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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,

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

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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.

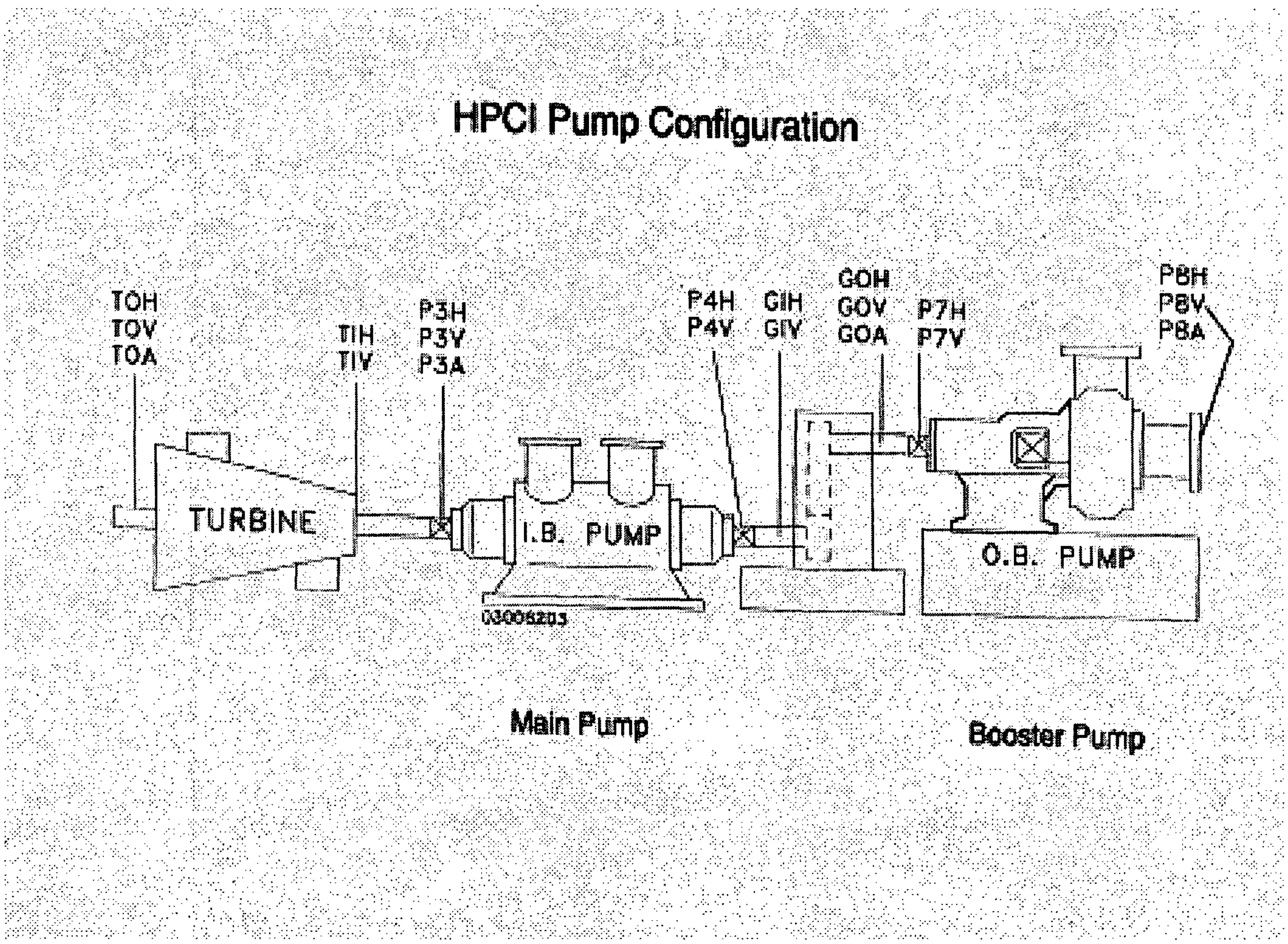
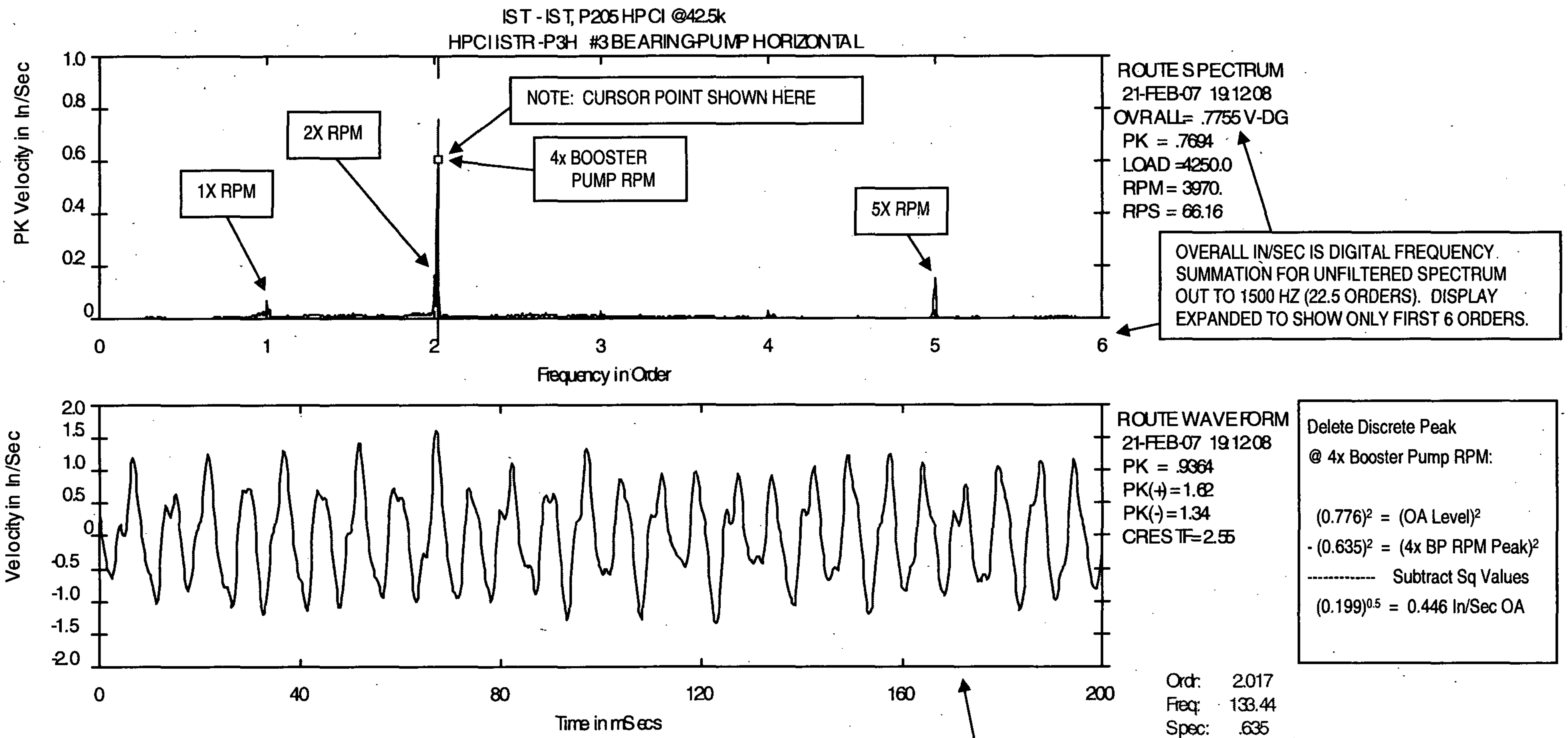


