP or Nuclear Regulatory Commission resources.

Spectral analysis of quarterly minimum flow vibration results and less frequent large flow vibration results in accordance with CCNPP's Rotating Machinery Vibration Monitoring Program will continue to provide adequate assurance that increases in vibration levels at discrete frequencies which are not sufficiently large to affect the overall vibration reading will be detected and analyzed.

2.2.3 Additional Information Provided by the Licensee

In its submittal, the licensee has provided two attachments. The first provides a brief dissertation on the effect of pump operation at low flow rates and quotes material from “Centrifugal Pump Clinic” by Igor Karassik and is not repeated in this SE. The second attachment provides a discussion of the licensee’s methodology of evaluating raw vibration data and is included below.

Calvert Cliffs Nuclear Power Plant has had a Rotating Machinery Vibration Monitoring Program for over eight years. During the Second 10-Year 1ST Interval, the IST reference values, alert and action limits, and vibration measurements used displacement (mils). During this same time frame, the vibration measurements for the Rotating Machinery Vibration Monitoring Program used velocity (inches per second - ips). For numerous years, these measurements have been recorded simultaneously (i.e., at the same time and the same pump operating conditions) and at the same locations on each pump during the IST surveillance tests. Although there is no direct quantitative

correlation which can be made between displacement and velocity, a qualitative comparison was made in that no degrading trend exists in terms of displacement or velocity.

The new velocity reference values and alert/action limits were developed using this data. Although there are several years of data available, the evaluation was generally limited to data acquired since 1995 to ensure the reference values reflected and validated current pump performance levels. Where major maintenance (such as pump/driver overhaul/replacement or changes in the attached piping configuration) changed baseline pump vibration levels, a shorter period of time may have been used. During this time frame, there were numerous quarterly tests performed for each LPSI pump in the minimum recirculation flow configuration. Additionally, each LPSI pump was tested at least once in the large flow configuration during this time frame. Although in some cases the large flow reference values may be based primarily on one test result, such as due to comparatively recent maintenance, it should be noted that CCNPP implemented large flow testing of standby pumps approximately 1991 and has performed large flow testing during each refueling outage, at a minimum, since then. Therefore, several data points for each pump bearing vibration measurement were available for qualitative comparison even if they could not be directly incorporated into calculating the new reference value due to subsequent maintenance.

The process used to develop the new velocity reference values is outlined below:

1. The raw data was evaluated to determine if any long-term or short-term degrading trends or significant unexplainable changes in vibration levels existed. This included spectral analysis which confirmed the source of the higher overall vibration levels recorded during quarterly minimum recirculation flow testing are a result of the phenomena discussed in Attachment (1).

2. The vibration data obtained during quarterly minimum recirculation flow testing was compared to the vibration data obtained during large flow testing. This also included spectral analysis to confirm that the reduction in overall vibration levels recorded during large flow testing was due to the reduction of the contributors identified during the spectral analysis of the overall vibration levels recorded during quarterly minimum recirculation flow testing.

3. The major maintenance history during the time frame being evaluated was reviewed for each pump/driver. Where vibration levels were significantly changed following major maintenance (e.g., overhaul or replacement of the pump or driver), the performance data prior to the maintenance was discarded.

4. The raw data was reviewed to evaluate its consistency. Data points which appeared to be outliers (i.e., anomalous data points which were unusually high or low) were evaluated and generally eliminated from the data population, as long as they were unique and not part of a degrading trend.

5. The data trends for all the pump bearing vibration measurements were compared to each other to identify any pump bearing vibration measurements with unusual characteristics. No significant differences were noted.

6. The reference value for each pump bearing vibration measurement was based on averaging the remaining raw data points. The sensitivity of each reference value was evaluated by comparing the reference values with the averages obtained using all the raw data, including the data points considered anomalous. In all cases, there were a sufficient number of data points available so that eliminating the data points of lower confidence did not have an appreciable effect on the reference value.

