PSE&G Research Corporation

RESEARCH AND TESTING LABORATORY REPORT

To the Technical Manager -
Hope Creek Generating Station - PSE&G

June 3, 1987

Report No. 71125

Attention: W. H. Schell

TRANSIENT AND STEADY STATE ANALYSIS OF THE 1AP AND 1BP REACTOR RECIRCULATION PUMPS - HOPE CREEK GENERATING STATION

Requested By: Gary Stith, Engineer

Test Conducted By: W. Pryor

INTRODUCTION

The PSE&G Research and Testing Laboratory's Vibration Test Group was requested to evaluate the mechanical condition of the 1AP and 1BP Reactor Recirculation Pumps based on their vibration response characteristics. Specific project objectives as outlined by plant personnel were to: 1) Evaluate the balance condition of the RCP rotor assemblies; 2) Determine the cause of the high vibration alarms received in the control room; 3) Investigate the possibility of RCP vibration contributing to the cracking of the discharge valve drain line.

The data contained in this report was acquired at the Hope Creek Station between 13 and 15 February 1987, during a unit start-up. This report documents the vibration response characteristics of the RCP system over that time period. As such this report represents a valuable reference from which future analysis and malfunction diagnosis can be based.

TEST METHOD

The steady state and transient data contained in this report was acquired from the shaft relative buffered outputs which are located on the front panel of the permanently installed vibration monitoring system. Shaft vibration was sensed utilizing the installed proximity transducers on each pump. This transducer system measures peak-to-peak shaft vibration in mils relative to the transducer mounting bracket. Signals from the proximity probes were combined with a once-per-turn keyphasor pulse. The keyphasor is necessary for phase angle measurement and variable speed tracking.

TEST METHOD (cont'd.)

The steady state data presented in the report consists of orbit, timebase, and spectrum information. This data details shaft response at several load points. Steady state data provides a powerful tool for evaluating the influences of various rotor preloads, a wide variety of instability mechanisms, plus a entire array of rotor response characteristics from simple imbalance to complex modal studies.

Transient data was acquired during a start-up of the unit. Start-up data is presented in the form of bode, polar, and cascade presentation formats. Bode and polar plots are used to detail the synchronous response of the rotating element. This data is important in the identification of rotor balance resonances and the measurement of system damping characteristics. Cascade information documents excitations outside of the running speed range. Cascade data is used in the evaluation of rotor instabilities such as oil whirl and oil whip, rubs, and vane passing activity.

The data presented in this report was acquired on magnetic tape utilizing a 14 channel Honeywell 101 instrument grade FM tape recorder. Vibration data was recorded at a tape speed of 0.9375 IPS. At this tape speed the recorder has a frequency response of DC to 18,750 CPM. The recorded vibration data was subsequently reduced to hard copy data presentation formats via the Bently Nevada ADRE machinery diagnostic computer system. The ADRE system consists of a Bently Nevada DVF2 tracking filter, Hewlett Packard 3582A dual channel spectrum analyzer, and a HP 9836C desktop computer. Operating software for the system was developed by Bently Nevada Corporation.

TEST RESULTS AND RECOMMENDATIONS

1. Both RCP rotor assemblies are well balanced at this time. There is currently no need to conduct a trim balance of the units.

2. The data indicates that shaft runout is a major contributor to the overall vibration levels currently measured at the Smart Monitors. Runout is relatively easy to remedy and can be corrected during the forthcoming refueling outage. The Research and Testing Laboratory is available to discuss this situation further with the plant and assist in correcting the problem.

TEST RESULTS AND RECOMMENDATIONS (cont'd.)

3. The high vibration levels are caused by impeller vane passing activity and occur in two speed ranges. For the 1AP pump these ranges are between 720-800 RPM and 1040-1090 RPM. On the 1BP pump the high vibration levels exist between 700-760 RPM and 1150-1200 RPM. Operation of the equipment in these speed ranges should be minimized.

4. Experience with RCP systems has shown that high vibration levels which occur in the lower speed range are caused by the excitation of the pump's first bending resonance by the impeller vane passing frequency. The presence of impeller vane passing activity is considered to be indicative of a machinery malfunction which can limit the long term reliability and operation of the pump. It is, therefore, strongly recommended that every effort be made to eliminate this activity.

5. The specific cause of the high vibration levels measured at the higher speed range is currently unknown. From the data it appears that this response is due to a structural resonance. Further testing is warranted during the refueling outage to identify and correct the cause of this response.

6. Available data does not allow us to determine if the RC Pump vibration contributed to the cracking of the discharge valve drain line. It is possible that pressure pulsations caused by impeller vane passing activity contributed to the failure. Further testing when the unit is down for refueling is necessary to make this determination.

Refer to Table 1 for the vibration summary of the 1AP pump system.

Refer to Table 2 for the vibration summary of the 1BP pump system.

Refer to Tab 1 for the transient and steady state vibration data of 1AP pump.

Refer to Tab 2 for the transient and steady state vibration data of 1BP pump.

Refer to Tab 3 for the Bently Nevada Applications Note: "Glitch, Definition of and Methods of Correction, including Shaft Burnishing to Remove Electrical Runout."

Refer to Figure No. 1 for a listing of the test equipment.

DISCUSSION AND CONCLUSIONS

1AP and 1BP Reactor Recirculation Pumps

Analysis of the RCP rotating element reveals that both Pumps display similar response characteristics. As a result the following discussion pertains to both pumps unless specifically noted.

Evaluation of transient and steady state data indicates that both pumps are acceptable for continued operation under full load conditions and that both pumps contain rotating elements that are well balanced The condition of the rotors balance is easily viewed on the start-up Bode and Polar plots where 1X running speed information has been corrected for shaft runout. When corrected for runout the 1AP pump displays approximately 1 mil of running speed motion while the 1BP pump shows about 2.25 mils of motion due to mass imbalance. This indicates that while some reduction in overall vibration levels could be achieved through trim balancing, the high vibration levels noted by plant personnel are not due to rotor imbalance. As previously stated, the rotors are well balanced for the speed at which they operate, thus, it is not deemed necessary to undertake a rotor balancing program at this time.

Data collected on both rotors does indicate, however, that measured overall vibration levels could be reduced by eliminating the shaft runout in the transducer target area. Runout can result from eccentricity, scratches, non-uniform surface hardness, etc. in the area observed by the proximity probe. The result of runout is an error in the vibration levels measured by the permanently installed monitoring system. From our analysis of the rotors a significant reduction in overall vibration levels could be expected if the runout was eliminated. It is, therefore, our recommendation that the probe target area be checked and corrected for runout during the next refueling outage. For more information on shaft runout and methods of correction, see the attached Bently Nevada Applications Note "Glitch, Definition of and methods for correction, including shaft burnishing to remove electrical runout." This Applications Note is included in Tab 3 of this report.

Evaluation of acquired data reveals that the high vibration alarms are due to vane passing excitations. Vane passing activity is noted over the entire operating speed of the pumps, but there are 2 speed ranges where there is a significant increase in overall vibration levels. For the 1AP pump these ranges are from 720-800 RPM and 1040-1090 RPM. The response

DISCUSSION AND CONCLUSIONS (cont'd.)

characteristics for the 1BP pump are very similar to the 1AP pump except that the ranges in which the high vibration occurs differ slightly. On the 1BP pump high vibration was measured between 700-760 RPM and from 1150-1200 RPM. Maximum amplitudes through these speed ranges can be viewed on Vibration Summary Tables 1 and 2.

Previous experience with these and RCP systems of similar design at other stations has shown that the lower speed range high vibration is due to an excitation of the pumps first bending resonance by the impellers blade passing frequency. Peak amplitudes due to the 5X component were measured to approach 3.0 mils on the 1AP pump and are approximately 4.0 mils on the 1BP Pump. Currently the resonance is well damped and should not have an immediate effect on machinery operation. This activity was noted and discussed with the machinery manufacturer during start-up testing. At that time, it was the manufacturers contention that the 5X component was due to the operation of the pumps at off-design conditions (ie. water temperature, pressure and density). They further stated that they would not expect this activity to exist once the unit was operated under design conditions.

The presence of vane passing is considered to be a machinery malfunction which limits the long term reliability of the pumping system. As a result, it is our strong recommendation that engineering and the manufacturer be consulted in order to eliminate the vane passing activity. Until a design change can be implemented, operation of the pumps in the speed ranges previously noted should be minimized.

The upper speed range high vibration amplitudes are due to a 15X running speed component. For the 1AP pump about 3.0 mils is attributable to this activity and on the 1BP pump this vibration component results in approximately 3.5 mils of dynamic response. From the data it appears that the 15X component is the result of some type of structural excitation. At the present time the exact nature of this component is unknown and further testing is warranted to identify the cause and correct for this problem. Until the cause can be identified, machinery operation in this speed range should be avoided.

Based on available data, it is impossible for us to determine if the RCP vibration contributed to the cracking of the discharge valve drain line. It is possible however for the drain line to be excited by pressure pulsations created by the impeller vane passing frequency. Since this section of piping is small in

DISCUSSION AND CONCLUSIONS (cont'd.)

diameter, long, and unsupported, the resonant frequency of this section would be prone to structural excitation which could lead to fatigue cracking. To determine the resonant frequency of the pipe is very simple and does not require a great deal of time. It could be tested, by the Research and Testing Laboratory, during the refueling outage and the results compared to the transient vibration data in order to determine if the RCP response contributed to the problem.

R. A. Konnyu/gp

Materials Test Engineer

Manager,
Materials Division

WTP:mth
2593H

C G. Stith

Table No. 1

A RCP VIBRATION SUMMARY
HOPE CREEK GENERATING STATION
13-15 FEBRUARY, 1987

SPEED RPM	PROBE ID	VIBRATION AMPLITUDES O.A. MILS	1X MILS	1X PHASE DEGREES	5X MILS	15X MILS
400	1XD	4.8	4.2	157	---	---
	1YD	5.2	4.2	246	0.7	---
760	1XD	5.6	4.5	169	1.0	---
	1YD	7.6	4.4	258	2.6	---
1065	1XD	9.6	4.6	166	0.3	2.8
	1YD	6.5	4.4	253	2.0	---
1285	XD	6.3	4.9	168	1.2	---
	1YD	5.9	4.7	257	1.3	---

NOTE: O.A. - OVERALL UNFILTERED VIBRATION LEVEL

Table No. 2

B RCP VIBRATION SUMMARY
HOPE CREEK GENERATING STATION
13-15 FEBRUARY, 1987

SPEED RPM	PROBE ID	VIBRATION AMPLITUDES O.A. MILS	1X MILS	1X PHASE DEGREES	5X MILS	10X MILS	15X MILS
385	1XD	3.3	1.0	163	0.1	---	---
	1YD	3.5	1.1	239	0.5	---	---
730	1XD	4.1	1.4	168	1.0	---	---
	1YD	9.1	2.3	257	4.2	---	---
1180	1XD	3.8	2.5	173	0.4	---	---
	1YD	9.9	4.2	266	1.6	---	3.5
1290	1XD	5.1	2.9	169	1.0	1.0	---
	1YD	6.2	3.5	264	1.2	---	0.6

NOTE: O.A. - OVERALL UNFILTERED VIBRATION LEVEL

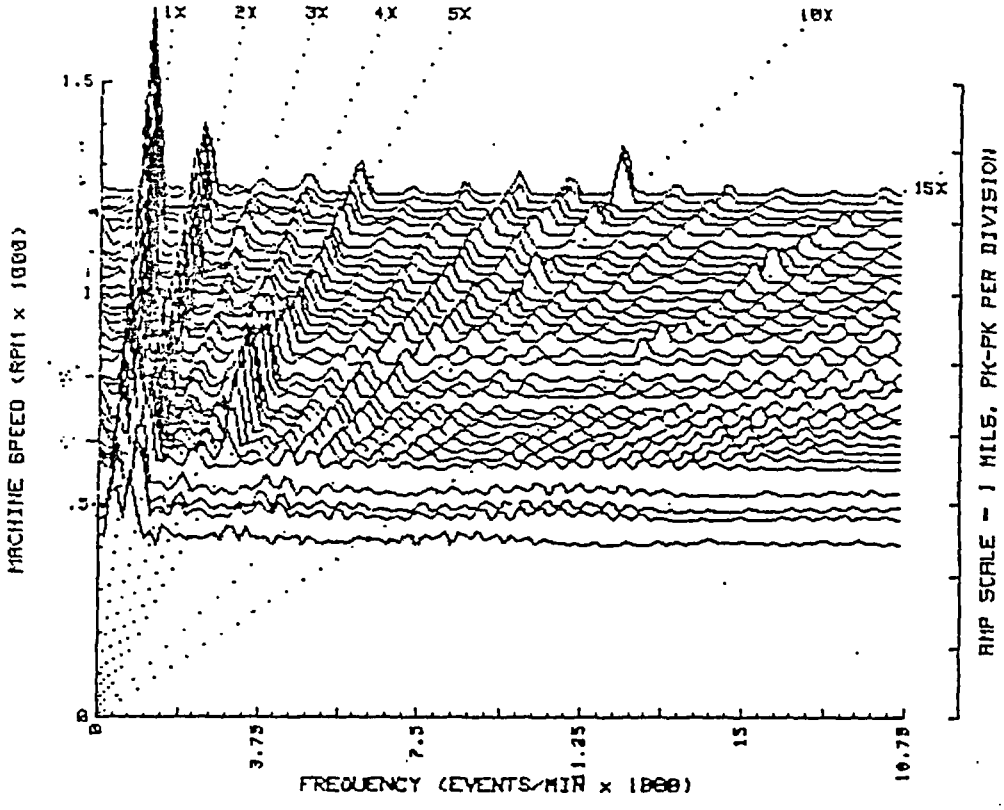
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: B RCP
MACHINE ID: PUMP PEPP TO BISCH.
PROBE ID: 1XD