Figure 1. Pilgrim HPCI Pump configuration and Monitoring Points

ATTACHMENT 2

TO ENTERGY LETTER 2.07.056

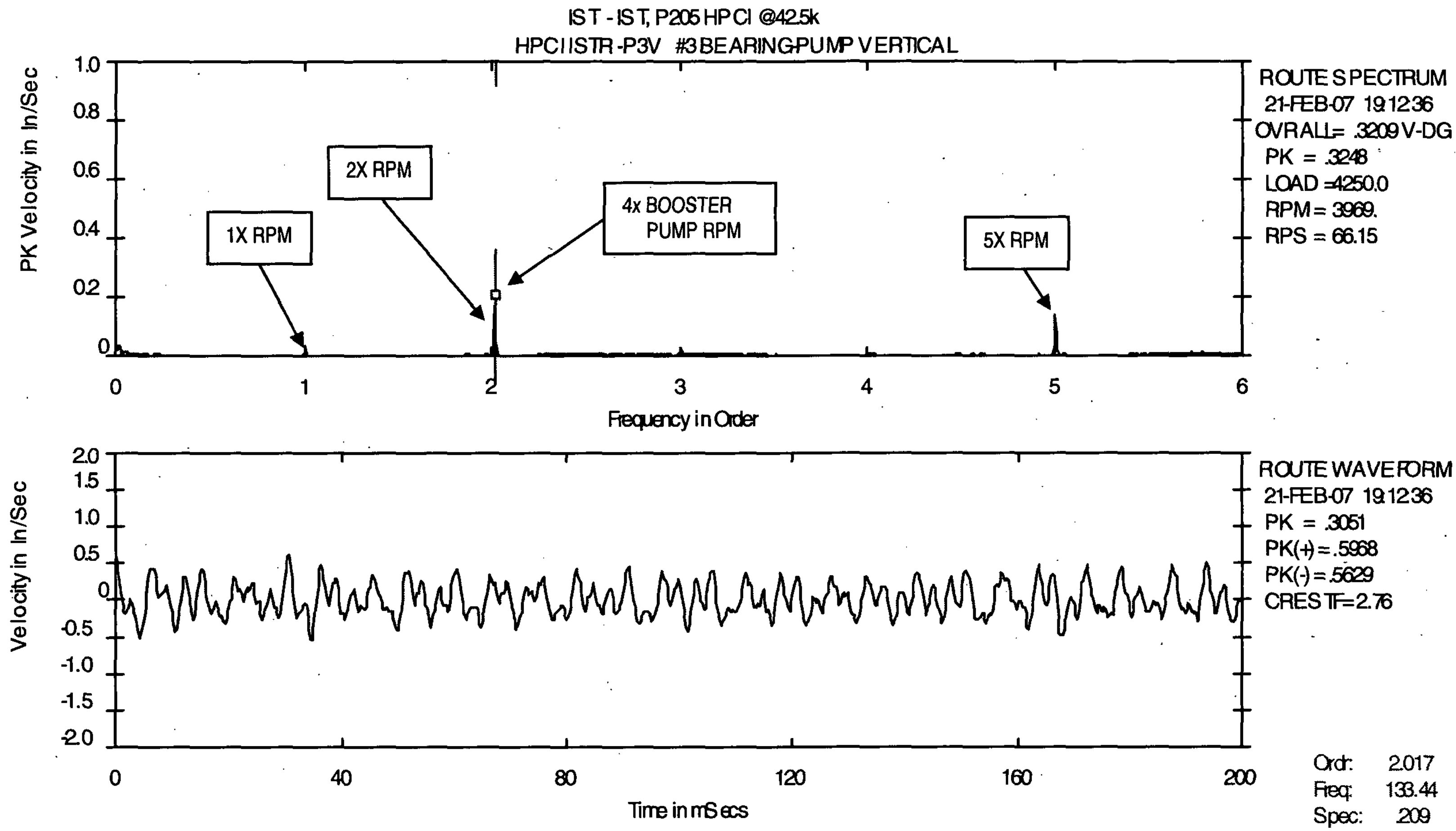
HPCI Main Pump Vibration Data
(10 pages)



