Designated Original

Entergy

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Stephen J. Bethay
Director, Nuclear Assessment

January 31, 2008

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Pilgrim Fourth Ten-Year In-service Testing (IST) Program, IST Relief Request PR-03, Rev. 3

LETTER NUMBER: 2.08.007

REFERENCES:

1. NRC Letter, Pilgrim Nuclear Power Station-Entergy Relief Request PR-03, High Pressure Coolant Injection Pump (TAC NO. MB8773) dated August 29, 2005
2. Entergy Letter No. 2.06.008, Pilgrim Fourth Ten-Year In-service Testing (IST) Program, IST Relief Request PR-03, Rev. 3, dated June 29, 2006
3. Entergy Letter No. 2.07.056, Response to NRC Request for Additional Information Related to Pilgrim In-service Testing (IST) Relief Request PR-03 (TAC NO: MD2478), July 12, 2007

Dear Sir or Madam:

By this letter Entergy submits the HPCI Pump Relief Request PR-03, Revision 3 (Attachment 1) for NRC approval to continue for the remaining duration of the IST interval the alternative testing previously approved by the NRC in Reference 1. The PR-03 Rev. 3 includes updated information based on the results of NRC approved alternative comprehensive test and additional information concerning the alternative testing.

Entergy submitted Relief Request, PR-03, Rev. 2 for the fourth IST interval and NRC approved the alternative testing for use until August 29, 2008. The fourth IST interval began on December 7, 2002 and ends on December 6, 2012.

Entergy submitted additional information by Reference 3 in response to NRC Request for Additional Information. This response stated that Entergy will provide an assessment of the HPCI pump vibration and performance assessment by an independent contractor. Attachment 2 provides Reference 3 in its entirety and Attachment 3 provides the contractor report in support of the HPCI Pump Relief Request, PR-03, Rev. 3.

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Rec'd 2/12/08
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The scope of this relief applies to ASME OMa-1996, ISTB 5.2.3, Comprehensive Test for HPCI pumps and includes confirmation of operational readiness of HPCI pumps based on the NRC approved alternative comprehensive test results and historical pump test data.

Pursuant to 10 CFR 50.55 a(a)(3)(i), Entergy proposes to continue to use the alternative testing to comply with ISTB 5.2.3. The proposed alternative provides an acceptable level of quality and safety because it verifies the operational readiness of the as-built configuration of the HPCI pump, and the historical data has shown no signs of degradation in the HPCI pump.

Pilgrim intends to continue to perform the alternative comprehensive HPCI surveillance test as approved for the remaining duration of the Fourth IST interval.

This letter contains no new commitments.

If you have any questions or require additional information, please contact Mr. Joseph Lynch, Licensing Manager, at (508) 830-8403.

Sincerely,

Stephen J. Bethay

Stephen J. Bethay

WGL/dl

Attachment:
1. HPCI Pump Relief Request, PR-03, Revision 3 (86 pages)
2. Reference 3, Entergy Letter No. 2.07.056, dated July 12, 2007 (25 pages)
3. Contractor Report, "Independent Assessment of Pilgrim High Pressure Coolant Injection Pump Vibration and Performance", dated January, 2008 (14 pages)

cc: Mr. James S. Kim, Project Manager
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ATTACHMENT 1

HPCI Pump Relief Request, PR-03, Revision 3, (8 pages)

Enclosure 1 to PR-03, Rev. 3 (11 pages)
Enclosure 2 to PR-03, Rev. 3 (66 pages)

(Total 86 pages)

PUMP RELIEF REQUEST PR-03, Revision 3

PUMP: P-205 (Main/Booster)

SYSTEM: High Pressure Coolant Injection (HPCI)

CLASS: 2

FUNCTION: Provides emergency core cooling subsequent to a small break LOCA.

TEST REQUIREMENTS:

ASME OM Code OMa-1996, ISTB 5.2.3, Comprehensive Test

ISTB 5.2.3(d): Vibration (displacement or velocity) shall be determined and compared with corresponding reference values. Vibration measurements are to be broad band (unfiltered). If velocity measurements are used, they shall be peak. If displacement amplitudes are used, they shall be peak-to-peak.

ISTB 5.2.3(e): All deviations from the reference values shall be compared with the ranges of Tables ISTB 5.2.1-1 and ISTB 5.2.3-1 and corrective action taken as specified in paragraph ISTB 6.2. The vibration measurements shall be compared to the relative and absolute criteria shown in the Alert and Required Action Ranges of Table ISTB 5.2.1-1. For example, if vibration exceeds either 6 V_r or 0.7 in./sec, the pump is in the Required Action Range.

RELIEF REQUESTED:

Relief is requested from the ASME OMa-1996, ISTB 5.2.3(d) required method of determining the vibration velocity (V_v) overall value for surveillance test use and for establishing reference values for the HPCI Main pump inboard (turbine side) bearing horizontal point (P3H) and the Main pump outboard (gearbox side) bearing horizontal point (P4H). PNPS proposes that the vibration occurring at the discrete frequency component that is at exactly 4x Booster pump RPM not be included as part of the vibration spectrum vector summing process to obtain the Main pump overall value for these points during comprehensive pump testing. This method is equivalent to extracting the discrete frequency component that is at exactly 4x Booster pump RPM from the broad band vibration spectrum. Since ISTB 5.2.3(d) requires broad band vibration measurements, NRC approved alternative testing is required to demonstrate the operational readiness of the HPCI pump taking into account the as-built configuration of the HPCI pump as specified in ISTB 4.3(g) and associated footnote.

Pilgrim requests relief from the Code requirements of paragraph ISTB 5.2.3(e) for the HPCI Main and Booster Pumps specifically from the vibration velocity (V_v) acceptance criteria specified in Table ISTB 5.2.1-1 for all Main pump and Booster pump vibration points except for the Booster pump outboard horizontal axial vibration point (P8A). Pilgrim proposes to expand the Acceptable Range identified in Table ISTB 5.2.1-1, for pump Quarterly and Biennial Comprehensive vibration monitoring.

BASIS FOR RELIEF:

Relief from the referenced Code requirements is based on the determination that the proposed alternative testing would provide an acceptable level of quality and safety in accordance with 10 CFR 50.55 a(a)(3)(i), as evidenced by the results of recent pump tests performed in November 2005 and February 2006, and historical vibration test data.

Historic testing and analysis performed on the HPCI System by PNPS (and the pump manufacturer) have consistently revealed characteristic pump vibration levels that exceed the acceptance criteria stated in Table ISTB 5.2.1-1. High vibration appears on the Main pump bearing housings at approximately 2x RPM in the horizontal direction, which is caused by Booster pump excitation (at 4x RPM of the booster pump). Under normal circumstances at 4000 rpm, the vibration amplitude at the Main pump bearings in the horizontal direction exceeds the OM Code absolute vibration Required Action Range of > 0.7 in./sec. Additionally, under the same conditions, all of the remaining HPCI Main and Booster pump vibration monitoring points, except for two, typically exceed the OM Code absolute acceptable range upper value of 0.325 in./sec.

The vibration characteristics of the HPCI pump are predominantly a function of the pump design and should be identified as such rather than attributed to pump degradation. The high vibration has been present to the same order of magnitude since the pump was new. Although existing vibration levels of the HPCI pump are higher than the acceptance criteria provided in Table ISTB 5.2.1-1, they reflect the unique operating characteristics of the HPCI pump design configuration. There are no major vibrational concerns that would result in pump degradation or would prevent the HPCI pump from performing its design safety function for an extended period of operation.

The purpose of the Code required testing is to demonstrate the operational readiness of the HPCI pump by monitoring pump vibrations for degradation and taking corrective actions when those vibration levels exceed the Code specified values. The Code specifies in ISTB 4.3(g) footnote that the reference vibration measurements should be representative of the pump and that the measured vibration will not prevent the pump from fulfilling its function. Accordingly, Pilgrim is proposing an alternative testing to demonstrate the operational readiness by taking into consideration the vibration measurements representative of the as-built configuration of the HPCI pump.

<u>Alternate Testing to the ASME OMa-1996 Code</u>:

Pilgrim proposes alternative testing as follows.

1. The alternative testing proposes to remove the 4x Booster pump RPM frequency component (discrete peak) from the vibration spectrum of the Main pump since its amplitude is not related to the physical condition or rotating dynamics of the Main pump rotor or bearing system. The Main pump vibration spectrum, with this single 4x Booster pump RPM frequency component removed, has been shown to be stable and more useful for monitoring actual pump condition. When this vibration frequency component at 4x Booster pump RPM is subtracted from the Main pump vibration spectrum the remaining vibration, which is attributed to the Main pump, is below the OM Code Required Action Range. This corrected vibration level provides a more representative measurement of the pump condition to be used for trending.

2. All other discrete vibration peaks observed at the Main pump horizontal vibration points will be evaluated during each pump vibration test, and will have an Acceptable Range upper limit of 1.05 V_r and an Alert Range upper limit 1.3 V_r. The reviews of the frequency spectrum data ensure that any significant change in the vibration signature will be noted regardless of whether the severity causes the overall level to exceed its criteria. For example, if the overall vibration level is acceptable but the 1x RPM component has increased to greater than 1.3 times the reference value overall level (Vr), then the pump will be placed in the vibration Required Action Range (>0.7in./sec).

3. PNPS will increase the ASME OMa-1996, ISTB 5.2.3 required frequency for vibration monitoring (that is part of the comprehensive testing) from once/2 years to once/year. The Code required comprehensive test for flow rates would continue to be once/2 years. Given that the HPCI vibration will normally exceed the OM Code limiting Alert Range of >0.325 in./sec, the once/year frequency will be doubled to twice/year. The twice/year frequency will be the commitment frequency. However, the normal PNPS practice will be to monitor vibration in the same manner during each of the Quarterly Group B Hydraulic Tests, whenever practicable. Thus, vibration monitoring will be performed up to 8 times in two years as part of the Group B Hydraulic Tests; instead of once/2 years as part of the Comprehensive pump tests.

4. As normal practice, Pilgrim will continue to monitor vibration of HPCI pump during each of the Quarterly Group B Hydraulic Tests in the same manner as required by the OM Code. The preventive maintenance (PM) procedure will also typically be performed, which provides for vibration monitoring of specific pumps for preventive maintenance and balancing, and includes vibration monitoring and trending of the HPCI pump to detect and monitor changes in equipment conditions. As shown in the HPCI pump configuration figure, vibration monitoring is performed at locations required by the OM Code and at additional locations within the scope of the PM procedure (perpendicular to the shaft in the horizontal and vertical positions at each bearing locations and at axial direction to the shaft). Vibration monitoring is thereby routinely performed for the Main pump, Booster pump, Speed Reduction Gearbox, and Steam Turbine. Using the vibration data collected at these points, an accurate diagnosis is made by analyzing the vibration spectrum and planned maintenance is determined to prevent failures. Thus, HPCI pump vibration monitoring will be performed up to 8 times in 2 years as part of Group B Hydraulic Tests and preventive or corrective maintenance will be implemented as necessary to prevent failures. Enclosures 1 and 2 provide HPCI pump vibration spectrum at locations required by the OM Code procedure.

5. Pilgrim will continue current HPCI pump and turbine monitoring and maintenance activities, with changes as conditions warrant, as follows:

   - Quarterly pump and valve operability tests will be performed to ensure the HPCI pump and turbine function for the intended safety function.

   - Quarterly lubrication oil sampling and periodic laboratory analysis as appropriate for the pressure-fed bearings on the Turbine, Main pump, and Gear Reducer and once/cycle (2 years) sampling and analysis for the non-pressure fed Booster pump will be performed. Lubrication oil analysis currently performed includes viscosity, acidity, residue, water content, metals by A.E. spectrometry, and ferrogram readings. This type of monitoring will detect degradation of the turbine or pump bearings due to accelerated wear, fretting, surface fatigue, or oil contamination.

   - HPCI pump and Turbine lube oil system is serviced as-needed weekly. HPCI gland seal condenser hot well pump and motor bearings and HPCI auxiliary lube oil pump and motor bearings are serviced semiannually for lubrication.

   - HPCI Turbine/Main pump, Main pump/Reducer, and Reducer/Booster pump gear-type shaft couplings are cleaned, examined, and grease-lubricated every 2 years. These examinations detect excessive wear, fretting, heating, or fatigue due to any unusual loading conditions.

   Past monitoring and maintenance activities have shown no evidence or observations of degradation in the HPCI Turbine, Main pump, Gear Reducer, or Booster pump. The attached HPCI and Booster pump historical vibration spectrum (Attachment 4) supports this conclusion. Thus, the continuation of the above periodic monitoring and maintenance activities will ensure that the HPCI pump remains in a high level of operational readiness and that degradation of HPCI pump mechanical condition, reliability, or performance will be detected and corrected in a timely manner.

Technical Justification:

PNPS has conducted an evaluation of the HPCI pump vibration characteristics. An important conclusion of this evaluation is that the mechanical condition of the Main pump can be monitored satisfactorily by disregarding the single frequency component caused by the excitation at 4x Booster pump RPM. The four-vane impeller of the Booster pump generates the excitation force hydraulically. This small pressure pulsation force exists at the vane passing frequency (number of vanes times RPM) for all centrifugal pumps and is usually seen as a significant but not particularly troublesome component on the frequency spectrum for vibration measurements taken at the bearing housings. For the HPCI pump, this vane passing frequency is a problem because it coincides with a hydraulic standing wave resonance in the cross-over piping from the Booster pump to the Main pump when the machine is operating at the rated speed of 4000 RPM. There is an acoustic pressure standing wave pattern, at the 4x RPM frequency, whose wavelength in water is equal to an even fraction (1/4 or 1/2) of the dimensional length inside the cross-over pipe. This is the same principle on which an organ pipe generates a pure tone pneumatic pressure standing wave.

In addition, and exacerbating the vibration resonance condition, the Main pump pedestal experiences a horizontal structural primary rocking mode of the pump pedestal at this same frequency when the Main pump is operating at the rated speed of 4000 RPM. The vibration mode is the second fundamental rocking mode, which is a torsional or twisting mode where the two end bearings move 180 degrees out of phase horizontally. The result of these coincident acoustic and structural resonances is that the Main pump exhibits high vibration in the horizontal direction at the 4x Booster pump RPM frequency. This is solely due to the excitation from the Booster pump being amplified by the coincident resonances. This level of vibration at 4x Booster pump RPM would be seen on the Main pump bearing housings even if the Main pump was not actually running (which is not possible as both pumps are on the same drive train).

The resonant vibration condition at the 4000 RPM operating speed is not detrimental and will not prevent the HPCI pump from fulfilling its function. At the 134 Hz frequency of the resonant vibration on the Main pump, caused by the excitation at 4x Booster pump RPM, the actual displacement amplitude at 0.7 in/sec peak velocity amplitude is 0.0017 inches peak-to-peak. This displacement imposes negligible alternating stresses on the pump pedestal, housings, and connected piping. The peak-to-peak displacement is also less than the Main pump fluid film journal bearing clearances and would impose negligible loading to these bearings.

The purpose of the ASME OM Code for pump testing is to monitor pumps for degradation. The concept of vibration monitoring is to establish baseline values for vibration when the pump is known to be in good working condition, such as after a maintenance overhaul. From that reference point, trending is performed to monitor for degradation based on the ratio of subsequent vibration levels relative to the reference values. The OM Code also establishes absolute vibration level criteria for Alert (>0.325 in/sec) and Required Action (>0.7 in/sec). In doing so, it was recognized that absolute vibration level limits (as opposed to relative change or ratio limits) are not always quantitatively linked directly with pump physical condition and the following remarks are stated in the ASME OMa Code 1996:

> " Vibration measurements of pumps may be foundation, driver, and piping dependent. Therefore, if 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 levels will not prevent the pump from fulfilling its function. "

An important conclusion of the PNPS HPCI pump vibration evaluation is that the mechanical condition of the Main pump can be monitored satisfactorily by disregarding the single frequency component caused by the excitation at 4x Booster pump RPM. A single peak frequency component can be effectively isolated and deleted from a vibration spectrum using the mean-squared subtraction method, that is, the discrete component amplitude (in/sec peak) is squared and subtracted from the spectrum overall level squared, then the square root of that difference represents the overall vibration level that exists without the energy contributed by the deleted component. It has been found that when this method is used, the remaining vibration overall level is much more consistent, stable, and trendable.

This method of vibration level correction has been applied to historical spectrums. The 4x Booster pump RPM component was taken out of the calculation for the main pump overall vibration level. This data shows that when the 4x Booster pump RPM component is deleted from the Main pump vibration, the level is below the Required Action Range (> 0.7 in./sec) but still within the Alert Range (> 0.325 in./sec). It was also shown that the potential effects from the dynamic alignment of pump shaft couplings (at 2X Main pump RPM) can still be monitored effectively.

The vibration spectra derived from the NRC approved alternative test conducted in November 2005 conforms to the historical vibration spectra documented since 1994. Enclosure 1 provides the November 2005 test results and Enclosure 2 provides the historical tests results. Since the observed vibration spectra have not changed, no degradation in the established operational readiness of the HPCI pump has taken place. Also, the alternative test verifies the operational readiness of the HPCI pump in its as-built configuration as stipulated by ISTB 4.3(g) with corresponding footnote.

<u>Impact of Potential Modifications</u>:

For the HPCI Main and Booster pumps, it has been determined that the vibration is foundation and piping dependent. To reduce the HPCI Main and Booster pump vibration down to levels that meet acceptable OM Code vibration criteria requires modifications to the HPCI pump, mounting components, foundation and/or cross-over (interconnecting) piping.

As suggested in a Byron Jackson Tech Note, this vibration may be improved by modifying the interconnecting piping and the Main pump mounting pedestal. The alternative modification changes the Booster pump impeller from four to five vanes to alter the forcing function of the standing wave resonance.

The proposed Byron Jackson modifications, other than replacing the Booster pump impeller, are generally very difficult to implement successfully. Altering the natural frequency of a large pump installation requires either considerable additions of stiffening components or substantial additions of mass. Often the results of such design changes are unsuccessful or unfavorable due to the variable speed operation requirements.

Modification of the HPCI Booster pump would require replacing the current four-vane impeller with an upgraded five-vane impeller. The impeller modification, although yielding predictable results, requires extensive work to the HPCI pump at a time when such a major rebuild of this pump is not otherwise necessary or desired. The expected result would be a modest decrease in the vibration caused on the Main pump at 4000 RPM, although the vibration would remain above the 0.325 inch/sec Alert Range criteria. A small decrease in hydraulic performance is also expected when changing from a four to five-vane impeller. The proposed major modification would cost approximately $500,000 without a compensating improvement in the pump vibration. Most HPCI pump vibration points would remain above the 0.325 in./sec Alert Criteria. Accordingly, the proposed modification would not achieve the underlying objective of performing the Code required testing without the need for Code relief.

PNPS has also concluded that none of the possible modifications that could be performed on the HPCI pump, mounting pedestal, or cross-over piping are necessary. This is primarily due to the nature of the HPCI pump service profile. The Byron Jackson Tech Note describes the following consideration in the Technical Discussion:

> " Pumping systems in which the vane passing pressure pulsations form standing waves in the attached piping are not unusual, especially if the pumps have a variable speed driver. Standing waves are highly dependent upon water temperature. Thus, measured vibration amplitudes often vary from test to test. "

The HPCI pump service is such that the pump runs for short periods of time at highly variable speeds. The pump inservice testing at PNPS is performed with the pump operating at or close to its rated speed (4000 RPM) and flow conditions (4250 GPM) that are unique to PNPS. For this particular pump configuration, this pump speed corresponds to the point where the acoustic resonant vibration is typically most pronounced. In actual service for high pressure coolant injection to the reactor, the pump will operate at the speed that the flow controller requires to maintain reactor water level. The flow rate of 4250 GPM is the maximum makeup flow rate for which the HPCI System was intended to be capable of maintaining reactor water level. This flow rate is far in excess of the decay heat makeup water requirements for the reactor in the isolated condition in the absence of a major leak. The pump speed required is also dependent on reactor pressure with the required speed decreasing along with reactor pressure.

The same general HPCI pump configuration is used at other plants but often with different pump impellers, rated speeds and plant design flow rates. For these plants the vibration characteristics at the inservice testing points are markedly different for that reason. The vibration monitoring performed (including a frequency spectral review) to date under the IST program and the PNPS Pump Vibration Monitoring Program has shown that there has not been degradation of these HPCI pump components.

Inservice Testing can be successfully performed for the PNPS HPCI pump using the methods proposed in this relief request, along with monitoring and maintenance activities currently in practice. Any significant degradation of the HPCI pump components will be readily identified using the vibration spectral analysis methods and other preventive monitoring activities described in this relief request. Therefore, Entergy believes that the proposed alternative testing and monitoring for the PNPS HPCI pump will provide an acceptable level of quality and safety in accordance with 10 CFR 50.55 a(a)(3)(i).

<u>ALTERNATE TESTING</u>:

To allow for practicable monitoring of vibration levels on the HPCI pump, alternate vibration acceptance criteria are necessary. A full spectrum review will be performed for all IST vibration points during each proposed comprehensive test, utilizing the following criteria.

The table below provides the acceptance criteria that are applied to the overall vibration level for the Main pump. The note explains that for the horizontal Main pump points, the discrete frequency component at 4x Booster pump RPM will be extracted from the overall value using the mean-squared subtraction. The two extracted discrete peaks (points P3H and P4H) will be evaluated separately, and will have an Acceptance Range upper limit of 1.05Vr and Alert Range upper limit of 1.3Vr (where Vr equals the vibration reference overall value).

The table boxes in ***bold italics*** have values that have been modified from the OM Code vibration criteria. The ***Alert vibration range of 1.5Vr to 6Vr*** (in lieu of the OM Code range of 2.5Vr to 6Vr) has been applied as the modified OM vibration criteria. The absolute limiting upper Alert Values (i.e. 0.375, 0.450, 0.500, 0.550, and 0.600) are based upon existing pump reference values, and fall between the values of 1.25Vr and 1.5Vr. All of the modified Alert Values have been compared to historical pump vibration data.

The Table row for P8A is in compliance with the OM Code vibration criteria, and has been placed into this relief request for information only.

MAIN PUMP**

Test Parameter	Vibration Point	Acceptable Range	Alert Range	Required Action Range
V_v	Main pump** Horizontal Inboard (P3H)	***≤ 1.5 V_r but not > 0.550 in./sec***	***> 1.5 V_r to 6 V_r or > 0.550 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Main pump** Horizontal Outboard (P4H)	***≤ 1.5 V_r but not > 0.600 in./sec***	***> 1.5 V_r to 6 V_r or > 0.600 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Main pump Vertical Inboard (P3V)	***≤ 1.5 V_r but not > 0.450 in./sec***	***> 1.5 V_r to 6 V_r or > 0.450 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Main pump Vertical Outboard (P4V)	***≤ 1.5 V_r but not > 0.375 in./sec***	***> 1.5 V_r to 6 V_r or > 0.375 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Main pump Axial Inboard (P3A))	***≤ 1.5 V_r but not > 0.500 in./sec***	***> 1.5 V_r to 6 V_r or > 0.500 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec

**Note: For Main pump Horizontal vibration points P3H and P4H, a frequency spectrum analysis will be performed for each pump vibration operability test and the discrete peak at 4x Booster pump RPM will be extracted (using mean-squared subtraction method) from the vibration spectrum overall value. In addition, all other vibration spectrum discrete peaks (including the extracted discrete peak) will be evaluated during each test, and will have an Acceptable Range upper limit of 1.05 V_r and an Alert Range upper limit 1.3 V_r.

BOOSTER PUMP

Test Parameter	Vibration Point	Acceptable Range	Alert Range	Required Action Range
V_v	Booster pump Horizontal Inboard (P7H)	***≤ 1.5 V_r but not > 0.450 in./sec***	***> 1.5 V_r to 6 V_r or > 0.450 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Booster pump Horizontal Outboard (P8H)	***≤ 1.5 V_r but not > 0.500 in./sec***	***> 1.5 V_r to 6 V_r or > 0.500 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Booster pump Vertical Inboard (P7V)	***≤ 1.5 V_r but not > 0.400 in./sec***	***> 1.5 V_r to 6 V_r or > 0.400 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Booster pump Vertical Outboard (P8V)	***≤ 1.5 V_r but not > 0.500 in./sec***	***> 1.5 V_r to 6 V_r or > 0.500 to 0.70 in./sec***	> 6 V_r or > 0.70 in./sec
V_v	Booster pump Axial Outboard (P8A)	≤ 2.5 V_r but not > 0.325 in./sec	> 2.5 V_r to 6 V_r or > 0.325 to 0.70 in./sec	> 6 V_r or > 0.70 in./sec

DURATION OF PROPOSED ALTERNATIVE

The proposed alternative testing shall apply for the remainder of the 4th Inservice Testing Interval at Pilgrim.

REFERENCES

1. NRC Letter, Pilgrim Nuclear Power Station- Entergy Relief Request PR-03 High Pressure Coolant Injection Pump (TAC NO. MB8773), dated August 29, 2005

2. Entergy Letter No. 02.05.042, Response to NRC Request for Additional Information Related to Pilgrim In-service Testing (IST) Relief Request PR-03 (TAC NO. MB8773), dated May 24, 2005

3. Entergy Letter No. 02.05.012, Pilgrim Fourth Ten-year In-Service Testing Program, IST relief Request PR-03, dated February 24, 2005

ENCLOSURES

Enclosure 1: HPCI pump November 2005 Vibration Test Results (11 pages)

Enclosure 2: HPCI pump Configuration and Historical Vibration Test Results (66 pages)

ENCLOSURE 1

HPCI PUMP NOVEMBER 2005 VIBRATION TEST RESULTS
(11 pages)

(Pilgrim Seeks Relief for P3H and P4H Points.
Data for the remaining point is provided for information)

1. Relief Point P3H Data
2. Relief Point P4H Data
3. Point P3V Data
4. Point P3A Data
5. Point P4V Data
6. Point P7H Data
7. Point P7V Data
8. Point P8H Data
9. Point P8V Data
10. Point P8A Data

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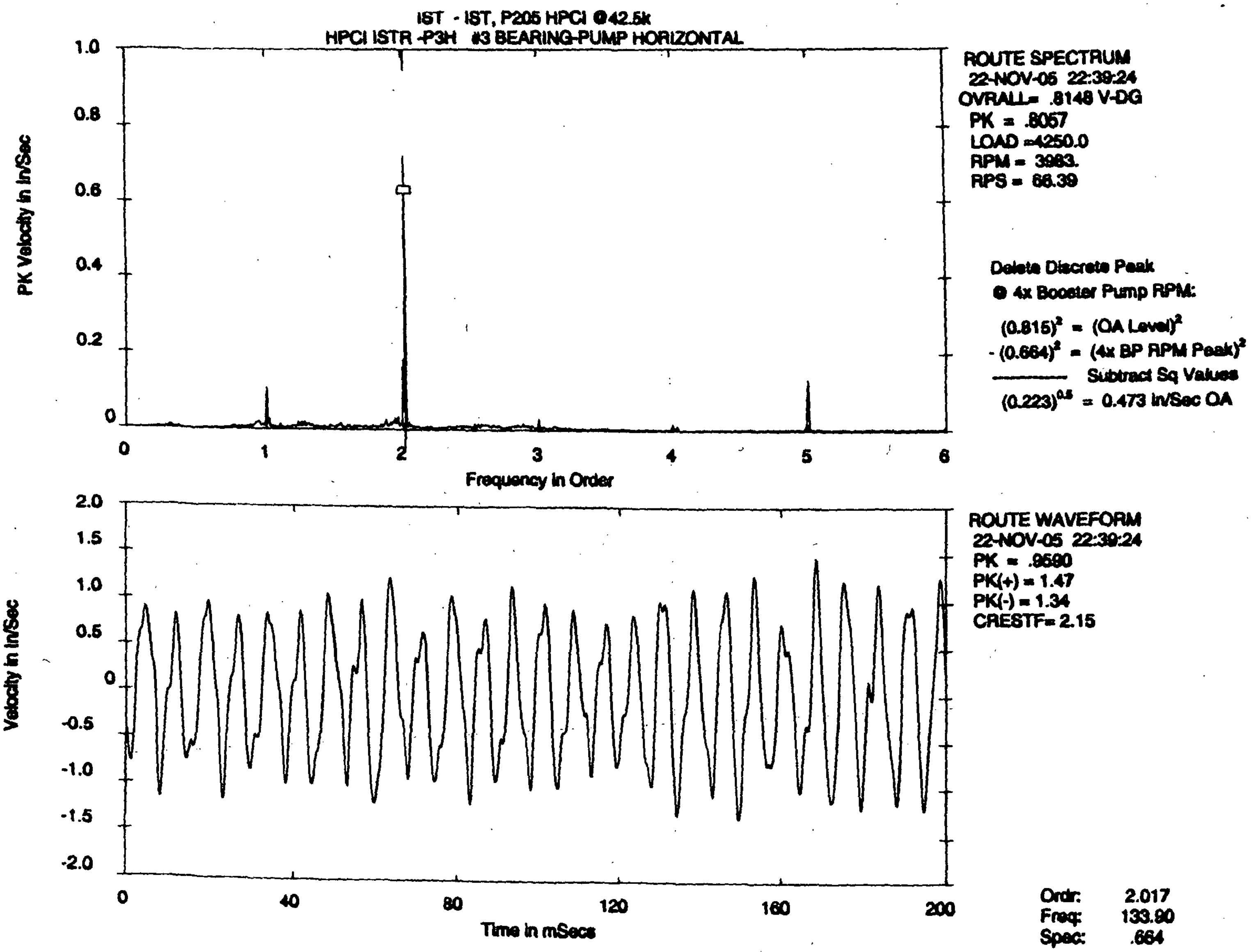
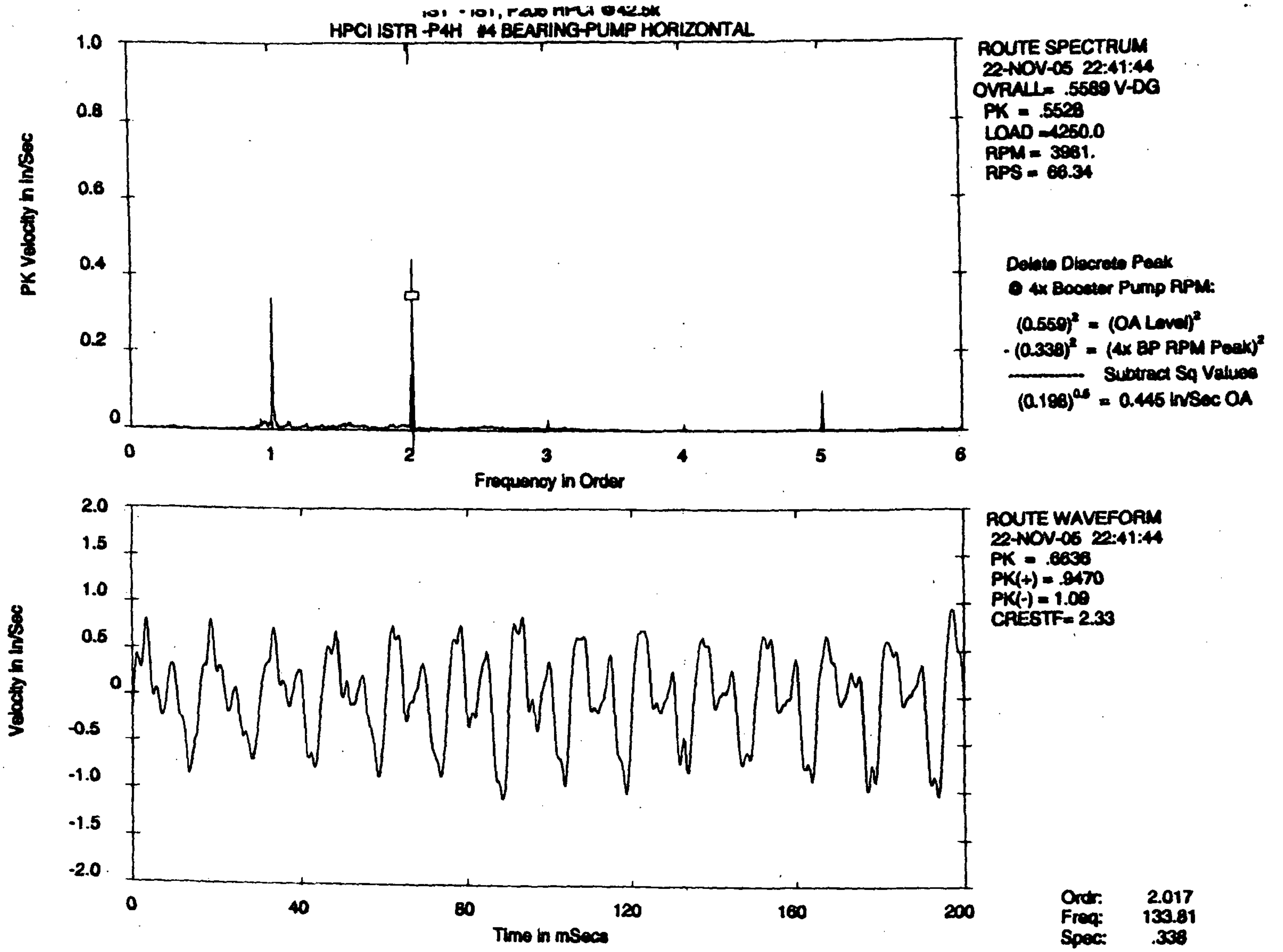
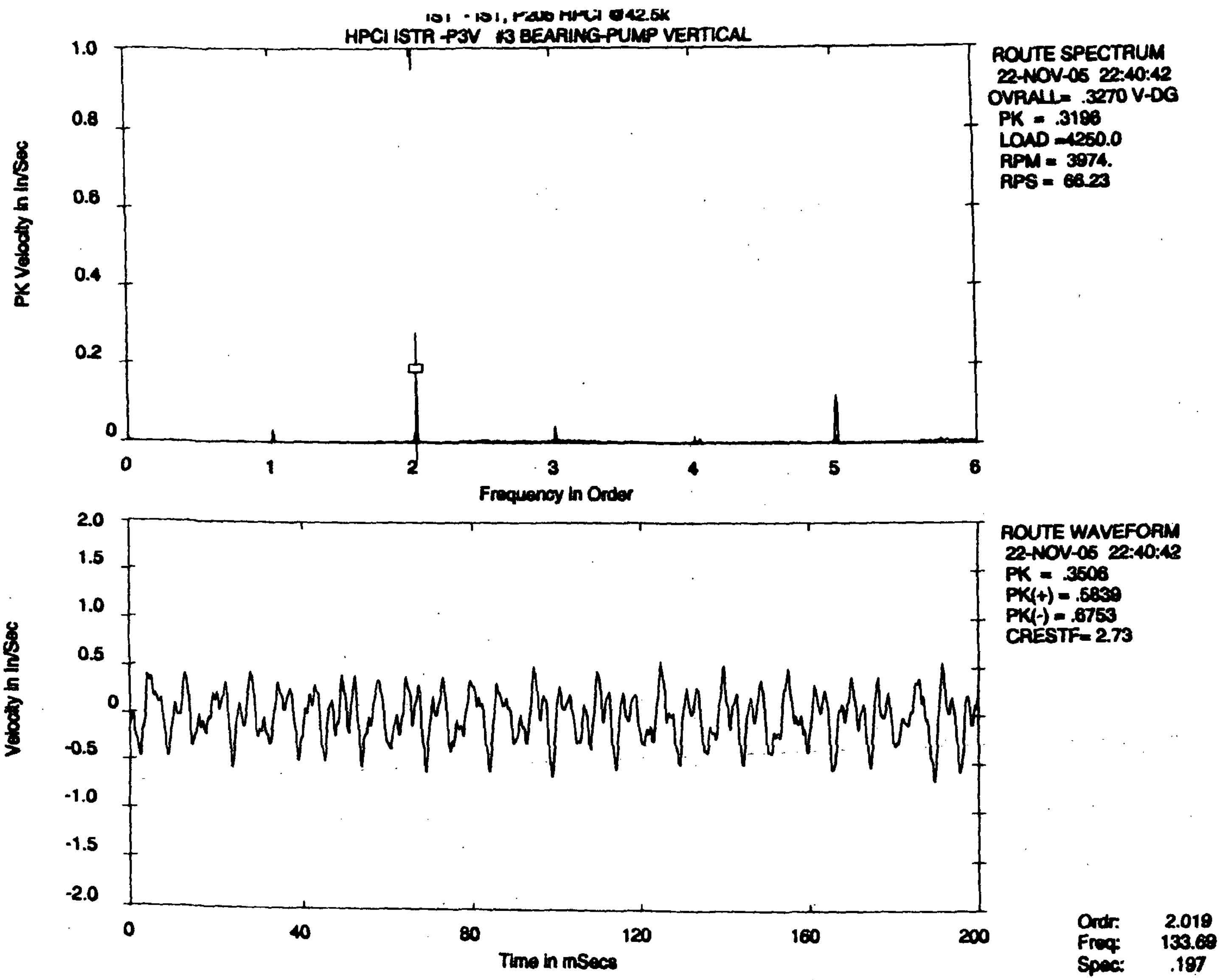
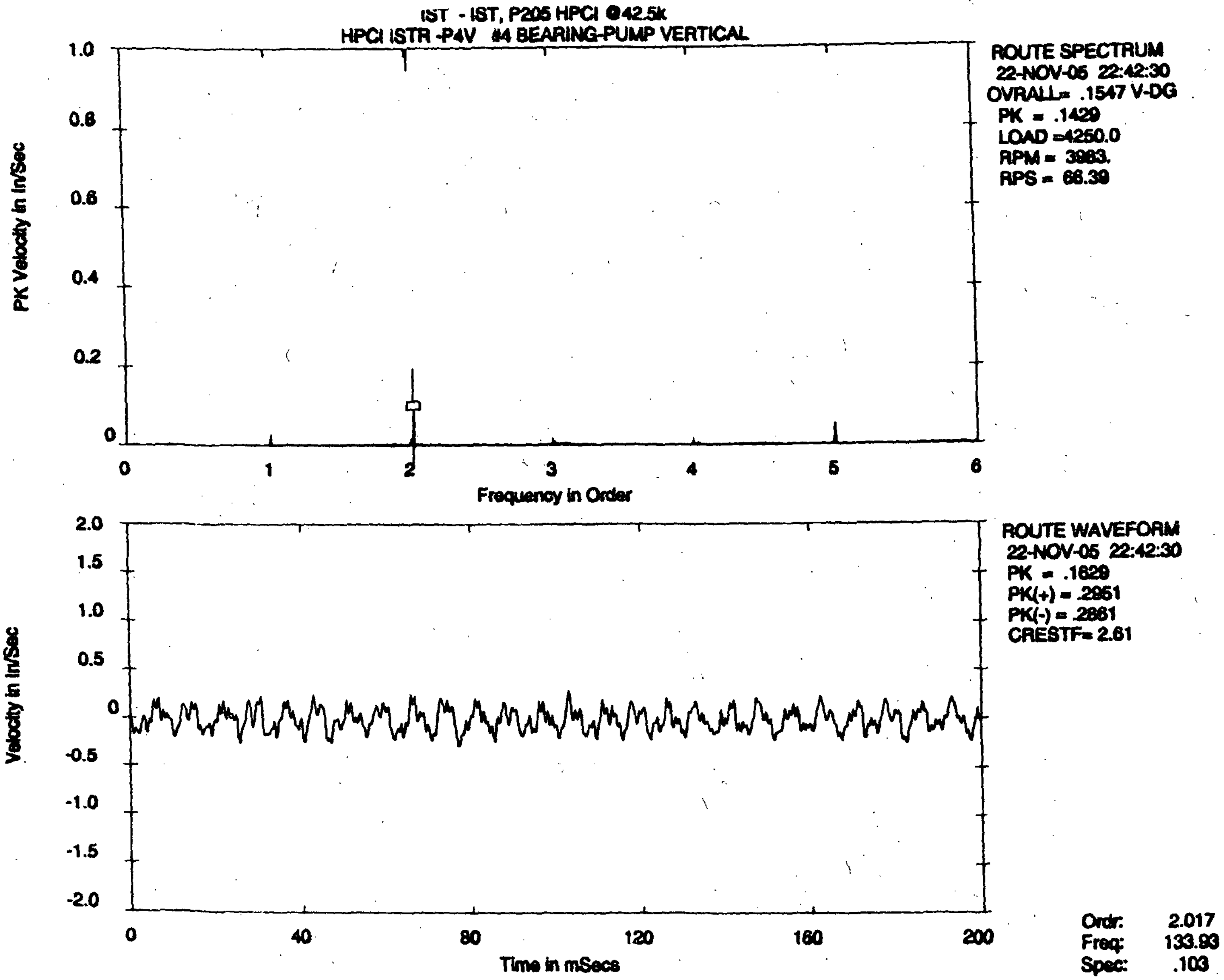
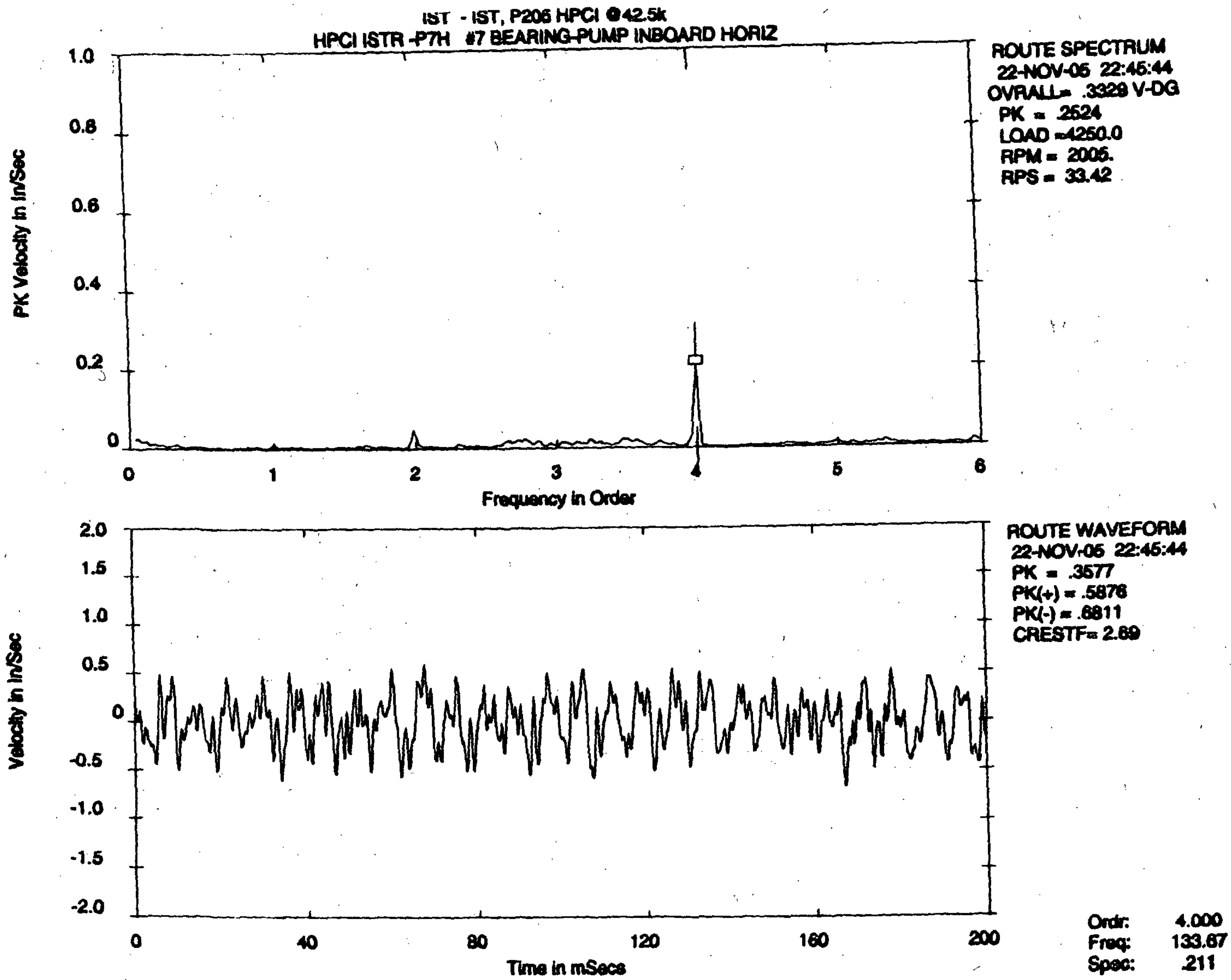

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P3H #3 BEARING-PUMP HORIZONTAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6
Frequency in Order
ROUTE SPECTRUM
22-NOV-05 22:39:24
OVRALL= .8148 V-DG
PK = .8057
LOAD =4250.0
RPM = 3983.
RPS = 66.39
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.815)² = (OA Level)²
- (0.664)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.223)^0.5 = 0.473 In/Sec OA
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0 40 80 120 160 200
Time in mSecs
ROUTE WAVEFORM
22-NOV-05 22:39:24
PK = .9590
PK(+) = 1.47
PK(-) = 1.34
CRESTF= 2.15
Ordr: 2.017
Freq: 133.90
Spec: .664


HPCI ISTR -P4H #4 BEARING-PUMP HORIZONTAL
PK Velocity in In/Sec
Frequency in Order
ROUTE SPECTRUM
22-NOV-05 22:41:44
OVRALL= .5589 V-DG
PK = .5528
LOAD =4250.0
RPM = 3981.
RPS = 66.34
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.559)² = (OA Level)²
- (0.338)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.198)^0.5 = 0.445 In/Sec OA
Velocity in In/Sec
Time in mSecs
ROUTE WAVEFORM
22-NOV-05 22:41:44
PK = .8636
PK(+) = .9470
PK(-) = 1.09
CRESTF= 2.33
Ordr: 2.017
Freq: 133.81
Spec: .338

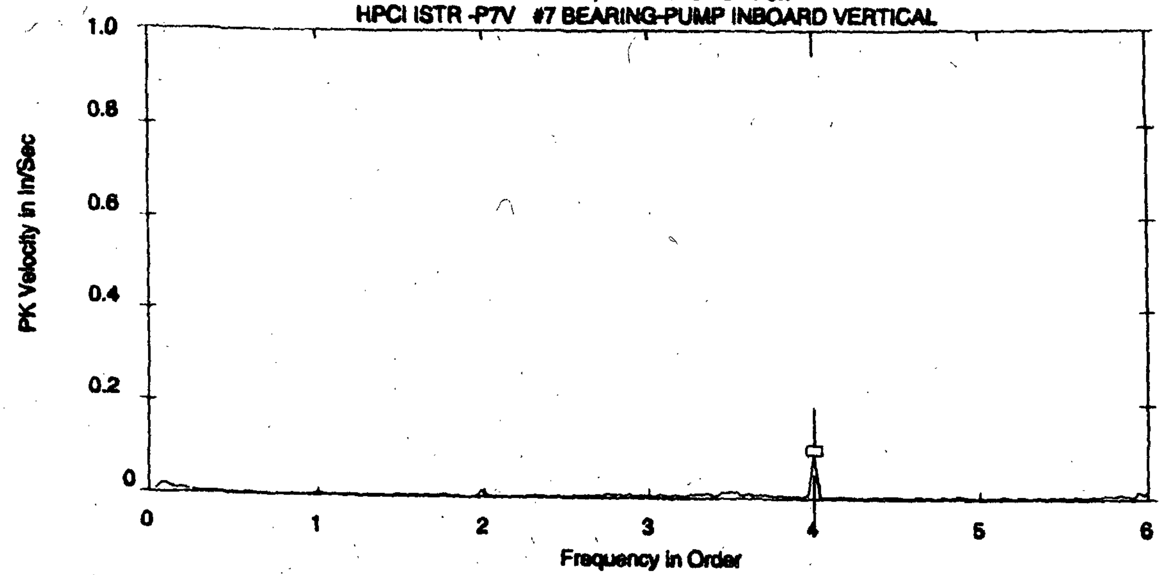

HPCI ISTR -P3V #3 BEARING-PUMP VERTICAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
22-NOV-05 22:40:42
OVRALL= .3270 V-DG
PK = .3198
LOAD =4250.0
RPM = 3974.
RPS = 66.23
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
ROUTE WAVEFORM
22-NOV-05 22:40:42
PK = .3506
PK(+) = .5839
PK(-) = .6753
CRESTF= 2.73
Ordr: 2.019
Freq: 133.69
Spec: .197


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P4V #4 BEARING-PUMP VERTICAL
ROUTE SPECTRUM
22-NOV-05 22:42:30
OVRALL= .1547 V-DG
PK = .1429
LOAD =4250.0
RPM = 3983.
RPS = 66.39
PK Velocity in In/Sec
Frequency in Order
ROUTE WAVEFORM
22-NOV-05 22:42:30
PK = .1629
PK(+) = .2951
PK(-) = .2861
CRESTF= 2.61
Velocity in In/Sec
Time in mSecs
Ordr: 2.017
Freq: 133.93
Spec: .103

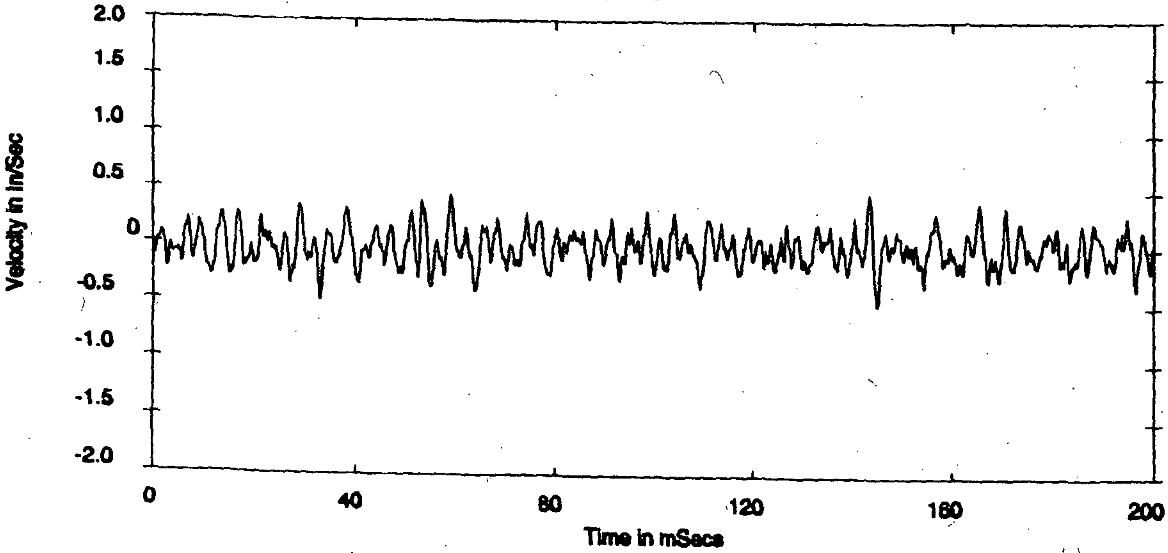


IST - IST, P206 HPCI @42.5k
HPCI ISTR -P7H #7 BEARING-PUMP INBOARD HORIZ
ROUTE SPECTRUM
22-NOV-05 22:45:44
OVRALL= .3329 V-DG
PK = .2524
LOAD =4250.0
RPM = 2005.
RPS = 33.42
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE WAVEFORM
22-NOV-05 22:45:44
PK = .3577
PK(+) = .5876
PK(-) = .6811
CRESTF= 2.69
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.000
Freq: 133.67
Spec: .211

IS1 - IST, P205 HPCI @42.5k
HPCI ISTR -P7V #7 BEARING-PUMP INBOARD VERTICAL

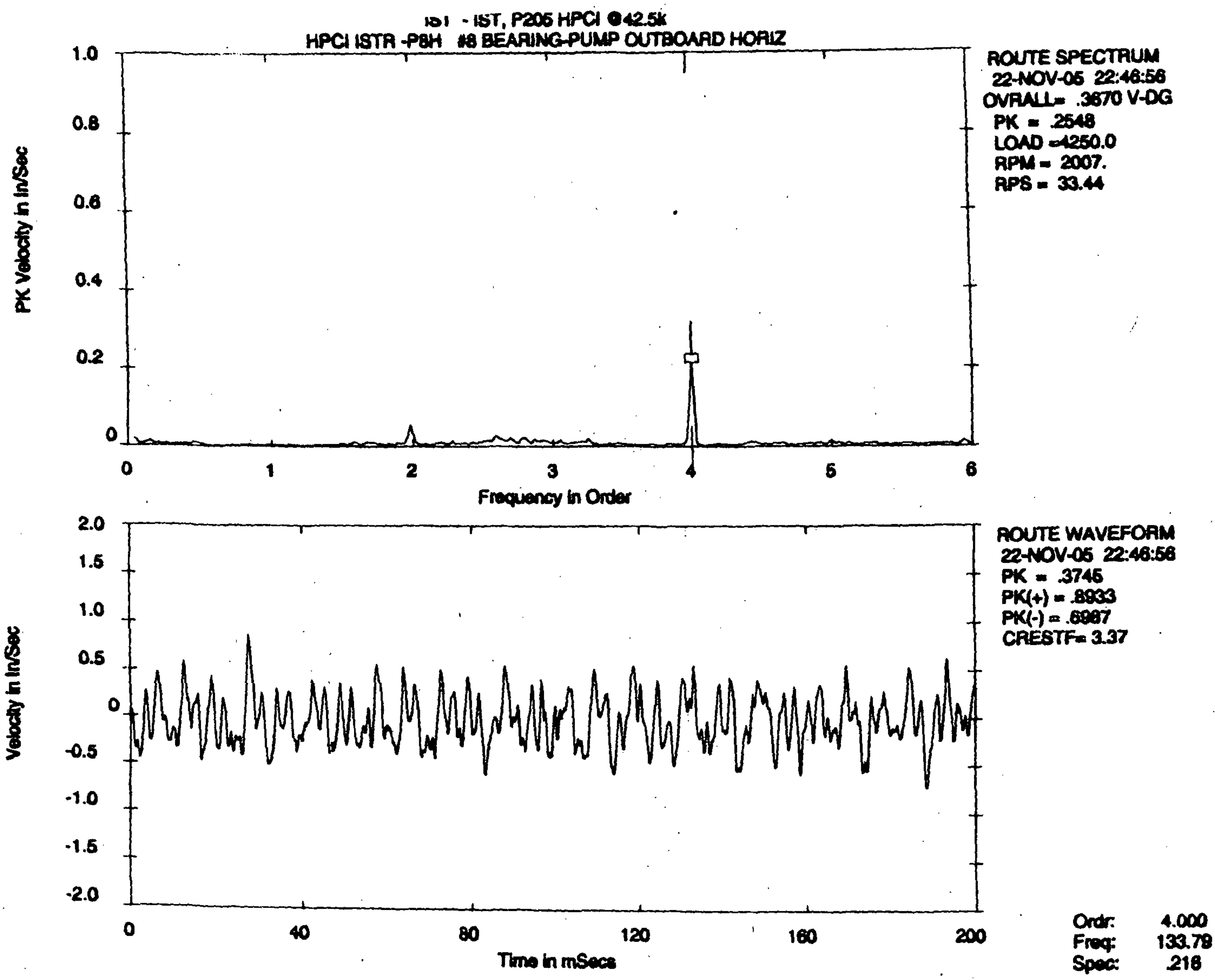


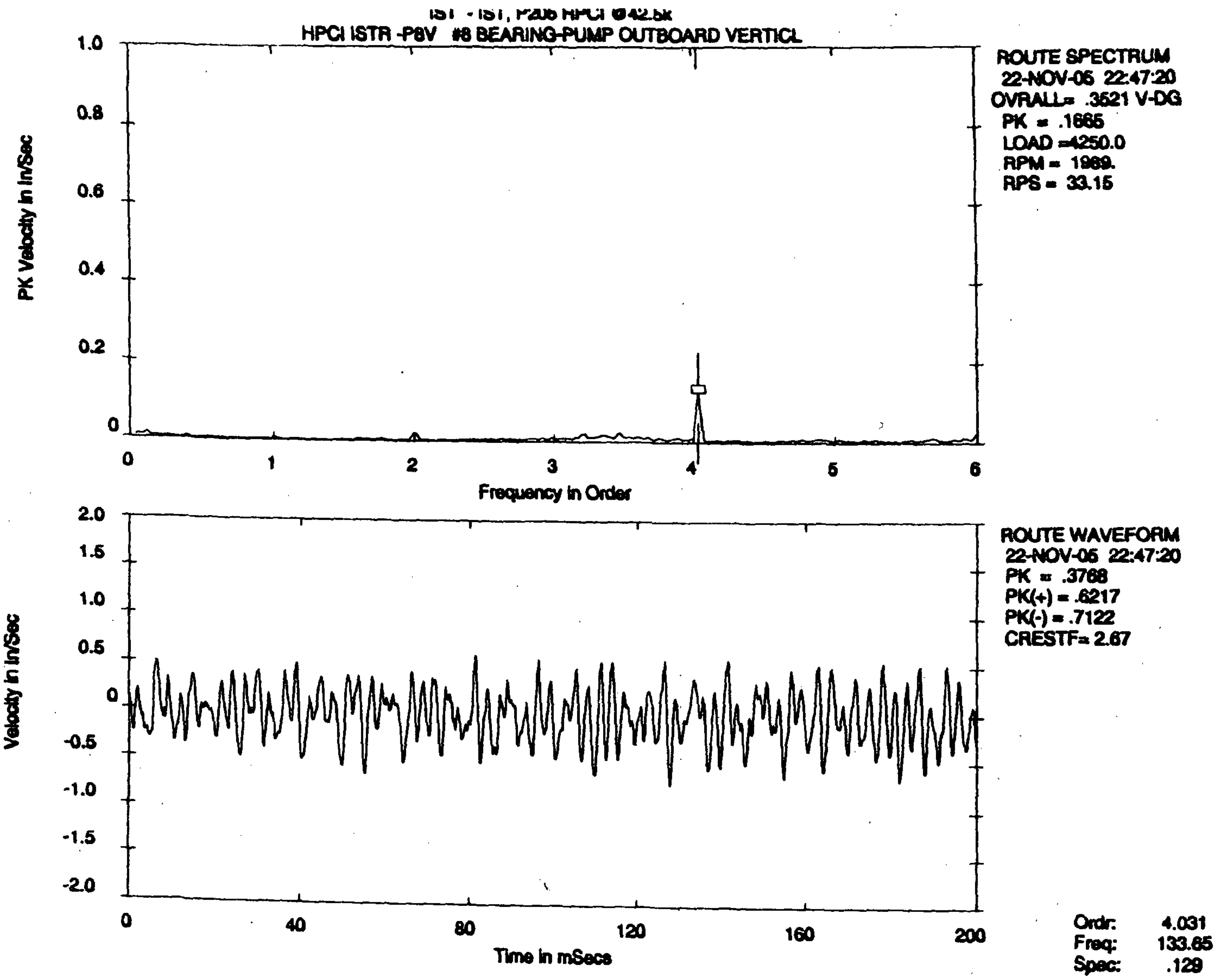
ROUTE SPECTRUM
22-NOV-05 22:46:12
OVRALL= .2395 V-DG
PK = .1263
LOAD =4250.0
RPM = 2007.
RPS = 33.45

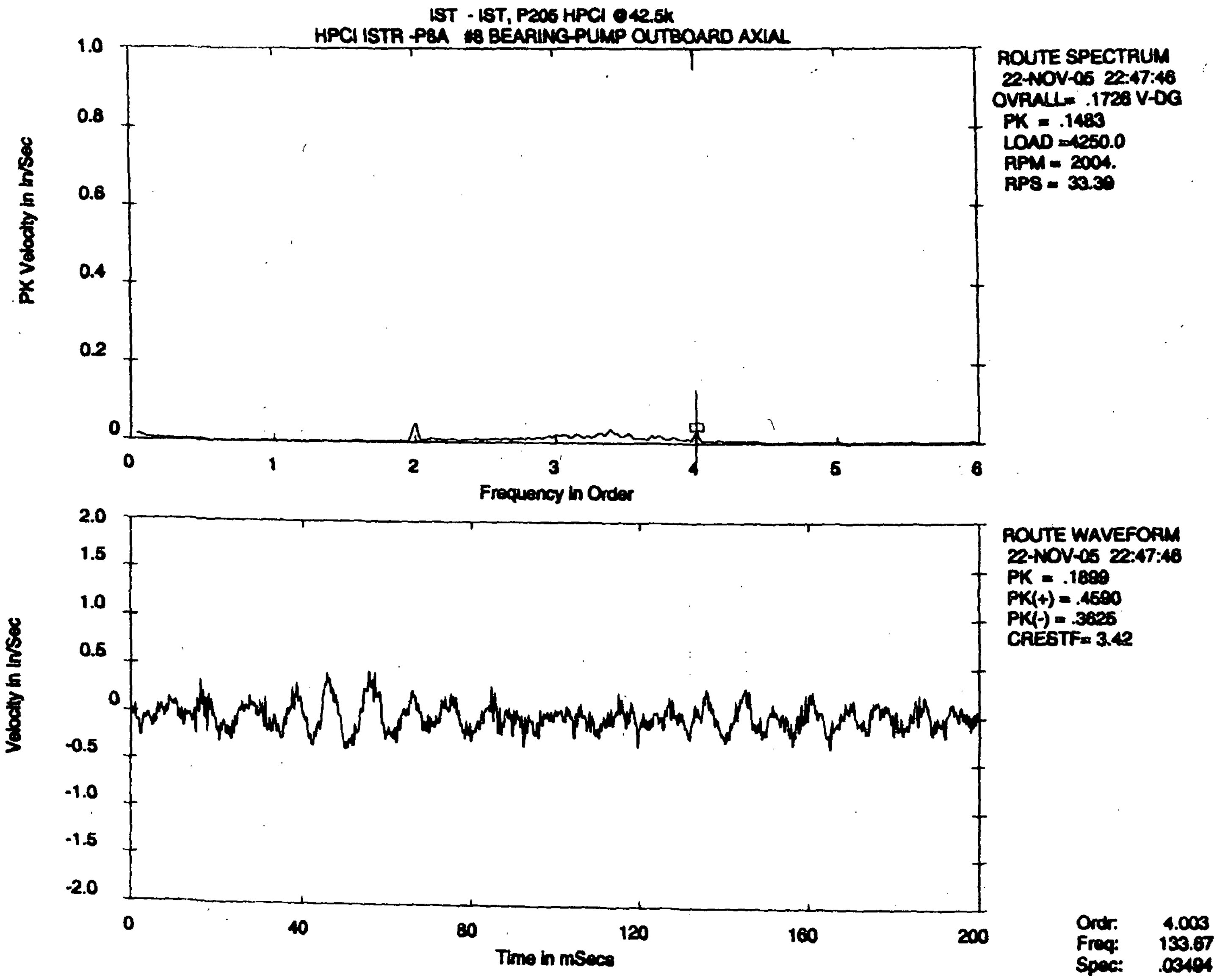


ROUTE WAVEFORM
22-NOV-05 22:46:12
PK = .2212
PK(+) = .4963
PK(-) = .4890
CRESTF= 3.17

Ordr: 3.997
Freq: 133.70
Spec: .09500


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8H #8 BEARING-PUMP OUTBOARD HORIZ
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
22-NOV-05 22:46:56
OVRALL= .3670 V-DG
PK = .2548
LOAD =4250.0
RPM = 2007.
RPS = 33.44
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
ROUTE WAVEFORM
22-NOV-05 22:46:56
PK = .3745
PK(+) = .8933
PK(-) = .6967
CRESTF= 3.37
Ordr: 4.000
Freq: 133.79
Spec: .216


IST - IST, P206 HPCI @42.5K
HPCI ISTR -P8V #8 BEARING-PUMP OUTBOARD VERTICL
ROUTE SPECTRUM
22-NOV-06 22:47:20
OVRALL= .3521 V-DG
PK = .1665
LOAD =4250.0
RPM = 1989.
RPS = 33.15
PK Velocity in In/Sec
Frequency in Order
ROUTE WAVEFORM
22-NOV-06 22:47:20
PK = .3768
PK(+) = .6217
PK(-) = .7122
CRESTF= 2.67
Velocity in In/Sec
Time in mSecs
Ordr: 4.031
Freq: 133.65
Spec: .129


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8A #8 BEARING-PUMP OUTBOARD AXIAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
22-NOV-05 22:47:46
OVRALL= .1726 V-DG
PK = .1483
LOAD =4250.0
RPM = 2004.
RPS = 33.39
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
ROUTE WAVEFORM
22-NOV-05 22:47:46
PK = .1899
PK(+) = .4590
PK(-) = .3625
CRESTF= 3.42
Ordr: 4.003
Freq: 133.67
Spec: .03494

ENCLOSURE 2

HPCI PUMP CONFIGURATION AND HISTORICAL VIBRATION TEST RESULTS
(Total 66 pages)

(Pilgrim seeks Relief for P3H and P4H Points. Data for the remaining point is provided for information)

HPCI Pump Layout

1. HPCI Pump Configuration
2. HPCI Pump Configuration
3. HPCI Pump Configuration
4. HPCI Pump Vibration Monitoring Program

Relief Point P3H Data

5. P3H HPCI Vibration Spectrum Data, Nov. 24, 2004
6. P3H HPCI Vibration Spectrum Data, Aug. 24, 2004
7. P3H HPCI Vibration Spectrum Data, Dec. 17, 1997
8. P3H HPCI Vibration Spectrum Data, May 06, 1996
9. P3H HPCI Vibration Spectrum Data, Nov. 20, 1995
10. P3H HPCI Vibration Spectrum Data, May 25, 1994

Relief Point P4H Data

11. P4H HPCI Vibration Spectrum Data, Nov. 24, 2004
12. P4H HPCI Vibration Spectrum Data, Aug. 24, 2004
13. P4H HPCI Vibration Spectrum Data, Dec. 17, 1997
14. P4H HPCI Vibration Spectrum Data, May 06, 1996
15. P4H HPCI Vibration Spectrum Data, Nov. 20, 1995
16. P4H HPCI Vibration Spectrum Data, May 25, 1994

Point P3V Data

17. P3V HPCI Vibration Spectrum Data, Nov. 24, 2004
18. P3V HPCI Vibration Spectrum Data, Aug. 24, 2004
19. P3V HPCI Vibration Spectrum Data, Dec. 17, 1997
20. P3V HPCI Vibration Spectrum Data, May 06, 1996
21. P3V HPCI Vibration Spectrum Data, Nov. 20, 1995
22. P3V HPCI Vibration Spectrum Data, May 25, 1994

Point P3A Data

23. P3A HPCI Vibration Spectrum Data, Nov. 24, 2004
24. P3A HPCI Vibration Spectrum Data, Aug. 24, 2004
25. P3A HPCI Vibration Spectrum Data, Dec. 17, 1997
26. P3A HPCI Vibration Spectrum Data, May 06, 1996
27. P3A HPCI Vibration Spectrum Data, Nov. 20, 1995
28. P3A HPCI Vibration Spectrum Data, May 25, 1994

Point P4V Data

29. P4V HPCI Vibration Spectrum Data, Nov. 24, 2004
30. P4V HPCI Vibration Spectrum Data, Aug. 24, 2004
31. P4V HPCI Vibration Spectrum Data, Dec. 17, 1997
32. P4V HPCI Vibration Spectrum Data, May 06, 1996
33. P4V HPCI Vibration Spectrum Data, Nov. 20, 1995
34. P4V HPCI Vibration Spectrum Data, May 25, 1994

Point P7H Data

35. P7H HPCI Vibration Spectrum Data, Nov. 24, 2004
36. P7H HPCI Vibration Spectrum Data, Aug. 24, 2004
37. P7H HPCI Vibration Spectrum Data, Dec. 17, 1997
38. P7H HPCI Vibration Spectrum Data, May 06, 1996
39. P7H HPCI Vibration Spectrum Data, Nov. 20, 1995
40. P7H HPCI Vibration Spectrum Data, May 25, 1994

Point P7V Data

41. P7V HPCI Vibration Spectrum Data, Nov. 24, 2004
42. P7V HPCI Vibration Spectrum Data, Aug. 24, 2004
43. P7V HPCI Vibration Spectrum Data, Dec. 17, 1997
44. P7V HPCI Vibration Spectrum Data, May 06, 1996
45. P7V HPCI Vibration Spectrum Data, Nov. 20, 1995
46. P7V HPCI Vibration Spectrum Data, May 25, 1994

