UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE INSERVICE TESTING PROGRAM

CONSUMERS POWER

PALISADES PLANT

DOCKET NUMBER 50-255

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 Sections (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. The NRC staff's findings with respect to authorizing alternatives and granting or not granting the relief requested as part of the licensee's IST program are contained in this safety evaluation (SE).

2.0 BACKGROUND

In its letter of September 18, 1995, Consumers Power, the licensee for the Palisades Plant, requested that the NRC authorize an alternative to the ASME Code pursuant to 10 CFR 50.55a(a)(3)(ii). Specifically, the licensee requested that the NRC authorize an alternative for the vibration alert limits for the containment spray pumps and the low pressure safety injection pumps.

The IST program for the Palisades Plant complies with the 1989 Edition of Section XI which, by reference, incorporates Part 6, "Inservice Testing of Pumps in Light-Water Reactor Power Plants," of the ASME Operations and Maintenance (OM) Standard OMa-1988. The program is in the initial stages of implementation following the beginning of the new 10-year interval in May 1995.

3.0 REQUESTED ALTERNATIVE

The Class 2 containment spray pumps (P-55A, P-54B/C) and low pressure safety injection pumps (P-67A/B) are tested quarterly in accordance with the

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code-specified frequency. The pumps are tested in a low flow condition through instrumented recirculation lines which is acceptable per the code; however, the low flow condition is not optimum for operating the pumps and, as a result, the vibration readings are consistently higher than what would be expected to occur if the pumps were operated under full-flow conditions. The values generally exceed the alert limit in OM-6, requiring that the pumps be tested every 6 weeks. Therefore, the licensee proposes to assign higher values to the alert limits for each pump based on historical data.

3.1 Basis for Relief

The licensee states:

> The Containment Spray Pumps and the Low Pressure Safety Injection Pumps are tested quarterly using flow circuits of limited capacity; no alternative flowpaths exist for on-line testing. As a result, the Containment Spray Pumps are tested at approximately 10% of rated capacity and the Low Pressure Safety Injection Pumps are tested at approximately 6% of rated capacity. For centrifugal pumps of this size, vibrations are considerably higher at lower flowrates than at normal operating flowrates due to energy dissipation, internal recirculation, and subsequent cavitation effects. These reduced pump flowrates result in higher, yet consistent, vibration levels measured during surveillance testing. Correspondence from the vendor (Ingersoll-Rand), dated June 22, 1987 (Attachment 3 [to the September 18, 1995, letter]), states that a flowrate of 1140 gpm (≈35% of rated capacity) should be used for Low Pressure Safety Injection Pump testing. The letter goes on to state, however, that as the pump operates within acceptable vibration levels at the originally recommended minimum flow of 163 gpm, mechanical problems would not be expected. Due to their similar design and capacity, flowrate of the same magnitude is assumed to be required for acceptable Containment Spray Pump performance.
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> Pump recirculation is described in detail in McGraw-Hill's "Pump Handbook," 2nd Edition. Operation of centrifugal pumps at reduced flowrates and associated problems are also addressed in Igor Karassik's "Centrifugal Pump Clinic," 2nd Edition.
>
> Results from two Containment Spray Pump special tests at 38% of rated capacity (2/11/91 and 4/7/92) and a Low Pressure Safety Injection Pump performance test (1/19/91 - 1/20/91) showed all vibration levels to be below the maximum alert limit specified in OM-6. The pumps were determined to be mechanically sound and operating acceptably following the performance of these tests. These higher flow tests confirm that reduced flowrate testing causes internal recirculation which in turn leads to higher vibration readings. Subsequent tests for all five pumps at the reduced flowrates currently

being used show vibrations in IPS-RMS [inches per second-root mean square] that fall in the alert range as defined by OM-6.

The higher vibrations during low flow testing have been trended since May of 1991 and show no signs of increasing. Channel for channel, the vibrations are higher, but consistent with the vibrations recorded at higher flowrates. Detailed vibration signatures taken following every RMS reading do not indicate any pump degradation or problems per industry standards. Although there is significant "noise" typical of a cavitation-like disturbance, the levels across the spectrum are low enough such that any vibration symptom would be easily identified. Additionally, the vibration signatures have acceptable IPS-Peak values which indicates that the IPS-RMS values used for trending are complex combinations of many superimposed inputs.

Based on this discussion, the vibration levels at reduced flowrates are acceptable, expected, and do not prohibit useful predictive testing. However, application of the OM-6 alert limits for vibrations would inappropriately require these pumps to be regularly placed on alert and tested at double the normal test frequency, or would require significant system redesign and modification. This additional testing burden would not be warranted and would only contribute to pump degradation due to low flowrate testing. Furthermore, no benefit can be expected from this additional testing or from any system modification. Therefore, in accordance with 10 CFR 50.55a(a)(3)(ii), implementation of the >.325 IPS-Peak or >.228 IPS-RMS (corrected for RMS) alert range limit for these specific pumps represents an undue hardship without a compensating increase in quality or safety. Additionally, it is impractical to meet the vibration alert requirements because the pumps must be tested at low flowrates through mini-recirc lines due to system design.