7. The results were then qualitatively compared to the results obtained from similar evaluations performed to establish the reference values for the HPSI pumps and containment spray pumps. The same effects were noted for the HPSI and containment spray pumps, although the magnitude was not as great because they are operated at approximately 8% and 4%, respectively, of their Best Efficiency Flow Rate during quarterly minimum recirculation flow tests. (Additionally, the HPSI pumps are multi-stage which reduces the magnitude of the force imbalance.) The Best Efficiency Flow Rate for each pump type is based on the original Vendor Pump Curve. It is used instead of the system's design flow rate because the onset of pump internal recirculation and cavitation is a function of the pumps' performance characteristics, not the system's design requirements.

11 LPSI	Minimum Recirculation Flow Test					Large Flow Test				
	PIH*	PIV*	POH*	POV*	POA*	PIH*	PIV*	POH*	POV*	POA*
Reference Limit	.24	.55	.11	.34	.09	.09	.08	.06	.06	.04
Alert Limit	.325	.630	.275	.425	.225	.225	.200	.150	.150	.100
Action Limit	.700	.700	.660	.700	.540	.540	.480	.360	.360	.240

12 LPSI	Minimum Recirculation Flow Test					Large Flow Test				
	PIH	PIV	POH	POV	POA	PIH	PIV	POH	POV	POA
Reference Limit	.40	.43	.13	.29	.08	.17	.12	.08	.16	.05
Alert Limit	.500	.538	.325	.363	.200	.325	.300	.200	.325	.125
Action Limit	.700	.700	.700	.700	.480	.700	.700	.480	.700	.300

21 LPSI	Minimum Recirculation Flow Test					Large Flow Test				
	PIH	PIV	POH	POV	POA	PIH	PIV	POH	POV	POA
Reference Limit	.22	.45	.10	.31	.09	.08	.12	.05	.08	.03
Alert Limit	.325	.563	.250	.388	.225	.200	.300	.125	.200	.075
Action Limit	.700	.700	.600	.700	.540	.480	.700	.300	.480	.180

* PIH - Pump Inboard - Horizontal
* PIV - Pump Inboard - Vertical
* POH - Pump Outboard - Horizontal
* POV - Pump Outboard - Vertical
* POA - Pump Outboard - Axial

22 LPSI	Minimum Recirculation Flow Test					Large Flow Test				
	PIH	PIV	POH	POV	POA	PIH	PIV	POH	POV	POA
Reference Limit	.25	.31	.09	.28	.10	.08	.09	.06	.05	.04
Alert Limit	.325	.388	.225	.350	.250	.200	.225	.150	.125	.100
Action Limit	.700	.700	.540	.700	.600	.480	.540	.360	.300	.240

2.2.4 Evaluation

The Code requires in Paragraph 6.1 of OM-6 that when a measured pump overall vibration parameter is recorded in the alert range as specified in Table 3a of OM-6, the test frequency of the pump shall be doubled until the cause of the deviation is determined and the condition is corrected. A pump in the alert range is required to double its quarterly test frequency to approximately once every 6 weeks. In addition, pumps tested on a refueling outage frequency (e.g., in accordance with GL 89-04, Position 9) would also require double of the test frequency when they entered the alert range unless the condition is corrected prior to exiting the outage. The doubling of the test frequency serves to provide more information on the deviation for a determination of its cause. A pump is still considered operable when either the vibration or hydraulic parameters are in the alert range as applicable.

The LPSI pumps at Calvert Cliffs serve a residual heat removal function during cold shutdowns and refueling outages as well as low-pressure safety injection during certain design-basis events. During quarterly inservice testing, these pumps use the recirculation line as the test flow path. The licensee states that the maximum capacity of the recirculation line is 40 - 50 gpm which they state is approximately 1.3 to 1.6 percent of the best efficiency point of each LPSI pump. This is viewed to be a very low recirculation flow rate for a pump of this design. The licensee has provided a detailed description of the problems associated with operating centrifugal pumps at conditions similar to those experienced by the LPSI pumps at Calvert Cliffs. Amongst these problems include potential increased overall pump vibration levels due to the large force imbalance on the pump impeller because of internal flow recirculation.

Relief Request PR-01 was granted for the licensee’s third 10-year IST program interval to test the pumps consistent with Position 9 of GL 89-04. This testing included quarterly vibration measurements using the reticulation coupled with substantial flow tests at cold shutdowns or refueling outages during which both pump flow and vibration data would be recorded and evaluated. The licensee has implemented the alternative testing. PR-01 did not discuss the issues brought forward in this relief request.