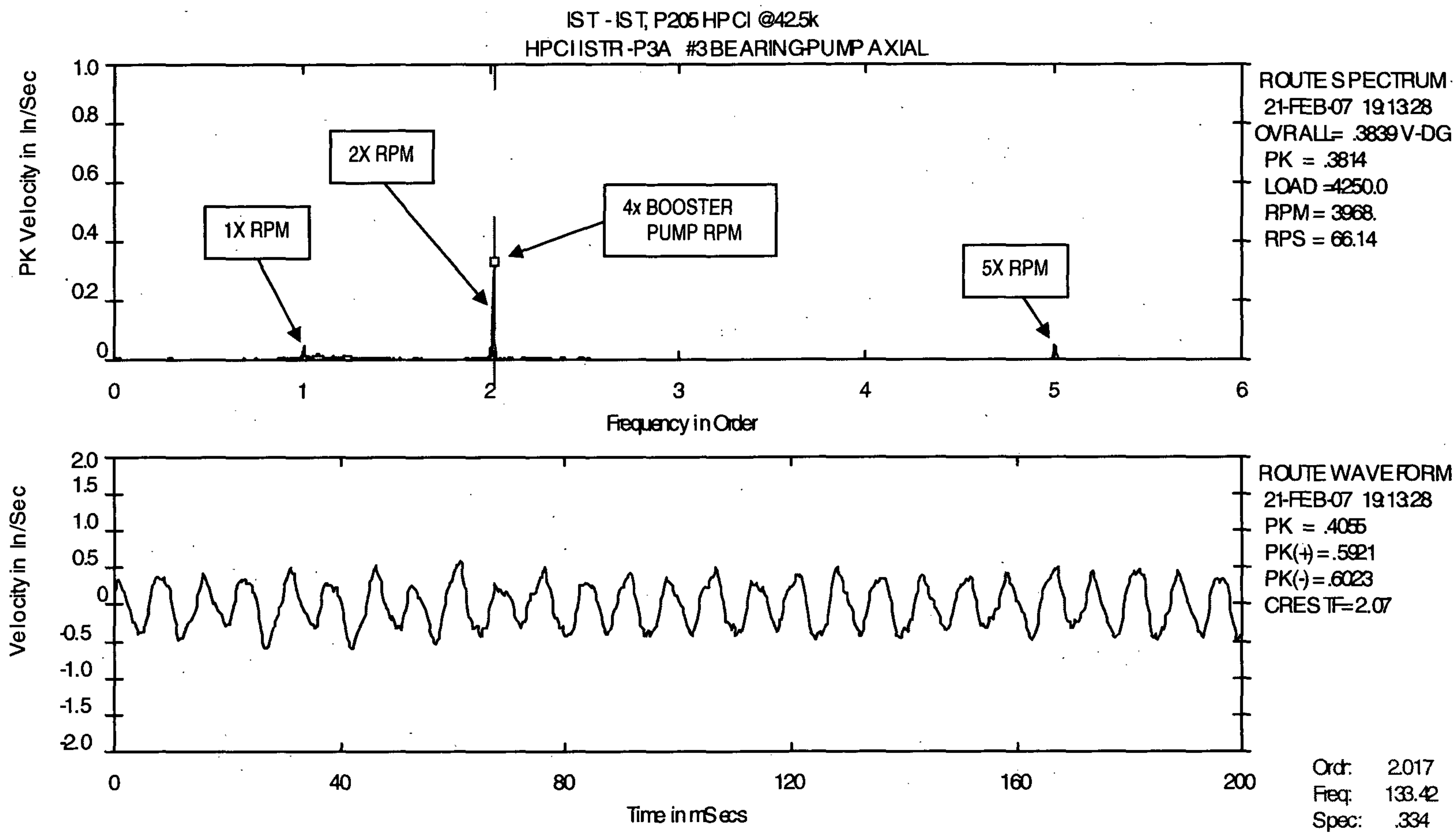
THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP TURBINE-END BEARING HORIZONTAL (P3H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM, WHICH IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM.
THE 1x MAIN PUMP RPM LEVEL IS 0.079 IN/SEC WHILE 2x RPM IS 0.194 IN/SEC. THIS 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