RUNUP

RUN: 1 DATE: 14 FEB 87 TIME: 1500



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: B RCP
MACHINE ID: PUMP
PROBE ID: 1YD

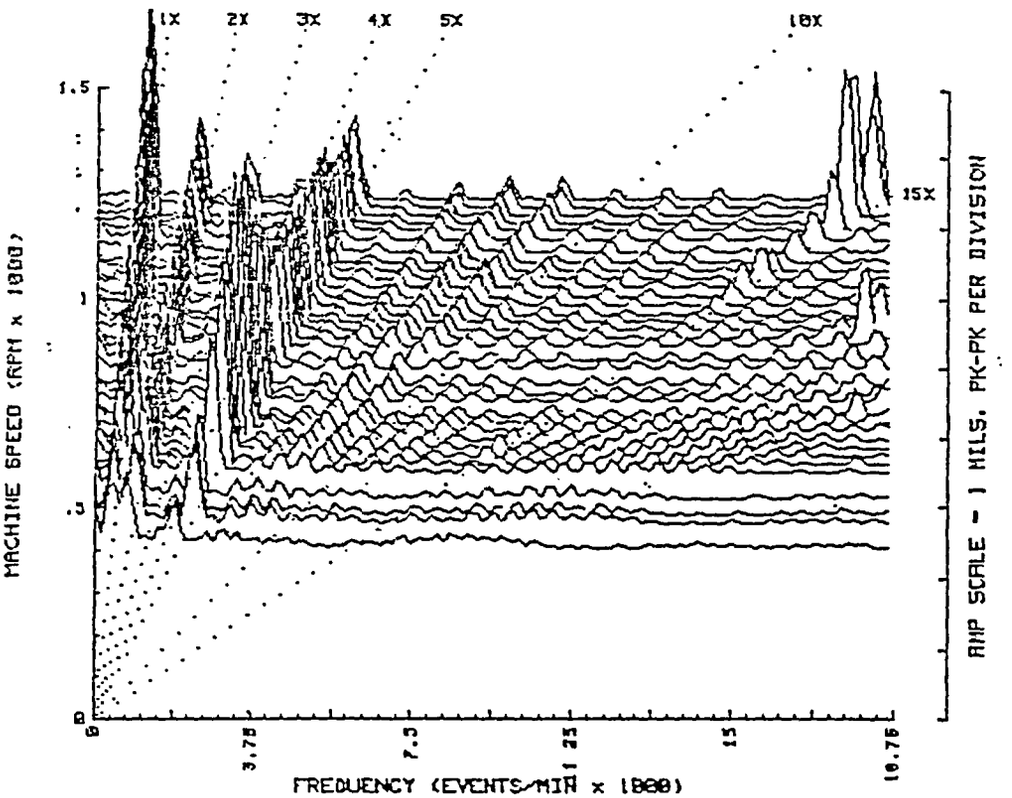
IN LINE TO DISCH.

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

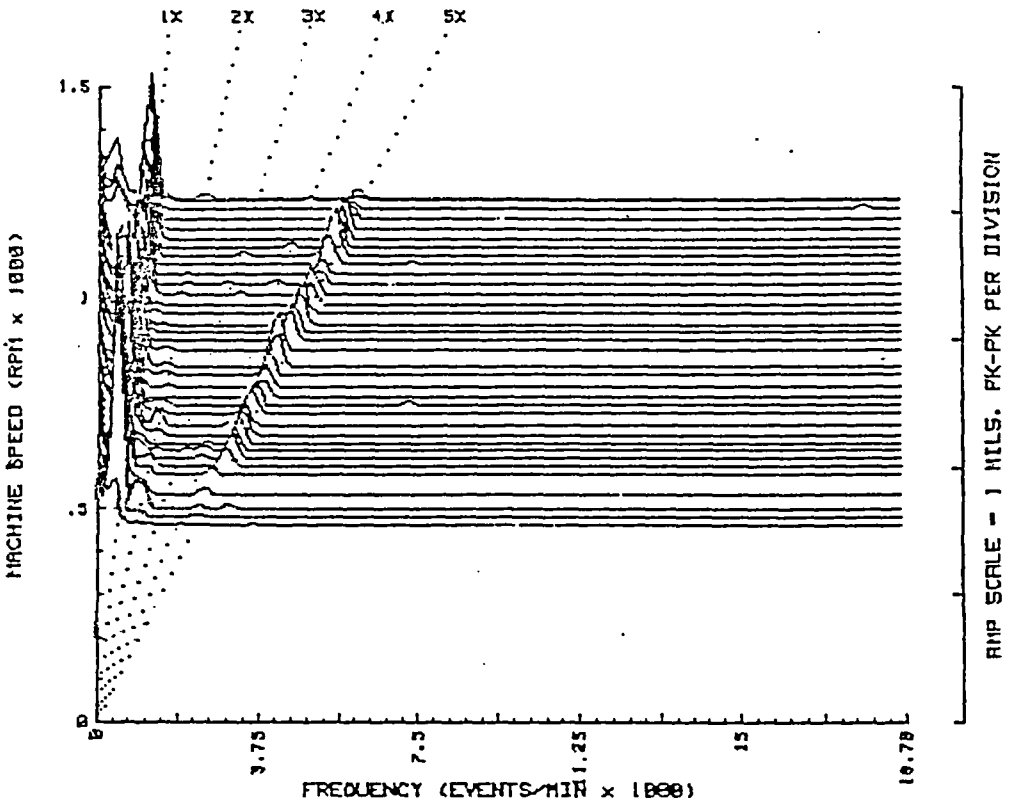
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: B RCP
MACHINE ID: PUMP
PROBE ID: 1AD

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

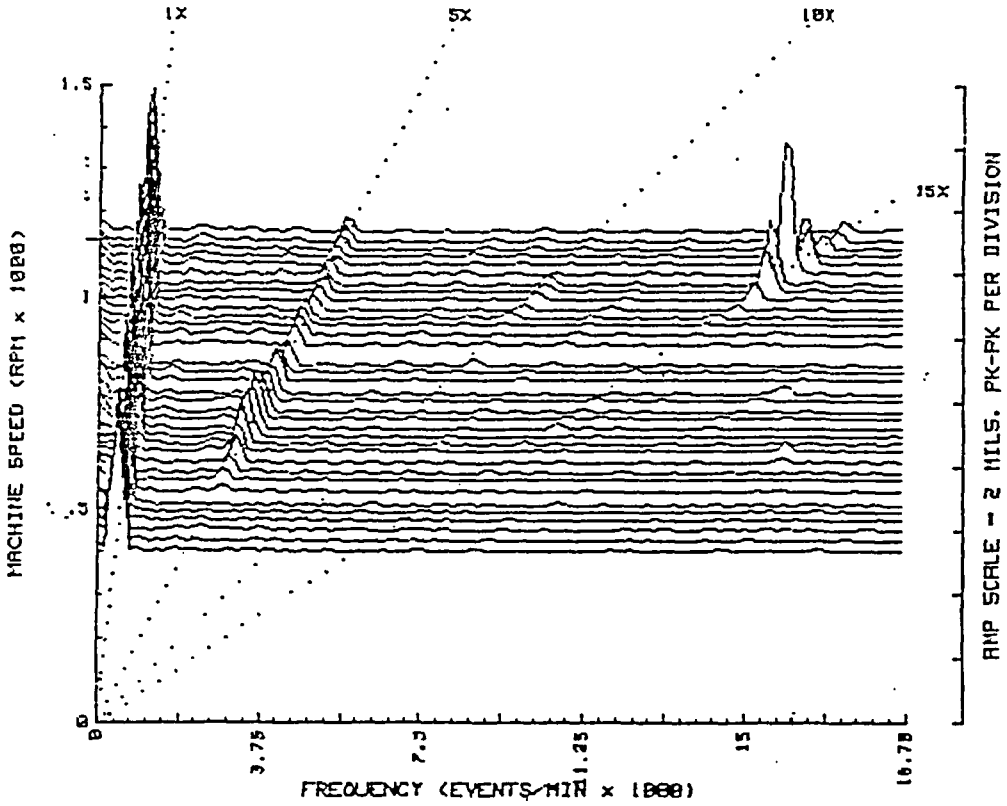
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: A RCP
MACHINE ID: PUMP
PROBE ID: 1XD — IN-LINE WITH DISCH.

RUNDOWN

RUN: 1

DATE: 14 FEB 87

TIME: 1500



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

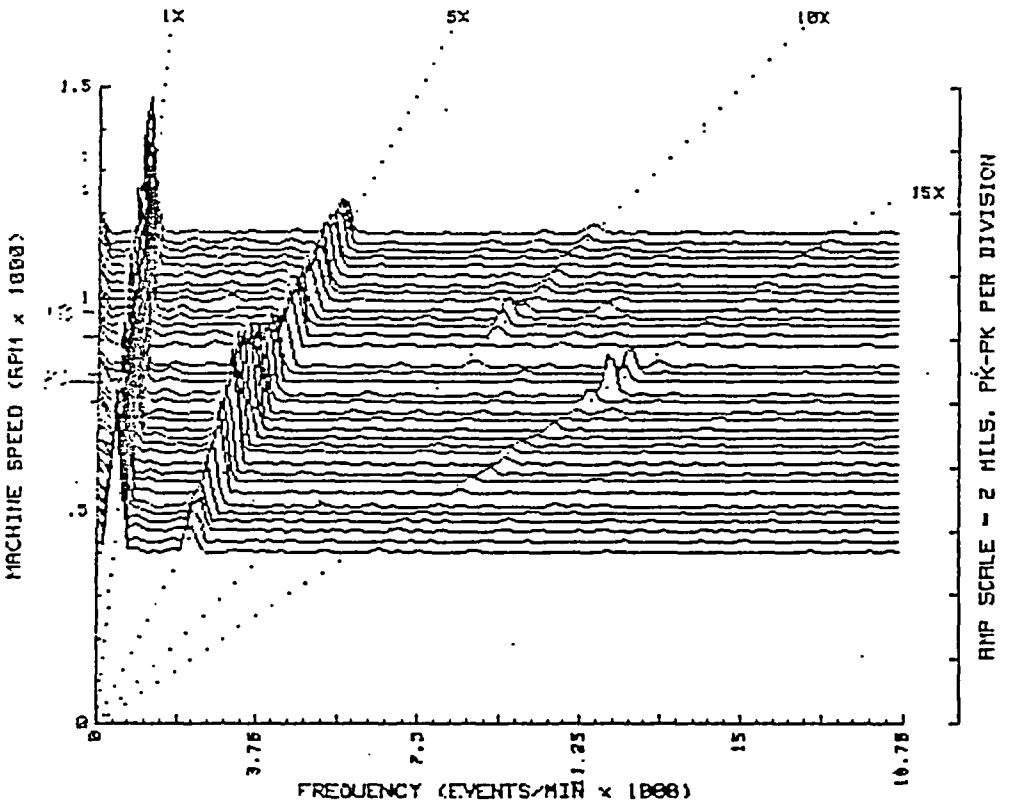
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: A RCP
MACHINE ID: PUMP
PROBE ID: 1YD - PERP. TO DISCH.

RUNDOWN

RUN: 1

DATE: 14 FEB 87

TIME: 1500



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

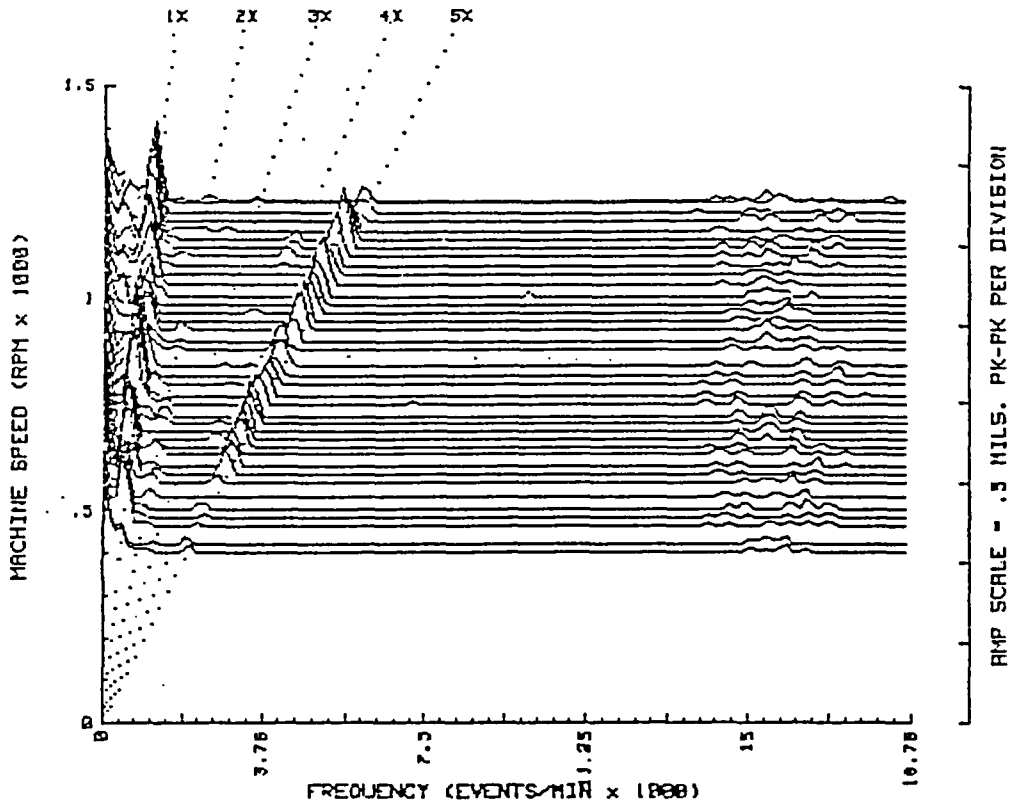
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: A RCP
MACHINE ID: PUMP
PROBE ID:

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



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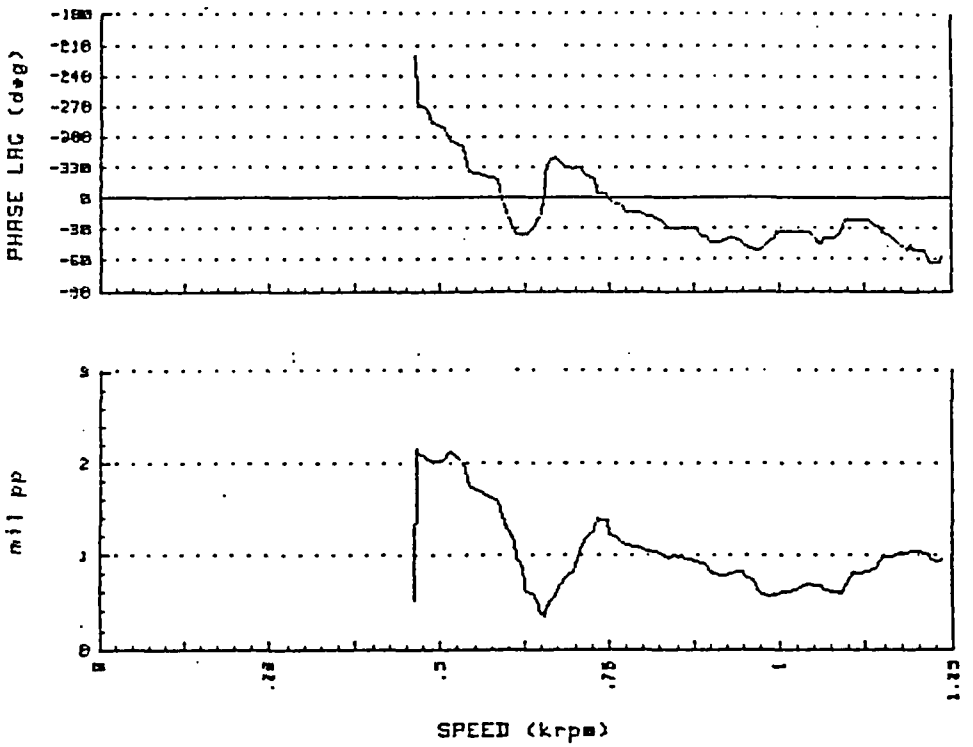
MATERIALS DIVISION

VIBRATION TEST DEPT.

PLANT ID:	HOPE CREEK GEN STA.
TRAIN ID:	B RCP
MACHINE ID:	PUMP
SOLID DATA: Uncomp	1AD

RUNUP

RUN: 1 DATE: 14 FEB 87 TIME: 1500



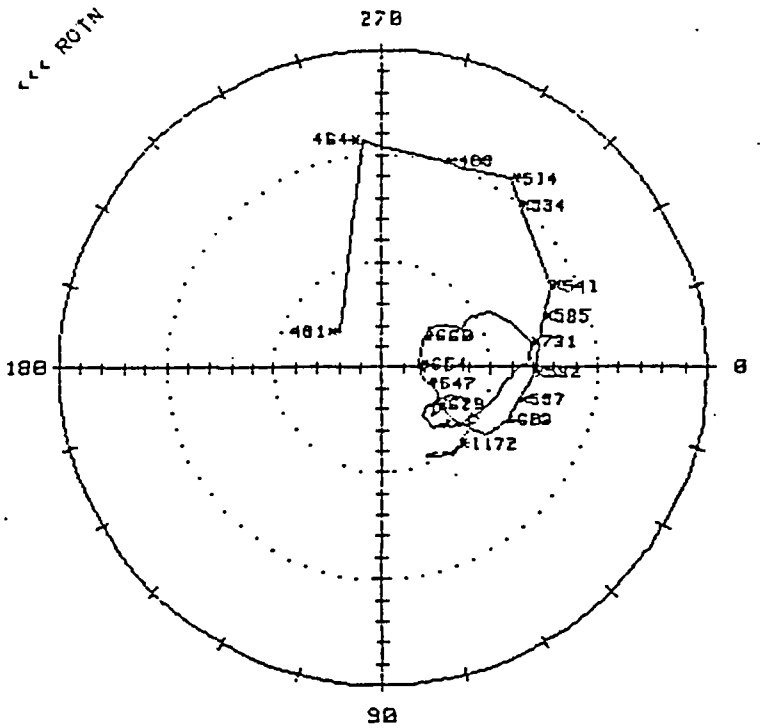
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

PLANT ID:	HOPE CREEK GEN STA.
TRAIN ID:	B RCP
MACHINE ID:	PUMP
SOLID DATA: Uncomp	1AD

RUNUP

RUN: 1 DATE: 14 FEB 87 TIME: 1500



FULL SCALE AMP = 3 mil pp AMP PER DIV = .2 mil pp

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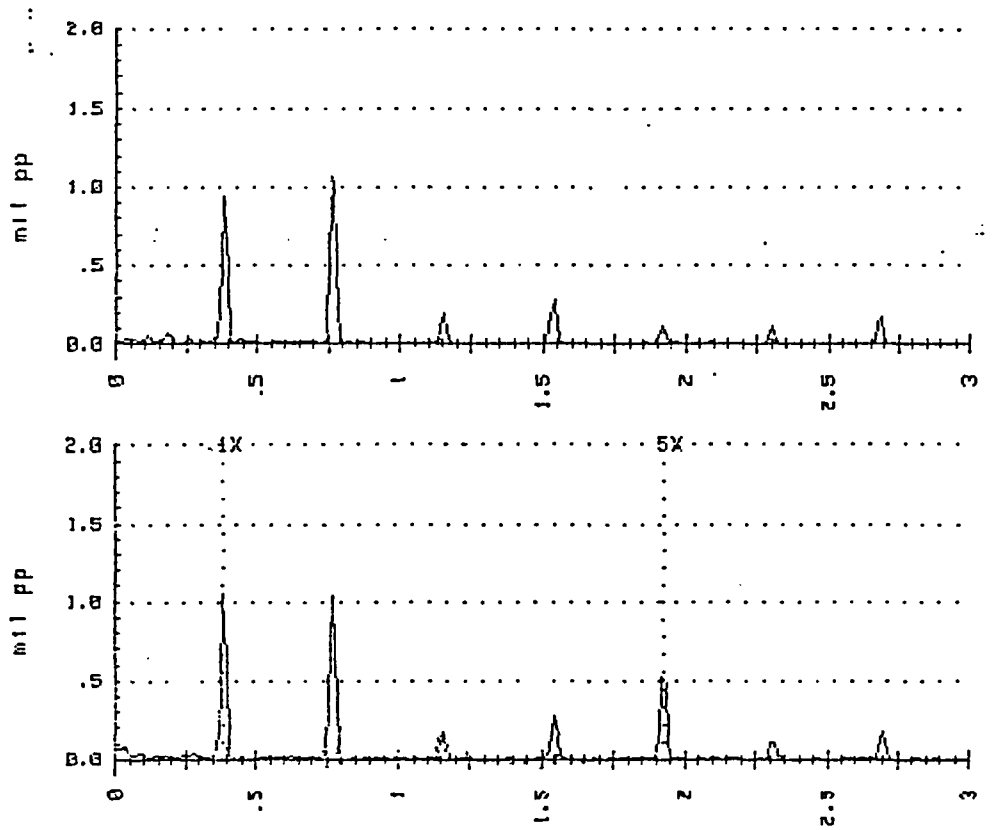
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 14 FEB 87 TIME: 15:00 PROBE ID: 1XD
OVERALL AMP = 3.22 TO 3.26 mil pp
1X = 383 RPM

RUN: 1 DATE: 14 FEB 87 TIME: 15:00 PROBE ID: 1YD
OVERALL AMP = 3.41 TO 5.14 mil pp
1X = 385 RPM



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK
TRAIN ID: B RCP
MACHINE ID: PUMP

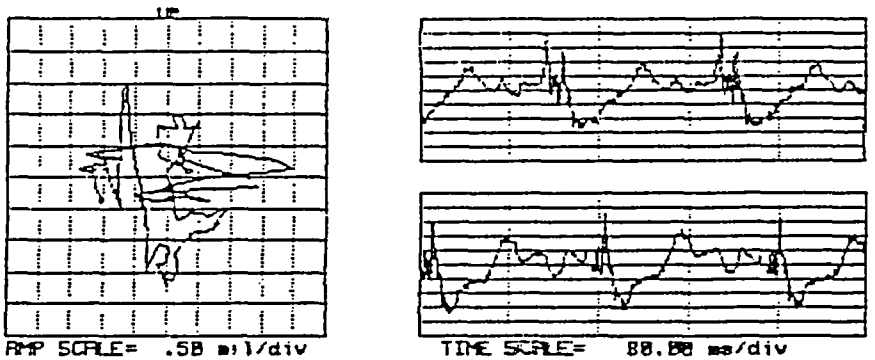
PLOT NO:

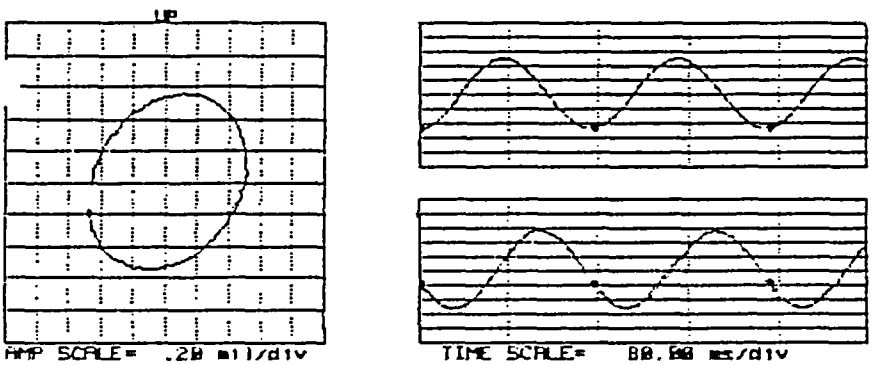
RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
UNFILTERED
SLOW ROLL COMPENSATED DATA
PROBE #2 ID: 1YD
UNFILTERED
SLOW ROLL COMPENSATED DATA
ROTATION: CCW
RPM(START)= 384 RPM(END)= 384

ORIENTATION= 0 deg
MAX AMP= 3.30 mil pp

ORIENTATION= 90 deg
MAX AMP= 3.50 mil pp





RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
1X FILTERED
SLOW ROLL COMPENSATED DATA
PROBE #2 ID: 1YD
1X FILTERED
SLOW ROLL COMPENSATED DATA
ROTATION: CCW
RPM(START)= 384 RPM(END)= 384

ORIENTATION= 0 deg
1X VECTOR= 1.00 mil pp @-163

ORIENTATION= 90 deg
1X VECTOR= 1.10 mil pp @-239

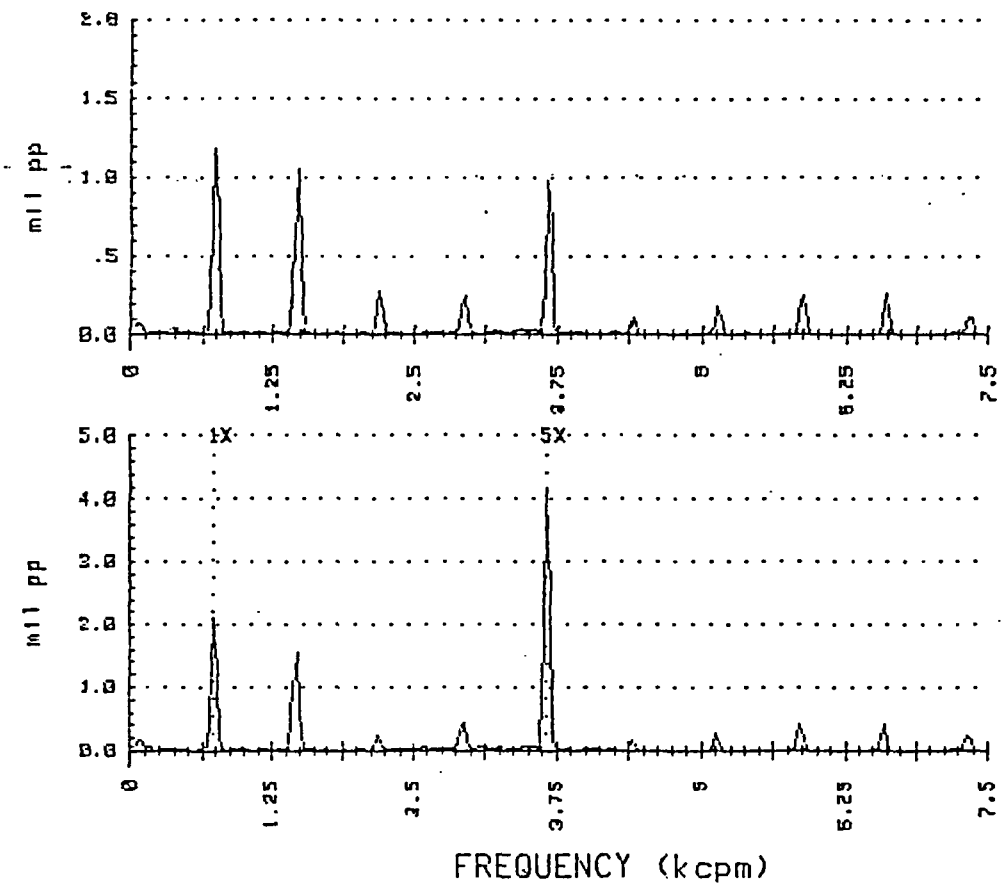
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 14 FEB 87 TIME: 21:00 PROBE ID: 1XD
OVERALL AMP = 3.91 TO 4.06 mil pp
1X = 733 RPM

