

High Pressure Coolant Injection Pump Vibration Issue

Wednesday, December 8, 2004

1:00 p.m. - 4:00 p.m.

U.S. Nuclear Regulatory Commission
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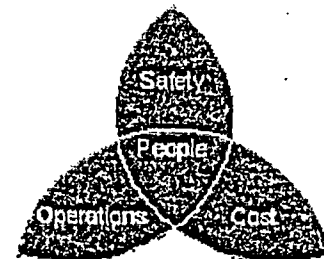
HPCI In-Service Testing

**Pilgrim Nuclear
Power Station
December 8, 2004**



HPCI In-Service Testing

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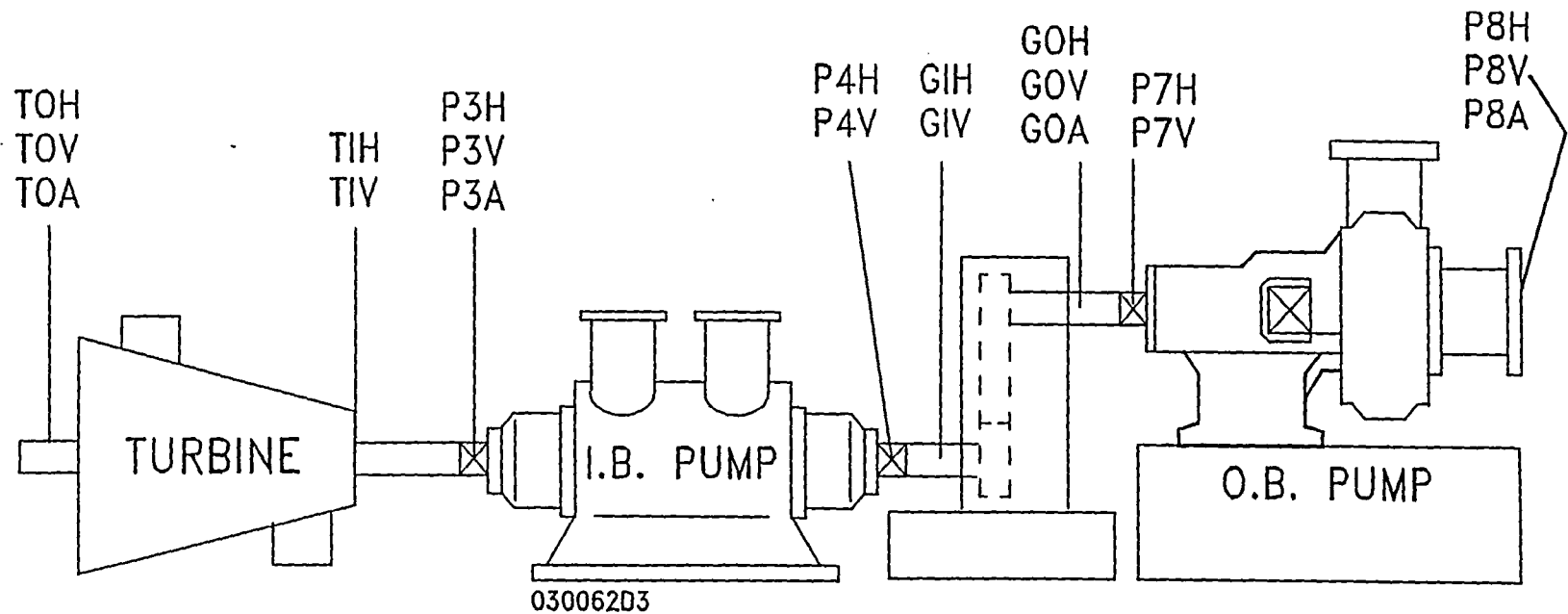
Meeting Purpose

- ♦ Summarize the basis for the Pilgrim request concerning HPCI IST vibration monitoring
- ♦ Answer Staff questions about the basis for Pilgrim's conclusions

Agenda

- ♦ HPCI System Pump Configuration
- ♦ HPCI System Safety Function
- ♦ HPCI System IST Vibration Monitoring
- ♦ HPCI System Vibration
- ♦ Code Requirements
- ♦ Vendor Recommendations
- ♦ Conclusion