Point P8H Data

47. P8H HPCI Vibration Spectrum Data, Nov. 24, 2004
48. P8H HPCI Vibration Spectrum Data, Aug. 24, 2004
49. P8H HPCI Vibration Spectrum Data, Dec. 17, 1997
50. P8H HPCI Vibration Spectrum Data, May 06, 1996
51. P8H HPCI Vibration Spectrum Data, Nov. 20, 1995
52. P8H HPCI Vibration Spectrum Data, May 25, 1994

Point P8V Data

53. P8V HPCI Vibration Spectrum Data, Nov. 24, 2004
54. P8V HPCI Vibration Spectrum Data, Aug. 24, 2004
55. P8V HPCI Vibration Spectrum Data, Dec. 17, 1997
56. P8V HPCI Vibration Spectrum Data, May 06, 1996
57. P8V HPCI Vibration Spectrum Data, Nov. 20, 1995
58. P8V HPCI Vibration Spectrum Data, May 25, 1994

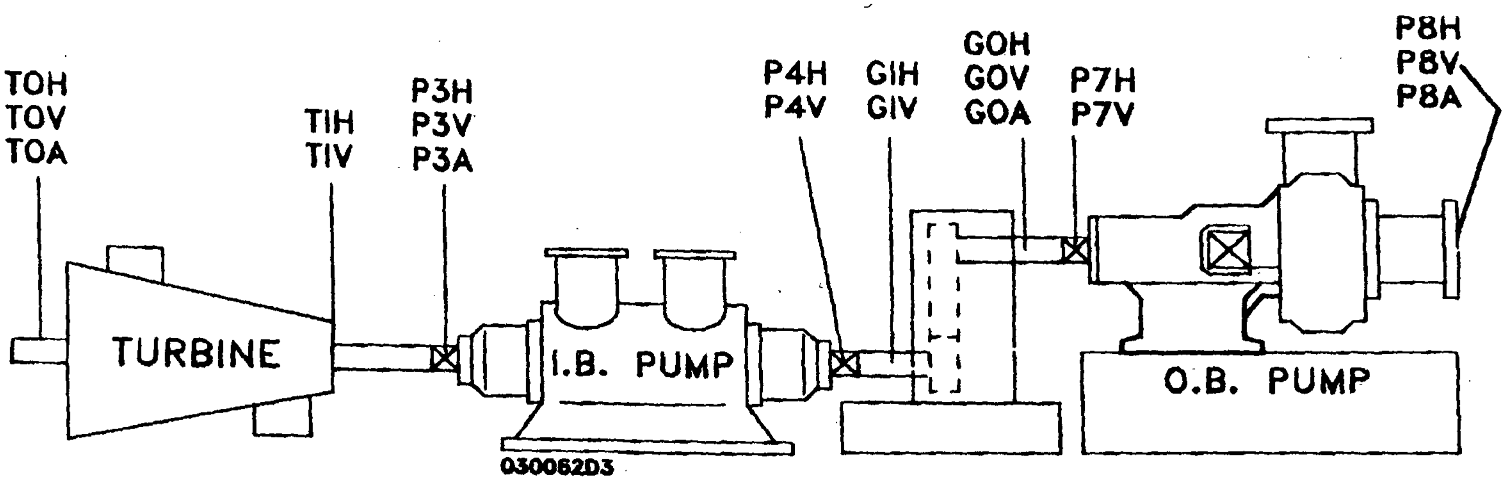
Point P8A Data

59. P8A HPCI Vibration Spectrum Data, Nov. 24, 2004
60. P8A HPCI Vibration Spectrum Data, Aug. 24, 2004
61. P8A HPCI Vibration Spectrum Data, Dec. 17, 1997
62. P8A HPCI Vibration Spectrum Data, July 31, 1996*
63. P8A HPCI Vibration Spectrum Data, Nov. 20, 1995
64. P8A HPCI Vibration Spectrum Data, May 25, 1994

*July 31, 1996 data is submitted since May 06, 1996 data is not available for point P8A.

encl001.PDF

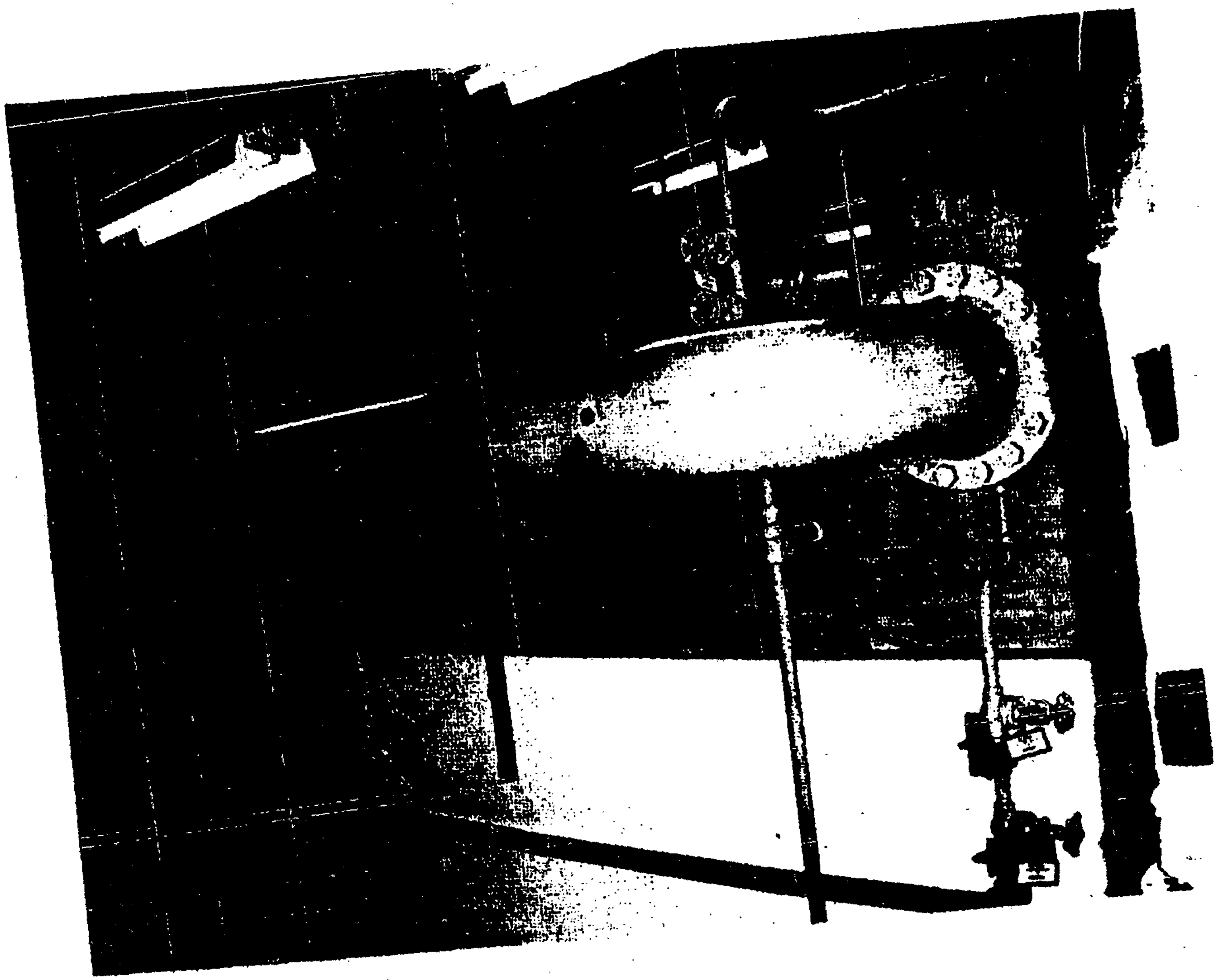
HPCI Pump Configuration



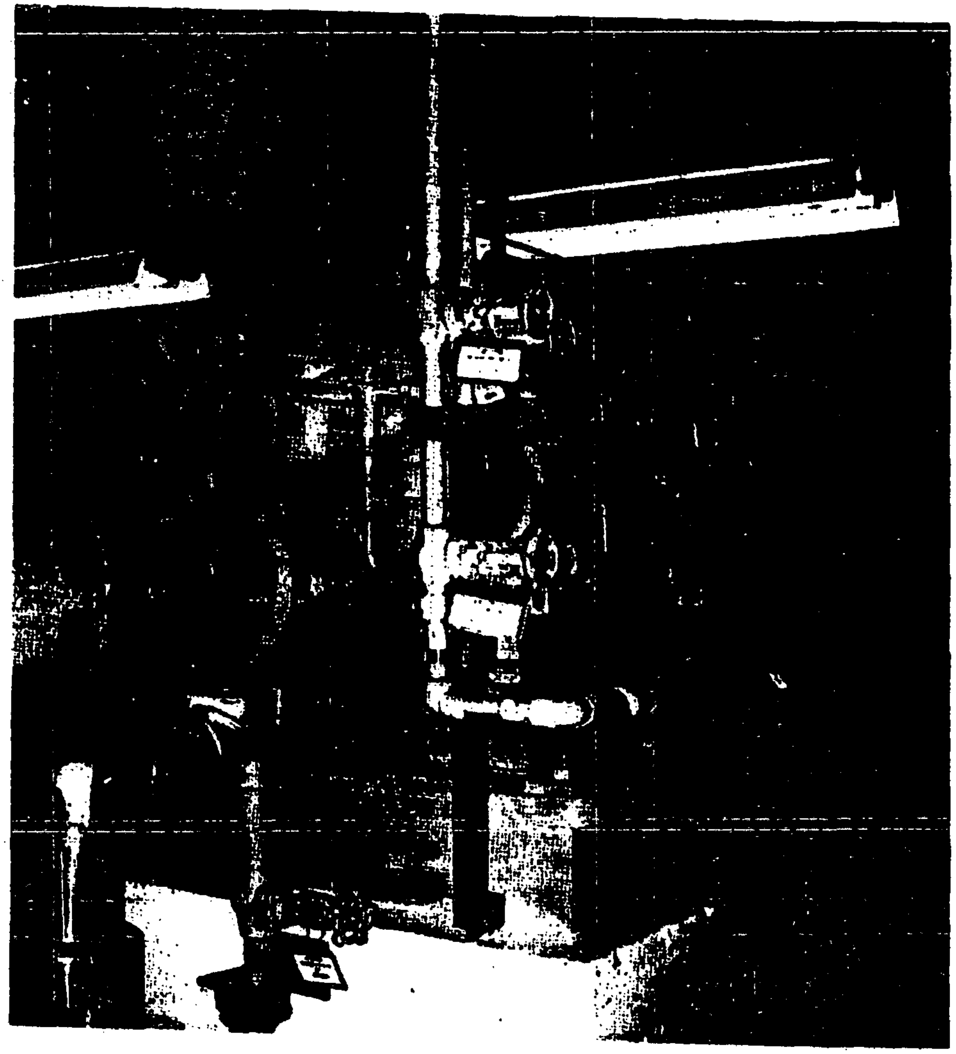
Main Pump

Booster Pump

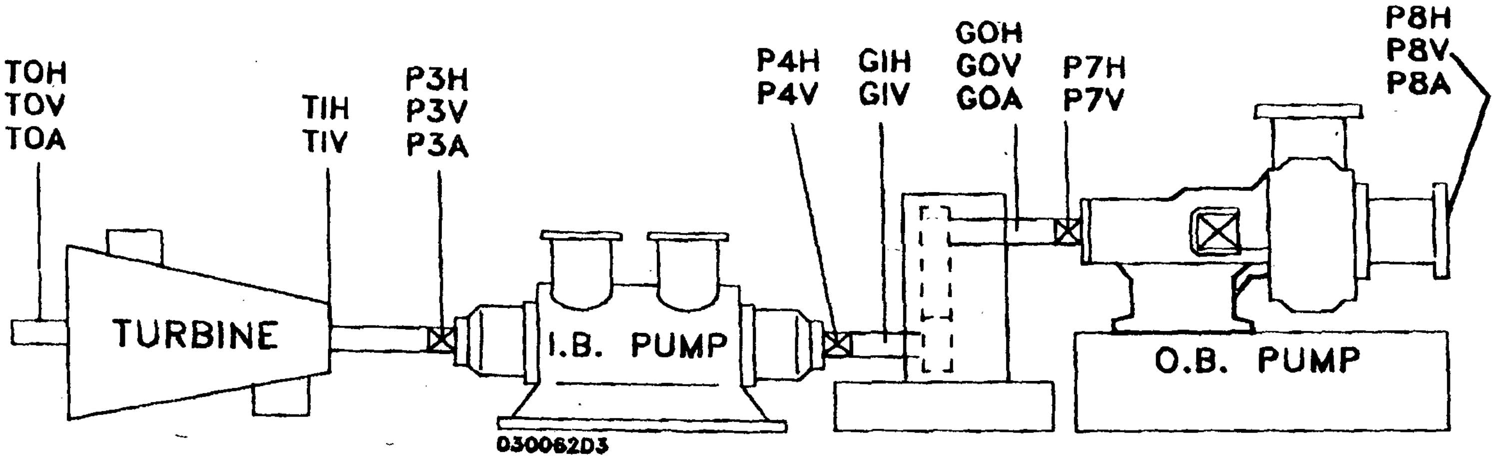
HPCI Pump Configuration



HPCI Pump Configuration



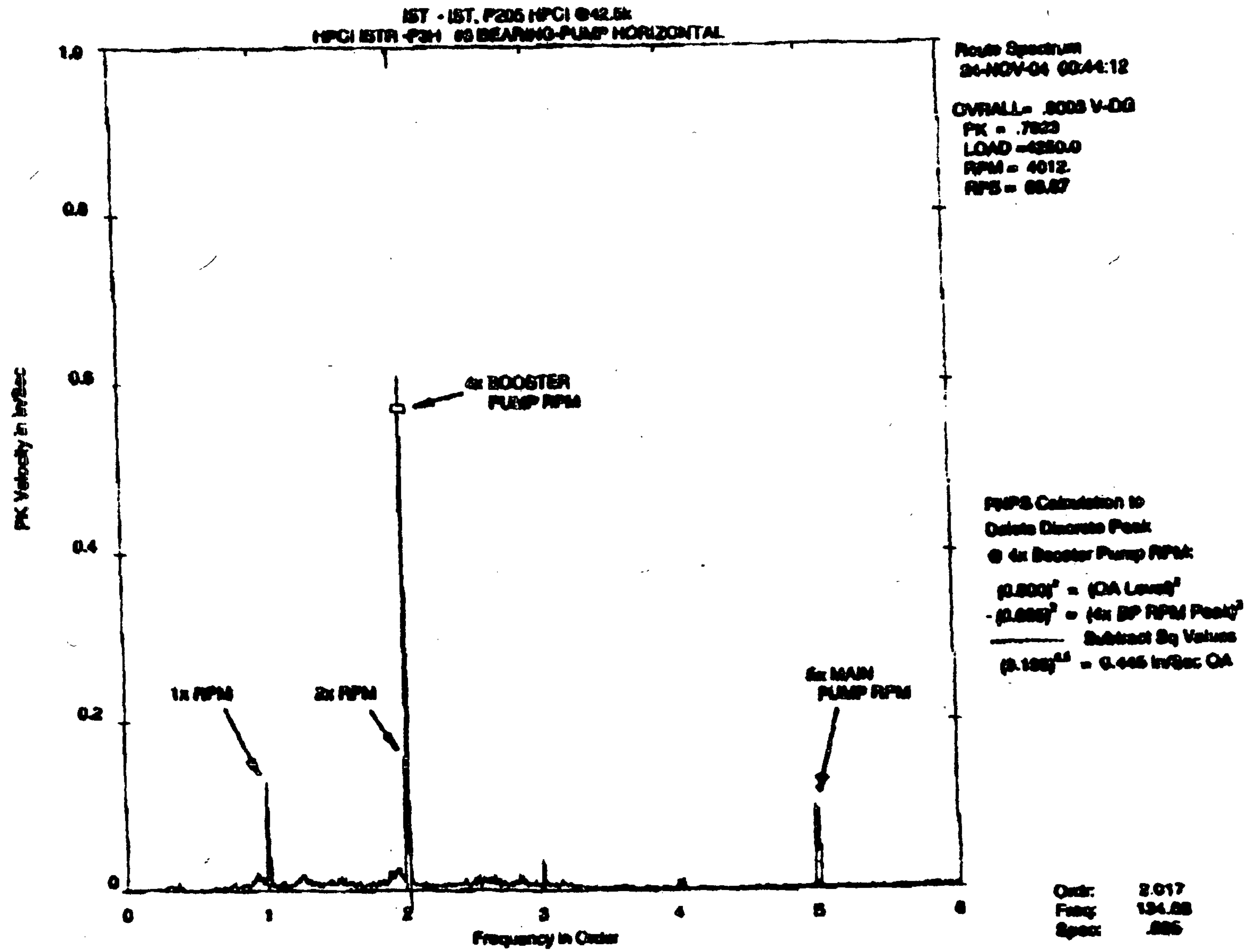
HPCI Pump Vibration Monitoring Program



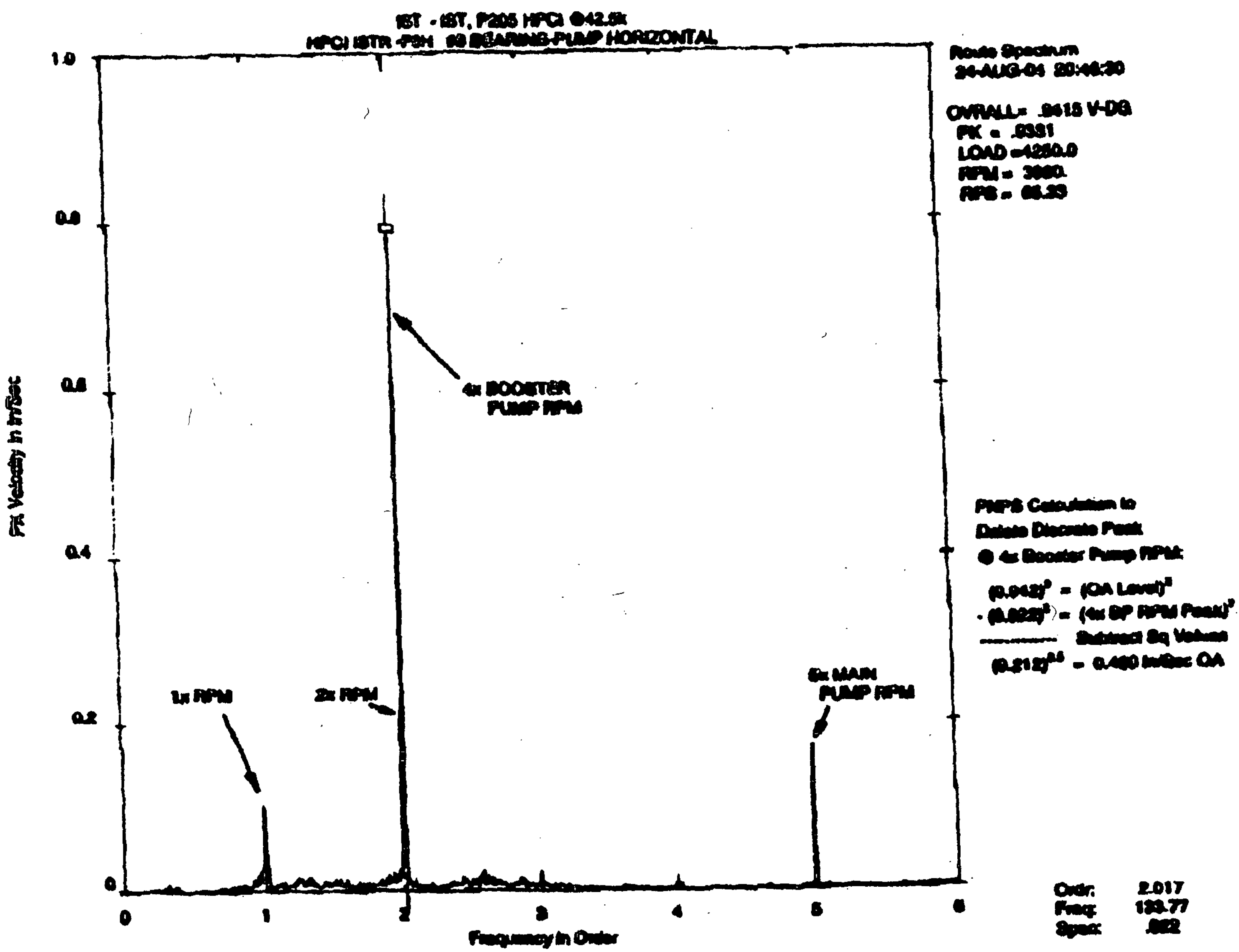
P3H	P4H	P7H	P8H
P3V	P4V	P7V	P8V
P3A			P8A

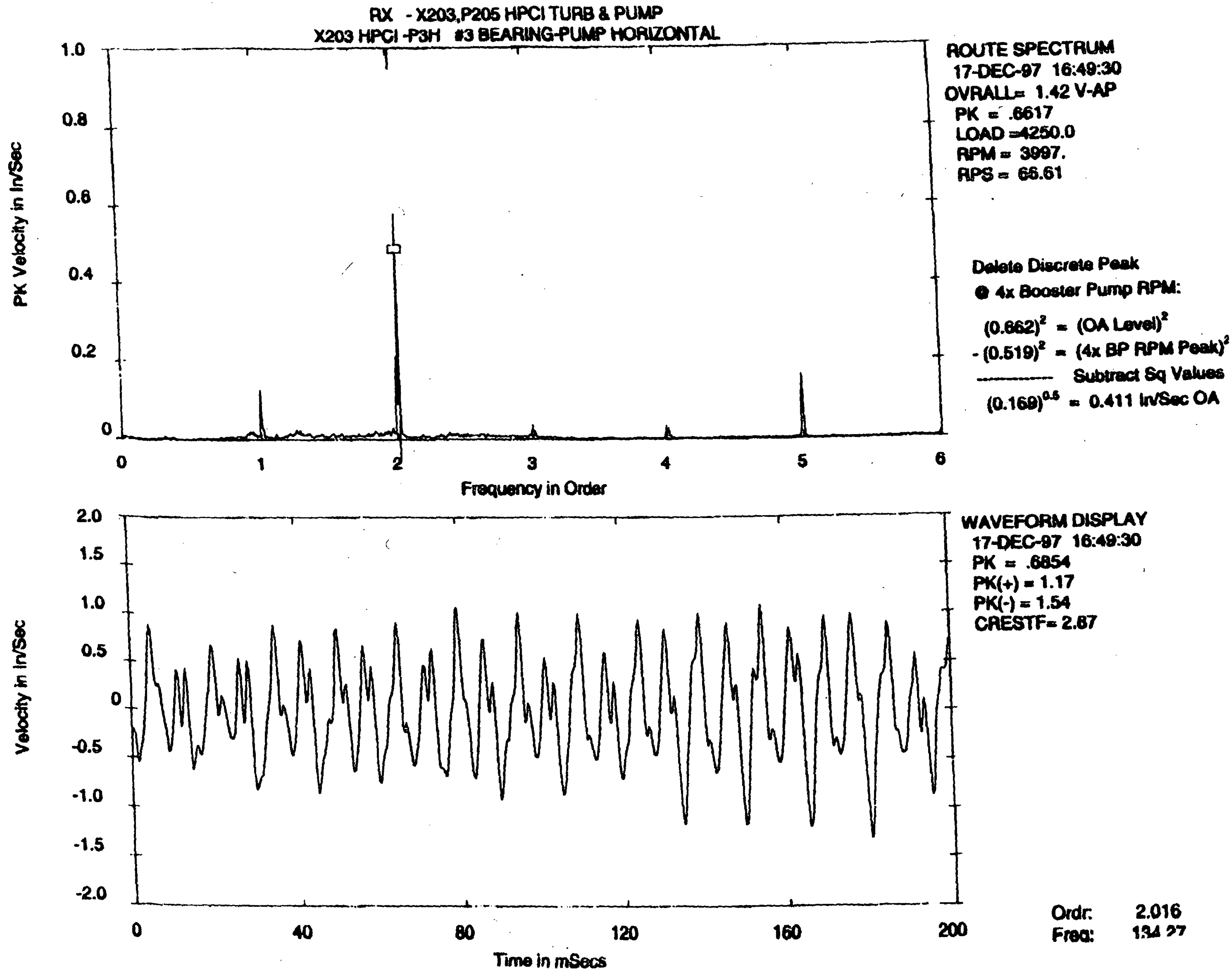
Other points are monitored as part of Vibration Monitoring for Preventive Maintenance and Balance

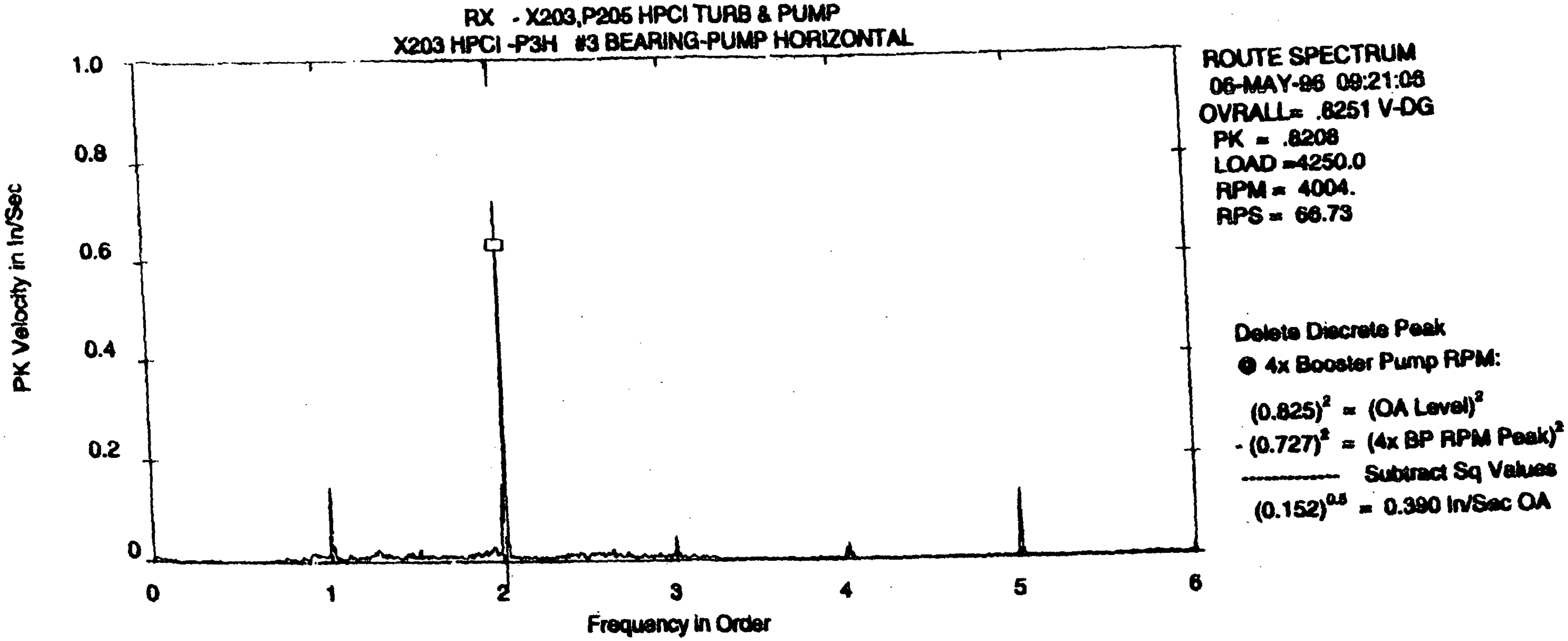
HPCI Data November 24, 2004



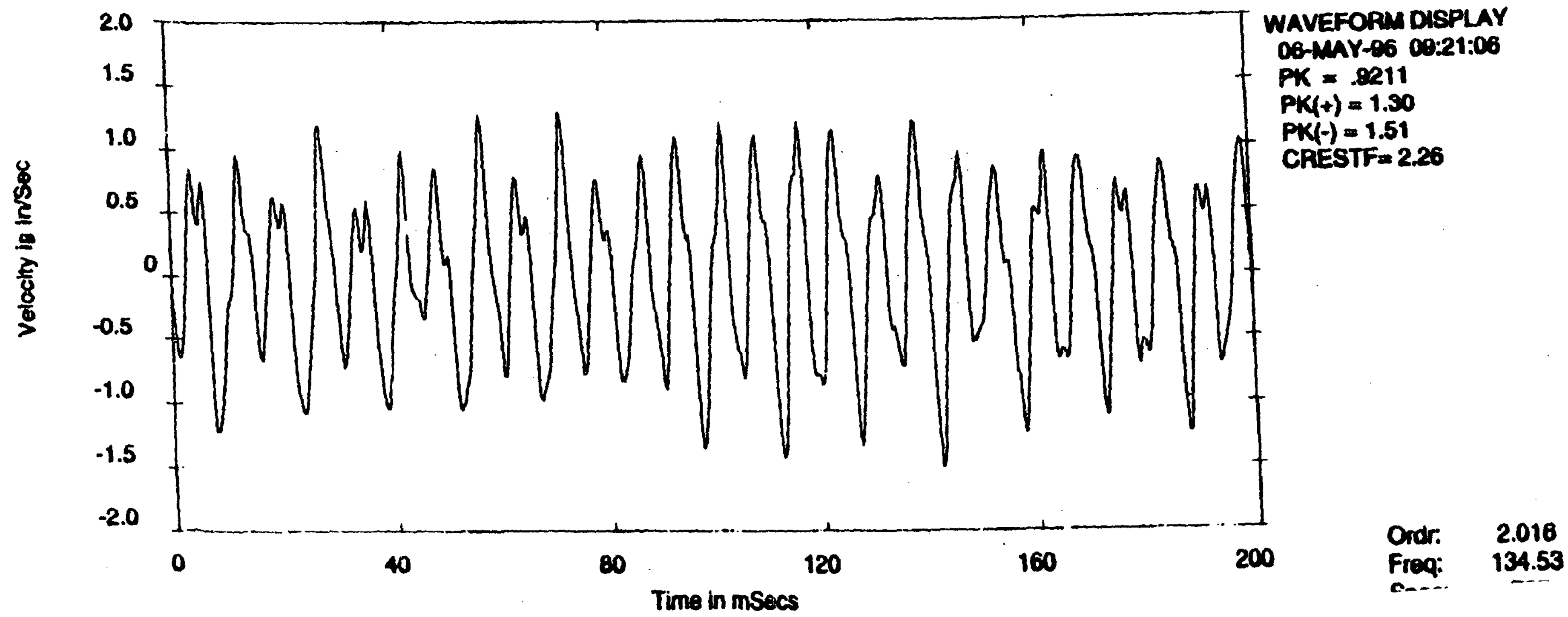
HPCI Data August 24, 2004




RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P3H #3 BEARING-PUMP HORIZONTAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
17-DEC-97 16:49:30
OVRALL= 1.42 V-AP
PK = .6617
LOAD =4250.0
RPM = 3997.
RPS = 66.61
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.662)² = (OA Level)²
- (0.519)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.169)^0.5 = 0.411 In/Sec OA
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
WAVEFORM DISPLAY
17-DEC-97 16:49:30
PK = .6854
PK(+) = 1.17
PK(-) = 1.54
CRESTF= 2.87
Ordr: 2.016
Freq: 134.27



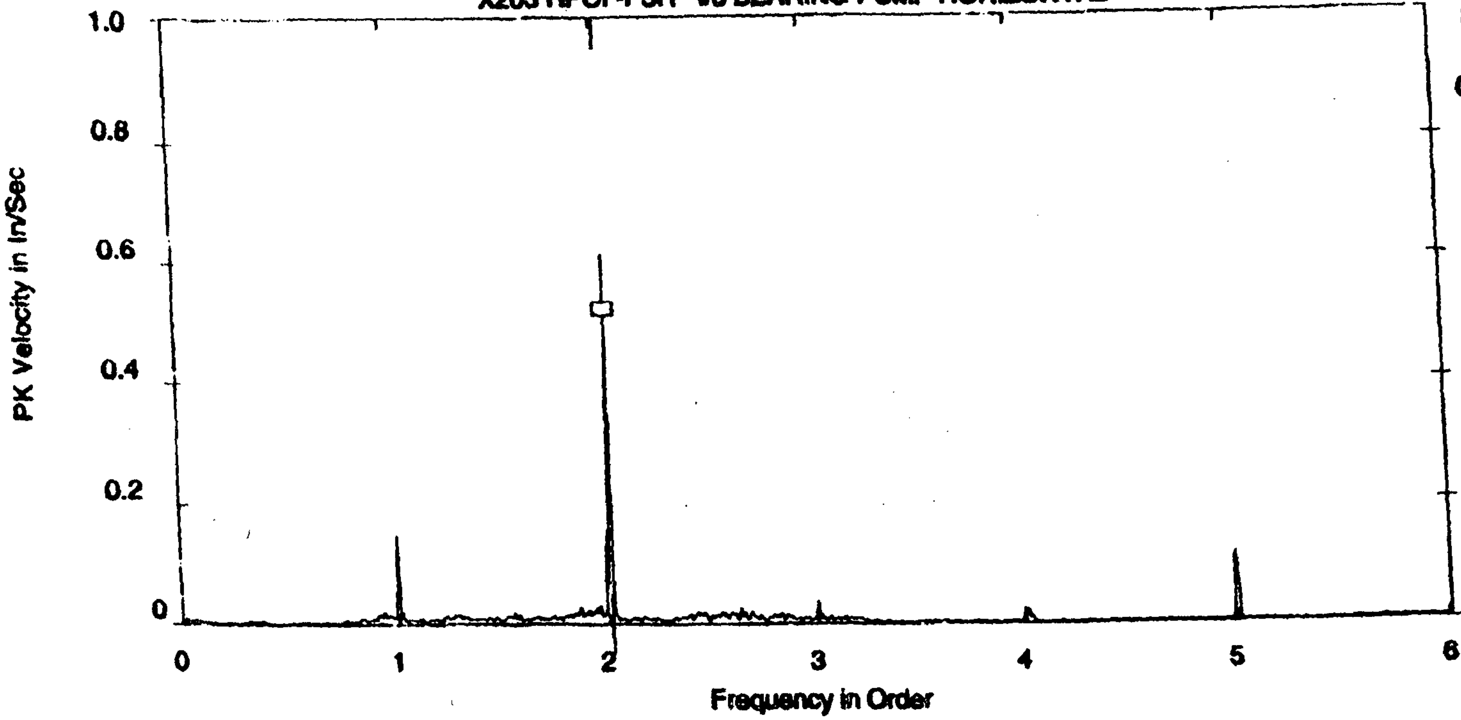
RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P3H #3 BEARING-PUMP HORIZONTAL
ROUTE SPECTRUM
06-MAY-96 09:21:06
OVRALL= .8251 V-DG
PK = .8208
LOAD =4250.0
RPM = 4004.
RPS = 66.73
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.825)² = (OA Level)²
- (0.727)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.152)^0.5 = 0.390 In/Sec OA
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order



WAVEFORM DISPLAY
06-MAY-96 09:21:06
PK = .9211
PK(+) = 1.30
PK(-) = 1.51
CRESTF= 2.26
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.016
Freq: 134.53

RX - X203, P205 HPCI TURB & PUMP

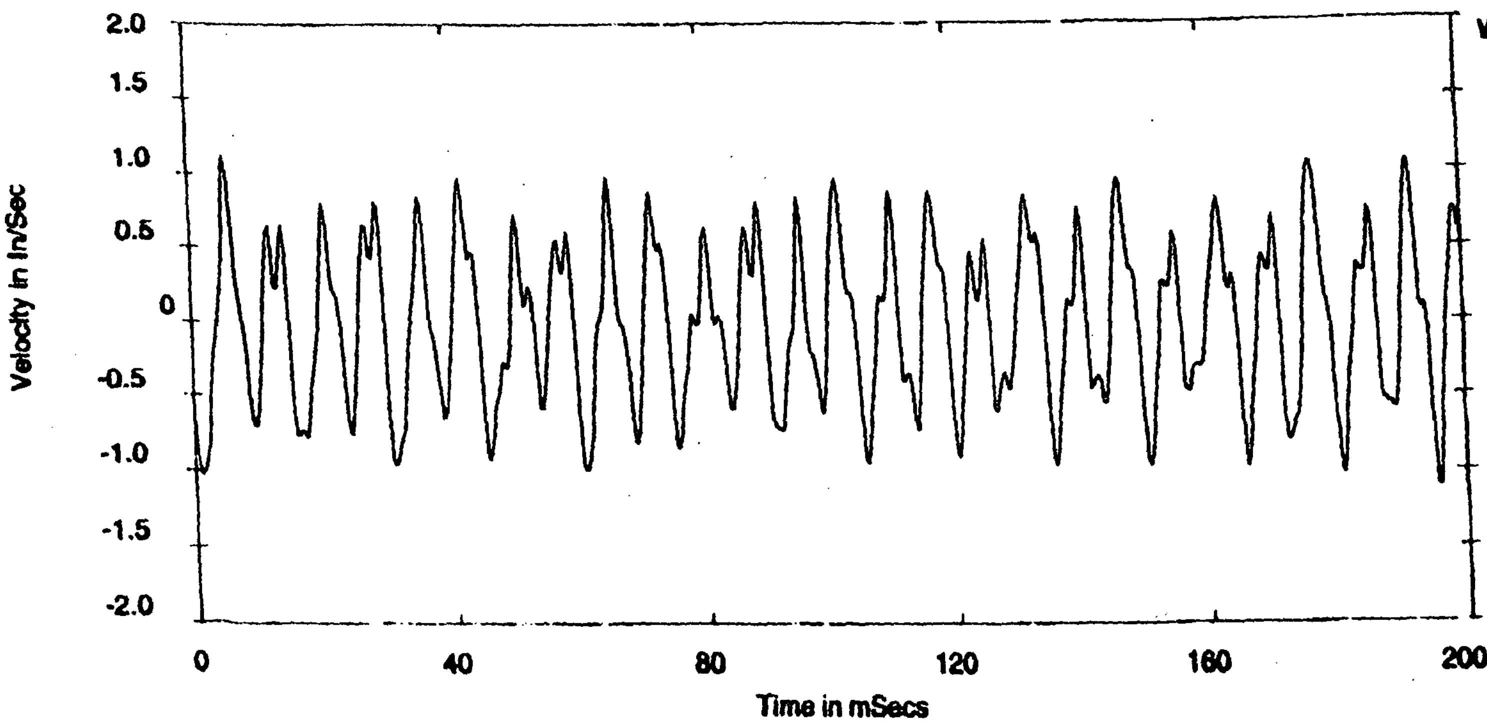
X203 HPCI -P3H #3 BEARING-PUMP HORIZONTAL



ROUTE SPECTRUM
20-NOV-95 01:58:31
OVRALL= .6703 V-DG
PK = .6638
LOAD =4250.0
RPM = 3998.
RPS = 66.63

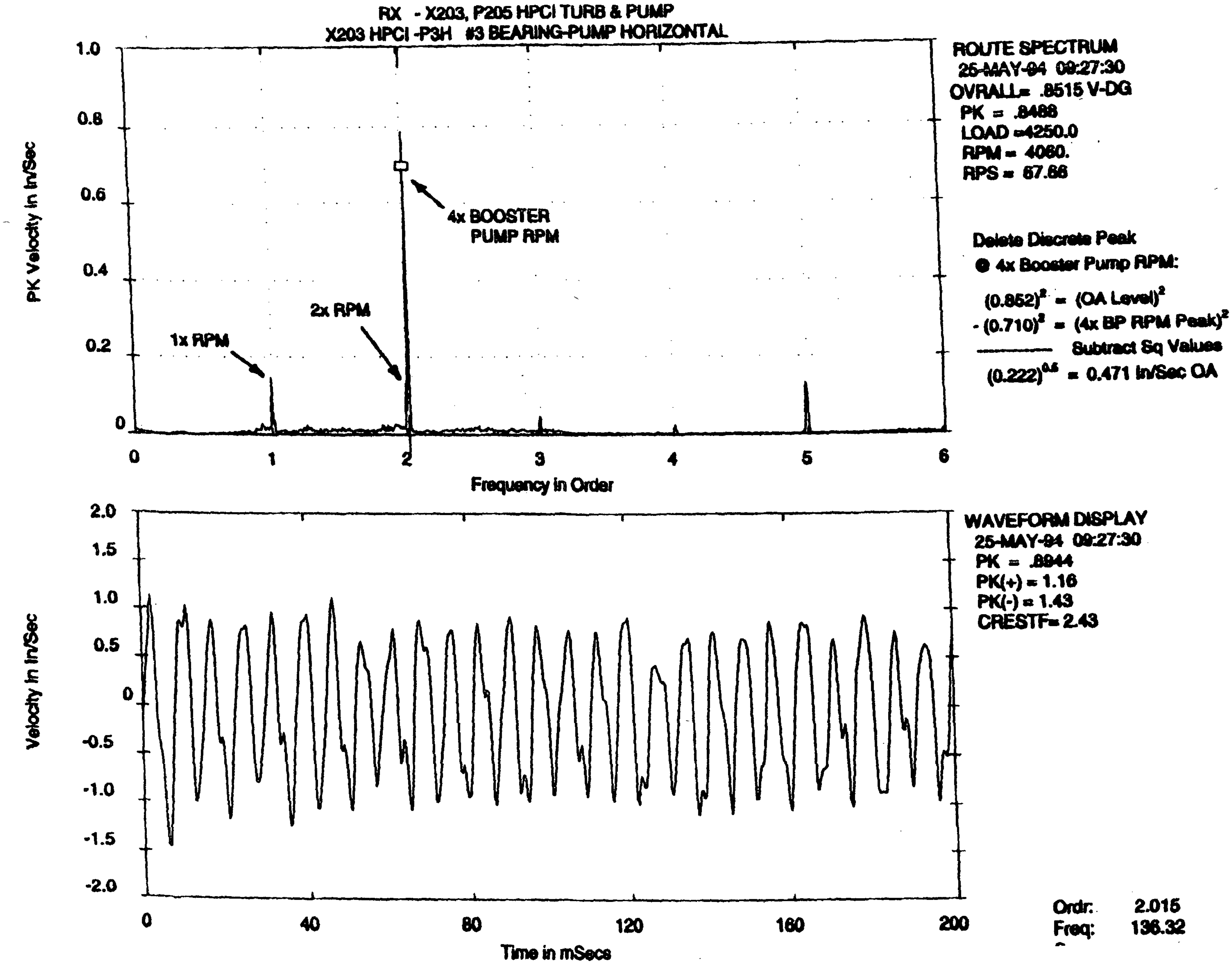
Delete Discrete Peak
@ 4x Booster Pump RPM:

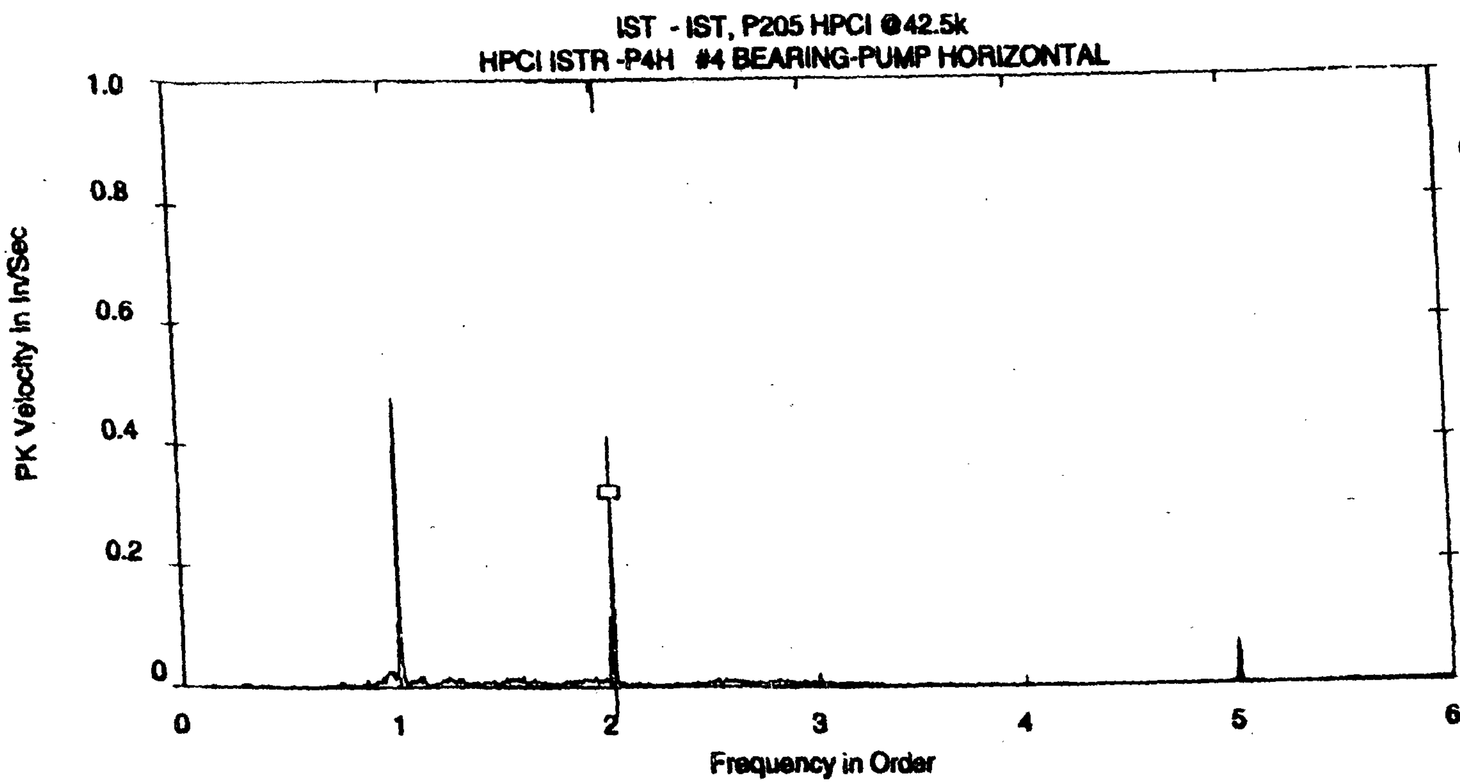
$(0.670)^2$ = (OA Level)^2
- $(0.518)^2$ = (4x BP RPM Peak)
———— Subtract Sq Values
$(0.181)^{0.5}$ = 0.425 In/Sec OA



WAVEFORM DISPLAY
20-NOV-95 01:58:31
PK = .7635
PK(+) = 1.23
PK(-) = 1.18
CRESTF= 2.16

Ordr: 2.016
Freq: 134.34

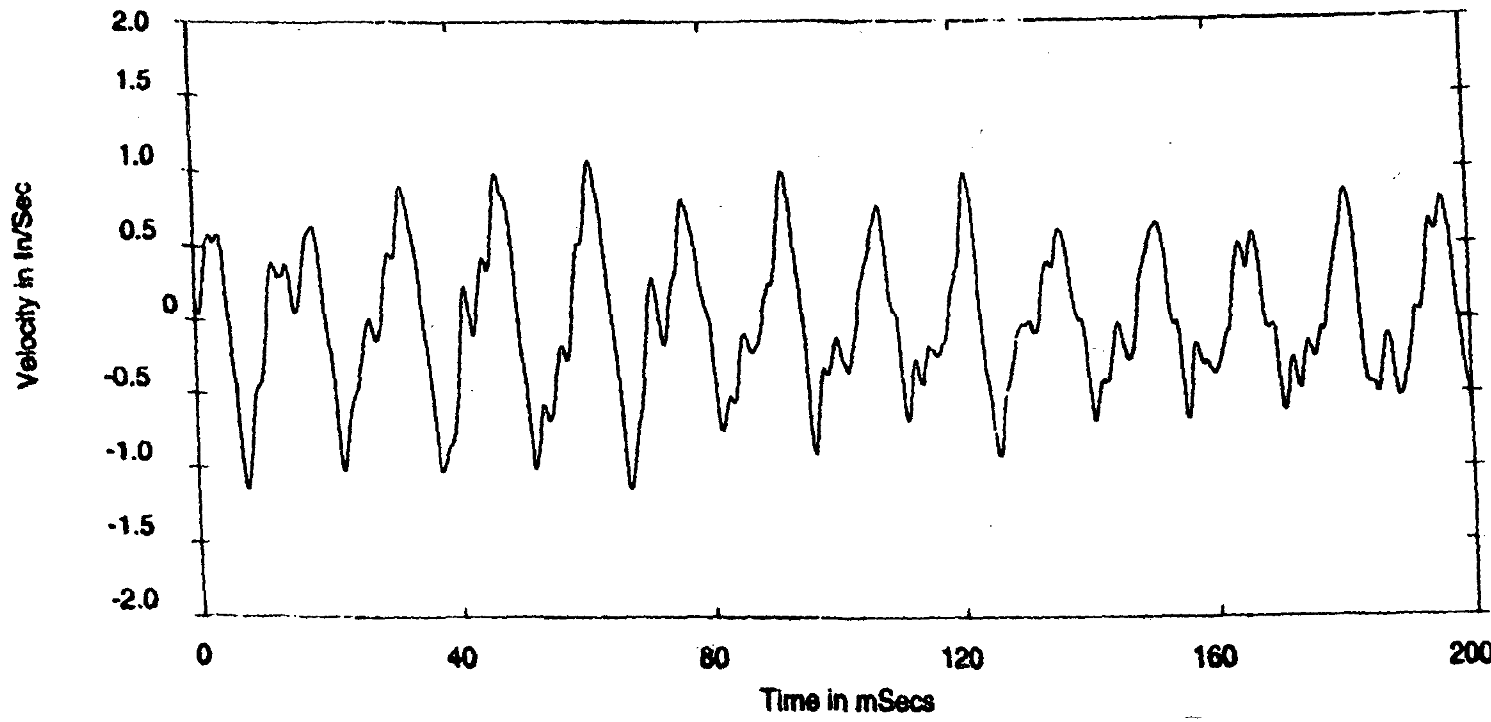

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P3H #3 BEARING-PUMP HORIZONTAL
PK Velocity in In/Sec
4x BOOSTER PUMP RPM
2x RPM
1x RPM
Frequency in Order
ROUTE SPECTRUM
25-MAY-94 09:27:30
OVRALL= .8515 V-DG
PK = .8488
LOAD =4250.0
RPM = 4060.
RPS = 67.66
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.852)² = (OA Level)²
- (0.710)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.222)^0.5 = 0.471 In/Sec OA
Velocity in In/Sec
Time in mSecs
WAVEFORM DISPLAY
25-MAY-94 09:27:30
PK = .8944
PK(+) = 1.16
PK(-) = 1.43
CRESTF= 2.43
Ordr: 2.015
Freq: 136.32



ROUTE SPECTRUM
24-NOV-04 00:54:26
OVRALL= .6774 V-DG
PK = .6719
LOAD =4250.0
RPM = 4017.
RPS = 66.95

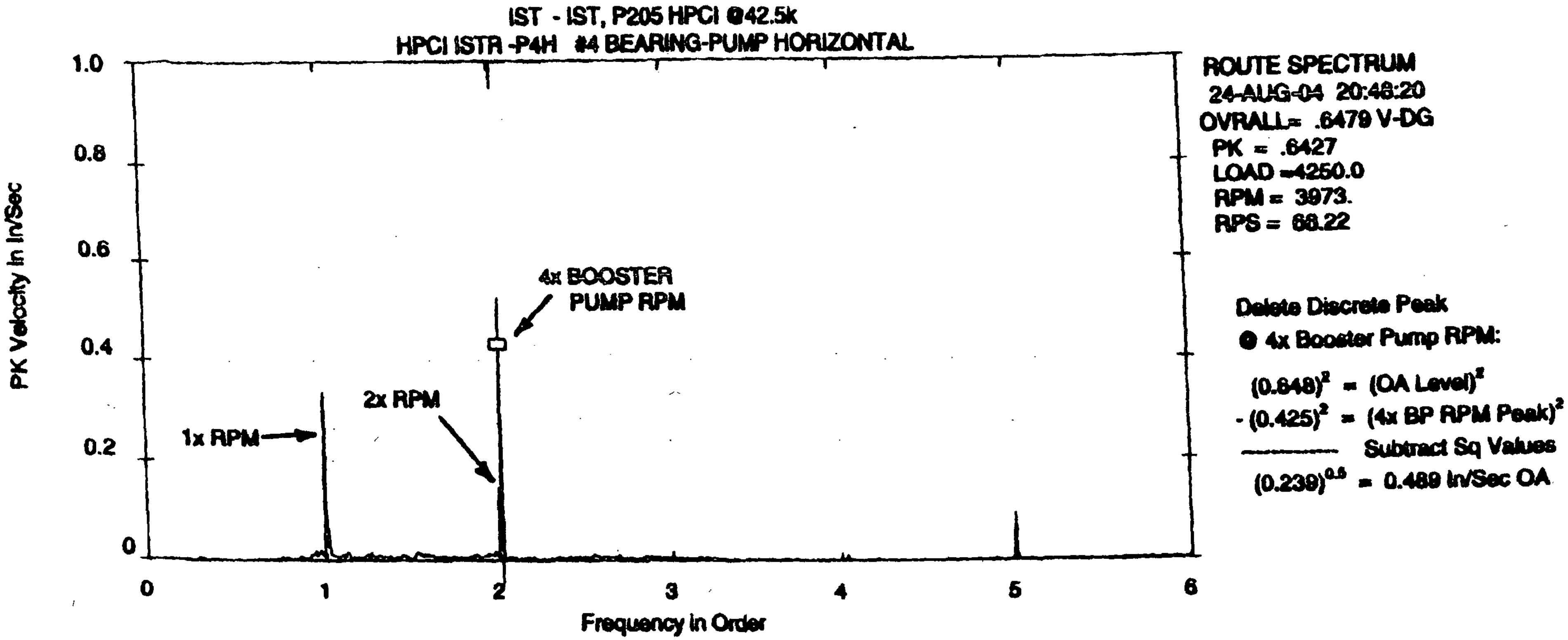
Delete Discrete Peak
@ 4x Booster Pump RPM:

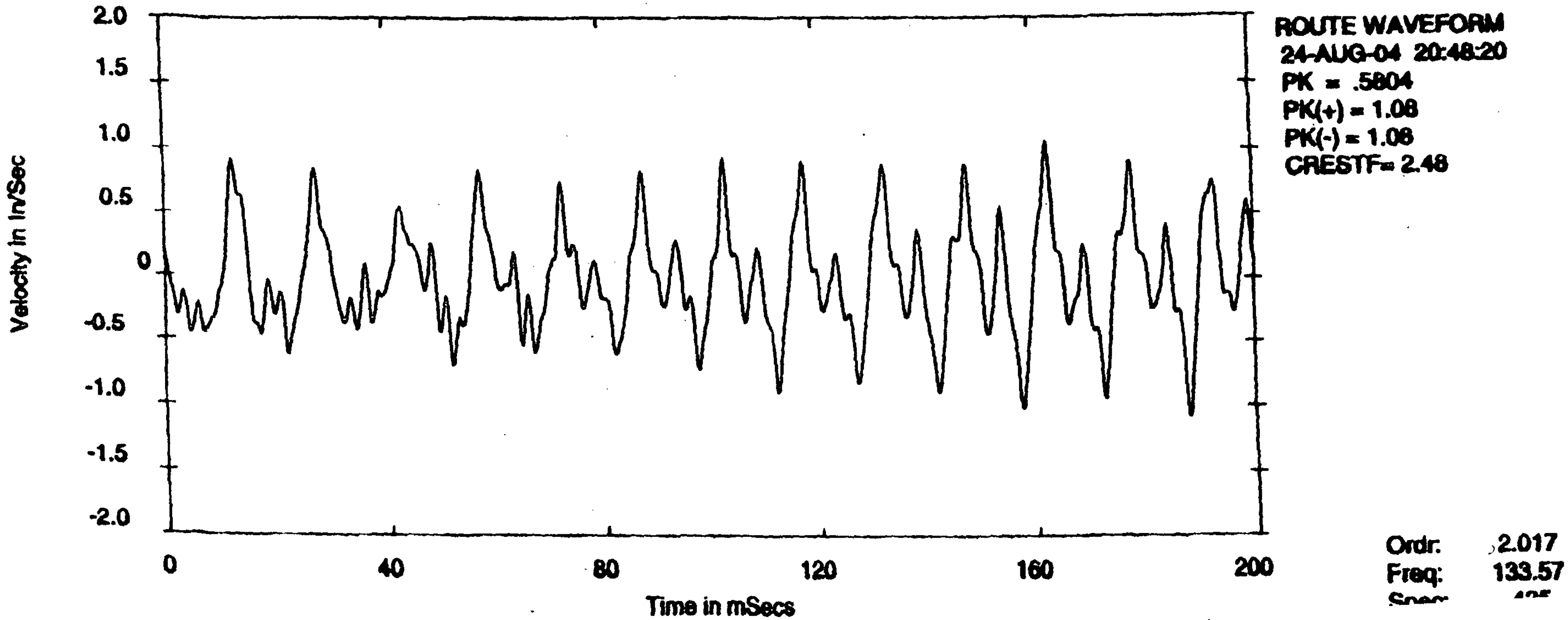
$(0.677)^2$ = $(\text{OA Level})^2$
$-(0.319)^2$ = (4x BP RPM Peak
Subtract Sq Value
$(0.357)^{0.5}$ = 0.597 In/Sec OA



ROUTE WAVEFORM
24-NOV-04 00:54:26
PK = .6896
PK(+) = 1.09
PK(-) = 1.13
CRESTF= 2.35

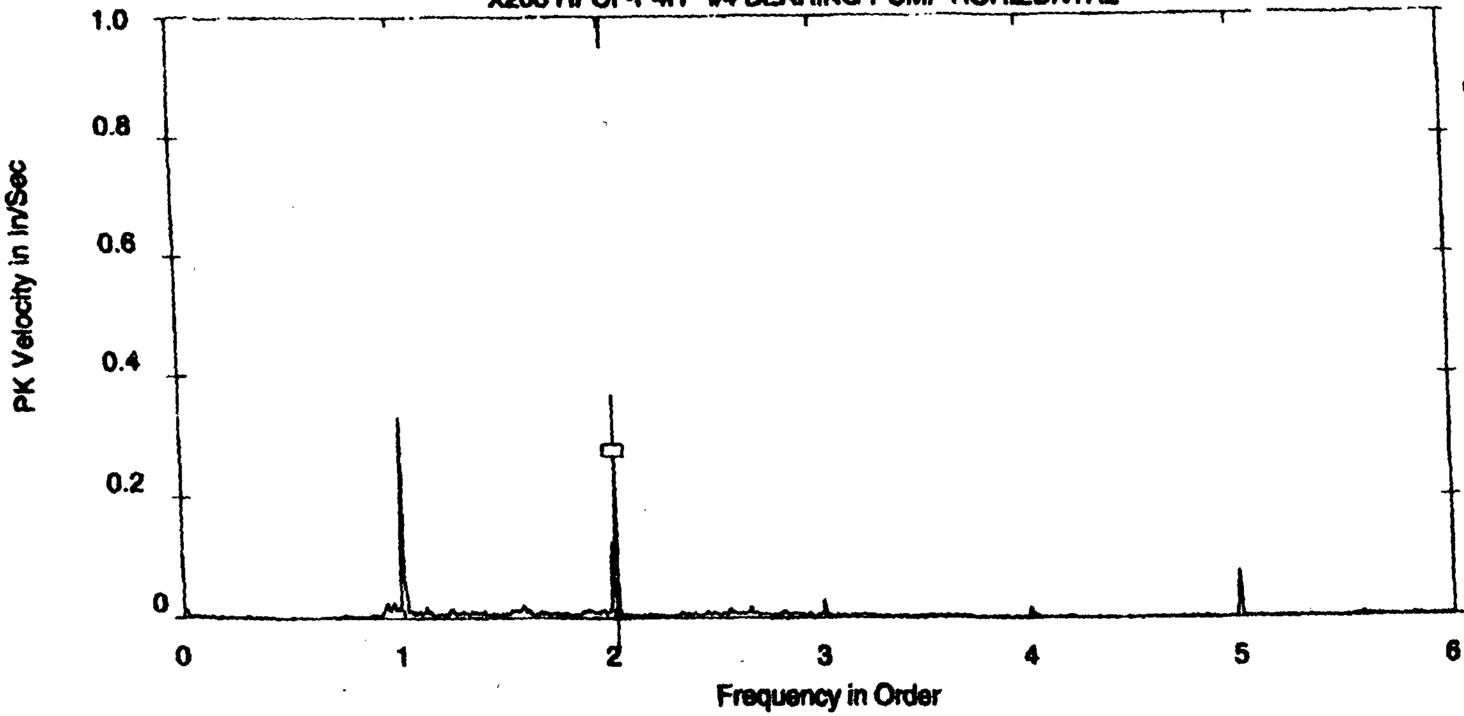
Ordr: 2.017
Freq: 135.05


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P4H #4 BEARING-PUMP HORIZONTAL
ROUTE SPECTRUM
24-AUG-04 20:48:20
OVRALL= .6479 V-DG
PK = .6427
LOAD =4250.0
RPM = 3973.
RPS = 66.22
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.648)² = (OA Level)²
- (0.425)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.239)^0.5 = 0.489 In/Sec OA
4x BOOSTER PUMP RPM
2x RPM
1x RPM
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order


ROUTE WAVEFORM
24-AUG-04 20:48:20
PK = .5804
PK(+) = 1.08
PK(-) = 1.08
CRESTF= 2.48
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.017
Freq: 133.57

RX - X203,P205 HPCI TURB & PUMP

X203 HPCI -P4H #4 BEARING-PUMP HORIZONTAL



ROUTE SPECTRUM
17-DEC-97 16:53:18
OVRALL= 1.11 V-AP
PK = .5153
LOAD =4250.0
RPM = 3996.
RPS = 66.61

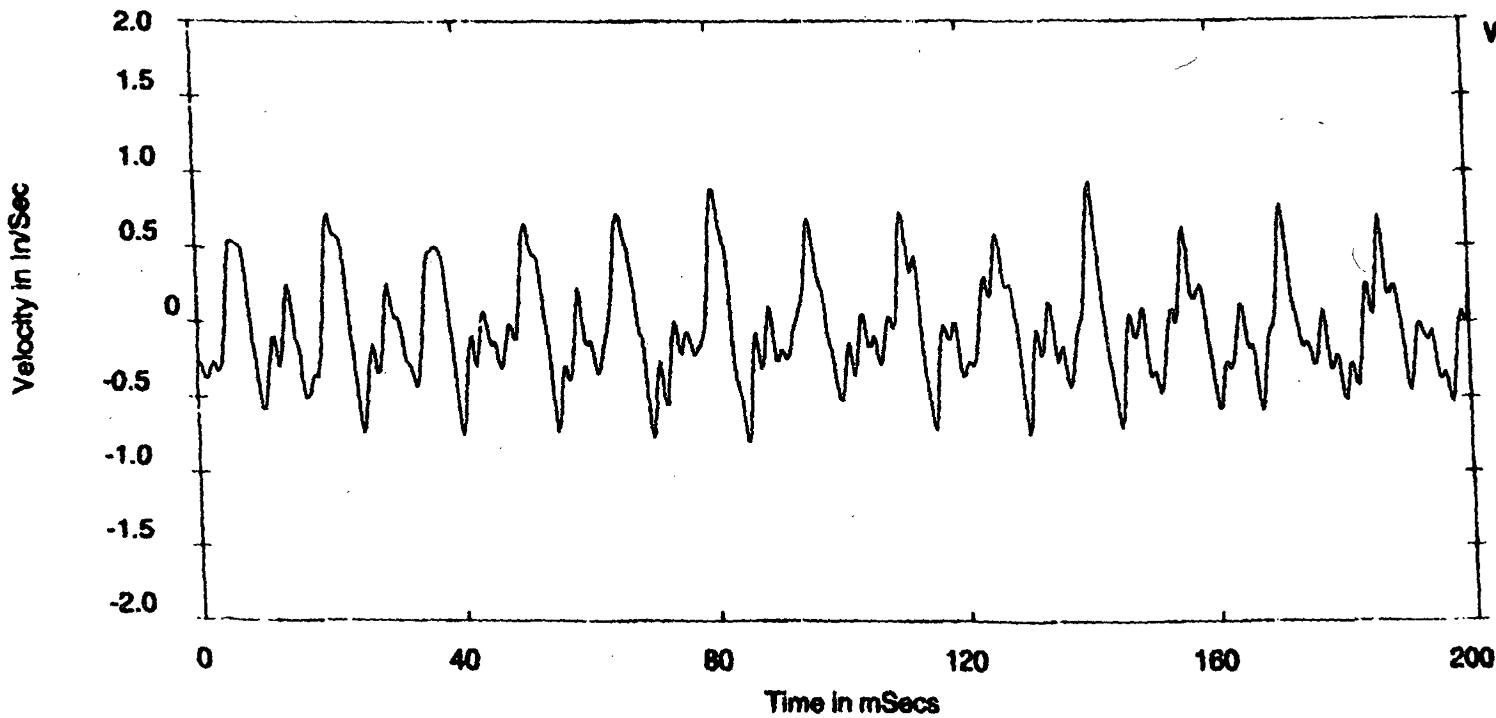
Delete Discrete Peak
@ 4x Booster Pump RPM:

$(0.515)^2 = (\text{OA Level})^2$

$-(0.272)^2 = (\text{4x BP RPM Peak})^2$

Subtract Sq Values

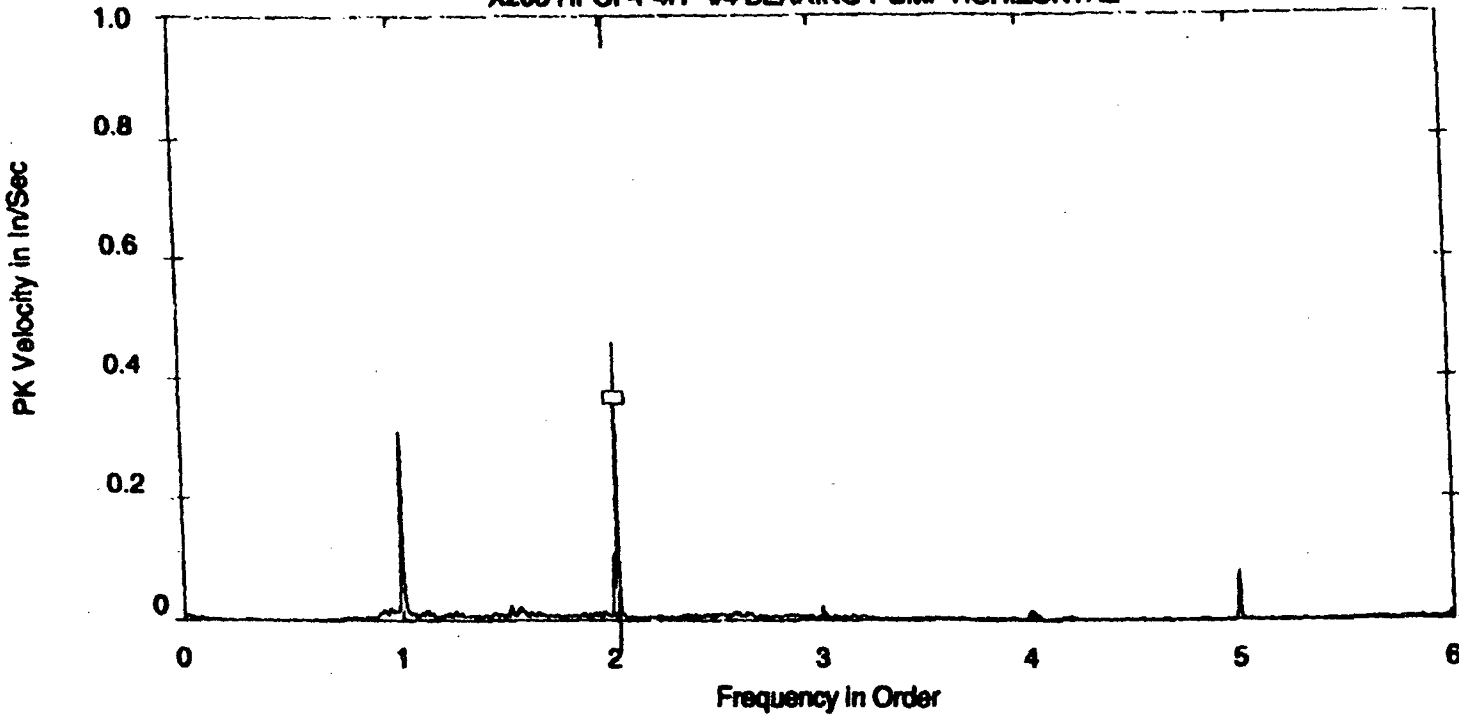
$(0.191)^{0.5} = 0.437$ In/Sec OA



WAVEFORM DISPLAY
17-DEC-97 16:53:18
PK = .4948
PK(+) = .9773
PK(-) = .7628
CRESTF= 3.15

Ordr: 2.013
Freq: 134.11

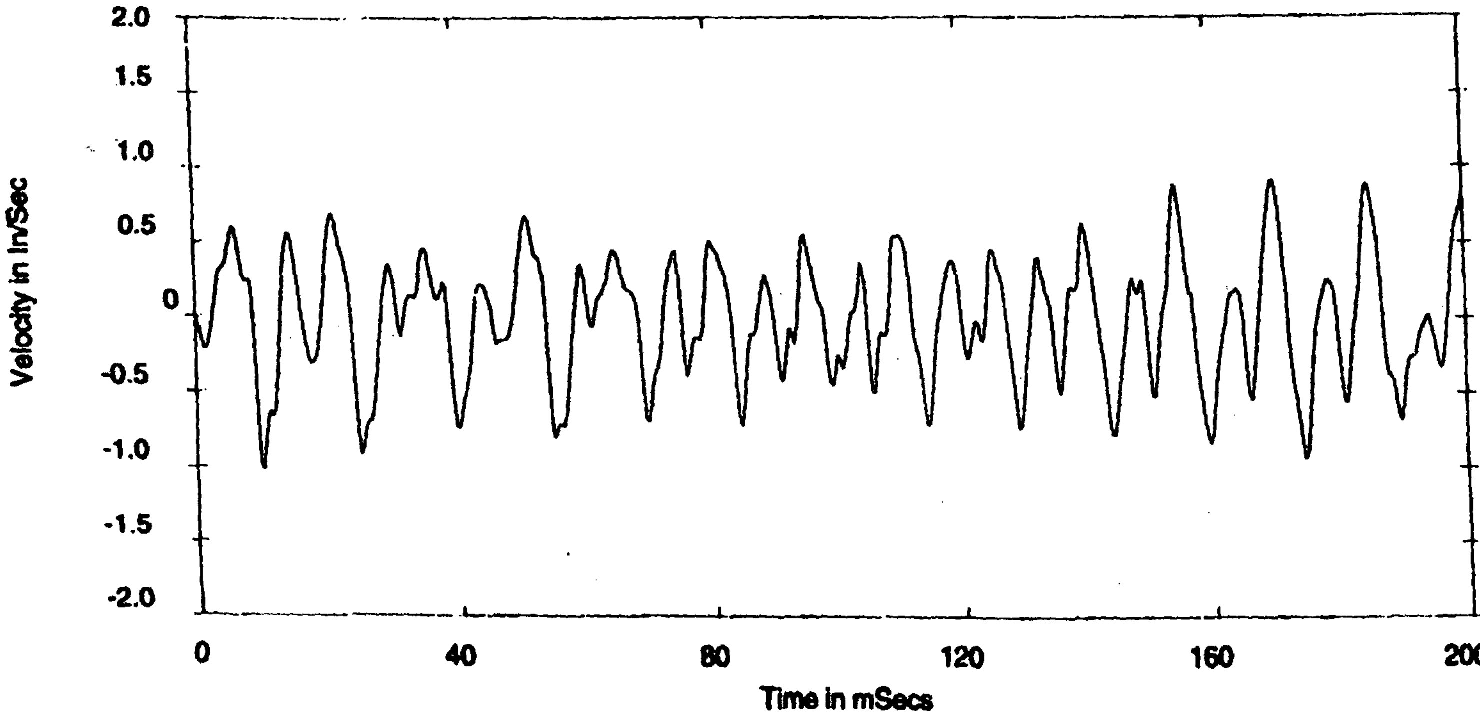
RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P4H #4 BEARING-PUMP HORIZONTAL



ROUTE SPECTRUM
06-MAY-96 09:23:46
OVRALL= .6006 V-DG
PK = .6001
LOAD =4250.0
RPM = 4009.
RPS = 66.82

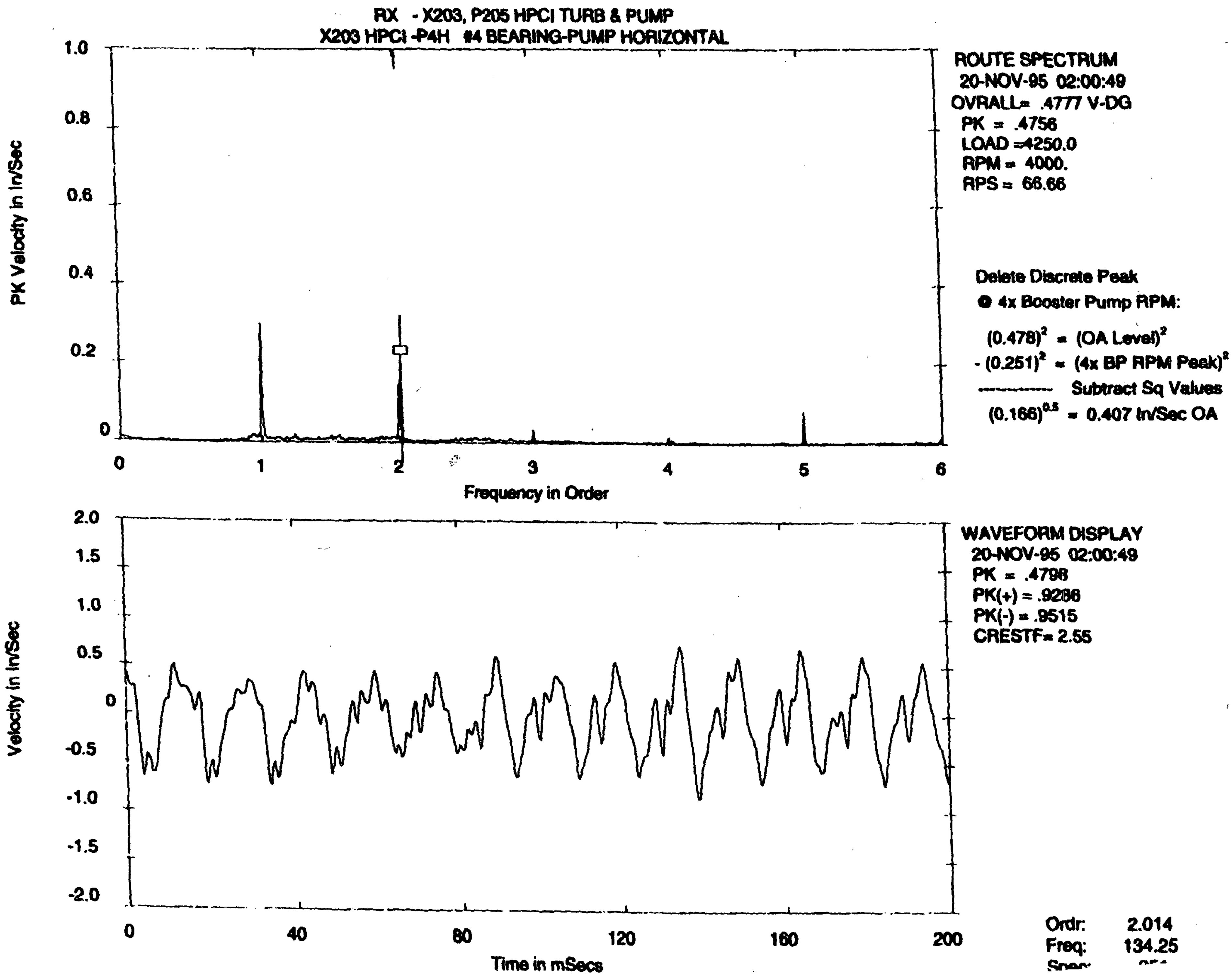
Delete Discrete Peak
@ 4x Booster Pump RPM:

$(0.601)^2$ = $(\text{OA Level})^2$
$- (0.421)^2$ = $(\text{4x BP RPM Peak})^2$
———— Subtract Sq Values
$(0.184)^{0.5}$ = 0.429 In/Sec OA

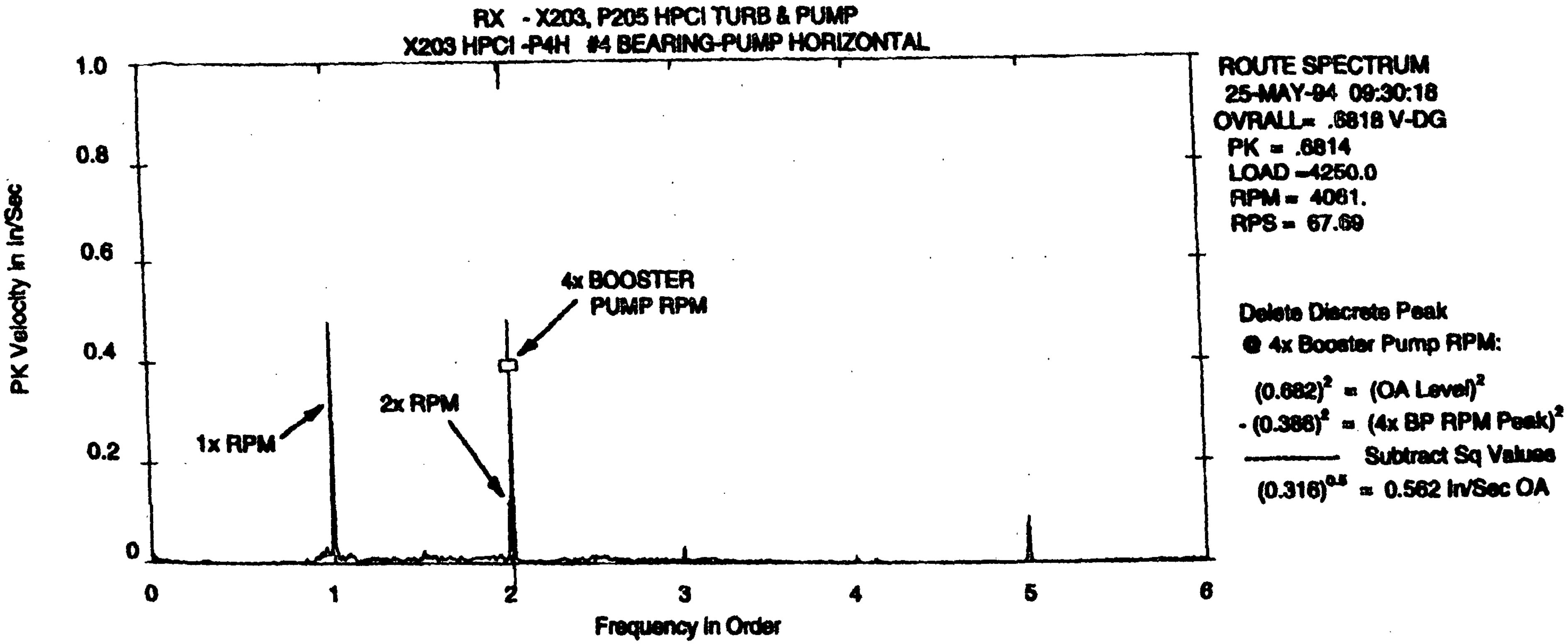


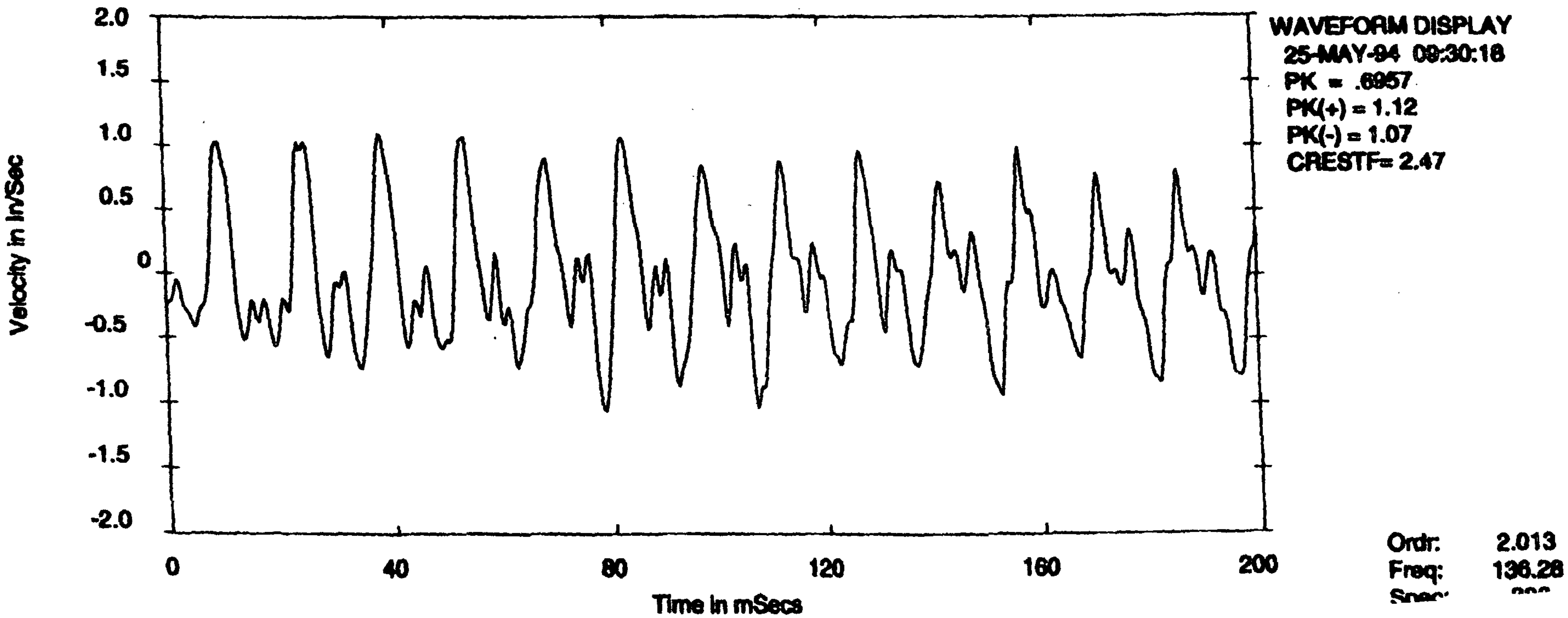
WAVEFORM DISPLAY
06-MAY-96 09:23:46
PK = .5673
PK(+) = 1.10
PK(-) = 1.03
CRESTF= 2.44

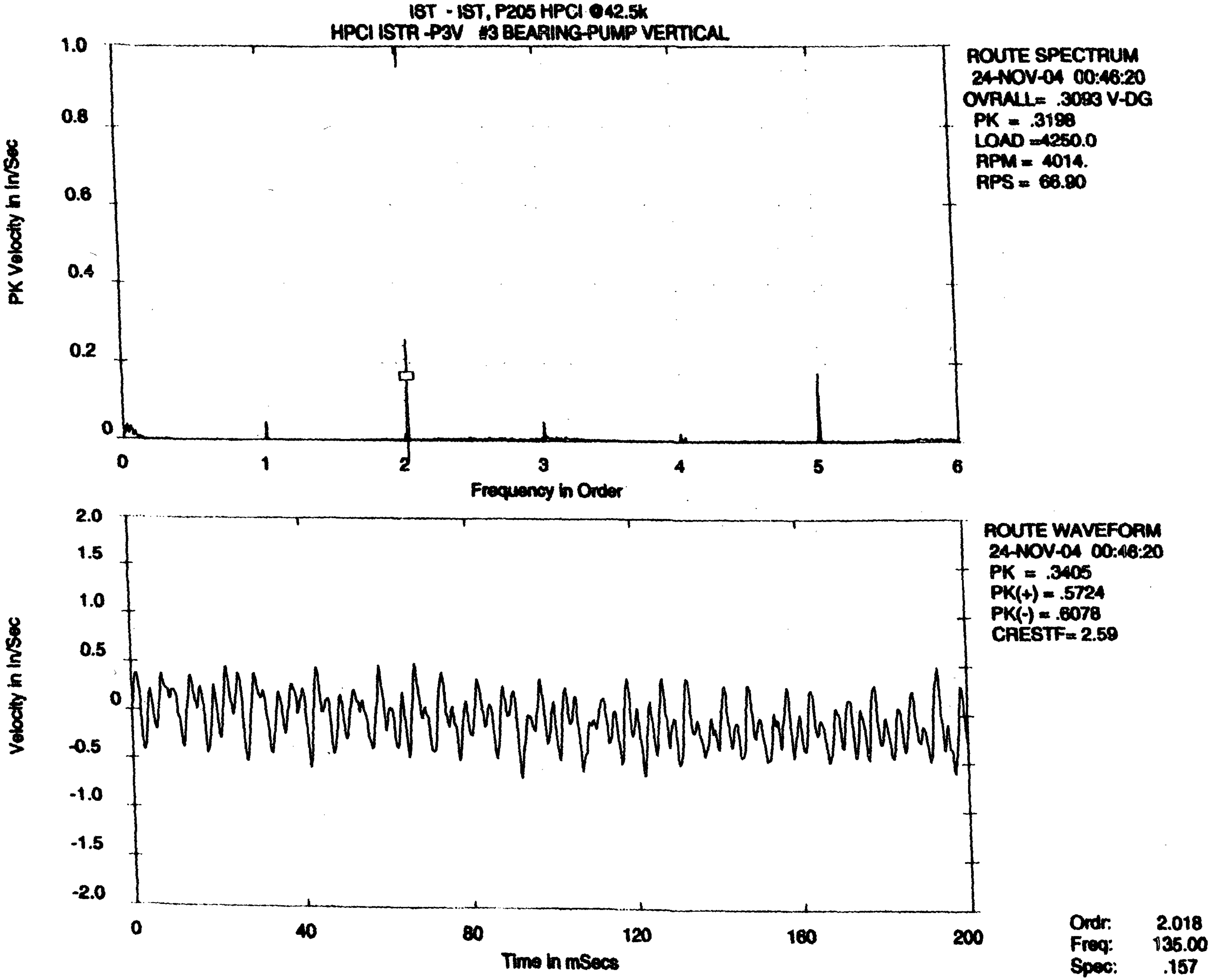
Ordr: 2.013
Freq: 134.53
Spec: .421



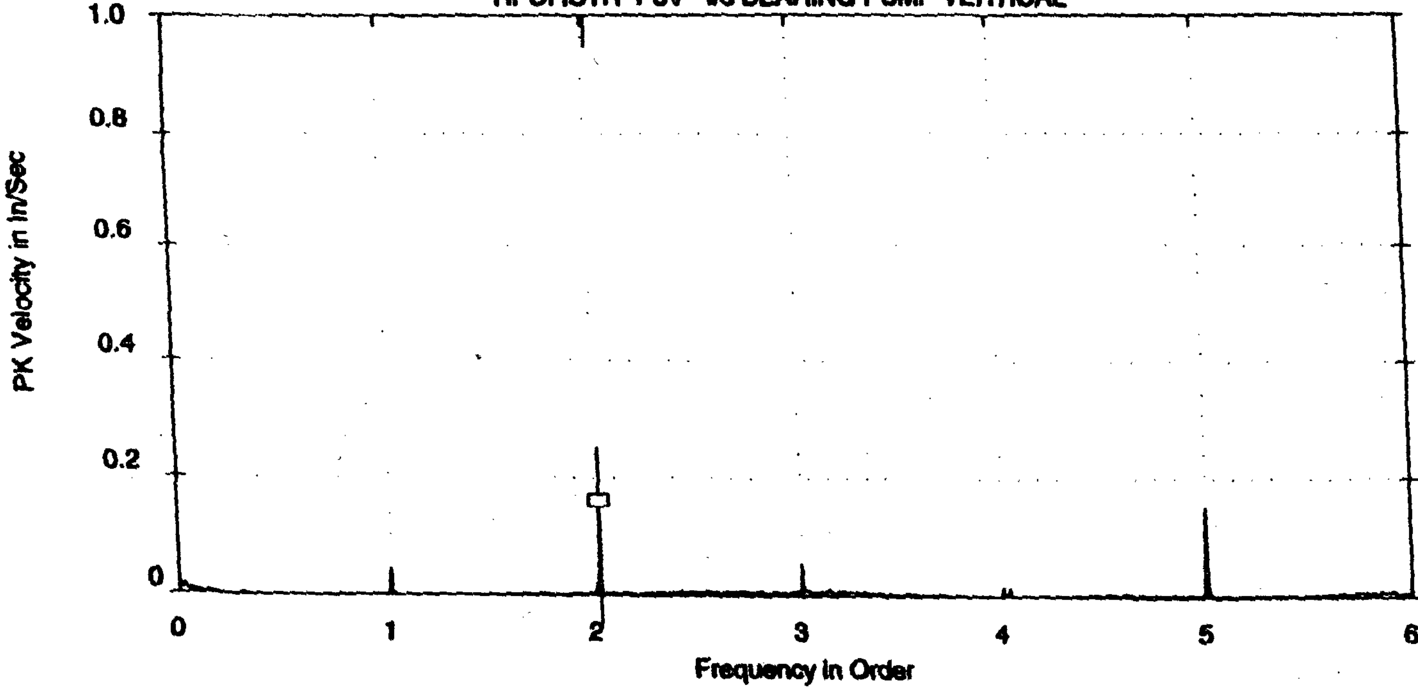
RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P4H #4 BEARING-PUMP HORIZONTAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
20-NOV-95 02:00:49
OVRALL= .4777 V-DG
PK = .4756
LOAD =4250.0
RPM = 4000.
RPS = 66.66
Delete Discrete Peak
@ 4x Booster Pump RPM:
(0.478)² = (OA Level)²
- (0.251)² = (4x BP RPM Peak)²
Subtract Sq Values
(0.166)^0.5 = 0.407 In/Sec OA
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
WAVEFORM DISPLAY
20-NOV-95 02:00:49
PK = .4798
PK(+) = .9286
PK(-) = .9515
CRESTF= 2.55
Ordr: 2.014
Freq: 134.25


RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P4H #4 BEARING-PUMP HORIZONTAL
ROUTE SPECTRUM
25-MAY-94 09:30:18
OVRALL= .6818 V-DG
PK = .6814
LOAD =4250.0
RPM = 4061.
RPS = 67.69
Delete Discrete Peak
@ 4x Booster Pump RPM:
$(0.682)^2$ = $(\text{OA Level})^2$
$-(0.366)^2$ = $(\text{4x BP RPM Peak})^2$
Subtract Sq Values
$(0.316)^{0.5}$ = 0.562 In/Sec OA
4x BOOSTER PUMP RPM
1x RPM
2x RPM
PK Velocity in In/Sec
Frequency in Order

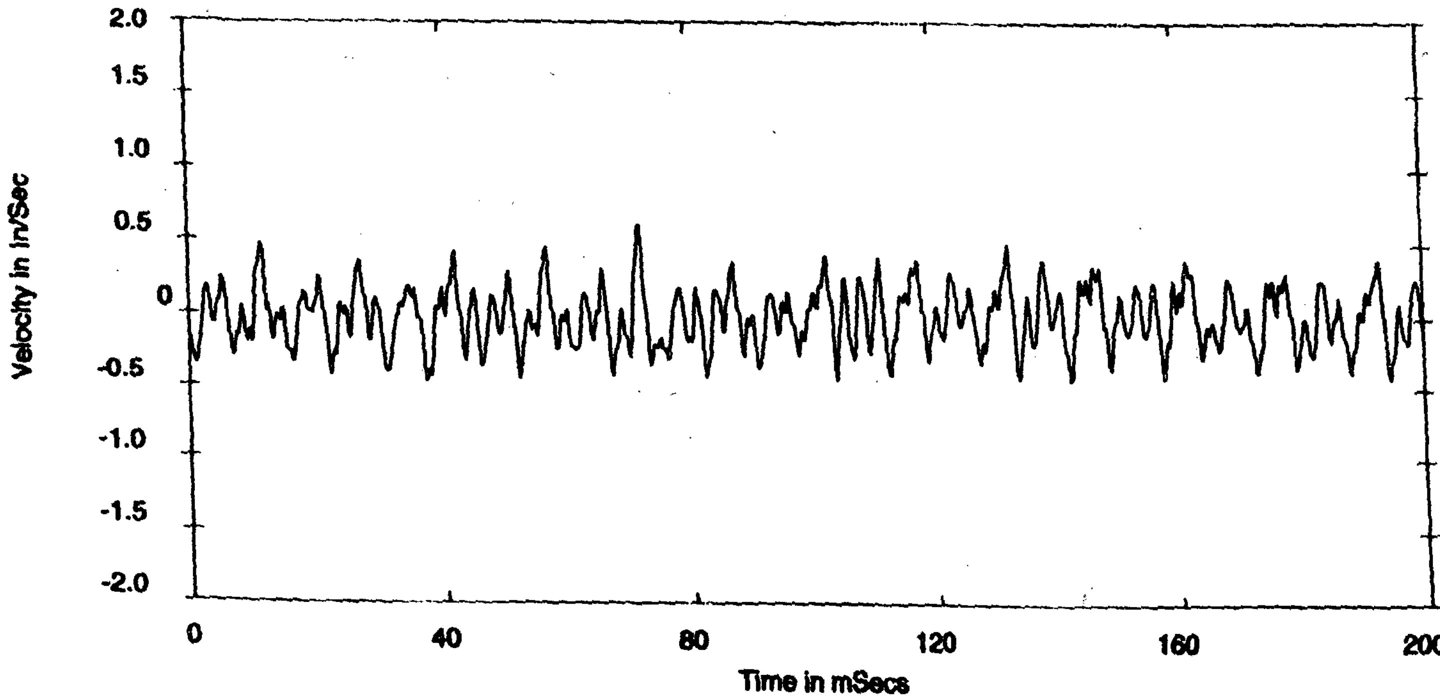

WAVEFORM DISPLAY
25-MAY-94 09:30:18
PK = .6957
PK(+) = 1.12
PK(-) = 1.07
CRESTF= 2.47
Velocity in In/Sec
Time in mSecs
Ordr: 2.013
Freq: 136.28


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P3V #3 BEARING-PUMP VERTICAL
ROUTE SPECTRUM
24-NOV-04 00:46:20
OVRALL= .3093 V-DG
PK = .3198
LOAD =4250.0
RPM = 4014.
RPS = 66.90
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE WAVEFORM
24-NOV-04 00:46:20
PK = .3405
PK(+) = .5724
PK(-) = .6078
CRESTF= 2.59
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.018
Freq: 135.00
Spec: .157

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P3V #3 BEARING-PUMP VERTICAL

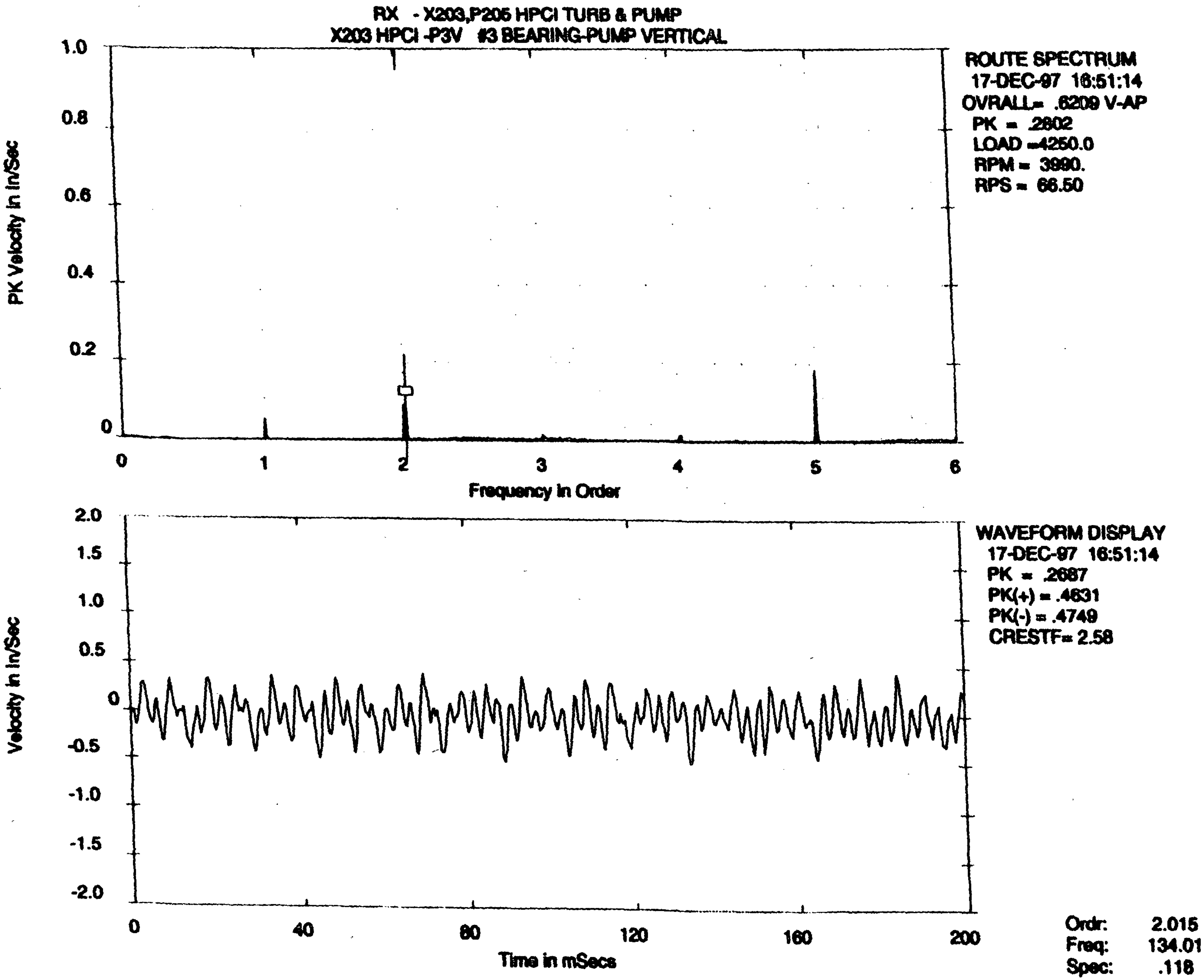


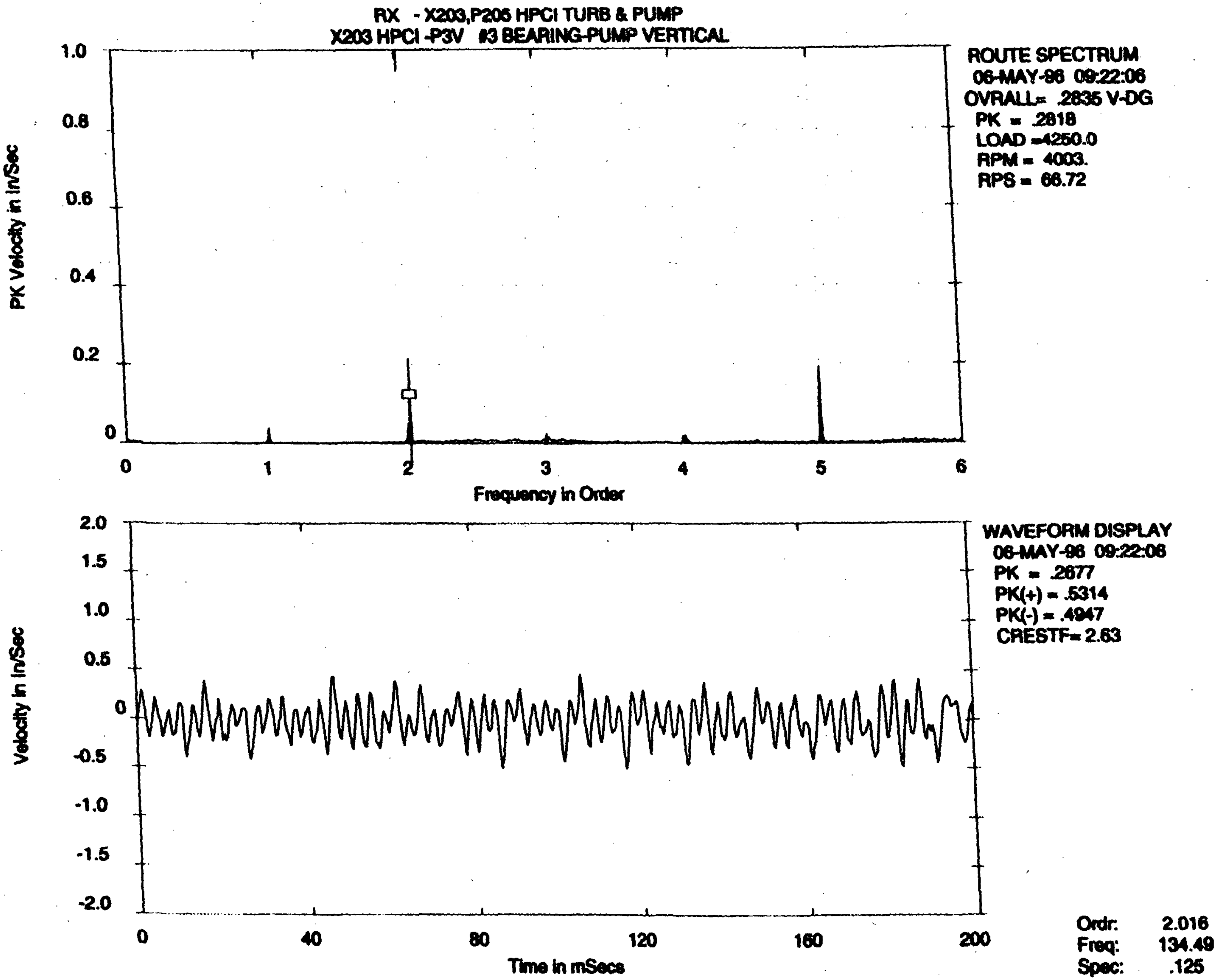
ROUTE SPECTRUM
24-AUG-04 20:47:06
OVRALL= .2864 V-DG
PK = .2821
LOAD =4250.0
RPM = 3971.
RPS = 66.18

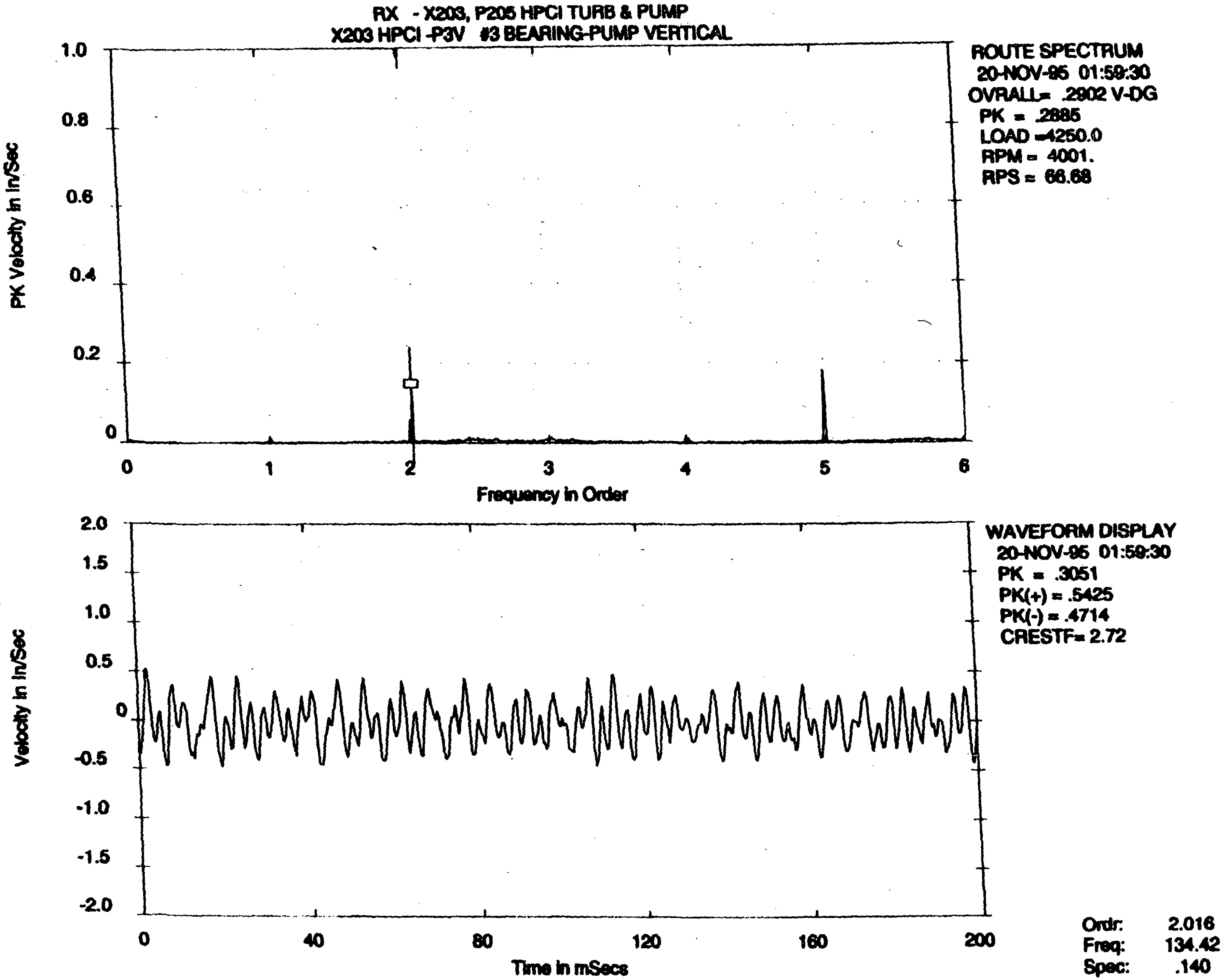


ROUTE WAVEFORM
24-AUG-04 20:47:06
PK = .2857
PK(+) = .6158
PK(-) = .5457
CRESTF= 3.05

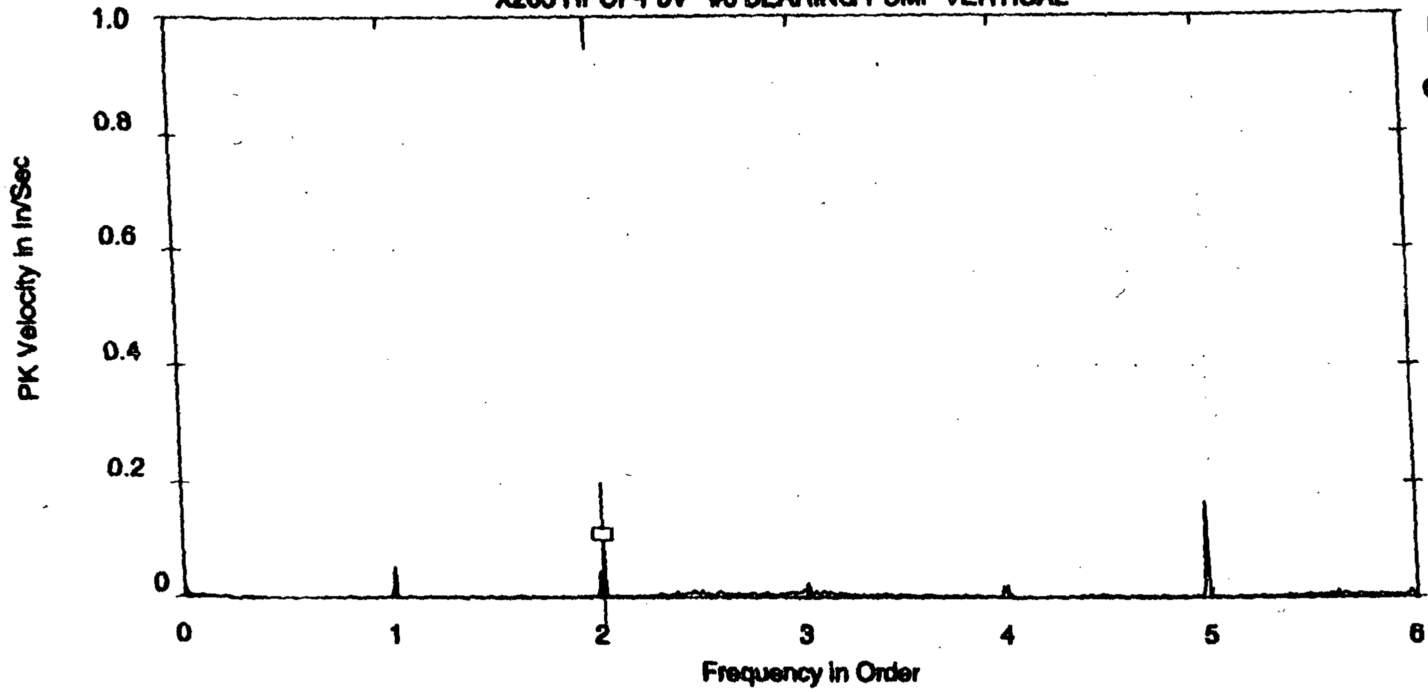
Ordr: 2.019
Freq: 133.59
Spec: .151


RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P3V #3 BEARING-PUMP VERTICAL
ROUTE SPECTRUM
17-DEC-97 16:51:14
OVRALL= .6209 V-AP
PK = .2802
LOAD =4250.0
RPM = 3990.
RPS = 66.50
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
17-DEC-97 16:51:14
PK = .2687
PK(+) = .4631
PK(-) = .4749
CRESTF= 2.58
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.015
Freq: 134.01
Spec: .118

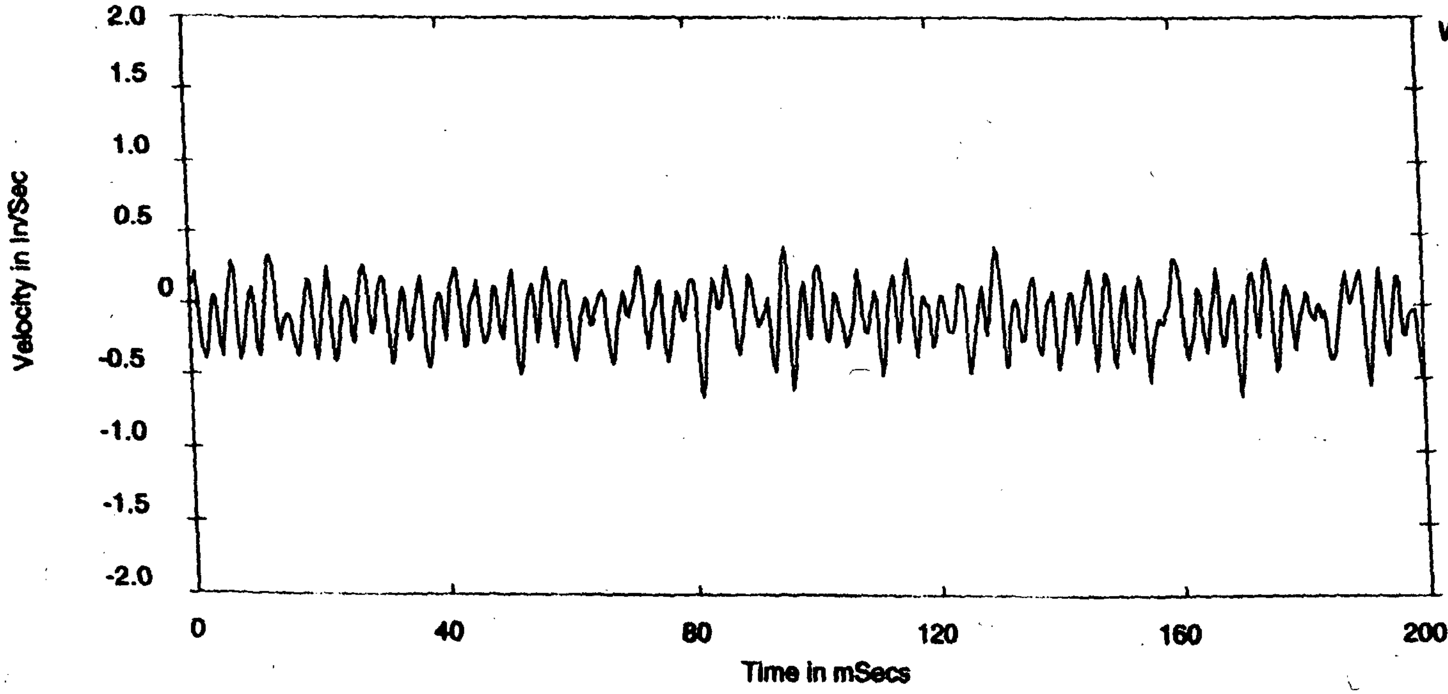

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P3V #3 BEARING-PUMP VERTICAL
ROUTE SPECTRUM
06-MAY-96 09:22:06
OVRALL= .2835 V-DG
PK = .2818
LOAD =4250.0
RPM = 4003.
RPS = 66.72
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
06-MAY-96 09:22:06
PK = .2677
PK(+) = .5314
PK(-) = .4947
CRESTF= 2.63
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.016
Freq: 134.49
Spec: .125


RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P3V #3 BEARING-PUMP VERTICAL
ROUTE SPECTRUM
20-NOV-95 01:59:30
OVRALL= .2902 V-DG
PK = .2885
LOAD =4250.0
RPM = 4001.
RPS = 66.68
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
20-NOV-95 01:59:30
PK = .3051
PK(+) = .5425
PK(-) = .4714
CRESTF= 2.72
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.016
Freq: 134.42
Spec: .140

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P3V #3 BEARING-PUMP VERTICAL

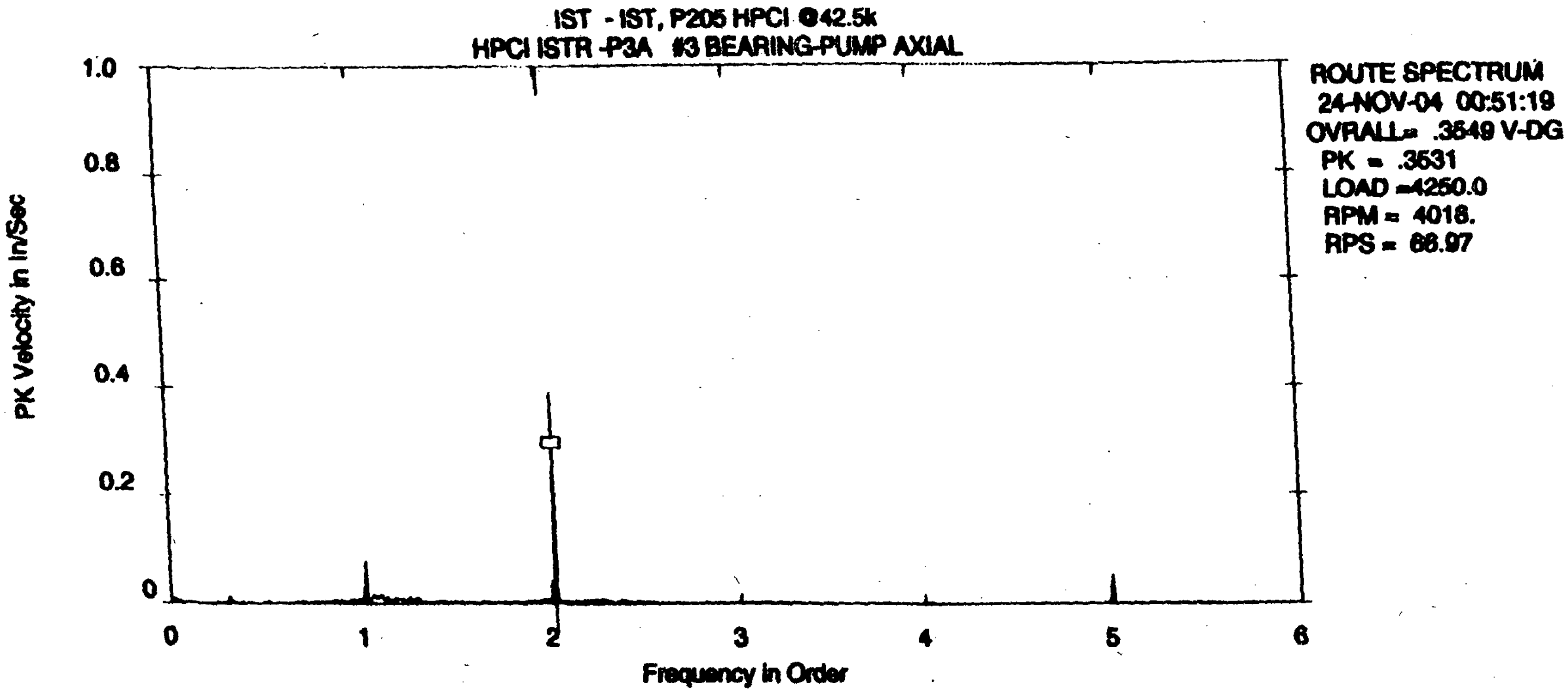


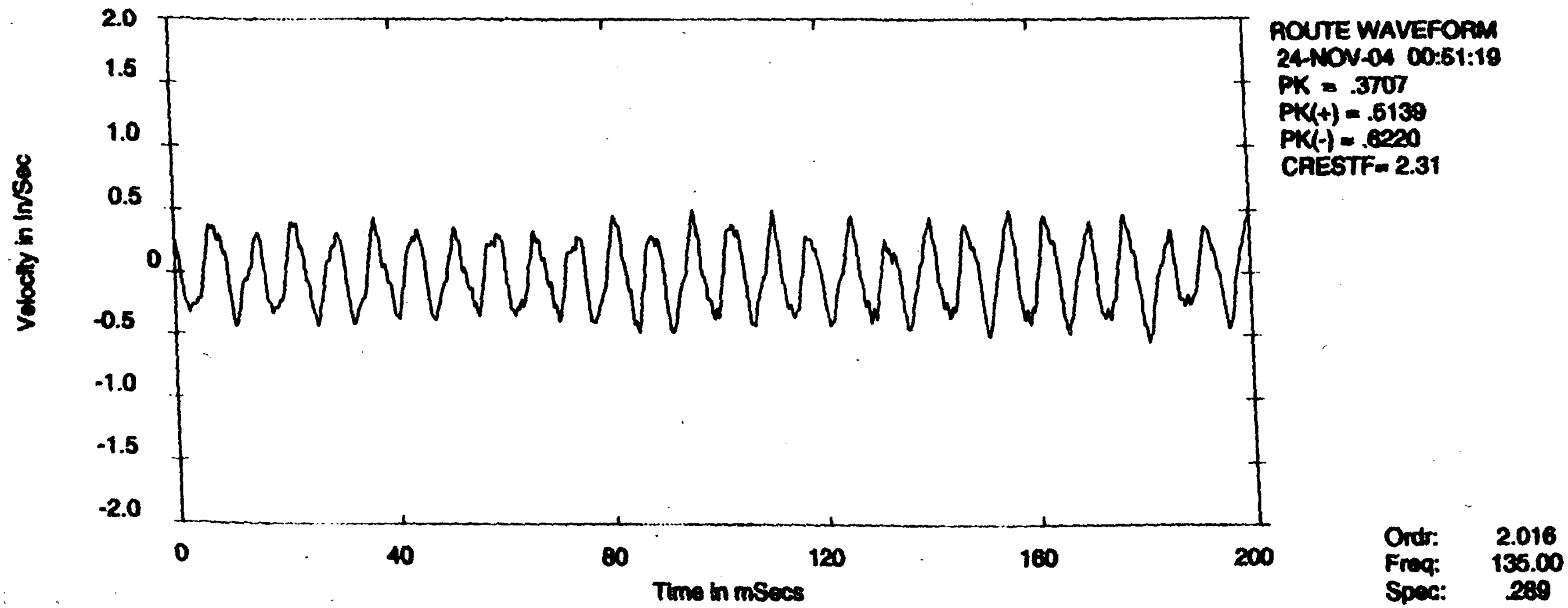
ROUTE SPECTRUM
25-MAY-94 09:28:50
OVRALL= .2848 V-DG
PK = .2827
LOAD =4250.0
RPM = 4075.
RPS = 67.92

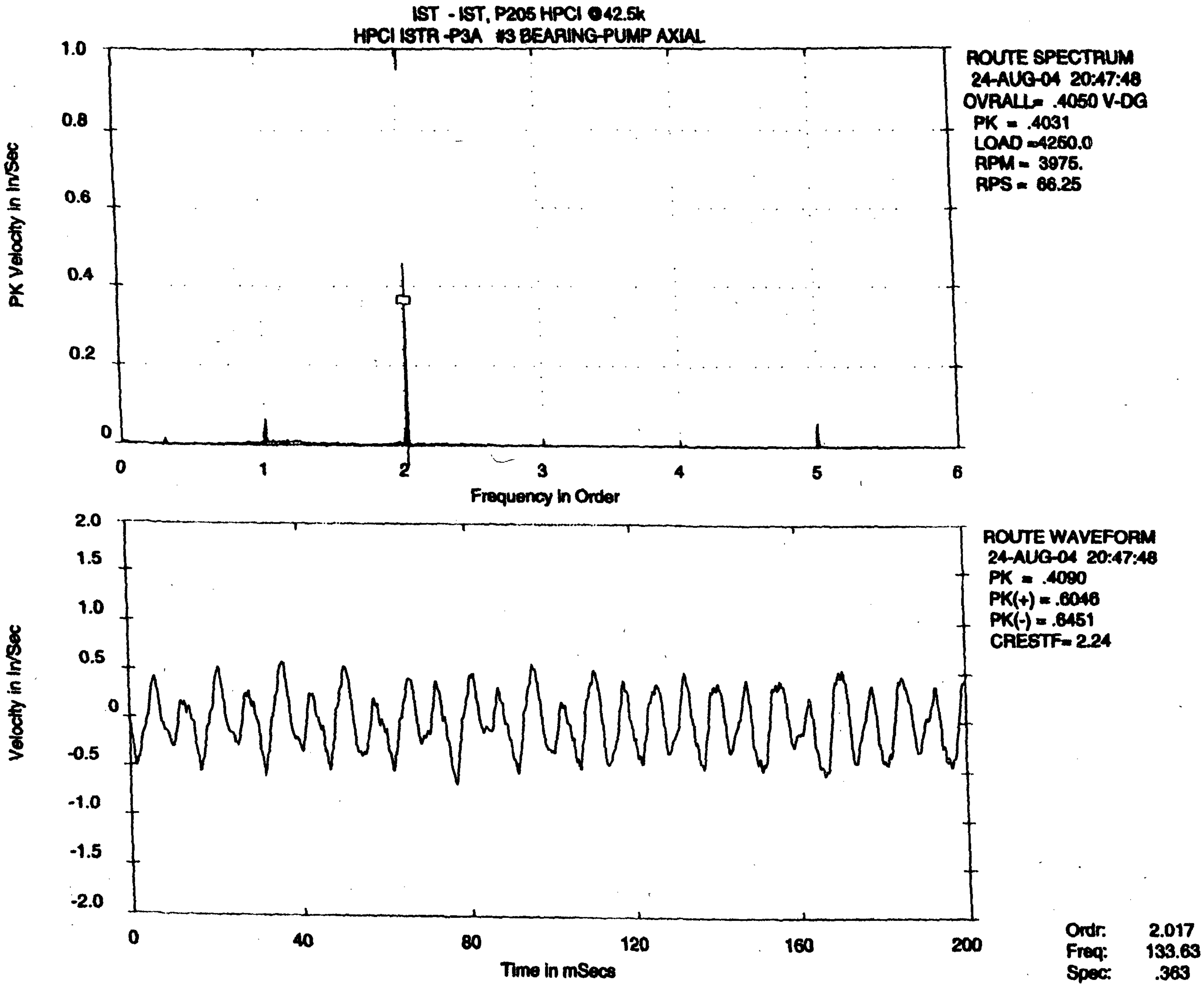


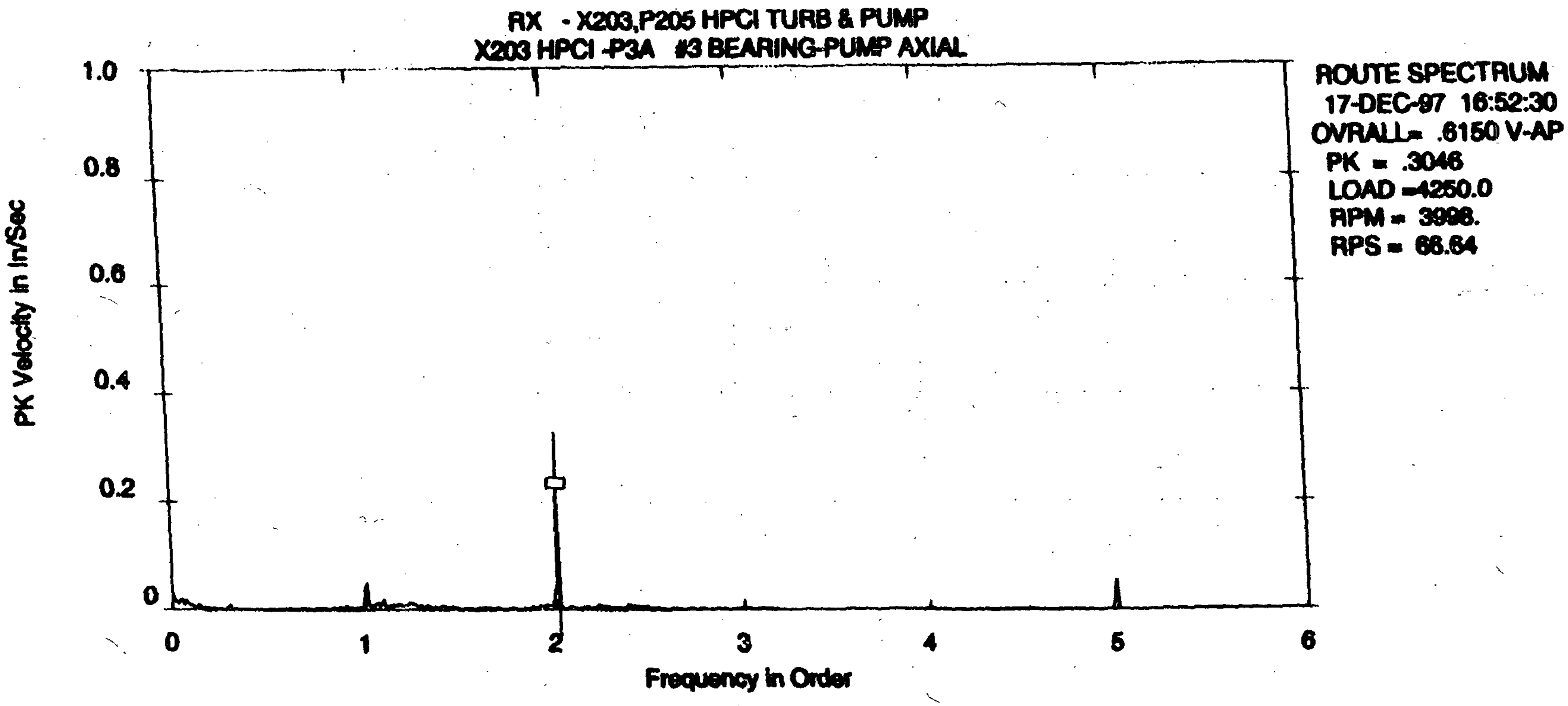
WAVEFORM DISPLAY
25-MAY-94 09:28:50
PK = .2926
PK(+) = .5419
PK(-) = .5849
CRESTF= 2.79

Ordr: 2.008
Freq: 136.25
Spec: .100

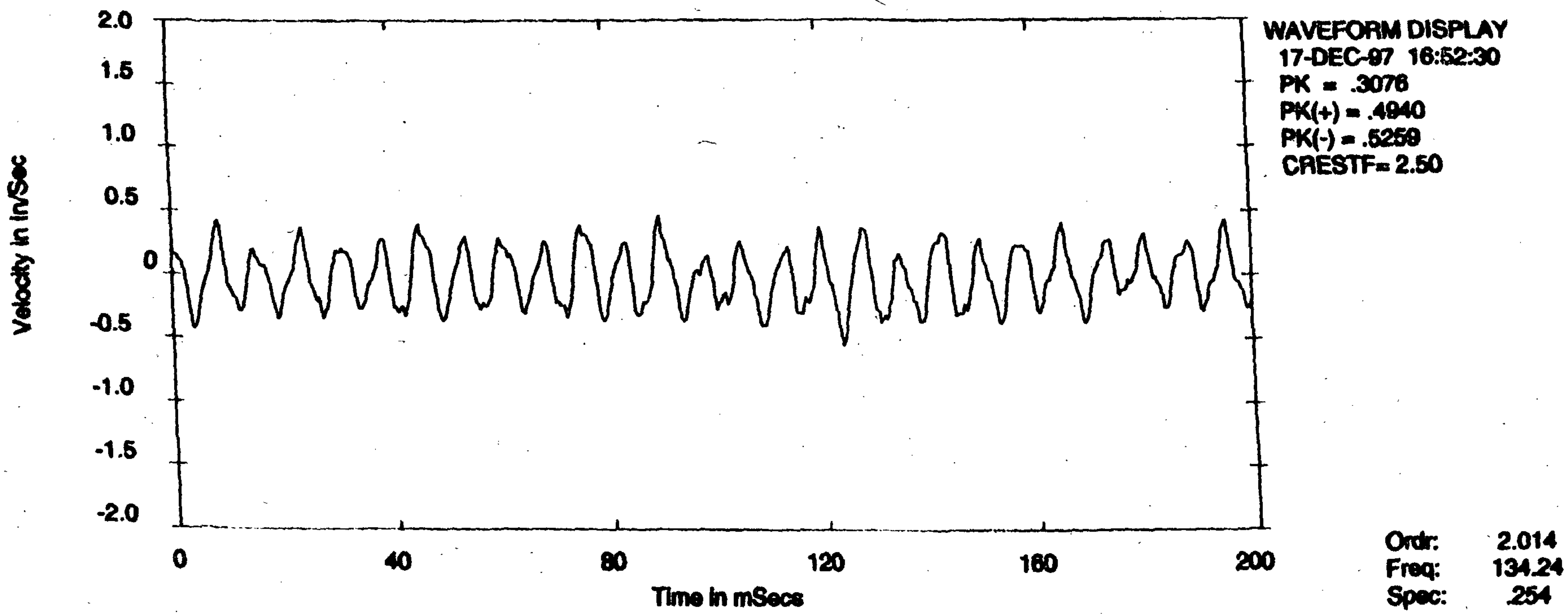

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P3A #3 BEARING-PUMP AXIAL
ROUTE SPECTRUM
24-NOV-04 00:51:19
OVRALL= .3549 V-DG
PK = .3531
LOAD =4250.0
RPM = 4018.
RPS = 66.97
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order


ROUTE WAVEFORM
24-NOV-04 00:51:19
PK = .3707
PK(+) = .5139
PK(-) = .6220
CRESTF= 2.31
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.016
Freq: 135.00
Spec: .289


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P3A #3 BEARING-PUMP AXIAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
24-AUG-04 20:47:48
OVRALL= .4050 V-DG
PK = .4031
LOAD =4250.0
RPM = 3975.
RPS = 66.25
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
ROUTE WAVEFORM
24-AUG-04 20:47:48
PK = .4090
PK(+) = .6046
PK(-) = .6451
CRESTF= 2.24
Ordr: 2.017
Freq: 133.63
Spec: .363

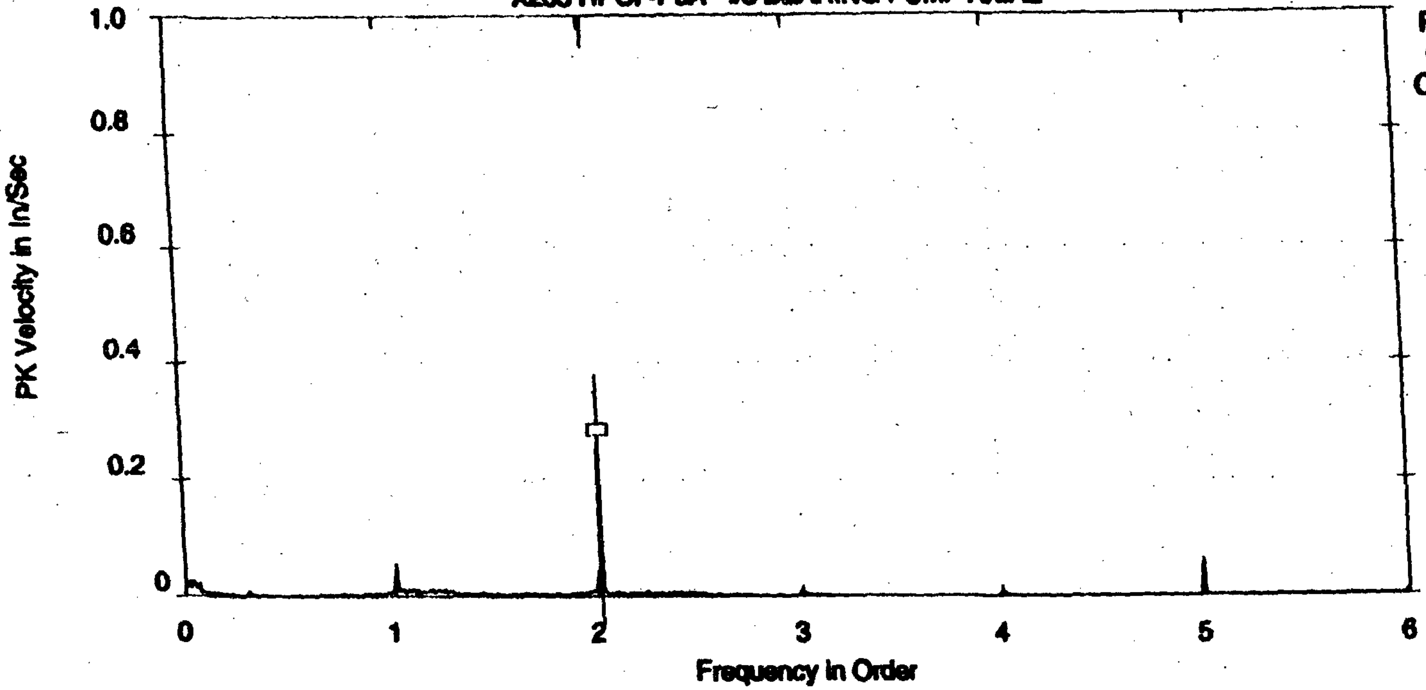


RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P3A #3 BEARING-PUMP AXIAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
17-DEC-97 16:52:30
OVRALL= .6150 V-AP
PK = .3046
LOAD =4250.0
RPM = 3998.
RPS = 66.64