In its third 10-year interval, the licensee implemented OM-6 for testing of pumps. Included in the testing were requirements to test pumps with rotational speeds in excess of 600 rpm using overall vibration velocity vs. vibration displacement. Velocity measurements are regarded as a more accurate indication of pump degradation for pumps with a rotational speed greater than 600 rpm. The licensee’s proposed alternative includes current vibration reference values for all four LPSI pumps. Five of these reference values are above the Code absolute alert limit of 0.325 ips. In addition, four parameters are within 0.05 ips of the alert range with two of those parameters having exceeded the absolute alert limit at least once since the third 10-year interval was implemented.

Several other licensees have noted increased vibration levels relative to the absolute acceptance criteria when updating to OM-6. In some instances, these levels were above the Code alert and, in at least two cases, the required action vibration absolute acceptance criteria. When the level of the overall vibration velocity is not determined to be detrimental to the operation of the pump, a licensee will typically request relief from the Code absolute acceptance criteria stating, in the case of the absolute alert acceptance criteria, that it is a hardship to double the pump test frequency because the condition of the pump is acceptable.

In its evaluation of these proposed alternatives, the staff ensures that the licensee has demonstrated that (1) the measured vibration has historically operated at the current magnitude; (2) the vibration contributor causing this magnitude can be identified; (3) this vibration magnitude will not cause degradation from this contributor alone; and (4) degradation can be trended in the long term. Licensees provide this information by reviewing historic vibration information, consulting with the pump manufacturer to evaluate current pump performance, using spectral analysis to evaluate the noise contributors, and describing actions attempted to lower the vibration levels. For pumps which are tested at low flow conditions and determined to be in acceptable condition, the major noise contributor is found to be the vane pass frequency which occurs at a multiple of the number of impeller vanes. A number of proposed alternatives to use new vibration absolute alert acceptance criteria have been authorized when this specific information is provided and the condition of the pump is evaluated to be acceptable.

The licensee included in its proposed alternative vibration data on the four LPSI pumps. This information was based on test data collected since 1995 measuring overall vibration in inches per second (ips). It was noted that although the proposed alternative applies to all vibration parameters, not all of these parameters are in the alert range. The licensee has provided information on the current testing that these pumps are subjected to, including testing at increased flow rates which documents a significant reduction in the average overall vibration values. In addition, the licensee describes activities included in their rotating machinery vibration monitoring program to establish new alert limits for the LPSI pumps which are also provided in the above tables.

The licensee proposes to establish new ranges for all LPSI pump vibration parameters as follows:

> For LPSI pump vibration parameters with reference values from 0.26 ips to 0.50 ips, the alert limit will be 1.25 times the reference value ($1.25V_R$); and
>
> For LPSI vibration parameters with reference values above 0.50 ips, the alert limit is 0.630 ips.

The licensee's request as written would allow all LPSI pump vibration parameters to be subject to the higher alert vibration limits if their current vibration levels exceeded 0.26 ips. This alternative is not currently a part of the Code. The relief request as proposed would create a much larger margin for required action (i.e., increased testing), and allow testing and analysis to be deferred on potential problems that the Code alert limits would require the licensee to address. In addition to allowing degradation of vibration parameters to the alternate limits, the proposed alternative would also allow vibration parameters with reference values currently

above 0.26 ips to degrade to 0.63 ips without requiring the licensee to take corrective action. This condition is also not currently allowed in the Code and is inconsistent with previous authorized alternatives on this issue.

On March 21, 2000, the staff discussed with the licensee its concerns with this proposed alternative. As a result of this phone call, the licensee supplemented its proposed alternative in a submittal dated May 19, 2000. The licensee stated in its submittal that it would not revise reference values simply to avoid corrective action. They were only to be utilized when high vibration levels could be confirmed as being due to testing the LPSI pumps at low flow conditions. These clarifications satisfied the concerns of the staff in this area.