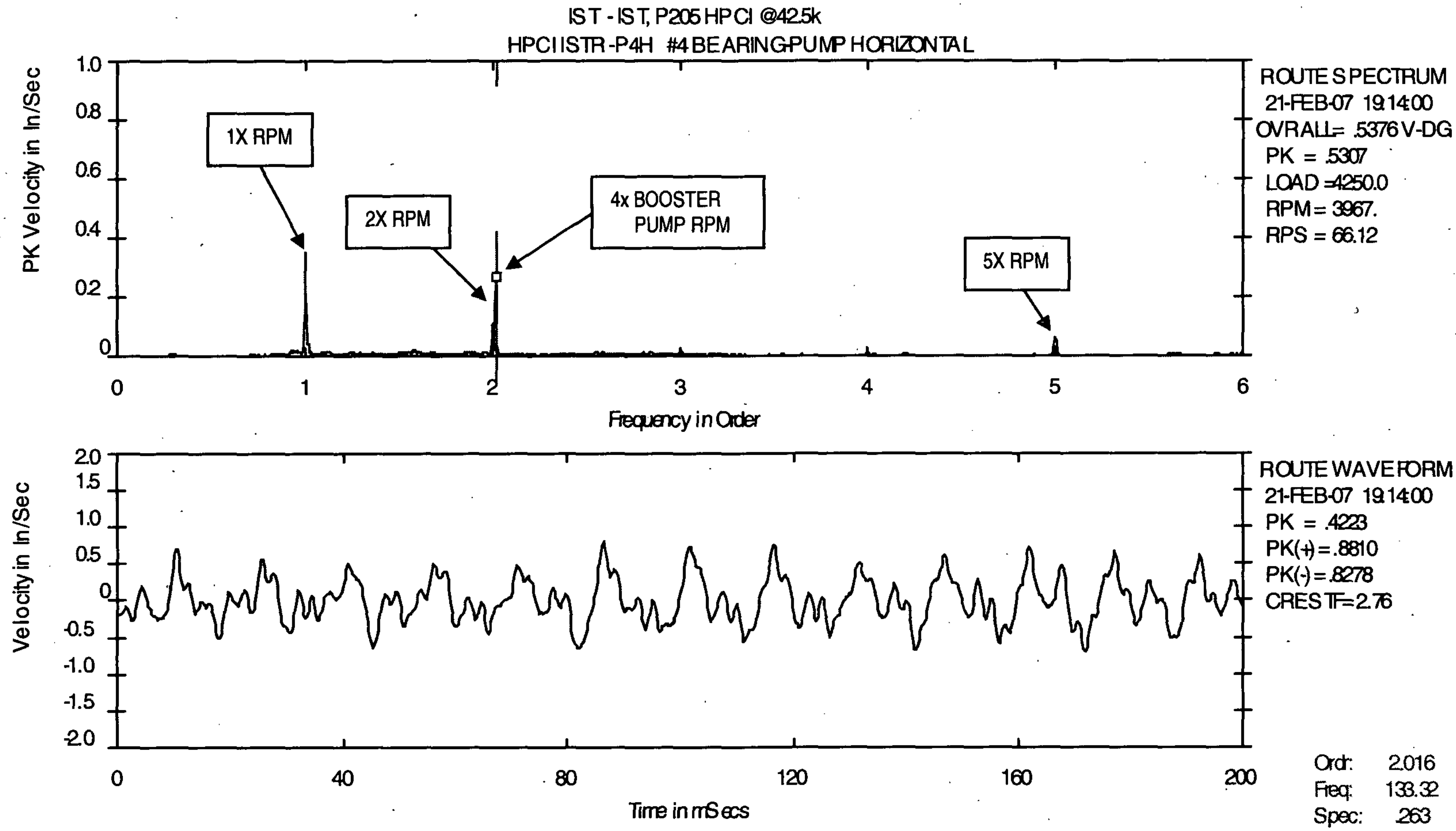
CURSOR POINT VALUES



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.



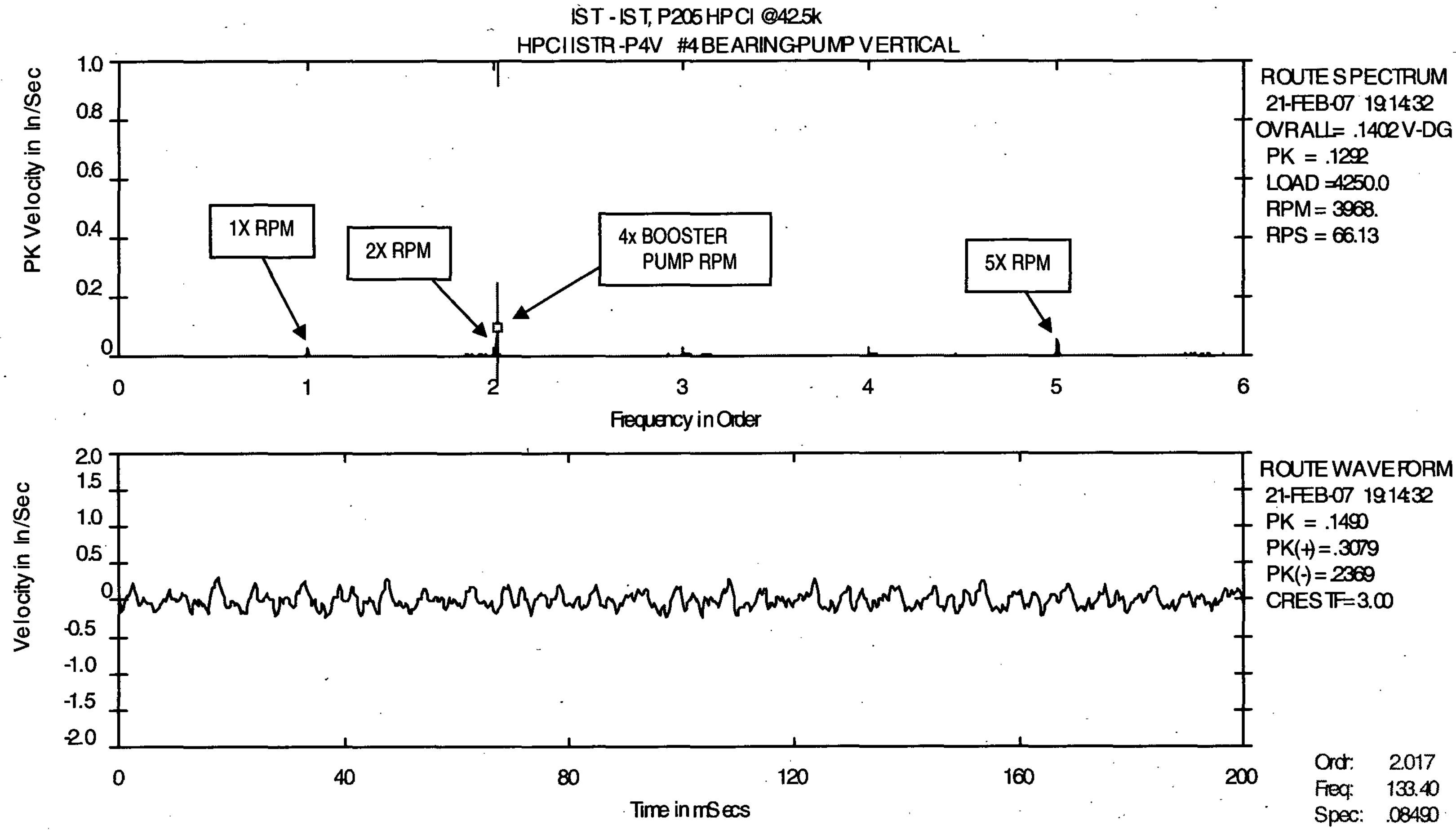
THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP TURBINE-END BEARING AXIAL (P3A). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS HIGHEST AT 4x BOOSTER PUMP RPM, WHICH AGAIN IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM, BUT THE OVERALL LEVEL IS MUCH LOWER THAN P3H.
THE 1x MAIN PUMP RPM LEVEL IS 0.063 IN/SEC 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.