RUN: 1 DATE: 14 FEB 87 TIME: 21:00 PROBE ID: 1YD
OVERALL AMP = 8.60 TO 9.00 mil pp
1X = 732 RPM



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MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 14 FEB 87 TIME: 21:00

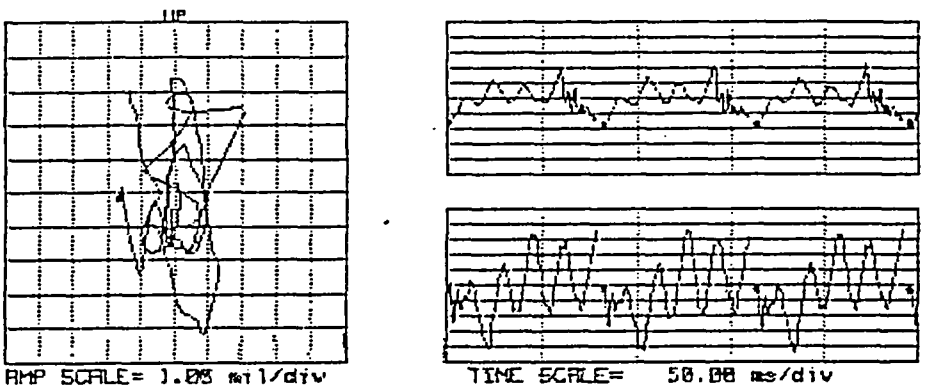
PROBE #1 ID: 1XD
UNFILTERED

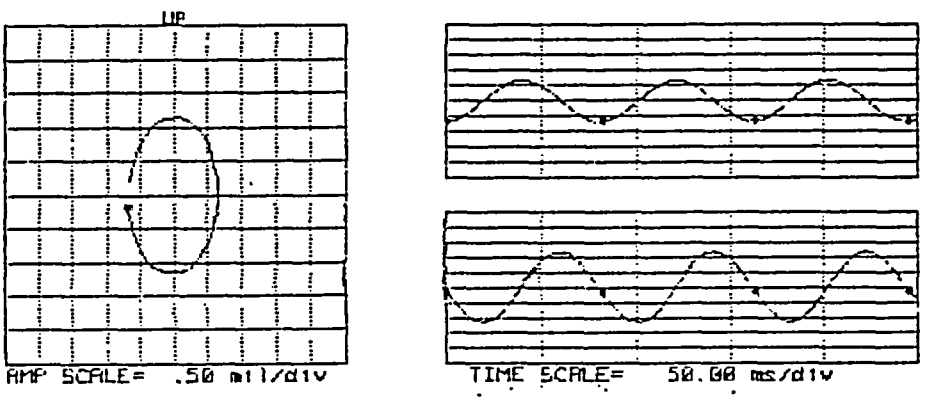
ORIENTATION= 0 deg
MAX AMP= 4.06 mil pp

PROBE #2 ID: 1YD
UNFILTERED

ORIENTATION= 90 deg
MAX AMP= 9.10 mil pp

ROTATION: CCW
RPM(START)= 733 RPM(END)= 734





RUN: 1 DATE: 14 FEB 87 TIME: 21:00

PROBE #1 ID: 1XD
1X FILTERED

ORIENTATION= 0 deg
1X VECTOR= 1.36 mil pp @-168

PROBE #2 ID: 1YD
1X FILTERED

ORIENTATION= 90 deg
1X VECTOR= 2.30 mil pp @-257

ROTATION: CCW
RPM(START)= 733 RPM(END)= 733

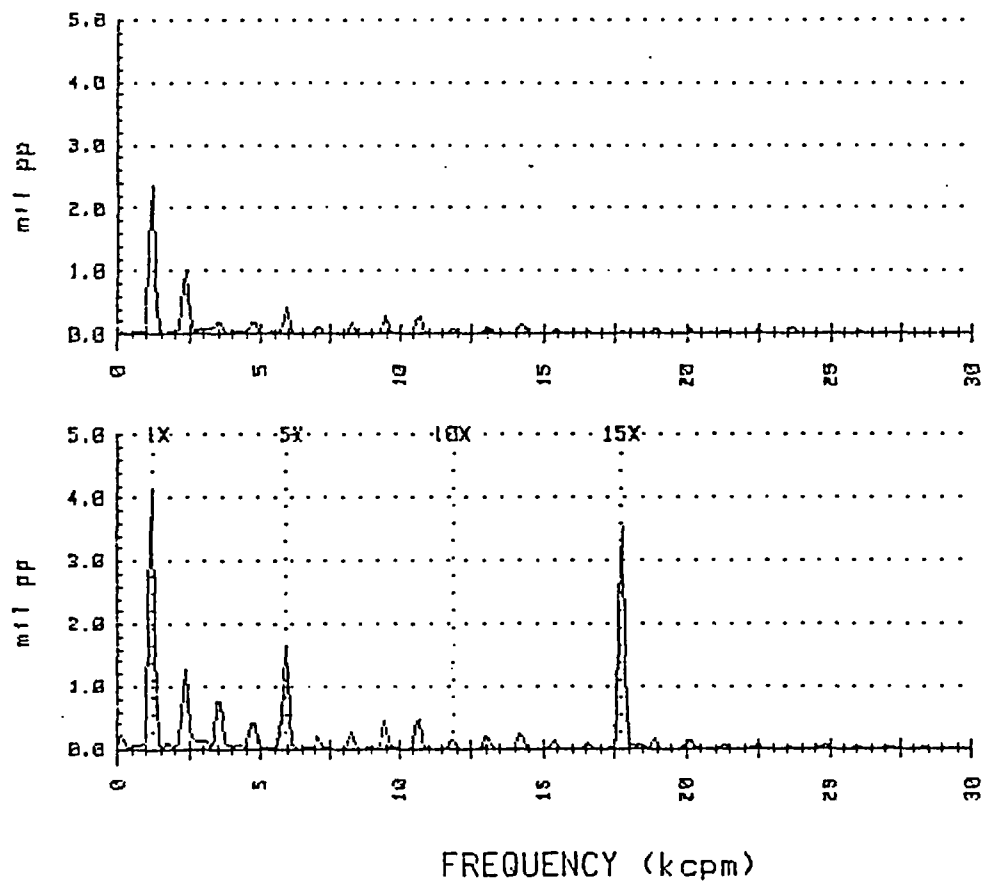
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 6:00 PROBE ID: 1XD
OVERALL AMP = 3.79 TO 4.09 mil pp
1X = 1337 RPM

RUN: 1 DATE: 15 FEB 87 TIME: 6:00 PROBE ID: 1YD
OVERALL AMP = 9.80 TO 10.20 mil pp
1X = 1181 RPM



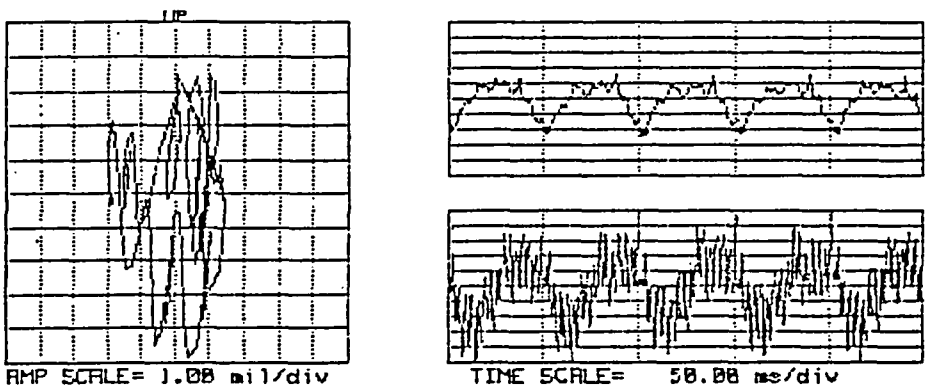
PSE&G RESEARCH CORP PLANT ID: HOPE CREEK GEN STA PLOT NO:
MATERIALS DIVISION TRAIN ID: B RCP
VIBRATION TEST DEPT. MACHINE ID: PUMP

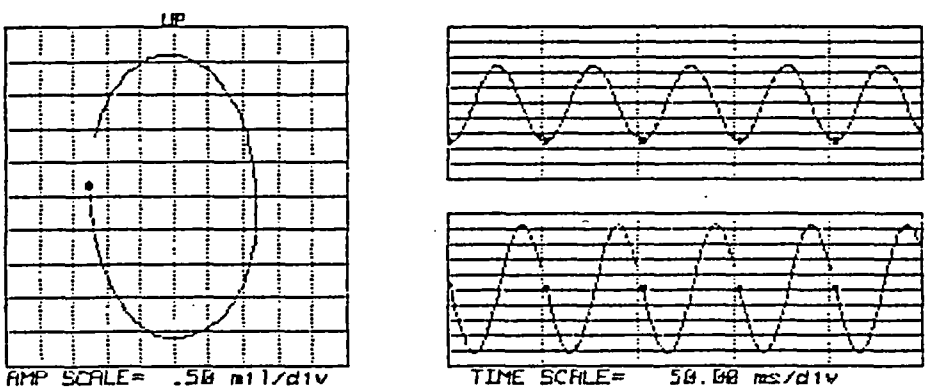
RUN: 1 DATE: 15 FEB 87 TIME: 6:00

PROBE #1 ID: 1XD ORIENTATION= 0 deg
UNFILTERED MAX AMP= 3.81 mil pp

PROBE #2 ID: 1YD ORIENTATION= 90 deg
UNFILTERED MAX AMP= 9.90 mil pp

ROTATION: CCW
RPM(START)= 1181 RPM(END)= 1182





RUN: 1 DATE: 15 FEB 87 TIME: 6:00

PROBE #1 ID: 1XD ORIENTATION= 0 deg
1X FILTERED 1X VECTOR= 2.47 mil pp @-173

PROBE #2 ID: 1YD ORIENTATION= 90 deg
1X FILTERED 1X VECTOR= 4.20 mil pp @-266

ROTATION: CCW
RPM(START)= 1183 RPM(END)= 1182

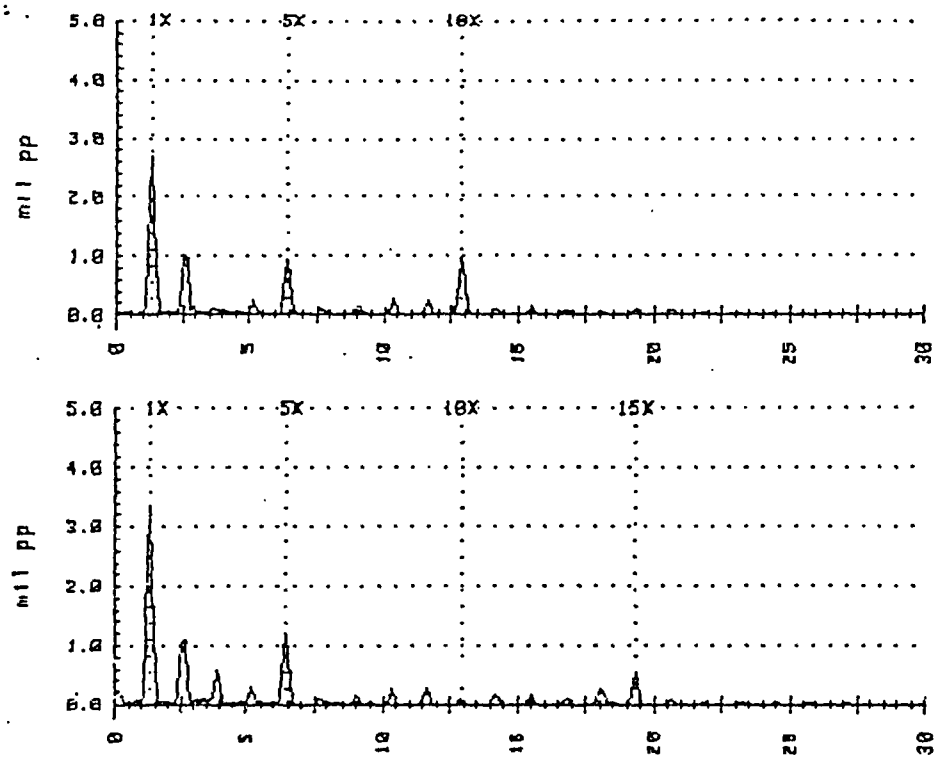
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 14:54 PROBE ID: 1XD
OVERALL AMP = 4.90 TO 5.03 mil pp
1X = 1289 RPM