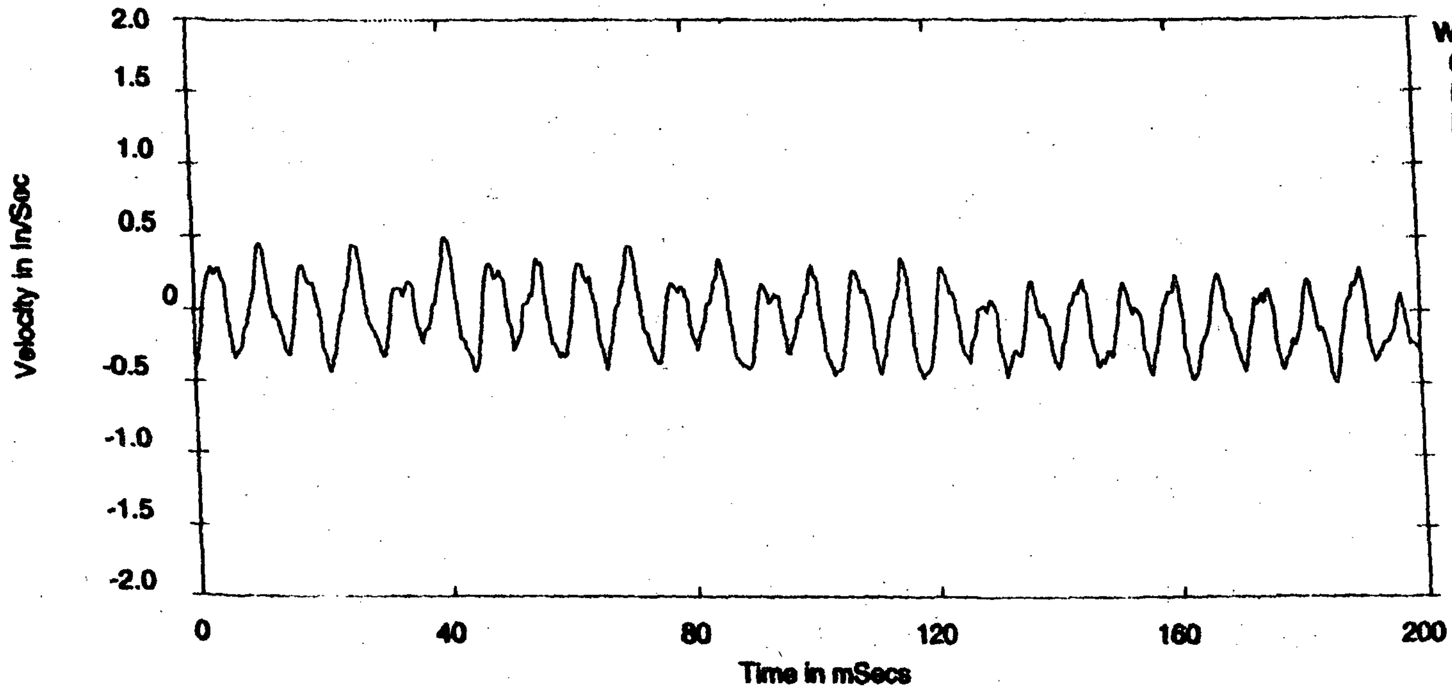


Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
WAVEFORM DISPLAY
17-DEC-97 16:52:30
PK = .3076
PK(+) = .4940
PK(-) = .5259
CRESTF= 2.50
Ordr: 2.014
Freq: 134.24
Spec: .254

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P3A #3 BEARING-PUMP AXIAL

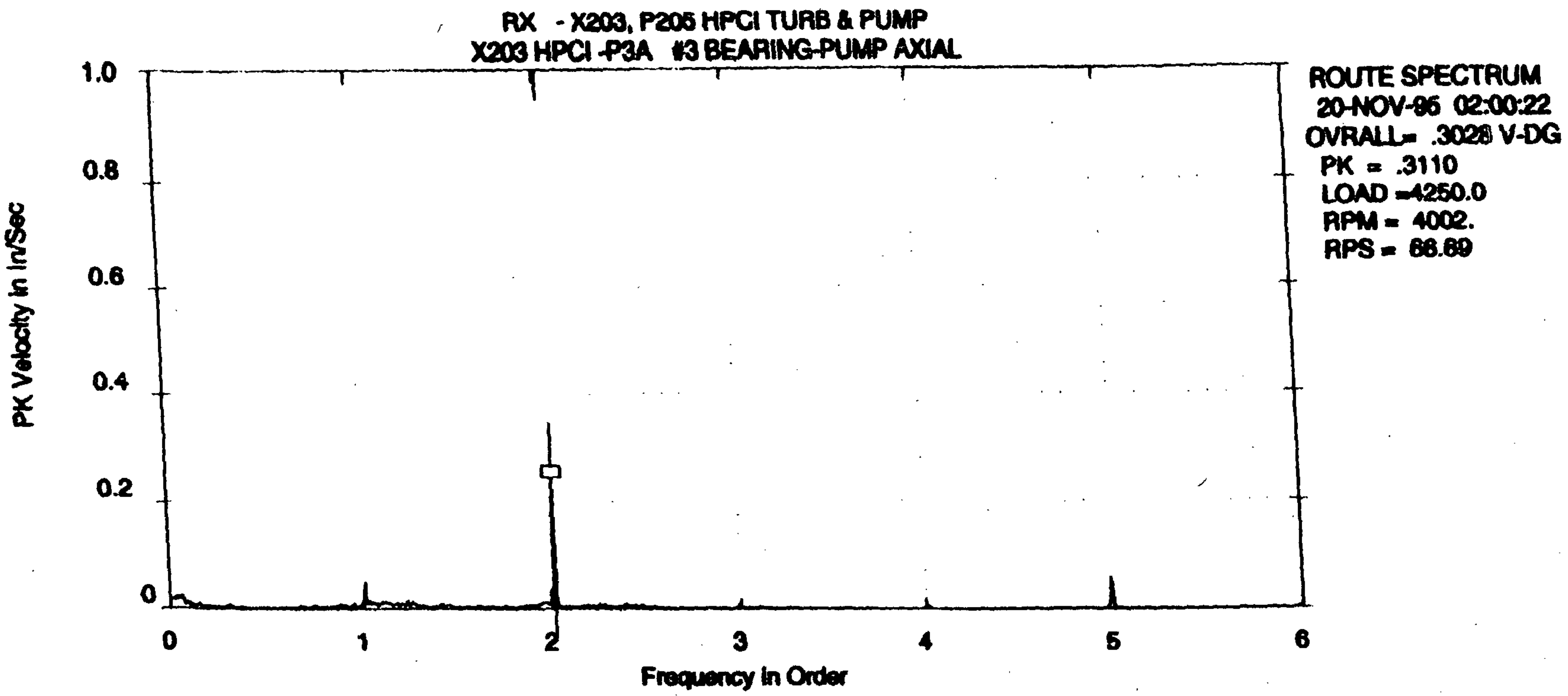


ROUTE SPECTRUM
06-MAY-96 09:23:10
OVRALL= .3468 V-DG
PK = .3533
LOAD =4250.0
RPM = 4008.
RPS = 66.80

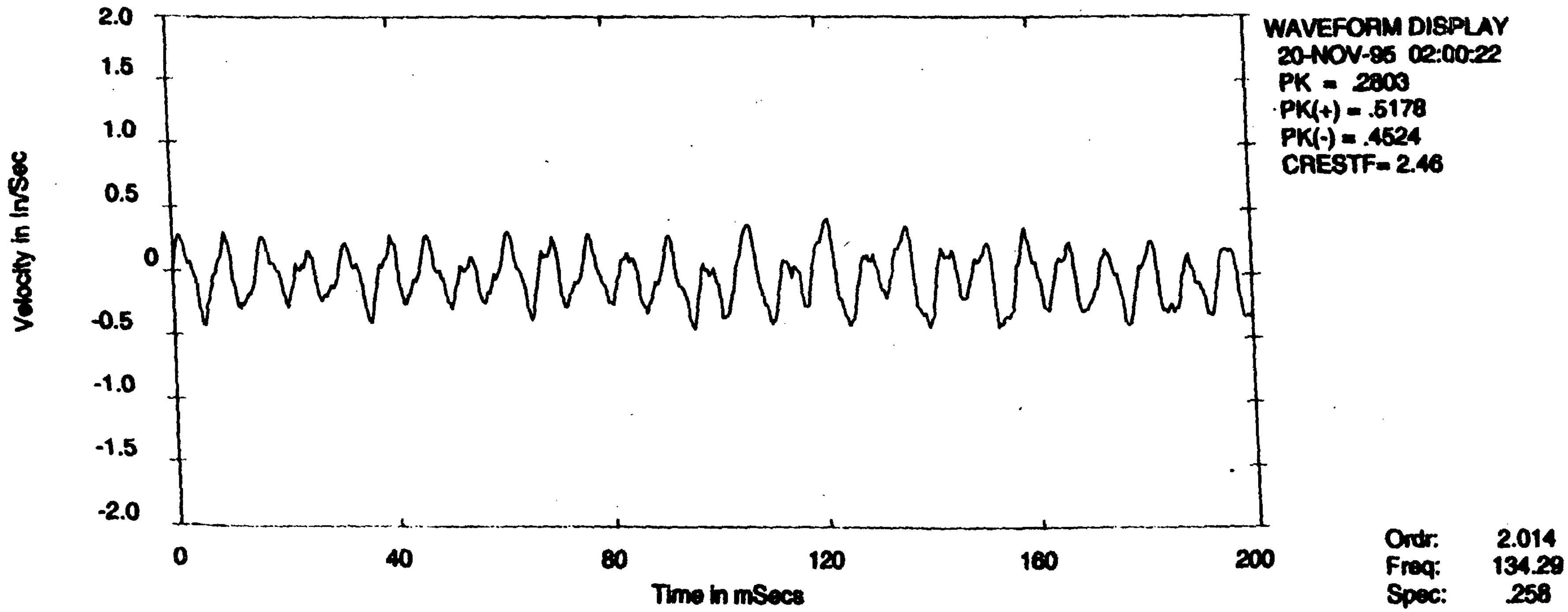


WAVEFORM DISPLAY
06-MAY-96 09:23:10
PK = .3319
PK(+) = .6491
PK(-) = .4948
CRESTF= 2.71

Ordr: 2.014
Freq: 134.56
Spec: .310

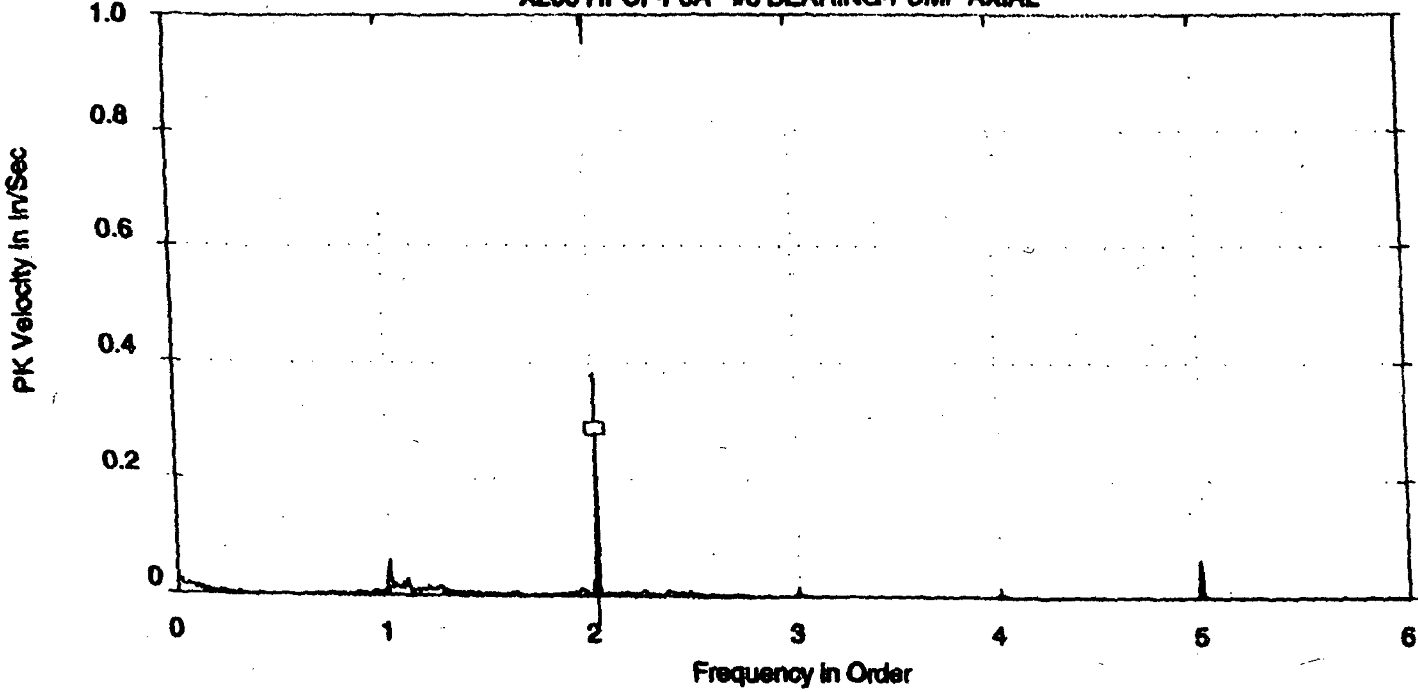


RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P3A #3 BEARING-PUMP AXIAL
ROUTE SPECTRUM
20-NOV-95 02:00:22
OVRALL= .3028 V-DG
PK = .3110
LOAD =4250.0
RPM = 4002.
RPS = 66.69
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order

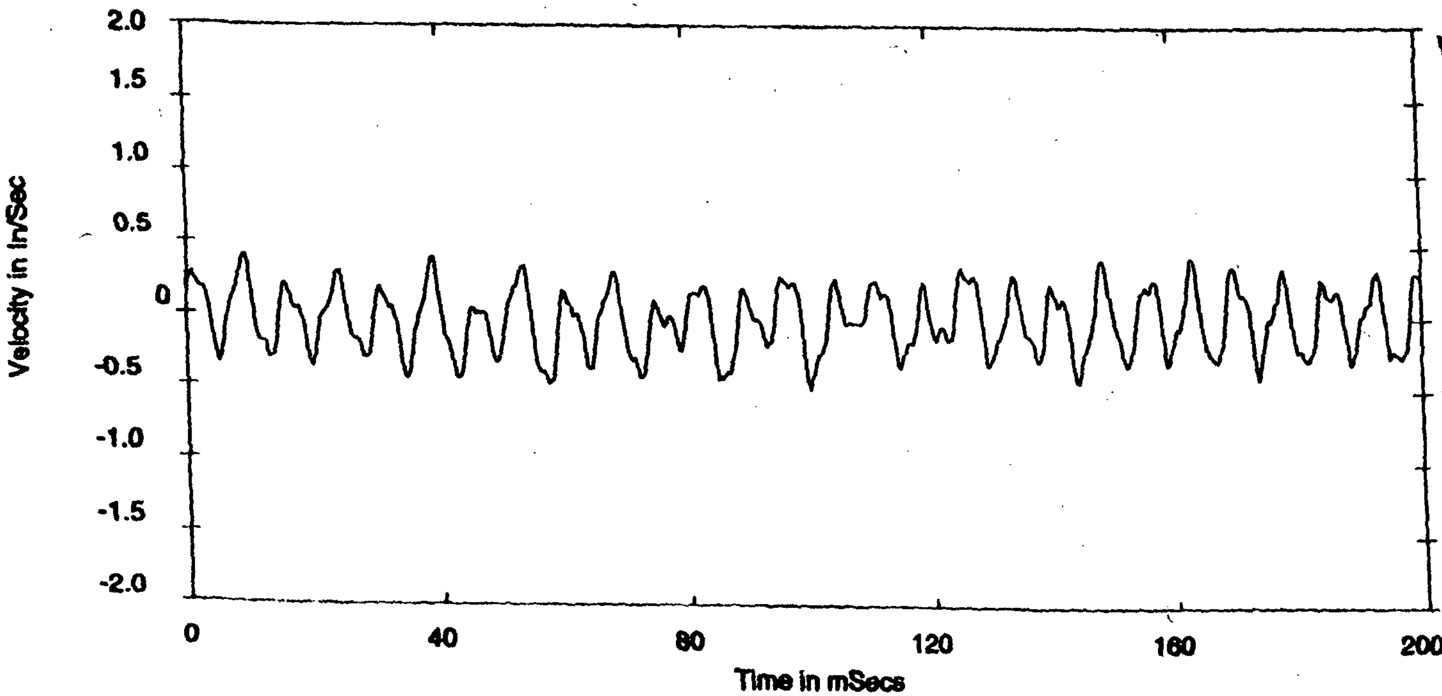


WAVEFORM DISPLAY
20-NOV-95 02:00:22
PK = .2803
PK(+) = .5178
PK(-) = .4524
CRESTF= 2.46
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 2.014
Freq: 134.29
Spec: .258

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P3A #3 BEARING-PUMP AXIAL

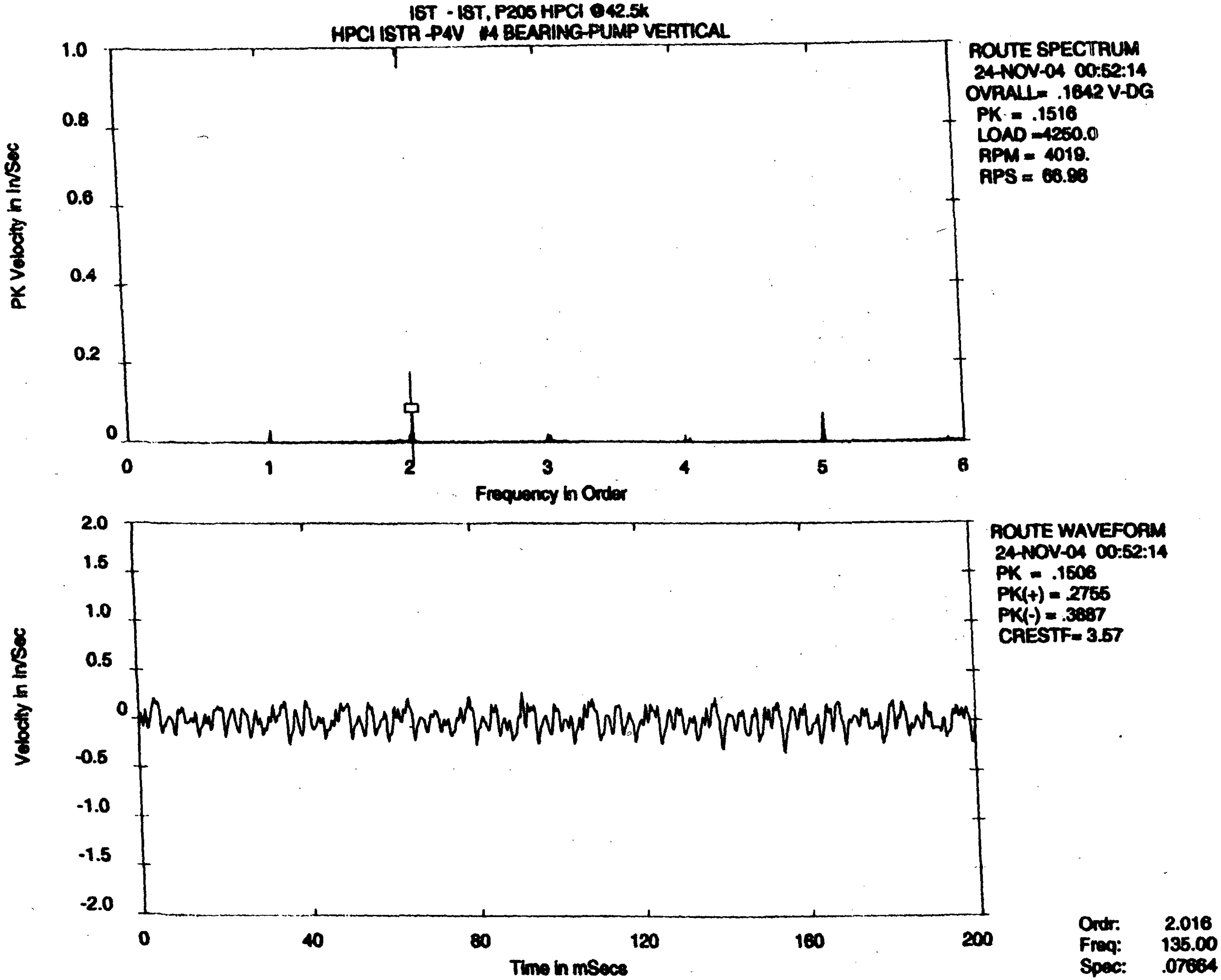


ROUTE SPECTRUM
25-MAY-94 09:29:50
OVRALL= .3312 V-DG
PK = .3370
LOAD =4250.0
RPM = 4059.
RPS = 67.64



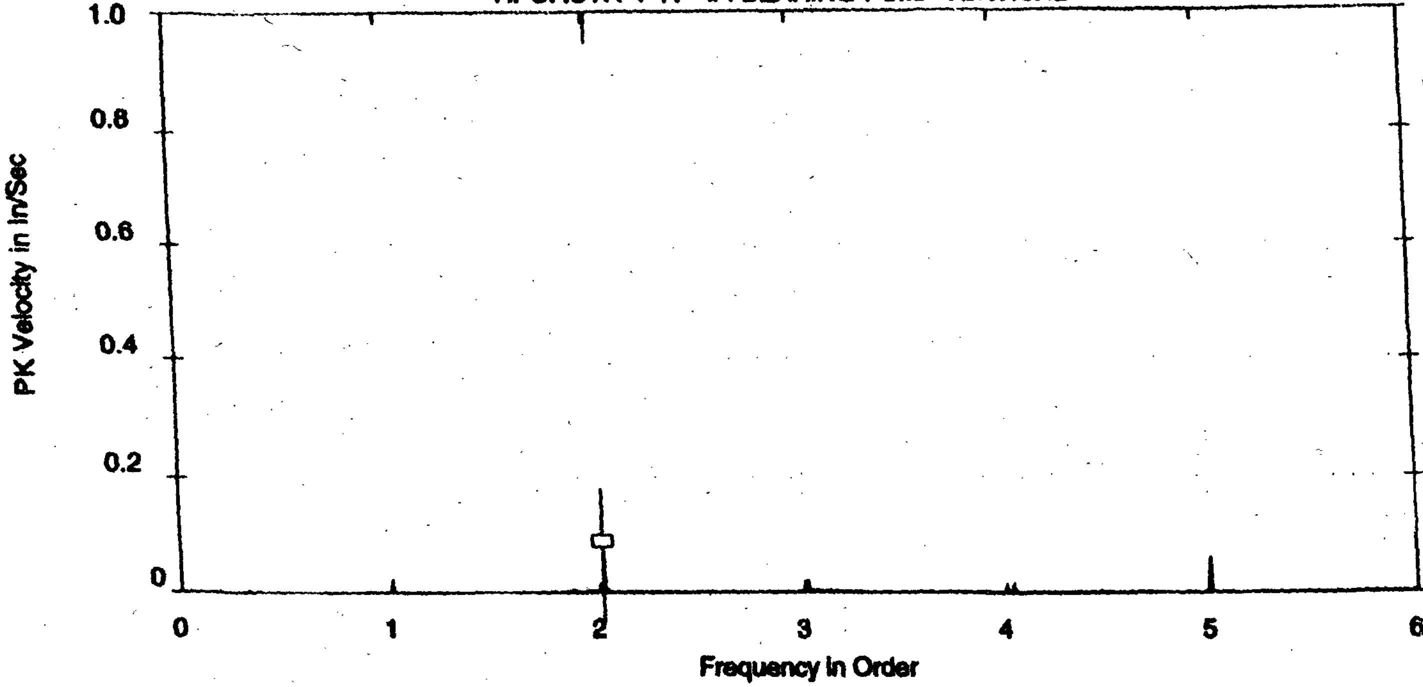
WAVEFORM DISPLAY
25-MAY-94 09:29:50
PK = .3123
PK(+) = .4462
PK(-) = .4855
CRESTF= 2.25

Ordr: 2.014
Freq: 136.23
Spec: .280

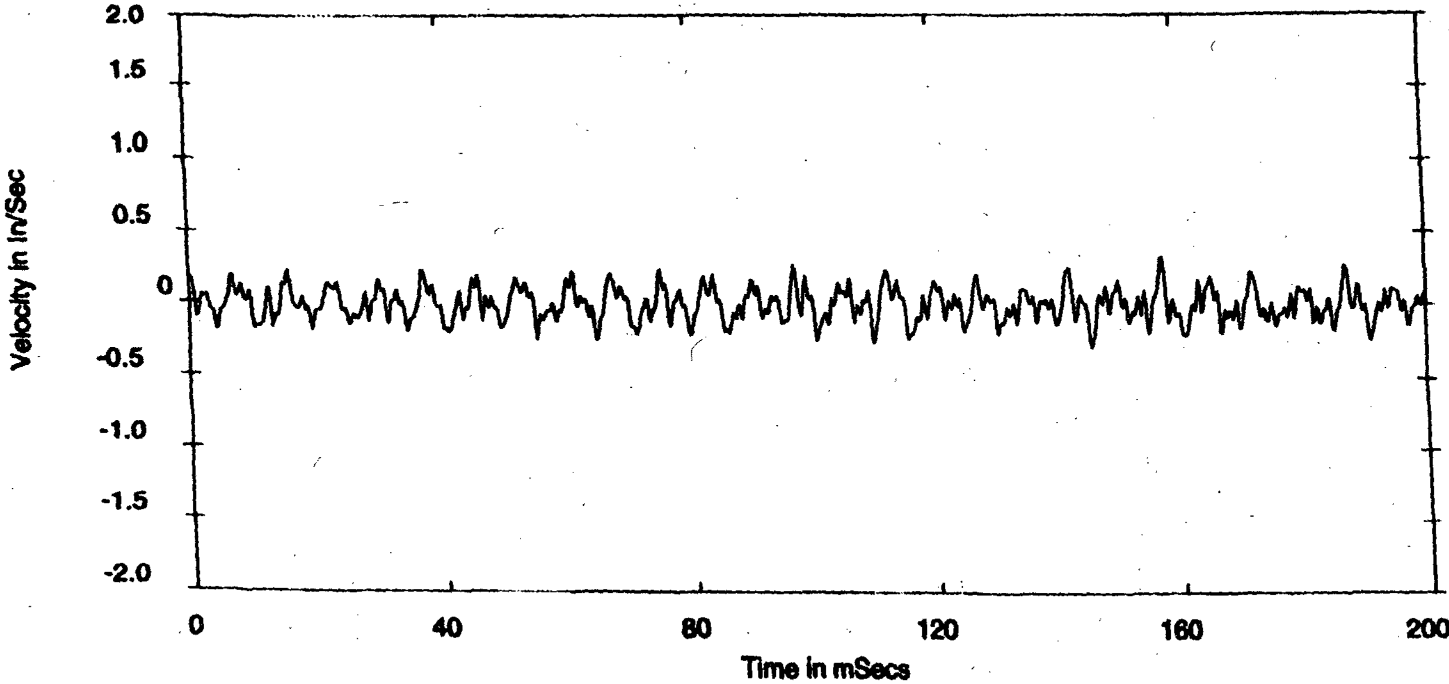


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P4V #4 BEARING-PUMP VERTICAL
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
24-NOV-04 00:52:14
OVRALL= .1642 V-DG
PK = .1516
LOAD =4250.0
RPM = 4019.
RPS = 66.98
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
ROUTE WAVEFORM
24-NOV-04 00:52:14
PK = .1506
PK(+) = .2755
PK(-) = .3887
CRESTF= 3.57
Ordr: 2.016
Freq: 135.00
Spec: .07664

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P4V #4 BEARING-PUMP VERTICAL

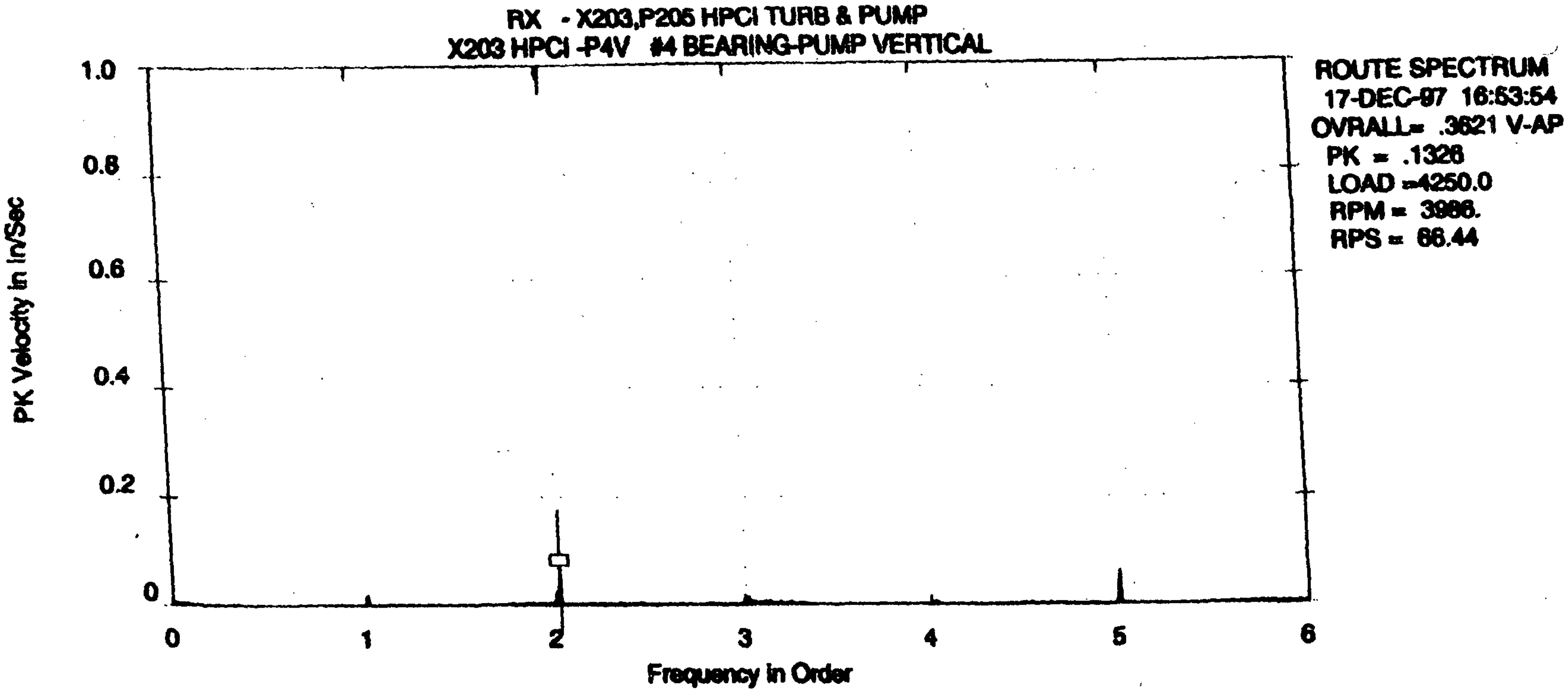


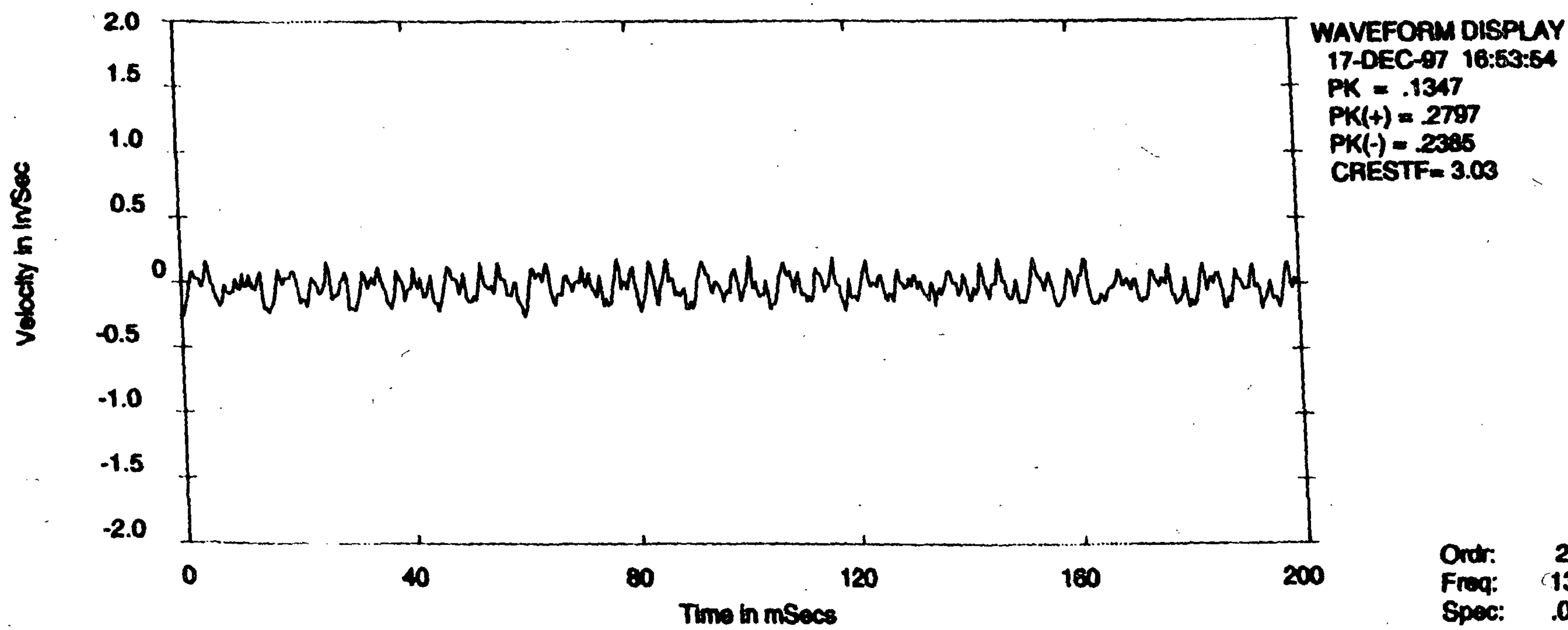
ROUTE SPECTRUM
24-AUG-04 20:48:46
OVRALL= .1474 V-DG
PK = .1341
LOAD =4250.0
RPM = 3976.
RPS = 66.27



ROUTE WAVEFORM
24-AUG-04 20:48:46
PK = .1549
PK(+) = .3373
PK(-) = .2904
CRESTF= 3.07

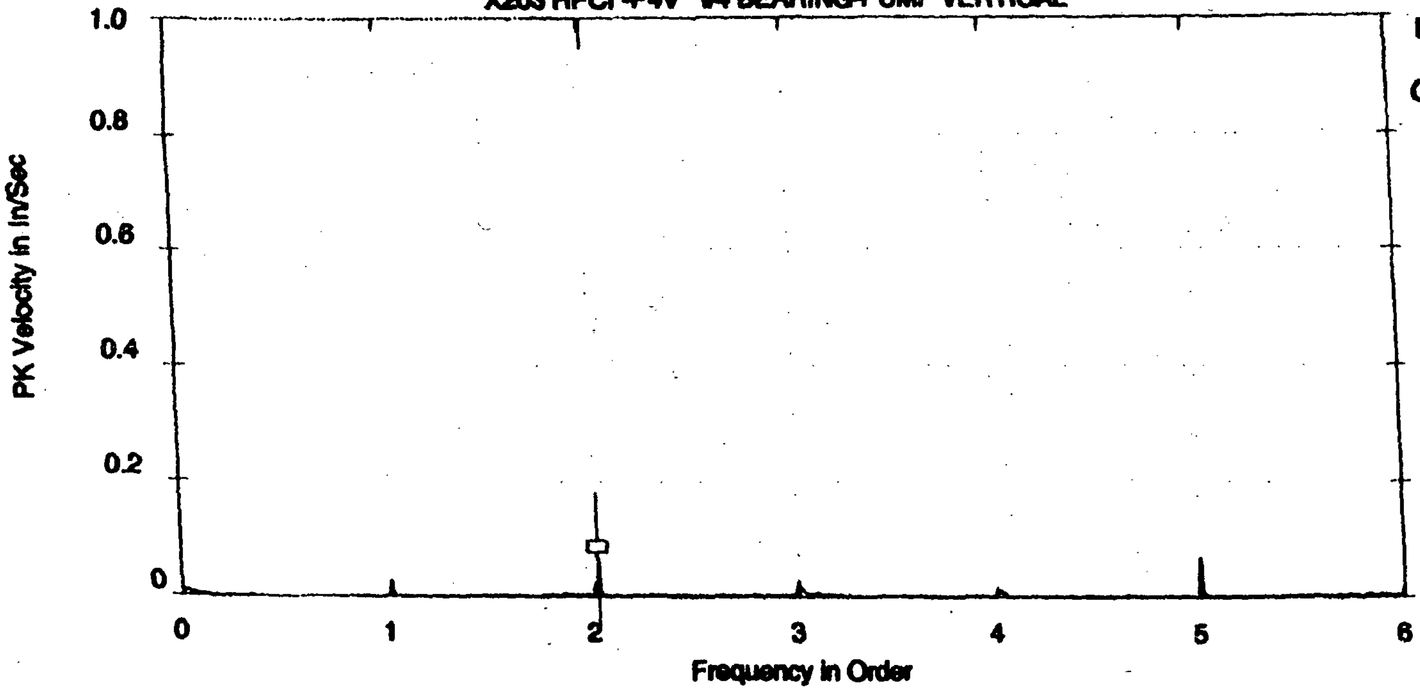
Ordr: 2.016
Freq: 133.59
Spec: .07974



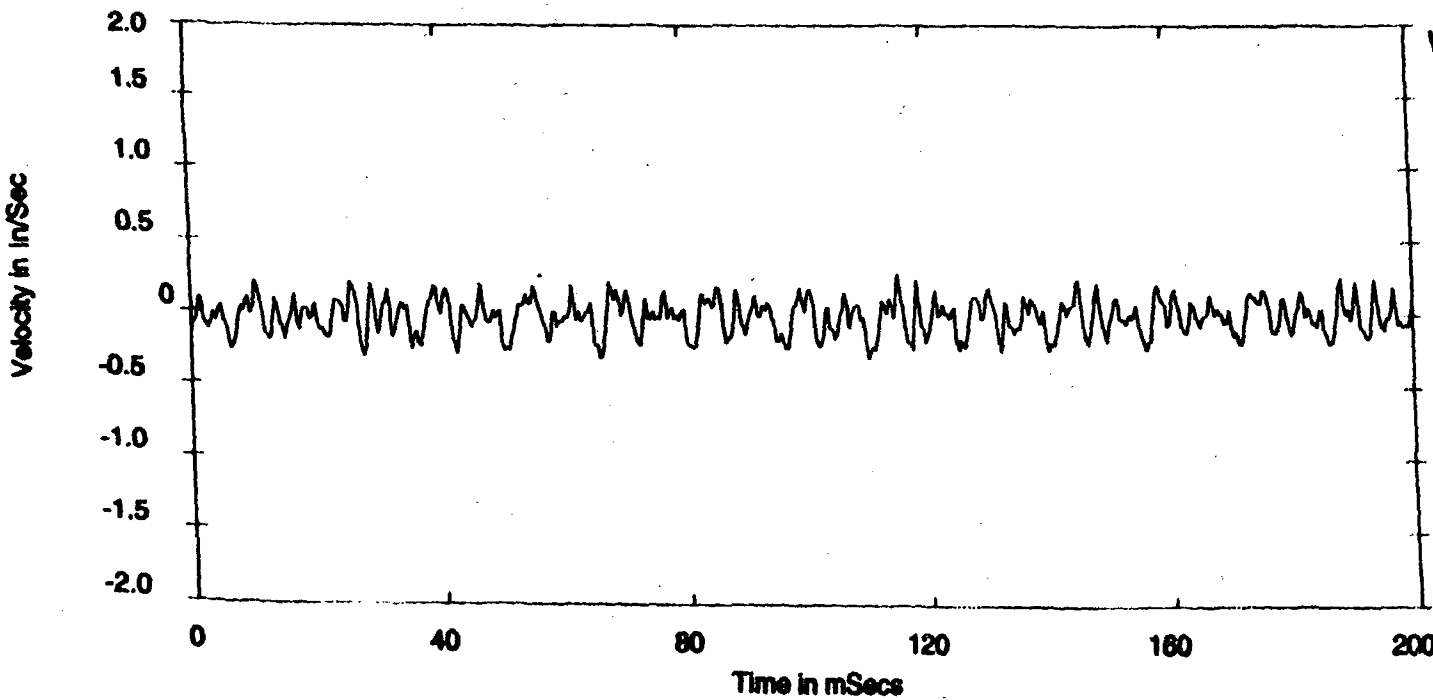


Ordr: 2.017
Freq: 133.97
Spec: .07982

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P4V #4 BEARING-PUMP VERTICAL



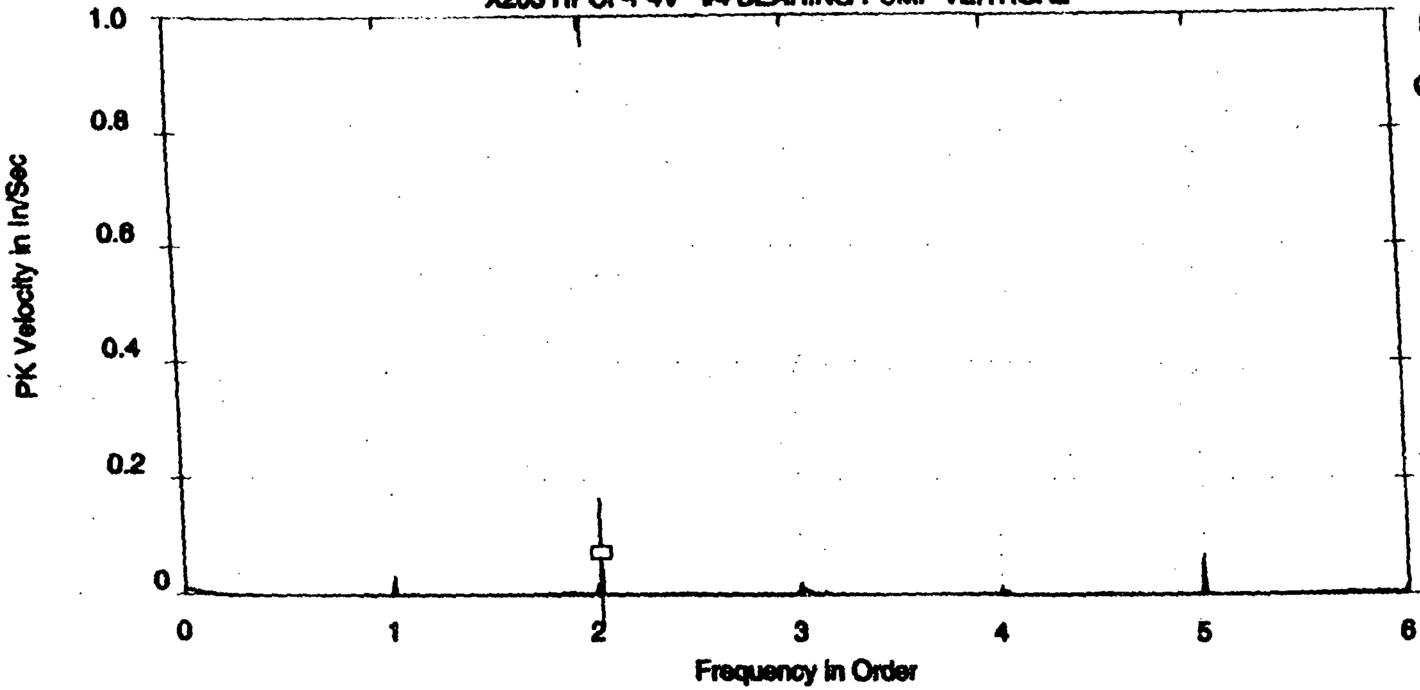
ROUTE SPECTRUM
06-MAY-96 09:24:24
OVRALL= .1621 V-DG
PK = .1533
LOAD =4250.0
RPM = 3999.
RPS = 66.66



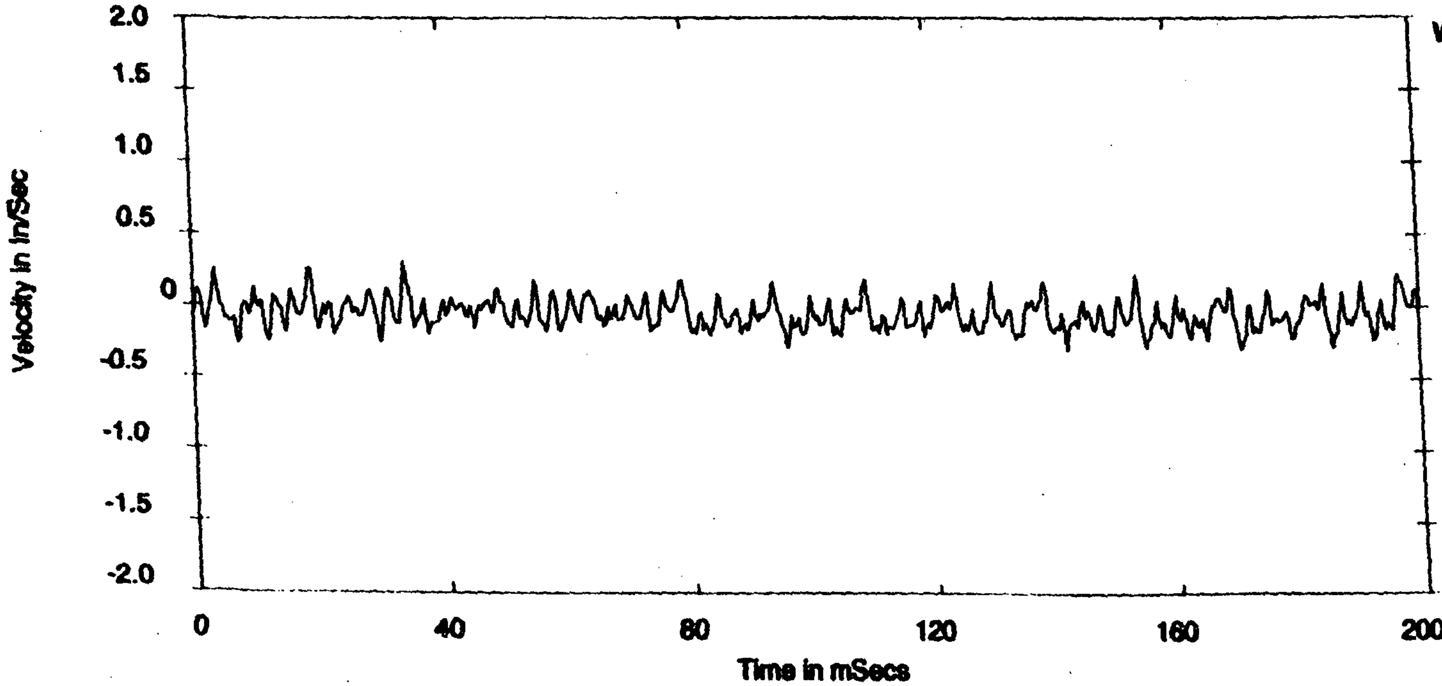
WAVEFORM DISPLAY
06-MAY-96 09:24:24
PK = .1704
PK(+) = .3405
PK(-) = .2944
CRESTF= 2.88

Ordr: 2.017
Freq: 134.47
Spec: .08144

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P4V #4 BEARING-PUMP VERTICAL



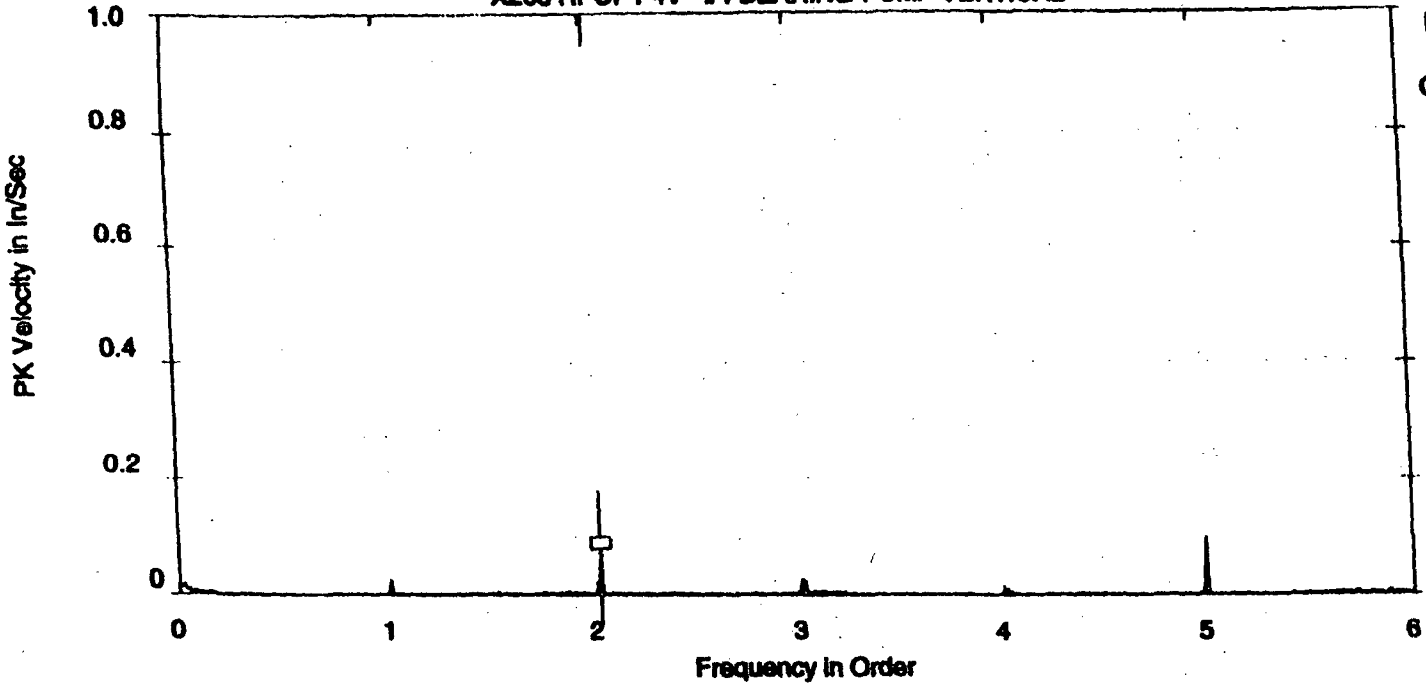
ROUTE SPECTRUM
20-NOV-95 02:01:17
OVRALL= .1456 V-DG
PK = .1375
LOAD =4250.0
RPM = 3992.
RPS = 66.54



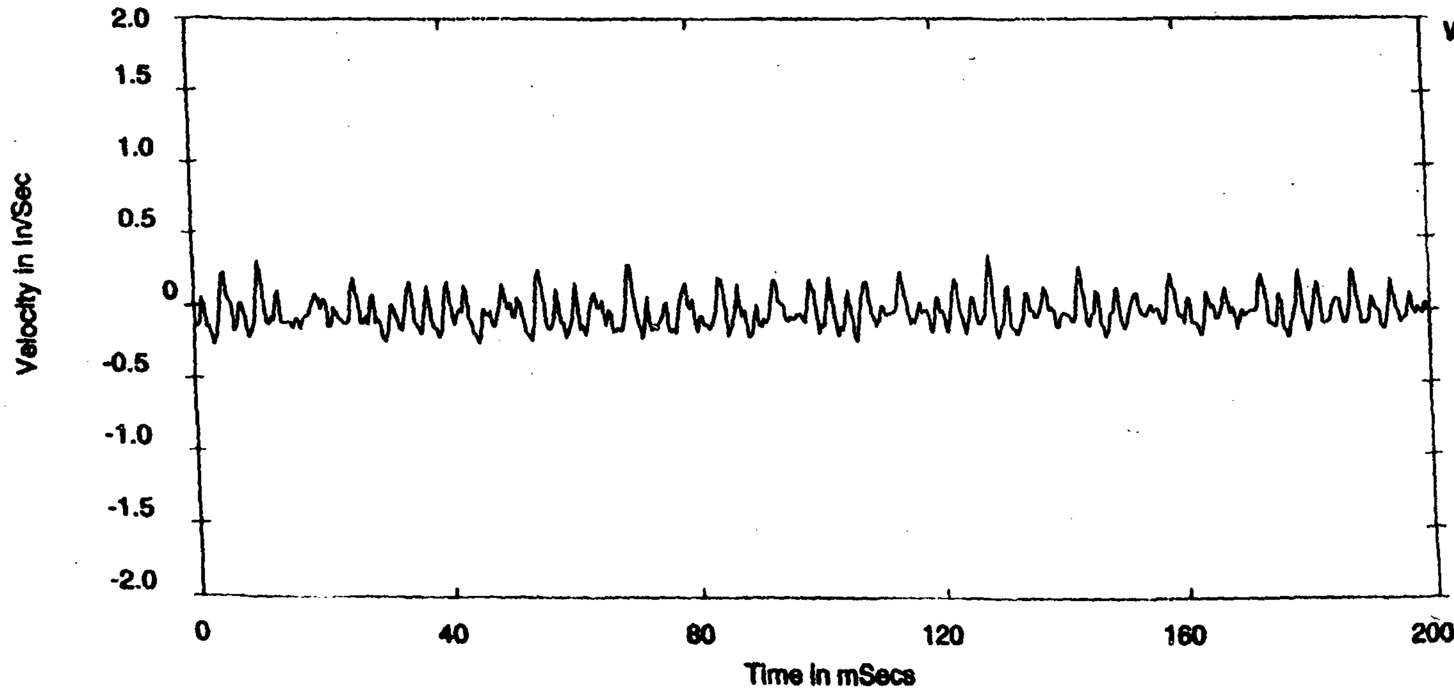
WAVEFORM DISPLAY
20-NOV-95 02:01:17
PK = .1486
PK(+) = .3539
PK(-) = .2796
CRESTF= 3.26

Ordr: 2.016
Freq: 134.17
Spec: .06989

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P4V #4 BEARING-PUMP VERTICAL



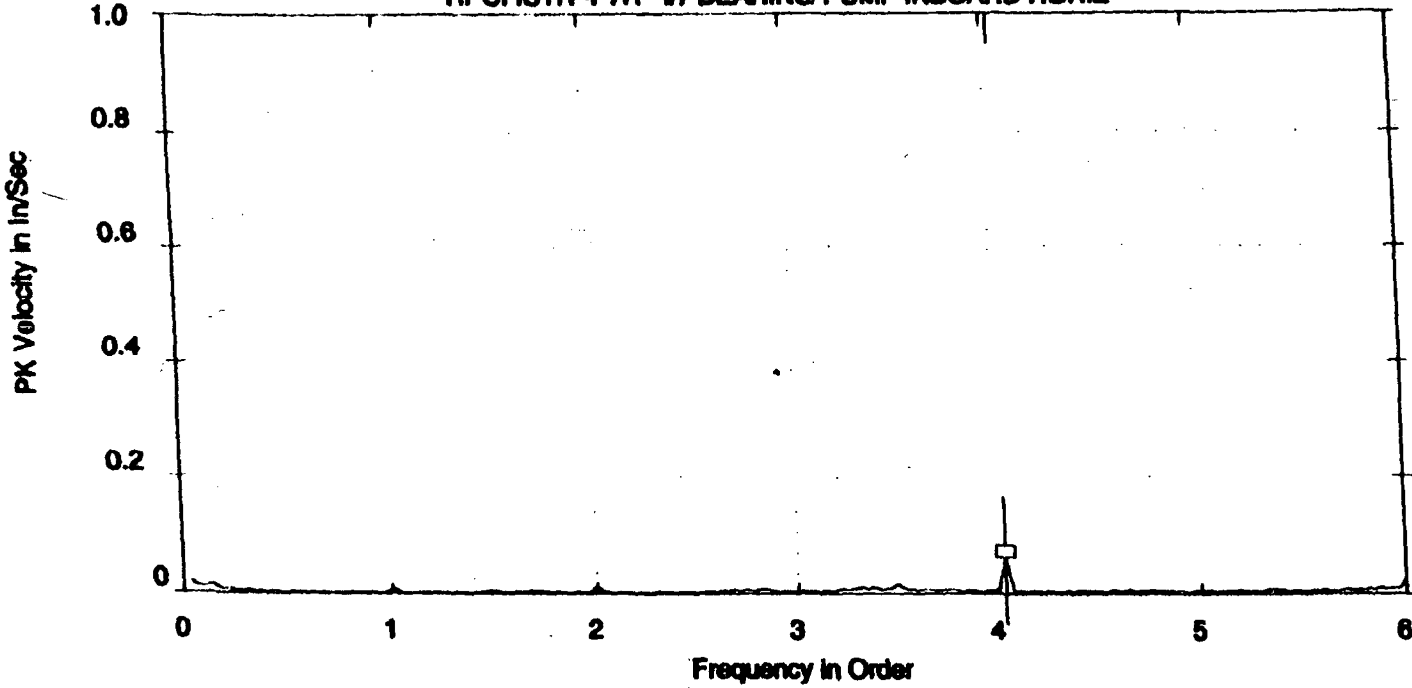
ROUTE SPECTRUM
25-MAY-94 09:30:46
OVRALL= .1682 V-DG
PK = .1634
LOAD =4250.0
RPM = 4055.
RPS = 67.58



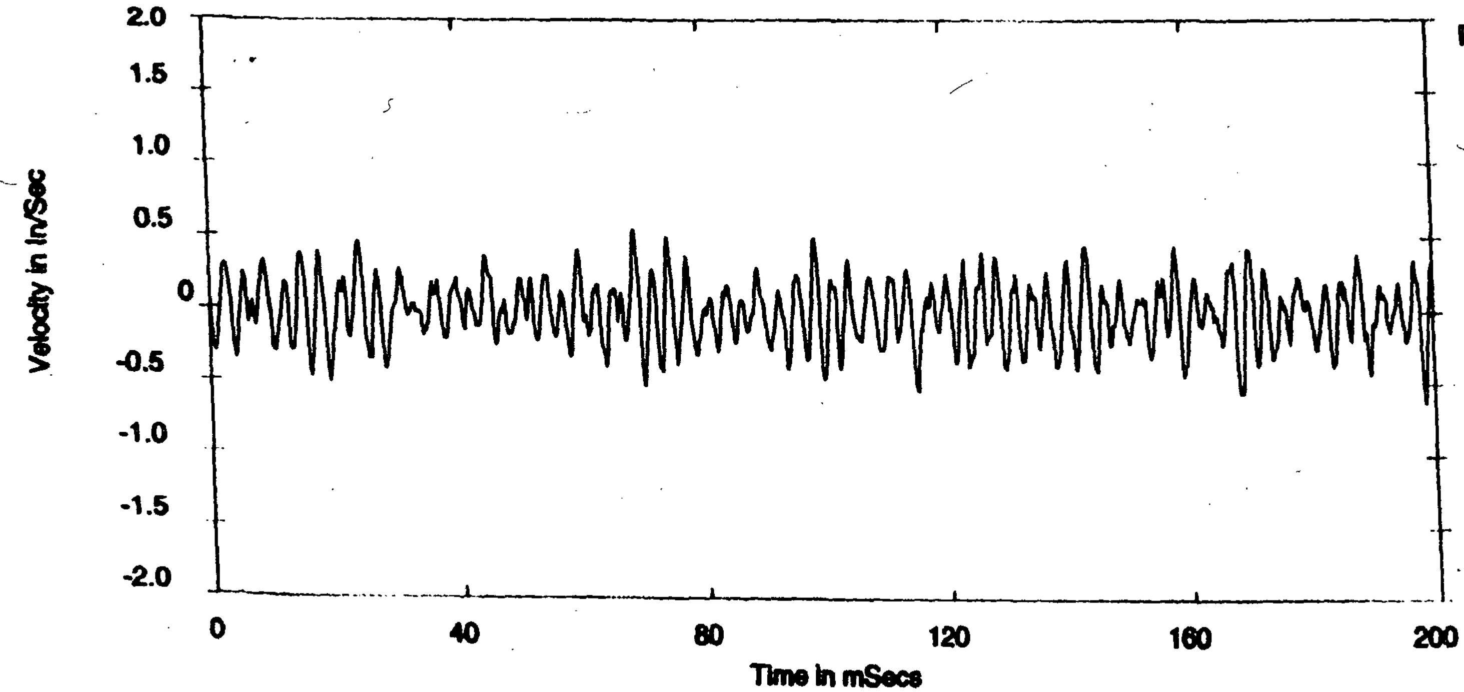
WAVEFORM DISPLAY
25-MAY-94 09:30:46
PK = .1584
PK(+) = .3902
PK(-) = .2620
CRESTF= 3.35

Ordr: 2.016
Freq: 136.25
Spec: .07871

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P7H #7 BEARING-PUMP INBOARD HORIZ

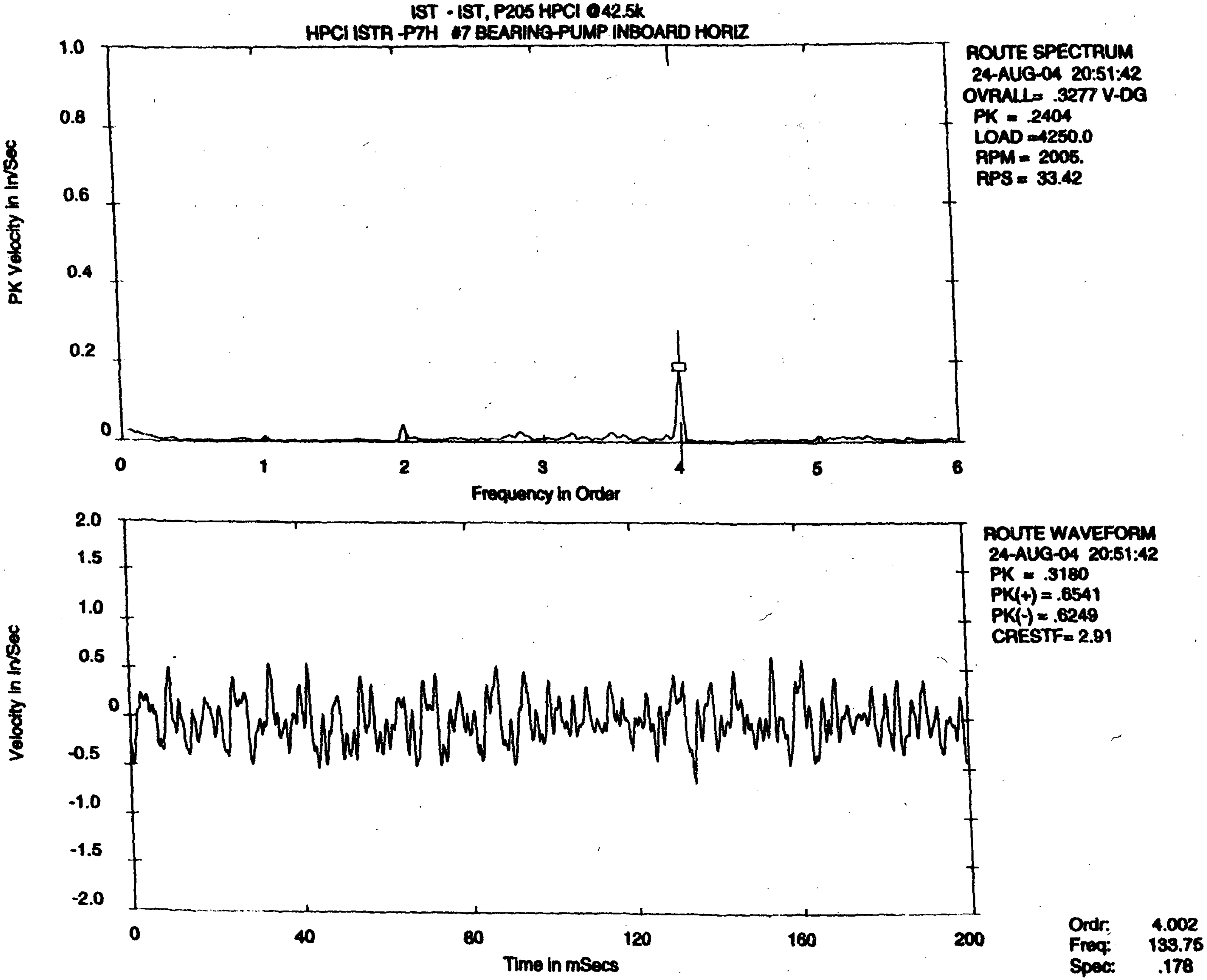


ROUTE SPECTRUM
24-NOV-04 00:47:45
OVRALL= .2981 V-DG
PK = .1027
LOAD =4250.0
RPM = 2008.
RPS = 33.47

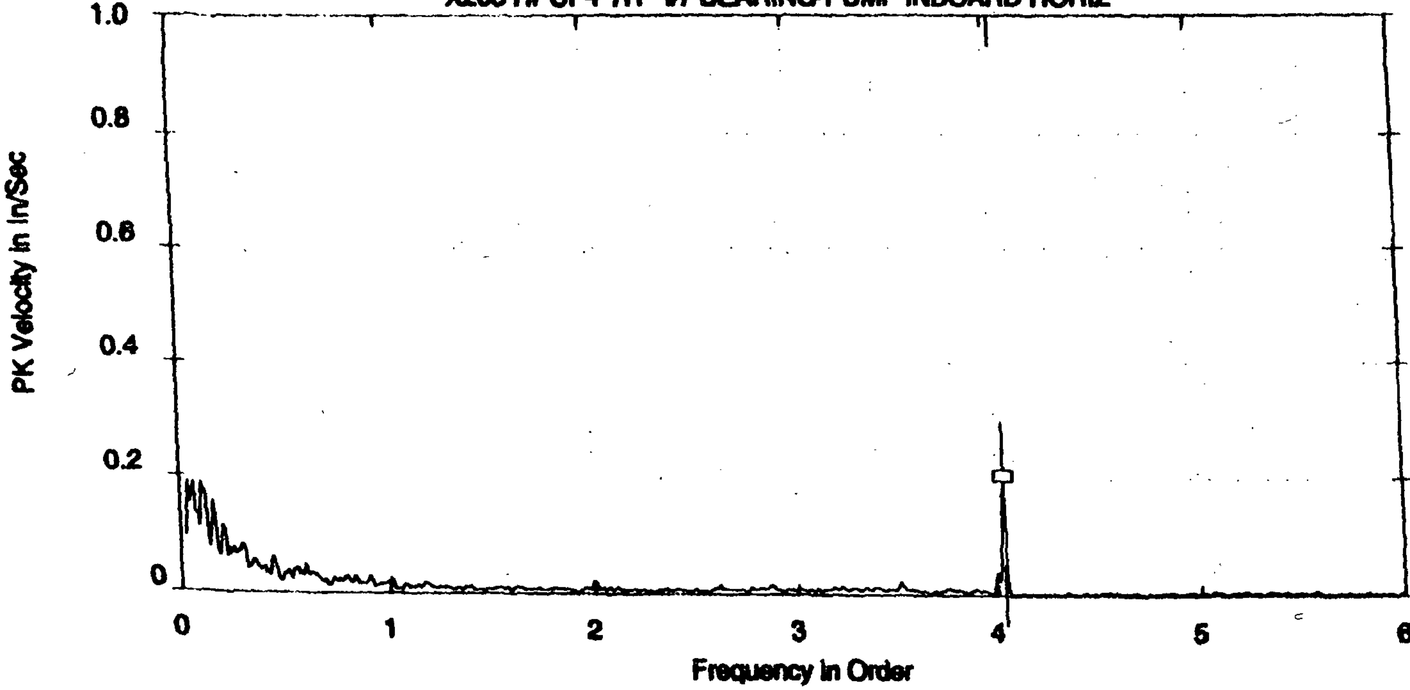


ROUTE WAVEFORM
24-NOV-04 00:47:45
PK = .3023
PK(+) = .5694
PK(-) = .6280
CRESTF= 2.94

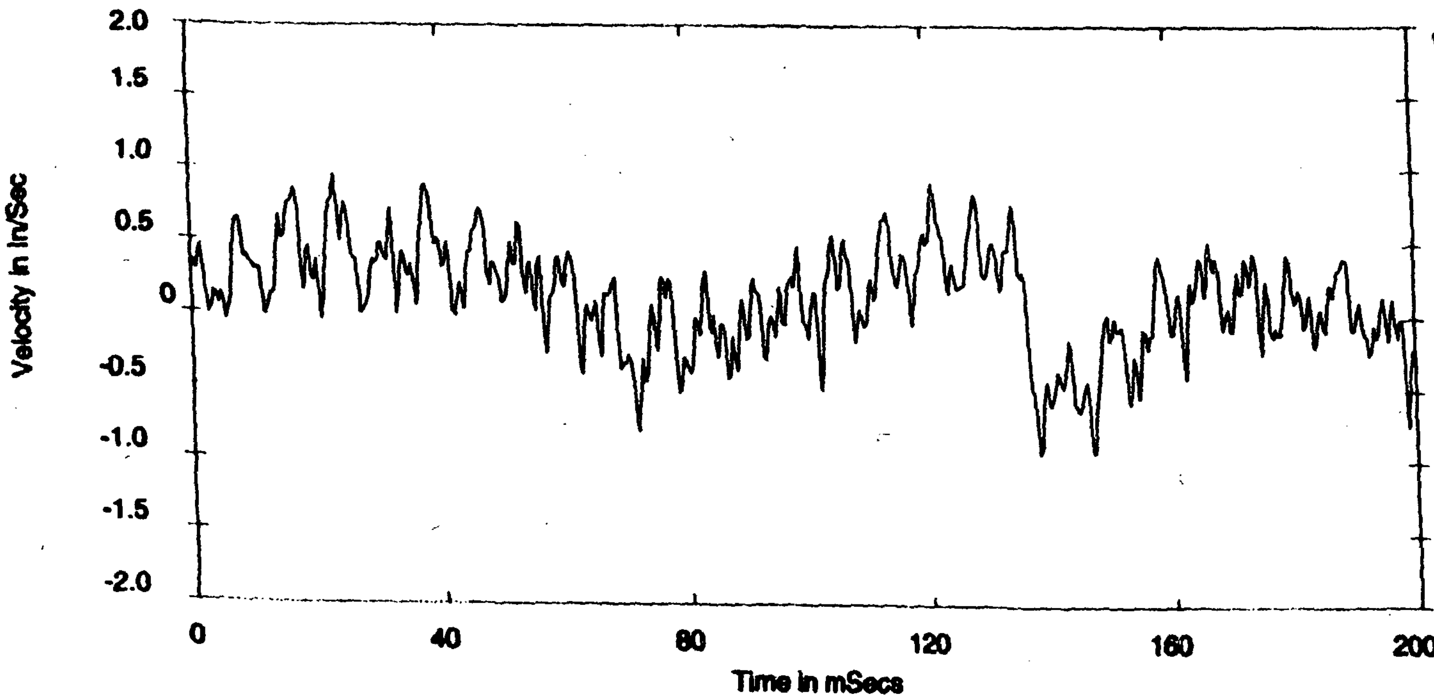
Ordr: 4.035
Freq: 135.04
Spec: .06375


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P7H #7 BEARING-PUMP INBOARD HORIZ
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE SPECTRUM
24-AUG-04 20:51:42
OVRALL= .3277 V-DG
PK = .2404
LOAD =4250.0
RPM = 2005.
RPS = 33.42
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
ROUTE WAVEFORM
24-AUG-04 20:51:42
PK = .3180
PK(+) = .6541
PK(-) = .6249
CRESTF= 2.91
Ordr: 4.002
Freq: 133.75
Spec: .178