Ideally, three standard deviations should encompass 99.7% of all the vibration readings taken, assuming identical conditions and no degradation. Utilizing additional standard deviation prevents obvious data scatter from placing any unit on alert and causing unnecessary increased testing frequency. The resulting alert levels (mean +45) were examined for the degree of vibration permitted based on industry standards. It was determined that no unit would run into the "extreme" or "very rough" range as a result of the relaxed limits. Additionally, the alert limits are adequately below the required action ranges, and will provide sufficient time to predict failure and to schedule repair.

In addition to the quarterly inservice testing using the installed mini-recirculation lines, the Containment Spray Pumps will be tested at a substantial flowrate beginning in

the 1997 refueling outage. The Low Pressure Safety Injection Pumps are currently tested at a substantial flowrate per Special Test Procedure T-261. These tests will be/are scheduled at nominal 10-year intervals or following pump maintenance which may result in hydraulic or mechanical performance changes not detectable by the quarterly testing method. The testing schedule will coincide with plant refueling outages. Acceptable vibration performance will be confirmed during these tests.

3.2 Proposed Alternative

The licensee proposes:

> CPCo [Consumers Power Company] requests relief from the alert limits specified in OM-6 and proposes the following vibration acceptance criteria limits for the Containment Spray and Low Pressure Safety Injection Pumps.
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> The required action limits will be as specified in OM-6, Table 3a, for all vibration locations and channels; the limit is >.490 IPS-RMS (corrected for RMS).
>
> Alert limits will be determined as follows based on pump vibration test data collected between 1991 and mid-1995. For channels with reference values adequately below the OM-6 specified alert limit, .228 IPS-RMS (corrected for RMS) will be utilized per Table 3a. If the channel was consistently close to or above .228 IPS-RMS, the mean value plus four standard deviations will be used for the alert limit. The resulting values of the new alert limits are listed in Attachment 2 [to the September 18, 1995, letter].

The proposed acceptance criteria given in Attachment 2 to the September 18, 1995, letter were as follows:

Vibration References and Ranges (Proposed)

P-67A Pump Vibrations

Point ID	Channel ID	Reference Vibrations (IPS-RMS)	Acceptable Range (IPS-RMS)	Alert Range (IPS-RMS	Required Action Range (IPS-RMS)
0118	1 (V)	.180	VIBES ≤ .271	.271 < V ≤ .490	VIBES > .490
0118	2 (A)	.100	VIBES ≤ .228	.228 < V ≤ .490	VIBES > .490
0118	3 (H)	.210	VIBES ≤ .400	.400 < V ≤ .490	VIBES > .490

P-67B Pump Vibrations

Point ID	Channel ID	Reference Vibrations (IPS-RMS)	Acceptable Range (IPS-RMS)	Alert Range (IPS-RMS	Required Action Range (IPS-RMS)
0936	1 (V)	.170	VIBES ≤ .242	.242 < V ≤ .490	VIBES > .490
0936	2 (A)	.110	VIBES ≤ .228	.228 < V ≤ .490	VIBES > .490
0936	3 (H)	.190	VIBES ≤ .359	.359 < V ≤ .490	VIBES > .490

P-54A Pump Vibrations

Point ID	Channel ID	Reference Vibrations (IPS-RMS)	Acceptable Range (IPS-RMS)	Alert Range (IPS-RMS	Required Action Range (IPS-RMS)
0922	1 (V)	.230	VIBES ≤ .337	.337 < V ≤ .490	VIBES > .490
0922	2 (A)	.130	VIBES ≤ .228	.228 < V ≤ .490	VIBES > .490
0922	3 (H)	.250	VIBES ≤ .325	.325 < V ≤ .490	VIBES > .490

P-54B Pump Vibrations

Point ID	Channel ID	Reference Vibrations (IPS-RMS)	Acceptable Range (IPS-RMS)	Alert Range (IPS-RMS)	Required Action Range (IPS-RMS)
0933	1 (V)	.300	VIBES ≤ .331	.331 < V ≤ .490	VIBES > .490
0933	2 (A)	.200	VIBES ≤ .304	.304 < V ≤ .490	VIBES > .490
0933	3 (H)	.340	VIBES ≤ .416	.416 < V ≤ .490	VIBES > .490

P-54C Pump Vibrations

Point ID	Channel ID	Reference Vibrations (IPS-RMS)	Acceptable Range (IPS-RMS)	Alert Range (IPS-RMS	Required Action Range (IPS-RMS)
0930	1 (V)	.190	VIBES ≤ .256	.256 < V ≤ .490	VIBES > .490
0930	2 (A)	.160	VIBES ≤ .228	.228 < V ≤ .490	VIBES > .490
0930	3 (H)	.300	VIBES ≤ .352	.352 < V ≤ .490	VIBES > .490

Additional information was provided in several other attachments to the licensee's submittal listed below:

Attachment 3 "Ingersoll-Rand Letter of June 22, 1987"