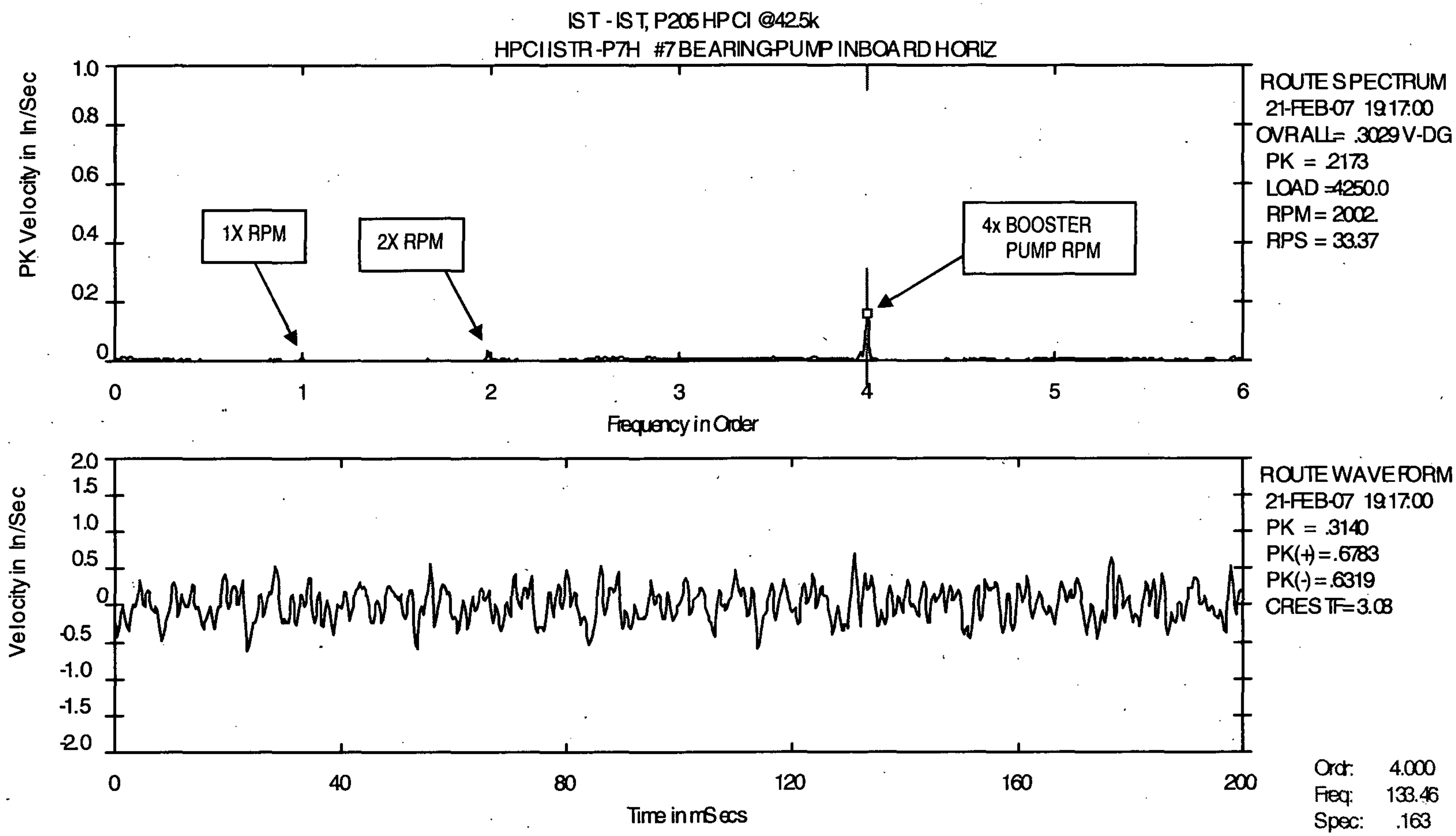
Delete Discrete Peak
@ 4x Booster Pump RPM:

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

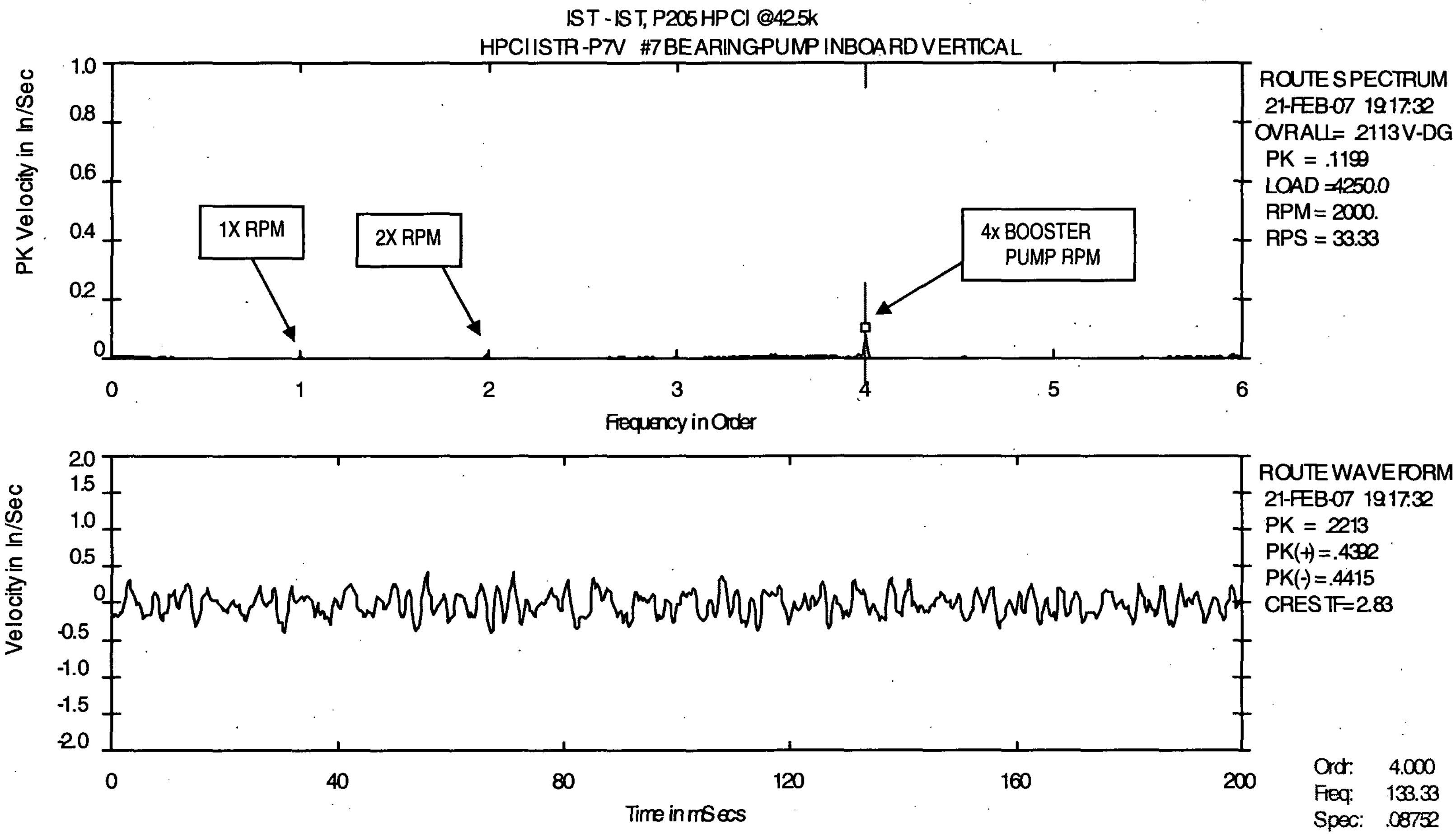
THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP GEARBOX-END BEARING HORIZONTAL (P4H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 1x MAIN PUMP RPM AND 4x BOOSTER PUMP RPM, WHICH IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM.
THE 1x MAIN PUMP RPM LEVEL IS 0.358 IN/SEC, INDICATING SOME 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.