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P7H #7 BEARING-PUMP INBOARD HORIZ

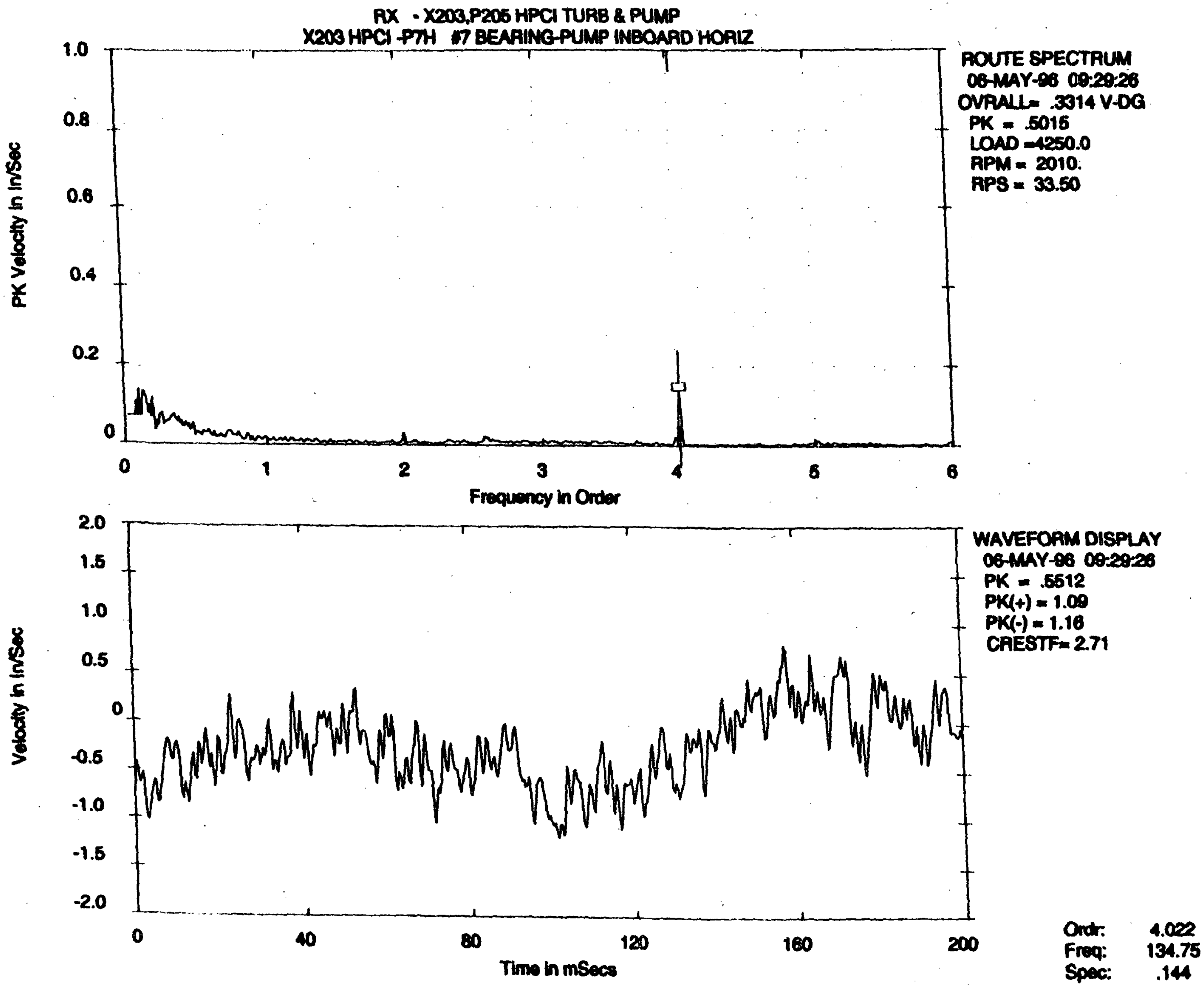


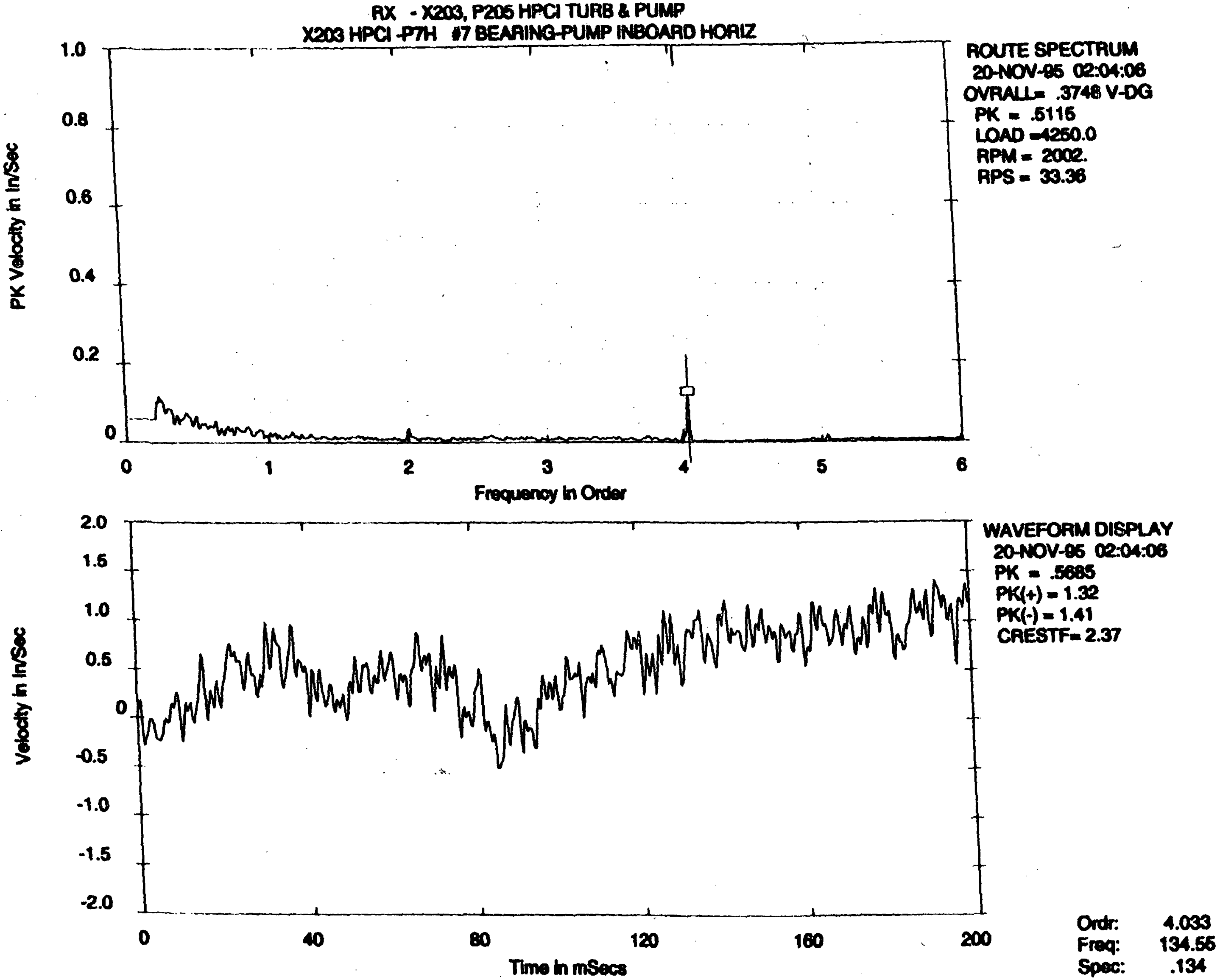
ROUTE SPECTRUM
17-DEC-97 21:49:48
OVRALL= 1.98 V-AP
PK = .8538
LOAD =4250.0
RPM = 1993.
RPS = 33.21



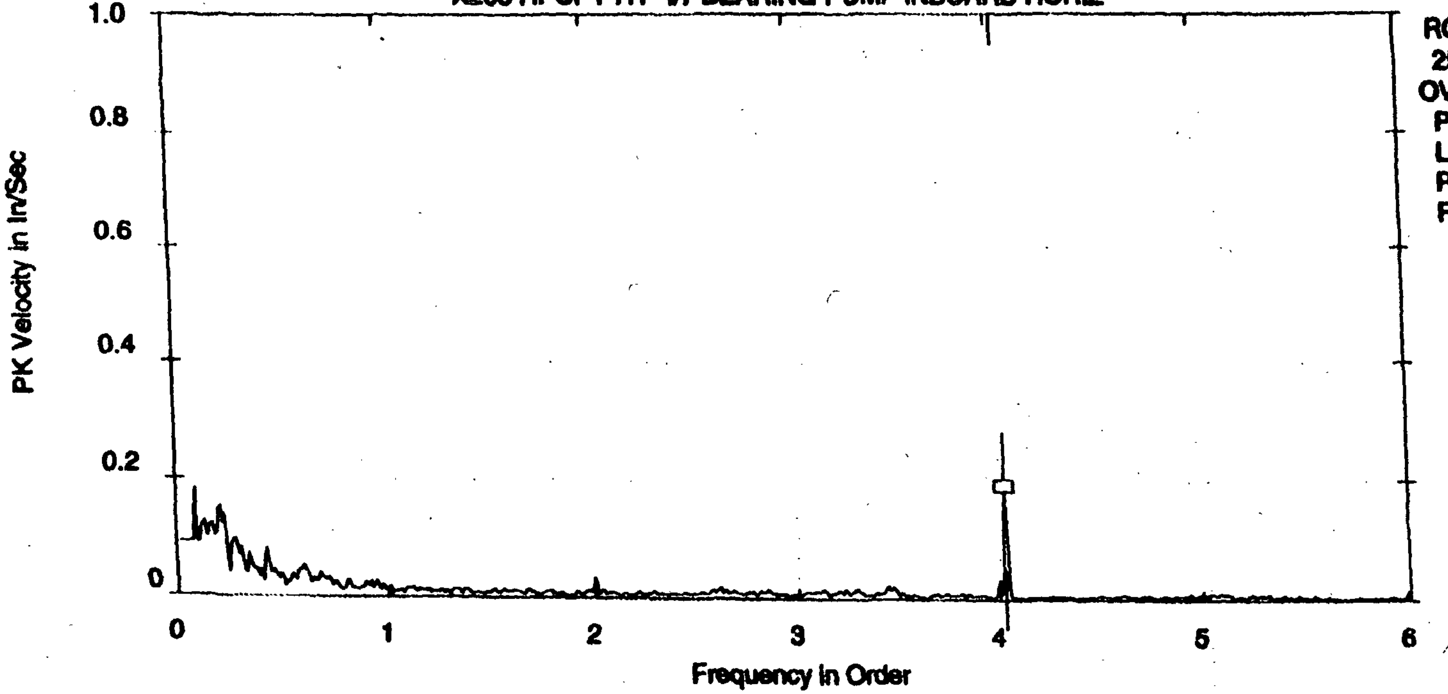
WAVEFORM DISPLAY
17-DEC-97 21:49:48
PK = .4923
PK(+) = 1.14
PK(-) = 1.21
CRESTF= 3.11

Ordr: 4.033
Freq: 133.95
Spec: .214

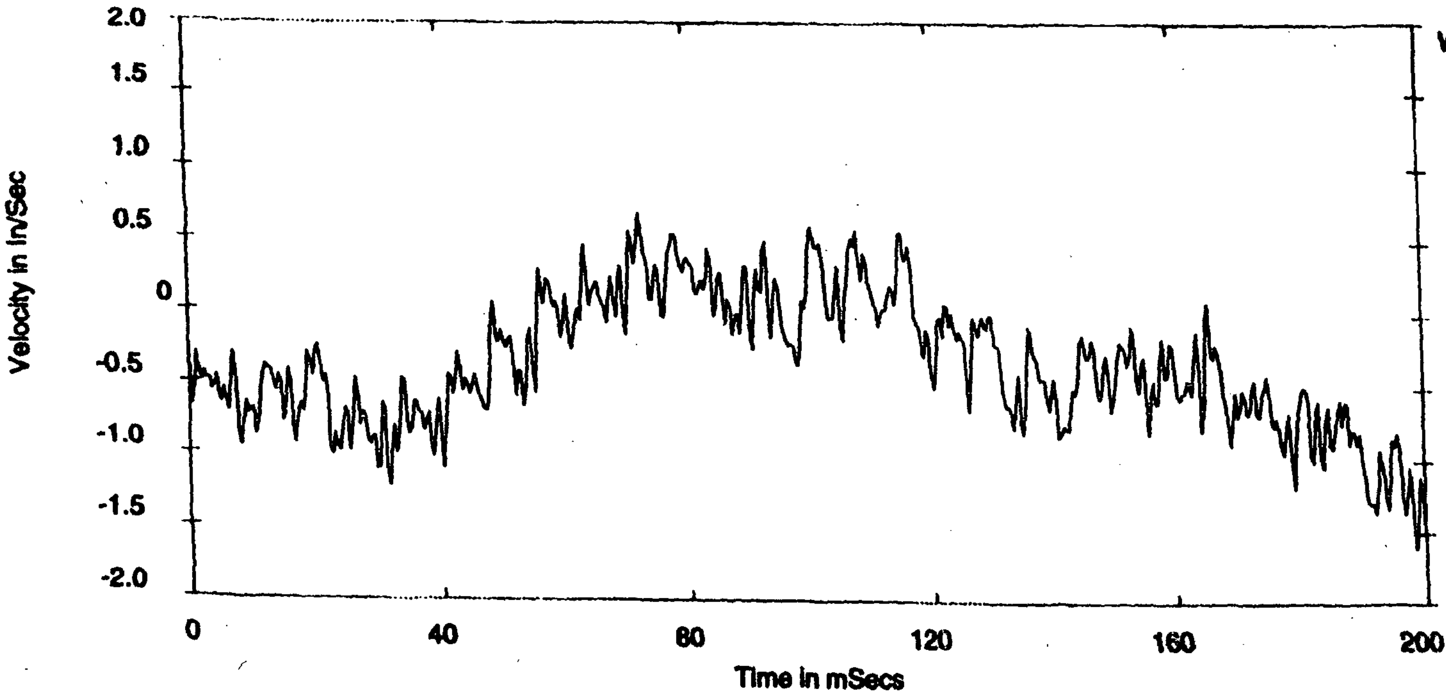

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P7H #7 BEARING-PUMP INBOARD HORIZ
ROUTE SPECTRUM
06-MAY-96 09:29:26
OVRALL= .3314 V-DG
PK = .5015
LOAD =4250.0
RPM = 2010.
RPS = 33.50
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
06-MAY-96 09:29:26
PK = .5512
PK(+) = 1.09
PK(-) = 1.16
CRESTF= 2.71
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.022
Freq: 134.75
Spec: .144


RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P7H #7 BEARING-PUMP INBOARD HORIZ
ROUTE SPECTRUM
20-NOV-95 02:04:06
OVRALL= .3748 V-DG
PK = .5115
LOAD =4250.0
RPM = 2002.
RPS = 33.36
PK Velocity in In/Sec
Frequency in Order
WAVEFORM DISPLAY
20-NOV-95 02:04:06
PK = .5685
PK(+) = 1.32
PK(-) = 1.41
CRESTF= 2.37
Velocity in In/Sec
Time in mSecs
Ordr: 4.033
Freq: 134.55
Spec: .134

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P7H #7 BEARING-PUMP INBOARD HORIZ



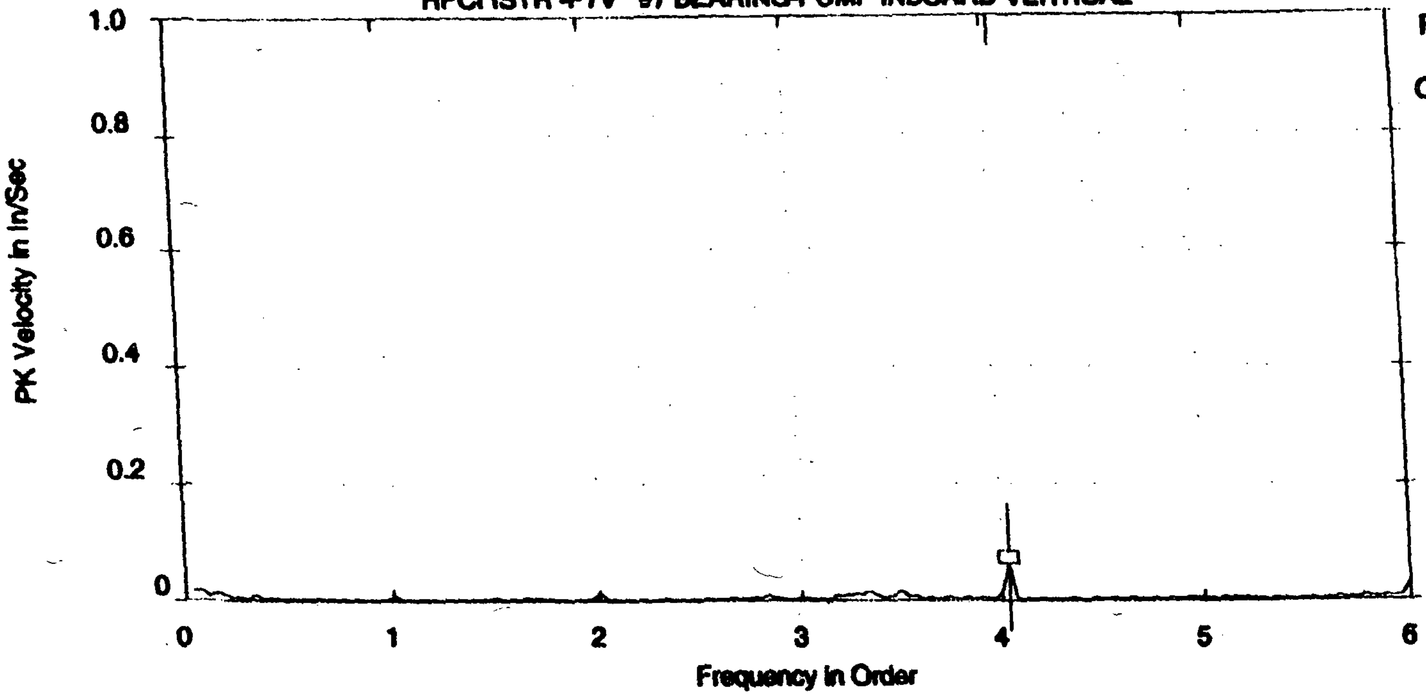
ROUTE SPECTRUM
25-MAY-94 09:33:50
OVRALL= .3657 V-DG
PK = .6181
LOAD =4250.0
RPM = 2029.
RPS = 33.81



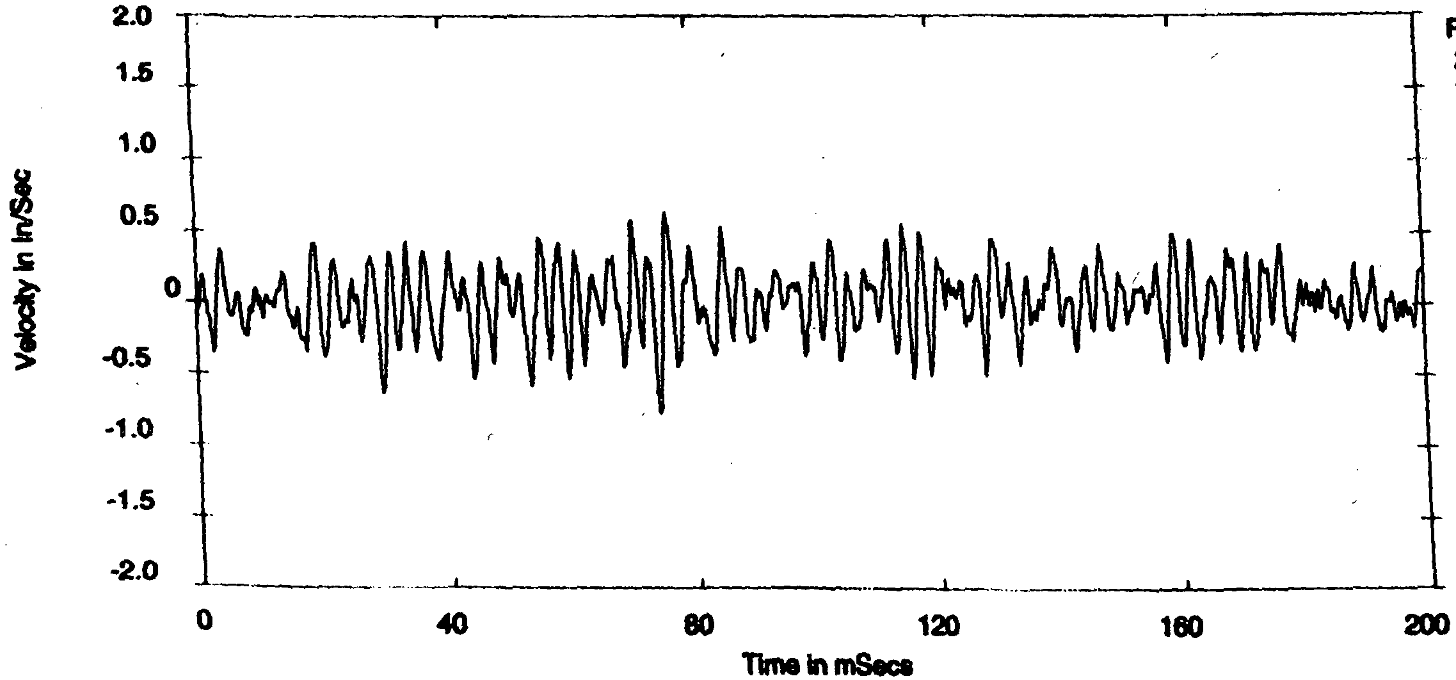
WAVEFORM DISPLAY
25-MAY-94 09:33:50
PK = .6344
PK(+) = 1.20
PK(-) = 1.13
CRESTF= 2.74

Ordr: 4.033
Freq: 136.36
Spec: .198

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P7V #7 BEARING-PUMP INBOARD VERTICAL



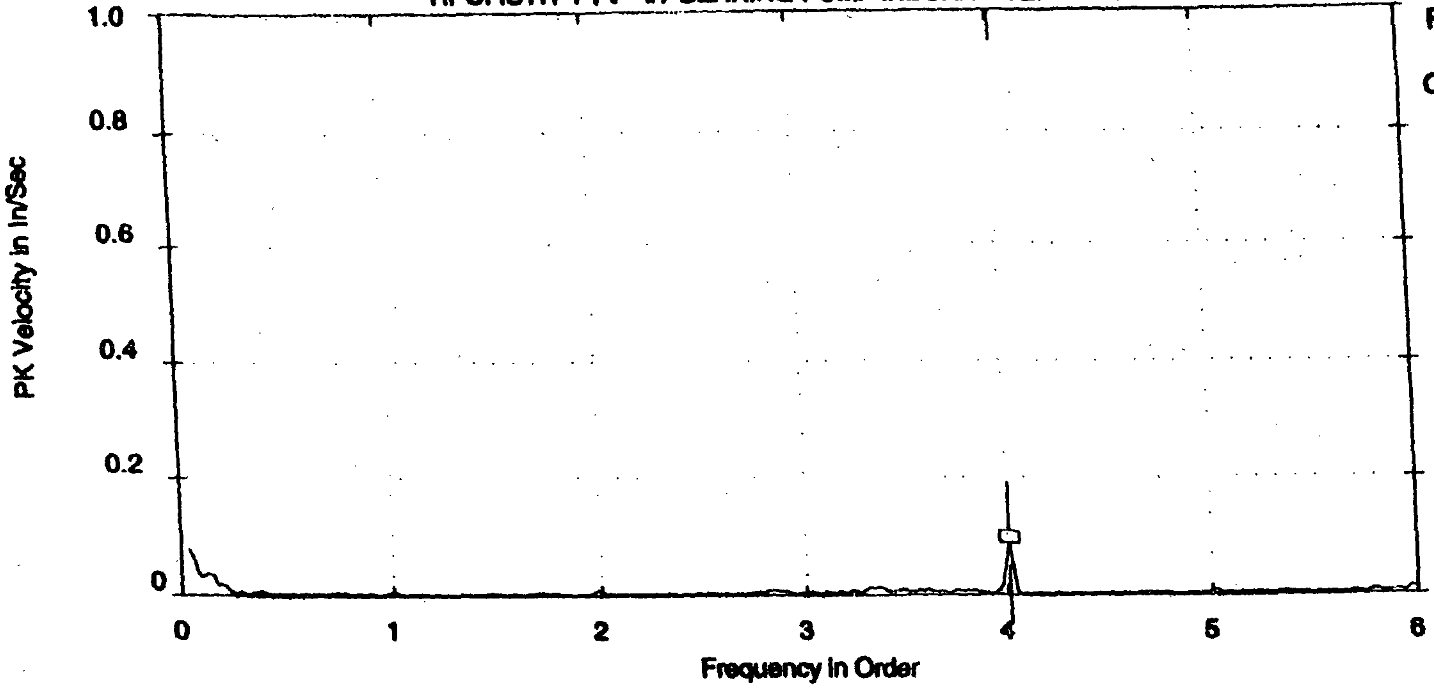
ROUTE SPECTRUM
24-NOV-04 00:48:16
OVRALL= .3021 V-DG
PK = .1053
LOAD =4250.0
RPM = 2007.
RPS = 33.45



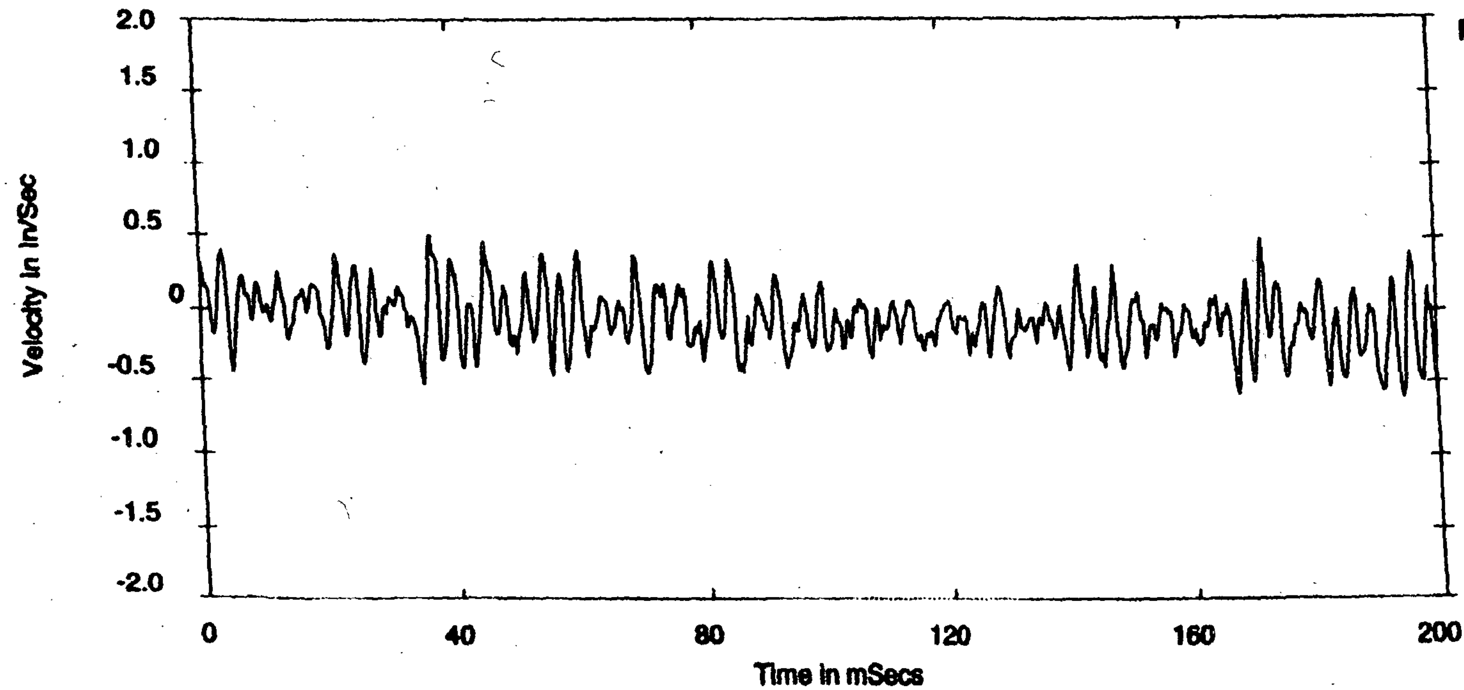
ROUTE WAVEFORM
24-NOV-04 00:48:16
PK = .3217
PK(+) = .6252
PK(-) = .7945
CRESTF= 3.49

Ordr: 4.033
Freq: 134.90
Spec: .06539

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P7V #7 BEARING-PUMP INBOARD VERTICAL

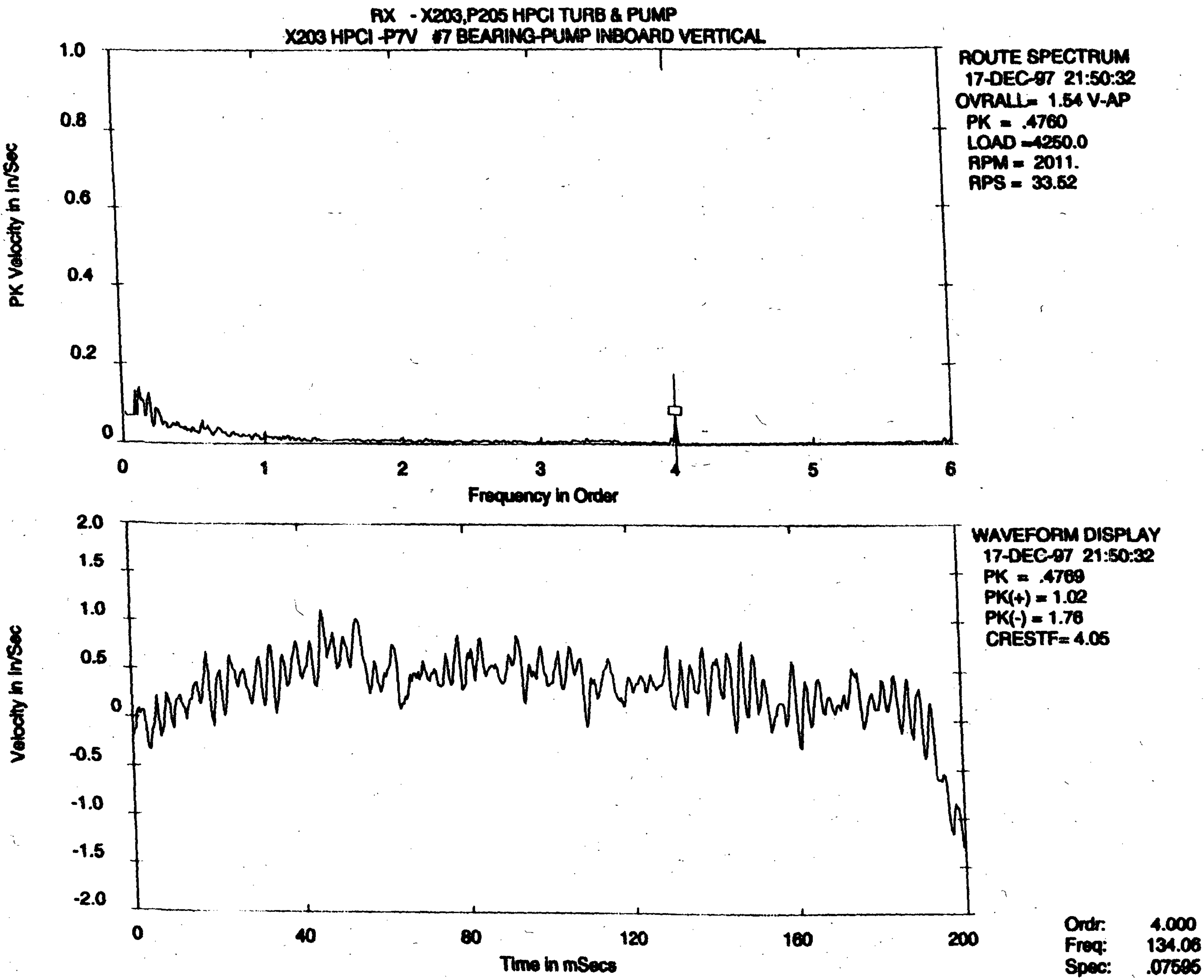


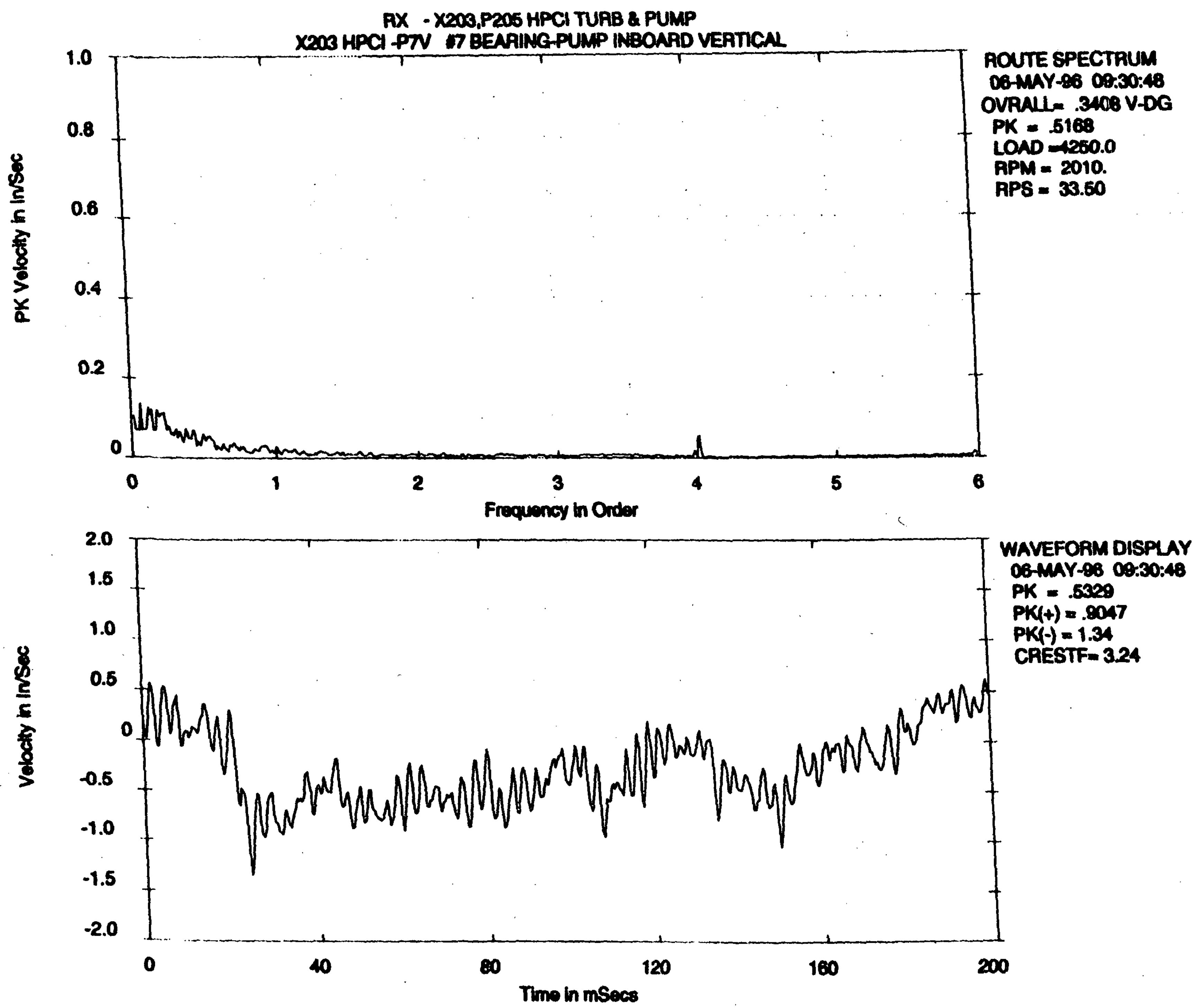
ROUTE SPECTRUM
24-AUG-04 20:52:14
OVRALL= .2490 V-DG
PK = .1579
LOAD =4250.0
RPM = 2000.
RPS = 33.33

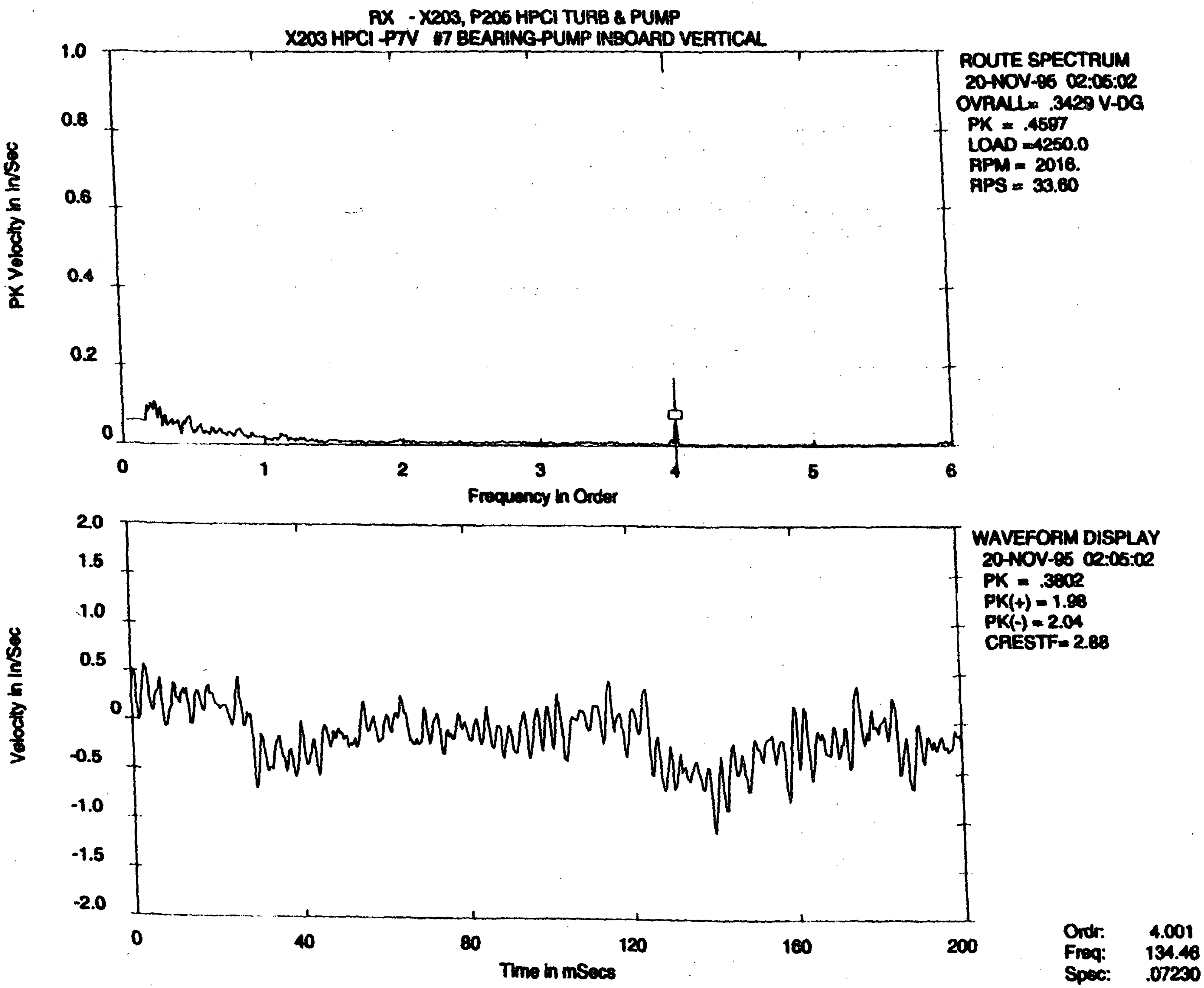


ROUTE WAVEFORM
24-AUG-04 20:52:14
PK = .2830
PK(+) = .5677
PK(-) = .5496
CRESTF= 2.84

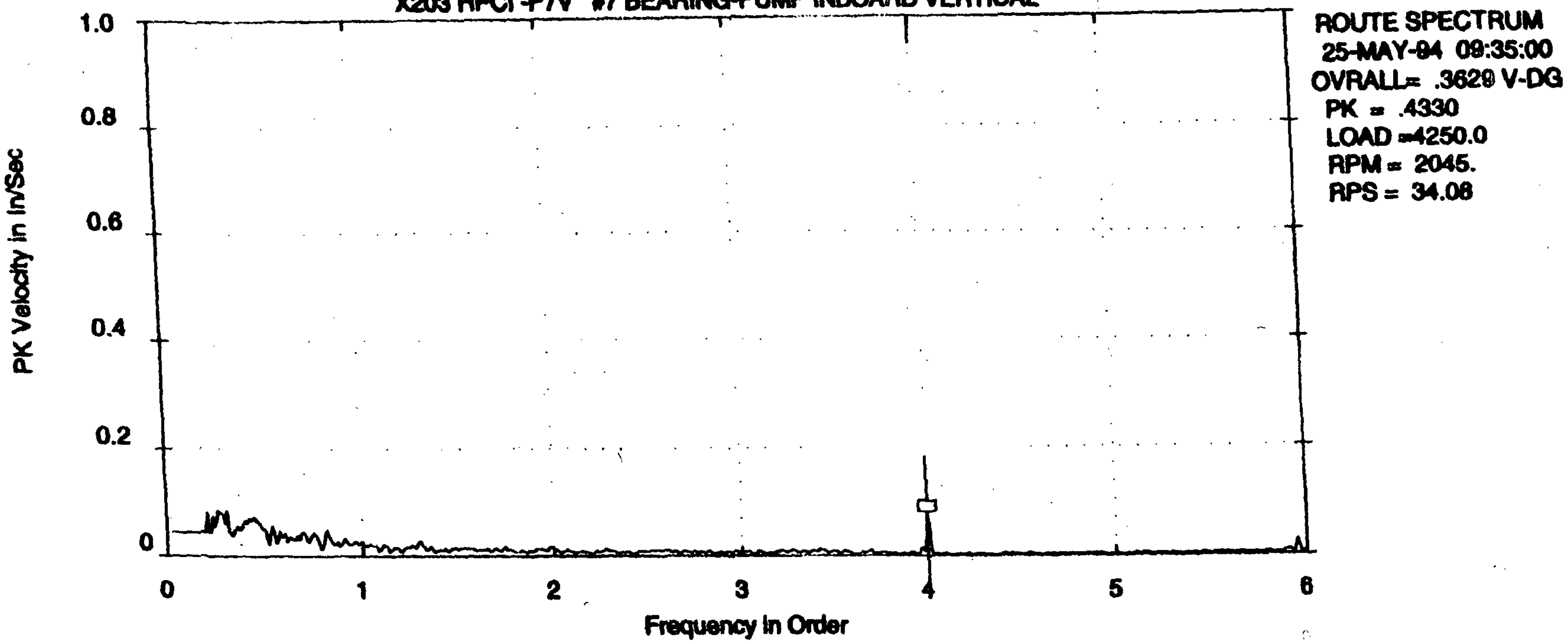
Ordr: 4.010
Freq: 133.67
Spec: .08995

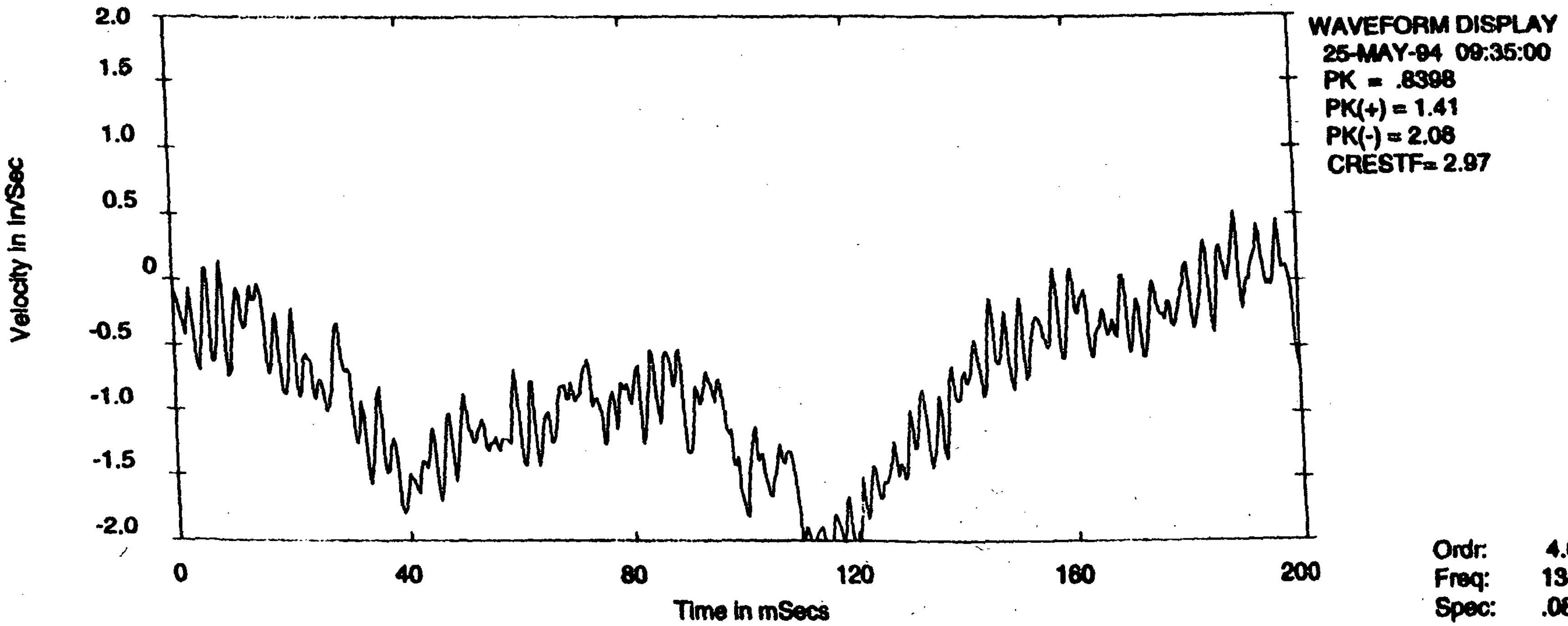

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P7V #7 BEARING-PUMP INBOARD VERTICAL
ROUTE SPECTRUM
17-DEC-97 21:50:32
OVRALL= 1.54 V-AP
PK = .4760
LOAD =4250.0
RPM = 2011.
RPS = 33.52
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
17-DEC-97 21:50:32
PK = .4769
PK(+) = 1.02
PK(-) = 1.76
CRESTF= 4.05
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.000
Freq: 134.06
Spec: .07595


RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P7V #7 BEARING-PUMP INBOARD VERTICAL
ROUTE SPECTRUM
06-MAY-96 09:30:48
OVRALL= .3408 V-DG
PK = .5168
LOAD =4250.0
RPM = 2010.
RPS = 33.50
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
06-MAY-96 09:30:48
PK = .5329
PK(+) = .9047
PK(-) = 1.34
CRESTF= 3.24
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs

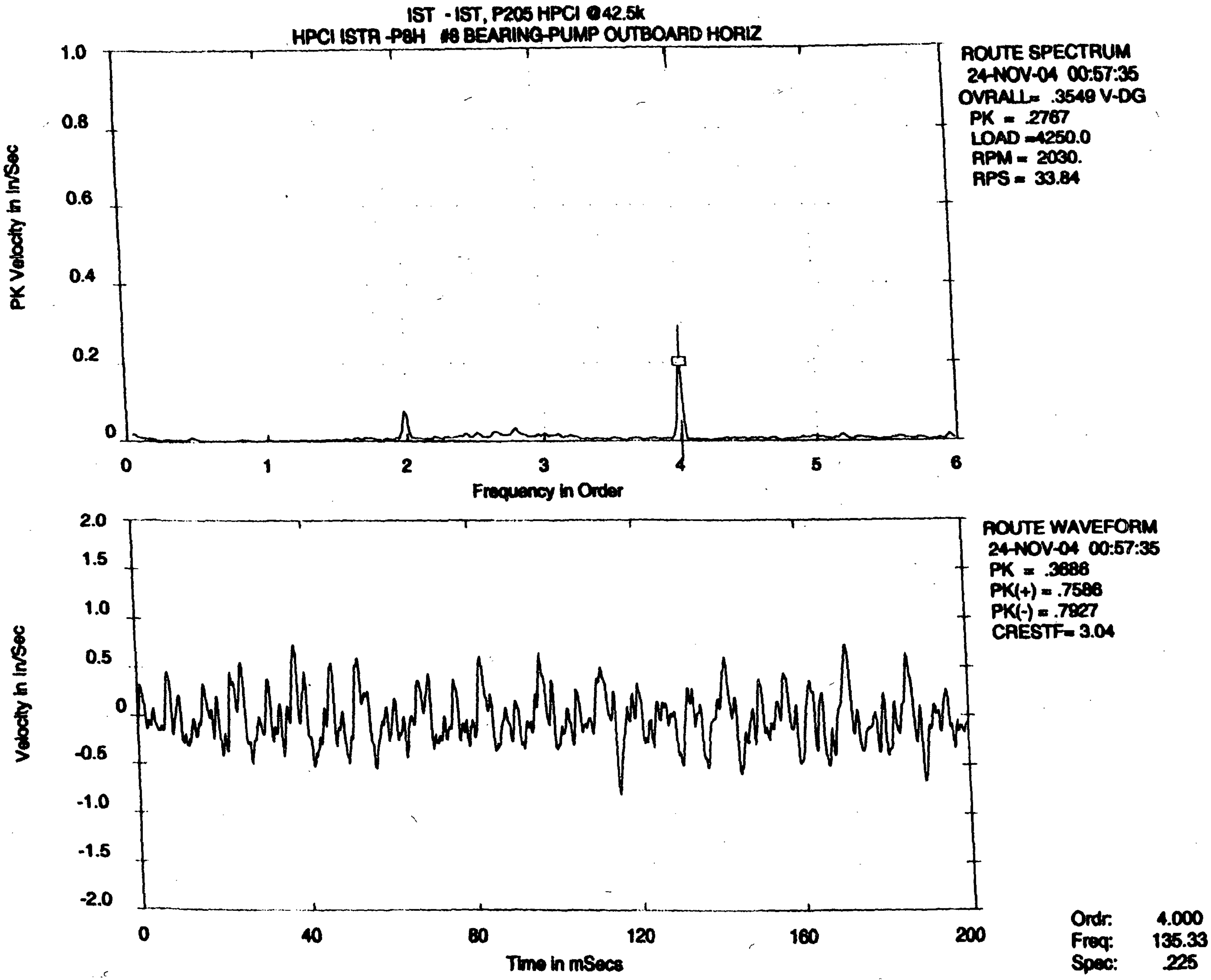

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P7V #7 BEARING-PUMP INBOARD VERTICAL
ROUTE SPECTRUM
20-NOV-95 02:05:02
OVRALL= .3429 V-DG
PK = .4597
LOAD =4250.0
RPM = 2016.
RPS = 33.60
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
20-NOV-95 02:05:02
PK = .3802
PK(+) = 1.98
PK(-) = 2.04
CRESTF= 2.88
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.001
Freq: 134.46
Spec: .07230

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P7V #7 BEARING-PUMP INBOARD VERTICAL

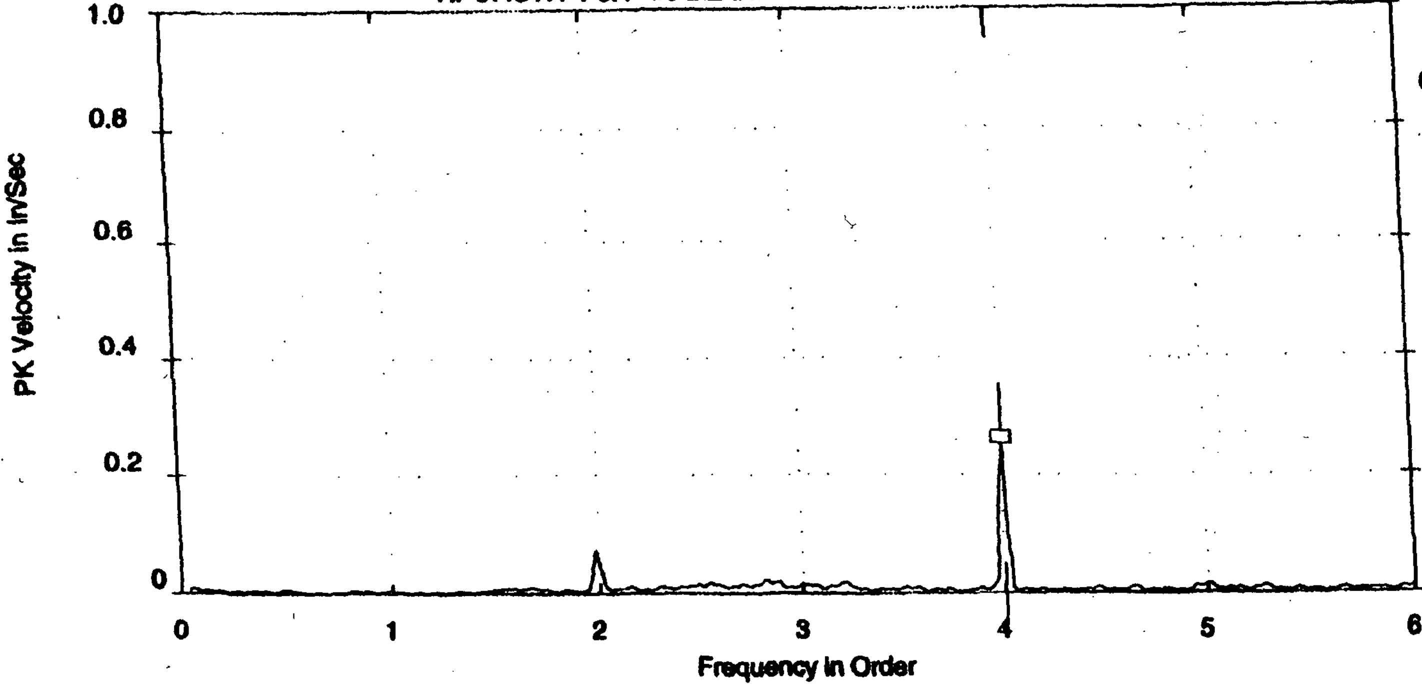




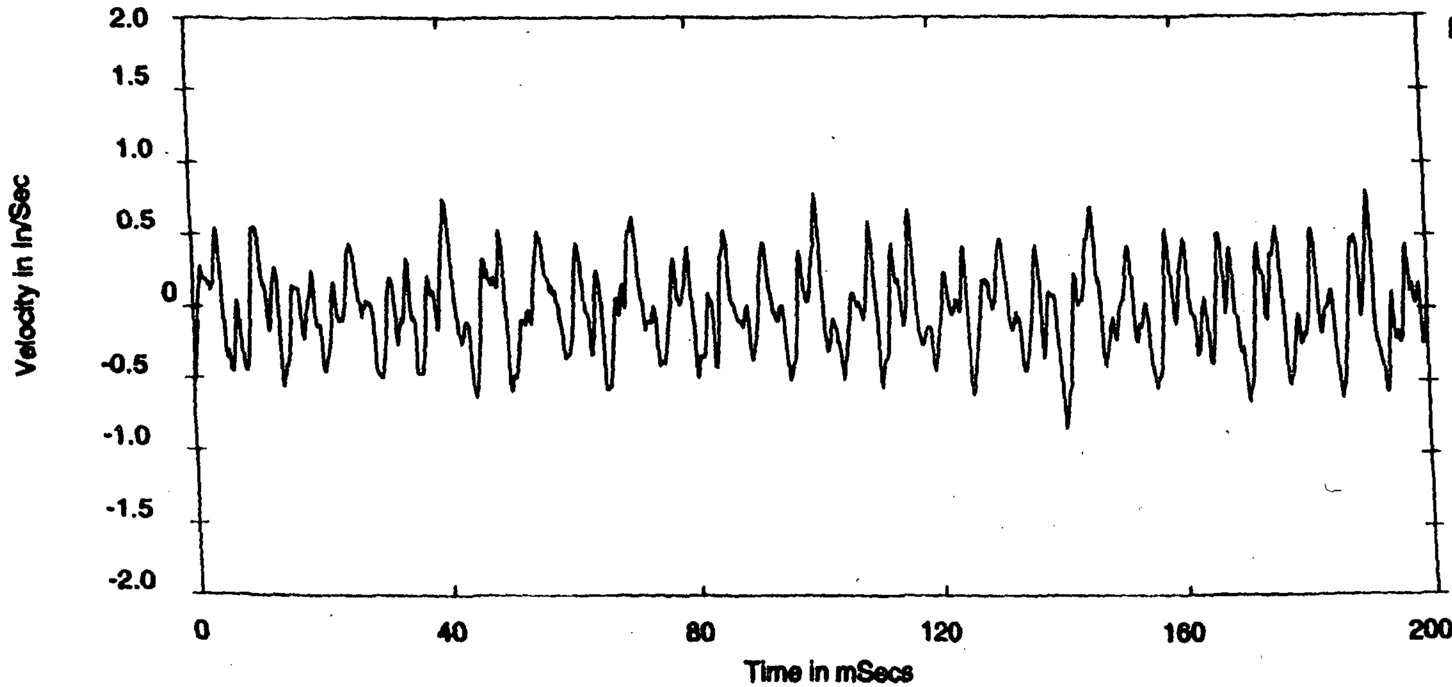
Ordr: 4.000
Freq: 136.34
Spec: .08568


IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8H #8 BEARING-PUMP OUTBOARD HORIZ
ROUTE SPECTRUM
24-NOV-04 00:57:35
OVRALL= .3549 V-DG
PK = .2767
LOAD =4250.0
RPM = 2030.
RPS = 33.84
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
ROUTE WAVEFORM
24-NOV-04 00:57:35
PK = .3688
PK(+) = .7586
PK(-) = .7927
CRESTF= 3.04
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.000
Freq: 135.33
Spec: .225

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8H #8 BEARING-PUMP OUTBOARD HORIZ

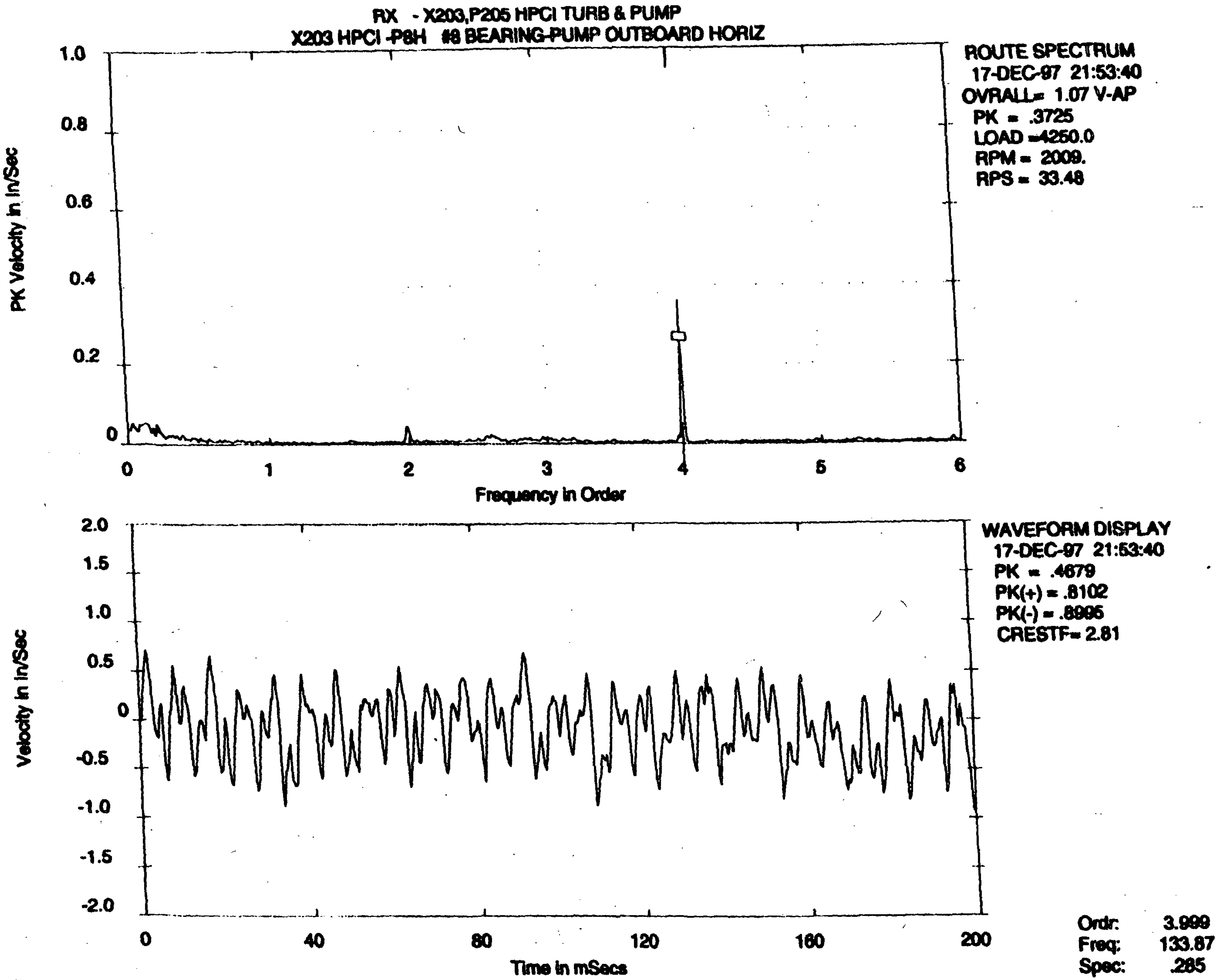


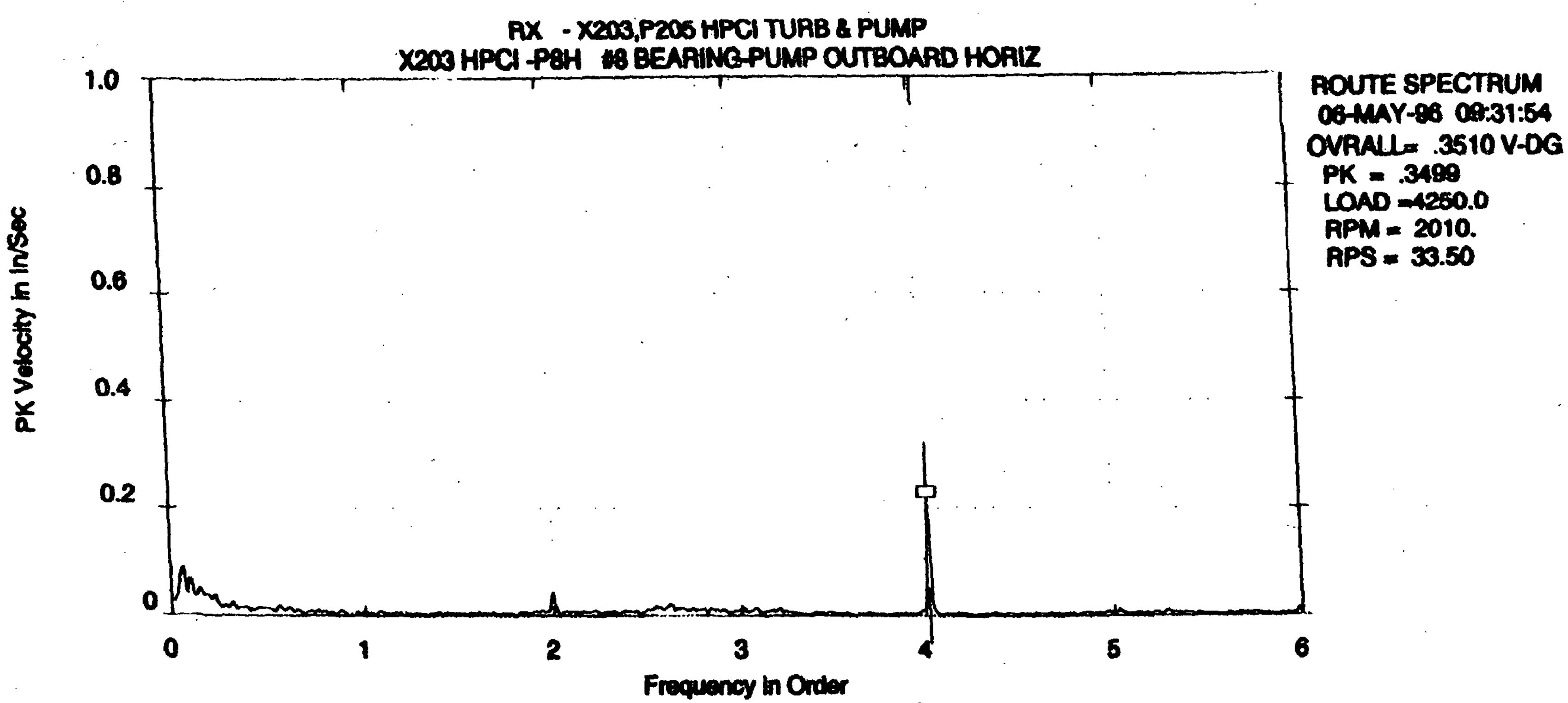
ROUTE SPECTRUM
24-AUG-04 20:52:44
OVRALL= .4133 V-DG
PK = .3018
LOAD =4250.0
RPM = 2004.
RPS = 33.40