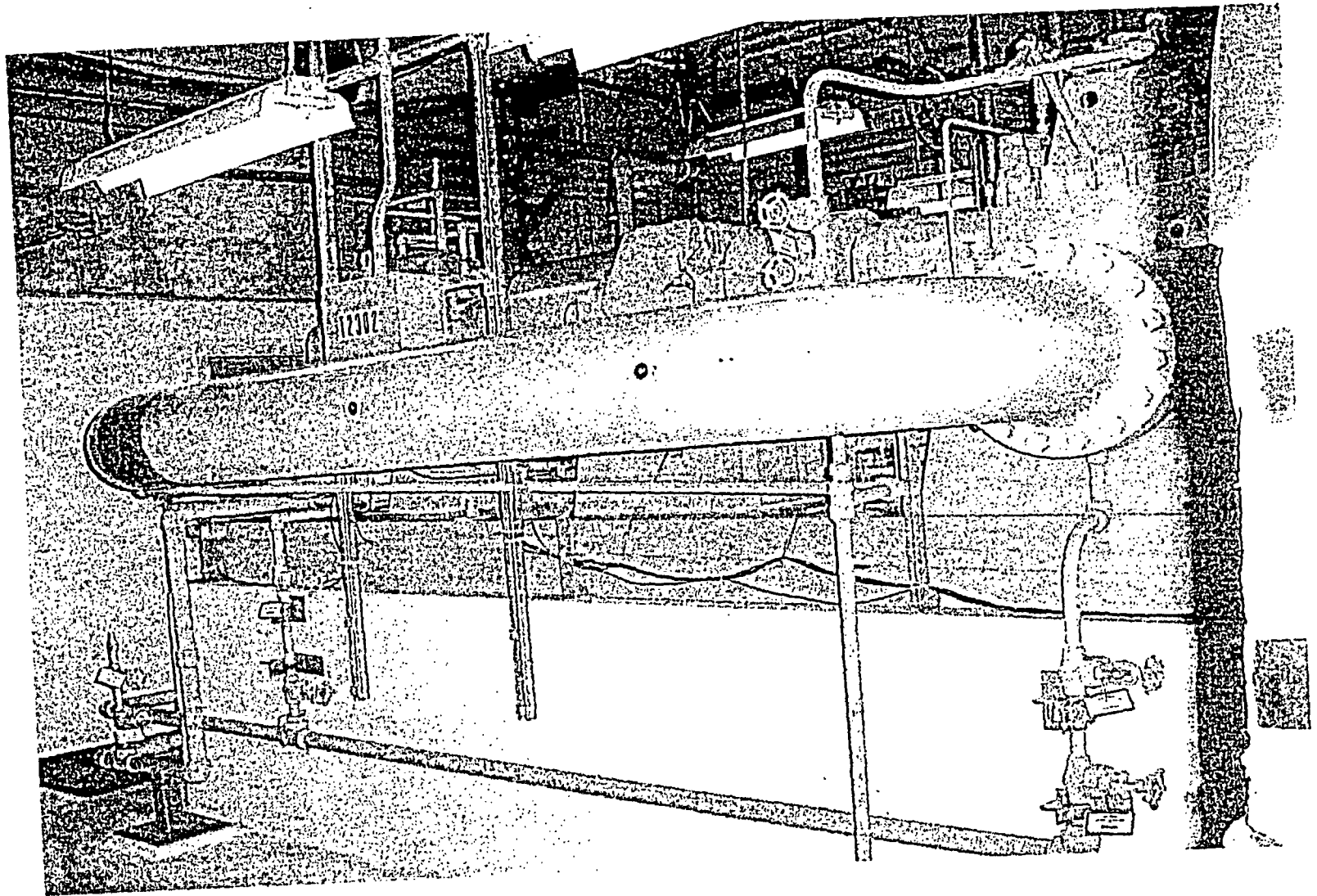
HPCI Pump Configuration



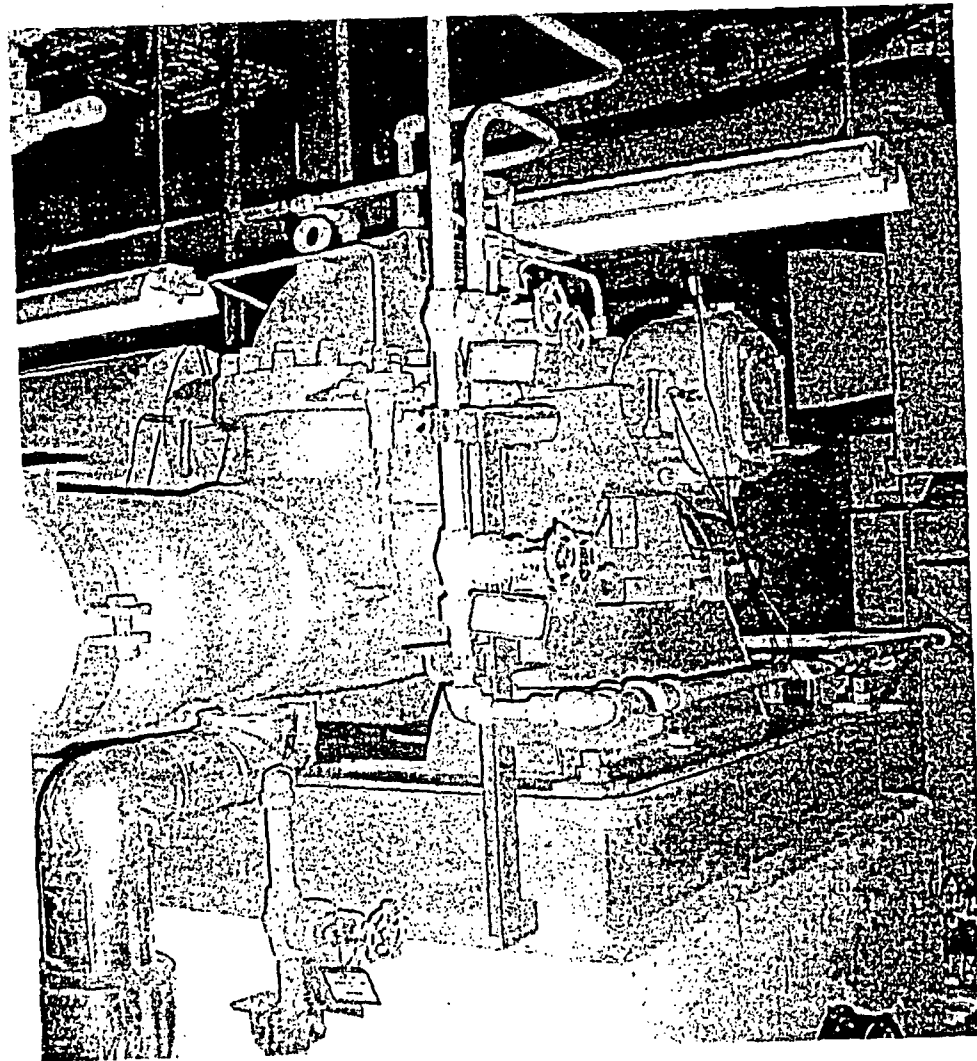
Main Pump

Booster Pump

HPCI Pump Configuration



HPCI Pump Configuration



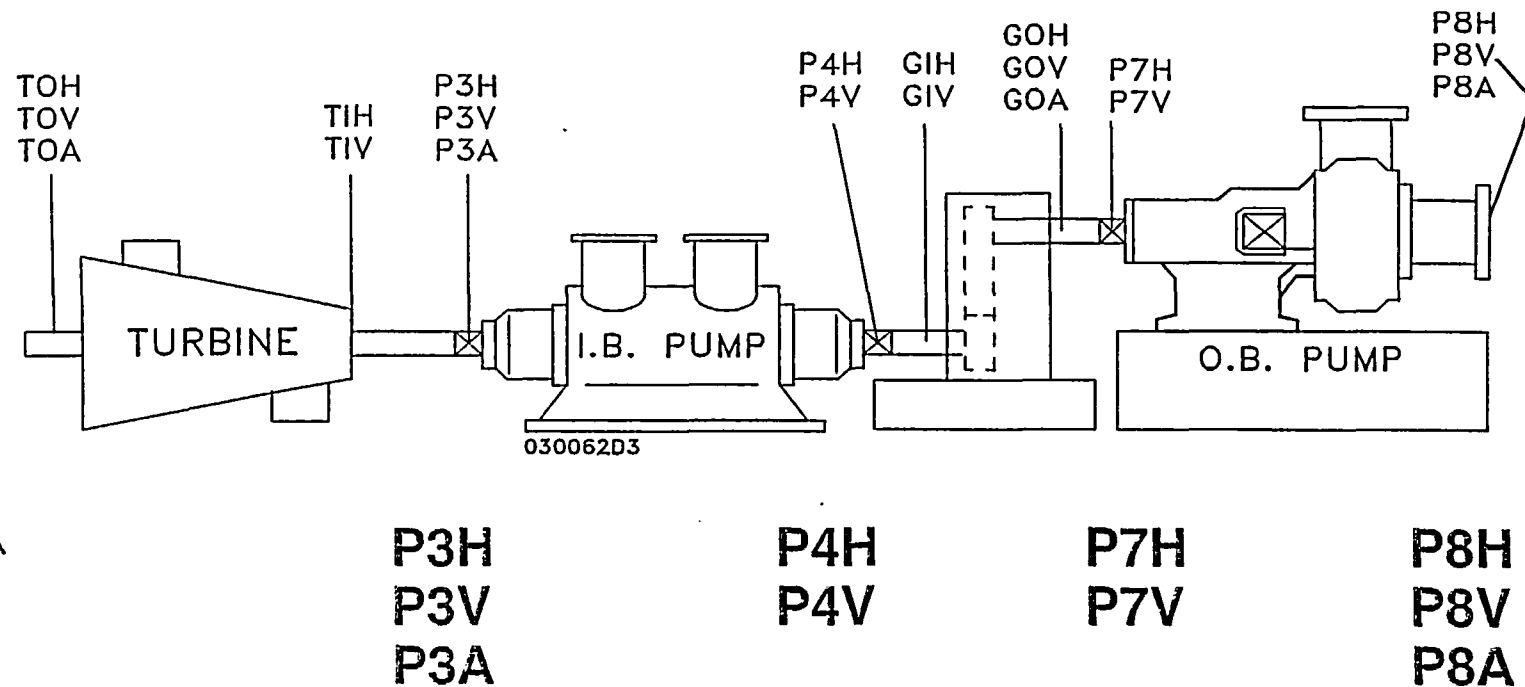
HPCI Function, Mission Time, and Operational Data

- **Designed to pump water into the vessel in the event of a small break**
- **Delivers 4250 GPM @ 1120 to 150 psig**
- **Mission time about 16 minutes for limiting break**
- **Operates intermittently during non-limiting small breaks.**
- **Back-up systems: ADS, Core Spray, LPCI, RCIC**

HPCI Function, Mission Time, and Operational Data

- **Equipment Qualification Profile time:
5 hours**
- **Pump speed decreases from rated as vessel depressurizes or operator controls flow**
- **Periodic Test (Surveillance) Duration:
1 hour/ quarter**
- **Cumulative operation since plant start:
about 270 hours**
- **Periodic test demands are comparable to
DBA requirements for operation at speed**