RUN: 1 DATE: 15 FEB 87 TIME: 14:54 PROBE ID: 1YD
OVERALL AMP = 5.57 TO 6.10 mil pp
1X = 1289 RPM



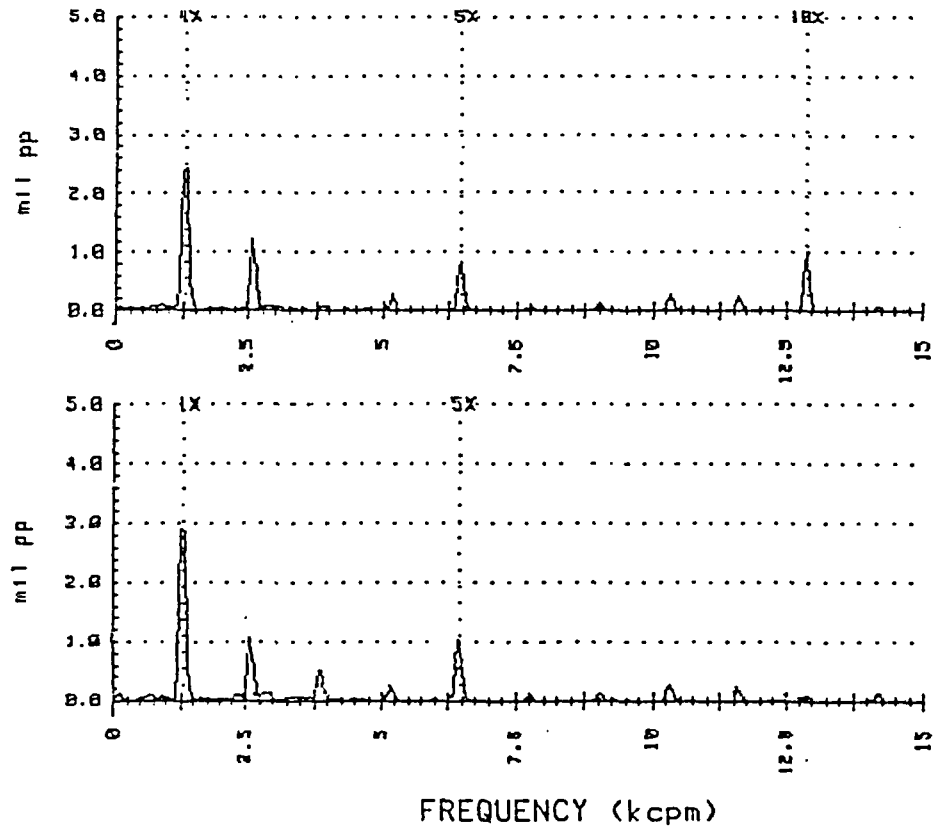
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 14:54 PROBE ID: 1XD
OVERALL AMP = 4.81 TO 5.23 mil pp
1X = 1289 RPM

RUN: 1 DATE: 15 FEB 87 TIME: 14:54 PROBE ID: 1YD
OVERALL AMP = 5.90 TO 6.27 mil pp
1X = 1289 RPM



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: B RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 14:54

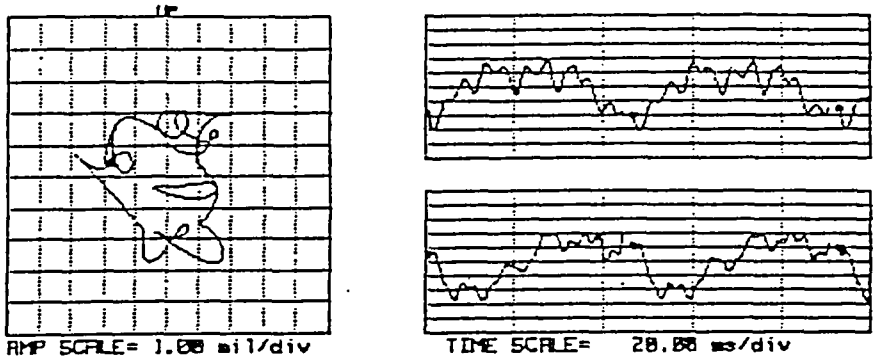
PROBE #1 ID: 1XD
UNFILTERED

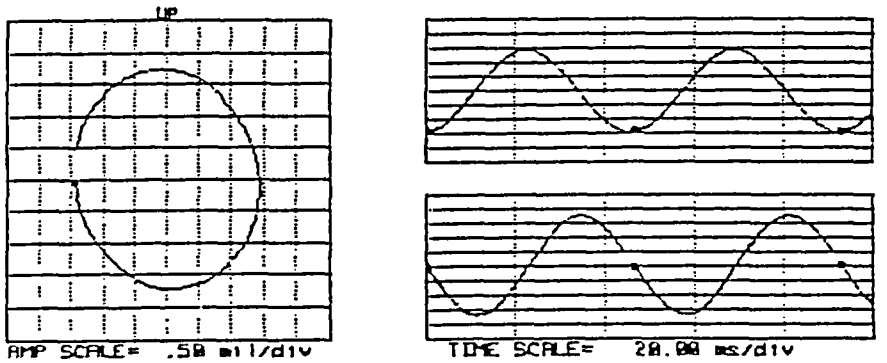
ORIENTATION= 0 deg
MAX AMP= 5.09 mil pp

PROBE #2 ID: 1YD
UNFILTERED

ORIENTATION= 90 deg
MAX AMP= 6.15 mil pp

ROTATION: CCW
RPM(START)= 1289 RPM(END)= 1290





RUN: 1 DATE: 15 FEB 87 TIME: 14:54

PROBE #1 ID: 1XD
1X FILTERED

ORIENTATION= 0 deg
1X VECTOR= 2.90 mil pp @-169

PROBE #2 ID: 1YD
1X FILTERED

ORIENTATION= 90 deg
1X VECTOR= 3.45 mil pp @-264

ROTATION: CCW
RPM(START)= 1289 RPM(END)= 1290

Figure No. 1

TEST EQUIPMENT CALIBRATION

ITEM NO.	DESCRIPTION	SERIAL NUMBER	CALIBRATION DUE DATE
1	HONEYWELL 101 14 CHANNEL FM TAPE RECORDER	0800135TG78	JANUARY 1988
2	BENTLY NEVADA DVF2 DUAL CHANNEL TRACKING FILTER	H502695	FEBRUARY 1988
3	HEWLETT PACKARD 3582A DUAL CHANNEL SPECTRUM ANALYZER	2602A07180	NOVEMBER 1987
4	BENTLY NEVADA 8 CHANNEL SIGNAL CONDITIONING AMPLIFIERS	J901001	FEBRUARY 1988
5	TEKTRONIX 5110 2 CHANNEL OSCILLOSCOPE	B130494	JUNE 1987
6	KEITHLEY 131 DIGITAL MULTIMETER	181127	AUGUST 1987

VIBRATION TESTING CONDUCTED IN ACCORDANCE WITH THE FOLLOWING PSE&G RESEARCH CORPORATION PROCEDURES

VP-2 PROCEDURE FOR VIBRATION ANALYSIS
VP-4 PROCEDURE FOR TEST SETUP OF VIBRATION INSTRUMENTATION
VP-5 PROCEDURE TO DEFINE VIBRATION TESTING REQUIREMENTS
VP-6 PROCEDURE TO DEFINE THE FORMAT OF FINAL REPORTS

Figure No. 1

TEST EQUIPMENT CALIBRATION

ITEM NO.	DESCRIPTION	SERIAL NUMBER	CALIBRATION DUE DATE
1	HONEYWELL 101 14 CHANNEL FM TAPE RECORDER	0800135TG78	JANUARY 1988
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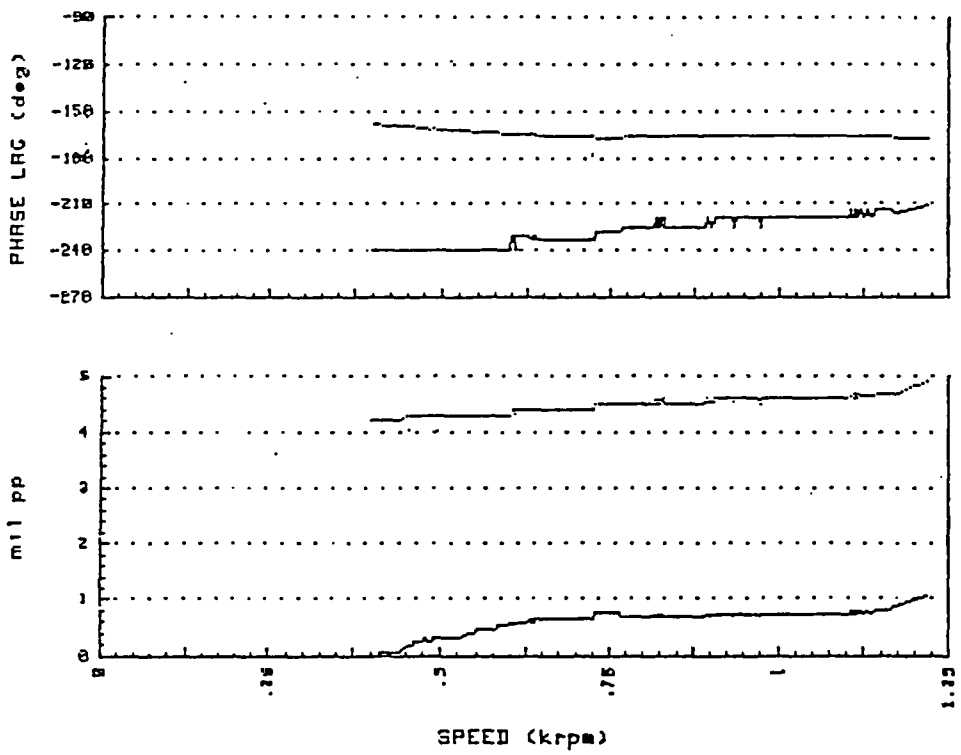
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

PLANT ID:	HOPE CREEK GEN STA.
TRAIN ID:	A RCP
MACHINE ID:	PUMP
SOLID DATA: Comp	1XD
DASHED DATA:Uncomp	1XD

RUNUP

RUN: 1 DATE: 14 FEB 87 TIME: 1500

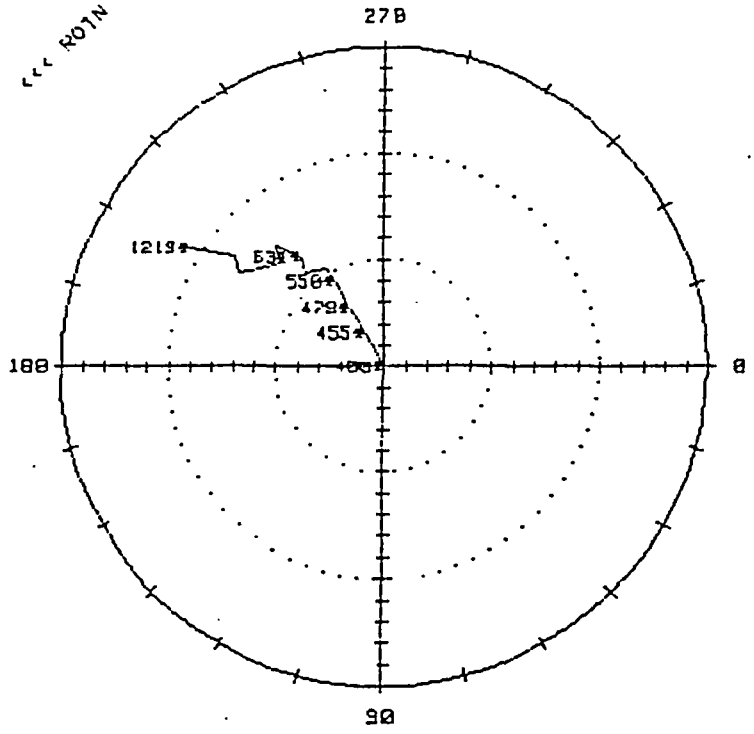


VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 400 RPM = 4.20 @ -158

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

	PLANT ID:	HOPE CREEK GEN STA.
	TRAIN ID:	A RCP
	MACHINE ID:	PUMP
RUNUP	SOLID DATA: Comp	1XD
RUN: 1	DATE: 14 FEB 87	TIME: 1500



FULL SCALE AMP = 1.5 mil pp AMP PER DIV = .1 mil pp

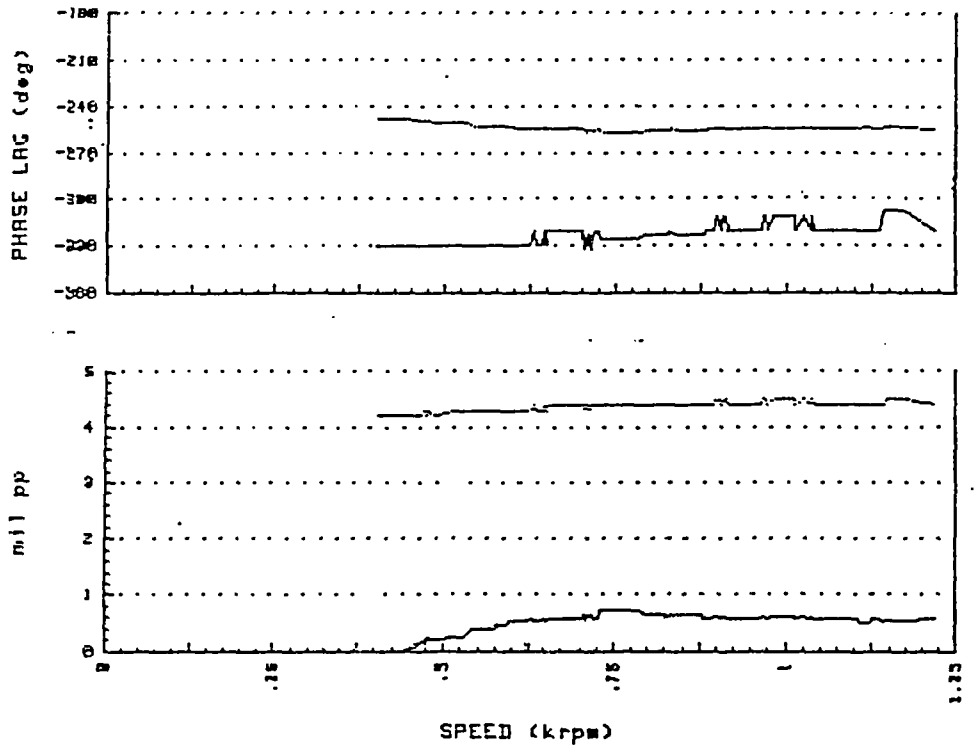
VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 400 RPM = 4.20 @ -158