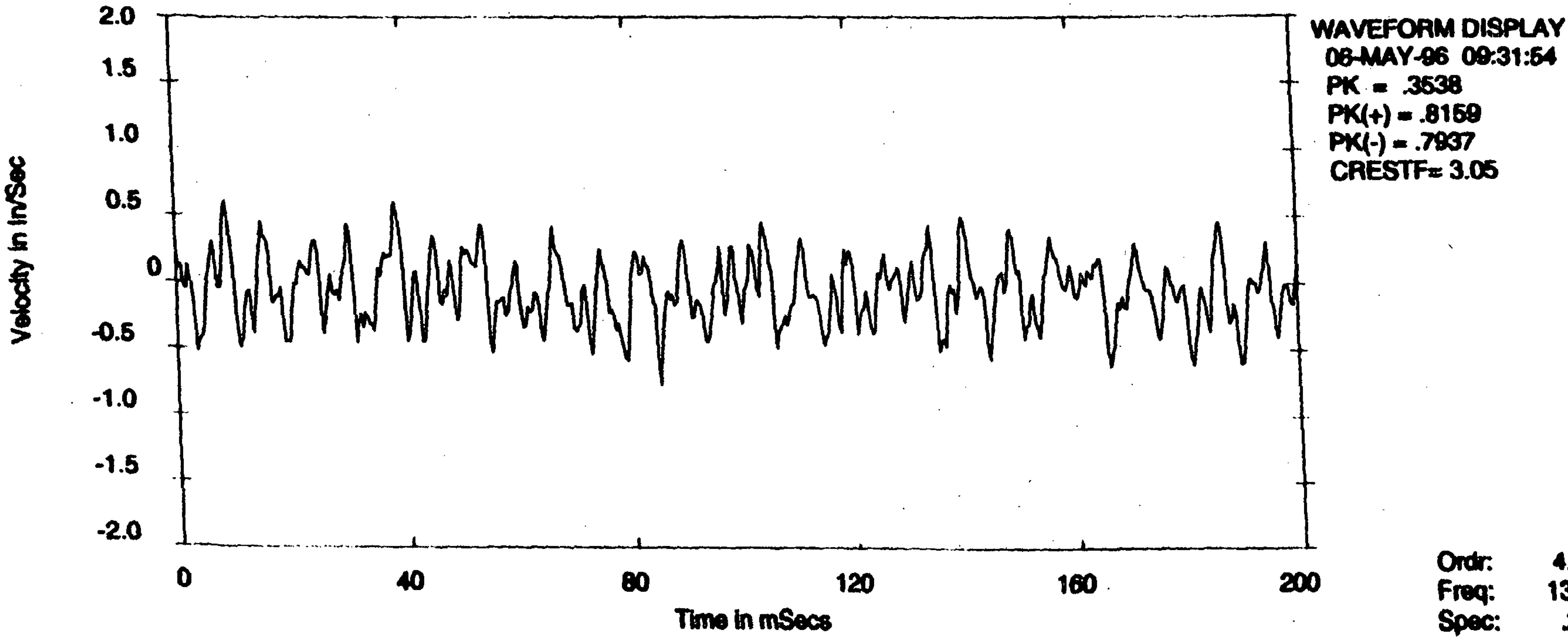


ROUTE WAVEFORM
24-AUG-04 20:52:44
PK = .4196
PK(+) = .8194
PK(-) = .8356
CRESTF= 2.82

Ordr:	3.999
Freq:	133.58
Spec:	.266

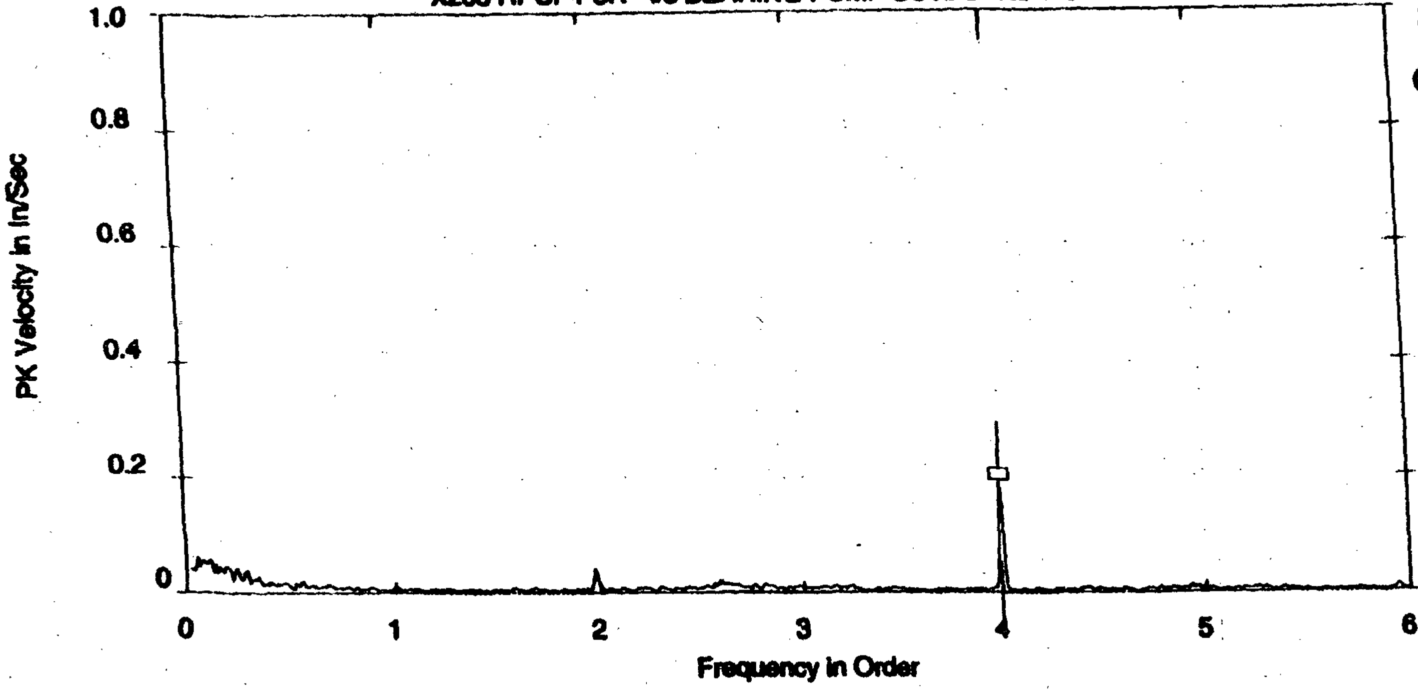

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P8H #8 BEARING-PUMP OUTBOARD HORIZ
ROUTE SPECTRUM
17-DEC-97 21:53:40
OVRALL= 1.07 V-AP
PK = .3725
LOAD =4250.0
RPM = 2009.
RPS = 33.48
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
17-DEC-97 21:53:40
PK = .4679
PK(+) = .8102
PK(-) = .8995
CRESTF= 2.81
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 3.999
Freq: 133.87
Spec: .285



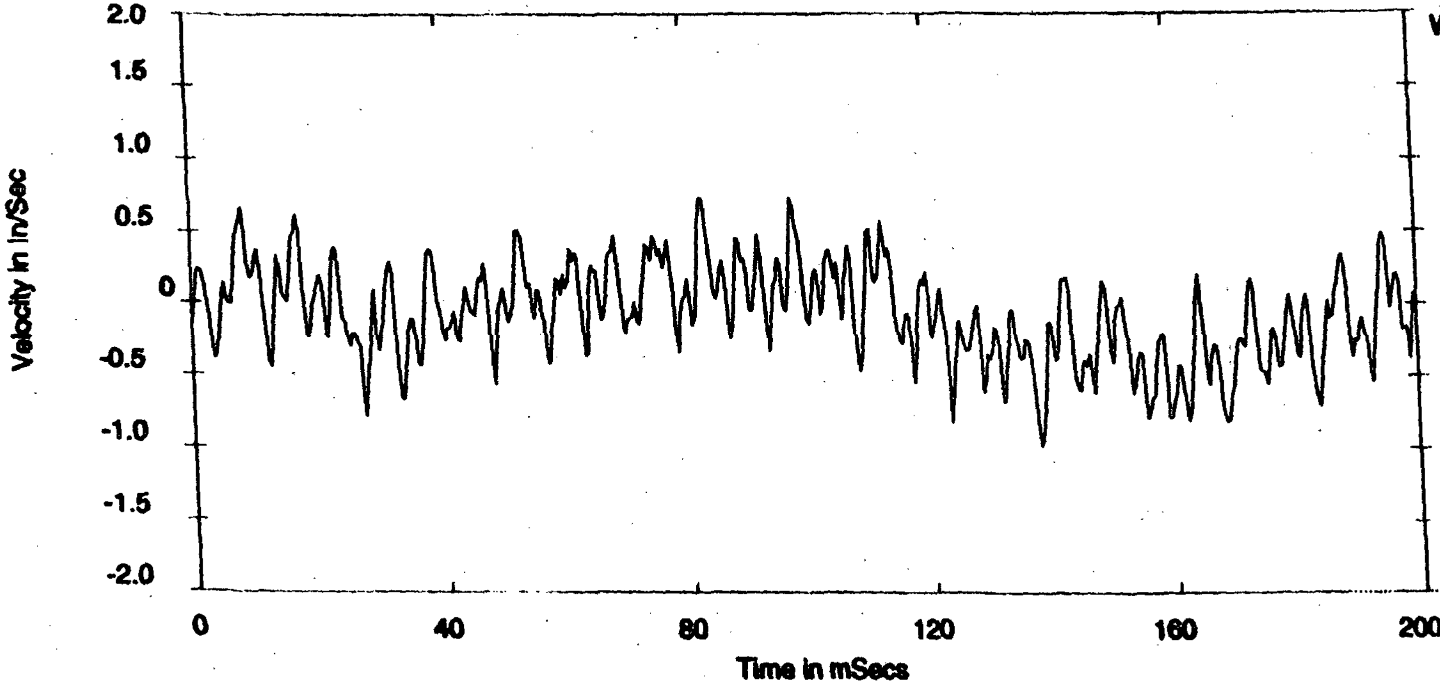


Ordr: 4.023
Freq: 134.78
Spec: .234

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P8H #8 BEARING-PUMP OUTBOARD HORIZ



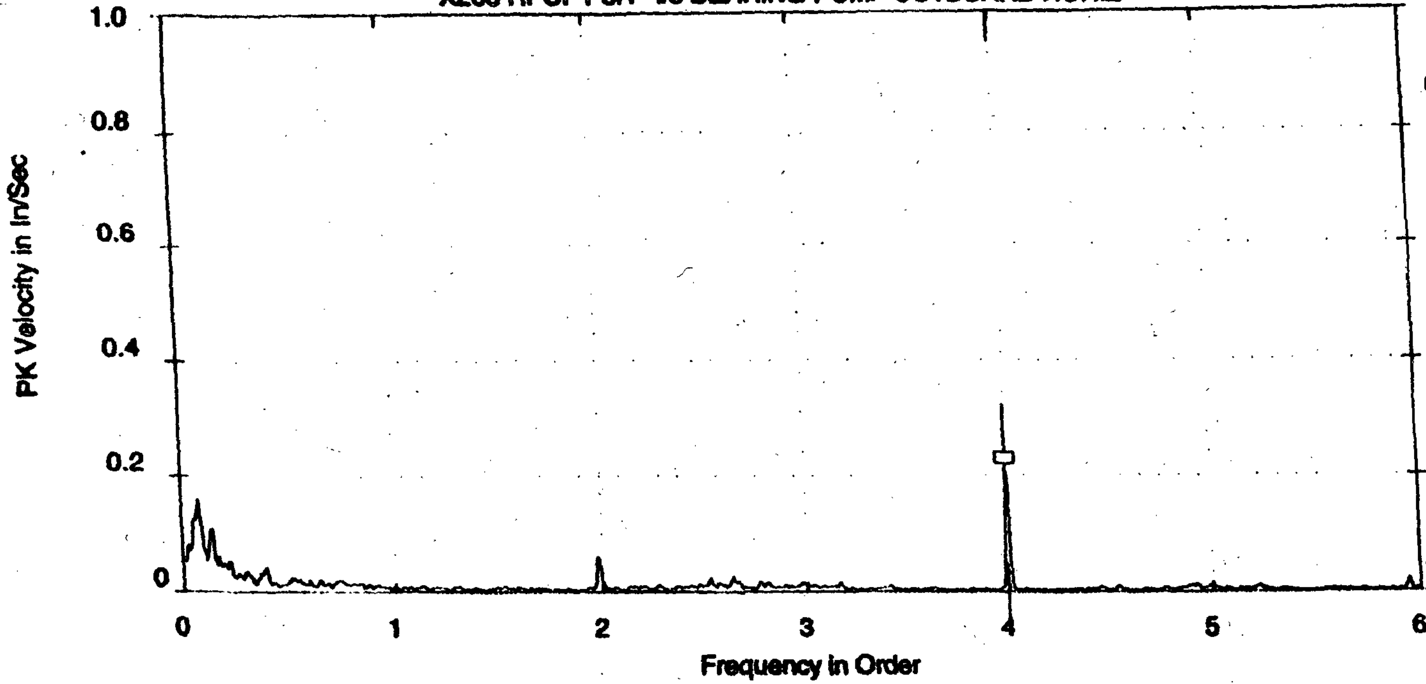
ROUTE SPECTRUM
20-NOV-95 02:08:21
OVRALL= .3581 V-DG
PK = .3339
LOAD =4250.0
RPM = 2018.
RPS = 33.63



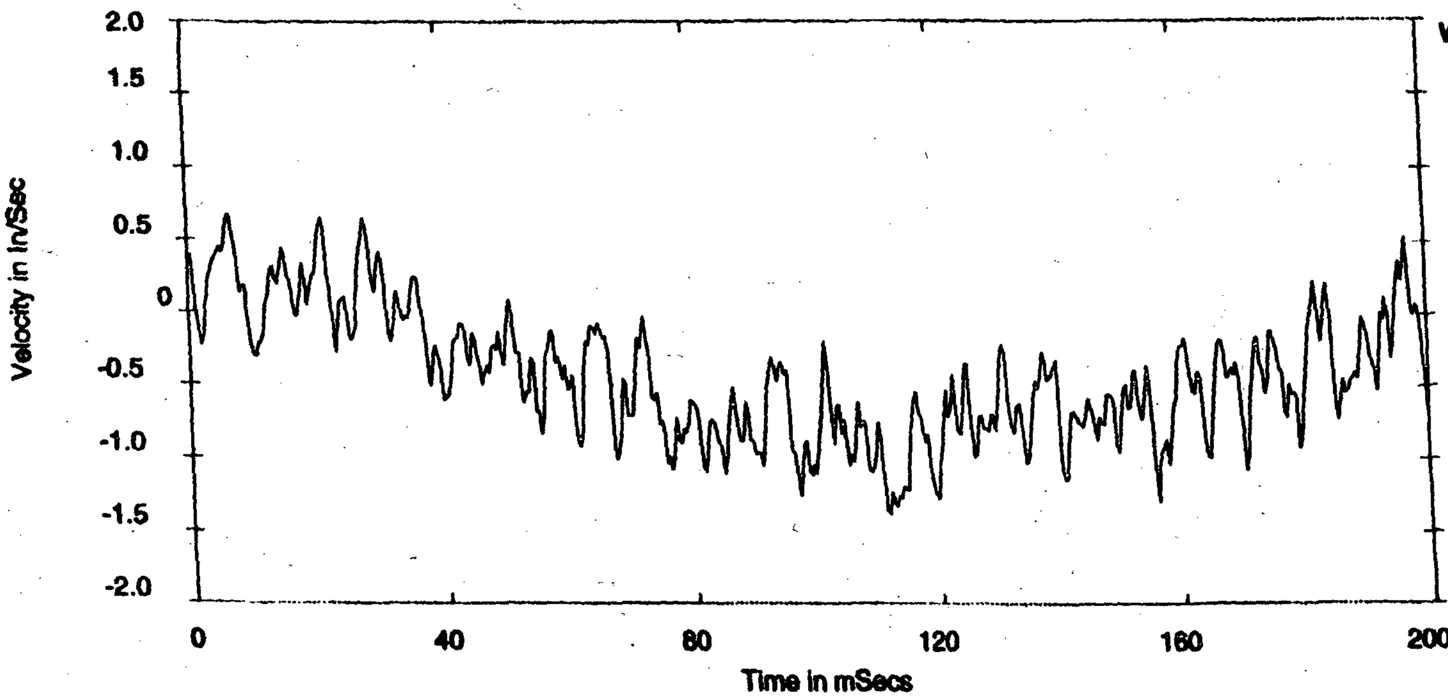
WAVEFORM DISPLAY
20-NOV-95 02:08:21
PK = .4641
PK(+) = .8959
PK(-) = .9881
CRESTF= 3.11

Ordr: 3.999
Freq: 134.49
Spec: .210

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P8H #8 BEARING-PUMP OUTBOARD HORIZ



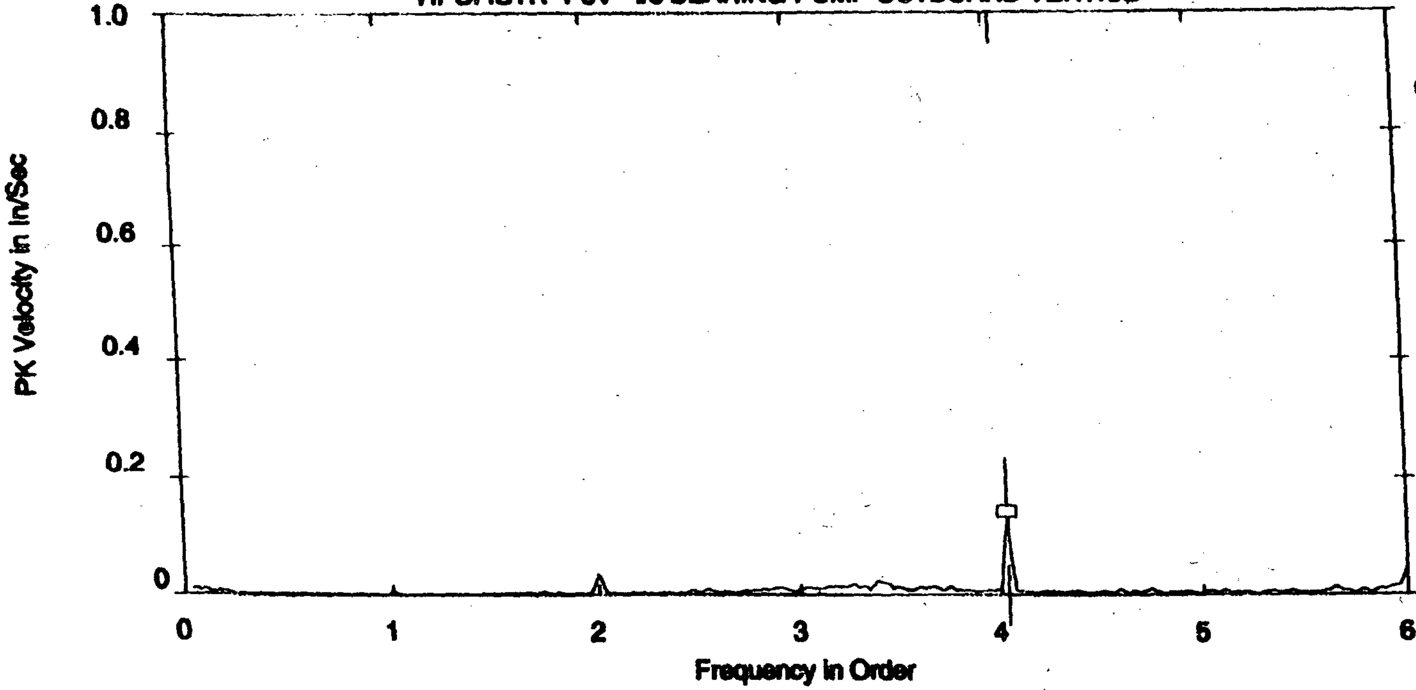
ROUTE SPECTRUM
25-MAY-94 09:36:10
OVRALL= .3571 V-DG
PK = .4744
LOAD =4250.0
RPM = 2046.
RPS = 34.11



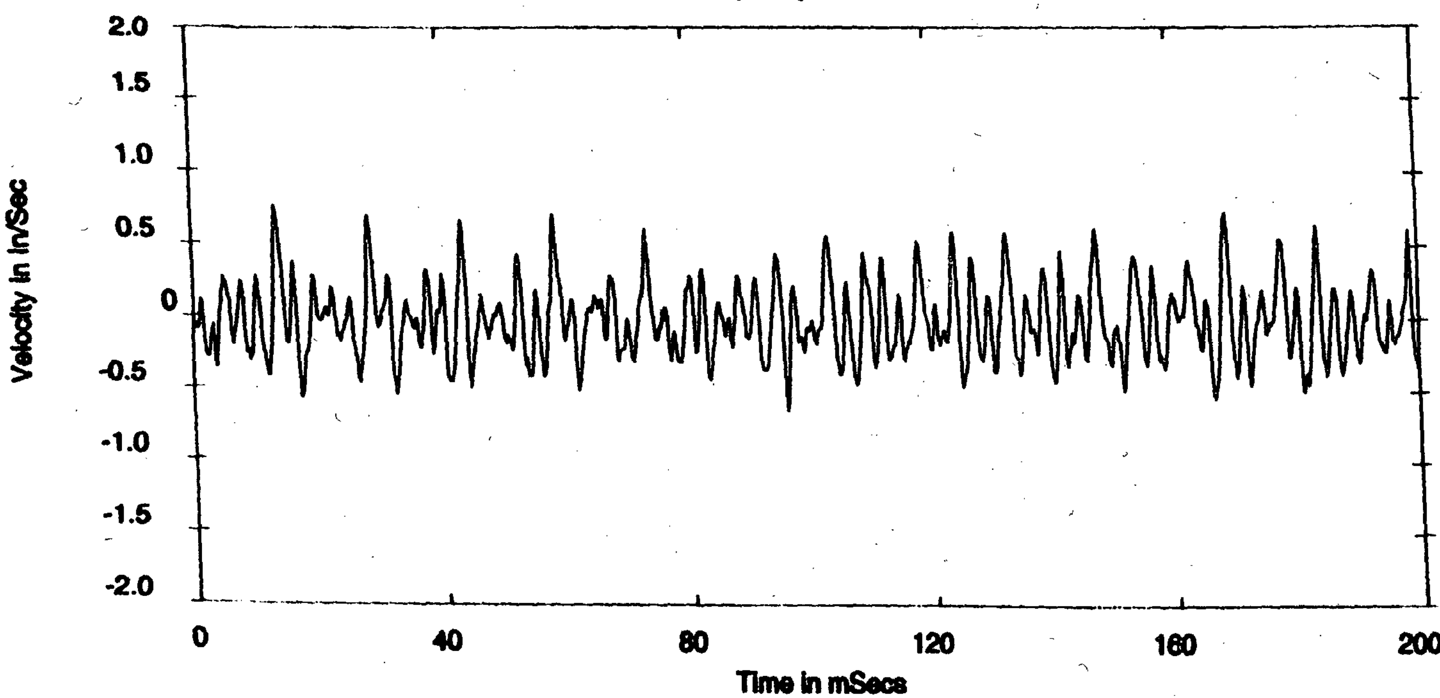
WAVEFORM DISPLAY
25-MAY-94 09:36:10
PK = .6248
PK(+) = .9390
PK(-) = 1.23
CRESTF= 2.71

Ordr: 3.999
Freq: 136.38
Spec: .248

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8V #8 BEARING-PUMP OUTBOARD VERTICL

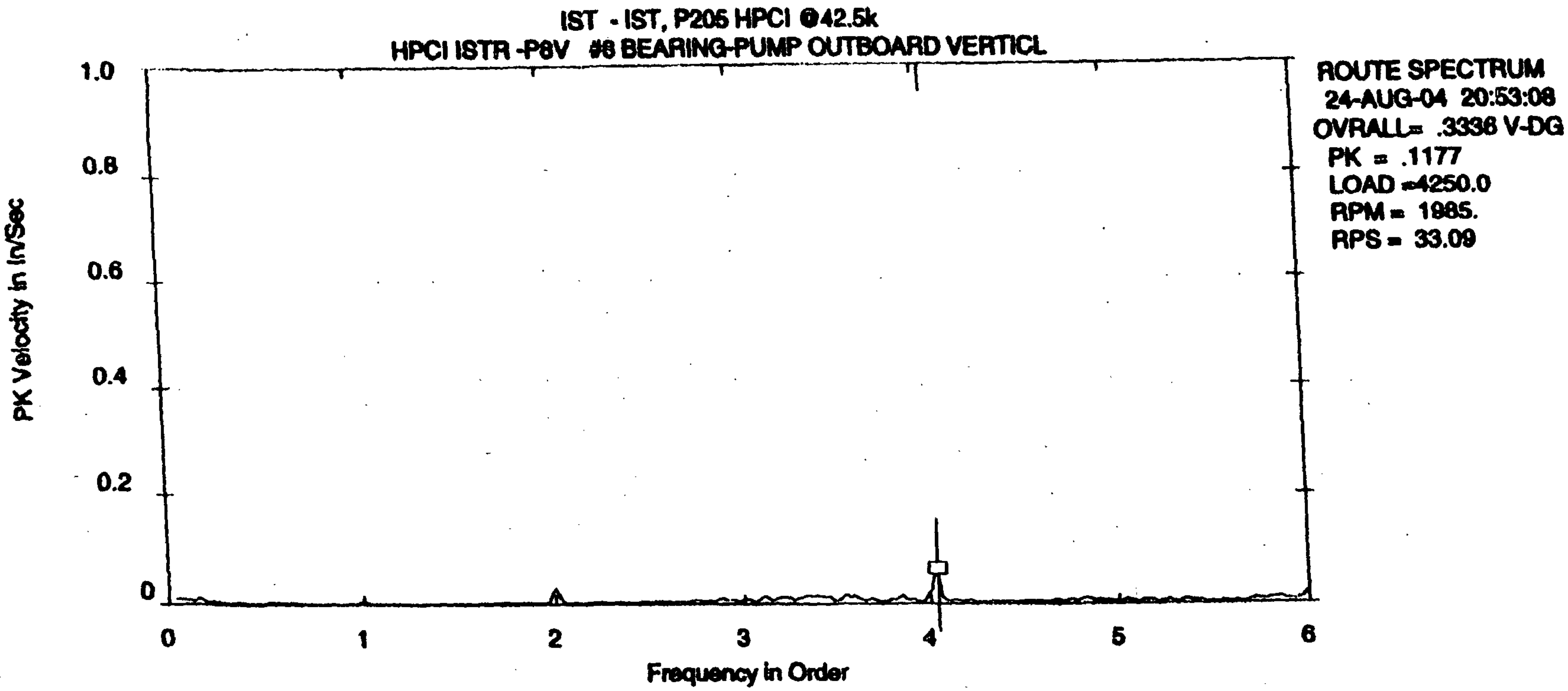


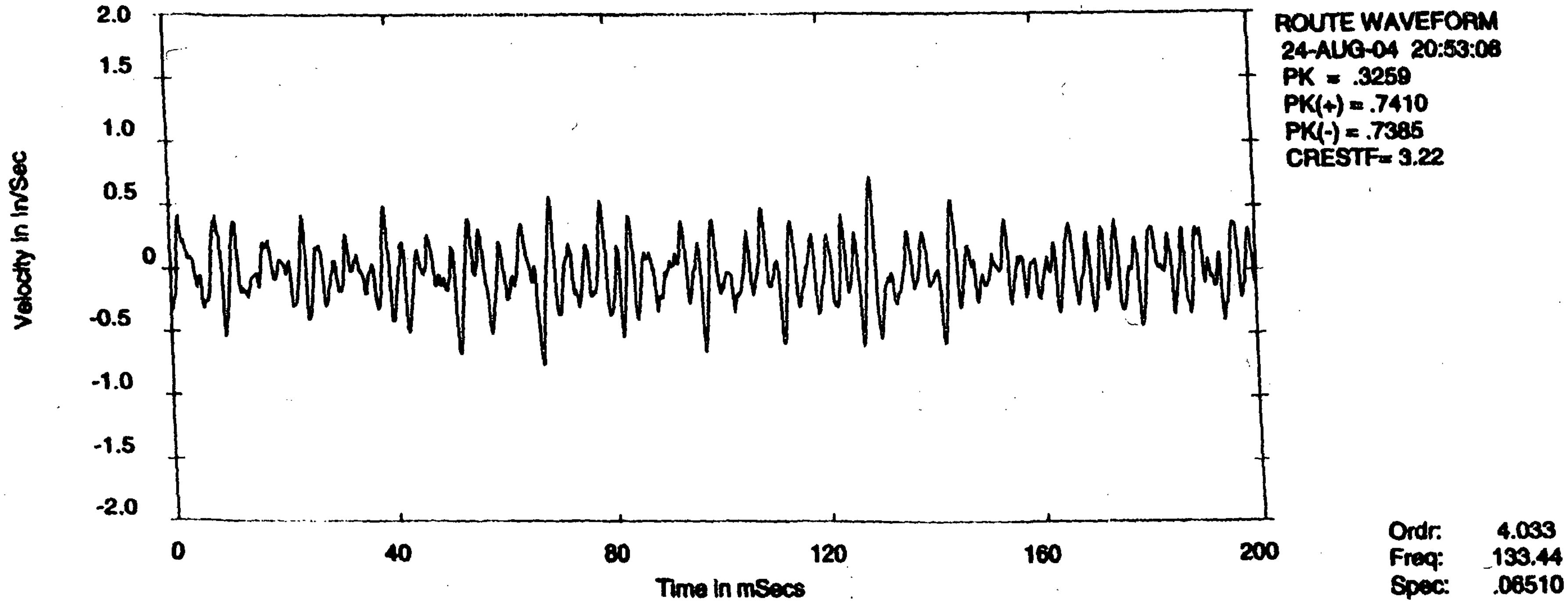
ROUTE SPECTRUM
24-NOV-04 00:50:19
OVRALL= .3576 V-DG
PK = .1753
LOAD =4250.0
RPM = 2007.
RPS = 33.45



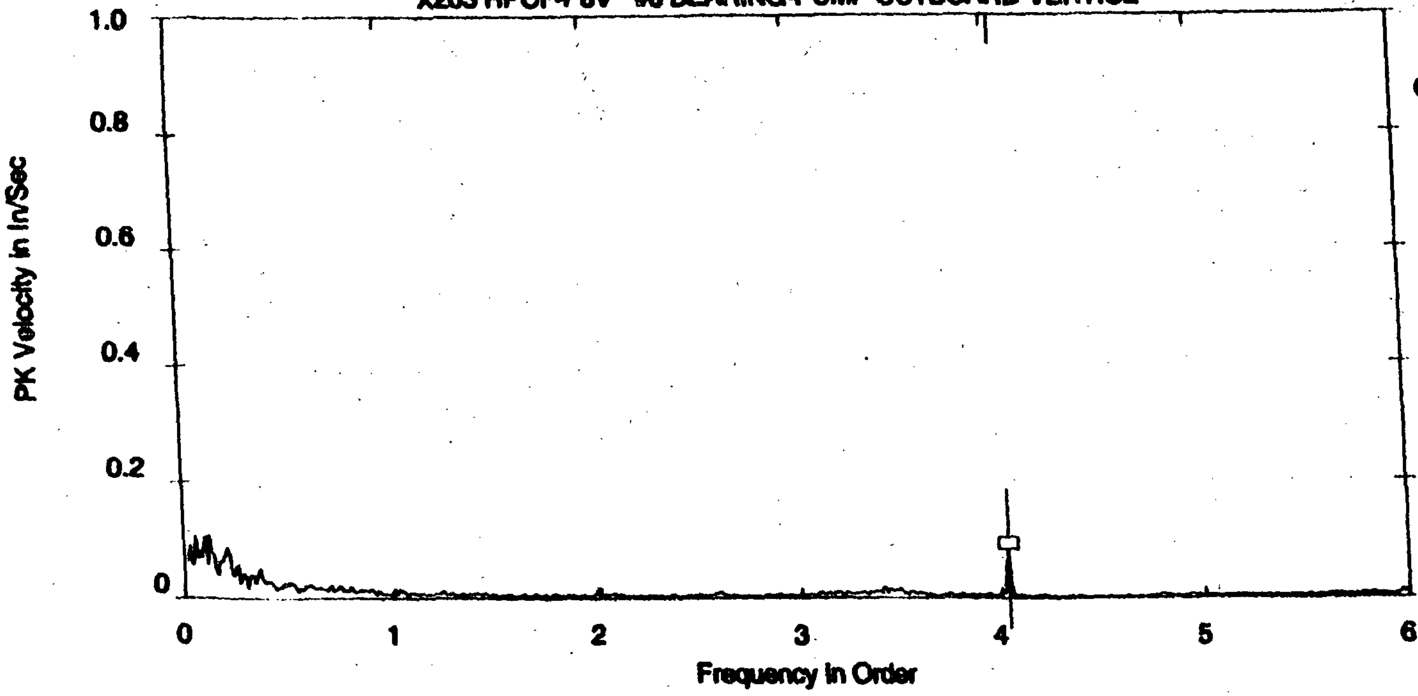
ROUTE WAVEFORM
24-NOV-04 00:50:19
PK = .3635
PK(+) = .7824
PK(-) = .6216
CRESTF= 3.04

Ordr: 4.036
Freq: 135.00
Spec: .133

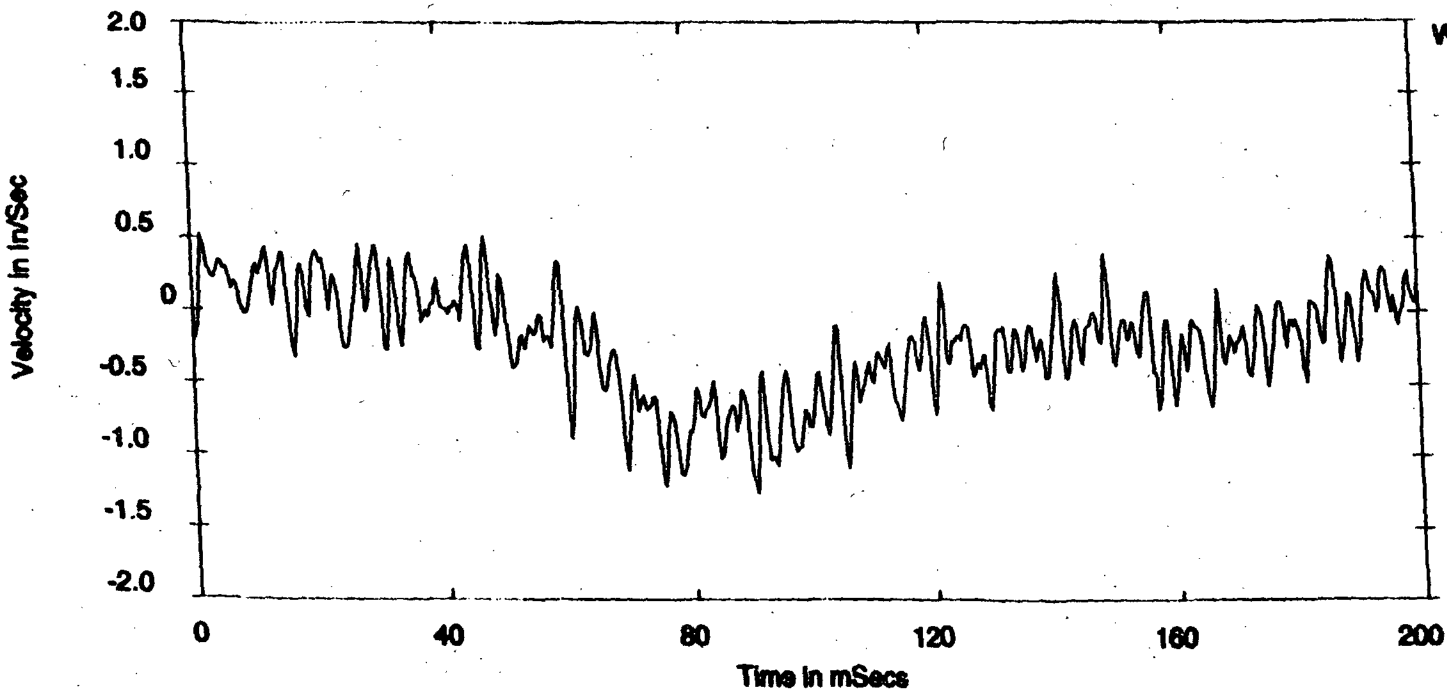

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8V #8 BEARING-PUMP OUTBOARD VERTICL
ROUTE SPECTRUM
24-AUG-04 20:53:08
OVRALL= .3336 V-DG
PK = .1177
LOAD =4250.0
RPM = 1985.
RPS = 33.09
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order


ROUTE WAVEFORM
24-AUG-04 20:53:08
PK = .3259
PK(+) = .7410
PK(-) = .7385
CRESTF= 3.22
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.033
Freq: 133.44
Spec: .08510

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P8V #8 BEARING-PUMP OUTBOARD VERTICL



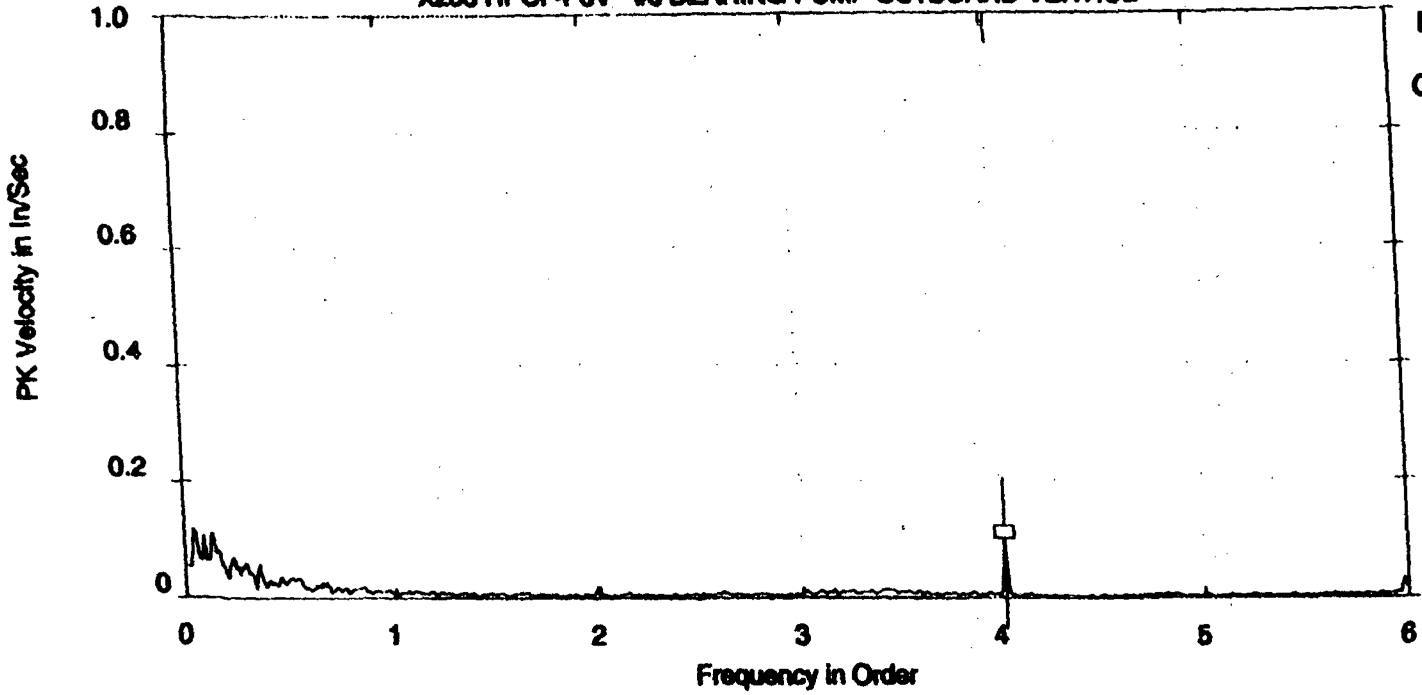
ROUTE SPECTRUM
17-DEC-97 21:54:16
OVRALL= 1.16 V-AP
PK = .3738
LOAD =4250.0
RPM = 1992.
RPS = 33.20



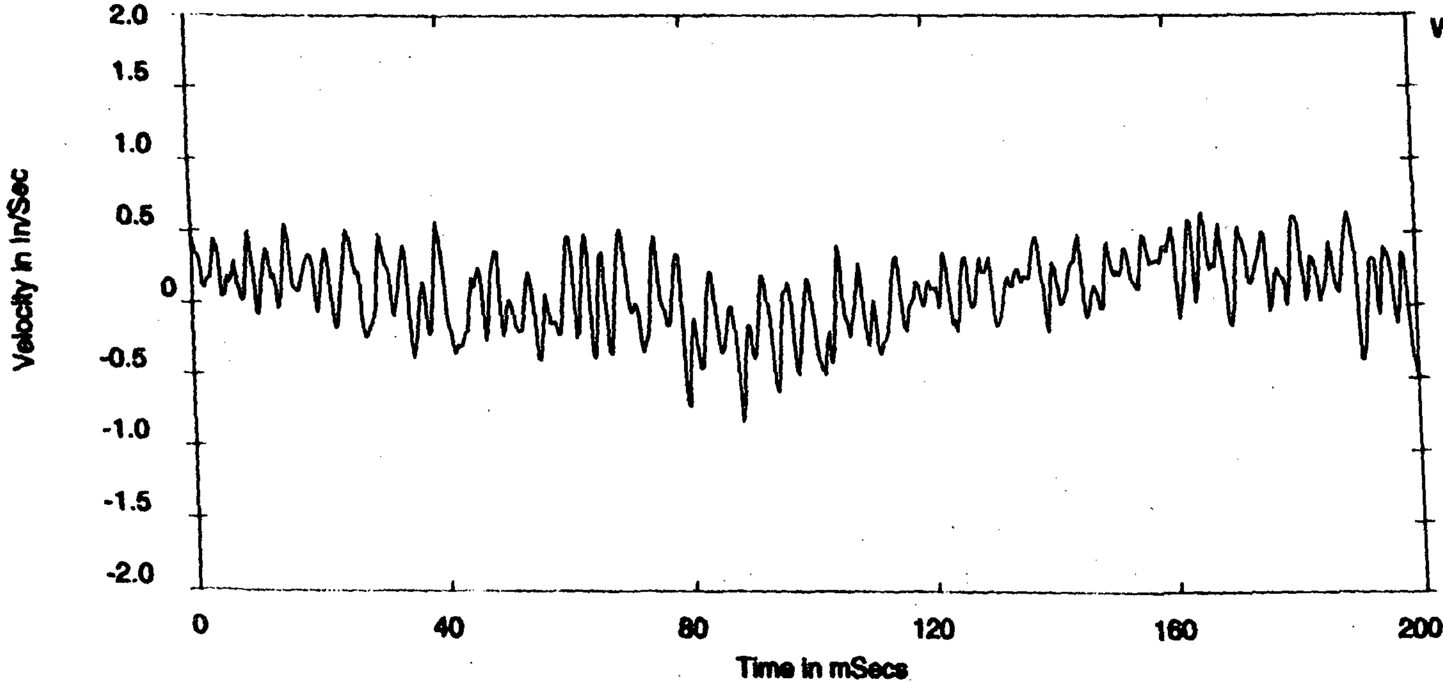
WAVEFORM DISPLAY
17-DEC-97 21:54:16
PK = .5256
PK(+) = .7513
PK(-) = 1.03
CRESTF= 3.02

Ordr: 4.038
Freq: 134.06
Spec: .08389

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P8V #8 BEARING-PUMP OUTBOARD VERTICL



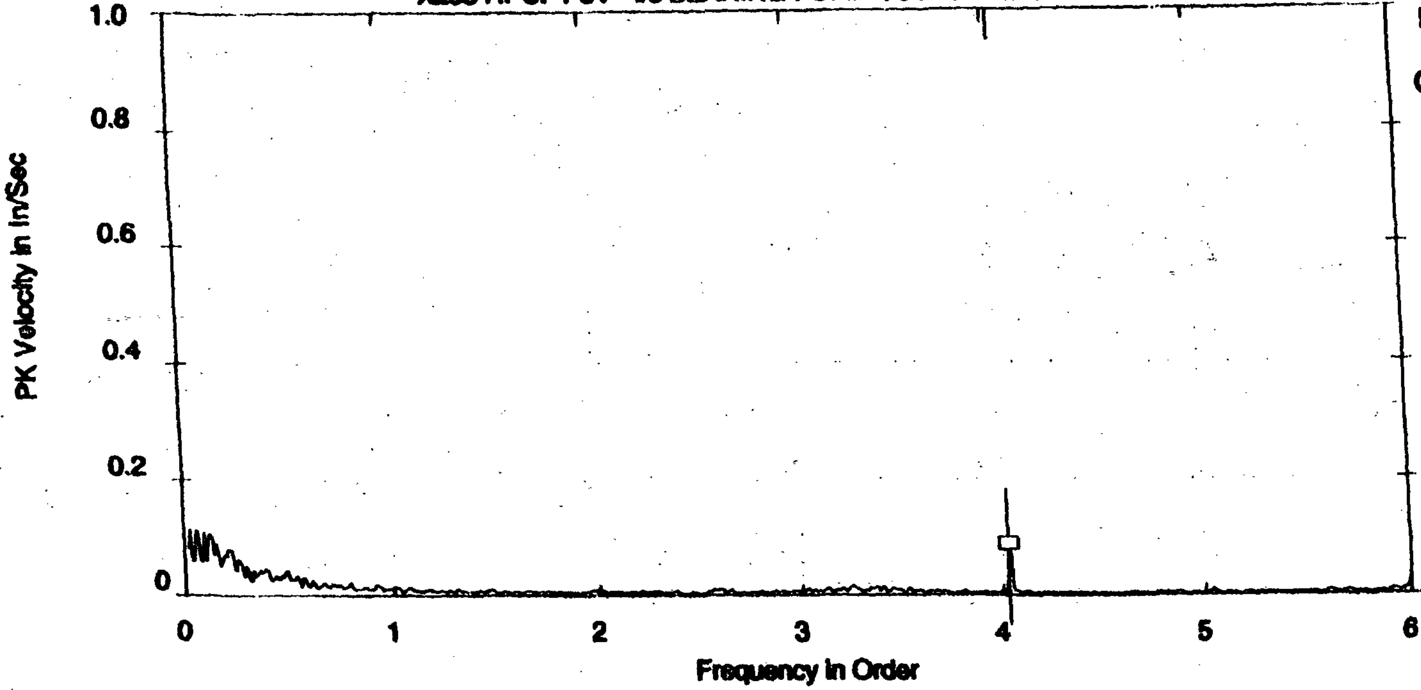
ROUTE SPECTRUM
06-MAY-96 09:32:30
OVRALL= .3159 V-DG
PK = .3983
LOAD =4250.0
RPM = 2010.
RPS = 33.50



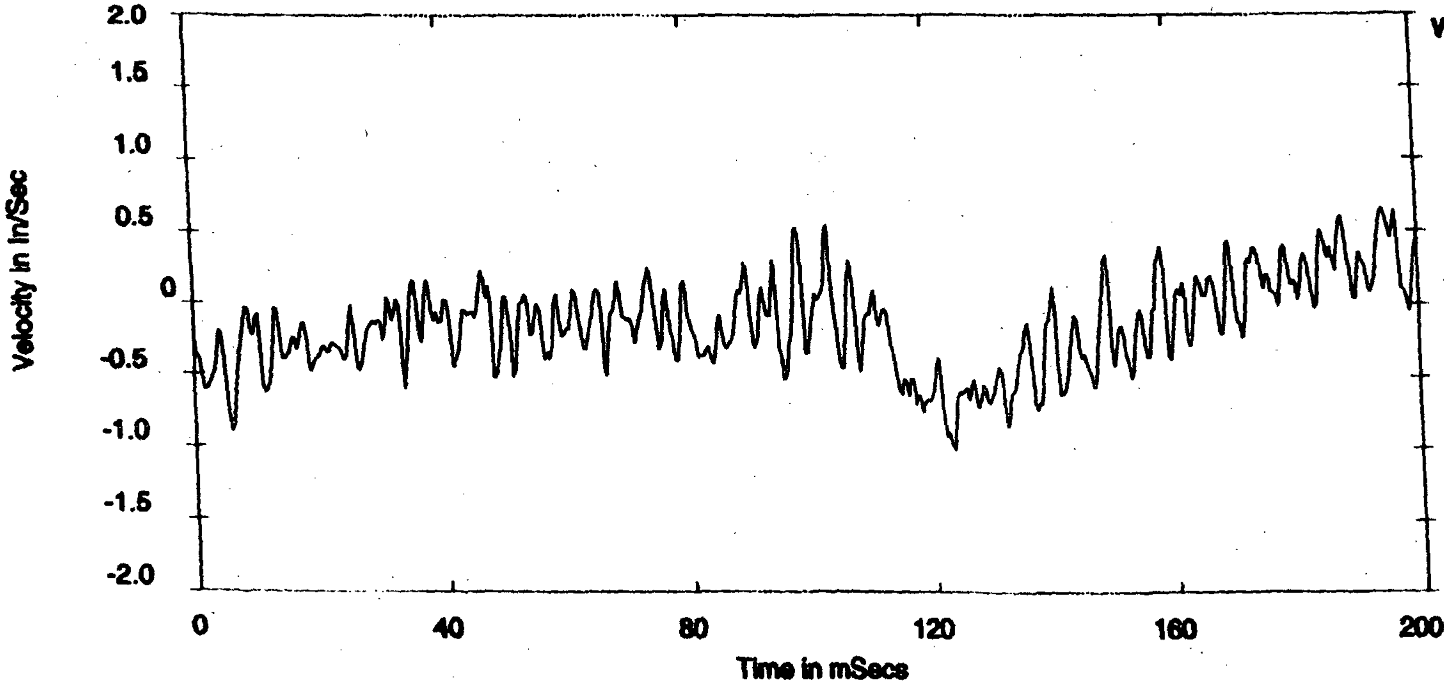
WAVEFORM DISPLAY
06-MAY-96 09:32:30
PK = .3696
PK(+) = .7723
PK(-) = 1.08
CRESTF= 3.44

Ordr: 4.020
Freq: 134.65
Spec: .102

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P8V #8 BEARING-PUMP OUTBOARD VERTICL



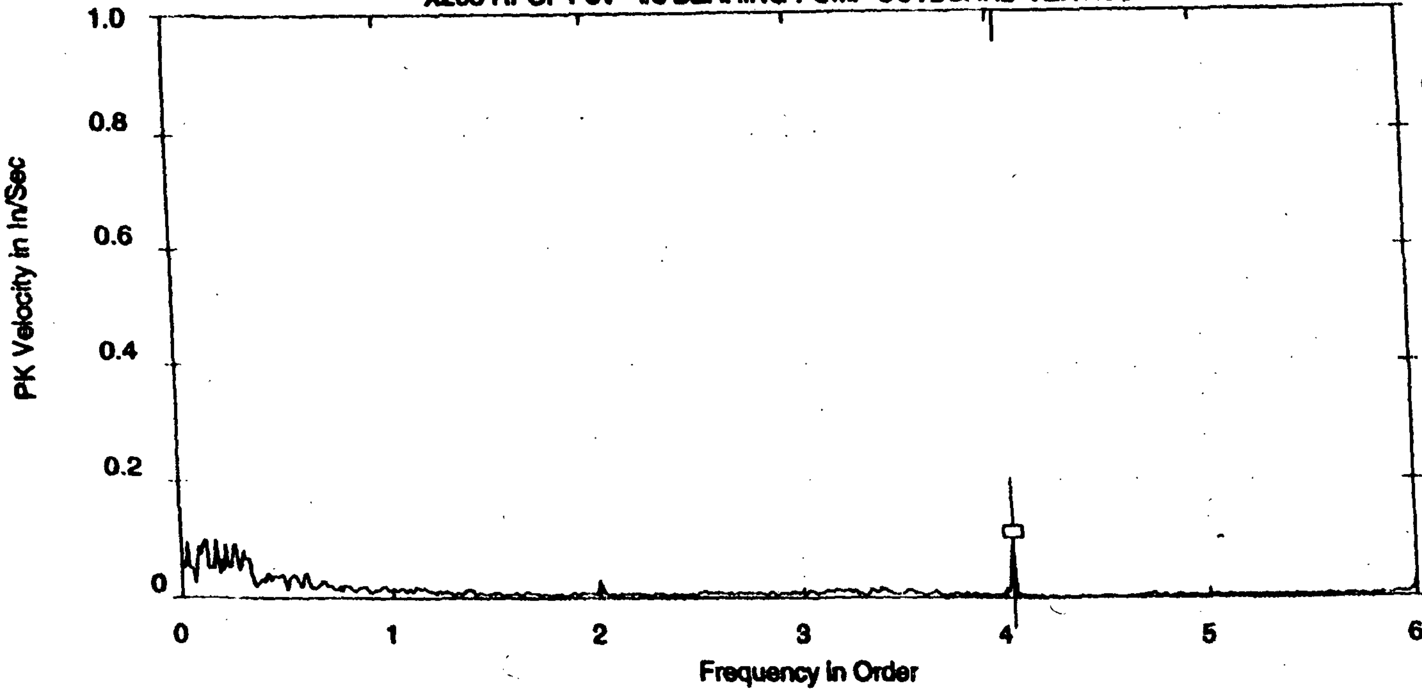
ROUTE SPECTRUM
20-NOV-95 02:06:48
OVRALL= .2974 V-DG
PK = .4175
LOAD =4250.0
RPM = 2001.
RPS = 33.34



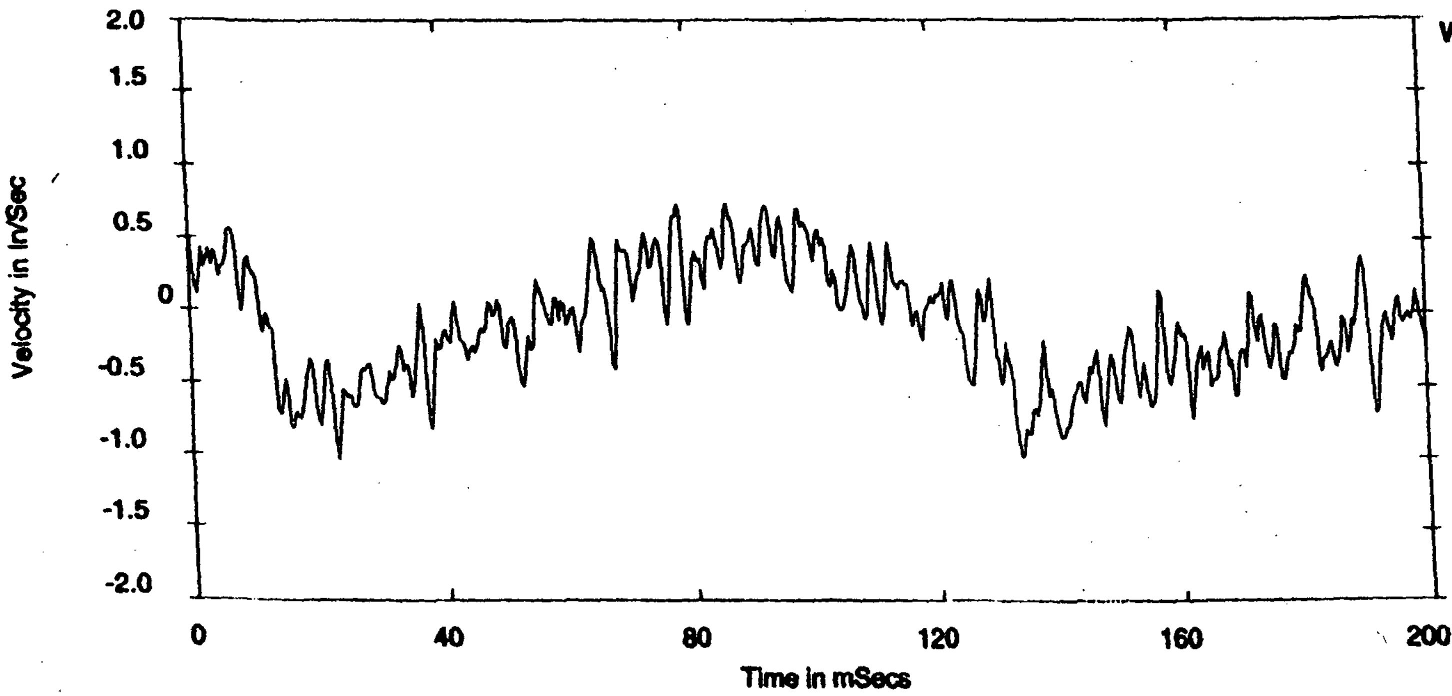
WAVEFORM DISPLAY
20-NOV-95 02:06:48
PK = .4490
PK(+) = .8496
PK(-) = .9196
CRESTF= 2.82

Ordr: 4.034
Freq: 134.52
Spec: .09221

RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P8V #8 BEARING-PUMP OUTBOARD VERTICL



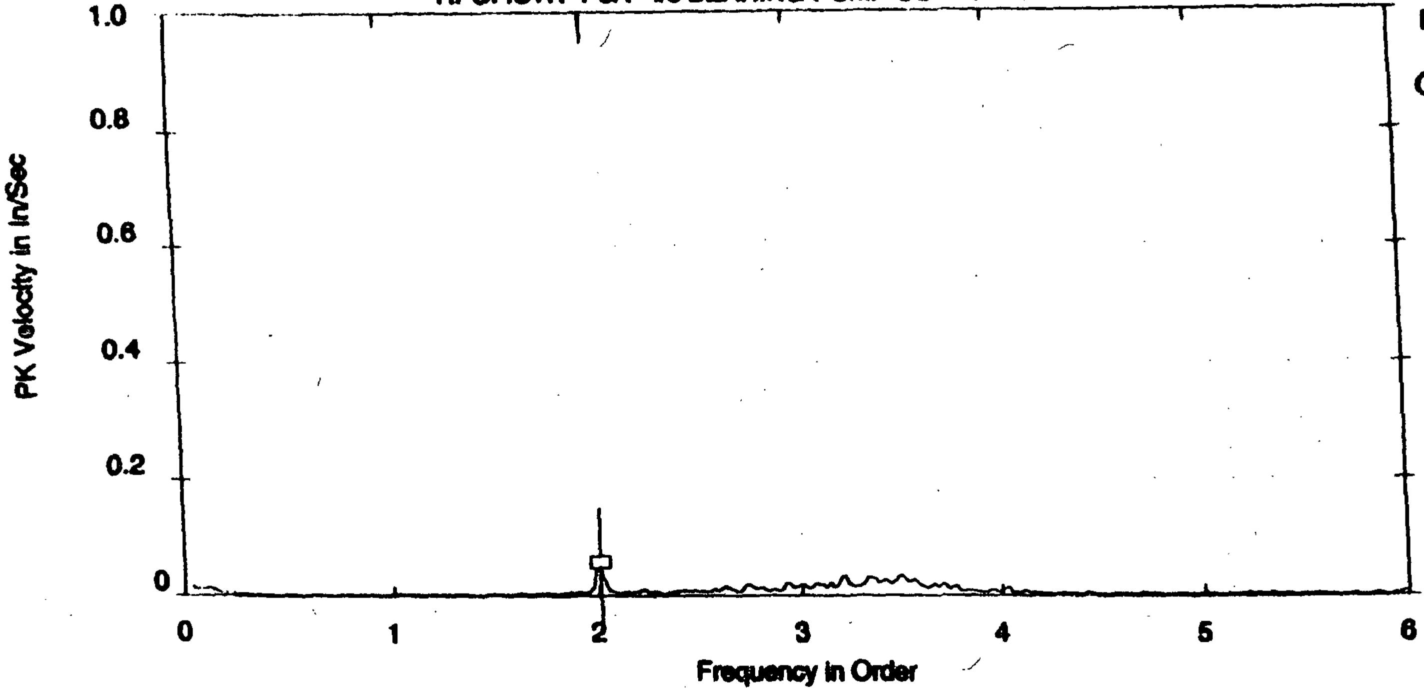
ROUTE SPECTRUM
25-MAY-94 09:36:36
OVRALL= .3279 V-DG
PK = .4190
LOAD =4250.0
RPM = 2025.
RPS = 33.75



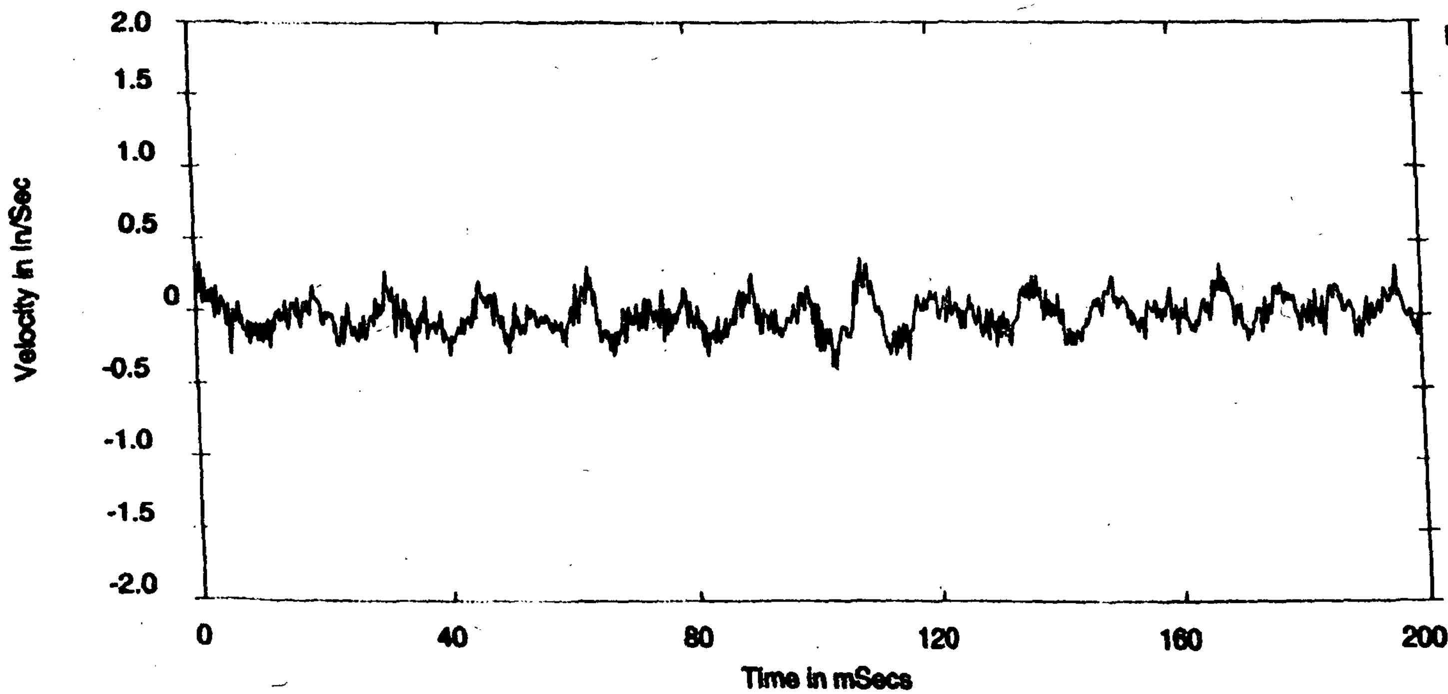
WAVEFORM DISPLAY
25-MAY-94 09:36:36
PK = .5485
PK(+) = .8559
PK(-) = 1.89
CRESTF= 4.52

Ordr: 4.035
Freq: 136.18
Spec: .107

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8A #8 BEARING-PUMP OUTBOARD AXIAL

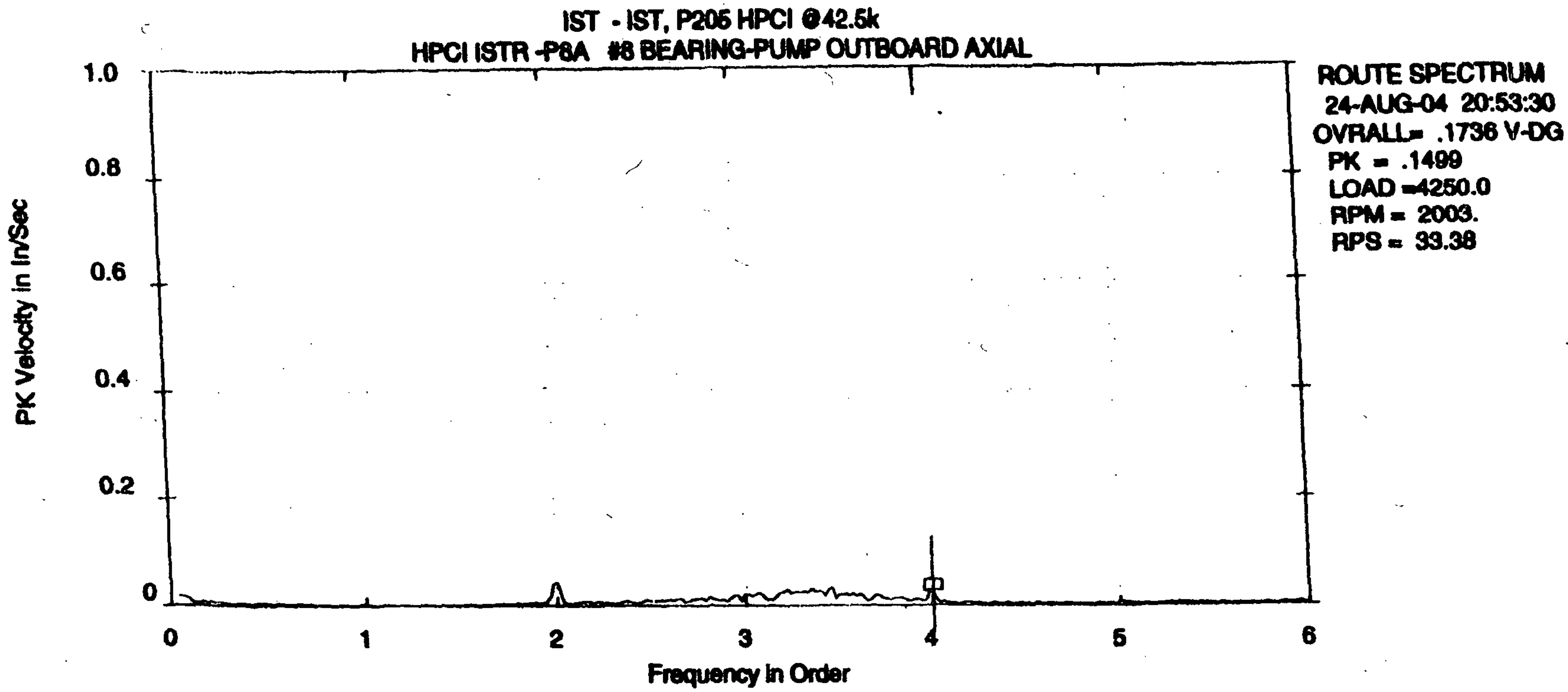


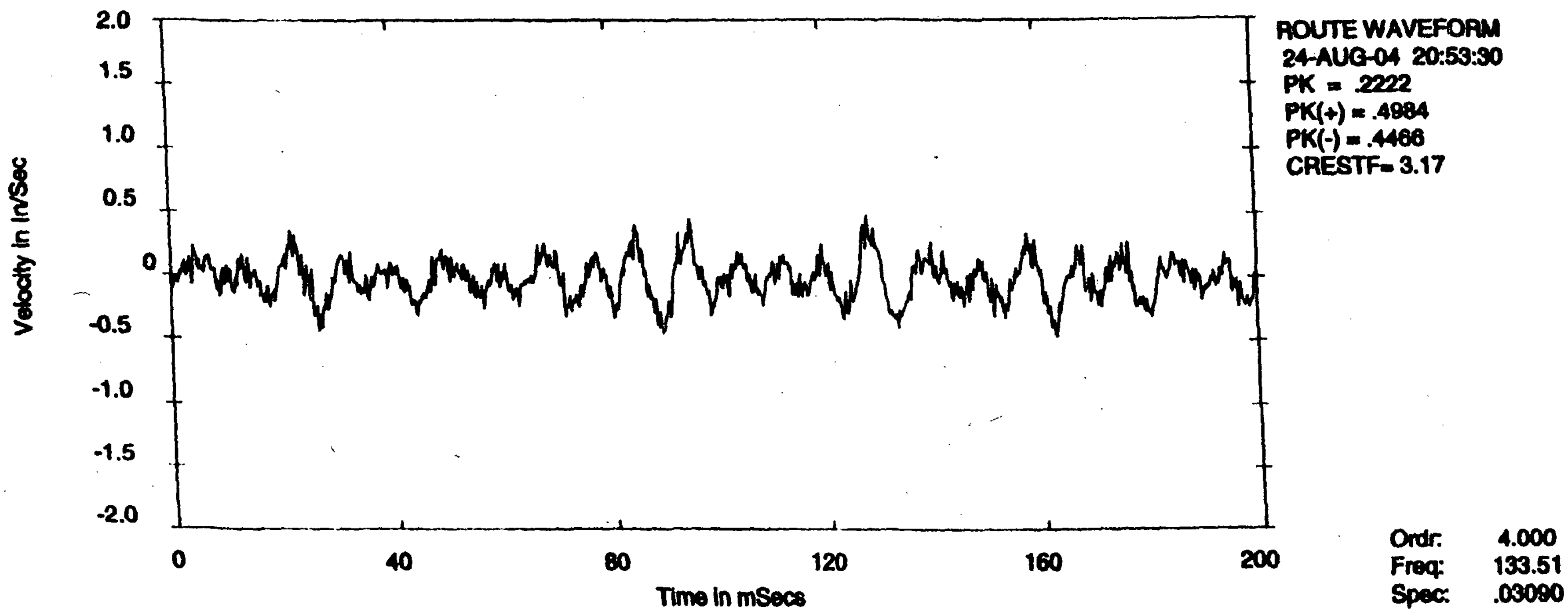
ROUTE SPECTRUM
24-NOV-04 00:57:05
OVRALL= .1761 V-DG
PK = .1523
LOAD =4250.0
RPM = 2017.
RPS = 33.62