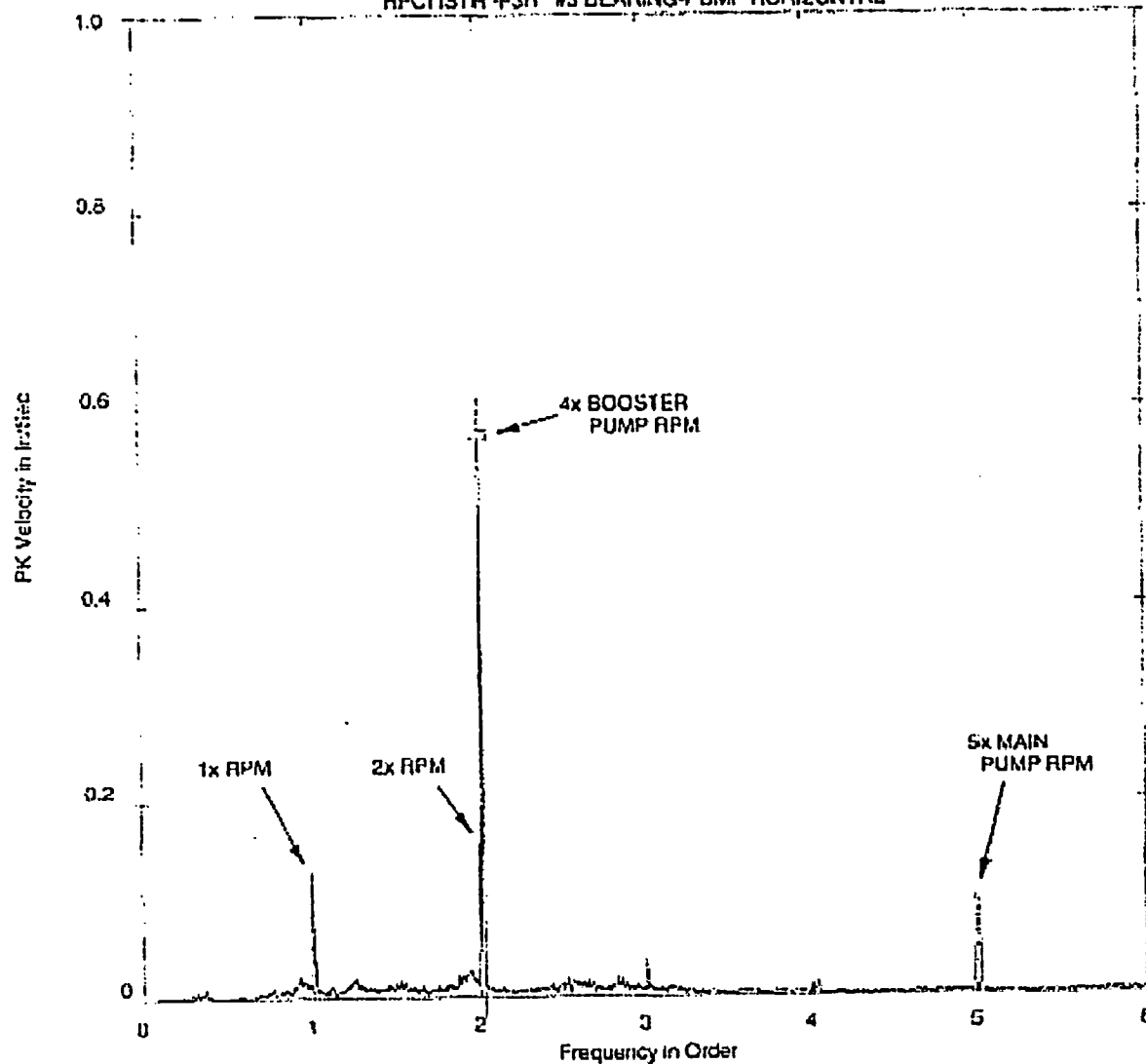
HPCI Pump Vibration Monitoring Program



Other points are monitored as part of Vibration Monitoring for Preventive Maintenance and Balance

HPCI Data November 24, 2004

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P3H #3 BEARING-PUMP HORIZONTAL