A revision was also provided in this submittal which specifically identified the vibration parameters for which the licensee was requesting relief. The licensee stated that maintenance activities on these pumps periodically resulted in the vibration reference values for certain parameters being increased while others on the same pump decreased when measured at low flow conditions. Post maintenance testing confirmed that the changes in vibration were due to the effects of low flow testing. The licensee provided two tables detailing which vibration parameter regularly exceeds or periodically exceeds or regularly challenges the Code absolute alert limit. These tables are reproduced below.

LPSI Bearing Parameters that Regularly Exceed 0.325 ips

LPSI Pump Bearing Vibration Parameter	Typical Vibration Value/Range (ips)
11 PIH	0.49
11 PIV	0.46
12 PIH	0.29-0.42
12 PIV	0.37-0.44
21 PIV	0.43-0.53
21 POV	0.29-0.34
22 PIV	0.29-0.37
22 POV	0.27-0.35

LPSI Bearing Parameters that Periodically Exceed or Regularly Challenge 0.325 ips

LPSI Pump Bearing Vibration Parameter	Typical Vibration Value/Range (ips)
11 POV	0.28-.034
12 POV	0.25-0.32
21 PIH	0.22-0.34
22 PIH	0.18-0.25

It has been the intent of the staff, with regards to proposed alternatives in this area, to authorize the alternative when the licensee can demonstrate that the vibration parameters are affected solely by the pump testing at low flow conditions. The licensee has also concluded that maintenance is a factor. Given the fact that extremely low flow testing conditions of these pumps occurred, slight variations in pump alignment after maintenance would be expected to affect the reference values. In addition, this licensee has proposed a graduated set of acceptance criteria that does not systematically place all vibration parameter alert limits at one new absolute alert limit. Finally, the inclusion of large flow tests demonstrates that the pumps are operating within the current acceptable Code limits. These aspects of the proposed alternative allow for the inclusion of vibration parameters that normally would not be considered for relief.

It would be a hardship for the licensee to meet the current Code vibration absolute alert acceptance criterion for the LPSI pump vibration parameters cited in this section of the SE because the pumps would be subject to unnecessary testing at low flow conditions which could potentially increase pump degradation.

The staff finds the proposed testing provides a reasonable assurance of operational readiness because the current condition of the pumps has been determined to be acceptable by testing, and the LPSI pumps have not experienced any degradation at the low flow testing condition. In addition, vibration measurement results at significantly higher flow rates has shown that the overall vibration levels are reduced for all LPSI pump vibration parameters.

2.2.5 Conclusion

The proposed alternative to the vibration alert range absolute acceptance criteria requirements of OM-6, Table 3a, for the LPSI pump vibration parameters listed in Section 2.2.4 of this SE is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the determination that compliance with the specified requirements results in a hardship without a compensating increase in the level of quality and safety.

2.2.6 Impracticality of Testing LPSI Pumps Currently in the Alert Range

During the course of its review, the staff determined that the licensee was not in compliance with the requirements of OM-6, Paragraph 6.1, for not doubling the test frequency, when one measured LPSI pump vibration pump parameter was in the alert range. OM-6 has no

provisions for testing of pumps which is determined to be impractical because a pump can be tested at any hydraulic performance point. The regulations, as specified in 10 CFR 50.55a (f)(5)(iv), regulation allow a determination of impracticality to be made provided that the licensee demonstrates the impracticality to the satisfaction of the Commission no later than 12 months after the expiration of the initial 10-year interval and each subsequent 10-year interval. The licensee did not make such a request. Had a request for relief from the Code corrective action requirements been made, it likely would not have met the “impracticality” determination under 10 CFR 50.55a (f)(6)(i) because the testing is currently being performed at power and the licensee has demonstrated that the pump is not degrading in its current testing regime (indeed, this is the justification to grant the change in the absolute vibration alert limits).

3.0 VALVE RELIEF REQUEST

3.1 Relief Request VR-14

The licensee has requested relief from the exercise test frequency requirements of OM-10, Paragraph 4.3.2.2, and the valve obturator movement requirements of OM-10, Paragraph 4.3.2.4, for the condensate storage tank (CST) vacuum breaker check valves 0-CD-6303A-VBV and 0-CD-6303A-VBV. The licensee has proposed to remove and inspect each valve at approximately the same time on a 4-year frequency not specifically tied to the refueling schedule for either unit.