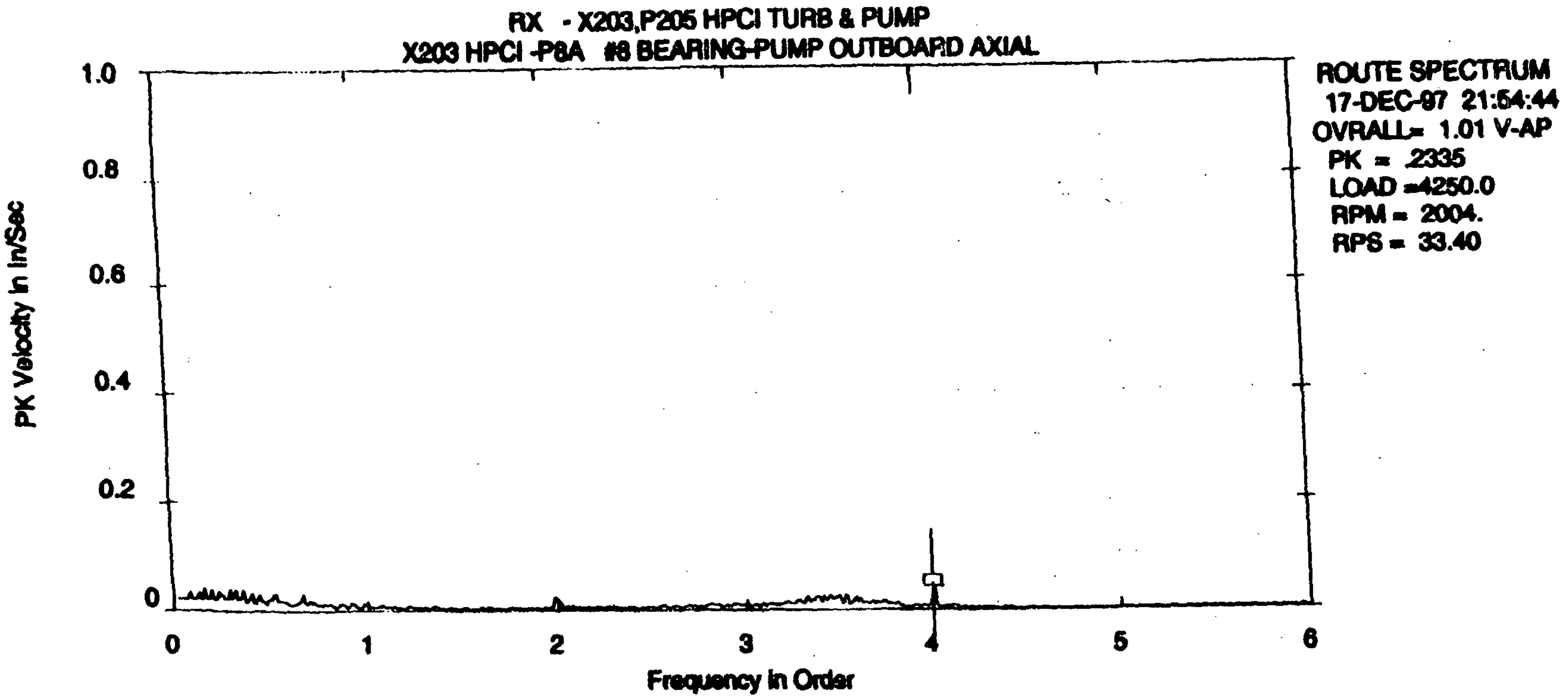


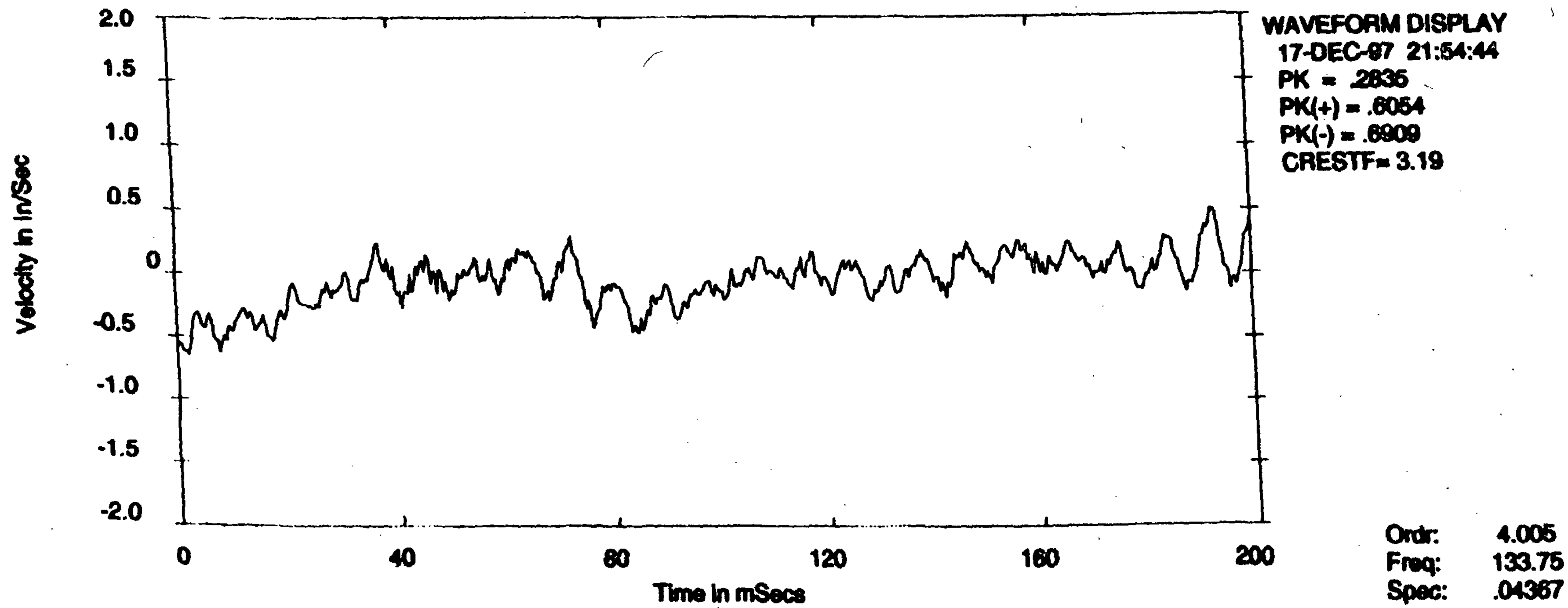
ROUTE WAVEFORM
24-NOV-04 00:57:05
PK = .1719
PK(+) = .3898
PK(-) = .3766
CRESTF= 3.21

Ordr: 2.008
Freq: 67.50
Spec: .04798

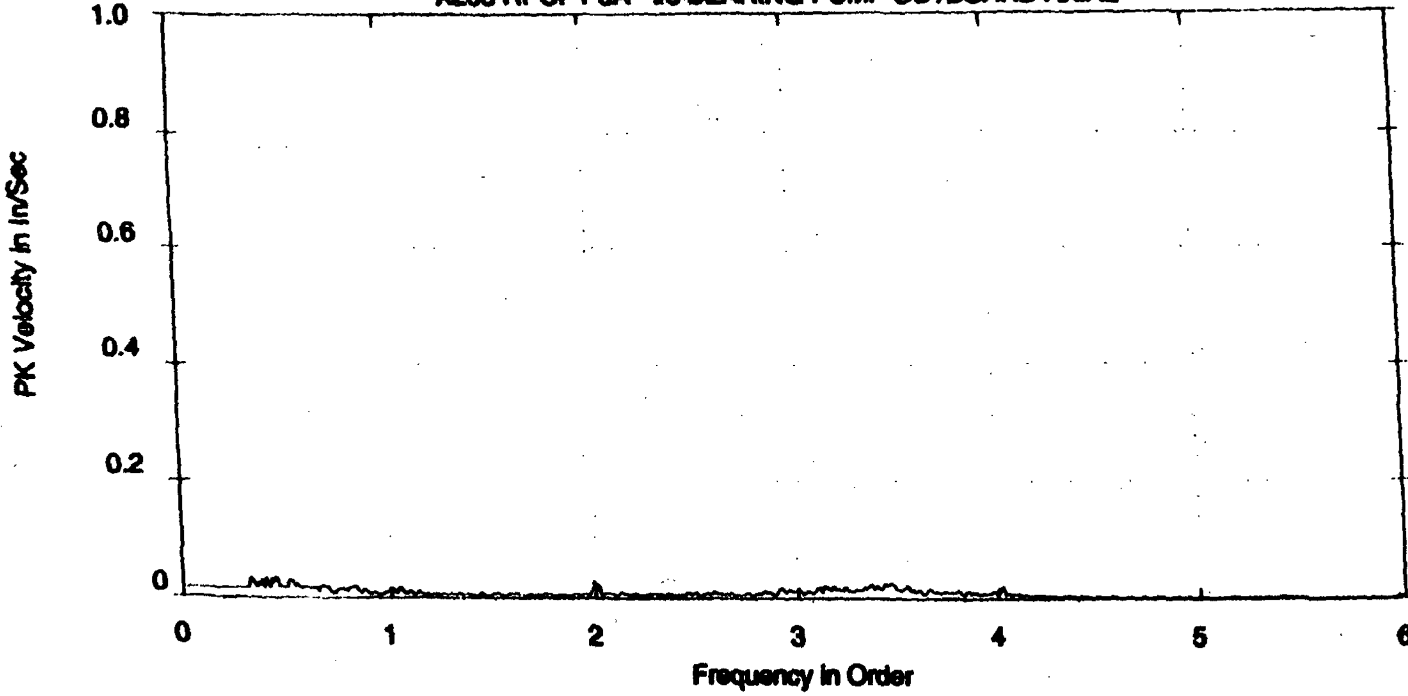

IST - IST, P205 HPCI @42.5k
HPCI ISTR -P8A #8 BEARING-PUMP OUTBOARD AXIAL
ROUTE SPECTRUM
24-AUG-04 20:53:30
OVRALL= .1736 V-DG
PK = .1499
LOAD =4250.0
RPM = 2003.
RPS = 33.38
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order


ROUTE WAVEFORM
24-AUG-04 20:53:30
PK = .2222
PK(+) = .4984
PK(-) = .4466
CRESTF= 3.17
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.000
Freq: 133.51
Spec: .03090

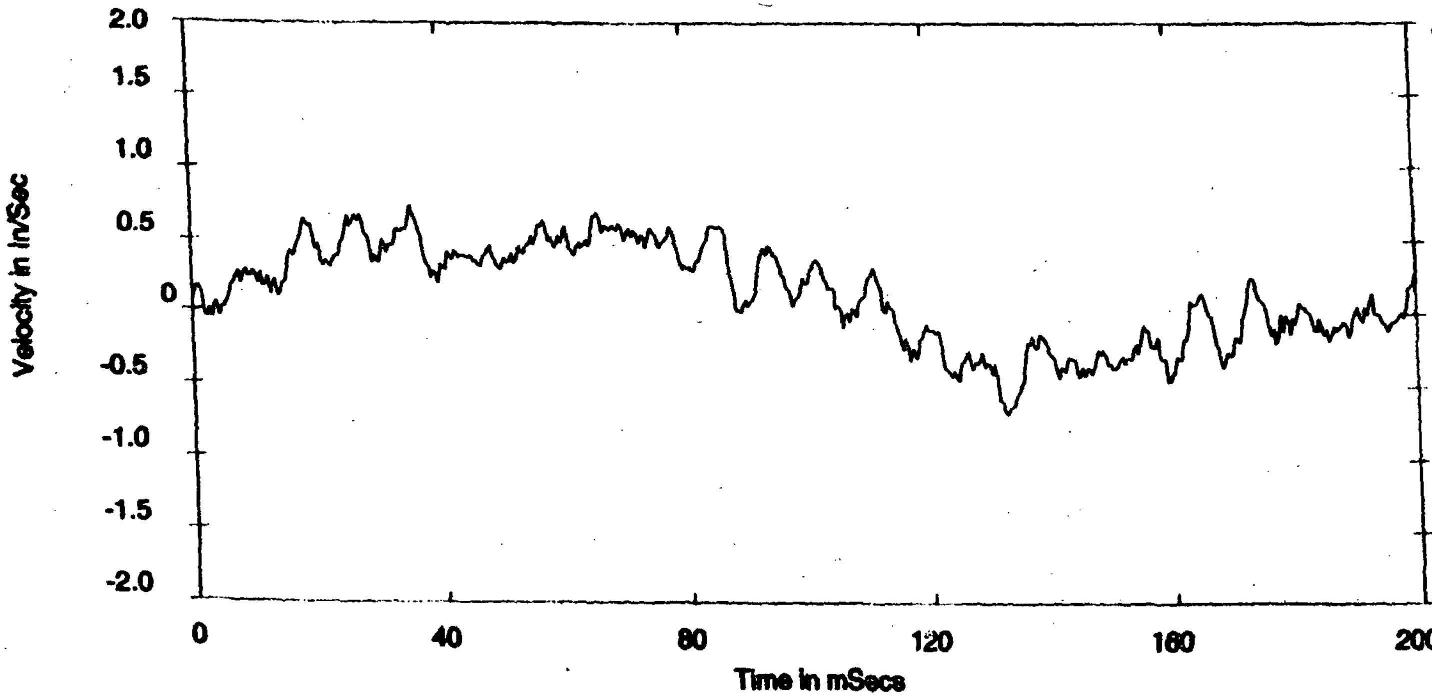

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P8A #8 BEARING-PUMP OUTBOARD AXIAL
ROUTE SPECTRUM
17-DEC-97 21:54:44
OVRALL= 1.01 V-AP
PK = .2335
LOAD =4250.0
RPM = 2004.
RPS = 33.40
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order


WAVEFORM DISPLAY
17-DEC-97 21:54:44
PK = .2835
PK(+) = .6054
PK(-) = .6909
CRESTF= 3.19
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.005
Freq: 133.75
Spec: .04367

RX - X203,P205 HPCI TURB & PUMP
X203 HPCI -P8A #8 BEARING-PUMP OUTBOARD AXIAL

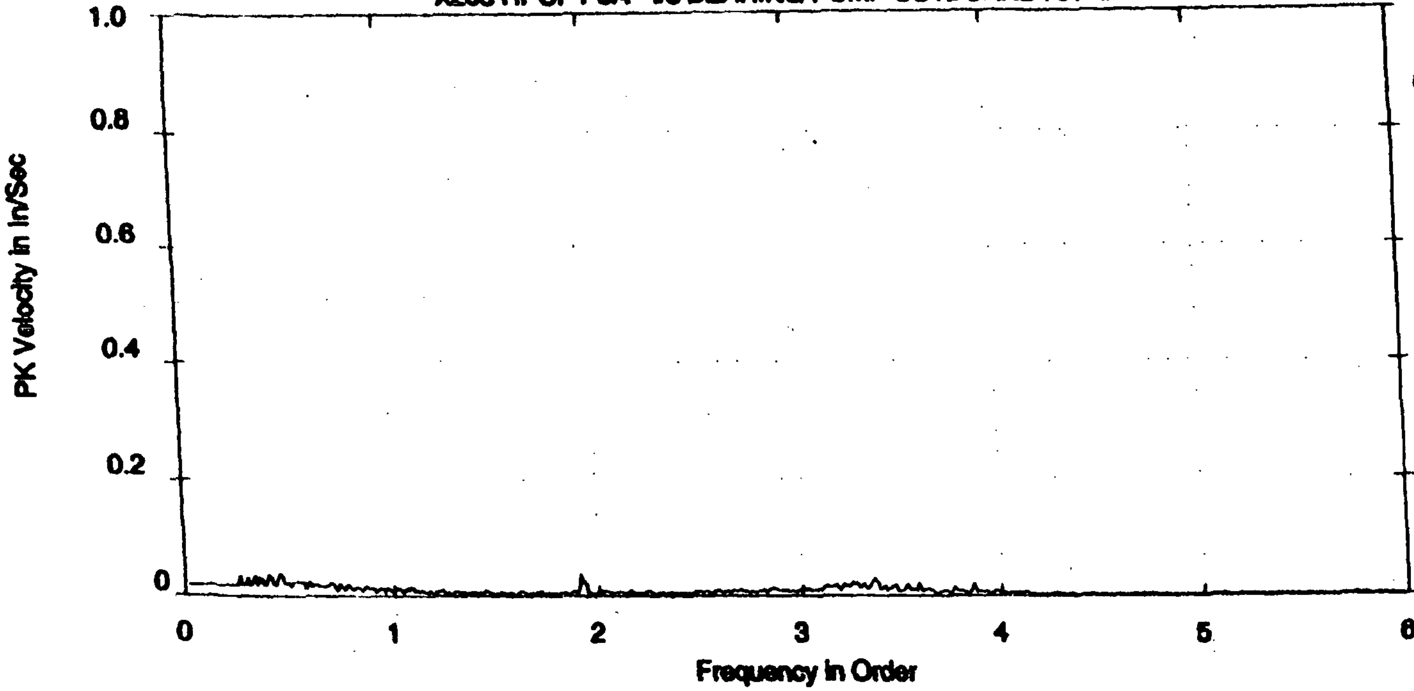


ROUTE SPECTRUM
31-JUL-96 09:54:50
OVRALL= .2007 V-DG
PK = .2261
LOAD =4250.0
RPM = 2025.
RPS = 33.75

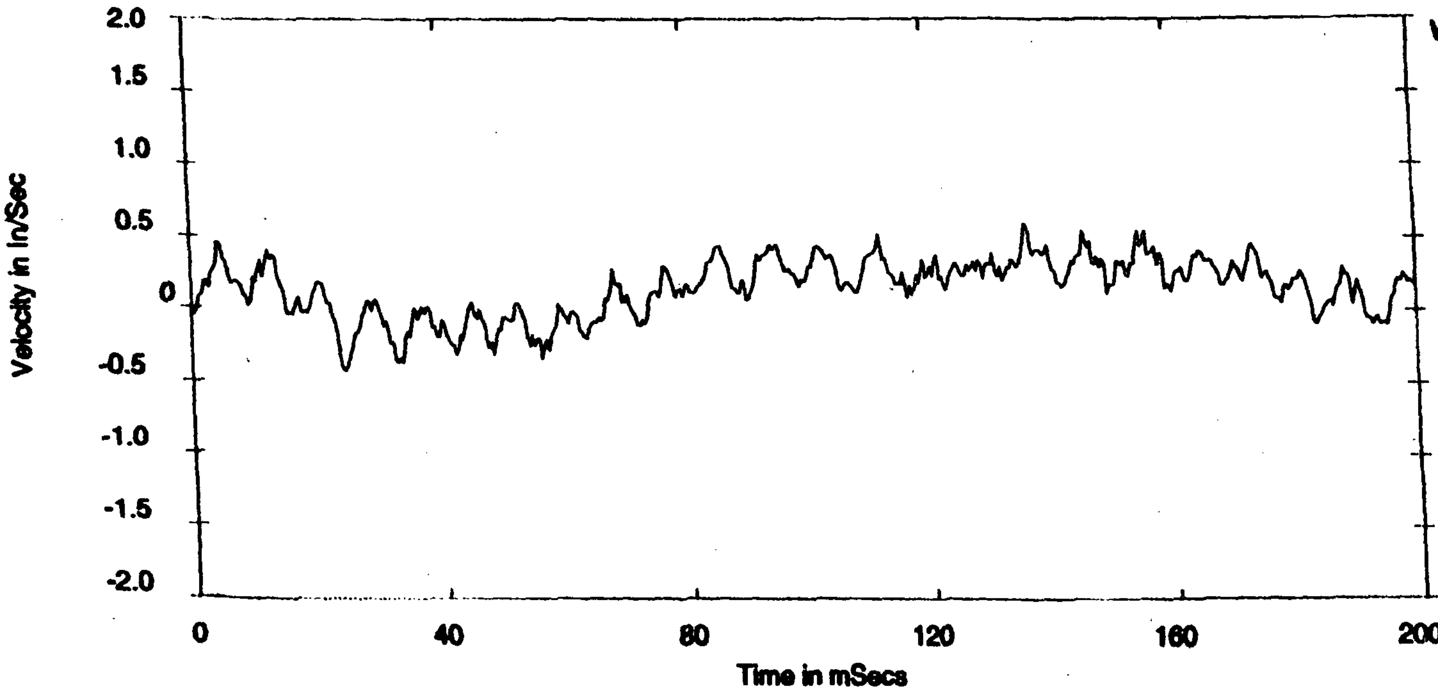


WAVEFORM DISPLAY
31-JUL-96 09:54:50
PK = .4697
PK(+) = .9066
PK(-) = 1.54
CRESTF= 3.25

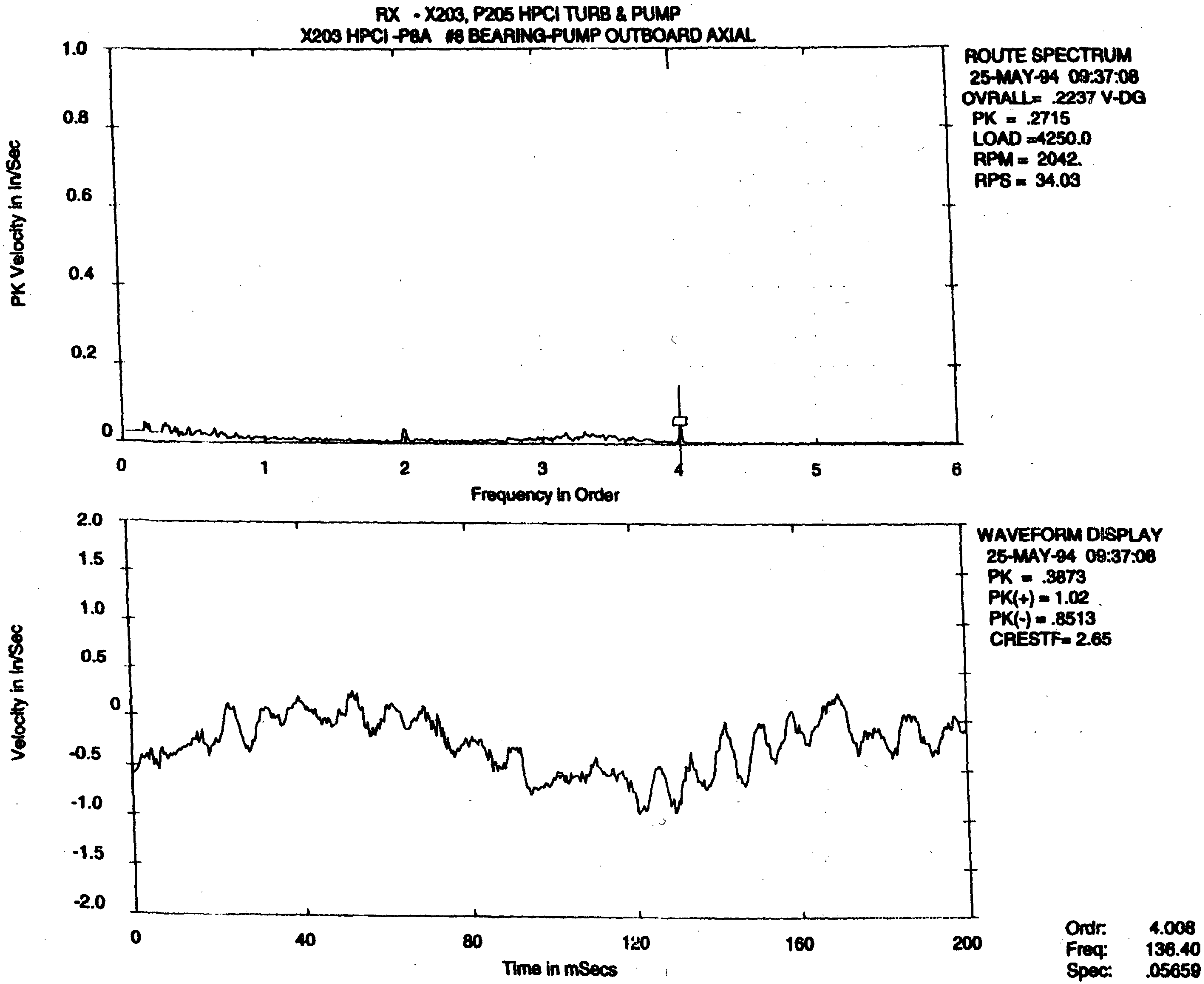
RX - X203, P206 HPCI TURB & PUMP
X203 HPCI -P8A #8 BEARING-PUMP OUTBOARD AXIAL



ROUTE SPECTRUM
20-NOV-95 02:07:18
OVRALL= .2017 V-DG
PK = .2314
LOAD =4250.0
RPM = 2087.
RPS = 34.78



WAVEFORM DISPLAY
20-NOV-95 02:07:18
PK = .2857
PK(+) = .5738
PK(-) = 1.01
CRESTF= 3.37


RX - X203, P205 HPCI TURB & PUMP
X203 HPCI -P8A #8 BEARING-PUMP OUTBOARD AXIAL
ROUTE SPECTRUM
25-MAY-94 09:37:08
OVRALL= .2237 V-DG
PK = .2715
LOAD =4250.0
RPM = 2042.
RPS = 34.03
PK Velocity in In/Sec
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Frequency in Order
WAVEFORM DISPLAY
25-MAY-94 09:37:08
PK = .3873
PK(+) = 1.02
PK(-) = .8513
CRESTF= 2.65
Velocity in In/Sec
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
0
40
80
120
160
200
Time in mSecs
Ordr: 4.008
Freq: 136.40
Spec: .05659

ATTACHMENT 2

Entergy Letter No. 2. 07.056, dated July 12, 2007 (25 pages)

Response to NRC Request for Additional Information Related to Pilgrim In-Service Testing (IST) Relief Request PR-03, Rev. 3

July 12, 2007

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Response to NRC Request for Additional Information Related to Pilgrim In-service Testing (IST) Relief Request PR-03 (TAC NO. MD2478)

LETTER NUMBER: 2.07.056

REFERENCES: 1. Entergy Letter No. 2.06.008, Pilgrim Fourth Ten-Year In-service Testing (IST) Program, IST Relief Request, PR-03, Rev. 3, dated June 29, 2006

Dear Sir or Madam:

The Attachment 1 to this letter provides Pilgrim response to NRC Request for Additional Information to complete the review and approval of IST Relief Request, PR-03 (Reference 1).

The Attachment 1 confirms that Entergy will provide results of an independent consultant's assessment of Pilgrim HPCI Pump vibration analysis in an expeditious manner by October 2007 or earlier, as soon it becomes available. NRC Staff at its option may defer the review of Pilgrim PR-03 until Entergy provides results of the consultant's assessment.

This submittal contains no new commitments.

If you have any questions or require additional information, please contact Mr. Bryan Ford, Licensing Manager, at (508) 830-8403.

Sincerely,

(original signed by S. Bethay)

Stephen J. Bethay

WGL/dl
Attachment 1: Response to NRC Request for Additional Information (12 pages)
Attachment 2: HPCI Main Pump Vibration Data (10 pages)

cc: Next page

cc: Mr. James S. Kim, Project Manager
Office of Nuclear Reactor Regulation
Mail Stop: 0-8B-1
U.S. Nuclear Regulatory Commission
1 White Flint North
11555 Rockville Pike
Rockville, MD 20852

U.S. Nuclear Regulatory Commission
Region 1
475 Allendale Road
King of Prussia, PA 19406

Senior Resident Inspector
Pilgrim Nuclear Power Station

ATTACHMENT 1

TO ENTERGY LETTER 2.07.056

ENTERGY RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION RELATED TO PILGRIM IST LEIF REQUEST PR-03 FOR HPCI PUMP

Reference: 1 Entergy Letter No. 2.06.008, "Pilgrim Fourth Ten-Year In-service Testing (IST) Program, IST Relief Request PR-03, Rev. 3", dated June 29, 2006

RAI Question 1:

The submitted revised relief request PR-03, Rev. 3 (Reference 1) did not demonstrate that compliance with Code requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Although the need to implement the Byron Jackson recommended modifications at an estimated cost of about $500,000 (as provided by Pilgrim) may be a hardship, the modification would likely lower the actual vibration levels of the HPCI Pump. Also, the licensee did not demonstrate that meeting the Code vibration acceptance criteria is impractical. The NRC staff is aware of licensees who have performed the design modification per Byron Jackson recommendations, and were able to reduce HPCI Pump vibration levels. Please explain.

Response:

The ASME OMa-1996 Code acceptance criteria for Group A and Comprehensive Tests are stipulated in ISTB Table 5.2.1-1. The stipulated "Alert Range" and "Required Action Range" values for the HPCI Pump are ">0.325-0.7 in/sec" and ">0.7 in/sec" respectively.

The Code also specifies in the ISTB 4.3(g) footnote that vibration measurements should be representative of the HPCI Main Pump and that measured vibration will not prevent the HPCI Main Pump from fulfilling its function.

During the Third IST Interval, prior ASME IST Code did not provide absolute Code values. For the Fourth IST interval, the ASME OMa Code provides absolute Code values for vibration surveillances. These absolute Code values do not take into consideration the as-built configuration of the HPCI Pump. Instead, the ISTP 4.3(g) footnote provides provisions to take into consideration the as-built configuration of HPCI Pump to determine the vibration value attributable to the HPCI Main Pump.

Besides Pilgrim, several other licensees[1] (Monticello, Cooper, Fermi-2, Calvert Cliffs, and Seabrook) could not meet the absolute Code values, and sought relief from the ISTB requirements. The NRC granted these requests. Pilgrim relief request follows NRC approved precedents.

---

1. NRC SERs, Monticello Nuclear Generating Plant- Evaluation of Relief Request NOS. PR-01, PR-02, PR-03, PR-04, PR-05 and VR-02, related to the Fourth 10-Year Interval Inservice Testing Program (TAC No. MB6807), dated July 17, 2003; Cooper Nuclear Station (TAC No. MB 6821), dated February 25, 2004; Fermi-2 (TAC No. MA 6390) dated February 17, 2000; Calvert Cliffs (TAC NO. MA7848 and MA7849) dated August 22, 2000; FPL Energy Seabrook Station submittal letter, "Revision to Inservice Test Program Relief Request PR-3" dated September 23, 2003; and NRC SER on Seabrook Station-Inservice Testing Program Relief Request PR-3 (TAC NO. MB8941), dated February 4, 2004.

Pilgrim HPCI Pump configuration consists of a Booster Pump and a HPCI Main Pump as shown in Figure 1. The OM Code requires vibration measurements of the HPCI Main Pump. Since the Booster Pump is coupled with the HPCI Main Pump, in order to comply with the Table 5.2.1-1 acceptance criteria, the vibration value representative of the HPCI Main Pump must be determined, excluding the Booster Pump vibration, taking into consideration ISTB 4.3(g) footnote, to demonstrate that the HPCI Main Pump fulfills its function. Accordingly, as required by the ISTB 4.3(g) footnote, Entergy proposed in Reference 1 the vibration values applicable to the HPCI Main Pump in compliance with ISTB 4.3(g) footnote and ISTB Table 5.2.1-1.

Entergy's approach requires separating the discrete peak attributable to the Booster Pump from the HPCI Main Pump spectrum. In Reference 1, Entergy described the separation of discrete peak attributable to the Booster Pump from the HPCI Main Pump spectrum to obtain vibration values specific to the HPCI Main Pump to comply with the OM Code requirement.

Other licensees have taken similar approaches to account for the vibration values specific to the HPCI Main Pump, either by retaining or deriving the cumulative vibration values of all components coupled with the HPCI Pump, that were observed prior to the OM Code became effective.

For example: NRC approved Monticello IST Relief Request PR-03 provides a good comparison to the Pilgrim Relief Request PR-03. Monticello HPCI Pump configuration is similar to the Pilgrim HPCI Pump configuration. Both Monticello and Pilgrim HPCI Pump configurations have Booster Pumps and HPCI Main Pumps.

NRC SER on Monticello (TAC No. MB6807), item 3.3.5 on page 8 states:

> *"NMC requested relief from the specific ASME OM Code requirements pursuant to 10 CFR 50.55a(a)(3)(ii) on the basis that complying with these [Table ISTP 5.2.1-1] requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The NRC staff authorized a similar relief for Monticello on September 9, 1994, for its previous 10-year IST interval."*
>
> *"HPCI pump P-209 at Monticello consists of a main pump and booster pump with a speed reducing gear driven by a common steam turbine. Because of this configuration, both pumps must be tested simultaneously. NMC's letter of November 22, 2002, states that because of this combination, high vibration levels are recorded at the main and booster pump bearings of both pumps. NMC characterized this high bearing vibration level as the normal vibration level of the HPCI pump bearings. Therefore, NMC stated that complying with the ASME OM Code requirements for HPCI pump P-209 would be a hardship without a compensating increase in level of quality and safety."*

NRC SER further states on page 9:

> *"NMC's evaluation of the HPCI pump vibration issue, coupled with historical pump vibration data, show that HPCI pump p-209 normally runs at high levels of vibration and has not experienced any failure to date. Requiring NMC to meet the ASME OM Code requirements by increasing the frequency of the HPCI pump testing would result in hardship without a compensating increase in the level of quality and safety. This is because of the additional testing that would need to be performed on a pump that adequately operates at elevated vibration levels. The proposed testing provides reasonable assurance of operational readiness because NMC will continue to test HPCI pump p-209 quarterly, and will maintain the OM Code alert ranges for axial and vertical components of vibration."*

Since Monticello's HPCI Pump configuration is similar to that of Pilgrim's HPCI Pump, NRC's Monticello HPCI Pump vibration evaluation conclusion is directly applicable to the Pilgrim HPCI Pump vibration evaluation.

There is no standard method in the OM Code or industry guidance that a licensee must follow to obtain a vibration value for the HPCI Main Pump from the as-built configuration within the prescribed OMa Code ISTB 4.3(g) footnote. The inboard and outboard horizontal points (P3H and P4H) of the HPCI Main Pump require values representative of the HPCI Main Pump. Since vibrations at these points are influenced by the Booster Pump (as explained by Monticello in its letter dated November 22, 2002 and reiterated by the NRC SER on Monticello), in the absence of a standard method or industry guidance, Pilgrim has selected the approach to extract the discrete peak attributable to the Booster Pump based upon the performance trending data, proven operability, and operational readiness of the HPCI Main Pump. ISTB 5.2.3(d) statement that vibration measurements are to be broad brand (unfiltered) applies to vibrations emerging from a single source. In the case of Pilgrim, vibrations are attributed to the Booster Pump and HPCI Main Pump as-built configuration. In the case of Pilgrim HPCI Main Pump, performance trending was used to determine the vibration values attributable to the HPCI Main Pump in accordance with ISTB 4.6. ISTB 4.6 states an analysis should be performed to establish new set of reference values and this analysis shall include verification of the pump's operational readiness. The analysis shall include both a pump level and **a system level evaluation** (emphasis added) of operational readiness, the cause of the change in pump performance, and an evaluation of all trends indicated by available data. The results of this analysis shall be documented in the record of tests. Entergy performed this analysis and docketed it by Reference 1. Thus, there is regulatory basis in the approach selected by Pilgrim to address the HPCI Main Pump surveillance for vibration measurements. The trending of the vibration data since 1994 has shown no signs of degradation. Therefore, relaxation in the absolute Code values is justified, similar to the afore mentioned licensees. There is no compelling basis to accept the absolute Code values for the HPCI Main Pump from the Code without considering the as-built configuration as specified in ISTB 4.3(g) footnote.

The OM Code recognized the complexity of certain as-built configurations while measuring and comparing the vibration data. Thus provided an avenue to derive the vibration value of the HPCI Main Pump based upon its as-built configuration; otherwise, the Code would not have prescribed the ISTB 4.3(g) footnote. 10 CFR 50.55a provides a methodology to seek NRC approval, when strict compliance with the Code can not be achieved or would impose undue burden on the licensee. Pilgrim is not alone in expressing the undue burden to comply with the regulation; Seabrook in its submittal seeking Inservice Test Program Relief Request PR-3, requested relief from the ISTB Table 5.2.1-1 requirement based on the undue burden. Likewise, Monticello also sought relief based on undue burden. Thus, Pilgrim relief request PR-03 follows the NRC approved industry precedents.

As explained in Reference 1, Pilgrim proposed an alternative pursuant to 10 CFR 50.55a(a)(3)(i) to monitor the HPCI Pump readiness (see pages 2 and 3 of Reference 1). This alternative approach to monitor the readiness of HPCI Pump provides assurance that any observed degradation in performance can be corrected in a timely manner. While the relief request qualifies for 10 CFR 50.55a(a)(3)(ii) for undue burden consideration, Entergy sought NRC approval on an alternative pursuant to (3)(i) because Pilgrim's Preventive Maintenance procedure and the fact that monitoring of HPCI Pump takes into consideration enhanced scope of performance monitoring as explained on pages 2 and 3 of Reference 1. Pilgrim's scope is significantly comprehensive, and warrants characterizing as an alternative pursuant to (3)(i), even though the basis for relief equally qualifies under the provision of (3)(ii), like that of Monticello.

Entergy in its submittal (Ref. 1) has provided extensive information concerning the justification for not making modifications to the HPCI system. Any modification to the HPCI system would not provide assurance that the vibrations would be reduced below the Code acceptance criteria, additionally the cost of such modification would easily exceed $500,000 on a time and material basis, thus placing undue burden to comply with the Code required absolute limits.

The Original Equipment Manufacturers (OEM) recommendations were reviewed, but such modifications to operating equipment that has shown no degradation is not justified and, since the proposed modifications do not typically result in sufficiently lower vibration levels below the OM limits, ASME Code relief is still required. Seabrook on the other hand provided a simple statement *"Implementing a design change solely for the purpose of establishing some test repeatability margin subjects Seabrook Station to an undue burden to comply with the regulation."* The same statement is applicable to Pilgrim Relief Request, PR-03 as well.

In summary, modifying a perfectly operating HPCI Pump presents no safety benefit. Since 1994, the HPCI Main Pump vibration data has been trended and the trend data shows no degradation in the pump performance, no operability issues have emerged, and no adverse conditions have been observed. The HPCI Pump has been tested over 240 hours since the start of Pilgrim Station without any problems. Its mission time for mitigating the consequences of design basis accidents is 30 minutes to 5 hours, which is within the range of 240 hours of establishing test duration. HPCI Pump has experienced a total of 270 hours total operation inclusive of approximately 240 hours of testing time. Thus, HPCI Pump's readiness has been demonstrated through Code required tests with over 270 hours of operation and testing times at the required flow with no operability issues, even though it operates at elevated vibration levels like that of Monticello or Seabrook HPCI Pumps. The vibrations have shown no degradation on the pump performance. Thus, there is no basis for modification for the purpose of establishing test repeatability to meet absolute Code vibration values that are derived without taking into consideration the as-built configuration of the HPCI Pump. HPCI Main Pump delivers the required flow at the required pressure in accordance with design basis to mitigate the consequences of design basis accidents. Entergy has concluded that the HPCI Pump is in an operationally readiness condition to perform its design basis function and is in compliance with the objective of the OM Code requirement.

In addition to the proposed alternative (in Reference 1), Entergy has selected an independent consultant to review the performance of the HPCI Pump, vibration data, and trending information to determine any improvements to reduce vibration. Entergy will provide the results of consultant's review to the NRC by October 2007. This independent evaluation is similar to other licensees' approach to resolve vibration issues.

RAI Question 2:

Please provide a detailed cost analysis showing the cost breakdowns resulting in the projected $ 500,000 cost to change the four-vane impeller with a five-vane impeller.

Response:

The cost, considered to be a minimum estimate, for the HPCI Booster Pump Rotating Element Replacement is as follows:

Craft Labor (Millwrights, Mechanics, Pipefitters, Laborers, w/Supervision)	$ 177,400.
Engineering	$ 34,000.

Materials (does not include cost escalation)	$ 110,000
Contingency	x 1.25

Subtotal Base	$ 402,000.
Total w/Entergy Adders & Loaders	≥ $ 500,000.

RAI Question 3:

Please provide a detailed analysis of the full spectrum pump vibration data addressing each peak and identifying probable cause including degradation, resonance, mechanical looseness, misalignment, flow turbulence, cavitation, or vibration-beating, etc.

Response:

The latest HPCI Pump vibration data (Attachment 2) provided with this response includes annotations showing the following vibration components of interest:

The high vibration on the HPCI Main Pump horizontally for points P3H and P4H is predominantly at just over 2x RPM and is due primarily to a hydraulic standing wave resonance in the interconnecting piping from the Booster Pump at the pump's vane-passing frequency (4x Booster Pump RPM) coinciding with structural resonances of the cross-over piping and the Main Pump pedestal when the machine is operating at the rated speed of 4000 RPM. The Main and Booster Pumps are connected via a speed reduction gear box (1.983 to 1 ratio) such that the Main Pump rated speed of 4000 RPM corresponds to a Booster Pump speed of 2017 RPM. This results in a high vibration discrete component on the Main Pump bearing housings appearing at just over 2x RPM in the horizontal direction but caused by the Booster Pump excitation at 4x Booster Pump RPM, transmitted and amplified by the interconnecting cross-over piping.

It is also evident that the Main Pump has a structural resonance coinciding with 4x Booster Pump RPM. The vibration mode is the second order horizontal torsional rocking of the Main Pump pedestal. This would not ordinarily be a problem except that this resonant frequency also coincides with the vane passing frequency (4x RPM) of the Booster Pump and the hydraulic resonance of the interconnecting piping. This coincidence of hydraulic excitation with both hydraulic and structural resonances results in the high vibration seen at the Main Pump but only at the discrete frequency that is just over 2x Main Pump RPM (typically at 2.017x RPM). The high resolution spectrums also show the separate discrete component at exactly 2x Main Pump RPM. A low level 2x RPM frequency component is typically present on all horizontal shaft pumps and is usually related to a slight distortion of the fundamental 1x RPM shaft orbit caused by misalignment. In this case, the 2x Main Pump RPM component is also amplified by the same structural resonance.

The Main Pump vibration spectrum also shows a discrete peak at 5X Main Pump RPM. This coincides with the Main Pump's five-vane impeller. Pump vibration spectra typically show a discrete frequency peak at the number of impeller vanes times running speed and this is not an unusual for the Main Pump.

In addition, the first fundamental horizontal rocking mode of the Main Pump appears to coincide closely with 1x RPM resulting in moderately high horizontal vibration at the Main Pump 4000 RPM rated speed, particularly at the gearbox-end bearing (P4H). This structural resonance at running speed causes the Main Pump to be particularly sensitive to otherwise normal unbalance and misalignment forces.

There are no other vibration spectrum frequency components that are noteworthy. There are no indications of mechanical looseness, cavitation, vibration-beating, or degradation of any kind. The frequency components for points P3 & P4 remain consistent with the earliest data obtained in the same format in 1994.

RAI Question 4:

Please provide input or recommendations from the pump supplier stating that the current HPCI Pump's vibration levels are acceptable for the required pump operation.

Response:

The HPCI Pump Original Equipment Manufacturer (OEM) is Flowserve (formerly Byron Jackson). Pilgrim has had discussions with Flowserve and there is ample industry operating experience related to HPCI Pump vibration issues. The OEM does not review and approve vibration data, this is the Owner's responsibility and is done in the context of the ASME OM Code. Flowserve has issued recommended actions and part replacements that Owners may take to reduce the effect of the Booster Pump hydraulic resonance effect, which includes replacing the four-vane pump impeller. It is expected that the OEM would continue to provide the same recommendations for parts replacements. Pilgrim has selected an independent pump consultant that is not currently affiliated with the OEM to review the Pilgrim HPCI Pump vibration information and provide the requested input and recommendations.

RAI Question 5:

In the Basis for Relief Section, Item 3, the licensee states that "PNPS will increase the ASME OMa-1 996, ISTB 5.2.3 required frequency for vibration monitoring (that is part of the comprehensive testing) from once/2 years to once/year." Whereas, Item 4, states "As normal practice, Pilgrim will continue to monitor vibration of the HPCI Pump during each of the Quarterly Group B Hydraulic Tests in the same manner as required by the CM Code. Thus, HPCI Pump vibration monitoring will be performed up to 8 times in 2 years as part of Group B Hydraulic Test." Please provide response to the following questions:

RAI Question (5a):

Item 3 states the frequency of vibration monitoring is once/year, whereas, Item 4 states the frequency of vibration monitoring is quarterly. Please explain and provide the correct frequency of vibration monitoring to be implemented as an alternative at Pilgrim.

Response:

Item 3 of the relief request states:

"Pilgrim will increase the ASME OMa-1996, ISTB 5.2.3 required frequency for vibration monitoring (that is part of the comprehensive testing) from once/2 years to once/year. The Code required comprehensive test for flow rates would continue to be once/2 years. ***Given that the HPCI vibration will normally exceed the OM Code limiting Alert Range of >0.325 in./sec, the once/year frequency will be doubled to twice/year. The twice/year frequency will be the commitment frequency.*** *However, the normal PNPS practice will be to monitor vibration in the same manner during each of the Quarterly Group B Hydraulic Tests, whenever practicable." (emphasis added)*

This means that the **Relief Request commitment frequency** for monitoring HPCI Pump vibration (Relief Request - Alternate Testing frequency) will be twice/year, instead of the OM

Code required vibration monitoring frequency (for a standby pump) of once/2years. If there is an unforeseen problem (i.e. equipment, human performance error, or other anomaly) that occurs during a Quarterly HPCI run which prevents collection of meaningful pump vibration data to meet the twice/year frequency (Relief Request commitment frequency), the Quarterly Test will be repeated to obtain the HPCI Pump vibration at the Relief Request commitment frequency of twice/year.

As an administrative practice PNPS will monitor vibration of the HPCI Pump during each of the Quarterly Group B Hydraulic Tests, whenever practicable. The vibration monitored during quarterly testing will be performed in same manner as required by the Code once/2 year Biennial Comprehensive Pump Test (applying the same OM Code required methods) vibration monitoring.

RAI Question (5b):

As mentioned in Item 4, vibration monitoring will be performed up to 8 times in 2 years. Please explain the meaning of the phrase "up to 8 times."

Response:

Item 4 of the relief request also states:

"As normal practice, Pilgrim will continue to monitor vibration of HPCI Pump during each of the Quarterly Group B Hydraulic Tests in the same manner as required by the OM Code. . . . . Thus, HPCI Pump vibration monitoring will be performed up to 8 times in 2 years as part of Group B Hydraulic Tests . . ."

This means that PNPS will administratively implement the practice to monitor vibration of the HPCI Pump during the Quarterly (Group B) Hydraulic Tests, in the same manner as required by the Code once/2 year Biennial Comprehensive pump test (applying the OM Code required methods) vibration monitoring. However, if there is an unforeseen problem (i.e. equipment, human performance error, or other anomaly) that occurs during a Quarterly HPCI run, which prevents collection of meaningful pump vibration data, the Quarterly Test will not be repeated just to obtain the HPCI Pump vibration at the administrative quarterly frequency. PNPS expects to successfully monitor HPCI Pump vibration during each quarterly test, which translates into the phrase *"vibration monitoring will be performed up to 8 times in 2 years"*.

RAI Question (5c):

As mentioned in Item 4, please provide the Section of the CM Code which requires vibration monitoring every quarter during Group B hydraulic testing.

Response

The OM Code does not require vibration monitoring during pump Group B hydraulic testing. PNPS proposes to administratively implement the practice to monitor vibration of the HPCI pump during the Quarterly (Group B) Hydraulic Tests.

RAI Question (5d):

Please provide the flow reference point (minimum or full design) at which vibration monitoring is to be performed during the quarterly Group B hydraulic test.

Response

All HPCI Pump testing is conducted at the flow reference point of 4250 GPM, which is at the full flow design value.

RAI Question 6:

In the Alternate Testing section (Page 2 of 8), Item 1, the licensee states "the alternative testing proposes to remove the 4x Booster Pump RPM frequency component (discrete peak) from the vibration spectrum of the main pump since its amplitude is not related to the physical condition or rotating dynamics of the main pump rotor or bearing system." The Main Pump and Booster Pumps are connected together by the gear box. The value of vibration measured at the main pump, is physically present at the main pump irrespective of the source of vibration. The actual vibration measured at the main pump can not be filtered. CM Code Section ISTB 5.2.3.d states that "vibration shall be determined and compared with corresponding reference values. Vibration measurements are to be broad band (unfiltered). If velocity measurements are used, they shall be peak." Therefore, please provide detailed verification that the proposed method of extracting the discrete frequencies where the high vibration peaks are experienced (1) demonstrates the HPCI Pump's current operational readiness and (2) will provide ongoing verification of pump operational readiness and trending of degradation during future testing.

Response:

All vibration measurements are currently, and will continue to be, broad band and unfiltered and in units of peak velocity. The proposal to remove the 4x Booster Pump RPM frequency component (discrete peak) from the vibration spectrum of the Main Pump is a post-processing analytical tool and does not change the manner in which vibration measurements are made nor does it actually delete any information from the data. The overall vibration amplitude is always determined by a calculation process performed in the frequency domain, it is the square root of the sum of the squares of the individual frequency components. It is a routine practice, in accordance with the Code (ISTB 4.7.1), to disregard the frequency components below 0.33x RPM and to disregard frequency components above 1000 Hz (this constitutes a "broad band" measurement). The purpose of the proposed analytical method of also subtracting the 4x Booster Pump RPM discrete frequency component from the Main Pump vibration spectrum overall level calculation is not to reduce the measured overall amplitude per se, but to determine an overall amplitude value that is directly related to the physical condition and rotating dynamics of the Main Pump rotor and bearing system. This simple analytical processing does not disregard or lose any actual vibration data; it is performed to calculate a more meaningful reference and trending parameter for the Main Pump. All vibration spectral data is retained and is reviewed as part of this processing, as seen in the attached data plots that show the vibration spectrums along with the simple calculation that determines the trending parameter for the P3H and P4H points on the Main Pump.

The vibration that is present as the 4x Booster Pump RPM frequency component has been shown not to be harmful to the Main Pump and bears no relation to the condition of the Main Pump. The vibration measured at the Main Pump is physically present at the Main Pump irrespective of the source of vibration, but it would be present at the same amplitude on the Main Pump even if the Main Pump was not running and, as such, it behaves the same as a high background noise. It has also been concluded that this resonant vibration condition at the 4000 RPM operating speed is not detrimental and will not prevent the HPCI Pump from fulfilling its function. At the 134 Hz frequency of the resonant vibration on the Main Pump caused by the excitation at 4x Booster Pump RPM, the actual displacement amplitude at 0.70 in/sec peak velocity amplitude is 0.0017 inches peak-to-peak. This displacement imposes negligible alternating stresses on the pump pedestal, housings, and connected piping. The peak-to-peak displacement is also less than the Main Pump fluid film journal bearing clearances and would impose negligible loading to these bearings. In addition, the 4x Booster Pump RPM frequency component, since it is caused by a hydraulic acoustic standing wave resonance, is highly variable in amplitude so that when it is included in the overall vibration amplitude calculation it renders the calculated overall value useless for trending purposes.

The HPCI Pump's current operational readiness is unaffected by this vibration condition because it has no adverse affect on the operation of the Booster or Main Pump. The ongoing verification of pump operational readiness and trending of degradation during future testing is assured by using the proposed analytical method for the spectrum analysis and overall level calculation. This method extracts the useful overall level as a trending parameter for the Main Pump operating condition that is unaffected by the Booster Pump hydraulic resonance effect.

RAI Question 7:

In the Alternate Testing section, Table -Main Pump (page 7 of 8), under the columns "Acceptable Range" and "Alert Range," the licensee provided range in terms of V, and their numerical values. Please provide, the basis of the selected "Acceptable Range" and "Alert Range," and their numerical values.

Response:

To allow for practicable monitoring of vibration levels on the HPCI Pump, and to provide a trigger point for heightened awareness when monitoring HPCI Pump vibration, an alternate vibration Acceptance Range and Alert Range have been included into this relief request. A full spectrum review will also be performed for all IST vibration points during each HPCI test in which vibration is collected and analyzed.

Since the HPCI Pump resides in the OM Code vibration Alert Range, and pump vibration is being monitored more frequently then specified by the OM Code for standby pumps that fall into the vibration Alert Range (OM Code requirement is to monitor vibration once per year) – the inclusion of revised Alert Range (lower limit value) is an enhancement which incorporates a useful trigger point which will implement a heightened awareness when there is an increase in the overall HPCI Pump vibration.

The assigned Acceptable upper limits (which are also the lower Alert limit) were established using the same methodology as the OM Code for establishing Acceptable Ranges. They are based upon a multiple of the specific vibration point reference values and are empirical in nature.

- The upper limit for the Acceptable Ranges (also lower Alert limit) were established as a value which is higher than the respective vibration point reference values and provides a meaningful trigger point for heightened awareness. The Acceptance upper limit must be high enough such that normal fluctuations in pump operation and vibration monitoring do not inadvertently trigger the limit and routinely place the pump in Alert test status. This would cause the pump to vacillate between the Acceptance Range and the Alert Range during expected variations in pump operation and vibration monitoring. This situation renders the Alert trigger point as more of an expected periodic nuisance alarm, without a meaningful purpose.

- The upper limit for the Acceptable Ranges (also lower Alert limit) was established at a value low enough such that a significant increase in pump vibration amplitude will activate the pump trigger for vibration Alert status which would result in a heightened awareness for future pump testing and monitoring.

The assigned Alert upper limits (6Vr or 0.70 in/sec) were established using the OM Code limits, and are not a deviation from the Code.

The relief request assigned a revised Alert vibration range of 1.5Vr to 6Vr, which incorporates a multiple of the reference vibration and is more conservative than the OM Code Alert range of 2.5Vr to 6Vr. The absolute limiting lower Alert Values (i.e. 0.375, 0.450, 0.500, 0.550, and 0.600) are based upon existing pump reference values, and fall between the values of 1.25Vr and 1.5Vr. All of the modified Alert Values have been compared to and are based upon the historical pump vibration data. These lower Alert values are set as low as reasonably practical, and are established at a value which is high enough above the reference values so as to not inadvertently trigger the vibration point Alert lower limit during routine HPCI Pump operation and testing.

RAI Question 8:

In the Alternate Testing Section, the last sentence of the first paragraph states "A full spectrum review will be performed for all IST vibration points during each proposed comprehensive test," Whereas Item 4 in the Basis for Relief Section states "As normal practice, Pilgrim will continue to monitor vibration of the HPCI Pump during each of the Quarterly Group B Hydraulic Tests in the same manner as required by the CM Code (see RAI Question 2). Please explain what kind of test (comprehensive or Group B test) will be performed to measure pump vibration quarterly and whether a full spectrum review will be performed quarterly.

Response:

The pump vibration quarterly "Group B Hydraulic Test" is identical to the vibration testing during the once/year "Comprehensive Pump Test".

As Item 2 in the "Basis for Relief" Section states:

> "All other discrete vibration peaks observed at the Main Pump horizontal vibration points will be evaluated during each pump vibration test, and will have an Acceptable Range upper limit of 1.05 Vr and an Alert Range upper limit 1.3 Vr. The reviews of the frequency spectrum data ensure that any significant change in the vibration signature will be noted regardless of whether the severity causes the overall level to exceed its criteria. For example, if the overall vibration level is acceptable but the 1x RPM component has increased to greater than 1.3 times the reference value overall level (Vr), then the pump will be placed in the vibration Required Action Range (>0.7 in./sec)."

This review, as described, inherently requires a complete spectrum analysis each time vibration data is evaluated.

RAI Question 9:

The revised relief request included additional vibration data from November 2005. Please provide quarterly vibration data **(if available)** for the quarterly tests performed from November 2005 through February 2007.

Response:

The data from the February 21, 2007 test is attached. Previously submitted test data from May 1994 through November 2005 is included with IST Relief Request PR-03, Rev. 3 (dated June

29, 2006). Additional data for the intervening time is available but is redundant and unnecessary for supporting the conclusions. For the attached plots, the overall vibration levels and the levels of the individual frequency components of interest are directly comparable and consistent with the November 22, 2005 test data as well as the earliest May 25, 1994 test data attached to the PR-03 submittal. The recent and historical vibration data show that there have been no significant changes to the vibration characteristics of the HPCI Main or Booster Pumps during the entire monitored period from 1994 to the present.

RAI Question 10:

In the second paragraph on page 2 of 8, Reference 1, the licensee states that "There are no major vibrational concerns that would result in pump degradation or would prevent the HPCI Pump from performing its design safety function for an extended period of operation." The HPCI Pump is a Type B (i.e standby) pump; and only being tested for "short" runs quarterly. Please provide a detailed analysis that includes evaluation of maximum accident conditions and maximum mission time showing that the HPCI Pump is in fact operable in its current configuration. Also, please submit this detailed analyses/evaluation (including input by pump expert or manufacturer) confirming that the HPCI Pump is currently operable for its purpose.

Response:

PNPS acceptance of the HPCI Pump vibration is not dependent on the short duration of the HPCI design basis mission. The vibration evaluation has concluded that the 4x Booster Pump RPM vibration component is due solely to a structural resonance that causes vibration amplification in the range of the pump maximum speed. The resonance is foundation, pedestal, and piping dependent, and bears no relationship to the mechanical condition of the Booster Pump or the Main Pump. It was determined that the vibration amplitude at 4x Booster Pump RPM caused no damage or degradation to any HPCI Pump components. It was also determined that the vibration spectrum information remained valid and could be used to trend the mechanical condition of the HPCI Pump, which currently shows no discernable change in mechanical condition since this monitoring began.

It should be noted that the HPCI Pump is a turbine-driven variable speed pump that is tested at approximately the rated speed of 4000 RPM. However, in actual design basis service for a small break LOCA the pump speed would, over a period of only a few hours, drop from the vicinity of the 4000 RPM rated speed to considerably lower speeds. At speeds significantly lower than the rated 4000 RPM, the vibration resonant amplification is less with the result that the vibration due to these resonant interactions will be reduced at these lower speeds.

The short duration mission time for the HPCI System following a small-break LOCA serves only to reinforce the conclusion that the Main and Booster Pump would not be adversely affected by the evaluated vibration condition, but it is not the justification for accepting the condition. That justification is based on the evaluation of the vibration and whether there is any potential degradation that can be caused by such a condition.