Route Spectrum
24-NOV-04 00:44:12

OVERALL= .8003 V-DG
PK = .7923
LOAD =4250.0
RPM = 4012.
RPS = 66.07

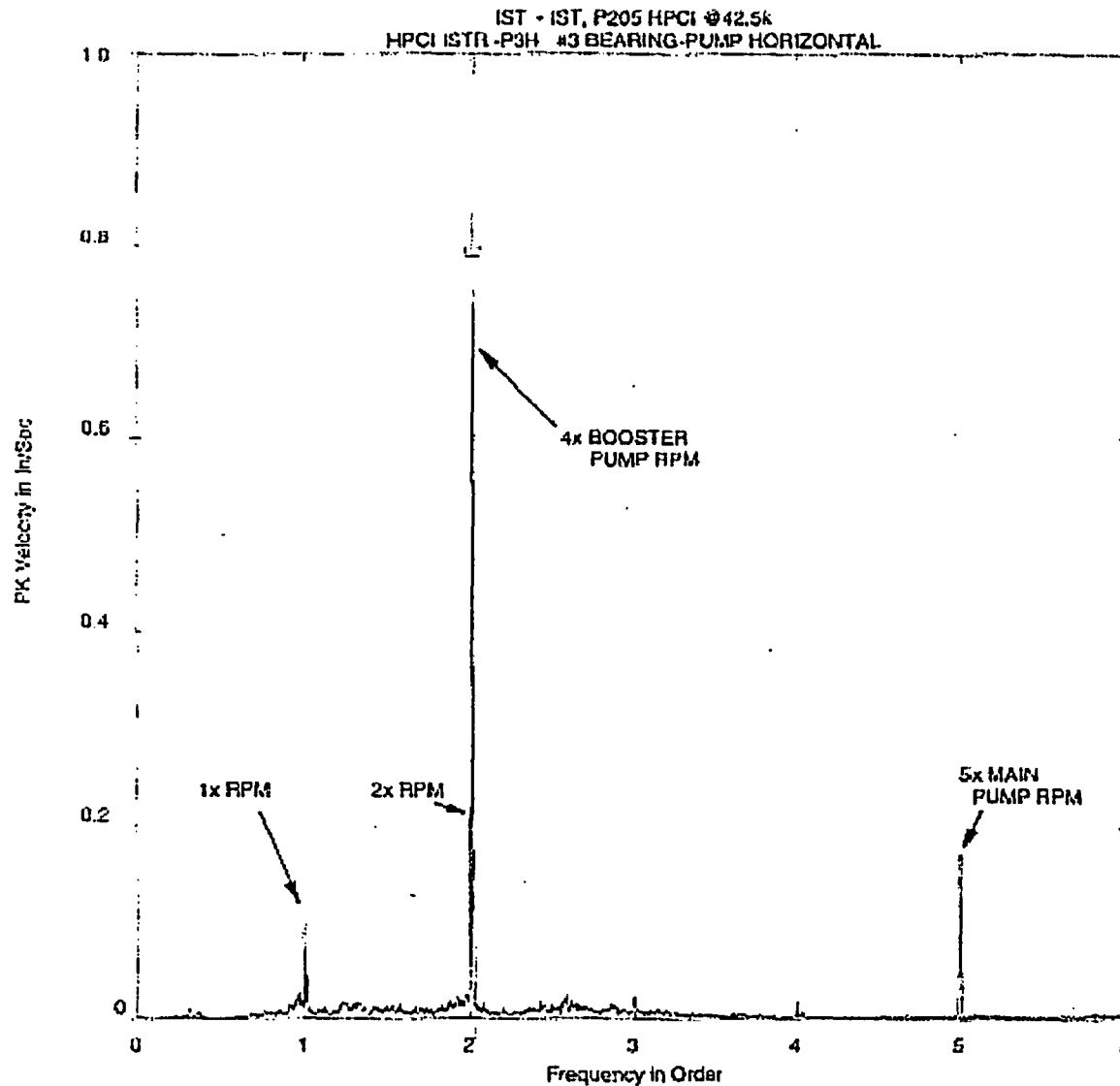
PNPS Calculation to
Delete Discrete Peak

@ 4x Booster Pump RPM:

$(0.800)^2 = \{OA\ Level\}^2$
 $-(0.605)^2 = \{4x\ BP\ RPM\ Peak\}^2$
 ----- Subtract Sq Values
 $(0.198)^{.5} = 0.445\ In/Sec\ OA$