3.1.1 Licensee’s Basis for Requesting Relief

The licensee states:

A. These check valves have no "position indication" which can be used to verify their full-stroke other than visual observation of the disc. However, stroking these check valves requires purging the nitrogen blanket on 12 CST for personnel safety. This will result in increased oxygen absorption in the stored condensate (and increased system/tank corrosion), as well as increased waste of nitrogen.

B. Exercising these check valves by "blowing" air into 12 CST at the rated flow rate is also not practical. This could pressurize 12 CST and increase absorbed oxygen levels. Use of nitrogen would prevent oxygen absorption, but would introduce personnel safety concerns due to the enclosed area. Furthermore, due to the physical constraints, setting up the required equipment and obtaining reliable data would be very difficult and potentially dangerous to personnel. There are no other similar parameters which could be used to establish "quantifiable acceptance criteria" or serve as "other positive indication" of obturator movement as discussed in NUREG-1482.

C. In theory, these valves could be exercised by securing the nitrogen blanketing system and taking a suction from 12 CST at the required flow rate in order to verify the valves open and prevent drawing a vacuum in the tank. However, in order to show that each vacuum breaker could provide the required overpressure protection (i.e., air flow rate), the other vacuum breaker would have to be blank-flanged. This creates the potential of damaging the vacuum breakers but, more

importantly, also creates the potential for damaging 12 CST if a vacuum breaker should fail or, more likely, be damaged.

D. These valves could be manually exercised in place by pushing in on the disc (there is no built-in manual operator). However, such operation is contrary to the Vendor's guidance. Additionally, the “setpoint" is so low (as recognized in the original Baltimore Gas and Electric Company Purchase Specification) that the required torque to open the valve could not be reliably measured on a repeatable basis nor trended.

E. These valves could be removed and inspected every refueling outage (because of their design, there is no valve disassembly required to inspect all moving parts and seating surfaces). However, 12 CST is common to both Units. As a result, a Temporary Alteration is required to avoid placing the operating Unit in a Technical Specification Action Statement. Clearly, removing and inspecting these valves during outages for both Units (i.e., every year) is not required. Per GL 89-04 Position 2, removing one of the two valves (on an alternating basis) each refueling outage (tied to Unit 1 or Unit 2) would be acceptable.

However, CCNPP considers the removal/inspection frequency permitted by this option to require a degree of resources, and to present potential concerns, which are disproportionate to the level of safety and quality provided. In other words, it does not provide a compensating increase in the level of safety or quality which is commensurate with the resources required or potential concerns. (Similarly, the Vendor recommendation that these valves being subject to preventive maintenance annually is also considered excessive.) This conclusion is based on the following:

1. The Temporary Alteration required to minimize the impact on both Units (i.e., prevent entering an Action Statement),

2. The potential personnel safety concerns, the potential increase in oxygen absorption of the stored condensate, and the economic cost presented by more frequent purging of the nitrogen blanket,

3. The satisfactory as-found condition of these valves when they were removed and inspected in October 1997 after more than 10 years of continuous service without inspection or maintenance,

4. The design and service conditions (e.g., stainless steel seat, disc, and spring in an inert atmosphere), and

5. The potential for damaging these valves each time they are handled (i.e., removed, inspected, and re-installed).

6. Removal and inspection of these valves does not require a refueling outage for either Unit. Therefore, the frequency should not be tied to a refueling outage in order to permit maximum scheduling flexibility and preclude unnecessary diversion of resources during an outage.

F. These valves are not easily accessible. They are located on top of 12 CST which is a high tank with a sloping top. As a result, accessing these valves presents potential personnel safety hazards due to the height and limited space. The entire tank is contained within an enclosure which is equipped with "bird doors" to prevent nesting of birds in the building. The valves, which hang vertically and open into the tank, are also protected by screens. During the inspection in October 1997, minimal dust and debris was found even though the valves had not been cleaned since their original installation.