Attachment 4 "Low Pressure Safety Injection Pumps, Pump Test Data"

Attachment 5 "Low Pressure Safety Injection Pumps, Performance Test Report from Special Test T-261, February 1991"

Attachment 6 "Low Pressure Safety Injection Pumps, Derivation of Vibration Acceptance Limits"

Attachment 7 "Containment Spray Pumps, Pump Test Data"

Attachment 8 "Containment Spray Pumps, Performance Test QO-10 Results and Evaluation of February 1991"

Attachment 9 "Containment Spray Pumps, Derivation of Vibration Acceptance Limits"

3.3 Evaluation

The licensee initially requested relief to use velocity versus mils for vibration measurements in a submittal dated June 28, 1991, during the second 10-year interval. NRC's July 15, 1992, safety evaluation denied the request based on lack of information such as specific velocity ranges and clarification as to the pumps covered by the relief request.

The relief request was resubmitted on December 29, 1992, clarifying that only the containment spray pumps and low pressure safety injection pumps were covered by the relief request. The request included specific velocity ranges for these pumps which exceeded the OM-6 absolute limits. The request was denied, indicating that the licensee must continue to meet the Code requirements for these pumps. In its letter of September 18, 1995, the licensee submitted a revised relief request with limits more consistent with the requirements of OM-6 and included detailed information on the past vibration performance of the pumps.

The licensee's submittal included a letter from Ingersoll-Rand (I-R) dated June 22, 1987. The letter discussed minimum flow for the low pressure safety injection pumps. The letter indicated that the originally recommended minimum flow of 163 gpm [gallons per minute] was based entirely on thermal criteria. These criteria established a flow value that would permit operation at low flows without heating the pumped liquid to a flash point. Use of the criteria, however, results in mechanical problems (i.e., vibration related damage), and I-R would not quantify operational hours versus mechanical damage for minimum flow operation. I-R recommended increasing the minimum flow to 1140 gpm [gallons per minute] for testing and for any extended period of operation. I-R noted, however, that if the pump operates within acceptable vibration levels while at 163 gpm, it would not expect any mechanical problems. I-R further cautioned that operation at shut-off flow conditions (i.e., zero flow) should be avoided for any length of time.

The licensee indicates, in the basis for relief, that the same precautions apply to the similar containment spray pumps. It continues to test pumps on minimum flow while closely monitoring the vibration levels, taking both the measurements for IST purposes and spectra data for predictive maintenance purposes.

OM-6, paragraph 5.2, specifies that if velocity measurements are used, they shall be peak. The licensee has established RMS (root-mean-square) reference values and acceptance criteria. In response to an OM Inquiry (OMI-94-2) dated April 28, 1994, the OM Committee answered in the affirmative whether it is the intent to allow vibration readings to be measured in RMS and mathematically

converted to peak (velocity) or peak-to-peak (displacement). For Palisades, the licensee proposes that, rather than mathematically convert RMS to peak, the RMS value be used and the acceptance criteria will be established using RMS values. RMS is related to the peak value by the following relationship:

$$x_{RMS} = [\frac{\sqrt{2}}{2}] x_{max}$$

The numerical value of an RMS reading is, then, approximately 0.7 times the peak value measured by the instrument. The proposed acceptance criteria are consistent with the alert and required action limits in Part 6 except that for reference values that are higher than normally expected, the proposed alert limits are higher than 0.325 inch per second (peak), or 0.228 inch per second RMS. Part 6 also specifies multipliers of 2.5 times the reference value for an alert limit and 6 times the reference value for a required action level; however, for the reference values given on the tables above, the absolute limits are below the multiplier limits, so the multipliers are not necessary. Therefore, the proposed reference values and limits and the use of RMS will give assurance of the continued operational readiness of the pumps.

Regarding the higher vibration experienced during quarterly testing on recirculation flow, it would be a hardship to require the licensee to install a full-flow recirculation line. An option that could be imposed would be to require the licensee to perform a full-flow test during each refueling outage, but such tests may not be practical except under conditions where the core is off-loaded. The licensee is performing a substantial-flow test at least once every 10 years and following any major maintenance or pump rebuild and the current testing is performed in accordance with the code since it does not specify that pumps cannot be tested on recirculation flow. In consideration that the required action limits will continue to be imposed and that continuing to test the pumps at a frequency of once every 6 weeks under low-flow conditions could be detrimental to the pumps, there are no compensating increases in the level of quality and safety in imposing the Code requirements for the alert limits. If the licensee performs maintenance or modifications that result in decreases in the reference values, the Code requirements must be met, including the use of multipliers. Additionally, if the vibration levels experienced during the 10-year test are indicative of problems, the pumps must be repaired or replaced prior to return to service. Also, as a provision to the authorization of the proposed alternative, the licensee must continue to monitor these pumps under their predictive maintenance program using data obtained by spectral analysis. With these stipulations, which are already part of the licensee's overall program for these pumps, the alternate alert limits and the use of RMS values is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the hardship or unusual difficulty without a compensating increase in the level of quality and safety if the Code alert values were imposed.

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