Ordr: 2.017
Freq: 134.88
Spec: .665

HPCI Data August 24, 2004



Route Spectrum
24-AUG-04 20:46:30

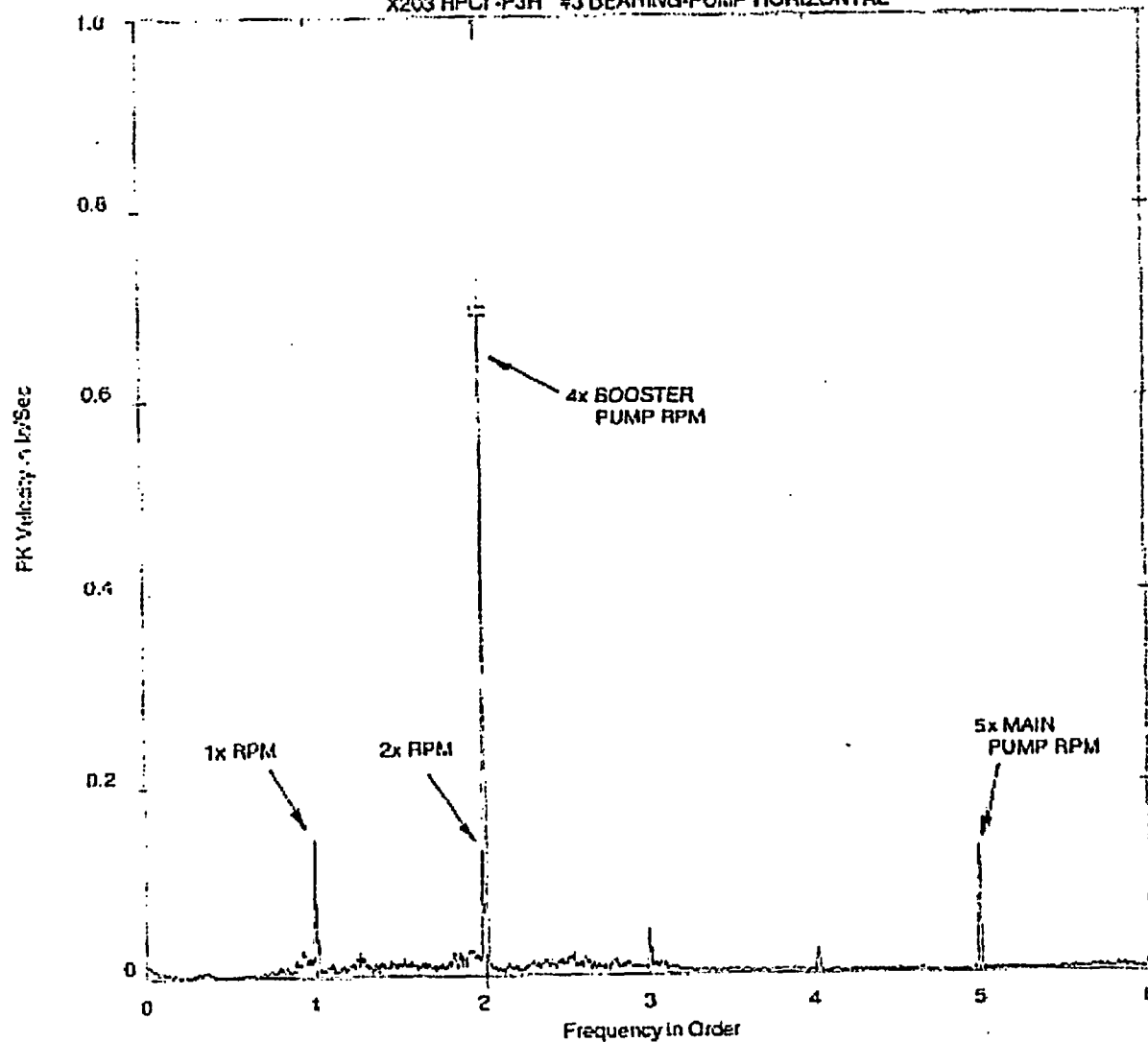
OVERALL= .9415 V-DG
PK = .9331
LOAD =4250.0
RPM = 3980.
RPS = 66.33

PNPS Calculation to
Delete Discrete Peak
@ 4x Booster Pump RPM:
 $(0.942)^2 = (\text{OA Level})^2$
 $-(0.822)^2 = (4x \text{ BP RPM Peak})^2$
----- Subtract Sq Values
 $(0.212)^{1/2} = 0.460 \text{ In/Sec OA}$