3.1.2 Alternative Testing

The licensee proposes:

> Each of these valves will be removed and inspected at a four year frequency for any signs of degradation which might affect their ability to perform their safety function. The removal and inspection schedule will not be specifically tied to the refueling schedule for either Unit. It is expected that both vacuum breaker valves will be removed and inspected at approximately the same time. However, such scheduling would be solely to minimize the potential safety impact on the Units and the cost/resources involved. Part-stroking these valves while installed is not considered practical. The accessible portions of the valves will be inspected in-place to the maximum extent practical on a two year frequency (i.e., alternating between in-place inspection and removal/inspection every two years).
>
> If, in the course of these inspections, a valve is found to be inoperable with respect to its function to open, then appropriate corrective action will be taken. During activities associated with valve removal and inspection and prior to system closure, appropriate precautions will be applied and inspections performed to ensure internal cleanliness standards are maintained and foreign materials are excluded from system internals. These measures may include creating controlled work areas, maintaining a tool and equipment accounting system, installation of covers during non-work periods, and final close-out inspections. Because there is no actual disassembly of the valves themselves required for an inspection, there is minimal potential to introduce a failure.

3.1.3 Evaluation

The Code requires that check valves, which are tested by disassembly and inspection, be performed every refueling outage. An alternative to the Code requirements may be authorized based on GL 89-04, Position 2, which allows sample disassembly and inspection of a group of check valves that are of the same manufacturer and model, are installed in the same orientation, and have the same service conditions. Another alternative is found in Appendix II of the 1996 addenda to the OM Code -1996 which, when implemented with the related requirements, allows a variety of activities performed on the check valve to substitute in the aggregate for the testing specified in the Code.

The licensee has propose to disassemble and inspect these valves once every 4 years. The licensee has also proposed to inspect these valves in place on the accessible areas every 2 years which will alternate with the disassembly and inspection. If during either the in place

inspection or the disassembly, the licensee discovers a valve to be inoperable, appropriate corrective action will be taken, which shall include examination of the other check valve. The proposed testing is consistent with Position 2 of GL 89-04 with two exceptions: the testing is not staggered and it would not necessarily occur during refueling outages.

The staff can find no unique burden in the licensee's basis for relief to defer testing of the check valves. Therefore, the Code required testing is not considered a hardship. However, given that the valves have recently been inspected and determined to be in acceptable condition, that the proposed testing does not increase the overall test interval for each valve, and that and in place examination is performed on these valves every 2 years, the proposed alternative testing is considered acceptable. The licensee's proposed alternative provides an acceptable level of quality and safety because the disassembly and inspection test interval will be maintained and the valves will be examined, either in place or by disassembly, once every 2 years. The licensee should note that the 2 and 4-year test frequencies described in this relief request are not subject to the 25% increase as described in many technical specifications.

3.1.4 Conclusion

The proposed alternative to the exercise test frequency requirements of OM-10, Paragraph 4.3.2.2, and the valve obturator movement requirements of OM-10, Paragraph 4.3.2.4, for the condensate storage tank vacuum breaker check valves 0-CD-6303A-VBV and 0-CD-6303A-VBV is authorized pursuant to 10 CFR 50.55a(a)(3)(i) based on the determination that the proposed alternative testing provides an acceptable level of quality and safety.

4.0 CONCLUSION

The proposed alternative (PR-05) to the Code frequency response lower range requirement of OM-6, Paragraph 4.6.1.6, for the reactor coolant charging pumps is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the determination that compliance with the specified requirements results in a hardship without a compensating increase in the level of quality and safety.

The proposed alternative (PR-11) to the vibration alert range absolute acceptance criteria requirements of OM-6, Table 3a, for the LPSI pump vibration parameters listed in Section 2.2.4 of this SE is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the determination that compliance with the specified requirements results in a hardship without a compensating increase in the level of quality and safety.

The proposed alternative (VR-14) to the exercise test frequency requirements of OM-10, Paragraph 4.3.2.2, and the valve obturator movement requirements of OM-10, Paragraph 4.3.2.4, for the condensate storage tank vacuum breaker check valves 0-CD-6303A-VBV and 0-CD-6303A-VBV is authorized pursuant to 10 CFR 50.55a(a)(3)(i) based on the determination that the proposed alternative testing provides an acceptable level of quality and safety.

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Date: August 22, 2000

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