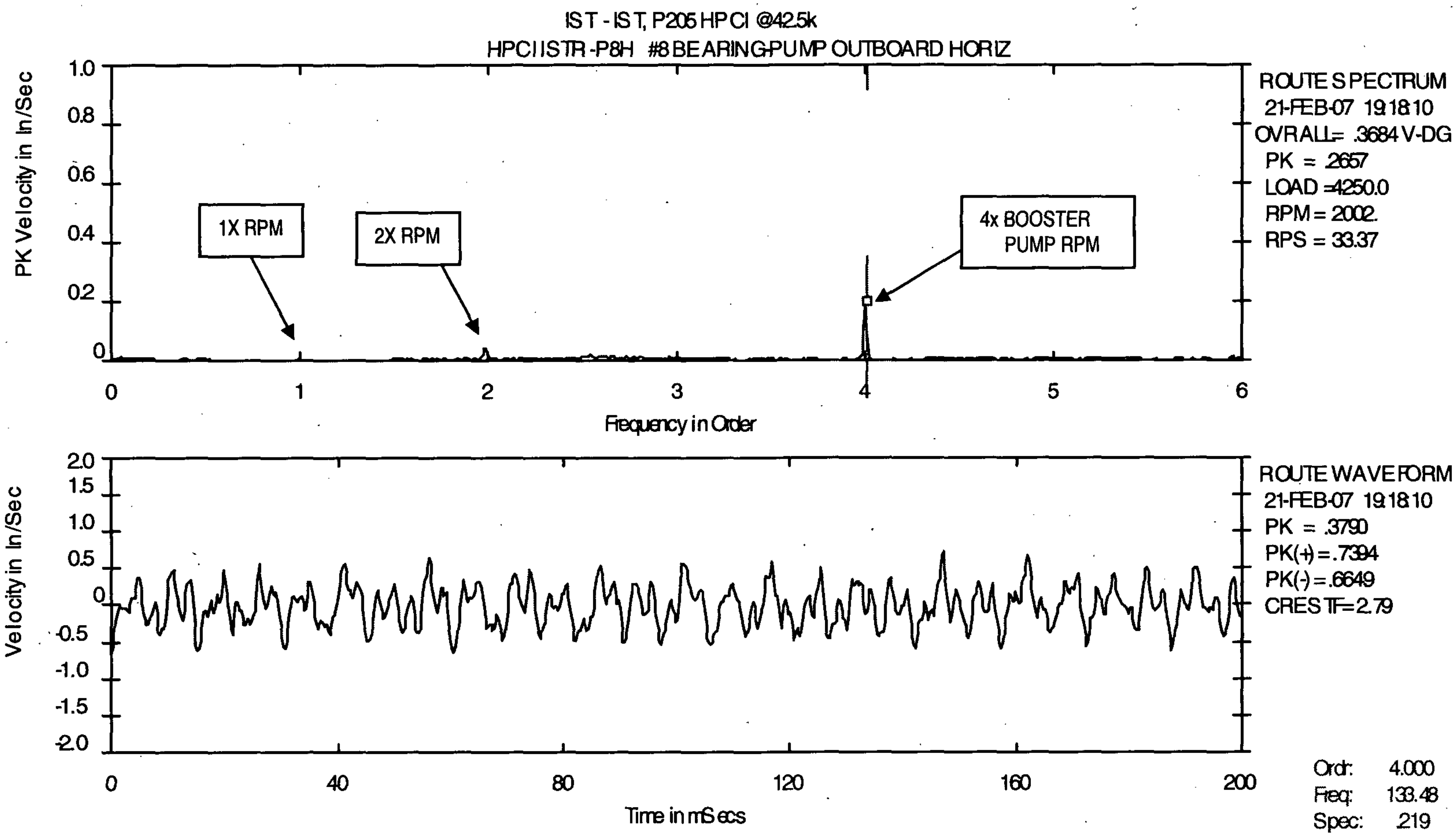
THIS IS VIBRATION DATA FOR THE HPCI MAIN PUMP GEARBOX-END BEARING VERTICAL (P4V). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS HIGHEST AT 4x BOOSTER PUMP RPM, WHICH AGAIN IS AT A NON-SYNCHRONOUS 2.017x MAIN PUMP RPM, BUT THE OVERALL LEVEL IS MUCH LOWER THAN P4H. THE 1x MAIN PUMP RPM LEVEL IS 0.028 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.



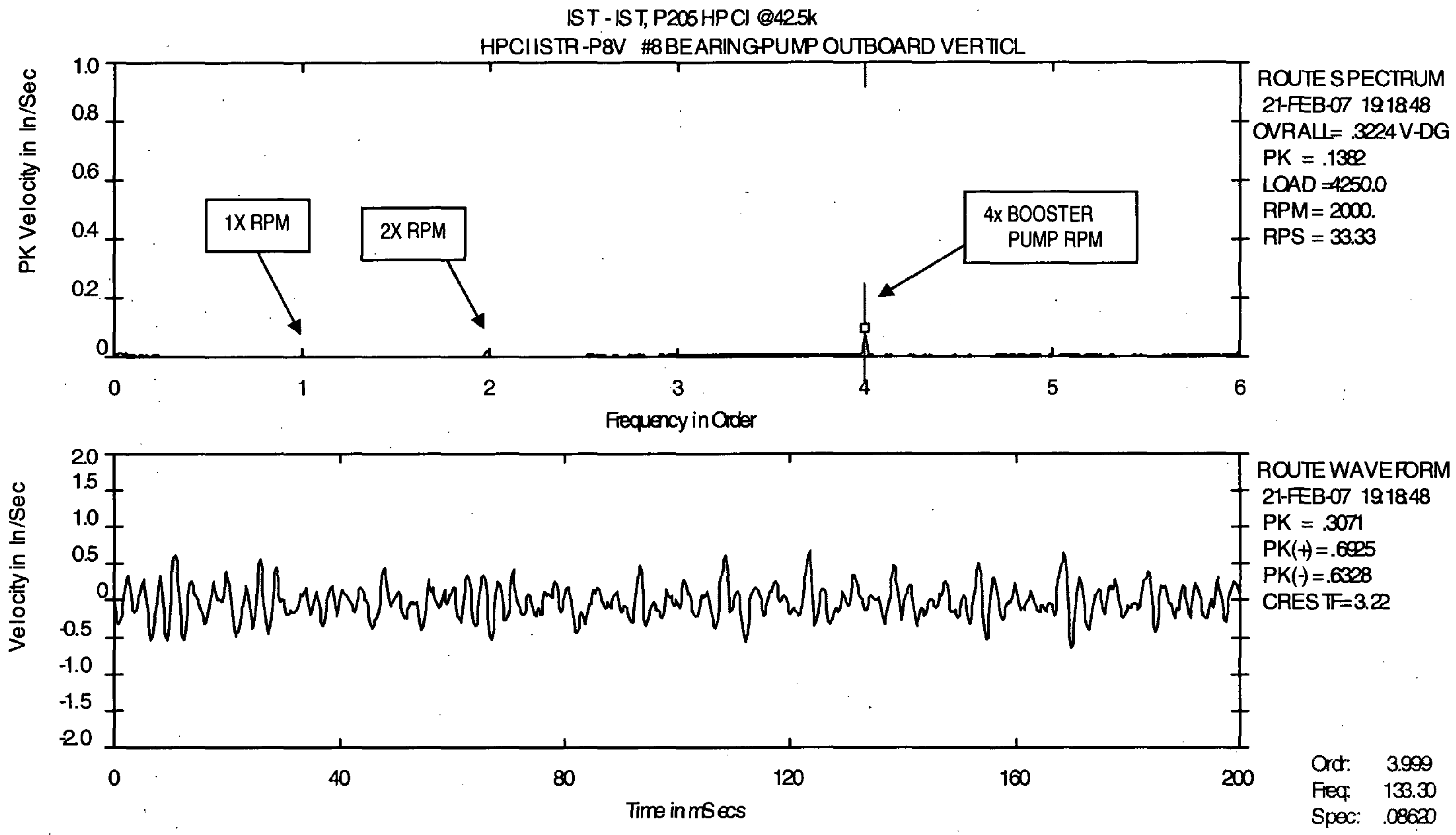
THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP GEARBOX-END BEARING HORIZONTAL (P7H). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.163 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER 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.