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

	PLANT ID:	HOPE CREEK GEN STA.
	TRAIN ID:	A RCP
	MACHINE ID:	PUMP
	SOLID DATA: Comp	1YD
RUNUP	DASHED DATA:Uncomp	1YD

RUN: 1 DATE: 14 FEB 87 TIME: 1500



VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 400 RPM = 4.20 @ -248

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

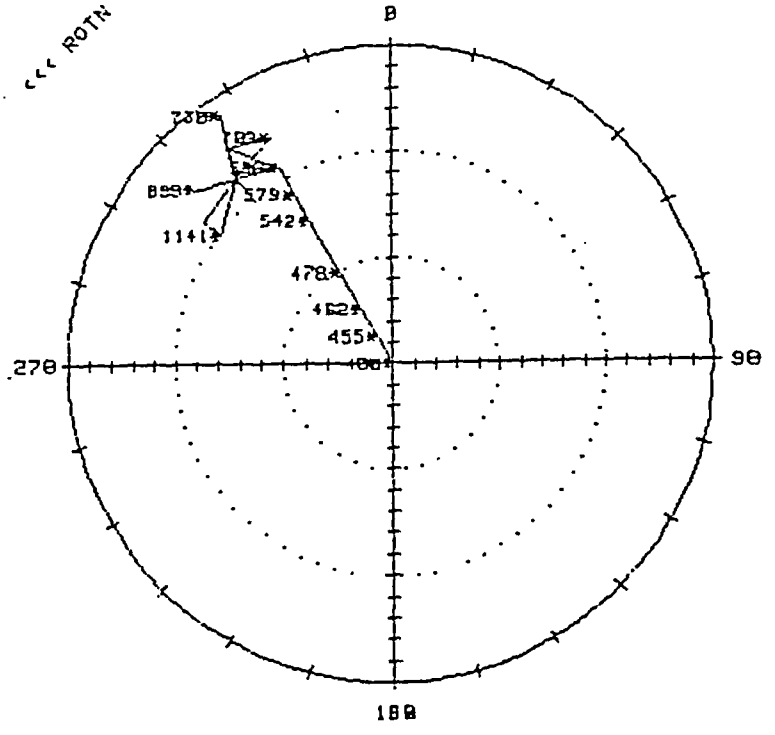
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: A RCP
MACHINE ID: PUMP
SOLID DATA: Comp 1YD

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



FULL SCALE AMP = .75 mil pp AMP PER DIV = .05 mil pp

VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 400 RPM = 4.20 @ -248

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

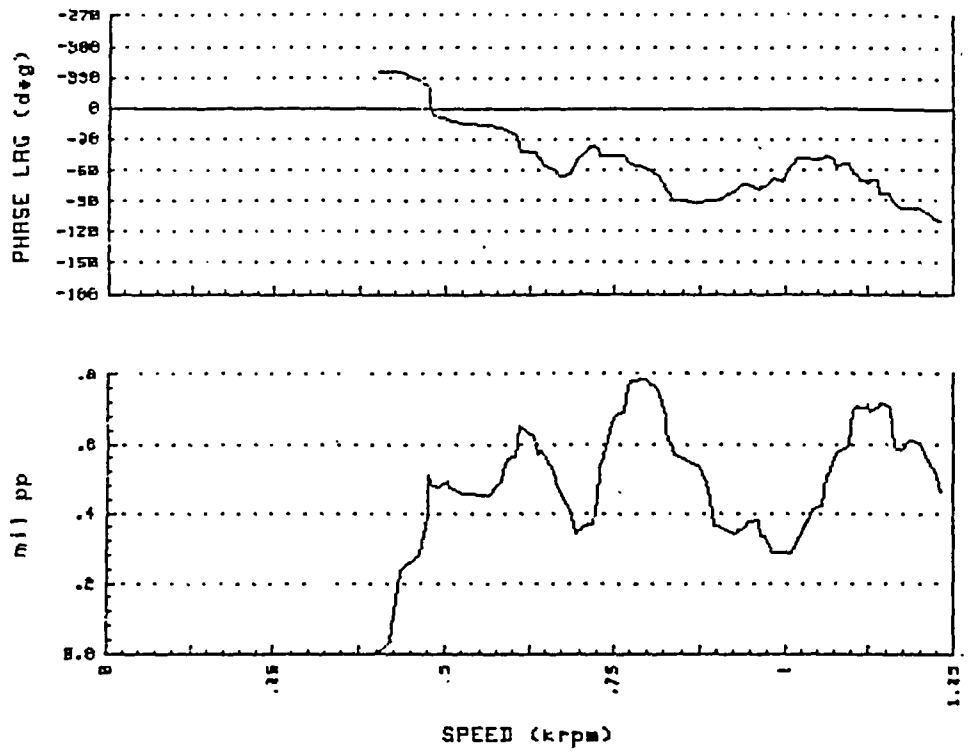
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: A RCP
MACHINE ID: PUMP
SOLID DATA: Comp

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 400 RPM = .16 @ -225

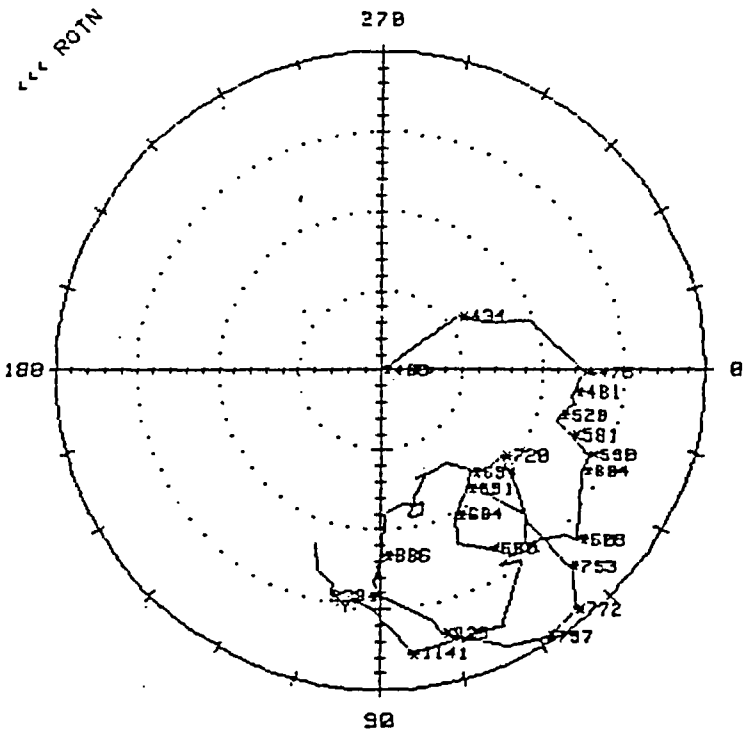
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: A RCP
MACHINE ID: PUMP
SOLID DATA: Comp

RUNUP

RUN: 1 DATE: 14 FEB 87 TIME: 1500



FULL SCALE AMP = .8 mil pp AMP PER DIV = .04 mil pp

VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 400 RPM = .16 @ -225

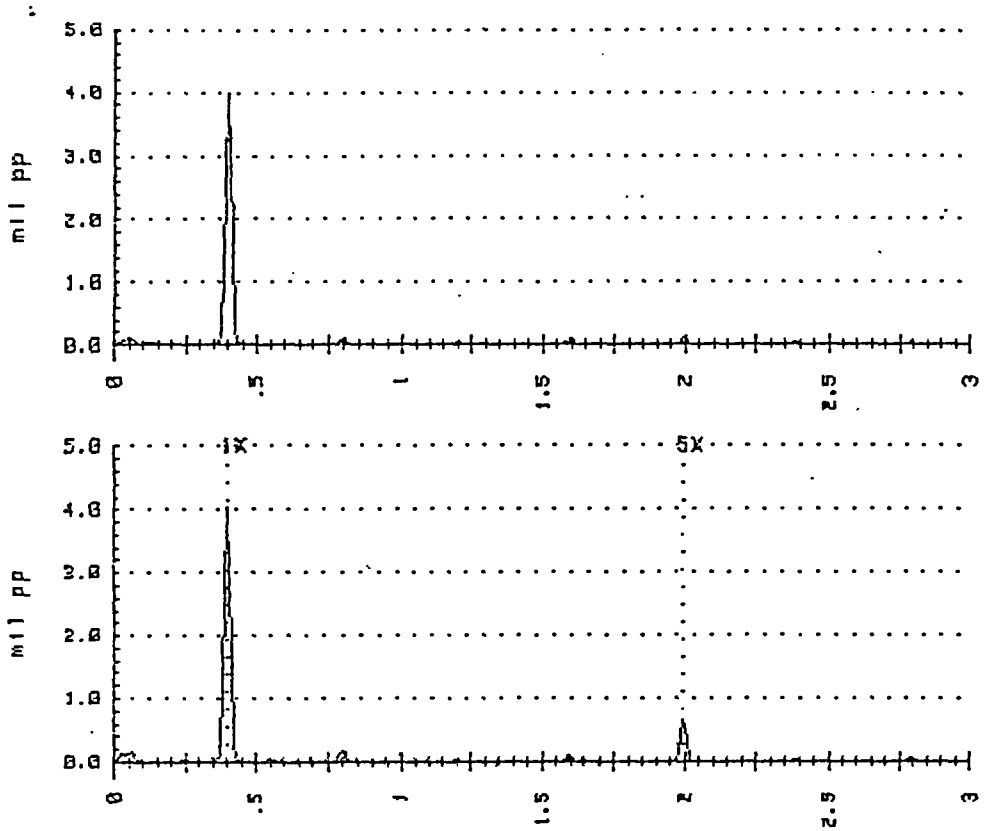
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: A RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 14 FEB 87 TIME: 15:00 PROBE ID: 1XD
OVERALL AMP = 4.87 TO 4.90 mil pp
1X = 399 RPM

RUN: 1 DATE: 14 FEB 87 TIME: 15:00 PROBE ID: 1YD
OVERALL AMP = 5.34 TO 5.50 mil pp
1X = 399 RPM



FREQUENCY (kcpm)

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK
TRAIN ID: A RCP
MACHINE ID: PUMP

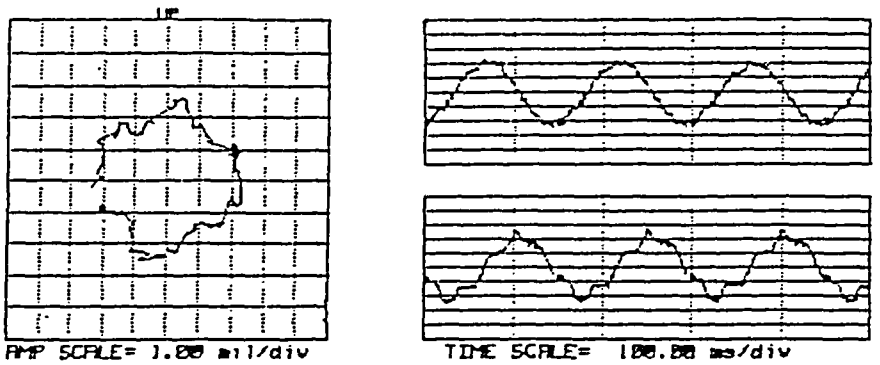
PLOT NO:

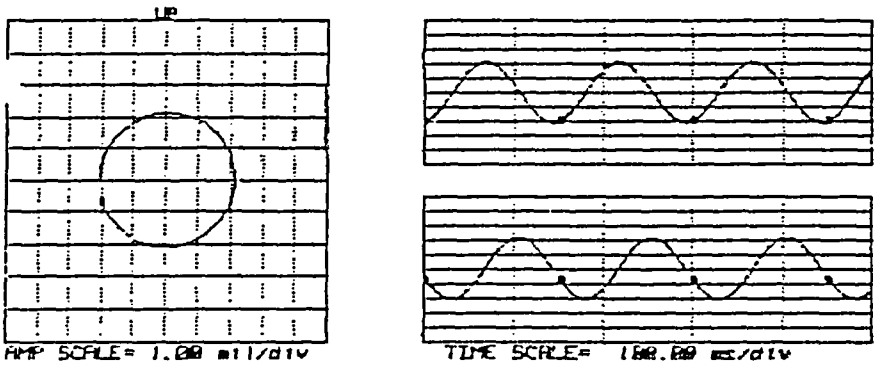
RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
UNFILTERED
SLOW ROLL COMPENSATED DATA
PROBE #2 ID: 1YD
UNFILTERED
SLOW ROLL COMPENSATED DATA
ROTATION: CCW
RPM(START)= 400 RPM(END)= 399

ORIENTATION= 0 deg
MAX AMP= 4.80 mil pp

ORIENTATION= 90 deg
MAX AMP= 5.20 mil pp





RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
1X FILTERED
SLOW ROLL COMPENSATED DATA
PROBE #2 ID: 1YD
1X FILTERED
SLOW ROLL COMPENSATED DATA
ROTATION: CCW
RPM(START)= 399 RPM(END)= 400