Ord: 2.017
Freq: 133.77
Spec: .822

HPCI Data May 25, 1994

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI-P3H #3 BEARING-PUMP HORIZONTAL



Route Spectrum
25-MAY-94 09:27:30

OVERALL = .8515 V-DG
PK = .8488
LOAD = 4250.0
RPM = 4000.
RPS = 67.66

PNPS Calculation to
Delete Discrete Peak
@ 4x Booster Pump RPM:

$(0.852)^2 = (\text{OA Level})^2$
 $-(0.710)^2 = (4x \text{ BP RPM Peak})^2$
 ----- Subtract Sq Values
 $(0.222)^{0.5} = 0.471 \text{ In/Sec OA}$

Ordr: 2.015
Frq: 136.32
Spec: .710

Code Requirements

OMa-1996, ISTB 4.0:

Reference Values are established by the program. Relative and Absolute Values are provided in ISTB Table 5.2.1-1.

Code Requirements

Note 1: ISTB 4.3 Reference Values, item (g) footnote for analysis:

“Vibration measurements of pumps may be foundation, driver, and piping dependent. Therefore, if the initial vibration readings are high and have no obvious relationship to the pump, then vibration measurements should be taken at the driver, at the foundation, and on the piping and analyzed to ensure that the reference vibration measurements are representative of the pump and that the measured vibration will not prevent the pump from fulfilling its function.”

Code Requirements

Note 2:STB 4.6: New Reference Values:

"In cases where pump's test parameters are within either the alert or required action ranges of Table ISTB 5.2.1-1, Table ISTB 5.2.1-2, Table ISTB 5.2.2-1, or Table ISTB 5.2.3-1, and the pump' continued use at the changed values is supported by an analysis, a new set of reference values may be established.
This analysis shall include verification of the pump's operational readiness. The analysis shall include both a pump level and system level evaluation of operational readiness, the use of the change in pump performance, and an evaluation of all trends indicated by the available data. The results of the test shall be documented in the record of the tests (see Article ISTB 7)."

Pilgrim Analysis

- **Pump performance Analysis**
 - Analyzed source of vibration
 - Vibration of concern is attributed to the Booster Pump and associated harmonics
 - Displacement due to vibration is lower than clearance of bearings
 - Vibration concern is only at rated speed. Pump operation time post accident is very short.
 - Adequate monitoring for degradation can be accomplished with corrections for booster pump induced vibration

Pilgrim Analysis

- **Pump performance Analysis (cont.)**
 - **Corrected vibration data indicates HPCI Main Pump is below required action range**
 - **No degradation of HPCI Pump performance will result from the vibration and the HPCI System will perform its design function**
- **Vendor Technical Notes were considered in the analysis**
- **Vibration trending has shown no degradation**
- **Intent of code requirements are met**

Vendor Recommendations for Reducing Vibration

- **Verify correct dynamic alignment of all shaft couplings**

Completed

- **Verify acoustic resonant condition from measured flow, RPM, water temperature, and vibration frequency**

Completed

Vendor Recommendations for Reducing Vibration

The Tech Note identified the following potential pump modifications (cont.):

- **Change the length of the interconnecting piping**

At Pilgrim this means shortening the cross over pipe. That is not practicable considering the as-built configuration

- **Install an acoustic filter in the interconnecting pipe**

No proven design available. Not practicable considering safety related application

Vendor Recommendations for Reducing Vibration

The Tech Note identified the following potential pump modifications (cont.):

- **Alter the mounted structural natural frequency of the injection pump**

Not practicable to significantly stiffen the structure

- **Change the number of vanes in the booster pump impeller**

Most realistic of options. Costs approximately \$487,000. Does not completely resolve issue. Will not improve system performance.

Conclusion

- **Historical pump trend data has been evaluated and confirms that HPCI pump is operable and degradation has not been observed**
- **Proposed program using new Reference Values which take into consideration as-built pump configuration are within the scope of ISTB 4.6 and 6.2 and provides an alternative for monitoring pump performance**
- **Proposed program meets the intent of the code and provides an equivalent level of protection as the code**
- **The vendor identified modifications are unwarranted and are an undue burden**