HPCI Pump Configuration

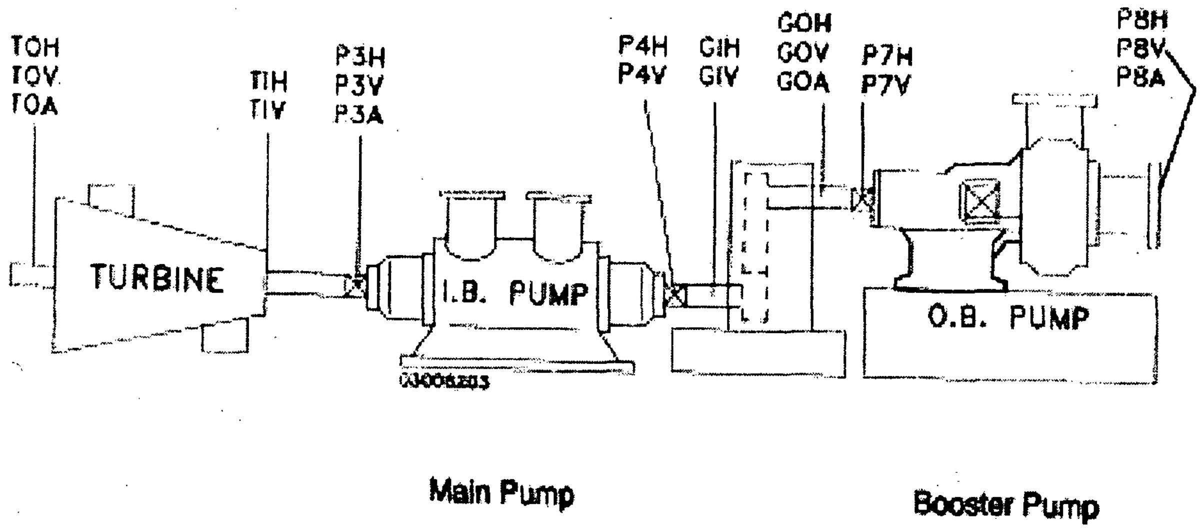
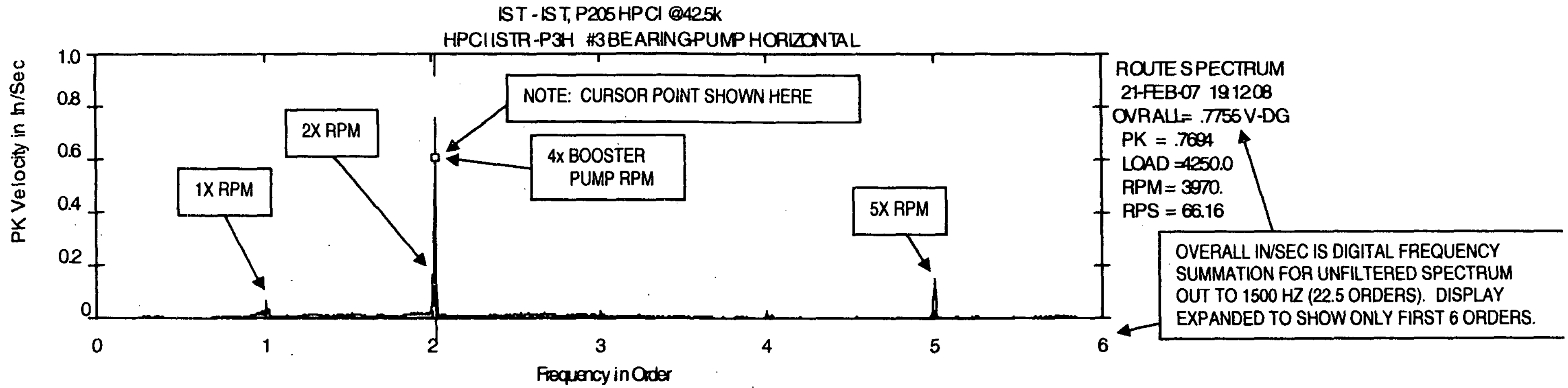


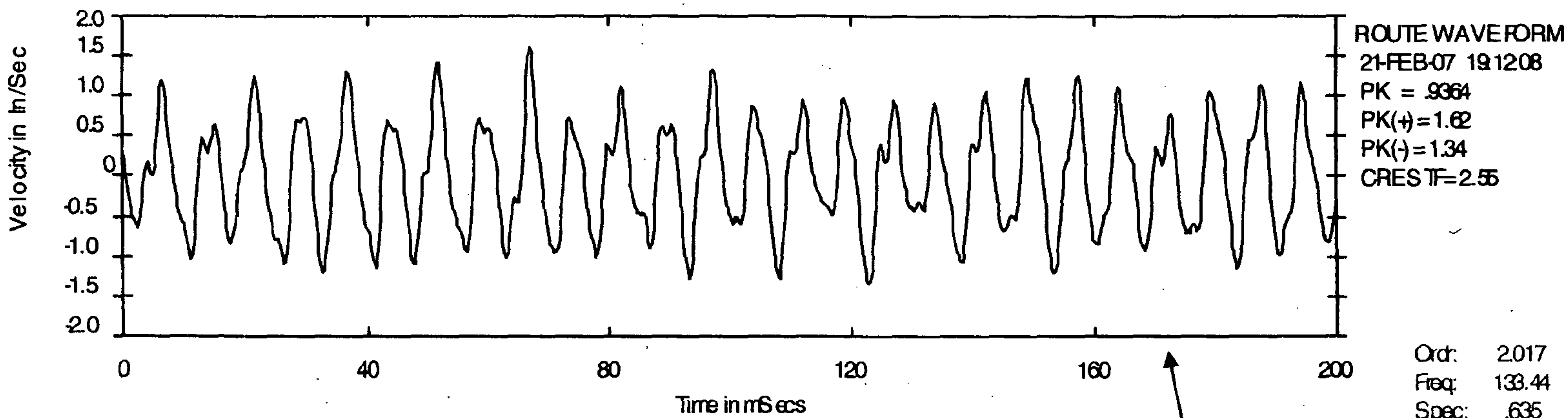
Figure 1. Pilgrim HPCI Pump configuration and Monitoring Points

ATTACHMENT 2

TO ENTERGY LETTER 2.07.056

HPCI Main Pump Vibration Data
(10 pages)





Delete Discrete Peak
@ 4x Booster Pump RPM:

$(0.776)^2$ = $(\text{OA Level})^2$

$-(0.635)^2$ = $(\text{4x BP RPM Peak})^2$

------------ Subtract Sq Values

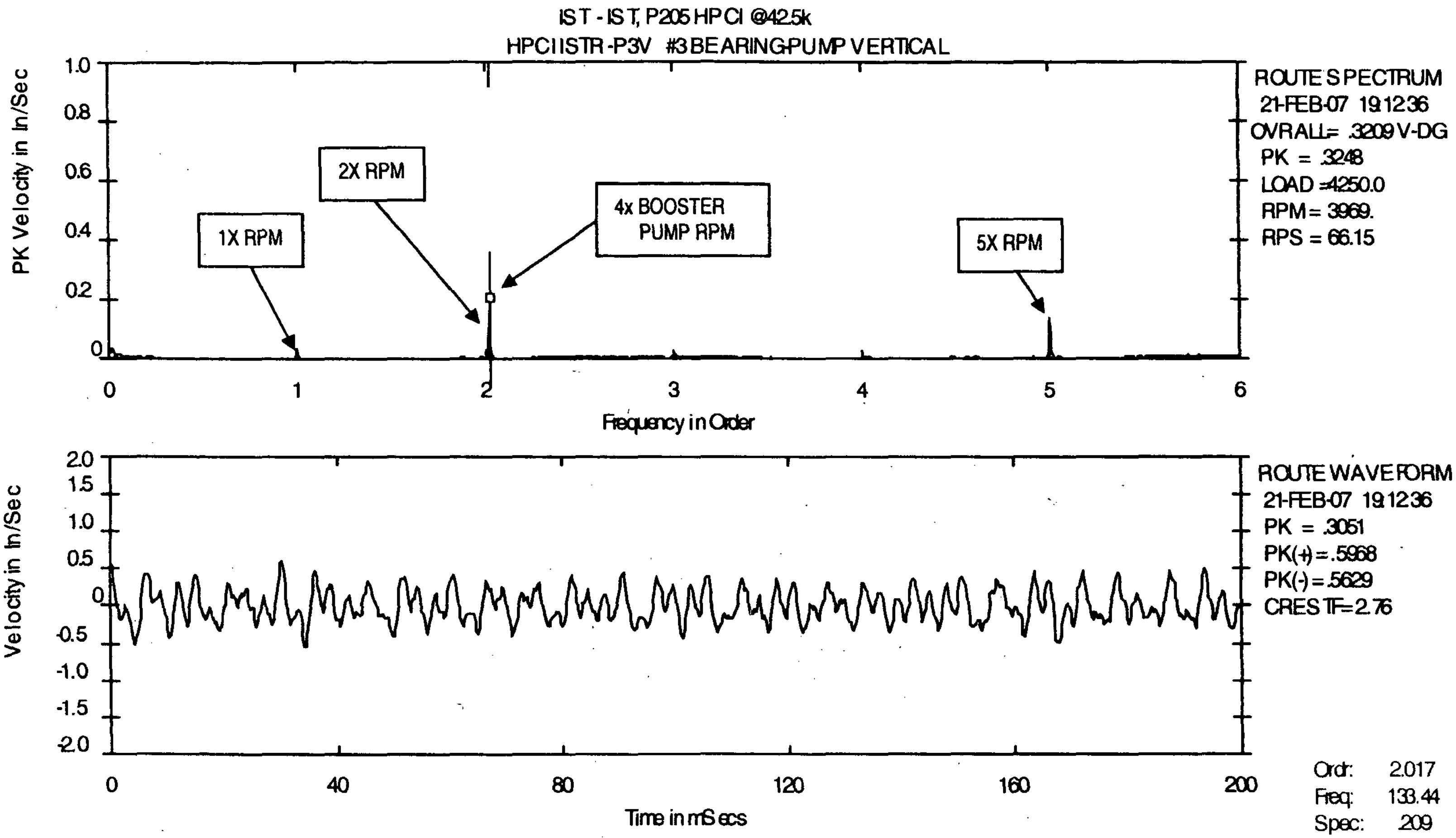
$(0.199)^{0.5}$ = 0.446 In/Sec OA

Ordr: 2.017
Freq: 133.44
Spec: .635

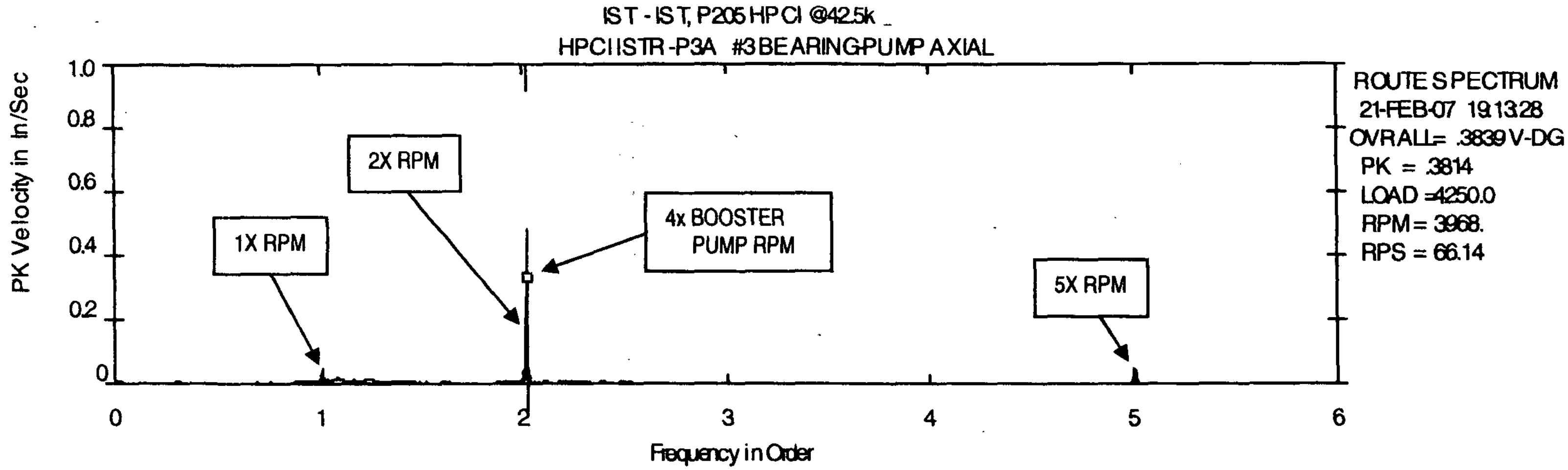
THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP TURBINE-END BEARING HORIZONTAL (P3H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM, WHICH IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM.
THE 1x MAIN PUMP RPM LEVEL IS 0.079 IN/SEC WHILE 2x RPM IS 0.194 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THE 0.175 IN/SEC @ 5x MAIN PUMP RPM IS DUE TO THE 5-VANE MAIN PUMP IMPELLER. THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

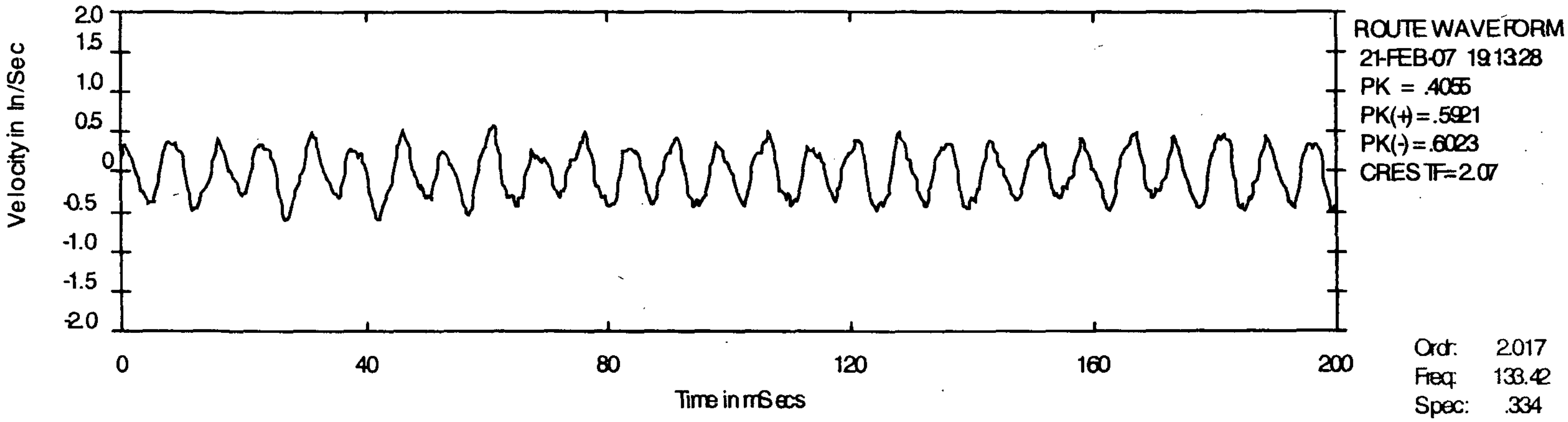
THIS IS THE LAST FRAME OF TIME HISTORY DATA IN VELOCITY (INCH/SEC) UNITS

CURSOR POINT VALUES

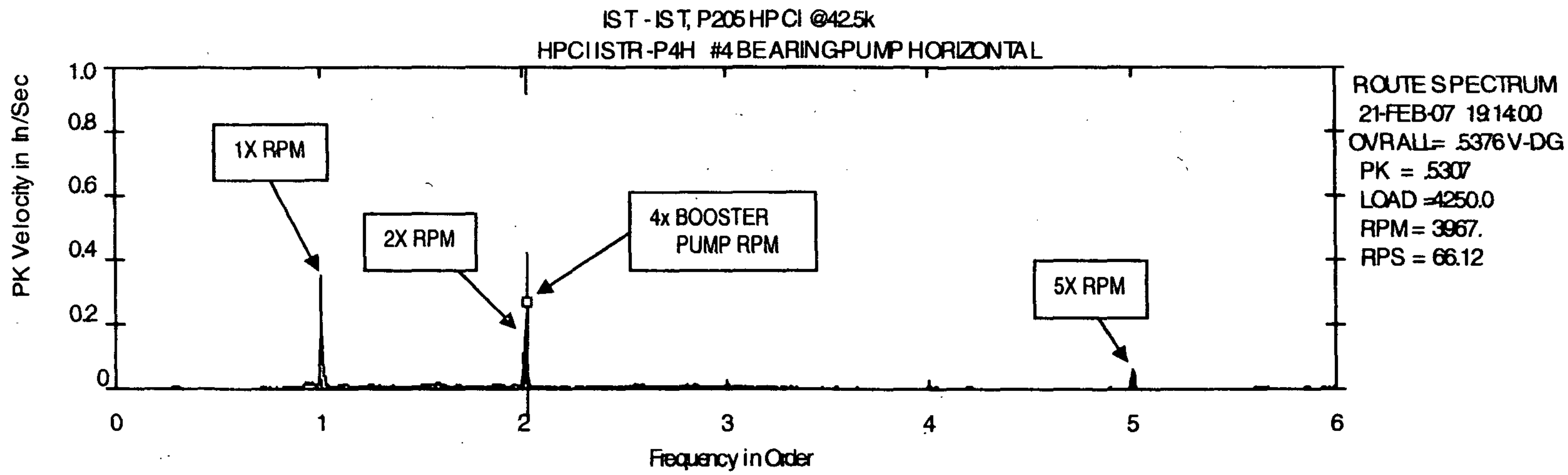


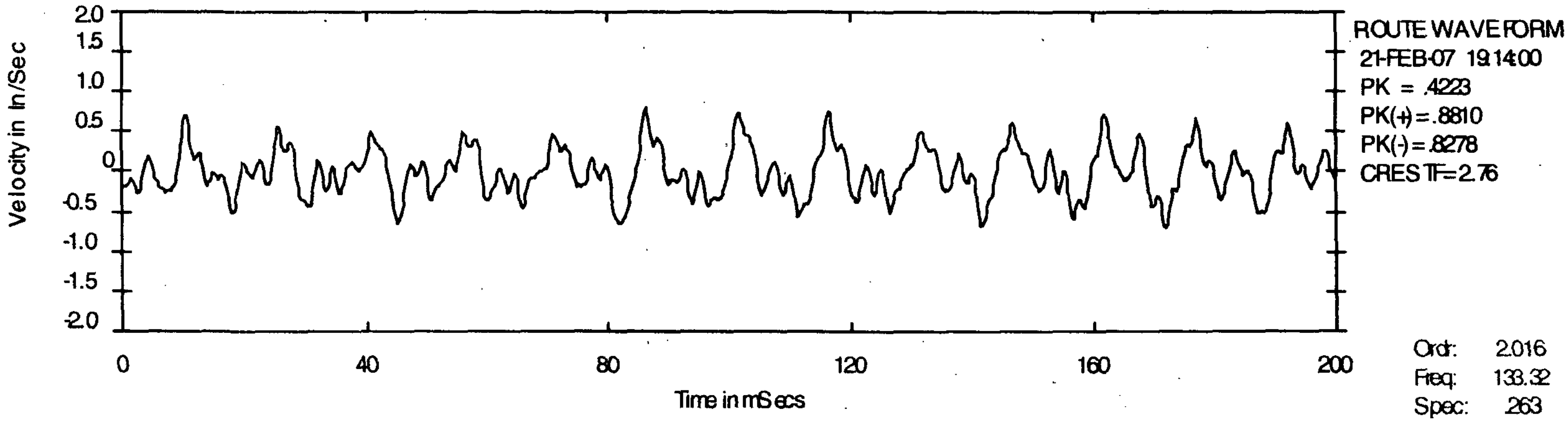
THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP TURBINE-END BEARING VERTICAL (P3V). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS HIGHEST AT 4x BOOSTER PUMP RPM, WHICH AGAIN IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM, BUT THE OVERALL LEVEL IS MUCH LOWER THAN P3H. THE 1x MAIN PUMP RPM LEVEL IS 0.038 IN/SEC WHILE 2x RPM IS 0.026 IN/SEC. THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT. THE 0.163 IN/SEC @ 5x MAIN PUMP RPM IS DUE TO THE 5-VANE MAIN PUMP IMPELLER. THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.





THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP TURBINE-END BEARING AXIAL (P3A). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS HIGHEST AT 4x BOOSTER PUMP RPM, WHICH AGAIN IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM, BUT THE OVERALL LEVEL IS MUCH LOWER THAN P3H.
THE 1x MAIN PUMP RPM LEVEL IS 0.063 IN/SEC WHILE 2x RPM IS 0.047 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THE 0.059 IN/SEC @ 5x MAIN PUMP RPM LEVEL IS DUE TO THE 5-VANE MAIN PUMP IMPELLER. THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

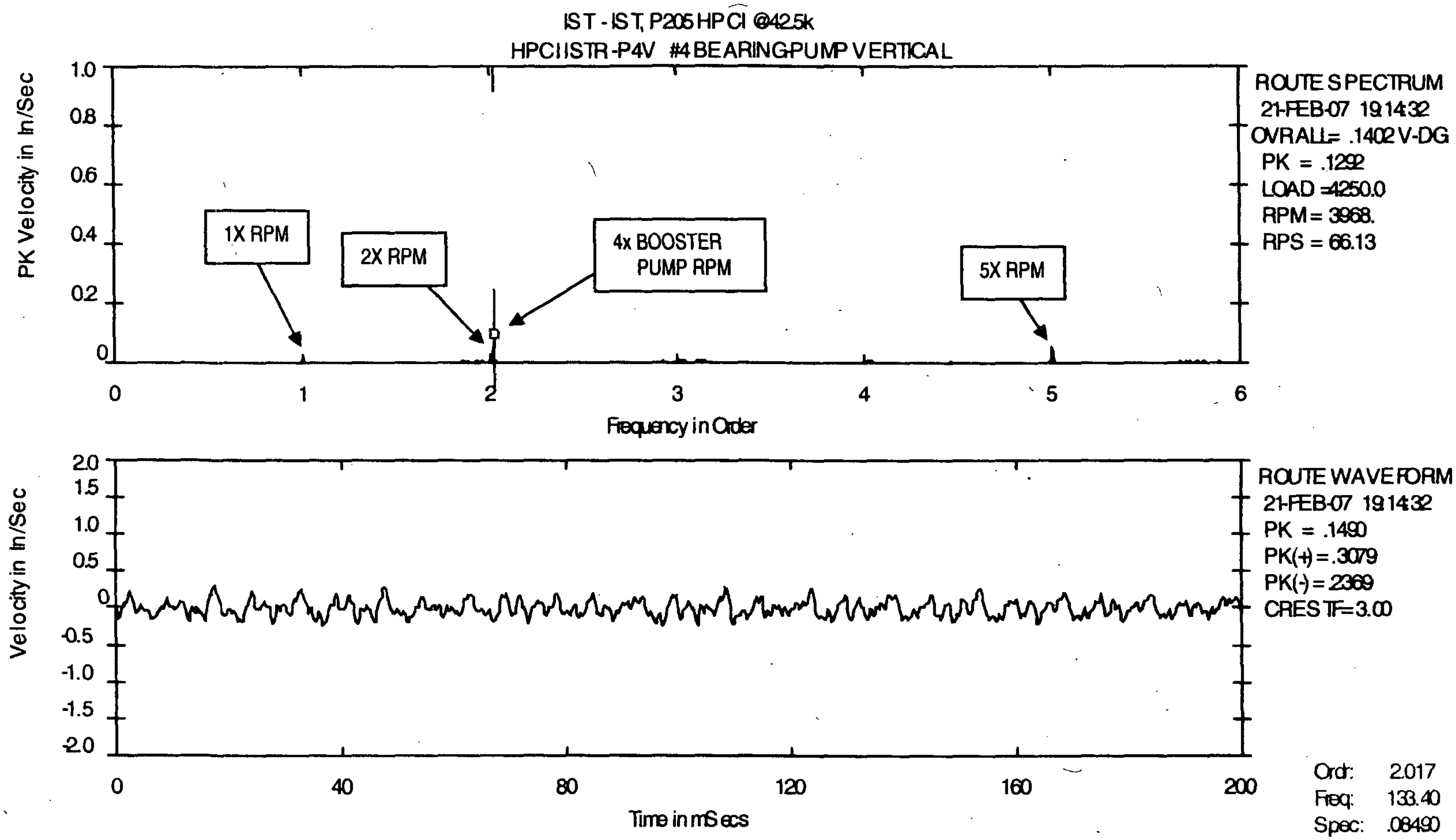




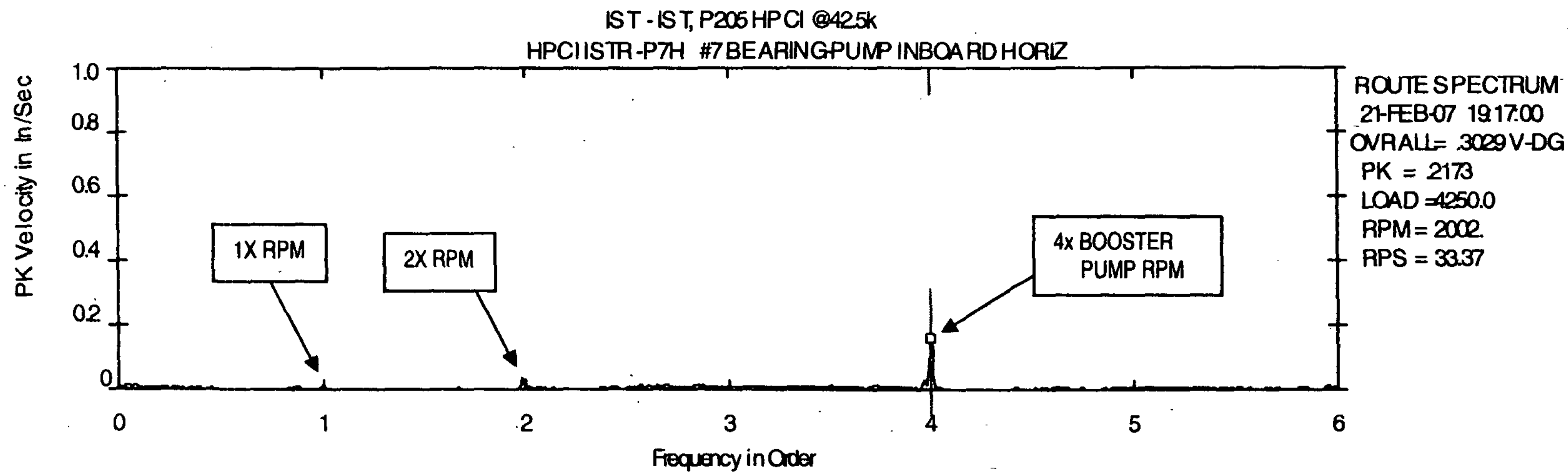
Delete Discrete Peak
@ 4x Booster Pump RPM:

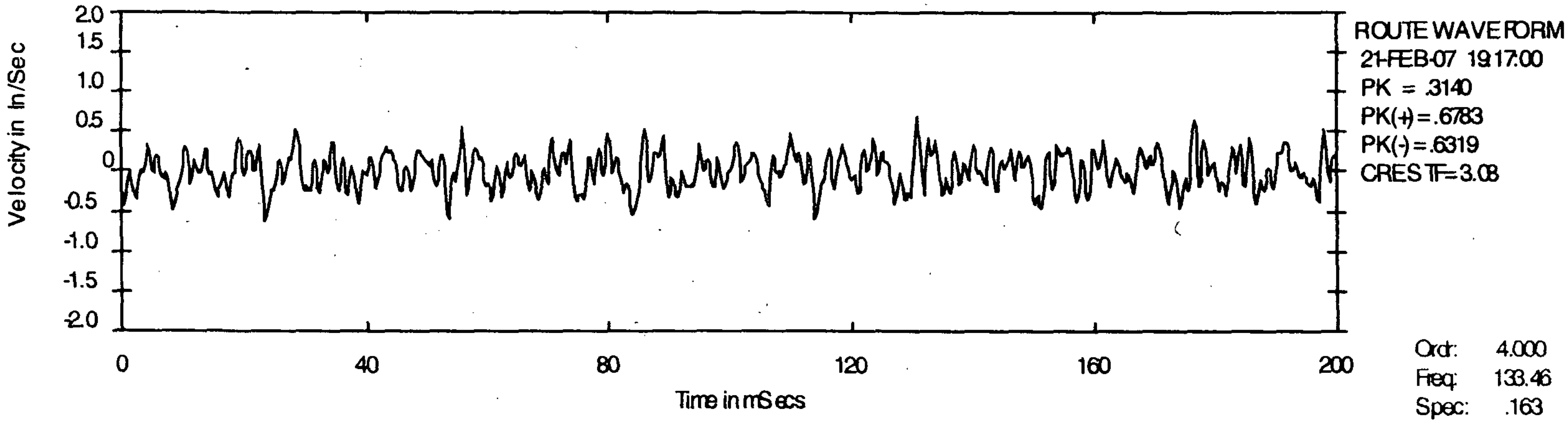
$(0.538)^2$ = (OA Level)^2
- $(0.263)^2$ = (4x BP RPM Peak)^2
------------ Subtract Sq Values
$(0.220)^{0.5}$ = 0.469 In/Sec OA

THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP GEARBOX-END BEARING HORIZONTAL (P4H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 1x MAIN PUMP RPM AND 4x BOOSTER PUMP RPM, WHICH IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM.
THE 1x MAIN PUMP RPM LEVEL IS 0.358 IN/SEC, INDICATING SOME RESONANT AMPLIFICATION FROM A SIDE-TO-SIDE ROCKING MODE.
THE 2x RPM IS 0.124 IN/SEC, INDICATING LITTLE EFFECT FROM MISALIGNMENT.
THE 0.075 IN/SEC @ 5x MAIN PUMP RPM LEVEL IS DUE TO THE 5-VANE MAIN PUMP IMPELLER. THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

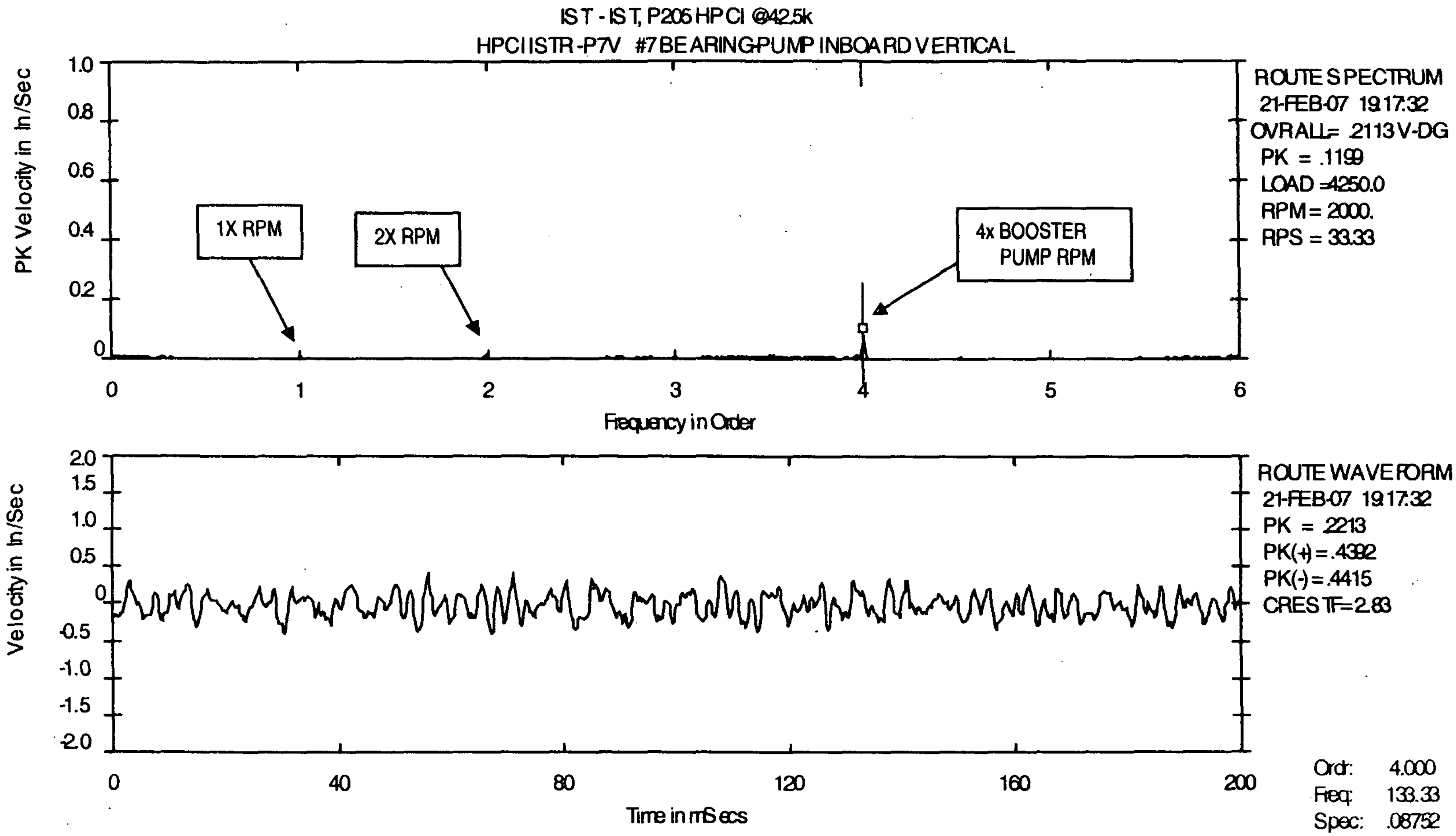


THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP GEARBOX-END BEARING VERTICAL (P4V). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS HIGHEST AT 4x BOOSTER PUMP RPM, WHICH AGAIN IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM, BUT THE OVERALL LEVEL IS MUCH LOWER THAN P4H. THE 1x MAIN PUMP RPM LEVEL IS 0.028 IN/SEC WHILE 2x RPM IS 0.018 IN/SEC. THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT. THE 0.064 IN/SEC @ 5x MAIN PUMP RPM IS DUE TO THE 5-VANE MAIN PUMP IMPELLER. THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

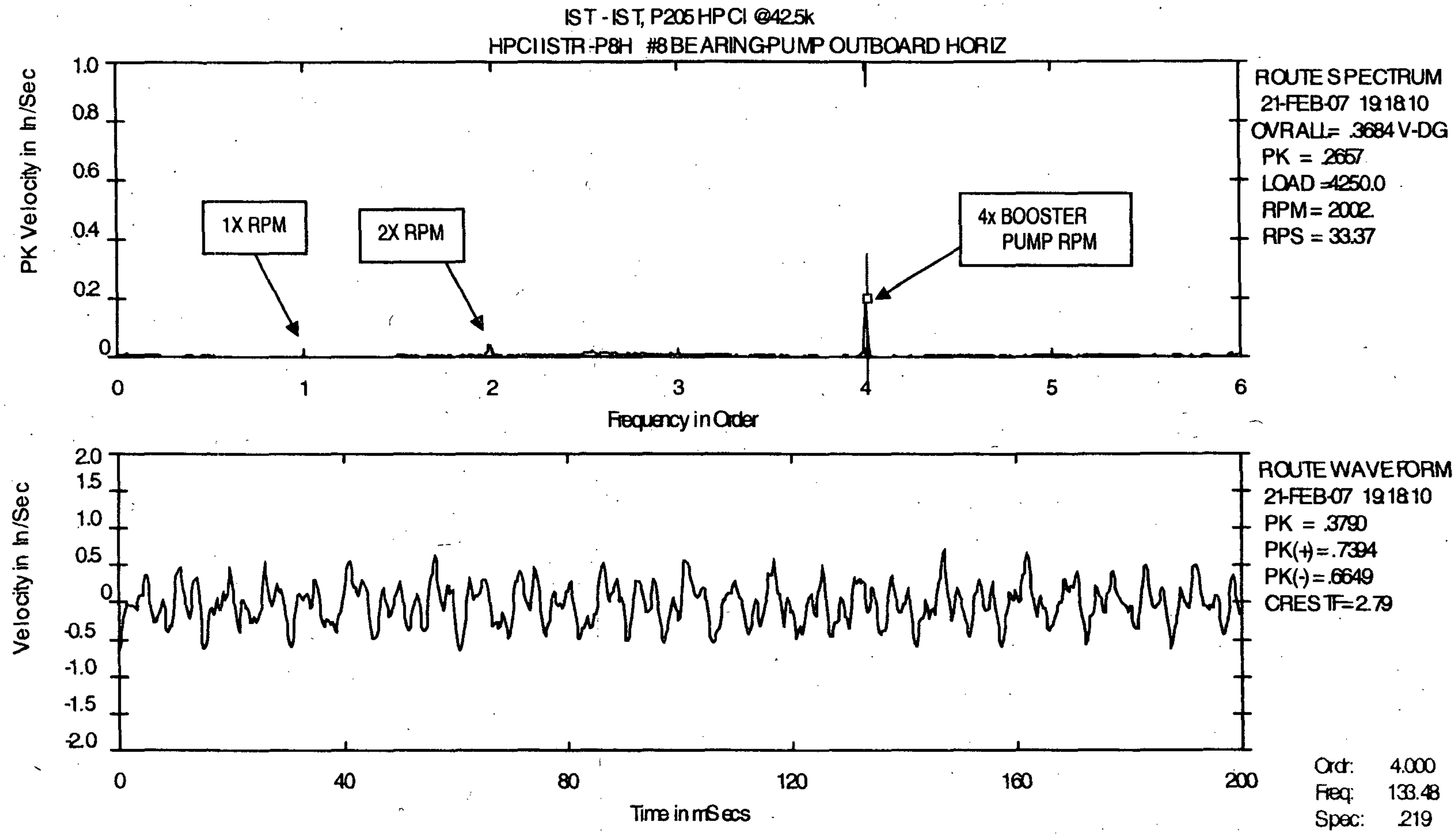




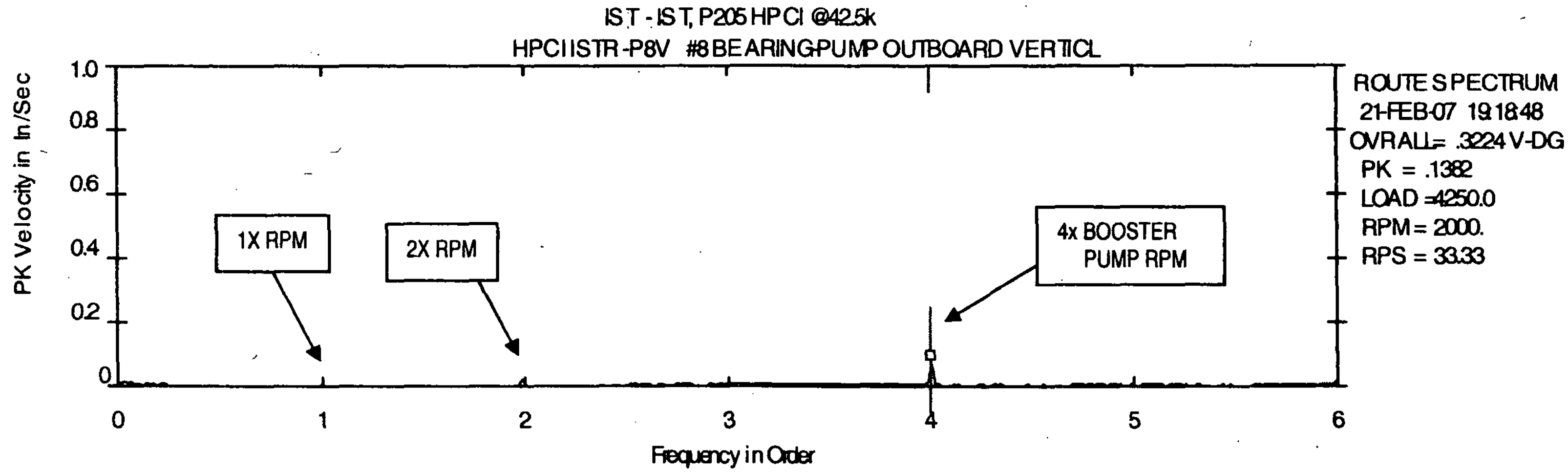
THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP GEARBOX-END BEARING HORIZONTAL (P7H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.163 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER PUMP RPM LEVEL IS 0.015 IN/SEC WHILE 2x RPM IS 0.044 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

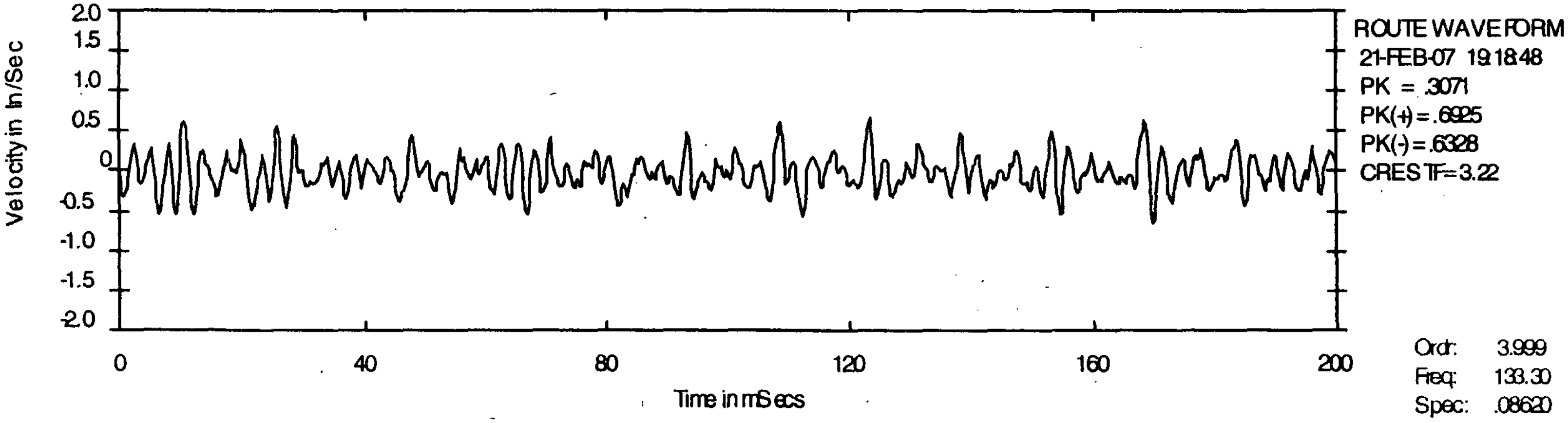


THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP GEARBOX-END BEARING VERTICAL (P7V). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.088 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER PUMP RPM LEVEL IS 0.008 IN/SEC WHILE 2x RPM IS 0.013 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

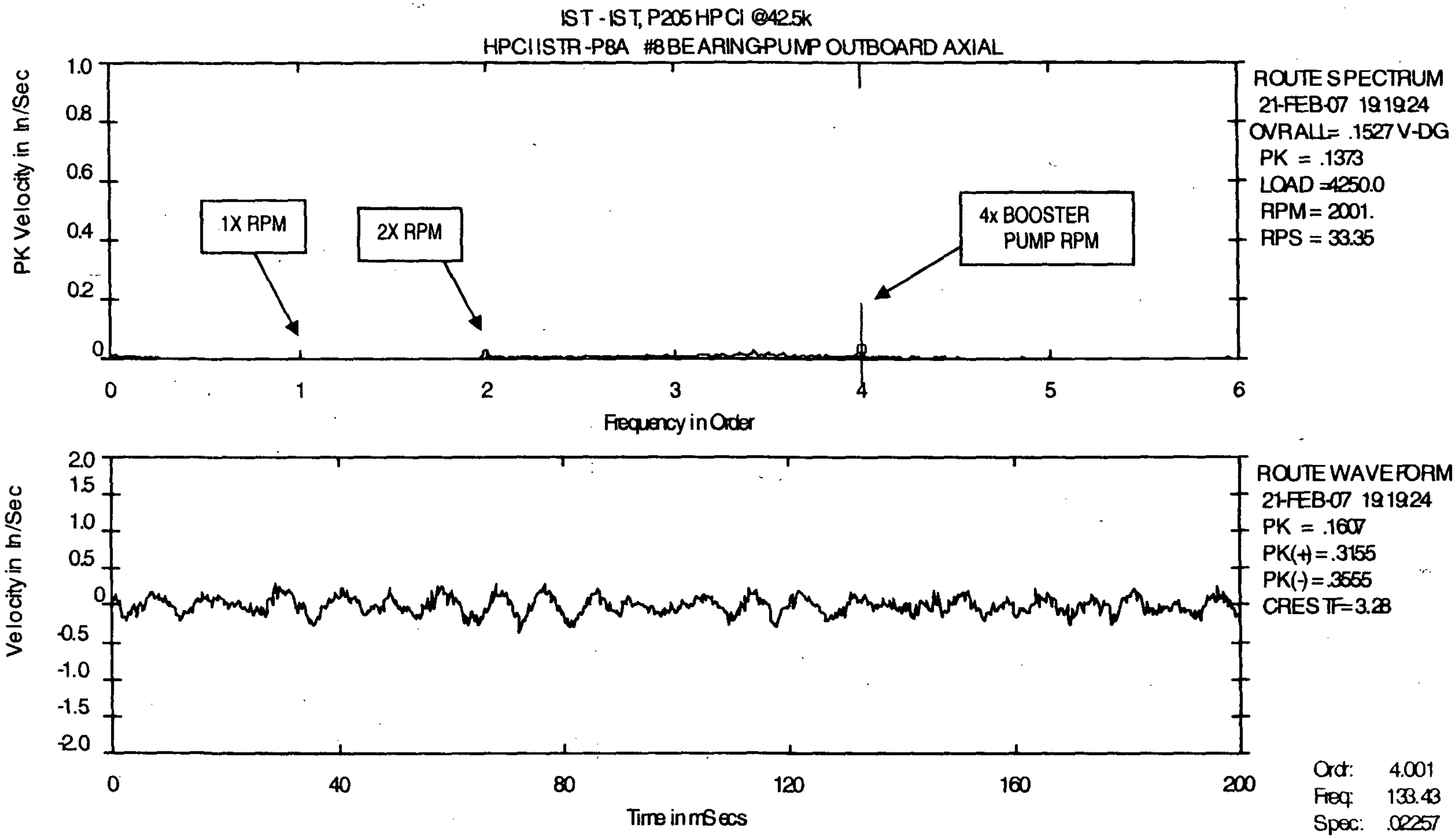


THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP OUTBOARD-END BEARING HORIZONTAL (P8H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.219 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER PUMP RPM LEVEL IS 0.004 IN/SEC WHILE 2x RPM IS 0.054 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.





THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP OUTBOARD-END BEARING VERTICAL (P8V). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.086 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER PUMP RPM LEVEL IS 0.005 IN/SEC WHILE 2x RPM IS 0.023 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.



THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP OUTBOARD-END BEARING VERTICAL (P8A). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 2x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.023 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER PUMP RPM LEVEL IS 0.003 IN/SEC WHILE 2x RPM IS 0.036 IN/SEC.
THIS VIBRATION SHOWS LITTLE UNBALANCE OR MISALIGNMENT.
THERE ARE NO OTHER SIGNIFICANT VIBRATION COMPONENTS.

ATTACHMENT 3

Contractor Report
Entergy Letter No. 2. 08.007, dated January 2008 (14 pages)

Independent Assessment of HPCI Pump Vibration and Performance

Pilgrim Nuclear Power Station

Independent Assessment of Pilgrim High Pressure Coolant Injection (HPCI) Pump Vibration and Performance

January, 2008

Mancini Consulting Services

Engineered Solutions for Superior Pump Performance[SM]

MICHAEL C. MANCINI CONSULTING SERVICES, INC

As the President and primary consultant of Mancini Consulting Services, Michael Mancini has over 30 years experience in pump design, engineering, and repair. Prior to his independent consultancy, he was a Vice President of Ingersoll Dresser Pump Company.

Michael began as a pump Design Engineer at Ingersoll-Rand in 1974, where he worked many years along side seasoned pump designers, including the renowned Dr. Paul Cooper, Igor Karassik, Val Lobonoff, and Fred Antunes. After a long tenure at Ingersoll-Rand, Michael left in 1990 to work independently with pump consultant Dr. Elemer Makay. While working with Dr. Makay he performed numerous pump projects, specializing in root cause analysis of degraded pumping systems and applying leading edge designs for improving pump life and performance. During this time period, Michael authored the Vertical Pump Maintenance Guideline for the Electric Power Research Institute (EPRI) and was appointed president of Hydro Engineering, Inc. (and later HydroAire, Inc.).

Mancini Consulting Services, established in early 2003, has provided training for over 500 mechanics and engineers, and has completed numerous industrial projects related to performing root cause analysis, developing pump specifications, and implementing strategic pump programs.

Michael Mancini is a member of the ASME OM Code, Subgroup ISTB, Inservice Testing of Pumps in Light Water Reactor Nuclear Power Plants. He is also currently part of an EPRI target action group on pump and motor smart component monitoring for new nuclear power plant designs.

Abstract

The consultant was requested to perform an independent assessment of the Pilgrim High Pressure Coolant Injection (HPCI) Pump turbine/pump configuration and the nature of the vibration associated with the HPCI main and booster pumps. The report results were to provide the consultant's expert opinion regarding the HPCI pump performance and its long term operational readiness.

The report concludes that the proposed methodology for monitoring the HPCI pump for degradation uses sound engineering judgment and pump performance monitoring practices. These monitoring and testing activities satisfactorily verify HPCI pump performance and ensure its long term operational readiness.

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Figures

Tables

1 Relief Request

The Pilgrim High Pressure Coolant Injection (HPCI) Pump Relief Request PR-03 proposes to use alternative testing to comply with the ASME OM Code Subsection ISTB 5.2.3[1]. This alternative testing includes mathematically subtracting out the vibration peak associated with the 4x Booster Pump speed, which exceeds 0.70 inches per second (ips) and places the pump in an "action required" condition. This discrete peak is not related to the physical condition or rotating dynamics of the Main Pump rotor or bearing system. The alternative testing also includes quarterly pump and valve operability tests, quarterly minimal analysis of oil samples for the pressure-fed bearings on the Turbine, Main Pump, and Gear Reducer, biannual in-depth lubrication oil sampling on both the pressure-fed and non-pressure-fed bearings, as-needed weekly service of the pump and turbine lube oil system, and cleaning and examination of gear-type shaft couplings every two years.

2 Problem Statement

The HPCI pump has exhibited an inherently high vibration, that exceeds the ASME OM Code Action required Range of 0.70 ips, since its installation at the Pilgrim Nuclear Station. The Main Pump and Booster pump have historically exhibited an inherently high base vibration (greater than 0.325 ips). Additionally, the Main Pump has a vibration peak that exceeds 0.70 ips at a frequency that corresponds with 4 times the speed of the Booster Pump when it is operating at the upper limit of its running speed (8,068 rpm or 4 x 2,017 or 134 Hz).[2] This vibration has been determined to be caused by a resonant frequency in the crossover piping that is excited by the Booster Pump vane pass frequency.

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[1] *ASME OM Code OMa-1996, ISTB 5.2.3, Comprehensive Test*

ISTB 5.2.3(d): Vibration (displacement or velocity) shall be determined and compared with corresponding reference values. Vibration measurements are to be broad band (unfiltered). If velocity measurements are used, they shall be peak. If displacement amplitudes are used, they shall be peak-to-peak.

ISTB 5.2.3(e): All deviations from the reference values shall be compared with the ranges paragraph ISTB 6.2. The vibration measurements shall be compared to the relative and absolute criteria shown in the Alert and Required Action Ranges of Table ISTB 5.2.1-1. For example, if vibration exceeds either 6 V_r or 0.70 in./sec, the pump is in the Required Action Range.

Footnote ISTB 4.3(g) - this footnote specifies that the reference vibration measurements should be representative of the pump, and that the measured vibration will not prevent pump from fulfilling its function.

[2] *This corresponds with approximately 2.05 times the main pump running speed.*

3 History

3.1 System Overview

The HPCI pump is driven by a steam turbine in series with a Booster Pump. The Booster Pump is run through a speed-reduction gearbox with a 1.983 to 1 ratio.

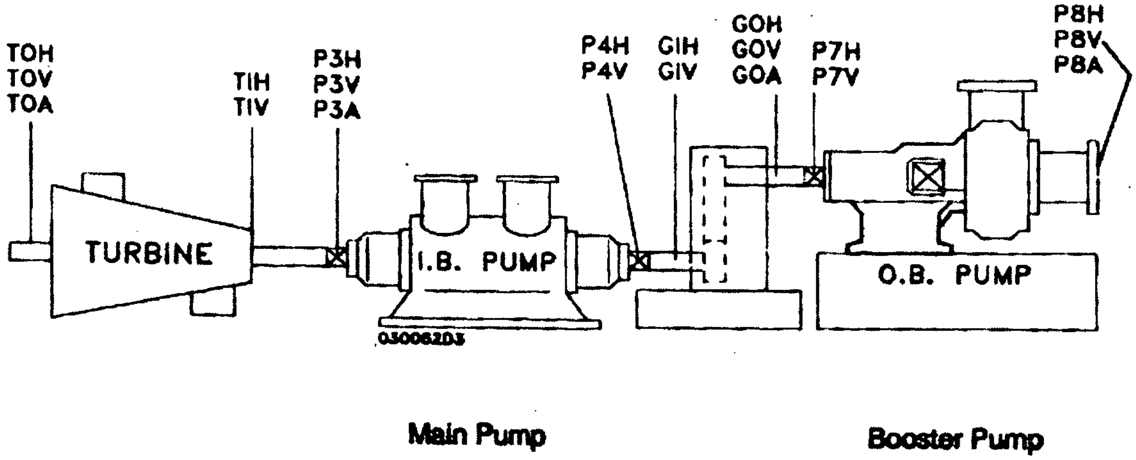

Figure 1: HPCI/Booster Pump Configuration

The HPCI system is safety-related and operates only during a loss of coolant accident (LOCA), during in-service testing (IST) exercises, and during rare plant transients in which the reactor vessel is bottled up following power operation. The unit is variable speed via the steam turbine drive and will operate at a speed during emergency conditions to provide the necessary coolant to the reactor based on reactor vessel pressure.

The pumping system has been designed such that the pump will deliver the required pressure at a maximum speed of 4,000 rpm based on a small break LOCA (less than 0.75 square feet). For smaller breaks, the required flow rate to the reactor will be less and the pumping system will operate at a reduced speed based on the lower system resistance. Also, in the case of a larger-scale (~ 0.75 square feet) small break LOCA, the reactor vessel pressure will decay in time, and the pump will see very little emergency duty at the rated speed with extended emergency service completed at changing lower speeds.

3.2 Pump Configuration

The HPCI pump is a Byron Jackson model DVMX two-stage axially-split pump. The pump has a double suction 1st stage impeller that discharges into a dual volute. The inboard and outboard radial bearings are sleeve-type journal bearings and the thrust bearing is a tilting pad-type bearing.

The Booster Pump is a Byron Jackson model DVS single-stage double-suction pump. The inboard and outboard bearings are spherical roller bearings.

3.3 Operating History

In the early years of the plant, the HPCI pumping system was being tested monthly on a go/no-go basis. Since 1992, the HPCI pump has been tested on a quarterly basis. The average annual testing time is 3-4 hours. In total, the HPCI pump has experienced approximately 180 hours of run time over the past 35 years.

3.4 Vibration Data

As discussed, the HPCI pump has experienced elevated vibrations from the time of its installation. This vibration can be separated into two main categories— base vibration inherent from the Main Pump design independent of any influences caused by the Booster Pump, and vibration resulting exclusively due to excitation forces emanating from the Booster Pump operation. The vibration is attributed to the as-built configuration of the HPCI pump system.

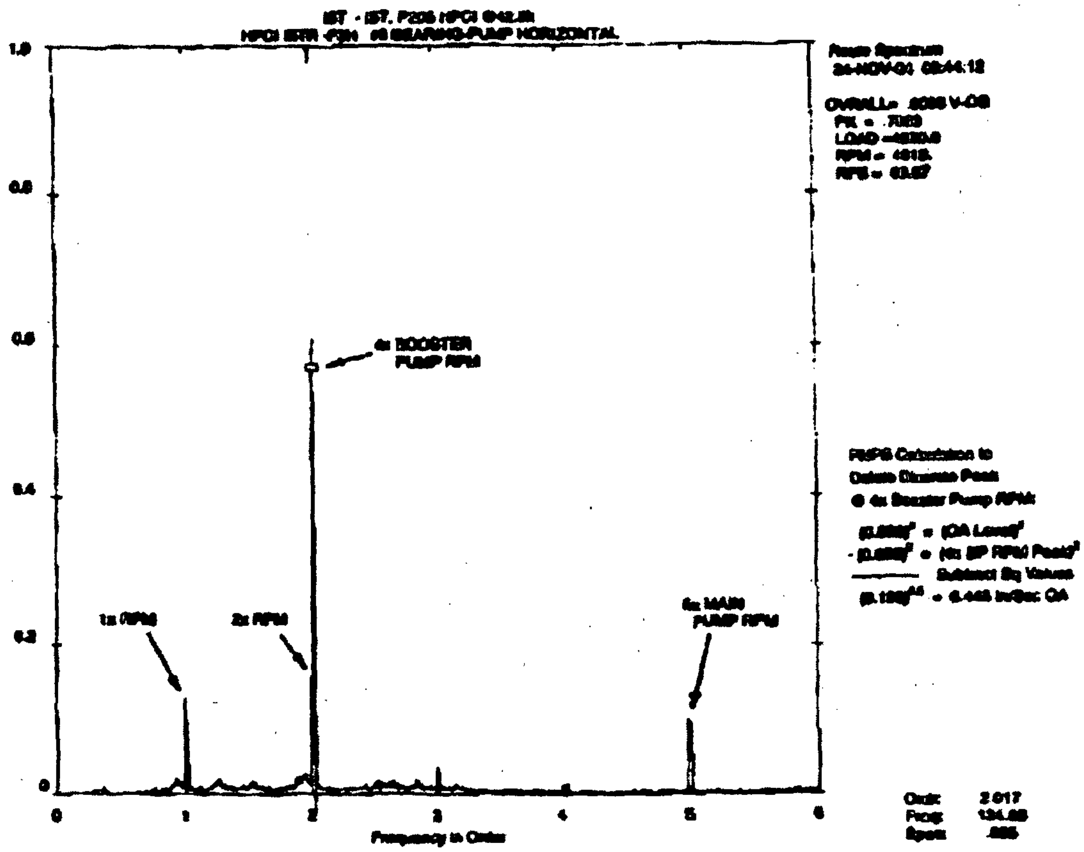

Figure 2: Total Vibration Plotted Against HPCI Running Speed

3.4.1 Main Pump

The Main Pump exhibits elevated base vibration and peaks at 1x and 5x of its tested running speed of 4,000 revolutions per minute (rpm). The 1x vibration peak has been determined to be caused by a horizontal structural rocking mode of the pump pedestal at this frequency. The 5x vibration peak is a result of impact loading of the exiting flow of the 5-vane impeller on the stationary casing dual-volute tongues.

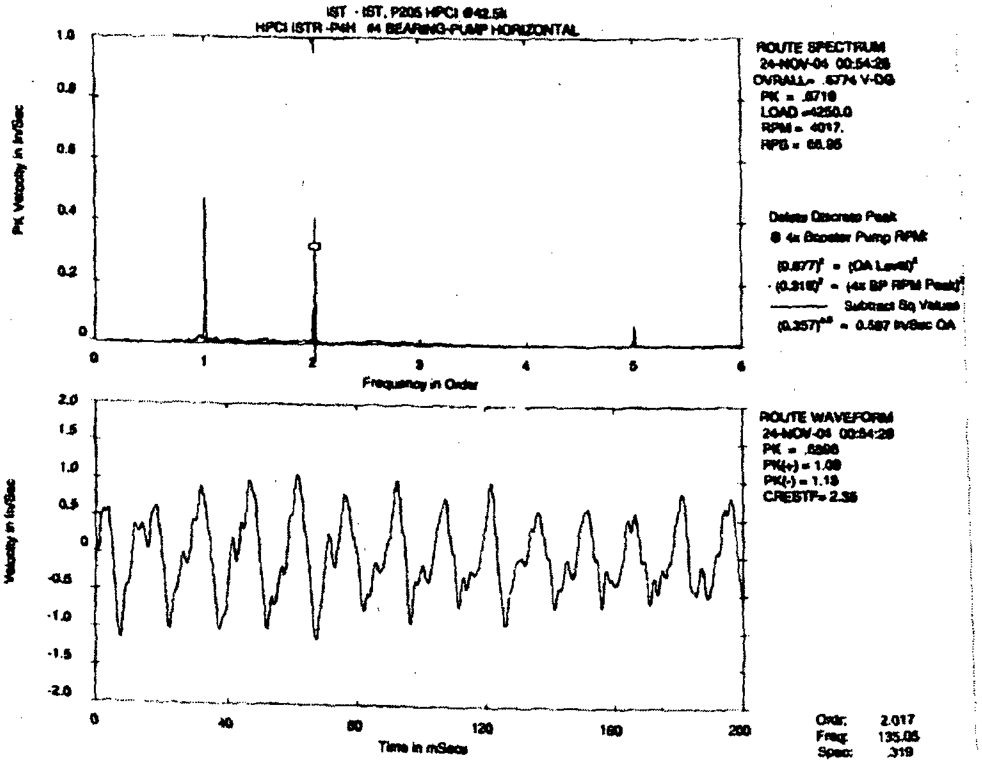

Figure 3: Vibration vs. HPCI Running Speed- Booster Pump Related Vibration Subtracted

3.4.2 Booster Pump

The elevated vibration experienced on the HPCI Main Pump that is generated by Booster Pump operation is experienced mainly at 4 times the Booster Pump running speed (approximately 2.05 times the Main Pump running speed) in the horizontal direction. This vibration is detected by accelerometers mounted at the HPCI pump bearing housings. This vibration is defined in the Apparent Cause section.

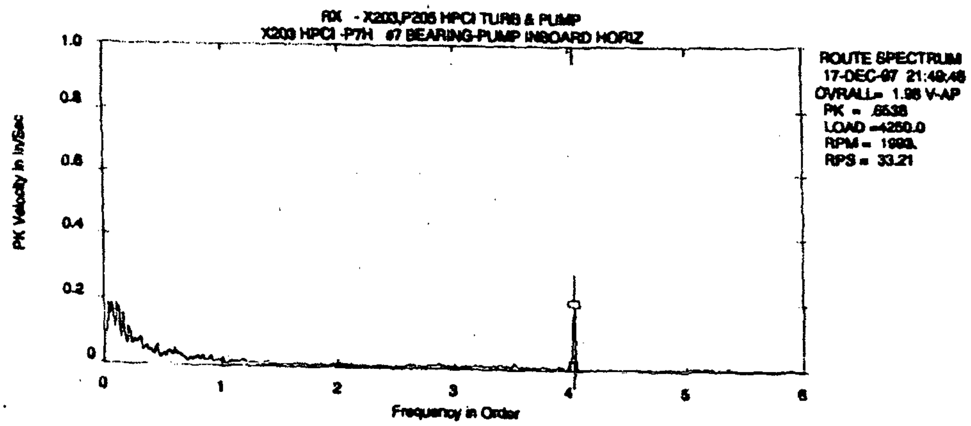

Figure 4: Vibration Plotted Against Booster Pump Running Speed

3.4.3 Summary of Vibration Data

After an in-depth review of the historical vibration data, it is clear that vibration frequencies and values have remained unchanged in the period that this data has been recorded. The constancy of the trendable base vibration values supports the statement that this vibration is not harmful to the pump internal elements. It can be expected that peak vibration parameters at the 2.05x frequency caused by this acoustic resonance will remain within their historically established ranges.

3.5 Performance Data

3.5.1 Early Testing

Testing performed during the early years of the plant (1972-1978) were monthly tests with the objective of verifying that a discharge pressure of 1,225 pounds per square inch gauge (psig) could be reached at the 4,250 gpm flow. As such, many of the tests were performed at speeds less than the rated speed of 4,000 rpm; in fact, a majority of the tests taken between 1972 and 1973 were performed at 3,800 rpm and this lower speed is reflected in the hydraulic performance.

The testing data taken from 1972-1973 between the 3,900 rpm and 4,000 rpm speeds record an average ΔP of 1,196 pounds per square inch differential (psid) at an average flow rate of 4,250 gallons per minute (gpm) running at an average speed of 3,975 rpm. The testing data taken from 1977-1978 between the 3,900 rpm and 4,000 rpm speeds record an average ΔP of 1,197 psid at an average flow rate of 4,250 running at an average speed of 3,987 rpm.

3.5.2 Recent Testing

Performance testing during recent years reflects no degradation in pump performance. Tests taken from 1993-1997 record an average ΔP of 1,226 psid at an average flow of 4,263 gpm running at an average speed of 4,020 rpm. Tests taken from 2001-2007 record an average ΔP of 1,215 psid at an average flow of 4,252 gpm running at an average speed of 3,997 rpm.

3.5.3 Summary of Testing Values

The testing data is taken at differing operating speeds. A good comparison of tested values can be made if these values are adjusted using the affinity laws to estimate what the data would look as if it was all taken at the rated testing speed of 4,000 rpm.

	Average Tested Speed	Average Tested Flow	Average Tested Differential Pressure	Adjusted Flow	Adjusted Differential Pressure
	rpm	gpm	psig	gpm	psig
1972-1973	3,975	4,250	1,196	4,277	1,211
1977-1978	3,987	4,250	1,197	4,264	1,205
1993-1997	4,020	4,263	1,226	4,242	1,214
2001-2007	3,997	4,252	1,215	4,255	1,217

Table 1: Historical Testing Data Adjusted for 4,000 rpm

It is clear that recent performance has not degraded from performance recorded during the early years of the plant. In fact, recent in-service testing data shows a slightly better performance than early testing, due to improved test operating procedures and technological advancement in instrumentation.

4 Analysis

4.1 Apparent Root Cause

The apparent root cause for the vibration experienced at 4 times the Booster Pump operating speed is an excitation of the main-to-Booster Pump crossover piping resonant frequency at the Booster Pump vane pass frequency. The forcing function of this excitation is the impact loading of the Booster Pump impeller discharge upon the Booster Pump casing dual-volute tongues.

4.2 Validation of Apparent Cause

Byron-Jackson has confirmed that this is the apparent root cause in the Tech Note supplied to Pilgrim Station. Additionally, this root cause has been recognized industry-wide based on similar operating performance for installations employing the same pumping unit configuration utilizing the same models.

5 Remedial Actions

There are several courses of action that can be taken to reconcile the vibration issues:

- Make No Design Changes: No design changes will be made. The vibration peak at 2.05x will be mathematically subtracted from the vibration spectra to obtain representative and trendable vibration data of the HPCI Main Pump. Pilgrim will continue to implement the specified test program yearly HPCI vibration testing schedule (as necessitated by the remaining vibration exceeding 0.325 ips).
- Change the Booster Pump Impeller: Substituting the current 4 vane impeller design for a 5 or 7 vane impeller design will alter the frequency of the running speed at which IST is performed and remove this frequency from the range at which the acoustic resonance occurs to a margin of approximately 25% for a 5 vane impeller and 75% for a 7 vane impeller.
- Increase the Gear Ratio: Increasing the gear ratio will alter the maximum running speed of the Booster Pump, bringing it out of the resonant frequency range by a margin dependent on the new ratio. If this change is made, the Booster Pump impeller will need to be trimmed to maintain the design hydraulic requirements.
- Alter Crossover Piping: The resonant frequency of the crossover piping can be changed by altering the piping itself, either by changing the length or diameter of the piping.

6 Independent Assessment

6.1 No Design Changes

It has been determined that the vibration experienced by the pump is not detrimental to pump health. Data taken from tests run during the past 35 years show that there has been no measurable performance degradation in this pump, indicating that this vibration has not caused a large opening of the wear component clearances. Despite the elevated vibration experienced, trended performance data has shown that the current pump design delivers satisfactory performance and reliability. Maintaining the current pump design assures that no element is added that may cause unforeseen problems in the future.

6.2 Altering Number of Impeller Vanes

This change has been made at other plants with moderate success. However, the modified impeller will excite the acoustic resonance when the pumps are running at a lower speed. It must be taken into consideration that IST is performed at the maximum speed limit of where the pump will be run and that the pump will see very little operation during accident conditions at this speed. In an actual accident condition, there is a much greater probability that the pump will be run through a resonant frequency when operating with a 5 or 7 vane impeller. This scenario is much more troubling than the known conditions in which the pump is now being tested.

HPCI Pump Speed	Booster Pump Speed	Resonant Frequency	Booster Pump Vane Pass- 4 Vane	Margin	Booster Pump Vane Pass- 5 Vane	Margin	Booster Pump Vane Pass- 7 Vane	Margin
4,000	2,017		8,069	0.02%	10,086	24.98%	14,120	74.97%
3,600	1,815		7,262	10.02%	9,077	12.48%	12,708	57.47%
3,200	1,614		6,455	20.01%	8,069	0.02%	11,296	39.98%
2,800	1,412		5,648	30.01%	7,060	12.52%	9,884	22.48%
2,400	1,210	8070.0	4,841	40.01%	6,051	25.01%	8,472	4.98%
2,000	1,009		4,034	50.01%	5,043	37.51%	7,060	12.52%
1,600	807		3,227	60.01%	4,034	50.01%	5,648	30.01%
1,200	605		2,421	70.01%	3,026	62.51%	4,236	47.51%
800	403		1,614	80.00%	2,017	75.00%	2,824	65.01%

Table 2: Relationship between Number of Vanes and Resonant Frequency

6.3 Altering the Gear Ratio

Altering the gear ratio in the speed-reduction gearbox will remove pump operation from the resonant condition at the rated testing speed of 4,000 rpm. Trimming the impeller will also be helpful in this case, as it will increase the clearance between the impeller blade and the volute cutwater (Gap B), decreasing the intensity of the vane pass forcing function. However, similar to changing the number of impeller vanes, this alteration will bring the resonant frequency into a lower speed range. Once again, concerns of running through the resonant frequency during an actual accident condition are very strong.

HPCI Pump Speed	Resonant Frequency	Gear Ratio	Booster Pump Speed	Booster Pump Vane Pass	Margin	Gear Ratio	Booster Pump Speed	Booster Pump Vane Pass	Margin	Gear Ratio	Booster Pump Speed	Booster Pump Vane Pass	Margin
4,000			2,017	8,069	0.0%		2,222	8,889	10.1%		2,500	10,000	23.9%
3,600			1,815	7,262	10.0%		2,000	8,000	0.9%		2,250	9,000	11.5%
3,200			1,614	6,455	20.0%		1,778	7,111	11.9%		2,000	8,000	0.9%
2,800			1,412	5,648	30.0%		1,556	6,222	22.9%		1,750	7,000	13.3%
2,400	8,070	1.983	1,210	4,841	40.0%	1.800	1,333	5,333	33.9%	1.600	1,500	6,000	25.7%
2,000			1,009	4,034	50.0%		1,111	4,444	44.9%		1,250	5,000	38.0%
1,600			807	3,227	60.0%		889	3,556	55.9%		1,000	4,000	50.4%
1,200			605	2,421	70.0%		667	2,667	67.0%		750	3,000	62.8%
800			403	1,614	80.0%		444	1,778	78.0%		500	2,000	75.2%

Table 3: Relationship between Gear Ratio and Resonant Frequency

6.4 Altering Crossover Piping

Other utilities have attempted to detune the crossover piping through various means of stiffening. As expected, there has been little-to-no success with this change since it is the acoustic frequency, not the critical reed frequency that is being excited. In no utility has altering the crossover piping alone served to mitigate the vibration issue.

Altering the acoustic resonance requires a change in the pipe length, diameter, or fluid temperature. The current piping configuration represents the shortest length possible. Increasing the pipe length or diameter will reduce the acoustic frequency. A lower acoustic frequency will result in higher vibrations at lower speeds. This represents the same problem as increasing the number of impeller vanes or altering the gear ratio in that there is a high risk of running through the resonant frequency during an actual accident condition.

7 Conclusions

1) It has been determined that the vibration experienced by the pump is not detrimental to pump health. Despite the high vibration experienced, trended performance data has shown that the current pump design delivers satisfactory performance and reliability. Maintaining the current pump design assures that no element is added that may cause unforeseen problems in the future.
2) Performing a design change which "Alters Number of Impeller Vanes" has been made at other plants with moderate success. However, the modified impeller will excite the acoustic resonance when the pumps are running at a lower speed. This scenario is much more troubling than the known conditions in which the pump is now being tested.
3) Altering the gear ratio in the speed-reduction gearbox will remove pump operation from the resonant condition at the rated testing speed of 4,000 rpm. However, similar to changing the number of impeller vanes, this alteration will bring the resonant frequency into a lower speed range. Once again, strong concerns of running through the resonant frequency during an actual accident condition make this option a poor choice.
4) Performing a design change which "Alters the Pump Crossover Piping" has been made at other plants with little to no success.
   - Detuning the crossover piping through various means of stiffening will not improve vibration characteristics since this change does not impact the pump acoustic frequency.
   - Increasing the pipe length or diameter is the only crossover piping modification which will reduce the acoustic frequency. However, a lower acoustic frequency will result in higher vibrations at lower speeds. This represents the same problem as increasing the number of impeller vanes or altering the gear ratio, which also makes this option a poor choice.

5) A review of the present IST and performance monitoring practices utilized at Pilgrim (as described in relief request PR-03 Revision 3) concludes the following:
   - Mathematically subtracting the discrete vibration peak at 2.05x the Main Pump running speed is the safest and most conservative action that can be taken, considering the possible repercussions of bringing the forcing function of the resonant condition into a lower speed range where the pump would operate during an actual accident condition.
   - Mathematically subtracting the discrete vibration peak at 2.05x the Main Pump running speed will still allow the plant to monitor changes in vibration caused by the Main Pump rotor and bearing system, as this point is unrelated to these parameters.
   - Pilgrim Station's alternative testing plan includes more than sufficient monitoring to trend pump performance and will detect any degradation that may occur.

8 Summary

The independent assessment confirms that (a) the Pilgrim HPCI pump has not degraded during its 35 years of service due the observed pump vibration, and (b) the proposed HPCI pump inservice testing and performance monitoring activities successfully monitor pump health, and ensure the continued operational readiness of this pump to meet its safety function.

Appendix A: Documents Reviewed by Mancini Consulting Services

ESR Response Memorandum No. ERM 90-445 Rev.2 — *Date: 6/17/1994*
- *Response to ESR 90-146*
- *Vibration Frequencies of Interest*
- *Telephone Call Record- Byron Jackson*
- *Byron Jackson TechNote No. 9112-80-018*

Outgoing Letter from Entergy to NRC- ELNRC 1.2.04.010 — *Date: 2/10/2004*
- *Pilgrim Response to NRC Request for Additional Information*
- *HPCI Pump IST Vibration Evaluation*

Outgoing Letter from Entergy to NRC- ELNRC 2.04.046 — *Date: 6/2/2004*
- *HPCI Pump Relief Request PR-03, Revision 1*
- *Additional Information*
- *Summary of Commitments*

HPCI Inservice Testing Vibration Exemption Presentation — *Date: 12/8/2004*

Outgoing Letter from Entergy to NRC- ELNRC 2.05.012 — *Date: 2/24/2005*
- *HPCI Pump Relief Request PR-03, Revision 2*
- *Summary of Commitments*
- *Response to NRC Draft Request for Additional Information*
- *HPCI Pump Configuration and Historical and Current Vibration Data*

Incoming Letter from NRC to Entergy- NRCLE 1.1.05.0107 — *Date: 8/29/2005*
- *Safety Evaluation by the Office of the NRC- Docket No. 50-293*

Outgoing Letter from Entergy to NRC- ELNRC 1.2.06.008 — *Date: 6/29/2006*
- *HPCI Pump Relief Request PR-03, Revision 3*
- *HPCI pump November 2005 Vibration Test Results*
- *HPCI pump Configuration and Historical Vibration Test Results*

Byron Jackson Pumps V-0303 — *Date: 9/19/2006*
- *Technical Manual for Installation, Operation, and Maintenance of B.J. Horizontal Double-Bearing Pumps (Type DVMX)*
- *Pump Assembly for High Pressure Coolant Injection Instruction Type "DVMX and DVS"*
- *Bill of Materials*
- *Specification No. D.12- Welding Procedure for Intermittent Welding Impeller Wear Rings to Impellers*
- *Procedure for Tightening Case Parting Nuts*
- *Installation, Operation, and Maintenance Instructions- Type "U" Mechanical Seals*
- *Borg-Warner Separators- Cyclone and Magnetic*
- *Instruction Manual- Speedmaster 4000 Series High-Speed Unit*

Outgoing Letter from Entergy to NRC- ELNRC 2.07.056 — *Date: 7/12/2007*
- *Response to NRC Request for Additional Information*
- *HPCI Main Pump Vibration Data*

Historical Tested Performance Data — *Date: 1972-1973, 1977-1978*

HPCI Pump Trends — *Date: 3/5/1993 – 8/21/2007*

Byron Jackson Drawing No. 2271-7-1 Rev. E3	*DVS IF 5825 Cross-Section*
Boston Edison Company Drawing No. MIJ6-4	*Process Diagram, HPCI System*
Byron Jackson Drawing No. 2271-8-1 Rev. E2	*DVMX Pump IF-5824 Cross-Section*
Byron Jackson Drawing No. 2F-1245	*Piping Diagram 10x12x15 2 Stg. DVMX*