ORIENTATION= 0 deg
1X VECTOR= 4.20 mil pp @-157

ORIENTATION= 90 deg
1X VECTOR= 4.20 mil pp @-246

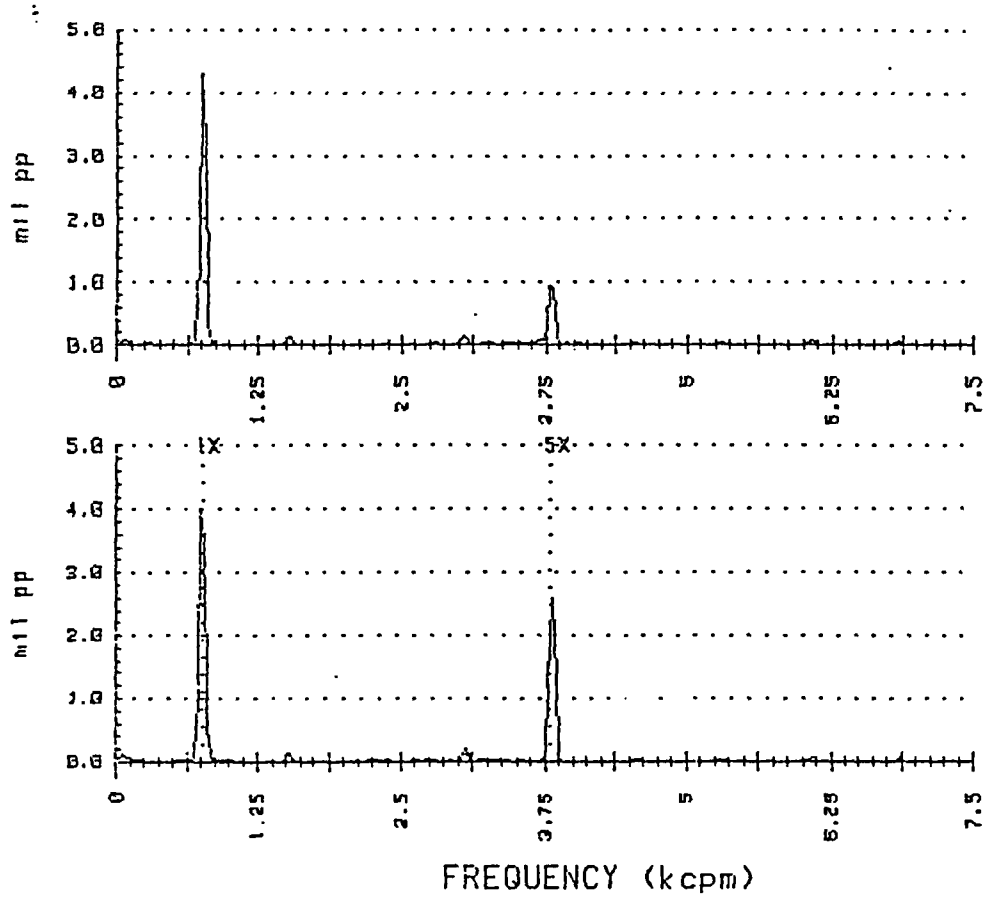
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: A RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 14 FEB 87 TIME: 21:40 PROBE ID: 1XD
OVERALL AMP = 5.60 TO 5.90 mil pp
1X = 758 RPM

RUN: 1 DATE: 14 FEB 87 TIME: 21:40 PROBE ID: 1YD
OVERALL AMP = 7.30 TO 7.70 mil pp
1X = 759 RPM



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK
TRAIN ID: A RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 14 FEB 87 TIME: 15:00

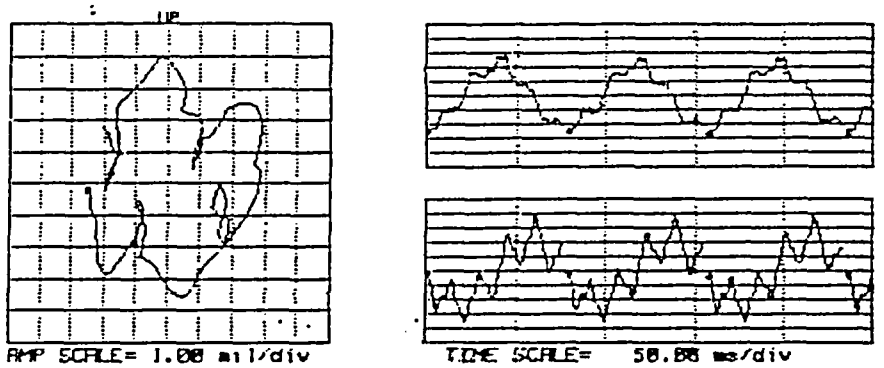
PROBE #1 ID: 1XD
UNFILTERED

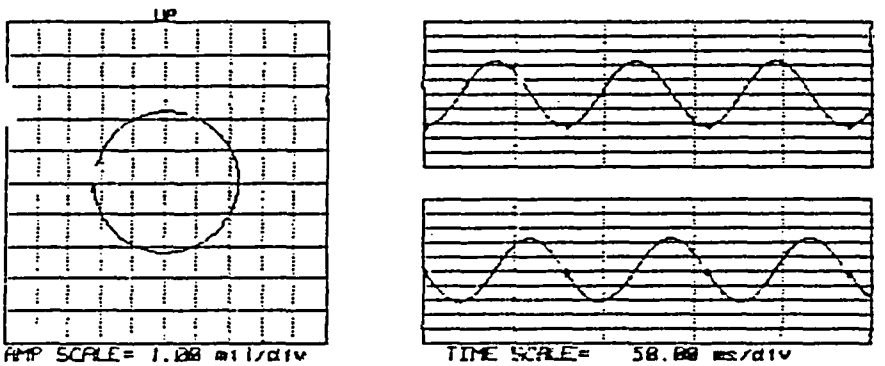
ORIENTATION= 0 deg
MAX AMP= 5.60 mil pp

PROBE #2 ID: 1YD
UNFILTERED

ORIENTATION= 90 deg
MAX AMP= 7.60 mil pp

ROTATION: CCW
RPM(START)= 758 RPM(END)= 765





RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
1X FILTERED

ORIENTATION= 0 deg
1X VECTOR= 4.50 mil pp @-169

PROBE #2 ID: 1YD
1X FILTERED

ORIENTATION= 90 deg
1X VECTOR= 4.40 mil pp @-258

ROTATION: CCW
RPM(START)= 755 RPM(END)= 764

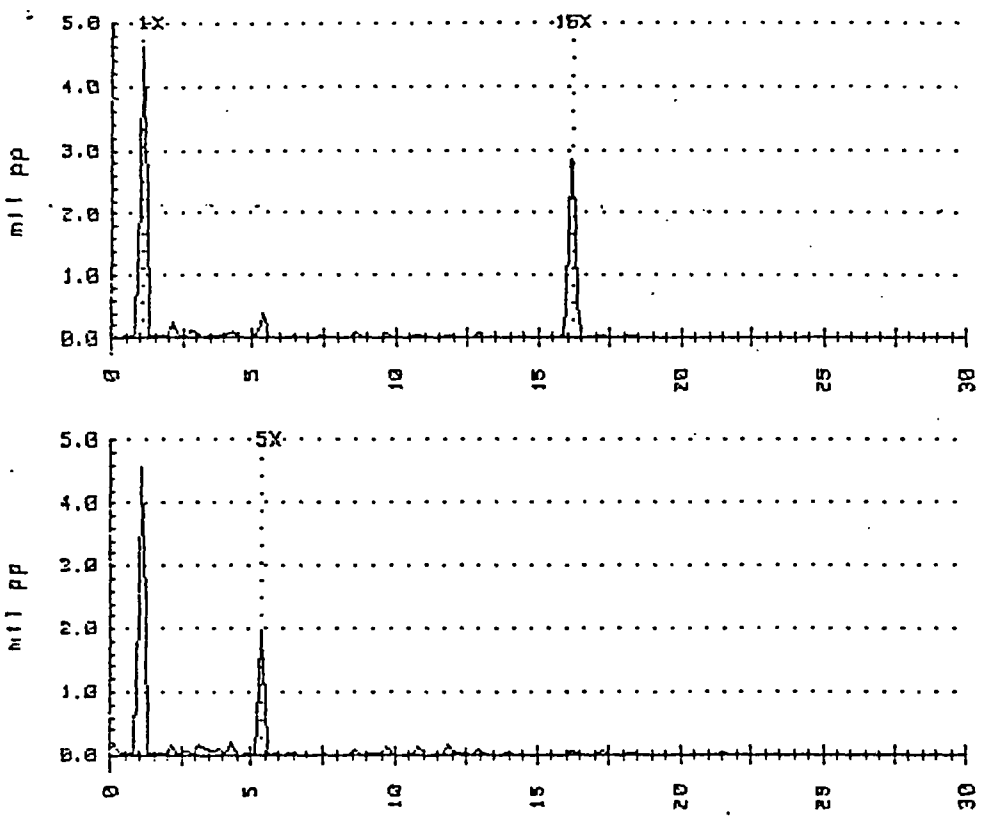
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: A RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 00:30 PROBE ID: 1XD
OVERALL AMP = 8.00 TO 8.40 mil pp
1X = 1076 RPM

RUN: 1 DATE: 15 FEB 87 TIME: 00:30 PROBE ID: 1YD
OVERALL AMP = 6.10 TO 6.30 mil pp
1X = 1078 RPM



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK
TRAIN ID: A RCP
MACHINE ID: PUMP

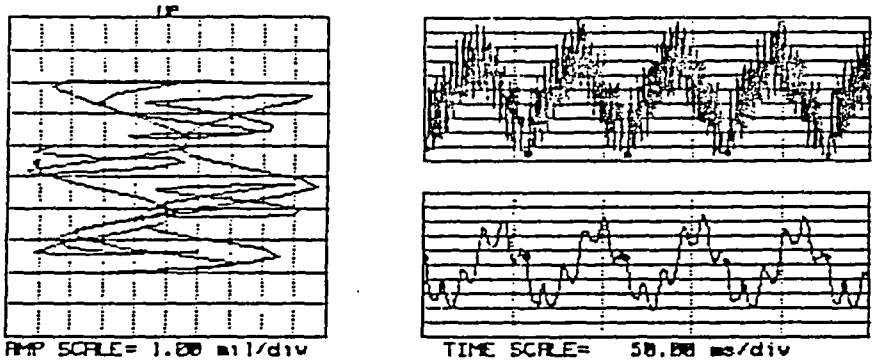
PLOT NO:

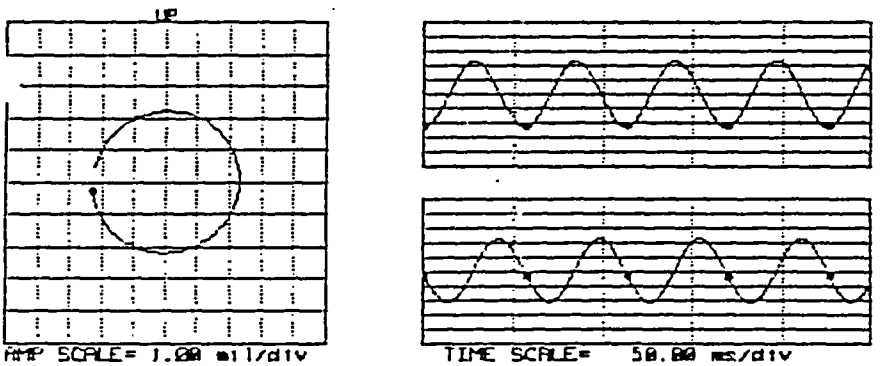
RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
UNFILTERED
SLOW ROLL COMPENSATED DATA
PROBE #2 ID: 1YD
UNFILTERED
SLOW ROLL COMPENSATED DATA
ROTATION: CCW
RPM(START)= 1065 RPM(END)= 1065

ORIENTATION= 0 deg
MAX AMP= 9.60 mil pp

ORIENTATION= 90 deg
MAX AMP= 6.50 mil pp





RUN: 1 DATE: 14 FEB 87 TIME: 15:00

PROBE #1 ID: 1XD
1X FILTERED
SLOW ROLL COMPENSATED DATA
PROBE #2 ID: 1YD
1X FILTERED
SLOW ROLL COMPENSATED DATA
ROTATION: CCW
RPM(START)= 1063 RPM(END)= 1062

ORIENTATION= 0 deg
1X VECTOR= 4.60 mil pp @-166

ORIENTATION= 90 deg
1X VECTOR= 4.40 mil pp @-253

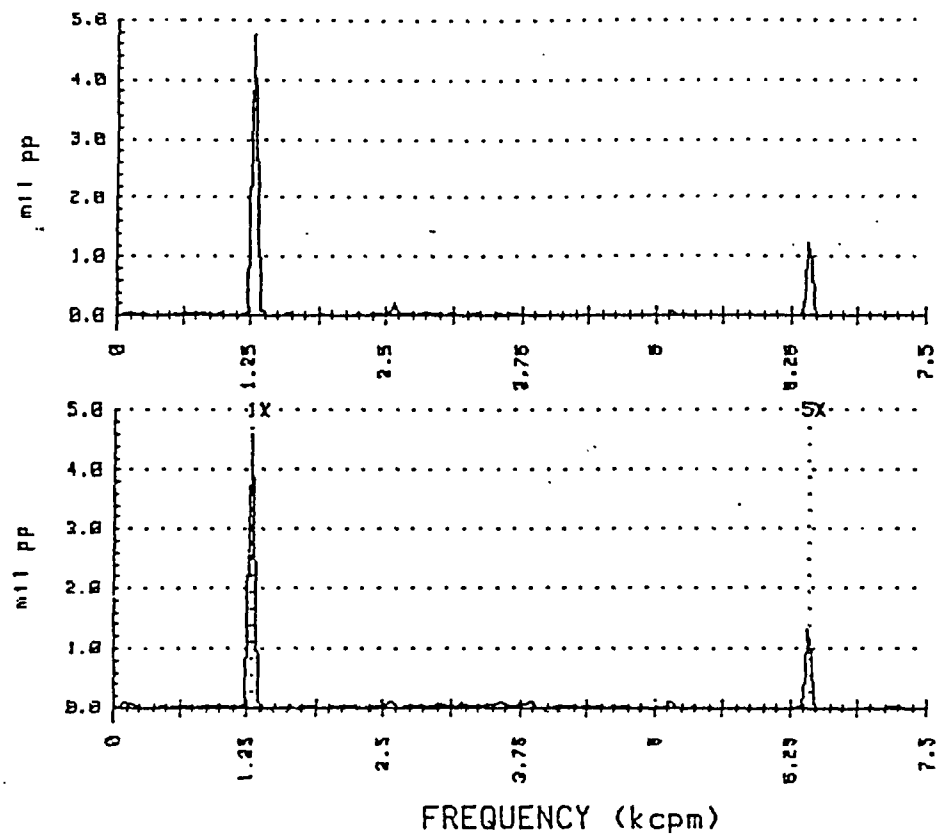
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: A RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 14:54 PROBE ID: 1XD
OVERALL AMP = 6.11 TO 6.33 mil pp
1X = 1285 RPM