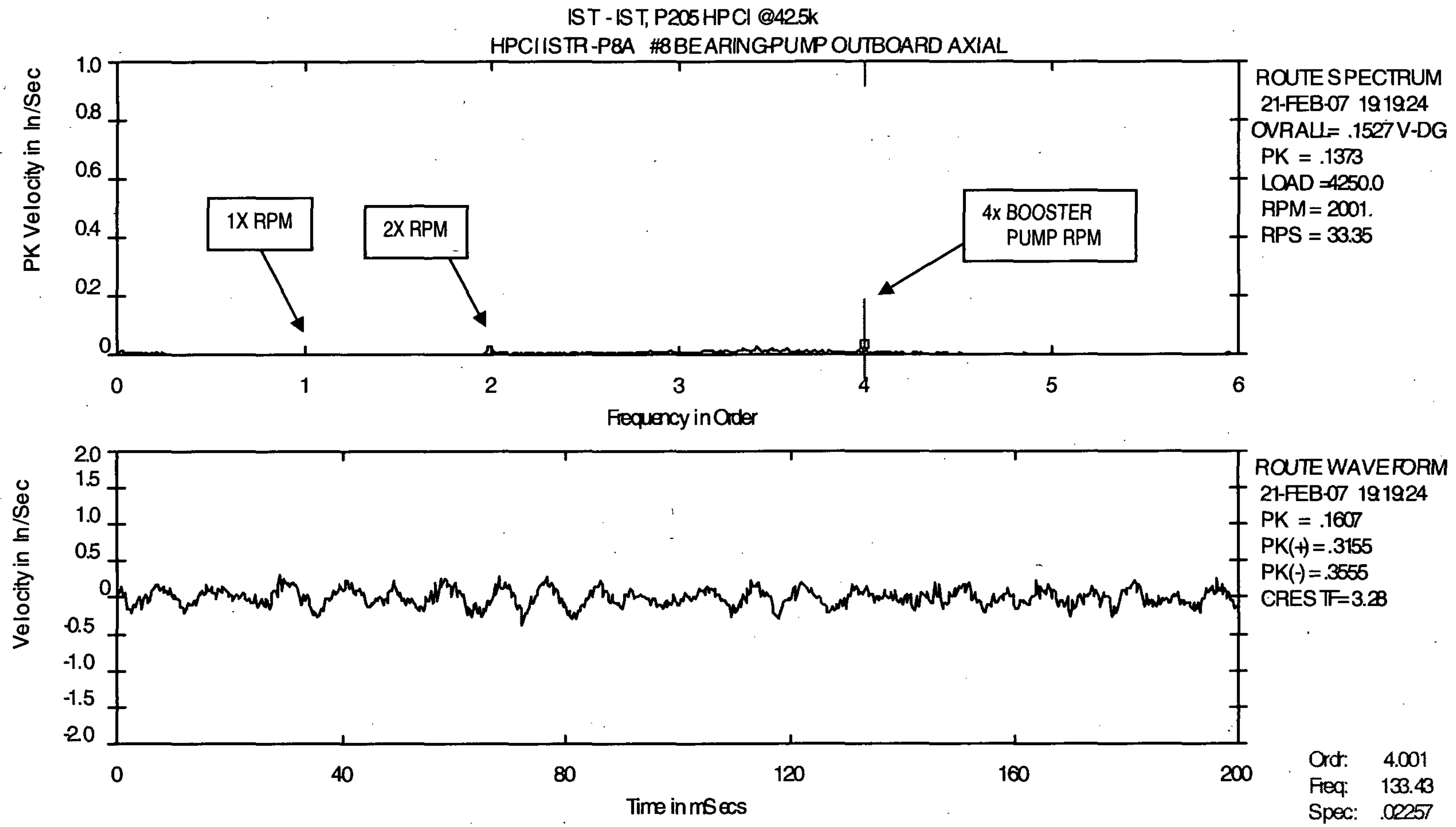
THIS IS VIBRATION DATA FOR THE HPCI BOOSTER PUMP GEARBOX-END BEARING VERTICAL (P7V). THE SPECTRUM AND WAVEFORM SHOW THAT VIBRATION IS PREDOMINANTLY AT 4x BOOSTER PUMP RPM BUT AT A LOW OVERALL LEVEL.
THE 0.088 IN/SEC @ 4x MAIN PUMP RPM LEVEL IS DUE TO THE 4-VANE BOOSTER PUMP IMPELLER.
THE 1x BOOSTER PUMP 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.