RUN: 1 DATE: 15 FEB 87 TIME: 14:54 PROBE ID: 1YD
OVERALL AMP = 6.48 TO 6.60 mil pp
1X = 1285 RPM



PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLANT ID: HOPE CREEK GEN STA
TRAIN ID: A RCP
MACHINE ID: PUMP

PLOT NO:

RUN: 1 DATE: 15 FEB 87 TIME: 14:54

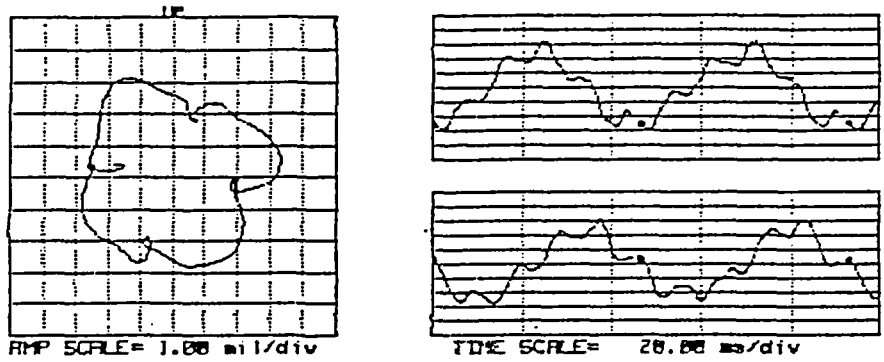
PROBE #1 ID: 1XD
UNFILTERED

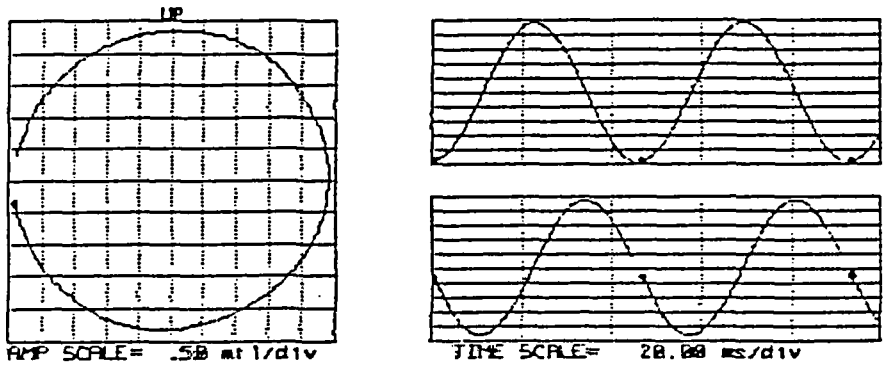
ORIENTATION= 0 deg
MAX AMP= 6.25 mil pp

PROBE #2 ID: 1YD
UNFILTERED

ORIENTATION= 90 deg
MAX AMP= 5.90 mil pp

ROTATION: CCW
RPM(START)= 1285 RPM(END)= 1285





RUN: 1 DATE: 15 FEB 87 TIME: 14:54

PROBE #1 ID: 1XD
1X FILTERED

ORIENTATION= 0 deg
1X VECTOR= 4.85 mil pp @-168

PROBE #2 ID: 1YD
1X FILTERED

ORIENTATION= 90 deg
1X VECTOR= 4.69 mil pp @-257

ROTATION: CCW
RPM(START)= 1284 RPM(END)= 1284

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

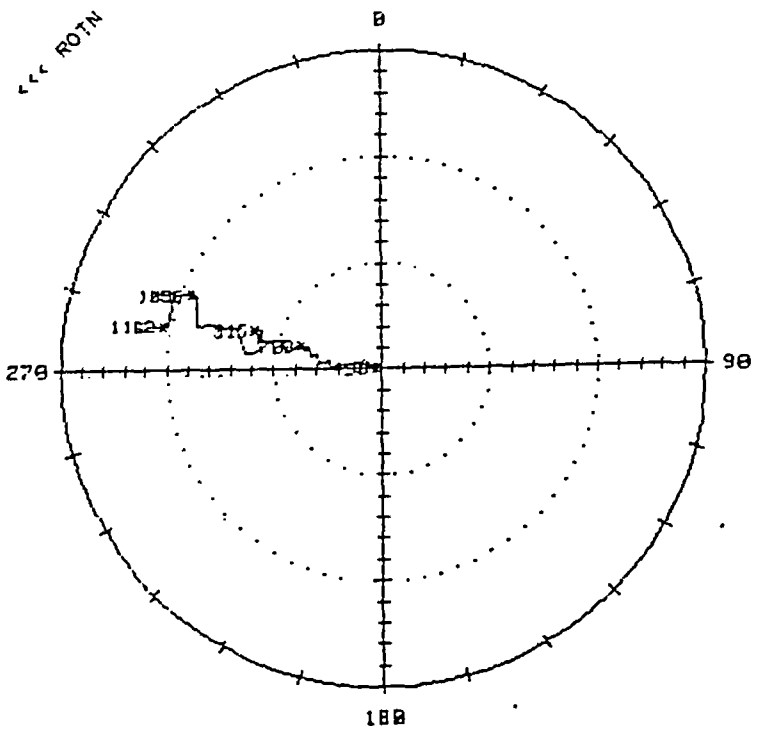
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: B RCP
MACHINE ID: PUMP
SOLID DATA: Comp 1YD

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



FULL SCALE AMP = 3 mil pp AMP PER DIV = .2 mil pp

VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 433 RPM = 1.14 @ -243

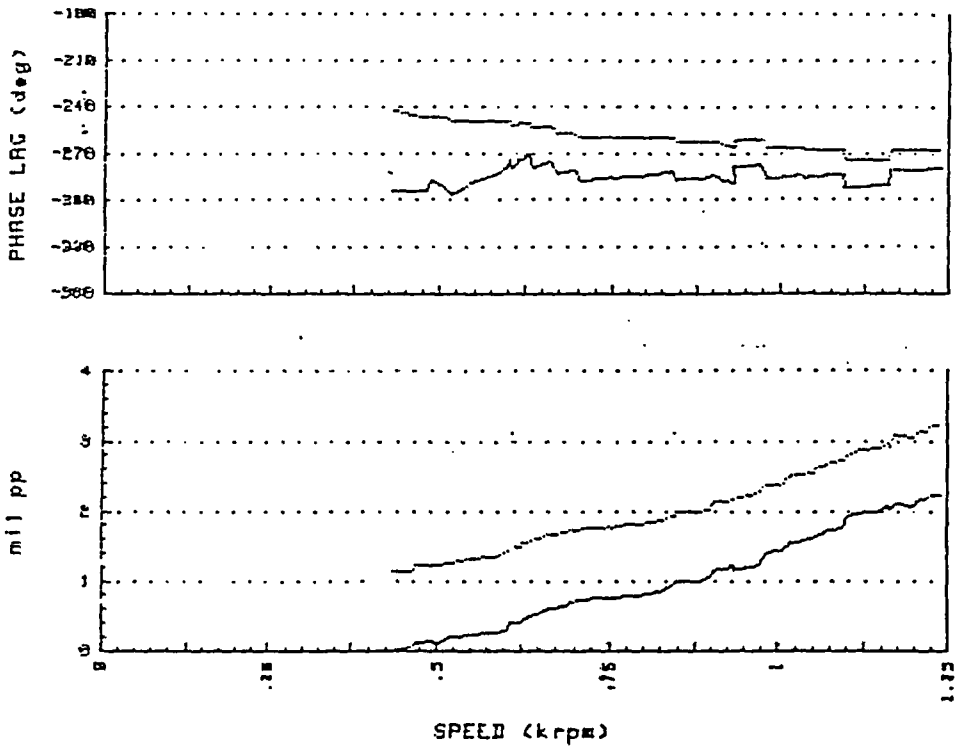
PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

PLANT ID:	HOPE CREEK GEN STA.
TRAIN ID:	B RCP
MACHINE ID:	PUMP
SOLID DATA: Comp	1YD
DASHED DATA:Uncomp	1YD

RUNUP

RUN: 1 DATE: 14 FEB 87 TIME: 1500



VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 433 RPM = 1.14 @ -243

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

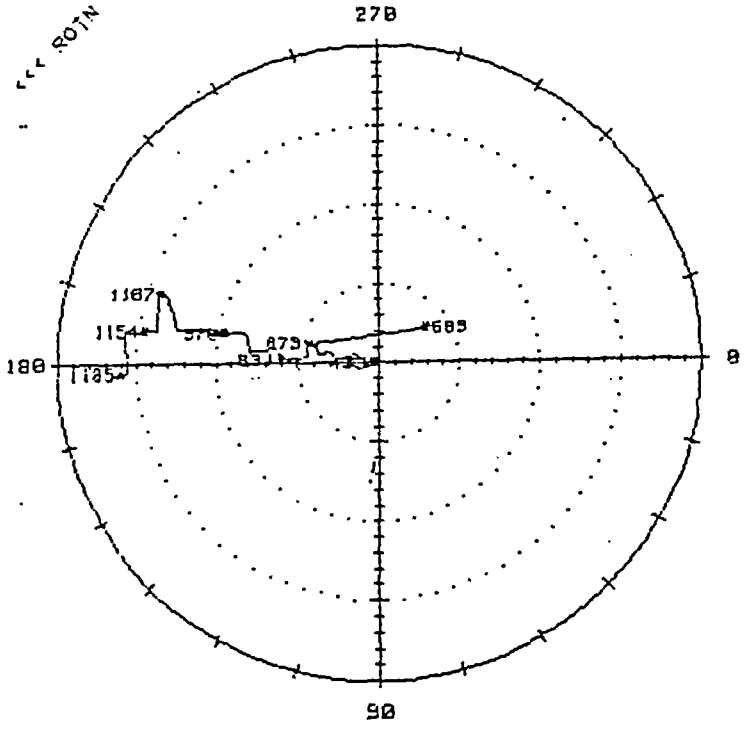
PLANT ID: HOPE CREEK GEN STA.
TRAIN ID: B RCP
MACHINE ID: PUMP
SOLID DATA: Comp 1XD

RUNUP

RUN: 1

DATE: 14 FEB 87

TIME: 1500



FULL SCALE AMP = 2 mil pp AMP PER DIV = .1 mil pp

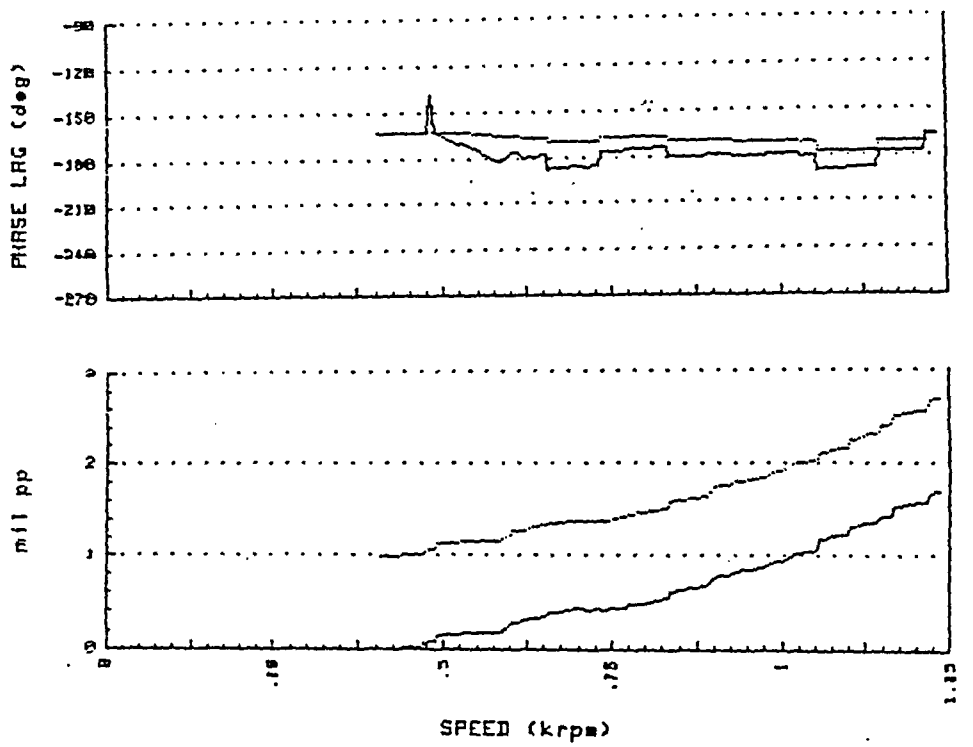
VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 433 RPM = .99 @ -163

PSE&G RESEARCH CORP
MATERIALS DIVISION
VIBRATION TEST DEPT.

PLOT NO:

	PLANT ID:	HOPE CREEK GEN STA.
	TRAIN ID:	B RCP
:	MACHINE ID:	PUMP
:	SOLID DATA: Comp	1XD
RUNUP	DASHED DATA:Uncomp	1XD

RUN: 1 DATE: 14 FEB 87 TIME: 1500



VECTOR(S) SUBTRACTED FROM SOLID DATA:
SLOW ROLL (mil pp) @ 404 RPM = .99 @ -163